Surveillance Report

Report Details

Surveillance generated by nf-ncov-voc for lineage/clade: Unknown
This report is generated on 2024-12-03 using 924 number of genomes collected between 2024-01-25 and 2024-09-26

Additional Information

Organism: Severe acute respiratory syndrome coronavirus 2
Reference Accession: NC_045512.2
Reference Database Name: RefSeq

Table 1: Indicator Summary

This table contains key indicators identified

Surveillance Indicator	Functional Categories	Mutations
Transmissibility between humans	transmissibility	D614G, H655Y, H69del, K417N, N440K, N501Y, P681R, S373P, V70del
Infection Severity	ACE2 receptor binding affinity, viral load, outcome hazard ratio	D405N, D614G, D796Y, F486P, G339H, H655Y, H69del, K417N, N440K, N460K, N501Y, N679K, N764K, N969K, P681R, Q498R, Q954H, R346T, R408S, S371F, S373P, V70del, Y505H
Immunity after natural infection	convalescent plasma escape, reinfection, humoral response durability	A475V, D614G, H655Y, H69del, K417N, N440K, N450D, N501Y, P681R, V70del
Vaccines	vaccine neutralization efficacy	D405N, D614G, D796Y, H655Y, H69del, K417N, N440K, N501Y, N679K, N764K, N969K, P681R, Q498R, Q954H, R408S, S371F, S373P, V70del, Y505H
Monoclonal antibodies	monoclonal antibody serial passage escape, pharmaceutical effectiveness	A475V, D405N, D614G, D796Y, F486P, H655Y, H69del, K417N, L452W, N440K, N450D, N460K, N501Y, N679K, N764K, N969K, P681R, Q498R, Q954H, R408S, S371F, S373P, V70del, Y505H
Diagnostics	clinical indicators, antigenic test failure, symptom prevalence	D614G, H69del, K417N, N501Y, P681R, V70del

Table 2: Mutation Details Summary

This table contains key functional impacts of mutations identified

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
H69del	convalescent plasma escape	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	antibody epitope effects	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	vaccinee plasma binding	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	immunosuppression variant emergence	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	convalescent plasma binding	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	anthropozoonotic events	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	trafficking	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	symptom prevalence	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	virion structure	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	vaccine efficacy	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	aerosolization	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	environmental condition stability	Pokay	KP.2.3.1	3	ATACATG	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
H69del	reinfection	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	tissue specific neutralization	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	clinical indicators	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	tissue specific replication effects	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	transmissibility	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	outcome hazard ratio	Pokay	KP.2.3.1	3	ATACATG	A	1.0
H69del	viral load	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	convalescent plasma escape	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	antibody epitope effects	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	vaccinee plasma binding	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	immunosuppression variant emergence	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	convalescent plasma binding	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	anthropozoonotic events	Pokay	KP.2.3.1	3	ATACATG	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
V70del	trafficking	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	symptom prevalence	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	virion structure	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	vaccine efficacy	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	aerosolization	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	environmental condition stability	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	reinfection	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	tissue specific neutralization	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	clinical indicators	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	tissue specific replication effects	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	transmissibility	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	outcome hazard ratio	Pokay	KP.2.3.1	3	ATACATG	A	1.0
V70del	viral load	Pokay	KP.2.3.1	3	ATACATG	A	1.0
G339H	gene expression increase	Pokay	KP.2.3.1	3	GG	CA	1.0
G339H	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	GG	CA	1.0
R346T	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	G	C	1.0
R346T	gene expression increase	Pokay	KP.2.3.1	3	G	C	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
K356T	gene expression increase	Pokay	KP.2.3.1	3	A	C	1.0
S371F	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	C	T	1.0
S371F	antibody epitope effects	Pokay	KP.2.3.1	3	C	T	1.0
S371F	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	C	T	1.0
S371F	vaccinee plasma binding	Pokay	KP.2.3.1	3	C	T	1.0
S371F	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	C	T	1.0
S373P	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	C	1.0
S373P	antibody epitope effects	Pokay	KP.2.3.1	3	T	C	1.0
S373P	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	T	C	1.0
S373P	vaccinee plasma binding	Pokay	KP.2.3.1	3	T	C	1.0
S373P	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	C	1.0
S373P	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	T	C	1.0
S373P	transmissibility	Pokay	KP.2.3.1	3	T	C	1.0
D405N	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	G	A	1.0
D405N	antibody epitope effects	Pokay	KP.2.3.1	3	G	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
D405N	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	G	A	1.0
D405N	vaccinee plasma binding	Pokay	KP.2.3.1	3	G	A	1.0
D405N	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	G	A	1.0
R408S	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	A	C	1.0
R408S	antibody epitope effects	Pokay	KP.2.3.1	3	A	C	1.0
R408S	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	A	C	1.0
R408S	vaccinee plasma binding	Pokay	KP.2.3.1	3	A	C	1.0
R408S	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	A	C	1.0
R408S	gene expression increase	Pokay	KP.2.3.1	3	A	C	1.0
R408S	vaccine efficacy	Pokay	KP.2.3.1	3	A	C	1.0
K417N	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	G	T	1.0
K417N	antibody epitope effects	Pokay	KP.2.3.1	3	G	T	1.0
K417N	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	G	T	1.0
K417N	convalescent plasma escape	Pokay	KP.2.3.1	3	G	T	1.0
K417N	convalescent plasma binding	Pokay	KP.2.3.1	3	G	T	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
K417N	vaccinee plasma binding	Pokay	KP.2.3.1	3	G	T	1.0
K417N	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	G	T	1.0
K417N	T cell evasion	Pokay	KP.2.3.1	3	G	T	1.0
K417N	tissue specific neutralization	Pokay	KP.2.3.1	3	G	T	1.0
K417N	trafficking	Pokay	KP.2.3.1	3	G	T	1.0
K417N	environmental condition stability	Pokay	KP.2.3.1	3	G	T	1.0
K417N	outcome hazard ratio	Pokay	KP.2.3.1	3	G	T	1.0
K417N	humoral response durability	Pokay	KP.2.3.1	3	G	T	1.0
K417N	anthropozoonotic events	Pokay	KP.2.3.1	3	G	T	1.0
K417N	reinfection	Pokay	KP.2.3.1	3	G	T	1.0
K417N	symptom prevalence	Pokay	KP.2.3.1	3	G	T	1.0
K417N	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	G	T	1.0
K417N	gene expression increase	Pokay	KP.2.3.1	3	G	T	1.0
K417N	virion structure	Pokay	KP.2.3.1	3	G	T	1.0
K417N	viral load	Pokay	KP.2.3.1	3	G	T	1.0
K417N	transmissibility	Pokay	KP.2.3.1	3	G	T	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N440K	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	G	1.0
N440K	antibody epitope effects	Pokay	KP.2.3.1	3	T	G	1.0
N440K	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	T	G	1.0
N440K	convalescent plasma escape	Pokay	KP.2.3.1	3	T	G	1.0
N440K	vaccinee plasma binding	Pokay	KP.2.3.1	3	T	G	1.0
N440K	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	G	1.0
N440K	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	T	G	1.0
N440K	transmissibility	Pokay	KP.2.3.1	3	T	G	1.0
N440K	reinfection	Pokay	KP.2.3.1	3	T	G	1.0
N450D	convalescent plasma escape	Pokay	KP.2.3.1	3	A	G	1.0
N450D	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	A	G	1.0
N450D	antibody epitope effects	Pokay	KP.2.3.1	3	A	G	1.0
L452W	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	CT	TG	1.0
N460K	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	A	1.0
N460K	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N460K	gene expression increase	Pokay	KP.2.3.1	3	T	A	1.0
N460K	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	T	A	1.0
A475V	convalescent plasma escape	Pokay	KP.2.3.1	3	C	T	1.0
A475V	antibody epitope effects	Pokay	KP.2.3.1	3	C	T	1.0
A475V	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	C	T	1.0
A475V	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	C	T	1.0
F486P	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	TT	CC	1.0
F486P	gene expression increase	Pokay	KP.2.3.1	3	TT	CC	1.0
F486P	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	TT	CC	1.0
Q498R	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	A	G	1.0
Q498R	antibody epitope effects	Pokay	KP.2.3.1	3	A	G	1.0
Q498R	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	A	G	1.0
Q498R	vaccinee plasma binding	Pokay	KP.2.3.1	3	A	G	1.0
Q498R	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	A	G	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N501Y	vaccinee plasma binding	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	antibody epitope effects	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	virion structure	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	convalescent plasma escape	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	reinfection	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	vaccine efficacy	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	trafficking	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	anthropozoonotic events	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	convalescent plasma binding	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	T cell evasion	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	transmissibility	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	tissue specific neutralization	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	environmental condition stability	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	outcome hazard ratio	Pokay	KP.2.3.1	3	A	T	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N501Y	symptom prevalence	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	aerosolization	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	clinical indicators	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	tissue specific replication effects	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	viral load	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	humoral response durability	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	syncytium formation	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	immunosuppression variant emergence	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	homoplasy	Pokay	KP.2.3.1	3	A	T	1.0
N501Y	monoclonal antibody serial passage escape	Pokay	KP.2.3.1	3	A	T	1.0
Y505H	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	C	1.0
Y505H	antibody epitope effects	Pokay	KP.2.3.1	3	T	C	1.0
Y505H	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	T	C	1.0
Y505H	vaccinee plasma binding	Pokay	KP.2.3.1	3	T	C	1.0
Y505H	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	C	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
Y505H	gene expression increase	Pokay	KP.2.3.1	3	T	C	1.0
Y505H	anthropozoonotic events	Pokay	KP.2.3.1	3	T	C	1.0
D614G	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	A	G	1.0
D614G	convalescent plasma binding	Pokay	KP.2.3.1	3	A	G	1.0
D614G	vaccinee plasma binding	Pokay	KP.2.3.1	3	A	G	1.0
D614G	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	A	G	1.0
D614G	antibody epitope effects	Pokay	KP.2.3.1	3	A	G	1.0
D614G	convalescent plasma escape	Pokay	KP.2.3.1	3	A	G	1.0
D614G	virion structure	Pokay	KP.2.3.1	3	A	G	1.0
D614G	reinfection	Pokay	KP.2.3.1	3	A	G	1.0
D614G	vaccine efficacy	Pokay	KP.2.3.1	3	A	G	1.0
D614G	trafficking	Pokay	KP.2.3.1	3	A	G	1.0
D614G	anthropozoonotic events	Pokay	KP.2.3.1	3	A	G	1.0
D614G	T cell evasion	Pokay	KP.2.3.1	3	A	G	1.0
D614G	transmissibility	Pokay	KP.2.3.1	3	A	G	1.0
D614G	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	A	G	1.0
D614G	tissue specific neutralization	Pokay	KP.2.3.1	3	A	G	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
D614G	environmental condition stability	Pokay	KP.2.3.1	3	A	G	1.0
D614G	aerosolization	Pokay	KP.2.3.1	3	A	G	1.0
D614G	clinical indicators	Pokay	KP.2.3.1	3	A	G	1.0
D614G	tissue specific replication effects	Pokay	KP.2.3.1	3	A	G	1.0
D614G	humoral response durability	Pokay	KP.2.3.1	3	A	G	1.0
D614G	outcome hazard ratio	Pokay	KP.2.3.1	3	A	G	1.0
D614G	syncytium formation	Pokay	KP.2.3.1	3	A	G	1.0
D614G	immunosuppression variant emergence	Pokay	KP.2.3.1	3	A	G	1.0
D614G	symptom prevalence	Pokay	KP.2.3.1	3	A	G	1.0
D614G	viral load	Pokay	KP.2.3.1	3	A	G	1.0
H655Y	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	antibody epitope effects	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	virion structure	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	convalescent plasma escape	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	reinfection	Pokay	KP.2.3.1	3	C	T	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
H655Y	vaccine efficacy	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	trafficking	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	anthropozoonotic events	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	convalescent plasma binding	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	T cell evasion	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	transmissibility	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	outcome hazard ratio	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	vaccinee plasma binding	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	C	T	1.0
H655Y	homoplasy	Pokay	KP.2.3.1	3	C	T	1.0
N679K	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	G	1.0
N679K	antibody epitope effects	Pokay	KP.2.3.1	3	T	G	1.0
N679K	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	T	G	1.0
N679K	vaccinee plasma binding	Pokay	KP.2.3.1	3	T	G	1.0
N679K	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	G	1.0
P681R	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	C	G	1.0
P681R	trafficking	Pokay	KP.2.3.1	3	C	G	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
P681R	convalescent plasma escape	Pokay	KP.2.3.1	3	C	G	1.0
P681R	antibody epitope effects	Pokay	KP.2.3.1	3	C	G	1.0
P681R	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	C	G	1.0
P681R	convalescent plasma binding	Pokay	KP.2.3.1	3	C	G	1.0
P681R	vaccinee plasma binding	Pokay	KP.2.3.1	3	C	G	1.0
P681R	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	C	G	1.0
P681R	outcome hazard ratio	Pokay	KP.2.3.1	3	C	G	1.0
P681R	vaccine efficacy	Pokay	KP.2.3.1	3	C	G	1.0
P681R	viral load	Pokay	KP.2.3.1	3	C	G	1.0
P681R	symptom prevalence	Pokay	KP.2.3.1	3	C	G	1.0
P681R	transmissibility	Pokay	KP.2.3.1	3	C	G	1.0
P681R	virion structure	Pokay	KP.2.3.1	3	C	G	1.0
N764K	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	C	A	1.0
N764K	antibody epitope effects	Pokay	KP.2.3.1	3	C	A	1.0
N764K	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	C	A	1.0
N764K	vaccinee plasma binding	Pokay	KP.2.3.1	3	C	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N764K	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	C	A	1.0
D796Y	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	G	T	1.0
D796Y	antibody epitope effects	Pokay	KP.2.3.1	3	G	T	1.0
D796Y	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	G	T	1.0
D796Y	vaccinee plasma binding	Pokay	KP.2.3.1	3	G	T	1.0
D796Y	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	G	T	1.0
S939F	anthropozoonotic events	Pokay	KP.2.3.1	3	C	T	1.0
Q954H	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	A	T	1.0
Q954H	antibody epitope effects	Pokay	KP.2.3.1	3	A	T	1.0
Q954H	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	A	T	1.0
Q954H	vaccinee plasma binding	Pokay	KP.2.3.1	3	A	T	1.0
Q954H	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	A	T	1.0
N969K	pharmaceutical effectiveness	Pokay	KP.2.3.1	3	T	A	1.0
N969K	antibody epitope effects	Pokay	KP.2.3.1	3	T	A	1.0
N969K	vaccine neutralization efficacy	Pokay	KP.2.3.1	3	T	A	1.0

Mutations	Functional Category	Annotation Resource	Lineages	Sequence Depth	Reference Allele	Alternate Allele	Alternate Frequency
N969K	vaccinee plasma binding	Pokay	KP.2.3.1	3	T	A	1.0
N969K	ACE2 receptor binding affinity	Pokay	KP.2.3.1	3	T	A	1.0
T9I	homoplasy	Pokay	KP.2.3.1	3	C	T	1.0
T9I	frequency based fitness	Pokay	KP.2.3.1	3	C	T	1.0
D3H	frequency based fitness	Pokay	KP.2.3.1	3	G	C	1.0
Q19E	frequency based fitness	Pokay	KP.2.3.1	3	C	G	1.0
F53F	frequency based fitness	Pokay	KP.2.3.1	3	C	T	1.0
F112F	frequency based fitness	Pokay	KP.2.3.1	3	C	T	1.0
P13L	homoplasy	Pokay	KP.2.3.1	3	C	T	1.0
P13L	T cell evasion	Pokay	KP.2.3.1	3	C	T	1.0

Table 3: Functional Effect Summary

This table contains detailed functional descriptions of each functional category

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.525 reduced 4.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
H69del	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
H69del	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
H69del	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
H69del	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
H69del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
H69del	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
H69del	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
H69del	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
H69del	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H69del	vaccinee plasma binding	Pokay	Neutralization activity of almost all Moderna Phase 1 sera tested actually *increased*.	2021	Shen et al. (2021)
H69del	immunosuppression variant emergence	Pokay	The delH69/V70 enhances viral infectivity, indicating its effect on virus fitness is independent to the N501Y RBM change [with which it is found in lineage B.1.1.7] Possibly arisen as a result of the virus evolving from immune selection pressure in infected individuals and possibly only one chronic infection in the case of lineage B.1.1.7.	2020	Kemp et al. (2020)
H69del	convalescent plasma escape	Pokay	One convalescent sera tested showed 4-fold or greater reduction in neutralization efficiency.	2021	Alenquer et al. (2021)
H69del	convalescent plasma escape	Pokay	Neutralization activity of almost all convalescent sera tested decreased ~2x.	2021	Shen et al. (2021)
H69del	convalescent plasma escape	Pokay	Neutralization activity of convalescent sera tested decreased ~2x with this B.1.1.7 pseudotyped virus.	2021	Shen et al. (2021)
H69del	antibody epitope effects	Pokay	Reduces neutralization by structurally unmapped mAb COVA1-21 (cluster XI).	2021	Rees-Spear et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	convalescent plasma binding	Pokay	Viruses containing the point mutations of B.1.1.7 showed that the single point mutations (Δ69-70 and N501Y) were neutralized as efficiently as D614G across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
H69del	anthropozoonotic events	Pokay	This deletion outside the receptor binding domain in pseudotyped VSV promoted the capacity of pseudotyped VSV to transduce black flying fox (Pteropus alecto) kidney PabKi.1 cells (17.8%) to a level twice that of human epithelial-like Huh-7 cells (9.8%)	2023	Li et al. (2023)
H69del	convalescent plasma binding	Pokay	No notable change in neutralization efficiency, despite N439K by itself showing a ~2x decrease on average in 16 health workers' convalescent sera.	2021	Alenquer et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was somewhat lower against B.1.1.7 in sera tested from most of the 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
H69del	antibody epitope effects	Pokay	B.1.1.7 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2489.	2021	Chen et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.1.7 sample. Contrast this with 1.3-fold reduction for just the pseudovirus combination of 'key' B.1.1.7 mutation N501Y.	2021	Bates et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing slight decrease in infection rate amongst the cells, much closer to D614G activity level than Y453F alone, suggesting compensatory effects between the deletion and the mutation in human cell entry fitness.	2021	Tada et al. (2021)
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing moderate decrease in infection rate amongst the cells, significantly lower than the deletion or Y453F alone, or their combination, suggesting a synergistic effect on poorer human cell entry fitness.	2021	Tada et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.298 virus has reduced neutralization activity vs wild type: 1.4x (30 sera Pfizer median 9 days post 2nd dose) and 1.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing mild to modest decrease in infection rate amongst the cells, suggesting a net mild negative effect on human cell entry fitness.	2021	Tada et al. (2021)
H69del	convalescent plasma binding	Pokay	Lentiviral pseudotyped with the key mutations from Mink Cluster 5 was neutralized more easily than D614G in 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing no change in infection rate amongst the cells, markedly higher infectivity than either mutation alone, suggesting a synergistic net neutral effect on human cell entry fitness.	2021	Tada et al. (2021)
H69del	trafficking	Pokay	Lentiviral pseudotyped with all key mutations from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing major (~50%) decrease in infection rate amongst the cells, suggesting that this anthropozoonotic event is driven by other factors at the expense of human cell entry fitness.	2021	Tada et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7+E484K reduced 2.8x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster. Compare with 1.2x reduction for B.1.1.7 without E484K.	2021	Choi et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Sera after the second dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 + E484K variant of ~6.7x, markedly higher than B.1.1.7 alone. For first dose sera, a 9.7x drop was observed.	2021	Collier et al. (2021)
H69del	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was markedly worse against B.1.1.7 + E484K than the lineage alone, with a 11.4x drop.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	antibody epitope effects	Pokay	Ablates Class 3 N-terminal domain targeting antibody COV2-2489, diminishes COV2-2676.	2021	Chen et al. (2021)
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, moreso than this combination with the addition of P681H.	2021	Tada et al. (2021)
H69del	symptom prevalence	Pokay	In comparison of B.1.1.7 lineage (193 cases) vs. 'wildtype' (125) in Berlin Jan 18 to March 29 2021, significant symptom changes are absent loss of smell/taste (P	2021	van Loon et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	This mutation combination causes major increase in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus, but combined with the complete set of B.1.1.7 lineage variants no major change vs wild type affnity is observed.	2021	Tada et al. (2021)
H69del	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA1-18 (~4x), COVA2-15 (~9x). PG: these effects are laregly missing in the deletion-alone data	2021	Shen et al. (2021)
H69del	symptom prevalence	Pokay	A higher proportion of cases infected with the B.1.1.7 variant were hypoxic on admission compared to other variants (70.0% vs 62.5%, p	2021	Snell et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	virion structure	Pokay	The Ratio of S2 (processed Spike) to full length Spike is higher for this mutation combination, due to a drop in the full length Spike measured, suggesting that this mutation compensates for decreased Spike production by improved proteolytic processing.	2021	Tada et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.1.7 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.1.7 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
H69del	convalescent plasma escape	Pokay	Mean 2.6x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.1.7 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 33%, Day 43 100%, Day 119 100%, Day 209 96%. Detectable antibodies against B.1.1.7 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 54%, Day 43 100%, Day 119 100%, Day 209 88%. Detectable antibodies against B.1.1.7 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 83%, Days 43,119,209 100%.	2021	Pegu et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Using national surveillance data from Israel, using Pfizer vaccine and an estimated prevalence of the B.1.1.7 variant of 94.5% among SARS-CoV-2 infections: Adjusted estimates of vaccine effectiveness 7+ days after second dose were 95·3% (95% CI 94.9–95.7): 91.5% against asymptomatic SARS-CoV-2 infection (90·7–92·2: 40.9 vs 1.8 per 100 000 person-days), 97·0% against symptomatic COVID-19 (96.7–97.2%), 97.2% against COVID-19-related hospitalisation (96.8–97.5%), 97.5% against severe or critical COVID-19-related hospitalisation (97.1–97.8%), and 96.7% against COVID-19-related death (96.0–97.3%). In all age groups, as vaccine coverage increased, the incidence of SARS-CoV-2 outcomes declined	2021	Haas et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 8192 for B.1.351 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
H69del	virion structure	Pokay	CryoEM analysis of B.1.1.7 demonstrates an increased propensity for 'up', receptor accessible conformation of the Spike protein trimer.	2021	Cai et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	SARS-CoV-2 infection was confirmed in three HCWs working a single shift: all presented with mild symptoms of COVID-19. The two physicians were fully vaccinated with BNT162b2 vaccine, with the second dose administered 1 month before symptom onset. Both had high titres of IgG anti-spike antibodies at the time of diagnosis. WGS confirmed that all virus strains were VOC 202012/01-lineage B.1.1.7, suggesting a common source of exposure. Epidemiological investigation revealed that the suspected source was a SARS-CoV-2-positive patient who required endotracheal intubation due to severe COVID-19. All procedures were carried out using a full suite of personal protective equipment (PPE).	2021	Loconsole et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 1422 test-positive were Alpha. Two dose vaccine efficacy against Alpha was 98.4% [96.9-99.1%], one dose VE was 90.1% (82.9-94.2%).	2021	Bruxvoort et al. (2021)
H69del	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms, similarly neutralized B.1.1.7 and D614G.	2021	Planas et al. (2021)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Alpha (B.1.1.7) has an IC50 fold change of 1.19x.	2022	Yuan et al. (2022)
H69del	antibody epitope effects	Pokay	B.1.1.7 pseudotyped virus model impairs binding by RBD-directed mAb 910-30. B.1.1.7 pseudotyped virus model abolishes N-terminal-domain-directed mAbs 5-24, 4-8, and 4A8. B.1.1.7 pseudotyped virus model impairs binding by N-terminal-domain-directe d mAbs 2-17, 4-19, 5-7.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	1.4x improvement in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. 2x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
H69del	aerosolization	Pokay	Alpha variant cases in a large campus study showed fine-aerosol shedding amongst unmasked participants remained significantly greater for alpha variant infections (18-fold, 95% CI, 3.4 to 92-fold) after adjusting for the increased viral RNA in MTS and saliva, the number of coughs during sampling sessions, and symptom. After controlling for the effect of masks and numbers of coughs during sampling, alpha variant infection was associated with a 100-fold (95% CI, 16 to 650-fold) increase in coarse- and a 73-fold (95% CI, 15 to 350-fold) increase in fine-aerosol RNA shedding.	2021	Adenaiye et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	environmental condition stability	Pokay	No differences in the stability of B.1.1.7 observed in the absence of simulated sunlight at either 20°C or 40°C (with a mean time for a 90% loss of viral infectivity across all dark conditions of 6.2 hours). However, a small but statistically significant difference in the stability was observed in simulated sunlight at 20°C and 20% relative humidity, with B.1.1.7 restoring wild type 90% loss time of 11 minutes vs. 7 and 8 minutes for B.1.319 (D614G) and B.28 (V367F) early 2020 viruses respectively.	2021	Schuit et al. (2021)
H69del	trafficking	Pokay	Modelling the Alpha variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increase 3.9x relative to wild type (5.4 vs 1.4). This is less efficient than Delta (11x vs wildtype using a P681R mutation instead). [del ~144 changed due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a co-infection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.1.7 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine. This is despite three mutations (Y144del, D614G, and P681H) overlapping T-cell epitope hotspots.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	environmental condition stability	Pokay	Treatment with heat, soap and ethanol revealed similar inactivation profiles indicative of a comparable susceptibility towards disinfection. Furthermore, we observed comparable surface stability on steel, silver, copper and face masks.	2021	Meister et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	The NAb titers (PRNT50) of sera collected from 38 vaccine recipients four-weeks after the second dose of inactivated whole-virion SARS-CoV-2 BBV152/COVAXIN vaccine [which contains D614G] were not significantly different between B.1.1.7 virus and ancestral D614G virus.	2021	Sapkal et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 vaccine demonstrated vaccine effectiveness [symptomatic or asymptomatic in cohort opf routinely NAAT-monitored UK HCWs] of 72% (95% CI 58-86) 21 days after first dose and 86% (95% CI 76-97) seven days after two doses in the antibody negative cohort. This cohort was vaccinated when the dominant variant in circulation was B.1.1.7 and demonstrates effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	Between December 19, 2020 and Jan 24, 2021, 7214 of 9109 eligible HCWs at Sheba Medical Center in Israel had received one or more doses of BNT162b2 (Pfizer) vaccine. Adjusted rate reduction in SARS-CoV-2 NAAT positivity infection compared with unvaccinated workers 1-14 days after 1st dose was 30% (95% CI: 2-50), and 75% (95% CI: 72-84) after 15-28 days. Adjusted rate reduction in symptomatic COVID-19 compared with unvaccinated workers 1-14 days after 1st dose was 47% (95% CI: 17-66), and 85% (95% CI: 71-92) after 15-28 days. [Though often cited as an indicator of VE for B.1.1.7, during this time period in Israel, the prevalence of the B.1.1.7 variant increased from ~20% to 50% of cases (covariants.org), therefore these VE numbers likely represent a mix of B.1.1.7 and other lineage effects.]	2021	Amit et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	We found that a single dose of the BNT162b2 vaccine is about 60-70% effective at preventing symptomatic disease in adults aged 70 years and older in England and that two doses are about 85-90% effective. Those who were vaccinated and went on to have symptoms had a 44% lower risk of being admitted hospital and a 51% lower risk of death compared with people who were unvaccinated. We also found that a single dose of the ChAdOx1-S vaccine was about 60-75% effective against symptomatic disease and provided an additional protective effect against hospital admission—it is too early to assess the effect on mortality. The B.1.1.7 variant now dominates in the UK and these results will largely reflect vaccine effectiveness against this variant.	2021	Lopez Bernal et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	antibody epitope effects	Pokay	Neutralization of the 47D10. Alpha (B.1.1.7) has an IC50 fold change of 0.40x.	2022	Yuan et al. (2022)
H69del	anthropozoonotic events	Pokay	First documented cases of domestic cat and dog infections with the B.1.1.7 strain.	2021	Hamer et al. (2021)
H69del	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (48.7%: 95% confidence interval [CI], 45.5 to 51.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 93.7% (95% CI, 91.6 to 95.3) among those with the alpha variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 74.5% (95% CI, 68.4 to 79.4) among those with the alpha variant.	2021	Lopez Bernal et al. (2021)
H69del	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA2-15 (~9x), B38 (~14x), S309 (~190x) by this B.1.1.7 pseudotyped virus model.	2021	Shen et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	We observed a sharp decline in cases when ~50% of the elderly population was 2 weeks beyond their first vaccination dose and at a time point during which the B.1.1.7 variant gained transmission dominance. In support of this finding, it was suggested that, after the first vaccination dose, more than 70% of patients develop neutralization antibodies,15 and the vaccine efficiency can reach 85%.	2021	Munitz et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	convalescent plasma escape	Pokay	Neutralizing antibody titers of 2/20 (10%) samples showed >10x reduction (sera collected ~1mo post Jan 2020 first wave in China). Neutralizing antibody titers of 8/20 samples (40%) decreased below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
H69del	antibody epitope effects	Pokay	Lessens the potency of mAbs COVA2-17 (~5x, similar to N501Y alone), COVA1-12 (~11x) and COVA1-21 (>100x), which do not compete allosterically.	2021	Rees-Spear et al. (2021)
H69del	reinfection	Pokay	36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020. Possible reinfections were identified in 249 (0.7% [95% CI 0.6-0.8]) of 36509 app users who reported a positive swab test before Oct 1, 2020, but there was no evidence that the frequency of reinfections was higher for the B.1.1.7 variant than for pre-existing variants.	2021	Graham et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 virus has reduced neutralization activity vs wild type: 2.1x (30 sera Pfizer median 9 days post 2nd dose) and 2.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA. Note that Y145del was actually noted in the paper as the effect of their DNA construct, but this is equivalent at the protein level to the more commonly annotated Y144del.	2021	Garcia-Beltran et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaulated against VSV pseudotypes: neutralized D614G at week 2, whereas B.1.1.7 started to be neutralized at week 3, although less efficiently than D614G. B.1.1.7 and D614G strains were similarly neutralized at week 4 (1 week after booster dose).	2021	Planas et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Neutralization assays of B.1.1.7 virus showed a reduction of 2.5-fold (14 days post 2nd dose AstraZeneca, n	2021	Supasa et al. (2021)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.39x.	2022	Yuan et al. (2022)
H69del	vaccine efficacy	Pokay	In Minnesota in early 2021 when Alpha was prevalent, vaccine efficacy was estimated as: mRNA-1273 86% (95%CI: 81-90.6%) and BNT162b2: 76% (95%CI: 69-81%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. [variant list included is ancestral Alpha, as this was an observational study no variant list was given]	2021	Puranik et al. (2021)
H69del	antibody epitope effects	Pokay	~20x resistence to mAb CQ038 by B.1.1.7 pseudotyped virus	2021	Hu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	reinfection	Pokay	Reinfection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) B.1.1.7 variant in an immunocompromised 16yo female with end stage renal disease 94 days after initial infection with a B.1.2 lineage virus. Both lineages were the prevalent one at the time of 1st and 2nd infections respectively in Texas, where the patient was located (suggesting exposure risk rather than lineage immune evasion).	2021	Marquez et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Alpha Variant B.1.1.7 RBD significantly better than GenScript IgG FL18-740 w.t. ACE-2 mAB. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
H69del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.44x.	2022	Yuan et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 (Pfizer) vaccine showed vaccine effectiveness of 70% (95% CI 55-85) 21 days after first dose and 85% (74-96) 7 days after two doses in the study population. Our findings show that the BNT162b2 vaccine can prevent both symptomatic and asymptomatic infection in working-age adults. This cohort (8203 treatment, 15121 control) was vaccinated when the dominant variant in circulation was B.1.1.7 and shows effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	convalescent plasma escape	Pokay	NTD-specific nAbs showed a substantial (3-450x) decrease in neutralization potency against the recently reported highly transmissible B.1.1.7 variant of concern, whereas RBD-specific nAbs were either unaffected or showed lower decreases in potency.	2021	Graham et al. (2021)
H69del	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: results (only one nasal swab from different previously infected vacinee neutralizing at weeks 3 and 6 against B.1.1.7 and D614G) suggest that vaccinees probably do not elicit an early humoral response detectable at mucosal surfaces even though sera neutralization was observed. They strengthen the hypothesis that some vaccines may not protect against viral acquisition and infection of the oral–nasal region, but may prevent severe disease associated with viral dissemination in the lower respiratory tract.	2021	Planas et al. (2021)
H69del	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Alpha Molnupiravir (MK-4482) had ~2.75x fold drop.	2022	Rosenke et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7 reduced 1.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	reinfection	Pokay	Second infection in December 2020 with B.1.1.7 after April 2020 initial infection with B.2 in a 78-year-old man with a history of Type 2 diabetes mellitus, diabetic nephropathy on hemodialysis, chronic obstructive pulmonary disease (COPD), mixed central and obstructive sleep apnea, ischemic heart disease, with no history of immunosuppression.	2021	Harrington et al. (2021)
H69del	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 1 (B.1.1.7) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
H69del	trafficking	Pokay	~2.5x cleavage of S2 relative to WA1 (D614G) wildtype by Alpha variant variant as measured by mass spectrometry of Vero-TMPRSS culture.	2021	Esclera et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Virus neutralisation activity (using a live SARS-CoV-2 microneutralisation assay (ND50)) by vaccine induced antibodies was 9-fold lower against the B.1.1.7 variant than against a canonical non B.1.1.7 lineage. Vaccine efficacy against symptomatic NAAT positive infection was similar for B.1.1.7 and non-B.1.1.7 lineages (74.6% [95%CI 41.6-88.9] and 84% [95% CI 70.7-91.4] respectively). Furthermore, vaccination with ChAdOx1 nCoV-19 results in a reduction in the duration of shedding and viral load, which may translate into a material impact on transmission of disease.	2021	Emary et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Alpha (B.1.1.7) variant is 1.0x fold the wildtype in 42 COVI.	2022	Kumar et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 15.4% in this B.1.1.7 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	2.1x drop in neutralization using sera collected from 14 healthy adult participants that received two injections of the mRNA-1273 (Moderna) vaccine at a dose of 100 µg (18-55 years: day 1 (n	2021	Edara et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	B.1.1.7 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. A cohort of 12 Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed no statistically sognificant change in neutralization effiacacy.	2021	Ikegame et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	NVX-CoV2373 [Novavax] vaccine in phase 3 trial was 89.7% (95% CI, 80.2-94.6) effective in preventing COVID-19, with no hospitalizations or deaths reported. There were five cases of severe Covid-19, all in the placebo group. Post hoc analysis revealed efficacies of 96.4% (73.8-99.5) and 86.3% (71.3-93.5) against the prototype strain and B.1.1.7 variant, respectively.	2021	Heath et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 Spike variants lentivirus. 3.5x reduction in neutralization with Moderna vaccinated patient sera after 29 days (1st dose). 2.0x reduction in neutralization with Moderna vaccinated patient sera after 57 days (2nd dose). 2.1x reduction in neutralization with Novavax Phase 1 post-vaccination sera.	2021	Shen et al. (2021)
H69del	clinical indicators	Pokay	After adjusting for the age factor, in a prospective Chinese cohort study B.1.1.7 variant infection (compared to B.1.140) was the risk factor for C-reactive protein (P	2021	Song et al. (2021)
H69del	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against symptomatic infection caused by Alpha, vaccine effectiveness with partial vaccination (≥14 days after dose 1) was higher for mRNA-1273 (83%) than BNT162b2 (66%) and ChAdOx1 (64%), and full vaccination (≥7 days after dose 2) increased vaccine effectiveness for BNT162b2 (89%) and mRNA-1273 (92%).	2021	Nasreen et al. (2021)
H69del	trafficking	Pokay	Live virus was tested ex vivo in reconstituted brochial epithelium, and out competed wild type.	2021	Touret et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Mean 1.7x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.1.7. We observed a dramatic increase (relative to D614G) in binding of soluble ACE2 to B.1.1.7, and to a lesser extent to B.1.351, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 93 pM for binding to the Alpha B1.1.7. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
H69del	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.1.7 lineage effectiveness was observed as 29.5% (95% CI [22.9,35.5]) against infection, and 54.1% against severe/critical/fatal disease (95% CI [26.1-71.9]). Two weeks or more after 2nd dose, effectiveness climbed to 89.5% [85.9,92.3] against infection, and 100% against severe/critical/fatal disease (95% CI [81.7,100]).		UNKNOWN et al. ()
H69del	pharmaceutical effectiveness	Pokay	Lilly's LY-CoV16 showed marked reduction in neutralization of B.1.1.7.	2021	Dejnirattisai et al. (2021)
H69del	convalescent plasma escape	Pokay	Sera neutralized the B1.1.7 isolate with a lower potency (2-fold: 95% CL: 1.5 – 3-fold), and those with the lowest homotypic neutralizing potency had undetectable heterotypic potency (2/25).	2021	Skelly et al. (2021)
H69del	tissue specific replication effects	Pokay	In this report, by using a lower infectious dose, we demonstrate that B.1.1.7 (cultured sample Hong Kong/HKPU-00015/2021) exhibits higher infectivity and/or replication efficiency in the nasal epithelium. (Hamster model of infection)	2021	Mok et al. (2021)
H69del	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	20/29 sera after the first dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 variant of 3.2 ± 5.7. After the second dose, the GMT was markedly increased compared with the first-dose titres, with a fold change of 1.9 ± 0.9 (mean ± s.d.). Neutralization GMT of 27 subjects post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)
H69del	transmissibility	Pokay	We estimate that this [B.1.1.17] variant has a 43–90% (range of 95% credible intervals 38–130%) higher reproduction number than preexisting variants. Data from other countries yield similar results: we estimate that R for VOC 202012/01 relative to other lineages is 55% (45–66%) higher in Denmark, 74% (66–82%) higher in Switzerland, and 59% (56–63%) higher in the United States, with consistent rates of displacement across regions within each country.	2021	Davies et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Lineage B.1.1.7 spike–pseudotyped VSV was tested for neutralization vs Wuhan reference genome pseudotype in 40 sera collected 7 or 21 days post-booster dose. Statistically significant change (22%) in neutralization was observed among the 26 sera from those <	2021	Muik et al. (2021)
H69del	transmissibility	Pokay	At the national level (Italy), we estimated a mean relative transmissibility of B.1.1.7 (compared to historical lineages) ranging between 1.55 and 1.57 (with confidence intervals between 1.45 and 1.66).	2021	Stefanelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.1.7 defining mutations: Significant shift to asymptomatic cases (27.4% vs 18.6% for non-VOC cases). Significant shift to infection in those without pre-existing conditions (44.8% vs 89% for non-VOC cases). Significant increase in hospitalization rate (11% vs 7.5% for non-VOC cases). Significant increase in ICU rate (1.4% vs 0.6% for non-VOC cases). Significant decrease in death rate (2.0% vs vs 4.0% for non-VOC cases).	2021	Funk et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Vaccine elicited antibodies neutralized virus with the B.1.1.7 spike protein with titers similar to D614G virus. Serum specimens from individuals vaccinated with the BNT162b2 mRNA vaccine neutralized D614G virus with titers that were on average 7-fold greater than convalescent sera.	2021	Tada et al. (2021)
H69del	transmissibility	Pokay	Oslo, Norway: Within households, we find an increase in the secondary attack rate by 60% (20% 114%) compared to other variants. In general, we find a significant increase in the estimated reproduction number of 24% (95% CI 0% - 52%), or an absolute increase of 0.19 compared to other variants.	2021	Lindstrøm et al. (2021)
H69del	transmissibility	Pokay	Based on ~300,000 RT-PCR samples collected from December 6th 2020 to February 10th 2021 in Israel, the B.1.1.7 is 45% (95% CI:20-60%) more transmissible than the wild-type strain, and become dominant in Israel within 3.5 weeks.	2021	Munitz et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	outcome hazard ratio	Pokay	The matching-adjusted conditional odds ratio of hospitalisation was 1.58 (95% confidence interval 1.50 to 1.67) for COVID-19 patients infected with a SGTF-associated variant [primarily B.1.1.7], compared to those infected with non-SGTF-associated variants. The effect was modified by age (p<0.001), with ORs of 0.96-1.13 below age 20 years and 1.57-1.67 in age groups 40 years or older.	2021	Nyberg et al. (2021)
H69del	outcome hazard ratio	Pokay	Using UK data 1 November 2020 to 14 February 2021, while correcting for misclassification of PCR test Spike Gene Target Failure (SGTF) and missingness in SGTF status, we estimate that the hazard of death associated with B.1.1.7 is 61% (42–82%) higher than with pre-existing variants after adjustment for age, sex, ethnicity, deprivation, residence in a care home, the local authority of residence and test date. This corresponds to the absolute risk of death for a 55–69-year-old man increasing from 0.6% to 0.9% (95% confidence interval, 0.8–1.0%) within 28 days of a positive test in the community.	2021	Davies et al. (2021)
H69del	viral load	Pokay	B.1.1.7 samples showed average Ct cycle threshold of 21.9 vs 23 for wildtype (i.e. ~2x higher viral load) comparing 37758 and 22535 samples respectively.	2021	Roquebert et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	transmissibility	Pokay	Based on 36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020, Rt of B.1.1.7 was 1.35x (95% CI 1.02-1.69) relative to pre-existing variants. However, Rt fell below 1 during regional and national lockdowns, even in regions with high proportions of infections with the B.1.1.7 variant.	2021	Graham et al. (2021)
H69del	outcome hazard ratio	Pokay	341 samples collected Nov 9 to Dec 20, 2020 were sequenced from two London (UK) hospitals. 198 (58%) of 341 had B.1.1.7 infection and 143 (42%) had non-B.1.1.7 infection. No evidence was found of an association between severe disease and death and lineage (B.1.1.7 vs non-B.1.1.7) in unadjusted analyses (prevalence ratio [PR] 0·97 [95% CI 0·72-1·31]), or in analyses adjusted for hospital, sex, age, comorbidities, and ethnicity (adjusted PR 1·02 [0·76-1·38]).	2021	Frampton et al. (2021)
H69del	outcome hazard ratio	Pokay	From Sept 28 to Dec 27, 2020, positive COVID-19 tests were reported by 36 920 COVID Symptom Study app users whose region was known and who reported as healthy on app sign-up. We found no changes in reported symptoms or disease duration associated with B.1.1.7.	2021	Graham et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	viral load	Pokay	The 249 B.1.1.7 (a.k.a. N501Y.V1) variant cases in three Paris hospital labs had a ~10-fold viral load increase (~3.3 Ct drop in N gene probe) compared to 332 ancestral lineage cases from the same time frame (2020-12-20 to 2021-02-26). PG: BUT there is a discrepancy in drop between the ORF1ab and N probes, with the former suggesting only a 2-fold drop, consistent with the drop observed in B.1.351. This might indicate higher subgenomic RNA content in B.1.1.7 skewing the change.	2021	Teyssou et al. (2021)
H69del	viral load	Pokay	Using lack of S probe detection as a proxy for B.1.1.7 status, 275 putative B.1.1.7 samples and 390 ' wild type' SARS-CoV-2 positive samples in Wales were compared for Ct values, suggesting ~12-fold increase (~3.5 Ct decrease) in viral load for B.1.1.7 samples.	2021	Couzens et al. (2021)
H69del	outcome hazard ratio	Pokay	The mortality hazard ratio associated with infection with [B.1.1.7] compared with infection with previously circulating variants was 1.64 (95% confidence interval 1.32 to 2.04) in patients who tested positive for covid-19 in the community (54906 matched pairs of participants who tested positive for SARS-CoV-2 in pillar 2 between 1 October 2020 and 29 January 2021). In this comparatively low risk group, this represents an increase in deaths from 2.5 to 4.1 per 1000 detected cases.	2021	Challen et al. (2021)

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H69del	viral load	Pokay	In a study of 1260 ICU subjects, viral load distributions (collected within 48h of admission) were elevated in both seropositive and seronegative subjects infected with B.1.1.7 ('UK variant'). PG: The PANGO tool defining Spike variants for B.1.1.7 are listed here, whereas the paper only used a test for D1118H.	2021	Ratcliff et al. (2021)
H69del	viral load	Pokay	This study reveals that B.1.1.7 SARS-CoV-2 variant is a slower-growing virus than parental B.1. Further, a higher replication along with reduced infectious viral titer was hypothesized to be linked to higher transmission with reduced pathogenicity.	2021	Nyayanit et al. (2021)
H69del	viral load	Pokay	We found that the British variant (clade B.1.1.7), compared to an ancestral SARS-CoV-2 clade B virus, produced higher levels of infectious virus late in infection and had a higher replicative fitness in human airway, alveolar and intestinal organoid models.	2021	Lamers et al. (2021)
H69del	outcome hazard ratio	Pokay	Danish study of the B.1.1.7 lineage shows hospital admission odds ratio of 1.63 vs other lineages. The adjusted OR was increased in all strata of age.	2021	Bager et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	This mutation causes major decrease in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus.	2021	Tada et al. (2021)
H69del	transmissibility	Pokay	Ontario, Feb 2021: The secondary attack rate for VOC index cases in this matched cohort was 1.31 times higher than non-VOC index cases (RR	2021	Buchan et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	viral load	Pokay	The median Ct value of RT-qPCR tests of the N-gene target in the Daxing B.1.1.7 group was significantly lower than the Shunyi B.1.470 group (P	2021	Song et al. (2021)
H69del	transmissibility	Pokay	Primary cases infected with B.1.1.7 had an increased transmissibility of 1.5-1.7 times that of primary cases infected with other lineages. The increased transmissibility of B.1.1.7 was multiplicative across age and viral load.	2021	Lyngse et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	VSV pseudotype B.1.1.7 showed 1.77-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
H69del	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 5.2-fold against B.1.1.7 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
H69del	outcome hazard ratio	Pokay	Using primarily S-defining mutations for lineage B.1.1.7, most models of hospitalization and fatality risk ratios from consortium members show elevated ratios (~1.3-1.7x).	2021	UNKNOWN et al. (2021)
H69del	trafficking	Pokay	VSV pseudotype B.1.1.7 showed no significant difference in cell entry relative to wild type in 6 cell lines. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	Six fold increase in affinity for ACE2 by the B.1.1.7 lineage vs wild type is driven by a drop in observed dissociation rate constant.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	environmental condition stability	Pokay	Relative to D614G, this mutation demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
H69del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, but to a smaller extent than N501Y and the deletion alone.	2021	Tada et al. (2021)
H69del	convalescent plasma binding	Pokay	These key B.1.1.7 mutations as a combination neutralized slightly less well than D614G and this was noticeable in the lack of sera with high neutralizing titer for the viruses across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
H69del	convalescent plasma binding	Pokay	Slight neutralization improvement on average in 16 health workers' convalescent sera.	2021	Alenquer et al. (2021)
H69del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H69del	outcome hazard ratio	Pokay	In Ontario, using a retrospective matched case (age, gender and onset date) study of 6,312 Omicron cases vs 8,875 Delta, the adjusted risk of hospitalization or death was 54% lower (HR	2021	Ulloa et al. (2021)
H69del	reinfection	Pokay	Population-level evidence suggests that the Omicron variant is associated with substantial ability to evade immunity from prior infection, evidenced by a reinfection hazard ratio of 2.39 (CI95: 1.88-3.11) relative to primary infection in the initial part of South Africa's 4th covid-19 wave (November 2021). In contrast, there is no population-wide epidemiological evidence of immune escape associated with the Beta or Delta variants. [minimal variant signature for Omicron (B.1.1.529) used based on H69del PCR dropout observed in November 2021 coincident with the rise of Omicron]	2021	Pulliam et al. (2021)
H69del	immunosuppression variant emergence	Pokay	The so-called 'delta F' variant combination previously observed in mink spillover events also emerged in a lymphoma patient (non-Hodgkin diffuse B-cell lymphoma IV stage B) with a long-term COVID-19 infection (4 months) where 18 de novo mutation occureed overall. Patient was taking rituximab, the B-cell-depleting agent, and had no detectable neutralizing antibody response.	2021	Bazykin et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccinee plasma binding	Pokay	1.14x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.51x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis).	2021	Gong et al. (2021)
H69del	convalescent plasma binding	Pokay	1.33x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
H69del	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.1.7 aka Alpha) had 5.43x increased binding relative to D614G alone.	2021	Gong et al. (2021)
H69del	convalescent plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed a 1.15x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H69del	vaccinee plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed no change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.28x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
V70del	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.525 reduced 4.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
V70del	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
V70del	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
V70del	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
V70del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
V70del	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
V70del	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
V70del	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
V70del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
V70del	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
V70del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
V70del	vaccinee plasma binding	Pokay	Neutralization activity of almost all Moderna Phase 1 sera tested actually *increased*.	2021	Shen et al. (2021)
V70del	immunosuppression variant emergence	Pokay	The delH69/V70 enhances viral infectivity, indicating its effect on virus fitness is independent to the N501Y RBM change [with which it is found in lineage B.1.1.7] Possibly arisen as a result of the virus evolving from immune selection pressure in infected individuals and possibly only one chronic infection in the case of lineage B.1.1.7.	2020	Kemp et al. (2020)
V70del	convalescent plasma escape	Pokay	One convalescent sera tested showed 4-fold or greater reduction in neutralization efficiency.	2021	Alenquer et al. (2021)
V70del	convalescent plasma escape	Pokay	Neutralization activity of almost all convalescent sera tested decreased ~2x.	2021	Shen et al. (2021)
V70del	convalescent plasma escape	Pokay	Neutralization activity of convalescent sera tested decreased ~2x with this B.1.1.7 pseudotyped virus.	2021	Shen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	antibody epitope effects	Pokay	Reduces neutralization by structurally unmapped mAb COVA1-21 (cluster XI).	2021	Rees-Spear et al. (2021)
V70del	convalescent plasma binding	Pokay	Viruses containing the point mutations of B.1.1.7 showed that the single point mutations (Δ69-70 and N501Y) were neutralized as efficiently as D614G across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
V70del	anthropozoonotic events	Pokay	This deletion outside the receptor binding domain in pseudotyped VSV promoted the capacity of pseudotyped VSV to transduce black flying fox (Pteropus alecto) kidney PabKi.1 cells (17.8%) to a level twice that of human epithelial-like Huh-7 cells (9.8%)	2023	Li et al. (2023)
V70del	convalescent plasma binding	Pokay	No notable change in neutralization efficiency, despite N439K by itself showing a ~2x decrease on average in 16 health workers' convalescent sera.	2021	Alenquer et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was somewhat lower against B.1.1.7 in sera tested from most of the 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
V70del	antibody epitope effects	Pokay	B.1.1.7 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2489.	2021	Chen et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.1.7 sample. Contrast this with 1.3-fold reduction for just the pseudovirus combination of 'key' B.1.1.7 mutation N501Y.	2021	Bates et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing slight decrease in infection rate amongst the cells, much closer to D614G activity level than Y453F alone, suggesting compensatory effects between the deletion and the mutation in human cell entry fitness.	2021	Tada et al. (2021)
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing moderate decrease in infection rate amongst the cells, significantly lower than the deletion or Y453F alone, or their combination, suggesting a synergistic effect on poorer human cell entry fitness.	2021	Tada et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.298 virus has reduced neutralization activity vs wild type: 1.4x (30 sera Pfizer median 9 days post 2nd dose) and 1.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing mild to modest decrease in infection rate amongst the cells, suggesting a net mild negative effect on human cell entry fitness.	2021	Tada et al. (2021)
V70del	convalescent plasma binding	Pokay	Lentiviral pseudotyped with the key mutations from Mink Cluster 5 was neutralized more easily than D614G in 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing no change in infection rate amongst the cells, markedly higher infectivity than either mutation alone, suggesting a synergistic net neutral effect on human cell entry fitness.	2021	Tada et al. (2021)
V70del	trafficking	Pokay	Lentiviral pseudotyped with all key mutations from Mink Cluster 5 lineage, was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing major (~50%) decrease in infection rate amongst the cells, suggesting that this anthropozoonotic event is driven by other factors at the expense of human cell entry fitness.	2021	Tada et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7+E484K reduced 2.8x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster. Compare with 1.2x reduction for B.1.1.7 without E484K.	2021	Choi et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Sera after the second dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 + E484K variant of ~6.7x, markedly higher than B.1.1.7 alone. For first dose sera, a 9.7x drop was observed.	2021	Collier et al. (2021)
V70del	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was markedly worse against B.1.1.7 + E484K than the lineage alone, with a 11.4x drop.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	antibody epitope effects	Pokay	Ablates Class 3 N-terminal domain targeting antibody COV2-2489, diminishes COV2-2676.	2021	Chen et al. (2021)
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, moreso than this combination with the addition of P681H.	2021	Tada et al. (2021)
V70del	symptom prevalence	Pokay	In comparison of B.1.1.7 lineage (193 cases) vs. 'wildtype' (125) in Berlin Jan 18 to March 29 2021, significant symptom changes are absent loss of smell/taste (P	2021	van Loon et al. (2021)
V70del	ACE2 receptor binding affinity	Pokay	This mutation combination causes major increase in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus, but combined with the complete set of B.1.1.7 lineage variants no major change vs wild type affnity is observed.	2021	Tada et al. (2021)
V70del	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA1-18 (~4x), COVA2-15 (~9x). PG: these effects are laregly missing in the deletion-alone data	2021	Shen et al. (2021)
V70del	symptom prevalence	Pokay	A higher proportion of cases infected with the B.1.1.7 variant were hypoxic on admission compared to other variants (70.0% vs 62.5%, p	2021	Snell et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	virion structure	Pokay	The Ratio of S2 (processed Spike) to full length Spike is higher for this mutation combination, due to a drop in the full length Spike measured, suggesting that this mutation compensates for decreased Spike production by improved proteolytic processing.	2021	Tada et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.1.7 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.1.7 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
V70del	convalescent plasma escape	Pokay	Mean 2.6x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.1.7 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 33%, Day 43 100%, Day 119 100%, Day 209 96%. Detectable antibodies against B.1.1.7 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 54%, Day 43 100%, Day 119 100%, Day 209 88%. Detectable antibodies against B.1.1.7 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 83%, Days 43,119,209 100%.	2021	Pegu et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Using national surveillance data from Israel, using Pfizer vaccine and an estimated prevalence of the B.1.1.7 variant of 94.5% among SARS-CoV-2 infections: Adjusted estimates of vaccine effectiveness 7+ days after second dose were 95·3% (95% CI 94.9–95.7): 91.5% against asymptomatic SARS-CoV-2 infection (90·7–92·2: 40.9 vs 1.8 per 100 000 person-days), 97·0% against symptomatic COVID-19 (96.7–97.2%), 97.2% against COVID-19-related hospitalisation (96.8–97.5%), 97.5% against severe or critical COVID-19-related hospitalisation (97.1–97.8%), and 96.7% against COVID-19-related death (96.0–97.3%). In all age groups, as vaccine coverage increased, the incidence of SARS-CoV-2 outcomes declined	2021	Haas et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 8192 for B.1.351 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
V70del	virion structure	Pokay	CryoEM analysis of B.1.1.7 demonstrates an increased propensity for 'up', receptor accessible conformation of the Spike protein trimer.	2021	Cai et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	SARS-CoV-2 infection was confirmed in three HCWs working a single shift: all presented with mild symptoms of COVID-19. The two physicians were fully vaccinated with BNT162b2 vaccine, with the second dose administered 1 month before symptom onset. Both had high titres of IgG anti-spike antibodies at the time of diagnosis. WGS confirmed that all virus strains were VOC 202012/01-lineage B.1.1.7, suggesting a common source of exposure. Epidemiological investigation revealed that the suspected source was a SARS-CoV-2-positive patient who required endotracheal intubation due to severe COVID-19. All procedures were carried out using a full suite of personal protective equipment (PPE).	2021	Loconsole et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 1422 test-positive were Alpha. Two dose vaccine efficacy against Alpha was 98.4% [96.9-99.1%], one dose VE was 90.1% (82.9-94.2%).	2021	Bruxvoort et al. (2021)
V70del	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms, similarly neutralized B.1.1.7 and D614G.	2021	Planas et al. (2021)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Alpha (B.1.1.7) has an IC50 fold change of 1.19x.	2022	Yuan et al. (2022)
V70del	antibody epitope effects	Pokay	B.1.1.7 pseudotyped virus model impairs binding by RBD-directed mAb 910-30. B.1.1.7 pseudotyped virus model abolishes N-terminal-domain-directed mAbs 5-24, 4-8, and 4A8. B.1.1.7 pseudotyped virus model impairs binding by N-terminal-domain-directe d mAbs 2-17, 4-19, 5-7.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	1.4x improvement in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. 2x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
V70del	aerosolization	Pokay	Alpha variant cases in a large campus study showed fine-aerosol shedding amongst unmasked participants remained significantly greater for alpha variant infections (18-fold, 95% CI, 3.4 to 92-fold) after adjusting for the increased viral RNA in MTS and saliva, the number of coughs during sampling sessions, and symptom. After controlling for the effect of masks and numbers of coughs during sampling, alpha variant infection was associated with a 100-fold (95% CI, 16 to 650-fold) increase in coarse- and a 73-fold (95% CI, 15 to 350-fold) increase in fine-aerosol RNA shedding.	2021	Adenaiye et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	environmental condition stability	Pokay	No differences in the stability of B.1.1.7 observed in the absence of simulated sunlight at either 20°C or 40°C (with a mean time for a 90% loss of viral infectivity across all dark conditions of 6.2 hours). However, a small but statistically significant difference in the stability was observed in simulated sunlight at 20°C and 20% relative humidity, with B.1.1.7 restoring wild type 90% loss time of 11 minutes vs. 7 and 8 minutes for B.1.319 (D614G) and B.28 (V367F) early 2020 viruses respectively.	2021	Schuit et al. (2021)
V70del	trafficking	Pokay	Modelling the Alpha variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increase 3.9x relative to wild type (5.4 vs 1.4). This is less efficient than Delta (11x vs wildtype using a P681R mutation instead). [del ~144 changed due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a co-infection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.1.7 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine. This is despite three mutations (Y144del, D614G, and P681H) overlapping T-cell epitope hotspots.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	environmental condition stability	Pokay	Treatment with heat, soap and ethanol revealed similar inactivation profiles indicative of a comparable susceptibility towards disinfection. Furthermore, we observed comparable surface stability on steel, silver, copper and face masks.	2021	Meister et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	The NAb titers (PRNT50) of sera collected from 38 vaccine recipients four-weeks after the second dose of inactivated whole-virion SARS-CoV-2 BBV152/COVAXIN vaccine [which contains D614G] were not significantly different between B.1.1.7 virus and ancestral D614G virus.	2021	Sapkal et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 vaccine demonstrated vaccine effectiveness [symptomatic or asymptomatic in cohort opf routinely NAAT-monitored UK HCWs] of 72% (95% CI 58-86) 21 days after first dose and 86% (95% CI 76-97) seven days after two doses in the antibody negative cohort. This cohort was vaccinated when the dominant variant in circulation was B.1.1.7 and demonstrates effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	Between December 19, 2020 and Jan 24, 2021, 7214 of 9109 eligible HCWs at Sheba Medical Center in Israel had received one or more doses of BNT162b2 (Pfizer) vaccine. Adjusted rate reduction in SARS-CoV-2 NAAT positivity infection compared with unvaccinated workers 1-14 days after 1st dose was 30% (95% CI: 2-50), and 75% (95% CI: 72-84) after 15-28 days. Adjusted rate reduction in symptomatic COVID-19 compared with unvaccinated workers 1-14 days after 1st dose was 47% (95% CI: 17-66), and 85% (95% CI: 71-92) after 15-28 days. [Though often cited as an indicator of VE for B.1.1.7, during this time period in Israel, the prevalence of the B.1.1.7 variant increased from ~20% to 50% of cases (covariants.org), therefore these VE numbers likely represent a mix of B.1.1.7 and other lineage effects.]	2021	Amit et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	We found that a single dose of the BNT162b2 vaccine is about 60-70% effective at preventing symptomatic disease in adults aged 70 years and older in England and that two doses are about 85-90% effective. Those who were vaccinated and went on to have symptoms had a 44% lower risk of being admitted hospital and a 51% lower risk of death compared with people who were unvaccinated. We also found that a single dose of the ChAdOx1-S vaccine was about 60-75% effective against symptomatic disease and provided an additional protective effect against hospital admission—it is too early to assess the effect on mortality. The B.1.1.7 variant now dominates in the UK and these results will largely reflect vaccine effectiveness against this variant.	2021	Lopez Bernal et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	antibody epitope effects	Pokay	Neutralization of the 47D10. Alpha (B.1.1.7) has an IC50 fold change of 0.40x.	2022	Yuan et al. (2022)
V70del	anthropozoonotic events	Pokay	First documented cases of domestic cat and dog infections with the B.1.1.7 strain.	2021	Hamer et al. (2021)
V70del	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (48.7%: 95% confidence interval [CI], 45.5 to 51.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 93.7% (95% CI, 91.6 to 95.3) among those with the alpha variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 74.5% (95% CI, 68.4 to 79.4) among those with the alpha variant.	2021	Lopez Bernal et al. (2021)
V70del	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA2-15 (~9x), B38 (~14x), S309 (~190x) by this B.1.1.7 pseudotyped virus model.	2021	Shen et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	We observed a sharp decline in cases when ~50% of the elderly population was 2 weeks beyond their first vaccination dose and at a time point during which the B.1.1.7 variant gained transmission dominance. In support of this finding, it was suggested that, after the first vaccination dose, more than 70% of patients develop neutralization antibodies,15 and the vaccine efficiency can reach 85%.	2021	Munitz et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	convalescent plasma escape	Pokay	Neutralizing antibody titers of 2/20 (10%) samples showed >10x reduction (sera collected ~1mo post Jan 2020 first wave in China). Neutralizing antibody titers of 8/20 samples (40%) decreased below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
V70del	antibody epitope effects	Pokay	Lessens the potency of mAbs COVA2-17 (~5x, similar to N501Y alone), COVA1-12 (~11x) and COVA1-21 (>100x), which do not compete allosterically.	2021	Rees-Spear et al. (2021)
V70del	reinfection	Pokay	36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020. Possible reinfections were identified in 249 (0.7% [95% CI 0.6-0.8]) of 36509 app users who reported a positive swab test before Oct 1, 2020, but there was no evidence that the frequency of reinfections was higher for the B.1.1.7 variant than for pre-existing variants.	2021	Graham et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 virus has reduced neutralization activity vs wild type: 2.1x (30 sera Pfizer median 9 days post 2nd dose) and 2.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA. Note that Y145del was actually noted in the paper as the effect of their DNA construct, but this is equivalent at the protein level to the more commonly annotated Y144del.	2021	Garcia-Beltran et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaulated against VSV pseudotypes: neutralized D614G at week 2, whereas B.1.1.7 started to be neutralized at week 3, although less efficiently than D614G. B.1.1.7 and D614G strains were similarly neutralized at week 4 (1 week after booster dose).	2021	Planas et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Neutralization assays of B.1.1.7 virus showed a reduction of 2.5-fold (14 days post 2nd dose AstraZeneca, n	2021	Supasa et al. (2021)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.39x.	2022	Yuan et al. (2022)
V70del	vaccine efficacy	Pokay	In Minnesota in early 2021 when Alpha was prevalent, vaccine efficacy was estimated as: mRNA-1273 86% (95%CI: 81-90.6%) and BNT162b2: 76% (95%CI: 69-81%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. [variant list included is ancestral Alpha, as this was an observational study no variant list was given]	2021	Puranik et al. (2021)
V70del	antibody epitope effects	Pokay	~20x resistence to mAb CQ038 by B.1.1.7 pseudotyped virus	2021	Hu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	reinfection	Pokay	Reinfection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) B.1.1.7 variant in an immunocompromised 16yo female with end stage renal disease 94 days after initial infection with a B.1.2 lineage virus. Both lineages were the prevalent one at the time of 1st and 2nd infections respectively in Texas, where the patient was located (suggesting exposure risk rather than lineage immune evasion).	2021	Marquez et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Alpha Variant B.1.1.7 RBD significantly better than GenScript IgG FL18-740 w.t. ACE-2 mAB. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
V70del	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.44x.	2022	Yuan et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 (Pfizer) vaccine showed vaccine effectiveness of 70% (95% CI 55-85) 21 days after first dose and 85% (74-96) 7 days after two doses in the study population. Our findings show that the BNT162b2 vaccine can prevent both symptomatic and asymptomatic infection in working-age adults. This cohort (8203 treatment, 15121 control) was vaccinated when the dominant variant in circulation was B.1.1.7 and shows effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	convalescent plasma escape	Pokay	NTD-specific nAbs showed a substantial (3-450x) decrease in neutralization potency against the recently reported highly transmissible B.1.1.7 variant of concern, whereas RBD-specific nAbs were either unaffected or showed lower decreases in potency.	2021	Graham et al. (2021)
V70del	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: results (only one nasal swab from different previously infected vacinee neutralizing at weeks 3 and 6 against B.1.1.7 and D614G) suggest that vaccinees probably do not elicit an early humoral response detectable at mucosal surfaces even though sera neutralization was observed. They strengthen the hypothesis that some vaccines may not protect against viral acquisition and infection of the oral–nasal region, but may prevent severe disease associated with viral dissemination in the lower respiratory tract.	2021	Planas et al. (2021)
V70del	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Alpha Molnupiravir (MK-4482) had ~2.75x fold drop.	2022	Rosenke et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7 reduced 1.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	reinfection	Pokay	Second infection in December 2020 with B.1.1.7 after April 2020 initial infection with B.2 in a 78-year-old man with a history of Type 2 diabetes mellitus, diabetic nephropathy on hemodialysis, chronic obstructive pulmonary disease (COPD), mixed central and obstructive sleep apnea, ischemic heart disease, with no history of immunosuppression.	2021	Harrington et al. (2021)
V70del	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 1 (B.1.1.7) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
V70del	trafficking	Pokay	~2.5x cleavage of S2 relative to WA1 (D614G) wildtype by Alpha variant variant as measured by mass spectrometry of Vero-TMPRSS culture.	2021	Esclera et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Virus neutralisation activity (using a live SARS-CoV-2 microneutralisation assay (ND50)) by vaccine induced antibodies was 9-fold lower against the B.1.1.7 variant than against a canonical non B.1.1.7 lineage. Vaccine efficacy against symptomatic NAAT positive infection was similar for B.1.1.7 and non-B.1.1.7 lineages (74.6% [95%CI 41.6-88.9] and 84% [95% CI 70.7-91.4] respectively). Furthermore, vaccination with ChAdOx1 nCoV-19 results in a reduction in the duration of shedding and viral load, which may translate into a material impact on transmission of disease.	2021	Emary et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Alpha (B.1.1.7) variant is 1.0x fold the wildtype in 42 COVI.	2022	Kumar et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 15.4% in this B.1.1.7 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	2.1x drop in neutralization using sera collected from 14 healthy adult participants that received two injections of the mRNA-1273 (Moderna) vaccine at a dose of 100 µg (18-55 years: day 1 (n	2021	Edara et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	B.1.1.7 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. A cohort of 12 Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed no statistically sognificant change in neutralization effiacacy.	2021	Ikegame et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	NVX-CoV2373 [Novavax] vaccine in phase 3 trial was 89.7% (95% CI, 80.2-94.6) effective in preventing COVID-19, with no hospitalizations or deaths reported. There were five cases of severe Covid-19, all in the placebo group. Post hoc analysis revealed efficacies of 96.4% (73.8-99.5) and 86.3% (71.3-93.5) against the prototype strain and B.1.1.7 variant, respectively.	2021	Heath et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 Spike variants lentivirus. 3.5x reduction in neutralization with Moderna vaccinated patient sera after 29 days (1st dose). 2.0x reduction in neutralization with Moderna vaccinated patient sera after 57 days (2nd dose). 2.1x reduction in neutralization with Novavax Phase 1 post-vaccination sera.	2021	Shen et al. (2021)
V70del	clinical indicators	Pokay	After adjusting for the age factor, in a prospective Chinese cohort study B.1.1.7 variant infection (compared to B.1.140) was the risk factor for C-reactive protein (P	2021	Song et al. (2021)
V70del	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against symptomatic infection caused by Alpha, vaccine effectiveness with partial vaccination (≥14 days after dose 1) was higher for mRNA-1273 (83%) than BNT162b2 (66%) and ChAdOx1 (64%), and full vaccination (≥7 days after dose 2) increased vaccine effectiveness for BNT162b2 (89%) and mRNA-1273 (92%).	2021	Nasreen et al. (2021)
V70del	trafficking	Pokay	Live virus was tested ex vivo in reconstituted brochial epithelium, and out competed wild type.	2021	Touret et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Mean 1.7x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.1.7. We observed a dramatic increase (relative to D614G) in binding of soluble ACE2 to B.1.1.7, and to a lesser extent to B.1.351, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
V70del	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 93 pM for binding to the Alpha B1.1.7. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
V70del	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.1.7 lineage effectiveness was observed as 29.5% (95% CI [22.9,35.5]) against infection, and 54.1% against severe/critical/fatal disease (95% CI [26.1-71.9]). Two weeks or more after 2nd dose, effectiveness climbed to 89.5% [85.9,92.3] against infection, and 100% against severe/critical/fatal disease (95% CI [81.7,100]).		UNKNOWN et al. ()
V70del	pharmaceutical effectiveness	Pokay	Lilly's LY-CoV16 showed marked reduction in neutralization of B.1.1.7.	2021	Dejnirattisai et al. (2021)
V70del	convalescent plasma escape	Pokay	Sera neutralized the B1.1.7 isolate with a lower potency (2-fold: 95% CL: 1.5 – 3-fold), and those with the lowest homotypic neutralizing potency had undetectable heterotypic potency (2/25).	2021	Skelly et al. (2021)
V70del	tissue specific replication effects	Pokay	In this report, by using a lower infectious dose, we demonstrate that B.1.1.7 (cultured sample Hong Kong/HKPU-00015/2021) exhibits higher infectivity and/or replication efficiency in the nasal epithelium. (Hamster model of infection)	2021	Mok et al. (2021)
V70del	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	20/29 sera after the first dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 variant of 3.2 ± 5.7. After the second dose, the GMT was markedly increased compared with the first-dose titres, with a fold change of 1.9 ± 0.9 (mean ± s.d.). Neutralization GMT of 27 subjects post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)
V70del	transmissibility	Pokay	We estimate that this [B.1.1.17] variant has a 43–90% (range of 95% credible intervals 38–130%) higher reproduction number than preexisting variants. Data from other countries yield similar results: we estimate that R for VOC 202012/01 relative to other lineages is 55% (45–66%) higher in Denmark, 74% (66–82%) higher in Switzerland, and 59% (56–63%) higher in the United States, with consistent rates of displacement across regions within each country.	2021	Davies et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Lineage B.1.1.7 spike–pseudotyped VSV was tested for neutralization vs Wuhan reference genome pseudotype in 40 sera collected 7 or 21 days post-booster dose. Statistically significant change (22%) in neutralization was observed among the 26 sera from those <	2021	Muik et al. (2021)
V70del	transmissibility	Pokay	At the national level (Italy), we estimated a mean relative transmissibility of B.1.1.7 (compared to historical lineages) ranging between 1.55 and 1.57 (with confidence intervals between 1.45 and 1.66).	2021	Stefanelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.1.7 defining mutations: Significant shift to asymptomatic cases (27.4% vs 18.6% for non-VOC cases). Significant shift to infection in those without pre-existing conditions (44.8% vs 89% for non-VOC cases). Significant increase in hospitalization rate (11% vs 7.5% for non-VOC cases). Significant increase in ICU rate (1.4% vs 0.6% for non-VOC cases). Significant decrease in death rate (2.0% vs vs 4.0% for non-VOC cases).	2021	Funk et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Vaccine elicited antibodies neutralized virus with the B.1.1.7 spike protein with titers similar to D614G virus. Serum specimens from individuals vaccinated with the BNT162b2 mRNA vaccine neutralized D614G virus with titers that were on average 7-fold greater than convalescent sera.	2021	Tada et al. (2021)
V70del	transmissibility	Pokay	Oslo, Norway: Within households, we find an increase in the secondary attack rate by 60% (20% 114%) compared to other variants. In general, we find a significant increase in the estimated reproduction number of 24% (95% CI 0% - 52%), or an absolute increase of 0.19 compared to other variants.	2021	Lindstrøm et al. (2021)
V70del	transmissibility	Pokay	Based on ~300,000 RT-PCR samples collected from December 6th 2020 to February 10th 2021 in Israel, the B.1.1.7 is 45% (95% CI:20-60%) more transmissible than the wild-type strain, and become dominant in Israel within 3.5 weeks.	2021	Munitz et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	outcome hazard ratio	Pokay	The matching-adjusted conditional odds ratio of hospitalisation was 1.58 (95% confidence interval 1.50 to 1.67) for COVID-19 patients infected with a SGTF-associated variant [primarily B.1.1.7], compared to those infected with non-SGTF-associated variants. The effect was modified by age (p<0.001), with ORs of 0.96-1.13 below age 20 years and 1.57-1.67 in age groups 40 years or older.	2021	Nyberg et al. (2021)
V70del	outcome hazard ratio	Pokay	Using UK data 1 November 2020 to 14 February 2021, while correcting for misclassification of PCR test Spike Gene Target Failure (SGTF) and missingness in SGTF status, we estimate that the hazard of death associated with B.1.1.7 is 61% (42–82%) higher than with pre-existing variants after adjustment for age, sex, ethnicity, deprivation, residence in a care home, the local authority of residence and test date. This corresponds to the absolute risk of death for a 55–69-year-old man increasing from 0.6% to 0.9% (95% confidence interval, 0.8–1.0%) within 28 days of a positive test in the community.	2021	Davies et al. (2021)
V70del	viral load	Pokay	B.1.1.7 samples showed average Ct cycle threshold of 21.9 vs 23 for wildtype (i.e. ~2x higher viral load) comparing 37758 and 22535 samples respectively.	2021	Roquebert et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	transmissibility	Pokay	Based on 36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020, Rt of B.1.1.7 was 1.35x (95% CI 1.02-1.69) relative to pre-existing variants. However, Rt fell below 1 during regional and national lockdowns, even in regions with high proportions of infections with the B.1.1.7 variant.	2021	Graham et al. (2021)
V70del	outcome hazard ratio	Pokay	341 samples collected Nov 9 to Dec 20, 2020 were sequenced from two London (UK) hospitals. 198 (58%) of 341 had B.1.1.7 infection and 143 (42%) had non-B.1.1.7 infection. No evidence was found of an association between severe disease and death and lineage (B.1.1.7 vs non-B.1.1.7) in unadjusted analyses (prevalence ratio [PR] 0·97 [95% CI 0·72-1·31]), or in analyses adjusted for hospital, sex, age, comorbidities, and ethnicity (adjusted PR 1·02 [0·76-1·38]).	2021	Frampton et al. (2021)
V70del	outcome hazard ratio	Pokay	From Sept 28 to Dec 27, 2020, positive COVID-19 tests were reported by 36 920 COVID Symptom Study app users whose region was known and who reported as healthy on app sign-up. We found no changes in reported symptoms or disease duration associated with B.1.1.7.	2021	Graham et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	viral load	Pokay	The 249 B.1.1.7 (a.k.a. N501Y.V1) variant cases in three Paris hospital labs had a ~10-fold viral load increase (~3.3 Ct drop in N gene probe) compared to 332 ancestral lineage cases from the same time frame (2020-12-20 to 2021-02-26). PG: BUT there is a discrepancy in drop between the ORF1ab and N probes, with the former suggesting only a 2-fold drop, consistent with the drop observed in B.1.351. This might indicate higher subgenomic RNA content in B.1.1.7 skewing the change.	2021	Teyssou et al. (2021)
V70del	viral load	Pokay	Using lack of S probe detection as a proxy for B.1.1.7 status, 275 putative B.1.1.7 samples and 390 ' wild type' SARS-CoV-2 positive samples in Wales were compared for Ct values, suggesting ~12-fold increase (~3.5 Ct decrease) in viral load for B.1.1.7 samples.	2021	Couzens et al. (2021)
V70del	outcome hazard ratio	Pokay	The mortality hazard ratio associated with infection with [B.1.1.7] compared with infection with previously circulating variants was 1.64 (95% confidence interval 1.32 to 2.04) in patients who tested positive for covid-19 in the community (54906 matched pairs of participants who tested positive for SARS-CoV-2 in pillar 2 between 1 October 2020 and 29 January 2021). In this comparatively low risk group, this represents an increase in deaths from 2.5 to 4.1 per 1000 detected cases.	2021	Challen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	viral load	Pokay	In a study of 1260 ICU subjects, viral load distributions (collected within 48h of admission) were elevated in both seropositive and seronegative subjects infected with B.1.1.7 ('UK variant'). PG: The PANGO tool defining Spike variants for B.1.1.7 are listed here, whereas the paper only used a test for D1118H.	2021	Ratcliff et al. (2021)
V70del	viral load	Pokay	This study reveals that B.1.1.7 SARS-CoV-2 variant is a slower-growing virus than parental B.1. Further, a higher replication along with reduced infectious viral titer was hypothesized to be linked to higher transmission with reduced pathogenicity.	2021	Nyayanit et al. (2021)
V70del	viral load	Pokay	We found that the British variant (clade B.1.1.7), compared to an ancestral SARS-CoV-2 clade B virus, produced higher levels of infectious virus late in infection and had a higher replicative fitness in human airway, alveolar and intestinal organoid models.	2021	Lamers et al. (2021)
V70del	outcome hazard ratio	Pokay	Danish study of the B.1.1.7 lineage shows hospital admission odds ratio of 1.63 vs other lineages. The adjusted OR was increased in all strata of age.	2021	Bager et al. (2021)
V70del	ACE2 receptor binding affinity	Pokay	This mutation causes major decrease in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus.	2021	Tada et al. (2021)
V70del	transmissibility	Pokay	Ontario, Feb 2021: The secondary attack rate for VOC index cases in this matched cohort was 1.31 times higher than non-VOC index cases (RR	2021	Buchan et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	viral load	Pokay	The median Ct value of RT-qPCR tests of the N-gene target in the Daxing B.1.1.7 group was significantly lower than the Shunyi B.1.470 group (P	2021	Song et al. (2021)
V70del	transmissibility	Pokay	Primary cases infected with B.1.1.7 had an increased transmissibility of 1.5-1.7 times that of primary cases infected with other lineages. The increased transmissibility of B.1.1.7 was multiplicative across age and viral load.	2021	Lyngse et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	VSV pseudotype B.1.1.7 showed 1.77-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
V70del	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 5.2-fold against B.1.1.7 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
V70del	outcome hazard ratio	Pokay	Using primarily S-defining mutations for lineage B.1.1.7, most models of hospitalization and fatality risk ratios from consortium members show elevated ratios (~1.3-1.7x).	2021	UNKNOWN et al. (2021)
V70del	trafficking	Pokay	VSV pseudotype B.1.1.7 showed no significant difference in cell entry relative to wild type in 6 cell lines. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
V70del	ACE2 receptor binding affinity	Pokay	Six fold increase in affinity for ACE2 by the B.1.1.7 lineage vs wild type is driven by a drop in observed dissociation rate constant.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	environmental condition stability	Pokay	Relative to D614G, this mutation demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
V70del	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, but to a smaller extent than N501Y and the deletion alone.	2021	Tada et al. (2021)
V70del	convalescent plasma binding	Pokay	These key B.1.1.7 mutations as a combination neutralized slightly less well than D614G and this was noticeable in the lack of sera with high neutralizing titer for the viruses across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
V70del	convalescent plasma binding	Pokay	Slight neutralization improvement on average in 16 health workers' convalescent sera.	2021	Alenquer et al. (2021)
V70del	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
V70del	immunosuppression variant emergence	Pokay	The so-called 'delta F' variant combination previously observed in mink spillover events also emerged in a lymphoma patient (non-Hodgkin diffuse B-cell lymphoma IV stage B) with a long-term COVID-19 infection (4 months) where 18 de novo mutation occureed overall. Patient was taking rituximab, the B-cell-depleting agent, and had no detectable neutralizing antibody response.	2021	Bazykin et al. (2021)
V70del	vaccinee plasma binding	Pokay	1.14x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
V70del	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.51x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis).	2021	Gong et al. (2021)
V70del	convalescent plasma binding	Pokay	1.33x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
V70del	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.1.7 aka Alpha) had 5.43x increased binding relative to D614G alone.	2021	Gong et al. (2021)
V70del	convalescent plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed a 1.15x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
V70del	vaccinee plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed no change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.28x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
G339H	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.15 fold	2020	Starr et al. (2020)
G339H	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
R346T	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
R346T	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.15 fold	2020	Starr et al. (2020)
R346T	ACE2 receptor binding affinity	Pokay	Experimentally, ACE2 binding affinity increased 0.06 fold	2020	Starr et al. (2020)
K356T	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.14 fold	2020	Starr et al. (2020)
S371F	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
S371F	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
S371F	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
S371F	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
S371F	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
S371F	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S371F	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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S371F	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
S371F	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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S371F	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S371F	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
S373P	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
S373P	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
S373P	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S373P	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
S373P	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
S373P	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
S373P	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

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S373P	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
S373P	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
S373P	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
S373P	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
S373P	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S373P	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
S373P	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S373P	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
S373P	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
S373P	monoclonal antibody serial passage escape	Pokay	Reduce affinity for mildly cross-reactive CR3022 (2003 pandemic SARS monoclonal antibody cross-reactive to SARS-CoV-2)	2020	Long et al. (2020)
S373P	transmissibility	Pokay	On December 7, 2021 the estimate of Omicron effective reproduction rate (Rt) is 3.12 [presumably R0 is higher], compared to 1.12 for the dominant Delta VOC at that time. [shorthand of variant list shraed by all contemporary BA lineage used here]	2021	UNKNOWN et al. (2021)
D405N	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D405N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
D405N	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
D405N	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
D405N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
D405N	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
D405N	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
D405N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D405N	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D405N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D405N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D405N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D405N	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)

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D405N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D405N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D405N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D405N	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
R408S	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
R408S	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
R408S	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
R408S	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
R408S	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
R408S	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
R408S	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
R408S	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
R408S	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
R408S	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
R408S	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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R408S	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
R408S	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
R408S	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
R408S	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
R408S	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.21 fold	2020	Starr et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
R408S	vaccine efficacy	Pokay	In a study of 481 vaccinees going from lowest to highest infection rate, 2 doses of CoronaVac and 1 dose of BNT162b2 had the lowest infection rate at 6.3%, then it was 3 doses of BNT162b2 having a infection rate of 16.6%. 2 and 3 doses of CoronaVac had 48.6% and 20.6% infection rate respectively. 2 doses of BNT162b2 has the highest infection rate at 49.2%.	2022	Zhou et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
K417N	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
K417N	convalescent plasma escape	Pokay	The 501Y.V2 to first wave IC50 ratio ranged from 6 to 200-fold. Averaging across all 7 participant convalescent sera highlighted the dramatic decrease in sensitivity to neutralization of authentic 501Y.V2 variants. PG: I'm purposefully ignoring D614G and A701V as contributors	2021	Cele et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In human sera 8 weeks post-vaccination with INO-4800, a ~7-fold reduction in B.1.351 neutralization was observed.	2021	Andrade et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Four fold reduction in neutralization efficiency was observed in sera of ferrets post-vaccination with INO-4800 (DNA plasmid pGX9501 encoding full length Spike).	2021	Riddell et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Monovalent mRNA-1273.351 encodes for the S protein found in the B.1.351 lineage and (2) mRNA-1273.211 comprising a 1:1 mix of mRNA-1273 and mRNA-1273.351. In a mouse study, primary vaccination series of mRNA-1273.351 was effective at increasing neutralizing antibody titers against the B.1.351 lineage, while mRNA-1273.211 was most effective at providing broad cross-variant neutralization. In addition, these results demonstrated a third dose of mRNA-1273.351 significantly increased both wild-type and B.1.351-specific neutralization titers.	2021	Wu et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Pzifer vaccinees that tested positive at least a week after the second dose were indeed disproportionally infected with B.1.351, as compared with unvaccinated individuals (odds ratio of 8:1), but were all infected before 14 days post second vaccination.	2021	Kustin et al. (2021)
K417N	convalescent plasma escape	Pokay	Mean 8.2x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Mean 6.3x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals (5/9) and recipients of a only a single dose of mRNA vaccine (10/11) – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
K417N	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 8 for B.1.351 virus. Compare to much stronger neutralization titers for B.1.1.7 (256) and wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.351 sample. Contrast this with 1.4-fold reduction for just the pseudovirus combination of 'key' B.1.351 mutations K417N+E484K+N501Y. WA1 and B.1.351 FRNT50 titers correlated weakly at the individual level, with some individual’s serum potently neutralizing WA1 while having FRNT50 for B.1.351 below the assay limit of detection (1:20).	2021	Bates et al. (2021)
K417N	convalescent plasma binding	Pokay	Sera from individuals who have been infected with Delta does not have strong neutralising activity against Beta.	2021	UNKNOWN et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms had mean ~6x reduction in neutralizing titers, and 40% of the samples lacked any activity against B.1.351.	2021	Planas et al. (2021)
K417N	vaccinee plasma binding	Pokay	Sera from individuals who have been vaccinated and have had subsequent recent Delta infection have a high level of neutralising activity against Beta.	2021	UNKNOWN et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Beta Variant B.1.351 RBD significantly better than w.t. SARS-CoV-2 RBD. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v2 virus has reduced neutralization activity vs wild type: 41.2x (30 sera Pfizer median 9 days post 2nd dose) and 20.8x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Pseudotype lentivirus for the full B.1.351 Spike variant list shows increase affinity for ACE2 as measured by IC50. This is in contrast to B.1.1.7 which showed no major change, indicating that the shared N501Y mutation is the driver of affinity change, attentuated in the B.1.1.7 mutatioon set, but maintained in the B.1.351 lineage.	2021	Tada et al. (2021)

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K417N	vaccine neutralization efficacy	Pokay	[Contrary to how this paper has been cited, Voysey et al. do NOT show evidence of decreased effectiveness of ChAdOx1 (AstraZeneca) against the South African B.1.351 lineage. Insufficient numbers reaching the primary study endpoint were available in that arm of the vaccine study to report any statistics from the South African participants. Additionally, the study period of the paper ended in November 2020, while the earliest reported case of this lineage is October (covariants.org), only becoming dominant by mid-November.]	2021	Voysey et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.351. We observed an increase (relative to D614G) in binding of soluble ACE2 to B.1.351, and to a much gearter extent to B.1.1.7, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Relative to B.1.1.117, PRNT50 line virus neutralizating antibody activity assay of B.1.351 showed ~11x reduction in 13 vacinees's sera collected through 41 days after vaccination. Neutralization by a placebo control group of 6 naturally infected patients showed a smaller ~8x drop (starting from a ~50% higher PRNT50 value than vacinees for B.1.1.117 neutralization). Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed ~4x reduction in neutralization (ID50) for full B.1.351 pseudotype HIV-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a slightly higher 4.6x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.899x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
K417N	convalescent plasma escape	Pokay	A 1.8-fold drop in FRNT50 for B.1.351 was observed in 44 sera collected between 1 and 301 post-infection.	2021	Bates et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	3.2x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v1 reduced 6.9x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
K417N	T cell evasion	Pokay	Encouragingly, we find that the majority of T cell responses in recipients of two doses of the BNT162b2 vaccine are generated by epitopes that are invariant between the [wildtype] and two of the current variants of concern (B.1.1.7 and B.1.351). In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals and recipients of a only a single dose of mRNA vaccine – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
K417N	convalescent plasma escape	Pokay	The neutralizing activity of 16/20 convalescent sera was significantly lower against this pseudotyped virus model of B.1.351, with similar results for the live virus.	2021	Wang et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.803x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	antibody epitope effects	Pokay	B.1.351 pseudotyped virus model ablates neutralization by RBD-directed mAbs CB6, 4-20, 2-4, 2-43, 910-30, 2-302-15, LY-Cov555, C121. B.1.351 pseudotyped virus model severely impairs neutralization by RBD-directed mAb 1-20. B.1.351 pseudotyped virus model impairs neutralization by RBD-directed mAb REGN10933. B.1.351 pseudotyped virus model ablates neutralization by N-terminal-domain-directed mAbs 5-24, 4-8, 4A8, 4-19. B.1.351 pseudotyped virus model severely impairs neutralization by N-terminal-domain-directed mAb 2-17. B.1.351 pseudotyped virus model impairs neutralization by N-terminal-domain-directed mAb 5-7. PG: Live virus data for the same mAbs is similar, but 1-20 becomes severally impaired, REGN10933 activity is ablated, and Brii-196 becomes impaired.	2021	Wang et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 (12.4x in twelve Moderna-recipient sera: 10.3x in ten Pfizer-recipient sera). [this is a larger list of B.1.351 than modeled by Wang et al. (2021) by including L18F and R246I, less effective at neutralizing]	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaluated against VSV pseudotypes: while BD614G and B.1.1.7 were neutralized earlier, the anti-B.1.351 response was negative up to week 3, and became detectable at week 4 (1 week after booster dose), at a level lower than the two other viruses (~10x vs D614G) through week 6, the last timepoint measured. Three vaccinees never showed detectable neutralization to B.1.351 even after second dose.	2021	Planas et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 0.036x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
K417N	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: while B.1.1.7 and D614G showed neutralization by nasal swab from only one different previously infected vacinee neutralizing at weeks 3 and 6, B.1.351 showed zero neutralization at either time point in any sample (and relatively impaired serum neutralization).	2021	Planas et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v2 reduced 7.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.351 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	B.1.351 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. Only 1 out of 12 serum samples from a cohort of Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed effective neutralization (IC90) at full serum strength (average realtive decrease was 6.1x vs wild type).	2021	Ikegame et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.07x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In a randomized phase 2a-b control trial of the Novavax (NVX-CoV2373) vaccine in South Africa, where B.1.351 virus dominates, efficacy was 60.1% (95% CI, 19.9 to 80.1) in HIV-negative and initially SARS-CoV-2 seronegative participants using the primary endpoint of laboratory-confirmed symptomatic Covid-19 at 7 days or more after the second dose among participants.	2021	Shinde et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	DARPin SR22 molecule had a 1.57x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.054x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	pharmaceutical effectiveness	Pokay	B.1.351 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of B.1.351. There was also escape from neutralization of B.1.351 by REGN10933 and a modest reduction in neutralization of B.1.351 by AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized B.1.351.	2021	Dejnirattisai et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 6.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 99.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
K417N	trafficking	Pokay	Lentiviral pseudotyped with all key mutations from B.1.351 lineage was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing modest decrease in infection rate amongst the cells, suggesting some synergy between the mutations to decrease cell entry fitness (i.e. cell entry is liklely not the driver of this lineage's dominance).	2021	Tada et al. (2021)
K417N	convalescent plasma escape	Pokay	The most significant loss of neutralizing activity (PsVNA50 assay) using 6 hyperimmune immunoglobulin preparations from convalescent plasma was seen against authentic B.1.351 lineage virus (9.2-fold). Neutralization against 10 convalescent plasma was poorer (18.7x).	2021	Tang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	environmental condition stability	Pokay	Treatment with heat, soap and ethanol revealed similar inactivation profiles indicative of a comparable susceptibility towards disinfection. Furthermore, we observed comparable surface stability on steel, silver, copper and face masks.	2021	Meister et al. (2021)
K417N	environmental condition stability	Pokay	Relative to D614G, this mutation set (B.1.351+) demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
K417N	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
K417N	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
K417N	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
K417N	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
K417N	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	outcome hazard ratio	Pokay	In Ontario, using a retrospective matched case (age, gender and onset date) study of 6,312 Omicron cases vs 8,875 Delta, the adjusted risk of hospitalization or death was 54% lower (HR	2021	Ulloa et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~10-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~3 fold without the deletion] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were significant, but ~500x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.351 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 71%, Day 209 54%. Detectable antibodies against B.1.351 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 79%, Day 209 58%. Detectable antibodies against B.1.351 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 63%, Day 43 100%, Day 119 71%, Day 209 79%. Decreased neutralization on some assays was seen especially in those vaccinees tested that were 71+.	2021	Pegu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In an Ontario long term care facility, cumulatively, weaker BNT162b2 vaccine stimulation, age/comorbidities, produced a ~130-fold reduction in apparent neutralization titers in mean 88yo LTCH residents against Beta (B.1.351), relative to staff vaccinees against D614G wild type. 37.9% of 116 two-dose-mRNA-vaccinated residents had undetectable neutralizing antibodies to B.1.351. mRNA-1273 vaccinee sera displayed ~2 better neutralization than BNT162b2. [common defining B.1.351 mutations noted, as the manuscript does not provide details]	2021	Abe et al. (2021)
K417N	antibody epitope effects	Pokay	Anti-NTD CV1 mAb isolated from an early pandemic case was unable to neutralize either partial B.1.351 variant pseudovirus used (A701V or L242del). The neutralization potency of mAb CV30, which contacts K417 and N501 but not E484, was ~10-fold weaker toward both B.1.351 variants. The neutralization potency of anti-RBD mAb CV3-1 was 3-4-fold less potent against the B.1.351 variants, while anti-RBD mAb CV2-75 was modestly less effective.	2021	Stamatatos et al. (2021)
K417N	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, 7 of 15 neutralized this B.1.351 pseudotype that includes the L242del, and only one had titers above 100. Only one of the 15 sera achieved 80% neutralization. [compare to 5 and 1 for pseudotype without the deletion]	2021	Stamatatos et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Pseudotyped viruses for B.1.351 was 3.4-fold resistant to neutralization by 6 BNT162b2 vaccine sera 28 days post-booster compared to wild type. Neutralization by 3 Moderna vaccine sera 28 days post-booster was 2.2-fold resistant. [Exact list of B.1.351 mutations used in these assays was not included in the preprint]	2021	Tada et al. (2021)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Beta Molnupiravir (MK-4482) had ~1.75x fold drop.	2022	Rosenke et al. (2022)
K417N	ACE2 receptor binding affinity	Pokay	The B.1.351 variant constellation causes an ~20-fold increase in affinity for ACE2 compared with Wuhan RBD, which may influence transmissibility.	2021	Zhou et al. (2021)
K417N	humoral response durability	Pokay	In a prospective study of 107 hospitalized patients, decrease of IgG rates and serological assays becoming negative did not imply loss of neutralizing capacity. Our results indicate a sustained humoral response against the ancestral strain and the D614G, B.1.1.7 and P.1 variants for at least 6 months (last of two samples taken) in patients previously hospitalized for COVID-19. A weaker protection was however observed for the B.1.351 variant.	2020	Betton et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Beta variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but A701V is downstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)
K417N	outcome hazard ratio	Pokay	Compared to Alpha (B.1.1.7) variant, odds of progressing to severe disease were 1.24-fold (95% CI: 1.11-1.39) higher for Beta. Odds of progressing to critical disease were 1.49-fold (95% CI: 1.13-1.97) higher. Odds of COVID-19 death were 1.57-fold (95% CI: 1.03-2.43) higher.	2021	Abu-Raddad et al. (2021)
K417N	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Beta (B.1.351) variant is 0.4x fold the wildtype.	2022	Kumar et al. (2022)
K417N	convalescent plasma escape	Pokay	In 34 convalescent cases 4–9 weeks following infection in June 2020, before the emergence of B.1.1.7, neutralization titers against B.1.351 were, on average, 13.3-fold reduced compared with an early Victoria sample ($p < 0.0001$). Significantly, 18 of 34 samples failed to reach 50% neutralization at a plasma dilution of 1:20, with a number showing a near total reduction of neutralization activity. In 13 convalescent cases 4–9 weeks following infection with B.1.1.7, neutralization titers against B.1.351 were, on average, 3.1-fold reduced compared with an early Victoria sample ($p < 0.0001$).	2021	Zhou et al. (2021)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Beta (B.1.351) has an IC50 fold change of 0.15x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Vaccine plasma neutralization of B.1.351-spike virus was nominally robust but lower (~3x) than other variants of concern.	2021	Liu et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v3 reduced 8.4x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
K417N	antibody epitope effects	Pokay	Testing against B.1.351 the 20 most effective mAbs (19 anti-RBD, 1 anti-NTD) from a screen of 377 against wild type, 4 of 20 antibodies had >10-fold fall in neutralization titers, with most of these showing a complete knockout of activity. This is in line with the key roles of K417, E484, and N501, in particular E484, in antibody recognition of the ACE2 interaction surface of the RBD. Regeneron mAb cocktail: The neutralization of REGN10987 was unaffected by B.1.351, while REGN10933 was severely impaired (773-fold). AstraZeneca mAb cocktail: Neutralization by the AZ pair of antibodies was little affected on B.1.351 compared with Victoria.	2021	Zhou et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	A two-dose regimen of (AstraZeneca) ChAdOx1-nCoV19 did not show protection against mild-moderate Covid-19 due to B.1.351 variant, however, vaccine efficacy against severe Covid-19 is undetermined.	2021	Madhi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	The Janssen single dose vaccine showed 72% efficacy at preventing moderate and severe disease, which was reduced to 57% in South Africa, where 92.6% of infections are estimated to have been B.1.351. 100% reduction in hospitalization risk remains across variants after 28 days post-vaccination.		UNKNOWN et al. ()
K417N	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, B.1.351 lineage virus was able to infect and replicate in common lab mouse strains, with high titer. PG: The virus used in these expriments has a non-typical deletion+sub in the 242 region.	2021	Montagutelli et al. (2021)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	Sera from healthcare workers (n	2021	Zhou et al. (2021)
K417N	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Beta (B.1.351) has an IC50 fold change of 0.88x.	2022	Yuan et al. (2022)
K417N	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.351 defining mutations: Significant shift to infection in those without pre-existing conditions (79.6% vs 89% for non-VOC cases). Significant increase in hospitalization rate (19.3% vs 7.5% for non-VOC cases). Significant increase in ICU rate (2.3% vs 0.6% for non-VOC cases). PG: seems to be different notations around the LAL deletion, using the minimal shared definition to catch as many as possible.	2021	Funk et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v1 virus has reduced neutralization activity vs wild type: 34.5x (30 sera Pfizer median 9 days post 2nd dose) and 27.7x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 29.8% in this B.1.351 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Using B.1.351 defining mutations for Spike, observed 4x average decrease in neutralization efficiency (but still relevant titres) for sera from 10 BNT162b2 vaccinees 12 days after second dose, but only one relevant titre 12 days after first dose. Compares unfavorably to wild type or B.1.1.7 titres.	2021	Alenquer et al. (2021)
K417N	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, one third (5/15) of sera neutralized this B.1.351 pseudotype and only three had ID50 titers above 100. Only two of the 15 sera achieved 80% neutralization.	2021	Stamatatos et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~3-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~10 fold with L242del] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were signficiant, but >100x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)
K417N	reinfection	Pokay	4 health care workers in the 20's and 30's with no underlying conditions and seropositivity or confirmed 2020 SARS-CoV-2 infections were confirmed to have B.1.351 infection during a Februrary 2021 hospital outbreak in Luxembourg. Symptoms were mostly mild on first infection, and milder on second infection.	2021	Staub et al. (2021)
K417N	reinfection	Pokay	Hamsters re-infected with B.1.351 virus after seroversion from previous infection with a lineage A virus did not transmit virus to naive sentinels via direct contact transmission, in contrast to the non-seroconverted animals. They had little infectious virus and no pathology in the lungs. Initial infection with SARS-CoV-2 lineage A does not prevent heterologous reinfection with B.1.351, but prevents disease and onward transmission.	2021	Yinda et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	symptom prevalence	Pokay	Inoculation with the B.1.351 isolate resulted in lower clinical scores in 6 rhesus macaques that correlated with lower virus titers in the lungs, less severe histologic lung lesions and less viral antigen detected in the lungs. Our comparative pathogenicity study suggests that ongoing circulation under diverse evolutionary pressure favors transmissibility and immune evasion rather than an increase in intrinsic pathogenicity.	2021	Munster et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v3 virus has reduced neutralization activity vs wild type: 42.4x (30 sera Pfizer median 9 days post 2nd dose) and 19.2x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	The neutralization activities of two vaccines developed in China were tested against 501Y.V2 authentic virus: inactivated BBIBP-CorV (no significant change) and recombinant dimeric RBD vaccine ZF2001 (~1.6x reduction vs wildtype, p	2021	Huang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Most of the plasma from 55 Pfizer vaccinees developed high percentages of Wuhan-Hu-1 S-ACE2 blocking activity, peaking at day 28 (7 days post-boost). A strikingly consistent hierarchy of reduction in plasma antibody binding by variant S and RBD antigens was observed among study participants, with progressively decreased binding for B.1.1.7 (not significant), P.1 (significant) and B.1.351 (significant) compared to Wuhan-Hu-1 antigens.	2021	Röltgen et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	During an outbreak of SARS-CoV-2 501Y.V2 in a nursing home, all non-vaccinated residents (5/5) versus half of those fully vaccinated 2-5 weeks prior with BNT162b2 (13/26) were infected. Two of 13 vaccinated versus 4 of 5 non-vaccinated residents presented severe disease. BNT162b2 did not prevent the outbreak, but reduced transmission and disease severity. Among the 13 fully vaccinated residents who were infected, 2 (15.4%) presented with an asymptomatic disease, 9 (69.2%) developed mild to moderate symptoms, and 2 (15.4%) progressed to severe disease with fatal evolution secondary to acute respiratory distress syndrome (ARDS). There was no relationship between anti-S antibody levels at diagnosis and disease severity. Overall, the proportion of residents with severe disease in the non-vaccinated group (4/5) was higher than that in the vaccinated group (2/13). Only 1 vaccinated staff, but 10 unvaccinated were infected in the outbreak (no severe disease).	2021	Bailly et al. (2021)

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K417N	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 in sera from all 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 1625 for B.1.351 virus. This compares favorably (stronger) to most post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	2.5x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. >3x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
K417N	convalescent plasma escape	Pokay	B.1.1.351 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Study 3001 on Ad26.COV2.S (Jannsen vaccine) conducted September 21, 2020 through January 22, 2021 overlaps the emergence and dominance of the B.1.351 lineage of SARS-CoV-2 in South Africa. The SA arms of the Phase 3 double blind study showed severe/critical disease VE of 73.1% (95% CI: 40.0-89.4), and moderate to severe/critical disease VE of 52.0% (95% CI: 30.3-67.4). Compare to 78.0% and 74.4% for North American arm of the study during the same period (with low B.1.351 prevalence). Of the 66.9% of SA severe infections that have been sequenced as of this report, 94.5% are B.1.351.	2021	UNKNOWN et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	The dominant circulating B.1.351 spike variant originating in RSA, which harbors E484K and additional substitutions in the RBD, NTD, and S2 and deletions in the NTD (amino acids 242–244), was neutralized with a 5.02-fold reduced titer	2021	Solfrosi et al. (2021)
K417N	convalescent plasma escape	Pokay	B.1.1.351 in 19 convalescent human sera ~1mo post infection had mild to moderate resistance against all samples	2021	Chen et al. (2021)
K417N	antibody epitope effects	Pokay	B.1.1.351 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58. B.1.1.351 variant constellation ablates Class 3 N-terminal domain targeting antibodies COV2-2489 and COV2-2676 (the only two tested).	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	In a Syrian hamster model, B.1.351 variant virus had >4x reduction in YRNT90 (measure of neutralization) using wild type convalescent sera. PG: Note that exact sequence for B.1.351 used was not disclosed.	2021	Cochin et al. (2021)
K417N	convalescent plasma escape	Pokay	In 13 plasma collected ~1mo after B.1.1.7 infection (nursing home in Ticino, Switzerland), neutralization reduced to undetectable levels in many plasma for B.1.351 pseudotyped virus, as well as WT and other VOCs. [paper does not detail the B.1.351 variants used, using the most popular as a stad in]	2021	McCallum et al. (2021)
K417N	convalescent plasma binding	Pokay	VSV pseudotype B.1.351 showed 7.86-fold decrease in NT50 vs wild type in sera from 9 ICU patients undergoing treatment in Germany (pre-variant infections).	2021	Hoffman et al. (2021)
K417N	antibody epitope effects	Pokay	Abrogates Bamlanivimab, Etesevimab, or their combined use neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction.	2021	Hoffman et al. (2021)
K417N	convalescent plasma escape	Pokay	Approximately 6-fold reduction in 15 ICU patient convalescent plasma neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction.	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	Vaccine elicited antibodies neutralized virus with the B.1.351 spike protein had an average 3-fold reduction in titer (1:500), a titer that was still higher than the average titer with which convalescent sera neutralized D614G (1:139). Serum specimens from individuals vaccinated with the BNT162b2 mRNA vaccine neutralized D614G virus with titers that were on average 7-fold greater than convalescent sera.	2021	Tada et al. (2021)
K417N	trafficking	Pokay	In one of eight cell lines tested (293T lung cells), a modest increase in cell entry was observed.	2021	Hoffman et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 6.5-fold against B.1.351 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	VSV pseudotype B.1.351 entry mediated by the S proteins of the B.1.351 variant was completely resistant to blocking by REGN10989 and Bamlanivimab. Entry driven by the S proteins of the B.1.351 was partially resistant against Casirivimab.	2021	Hoffman et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	B.1.351 pseudotyped lentivirus showed 3.4 and 3.8x reduction in IC50 serum dilution concentration for sera from BNT162b2 (Pzifer) or mRNA1273 (Moderna) vacinees collected 28 days following booster dose.	2021	Zhou et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	VSV pseudotype B.1.351 showed 7.85-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.351 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.351 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
K417N	trafficking	Pokay	VSV pseudotype B.1.351 showed slight decrease in cell entry relative to wild type in 263T-ACE2 (kidney) cell line, and slight increase in Calu-3 (lung). Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)
K417N	convalescent plasma binding	Pokay	We analyzed 34 convalescent samples including the WHONIBSC 20/130 reference serum, and, although a few sera showed near identical FRNT 50 values, the FRNT50 dilutions for the B.1.1.7 strain were 2.9-fold lower (geometric mean) than those for the Victoria strain ($p < 0.0001$). Sera from 13 subjects post-B.1.1.7 infection showed no significant change in neutralization against Victoria (~wild type), suggesting that B.1.1.7 infection also protects against ancestral virus. [Note that D1119H was included in the original paper, assuming typographical error and correcting to D1118H]	2021	Supasa et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In 15 Pzifer non-senior vaccinee sera collected 3-4 weeks post-booster [using Table S1, not the text that says 2-3 weeks], neutralization was reduced ~11x.	2021	Hoffman et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.351 lineage effectiveness was observed as 16.9% (95% CI [10.4,23.0]) against infection, and 0% against severe/critical/fatal disease (95% CI [0-19.0]). Two weeks or more after 2nd dose, effectiveness climbed to 75.0% [70.5,78.9] against infection, and 100% against severe/critical/fatal disease (95% CI [73.7,100]).		UNKNOWN et al. ()
K417N	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
K417N	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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K417N	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
K417N	antibody epitope effects	Pokay	>20% (ELISA significance threshold) drop in antibody binding (ELISA) by this variant against IgG1 monoclonal antibody ab1.	2021	Sun et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Causes no detectable change in KD value for antibody binding of P5A-1D2.	2021	Zhang et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Reported 3-fold decrease in affinity compared to wild-type RBD on the cell surface (Kd	2021	Tian et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Causes no detectable change in KD value for antibody binding of P22A-1D1.	2021	Zhang et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	The K417N mutation decreased the affinity ~4 fold, mainly by decreasing the k(on) but also by increasing the k(off) as measured by surface plasmon resonance.	2021	Barton et al. (2021)
K417N	monoclonal antibody serial passage escape	Pokay	Escape mutation against monoclonal antibody LY-CoV016	2021	Starr et al. (2021)
K417N	antibody epitope effects	Pokay	No detectable fold drop in IC50 of P5A-3C8.	2021	Zhang et al. (2021)
K417N	monoclonal antibody serial passage escape	Pokay	In vitro selection against class 1 (Spike 'up' conformation) monoclonal antibody C682, and to a lesser extent C614 and C660	2021	Wang et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Causes 7.5 fold decrease in KD value for antibody binding of P2C-1F11.	2021	Zhang et al. (2021)

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K417N	ACE2 receptor binding affinity	Pokay	Causes 1.5 fold decrease in KD value of antibody binding of ACE2.	2021	Zhang et al. (2021)
K417N	convalescent plasma escape	Pokay	In 19 convalescent human sera ~1mo post infection, Two-tailed Wilcoxon matched-pairs signed-rank test shows mild resistance P	2021	Chen et al. (2021)
K417N	antibody epitope effects	Pokay	No detectable fold drop in IC50 of P5A-1D2.	2021	Zhang et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Causes 36.9 fold decrease in KD value for antibody binding of P5A-3C8.	2021	Zhang et al. (2021)
K417N	trafficking	Pokay	Lentiviral pseudotyped with this individual mutation from B.1.351 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing mild decrease in infection rate amongst the cells, suggesting that this mutation does not contributing to cell entry fitness.	2021	Tada et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	COR-101 lost ~6x binding against this isolated mutation. Estesevimab lost ~100x binding against this isolated mutation.	2021	Engelhart et al. (2021)
K417N	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.1 fold	2020	Starr et al. (2020)
K417N	antibody epitope effects	Pokay	Pseudotyped virus model ablates binding by RBD-directed mAbs CB6 and 910-30 (targeting the inner side of the RBD). Pseudotyped virus model impairs binding by RBD-directed mAbs 4-20 and REGN10933.	2021	Wang et al. (2021)
K417N	antibody epitope effects	Pokay	5 antibodies tested were less potent against K417N by ten-fold or more (class 1 mAbs)	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	virion structure	Pokay	Estimated free energy change (ddG) for this variant is -0.86 kcal/mol (i.e. destabilizing relative to wild type)	2021	Spratt et al. (2021)
K417N	antibody epitope effects	Pokay	1.1 fold drop in IC50 of P2C-1F11.	2021	Zhang et al. (2021)
K417N	antibody epitope effects	Pokay	No detectable fold drop in IC50 of P22A-1D1.	2021	Zhang et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In Moderna vaccinee sera, 2.7x reduction in neutralization, and 6.4 for the full B.1.351 Spike mutation complement, but despite the observed decreases, titers in human vaccinee sera against the B.1.351 variant remained at clinically significant level of ~1/300.	2021	Wu et al. (2021)
K417N	convalescent plasma escape	Pokay	27% of 44 early pandemic exposure convalescent plasma/sera lose all activity against a RBD triple mutant pseudovirus (RBD mutatants of the 501Y.V2 'South African' lineage), while only 23% retained high titres	2021	Wibmer et al. (2021)
K417N	viral load	Pokay	B.1.351 and P.1 samples showed average Ct cycle threshold of 22.2 vs 23 for wildtype (i.e. ~60% higher viral load) comparing 3360 and 22535 samples respectively.	2021	Roquebert et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	This mutated version of RBD completely abolishes the binding to a therapeutic antibody, Bamlanivimab, in vitro.	2021	Liu et al. (2021)
K417N	antibody epitope effects	Pokay	Ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58.	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccine neutralization efficacy	Pokay	In a cohort of 20 patients 8+ weeks after second vaccine dose of Moderna (mRNA-1273) or Pfizer-BioNTech (BNT162b2) vaccines, a significant (0.5 to 20-fold, but average ~2x) decrease in neutralization by vaccine plasma was observed.	2021	Wang et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	The affinity of the B.1.351 RBD variants for ACE2 increased by 3.7 fold as measured by surface plasmon resonance relative to wild type RBD by increasing the k(on) and decreasing the k(off) rate constants.	2021	Barton et al. (2021)
K417N	antibody epitope effects	Pokay	Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody CA1 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody LyCoV016 (also known as CB6 or JS016) on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody CC12.1 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody BD23 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody C119 (also known as CB6 or JS016) on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody P2B-2F6 on 501Y.V2 ('South African') lineage background	2021	Wibmer et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	In 19 convalescent human sera ~1mo post infection had mild to moderate resistance against most samples	2021	Chen et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	Tixagevimab, Regdanvimab and COR-101 display reduced binding affinity to virus pseudotyped as RBD from B.1.351.	2021	Engelhart et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	This combination showed ~3x increase binding to ACE2 vs wild type, about half that of the B.1.1.7 lineage, suggesting that the K417N mutation is slightly detrimental to ACE2 binding, probably as a result of disrupting the salt bridge formed with ACE2 residue D30	2021	Collier et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	Observed 1.4-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against pseudotype B.1.351 key variants lentivirus. Compare to 8.8-fold reduction against cultured B.1.351 virus.	2021	Bates et al. (2021)
K417N	antibody epitope effects	Pokay	Complete loss of binding in ELISA by the variant against monoclonal antibodies ab8 and IgG1 ab1. Complete loss for the same antibodies was also observed against S1 pseudotyped and full Spike protein trimers with both B.1.351 and P.1 lineage variants, with slight binding signal for P.1 against IgG1 at the highest concentration tested (1uM). Complete loss of neutralization by these two antibodies was also observed.	2021	Sun et al. (2021)

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K417N	ACE2 receptor binding affinity	Pokay	Using Mircoscale Thermopheresis, the B.1.351 variant harboring three mutations, binds ACE2 at nearly five-fold greater affinity than the original SARS-COV-2 RBD (Kd 87.6, vs 402.5 nM).	2021	Ramanathan et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	RBD containing the N501Y mutation results in 9-fold stronger binding to the hACE2 receptor than wild type RBD. The E484K mutation does not significantly influence the affinity for the receptor, while K417N attenuates affinity. As a result, RBD from B.1.351 containing all three mutations binds 3-fold stronger to hACE2 than wild type RBD but 3-fold weaker than N501Y.	2021	Laffeber et al. (2021)
K417N	viral load	Pokay	The 62 B.1.351 (a.k.a. N501Y.V2) variant cases in three Paris hospital labs had a ~2-fold viral load increase (~1 Ct drop in both N and ORF1ab probes) compared to 332 ancestral lineage cases from the same time frame (2020-12-20 to 2021-02-26).	2021	Teyssou et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Reported slight increase in affinity compared to wild-type RBD on the cell surface (Kd	2021	Tian et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Studying the key covariants in lineage of concern 501Y.V2, observed about 2-fold increase in ACE2 binding vs wildtype, but greatly decreased mAb binding, suggesting evolutionary optimum tension between immune evasion and ACE2 binding affinity as the N501Y variant alone has 10x increase in affinity but no effect on tested mAb binding.	2021	Liu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	ACE2 receptor binding affinity	Pokay	The affinity of ACE2 for this mutation combination was twice as high as for wild type. Having in mind that the affinity of SARS-CoV-2 for ACE2 is only 4-fold higher compared to SARS-CoV-1, this factor of 2 is expected to be biologically significant.	2021	Vogel et al. (2021)
K417N	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 2 (B.1.351) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
K417N	transmissibility	Pokay	36,590 variant-specific RT-PCR tests were performed on samples collected between April 12 and May 7, 2021 in France to compare variant spread. Compared to January to March 2021, B.1.351 variant had a significant transmission advantage over B.1.1.7 in some regions (15.1 to 16.1% in Île-de-France and 16.1 to 18.8% in Hauts-de-France). This shift in transmission advantage is consistent with the immune evasion abilities of B.1.351 and the high levels of immunization in these regions.	2021	Roquebert et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	transmissibility	Pokay	Assuming complete cross-protection, we estimate 501Y.V2/B.1.351 was 1.50 (95% CrI: 1.20-2.13) times as transmissible than previously circulating variants. Assuming instead that 501Y.V2 is identically transmissible, the new variant evades 21% (95% CrI: 11-36%) of previously acquired immunity. Reality may lie between these extremes, with an intermediate increase in transmissibility and mildly imperfect cross-protection from past exposure.	2021	Pearson et al. (2021)
K417N	convalescent plasma escape	Pokay	Average ~10-fold reduction in neutralization efficacy in convalescent sera of 16 health workers infected in Spring 2020.	2021	Alenquer et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In a multicenter, double-blind, randomized, controlled trial to assess the safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) with enrollment June 24 and November 9, 2020 from ~2000 HIV-negative 18-64 year olds (1:1 placebo to treatment), incidence of serious adverse events 14 or more days post- 2nd dose was balanced between the vaccine and placebo groups. A two-dose regimen of the ChAdOx1 nCoV-19 vaccine did not show protection against mild-to-moderate Covid-19 due to the B.1.351 variant. Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed 3.5x reduction in neutralization (ID50) for B.1.351 RBD pseudotype HIB-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a similar 3.2x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	convalescent plasma escape	Pokay	Neutralizing antibody titers of 18 samples (90%) decreased against this B.1.351 pseudotyped virus below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
K417N	antibody epitope effects	Pokay	Abolished neutralization by mAbs CQ026 and CQ038, greatly diminished neutralization by CQ012 and CQ046.	2021	Hu et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	This variant of key B.1.351 lineage mutations showed ~10x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	This variant showed ~10x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	Trachea viral loads were tested by qRT■PCR and RNA scope at 3 dpi on 5 8■month■old male mice and there was a ~750x fold drop in the R3P1-E4 antibody in comparison to the IgG control.	2022	Li et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	Lung viral loads were tested by qRT■PCR and RNA scope at 3 dpi on 5 8■month■old male mice and there was a ~2266x fold drop in the R3P1-E4 antibody in comparison to the IgG control.	2022	Li et al. (2022)
K417N	pharmaceutical effectiveness	Pokay	100% of the 5 8■month■old male R3P1-E4 antibody treated mice suvived 14 days after infection while only 60% the control group mice survived 5 days post infection.	2022	Li et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	trafficking	Pokay	~5x more efficient S2 domain cleavage compared to wild type, compared to 4x by D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3). [N501Y+D614G does not show an increase in cleavage, therefore a synergistic effect of the trio is implied]	2021	Kim et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	This variant showed >5x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
K417N	trafficking	Pokay	~9x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction (no synergy as level approx. that of N501Y alone).	2021	Kuzmina et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	This variant showed only minor in Pfizer sera (one or two dose) neutralization efficiency vs D614G (using lentivirus pseudotype).	2021	Kuzmina et al. (2021)
K417N	trafficking	Pokay	~2x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	Bamlanivimab (LY-CoV555) lost ~32x binding against this double mutation. COR-101 lost ~160x binding against this double mutation. Casirivimab lost ~16x binding against this double mutation. Estesevimab lost ~32x binding against this double mutation. Regdanvimab lost ~4x binding against this double mutation. Tixagevimab lost ~12x binding against this double mutation.	2021	Engelhart et al. (2021)
K417N	trafficking	Pokay	~13x more infective as D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	trafficking	Pokay	Approximately as infective as D614G alone in HEK293T-ACE2 cells 48h post-transduction (~additive effects of the individual variants).	2021	Kuzmina et al. (2021)
K417N	pharmaceutical effectiveness	Pokay	COR-101 lost ~20x binding against this double mutation. Estesevimab lost ~16x binding against this double mutation. Regdanvimab lost ~6x binding against this double mutation. M396 lost ~10x binding against this double mutation.	2021	Engelhart et al. (2021)
K417N	vaccine neutralization efficacy	Pokay	In post-vaccination sera from individuals who received one (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
K417N	convalescent plasma escape	Pokay	~7x reduction in neutralization by key B.1.351 lineage RBD variant combination in sera collected from cohort of 10 with severe disease 21 to 63 days post-onset. Two of the cohort showed no neutralization against this variant.	2021	Kuzmina et al. (2021)
K417N	convalescent plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.04x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset, in contrast to the largely positive binding values for each individual mutation that comprises the set.	2021	Gong et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.351 aka Beta) showed a 3.56x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
K417N	vaccinee plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.28x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. It shows a 1.17x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
K417N	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.5x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
K417N	convalescent plasma binding	Pokay	2.16x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
K417N	vaccinee plasma binding	Pokay	1.76x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.75x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
N440K	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N440K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
N440K	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
N440K	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N440K	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N440K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
N440K	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
N440K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

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N440K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N440K	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
N440K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N440K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
N440K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
N440K	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

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N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N440K	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments shows ablated neutralization efficacy (NT50 ~ 0) in two of 21 convalescents plasma collected mean 1.3 months post infection. Greater than 4-fold reduction was observed in most of the other plasma. 14 vaccinee plasma showed a slightly lower reduction in efficacy, albeit from a higher average starting point titre than convalescents.	2021	Schmidt et al. (2021)
N440K	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
N440K	monoclonal antibody serial passage escape	Pokay	Positive selection (up to 45% of supernatant sequences) under two rounds of C135 monoclonal antibody passage, eliminated in subsequent passages	2020	Weisblum et al. (2020)

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N440K	transmissibility	Pokay	The N440K variant produced ten times higher infectious viral titers than a prevalent A2a strain, and over 1000 folds higher titers than a much less prevalent A3i strain prototype in Caco2 cells. Interestingly, A3i strain showed the highest viral RNA levels, but the lowest infectious titers in the culture supernatants, indicating the absence of correlation between the RNA content and the infectivity of the sample.	2021	Tandel et al. (2021)
N440K	pharmaceutical effectiveness	Pokay	This individual mutation found in the epitope from Sotrovimab causes a 0.7x reduction in neutralization efficacy using a VSV model on Vero E6 cells.	2021	Cathcart et al. (2021)
N440K	monoclonal antibody serial passage escape	Pokay	Class 3 antibody C669 mildly selected for the emergence of the N440K mutation in vitro (in contrast to N440H which caused mild escape in Class 1/2 mAb C653).	2021	Wang et al. (2021)
N440K	antibody epitope effects	Pokay	Greater than 10-fold reduction of binding effeiency vs wild type for mAb LY-CoV555. Abolishes binding of mAb ADG-1.	2021	Rappazzo et al. (2021)
N440K	antibody epitope effects	Pokay	Resistent to class 3 antibodies (i.e. Abs that do not directly interfere with ACE2 binding).	2021	Wang et al. (2021)
N440K	ACE2 receptor binding affinity	Pokay	Experimentally, ACE2 binding affinity increased 0.07 fold	2020	Starr et al. (2020)
N440K	antibody epitope effects	Pokay	Ablates binding by class 3 mAbs such as C135 that do not directly interfere with ACE2 binding, but clonal somatic mutations of memory B cells at 6.2 months (evolving humoral immune response) show pronounced increase in binding to the variant.	2021	Gaebler et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N440K	antibody epitope effects	Pokay	N501Y substitution decreased the neutralizing and binding activities of CB6 and increased that of BD-23	2021	Cheng et al. (2021)
N440K	reinfection	Pokay	A 47yo Indian male was reinfected with B.1.36 lineage virus in September 2020 after infection with genetically distinct B.1.36 virus in July, with negative PCR tests in between. While the forst episode was asymptomatic, the second included fever, cough, and malaise. The second case additionally contained stopgain ORF3a:E261*	2021	Rani et al. (2021)
N450D	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments shows ablated neutralization efficacy (NT50 ~ 0) in two of 21 convalescents plasma collected mean 1.3 months post infection. Greater than 4-fold reduction was observed in most of the other plasma. 14 vaccinee plasma showed a slightly lower reduction in efficacy, albeit from a higher average starting point titre than convalescents.	2021	Schmidt et al. (2021)
N450D	convalescent plasma escape	Pokay	Strong reduction in neutralization capability of all 4 convalescent sera tested (2 ablations).	2021	Liu et al. (2021)
N450D	convalescent plasma escape	Pokay	Escape mutant found after in passage in plasma pool of 26 convalescents obtained mean 1.3 months post infection.	2021	Schmidt et al. (2021)
N450D	monoclonal antibody serial passage escape	Pokay	Escape variant 95% appearance in 2 passages against Regeneron monoclonal antibody RGN10934 @ 50ug/mL	2020	Baum et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N450D	antibody epitope effects	Pokay	Mutant screen in neutralization assay with a broad range of monoclonal antibodies shows resistence to more than one antibody.	2021	Liu et al. (2021)
N450D	antibody epitope effects	Pokay	Highly resistant to mAb SARS2-07 nd moderately resistant to SARS2-16 of 10 antibodies tested.	2020	Liu et al. (2020)
N450D	convalescent plasma escape	Pokay	No effective neutralization in 2 out of the 4 sera tested.	2021	Liu et al. (2021)
L452W	monoclonal antibody serial passage escape	Pokay	Ranked effective mutant against this position in the RBD for highly neutralizing COV2-2096	2020	Greaney et al. (2020)
N460K	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
N460K	ACE2 receptor binding affinity	Pokay	Experimentally, ACE2 binding affinity increased 0.09 fold	2020	Starr et al. (2020)
N460K	pharmaceutical effectiveness	Pokay	Inhibition of Omicron BA.2 RBD point mutant pseudotypes due to 3 mRNA vaccine doses results in high relative infection for this mutation, for individuals previously infected.	2022	Witte et al. (2022)
N460K	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.16 fold	2020	Starr et al. (2020)
N460K	ACE2 receptor binding affinity	Pokay	Selected with increasing proportion during in vitro evolution of Spike against ACE2 receptor	2021	Zahradnik et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N460K	pharmaceutical effectiveness	Pokay	Inhibition of Omicron (B.1.1.529 [BA.1]) RBD point mutant pseudotypes under no vaccination results in high relative infection for this mutation, for individuals previously infected.	2022	Witte et al. (2022)
N460K	pharmaceutical effectiveness	Pokay	Inhibition of Omicron BA.2 RBD point mutant pseudotypes due to 1/2 mRNA vaccines results in high relative infection for this mutation, for individuals previously infected.	2022	Witte et al. (2022)
N460K	monoclonal antibody serial passage escape	Pokay	Escape mutation against monoclonal antibody LY-CoV016	2021	Starr et al. (2021)
A475V	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
A475V	antibody epitope effects	Pokay	Ablates binding by class 3 mAbs such as C135 that do not directly interfere with ACE2 binding, but clonal somatic mutations of memory B cells at 6.2 months (evolving humoral immune response) show pronounced increase in binding to the variant.	2021	Gaebler et al. (2021)
A475V	convalescent plasma escape	Pokay	Resistant to a pool of 10 convalescent sera (but less than 4x, a typical threshold for definition of escape)	2020	Li et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
A475V	pharmaceutical effectiveness	Pokay	COR-101 lost ~50x binding against this isolated mutation. Estesevimab lost ~8x binding against this isolated mutation. Sotrovimab lost ~30x binding against this isolated mutation. Tixagevimab lost ~15x binding against this isolated mutation. m396 lost ~8x binding against this isolated mutation.	2021	Engelhart et al. (2021)
A475V	antibody epitope effects	Pokay	Resistent to some neutralizing antibodies: mAbs 157, 247, CB6, P2C-1F11, B38, and CA1	2020	Li et al. (2020)
A475V	monoclonal antibody serial passage escape	Pokay	The engineered mutation cause 10-fold or more increase in the disassociation constant with C102, C105 and C144 monoclonal antibodies vs. wild type Spike protein RBD domain AAs.	2020	Barnes et al. (2020)
A475V	antibody epitope effects	Pokay	Resistent to some class 1 (Spike ' up' conformation) antibodies tested.	2021	Wang et al. (2021)
A475V	monoclonal antibody serial passage escape	Pokay	Escape mutation against monoclonal antibody LY-CoV016, minimal ACE2 binding affinity loss	2021	Starr et al. (2021)
F486P	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
F486P	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.22 fold	2020	Starr et al. (2020)
F486P	monoclonal antibody serial passage escape	Pokay	Ranked modestly effective mutant against this position in the RBD for highly neutralizing COV2-2832 monoclonal antibody	2020	Greaney et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
F486P	monoclonal antibody serial passage escape	Pokay	Escape mutation against monoclonal antibody LY-CoV555 (antibody that forms the basis for Eli Lilly's bamlanivimab)	2021	Starr et al. (2021)
Q498R	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Q498R	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Q498R	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
Q498R	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
Q498R	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Q498R	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
Q498R	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Q498R	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
Q498R	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
Q498R	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q498R	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
Q498R	ACE2 receptor binding affinity	Pokay	Y501 makes a pi interaction with Y41 and places R498 to make a hydrogen bond and salt bridge to Q42 and D38 of ACE2, forming a strong network of new interactions supporting the impact of these residues on affinity. Q498R alone appears to decrease ACE2 binding. The synergism of Q498R with N501Y (and E484K) increases ACE2 binding by ~50- fold relative to WT.	2021	Zahradnik et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q498R	ACE2 receptor binding affinity	Pokay	Y501 makes a pi interaction with Y41 and places R498 to make a hydrogen bond and salt bridge to Q42 and D38 of ACE2, forming a strong network of new interactions supporting the impact of these residues on affinity. Q498R alone appears to decrease ACE2 binding. The synergism of Q498R with N501Y (and E484K) increases ACE2 binding by ~50- fold relative to WT. The extent of affinity increase with Q498R and N501Y is not exactly quantified, as E484K always emerged with this duo during in vitro evolution.	2021	Zahradnik et al. (2021)
N501Y	vaccinee plasma binding	Pokay	Out of 10 individuals with 3 doses of the BNT162b2/BNT162b2/BNT162b 2 vaccine had a neutralizing titer in B.1.640.2 variant was ~5.6x folds more significant in 9 individuals.	2022	Arora et al. (2022)
N501Y	vaccinee plasma binding	Pokay	Out of 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine, neutralizing titer in B.1.640.2 variant was ~1000x folds more significant in 8 individuals.	2022	Arora et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N501Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
N501Y	virion structure	Pokay	CryoEM reveals the P.1 trimer to adopt exclusively a conformation in which one of the receptor-binding domains is in the “up” position.	2021	Wang et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In 12 Moderna vaccinee sera 15 days post second dose (43 days since first vaccination), an average 2.8x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 4.8x decrease against the full P.1 type vs WA-1 was observed, though overall with a higher ID50 reciprocal value. In 10 Pfizer vaccinee sera 7 days or more post second dose (28 days or more since first vaccination), an average 2.2x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.8x decrease against the full P.1 type vs WA-1 was observed, with similar variant ID50 reciprocal value.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma escape	Pokay	In convalescent sera one month or more post-infection in Spring 2020, an average 6.5x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.4x decrease against the full P.1 type vs WA-1 was observed, with better full P.1 ID50 reciprocal value compared to the 10-mutation model.	2021	Wang et al. (2021)
N501Y	antibody epitope effects	Pokay	Amongst RBD-targeting Emergency Use Authorized monoclonal antibody treatments CB6, LY-CoV555 and REGN10933 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1, but REGN10987 activity remains strong. RBD-targeting monoclonal antibodies 2-15 and C121 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1. N terminal domain targeting monoclonal antibodies 5-7, 4-8, 4-18 and 2-17 have abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1.	2021	Wang et al. (2021)
N501Y	reinfection	Pokay	After a 128 day interval, a patient in Sao Paulo State, Brazil reinfected with P.1 (first episode likely predates P.1 emergence). Both cases were fairly mild (difficulty breathing, tiredness, dizziness and fatigue).	2021	Malta Romano et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 349 test-positive were Gamma. Two dose vaccine efficacy against Gamma was 95.5 (90.9-97.8%), one dose VE was 74.2 (43.8-88.1%).	2021	Bruxvoort et al. (2021)
N501Y	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Gamma variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but H655Y is upstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)
N501Y	reinfection	Pokay	Three healthcare workers (29-50yo) had confirmed P.1 [Gamma] re-infection in the Amazonas region of Brazil 3-9 months after initial infection from viruses with distinct lineage from P.1, but mild symptoms upon re-infection and evidence for infectiousness during re-infection.	2021	Naveca et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Mean 3.0x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
N501Y	convalescent plasma escape	Pokay	Mean 4.1x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
N501Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Gamma (P.1) variant is 0.6x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was slightly lower against B.1.1.248 variant constellation in sera tested from most of the 15 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 16.6% in this B.1.1.248 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
N501Y	antibody epitope effects	Pokay	B.1.1.248 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07. B.1.1.248 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2676.	2021	Chen et al. (2021)
N501Y	convalescent plasma escape	Pokay	B.1.1.7 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)
N501Y	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, P.1 lineage virus was able to infect and replicate in common lab mouse strains, with high titer.	2021	Montagutelli et al. (2021)
N501Y	convalescent plasma escape	Pokay	B.1.1.248 variant constellation in 10 convalescent human sera ~1mo post infection had mild to moderate resistance against most samples, P	2021	Chen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 4.3-fold against P.1 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped P.1 virus has reduced neutralization activity vs wild type: 6.7x (30 sera Pfizer median 9 days post 2nd dose) and 4.5x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Using P.1 defining mutations for Spike, observed 4x average decrease in neutralization efficiency (but still relevant titres) for sera from 10 BNT162b2 vaccinees 12 days after second dose, but only one relevant titre 12 days after first dose. Compares unfavorably to wild type or B.1.1.7 titres.	2021	Alenquer et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In human sera 8 weeks post-vaccination with INO-4800, a ~2-fold reduction in P.1 neutralization was observed.	2021	Andrade et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Among 46,884 HCWs in Manaus, Brazil vaccinated with at least one dose of CoronaVac, a 0.50-fold reduction (adjusted vaccine effectiveness, 49.6%: 95% CI, 11.3 - 71.4) in the odds of symptomatic SARS-CoV-2 infection was observed during the period 14 days or more after receiving the first dose. Estimated vaccine effectiveness of at least one dose against any SARS-CoV-2 infection was 35.1% (95% CI, –6.6 - 60.5) in the same time period.	2021	Hitchlings et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	VSV pseudotype P.1 entry mediated by the S proteins of the P.1 variant was completely resistant to blocking by REGN10989 and Bamlanivimab. Cell fusion proficiency was slight impaired. Entry driven by the S proteins of the B.1.351 was partially resistant against Casirivimab.	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma binding	Pokay	VSV pseudotype P.1 showed 4.8-fold decrease in NT50 vs wild type in sera from 9 ICU patients undergoing treatment in Germany (pre-variant infections).	2021	Hoffman et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	VSV pseudotype P.1 showed 5.12-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)
N501Y	trafficking	Pokay	VSV pseudotype P.1 showed slight decrease in cell entry relative to wild type in 262T and 263T-ACE2 (kidney) cell lines. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)
N501Y	convalescent plasma binding	Pokay	Neutralizing antibodies that were generated following a mild infection with SARS-CoV-2 B.1.128 were effective in vitro, and likely protective, against the SARS-CoV-2 P.1. variant in the majority of individuals based on 60 convalescent sera tested.	2021	Mendes-Correa et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
N501Y	convalescent plasma escape	Pokay	In 13 plasma collected ~1mo after B.1.1.7 infection (nursing home in Ticino, Switzerland), neutralization reduced to undetectable levels in many plasma for P.1 pseudotyped virus, as well as WT and other VOCs. [paper does not detail the P.1 variants used, using the most popular as a stand in]	2021	McCallum et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	1.15x *increase* in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against P.1 reduced 3.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	P.1 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with Lilly mAb combination LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of P.1. There was also escape from neutralization of P.1 by REGN10933 (one of 2 in Regeneron's mAb cocktail) and a modest reduction in neutralization of P.1 by AstraZeneca's AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized P.1 with all reaching a plateau at 100% neutralization: interestingly, ADG30 showed a slight increase of neutralization of P.1. S309 Vir was largely unaffected, although for several viruses, including P.1, the antibody failed to completely neutralize, conceivably reflecting incomplete glycosylation at N343, since the sugar interaction is key to binding of this antibody.	2021	Dejnirattisai et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	P.1 lineage titers were reduced 7.6-fold and 9-fold for the BNT162b2 Pfizer (sera collected 4-14 days post-booster) and ChAdOx1 nCoV-19 AstraZeneca (sera collected 14 or 28 days post-booster) vaccines respectively.	2021	Dejnirattisai et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 2896 for P.1 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
N501Y	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 256 for B.1.1.7 virus. Compare to somewhat stronger neutralization titer for wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Detectable antibodies against P.1 at various time points using pseudovirus neutralization in Moderna vaccinee cohort: Day 43 100%, Day 209 85%.	2021	Pegu et al. (2021)
N501Y	T cell evasion	Pokay	PBMCs of 11 mild COVID-19 patients collected 38-80 days after symptom onset were stimulated with the 15-mer peptide pools (w/ 10 residue overlaps) from the wholle viral proteome, showing no significant CD4+ cell count effect for P.1, and a slight increase in CD8+ percentage (p	2021	Tarke et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	transmissibility	Pokay	The relative transmissibility of P.1 estimated at the national level (Italy) varied according to the assumed degree of cross-protection granted by infection with other lineages and ranged from 1.12 (95%CI 1.03-1.23) in the case of complete immune evasion by P.1 to 1.39 (95%CI 1.26-1.56) in the case of complete cross-protection. PG: variant list has been abbreviated due to mixed K417 bases in this lineage, potential miscalls of deletions	2021	Stefanelli et al. (2021)
N501Y	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
N501Y	convalescent plasma escape	Pokay	The 501Y.V2 to first wave IC50 ratio ranged from 6 to 200-fold. Averaging across all 7 participant convalescent sera highlighted the dramatic decrease in sensitivity to neutralization of authentic 501Y.V2 variants. PG: I'm purposefully ignoring D614G and A701V as contributors	2021	Cele et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In human sera 8 weeks post-vaccination with INO-4800, a ~7-fold reduction in B.1.351 neutralization was observed.	2021	Andrade et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Four fold reduction in neutralization efficiency was observed in sera of ferrets post-vaccination with INO-4800 (DNA plasmid pGX9501 encoding full length Spike).	2021	Riddell et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Monovalent mRNA-1273.351 encodes for the S protein found in the B.1.351 lineage and (2) mRNA-1273.211 comprising a 1:1 mix of mRNA-1273 and mRNA-1273.351. In a mouse study, primary vaccination series of mRNA-1273.351 was effective at increasing neutralizing antibody titers against the B.1.351 lineage, while mRNA-1273.211 was most effective at providing broad cross-variant neutralization. In addition, these results demonstrated a third dose of mRNA-1273.351 significantly increased both wild-type and B.1.351-specific neutralization titers.	2021	Wu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Pzifer vaccinees that tested positive at least a week after the second dose were indeed disproportionally infected with B.1.351, as compared with unvaccinated individuals (odds ratio of 8:1), but were all infected before 14 days post second vaccination.	2021	Kustin et al. (2021)
N501Y	convalescent plasma escape	Pokay	Mean 8.2x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Mean 6.3x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma escape	Pokay	In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals (5/9) and recipients of a only a single dose of mRNA vaccine (10/11) – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
N501Y	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 8 for B.1.351 virus. Compare to much stronger neutralization titers for B.1.1.7 (256) and wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.351 sample. Contrast this with 1.4-fold reduction for just the pseudovirus combination of 'key' B.1.351 mutations K417N+E484K+N501Y. WA1 and B.1.351 FRNT50 titers correlated weakly at the individual level, with some individual’s serum potently neutralizing WA1 while having FRNT50 for B.1.351 below the assay limit of detection (1:20).	2021	Bates et al. (2021)
N501Y	convalescent plasma binding	Pokay	Sera from individuals who have been infected with Delta does not have strong neutralising activity against Beta.	2021	UNKNOWN et al. (2021)

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N501Y	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms had mean ~6x reduction in neutralizing titers, and 40% of the samples lacked any activity against B.1.351.	2021	Planas et al. (2021)
N501Y	vaccinee plasma binding	Pokay	Sera from individuals who have been vaccinated and have had subsequent recent Delta infection have a high level of neutralising activity against Beta.	2021	UNKNOWN et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Beta Variant B.1.351 RBD significantly better than w.t. SARS-CoV-2 RBD. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v2 virus has reduced neutralization activity vs wild type: 41.2x (30 sera Pfizer median 9 days post 2nd dose) and 20.8x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Pseudotype lentivirus for the full B.1.351 Spike variant list shows increase affinity for ACE2 as measured by IC50. This is in contrast to B.1.1.7 which showed no major change, indicating that the shared N501Y mutation is the driver of affinity change, attentuated in the B.1.1.7 mutatioon set, but maintained in the B.1.351 lineage.	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	[Contrary to how this paper has been cited, Voysey et al. do NOT show evidence of decreased effectiveness of ChAdOx1 (AstraZeneca) against the South African B.1.351 lineage. Insufficient numbers reaching the primary study endpoint were available in that arm of the vaccine study to report any statistics from the South African participants. Additionally, the study period of the paper ended in November 2020, while the earliest reported case of this lineage is October (covariants.org), only becoming dominant by mid-November.]	2021	Voysey et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.351. We observed an increase (relative to D614G) in binding of soluble ACE2 to B.1.351, and to a much gearter extent to B.1.1.7, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Relative to B.1.1.117, PRNT50 line virus neutralizating antibody activity assay of B.1.351 showed ~11x reduction in 13 vacinees's sera collected through 41 days after vaccination. Neutralization by a placebo control group of 6 naturally infected patients showed a smaller ~8x drop (starting from a ~50% higher PRNT50 value than vacinees for B.1.1.117 neutralization). Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed ~4x reduction in neutralization (ID50) for full B.1.351 pseudotype HIV-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a slightly higher 4.6x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.899x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
N501Y	convalescent plasma escape	Pokay	A 1.8-fold drop in FRNT50 for B.1.351 was observed in 44 sera collected between 1 and 301 post-infection.	2021	Bates et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	3.2x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v1 reduced 6.9x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
N501Y	T cell evasion	Pokay	Encouragingly, we find that the majority of T cell responses in recipients of two doses of the BNT162b2 vaccine are generated by epitopes that are invariant between the [wildtype] and two of the current variants of concern (B.1.1.7 and B.1.351). In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals and recipients of a only a single dose of mRNA vaccine – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
N501Y	convalescent plasma escape	Pokay	The neutralizing activity of 16/20 convalescent sera was significantly lower against this pseudotyped virus model of B.1.351, with similar results for the live virus.	2021	Wang et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.803x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	B.1.351 pseudotyped virus model ablates neutralization by RBD-directed mAbs CB6, 4-20, 2-4, 2-43, 910-30, 2-302-15, LY-Cov555, C121. B.1.351 pseudotyped virus model severely impairs neutralization by RBD-directed mAb 1-20. B.1.351 pseudotyped virus model impairs neutralization by RBD-directed mAb REGN10933. B.1.351 pseudotyped virus model ablates neutralization by N-terminal-domain-directed mAbs 5-24, 4-8, 4A8, 4-19. B.1.351 pseudotyped virus model severely impairs neutralization by N-terminal-domain-directed mAb 2-17. B.1.351 pseudotyped virus model impairs neutralization by N-terminal-domain-directed mAb 5-7. PG: Live virus data for the same mAbs is similar, but 1-20 becomes severally impaired, REGN10933 activity is ablated, and Brii-196 becomes impaired.	2021	Wang et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 (12.4x in twelve Moderna-recipient sera: 10.3x in ten Pfizer-recipient sera). [this is a larger list of B.1.351 than modeled by Wang et al. (2021) by including L18F and R246I, less effective at neutralizing]	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaluated against VSV pseudotypes: while BD614G and B.1.1.7 were neutralized earlier, the anti-B.1.351 response was negative up to week 3, and became detectable at week 4 (1 week after booster dose), at a level lower than the two other viruses (~10x vs D614G) through week 6, the last timepoint measured. Three vaccinees never showed detectable neutralization to B.1.351 even after second dose.	2021	Planas et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 0.036x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
N501Y	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: while B.1.1.7 and D614G showed neutralization by nasal swab from only one different previously infected vacinee neutralizing at weeks 3 and 6, B.1.351 showed zero neutralization at either time point in any sample (and relatively impaired serum neutralization).	2021	Planas et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v2 reduced 7.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.351 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	B.1.351 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. Only 1 out of 12 serum samples from a cohort of Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed effective neutralization (IC90) at full serum strength (average realtive decrease was 6.1x vs wild type).	2021	Ikegame et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.07x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In a randomized phase 2a-b control trial of the Novavax (NVX-CoV2373) vaccine in South Africa, where B.1.351 virus dominates, efficacy was 60.1% (95% CI, 19.9 to 80.1) in HIV-negative and initially SARS-CoV-2 seronegative participants using the primary endpoint of laboratory-confirmed symptomatic Covid-19 at 7 days or more after the second dose among participants.	2021	Shinde et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	DARPin SR22 molecule had a 1.57x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.054x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	B.1.351 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of B.1.351. There was also escape from neutralization of B.1.351 by REGN10933 and a modest reduction in neutralization of B.1.351 by AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized B.1.351.	2021	Dejnirattisai et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 6.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 99.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
N501Y	trafficking	Pokay	Lentiviral pseudotyped with all key mutations from B.1.351 lineage was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing modest decrease in infection rate amongst the cells, suggesting some synergy between the mutations to decrease cell entry fitness (i.e. cell entry is liklely not the driver of this lineage's dominance).	2021	Tada et al. (2021)
N501Y	convalescent plasma escape	Pokay	The most significant loss of neutralizing activity (PsVNA50 assay) using 6 hyperimmune immunoglobulin preparations from convalescent plasma was seen against authentic B.1.351 lineage virus (9.2-fold). Neutralization against 10 convalescent plasma was poorer (18.7x).	2021	Tang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	environmental condition stability	Pokay	Treatment with heat, soap and ethanol revealed similar inactivation profiles indicative of a comparable susceptibility towards disinfection. Furthermore, we observed comparable surface stability on steel, silver, copper and face masks.	2021	Meister et al. (2021)
N501Y	environmental condition stability	Pokay	Relative to D614G, this mutation set (B.1.351+) demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
N501Y	outcome hazard ratio	Pokay	In the Parana state of Brazil, patients aged 20-29 years experienced a tripling of their case fatality rate (CFR), from 0.04% to 0.13%, while those aged 30-39, 40-49, 50-59 experienced approximate CFR doubling comparing February to January in 2021. Notably, the observed CFR increase coincided with the second consecutive month of declining number of diagnosed SARS-CoV-2 cases. Taken together, these preliminary findings suggest significant increases in CFR in young and middle-aged adults after identification of a novel SARS-CoV-2 strain circulating in Brazil. [this is somewhat indirect evidence that assume greatly increasing proportion of P.1 cases in March (70%) compared to February, but the first official ID of P.1 in Parana state (Feb 16th) may be due to testing procedures rather than actual prevalence]	2021	Santos de Oliviera et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	outcome hazard ratio	Pokay	In the Southern Brazilian stats of Rio Grande do Sul, comparing pre-P.1 and post-P.1 waves: The increase in Case Fatality Rate occurred in a greatest intensity in the population between 20 and 59 years old and among patients without pre-existing risk conditions. Female 20 to 39 years old, with no pre-existing risk conditions, were at risk of death 5.65 times higher in February (95%CI	2021	Ribas Freitas et al. (2021)
N501Y	outcome hazard ratio	Pokay	On average across 7 European countries studied, using P.1 defining mutations: Significant shift to infection in those without pre-existing conditions (27.8% vs 89% for non-VOC cases). Significant increase in hospitalization rate (20% vs 7.5% for non-VOC cases). Significant increase in ICU rate (2.1% vs 0.6% for non-VOC cases). Significant increase in health care worker rate (19.8% vs 8.0% for non-VOC cases).	2021	Funk et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	This variant was designated A.27.RN according to its phylogenetic clade classification. It emerged in parallel with the B.1.1.7 variant, increased to >50% of all SARS-CoV-2 variants by week five. Subsequently it decreased to <10% of all variants by calendar week eight when B.1.1.7 had become the dominant strain. Antibodies induced by BNT162b2 (Pfizer) vaccination neutralized A.27.RN but with a two-to-threefold reduced efficacy as compared to the wild-type and B.1.1.7 strains.	2021	Mallm et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
N501Y	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N501Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N501Y	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N501Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was somewhat lower against B.1.1.7 in sera tested from most of the 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
N501Y	antibody epitope effects	Pokay	B.1.1.7 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2489.	2021	Chen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.1.7 sample. Contrast this with 1.3-fold reduction for just the pseudovirus combination of 'key' B.1.1.7 mutation N501Y.	2021	Bates et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7+E484K reduced 2.8x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster. Compare with 1.2x reduction for B.1.1.7 without E484K.	2021	Choi et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Sera after the second dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 + E484K variant of ~6.7x, markedly higher than B.1.1.7 alone. For first dose sera, a 9.7x drop was observed.	2021	Collier et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was markedly worse against B.1.1.7 + E484K than the lineage alone, with a 11.4x drop.	2021	Collier et al. (2021)
N501Y	antibody epitope effects	Pokay	Ablates Class 3 N-terminal domain targeting antibody COV2-2489, diminishes COV2-2676.	2021	Chen et al. (2021)
N501Y	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, moreso than this combination with the addition of P681H.	2021	Tada et al. (2021)
N501Y	symptom prevalence	Pokay	In comparison of B.1.1.7 lineage (193 cases) vs. 'wildtype' (125) in Berlin Jan 18 to March 29 2021, significant symptom changes are absent loss of smell/taste (P	2021	van Loon et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	This mutation combination causes major increase in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus, but combined with the complete set of B.1.1.7 lineage variants no major change vs wild type affnity is observed.	2021	Tada et al. (2021)
N501Y	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA1-18 (~4x), COVA2-15 (~9x). PG: these effects are laregly missing in the deletion-alone data	2021	Shen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	symptom prevalence	Pokay	A higher proportion of cases infected with the B.1.1.7 variant were hypoxic on admission compared to other variants (70.0% vs 62.5%, p	2021	Snell et al. (2021)
N501Y	virion structure	Pokay	The Ratio of S2 (processed Spike) to full length Spike is higher for this mutation combination, due to a drop in the full length Spike measured, suggesting that this mutation compensates for decreased Spike production by improved proteolytic processing.	2021	Tada et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.1.7 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.1.7 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
N501Y	convalescent plasma escape	Pokay	Mean 2.6x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.1.7 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 33%, Day 43 100%, Day 119 100%, Day 209 96%. Detectable antibodies against B.1.1.7 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 54%, Day 43 100%, Day 119 100%, Day 209 88%. Detectable antibodies against B.1.1.7 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 83%, Days 43,119,209 100%.	2021	Pegu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Using national surveillance data from Israel, using Pfizer vaccine and an estimated prevalence of the B.1.1.7 variant of 94.5% among SARS-CoV-2 infections: Adjusted estimates of vaccine effectiveness 7+ days after second dose were 95·3% (95% CI 94.9–95.7): 91.5% against asymptomatic SARS-CoV-2 infection (90·7–92·2: 40.9 vs 1.8 per 100 000 person-days), 97·0% against symptomatic COVID-19 (96.7–97.2%), 97.2% against COVID-19-related hospitalisation (96.8–97.5%), 97.5% against severe or critical COVID-19-related hospitalisation (97.1–97.8%), and 96.7% against COVID-19-related death (96.0–97.3%). In all age groups, as vaccine coverage increased, the incidence of SARS-CoV-2 outcomes declined	2021	Haas et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 8192 for B.1.351 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
N501Y	virion structure	Pokay	CryoEM analysis of B.1.1.7 demonstrates an increased propensity for 'up', receptor accessible conformation of the Spike protein trimer.	2021	Cai et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	SARS-CoV-2 infection was confirmed in three HCWs working a single shift: all presented with mild symptoms of COVID-19. The two physicians were fully vaccinated with BNT162b2 vaccine, with the second dose administered 1 month before symptom onset. Both had high titres of IgG anti-spike antibodies at the time of diagnosis. WGS confirmed that all virus strains were VOC 202012/01-lineage B.1.1.7, suggesting a common source of exposure. Epidemiological investigation revealed that the suspected source was a SARS-CoV-2-positive patient who required endotracheal intubation due to severe COVID-19. All procedures were carried out using a full suite of personal protective equipment (PPE).	2021	Loconsole et al. (2021)

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N501Y	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 1422 test-positive were Alpha. Two dose vaccine efficacy against Alpha was 98.4% [96.9-99.1%], one dose VE was 90.1% (82.9-94.2%).	2021	Bruxvoort et al. (2021)
N501Y	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms, similarly neutralized B.1.1.7 and D614G.	2021	Planas et al. (2021)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Alpha (B.1.1.7) has an IC50 fold change of 1.19x.	2022	Yuan et al. (2022)
N501Y	antibody epitope effects	Pokay	B.1.1.7 pseudotyped virus model impairs binding by RBD-directed mAb 910-30. B.1.1.7 pseudotyped virus model abolishes N-terminal-domain-directed mAbs 5-24, 4-8, and 4A8. B.1.1.7 pseudotyped virus model impairs binding by N-terminal-domain-directe d mAbs 2-17, 4-19, 5-7.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	1.4x improvement in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. 2x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
N501Y	aerosolization	Pokay	Alpha variant cases in a large campus study showed fine-aerosol shedding amongst unmasked participants remained significantly greater for alpha variant infections (18-fold, 95% CI, 3.4 to 92-fold) after adjusting for the increased viral RNA in MTS and saliva, the number of coughs during sampling sessions, and symptom. After controlling for the effect of masks and numbers of coughs during sampling, alpha variant infection was associated with a 100-fold (95% CI, 16 to 650-fold) increase in coarse- and a 73-fold (95% CI, 15 to 350-fold) increase in fine-aerosol RNA shedding.	2021	Adenaiye et al. (2021)

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N501Y	environmental condition stability	Pokay	No differences in the stability of B.1.1.7 observed in the absence of simulated sunlight at either 20°C or 40°C (with a mean time for a 90% loss of viral infectivity across all dark conditions of 6.2 hours). However, a small but statistically significant difference in the stability was observed in simulated sunlight at 20°C and 20% relative humidity, with B.1.1.7 restoring wild type 90% loss time of 11 minutes vs. 7 and 8 minutes for B.1.319 (D614G) and B.28 (V367F) early 2020 viruses respectively.	2021	Schuit et al. (2021)
N501Y	trafficking	Pokay	Modelling the Alpha variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increase 3.9x relative to wild type (5.4 vs 1.4). This is less efficient than Delta (11x vs wildtype using a P681R mutation instead). [del ~144 changed due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a co-infection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.1.7 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine. This is despite three mutations (Y144del, D614G, and P681H) overlapping T-cell epitope hotspots.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	The NAb titers (PRNT50) of sera collected from 38 vaccine recipients four-weeks after the second dose of inactivated whole-virion SARS-CoV-2 BBV152/COVAXIN vaccine [which contains D614G] were not significantly different between B.1.1.7 virus and ancestral D614G virus.	2021	Sapkal et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 vaccine demonstrated vaccine effectiveness [symptomatic or asymptomatic in cohort opf routinely NAAT-monitored UK HCWs] of 72% (95% CI 58-86) 21 days after first dose and 86% (95% CI 76-97) seven days after two doses in the antibody negative cohort. This cohort was vaccinated when the dominant variant in circulation was B.1.1.7 and demonstrates effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Between December 19, 2020 and Jan 24, 2021, 7214 of 9109 eligible HCWs at Sheba Medical Center in Israel had received one or more doses of BNT162b2 (Pfizer) vaccine. Adjusted rate reduction in SARS-CoV-2 NAAT positivity infection compared with unvaccinated workers 1-14 days after 1st dose was 30% (95% CI: 2-50), and 75% (95% CI: 72-84) after 15-28 days. Adjusted rate reduction in symptomatic COVID-19 compared with unvaccinated workers 1-14 days after 1st dose was 47% (95% CI: 17-66), and 85% (95% CI: 71-92) after 15-28 days. [Though often cited as an indicator of VE for B.1.1.7, during this time period in Israel, the prevalence of the B.1.1.7 variant increased from ~20% to 50% of cases (covariants.org), therefore these VE numbers likely represent a mix of B.1.1.7 and other lineage effects.]	2021	Amit et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	We found that a single dose of the BNT162b2 vaccine is about 60-70% effective at preventing symptomatic disease in adults aged 70 years and older in England and that two doses are about 85-90% effective. Those who were vaccinated and went on to have symptoms had a 44% lower risk of being admitted hospital and a 51% lower risk of death compared with people who were unvaccinated. We also found that a single dose of the ChAdOx1-S vaccine was about 60-75% effective against symptomatic disease and provided an additional protective effect against hospital admission—it is too early to assess the effect on mortality. The B.1.1.7 variant now dominates in the UK and these results will largely reflect vaccine effectiveness against this variant.	2021	Lopez Bernal et al. (2021)

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N501Y	antibody epitope effects	Pokay	Neutralization of the 47D10. Alpha (B.1.1.7) has an IC50 fold change of 0.40x.	2022	Yuan et al. (2022)
N501Y	anthropozoonotic events	Pokay	First documented cases of domestic cat and dog infections with the B.1.1.7 strain.	2021	Hamer et al. (2021)
N501Y	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (48.7%: 95% confidence interval [CI], 45.5 to 51.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 93.7% (95% CI, 91.6 to 95.3) among those with the alpha variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 74.5% (95% CI, 68.4 to 79.4) among those with the alpha variant.	2021	Lopez Bernal et al. (2021)
N501Y	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA2-15 (~9x), B38 (~14x), S309 (~190x) by this B.1.1.7 pseudotyped virus model.	2021	Shen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	We observed a sharp decline in cases when ~50% of the elderly population was 2 weeks beyond their first vaccination dose and at a time point during which the B.1.1.7 variant gained transmission dominance. In support of this finding, it was suggested that, after the first vaccination dose, more than 70% of patients develop neutralization antibodies,15 and the vaccine efficiency can reach 85%.	2021	Munitz et al. (2021)

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N501Y	convalescent plasma escape	Pokay	Neutralizing antibody titers of 2/20 (10%) samples showed >10x reduction (sera collected ~1mo post Jan 2020 first wave in China). Neutralizing antibody titers of 8/20 samples (40%) decreased below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
N501Y	antibody epitope effects	Pokay	Lessens the potency of mAbs COVA2-17 (~5x, similar to N501Y alone), COVA1-12 (~11x) and COVA1-21 (>100x), which do not compete allosterically.	2021	Rees-Spear et al. (2021)
N501Y	reinfection	Pokay	36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020. Possible reinfections were identified in 249 (0.7% [95% CI 0.6-0.8]) of 36509 app users who reported a positive swab test before Oct 1, 2020, but there was no evidence that the frequency of reinfections was higher for the B.1.1.7 variant than for pre-existing variants.	2021	Graham et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 virus has reduced neutralization activity vs wild type: 2.1x (30 sera Pfizer median 9 days post 2nd dose) and 2.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA. Note that Y145del was actually noted in the paper as the effect of their DNA construct, but this is equivalent at the protein level to the more commonly annotated Y144del.	2021	Garcia-Beltran et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaulated against VSV pseudotypes: neutralized D614G at week 2, whereas B.1.1.7 started to be neutralized at week 3, although less efficiently than D614G. B.1.1.7 and D614G strains were similarly neutralized at week 4 (1 week after booster dose).	2021	Planas et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralization assays of B.1.1.7 virus showed a reduction of 2.5-fold (14 days post 2nd dose AstraZeneca, n	2021	Supasa et al. (2021)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.39x.	2022	Yuan et al. (2022)
N501Y	vaccine efficacy	Pokay	In Minnesota in early 2021 when Alpha was prevalent, vaccine efficacy was estimated as: mRNA-1273 86% (95%CI: 81-90.6%) and BNT162b2: 76% (95%CI: 69-81%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. [variant list included is ancestral Alpha, as this was an observational study no variant list was given]	2021	Puranik et al. (2021)
N501Y	antibody epitope effects	Pokay	~20x resistence to mAb CQ038 by B.1.1.7 pseudotyped virus	2021	Hu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	reinfection	Pokay	Reinfection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) B.1.1.7 variant in an immunocompromised 16yo female with end stage renal disease 94 days after initial infection with a B.1.2 lineage virus. Both lineages were the prevalent one at the time of 1st and 2nd infections respectively in Texas, where the patient was located (suggesting exposure risk rather than lineage immune evasion).	2021	Marquez et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Alpha Variant B.1.1.7 RBD significantly better than GenScript IgG FL18-740 w.t. ACE-2 mAB. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.44x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 (Pfizer) vaccine showed vaccine effectiveness of 70% (95% CI 55-85) 21 days after first dose and 85% (74-96) 7 days after two doses in the study population. Our findings show that the BNT162b2 vaccine can prevent both symptomatic and asymptomatic infection in working-age adults. This cohort (8203 treatment, 15121 control) was vaccinated when the dominant variant in circulation was B.1.1.7 and shows effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma escape	Pokay	NTD-specific nAbs showed a substantial (3-450x) decrease in neutralization potency against the recently reported highly transmissible B.1.1.7 variant of concern, whereas RBD-specific nAbs were either unaffected or showed lower decreases in potency.	2021	Graham et al. (2021)
N501Y	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: results (only one nasal swab from different previously infected vacinee neutralizing at weeks 3 and 6 against B.1.1.7 and D614G) suggest that vaccinees probably do not elicit an early humoral response detectable at mucosal surfaces even though sera neutralization was observed. They strengthen the hypothesis that some vaccines may not protect against viral acquisition and infection of the oral–nasal region, but may prevent severe disease associated with viral dissemination in the lower respiratory tract.	2021	Planas et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Alpha Molnupiravir (MK-4482) had ~2.75x fold drop.	2022	Rosenke et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7 reduced 1.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	reinfection	Pokay	Second infection in December 2020 with B.1.1.7 after April 2020 initial infection with B.2 in a 78-year-old man with a history of Type 2 diabetes mellitus, diabetic nephropathy on hemodialysis, chronic obstructive pulmonary disease (COPD), mixed central and obstructive sleep apnea, ischemic heart disease, with no history of immunosuppression.	2021	Harrington et al. (2021)
N501Y	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 1 (B.1.1.7) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
N501Y	trafficking	Pokay	~2.5x cleavage of S2 relative to WA1 (D614G) wildtype by Alpha variant variant as measured by mass spectrometry of Vero-TMPRSS culture.	2021	Esclera et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Virus neutralisation activity (using a live SARS-CoV-2 microneutralisation assay (ND50)) by vaccine induced antibodies was 9-fold lower against the B.1.1.7 variant than against a canonical non B.1.1.7 lineage. Vaccine efficacy against symptomatic NAAT positive infection was similar for B.1.1.7 and non-B.1.1.7 lineages (74.6% [95%CI 41.6-88.9] and 84% [95% CI 70.7-91.4] respectively). Furthermore, vaccination with ChAdOx1 nCoV-19 results in a reduction in the duration of shedding and viral load, which may translate into a material impact on transmission of disease.	2021	Emary et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Alpha (B.1.1.7) variant is 1.0x fold the wildtype in 42 COVI.	2022	Kumar et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 15.4% in this B.1.1.7 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	2.1x drop in neutralization using sera collected from 14 healthy adult participants that received two injections of the mRNA-1273 (Moderna) vaccine at a dose of 100 µg (18-55 years: day 1 (n	2021	Edara et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	B.1.1.7 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. A cohort of 12 Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed no statistically sognificant change in neutralization effiacacy.	2021	Ikegame et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	NVX-CoV2373 [Novavax] vaccine in phase 3 trial was 89.7% (95% CI, 80.2-94.6) effective in preventing COVID-19, with no hospitalizations or deaths reported. There were five cases of severe Covid-19, all in the placebo group. Post hoc analysis revealed efficacies of 96.4% (73.8-99.5) and 86.3% (71.3-93.5) against the prototype strain and B.1.1.7 variant, respectively.	2021	Heath et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 Spike variants lentivirus. 3.5x reduction in neutralization with Moderna vaccinated patient sera after 29 days (1st dose). 2.0x reduction in neutralization with Moderna vaccinated patient sera after 57 days (2nd dose). 2.1x reduction in neutralization with Novavax Phase 1 post-vaccination sera.	2021	Shen et al. (2021)
N501Y	clinical indicators	Pokay	After adjusting for the age factor, in a prospective Chinese cohort study B.1.1.7 variant infection (compared to B.1.140) was the risk factor for C-reactive protein (P	2021	Song et al. (2021)
N501Y	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against symptomatic infection caused by Alpha, vaccine effectiveness with partial vaccination (≥14 days after dose 1) was higher for mRNA-1273 (83%) than BNT162b2 (66%) and ChAdOx1 (64%), and full vaccination (≥7 days after dose 2) increased vaccine effectiveness for BNT162b2 (89%) and mRNA-1273 (92%).	2021	Nasreen et al. (2021)
N501Y	trafficking	Pokay	Live virus was tested ex vivo in reconstituted brochial epithelium, and out competed wild type.	2021	Touret et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Mean 1.7x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.1.7. We observed a dramatic increase (relative to D614G) in binding of soluble ACE2 to B.1.1.7, and to a lesser extent to B.1.351, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 93 pM for binding to the Alpha B1.1.7. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.1.7 lineage effectiveness was observed as 29.5% (95% CI [22.9,35.5]) against infection, and 54.1% against severe/critical/fatal disease (95% CI [26.1-71.9]). Two weeks or more after 2nd dose, effectiveness climbed to 89.5% [85.9,92.3] against infection, and 100% against severe/critical/fatal disease (95% CI [81.7,100]).		UNKNOWN et al. ()
N501Y	pharmaceutical effectiveness	Pokay	Lilly's LY-CoV16 showed marked reduction in neutralization of B.1.1.7.	2021	Dejnirattisai et al. (2021)
N501Y	convalescent plasma escape	Pokay	Sera neutralized the B1.1.7 isolate with a lower potency (2-fold: 95% CL: 1.5 – 3-fold), and those with the lowest homotypic neutralizing potency had undetectable heterotypic potency (2/25).	2021	Skelly et al. (2021)
N501Y	tissue specific replication effects	Pokay	In this report, by using a lower infectious dose, we demonstrate that B.1.1.7 (cultured sample Hong Kong/HKPU-00015/2021) exhibits higher infectivity and/or replication efficiency in the nasal epithelium. (Hamster model of infection)	2021	Mok et al. (2021)
N501Y	convalescent plasma escape	Pokay	Neutralization capacity GMT of 27 subjects' sera post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	20/29 sera after the first dose of Pfizer showed an average reduction in neutralization titres against the B.1.1.7 variant of 3.2 ± 5.7. After the second dose, the GMT was markedly increased compared with the first-dose titres, with a fold change of 1.9 ± 0.9 (mean ± s.d.). Neutralization GMT of 27 subjects post-infection was considerably higher (stronger) than after the second Pfizer dose, and 4.5x drop in B.1.1.7 neutralization was observed.	2021	Collier et al. (2021)
N501Y	transmissibility	Pokay	We estimate that this [B.1.1.17] variant has a 43–90% (range of 95% credible intervals 38–130%) higher reproduction number than preexisting variants. Data from other countries yield similar results: we estimate that R for VOC 202012/01 relative to other lineages is 55% (45–66%) higher in Denmark, 74% (66–82%) higher in Switzerland, and 59% (56–63%) higher in the United States, with consistent rates of displacement across regions within each country.	2021	Davies et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Lineage B.1.1.7 spike–pseudotyped VSV was tested for neutralization vs Wuhan reference genome pseudotype in 40 sera collected 7 or 21 days post-booster dose. Statistically significant change (22%) in neutralization was observed among the 26 sera from those <	2021	Muik et al. (2021)
N501Y	transmissibility	Pokay	At the national level (Italy), we estimated a mean relative transmissibility of B.1.1.7 (compared to historical lineages) ranging between 1.55 and 1.57 (with confidence intervals between 1.45 and 1.66).	2021	Stefanelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.1.7 defining mutations: Significant shift to asymptomatic cases (27.4% vs 18.6% for non-VOC cases). Significant shift to infection in those without pre-existing conditions (44.8% vs 89% for non-VOC cases). Significant increase in hospitalization rate (11% vs 7.5% for non-VOC cases). Significant increase in ICU rate (1.4% vs 0.6% for non-VOC cases). Significant decrease in death rate (2.0% vs vs 4.0% for non-VOC cases).	2021	Funk et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Vaccine elicited antibodies neutralized virus with the B.1.1.7 spike protein with titers similar to D614G virus. Serum specimens from individuals vaccinated with the BNT162b2 mRNA vaccine neutralized D614G virus with titers that were on average 7-fold greater than convalescent sera.	2021	Tada et al. (2021)
N501Y	transmissibility	Pokay	Oslo, Norway: Within households, we find an increase in the secondary attack rate by 60% (20% 114%) compared to other variants. In general, we find a significant increase in the estimated reproduction number of 24% (95% CI 0% - 52%), or an absolute increase of 0.19 compared to other variants.	2021	Lindstrøm et al. (2021)
N501Y	transmissibility	Pokay	Based on ~300,000 RT-PCR samples collected from December 6th 2020 to February 10th 2021 in Israel, the B.1.1.7 is 45% (95% CI:20-60%) more transmissible than the wild-type strain, and become dominant in Israel within 3.5 weeks.	2021	Munitz et al. (2021)

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N501Y	outcome hazard ratio	Pokay	The matching-adjusted conditional odds ratio of hospitalisation was 1.58 (95% confidence interval 1.50 to 1.67) for COVID-19 patients infected with a SGTF-associated variant [primarily B.1.1.7], compared to those infected with non-SGTF-associated variants. The effect was modified by age (p<0.001), with ORs of 0.96-1.13 below age 20 years and 1.57-1.67 in age groups 40 years or older.	2021	Nyberg et al. (2021)
N501Y	outcome hazard ratio	Pokay	Using UK data 1 November 2020 to 14 February 2021, while correcting for misclassification of PCR test Spike Gene Target Failure (SGTF) and missingness in SGTF status, we estimate that the hazard of death associated with B.1.1.7 is 61% (42–82%) higher than with pre-existing variants after adjustment for age, sex, ethnicity, deprivation, residence in a care home, the local authority of residence and test date. This corresponds to the absolute risk of death for a 55–69-year-old man increasing from 0.6% to 0.9% (95% confidence interval, 0.8–1.0%) within 28 days of a positive test in the community.	2021	Davies et al. (2021)
N501Y	viral load	Pokay	B.1.1.7 samples showed average Ct cycle threshold of 21.9 vs 23 for wildtype (i.e. ~2x higher viral load) comparing 37758 and 22535 samples respectively.	2021	Roquebert et al. (2021)

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N501Y	transmissibility	Pokay	Based on 36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020, Rt of B.1.1.7 was 1.35x (95% CI 1.02-1.69) relative to pre-existing variants. However, Rt fell below 1 during regional and national lockdowns, even in regions with high proportions of infections with the B.1.1.7 variant.	2021	Graham et al. (2021)
N501Y	outcome hazard ratio	Pokay	341 samples collected Nov 9 to Dec 20, 2020 were sequenced from two London (UK) hospitals. 198 (58%) of 341 had B.1.1.7 infection and 143 (42%) had non-B.1.1.7 infection. No evidence was found of an association between severe disease and death and lineage (B.1.1.7 vs non-B.1.1.7) in unadjusted analyses (prevalence ratio [PR] 0·97 [95% CI 0·72-1·31]), or in analyses adjusted for hospital, sex, age, comorbidities, and ethnicity (adjusted PR 1·02 [0·76-1·38]).	2021	Frampton et al. (2021)
N501Y	outcome hazard ratio	Pokay	From Sept 28 to Dec 27, 2020, positive COVID-19 tests were reported by 36 920 COVID Symptom Study app users whose region was known and who reported as healthy on app sign-up. We found no changes in reported symptoms or disease duration associated with B.1.1.7.	2021	Graham et al. (2021)

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N501Y	viral load	Pokay	The 249 B.1.1.7 (a.k.a. N501Y.V1) variant cases in three Paris hospital labs had a ~10-fold viral load increase (~3.3 Ct drop in N gene probe) compared to 332 ancestral lineage cases from the same time frame (2020-12-20 to 2021-02-26). PG: BUT there is a discrepancy in drop between the ORF1ab and N probes, with the former suggesting only a 2-fold drop, consistent with the drop observed in B.1.351. This might indicate higher subgenomic RNA content in B.1.1.7 skewing the change.	2021	Teyssou et al. (2021)
N501Y	viral load	Pokay	Using lack of S probe detection as a proxy for B.1.1.7 status, 275 putative B.1.1.7 samples and 390 ' wild type' SARS-CoV-2 positive samples in Wales were compared for Ct values, suggesting ~12-fold increase (~3.5 Ct decrease) in viral load for B.1.1.7 samples.	2021	Couzens et al. (2021)
N501Y	outcome hazard ratio	Pokay	The mortality hazard ratio associated with infection with [B.1.1.7] compared with infection with previously circulating variants was 1.64 (95% confidence interval 1.32 to 2.04) in patients who tested positive for covid-19 in the community (54906 matched pairs of participants who tested positive for SARS-CoV-2 in pillar 2 between 1 October 2020 and 29 January 2021). In this comparatively low risk group, this represents an increase in deaths from 2.5 to 4.1 per 1000 detected cases.	2021	Challen et al. (2021)

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N501Y	viral load	Pokay	In a study of 1260 ICU subjects, viral load distributions (collected within 48h of admission) were elevated in both seropositive and seronegative subjects infected with B.1.1.7 ('UK variant'). PG: The PANGO tool defining Spike variants for B.1.1.7 are listed here, whereas the paper only used a test for D1118H.	2021	Ratcliff et al. (2021)
N501Y	viral load	Pokay	This study reveals that B.1.1.7 SARS-CoV-2 variant is a slower-growing virus than parental B.1. Further, a higher replication along with reduced infectious viral titer was hypothesized to be linked to higher transmission with reduced pathogenicity.	2021	Nyayanit et al. (2021)
N501Y	viral load	Pokay	We found that the British variant (clade B.1.1.7), compared to an ancestral SARS-CoV-2 clade B virus, produced higher levels of infectious virus late in infection and had a higher replicative fitness in human airway, alveolar and intestinal organoid models.	2021	Lamers et al. (2021)
N501Y	outcome hazard ratio	Pokay	Danish study of the B.1.1.7 lineage shows hospital admission odds ratio of 1.63 vs other lineages. The adjusted OR was increased in all strata of age.	2021	Bager et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	This mutation causes major decrease in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus.	2021	Tada et al. (2021)
N501Y	transmissibility	Pokay	Ontario, Feb 2021: The secondary attack rate for VOC index cases in this matched cohort was 1.31 times higher than non-VOC index cases (RR	2021	Buchan et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	viral load	Pokay	The median Ct value of RT-qPCR tests of the N-gene target in the Daxing B.1.1.7 group was significantly lower than the Shunyi B.1.470 group (P	2021	Song et al. (2021)
N501Y	transmissibility	Pokay	Primary cases infected with B.1.1.7 had an increased transmissibility of 1.5-1.7 times that of primary cases infected with other lineages. The increased transmissibility of B.1.1.7 was multiplicative across age and viral load.	2021	Lyngse et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	VSV pseudotype B.1.1.7 showed 1.77-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 5.2-fold against B.1.1.7 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
N501Y	outcome hazard ratio	Pokay	Using primarily S-defining mutations for lineage B.1.1.7, most models of hospitalization and fatality risk ratios from consortium members show elevated ratios (~1.3-1.7x).	2021	UNKNOWN et al. (2021)
N501Y	trafficking	Pokay	VSV pseudotype B.1.1.7 showed no significant difference in cell entry relative to wild type in 6 cell lines. Cell fusion proficiency was unchanged.	2021	Hoffman et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Six fold increase in affinity for ACE2 by the B.1.1.7 lineage vs wild type is driven by a drop in observed dissociation rate constant.	2021	Collier et al. (2021)

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N501Y	environmental condition stability	Pokay	Relative to D614G, this mutation demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
N501Y	trafficking	Pokay	Lentiviral pseudotyped with this mutation set from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing significant (40%) increase in infection rate amongst the cells, much more than the effect of either the deletion or the point mutation alone, suggetsing that this combination has a synergistic effect contributing to cell entry fitness, but to a smaller extent than N501Y and the deletion alone.	2021	Tada et al. (2021)
N501Y	convalescent plasma binding	Pokay	These key B.1.1.7 mutations as a combination neutralized slightly less well than D614G and this was noticeable in the lack of sera with high neutralizing titer for the viruses across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
N501Y	convalescent plasma binding	Pokay	Slight neutralization improvement on average in 16 health workers' convalescent sera.	2021	Alenquer et al. (2021)
N501Y	convalescent plasma escape	Pokay	One convalescent sera tested showed 4-fold or greater reduction in neutralization efficiency.	2021	Alenquer et al. (2021)
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~10-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~3 fold without the deletion] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were significant, but ~500x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.351 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 71%, Day 209 54%. Detectable antibodies against B.1.351 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 79%, Day 209 58%. Detectable antibodies against B.1.351 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 63%, Day 43 100%, Day 119 71%, Day 209 79%. Decreased neutralization on some assays was seen especially in those vaccinees tested that were 71+.	2021	Pegu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In an Ontario long term care facility, cumulatively, weaker BNT162b2 vaccine stimulation, age/comorbidities, produced a ~130-fold reduction in apparent neutralization titers in mean 88yo LTCH residents against Beta (B.1.351), relative to staff vaccinees against D614G wild type. 37.9% of 116 two-dose-mRNA-vaccinated residents had undetectable neutralizing antibodies to B.1.351. mRNA-1273 vaccinee sera displayed ~2 better neutralization than BNT162b2. [common defining B.1.351 mutations noted, as the manuscript does not provide details]	2021	Abe et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Anti-NTD CV1 mAb isolated from an early pandemic case was unable to neutralize either partial B.1.351 variant pseudovirus used (A701V or L242del). The neutralization potency of mAb CV30, which contacts K417 and N501 but not E484, was ~10-fold weaker toward both B.1.351 variants. The neutralization potency of anti-RBD mAb CV3-1 was 3-4-fold less potent against the B.1.351 variants, while anti-RBD mAb CV2-75 was modestly less effective.	2021	Stamatatos et al. (2021)
N501Y	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, 7 of 15 neutralized this B.1.351 pseudotype that includes the L242del, and only one had titers above 100. Only one of the 15 sera achieved 80% neutralization. [compare to 5 and 1 for pseudotype without the deletion]	2021	Stamatatos et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped viruses for B.1.351 was 3.4-fold resistant to neutralization by 6 BNT162b2 vaccine sera 28 days post-booster compared to wild type. Neutralization by 3 Moderna vaccine sera 28 days post-booster was 2.2-fold resistant. [Exact list of B.1.351 mutations used in these assays was not included in the preprint]	2021	Tada et al. (2021)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Beta Molnupiravir (MK-4482) had ~1.75x fold drop.	2022	Rosenke et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	The B.1.351 variant constellation causes an ~20-fold increase in affinity for ACE2 compared with Wuhan RBD, which may influence transmissibility.	2021	Zhou et al. (2021)
N501Y	humoral response durability	Pokay	In a prospective study of 107 hospitalized patients, decrease of IgG rates and serological assays becoming negative did not imply loss of neutralizing capacity. Our results indicate a sustained humoral response against the ancestral strain and the D614G, B.1.1.7 and P.1 variants for at least 6 months (last of two samples taken) in patients previously hospitalized for COVID-19. A weaker protection was however observed for the B.1.351 variant.	2020	Betton et al. (2020)
N501Y	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Beta variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but A701V is downstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)
N501Y	outcome hazard ratio	Pokay	Compared to Alpha (B.1.1.7) variant, odds of progressing to severe disease were 1.24-fold (95% CI: 1.11-1.39) higher for Beta. Odds of progressing to critical disease were 1.49-fold (95% CI: 1.13-1.97) higher. Odds of COVID-19 death were 1.57-fold (95% CI: 1.03-2.43) higher.	2021	Abu-Raddad et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Beta (B.1.351) variant is 0.4x fold the wildtype.	2022	Kumar et al. (2022)
N501Y	convalescent plasma escape	Pokay	In 34 convalescent cases 4–9 weeks following infection in June 2020, before the emergence of B.1.1.7, neutralization titers against B.1.351 were, on average, 13.3-fold reduced compared with an early Victoria sample ($p < 0.0001$). Significantly, 18 of 34 samples failed to reach 50% neutralization at a plasma dilution of 1:20, with a number showing a near total reduction of neutralization activity. In 13 convalescent cases 4–9 weeks following infection with B.1.1.7, neutralization titers against B.1.351 were, on average, 3.1-fold reduced compared with an early Victoria sample ($p < 0.0001$).	2021	Zhou et al. (2021)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Beta (B.1.351) has an IC50 fold change of 0.15x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Vaccine plasma neutralization of B.1.351-spike virus was nominally robust but lower (~3x) than other variants of concern.	2021	Liu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v3 reduced 8.4x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Testing against B.1.351 the 20 most effective mAbs (19 anti-RBD, 1 anti-NTD) from a screen of 377 against wild type, 4 of 20 antibodies had >10-fold fall in neutralization titers, with most of these showing a complete knockout of activity. This is in line with the key roles of K417, E484, and N501, in particular E484, in antibody recognition of the ACE2 interaction surface of the RBD. Regeneron mAb cocktail: The neutralization of REGN10987 was unaffected by B.1.351, while REGN10933 was severely impaired (773-fold). AstraZeneca mAb cocktail: Neutralization by the AZ pair of antibodies was little affected on B.1.351 compared with Victoria.	2021	Zhou et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	A two-dose regimen of (AstraZeneca) ChAdOx1-nCoV19 did not show protection against mild-moderate Covid-19 due to B.1.351 variant, however, vaccine efficacy against severe Covid-19 is undetermined.	2021	Madhi et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The Janssen single dose vaccine showed 72% efficacy at preventing moderate and severe disease, which was reduced to 57% in South Africa, where 92.6% of infections are estimated to have been B.1.351. 100% reduction in hospitalization risk remains across variants after 28 days post-vaccination.		UNKNOWN et al. ()
N501Y	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, B.1.351 lineage virus was able to infect and replicate in common lab mouse strains, with high titer. PG: The virus used in these expriments has a non-typical deletion+sub in the 242 region.	2021	Montagutelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Sera from healthcare workers (n	2021	Zhou et al. (2021)
N501Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Beta (B.1.351) has an IC50 fold change of 0.88x.	2022	Yuan et al. (2022)
N501Y	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.351 defining mutations: Significant shift to infection in those without pre-existing conditions (79.6% vs 89% for non-VOC cases). Significant increase in hospitalization rate (19.3% vs 7.5% for non-VOC cases). Significant increase in ICU rate (2.3% vs 0.6% for non-VOC cases). PG: seems to be different notations around the LAL deletion, using the minimal shared definition to catch as many as possible.	2021	Funk et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v1 virus has reduced neutralization activity vs wild type: 34.5x (30 sera Pfizer median 9 days post 2nd dose) and 27.7x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 29.8% in this B.1.351 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Using B.1.351 defining mutations for Spike, observed 4x average decrease in neutralization efficiency (but still relevant titres) for sera from 10 BNT162b2 vaccinees 12 days after second dose, but only one relevant titre 12 days after first dose. Compares unfavorably to wild type or B.1.1.7 titres.	2021	Alenquer et al. (2021)
N501Y	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, one third (5/15) of sera neutralized this B.1.351 pseudotype and only three had ID50 titers above 100. Only two of the 15 sera achieved 80% neutralization.	2021	Stamatatos et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~3-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~10 fold with L242del] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were signficiant, but >100x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)
N501Y	reinfection	Pokay	4 health care workers in the 20's and 30's with no underlying conditions and seropositivity or confirmed 2020 SARS-CoV-2 infections were confirmed to have B.1.351 infection during a Februrary 2021 hospital outbreak in Luxembourg. Symptoms were mostly mild on first infection, and milder on second infection.	2021	Staub et al. (2021)
N501Y	reinfection	Pokay	Hamsters re-infected with B.1.351 virus after seroversion from previous infection with a lineage A virus did not transmit virus to naive sentinels via direct contact transmission, in contrast to the non-seroconverted animals. They had little infectious virus and no pathology in the lungs. Initial infection with SARS-CoV-2 lineage A does not prevent heterologous reinfection with B.1.351, but prevents disease and onward transmission.	2021	Yinda et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	symptom prevalence	Pokay	Inoculation with the B.1.351 isolate resulted in lower clinical scores in 6 rhesus macaques that correlated with lower virus titers in the lungs, less severe histologic lung lesions and less viral antigen detected in the lungs. Our comparative pathogenicity study suggests that ongoing circulation under diverse evolutionary pressure favors transmissibility and immune evasion rather than an increase in intrinsic pathogenicity.	2021	Munster et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v3 virus has reduced neutralization activity vs wild type: 42.4x (30 sera Pfizer median 9 days post 2nd dose) and 19.2x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The neutralization activities of two vaccines developed in China were tested against 501Y.V2 authentic virus: inactivated BBIBP-CorV (no significant change) and recombinant dimeric RBD vaccine ZF2001 (~1.6x reduction vs wildtype, p	2021	Huang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Most of the plasma from 55 Pfizer vaccinees developed high percentages of Wuhan-Hu-1 S-ACE2 blocking activity, peaking at day 28 (7 days post-boost). A strikingly consistent hierarchy of reduction in plasma antibody binding by variant S and RBD antigens was observed among study participants, with progressively decreased binding for B.1.1.7 (not significant), P.1 (significant) and B.1.351 (significant) compared to Wuhan-Hu-1 antigens.	2021	Röltgen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	During an outbreak of SARS-CoV-2 501Y.V2 in a nursing home, all non-vaccinated residents (5/5) versus half of those fully vaccinated 2-5 weeks prior with BNT162b2 (13/26) were infected. Two of 13 vaccinated versus 4 of 5 non-vaccinated residents presented severe disease. BNT162b2 did not prevent the outbreak, but reduced transmission and disease severity. Among the 13 fully vaccinated residents who were infected, 2 (15.4%) presented with an asymptomatic disease, 9 (69.2%) developed mild to moderate symptoms, and 2 (15.4%) progressed to severe disease with fatal evolution secondary to acute respiratory distress syndrome (ARDS). There was no relationship between anti-S antibody levels at diagnosis and disease severity. Overall, the proportion of residents with severe disease in the non-vaccinated group (4/5) was higher than that in the vaccinated group (2/13). Only 1 vaccinated staff, but 10 unvaccinated were infected in the outbreak (no severe disease).	2021	Bailly et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 in sera from all 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 1625 for B.1.351 virus. This compares favorably (stronger) to most post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	2.5x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. >3x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
N501Y	convalescent plasma escape	Pokay	B.1.1.351 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	Study 3001 on Ad26.COV2.S (Jannsen vaccine) conducted September 21, 2020 through January 22, 2021 overlaps the emergence and dominance of the B.1.351 lineage of SARS-CoV-2 in South Africa. The SA arms of the Phase 3 double blind study showed severe/critical disease VE of 73.1% (95% CI: 40.0-89.4), and moderate to severe/critical disease VE of 52.0% (95% CI: 30.3-67.4). Compare to 78.0% and 74.4% for North American arm of the study during the same period (with low B.1.351 prevalence). Of the 66.9% of SA severe infections that have been sequenced as of this report, 94.5% are B.1.351.	2021	UNKNOWN et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The dominant circulating B.1.351 spike variant originating in RSA, which harbors E484K and additional substitutions in the RBD, NTD, and S2 and deletions in the NTD (amino acids 242–244), was neutralized with a 5.02-fold reduced titer	2021	Solfrosi et al. (2021)
N501Y	convalescent plasma escape	Pokay	B.1.1.351 in 19 convalescent human sera ~1mo post infection had mild to moderate resistance against all samples	2021	Chen et al. (2021)
N501Y	antibody epitope effects	Pokay	B.1.1.351 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58. B.1.1.351 variant constellation ablates Class 3 N-terminal domain targeting antibodies COV2-2489 and COV2-2676 (the only two tested).	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma escape	Pokay	In a Syrian hamster model, B.1.351 variant virus had >4x reduction in YRNT90 (measure of neutralization) using wild type convalescent sera. PG: Note that exact sequence for B.1.351 used was not disclosed.	2021	Cochin et al. (2021)
N501Y	convalescent plasma escape	Pokay	In 13 plasma collected ~1mo after B.1.1.7 infection (nursing home in Ticino, Switzerland), neutralization reduced to undetectable levels in many plasma for B.1.351 pseudotyped virus, as well as WT and other VOCs. [paper does not detail the B.1.351 variants used, using the most popular as a stad in]	2021	McCallum et al. (2021)
N501Y	convalescent plasma binding	Pokay	VSV pseudotype B.1.351 showed 7.86-fold decrease in NT50 vs wild type in sera from 9 ICU patients undergoing treatment in Germany (pre-variant infections).	2021	Hoffman et al. (2021)
N501Y	antibody epitope effects	Pokay	Abrogates Bamlanivimab, Etesevimab, or their combined use neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction.	2021	Hoffman et al. (2021)
N501Y	convalescent plasma escape	Pokay	Approximately 6-fold reduction in 15 ICU patient convalescent plasma neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction.	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Vaccine elicited antibodies neutralized virus with the B.1.351 spike protein had an average 3-fold reduction in titer (1:500), a titer that was still higher than the average titer with which convalescent sera neutralized D614G (1:139). Serum specimens from individuals vaccinated with the BNT162b2 mRNA vaccine neutralized D614G virus with titers that were on average 7-fold greater than convalescent sera.	2021	Tada et al. (2021)
N501Y	trafficking	Pokay	In one of eight cell lines tested (293T lung cells), a modest increase in cell entry was observed.	2021	Hoffman et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 6.5-fold against B.1.351 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	VSV pseudotype B.1.351 entry mediated by the S proteins of the B.1.351 variant was completely resistant to blocking by REGN10989 and Bamlanivimab. Entry driven by the S proteins of the B.1.351 was partially resistant against Casirivimab.	2021	Hoffman et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	B.1.351 pseudotyped lentivirus showed 3.4 and 3.8x reduction in IC50 serum dilution concentration for sera from BNT162b2 (Pzifer) or mRNA1273 (Moderna) vacinees collected 28 days following booster dose.	2021	Zhou et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	VSV pseudotype B.1.351 showed 7.85-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)

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N501Y	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.351 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.351 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
N501Y	trafficking	Pokay	VSV pseudotype B.1.351 showed slight decrease in cell entry relative to wild type in 263T-ACE2 (kidney) cell line, and slight increase in Calu-3 (lung). Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)
N501Y	convalescent plasma binding	Pokay	We analyzed 34 convalescent samples including the WHONIBSC 20/130 reference serum, and, although a few sera showed near identical FRNT 50 values, the FRNT50 dilutions for the B.1.1.7 strain were 2.9-fold lower (geometric mean) than those for the Victoria strain ($p < 0.0001$). Sera from 13 subjects post-B.1.1.7 infection showed no significant change in neutralization against Victoria (~wild type), suggesting that B.1.1.7 infection also protects against ancestral virus. [Note that D1119H was included in the original paper, assuming typographical error and correcting to D1118H]	2021	Supasa et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	In 15 Pzifer non-senior vaccinee sera collected 3-4 weeks post-booster [using Table S1, not the text that says 2-3 weeks], neutralization was reduced ~11x.	2021	Hoffman et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.351 lineage effectiveness was observed as 16.9% (95% CI [10.4,23.0]) against infection, and 0% against severe/critical/fatal disease (95% CI [0-19.0]). Two weeks or more after 2nd dose, effectiveness climbed to 75.0% [70.5,78.9] against infection, and 100% against severe/critical/fatal disease (95% CI [73.7,100]).		UNKNOWN et al. ()
N501Y	vaccine neutralization efficacy	Pokay	Sera from vaccinees [ChAdOx1 and BNT162b2 primarily used in UK] shows decreased ability to neutralize B.1.621 compared to first wave virus and Alpha, with a magnitude of change similar to Beta.	2021	UNKNOWN et al. (2021)
N501Y	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 69 test-positive were Mu. Two dose vaccine efficacy against Mu was 90.4% (73.9-96.5%), one dose VE was 45.8% (0.0-88.9%).	2021	Bruxvoort et al. (2021)
N501Y	vaccinee plasma binding	Pokay	Sera from individuals who have been vaccinated and have had subsequent recent Delta infection have a high level of neutralising activity against B.1.621.	2021	UNKNOWN et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma binding	Pokay	Sera from individuals who have been infected with Delta does not have strong neutralising activity against B.1.621	2021	UNKNOWN et al. (2021)
N501Y	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 71.46 for P.1 virus. Compare to much stronger neutralization titers for B.1.1.7 (256) and wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Mean 7.6x reduction of NT50 value B.1.621 (Mu) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster. [This is a greater reduction than Beta @ 6.3x]	2021	Uriu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Using live B.1.621 virus and a cytopathic effect-based assay, sera from 37 Pfizer/BioNTech BNT162b2 vaccinees collected 10-20 days post-booster showed significantly lower (95) but still 'robust' neutralization than against ancestral B.1 virus (107).	2021	Messali et al. (2021)
N501Y	convalescent plasma escape	Pokay	Mean 12.4x reduction of NT50 value B.1.621 (Mu) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset. [This is a greater reduction than Beta @ 8.2x]	2021	Uriu et al. (2021)
N501Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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N501Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
N501Y	vaccine efficacy	Pokay	In a study of 481 vaccinees going from lowest to highest infection rate, 2 doses of CoronaVac and 1 dose of BNT162b2 had the lowest infection rate at 6.3%, then it was 3 doses of BNT162b2 having a infection rate of 16.6%. 2 and 3 doses of CoronaVac had 48.6% and 20.6% infection rate respectively. 2 doses of BNT162b2 has the highest infection rate at 49.2%.	2022	Zhou et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In Moderna vaccinee sera, 2.7x reduction in neutralization, and 6.4 for the full B.1.351 Spike mutation complement, but despite the observed decreases, titers in human vaccinee sera against the B.1.351 variant remained at clinically significant level of ~1/300.	2021	Wu et al. (2021)
N501Y	convalescent plasma escape	Pokay	27% of 44 early pandemic exposure convalescent plasma/sera lose all activity against a RBD triple mutant pseudovirus (RBD mutatants of the 501Y.V2 'South African' lineage), while only 23% retained high titres	2021	Wibmer et al. (2021)

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N501Y	viral load	Pokay	B.1.351 and P.1 samples showed average Ct cycle threshold of 22.2 vs 23 for wildtype (i.e. ~60% higher viral load) comparing 3360 and 22535 samples respectively.	2021	Roquebert et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	This mutated version of RBD completely abolishes the binding to a therapeutic antibody, Bamlanivimab, in vitro.	2021	Liu et al. (2021)
N501Y	antibody epitope effects	Pokay	Ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58.	2021	Chen et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In a cohort of 20 patients 8+ weeks after second vaccine dose of Moderna (mRNA-1273) or Pfizer-BioNTech (BNT162b2) vaccines, a significant (0.5 to 20-fold, but average ~2x) decrease in neutralization by vaccine plasma was observed.	2021	Wang et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	The affinity of the B.1.351 RBD variants for ACE2 increased by 3.7 fold as measured by surface plasmon resonance relative to wild type RBD by increasing the k(on) and decreasing the k(off) rate constants.	2021	Barton et al. (2021)

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N501Y	antibody epitope effects	Pokay	Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody CA1 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody LyCoV016 (also known as CB6 or JS016) on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 1 (Spike 'up' conformation only, RBD targeting) monoclonal antibody CC12.1 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody BD23 on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody C119 (also known as CB6 or JS016) on 501Y.V2 ('South African') lineage background Ablates ELISA test binding for class 2 (Spike 'up' or ' down' conformation, RBD targeting) monoclonal antibody P2B-2F6 on 501Y.V2 ('South African') lineage background	2021	Wibmer et al. (2021)
N501Y	convalescent plasma escape	Pokay	In 19 convalescent human sera ~1mo post infection had mild to moderate resistance against most samples	2021	Chen et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Tixagevimab, Regdanvimab and COR-101 display reduced binding affinity to virus pseudotyped as RBD from B.1.351.	2021	Engelhart et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	This combination showed ~3x increase binding to ACE2 vs wild type, about half that of the B.1.1.7 lineage, suggesting that the K417N mutation is slightly detrimental to ACE2 binding, probably as a result of disrupting the salt bridge formed with ACE2 residue D30	2021	Collier et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Observed 1.4-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against pseudotype B.1.351 key variants lentivirus. Compare to 8.8-fold reduction against cultured B.1.351 virus.	2021	Bates et al. (2021)
N501Y	antibody epitope effects	Pokay	Complete loss of binding in ELISA by the variant against monoclonal antibodies ab8 and IgG1 ab1. Complete loss for the same antibodies was also observed against S1 pseudotyped and full Spike protein trimers with both B.1.351 and P.1 lineage variants, with slight binding signal for P.1 against IgG1 at the highest concentration tested (1uM). Complete loss of neutralization by these two antibodies was also observed.	2021	Sun et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Using Mircoscale Thermopheresis, the B.1.351 variant harboring three mutations, binds ACE2 at nearly five-fold greater affinity than the original SARS-COV-2 RBD (Kd 87.6, vs 402.5 nM).	2021	Ramanathan et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	RBD containing the N501Y mutation results in 9-fold stronger binding to the hACE2 receptor than wild type RBD. The E484K mutation does not significantly influence the affinity for the receptor, while K417N attenuates affinity. As a result, RBD from B.1.351 containing all three mutations binds 3-fold stronger to hACE2 than wild type RBD but 3-fold weaker than N501Y.	2021	Laffeber et al. (2021)
N501Y	viral load	Pokay	The 62 B.1.351 (a.k.a. N501Y.V2) variant cases in three Paris hospital labs had a ~2-fold viral load increase (~1 Ct drop in both N and ORF1ab probes) compared to 332 ancestral lineage cases from the same time frame (2020-12-20 to 2021-02-26).	2021	Teyssou et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Reported slight increase in affinity compared to wild-type RBD on the cell surface (Kd	2021	Tian et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Studying the key covariants in lineage of concern 501Y.V2, observed about 2-fold increase in ACE2 binding vs wildtype, but greatly decreased mAb binding, suggesting evolutionary optimum tension between immune evasion and ACE2 binding affinity as the N501Y variant alone has 10x increase in affinity but no effect on tested mAb binding.	2021	Liu et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	The affinity of ACE2 for this mutation combination was twice as high as for wild type. Having in mind that the affinity of SARS-CoV-2 for ACE2 is only 4-fold higher compared to SARS-CoV-1, this factor of 2 is expected to be biologically significant.	2021	Vogel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 2 (B.1.351) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
N501Y	transmissibility	Pokay	36,590 variant-specific RT-PCR tests were performed on samples collected between April 12 and May 7, 2021 in France to compare variant spread. Compared to January to March 2021, B.1.351 variant had a significant transmission advantage over B.1.1.7 in some regions (15.1 to 16.1% in Île-de-France and 16.1 to 18.8% in Hauts-de-France). This shift in transmission advantage is consistent with the immune evasion abilities of B.1.351 and the high levels of immunization in these regions.	2021	Roquebert et al. (2021)
N501Y	transmissibility	Pokay	Assuming complete cross-protection, we estimate 501Y.V2/B.1.351 was 1.50 (95% CrI: 1.20-2.13) times as transmissible than previously circulating variants. Assuming instead that 501Y.V2 is identically transmissible, the new variant evades 21% (95% CrI: 11-36%) of previously acquired immunity. Reality may lie between these extremes, with an intermediate increase in transmissibility and mildly imperfect cross-protection from past exposure.	2021	Pearson et al. (2021)
N501Y	convalescent plasma escape	Pokay	Average ~10-fold reduction in neutralization efficacy in convalescent sera of 16 health workers infected in Spring 2020.	2021	Alenquer et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	In a multicenter, double-blind, randomized, controlled trial to assess the safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) with enrollment June 24 and November 9, 2020 from ~2000 HIV-negative 18-64 year olds (1:1 placebo to treatment), incidence of serious adverse events 14 or more days post- 2nd dose was balanced between the vaccine and placebo groups. A two-dose regimen of the ChAdOx1 nCoV-19 vaccine did not show protection against mild-to-moderate Covid-19 due to the B.1.351 variant. Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed 3.5x reduction in neutralization (ID50) for B.1.351 RBD pseudotype HIB-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a similar 3.2x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)
N501Y	convalescent plasma escape	Pokay	Neutralizing antibody titers of 18 samples (90%) decreased against this B.1.351 pseudotyped virus below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
N501Y	antibody epitope effects	Pokay	Abolished neutralization by mAbs CQ026 and CQ038, greatly diminished neutralization by CQ012 and CQ046.	2021	Hu et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	This variant of key B.1.351 lineage mutations showed ~10x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	Trachea viral loads were tested by qRT■PCR and RNA scope at 3 dpi on 5 8■month■old male mice and there was a ~750x fold drop in the R3P1-E4 antibody in comparison to the IgG control.	2022	Li et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Lung viral loads were tested by qRT■PCR and RNA scope at 3 dpi on 5 8■month■old male mice and there was a ~2266x fold drop in the R3P1-E4 antibody in comparison to the IgG control.	2022	Li et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	100% of the 5 8■month■old male R3P1-E4 antibody treated mice suvived 14 days after infection while only 60% the control group mice survived 5 days post infection.	2022	Li et al. (2022)
N501Y	trafficking	Pokay	~5x more efficient S2 domain cleavage compared to wild type, compared to 4x by D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3). [N501Y+D614G does not show an increase in cleavage, therefore a synergistic effect of the trio is implied]	2021	Kim et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	This variant showed >5x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
N501Y	trafficking	Pokay	~9x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction (no synergy as level approx. that of N501Y alone).	2021	Kuzmina et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Tixagevimab, Regdanvimab and COR-101 display reduced binding affinity to virus pseudotyped as RBD from P.1.	2021	Engelhart et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	The affinity of the P.1 RBD variants for ACE2 increased by 5.3 fold as measured by surface plasmon resonance relative to wild type RBD by increasing the k(on) and decreasing the k(off) rate constants.	2021	Barton et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	The KD for the pseudotyped P.1-ACE2 interaction is 4.8 nM, showing that binding to P.1 is essentially indistinguishable from B.1.351 (4.0 nM), which binds with ~19x greater affinity that wild type.	2021	Dejnirattisai et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The presence of these B.1.417/B.1.429 defining variants in 189 post-mRNA-vaccination COVID-19 cases was proportionally in line with lineage prevalence in Northen California during the study period, suggesting no effect of these variants on immune escape.	2021	Jacobson et al. (2021)
N501Y	antibody epitope effects	Pokay	Pseudotype for Day 152 virus from a chronically infected patient, neutralizing activity of purified IgG from 3 donors was mostly unaffected by the single mutations (Q493K/R or N439K), but the day 152 S pseudotype was resistant to neutralization.	2021	Clark et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	This Spike pseudotype for Day 152 virus from a chronically infected patient was completely resistent to REGN10933.	2021	Clark et al. (2021)
N501Y	antibody epitope effects	Pokay	Pseudotype for Day 152 virus from a chronically infected patient: although mAb C1A-B12 had no activity against this pseudotype, all three affinity optimized versions were active: the antibody containing the most mutations, C1A-B12.3, was the most potent (IC50 <0.5 µg/mL).	2021	Clark et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	3rd exposure to antigen by Delta (B.1.617.2) (n	2022	Wang et al. (2022)
N501Y	vaccine efficacy	Pokay	In sera from 17 sero-positive blood donors, and 18 months post-infection (May 2020) sera from 17 health care workers in Sweden, a 40x drop in neutralization by Omicron (B.1.1.529) pseudotyped lentivirus was observed in HEK293T cells using the First WHO International Standard (20/136). Median IC50 reduction was ~6x for the blood donors, and ~4.5x for the health care workers.	2021	Sheward et al. (2021)
N501Y	vaccine efficacy	Pokay	In a Belgian study including 1,433,135 persons (vaccinated between July 2021 to April 2022) infection-acquired immunity offered additional protection against symptomatic infection with Omicron in vaccinated persons compared to those without previous infection, when the infection was up to one year previous.	2022	Braeye et al. (2022)
N501Y	vaccine efficacy	Pokay	Pseudotyped virus neutralization demonstrated that Bi-Nab35B5-47D10 can efficiently neutralize VBMs including Alpha (B.1.1.7), Beta (B.1.351) and Kappa (B.1.617.1) and VOCs including Delta (B.1.617.2).	2022	Yuan et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	Using molecular dynamics simulation, ACE2-RBD (Omicron) complex is destabilized by the E484A and Y505H mutations and stabilized by S477N and N501Y mutations.	2022	Zhang et al. (2022)
N501Y	trafficking	Pokay	~13x more infective as D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	Y501 makes a pi interaction with Y41 and places R498 to make a hydrogen bond and salt bridge to Q42 and D38 of ACE2, forming a strong network of new interactions supporting the impact of these residues on affinity. Q498R alone appears to decrease ACE2 binding. The synergism of Q498R with N501Y (and E484K) increases ACE2 binding by ~50- fold relative to WT.	2021	Zahradnik et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Log10ID50 of Omicron neutralizing antibodies is 0.686x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Omicron BA.4 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N501Y	viral load	Pokay	Viral load from lung tissue from 11 hamsters in 10 treatments for Omicron MK-4482 had the greatest drop 3 days post-infection determined by quantitative RT-PCR targeting sgE in comparison to Alpha MK-4482, Beta MK-4482 and Delta MK-4482.	2022	Rosenke et al. (2022)
N501Y	antibody epitope effects	Pokay	Ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58. Ablates Class 3 N-terminal domain targeting antibody COV2-2489, diminishes COV2-2676.	2021	Chen et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.0015x fold change in IC50 in B.1.1.529 Omicron	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	pharmaceutical effectiveness	Pokay	Omicron BA.5 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	In 20 sera from BNT162b2 mRNA vaccine inoculated participants, 6 displayed mild (2x) reductions in neutralization. This variant combination showed the highest reduction, but the magnitude of the differences was small compared to the >4x differences in HA-inhibition titers that have been used to signal potential need for a strain change in influenza vaccines.	2021	Xie et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was slightly to significantly lower against this variant combination in sera from all 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4) [In stark contrast to this combination plus K417N, which had no effect (P<0.0001 vs. P	2021	Chen et al. (2021)
N501Y	vaccinee plasma binding	Pokay	Out of 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine, neutralizing titer in Omicron was ~100x folds more significant in 3 individuals.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Values taken 28 days after booster dose was given for BBIBP-CorVvaccine to 390 participants with 130 participants in the 0-14d-10m, 0-21d-10m and 0-28d-10m group. The geometric mean titers (GMT) of neutralizing antibody in 0-28d-10m and 0-21d-10m group were significantly higher than 0-14d-10m group at month 3, month 6 and month 10 after the second dose. A sharply decrease by 4.85-fold (GMT: 94.4-20.3), 4.67-fold (GMT: 134.4-28.8) and 4.49-fold (GMT: 145.5-32.4) was observed from day 28 to month 10 after the second dose in 0-14d-10m, 0-21d-10m and 0-28d-10m group, respectively, and they had similar decline kinetics.	2022	Yao T et al. (2022)
N501Y	vaccinee plasma binding	Pokay	Out of 10 individuals with 3 doses of the BNT162b2/BNT162b2/BNT162b2 vaccine, neutralizing titer in Omicron was ~17.5x folds more significant in 9 individuals.	2022	Arora et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Omicron BA.4 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Omicron BA.5 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine efficacy	Pokay	Protection against symptomatic infection caused by Beta/Gamma (assumed by combined presence of N501Y and E484K) was also higher with partial vaccination for mRNA-1273 (77%) than BNT162b2 (60%) and ChAdOx1 (48%), and full vaccination increased effectiveness for BNT162b2 (84%).	2021	Nasreen et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Omicron Molnupiravir (MK-4482) had no statistically significant change.	2022	Rosenke et al. (2022)
N501Y	vaccine neutralization efficacy	Pokay	Log10ID50 of Omicron neutralizing antibodies is 0.722x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
N501Y	viral load	Pokay	Viral load from oral swabs from 11 hamsters in 10 treatments for Omicron MK-4482 had the greatest drop 3 days post-infection determined by quantitative RT-PCR targeting sgE in comparison to Alpha MK-4482, Beta MK-4482 and Delta MK-4482.	2022	Rosenke et al. (2022)
N501Y	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.025x fold change in IC50 in B.1.1.529 Omicron	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	In the case of VOC B.1.1.7+E484K, the addition of the E484K mutation to N501Y further increased the affinity, to ~15 fold higher than WT RBD (KD ~5 nM), by further increasing the k(on) as measured by surface plasmon resonance. Because the higher k(on) could result in mass transfer limiting binding, we confirmed that the kinetic measurement for this variant was not substantially affected by varying levels of immobilization.	2021	Barton et al. (2021)
N501Y	convalescent plasma escape	Pokay	In 19 convalescent human sera ~1mo post infection had mild to moderate resistance against all samples.	2021	Chen et al. (2021)
N501Y	syncytium formation	Pokay	~50% Vero cell-cell membrane fusion assay under infection with VSV pseudotyped virus relative to wild type, signficantly higher than D614G.	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	~12x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction (~additive effects of 501 and 484).	2021	Kuzmina et al. (2021)
N501Y	trafficking	Pokay	~6x more efficient S2 domain cleavage compared to wild type, compared to 4x by D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3). [N501Y+D614G does not show an increase in cleavage, therefore a synergistic effect of the trio is implied]	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~11x, Vero ~10x, and Calu-3 ~11x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	antibody epitope effects	Pokay	Pseudotype for Day 146 virus from a chronically infected patient, neutralizing activity of purified IgG from 3 donors was mostly unaffected by the single mutations (Q493K/R or N439K), but the day 146 S pseudotype was resistant to neutralization.	2021	Clark et al. (2021)
N501Y	antibody epitope effects	Pokay	Pseudotype for Day 146 virus from a chronically infected patient: resistant to neutralization by mAb C1A-B12, and was still resistant to the affinity enhanced antibodies derived from it (i.e. no affinity maturation effect on neutralization).	2021	Clark et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	This Spike pseudotype for Day 146 virus from a chronically infected patient was completely resistent to REGN10933. The variant had a 4-fold decrease in REGN10987 neutralization sensitivity (2nd component of the Regeneron mAb cocktail).	2021	Clark et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Y501 makes a pi interaction with Y41 and places R498 to make a hydrogen bond and salt bridge to Q42 and D38 of ACE2, forming a strong network of new interactions supporting the impact of these residues on affinity. Q498R alone appears to decrease ACE2 binding. The synergism of Q498R with N501Y (and E484K) increases ACE2 binding by ~50- fold relative to WT. The extent of affinity increase with Q498R and N501Y is not exactly quantified, as E484K always emerged with this duo during in vitro evolution.	2021	Zahradnik et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Using Microscale Thermopheresis, this variant binds ACE2 at nearly two-fold greater affinity than the original SARS-COV-2 RBD (203.7 nM vs 402.5 nM).	2021	Ramanathan et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	trafficking	Pokay	Decreased stability of RBD expression in yeast, suggesting decreased Spike protein stability.	2021	Motozono et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	N501Y residue inserts into a cavity at the binding interface near Y41 of ACE2. The additional interactions result in increased affinity of ACE2 for the N501Y mutant, accounting for its increased infectivity.	2021	Zhu et al. (2021)
N501Y	virion structure	Pokay	Estimated free energy change (ddG) for this variant is 0.69 kcal/mol (i.e. stabilizing relative to wild type)	2021	Spratt et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Reported 4-fold increase in affinity compared to wild-type RBD on the cell surface (Kd	2021	Tian et al. (2021)
N501Y	environmental condition stability	Pokay	Relative to D614G, this mutation demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 30 minutes or 1 hour	2021	Tada et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Experimentally, ACE2 binding affinity increased 0.24 fold	2020	Starr et al. (2020)
N501Y	antibody epitope effects	Pokay	Utilizing shark derived vnarbodies, S375F mutation on Omicron RBD disrupts the structure of β-strand, which inhibits binding with 20G6. 20G6 binds to a hidden epitope on RBD which is highly conserved in sarbecoviruses.	2022	Feng et al. (2022)
N501Y	ACE2 receptor binding affinity	Pokay	This single mutation causes major increase in binding affinity vs. wild type as measured by IC50 vs pseudotyped lentivirus, but combined with the complete set of B.1.1.7 lineage variants no major change vs wild type affnity is observed.	2021	Tada et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	~4-fold increase in binding affinity vs wild type.	2021	Motozono et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	In silico methods (PyMOL and PDBePISA) involving mutagenesis (N501Y mutation) and interface analysis focusing on the Spike RDB-ACE2 interaction showed that the SARS-CoV-2 N501Y mutant (lineage B.1.1.7) establishes a more significant number of interactions relating to the mutant residue Y501 (Spike RDB) with residues Y41 and K353 (ACE2). This finding shows that the increased infectivity of SARS-CoV-2 lineage B.1.1.7 is associated with the interaction force between the Spike RBD Y501 mutant residue with the ACE2 receptor, which in this strain is increased.	2021	UNKNOWN et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Reported 10-fold increase in ACE2 binding vs wildtype (Kd	2021	Liu et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Among the first selected and fixed variants in an in vitro evolution experiment for ACE2 binding. Calculated disassociation constant for this variant is nearly four fold lower than wild type (Kd	2021	Zahradnik et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	The most frequent RBM mutation N501Y (165,519 instances) makes defective the atypical N-glycosylation sequon NGV 501-503, becoming a key RBM position for the interaction with hACE2-binding hotspot 353.	2021	Gamez et al. (2021)
N501Y	convalescent plasma binding	Pokay	Viruses containing the point mutations of B.1.1.7 showed that the single point mutations (Δ69-70 and N501Y) were neutralized as efficiently as D614G across 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	convalescent plasma binding	Pokay	In 30 samples collected 111 to 260 days post onset of symptoms, the covalescent plasma can neutralize both the reference USA-WA1/2020 strain and the mouse adapted strain that contains the N501Y spike mutation with similar efficiency.	2021	Rathnasinghe et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	COR-101 lost ~8x binding against this isolated mutation. Regdanvimab lost ~6x binding against this isolated mutation.	2021	Engelhart et al. (2021)
N501Y	antibody epitope effects	Pokay	Wildtype elicits immune response, COVID-19 cohort epitope score > 99th percentile of the 497 pre-pandemic controls, mutant drops PIWAS epitope score from 3% to 1.2% (poorer immune recognition) Together with other B1.1.7 lineage mutational changes (Spike: Y144del, A570D, P681H, Nucleoprotein: D3L, S235F) resulted in only 2 or 579 individuals (0.3% of the population) having a dramatic reduction in PIWAS antigen scores, which reflects the peak epitope signal along the entire antigen.	2021	Haynes et al. (2021)
N501Y	antibody epitope effects	Pokay	4 antibodies tested were less potent against K417N by ten-fold or more, in both mAb classes 1 and 3	2021	Wang et al. (2021)
N501Y	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA1-18 (~4x), COVA2-15 (~9x), S309 (~3x)	2021	Shen et al. (2021)
N501Y	antibody epitope effects	Pokay	Lowered the neutralization potency of mAb COVA1-12 to the limit of the assay. Decrease in potency was observed against the N501Y pseudotype for the cluster IX mAb COVA2-17.	2021	Rees-Spear et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	immunosuppression variant emergence	Pokay	Appeared (day 128) and persisted in chronic (152 day) SARS-CoV-2 infection of immunocompromised patient with severe antiphospholipid syndrome	2020	Choi et al. (2020)
N501Y	convalescent plasma escape	Pokay	0.7x reduction in neutralization by key variant in several variants of concern in sera collected from cohort of 10 with severe disease 21 to 63 days post-onset.	2021	Kuzmina et al. (2021)
N501Y	trafficking	Pokay	This mutation alone accounts for most of the increased infectivity of the Alpha variant, as determined by modelling the infectivity of each Spike mutation independently in a competitive infection model of hamsters, and Vero E6 (NHP) and Calu-3 (human) cell lines.	2021	Liu et al. (2021)
N501Y	convalescent plasma escape	Pokay	As measured by surface plasmon resonance, RBD with the N501Y mutation alone showed a mean 2.1x decrease in binding affinity for six batches of hyperimmune immunoglobulin (hCoV-2IG) preparations generated from SARS-CoV-2 convalescent plasma.	2021	Tang et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	The N501Y mutation had the biggest effect on ACE2 affinity of any VOC mutation tested, increasing the affinity ~10 fold to KD ~7 nM, by increasing the k(on) ~1.8 fold and decreasing the k(off) by ~ 7 fold as measured by surface plasmon resonance.	2021	Barton et al. (2021)
N501Y	vaccine efficacy	Pokay	In this Canadian test-negative study of 324033 individuals, two doses of either mRNA vaccine (BNT162b2 (Pfizer-BioNTech) or mRNA-1273 (Moderna)) was not associated with appreciable vaccine escape by lineage Alpha [defined here as N501Y positive, but E484K negative].	2021	Chung et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	T cell evasion	Pokay	Vaccinated, but not post-infection sera, show decreased average T cell response to an N501Y peptide. When we primed transgenic mice expressing human HLA-DRB1*0401 with the Wuhan Hu-1 peptide pool, T cell responses to the B.1.1.7 variant peptide pool were significantly reduced (p	2021	Reynolds et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	1.2x drop in neutralization using sera collected from 14 healthy adult participants that received two injections of the mRNA-1273 (Moderna) vaccine at a dose of 100 µg (18-55 years: day 1 and day 14 post-2nd dose) against a recombinant single variant virus (modified replicating WA-1 cDNA clone) relative to contemporary circulating D614G variant (USA/GA-EHC-083E/2020) using a live-virus Focus Reduction Neutralization Test (FRNT) assay.	2021	Edara et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In a cohort of 20 patients 8+ weeks after second vaccine dose of Moderna (mRNA-1273) or Pfizer-BioNTech (BNT162b2) vaccines, a modest decrease in neutralization by vaccine plasma was observed.	2021	Wang et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	The presence of this variant in 189 post-mRNA-vaccination COVID-19 cases was proportionally in line with lineage prevalence in Northen California during the study period, suggesting no effect of these variants on immune escape.	2021	Jacobson et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccine neutralization efficacy	Pokay	Human sera from 6 two-dose Pfizer vaccinated individuals (47-68 days post 1st-dose) can neutralize both the reference USA-WA1/2020 strain and the mouse adapted SARS-CoV-2 strain that contains the N501Y spike mutation with similar efficiency.	2021	Rathnasinghe et al. (2021)
N501Y	antibody epitope effects	Pokay	Contrary to other reports on N501Y containing lineages (i.e. with additional mutations), N501Y alone may have an even greater affinity for a human monoclonal antibody specific for wild type. These results suggest that the individual N501Y mutation does not contribute to altered viral properties by itself, but may contribute to a collective conformational shift produced by multiple mutations.	2021	Klegerman et al. (2021)
N501Y	trafficking	Pokay	Lentiviral pseudotyped with this individual mutation from B.1.1.7 was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing slightly increased infection rate amongst the cells. [in what is essentially a replicate experiment in the same paper, because each B.1.351 lineage variant was independetly evaluated and N501 is in both lineages, a significant decrease was observed, therefore the error bars described in this paper should be interpreted carefully]	2021	Tada et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	Observed 1.3-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against pseudotype B.1.1.7 key variant lentivirus. Compare to 2.6-fold reduction against cultured B.1.1.7 virus.	2021	Bates et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	homoplasy	Pokay	Variant within the six key residues in the receptor binding domain (RBD). Independently reported in UK, Australia (same origin as UK), and South Africa (independent origin).	2021	Flores-Alanis et al. (2021)
N501Y	monoclonal antibody serial passage escape	Pokay	In vitro selection against class 1 (Spike 'up' conformation) monoclonal antibody C663, and to a lesser extent C613.	2021	Wang et al. (2021)
N501Y	antibody epitope effects	Pokay	Of 50 mAbs tested, major loss of neutralization observed for S2X128, S2D8, S2X192, S2D19, S2H14, S2H19.	2021	Collier et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	COR-101 lost ~20x binding against this double mutation. Estesevimab lost ~16x binding against this double mutation. Regdanvimab lost ~6x binding against this double mutation. M396 lost ~10x binding against this double mutation.	2021	Engelhart et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	In post-vaccination sera from individuals who received one (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
N501Y	convalescent plasma escape	Pokay	~7x reduction in neutralization by key B.1.351 lineage RBD variant combination in sera collected from cohort of 10 with severe disease 21 to 63 days post-onset. Two of the cohort showed no neutralization against this variant.	2021	Kuzmina et al. (2021)
N501Y	pharmaceutical effectiveness	Pokay	Bamlanivimab (LY-CoV555) lost ~64x binding against this double mutation. COR-101 lost ~50x binding against this double mutation. Casirivimab lost ~250x binding against this double mutation. Estesevimab lost ~16x binding against this double mutation. Regdanvimab lost ~32x binding against this double mutation. Tixagevimab lost ~10x binding against this double mutation.	2021	Engelhart et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	reinfection	Pokay	Partial sequencing of S gene reveals two cases of probable early 2021 B.1.1.7 lineage reinfection from non-B.1.1.7 original cases in Lombardy, with 45 to 90 days between infections (less than the typical 90 day guideline for this call). Patients were 56 and 58yo, immunocompenent, with one a former smoker with obesity and dyslipidemia. One case required intubation during first infection, but presented with mild symptoms upon reinfection. The other case convalesced at home during the first episode, but required CPAP support in the subacute clinical unit upon reinfection.	2021	Novazzi et al. (2021)
N501Y	vaccine neutralization efficacy	Pokay	This variant showed no change in Pfizer sera (one or two dose) neutralization efficiency vs D614G (using lentivirus pseudotype).	2021	Kuzmina et al. (2021)
N501Y	syncytium formation	Pokay	Slight increase in Vero cell-cell membrane fusion assay under infection with VSV pseudotyped virus relative to wild type, no change relative to D614G.	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~13x, Vero ~10x, and Calu-3 ~10x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	~4x more efficient S2 domain cleavage compared to wild type, no change relative to D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3).	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	9x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~9x, Vero ~8x, and Calu-3 ~8x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)
N501Y	trafficking	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H lineage was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing no significant change in infection rate amongst the cells, suggesting that this mutation does not contributing to cell entry fitness.	2021	Tada et al. (2021)
N501Y	convalescent plasma binding	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H ('Ohio') lineage was neutralized similarly to D614G in 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H lineage was tested on ACE2.293T cells for ACE2 affinity changes vs D614G alone, showing a ~70% drop in IC50 (i.e. increased affinity).	2021	Tada et al. (2021)
N501Y	anthropozoonotic events	Pokay	Mouse-adapted SARS-CoV-2 mutations after 11 serial passages in various immunocompromised mice strains.	2021	Rathnasinghe et al. (2021)
N501Y	convalescent plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.3x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.14x decrease in Spike binding (relative to D614G alone) by 5 plasma 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.27x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing P.1 aka Gamma) showed a 4.24x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
N501Y	convalescent plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.04x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset, in contrast to the largely positive binding values for each individual mutation that comprises the set.	2021	Gong et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.351 aka Beta) showed a 3.56x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	vaccinee plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.28x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. It shows a 1.17x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
N501Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.1.7 aka Alpha) had 5.43x increased binding relative to D614G alone.	2021	Gong et al. (2021)
N501Y	convalescent plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed a 1.15x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
N501Y	vaccinee plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed no change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.28x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N501Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 2.52x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis). Compare to full Spike variant complements for major lineages containing this variant subset: 5.43x (B.1.1.7 aka Alpha), 3.56x (B.1.351 aka Beta), 4.24x (P.1 aka Gamma).	2021	Gong et al. (2021)
N501Y	convalescent plasma binding	Pokay	1.65x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
N501Y	vaccinee plasma binding	Pokay	1.17x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
Y505H	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Y505H	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
Y505H	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Y505H	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
Y505H	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
Y505H	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Y505H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Y505H	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Y505H	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
Y505H	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
Y505H	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
Y505H	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Y505H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Y505H	ACE2 receptor binding affinity	Pokay	The hACE2-binding affinity of XBB.1.5 RBD has a dissociation constant KD of 3.4 nM, where S486P is the distinguishing Spike mutation vs parent XBB.1 RBD with a much weaker KD (19 nM), as measured by surface plasmon resonance (SPR) assays.	2023	Yue et al. (2023)
Y505H	ACE2 receptor binding affinity	Pokay	Using molecular dynamics simulation, ACE2-RBD (Omicron) complex is destabilized by the E484A and Y505H mutations and stabilized by S477N and N501Y mutations.	2022	Zhang et al. (2022)
Y505H	gene expression increase	Pokay	Experimentally, Spike gene expression increased 0.16 fold	2020	Starr et al. (2020)
Y505H	anthropozoonotic events	Pokay	Observed first in a single tiger (cohort of 5), potential adaptation.	2020	McAloose et al. (2020)
D614G	vaccine neutralization efficacy	Pokay	Subtype of the B.1.526 'New York' lineage, lentivirus pseudotyped with this mutation combination in showed no significant change in IC50 serum dilution concentration for sera from BNT162b2 (Pzifer) or mRNA1273 (Moderna) vacinees collected 28 days following booster dose.	2021	Zhou et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.526 reduced 2.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	convalescent plasma binding	Pokay	Subtype of the B.1.526 'New York' lineage, lentivirus pseudotyped with this mutation combination in showed no significant change in IC50 serum dilution concentration for 6 convalescent sera.	2021	Zhou et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Subtype of the B.1.526 'New York' lineage, lentivirus pseudotyped with this mutation combination in showed 3.6x reduction in both IC50 serum dilution concentration for sera from 5 BNT162b2 (Pzifer) or 3 mRNA1273 (Moderna) vacinees collected 28 days following booster dose.	2021	Zhou et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.526+E484K at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 43 100%, Day 209 88%.	2021	Pegu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	2.3x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	Subtype of the B.1.526 'New York' lineage, lentivirus pseudotyped with this mutation combination in showed 3.8x reduction in IC50 serum dilution concentration for 6 convalescent sera.	2021	Zhou et al. (2021)
D614G	vaccinee plasma binding	Pokay	Out of 10 individuals with 3 doses of the BNT162b2/BNT162b2/BNT162b 2 vaccine had a neutralizing titer in B.1.640.2 variant was ~5.6x folds more significant in 9 individuals.	2022	Arora et al. (2022)
D614G	vaccinee plasma binding	Pokay	Out of 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine, neutralizing titer in B.1.640.2 variant was ~1000x folds more significant in 8 individuals.	2022	Arora et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.427/429 reduced 2.1x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.1.7 in all samples at Day 43 and Day 209 using pseudotyped lentivirus neutralization in Moderna vaccinee cohort.	2021	Pegu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.429 virus has reduced neutralization activity vs wild type: 2.0x (30 sera Pfizer median 9 days post 2nd dose, 35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 2.7x reduction of NT50 value B.1.427 (Epsilon) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	6 of 11 (55%) vaccine recipients (Moderna or Pfizer), showed 2x reduction in neutralization to a B.1.429 lineage virus.	2021	Deng et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 2.3x reduction of NT50 value B.1.427 (Epsilon) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
D614G	virion structure	Pokay	CryoEM reveals the P.1 trimer to adopt exclusively a conformation in which one of the receptor-binding domains is in the “up” position.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In 12 Moderna vaccinee sera 15 days post second dose (43 days since first vaccination), an average 2.8x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 4.8x decrease against the full P.1 type vs WA-1 was observed, though overall with a higher ID50 reciprocal value. In 10 Pfizer vaccinee sera 7 days or more post second dose (28 days or more since first vaccination), an average 2.2x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.8x decrease against the full P.1 type vs WA-1 was observed, with similar variant ID50 reciprocal value.	2021	Wang et al. (2021)
D614G	convalescent plasma escape	Pokay	In convalescent sera one month or more post-infection in Spring 2020, an average 6.5x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.4x decrease against the full P.1 type vs WA-1 was observed, with better full P.1 ID50 reciprocal value compared to the 10-mutation model.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Amongst RBD-targeting Emergency Use Authorized monoclonal antibody treatments CB6, LY-CoV555 and REGN10933 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1, but REGN10987 activity remains strong. RBD-targeting monoclonal antibodies 2-15 and C121 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1. N terminal domain targeting monoclonal antibodies 5-7, 4-8, 4-18 and 2-17 have abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1.	2021	Wang et al. (2021)
D614G	reinfection	Pokay	After a 128 day interval, a patient in Sao Paulo State, Brazil reinfected with P.1 (first episode likely predates P.1 emergence). Both cases were fairly mild (difficulty breathing, tiredness, dizziness and fatigue).	2021	Malta Romano et al. (2021)
D614G	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 349 test-positive were Gamma. Two dose vaccine efficacy against Gamma was 95.5 (90.9-97.8%), one dose VE was 74.2 (43.8-88.1%).	2021	Bruxvoort et al. (2021)
D614G	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Gamma variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but H655Y is upstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	reinfection	Pokay	Three healthcare workers (29-50yo) had confirmed P.1 [Gamma] re-infection in the Amazonas region of Brazil 3-9 months after initial infection from viruses with distinct lineage from P.1, but mild symptoms upon re-infection and evidence for infectiousness during re-infection.	2021	Naveca et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 3.0x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 4.1x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Gamma (P.1) variant is 0.6x fold the wildtype.	2022	Kumar et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was slightly lower against B.1.1.248 variant constellation in sera tested from most of the 15 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 16.6% in this B.1.1.248 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	B.1.1.248 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07. B.1.1.248 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2676.	2021	Chen et al. (2021)
D614G	convalescent plasma escape	Pokay	B.1.1.7 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)
D614G	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, P.1 lineage virus was able to infect and replicate in common lab mouse strains, with high titer.	2021	Montagutelli et al. (2021)
D614G	convalescent plasma escape	Pokay	B.1.1.248 variant constellation in 10 convalescent human sera ~1mo post infection had mild to moderate resistance against most samples, P	2021	Chen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 4.3-fold against P.1 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped P.1 virus has reduced neutralization activity vs wild type: 6.7x (30 sera Pfizer median 9 days post 2nd dose) and 4.5x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA.	2021	Garcia-Beltran et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	pharmaceutical effectiveness	Pokay	P.1 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with Lilly mAb combination LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of P.1. There was also escape from neutralization of P.1 by REGN10933 (one of 2 in Regeneron's mAb cocktail) and a modest reduction in neutralization of P.1 by AstraZeneca's AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized P.1 with all reaching a plateau at 100% neutralization: interestingly, ADG30 showed a slight increase of neutralization of P.1. S309 Vir was largely unaffected, although for several viruses, including P.1, the antibody failed to completely neutralize, conceivably reflecting incomplete glycosylation at N343, since the sugar interaction is key to binding of this antibody.	2021	Dejnirattisai et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	P.1 lineage titers were reduced 7.6-fold and 9-fold for the BNT162b2 Pfizer (sera collected 4-14 days post-booster) and ChAdOx1 nCoV-19 AstraZeneca (sera collected 14 or 28 days post-booster) vaccines respectively.	2021	Dejnirattisai et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 2896 for P.1 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 256 for B.1.1.7 virus. Compare to somewhat stronger neutralization titer for wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Detectable antibodies against P.1 at various time points using pseudovirus neutralization in Moderna vaccinee cohort: Day 43 100%, Day 209 85%.	2021	Pegu et al. (2021)
D614G	T cell evasion	Pokay	PBMCs of 11 mild COVID-19 patients collected 38-80 days after symptom onset were stimulated with the 15-mer peptide pools (w/ 10 residue overlaps) from the wholle viral proteome, showing no significant CD4+ cell count effect for P.1, and a slight increase in CD8+ percentage (p	2021	Tarke et al. (2021)
D614G	transmissibility	Pokay	The relative transmissibility of P.1 estimated at the national level (Italy) varied according to the assumed degree of cross-protection granted by infection with other lineages and ranged from 1.12 (95%CI 1.03-1.23) in the case of complete immune evasion by P.1 to 1.39 (95%CI 1.26-1.56) in the case of complete cross-protection. PG: variant list has been abbreviated due to mixed K417 bases in this lineage, potential miscalls of deletions	2021	Stefanelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	Artificially constructed HIV-1 pseudovirus with set of mutations drawn from plasma passage escape experiments and mutations from variants of concern completely ablates neutralization in 19 of 21 convalescents plasma collected mean 1.3 months post infection. [actual Y145del from manuscript substituted with more common Y144del description]	2021	Schmidt et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	In human sera 8 weeks post-vaccination with INO-4800, a ~7-fold reduction in B.1.351 neutralization was observed.	2021	Andrade et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Four fold reduction in neutralization efficiency was observed in sera of ferrets post-vaccination with INO-4800 (DNA plasmid pGX9501 encoding full length Spike).	2021	Riddell et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Monovalent mRNA-1273.351 encodes for the S protein found in the B.1.351 lineage and (2) mRNA-1273.211 comprising a 1:1 mix of mRNA-1273 and mRNA-1273.351. In a mouse study, primary vaccination series of mRNA-1273.351 was effective at increasing neutralizing antibody titers against the B.1.351 lineage, while mRNA-1273.211 was most effective at providing broad cross-variant neutralization. In addition, these results demonstrated a third dose of mRNA-1273.351 significantly increased both wild-type and B.1.351-specific neutralization titers.	2021	Wu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pzifer vaccinees that tested positive at least a week after the second dose were indeed disproportionally infected with B.1.351, as compared with unvaccinated individuals (odds ratio of 8:1), but were all infected before 14 days post second vaccination.	2021	Kustin et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 8.2x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 6.3x reduction of NT50 value B.1.351 (Beta) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
D614G	convalescent plasma escape	Pokay	In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals (5/9) and recipients of a only a single dose of mRNA vaccine (10/11) – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
D614G	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 8 for B.1.351 virus. Compare to much stronger neutralization titers for B.1.1.7 (256) and wild type (456.1) in the same sera.	2021	Luftig et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.351 sample. Contrast this with 1.4-fold reduction for just the pseudovirus combination of 'key' B.1.351 mutations K417N+E484K+N501Y. WA1 and B.1.351 FRNT50 titers correlated weakly at the individual level, with some individual's serum potently neutralizing WA1 while having FRNT50 for B.1.351 below the assay limit of detection (1:20).	2021	Bates et al. (2021)
D614G	convalescent plasma binding	Pokay	Sera from individuals who have been infected with Delta does not have strong neutralising activity against Beta.	2021	UNKNOWN et al. (2021)
D614G	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms had mean ~6x reduction in neutralizing titers, and 40% of the samples lacked any activity against B.1.351.	2021	Planas et al. (2021)
D614G	vaccinee plasma binding	Pokay	Sera from individuals who have been vaccinated and have had subsequent recent Delta infection have a high level of neutralising activity against Beta.	2021	UNKNOWN et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Beta Variant B.1.351 RBD significantly better than w.t. SARS-CoV-2 RBD. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v2 virus has reduced neutralization activity vs wild type: 41.2x (30 sera Pfizer median 9 days post 2nd dose) and 20.8x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Pseudotype lentivirus for the full B.1.351 Spike variant list shows increase affinity for ACE2 as measured by IC50. This is in contrast to B.1.1.7 which showed no major change, indicating that the shared N501Y mutation is the driver of affinity change, attentuated in the B.1.1.7 mutatioon set, but maintained in the B.1.351 lineage.	2021	Tada et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	[Contrary to how this paper has been cited, Voysey et al. do NOT show evidence of decreased effectiveness of ChAdOx1 (AstraZeneca) against the South African B.1.351 lineage. Insufficient numbers reaching the primary study endpoint were available in that arm of the vaccine study to report any statistics from the South African participants. Additionally, the study period of the paper ended in November 2020, while the earliest reported case of this lineage is October (covariants.org), only becoming dominant by mid-November.]	2021	Voysey et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.351. We observed an increase (relative to D614G) in binding of soluble ACE2 to B.1.351, and to a much gearter extent to B.1.1.7, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Relative to B.1.1.117, PRNT50 line virus neutralizating antibody activity assay of B.1.351 showed ~11x reduction in 13 vacinees's sera collected through 41 days after vaccination. Neutralization by a placebo control group of 6 naturally infected patients showed a smaller ~8x drop (starting from a ~50% higher PRNT50 value than vacinees for B.1.1.117 neutralization). Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed ~4x reduction in neutralization (ID50) for full B.1.351 pseudotype HIV-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a slightly higher 4.6x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.899x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	A 1.8-fold drop in FRNT50 for B.1.351 was observed in 44 sera collected between 1 and 301 post-infection.	2021	Bates et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	3.2x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v1 reduced 6.9x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	T cell evasion	Pokay	Encouragingly, we find that the majority of T cell responses in recipients of two doses of the BNT162b2 vaccine are generated by epitopes that are invariant between the [wildtype] and two of the current variants of concern (B.1.1.7 and B.1.351). In over 90% of two dose mRNA vaccinees, heterotypic neutralizing titres (NT50) against B.1.1.7 and B.1.351 remain comfortably above the level associated with immune protection in recent vaccine trials. However, in over 50% of convalescent COVID-19 individuals and recipients of a only a single dose of mRNA vaccine – heterotypic neutralization dropped to negligible levels, particularly against B.1.351.	2021	Skelly et al. (2021)
D614G	convalescent plasma escape	Pokay	The neutralizing activity of 16/20 convalescent sera was significantly lower against this pseudotyped virus model of B.1.351, with similar results for the live virus.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Log10ID50 of Beta neutralizing antibodies is 0.803x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
D614G	antibody epitope effects	Pokay	B.1.351 pseudotyped virus model ablates neutralization by RBD-directed mAbs CB6, 4-20, 2-4, 2-43, 910-30, 2-302-15, LY-Cov555, C121. B.1.351 pseudotyped virus model severely impairs neutralization by RBD-directed mAb 1-20. B.1.351 pseudotyped virus model impairs neutralization by RBD-directed mAb REGN10933. B.1.351 pseudotyped virus model ablates neutralization by N-terminal-domain-directed mAbs 5-24, 4-8, 4A8, 4-19. B.1.351 pseudotyped virus model severely impairs neutralization by N-terminal-domain-directed mAb 2-17. B.1.351 pseudotyped virus model impairs neutralization by N-terminal-domain-directed mAb 5-7. PG: Live virus data for the same mAbs is similar, but 1-20 becomes severally impaired, REGN10933 activity is ablated, and Brii-196 becomes impaired.	2021	Wang et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 (12.4x in twelve Moderna-recipient sera: 10.3x in ten Pfizer-recipient sera). [this is a larger list of B.1.351 than modeled by Wang et al. (2021) by including L18F and R246I, less effective at neutralizing]	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaluated against VSV pseudotypes: while BD614G and B.1.1.7 were neutralized earlier, the anti-B.1.351 response was negative up to week 3, and became detectable at week 4 (1 week after booster dose), at a level lower than the two other viruses (~10x vs D614G) through week 6, the last timepoint measured. Three vaccinees never showed detectable neutralization to B.1.351 even after second dose.	2021	Planas et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 0.036x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
D614G	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: while B.1.1.7 and D614G showed neutralization by nasal swab from only one different previously infected vacinee neutralizing at weeks 3 and 6, B.1.351 showed zero neutralization at either time point in any sample (and relatively impaired serum neutralization).	2021	Planas et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v2 reduced 7.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.351 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	B.1.351 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. Only 1 out of 12 serum samples from a cohort of Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed effective neutralization (IC90) at full serum strength (average realtive decrease was 6.1x vs wild type).	2021	Ikegame et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.07x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	In a randomized phase 2a-b control trial of the Novavax (NVX-CoV2373) vaccine in South Africa, where B.1.351 virus dominates, efficacy was 60.1% (95% CI, 19.9 to 80.1) in HIV-negative and initially SARS-CoV-2 seronegative participants using the primary endpoint of laboratory-confirmed symptomatic Covid-19 at 7 days or more after the second dose among participants.	2021	Shinde et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	DARPin SR22 molecule had a 1.57x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.054x fold change in IC50 in B.1.351 Beta	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	pharmaceutical effectiveness	Pokay	B.1.351 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of B.1.351. There was also escape from neutralization of B.1.351 by REGN10933 and a modest reduction in neutralization of B.1.351 by AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized B.1.351.	2021	Dejnirattisai et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 6.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 99.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
D614G	convalescent plasma escape	Pokay	The most significant loss of neutralizing activity (PsVNA50 assay) using 6 hyperimmune immunoglobulin preparations from convalescent plasma was seen against authentic B.1.351 lineage virus (9.2-fold). Neutralization against 10 convalescent plasma was poorer (18.7x).	2021	Tang et al. (2021)
D614G	environmental condition stability	Pokay	Treatment with heat, soap and ethanol revealed similar inactivation profiles indicative of a comparable susceptibility towards disinfection. Furthermore, we observed comparable surface stability on steel, silver, copper and face masks.	2021	Meister et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	environmental condition stability	Pokay	Relative to D614G, this mutation set (B.1.351+) demonstrated significant increase in infectivity (i.e. heat stability) after incubation at 50C after 1 hour.	2021	Tada et al. (2021)
D614G	trafficking	Pokay	In two of eight cell lines tested (Caco-2 intenstinal and Calu-3 lung), a modest increase in cell entry was observed. This increase was not observed in a Calu-3 cell line with overexpressed ACE2. [the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
D614G	convalescent plasma escape	Pokay	Approximately 2-fold reduction in 15 ICU patient convalescent plasma neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction. [PG: note that the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
D614G	antibody epitope effects	Pokay	Abrogates Bamlanivimab neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction. Significant decrease in combined Etesevimab+Bamlanivimab neutralization except at the highest concentration measured. [PG: note that the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In 15 Pfizer non-senior vaccinee sera collected 3-4 weeks post-booster [using Table S1, not the text that says 2-3 weeks], neutralization was reduced ~3x (compared to ~11x for B.1.351). [the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.525 reduced 4.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
D614G	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
D614G	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
D614G	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
D614G	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was somewhat lower against B.1.1.7 in sera tested from most of the 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
D614G	antibody epitope effects	Pokay	B.1.1.7 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2489.	2021	Chen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Observed 8.8-fold reduction in neutralization efficiency of Pfizer vaccinee sera (collected 14 days after second dose) against cultured B.1.1.7 sample. Contrast this with 1.3-fold reduction for just the pseudovirus combination of 'key' B.1.1.7 mutation N501Y.	2021	Bates et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.298 virus has reduced neutralization activity vs wild type: 1.4x (30 sera Pfizer median 9 days post 2nd dose) and 1.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA.	2021	Garcia-Beltran et al. (2021)

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D614G	vaccine neutralization efficacy	Pokay	After one dose, individuals with prior infection showed enhanced T cell immunity, antibody secreting memory B cell response to spike and neutralizing antibodies effective against B.1.1.7 (authentic cell culture supernatants). By comparison, HCW receiving one vaccine dose without prior infection showed reduced immunity against variants. B.1.1.7 spike mutations resulted in increased, abrogated or unchanged T cell responses depending on human leukocyte antigen (HLA) polymorphisms. Study was 26 each post-infection and post first dose HCWs.	2021	Reynolds et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 2.6x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.1.7 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 33%, Day 43 100%, Day 119 100%, Day 209 96%. Detectable antibodies against B.1.1.7 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 54%, Day 43 100%, Day 119 100%, Day 209 88%. Detectable antibodies against B.1.1.7 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 83%, Days 43,119,209 100%.	2021	Pegu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Using national surveillance data from Israel, using Pfizer vaccine and an estimated prevalence of the B.1.1.7 variant of 94.5% among SARS-CoV-2 infections: Adjusted estimates of vaccine effectiveness 7+ days after second dose were 95·3% (95% CI 94.9–95.7): 91.5% against asymptomatic SARS-CoV-2 infection (90·7–92·2: 40.9 vs 1.8 per 100 000 person-days), 97·0% against symptomatic COVID-19 (96.7–97.2%), 97.2% against COVID-19-related hospitalisation (96.8–97.5%), 97.5% against severe or critical COVID-19-related hospitalisation (97.1–97.8%), and 96.7% against COVID-19-related death (96.0–97.3%). In all age groups, as vaccine coverage increased, the incidence of SARS-CoV-2 outcomes declined	2021	Haas et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 8192 for B.1.351 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
D614G	virion structure	Pokay	CryoEM analysis of B.1.1.7 demonstrates an increased propensity for 'up', receptor accessible conformation of the Spike protein trimer.	2021	Cai et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	SARS-CoV-2 infection was confirmed in three HCWs working a single shift: all presented with mild symptoms of COVID-19. The two physicians were fully vaccinated with BNT162b2 vaccine, with the second dose administered 1 month before symptom onset. Both had high titres of IgG anti-spike antibodies at the time of diagnosis. WGS confirmed that all virus strains were VOC 202012/01-lineage B.1.1.7, suggesting a common source of exposure. Epidemiological investigation revealed that the suspected source was a SARS-CoV-2-positive patient who required endotracheal intubation due to severe COVID-19. All procedures were carried out using a full suite of personal protective equipment (PPE).	2021	Loconsole et al. (2021)
D614G	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 1422 test-positive were Alpha. Two dose vaccine efficacy against Alpha was 98.4% [96.9-99.1%], one dose VE was 90.1% (82.9-94.2%).	2021	Bruxvoort et al. (2021)
D614G	convalescent plasma escape	Pokay	Using a new rapid neutralization assay, based on reporter cells that become positive for GFP after overnight infection, sera from 58 convalescent individuals collected up to 9 months after symptoms, similarly neutralized B.1.1.7 and D614G.	2021	Planas et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Alpha (B.1.1.7) has an IC50 fold change of 1.19x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	B.1.1.7 pseudotyped virus model impairs binding by RBD-directed mAb 910-30. B.1.1.7 pseudotyped virus model abolishes N-terminal-domain-directed mAbs 5-24, 4-8, and 4A8. B.1.1.7 pseudotyped virus model impairs binding by N-terminal-domain-directe d mAbs 2-17, 4-19, 5-7.	2021	Wang et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	1.4x improvement in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. 2x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.1.7). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
D614G	aerosolization	Pokay	Alpha variant cases in a large campus study showed fine-aerosol shedding amongst unmasked participants remained significantly greater for alpha variant infections (18-fold, 95% CI, 3.4 to 92-fold) after adjusting for the increased viral RNA in MTS and saliva, the number of coughs during sampling sessions, and symptom. After controlling for the effect of masks and numbers of coughs during sampling, alpha variant infection was associated with a 100-fold (95% CI, 16 to 650-fold) increase in coarse- and a 73-fold (95% CI, 15 to 350-fold) increase in fine-aerosol RNA shedding.	2021	Adenaiye et al. (2021)

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D614G	environmental condition stability	Pokay	No differences in the stability of B.1.1.7 observed in the absence of simulated sunlight at either 20°C or 40°C (with a mean time for a 90% loss of viral infectivity across all dark conditions of 6.2 hours). However, a small but statistically significant difference in the stability was observed in simulated sunlight at 20°C and 20% relative humidity, with B.1.1.7 restoring wild type 90% loss time of 11 minutes vs. 7 and 8 minutes for B.1.319 (D614G) and B.28 (V367F) early 2020 viruses respectively.	2021	Schuit et al. (2021)
D614G	trafficking	Pokay	Modelling the Alpha variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increase 3.9x relative to wild type (5.4 vs 1.4). This is less efficient than Delta (11x vs wildtype using a P681R mutation instead). [del ~144 changed due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a co-infection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	No significant difference in T-cell response to B.1.1.7 was observed (vs. ancestral) in blood drawn from 28 participants received the Pfizer-BioNTech vaccine and 2 received the Moderna vaccine. This is despite three mutations (Y144del, D614G, and P681H) overlapping T-cell epitope hotspots.	2021	Woldemeskel et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	The NAb titers (PRNT50) of sera collected from 38 vaccine recipients four-weeks after the second dose of inactivated whole-virion SARS-CoV-2 BBV152/COVAXIN vaccine [which contains D614G] were not significantly different between B.1.1.7 virus and ancestral D614G virus.	2021	Sapkal et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 vaccine demonstrated vaccine effectiveness [symptomatic or asymptomatic in cohort opf routinely NAAT-monitored UK HCWs] of 72% (95% CI 58-86) 21 days after first dose and 86% (95% CI 76-97) seven days after two doses in the antibody negative cohort. This cohort was vaccinated when the dominant variant in circulation was B.1.1.7 and demonstrates effectiveness against this variant.	2021	Hall et al. (2021)

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D614G	vaccine neutralization efficacy	Pokay	Between December 19, 2020 and Jan 24, 2021, 7214 of 9109 eligible HCWs at Sheba Medical Center in Israel had received one or more doses of BNT162b2 (Pfizer) vaccine. Adjusted rate reduction in SARS-CoV-2 NAAT positivity infection compared with unvaccinated workers 1-14 days after 1st dose was 30% (95% CI: 2-50), and 75% (95% CI: 72-84) after 15-28 days. Adjusted rate reduction in symptomatic COVID-19 compared with unvaccinated workers 1-14 days after 1st dose was 47% (95% CI: 17-66), and 85% (95% CI: 71-92) after 15-28 days. [Though often cited as an indicator of VE for B.1.1.7, during this time period in Israel, the prevalence of the B.1.1.7 variant increased from ~20% to 50% of cases (covariants.org), therefore these VE numbers likely represent a mix of B.1.1.7 and other lineage effects.]	2021	Amit et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	We found that a single dose of the BNT162b2 vaccine is about 60-70% effective at preventing symptomatic disease in adults aged 70 years and older in England and that two doses are about 85-90% effective. Those who were vaccinated and went on to have symptoms had a 44% lower risk of being admitted hospital and a 51% lower risk of death compared with people who were unvaccinated. We also found that a single dose of the ChAdOx1-S vaccine was about 60-75% effective against symptomatic disease and provided an additional protective effect against hospital admission—it is too early to assess the effect on mortality. The B.1.1.7 variant now dominates in the UK and these results will largely reflect vaccine effectiveness against this variant.	2021	Lopez Bernal et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Neutralization of the 47D10. Alpha (B.1.1.7) has an IC50 fold change of 0.40x.	2022	Yuan et al. (2022)
D614G	anthropozoonotic events	Pokay	First documented cases of domestic cat and dog infections with the B.1.1.7 strain.	2021	Hamer et al. (2021)
D614G	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (48.7%: 95% confidence interval [CI], 45.5 to 51.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 93.7% (95% CI, 91.6 to 95.3) among those with the alpha variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 74.5% (95% CI, 68.4 to 79.4) among those with the alpha variant.	2021	Lopez Bernal et al. (2021)
D614G	antibody epitope effects	Pokay	Reduction in neutralization by mAbs COVA2-15 (~9x), B38 (~14x), S309 (~190x) by this B.1.1.7 pseudotyped virus model.	2021	Shen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	We observed a sharp decline in cases when ~50% of the elderly population was 2 weeks beyond their first vaccination dose and at a time point during which the B.1.1.7 variant gained transmission dominance. In support of this finding, it was suggested that, after the first vaccination dose, more than 70% of patients develop neutralization antibodies,15 and the vaccine efficiency can reach 85%.	2021	Munitz et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	Neutralizing antibody titers of 2/20 (10%) samples showed >10x reduction (sera collected ~1mo post Jan 2020 first wave in China). Neutralizing antibody titers of 8/20 samples (40%) decreased below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
D614G	antibody epitope effects	Pokay	Lessens the potency of mAbs COVA2-17 (~5x, similar to N501Y alone), COVA1-12 (~11x) and COVA1-21 (>100x), which do not compete allosterically.	2021	Rees-Spear et al. (2021)
D614G	reinfection	Pokay	36920 COVID Symptom Study app users reported SARS-CoV-2 test positivity in late 2020. Possible reinfections were identified in 249 (0.7% [95% CI 0.6-0.8]) of 36509 app users who reported a positive swab test before Oct 1, 2020, but there was no evidence that the frequency of reinfections was higher for the B.1.1.7 variant than for pre-existing variants.	2021	Graham et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 virus has reduced neutralization activity vs wild type: 2.1x (30 sera Pfizer median 9 days post 2nd dose) and 2.3x (35 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA. Note that Y145del was actually noted in the paper as the effect of their DNA construct, but this is equivalent at the protein level to the more commonly annotated Y144del.	2021	Garcia-Beltran et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	The sera of 16 individuals with time course collection was evaulated against VSV pseudotypes: neutralized D614G at week 2, whereas B.1.1.7 started to be neutralized at week 3, although less efficiently than D614G. B.1.1.7 and D614G strains were similarly neutralized at week 4 (1 week after booster dose).	2021	Planas et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization assays of B.1.1.7 virus showed a reduction of 2.5-fold (14 days post 2nd dose AstraZeneca, n	2021	Supasa et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.39x.	2022	Yuan et al. (2022)
D614G	vaccine efficacy	Pokay	In Minnesota in early 2021 when Alpha was prevalent, vaccine efficacy was estimated as: mRNA-1273 86% (95%CI: 81-90.6%) and BNT162b2: 76% (95%CI: 69-81%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. [variant list included is ancestral Alpha, as this was an observational study no variant list was given]	2021	Puranik et al. (2021)
D614G	antibody epitope effects	Pokay	~20x resistence to mAb CQ038 by B.1.1.7 pseudotyped virus	2021	Hu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	reinfection	Pokay	Reinfection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) B.1.1.7 variant in an immunocompromised 16yo female with end stage renal disease 94 days after initial infection with a B.1.2 lineage virus. Both lineages were the prevalent one at the time of 1st and 2nd infections respectively in Texas, where the patient was located (suggesting exposure risk rather than lineage immune evasion).	2021	Marquez et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Alpha Variant B.1.1.7 RBD significantly better than GenScript IgG FL18-740 w.t. ACE-2 mAB. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Alpha (B.1.1.7) has an IC50 fold change of 1.44x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	A single dose of BNT162b2 (Pfizer) vaccine showed vaccine effectiveness of 70% (95% CI 55-85) 21 days after first dose and 85% (74-96) 7 days after two doses in the study population. Our findings show that the BNT162b2 vaccine can prevent both symptomatic and asymptomatic infection in working-age adults. This cohort (8203 treatment, 15121 control) was vaccinated when the dominant variant in circulation was B.1.1.7 and shows effectiveness against this variant.	2021	Hall et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	NTD-specific nAbs showed a substantial (3-450x) decrease in neutralization potency against the recently reported highly transmissible B.1.1.7 variant of concern, whereas RBD-specific nAbs were either unaffected or showed lower decreases in potency.	2021	Graham et al. (2021)
D614G	tissue specific neutralizatio n	Pokay	The nasal mucosa of Pfizer vaccinees with time course collection was evaluated against VSV pseudotypes: results (only one nasal swab from different previously infected vacinee neutralizing at weeks 3 and 6 against B.1.1.7 and D614G) suggest that vaccinees probably do not elicit an early humoral response detectable at mucosal surfaces even though sera neutralization was observed. They strengthen the hypothesis that some vaccines may not protect against viral acquisition and infection of the oral–nasal region, but may prevent severe disease associated with viral dissemination in the lower respiratory tract.	2021	Planas et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Alpha Molnupiravir (MK-4482) had ~2.75x fold drop.	2022	Rosenke et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.7 reduced 1.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	reinfection	Pokay	Second infection in December 2020 with B.1.1.7 after April 2020 initial infection with B.2 in a 78-year-old man with a history of Type 2 diabetes mellitus, diabetic nephropathy on hemodialysis, chronic obstructive pulmonary disease (COPD), mixed central and obstructive sleep apnea, ischemic heart disease, with no history of immunosuppression.	2021	Harrington et al. (2021)
D614G	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 1 (B.1.1.7) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)
D614G	trafficking	Pokay	~2.5x cleavage of S2 relative to WA1 (D614G) wildtype by Alpha variant variant as measured by mass spectrometry of Vero-TMPRSS culture.	2021	Esclera et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Virus neutralisation activity (using a live SARS-CoV-2 microneutralisation assay (ND50)) by vaccine induced antibodies was 9-fold lower against the B.1.1.7 variant than against a canonical non B.1.1.7 lineage. Vaccine efficacy against symptomatic NAAT positive infection was similar for B.1.1.7 and non-B.1.1.7 lineages (74.6% [95%CI 41.6-88.9] and 84% [95% CI 70.7-91.4] respectively). Furthermore, vaccination with ChAdOx1 nCoV-19 results in a reduction in the duration of shedding and viral load, which may translate into a material impact on transmission of disease.	2021	Emary et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Alpha (B.1.1.7) variant is 1.0x fold the wildtype in 42 COVI.	2022	Kumar et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 15.4% in this B.1.1.7 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	2.1x drop in neutralization using sera collected from 14 healthy adult participants that received two injections of the mRNA-1273 (Moderna) vaccine at a dose of 100 µg (18-55 years: day 1 (n	2021	Edara et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	B.1.1.7 pseudotyped VSV was tested for neutralization in a clonal HEK-293T ACE2 TMPRSS2 cell line optimized for highly efficient S-mediated infection. A cohort of 12 Argentinian recipients of the Gamaleya Sputnik V Ad26 / Ad5 vaccine showed no statistically sognificant change in neutralization effiacacy.	2021	Ikegame et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	NVX-CoV2373 [Novavax] vaccine in phase 3 trial was 89.7% (95% CI, 80.2-94.6) effective in preventing COVID-19, with no hospitalizations or deaths reported. There were five cases of severe Covid-19, all in the placebo group. Post hoc analysis revealed efficacies of 96.4% (73.8-99.5) and 86.3% (71.3-93.5) against the prototype strain and B.1.1.7 variant, respectively.	2021	Heath et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.1.7 Spike variants lentivirus. 3.5x reduction in neutralization with Moderna vaccinated patient sera after 29 days (1st dose). 2.0x reduction in neutralization with Moderna vaccinated patient sera after 57 days (2nd dose). 2.1x reduction in neutralization with Novavax Phase 1 post-vaccination sera.	2021	Shen et al. (2021)
D614G	clinical indicators	Pokay	After adjusting for the age factor, in a prospective Chinese cohort study B.1.1.7 variant infection (compared to B.1.140) was the risk factor for C-reactive protein (P	2021	Song et al. (2021)
D614G	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against symptomatic infection caused by Alpha, vaccine effectiveness with partial vaccination (≥14 days after dose 1) was higher for mRNA-1273 (83%) than BNT162b2 (66%) and ChAdOx1 (64%), and full vaccination (≥7 days after dose 2) increased vaccine effectiveness for BNT162b2 (89%) and mRNA-1273 (92%).	2021	Nasreen et al. (2021)
D614G	trafficking	Pokay	Live virus was tested ex vivo in reconstituted brochial epithelium, and out competed wild type.	2021	Touret et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 1.7x reduction of NT50 value B.1.1.7 (Alpha) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Flow cytometry was used on recombinant VSV proteins and yeast surface display to assess the binding of a labeled soluble ACE2 protein to cells expressing B.1.1.7. We observed a dramatic increase (relative to D614G) in binding of soluble ACE2 to B.1.1.7, and to a lesser extent to B.1.351, which both carry the N501Y mutation (see Fig 3).	2021	Planas et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 93 pM for binding to the Alpha B1.1.7. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In Qatar, where Pfizer vaccine use is prevalent (<10% of the population covered in the time period of the study ending Mar 31, 2021), any time after one dose (including the 2 weeks where no major effect is expected) B.1.1.7 lineage effectiveness was observed as 29.5% (95% CI [22.9,35.5]) against infection, and 54.1% against severe/critical/fatal disease (95% CI [26.1-71.9]). Two weeks or more after 2nd dose, effectiveness climbed to 89.5% [85.9,92.3] against infection, and 100% against severe/critical/fatal disease (95% CI [81.7,100]).		UNKNOWN et al. ()
D614G	pharmaceutical effectiveness	Pokay	Lilly's LY-CoV16 showed marked reduction in neutralization of B.1.1.7.	2021	Dejnirattisai et al. (2021)
D614G	convalescent plasma escape	Pokay	Sera neutralized the B1.1.7 isolate with a lower potency (2-fold: 95% CL: 1.5 – 3-fold), and those with the lowest homotypic neutralizing potency had undetectable heterotypic potency (2/25).	2021	Skelly et al. (2021)
D614G	tissue specific replication effects	Pokay	In this report, by using a lower infectious dose, we demonstrate that B.1.1.7 (cultured sample Hong Kong/HKPU-00015/2021) exhibits higher infectivity and/or replication efficiency in the nasal epithelium. (Hamster model of infection)	2021	Mok et al. (2021)
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Mean 1.7x reduction of NT50 value for C.37 (Lambda) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 3.4x reduction of NT50 value for C.37 (Lambda) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.048x fold change in IC50 in C.37 Lambda	2022	Chonira et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.038x fold change in IC50 in C.37 Lambda	2022	Chonira et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~10-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~3 fold without the deletion] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were significant, but ~500x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Detectable antibodies against B.1.351 at various time points using pseudotyped lentivirus neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 71%, Day 209 54%. Detectable antibodies against B.1.351 at various time points using live virus FRNT neutralization in Moderna vaccinee cohort: Day 29 8%, Day 43 100%, Day 119 79%, Day 209 58%. Detectable antibodies against B.1.351 at various time points using ACE2 blocking assay in Moderna vaccinee cohort: Day 29 63%, Day 43 100%, Day 119 71%, Day 209 79%. Decreased neutralization on some assays was seen especially in those vaccinees tested that were 71+.	2021	Pegu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In an Ontario long term care facility, cumulatively, weaker BNT162b2 vaccine stimulation, age/comorbidities, produced a ~130-fold reduction in apparent neutralization titers in mean 88yo LTCH residents against Beta (B.1.351), relative to staff vaccinees against D614G wild type. 37.9% of 116 two-dose-mRNA-vaccinated residents had undetectable neutralizing antibodies to B.1.351. mRNA-1273 vaccinee sera displayed ~2 better neutralization than BNT162b2. [common defining B.1.351 mutations noted, as the manuscript does not provide details]	2021	Abe et al. (2021)
D614G	antibody epitope effects	Pokay	Anti-NTD CV1 mAb isolated from an early pandemic case was unable to neutralize either partial B.1.351 variant pseudovirus used (A701V or L242del). The neutralization potency of mAb CV30, which contacts K417 and N501 but not E484, was ~10-fold weaker toward both B.1.351 variants. The neutralization potency of anti-RBD mAb CV3-1 was 3-4-fold less potent against the B.1.351 variants, while anti-RBD mAb CV2-75 was modestly less effective.	2021	Stamatatos et al. (2021)
D614G	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, 7 of 15 neutralized this B.1.351 pseudotype that includes the L242del, and only one had titers above 100. Only one of the 15 sera achieved 80% neutralization. [compare to 5 and 1 for pseudotype without the deletion]	2021	Stamatatos et al. (2021)

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D614G	vaccine neutralization efficacy	Pokay	Pseudotyped viruses for B.1.351 was 3.4-fold resistant to neutralization by 6 BNT162b2 vaccine sera 28 days post-booster compared to wild type. Neutralization by 3 Moderna vaccine sera 28 days post-booster was 2.2-fold resistant. [Exact list of B.1.351 mutations used in these assays was not included in the preprint]	2021	Tada et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Beta Molnupiravir (MK-4482) had ~1.75x fold drop.	2022	Rosenke et al. (2022)
D614G	ACE2 receptor binding affinity	Pokay	The B.1.351 variant constellation causes an ~20-fold increase in affinity for ACE2 compared with Wuhan RBD, which may influence transmissibility.	2021	Zhou et al. (2021)
D614G	humoral response durability	Pokay	In a prospective study of 107 hospitalized patients, decrease of IgG rates and serological assays becoming negative did not imply loss of neutralizing capacity. Our results indicate a sustained humoral response against the ancestral strain and the D614G, B.1.1.7 and P.1 variants for at least 6 months (last of two samples taken) in patients previously hospitalized for COVID-19. A weaker protection was however observed for the B.1.351 variant.	2020	Betton et al. (2020)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Beta variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but A701V is downstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)
D614G	outcome hazard ratio	Pokay	Compared to Alpha (B.1.1.7) variant, odds of progressing to severe disease were 1.24-fold (95% CI: 1.11-1.39) higher for Beta. Odds of progressing to critical disease were 1.49-fold (95% CI: 1.13-1.97) higher. Odds of COVID-19 death were 1.57-fold (95% CI: 1.03-2.43) higher.	2021	Abu-Raddad et al. (2021)
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Beta (B.1.351) variant is 0.4x fold the wildtype.	2022	Kumar et al. (2022)
D614G	convalescent plasma escape	Pokay	In 34 convalescent cases 4–9 weeks following infection in June 2020, before the emergence of B.1.1.7, neutralization titers against B.1.351 were, on average, 13.3-fold reduced compared with an early Victoria sample ($p < 0.0001$). Significantly, 18 of 34 samples failed to reach 50% neutralization at a plasma dilution of 1:20, with a number showing a near total reduction of neutralization activity. In 13 convalescent cases 4–9 weeks following infection with B.1.1.7, neutralization titers against B.1.351 were, on average, 3.1-fold reduced compared with an early Victoria sample ($p < 0.0001$).	2021	Zhou et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Beta (B.1.351) has an IC50 fold change of 0.15x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Vaccine plasma neutralization of B.1.351-spike virus was nominally robust but lower (~3x) than other variants of concern.	2021	Liu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.1.351-v3 reduced 8.4x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	antibody epitope effects	Pokay	Testing against B.1.351 the 20 most effective mAbs (19 anti-RBD, 1 anti-NTD) from a screen of 377 against wild type, 4 of 20 antibodies had >10-fold fall in neutralization titers, with most of these showing a complete knockout of activity. This is in line with the key roles of K417, E484, and N501, in particular E484, in antibody recognition of the ACE2 interaction surface of the RBD. Regeneron mAb cocktail: The neutralization of REGN10987 was unaffected by B.1.351, while REGN10933 was severely impaired (773-fold). AstraZeneca mAb cocktail: Neutralization by the AZ pair of antibodies was little affected on B.1.351 compared with Victoria.	2021	Zhou et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	A two-dose regimen of (AstraZeneca) ChAdOx1-nCoV19 did not show protection against mild-moderate Covid-19 due to B.1.351 variant, however, vaccine efficacy against severe Covid-19 is undetermined.	2021	Madhi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	The Janssen single dose vaccine showed 72% efficacy at preventing moderate and severe disease, which was reduced to 57% in South Africa, where 92.6% of infections are estimated to have been B.1.351. 100% reduction in hospitalization risk remains across variants after 28 days post-vaccination.		UNKNOWN et al. ()
D614G	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, B.1.351 lineage virus was able to infect and replicate in common lab mouse strains, with high titer. PG: The virus used in these expriments has a non-typical deletion+sub in the 242 region.	2021	Montagutelli et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Beta (B.1.351) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Sera from healthcare workers (n	2021	Zhou et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Beta (B.1.351) has an IC50 fold change of 0.88x.	2022	Yuan et al. (2022)
D614G	outcome hazard ratio	Pokay	On average across 7 European countries studied, using B.1.351 defining mutations: Significant shift to infection in those without pre-existing conditions (79.6% vs 89% for non-VOC cases). Significant increase in hospitalization rate (19.3% vs 7.5% for non-VOC cases). Significant increase in ICU rate (2.3% vs 0.6% for non-VOC cases). PG: seems to be different notations around the LAL deletion, using the minimal shared definition to catch as many as possible.	2021	Funk et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v1 virus has reduced neutralization activity vs wild type: 34.5x (30 sera Pfizer median 9 days post 2nd dose) and 27.7x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 29.8% in this B.1.351 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)
D614G	convalescent plasma escape	Pokay	Using convalescent sera from 15 early pandemic patients (Seattle Flu Study), mean 220 days post symptom onset (IQR 125-269, and three asymptomatic cases) with 27% WHO disease severity scale 3, one third (5/15) of sera neutralized this B.1.351 pseudotype and only three had ID50 titers above 100. Only two of the 15 sera achieved 80% neutralization.	2021	Stamatatos et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In sera collected from 15 early pandemic patients (Seattle Flu Study), mean 16 days post first dose with either Pfizer/BioNTech or Moderna vaccines, the median ID50 titers were ~3-fold lower against this B.1.351 pseudotyped virus relative to wild type. A single asymptomatic patient, who had no detectable RBD-specific IgG memory before vaccination, also did not elicit nAbs against the B.1.351 variant. [compare to ~10 fold with L242del] ID50 titres in non-infected mRNA vaccines more than two weeks post-booster were signficiant, but >100x weaker than in previously infected patients after first dose.	2021	Stamatatos et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped B.1.351 v3 virus has reduced neutralization activity vs wild type: 42.4x (30 sera Pfizer median 9 days post 2nd dose) and 19.2x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA. Notably, 36.7% (11/30) recipients of two-dose Pfizer and 42.9% (15/35) recipients of two-dose Moderna vaccines did not have detectable neutralization of at least one of the B.1.351 variants.	2021	Garcia-Beltran et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	The neutralization activities of two vaccines developed in China were tested against 501Y.V2 authentic virus: inactivated BBIBP-CorV (no significant change) and recombinant dimeric RBD vaccine ZF2001 (~1.6x reduction vs wildtype, p	2021	Huang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Most of the plasma from 55 Pfizer vaccinees developed high percentages of Wuhan-Hu-1 S-ACE2 blocking activity, peaking at day 28 (7 days post-boost). A strikingly consistent hierarchy of reduction in plasma antibody binding by variant S and RBD antigens was observed among study participants, with progressively decreased binding for B.1.1.7 (not significant), P.1 (significant) and B.1.351 (significant) compared to Wuhan-Hu-1 antigens.	2021	Röltgen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	During an outbreak of SARS-CoV-2 501Y.V2 in a nursing home, all non-vaccinated residents (5/5) versus half of those fully vaccinated 2-5 weeks prior with BNT162b2 (13/26) were infected. Two of 13 vaccinated versus 4 of 5 non-vaccinated residents presented severe disease. BNT162b2 did not prevent the outbreak, but reduced transmission and disease severity. Among the 13 fully vaccinated residents who were infected, 2 (15.4%) presented with an asymptomatic disease, 9 (69.2%) developed mild to moderate symptoms, and 2 (15.4%) progressed to severe disease with fatal evolution secondary to acute respiratory distress syndrome (ARDS). There was no relationship between anti-S antibody levels at diagnosis and disease severity. Overall, the proportion of residents with severe disease in the non-vaccinated group (4/5) was higher than that in the vaccinated group (2/13). Only 1 vaccinated staff, but 10 unvaccinated were infected in the outbreak (no severe disease).	2021	Bailly et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was significantly lower against B.1.351 in sera from all 24 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 1625 for B.1.351 virus. This compares favorably (stronger) to most post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	2.5x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received BBIBP-CorV (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the BBIBP-CorV vaccinee sera. >3x reduction in neutralization by serum collected 2 to 3 weeks after the second dose from vaccinees who had received CoronaVac (pVNT50 against VSV pseudotyped as B.1.351). Convalescent plasma had similar titer against wild type as the CoronaVac vaccinee sera.	2021	Wang et al. (2021)
D614G	convalescent plasma escape	Pokay	B.1.1.351 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Study 3001 on Ad26.COV2.S (Jannsen vaccine) conducted September 21, 2020 through January 22, 2021 overlaps the emergence and dominance of the B.1.351 lineage of SARS-CoV-2 in South Africa. The SA arms of the Phase 3 double blind study showed severe/critical disease VE of 73.1% (95% CI: 40.0-89.4), and moderate to severe/critical disease VE of 52.0% (95% CI: 30.3-67.4). Compare to 78.0% and 74.4% for North American arm of the study during the same period (with low B.1.351 prevalence). Of the 66.9% of SA severe infections that have been sequenced as of this report, 94.5% are B.1.351.	2021	UNKNOWN et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	The dominant circulating B.1.351 spike variant originating in RSA, which harbors E484K and additional substitutions in the RBD, NTD, and S2 and deletions in the NTD (amino acids 242–244), was neutralized with a 5.02-fold reduced titer	2021	Solfrosi et al. (2021)
D614G	convalescent plasma escape	Pokay	B.1.1.351 in 19 convalescent human sera ~1mo post infection had mild to moderate resistance against all samples	2021	Chen et al. (2021)
D614G	antibody epitope effects	Pokay	B.1.1.351 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07, COVOX-384, and S2H58. B.1.1.351 variant constellation ablates Class 3 N-terminal domain targeting antibodies COV2-2489 and COV2-2676 (the only two tested).	2021	Chen et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	In a Syrian hamster model, B.1.351 variant virus had >4x reduction in YRNT90 (measure of neutralization) using wild type convalescent sera. PG: Note that exact sequence for B.1.351 used was not disclosed.	2021	Cochin et al. (2021)
D614G	convalescent plasma escape	Pokay	In 13 plasma collected ~1mo after B.1.1.7 infection (nursing home in Ticino, Switzerland), neutralization reduced to undetectable levels in many plasma for B.1.351 pseudotyped virus, as well as WT and other VOCs. [paper does not detail the B.1.351 variants used, using the most popular as a stad in]	2021	McCallum et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.4x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Relative to B.1, Delta (B.1.617.2) shows mean 2.1x decrease in neutralization efficiency by 18 vaccinee sera (BNT162b2 and mRNA1273).	2021	Wilhelm et al. (2021)
D614G	convalescent plasma escape	Pokay	Relative to B.1, Delta (B.1.617.2) shows 3.64x decrease in neutralization efficiency by convalescent plasma [no cohort details provided]	2021	Wilhelm et al. (2021)
D614G	outcome hazard ratio	Pokay	B.1.526 (Iota) substantially increased IFR in older adults: by 46% (95% CI: 7.4 – 84%) among 45-64 year-olds, 82% (95% CI: 20 – 140%) among 65-74 year-olds, and 62% (95% CI: 45 – 80%) among 75+ during Nov 2020 – Apr 2021, compared to baseline IFR estimated for preexisting variants. [minimum clade defining mutations listed]	2021	Yang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Sera from vaccinees [ChAdOx1 and BNT162b2 primarily used in UK] shows decreased ability to neutralize B.1.621 compared to first wave virus and Alpha, with a magnitude of change similar to Beta.	2021	UNKNOWN et al. (2021)
D614G	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 69 test-positive were Mu. Two dose vaccine efficacy against Mu was 90.4% (73.9-96.5%), one dose VE was 45.8% (0.0-88.9%).	2021	Bruxvoort et al. (2021)
D614G	vaccinee plasma binding	Pokay	Sera from individuals who have been vaccinated and have had subsequent recent Delta infection have a high level of neutralising activity against B.1.621.	2021	UNKNOWN et al. (2021)
D614G	convalescent plasma binding	Pokay	Sera from individuals who have been infected with Delta does not have strong neutralising activity against B.1.621	2021	UNKNOWN et al. (2021)
D614G	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 71.46 for P.1 virus. Compare to much stronger neutralization titers for B.1.1.7 (256) and wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 7.6x reduction of NT50 value B.1.621 (Mu) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster. [This is a greater reduction than Beta @ 6.3x]	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Using live B.1.621 virus and a cytopathic effect-based assay, sera from 37 Pfizer/BioNTech BNT162b2 vaccinees collected 10-20 days post-booster showed significantly lower (95) but still 'robust' neutralization than against ancestral B.1 virus (107).	2021	Messali et al. (2021)
D614G	convalescent plasma escape	Pokay	Mean 12.4x reduction of NT50 value B.1.621 (Mu) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset. [This is a greater reduction than Beta @ 8.2x]	2021	Uriu et al. (2021)
D614G	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this lineage defining mutation combination from B.1.617.3 conferred a ~11.8x drop in neutralization (NT50) [suggesting role for T19R and T95I in half the sera].	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	syncytium formation	Pokay	Using ACE2-GFP+Spike-RFP fluorescence assay, this lineage defining mutation combination from B.1.617.3 increased syncytium formation ~2.3x.	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this lineage defining mutation combination from B.1.617.3 conferred a ~4.5x infectivity advantage to the spike particles.	2021	Mishra et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	51yo female with no severe COVID-19 risk factors tested positive 19 days after second dose of mRNA-1273 (Moderna) vaccine. Presented with sore throat, congestion, and headache developed: the next day she lost her sense of smell. Symptoms resolved over a one week period. Serum obtained 4 days after symptom onset was tested for neutralization against wild-type virus, the E484K mutant, and the B.1.526 variant. It was equally effective against each. These data suggest that the antibody response recognized these variants but was nonetheless insufficient to prevent a breakthrough infection. The virus detected matched neither B.1.1.7 nor B.1.526 VOC strains in wide circulation in New York at the time of infection, though shared some mutations.	2021	Hacisuleyman et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD mutation combination from B.1.617.3 did not confer an infectivity advantage to the spike particles.	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD mutation from B.1.617.3 did not confer an infectivity advantage to the spike particles.	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	trafficking	Pokay	~3.5x cleavage of S2 relative to WA1 (D614G) wildtype by Kappa (B.1.617.1) variant as measured by mass spectrometry of Vero-TMPRSS culture (compare to ~4.5x for closely related Delta B.1.617.2 also with P681R at the cleavage site).	2021	Esclera et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees) [exact set of variants used is not listed in the manuscript]	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Inferring from two B.1.617.1 variants tested, estimate baseline 3.3x reduction in ID50 relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.617.1) showed a 2x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Average 2x neutralization efficiency decrease against sera from 26 Phase II trial Covaxin (BBV152) vaccine recipents. Very similar to B.1.1.7 (~2x) in the same study, and the neutralization from 17 sera of natural infections across B1 lineages.	2021	Yadav et al. (2021)
D614G	convalescent plasma escape	Pokay	Relative to B.1, Kappa (B.1.617.1) shows 5.71x decrease in neutralization efficiency by convalescent plasma [no cohort details provided]	2021	Wilhelm et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Relative to B.1, Kappa (B.1.617.1) shows mean 1.97x decrease in neutralization efficiency by 18 vaccinee sera (BNT162b2 and mRNA1273).	2021	Wilhelm et al. (2021)
D614G	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.617.1) showed a 1.79x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.64x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.617.1) showed a 1.12x increase in binding (KD) relative to D614G, but described as 'not significant'. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Kappa (B.1.617.1) has an IC50 fold change of 80.2x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Kappa (B.1.617.1) has an IC50 fold change of 2.3x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Kappa (B.1.617.1) has an IC50 fold change of 0.68x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Kappa (B.1.617.1) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	In a cluster of B.1.617[.1] infections related to travel from India to USA, one patient with mild symptoms had received their second dose of Pfizer vaccine more than two weeks before the infection [i.e. vaccine breakthrough].	2021	Verghese et al. (2021)
D614G	trafficking	Pokay	~4.5x cleavage of S2 relative to WA1 (D614G) wildtype by Delta (B.1.617.2) variant as measured by mass spectrometry of Vero-TMPRSS culture (compare to ~3.5x for closely related Kappa B.1.617.1 also with P681R at the cleavage site).	2021	Esclera et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster. [Mutation list in publication appears to contain a typo with R158del instead of R158G]	2021	Choi et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Mean 2.6x reduction of NT50 value B.1.617.2 (Delta) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	Mean 4.0x reduction of NT50 value B.1.617.2 (Delta) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
D614G	trafficking	Pokay	Modelling the Delta variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increased 11x relative to wild type (15.3 vs 1.4). [del ~157 truncated due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a coinfection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.10x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
D614G	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.020x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
D614G	trafficking	Pokay	In primary human airway epithelial cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increase 1.9x relative to wild type (2.7 vs 1.4). This is the Delta variant with the P681R furin cleavage site mutation absent. [del ~157 truncated due to ambiguity]	2021	Liu et al. (2021)
D614G	immunosuppression variant emergence	Pokay	Studying 94 COVID-19 extended infection cases with genomics April 1 to October 17, 2020, one case developed 23 mutations in a 19 day period, including this combination in Spike.	2021	Landis et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	transmissibility	Pokay	Normalized for particle number, on ACE2.293T cells showed that the B.1.618 spike protein was about as infective as D614G wild type.	2021	Tada et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	The estimated vaccine effectiveness against R.1 strain SARS-CoV-2 infection among residents in a Kentucky skilled nursing facility was 66.2% (95% CI	2021	Cavanaugh et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Plasma neutralizing activity was also assessed against SARS-CoV-2 Delta, Omicron BA.1, BA.2 and BA.4/5 variants using viruses pseudotyped with appropriate variant spikeproteins. Delta breakthrough infection resulted in 15-fold increased neutralizing titers.	2022	Wang et al. (2022)
D614G	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 507 pM for binding to the Delta B.1.617.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Plasma neutralizing activity in 49 participants was measured using HIV-1 pseudotyped with the 100 WT SARS-CoV-2 spike protein. Delta breakthrough infection resulted in 11-fold increased geometric mean half-maximal neutralizing titer (NT50).	2022	Wang et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Log10ID50 of Delta neutralizing antibodies is 0.872x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)

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D614G	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Delta Variant B.1.617.2 RBD or w.t. SARS-CoV-2 RBD with nearly equal potency determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
D614G	vaccine neutralization efficacy	Pokay	Log10ID50 of Delta neutralizing antibodies is 0.952x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
D614G	outcome hazard ratio	Pokay	In the UK, of 43338 COVID-19-positive patients, 8682 had the Delta variant (median age 31 years [IQR 17–43]) and 196 were admitted to hospital within 14 days after the specimen was taken (adjusted hazard ratio [HR] 2.26 [95% CI 1.32–3.89] relative to Alpha cases). Being admitted to hospital or attending emergency care within 14 days for Delta cases had an adjusted HR 1.45 [95% CI 1.08–1.95] relative to Alpha. Most patients were unvaccinated (32 078 [74·0%] across both groups). The HRs for vaccinated patients were similar: 1.94 [95% CI 0.47–8.05] for hospitalization and 1.58 [0.69–3.61]) for hospital admission or emergency care attendance.	2021	Twohig et al. (2021)
D614G	vaccine efficacy	Pokay	During December 14, 2020–August 14, 2021, frontline worker without previous documented SARS-CoV-2 infection were monitored regularly. Of 4,217 participants, 3,483 (83%) were vaccinated: 2,278 (65%) received Pfizer-BioNTech, 1,138 (33%) Moderna, and 67 (2%) Janssen (Johnson & Johnson) COVID-19 vaccines. Adjusted VE during this Delta predominant period was 66% (95% CI	2021	Fowlkes et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Case 62541 cluster in Singapore included a fully vaccinated nurse 2 months post-vaccine [likely Pfizer based on dates and supply], and a doctor of unknown vaccine status. This cluster was caused by a B.1.617.2 virus [via crossreference to		UNKNOWN et al. ()
D614G	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.617.2 aka Delta) showed a 1.64x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.89x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()
D614G	vaccine efficacy	Pokay	136,160 reports from 14,997 nursing care facilities were broken into pre-Delta (Mar 1-May 9, 2021), intermediate (May 10-Jun 20, 2021) and Delta (Jun 21-Aug 1, 2021). Two doses of mRNA vaccines were 74.7% effective against infection among nursing home residents early in the vaccination program (March–May 2021). During June–July 2021, when B.1.617.2 (Delta) variant circulation predominated, effectiveness declined significantly to 53.1%.	2021	Nanduri et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	Using a matched test-negative, case- control study design in Qatar, BNT162b2 effectiveness against any Delta infection, symptomatic or asymptomatic, was 64.2% (95% CI: 38.1-80.1%) ≥14 days after the first dose and before the second dose, but was only 53.5% (95% CI: 43.9-61.4%) ≥14 days after the second dose, in a population in which a large proportion of fully vaccinated persons received their second dose several months earlier. Corresponding effectiveness measures for mRNA-1273 were 79.0% (95% CI: 58.9-90.1%) and 84.8% (95% CI: 75.9-90.8%), respectively. Effectiveness against any severe, critical, or fatal COVID-19 disease due to Delta was 89.7% (95% CI: 61.0-98.1%) for BNT162b2 and 100.0% (95% CI: 41.2-100.0%) for mRNA-1273, ≥14 days after the second dose. The lower VE in Qatar relative to those reported in some other jurisdictions such as the UK and Canada (75%+) may reflect waning of vaccine protection for those who received their second dose by end of 2020 or early 2021. Risk perception and behaviour amongst vaccinated individuals opver time may also play a role.	2021	Tang et al. (2021)
D614G	outcome hazard ratio	Pokay	In Denmark, for the period Jan 1 to Jun 27, 2021, Delta variant was associated with increased an risk ratio of 2.83 [95% CI 2.02–3.98] for hospitalization.	2021	Bager et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	Of 218 individuals with B.1.617.2 infection in Singapore, 84 had received a mRNA vaccine of which 71 were fully vaccinated, 130 were unvaccinated and 4 received a non-mRNA. Despite significantly older age in the vaccine breakthrough group, the odds of severe COVID-19 requiring oxygen supplementation was significantly lower following vaccination (adjusted odds ratio 0.07 95%CI: 0.015-0.335, p	2021	Chia et al. (2021)
D614G	vaccine efficacy	Pokay	The incidence rate of Covid-19 during the Delta-dominant period (Jul-Aug 2021) was lower for late vaccinated (49.0/1000 person-years) [formerly placebo] versus early vaccinated (77.1/1000 person-years) participants in the Moderna mRNA-1273 Phase 3 trials, representing a 36.4% VE reduction (95% CI 17.1%-51.5%). There were fewer severe Covid-19 cases in the late group (6: 6.2/1000 person-years) than early (13: 3.3/1000 person-years), representing a 46.0% reduction (95% CI –52.4%-83.2%). Three Covid-19 related hospitalizations occurred with two resulting deaths in the early group.	2021	Baden et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	2.3x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees) [exact set of variants used is not listed in the manuscript]	2021	Gong et al. (2021)
D614G	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Delta Molnupiravir (MK-4482) had ~4x fold drop.	2022	Rosenke et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against Delta, vaccine effectiveness after partial vaccination tended to be lower compared to Alpha for mRNA-1273 (72% vs. 83%) and BNT162b2 (56% vs. 66%), but was similar to Alpha for ChAdOx1 (67% vs. 64%). Full vaccination with BNT162b2 increased protection against Delta (87%) to levels comparable to Alpha (89%) and Beta/Gamma (84%). Delta-positive cases were biased towards young male residents of the Peel region.	2021	Nasreen et al. (2021)
D614G	outcome hazard ratio	Pokay	In Ontario between Feb 7 and Jun 27, 2021, increased risk with the Delta variant was 108% (95% CI 78%–140%) for hospitalization, 235% (95% CI 160%–331%) for ICU admission and 133% (95% CI 54%–231%) for death.	2021	UNKNOWN et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Vaccination of health care workers in Delhi was started in early 2021, with the ChdOx-1 (Astra Zeneca) vaccine. Surveillance has suggested B.1.1.7 dominance in the Delhi area during early 2021, with growth of B.1.617 since March 2021. During the wave of infections during March and April an outbreak of SARS-CoV-2 was confirmed in 33 vaccinated staff members at a single tertiary centre (age 27-77 years). Sequencing revealed that 16/33 were B.1.617.2, with a range of other B lineage viruses including B.1.1.7 for the rest except one A lineage case. Importantly no severe cases were documented in this event.	2021	Ferreira et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (30.7%: 95% confidence interval [CI], 25.2 to 35.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 88.0% (95% CI, 85.3 to 90.1) among those with the delta variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 67.0% (95% CI, 61.3 to 71.8) among those with the delta variant.	2021	Lopez Bernal et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.617.2 aka Delta) showed a 1.92x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.617.2 aka Delta) showed a 2.34x increase in binding (KD) relative to D614G. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	In Minnesota in July 2020 (when Delta variant prevalence was >70%), the effectiveness against infection for mRNA-1273 was estimated at 76% (95% CI: 58-87%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. An even more pronounced reduction in effectiveness was observed for BNT162b2 of 42% (95% CI: 13-62%). mRNA-1273 conferred a two-fold risk reduction against breakthrough infection compared to BNT162b2 (IRR	2021	Puranik et al. (2021)
D614G	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 2027 test-positive cases were Delta. Two dose vaccine efficacy against Delta decreased from 94.1% (90.5-96.3%) 14-60 days after vaccination to 80.0% (70.2-86.6%) 151-180 days after vaccination. Waning was less pronounced for non-Delta variants. VE against Delta was lower among individuals aged ≥65 years (75.2% [59.6-84.8%]) than those aged 18-64 years (87.9% [85.5-89.9%]). VE against Delta hospitalization was 97.6% (92.8-99.2%). One-dose VE was 77.0% (60.7-86.5%) against Delta infection.	2021	Bruxvoort et al. (2021)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Delta (B.1.617.2) has an IC50 fold change of 46.5x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Delta (B.1.617.2) has an IC50 fold change of 0.57x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Delta (B.1.617.2) has an IC50 fold change of 0.15x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Delta (B.1.617.2) has an IC50 fold change of 0.87x.	2022	Yuan et al. (2022)
D614G	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Delta (B.1.617.2) variant is 0.6x fold the wildtype.	2022	Kumar et al. (2022)
D614G	reinfection	Pokay	A 42yo Iranian male was reinfected with B.1.36 lineage virus 128 days after infection with genetically distinct B.1.36 virus, with negative PCR tests in between. In the first instance patient presented with cough, headache, severe diarrhea. In the second instance symptoms were more severe: body pain, shortness of breath, headache and anosmia. Anti-SARS-CoV-2 IgG and IgM tests were negative after both episodes. [Non-seroconversion may be associated with elevated risk of re-infection] [I210del is a homoplasy that has appeared in several disparate parts of the global phylogenetic tree, including A and B lineages, primarily in LMICs]	2021	Salehi-Vaziri et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	humoral response durability	Pokay	27yo female nurse reinfected in December 2020 (B.1.177) after initial infection in March 2020 (B.3), i.e. with a 9 month interval. Both cases were mild. No significant differences in the neutralizing capacity of the two lineages were observed in 4 sera taken (1 pre-reinfection, three post-reinfection). Neutralizing antibody titres (IC50) before and immediately after re-infection were <300 against both strains, and jumped >7x upon re-infection. Viral titres were also higher in the second case. Second case also includes N:p.A220V	2021	Brehm et al. (2021)
D614G	reinfection	Pokay	27yo female nurse reinfected in December 2020 (B.1.177) after initial infection in March 2020 (B.3). Both cases were mild. Second case also includes N:p.A220V	2021	Brehm et al. (2021)
D614G	syncytium formation	Pokay	Slight increase in Vero cell-cell membrane fusion assay under infection with VSV pseudotyped virus relative to wild type, no change relative to D614G.	2021	Kim et al. (2021)
D614G	trafficking	Pokay	~4x more efficient S2 domain cleavage compared to wild type, no change relative to D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3).	2021	Kim et al. (2021)
D614G	trafficking	Pokay	No change in infectivity (24h) relative to D614G alone in Caco-2 cells, Vero or Calu-3.	2021	Kim et al. (2021)
D614G	trafficking	Pokay	The entry efficiencies of Spike pseudotyped viruses bearing N501Y Variant 2 (B.1.351) mutant were about 3 to 4.4 times higher than that of the WT pseudovirus when viral input was normalized, suggesting that these spike variants promote the infectivity of SARS-CoV-2.	2021	Hu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	transmissibility	Pokay	36,590 variant-specific RT-PCR tests were performed on samples collected between April 12 and May 7, 2021 in France to compare variant spread. Compared to January to March 2021, B.1.351 variant had a significant transmission advantage over B.1.1.7 in some regions (15.1 to 16.1% in Île-de-France and 16.1 to 18.8% in Hauts-de-France). This shift in transmission advantage is consistent with the immune evasion abilities of B.1.351 and the high levels of immunization in these regions.	2021	Roquebert et al. (2021)
D614G	transmissibility	Pokay	Assuming complete cross-protection, we estimate 501Y.V2/B.1.351 was 1.50 (95% CrI: 1.20-2.13) times as transmissible than previously circulating variants. Assuming instead that 501Y.V2 is identically transmissible, the new variant evades 21% (95% CrI: 11-36%) of previously acquired immunity. Reality may lie between these extremes, with an intermediate increase in transmissibility and mildly imperfect cross-protection from past exposure.	2021	Pearson et al. (2021)
D614G	convalescent plasma escape	Pokay	Average ~10-fold reduction in neutralization efficacy in convalescent sera of 16 health workers infected in Spring 2020.	2021	Alenquer et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	In a multicenter, double-blind, randomized, controlled trial to assess the safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) with enrollment June 24 and November 9, 2020 from ~2000 HIV-negative 18-64 year olds (1:1 placebo to treatment), incidence of serious adverse events 14 or more days post- 2nd dose was balanced between the vaccine and placebo groups. A two-dose regimen of the ChAdOx1 nCoV-19 vaccine did not show protection against mild-to-moderate Covid-19 due to the B.1.351 variant. Serum samples obtained from 13 ChAdOx1 nCoV-19 vaccine recipients without SARS-CoV-2 infection through 41 days after vaccination showed 3.5x reduction in neutralization (ID50) for B.1.351 RBD pseudotype HIB-1 virus compared to D614G alone. This RBD variant combination's neutralization by a placebo control group of 6 naturally infected patients showed a similar 3.2x drop (though with D614G starting at a 1.7x higher titre than vaccinee sera).	2021	Madhi et al. (2021)
D614G	convalescent plasma escape	Pokay	Neutralizing antibody titers of 18 samples (90%) decreased against this B.1.351 pseudotyped virus below an ID50 threshold of 40 (sera collected ~8mo post Jan 2020 first wave in China).	2021	Hu et al. (2021)
D614G	antibody epitope effects	Pokay	Abolished neutralization by mAbs CQ026 and CQ038, greatly diminished neutralization by CQ012 and CQ046.	2021	Hu et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	This variant of key B.1.351 lineage mutations showed ~10x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	This variant showed ~10x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	~5x more efficient S2 domain cleavage compared to wild type, compared to 4x by D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3). [N501Y+D614G does not show an increase in cleavage, therefore a synergistic effect of the trio is implied]	2021	Kim et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	This variant showed >5x decrease in Pfizer sera (3 weeks post-first dose: n	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	~9x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction (no synergy as level approx. that of N501Y alone).	2021	Kuzmina et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	This variant showed only minor in Pfizer sera (one or two dose) neutralization efficiency vs D614G (using lentivirus pseudotype).	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	~2x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	The KD for the pseudotyped P.1-ACE2 interaction is 4.8 nM, showing that binding to P.1 is essentially indistinguishable from B.1.351 (4.0 nM), which binds with ~19x greater affinity that wild type.	2021	Dejnirattisai et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	reinfection	Pokay	A 47yo Indian male was reinfected with B.1.36 lineage virus in September 2020 after infection with genetically distinct B.1.36 virus in July, with negative PCR tests in between. While the forst episode was asymptomatic, the second included fever, cough, and malaise. The second case additionally contained stopgain ORF3a:E261*	2021	Rani et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD+RBD mutation combination from B.1.617.3 conferred a ~3x infectivity advantage to the spike particles [less than L452R or E484Q alone working with the delins].	2021	Mishra et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.617) showed a 1.85x increase in binding (KD) relative to D614G. [exact variant list not provided in manuscript, is inferred fro common knowledge]	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	1.4x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
D614G	transmissibility	Pokay	The combination caused a 3-fold increase in infectivity relative to D614G wild type. [compare to 3.5x for L452R alone]	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	Pseudotyped viruses for B.1.617 was 2.3-fold resistant to neutralization by convalescent sera compared to wild type - a finding that was similar to that of the 3-fold resistance of the South Africa B.1.351 variant using the same assay. The resistance of B.1.617 was caused by the L452R and E484Q mutation, based on results from viruses pseudotyped for individual variants within B.1.617. [details on the convalescent patient sera collection are not abundantly clear in the preprint]	2021	Tada et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this NTD+RBD mutation combination from B.1.617.3 conferred a ~3x drop in neutralization (NT50) [working with the delins, less than just L452R but more than just E484Q].	2021	Mishra et al. (2021)
D614G	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.617) showed a 1.30x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.18x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. [exact variant list not provided in manuscript, is inferred fro common knowledge]	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped viruses for B.1.617 was 4-fold resistant to neutralization by 6 BNT162b2 vaccine sera 28 days post-booster compared to wild type - a finding that was similar to that of the 3.4-fold resistance of the South Africa B.1.351 variant using the same assay. Neutralization by 3 Moderna vaccine sera 28 days post-booster was 5-fold resistant (vs. 2.2-fold for B.1.351). The resistance of B.1.617 was caused by the L452R and E484Q mutation, based on results from viruses pseudotyped for individual variants within B.1.617.	2021	Tada et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.617) showed a 1.22x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. [exact variant list not provided in manuscript, is inferred fro common knowledge]	2021	Gong et al. (2021)
D614G	syncytium formation	Pokay	Using ACE2-GFP+Spike-RFP fluorescence assay, this NTD+RBD mutation combination from B.1.617.3 increased syncytium formation ~2.5x.	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Normalized for particle number, on ACE2.293T cells showed that the B.1.617 spike protein was >2-fold increase in infectivity relative to D614G wild type.	2021	Tada et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this NTD+RBD mutation combination from B.1.617.3 conferred a 7.42x drop in neutralization (NT50) [mostly from 3 of the sera].	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 583 test-positive were Epsilon. Two dose vaccine efficacy against Epsilon was 97.6 (90.2-99.4%), one dose VE was 76.3 (48.1-89.1%).	2021	Bruxvoort et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this RBD mutation conferred a 2.36x drop in neutralization (NT50).	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Increased infectivity of the B.1.617 spike was attributed to L452R, which itself caused a 3.5-fold increase in infectivity relative to D614G wild type. [In combination with E484Q caused a somewhat less 3-fold increase]	2021	Tada et al. (2021)
D614G	transmissibility	Pokay	The L452R mutation increased the infectivity more than two-fold in these conditions.	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD+RBD mutation combination from B.1.617.3 conferred a ~2x infectivity advantage to the spike particles.	2021	Mishra et al. (2021)
D614G	syncytium formation	Pokay	Using ACE2-GFP+Spike-RFP fluorescence assay, this NTD+RBD mutation combination from B.1.617.3 increased syncytium formation ~2x.	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	symptom prevalence	Pokay	Compared to the clade 20A strains that predominated during phase 1 between March and May 2020, the Marseille-4 variant (characterized by this mutation plus N:p.M234I:A376T) was associated with a lower frequency of cough, rhinitis, and olfactory and gustatory disorders. By contrast, hypoxemia was more frequent in patients infected with the Marseille-4 variant.	2021	Fournier et al. (2021)
D614G	reinfection	Pokay	11 cases of re-infection with the ' Marseille-4' variant found within 1028 positive tests, where all of the earlier infections were from different strains. This lineage is also characterized by N:p.M234I:A376T	2021	Fournier et al. (2021)
D614G	convalescent plasma binding	Pokay	Lentiviral pseudotyped with the key mutations from 20A.EU2 lineage was neutralized slightly less than D614G in 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
D614G	trafficking	Pokay	Lentiviral pseudotyped with the key mutations from 20A.EU2 lineage was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing no significant change in infection rate amongst the cells, suggesting that this mutation does not contributing to cell entry fitness.	2021	Tada et al. (2021)
D614G	trafficking	Pokay	~13x more infective as D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	Approximately as infective as D614G alone in HEK293T-ACE2 cells 48h post-transduction (~additive effects of the individual variants).	2021	Kuzmina et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	syncytium formation	Pokay	~50% Vero cell-cell membrane fusion assay under infection with VSV pseudotyped virus relative to wild type, signficantly higher than D614G.	2021	Kim et al. (2021)
D614G	trafficking	Pokay	~12x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction (~additive effects of 501 and 484).	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	~6x more efficient S2 domain cleavage compared to wild type, compared to 4x by D614G alone in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3). [N501Y+D614G does not show an increase in cleavage, therefore a synergistic effect of the trio is implied]	2021	Kim et al. (2021)
D614G	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~11x, Vero ~10x, and Calu-3 ~11x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	The study demonstrated 1.92 and 1.09 fold reductions (ELISA) in the neutralizing titer against B.1.1.28.2 (P2) variant (n	2021	Sapkal et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Study 3001 on Ad26.COV2.S (Jannsen vaccine) conducted September 21, 2020 through January 22, 2021 overlaps the emergence and dominance of the P.1 & P.2 lineages of SARS-CoV-2 in Brazil. The Brazilian arm of the Phase 3 double blind study showed severe/critical disease VE of 81.9% (95% CI: 17.0-98.1), and moderate to severe/critical disease VE of 66.2% (95% CI: 51.0-77.1). Compare to 78.0% and 74.4% for North American arm of the study during the same period (with low B.1.351 prevalence). Of the 69.3% of mostly severe infections sequenced as of this report, 69.4% were of P.2 lineage [defining lineage SNPs reported here].	2021	UNKNOWN et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped viruses for B.1.618 was 2.7-fold resistant to neutralization by 6 BNT162b2 vaccine sera 28 days post-booster compared to wild type - a finding that was similar to that of the 3.4-fold resistance of the South Africa B.1.351 variant using the same assay. Neutralization by 3 Moderna vaccine sera 28 days post-booster was 3-fold resistant (vs. 2.2-fold for B.1.351). The resistance of B.1.618 was caused by the E484K mutation, based on results from viruses pseudotyped for individual variants within B.1.618.	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma escape	Pokay	Pseudotyped viruses for B.1.618 was 2.5-fold resistant to neutralization by convalescent sera compared to wild type - a finding that was similar to that of the 3-fold resistance of the South Africa B.1.351 variant using the same assay. The resistance of B.1.618 was caused by the E484K mutation, based on results from viruses pseudotyped for individual variants within B.1.618. [details on the convalescent patient sera collection are not abundantly clear in the preprint]	2021	Tada et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped P.2 virus has reduced neutralization activity vs wild type: 5.8x (30 sera Pfizer median 9 days post 2nd dose) and 2.9x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this NTD+RBD mutation combination from B.1.617.3 conferred a 1.34x drop in neutralization (NT50) [mostly from a single serum].	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD+RBD mutation combination from B.1.617.3 conferred a ~4x infectivity advantage to the spike particles.	2021	Mishra et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, RBD-specific mutation E484Q did not significantly confer infectivity advantage to the spike particles.	2021	Mishra et al. (2021)
D614G	syncytium formation	Pokay	Using ACE2-GFP+Spike-RFP fluorescence assay, this NTD+RBD mutation combination from B.1.617.3 did not affect syncytium formation.	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	This variant showed no change in Pfizer sera (one or two dose) neutralization efficiency vs D614G (using lentivirus pseudotype).	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~13x, Vero ~10x, and Calu-3 ~10x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)
D614G	trafficking	Pokay	9x more infectivity than D614G alone in HEK293T-ACE2 cells 48h post-transduction.	2021	Kuzmina et al. (2021)
D614G	trafficking	Pokay	More efficient infectivity (24h) compared to wild type, in Caco-2 cells ~9x, Vero ~8x, and Calu-3 ~8x. Compare to wild type at ~5x across cell types.	2021	Kim et al. (2021)
D614G	trafficking	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H lineage was tested on ACE2.293T cells. Luciferase activity was measured two days postinfection, showing no significant change in infection rate amongst the cells, suggesting that this mutation does not contributing to cell entry fitness.	2021	Tada et al. (2021)
D614G	convalescent plasma binding	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H ('Ohio') lineage was neutralized similarly to D614G in 10 convalescent sera from April 2020 infectees.	2021	Tada et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Lentiviral pseudotyped with the key mutations from COH.20G/677H lineage was tested on ACE2.293T cells for ACE2 affinity changes vs D614G alone, showing a ~70% drop in IC50 (i.e. increased affinity).	2021	Tada et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	anthropozoonotic events	Pokay	This mutation (a.k.a. 'Doug') outside the receptor binding domain, while highly favorable to improved human-human transmission, decreases transduction in naked mole-rat (Heterocephalus glaber) fibroblast and Japanese pipistrelle bat (Pipistrellus abramus) cell cultures using a pseudotyped VSV assay.	2023	Li et al. (2023)
D614G	trafficking	Pokay	The increased transduction with Spike D614G ranged from 1.3- to 2.4-fold in Caco-2 and Calu-3 cells expressing endogenous ACE2 and from 1.5- to 7.7-fold in A549ACE2 and Huh7.5ACE2 overexpressing ACE2. Although there is minimal difference in ACE2 receptor binding between the D614 and G614 Spike variants, the G614 variant is more resistant to proteolytic cleavage, suggesting a possible mechanism for the increased transduction.	2021	Daniloski et al. (2021)
D614G	trafficking	Pokay	~4x more efficient S2 domain cleavage compared to wild type in Caco-2 cells, mid-range of three cell line tested (Vero and Calu-3).	2021	Kim et al. (2021)
D614G	convalescent plasma binding	Pokay	1.14x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Using a lentivirus virus pseudotyped with D614G Spike, sera from vaccinated individuals who received the second dose (9–11 days post-second dose of Pfizer) exhibited a robust neutralizing potential, with a mean NT50 value of 99,000. This was an average of a 2-fold increase, relative to sera drawn from the individuals who received one dose of vaccination—mean NT50 dilution of 51,300. Importantly, a 6-fold increase in mean NT50 dilution was obtained when sera from the first vaccination dose was compared to convalescent sera from cohort with severe disease (NT50 51,000 vs 8,700) 21 to 63 days post-onset.	2021	Kuzmina et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.08x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.11x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	In four cell lines (including 293T-hACE2 cells), this mutation combination increases infectivity vs D614G alone	2020	Li et al. (2020)
D614G	vaccine neutralization efficacy	Pokay	Using a pseudovirus assay and 6 ChAdOx1 vaccinee sera, this NTD mutation conferred a 4.85x drop in neutralization (NT50).	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccine neutralization efficacy	Pokay	Pseudotyped D614G virus has reduced neutralization activity vs wild type: 1.2x (37 sera Pfizer median 9 days post 2nd dose, 37 sera Moderna median 18 days post 2nd dose). This was NOT significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
D614G	virion structure	Pokay	CryoEM shows increased proportion of 'one-up' trimer conformation of Spike proteins on the surface of virions, where the up conformation is presumed to be more likely to bind ACE2.	2020	Yurkovetskiy et al. (2020)
D614G	pharmaceutical effectiveness	Pokay	This individual mutation found in the epitope from Sotrovimab causes a 1.0x reduction in neutralization efficacy using a VSV model on Vero E6 cells.	2021	Cathcart et al. (2021)
D614G	virion structure	Pokay	Based on pseudotyped virus experiments, D614G may increase infectivity by assembling more functional S protein into the virion.	2020	Zhang et al. (2020)
D614G	vaccinee plasma binding	Pokay	1.43x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.37x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	transmissibility	Pokay	Using a pseudovirus assay, this NTD mutation combination from B.1.617.3 conferred a nearly two-fold infectivity advantage to the spike particles.	2021	Mishra et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	trafficking	Pokay	Among S variants tested, the D614G mutant shows the highest cell entry (~3.5x wild type), as supported by structural and binding analyses.	2020	Ozono et al. (2020)
D614G	trafficking	Pokay	We report here pseudoviruses carrying SG614 enter ACE2-expressing cells more efficiently than wild type (~9-fold). This increased entry correlates with less S1-domain shedding and higher S-protein incorporation into the virion. D614G does not alter S-protein binding to ACE2 or neutralization sensitivity of pseudoviruses. Thus, D614G may increase infectivity by assembling more functional S protein into the virion.	2020	UNKNOWN et al. (2020)
D614G	trafficking	Pokay	Circulating variant shown in vitro to not have major defects or enhancement of cell surface protein trafficking (i.e. Spike cleavage or fusion required for cell entry)	2021	Barrett et al. (2021)
D614G	environmental condition stability	Pokay	Relative to wild type, D614G showed increased infectivity (ie. cold stability) after storage at -20°C for up to 30 days.	2021	Huang et al. (2021)
D614G	convalescent plasma binding	Pokay	1.53x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a slight decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	viral load	Pokay	Hamsters infected with SARS-CoV-2 expressing spike(D614G) (G614 virus) produced higher infectious titres in nasal washes and the trachea, but not in the lungs, supporting clinical evidence showing that the mutation enhances viral loads in the upper respiratory tract of COVID-19 patients and may increase transmission.	2020	Plante et al. (2020)
D614G	virion structure	Pokay	Estimated free energy change (ddG) for this variant is 2.5 kcal/mol (i.e. stabilizing relative to wild type)	2021	Spratt et al. (2021)
D614G	syncytium formation	Pokay	Slight increase in Vero cell-cell membrane fusion assay under infection with VSV pseudotyped virus.	2021	Kim et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.35x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.05x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.45x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.97x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.5x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	virion structure	Pokay	Negative stain EM shows increased proportion of 'one-up' trimer conformation of Spike proteins on the surface of virions, where the up conformation is presumed to be more likely to bind ACE2.	2020	Weissman et al. (2020)
D614G	vaccinee plasma binding	Pokay	1.23x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.1x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	No change in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.1x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.526) showed a 1.34x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.19x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.526) showed a 1.02x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.526) showed a 1.78x increase in binding (KD) relative to D614G, even though each variant independently decreases binding.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.42x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.08x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.27x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma binding	Pokay	1.19x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.429 aka Epsilon) showed a 2.82x increase in binding (KD) relative to D614G, indicating a strong marginal effect for L452R.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.429 aka Epsilon) showed a 1.1x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. [Stark contrast to 2.15x increase in binding by convalescent plasma 8 months post infection, presumably via memory B cell affinity maturation against L452R effects] 1.12x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.429 aka Epsilon) showed a 1.1x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset, indicating ablated marginal effect from L452R.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.30x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. Compare to varied binding in full Spike variant complements for major lineages containing this variant subset: 1.28x increase (B.1.351 aka Beta), and 1.14x decrease (P.1 aka Gamma). 1.47x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. Compare to varied binding in full Spike variant complements for major lineages containing this variant subset: 1.17x increase (B.1.351 aka Beta), and 1.47x decrease (P.1 aka Gamma).	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.07x decrease in binding (KD) relative to D614G. Compare to increased binding in full Spike variant complements for major lineages containing this variant subset: 3.56x (B.1.351 aka Beta), 4.24x (P.1 aka Gamma).	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.66x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. Compare to decreased binding in full Spike variant complements for major lineages containing this variant subset: 0.96x (B.1.351 aka Beta), 0.77x (P.1 aka Gamma).	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.3x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.14x decrease in Spike binding (relative to D614G alone) by 5 plasma 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.27x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing P.1 aka Gamma) showed a 4.24x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.04x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset, in contrast to the largely positive binding values for each individual mutation that comprises the set.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.351 aka Beta) showed a 3.56x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	This variant combination (representing B.1.351 aka Beta) showed a 1.28x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. It shows a 1.17x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.29x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.39x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.96x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.65x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.08x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.23x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.37x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.58x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.14x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.51x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis).	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.33x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing B.1.1.7 aka Alpha) had 5.43x increased binding relative to D614G alone.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed a 1.15x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	This variant combination (representing B.1.1.7 aka Alpha) showed no change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.28x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination showed no change relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.64x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.35x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	convalescent plasma binding	Pokay	2.11x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.33x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.16x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.02x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.56x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.32x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.37x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.56x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.33x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.15x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.03x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.32x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.09x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.19x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.59x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.82x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.19x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	2.29x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.79x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.3x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.08x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	No significant change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.19x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	2.16x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.76x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.75x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.04x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.1x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.28x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma escape	Pokay	Relative to B.1, Epsilon (B.1.417/429) shows 1.74x-2.35x decrease in neutralization efficiency by convalescent plasma [no cohort details provided]	2021	Wilhelm et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	Relative to B.1, Epsilon (B.1.417/429) shows 1.74x-2.35x decrease in neutralization efficiency by 18 vaccinee sera (BNT162b2 and mRNA1273).	2021	Wilhelm et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.05x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.16x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	2.15x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 2.66x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.42x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	This variant appears twice in the experiments, with slightly different affinities (both ~1.2x decrease in binding relative to D614G) using flow cytometry and ACE2 ectodomains-Fc portion IgG complex.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.16x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.06x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 2.52x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis). Compare to full Spike variant complements for major lineages containing this variant subset: 5.43x (B.1.1.7 aka Alpha), 3.56x (B.1.351 aka Beta), 4.24x (P.1 aka Gamma).	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.17x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.29x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.18x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis).	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	No significant change in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.04x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.48x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.21x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.04x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	vaccine neutralization efficacy	Pokay	No significant change in virus neutralzation by 18 Pfizer two dose vaccinee sera compared to B.1.1.7. [results without including the used mutation A27S likely generalizable, as this is not a lineage defining mutation]	2021	Zuckerman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.14x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.11x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.23x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.26x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.11x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.19x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.1x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed essentially no change in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.12x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.58x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.02x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.47x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.06x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	2x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.12x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.3x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	vaccinee plasma binding	Pokay	1.32x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.22x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.56x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.69x decrease in binding (KD) relative to D614G.	2021	Gong et al. (2021)
D614G	convalescent plasma binding	Pokay	1.96x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
D614G	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.23x increase in binding (KD) relative to D614G, mostly due to decreased in 'off-rate' a.k.a. dissociation rate (Kdis).	2021	Gong et al. (2021)
D614G	vaccinee plasma binding	Pokay	1.09x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.08x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D614G	trafficking	Pokay	Quantification of the band intensities showed that the P681R mutation, which lies near the proteolytic processing site, caused a small increase in proteolytic processing as measured by a 2-fold decrease in the ratio of S/S2.	2021	Tada et al. (2021)
H655Y	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
H655Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
H655Y	virion structure	Pokay	CryoEM reveals the P.1 trimer to adopt exclusively a conformation in which one of the receptor-binding domains is in the “up” position.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	vaccine neutralization efficacy	Pokay	In 12 Moderna vaccinee sera 15 days post second dose (43 days since first vaccination), an average 2.8x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 4.8x decrease against the full P.1 type vs WA-1 was observed, though overall with a higher ID50 reciprocal value. In 10 Pfizer vaccinee sera 7 days or more post second dose (28 days or more since first vaccination), an average 2.2x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.8x decrease against the full P.1 type vs WA-1 was observed, with similar variant ID50 reciprocal value.	2021	Wang et al. (2021)
H655Y	convalescent plasma escape	Pokay	In convalescent sera one month or more post-infection in Spring 2020, an average 6.5x decrease in reciprocal ID50 value was observed ten key point mutations in Spike in the P.1 lineage vs wildtype. A 3.4x decrease against the full P.1 type vs WA-1 was observed, with better full P.1 ID50 reciprocal value compared to the 10-mutation model.	2021	Wang et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	antibody epitope effects	Pokay	Amongst RBD-targeting Emergency Use Authorized monoclonal antibody treatments CB6, LY-CoV555 and REGN10933 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1, but REGN10987 activity remains strong. RBD-targeting monoclonal antibodies 2-15 and C121 show abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1. N terminal domain targeting monoclonal antibodies 5-7, 4-8, 4-18 and 2-17 have abrogated neutralization activity against the ten key point mutations in Spike in the P.1 lineage vs wildtype or WA-1.	2021	Wang et al. (2021)
H655Y	reinfection	Pokay	After a 128 day interval, a patient in Sao Paulo State, Brazil reinfected with P.1 (first episode likely predates P.1 emergence). Both cases were fairly mild (difficulty breathing, tiredness, dizziness and fatigue).	2021	Malta Romano et al. (2021)
H655Y	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 349 test-positive were Gamma. Two dose vaccine efficacy against Gamma was 95.5 (90.9-97.8%), one dose VE was 74.2 (43.8-88.1%).	2021	Bruxvoort et al. (2021)
H655Y	trafficking	Pokay	~6x cleavage of S2 relative to WA1 (D614G) wildtype by Gamma variant as measured by mass spectrometry of Vero-TMPRSS culture [no mutations directly at furin cleavage site, but H655Y is upstream] Compare to 4.5x or less for variants of concern with direct furin clevage site mutations.	2021	Esclera et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	reinfection	Pokay	Three healthcare workers (29-50yo) had confirmed P.1 [Gamma] re-infection in the Amazonas region of Brazil 3-9 months after initial infection from viruses with distinct lineage from P.1, but mild symptoms upon re-infection and evidence for infectiousness during re-infection.	2021	Naveca et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Mean 3.0x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)
H655Y	convalescent plasma escape	Pokay	Mean 4.1x reduction of NT50 value P.1 (Gamma) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
H655Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Gamma (P.1) variant is 0.6x fold the wildtype.	2022	Kumar et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	The neutralizing activity of vaccine was slightly lower against B.1.1.248 variant constellation in sera tested from most of the 15 patients with the BNT162b2 mRNA vaccine. (Fig. 4)	2021	Chen et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	ELISpot assays show T cell neutralization reduced by 16.6% in this B.1.1.248 pseudotype relative to wild type in 18-20 pooled patient samples post second mRNA vaccine dose, with no significant difference between Pfizer and Moderna cohorts. Reduction was stronger in the S1 subunit than S2 (separate peptide pools were used).	2021	Gallagher et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	antibody epitope effects	Pokay	B.1.1.248 variant constellation ablates Class 1 receptor-binding-mot if targeting antibodies COV2-2050, 1B07. B.1.1.248 variant constellation ablates Class 3 N-terminal domain targeting antibody COV2-2676.	2021	Chen et al. (2021)
H655Y	convalescent plasma escape	Pokay	B.1.1.7 variant constellation two-tailed Wilcoxon matched-pairs signed-rank test against 10 convalescent sera P	2021	Chen et al. (2021)
H655Y	anthropozoonotic events	Pokay	Unlike wild type or B.1.1.7, P.1 lineage virus was able to infect and replicate in common lab mouse strains, with high titer.	2021	Montagutelli et al. (2021)
H655Y	convalescent plasma escape	Pokay	B.1.1.248 variant constellation in 10 convalescent human sera ~1mo post infection had mild to moderate resistance against most samples, P	2021	Chen et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Neutralizing antibody titers increased in previously infected vaccinees relative to uninfected vaccinees 4.3-fold against P.1 (contrast with 3.4 fold against original SARS-CoV-2).	2021	Leier et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Pseudotyped P.1 virus has reduced neutralization activity vs wild type: 6.7x (30 sera Pfizer median 9 days post 2nd dose) and 4.5x (35 sera Moderna median 18 days post 2nd dose). This was significant by ANOVA.	2021	Garcia-Beltran et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Using P.1 defining mutations for Spike, observed 4x average decrease in neutralization efficiency (but still relevant titres) for sera from 10 BNT162b2 vaccinees 12 days after second dose, but only one relevant titre 12 days after first dose. Compares unfavorably to wild type or B.1.1.7 titres.	2021	Alenquer et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	vaccine neutralization efficacy	Pokay	In human sera 8 weeks post-vaccination with INO-4800, a ~2-fold reduction in P.1 neutralization was observed.	2021	Andrade et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Among 46,884 HCWs in Manaus, Brazil vaccinated with at least one dose of CoronaVac, a 0.50-fold reduction (adjusted vaccine effectiveness, 49.6%: 95% CI, 11.3 - 71.4) in the odds of symptomatic SARS-CoV-2 infection was observed during the period 14 days or more after receiving the first dose. Estimated vaccine effectiveness of at least one dose against any SARS-CoV-2 infection was 35.1% (95% CI, –6.6 - 60.5) in the same time period.	2021	Hitchlings et al. (2021)
H655Y	pharmaceutical effectiveness	Pokay	VSV pseudotype P.1 entry mediated by the S proteins of the P.1 variant was completely resistant to blocking by REGN10989 and Bamlanivimab. Cell fusion proficiency was slight impaired. Entry driven by the S proteins of the B.1.351 was partially resistant against Casirivimab.	2021	Hoffman et al. (2021)
H655Y	convalescent plasma binding	Pokay	VSV pseudotype P.1 showed 4.8-fold decrease in NT50 vs wild type in sera from 9 ICU patients undergoing treatment in Germany (pre-variant infections).	2021	Hoffman et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	VSV pseudotype P.1 showed 5.12-fold reduction in neutralization efficiency vs wild type in 15 Pfizer BNT162b2 vaccinee sera 13-15 days post second dose. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)
H655Y	trafficking	Pokay	VSV pseudotype P.1 showed slight decrease in cell entry relative to wild type in 262T and 263T-ACE2 (kidney) cell lines. Cell fusion proficiency was slight impaired.	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	convalescent plasma binding	Pokay	Neutralizing antibodies that were generated following a mild infection with SARS-CoV-2 B.1.128 were effective in vitro, and likely protective, against the SARS-CoV-2 P.1. variant in the majority of individuals based on 60 convalescent sera tested.	2021	Mendes-Correa et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	PBMCs of Pfizer/BioNTech BNT162b2 (n	2021	Tarke et al. (2021)
H655Y	convalescent plasma escape	Pokay	In 13 plasma collected ~1mo after B.1.1.7 infection (nursing home in Ticino, Switzerland), neutralization reduced to undetectable levels in many plasma for P.1 pseudotyped virus, as well as WT and other VOCs. [paper does not detail the P.1 variants used, using the most popular as a stand in]	2021	McCallum et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	1.15x *increase* in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees)	2021	Gong et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against P.1 reduced 3.2x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	pharmaceutical effectiveness	Pokay	P.1 virus neutralization (as tested using biolayer interferometry) of both Lilly antibodies was severely impacted, with Lilly mAb combination LY-CoV16 and LY-CoV555 (due to mutations at 416 and 484 respectively) shows almost complete loss of neutralization of P.1. There was also escape from neutralization of P.1 by REGN10933 (one of 2 in Regeneron's mAb cocktail) and a modest reduction in neutralization of P.1 by AstraZeneca's AZD8895 (while AZD1061 and AZD7442 showed equal neutralization of all SARS-CoV-2 variants tested). The three Adagio antibodies neutralized P.1 with all reaching a plateau at 100% neutralization: interestingly, ADG30 showed a slight increase of neutralization of P.1. S309 Vir was largely unaffected, although for several viruses, including P.1, the antibody failed to completely neutralize, conceivably reflecting incomplete glycosylation at N343, since the sugar interaction is key to binding of this antibody.	2021	Dejnirattisai et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	P.1 lineage titers were reduced 7.6-fold and 9-fold for the BNT162b2 Pfizer (sera collected 4-14 days post-booster) and ChAdOx1 nCoV-19 AstraZeneca (sera collected 14 or 28 days post-booster) vaccines respectively.	2021	Dejnirattisai et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	In sera 1-2 weeks after BNT162b2 first dose, from six patients previously infected with B.1, antibody titer in a microneutralization assay was on average 2896 for P.1 virus. This compares favorably (stronger) to post-infection neutralization titer against all variants tested in the same sera (wild type, B.1.1.7, B.1.351, and P.1).	2021	Luftig et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	convalescent plasma binding	Pokay	In sera from six patients collected 1 to 12 weeks post-infection with B.1, antibody titer in a microneutralization assay was on average 256 for B.1.1.7 virus. Compare to somewhat stronger neutralization titer for wild type (456.1) in the same sera.	2021	Luftig et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Detectable antibodies against P.1 at various time points using pseudovirus neutralization in Moderna vaccinee cohort: Day 43 100%, Day 209 85%.	2021	Pegu et al. (2021)
H655Y	T cell evasion	Pokay	PBMCs of 11 mild COVID-19 patients collected 38-80 days after symptom onset were stimulated with the 15-mer peptide pools (w/ 10 residue overlaps) from the wholle viral proteome, showing no significant CD4+ cell count effect for P.1, and a slight increase in CD8+ percentage (p	2021	Tarke et al. (2021)
H655Y	transmissibility	Pokay	The relative transmissibility of P.1 estimated at the national level (Italy) varied according to the assumed degree of cross-protection granted by infection with other lineages and ranged from 1.12 (95%CI 1.03-1.23) in the case of complete immune evasion by P.1 to 1.39 (95%CI 1.26-1.56) in the case of complete cross-protection. PG: variant list has been abbreviated due to mixed K417 bases in this lineage, potential miscalls of deletions	2021	Stefanelli et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	outcome hazard ratio	Pokay	In the Parana state of Brazil, patients aged 20-29 years experienced a tripling of their case fatality rate (CFR), from 0.04% to 0.13%, while those aged 30-39, 40-49, 50-59 experienced approximate CFR doubling comparing February to January in 2021. Notably, the observed CFR increase coincided with the second consecutive month of declining number of diagnosed SARS-CoV-2 cases. Taken together, these preliminary findings suggest significant increases in CFR in young and middle-aged adults after identification of a novel SARS-CoV-2 strain circulating in Brazil. [this is somewhat indirect evidence that assume greatly increasing proportion of P.1 cases in March (70%) compared to February, but the first official ID of P.1 in Parana state (Feb 16th) may be due to testing procedures rather than actual prevalence]	2021	Santos de Oliviera et al. (2021)
H655Y	outcome hazard ratio	Pokay	In the Southern Brazilian stats of Rio Grande do Sul, comparing pre-P.1 and post-P.1 waves: The increase in Case Fatality Rate occurred in a greatest intensity in the population between 20 and 59 years old and among patients without pre-existing risk conditions. Female 20 to 39 years old, with no pre-existing risk conditions, were at risk of death 5.65 times higher in February (95%CI	2021	Ribas Freitas et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	outcome hazard ratio	Pokay	On average across 7 European countries studied, using P.1 defining mutations: Significant shift to infection in those without pre-existing conditions (27.8% vs 89% for non-VOC cases). Significant increase in hospitalization rate (20% vs 7.5% for non-VOC cases). Significant increase in ICU rate (2.1% vs 0.6% for non-VOC cases). Significant increase in health care worker rate (19.8% vs 8.0% for non-VOC cases).	2021	Funk et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	This variant was designated A.27.RN according to its phylogenetic clade classification. It emerged in parallel with the B.1.1.7 variant, increased to >50% of all SARS-CoV-2 variants by week five. Subsequently it decreased to <10% of all variants by calendar week eight when B.1.1.7 had become the dominant strain. Antibodies induced by BNT162b2 (Pfizer) vaccination neutralized A.27.RN but with a two-to-threefold reduced efficacy as compared to the wild-type and B.1.1.7 strains.	2021	Mallm et al. (2021)
H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
H655Y	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
H655Y	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
H655Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
H655Y	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
H655Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
H655Y	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
H655Y	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
H655Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
H655Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
H655Y	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against A.VOI.V2 (first identified in Angola) reduced 8.0x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)

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H655Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
H655Y	anthropozoonotic events	Pokay	Mouse-adapted SARS-CoV-2 mutations after 11 serial passages in various immunocompromised mice strains.	2021	Rathnasinghe et al. (2021)
H655Y	convalescent plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.3x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
H655Y	vaccinee plasma binding	Pokay	This variant combination (representing P.1 aka Gamma) showed a 1.14x decrease in Spike binding (relative to D614G alone) by 5 plasma 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.27x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing P.1 aka Gamma) showed a 4.24x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
H655Y	convalescent plasma binding	Pokay	1.48x increase in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset.	2021	Gong et al. (2021)
H655Y	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant showed a 1.21x increase in binding (KD) relative to D614G.	2021	Gong et al. (2021)
H655Y	vaccinee plasma binding	Pokay	1.04x increase in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.09x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees.	2021	Gong et al. (2021)
H655Y	homoplasy	Pokay	In experimental models of SARS-CoV-2 mutational evolution (without immune pressure), this mutation in the N terminal domain appears convergent.	2021	Borges et al. (2021)
H655Y	anthropozoonotic events	Pokay	Six minks were intranasally infected with WA1 isolate, all developed this mutation during infection.	2021	Esclera et al. (2021)
H655Y	anthropozoonotic events	Pokay	This mutation outside the receptor binding domain increases the virus transduction rate in tree shrew (Tupaia belangeri), (as it does in humans) according to pseudotyped VSV experiments.	2023	Li et al. (2023)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
H655Y	virion structure	Pokay	Estimated free energy change (ddG) for this variant is 0.87 kcal/mol (i.e. stabilizing relative to wild type)	2021	Spratt et al. (2021)
N679K	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N679K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

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N679K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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N679K	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
N679K	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

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N679K	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N679K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
N679K	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

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N679K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N679K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N679K	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N679K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N679K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
N679K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
N679K	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

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N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
N679K	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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N679K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N679K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 6.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
P681R	pharmaceutical effectiveness	Pokay	DARPin SR16m molecule had a 99.7x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
P681R	trafficking	Pokay	In two of eight cell lines tested (Caco-2 intenstinal and Calu-3 lung), a modest increase in cell entry was observed. This increase was not observed in a Calu-3 cell line with overexpressed ACE2. [the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
P681R	convalescent plasma escape	Pokay	Approximately 2-fold reduction in 15 ICU patient convalescent plasma neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction. [PG: note that the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	antibody epitope effects	Pokay	Abrogates Bamlanivimab neutralization as quantified by measuring virus-encoded luciferase activity in cell lysates at 16-18 h post transduction. Significant decrease in combined Etesevimab+Bamlanivimab neutralization except at the highest concentration measured. [PG: note that the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	In 15 Pfizer non-senior vaccinee sera collected 3-4 weeks post-booster [using Table S1, not the text that says 2-3 weeks], neutralization was reduced ~3x (compared to ~11x for B.1.351). [the virus tested as B.1.617 overlaps only partially with the Spike mutation lists used by PANGO, CDC, etc. for this lineage therefore the results should be interpreted carefully as transferable to B.1.617 generally]	2021	Hoffman et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.4x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Relative to B.1, Delta (B.1.617.2) shows mean 2.1x decrease in neutralization efficiency by 18 vaccinee sera (BNT162b2 and mRNA1273).	2021	Wilhelm et al. (2021)
P681R	convalescent plasma escape	Pokay	Relative to B.1, Delta (B.1.617.2) shows 3.64x decrease in neutralization efficiency by convalescent plasma [no cohort details provided]	2021	Wilhelm et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	trafficking	Pokay	~3.5x cleavage of S2 relative to WA1 (D614G) wildtype by Kappa (B.1.617.1) variant as measured by mass spectrometry of Vero-TMPRSS culture (compare to ~4.5x for closely related Delta B.1.617.2 also with P681R at the cleavage site).	2021	Esclera et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	1.5x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees) [exact set of variants used is not listed in the manuscript]	2021	Gong et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Inferring from two B.1.617.1 variants tested, estimate baseline 3.3x reduction in ID50 relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
P681R	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.617.1) showed a 2x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Average 2x neutralization efficiency decrease against sera from 26 Phase II trial Covaxin (BBV152) vaccine recipents. Very similar to B.1.1.7 (~2x) in the same study, and the neutralization from 17 sera of natural infections across B1 lineages.	2021	Yadav et al. (2021)
P681R	convalescent plasma escape	Pokay	Relative to B.1, Kappa (B.1.617.1) shows 5.71x decrease in neutralization efficiency by convalescent plasma [no cohort details provided]	2021	Wilhelm et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine neutralization efficacy	Pokay	Relative to B.1, Kappa (B.1.617.1) shows mean 1.97x decrease in neutralization efficiency by 18 vaccinee sera (BNT162b2 and mRNA1273).	2021	Wilhelm et al. (2021)
P681R	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.617.1) showed a 1.79x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.64x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
P681R	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.617.1) showed a 1.12x increase in binding (KD) relative to D614G, but described as 'not significant'. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Kappa (B.1.617.1) has an IC50 fold change of 80.2x.	2022	Yuan et al. (2022)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Kappa (B.1.617.1) has an IC50 fold change of 2.3x.	2022	Yuan et al. (2022)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Kappa (B.1.617.1) has an IC50 fold change of 0.68x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Kappa (B.1.617.1) has an IC50 fold change of 0.13x.	2022	Yuan et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	In a cluster of B.1.617[.1] infections related to travel from India to USA, one patient with mild symptoms had received their second dose of Pfizer vaccine more than two weeks before the infection [i.e. vaccine breakthrough].	2021	Verghese et al. (2021)
P681R	trafficking	Pokay	~4.5x cleavage of S2 relative to WA1 (D614G) wildtype by Delta (B.1.617.2) variant as measured by mass spectrometry of Vero-TMPRSS culture (compare to ~3.5x for closely related Kappa B.1.617.1 also with P681R at the cleavage site).	2021	Esclera et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against B.1.617.1-v1 ('Kappa') reduced 3.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster. [Mutation list in publication appears to contain a typo with R158del instead of R158G]	2021	Choi et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Mean 2.6x reduction of NT50 value B.1.617.2 (Delta) relative to wild type in 8 sera from adult BNT162b2 vaccinees (28-47yo) collected ~1m post booster.	2021	Uriu et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	convalescent plasma escape	Pokay	Mean 4.0x reduction of NT50 value B.1.617.2 (Delta) relative to wild type in 8 sera from older convalescent patients (52-92yo) collected 1-3m post symptom onset.	2021	Uriu et al. (2021)
P681R	trafficking	Pokay	Modelling the Delta variant in primary human airway epithelial (HAE) cultures, S1 to full length Spike ratio (measuring Spike furin cleavage processivity) increased 11x relative to wild type (15.3 vs 1.4). [del ~157 truncated due to ambiguity] Furthermore the RNA ratio of Delta versus Alpha-spike/Delta-backbone continuously increased from 2.8 on day 1 to 9.8 on day 5 post infection in a coinfection model in HAEs, suggesting the spike gene drives the improved replication of Delta variant.	2021	Liu et al. (2021)
P681R	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR22 had a 0.10x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
P681R	pharmaceutical effectiveness	Pokay	Trimeric proteins FSR16m had a 0.020x fold change in IC50 in B.1.617.2 Delta	2022	Chonira et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Plasma neutralizing activity was also assessed against SARS-CoV-2 Delta, Omicron BA.1, BA.2 and BA.4/5 variants using viruses pseudotyped with appropriate variant spikeproteins. Delta breakthrough infection resulted in 15-fold increased neutralizing titers.	2022	Wang et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 507 pM for binding to the Delta B.1.617.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Plasma neutralizing activity in 49 participants was measured using HIV-1 pseudotyped with the 100 WT SARS-CoV-2 spike protein. Delta breakthrough infection resulted in 11-fold increased geometric mean half-maximal neutralizing titer (NT50).	2022	Wang et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Log10ID50 of Delta neutralizing antibodies is 0.872x the WT pre-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Paradigm's ACE-2 variant LVE/STR chimera neutralizes Delta Variant B.1.617.2 RBD or w.t. SARS-CoV-2 RBD with nearly equal potency determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Log10ID50 of Delta neutralizing antibodies is 0.952x the WT 1 month post-third dose of pfizer-BioNTech BNT162b2 in 13 Kidney transplant recipients (KTR) with median age of 55.5.	2022	McEvoy C et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	outcome hazard ratio	Pokay	In the UK, of 43338 COVID-19-positive patients, 8682 had the Delta variant (median age 31 years [IQR 17–43]) and 196 were admitted to hospital within 14 days after the specimen was taken (adjusted hazard ratio [HR] 2.26 [95% CI 1.32–3.89] relative to Alpha cases). Being admitted to hospital or attending emergency care within 14 days for Delta cases had an adjusted HR 1.45 [95% CI 1.08–1.95] relative to Alpha. Most patients were unvaccinated (32 078 [74·0%] across both groups). The HRs for vaccinated patients were similar: 1.94 [95% CI 0.47–8.05] for hospitalization and 1.58 [0.69–3.61]) for hospital admission or emergency care attendance.	2021	Twohig et al. (2021)
P681R	vaccine efficacy	Pokay	During December 14, 2020–August 14, 2021, frontline worker without previous documented SARS-CoV-2 infection were monitored regularly. Of 4,217 participants, 3,483 (83%) were vaccinated: 2,278 (65%) received Pfizer-BioNTech, 1,138 (33%) Moderna, and 67 (2%) Janssen (Johnson & Johnson) COVID-19 vaccines. Adjusted VE during this Delta predominant period was 66% (95% CI	2021	Fowlkes et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Case 62541 cluster in Singapore included a fully vaccinated nurse 2 months post-vaccine [likely Pfizer based on dates and supply], and a doctor of unknown vaccine status. This cluster was caused by a B.1.617.2 virus [via crossreference to		UNKNOWN et al. ()

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccinee plasma binding	Pokay	This variant combination (representing lineage B.1.617.2 aka Delta) showed a 1.64x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in previously non-seroconverted subjects. 1.89x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 3 weeks after one dose of Pfizer/BioNtech BNT162b2 vaccine in post-infection vaccinees. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	nan		UNKNOWN et al. ()
P681R	vaccine efficacy	Pokay	136,160 reports from 14,997 nursing care facilities were broken into pre-Delta (Mar 1-May 9, 2021), intermediate (May 10-Jun 20, 2021) and Delta (Jun 21-Aug 1, 2021). Two doses of mRNA vaccines were 74.7% effective against infection among nursing home residents early in the vaccination program (March–May 2021). During June–July 2021, when B.1.617.2 (Delta) variant circulation predominated, effectiveness declined significantly to 53.1%.	2021	Nanduri et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine efficacy	Pokay	Using a matched test-negative, case- control study design in Qatar, BNT162b2 effectiveness against any Delta infection, symptomatic or asymptomatic, was 64.2% (95% CI: 38.1-80.1%) ≥14 days after the first dose and before the second dose, but was only 53.5% (95% CI: 43.9-61.4%) ≥14 days after the second dose, in a population in which a large proportion of fully vaccinated persons received their second dose several months earlier. Corresponding effectiveness measures for mRNA-1273 were 79.0% (95% CI: 58.9-90.1%) and 84.8% (95% CI: 75.9-90.8%), respectively. Effectiveness against any severe, critical, or fatal COVID-19 disease due to Delta was 89.7% (95% CI: 61.0-98.1%) for BNT162b2 and 100.0% (95% CI: 41.2-100.0%) for mRNA-1273, ≥14 days after the second dose. The lower VE in Qatar relative to those reported in some other jurisdictions such as the UK and Canada (75%+) may reflect waning of vaccine protection for those who received their second dose by end of 2020 or early 2021. Risk perception and behaviour amongst vaccinated individuals opver time may also play a role.	2021	Tang et al. (2021)
P681R	outcome hazard ratio	Pokay	In Denmark, for the period Jan 1 to Jun 27, 2021, Delta variant was associated with increased an risk ratio of 2.83 [95% CI 2.02–3.98] for hospitalization.	2021	Bager et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine efficacy	Pokay	Of 218 individuals with B.1.617.2 infection in Singapore, 84 had received a mRNA vaccine of which 71 were fully vaccinated, 130 were unvaccinated and 4 received a non-mRNA. Despite significantly older age in the vaccine breakthrough group, the odds of severe COVID-19 requiring oxygen supplementation was significantly lower following vaccination (adjusted odds ratio 0.07 95%CI: 0.015-0.335, p	2021	Chia et al. (2021)
P681R	vaccine efficacy	Pokay	The incidence rate of Covid-19 during the Delta-dominant period (Jul-Aug 2021) was lower for late vaccinated (49.0/1000 person-years) [formerly placebo] versus early vaccinated (77.1/1000 person-years) participants in the Moderna mRNA-1273 Phase 3 trials, representing a 36.4% VE reduction (95% CI 17.1%-51.5%). There were fewer severe Covid-19 cases in the late group (6: 6.2/1000 person-years) than early (13: 3.3/1000 person-years), representing a 46.0% reduction (95% CI –52.4%-83.2%). Three Covid-19 related hospitalizations occurred with two resulting deaths in the early group.	2021	Baden et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	2.3x reduction in neutralization (ID50) in sera 3 weeks after one dose of Pfizer/BioNTech BNT162b2 (up to 5 naive and post infection vaccinees) [exact set of variants used is not listed in the manuscript]	2021	Gong et al. (2021)
P681R	pharmaceutical effectiveness	Pokay	Infectious viral titers in lung tissue determined using a tissue culture infectious dose (TCID) assay in 10 hamsters showed that Delta Molnupiravir (MK-4482) had ~4x fold drop.	2022	Rosenke et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine efficacy	Pokay	Using a test-negative design using Ontario data between Dec 14, 2020 and May 30, 2021, 421,073 symptomatic community-dwelling individuals were tested. Against Delta, vaccine effectiveness after partial vaccination tended to be lower compared to Alpha for mRNA-1273 (72% vs. 83%) and BNT162b2 (56% vs. 66%), but was similar to Alpha for ChAdOx1 (67% vs. 64%). Full vaccination with BNT162b2 increased protection against Delta (87%) to levels comparable to Alpha (89%) and Beta/Gamma (84%). Delta-positive cases were biased towards young male residents of the Peel region.	2021	Nasreen et al. (2021)
P681R	outcome hazard ratio	Pokay	In Ontario between Feb 7 and Jun 27, 2021, increased risk with the Delta variant was 108% (95% CI 78%–140%) for hospitalization, 235% (95% CI 160%–331%) for ICU admission and 133% (95% CI 54%–231%) for death.	2021	UNKNOWN et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Vaccination of health care workers in Delhi was started in early 2021, with the ChdOx-1 (Astra Zeneca) vaccine. Surveillance has suggested B.1.1.7 dominance in the Delhi area during early 2021, with growth of B.1.617 since March 2021. During the wave of infections during March and April an outbreak of SARS-CoV-2 was confirmed in 33 vaccinated staff members at a single tertiary centre (age 27-77 years). Sequencing revealed that 16/33 were B.1.617.2, with a range of other B lineage viruses including B.1.1.7 for the rest except one A lineage case. Importantly no severe cases were documented in this event.	2021	Ferreira et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine efficacy	Pokay	Effectiveness after one dose of vaccine (BNT162b2 or ChAdOx1 nCoV-19) with the delta variant was (30.7%: 95% confidence interval [CI], 25.2 to 35.7): the results were similar for both vaccines. With the BNT162b2 vaccine, the effectiveness of two doses was 88.0% (95% CI, 85.3 to 90.1) among those with the delta variant. With the ChAdOx1 nCoV-19 vaccine, the effectiveness of two doses was 67.0% (95% CI, 61.3 to 71.8) among those with the delta variant.	2021	Lopez Bernal et al. (2021)
P681R	convalescent plasma binding	Pokay	This variant combination (representing lineage B.1.617.2 aka Delta) showed a 1.92x decrease in Spike binding (relative to D614G alone) by 5 plasma collected 8 months post-symptom-onset. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)
P681R	ACE2 receptor binding affinity	Pokay	Using flow cytometry and ACE2 ectodomains-Fc portion IgG complex, this variant combination (representing lineage B.1.617.2 aka Delta) showed a 2.34x increase in binding (KD) relative to D614G. [exact variant list not provided in manuscript, is inferred and represents minimal set agreed upon commonly]	2021	Gong et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	vaccine efficacy	Pokay	In Minnesota in July 2020 (when Delta variant prevalence was >70%), the effectiveness against infection for mRNA-1273 was estimated at 76% (95% CI: 58-87%) using age, sex, race, PCR testing and vaccination date matched cohorts of unvaccinated, Pfizer and Moderna vaccinees. An even more pronounced reduction in effectiveness was observed for BNT162b2 of 42% (95% CI: 13-62%). mRNA-1273 conferred a two-fold risk reduction against breakthrough infection compared to BNT162b2 (IRR	2021	Puranik et al. (2021)
P681R	vaccine efficacy	Pokay	In a 1:5 test-negative matched control study of 8153 individuals who received the Moderna mRNA-1273 vaccine, 2027 test-positive cases were Delta. Two dose vaccine efficacy against Delta decreased from 94.1% (90.5-96.3%) 14-60 days after vaccination to 80.0% (70.2-86.6%) 151-180 days after vaccination. Waning was less pronounced for non-Delta variants. VE against Delta was lower among individuals aged ≥65 years (75.2% [59.6-84.8%]) than those aged 18-64 years (87.9% [85.5-89.9%]). VE against Delta hospitalization was 97.6% (92.8-99.2%). One-dose VE was 77.0% (60.7-86.5%) against Delta infection.	2021	Bruxvoort et al. (2021)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Delta (B.1.617.2) has an IC50 fold change of 46.5x.	2022	Yuan et al. (2022)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Delta (B.1.617.2) has an IC50 fold change of 0.57x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Delta (B.1.617.2) has an IC50 fold change of 0.15x.	2022	Yuan et al. (2022)
P681R	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Delta (B.1.617.2) has an IC50 fold change of 0.87x.	2022	Yuan et al. (2022)
P681R	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Delta (B.1.617.2) variant is 0.6x fold the wildtype.	2022	Kumar et al. (2022)
P681R	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against A.23.1-v2 reduced 2.3x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
P681R	vaccine neutralization efficacy	Pokay	Neutralization efficiency (ID50) against A.23.1-v1 reduced 1.1x relative to D614G wildtype using pseudotyped VSV assay on 8 Moderna vaccinee sera one week post-booster.	2021	Choi et al. (2021)
P681R	trafficking	Pokay	This variant combination shows a ~3x decrease in cell entry efficiency (RLU measurement in 293T cells) compared to D614G, significantly less of a decrease than any B.1.617 lineage variants alone, suggesting a synergistic effect on cell entry while maintaining known immunity esacpe mutants.	2021	Ferriera et al. (2021)
P681R	viral load	Pokay	In 9 infected hamsters each for B.1 and B.1.617.1, no significant change in viral load or subgenomic RNA levels were detected.	2021	Yadav et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	symptom prevalence	Pokay	Gross examination of 3+3 hamster lung specimens showed pronounced congestion and hemorrhages on days 5 and 7 post-infection in the case of the B.1.617.1 as compared with the B.1. The lung lesions with the B.1 variant were minimal to mild whereas with B.1.617.1 they were moderate. For B.1 pneumonic changes were minimal to mild (inflammatory cell infiltration, focal consolidation and mild congestion). The pronounced changes (moderate to severe) with mononuclear infiltration in the alveolar interstitial space, interstitial septal thickening, consolidation and pneumocyte hyperplasia were observed with B.1.617.1 variant consistently.	2021	Yadav et al. (2021)
P681R	transmissibility	Pokay	Normalized for particle number, on ACE2.293T cells showed that the B.1.617 spike protein was >2-fold increase in infectivity relative to D614G wild type.	2021	Tada et al. (2021)
P681R	trafficking	Pokay	This mutation in the first base of the furin clevage site maintains the RXXR recognition motif, and is presumed to enhance cleavage based on the removal of a proline-directed phosphotase recognition site at S680. In a homologuous site in Infectious Bronchitis Virus (IBV, Gammacoronaviruses), abolition of S680 phosphorylation improves furin cleavage (and presumably cell entry). [Inference from similar positively charged substitution P681H actually described in the work]	2021	UNKNOWN et al. (2021)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
P681R	virion structure	Pokay	The Ratio of S2 (processed Spike) to full length Spike is higher for this mutation, due to a drop in the full length Spike measured, suggesting that this mutation compensates for decreased Spike production by improved proteolytic processing. [PG: Inferred by conservative AA substitution of described P681H]	2021	Tada et al. (2021)
P681R	trafficking	Pokay	Quantification of the band intensities showed that the P681R mutation, which lies near the proteolytic processing site, caused a small increase in proteolytic processing as measured by a 2-fold decrease in the ratio of S/S2.	2021	Tada et al. (2021)
N764K	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
N764K	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N764K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
N764K	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N764K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N764K	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N764K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
N764K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
N764K	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
N764K	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N764K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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D796Y	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
D796Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
D796Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
D796Y	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
D796Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
D796Y	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
D796Y	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
D796Y	vaccine neutralization efficacy	Pokay	This variant was designated A.27.RN according to its phylogenetic clade classification. It emerged in parallel with the B.1.1.7 variant, increased to >50% of all SARS-CoV-2 variants by week five. Subsequently it decreased to <10% of all variants by calendar week eight when B.1.1.7 had become the dominant strain. Antibodies induced by BNT162b2 (Pfizer) vaccination neutralized A.27.RN but with a two-to-threefold reduced efficacy as compared to the wild-type and B.1.1.7 strains.	2021	Mallm et al. (2021)
D796Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D796Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
D796Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

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D796Y	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
D796Y	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
D796Y	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)

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D796Y	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
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D796Y	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
D796Y	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
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D796Y	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

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D796Y	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

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D796Y	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
D796Y	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
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D796Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D796Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D796Y	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
D796Y	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
S939F	anthropozoonotic events	Pokay	This mutation outside the receptor binding domain significantly reduced the tropism of SARS-CoV-2 to MfuKi (eastern bent-wing bat kidney cell, Miniopterus fuliginosus) cell cultures using a pseudotyped VSV assay.	2023	Li et al. (2023)
Q954H	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
Q954H	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
Q954H	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
Q954H	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
Q954H	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Q954H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Q954H	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
Q954H	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
Q954H	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)
Q954H	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
Q954H	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
Q954H	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	pharmaceutical effectiveness	Pokay	Omicron BA.2 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.2 has an IC50 fold change of 0.07x.	2022	Yuan et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.2 has an IC50 fold change of 0.09x.	2022	Yuan et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.2 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.2 has an IC50 fold change of 0.04x.	2022	Yuan et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	Omicron BA.2 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N969K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.2 variant is 0.8x fold the wildtype.	2022	Kumar et al. (2022)
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 3.9x-fold lower (95% CI: 0.14x-0.17x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 78fM for binding to the Omicron BA.2. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2 (from South Africa/CERI-KRISP-K03 2307/2021) were 4.5-fold lower (95% CI: 4.3x-4.7x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 4.2-fold lower (95% CI: 5.8x-6.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.2.12.1 (from USA/NY-CDC-ASC2 10722700/2022) were 3.9x-fold lower (95% CI: 0.14x-0.18x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	pharmaceutical effectiveness	Pokay	Omicron (a.k.a. B.1.1.529) Spike pseudotyped VSV and Vero E6 cells has somewhat reduced neutralization (2.7x) vs wild type with monoclonal antibody Sotrovimab (a.k.a. VIR-7831). [delins at 214 omitted for syntax compatibility]	2021	Cathcart et al. (2021)
N969K	vaccine neutralization efficacy	Pokay	Omicron breakthrough infection after 3-dose vaccination resulted in a further 3.5-fold and 2.9-fold increase of Omicron BA.1 and BA.2 neutralizing titers. Omicron BA.4/5 showed the highest neutralization resistance of all variants tested, resulting in low geometric mean neutralizing titers in plasma samples obtained after the second vaccine dose (NT50	2022	Wang et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab47D10-35B5. Omicron BA.1 has an IC50 fold change of 0.08x.	2022	Yuan et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	Omicron B.1.1.529 (BA.1) neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N969K	pharmaceutical effectiveness	Pokay	Omicron (B.1.1.529 [BA.1]) have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs Bi-Nab35B5-47D10. Omicron BA.1 has an IC50 fold change of 0.30x.	2022	Yuan et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	vaccine neutralization efficacy	Pokay	Paradigms' ACE-2 variant LVE/STR chimera binds to SARS-2 Omicron variant B.1.1.529 spike protein trimer with high affinity. Determined using Surrogate Viral Neutralization Tests.	2022	Uhal B et al. (2022)
N969K	ACE2 receptor binding affinity	Pokay	L27, V34 and E90 mutation resulted in ultrahigh affinity binding of the LVE-ACE-2 domain to the widest variety of VOCs, with KDs of 73 pM for binding to the Omicron B.1.1.529. Values were obtained with LVE-ACE-2/mAB chimeras containing the Y-T-E sequence that enhances binding to the FcRn receptor, which in turn is expected to extend biological half-life 3-4-fold.	2022	Uhal B et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs 35B5. Omicron BA.1 has an IC50 fold change of 0.38x.	2022	Yuan et al. (2022)
N969K	vaccinee plasma binding	Pokay	All 10 individuals with 2 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 729 NT50.	2022	Arora et al. (2022)
N969K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Delta variant and was used to determine neutralizing antibodytitres. There was a 24.63x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 4.21x fold increase in antibody response pre-reinfection. There was a 39.27x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against B.1 variant and was used to determine neutralizing antibodytitres. There was a 6.76x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 2.06x fold increase in antibody response pre-reinfection. There was a 8.18x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N969K	vaccinee plasma binding	Pokay	All 10 individuals with 3 doses of the BNT162b2/BNT162b2 vaccine had a neutralizing titer in B.1 variant at an average of 3319 NT50.	2022	Arora et al. (2022)
N969K	antibody epitope effects	Pokay	Plaque reduction neutralization test (PRNT) was used uring primary infection, post sixty daysof second dose vaccination, pre-reinfection and reinfection against Omicron variant and was used to determine neutralizing antibodytitres. There was a 114.84x fold increase in antibody response from first infection to recovered and vaccinated with 2 doses (60 days). There was a 6.61x fold increase in antibody response pre-reinfection. There was a 1194.9x fold increase in antibody response during reinfection.	2022	Shete et al. (2022)
N969K	antibody epitope effects	Pokay	BnAb 002-S21F2 IC50 on the Omicron BA.1 variant is 1.0x fold the wildtype.	2022	Kumar et al. (2022)
N969K	antibody epitope effects	Pokay	Neutralization of the bsAbs 47D10. Omicron BA.1 has an IC50 fold change of 1.26x.	2022	Yuan et al. (2022)

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N969K	pharmaceutical effectiveness	Pokay	Omicron BA.3 have higher sensitivity to inhibition by soluble angiotensin converting enzyme 2 (ACE2) and the endosomal inhibitor chloroquine compared to D614G	2022	Neerukonda et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	Omicron BA.3 neutralization of the Omicron variants by antibodies induced by three doses of Pfizer/BNT162b2 mRNA vaccine was 7-8-fold less potent than the D614G, and the Omicron variants still evade neutralization more efficiently.	2022	Neerukonda et al. (2022)
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 4.2x-fold lower (95% CI: 0.15x-0.20x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.3 (from South Africa/NICD-N22404/2021) were 6.2-fold lower (95% CI: 11.8x-14.3x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	paired testing of vaccine sera against ancestral virus compared to Omicron BA.1 shows that 3-dose vaccine regimen provides over 50x fold increase in protection against Omicron(B.1.1.529 [BA.1]) compared to a 2-dose regimen.	2022	Hao et al. (2022)
N969K	pharmaceutical effectiveness	Pokay	4th antigenic exposure with Omicron (B.1.1.529 [BA.1])(n	2022	Wang et al. (2022)

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N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 3.4-fold lower (95% CI: 3.2x-3.6x) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.1 (from Botswana/R40B59_BHP_3321 001248/2021) were 28.7x-fold lower (95% CI: 0.03x-0.05) than against US-WA1/2020 using an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 17.2x-fold lower (95% CI: 0.6x-0.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, BA.4/5 (from) were 13.0-fold lower (95% CI: 4.2x-4.6x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
N969K	vaccinee plasma binding	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 1.5x-fold lower (95% CI: 0.05x-0.07x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
N969K	vaccine neutralization efficacy	Pokay	In 22 Pfizer/BNT162b2-vaccinated sera (ages 26-74, median 65) collected 1 month after dose 3, XD (from) were 4.4-fold lower (95% CI: 4.3x-4.7x) than against 208-428 972-1834 4.3-4.7 US-WA1/2020 usiong an infectious cDNA clone of mNG USA-WA1/2020.	2022	Kurhade et al. (2022)
T9I	homoplasy	Pokay	In experimental models of SARS-CoV-2 mutational evolution (without immune pressure), this mutation appears convergent.	2021	Borges et al. (2021)
T9I	frequency based fitness	Pokay	Calculated to have an increased fitness (11x overrepresentation vs expected count of ~300 in public genome datasets), analysis as of 2023-05-11	2023	UNKNOWN et al. (2023)
D3H	frequency based fitness	Pokay	Calculated to have an increased fitness (227x overrepresentation vs expected count of ~14 in public genome datasets), analysis as of 2023-05-11	2023	UNKNOWN et al. (2023)
Q19E	frequency based fitness	Pokay	Calculated to have an increased fitness (16x overrepresentation vs expected count of ~8 in public genome datasets), analysis as of 2023-05-11	2023	UNKNOWN et al. (2023)
F53F	frequency based fitness	Pokay	Calculated to have an increased fitness (163x overrepresentation vs expected count of ~567 in public genome datasets), analysis as of 2023-05-11	2023	UNKNOWN et al. (2023)

Mutations	Functional Category	Annotation Resource	Functional Effect	Publication Year	Citation
F112F	frequency based fitness	Pokay	Calculated to have an increased fitness (11x overrepresentation vs expected count of ~463 in public genome datasets), analysis as of 2023-05-11	2023	UNKNOWN et al. (2023)
P13L	homoplasy	Pokay	In experimental models of SARS-CoV-2 mutational evolution (without immune pressure), this mutation appears convergent.	2021	Borges et al. (2021)
P13L	T cell evasion	Pokay	Variant causes complete loss of T cell line responsiveness to B*27:05-restricted CD8+ N epitope QRNAPRITF 1-17(2,13).	2021	de Silva et al. (2021)

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