

COVID-19 Correlates of Risk Analysis Report

mock Study

USG COVID-19 Response Biostatistics Team

April 07, 2021

Contents

1	Summary Tables	25
2	Graphical Descriptions of Antibody Marker Data	31
2.1	Boxplots	31
2.2	Weighted RCDF plots	40
2.3	Weighted RCDF plots of threshold correlate concentration for vaccine efficacy	48
2.4	Spaghetti plots	52
2.5	Violin and line plots	54
3	Day 57 Univariate CoR: Cox Models of Risk	303
3.1	Hazard ratios	303
3.2	Marginalized risk and controlled vaccine efficacy plots	308
4	Day 29 Univariate CoR: Cox Models of Risk	313
4.1	Hazard ratios	313
4.2	Marginalized risk and controlled vaccine efficacy plots	318
5	Univariate CoR: Nonparametric Threshold Modeling	323
5.1	Plots and Tables with estimates and pointwise confidence interval for Day 57	324
5.2	Plots and Tables with estimates and pointwise confidence intervals for Day 29	329
5.3	Plots and Tables with estimates and pointwise confidence interval for Day 57 (monotone-corrected)	334
5.4	Plots and Tables with estimates and pointwise confidence intervals for Day 29 (monotone-corrected)	339
5.5	Plots and Tables with estimates and simultaneous confidence bands for Day 57	344
5.6	Plots and Tables with estimates and simultaneous confidence bands for Day 29	349
5.7	Plots and Tables with estimates and pointwise confidence interval for Day 57 (monotone-corrected)	354
5.8	Plots and Tables with estimates and pointwise confidence intervals for Day 29 (monotone-corrected)	359

List of Tables

1.1	Table 1. Demographic and Clinical Characteristics at Baseline in the baseline SARS-CoV-2 negative per-protocol cohort	25
1.2	Table 2. Demographic and Clinical Characteristics at Baseline in the baseline SARS-CoV-2 positive per-protocol cohort	27
1.3	Table 3. Antibody levels in the baseline SARS-CoV-2 negative per-protocol cohort (vaccine recipients)	28
1.4	Table 4. Antibody levels in the baseline SARS-CoV-2 positive per-protocol cohort (vaccine recipients)	29
1.5	Table 5. Antibody levels in the baseline SARS-CoV-2 positive per-protocol cohort (placebo recipients)	30
3.1	Inference for Day 57 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group: Hazard ratios per 10-fold increment in the marker*	303
3.2	Inference for Day 57 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group: Hazard ratios for Middle vs. Upper tertile vs. Lower tertile*	304
4.1	Inference for Day 29 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group: Hazard ratios per 10-fold increment in the marker*	313
4.2	Inference for Day 29 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group: Hazard ratios for Middle vs. Upper tertile vs. Lower tertile*	314
5.1	Table of risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.	325
5.2	Table of risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with pointwise 95% confidence intervals.	326
5.3	Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.	327
5.4	Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.	328
5.5	Table of risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with pointwise 95% confidence intervals.	330
5.6	Table of risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with pointwise 95% confidence intervals.	331
5.7	Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.	332

5.8	Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.	333
5.9	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.	335
5.10	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with pointwise 95% confidence intervals.	336
5.11	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.	337
5.12	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.	338
5.13	Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with pointwise 95% confidence intervals.	340
5.14	Table of monotone-corrected risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with pointwise 95% confidence intervals.	341
5.15	Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.	342
5.16	Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.	343
5.17	Table of risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.	345
5.18	Table of risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals.	346
5.19	Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.	347
5.20	Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.	348
5.21	Table of risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals.	350
5.22	Table of risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals.	351
5.23	Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.	352
5.24	Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.	353
5.25	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.	355
5.26	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals.	356
5.27	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.	357
5.28	Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.	358
5.29	Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals.	360

5.30 Table of monotone-corrected risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals.	361
5.31 Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.	362
5.32 Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.	363

List of Figures

2.1	Boxplots of D57 Ab markers: baseline negative vaccine arm	32
2.2	Boxplots of D57 fold-rise over D1 Ab markers: baseline negative vaccine arm	33
2.3	Boxplots of D29 Ab markers: baseline negative vaccine arm	34
2.4	Boxplots of D29 fold-rise over D1 Ab markers: baseline negative vaccine arm	35
2.5	Boxplots of D57 Ab markers: baseline positive vaccine arm	36
2.6	Boxplots of D57 fold-rise over D1 Ab markers: baseline positive vaccine arm	37
2.7	Boxplots of D29 Ab markers: baseline positive vaccine arm	38
2.8	Boxplots of D29 fold-rise over D1 Ab markers: baseline positive vaccine arm	39
2.9	RCDF plots for D57 Ab markers: baseline negative by treatment arm	40
2.10	RCDF plots for D57 fold-rise over D1 Ab markers: baseline negative by treatment arm	41
2.11	RCDF plots for D29 Ab markers: baseline negative by treatment arm	42
2.12	RCDF plots for D29 fold-rise over D1 Ab markers: baseline negative by treatment arm	43
2.13	RCDF plots for D57 Ab markers: baseline positive by treatment arm	44
2.14	RCDF plots for D57 fold-rise over D1 Ab markers: baseline positive by treatment arm	45
2.15	RCDF plots for D29 Ab markers: baseline positive by treatment arm	46
2.16	RCDF plots for D29 fold-rise over D1 Ab markers: baseline positive by treatment arm	47
2.17	Marker RCDF of D57 anti-Spike binding Ab: baseline negative vaccine arm	48
2.18	Marker RCDF of D57 anti-RBD binding Ab: baseline negative vaccine arm	49
2.19	Marker RCDF of D57 PsV-nAb ID50: baseline negative vaccine arm	50
2.20	Marker RCDF of D57 PsV-nAb ID80: baseline negative vaccine arm	51
2.21	Spaghetti Plots of Marker Trajectory: baseline negative vaccine arm	52
2.22	Spaghetti Plots of Marker Trajectory: baseline positive vaccine arm	53
2.23	lineplots of Binding Antibody to Spike: baseline negative placebo arm (2 timepoints)	54
2.24	lineplots of Binding Antibody to Spike: baseline negative vaccine arm (2 timepoints)	55
2.25	lineplots of Binding Antibody to RBD: baseline negative placebo arm (2 timepoints)	56
2.26	lineplots of Binding Antibody to RBD: baseline negative vaccine arm (2 timepoints)	57
2.27	lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (2 timepoints)	58
2.28	lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (2 timepoints)	59

2.29 lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (2 timepoints)	60
2.30 lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (2 timepoints)	61
2.31 violinplots of Binding Antibody to Spike: baseline negative placebo arm (2 timepoints)	62
2.32 violinplots of Binding Antibody to Spike: baseline negative vaccine arm (2 timepoints)	63
2.33 violinplots of Binding Antibody to RBD: baseline negative placebo arm (2 timepoints)	64
2.34 violinplots of Binding Antibody to RBD: baseline negative vaccine arm (2 timepoints)	65
2.35 violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (2 timepoints)	66
2.36 violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (2 timepoints) . .	67
2.37 violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (2 timepoints)	68
2.38 violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (2 timepoints) .	69
2.39 lineplots of Binding Antibody to Spike: baseline negative placebo arm (3 timepoints)	70
2.40 lineplots of Binding Antibody to Spike: baseline negative vaccine arm (3 timepoints)	71
2.41 lineplots of Binding Antibody to RBD: baseline negative placebo arm (3 timepoints)	72
2.42 lineplots of Binding Antibody to RBD: baseline negative vaccine arm (3 timepoints)	73
2.43 lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (3 timepoints) . .	74
2.44 lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (3 timepoints) . .	75
2.45 lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (3 timepoints) . .	76
2.46 lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (3 timepoints) . .	77
2.47 violinplots of Binding Antibody to Spike: baseline negative placebo arm (3 timepoints)	78
2.48 violinplots of Binding Antibody to Spike: baseline negative vaccine arm (3 timepoints)	79
2.49 violinplots of Binding Antibody to RBD: baseline negative placebo arm (3 timepoints)	80
2.50 violinplots of Binding Antibody to RBD: baseline negative vaccine arm (3 timepoints)	81
2.51 violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (3 timepoints)	82
2.52 violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (3 timepoints) . .	83
2.53 violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (3 timepoints)	84
2.54 violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (3 timepoints) .	85
2.55 lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (2 timepoints) . .	86
2.56 lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (2 timepoints) . .	87
2.57 lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (2 timepoints) . .	88
2.58 lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (2 timepoints) . .	89
2.59 lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (2 time- points)	90
2.60 lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (2 timepoints)	91
2.61 lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (2 time- points)	92
2.62 lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (2 timepoints)	93
2.63 violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (2 timepoints)	94

2.64 violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (2 timepoints)	95
2.65 violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (2 timepoints)	96
2.66 violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (2 timepoints)	97
2.67 violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (2 timepoints)	98
2.68 violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (2 timepoints)	99
2.69 violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (2 timepoints)	100
2.70 violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (2 timepoints)	101
2.71 lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (3 timepoints)	102
2.72 lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (3 timepoints)	103
2.73 lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (3 timepoints)	104
2.74 lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (3 timepoints)	105
2.75 lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (3 timepoints)	106
2.76 lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (3 timepoints)	107
2.77 lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (3 timepoints)	108
2.78 lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (3 timepoints)	109
2.79 violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (3 timepoints)	110
2.80 violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (3 timepoints)	111
2.81 violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (3 timepoints)	112
2.82 violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (3 timepoints)	113
2.83 violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (3 timepoints)	114
2.84 violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (3 timepoints)	115
2.85 violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (3 timepoints)	116
2.86 violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (3 timepoints)	117
2.87 lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (2 timepoints)	118
2.88 lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (2 timepoints)	119
2.89 lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (2 timepoints)	120
2.90 lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (2 timepoints)	121

2.91 lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (2 timepoints)	122
2.92 lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (2 timepoints)	123
2.93 lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (2 timepoints)	124
2.94 lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (2 timepoints)	125
2.95 violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (2 timepoints)	126
2.96 violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (2 timepoints)	127
2.97 violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (2 timepoints)	128
2.98 violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (2 timepoints)	129
2.99 violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condi- tion (2 timepoints)	130
2.100violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (2 timepoints)	131
2.101violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condi- tion (2 timepoints)	132
2.102violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (2 timepoints)	133
2.103lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (3 timepoints)	134
2.104lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (3 timepoints)	135
2.105lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (3 timepoints)	136
2.106lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (3 timepoints)	137
2.107lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (3 timepoints)	138
2.108lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (3 timepoints)	139
2.109lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (3 timepoints)	140
2.110lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (3 timepoints)	141
2.111violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (3 timepoints)	142
2.112violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (3 timepoints)	143

2.113violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (3 timepoints)	144
2.114violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (3 timepoints)	145
2.115violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (3 timepoints)	146
2.116violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (3 timepoints)	147
2.117violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (3 timepoints)	148
2.118violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (3 timepoints)	149
2.119lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (2 timepoints)	150
2.120lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (2 timepoints)	151
2.121lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (2 timepoints)	152
2.122lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (2 timepoints)	153
2.123lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (2 timepoints)	154
2.124lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (2 timepoints)	155
2.125lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (2 timepoints)	156
2.126lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (2 timepoints)	157
2.127violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (2 timepoints)	158
2.128violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (2 timepoints)	159
2.129violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (2 timepoints)	160
2.130violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (2 timepoints)	161
2.131violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (2 timepoints)	162
2.132violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (2 timepoints)	163
2.133violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (2 timepoints)	164
2.134violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (2 timepoints)	165

2.135lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (3 timepoints)	166
2.136lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (3 timepoints)	167
2.137lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (3 timepoints)	168
2.138lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (3 timepoints)	169
2.139lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (3 timepoints)	170
2.140lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (3 timepoints)	171
2.141lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (3 timepoints)	172
2.142lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (3 timepoints)	173
2.143violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (3 timepoints)	174
2.144violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (3 timepoints)	175
2.145violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (3 timepoints)	176
2.146violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (3 timepoints)	177
2.147violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (3 timepoints)	178
2.148violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (3 timepoints)	179
2.149violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (3 timepoints)	180
2.150violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (3 timepoints)	181
2.151lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (2 timepoints)	182
2.152lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	183
2.153lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (2 timepoints)	184
2.154lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	185
2.155lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (2 timepoints)	186
2.156lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	187

2.157lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (2 timepoints)	188
2.158lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	189
2.159violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (2 timepoints)	190
2.160violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	191
2.161violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (2 timepoints)	192
2.162violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	193
2.163violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (2 timepoints)	194
2.164violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	195
2.165violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (2 timepoints)	196
2.166violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (2 timepoints)	197
2.167lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (3 timepoints)	198
2.168lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	199
2.169lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (3 timepoints)	200
2.170lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	201
2.171lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (3 timepoints)	202
2.172lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	203
2.173lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (3 timepoints)	204
2.174lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	205
2.175violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (3 timepoints)	206
2.176violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	207
2.177violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (3 timepoints)	208
2.178violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	209

2.179violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (3 timepoints)	210
2.180violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	211
2.181violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (3 timepoints)	212
2.182violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (3 timepoints)	213
2.183lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (2 timepoints)	214
2.184lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (2 timepoints)	215
2.185lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (2 timepoints)	216
2.186lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (2 timepoints)	217
2.187lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (2 timepoints)	218
2.188lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (2 timepoints)	219
2.189lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (2 timepoints)	220
2.190lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (2 timepoints)	221
2.191violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (2 timepoints)	222
2.192violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (2 timepoints)	223
2.193violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (2 timepoints)	224
2.194violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (2 timepoints)	225
2.195violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (2 timepoints)	226
2.196violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (2 timepoints)	227
2.197violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (2 timepoints)	228
2.198violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (2 timepoints)	229
2.199lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (3 timepoints)	230
2.200lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (3 timepoints)	231

2.201lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (3 timepoints)	232
2.202lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (3 timepoints)	233
2.203lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (3 timepoints)	234
2.204lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (3 timepoints)	235
2.205lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (3 timepoints)	236
2.206lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (3 timepoints)	237
2.207violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (3 timepoints)	238
2.208violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (3 timepoints)	239
2.209violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (3 timepoints)	240
2.210violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (3 timepoints)	241
2.211violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (3 timepoints)	242
2.212violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (3 timepoints)	243
2.213violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (3 timepoints)	244
2.214violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (3 timepoints)	245
2.215lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	246
2.216lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	247
2.217lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	248
2.218lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	249
2.219lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	250
2.220lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	251
2.221lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	252
2.222lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	253

2.223violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	254
2.224violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	255
2.225violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	256
2.226violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	257
2.227violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	258
2.228violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	259
2.229violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)	260
2.230violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)	261
2.231lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	262
2.232lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	263
2.233lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	264
2.234lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	265
2.235lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	266
2.236lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	267
2.237lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	268
2.238lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	269
2.239violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	270
2.240violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	271
2.241violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	272
2.242violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	273
2.243violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	274
2.244violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	275

2.245violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)	276
2.246violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)	277
2.247scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 1	278
2.248scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 29	279
2.249scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 57	280
2.250scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 1	281
2.251scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 29	282
2.252scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 57	283
2.253scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 1	284
2.254scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 29	285
2.255scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 57	286
2.256scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 1	287
2.257scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 29	288
2.258scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 57	289
2.259scatterplots of Binding Antibody to Spike: by arm at day 1	290
2.260scatterplots of Binding Antibody to Spike: by arm at day 29	291
2.261scatterplots of Binding Antibody to Spike: by arm at day 57	292
2.262scatterplots of Binding Antibody to RBD: by arm at day 1	293
2.263scatterplots of Binding Antibody to RBD: by arm at day 29	294
2.264scatterplots of Binding Antibody to RBD: by arm at day 57	295
2.265scatterplots of Pseudovirus Neutralization ID50: by arm at day 1	296
2.266scatterplots of Pseudovirus Neutralization ID50: by arm at day 29	297
2.267scatterplots of Pseudovirus Neutralization ID50: by arm at day 57	298
2.268scatterplots of Pseudovirus Neutralization ID80: by arm at day 1	299
2.269scatterplots of Pseudovirus Neutralization ID80: by arm at day 29	300
2.270scatterplots of Pseudovirus Neutralization ID80: by arm at day 57	301
3.1 Forest plots of hazard ratios per 10-fold increase in the marker among baseline seronegative vaccine recipients and subgroups with 95% point-wise confidence intervals.	305
3.2 Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to spike markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	306
3.3 Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to RBD markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	306
3.4 Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID50 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	307

3.5 Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID80 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	307
3.6 Marginalized cumulative risk by Day 174 as functions of Day 57 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 174 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	308
3.7 Controlled VE with sensitivity analysis as functions of Day 57 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	309
3.8 Marginalized cumulative risk by Day 174 as functions of Day 57 markers above a threshold ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 174 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	310
3.9 Controlled VE as functions of Day 57 markers ($>=s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	311
3.10 Marginalized cumulative incidence rate curves for trichotomized Day 57 markers among baseline seronegative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.	312
 4.1 Forest plots of hazard ratios per 10-fold increase in the marker among baseline seronegative vaccine recipients and subgroups with 95% point-wise confidence intervals.	315
4.2 Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to spike markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	316
4.3 Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to RBD markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	316
4.4 Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID50 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	317
4.5 Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID80 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.	317
4.6 Marginalized cumulative risk by Day 202 as functions of Day 29 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 202 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	318
4.7 Controlled VE with sensitivity analysis as functions of Day 29 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	319

4.8 Marginalized cumulative risk by Day 202 as functions of Day 29 markers above a threshold ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 202 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	320
4.9 Controlled VE as functions of Day 29 markers ($>=s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.	321
4.10 Marginalized cumulative incidence rate curves for trichotomized Day 29 markers among baseline seronegative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.	322
5.1 Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	325
5.2 Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	326
5.3 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	327
5.4 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	328
5.5 Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	330
5.6 Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	331
5.7 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	332
5.8 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	333
5.9 Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	335
5.10 Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	336
5.11 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	337

5.12 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	338
5.13 Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	340
5.14 Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	341
5.15 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	342
5.16 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	343
5.17 Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	345
5.18 Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	346
5.19 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	347
5.20 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	348
5.21 Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	350
5.22 Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	351
5.23 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	352
5.24 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.	353

5.25 Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing	355
5.26 Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	356
5.27 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	357
5.28 Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	358
5.29 Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	360
5.30 Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	361
5.31 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	362
5.32 Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.	363

MOCK

Chapter 1

Summary Tables

Table 1. Demographic and Clinical Characteristics at Baseline in the baseline SARS-CoV-2 negative per-protocol cohort

Characteristics	Vaccine (N = 13295)	Placebo (N = 13359)	Total (N = 26654)
Age			
Age < 65	10518 (79.1%)	10234 (76.6%)	20752 (77.9%)
Age ≥ 65	2777 (20.9%)	3125 (23.4%)	5902 (22.1%)
Mean (Range)	47.2 (18.0, 85.0)	48.3 (18.0, 85.0)	47.7 (18.0, 85.0)
BMI			
Mean ± SD	30.0 ± 6.9	30.0 ± 7.0	30.0 ± 7.0
Risk for Severe Covid-19			
At-risk	2937 (22.1%)	3478 (26.0%)	6415 (24.1%)
Not at-risk	10358 (77.9%)	9881 (74.0%)	20239 (75.9%)
Age, Risk for Severe Covid-19			
Age < 65 At-risk	2279 (17.1%)	2454 (18.4%)	4733 (17.8%)
Age < 65 Not at-risk	8239 (62.0%)	7780 (58.2%)	16019 (60.1%)
Age ≥ 65	2777 (20.9%)	3125 (23.4%)	5902 (22.1%)
Sex			
Female	7437 (55.9%)	7365 (55.1%)	14802 (55.5%)
Male	5858 (44.1%)	5994 (44.9%)	11852 (44.5%)
Hispanic or Latino ethnicity			
Hispanic or Latino	1506 (11.3%)	1456 (10.9%)	2962 (11.1%)
Not Hispanic or Latino	10693 (80.4%)	10916 (81.7%)	21609 (81.1%)
Not reported and unknown	1096 (8.2%)	987 (7.4%)	2083 (7.8%)
Race			
White Non-Hispanic	7329 (55.1%)	7424 (55.6%)	14753 (55.4%)
Black or African American	1818 (13.7%)	1889 (14.1%)	3707 (13.9%)
Asian	695 (5.2%)	680 (5.1%)	1375 (5.2%)
American Indian or Alaska Native	231 (1.7%)	238 (1.8%)	469 (1.8%)
Native Hawaiian or Other Pacific Islander	134 (1.0%)	145 (1.1%)	279 (1.0%)
Multiracial	543 (4.1%)	553 (4.1%)	1096 (4.1%)
Other	268 (2.0%)	236 (1.8%)	504 (1.9%)
Not reported and unknown	934 (7.0%)	921 (6.9%)	1855 (7.0%)

(continued)

Characteristics	Vaccine (N = 13295)	Placebo (N = 13359)	Total (N = 26654)
-----------------	------------------------	------------------------	----------------------

This table summarises the per-protocol individuals without a COVID failure event < 7 days post Day 57.

MOCK

Table 2. Demographic and Clinical Characteristics at Baseline in the baseline SARS-CoV-2 positive per-protocol cohort

Characteristics	Vaccine (N = 1432)	Placebo (N = 1357)	Total (N = 2789)
Age			
Age < 65	1145 (80.0%)	1098 (80.9%)	2243 (80.4%)
Age ≥ 65	287 (20.0%)	259 (19.1%)	546 (19.6%)
Mean (Range)	46.0 (18.0, 85.0)	46.6 (18.0, 85.0)	46.3 (18.0, 85.0)
BMI			
Mean ± SD	30.1 ± 6.9	30.2 ± 7.1	30.2 ± 7.0
Risk for Severe Covid-19			
At-risk	302 (21.1%)	274 (20.2%)	576 (20.7%)
Not at-risk	1130 (78.9%)	1083 (79.8%)	2213 (79.3%)
Age, Risk for Severe Covid-19			
Age < 65 At-risk	248 (17.3%)	226 (16.7%)	474 (17.0%)
Age < 65 Not at-risk	897 (62.6%)	872 (64.3%)	1769 (63.4%)
Age ≥ 65	287 (20.0%)	259 (19.1%)	546 (19.6%)
Sex			
Female	809 (56.5%)	784 (57.8%)	1593 (57.1%)
Male	623 (43.5%)	573 (42.2%)	1196 (42.9%)
Hispanic or Latino ethnicity			
Hispanic or Latino	151 (10.5%)	167 (12.3%)	318 (11.4%)
Not Hispanic or Latino	1161 (81.1%)	1092 (80.5%)	2253 (80.8%)
Not reported and unknown	120 (8.4%)	98 (7.2%)	218 (7.8%)
Race			
White Non-Hispanic	808 (56.4%)	755 (55.6%)	1563 (56.0%)
Black or African American	193 (13.5%)	187 (13.8%)	380 (13.6%)
Asian	73 (5.1%)	67 (4.9%)	140 (5.0%)
American Indian or Alaska Native	32 (2.2%)	24 (1.8%)	56 (2.0%)
Native Hawaiian or Other Pacific Islander	13 (0.9%)	10 (0.7%)	23 (0.8%)
Multiracial	54 (3.8%)	64 (4.7%)	118 (4.2%)
Other	24 (1.7%)	27 (2.0%)	51 (1.8%)
Not reported and unknown	90 (6.3%)	93 (6.9%)	183 (6.6%)

This table summarises the per-protocol individuals without a COVID failure event < 7 days post Day 57.

Table 3. Antibody levels in the baseline SARS-CoV-2 negative per-protocol cohort (vaccine recipients)

Visit	Marker	Baseline SARS-CoV-2 Negative Vaccine Recipients							
		Cases*			Non-Cases/Control			Comparison	
N	Resp rate	GMT/GMC	N	Resp rate	GMT/GMC	Resp Rate Difference	GMTR/GMCR		
Day 29	Pseudovirus-nAb ID80	68 63.3/70.6 = 89.7% (79.7%, 95.1%)	145 (93, 225)	914 12472.7/13244.4 = 94.2% (91.5%, 96.0%)	189 (161, 223)	-4.5% (-14.6%, 1.5%)	0.76 (0.48, 1.23)		
Day 29	Pseudovirus-nAb ID50	68 59.2/70.6 = 83.8% (72.9%, 90.9%)	47 (32, 68)	914 11692.8/13244.4 = 88.3% (84.8%, 91.1%)	107 (91, 126)	-4.5% (-15.8%, 3.5%)	0.44 (0.29, 0.66)		
Day 29	Anti RBD IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	11529 (8039, 16533)	914 13244.4/13244.4 = 100.0% (100.0%, 100.0%)	23071 (19922, 26717)	0% (0%, 0%)	0.50 (0.34, 0.74)		
Day 29	Anti Spike IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	14090 (10465, 18970)	914 13244.4/13244.4 = 100.0% (100.0%, 100.0%)	41298 (36886, 46238)	0% (0%, 0%)	0.34 (0.25, 0.47)		
Day 29	Anti N IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	10803 (7192, 16225)	914 13244.4/13244.4 = 100.0% (100.0%, 100.0%)	23676 (20022, 27997)	0% (0%, 0%)	0.46 (0.29, 0.71)		
Day 57	Pseudovirus-nAb ID80	68 69.6/70.6 = 98.5% (90.0%, 99.8%)	969 (615, 1525)	913 13104.4/13224.4 = 99.1% (97.1%, 99.7%)	2249 (1825, 2773)	-0.6% (-9.1%, 1.8%)	0.43 (0.26, 0.71)		
Day 57	Pseudovirus-nAb ID50	68 67.5/70.6 = 95.6% (87.0%, 98.6%)	269 (168, 430)	913 13089.2/13224.4 = 99.0% (98.0%, 99.5%)	1516 (1239, 1854)	-3.4% (-12%, -0.2%)	0.18 (0.11, 0.30)		
Day 57	Anti RBD IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	301327 (202060, 449362)	913 13224.4/13224.4 = 100.0% (100.0%, 100.0%)	973921 (827156, 1146727)	0% (0%, 0%)	0.31 (0.20, 0.48)		
Day 57	Anti Spike IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	255230 (179140, 363638)	913 13224.4/13224.4 = 100.0% (100.0%, 100.0%)	2116696 (1851391, 2420019)	0% (0%, 0%)	0.12 (0.08, 0.18)		
Day 57	Anti N IgG (IU/ml)	68 70.6/70.6 = 100.0% (100.0%, 100.0%)	107900 (65092, 178862)	913 13224.4/13224.4 = 100.0% (100.0%, 100.0%)	327562 (268626, 399428)	0% (0%, 0%)	0.33 (0.19, 0.57)		

*Cases are baseline negative per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 57 study visit. Non-cases/Controls are baseline negative per-protocol vaccine recipients sampled into the random subcohort with no evidence of SARS-CoV-2 infection up to the time of data cut.

Table 4. Antibody levels in the baseline SARS-CoV-2 positive per-protocol cohort (vaccine recipients)

Visit	Marker	Baseline SARS-CoV-2 Positive Vaccine Recipients						Comparison	
		Cases*			Non-Cases/Control			Resp Rate Difference	GMTR/GMCR
N	Resp rate	GMT/GMC	N	Resp rate	GMT/GMC				
Day 29	Pseudovirus-nAb ID80	5 5/5 = 100.0% (100.0%, 100.0%)	150 (25, 920)	272 1404.9/1430 = 98.2% (93.7%, 99.5%)	428 (319, 574)	1.8% (0.5%, 6.3%)	0.35 (0.06, 2.20)		
Day 29	Pseudovirus-nAb ID50	5 5/5 = 100.0% (100.0%, 100.0%)	106 (36, 310)	272 1380.4/1430 = 96.5% (91.5%, 98.6%)	185 (140, 245)	3.5% (1.4%, 8.5%)	0.57 (0.19, 1.73)		
Day 29	Anti RBD IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	40654 (10948, 150955)	272 1430/1430 = 100.0% (100.0%, 100.0%)	35878 (27426, 46936)	0% (0%, 0%)	1.13 (0.30, 4.32)		
Day 29	Anti Spike IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	68840 (29630, 159939)	272 1430/1430 = 100.0% (100.0%, 100.0%)	80266 (64486, 99906)	0% (0%, 0%)	0.86 (0.36, 2.05)		
Day 29	Anti N IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	23923 (4582, 124898)	272 1430/1430 = 100.0% (100.0%, 100.0%)	43027 (32679, 56652)	0% (0%, 0%)	0.56 (0.10, 2.97)		
Day 57	Pseudovirus-nAb ID80	5 5/5 = 100.0% (100.0%, 100.0%)	4237 (1191, 15079)	272 1427/1427 = 100.0% (100.0%, 100.0%)	7960 (5597, 11320)	0% (0%, 0%)	0.53 (0.14, 1.99)		
Day 57	Pseudovirus-nAb ID50	5 5/5 = 100.0% (100.0%, 100.0%)	672 (194, 2330)	272 1427/1427 = 100.0% (100.0%, 100.0%)	5816 (3925, 8618)	0% (0%, 0%)	0.12 (0.03, 0.43)		
Day 57	Anti RBD IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	1480919 (390305, 5618998)	272 1427/1427 = 100.0% (100.0%, 100.0%)	2328268 (1783494, 3039446)	0% (0%, 0%)	0.64 (0.16, 2.48)		
Day 57	Anti Spike IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	1957762 (718965, 5331044)	272 1427/1427 = 100.0% (100.0%, 100.0%)	5409865 (4359477, 6713337)	0% (0%, 0%)	0.36 (0.13, 1.01)		
Day 57	Anti N IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	617037 (97362, 3910515)	272 1427/1427 = 100.0% (100.0%, 100.0%)	985914 (694873, 1398854)	0% (0%, 0%)	0.63 (0.10, 4.10)		

*Cases are baseline positive per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 57 study visit. Non-cases/Controls are baseline negative per-protocol vaccine recipients sampled into the random subcohort with no evidence of SARS-CoV-2 infection up to the time of data cut.

Table 5. Antibody levels in the baseline SARS-CoV-2 positive per-protocol cohort (placebo recipients)

Visit	Marker	Baseline SARS-CoV-2 Positive Placebo Recipients							
		Cases*				Non-Cases/Control			Comparison
		N	Resp rate	GMT/GMC	N	Resp rate	GMT/GMC	Resp Rate Difference	GMTR/GMCR
Day 29	Pseudovirus-nAb ID80	5	4/5 = 80.0% (15.2%, 98.9%)	174 (25, 1214)	268	1254.4/1353 = 92.7% (86.9%, 96.1%)	129 (98, 170)	-12.7% (-77.6%, 7.1%)	1.35 (0.19, 9.62)
Day 29	Pseudovirus-nAb ID50	5	3/5 = 60.0% (10.6%, 95.0%)	86 (8, 974)	268	1138.2/1353 = 84.1% (76.9%, 89.4%)	51 (40, 67)	-24.1% (-73.8%, 11.6%)	1.66 (0.14, 19.19)
Day 29	Anti RBD IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	30724 (3569, 264492)	268	1353/1353 = 100.0% (100.0%, 100.0%)	12825 (10030, 16398)	0% (0%, 0%)	2.40 (0.27, 20.91)
Day 29	Anti Spike IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	27991 (7525, 104124)	268	1353/1353 = 100.0% (100.0%, 100.0%)	18158 (14965, 22031)	0% (0%, 0%)	1.54 (0.41, 5.82)
Day 29	Anti N IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	24876 (2202, 280994)	268	1353/1353 = 100.0% (100.0%, 100.0%)	12484 (9406, 16568)	0% (0%, 0%)	1.99 (0.17, 22.88)
Day 57	Pseudovirus-nAb ID80	5	5/5 = 100.0% (100.0%, 100.0%)	3699 (266, 51498)	268	1325.2/1352 = 98.0% (93.3%, 99.4%)	1319 (932, 1868)	2% (0.6%, 6.7%)	2.80 (0.20, 39.94)
Day 57	Pseudovirus-nAb ID50	5	5/5 = 100.0% (100.0%, 100.0%)	977 (103, 9257)	268	1296.8/1352 = 95.9% (90.7%, 98.3%)	565 (404, 789)	4.1% (1.7%, 9.3%)	1.73 (0.18, 16.80)
Day 57	Anti RBD IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	1476833 (225751, 9661263)	268	1352/1352 = 100.0% (100.0%, 100.0%)	380897 (294838, 492076)	0% (0%, 0%)	3.88 (0.58, 25.81)
Day 57	Anti Spike IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	1064437 (267507, 4235504)	268	1352/1352 = 100.0% (100.0%, 100.0%)	676673 (526089, 870359)	0% (0%, 0%)	1.57 (0.39, 6.40)
Day 57	Anti N IgG (IU/ml)	5	5/5 = 100.0% (100.0%, 100.0%)	825430 (147265, 4626574)	268	1352/1352 = 100.0% (100.0%, 100.0%)	129537 (91471, 183444)	0% (0%, 0%)	6.37 (1.10, 36.98)

*Cases are baseline negative per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 57 study visit. Non-cases/Controls are baseline negative per-protocol vaccine recipients sampled into the random subcohort with no evidence of SARS-CoV-2 infection up to the time of data cut.

Chapter 2

Graphical Descriptions of Antibody Marker Data

2.1 Boxplots

2.1.1 Baseline seronegative

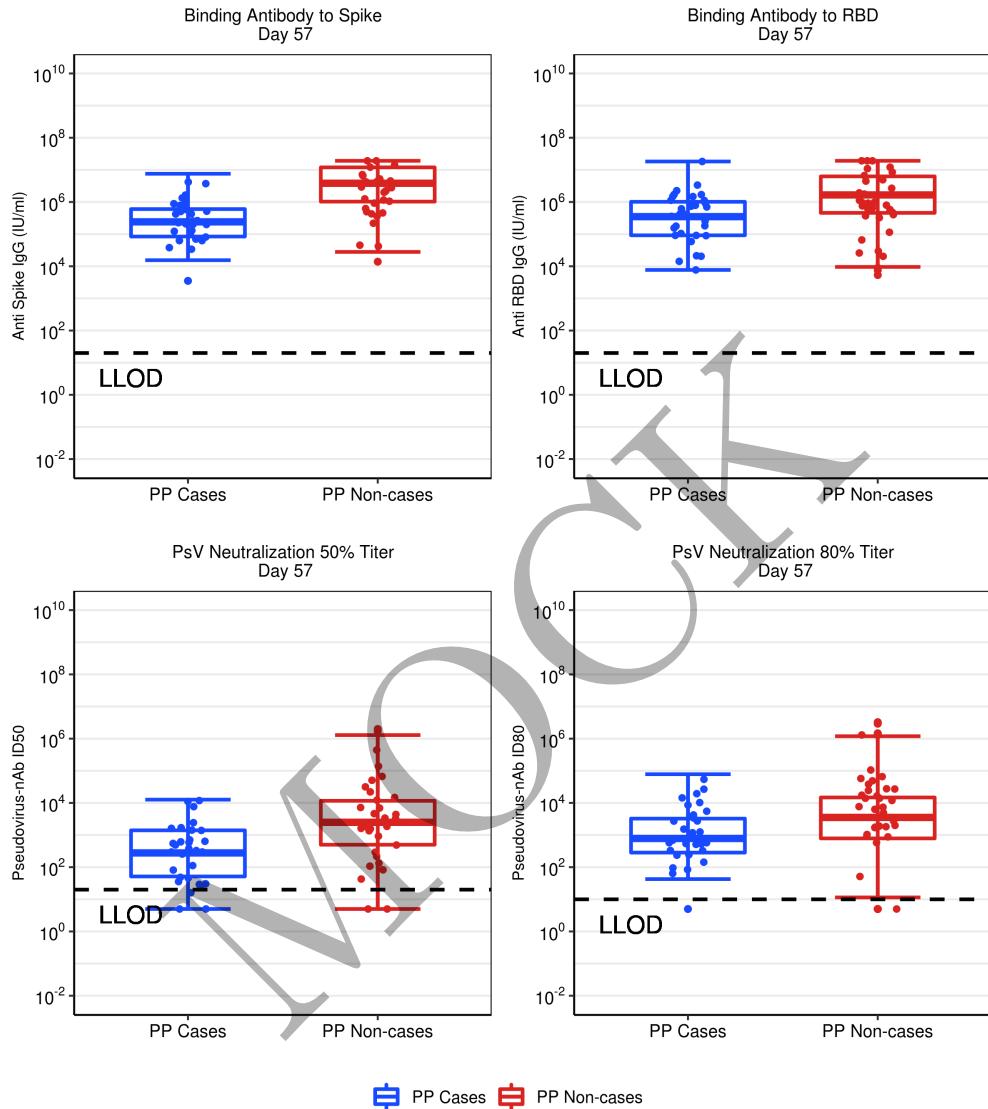


Figure 2.1: Boxplots of D57 Ab markers: baseline negative vaccine arm.

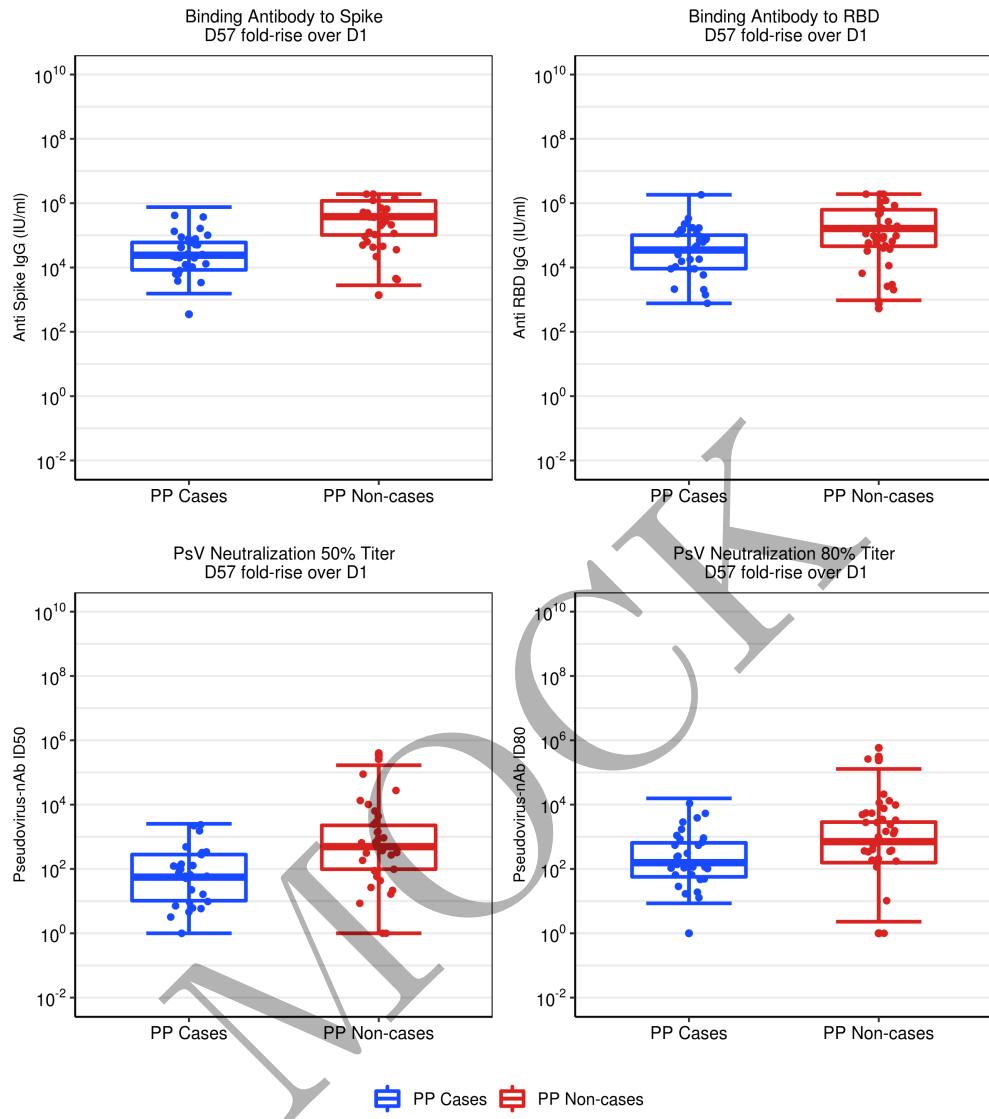


Figure 2.2: Boxplots of D57 fold-rise over D1 Ab markers: baseline negative vaccine arm.

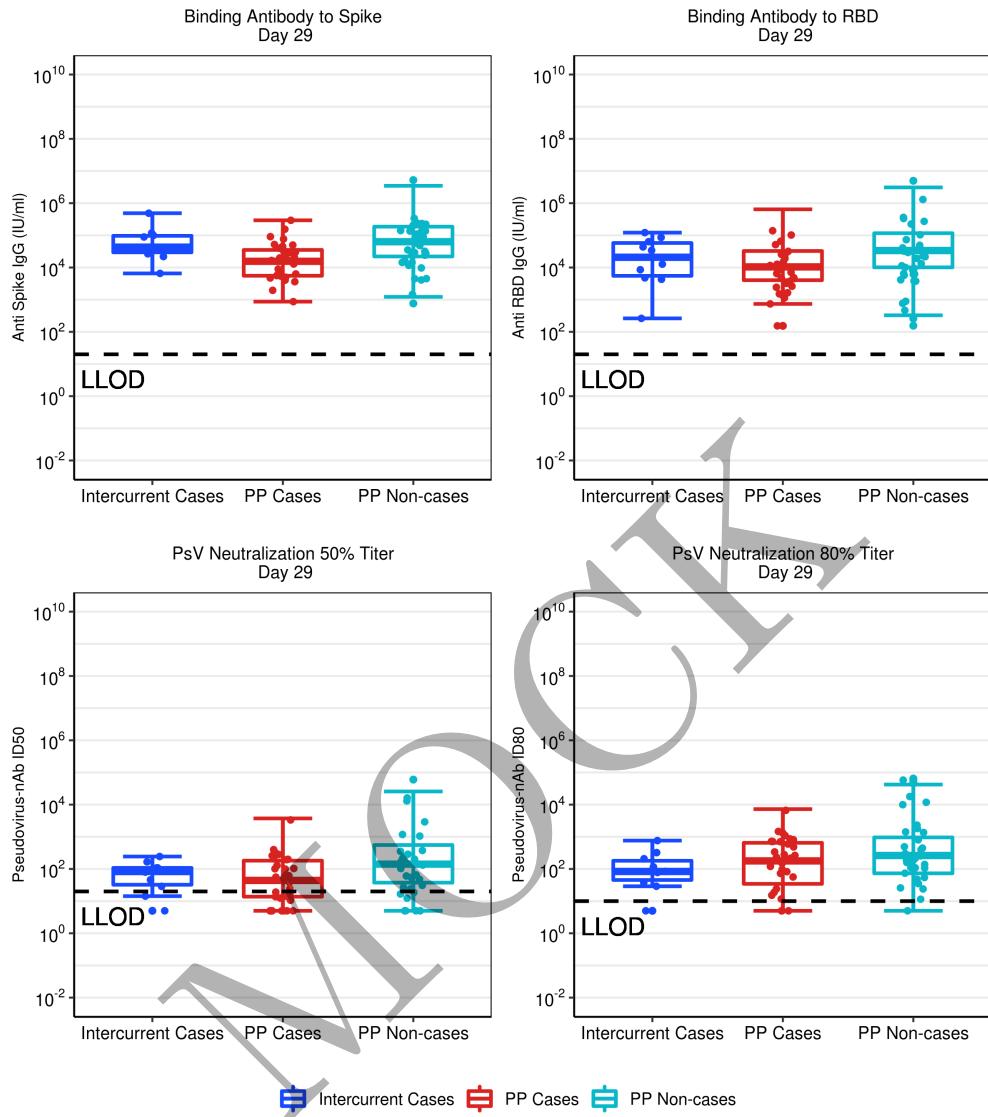


Figure 2.3: Boxplots of D29 Ab markers: baseline negative vaccine arm.

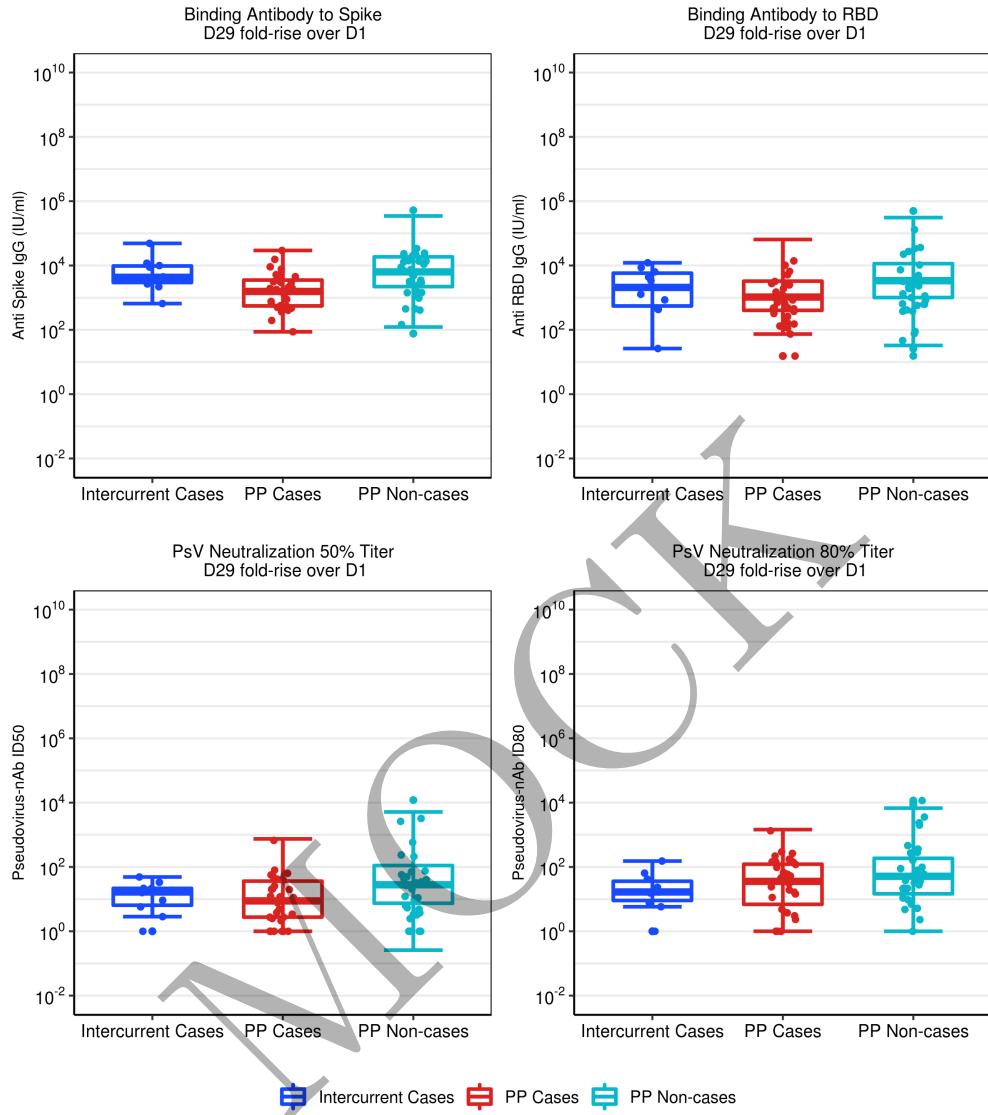


Figure 2.4: Boxplots of D29 fold-rise over D1 Ab markers: baseline negative vaccine arm.

2.1.2 Baseline seropositive

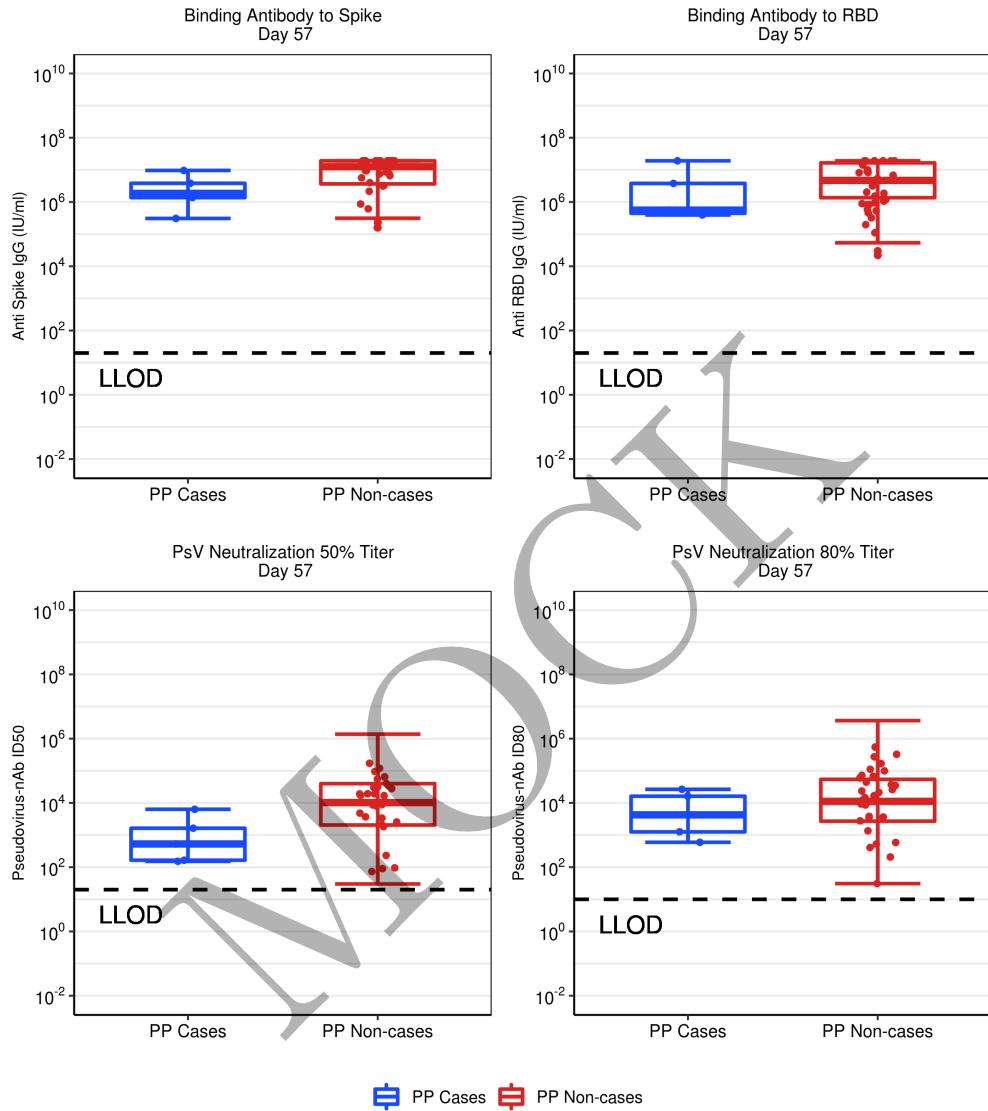


Figure 2.5: Boxplots of D57 Ab markers: baseline positive vaccine arm.



Figure 2.6: Boxplots of D57 fold-rise over D1 Ab markers: baseline positive vaccine arm.

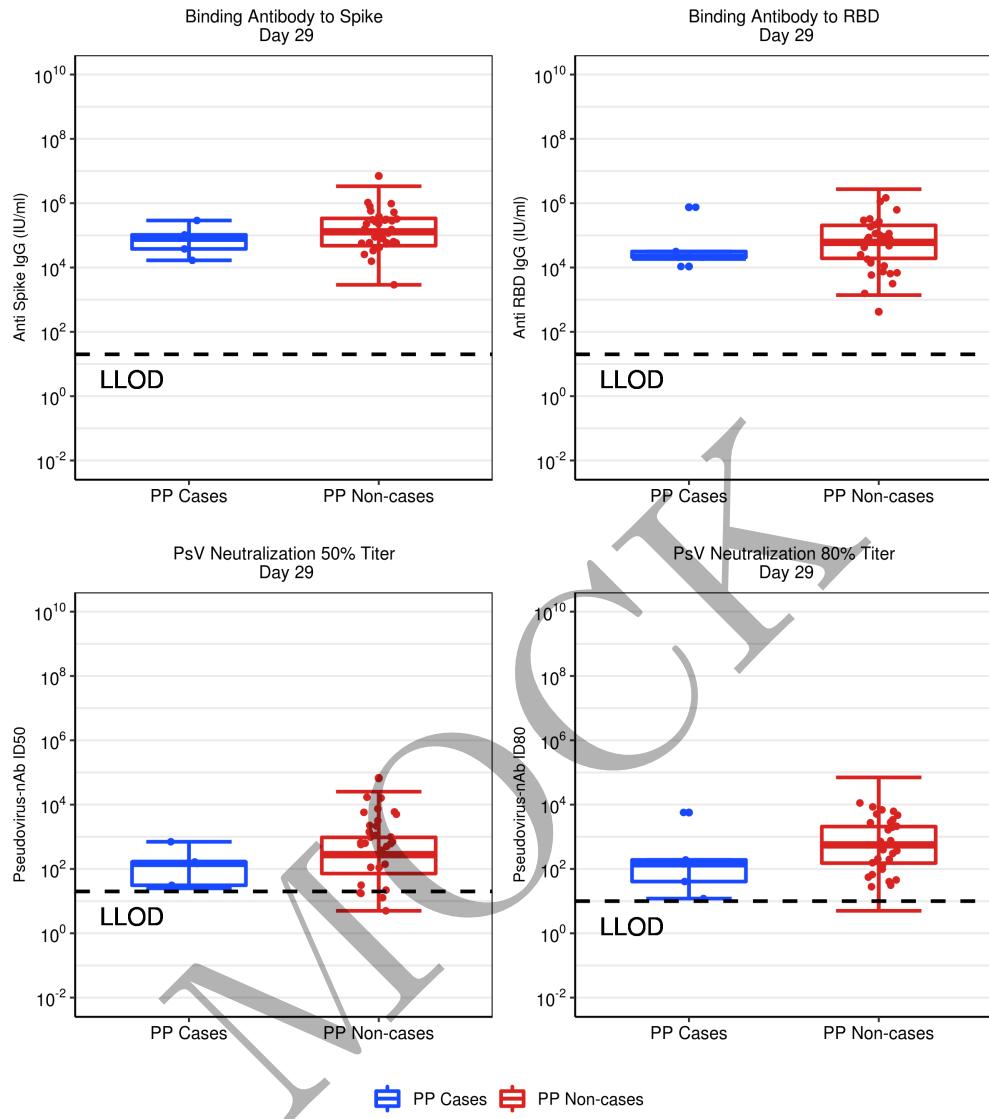


Figure 2.7: Boxplots of D29 Ab markers: baseline positive vaccine arm.

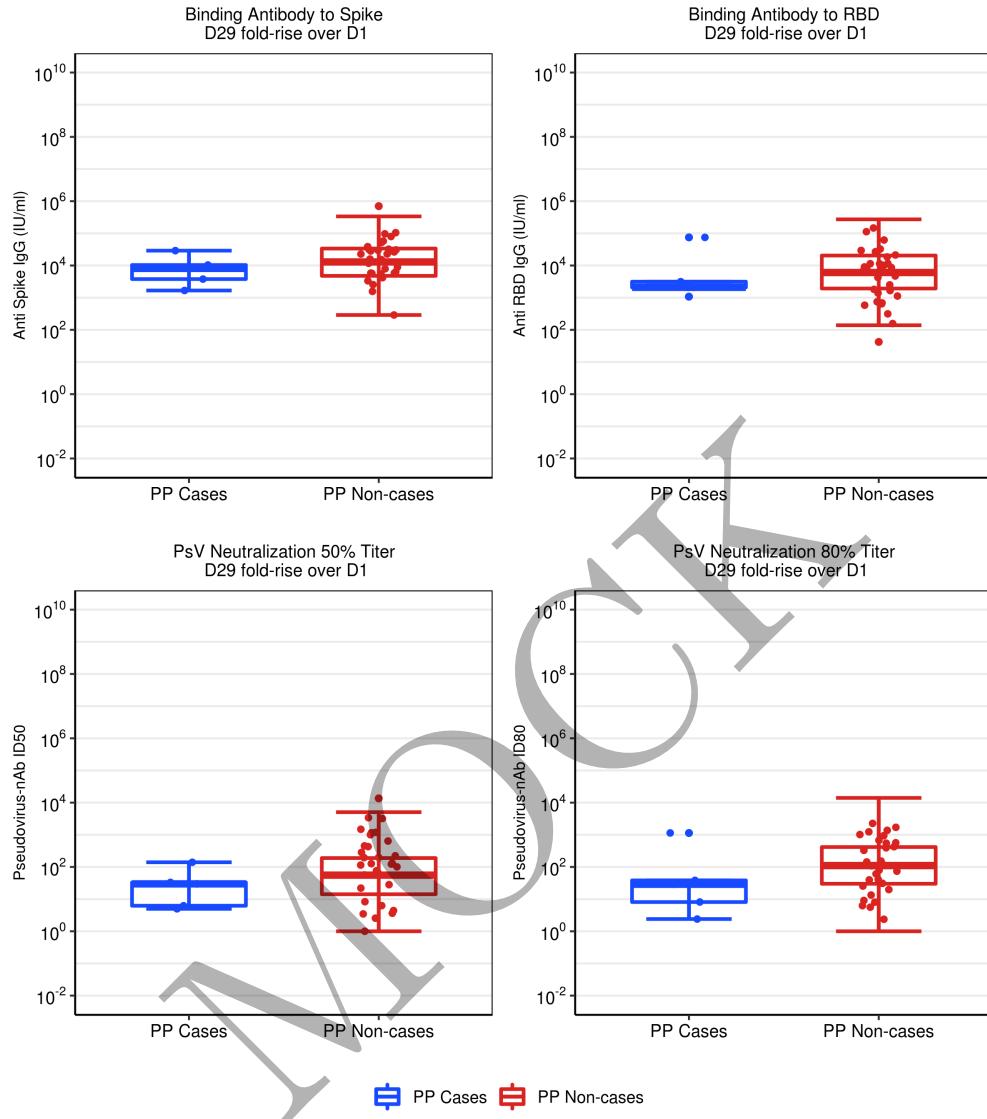


Figure 2.8: Boxplots of D29 fold-rise over D1 Ab markers: baseline positive vaccine arm.

2.2 Weighted RCDF plots

2.2.1 Baseline seronegative

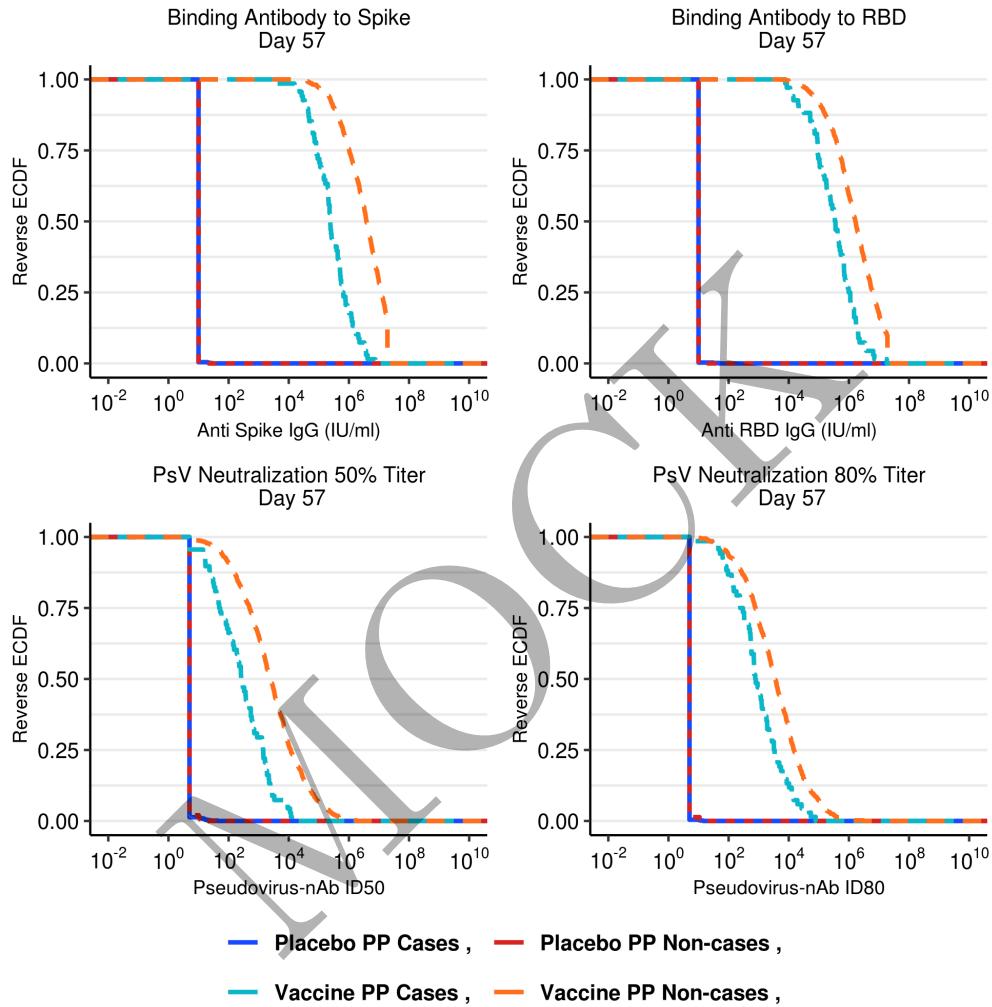


Figure 2.9: RCDF plots for D57 Ab markers: baseline negative by treatment arm.

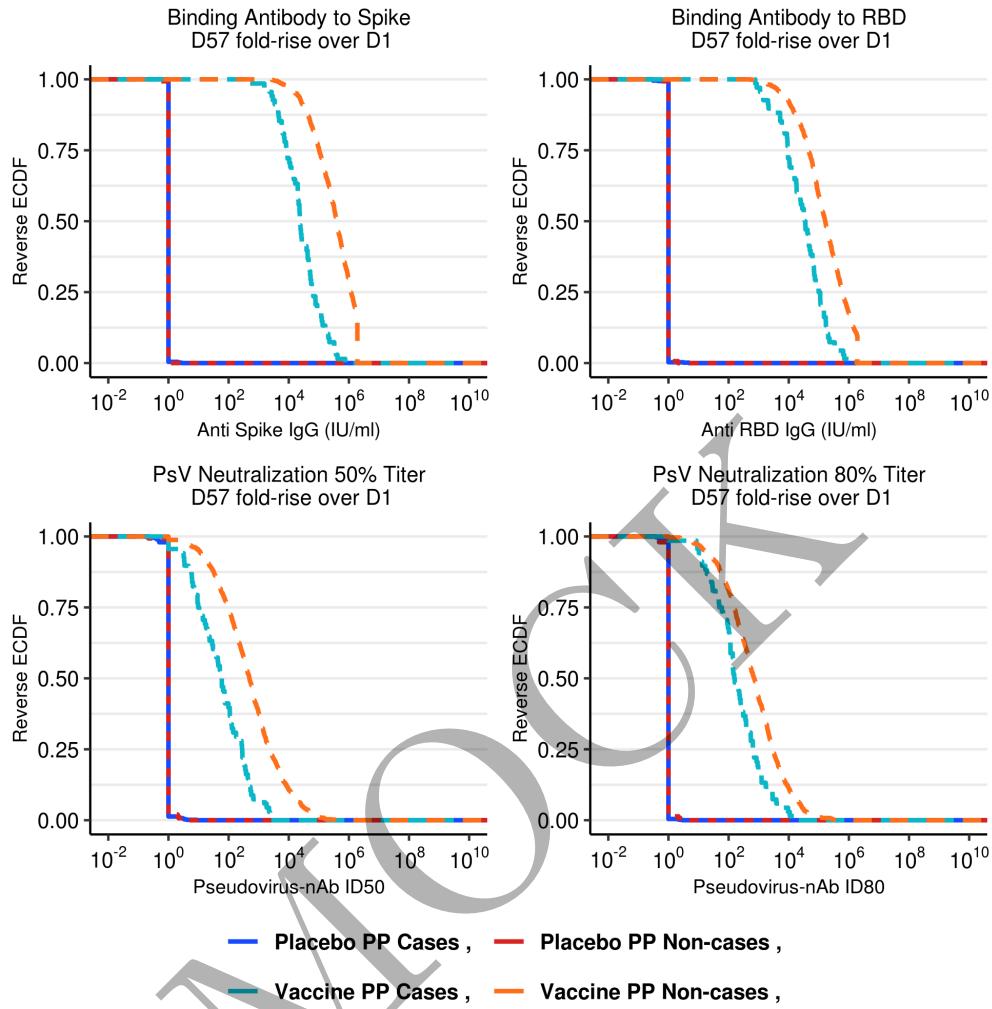


Figure 2.10: RCDF plots for D57 fold-rise over D1 Ab markers: baseline negative by treatment arm.



Figure 2.11: RCDF plots for D29 Ab markers: baseline negative by treatment arm.



Figure 2.12: RCDF plots for D29 fold-rise over D1 Ab markers: baseline negative by treatment arm.

2.2.2 Baseline seropositive

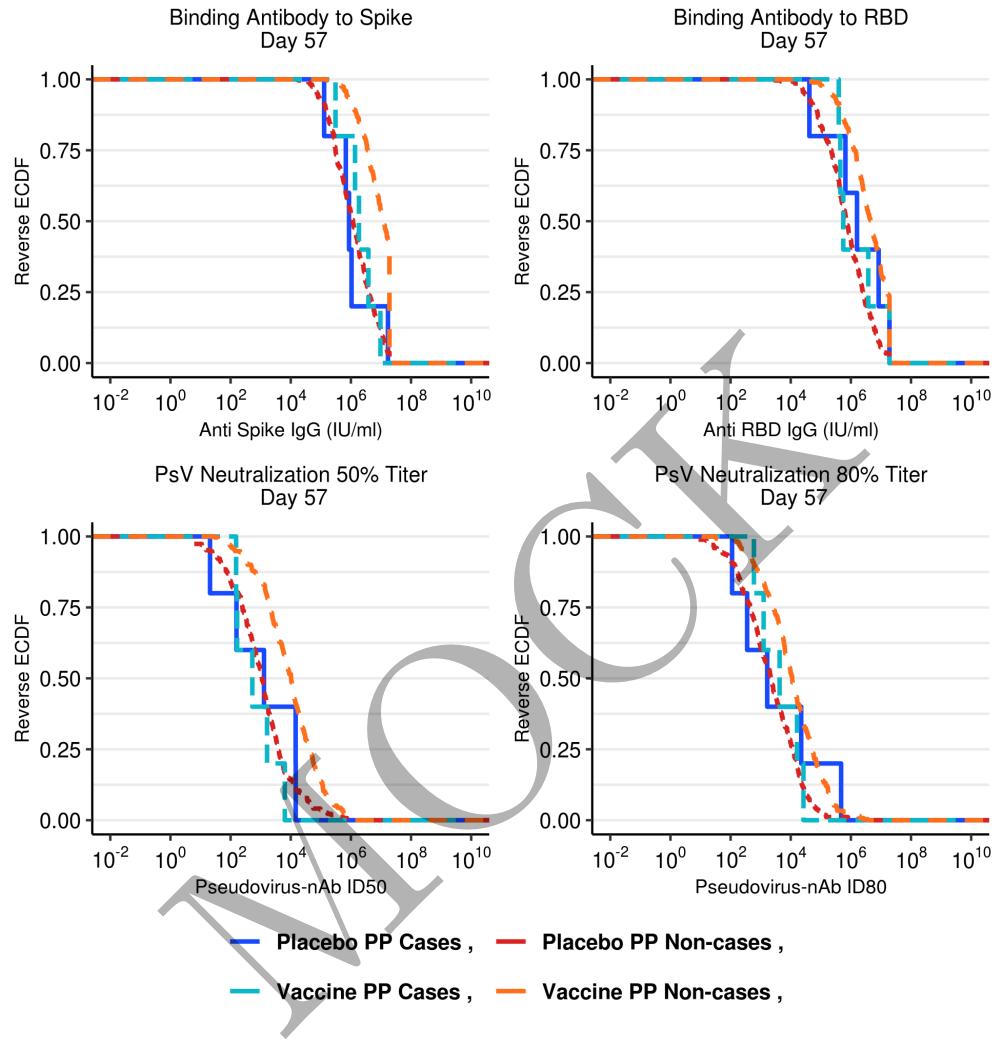


Figure 2.13: RCDF plots for D57 Ab markers: baseline positive by treatment arm.

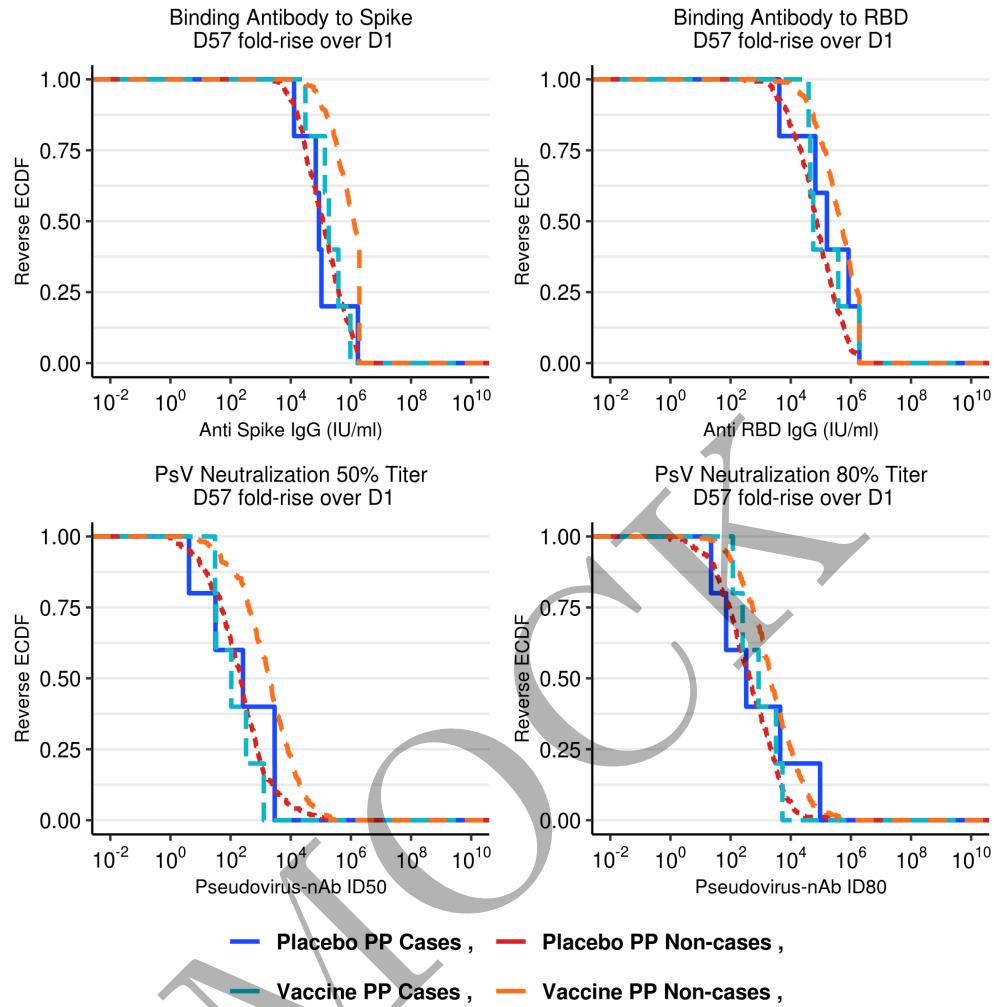


Figure 2.14: RCDF plots for D57 fold-rise over D1 Ab markers: baseline positive by treatment arm.



Figure 2.15: RCDF plots for D29 Ab markers: baseline positive by treatment arm.

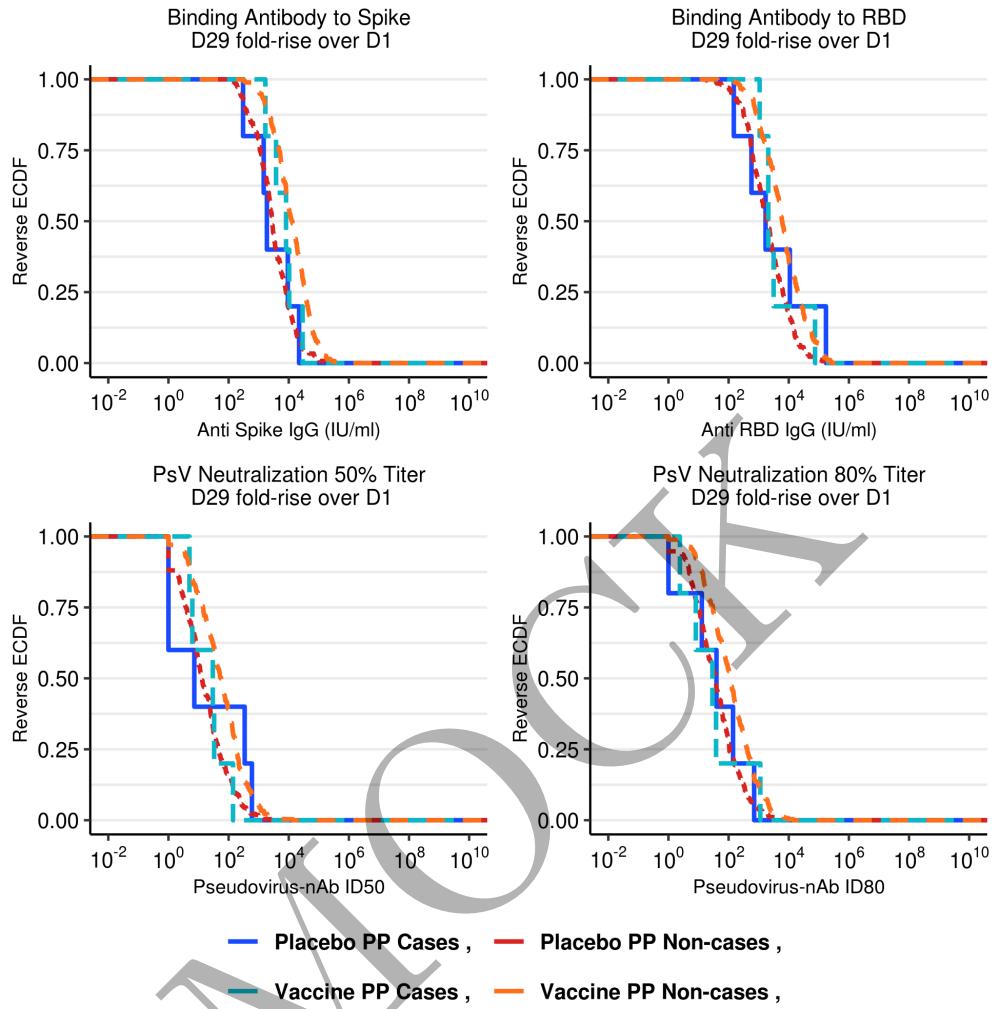


Figure 2.16: RCDF plots for D29 fold-rise over D1 Ab markers: baseline positive by treatment arm.

2.3 Weighted RCDF plots of threshold correlate concentration for vaccine efficacy

2.3.1 Baseline seronegative



Figure 2.17: Marker RCDF of D57 anti-Spike binding Ab: baseline negative vaccine arm

2.3. WEIGHTED RCDF PLOTS OF THRESHOLD CORRELATE CONCENTRATION FOR VACCINE EFFICACY49



Figure 2.18: Marker RCDF of D57 anti-RBD binding Ab: baseline negative vaccine arm



Figure 2.19: Marker RCDF of D57 PsV-nAb ID50: baseline negative vaccine arm

2.3. WEIGHTED RCDF PLOTS OF THRESHOLD CORRELATE CONCENTRATION FOR VACCINE EFFICACY51

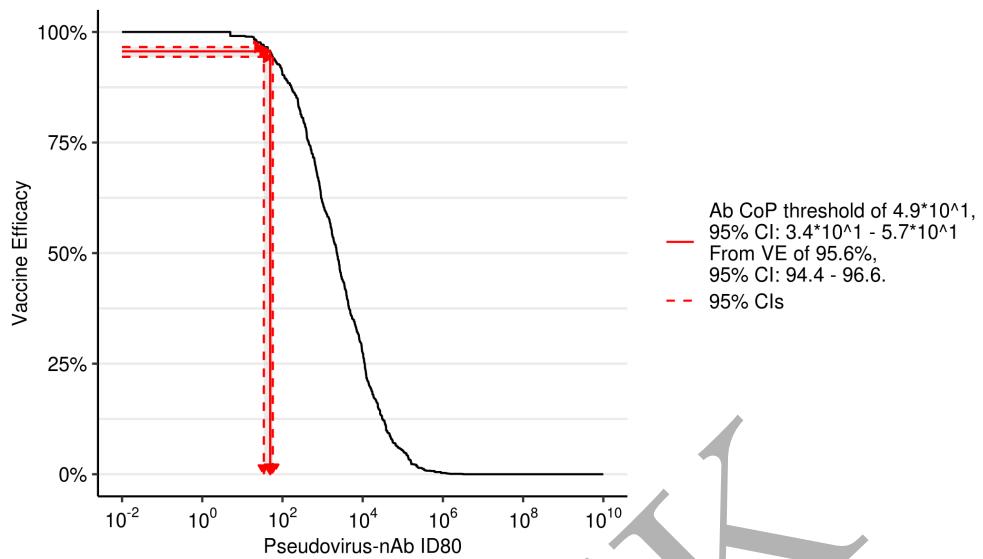


Figure 2.20: Marker RCDF of D57 PsV-nAb ID80: baseline negative vaccine arm

2.4 Spaghetti plots

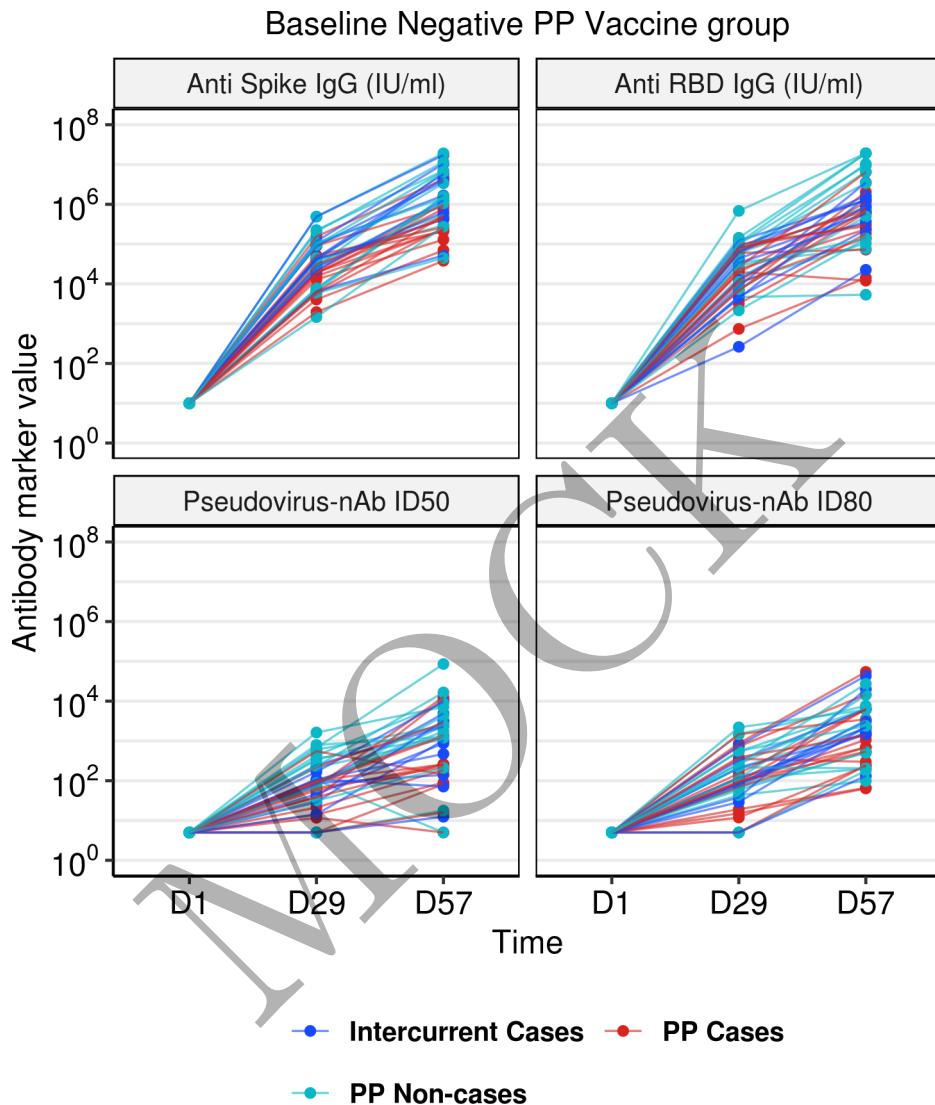


Figure 2.21: Spaghetti Plots of Marker Trajectory: baseline negative vaccine arm

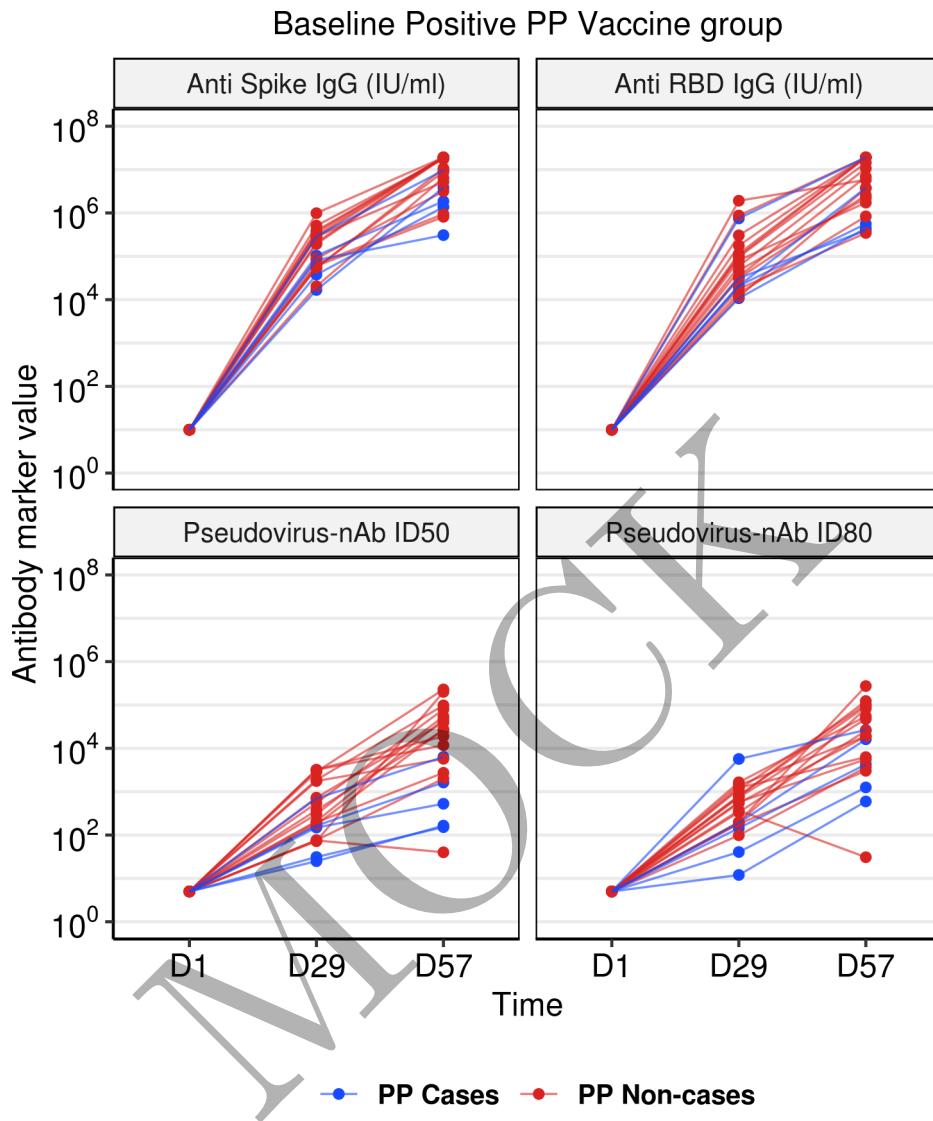


Figure 2.22: Spaghetti Plots of Marker Trajectory: baseline positive vaccine arm

2.5 Violin and line plots



Figure 2.23: lineplots of Binding Antibody to Spike: baseline negative placebo arm (2 timepoints)



Figure 2.24: lineplots of Binding Antibody to Spike: baseline negative vaccine arm (2 timepoints)

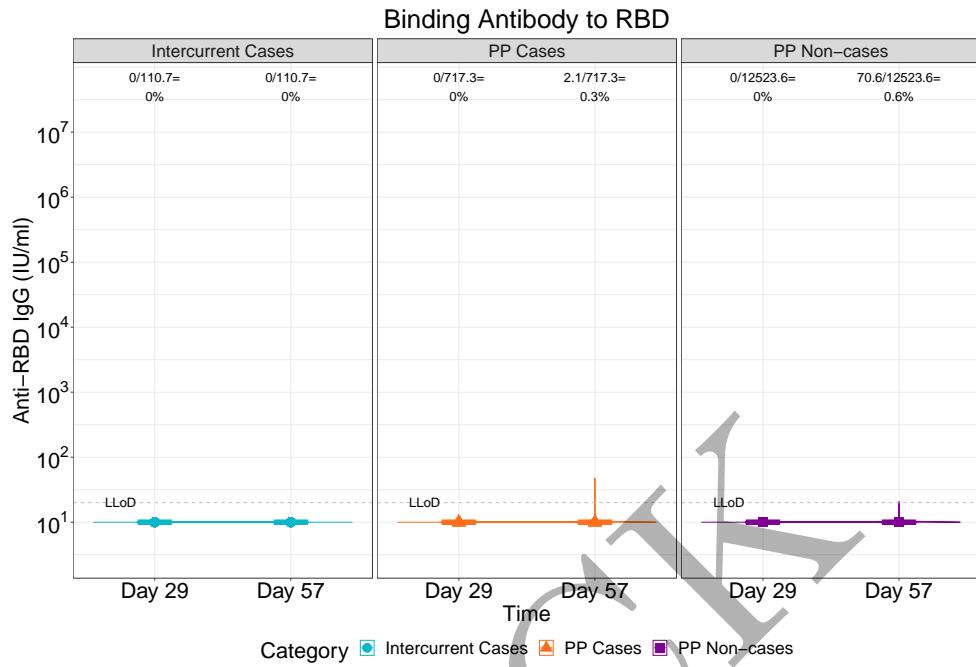


Figure 2.25: lineplots of Binding Antibody to RBD: baseline negative placebo arm (2 timepoints)



Figure 2.26: lineplots of Binding Antibody to RBD: baseline negative vaccine arm (2 timepoints)

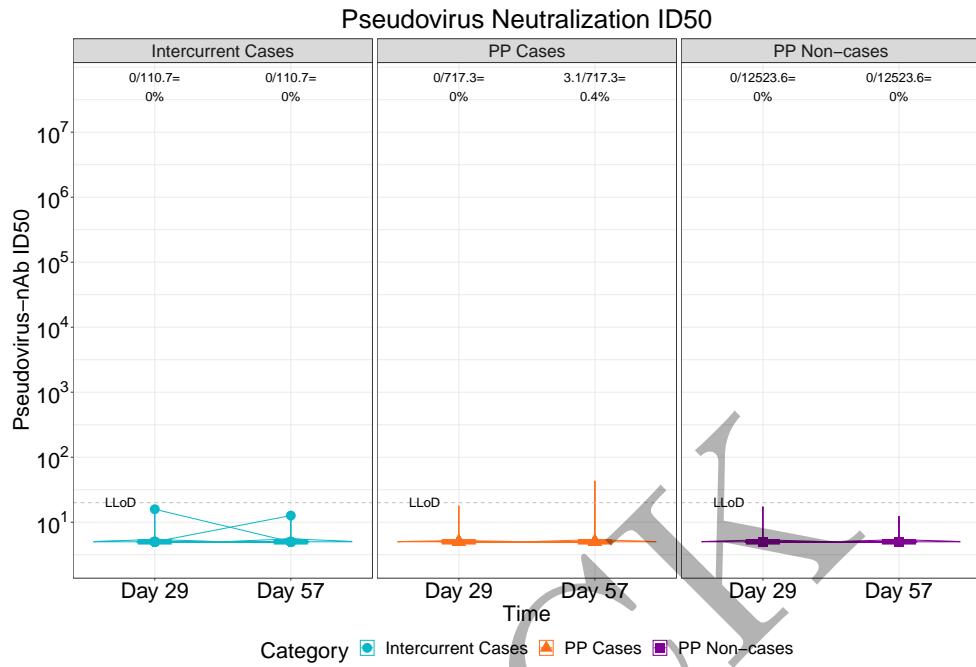


Figure 2.27: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (2 timepoints)

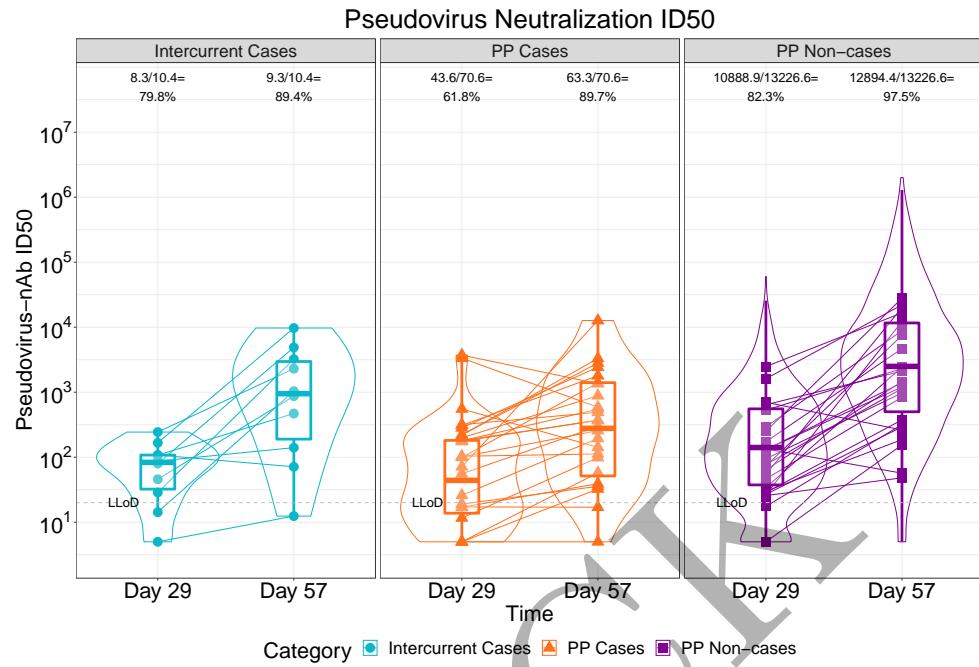


Figure 2.28: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (2 timepoints)



Figure 2.29: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (2 timepoints)

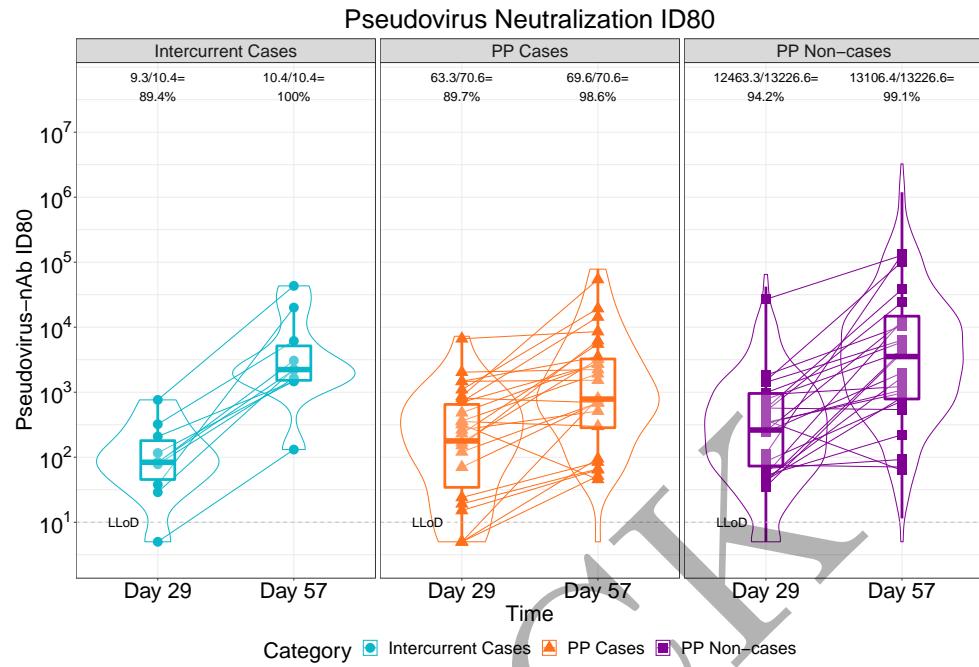


Figure 2.30: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (2 timepoints)



Figure 2.31: violinplots of Binding Antibody to Spike: baseline negative placebo arm (2 timepoints)

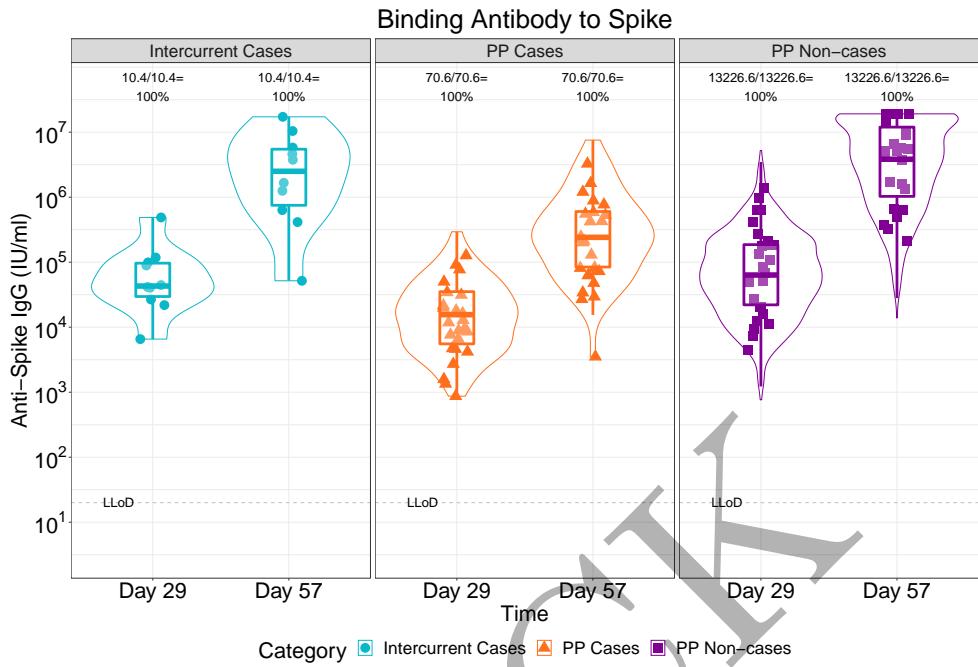


Figure 2.32: violinplots of Binding Antibody to Spike: baseline negative vaccine arm (2 timepoints)

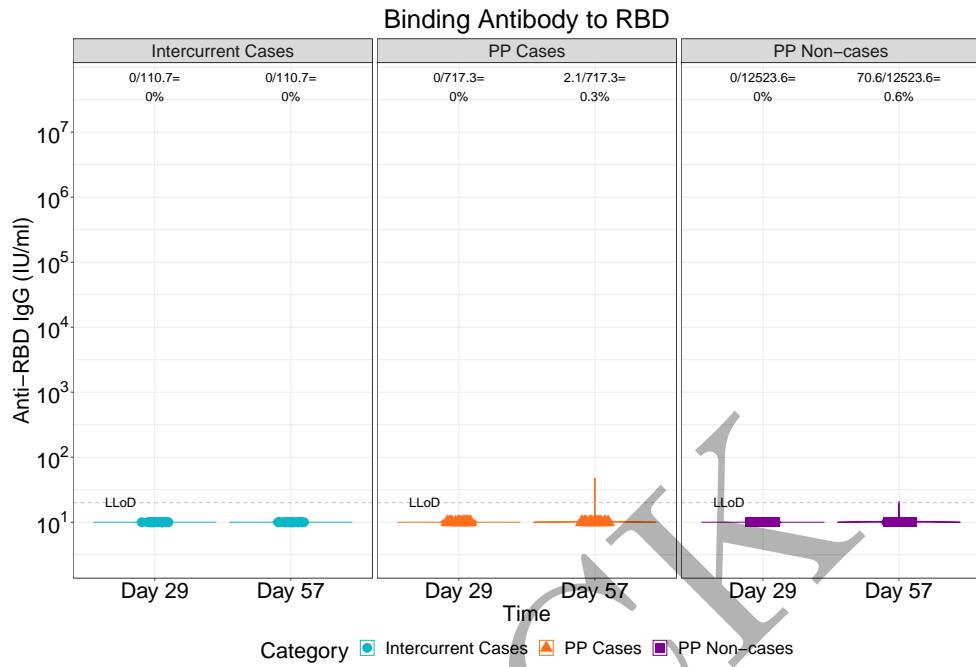


Figure 2.33: violinplots of Binding Antibody to RBD: baseline negative placebo arm (2 timepoints)



Figure 2.34: violinplots of Binding Antibody to RBD: baseline negative vaccine arm (2 timepoints)



Figure 2.35: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (2 timepoints)

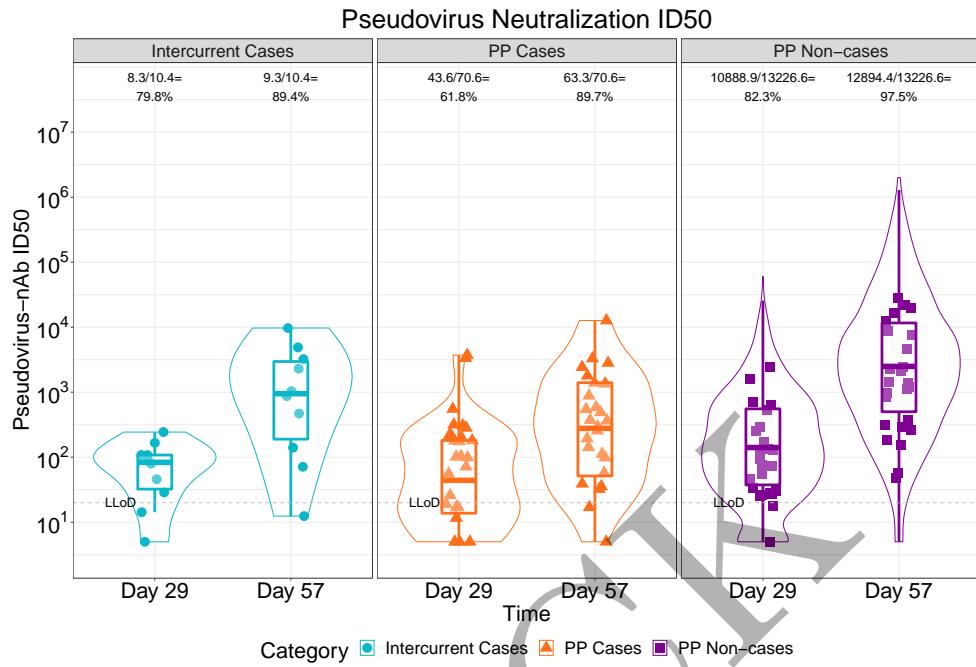


Figure 2.36: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (2 timepoints)



Figure 2.37: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (2 timepoints)



Figure 2.38: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (2 timepoints)

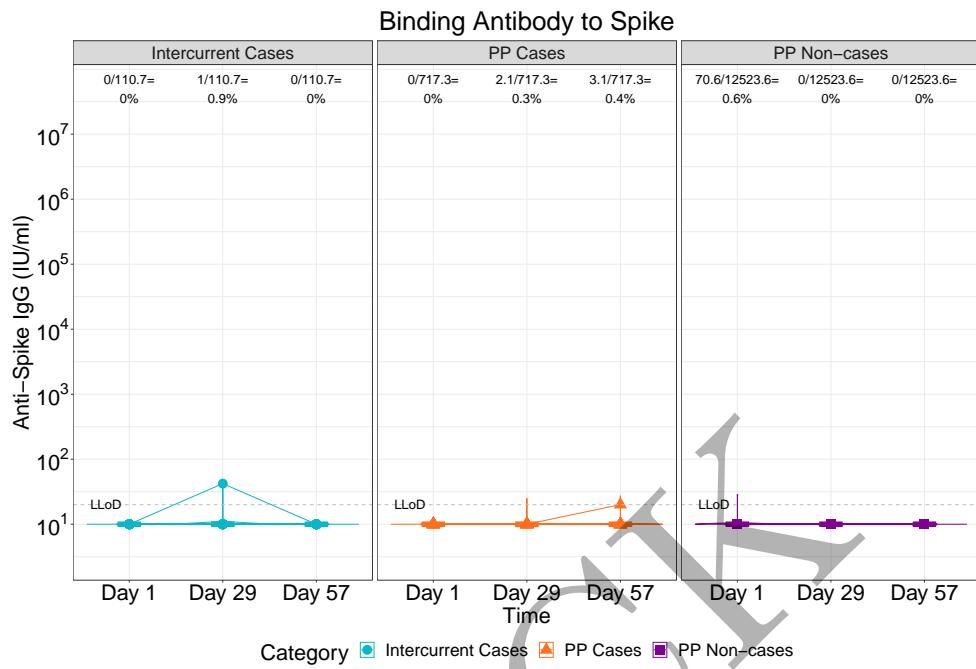


Figure 2.39: lineplots of Binding Antibody to Spike: baseline negative placebo arm (3 timepoints)

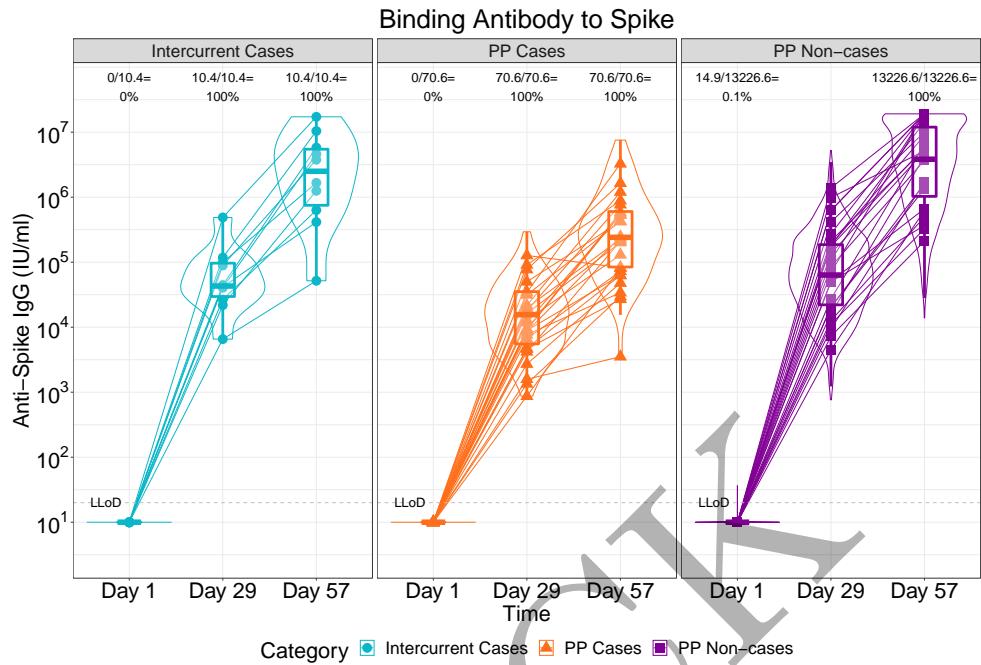


Figure 2.40: lineplots of Binding Antibody to Spike: baseline negative vaccine arm (3 timepoints)



Figure 2.41: lineplots of Binding Antibody to RBD: baseline negative placebo arm (3 timepoints)



Figure 2.42: lineplots of Binding Antibody to RBD: baseline negative vaccine arm (3 timepoints)



Figure 2.43: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (3 timepoints)

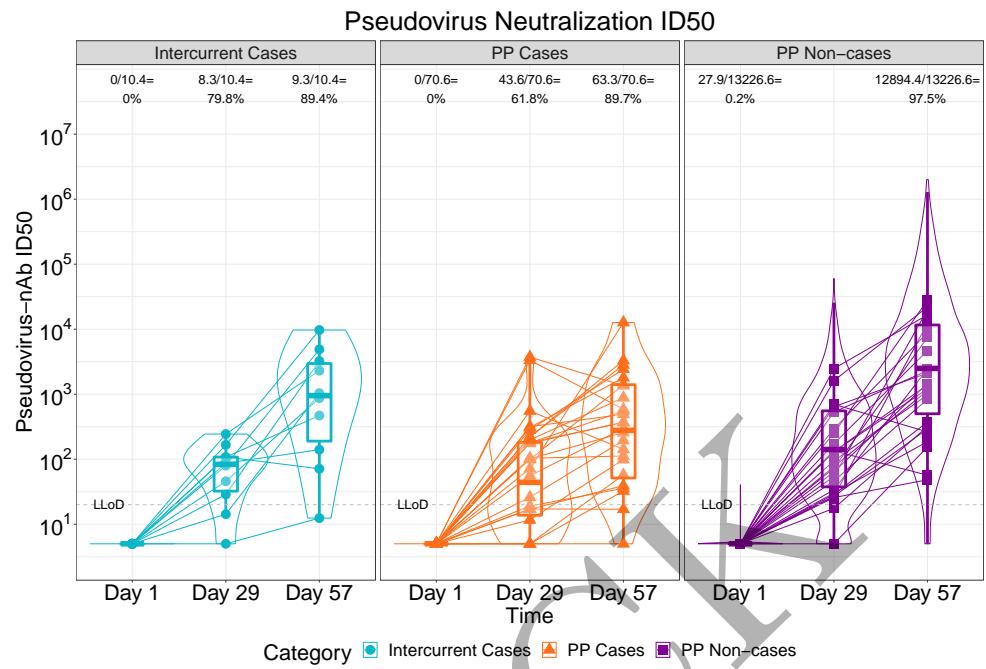


Figure 2.44: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (3 timepoints)



Figure 2.45: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (3 timepoints)

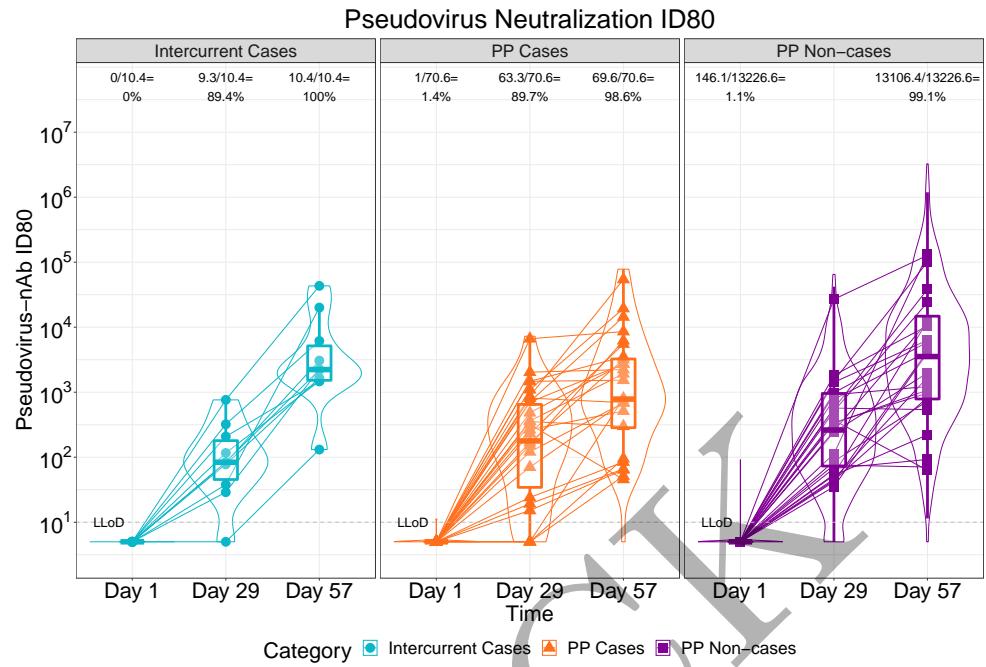


Figure 2.46: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (3 timepoints)



Figure 2.47: violinplots of Binding Antibody to Spike: baseline negative placebo arm (3 timepoints)



Figure 2.48: violinplots of Binding Antibody to Spike: baseline negative vaccine arm (3 timepoints)



Figure 2.49: violinplots of Binding Antibody to RBD: baseline negative placebo arm (3 timepoints)

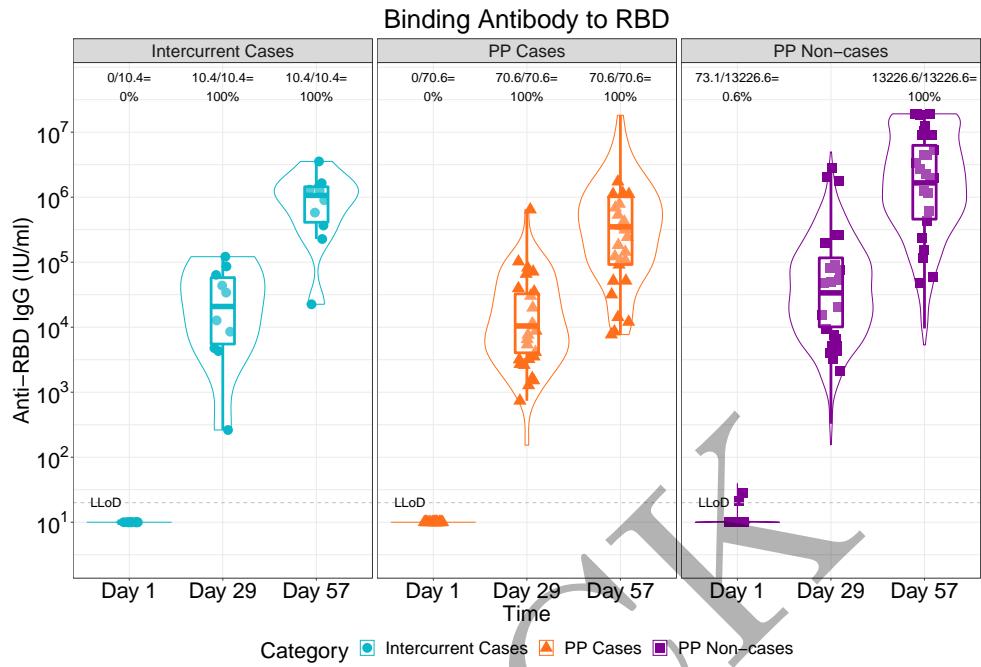


Figure 2.50: violinplots of Binding Antibody to RBD: baseline negative vaccine arm (3 timepoints)

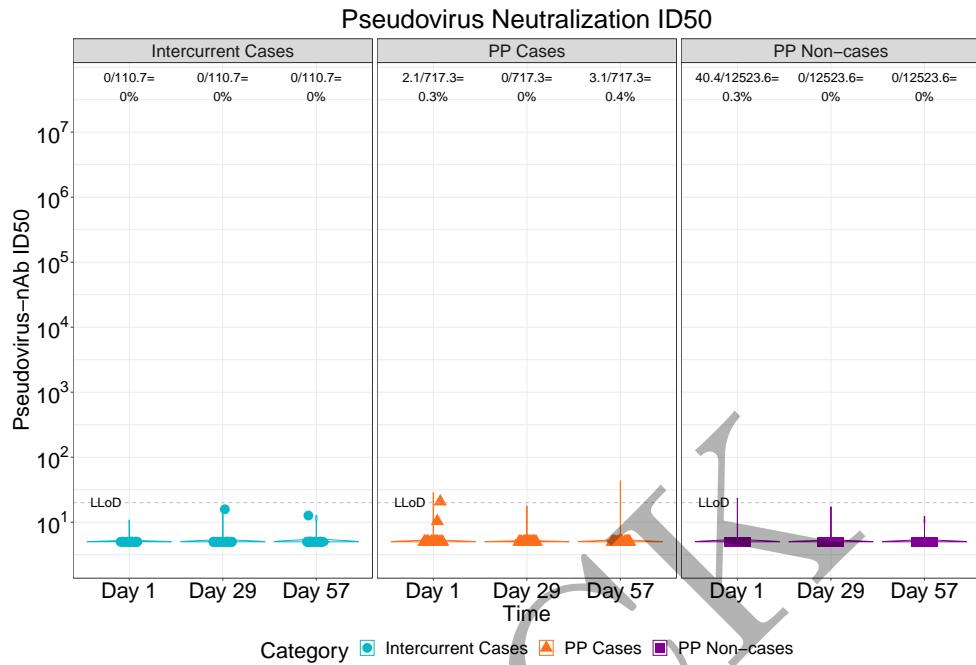


Figure 2.51: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (3 timepoints)

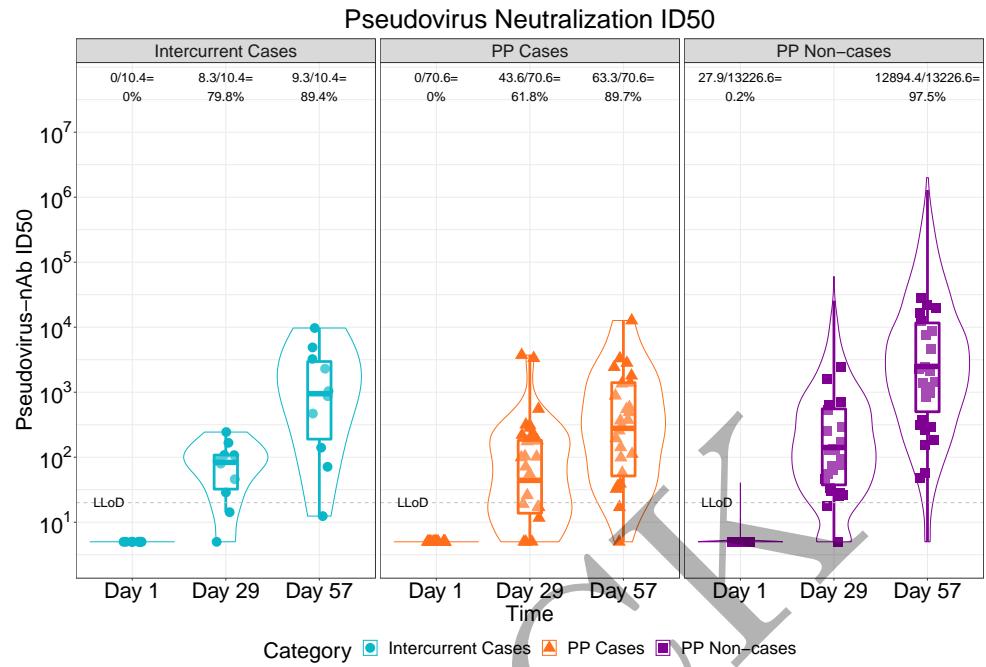


Figure 2.52: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (3 timepoints)

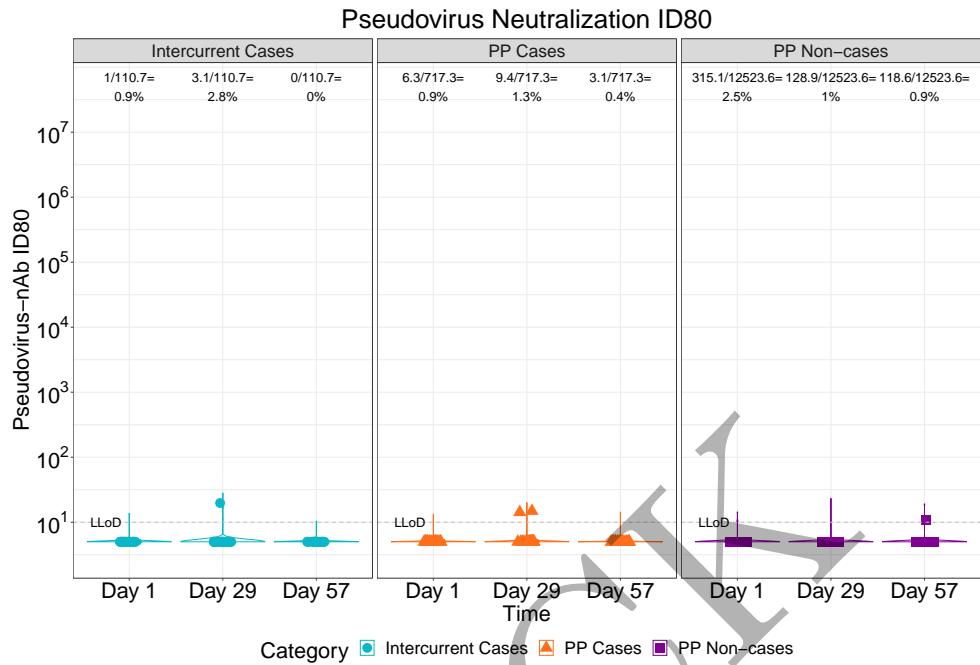


Figure 2.53: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (3 timepoints)

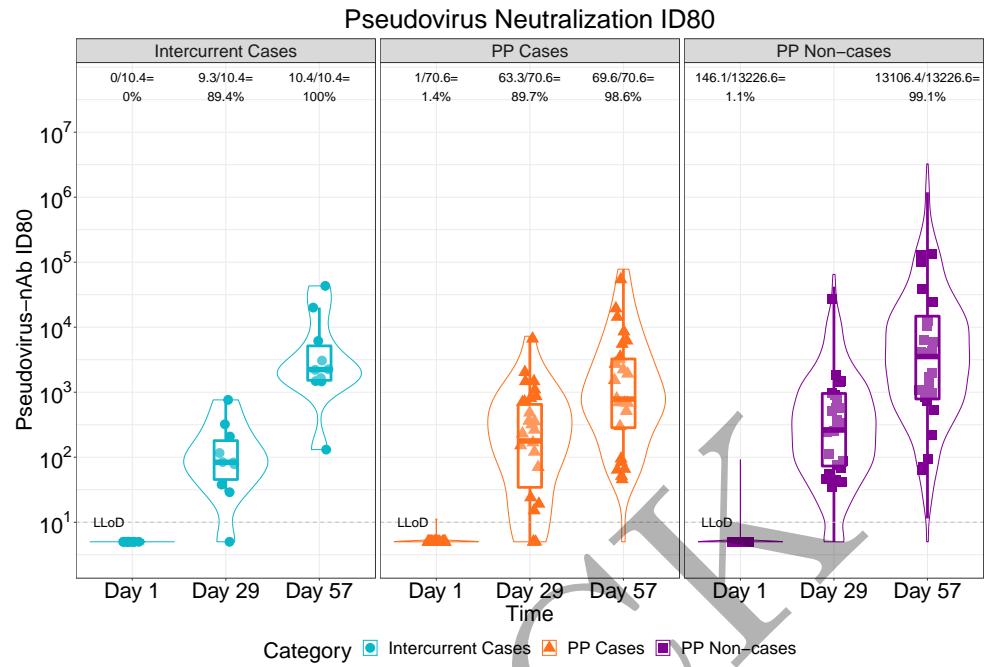


Figure 2.54: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (3 timepoints)

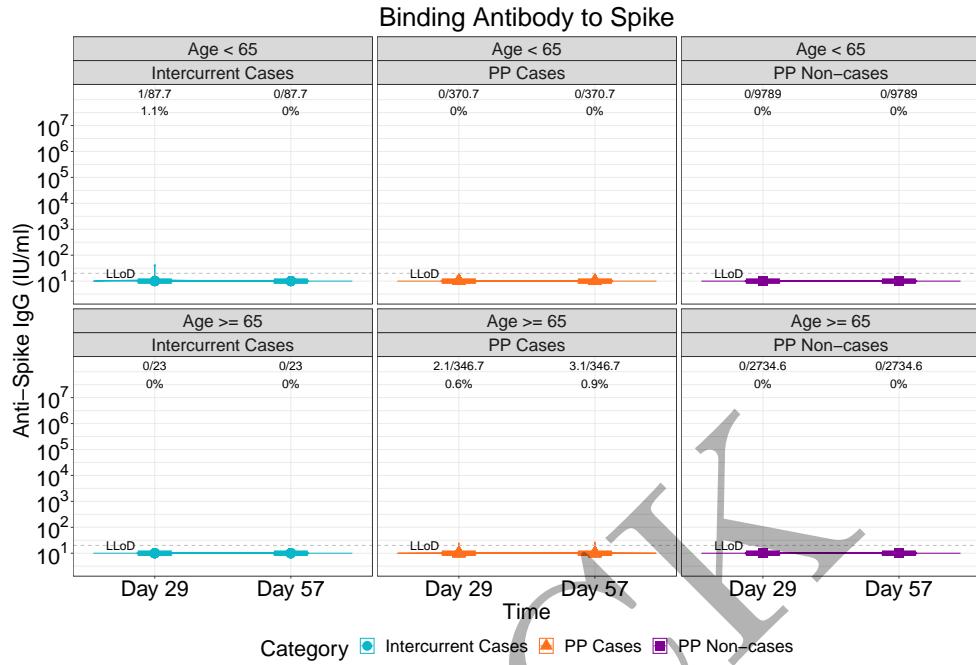


Figure 2.55: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (2 timepoints)

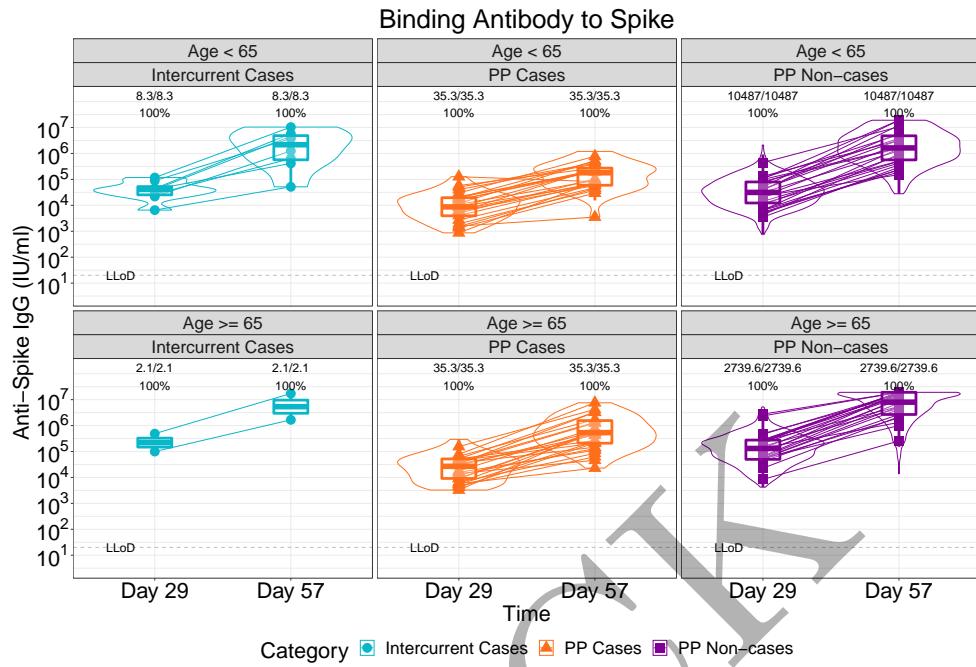


Figure 2.56: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (2 timepoints)

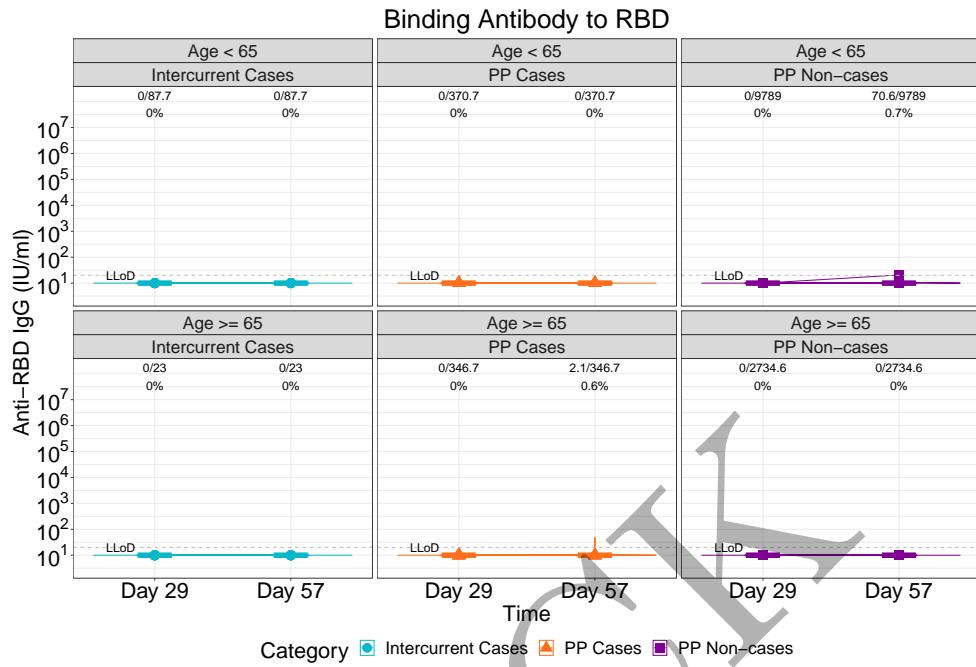


Figure 2.57: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (2 timepoints)

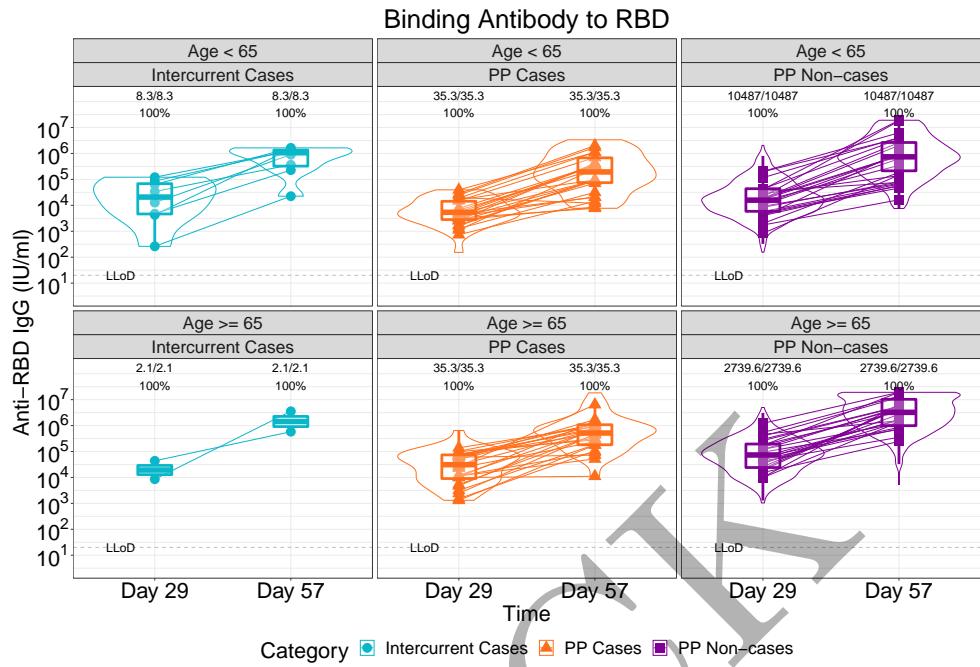


Figure 2.58: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (2 timepoints)

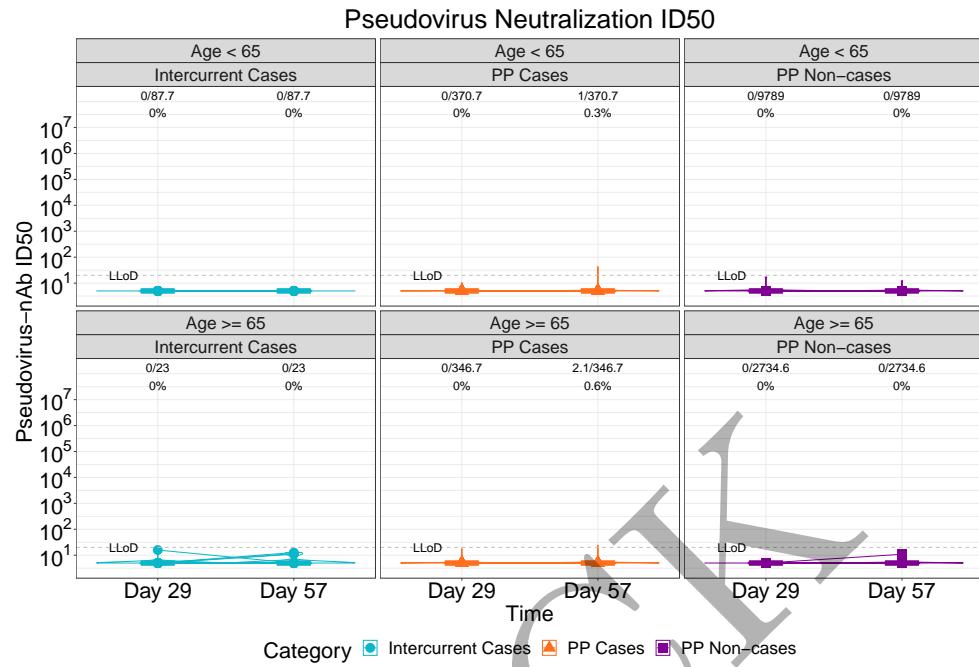


Figure 2.59: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (2 timepoints)

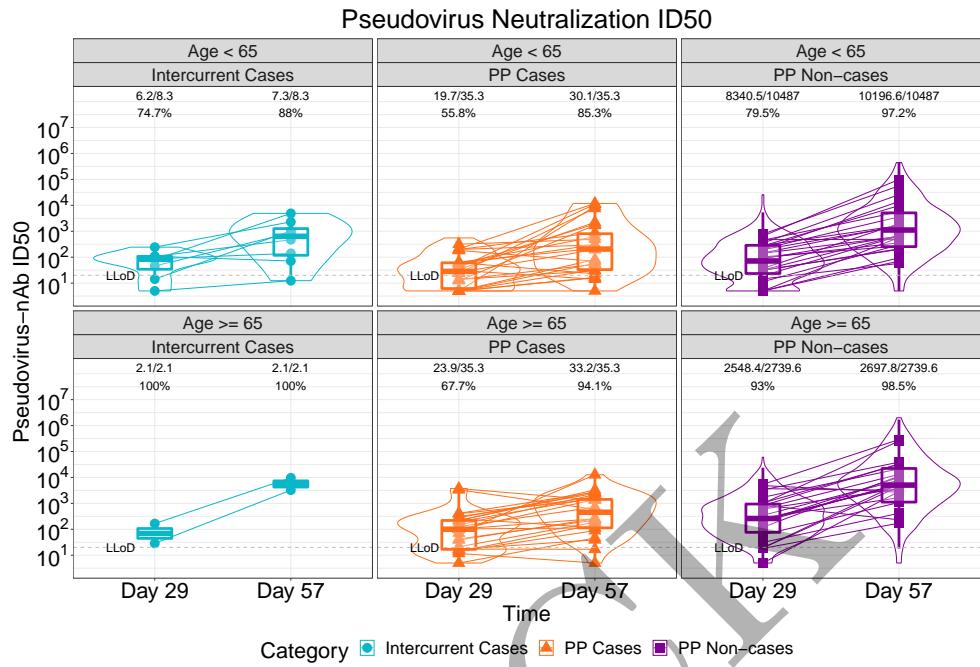


Figure 2.60: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (2 timepoints)

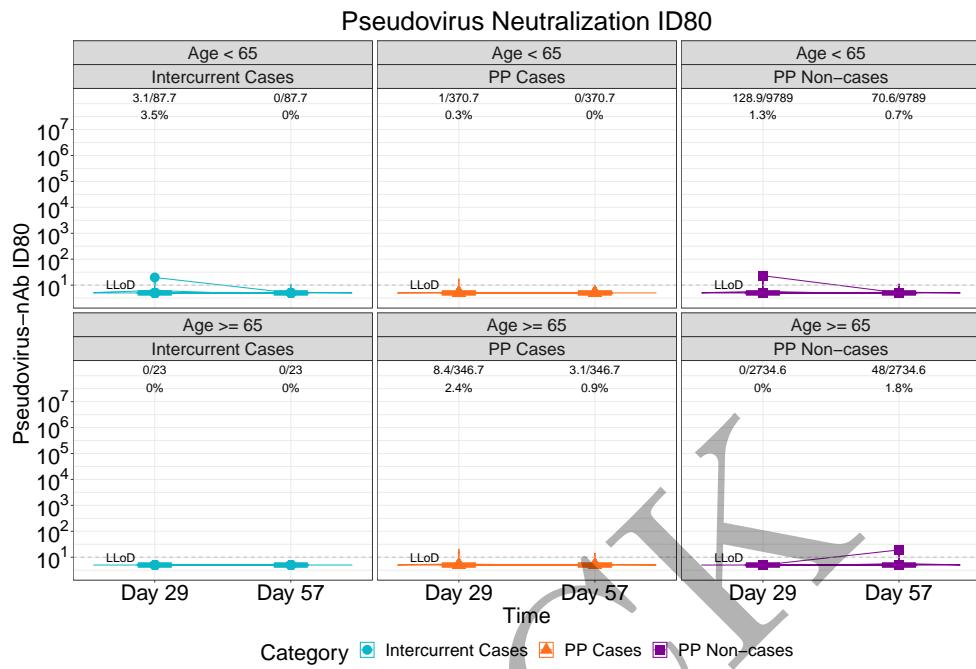


Figure 2.61: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (2 timepoints)

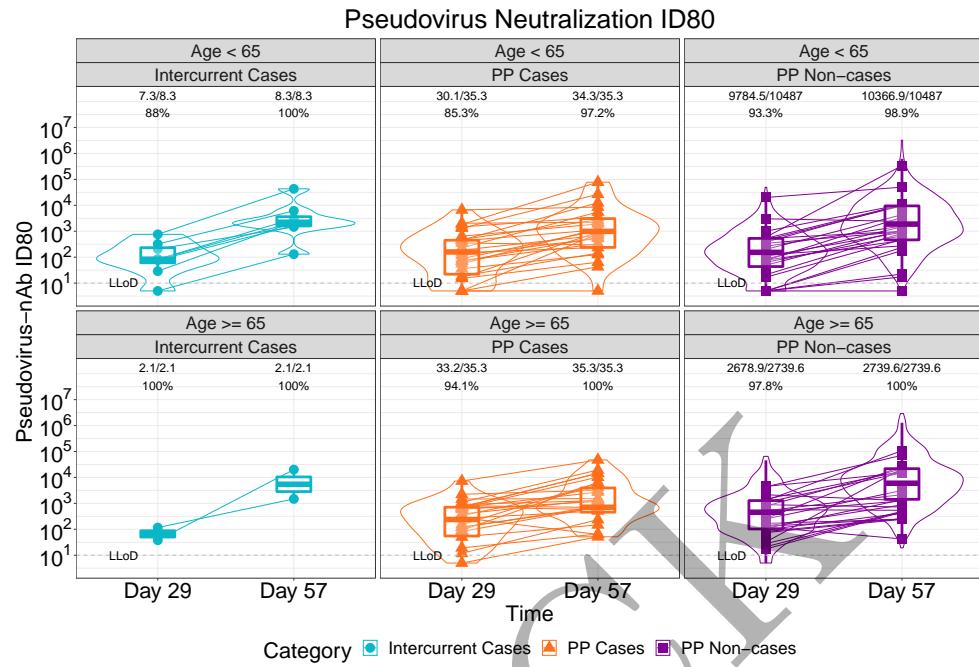


Figure 2.62: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (2 timepoints)

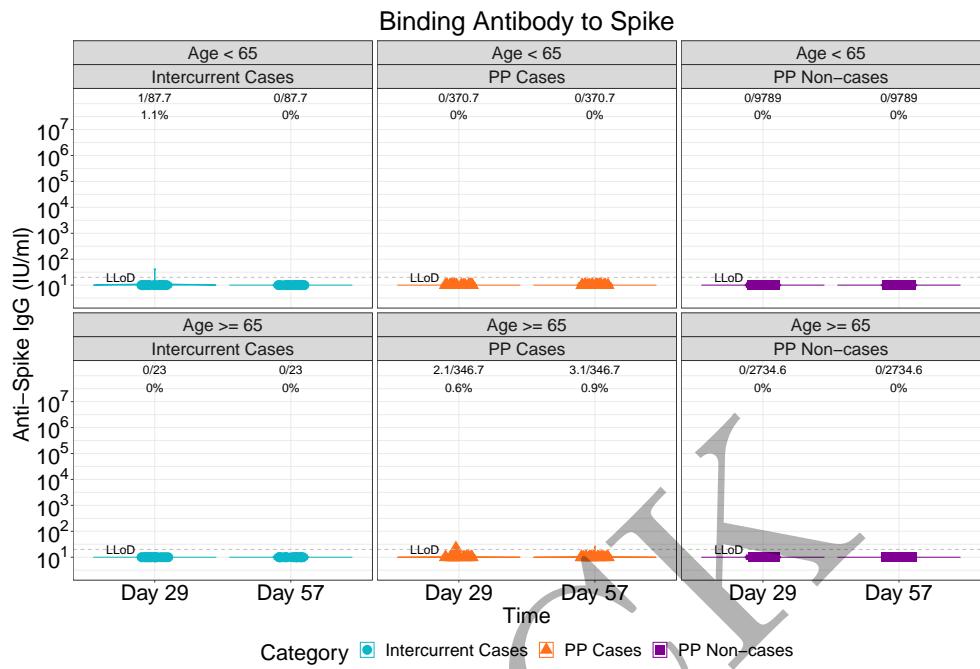


Figure 2.63: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (2 timepoints)

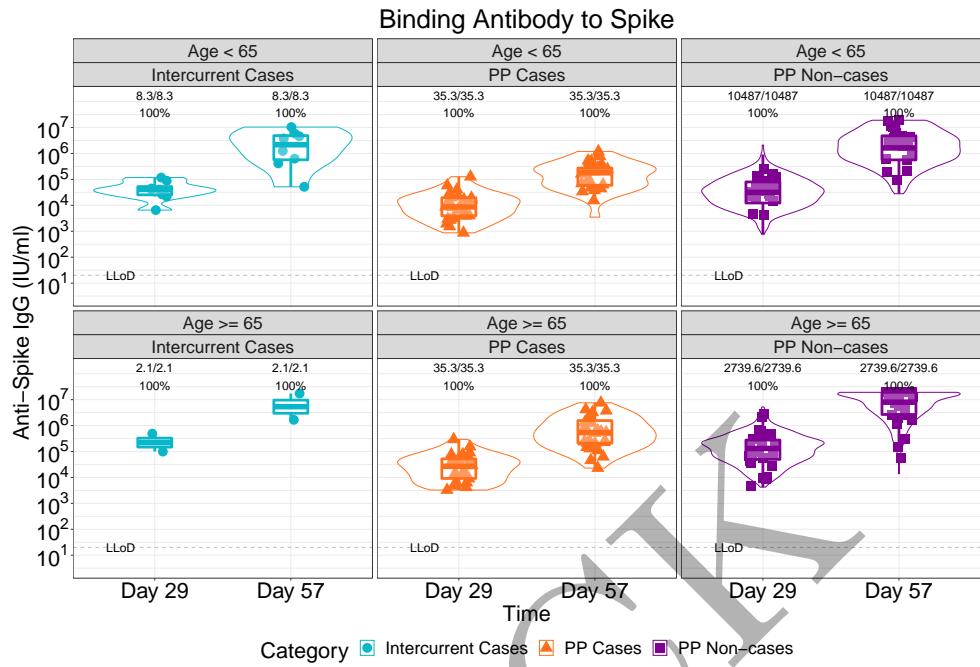


Figure 2.64: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (2 timepoints)

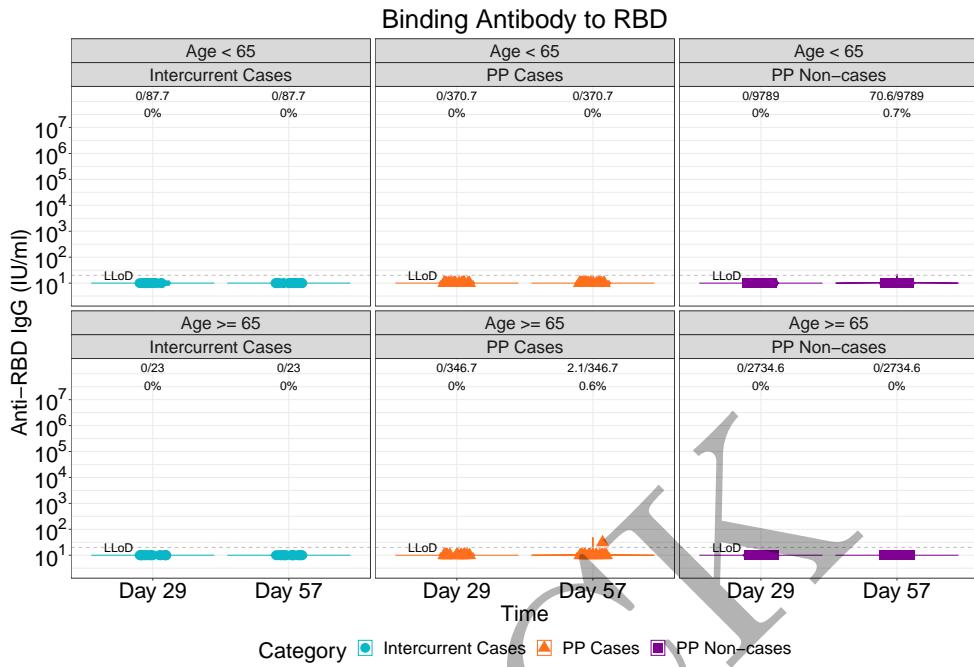


Figure 2.65: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (2 timepoints)

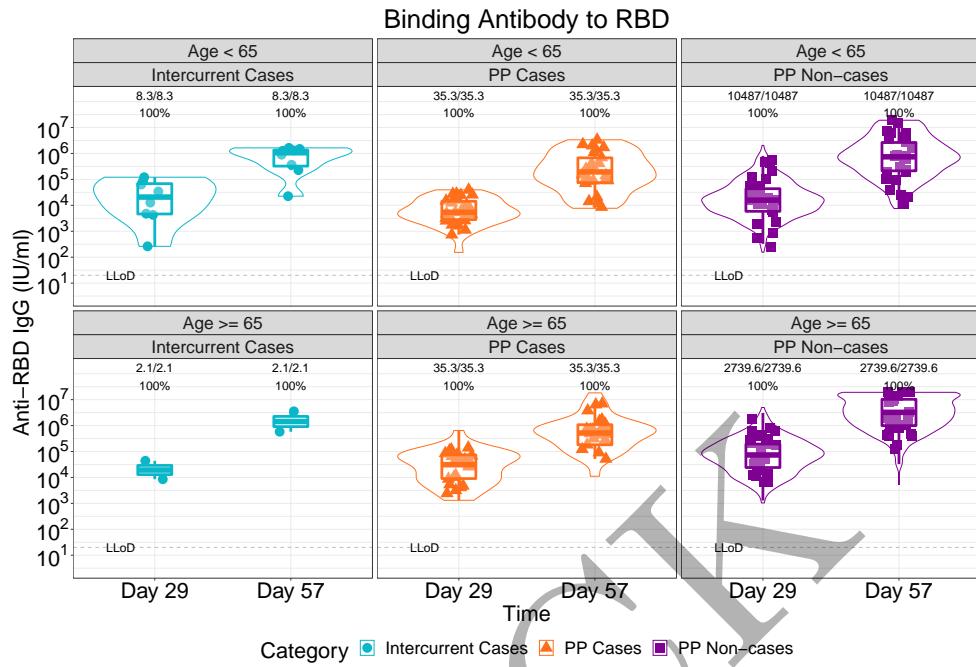


Figure 2.66: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (2 timepoints)

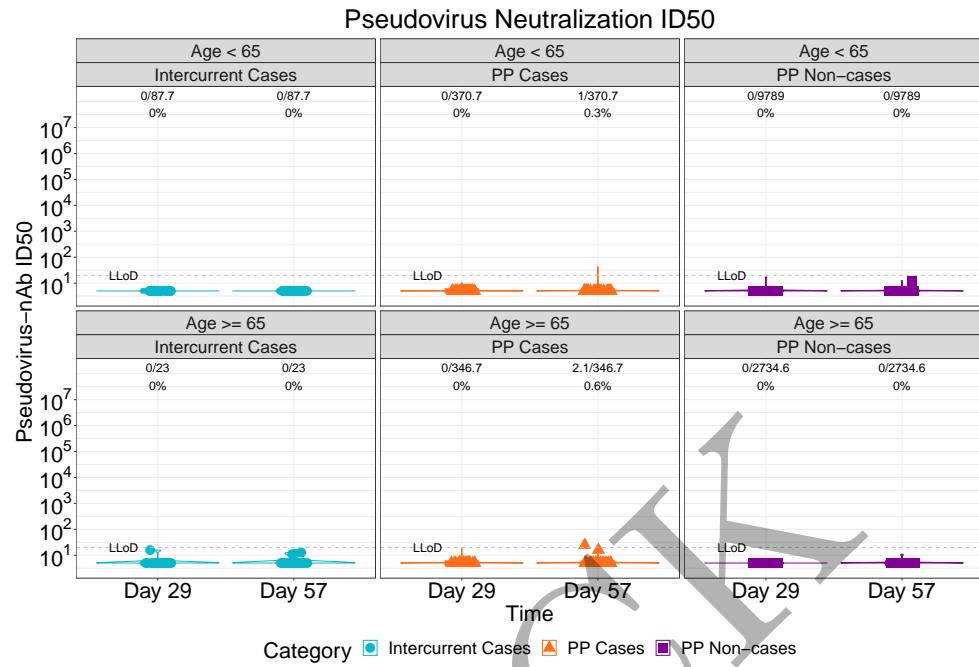


Figure 2.67: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (2 timepoints)

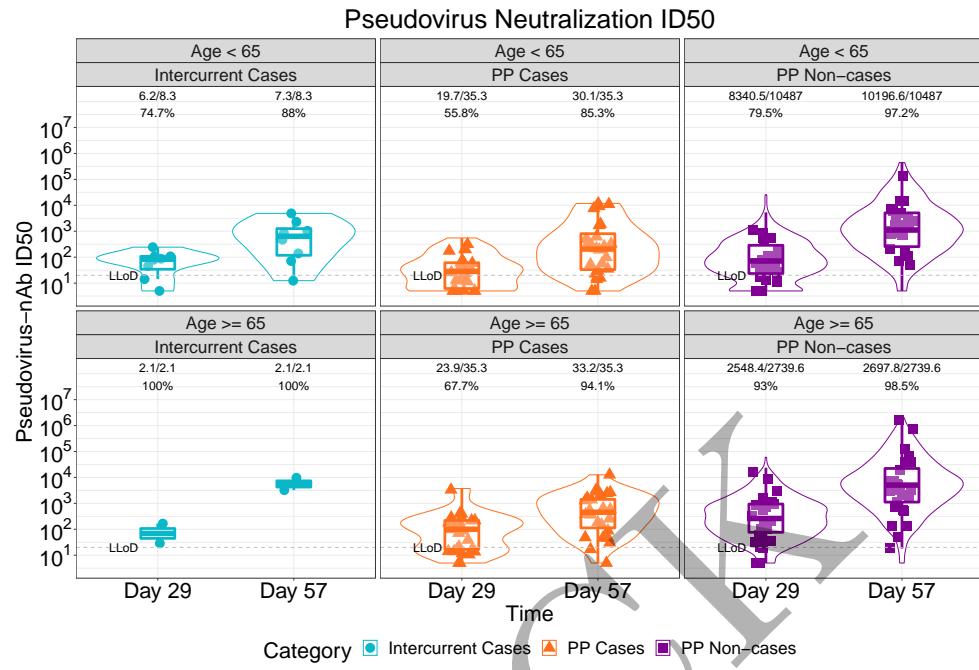


Figure 2.68: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (2 timepoints)

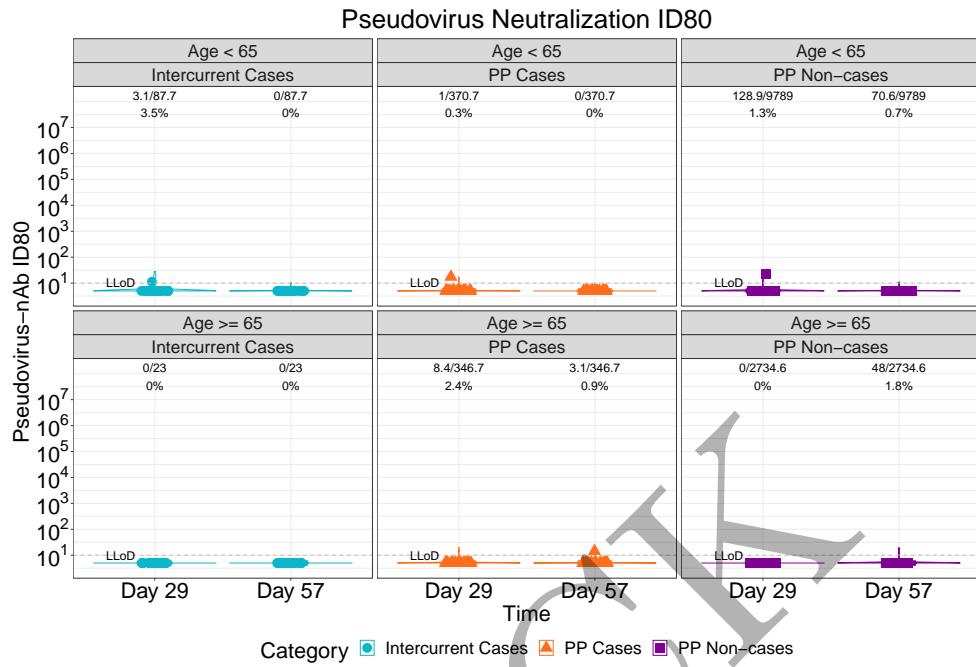


Figure 2.69: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (2 timepoints)

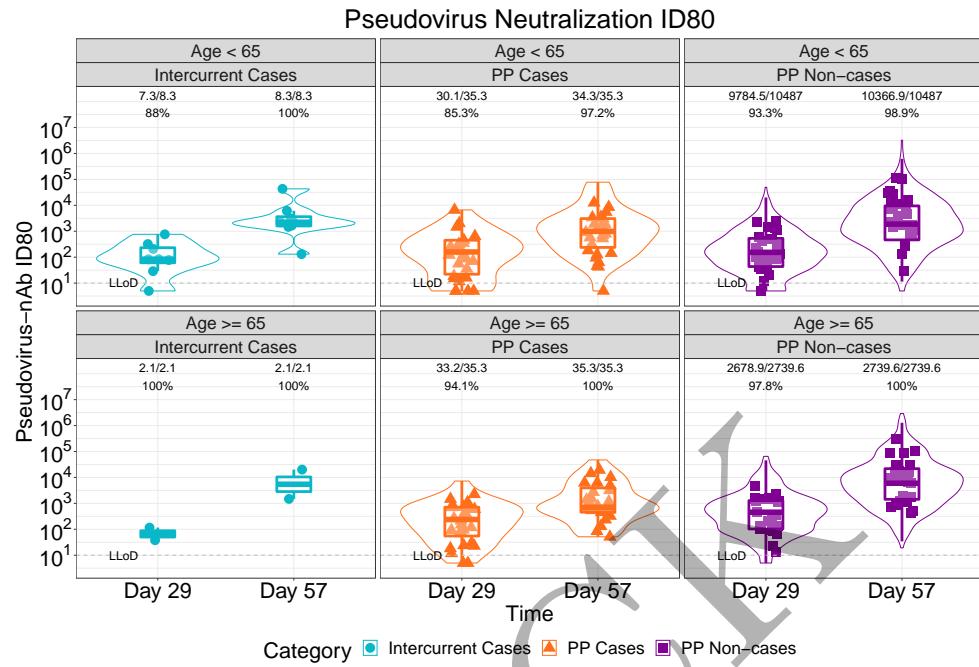


Figure 2.70: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (2 timepoints)

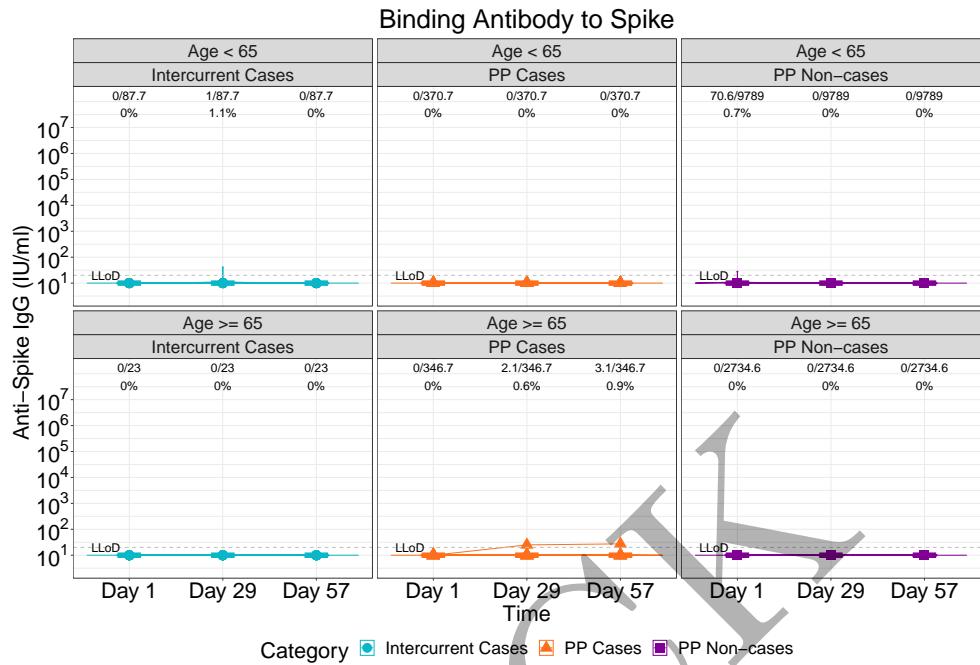


Figure 2.71: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (3 timepoints)

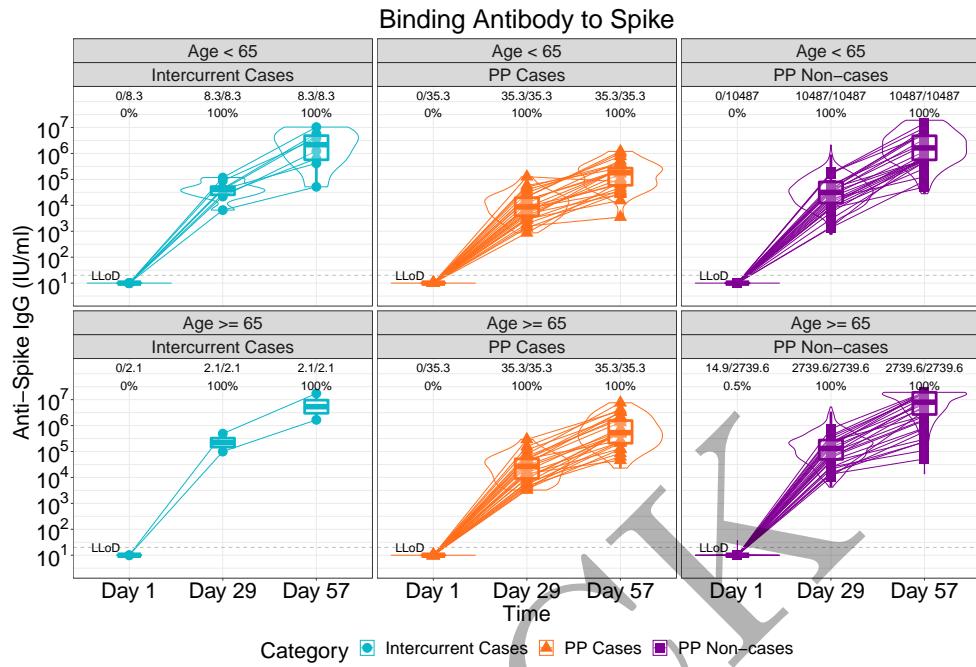


Figure 2.72: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (3 timepoints)

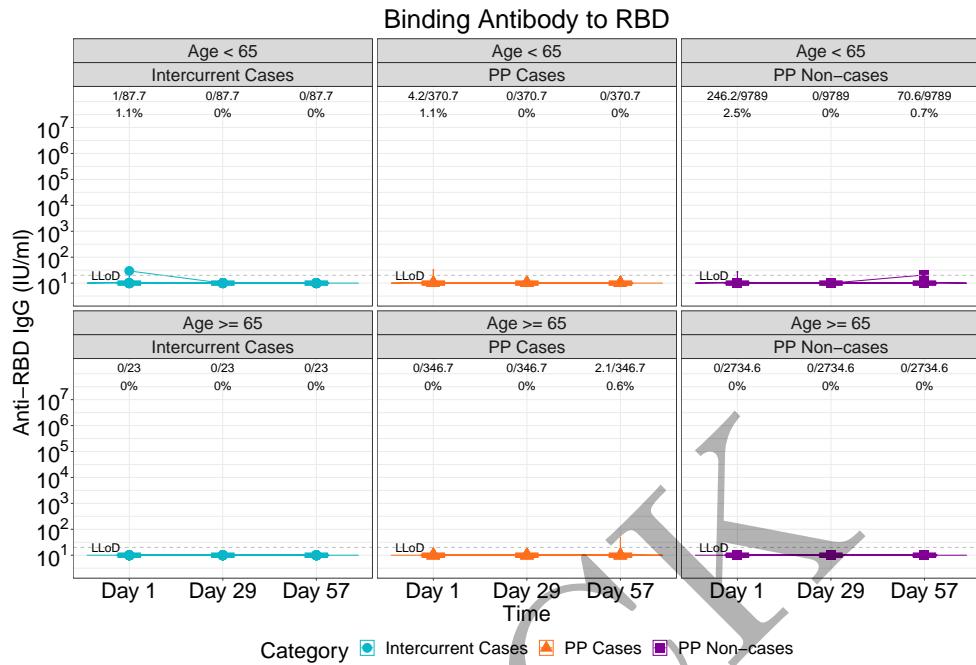


Figure 2.73: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (3 timepoints)

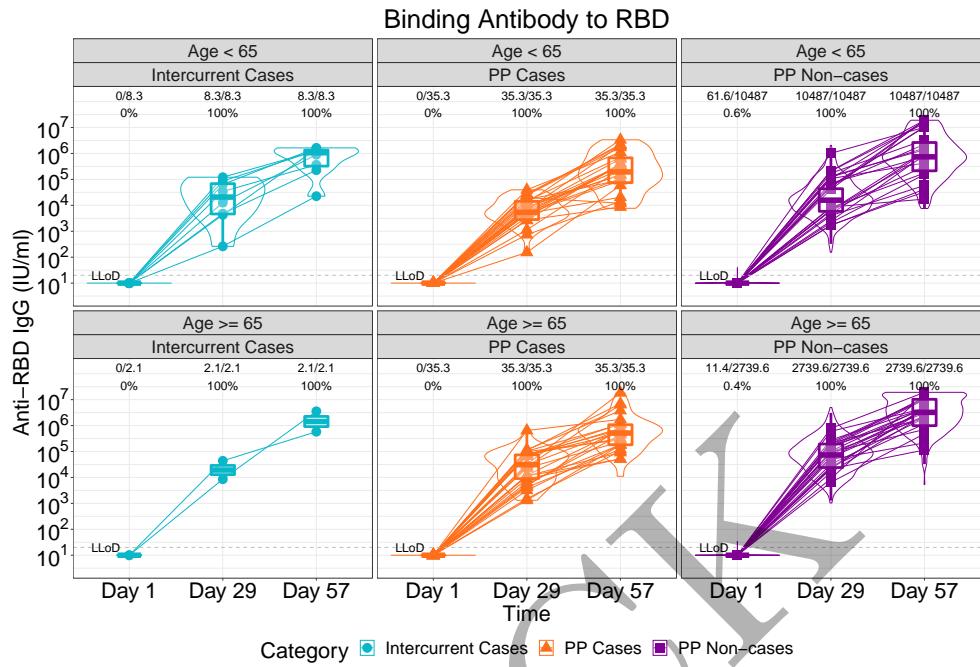


Figure 2.74: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (3 timepoints)

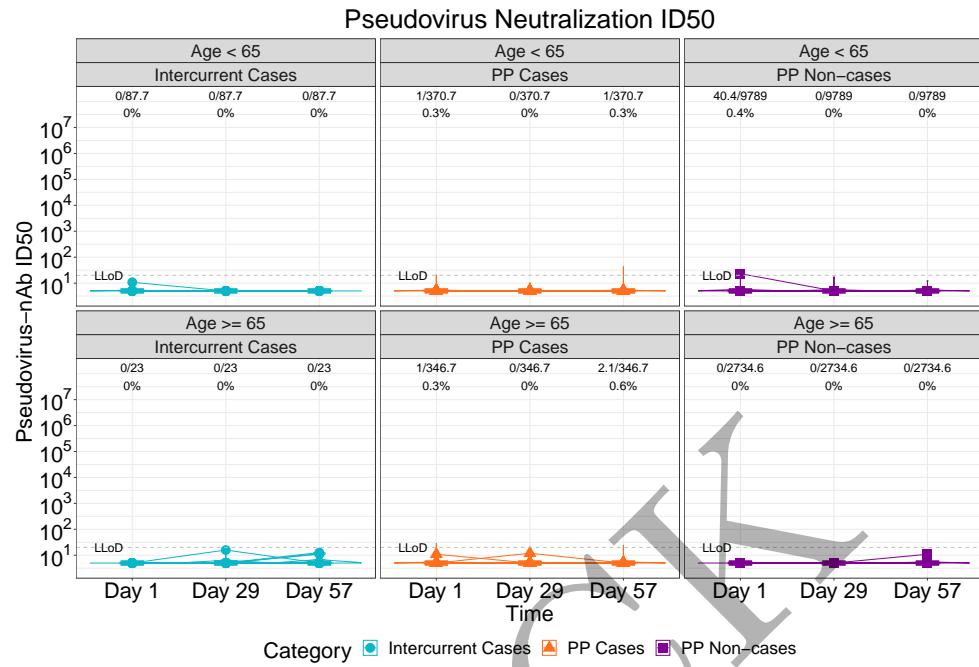


Figure 2.75: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (3 timepoints)

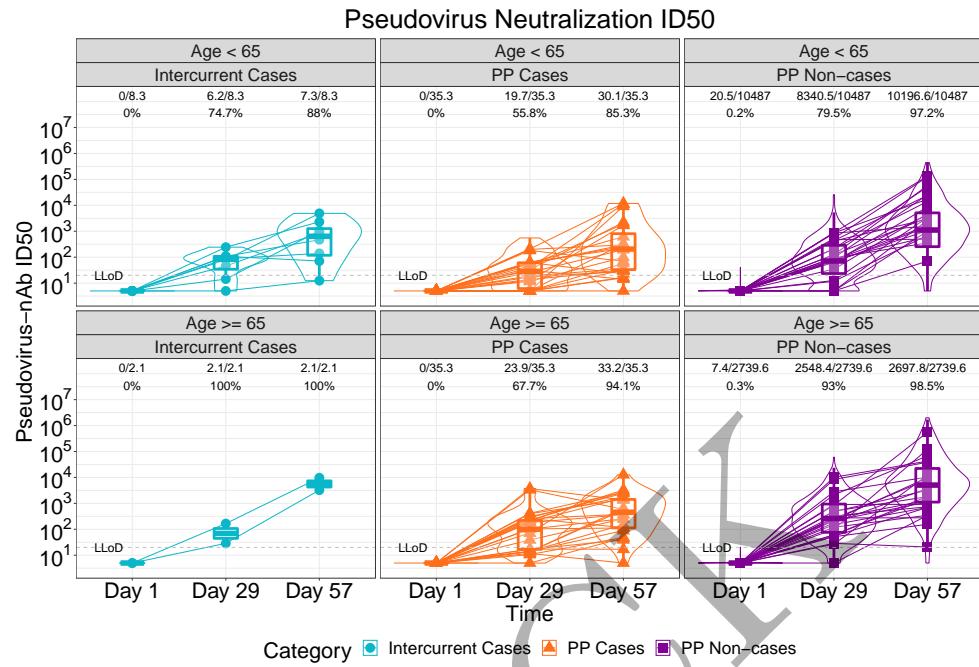


Figure 2.76: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (3 timepoints)

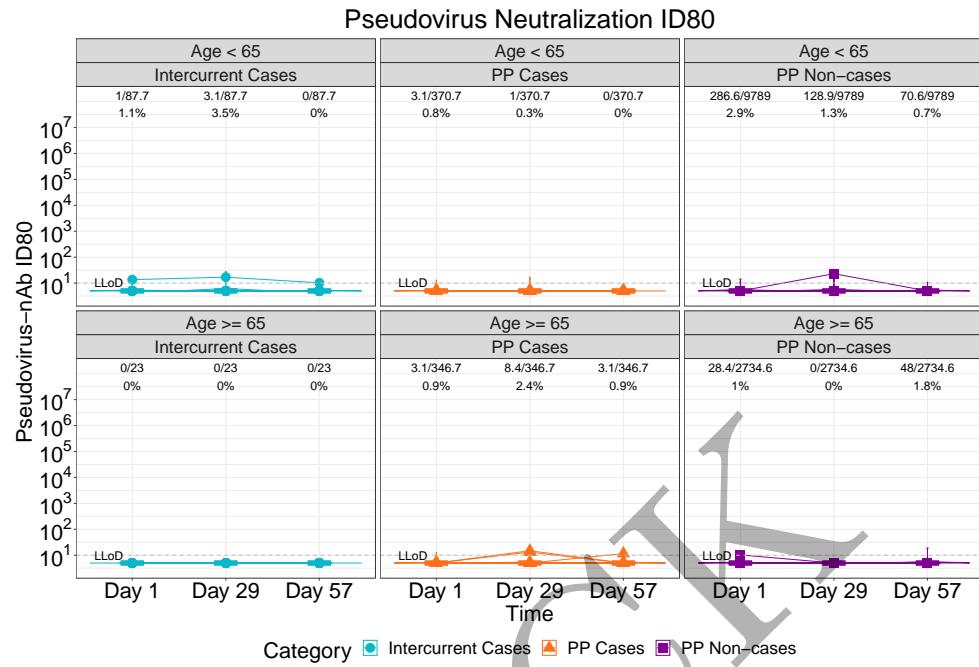


Figure 2.77: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (3 timepoints)

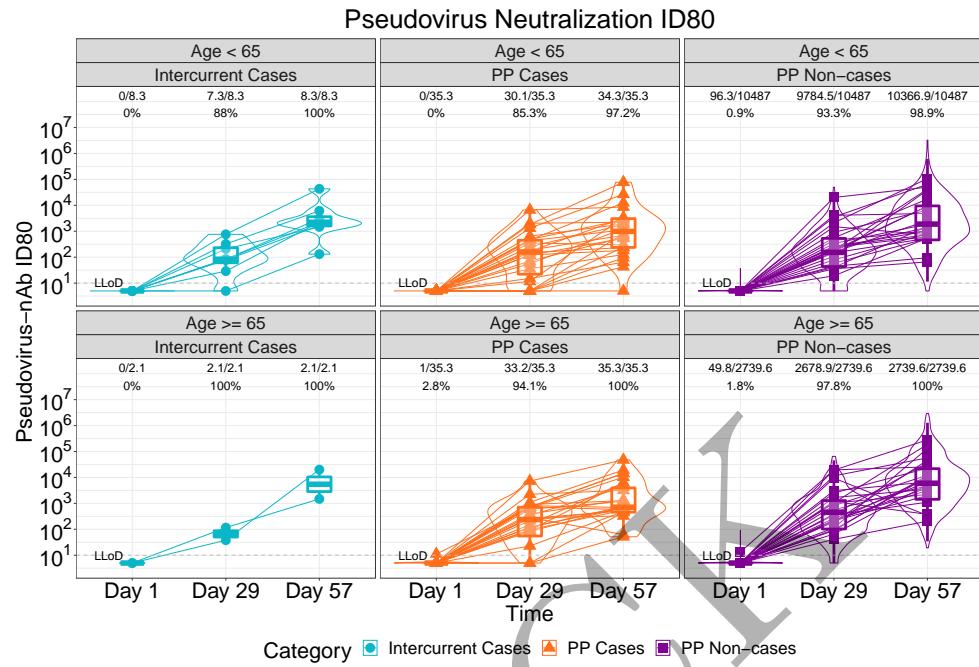


Figure 2.78: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (3 timepoints)

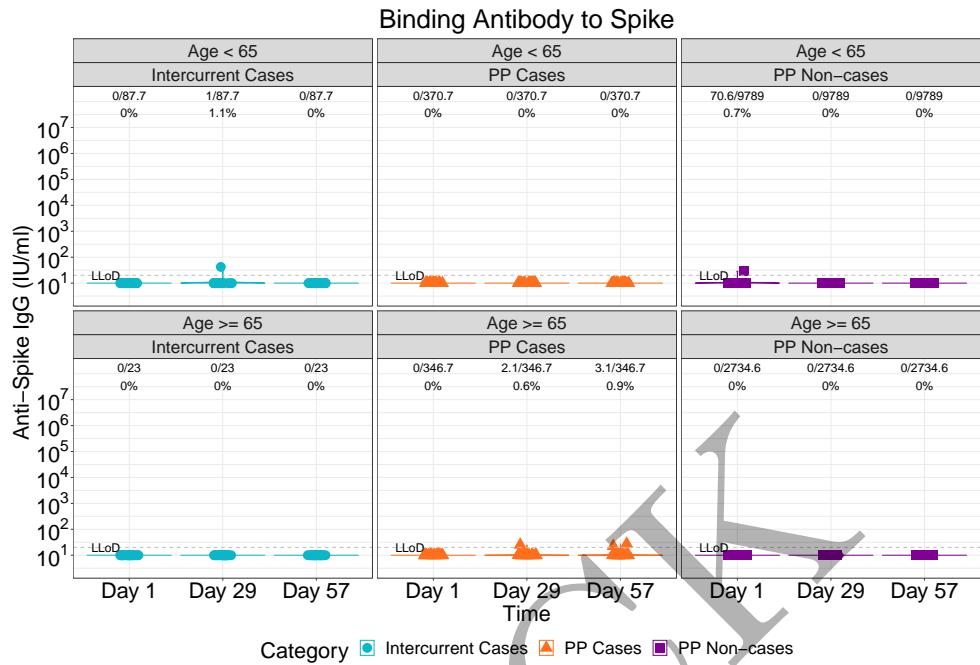


Figure 2.79: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (3 timepoints)

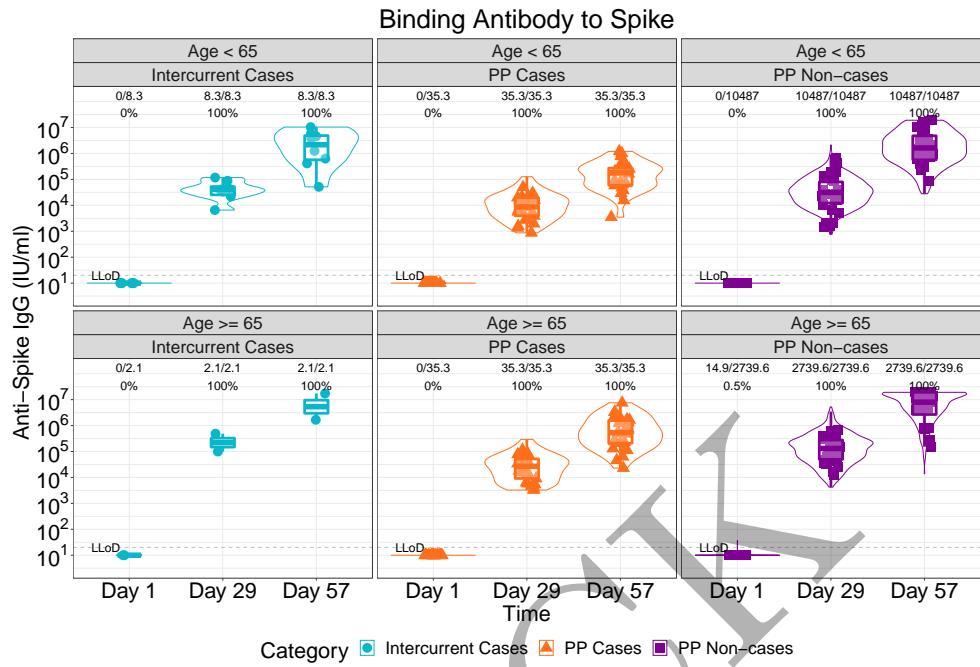


Figure 2.80: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (3 timepoints)

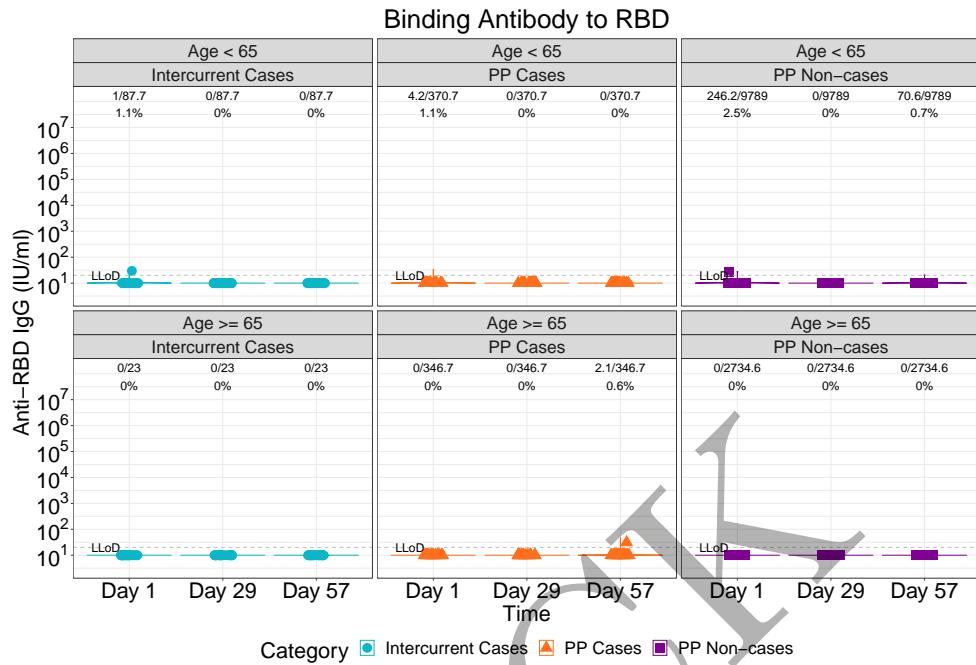


Figure 2.81: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (3 timepoints)

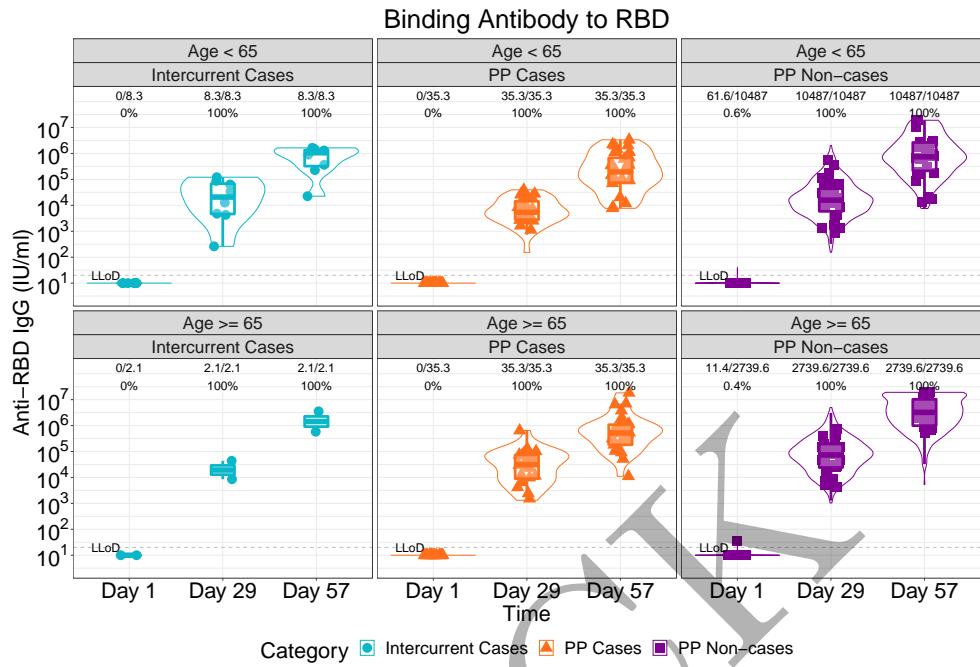


Figure 2.82: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (3 timepoints)

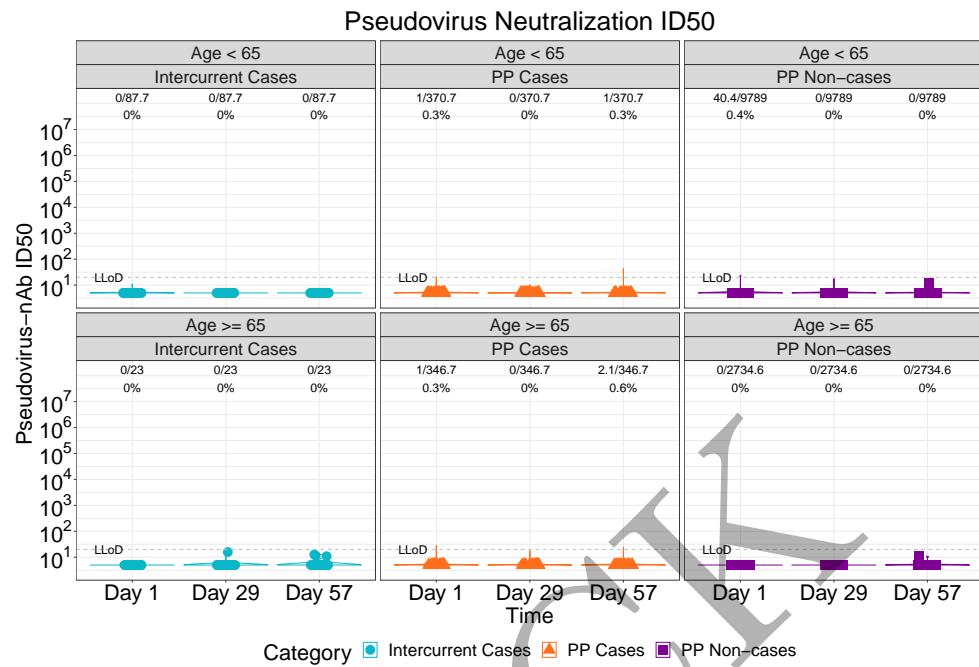


Figure 2.83: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (3 timepoints)

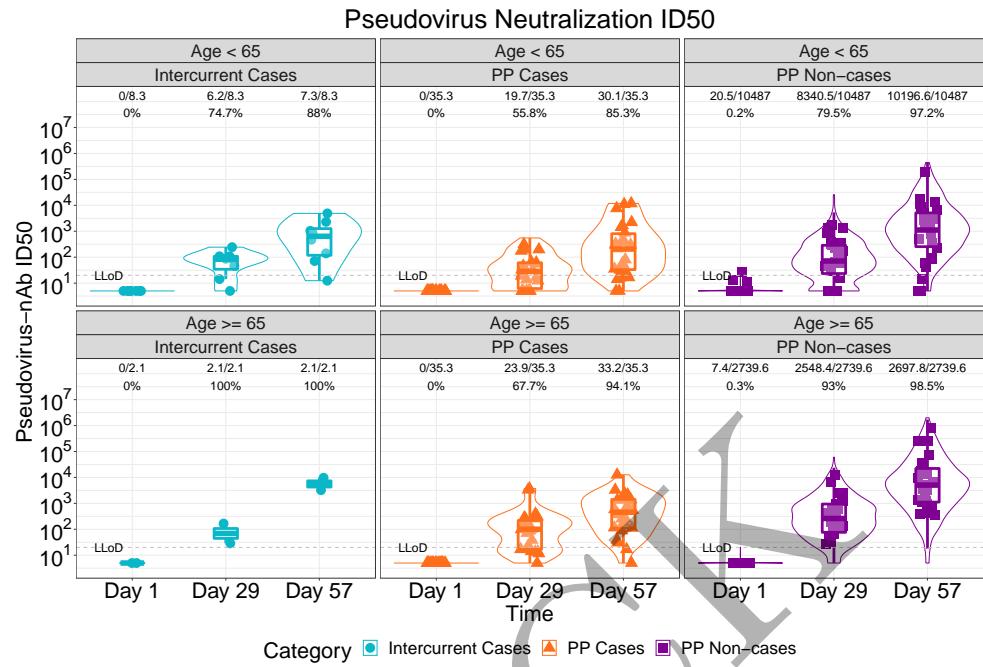


Figure 2.84: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (3 timepoints)

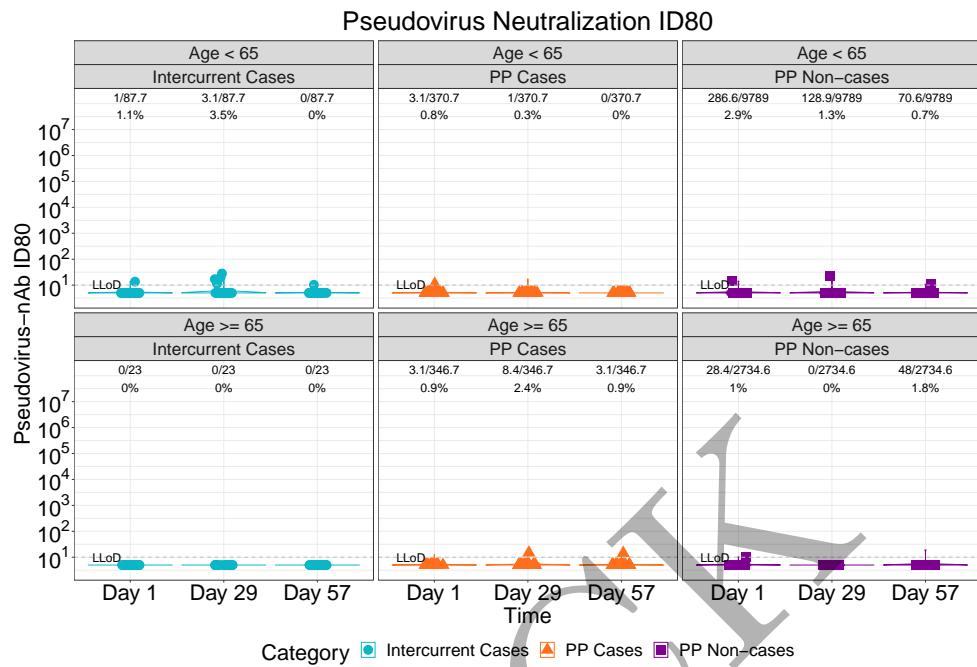


Figure 2.85: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (3 timepoints)

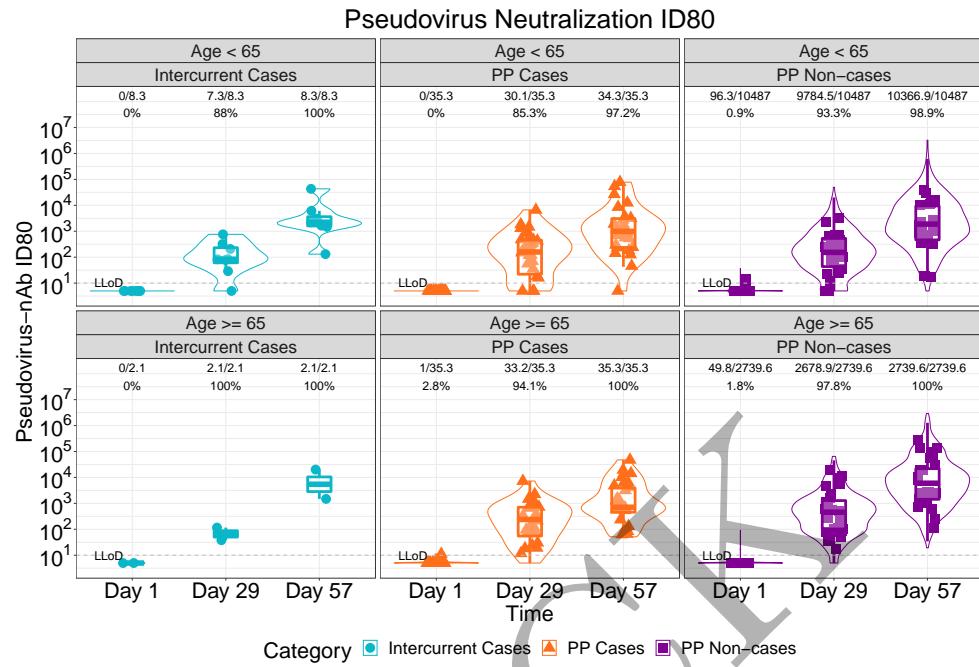


Figure 2.86: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (3 timepoints)

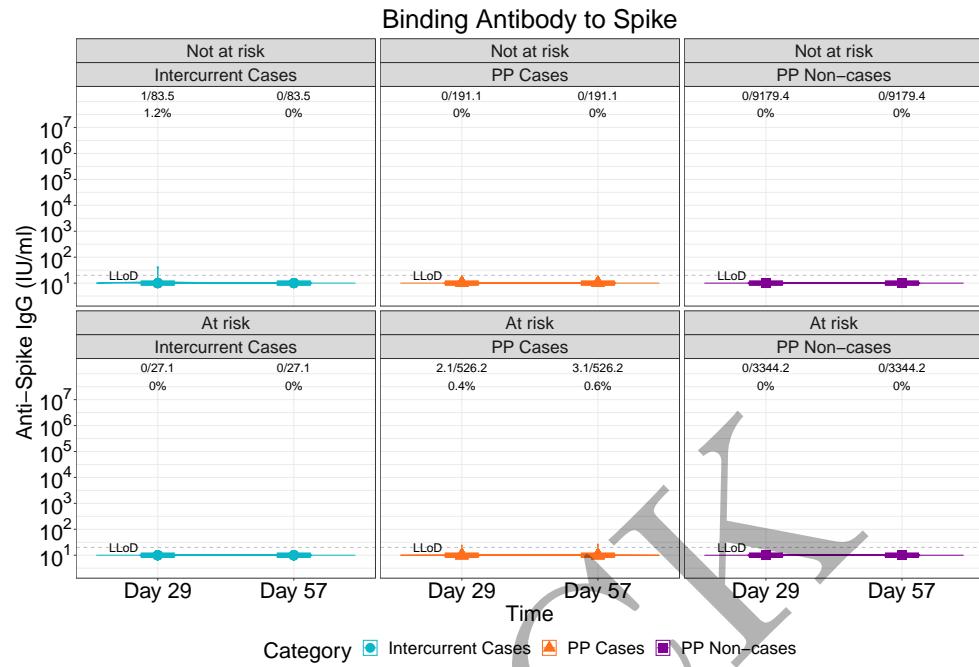


Figure 2.87: lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (2 timepoints)



Figure 2.88: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (2 timepoints)

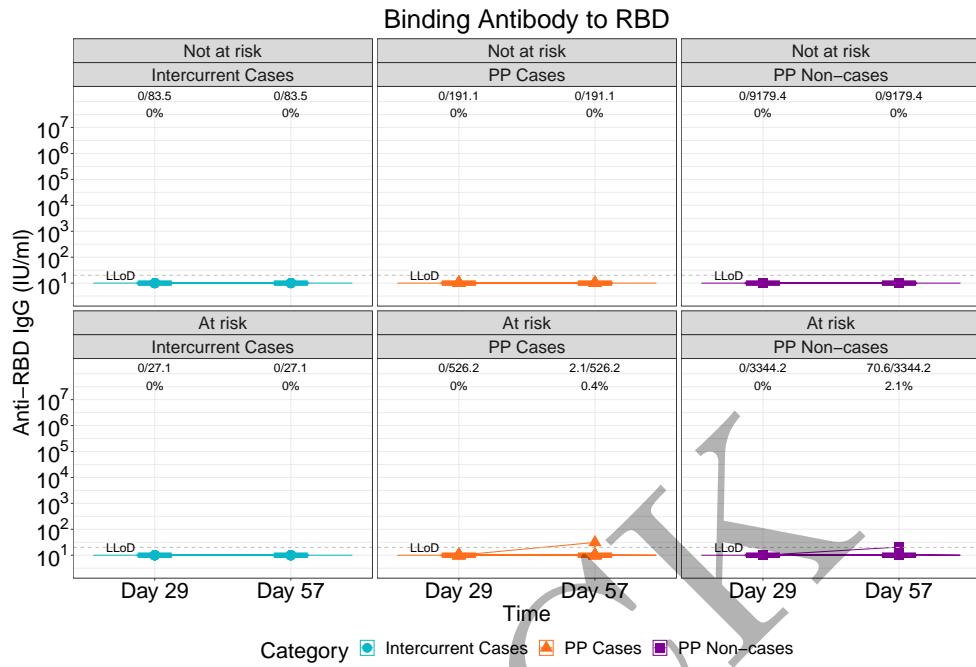


Figure 2.89: lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (2 timepoints)

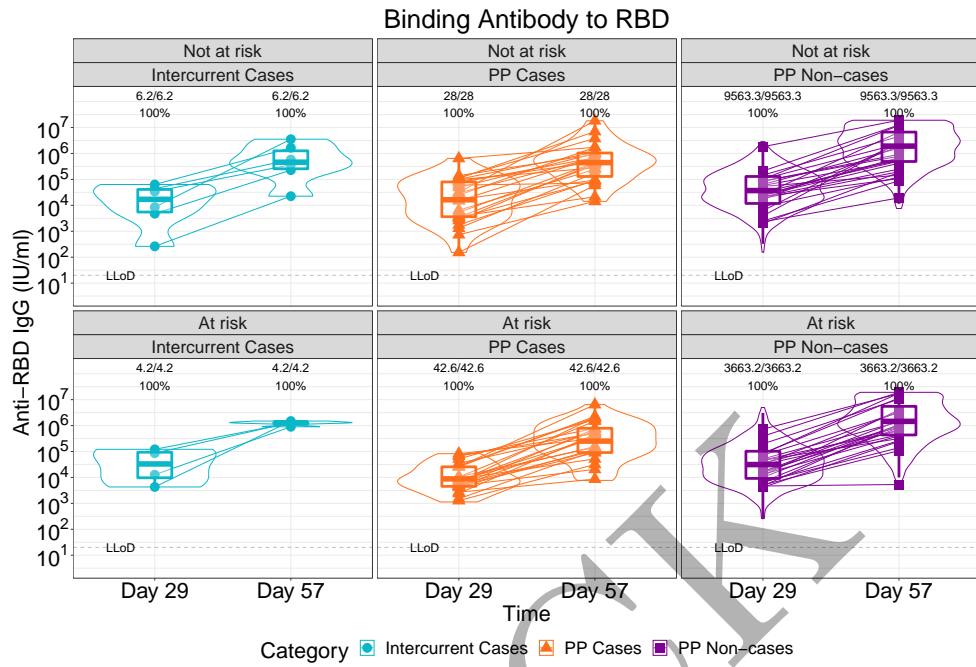


Figure 2.90: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (2 timepoints)

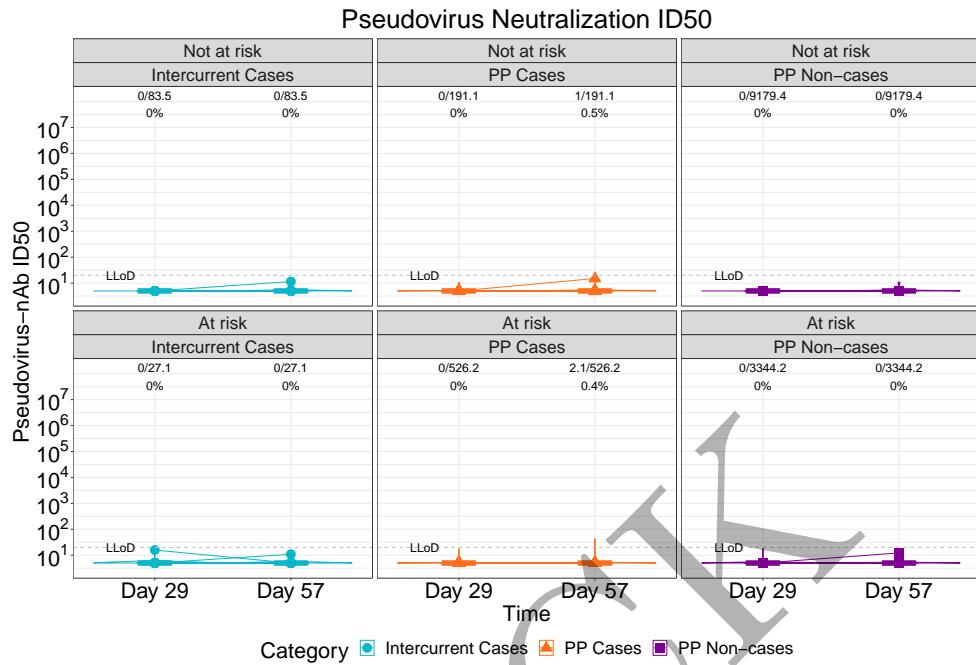


Figure 2.91: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (2 timepoints)

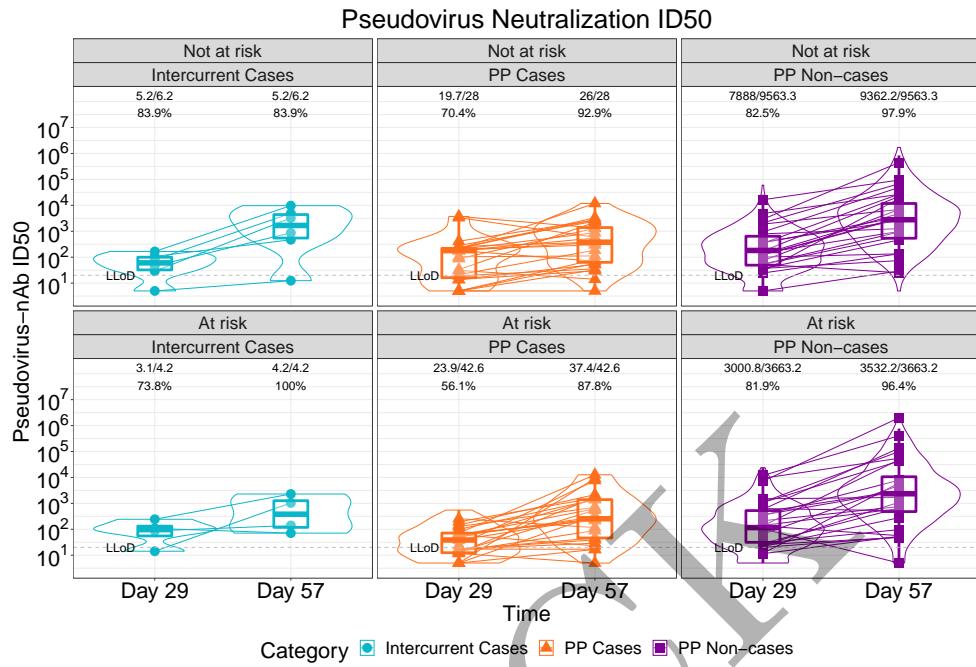


Figure 2.92: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (2 timepoints)

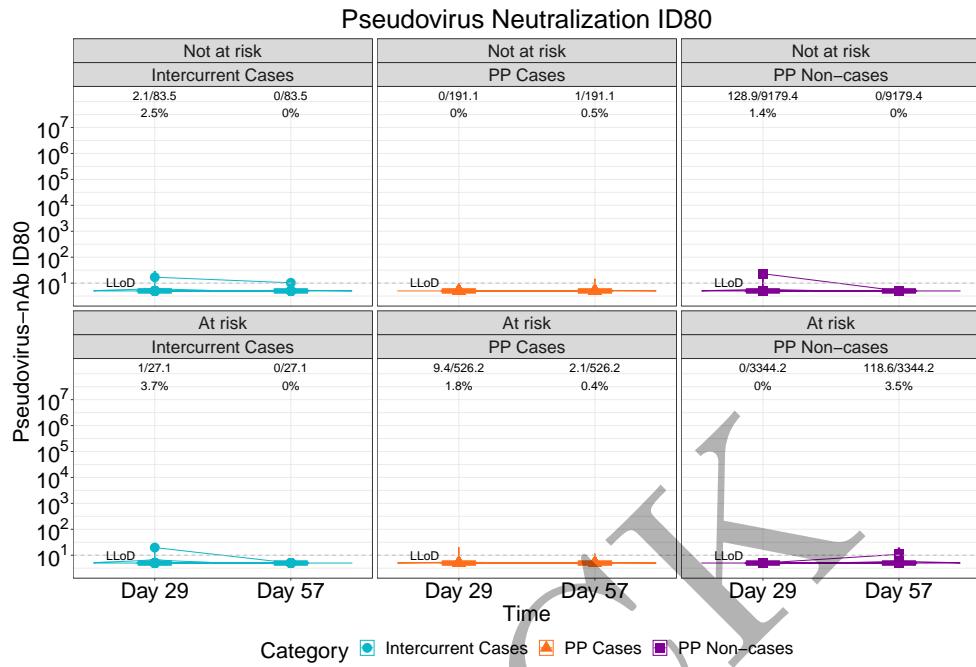


Figure 2.93: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (2 timepoints)

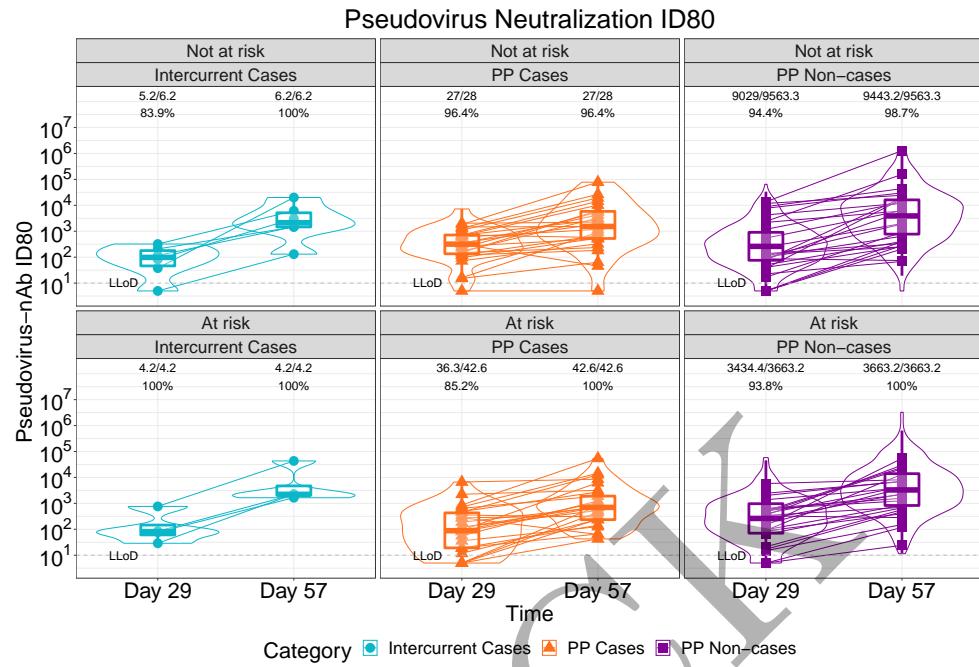


Figure 2.94: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (2 timepoints)

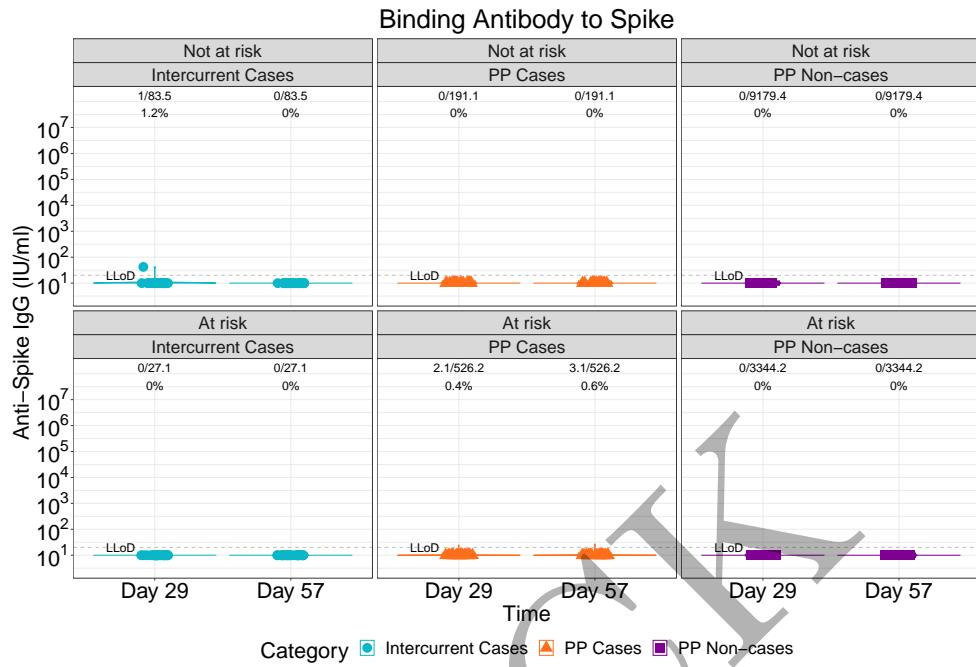


Figure 2.95: violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (2 timepoints)

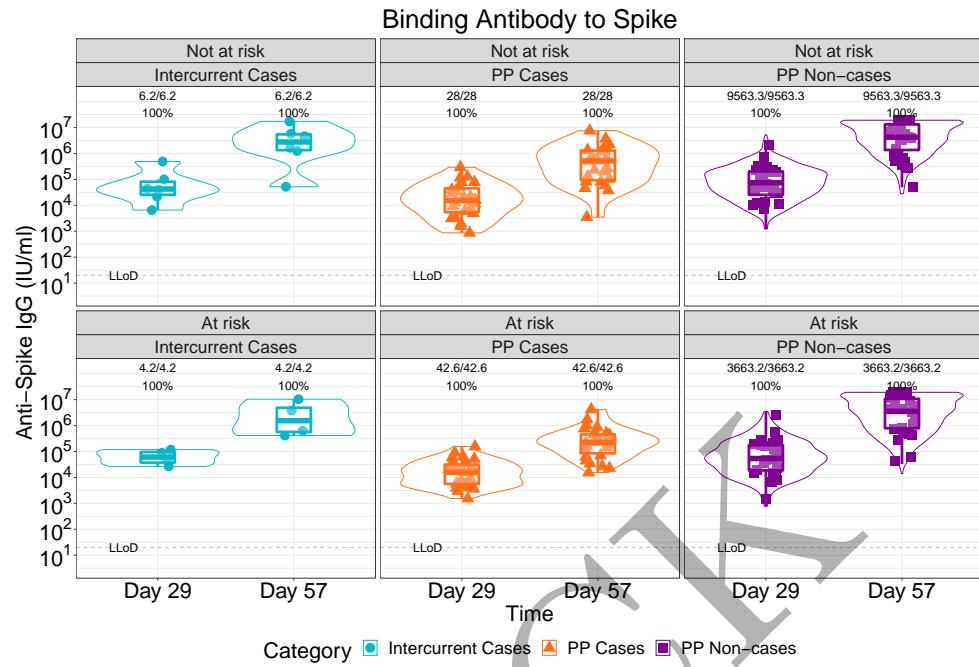


Figure 2.96: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (2 timepoints)

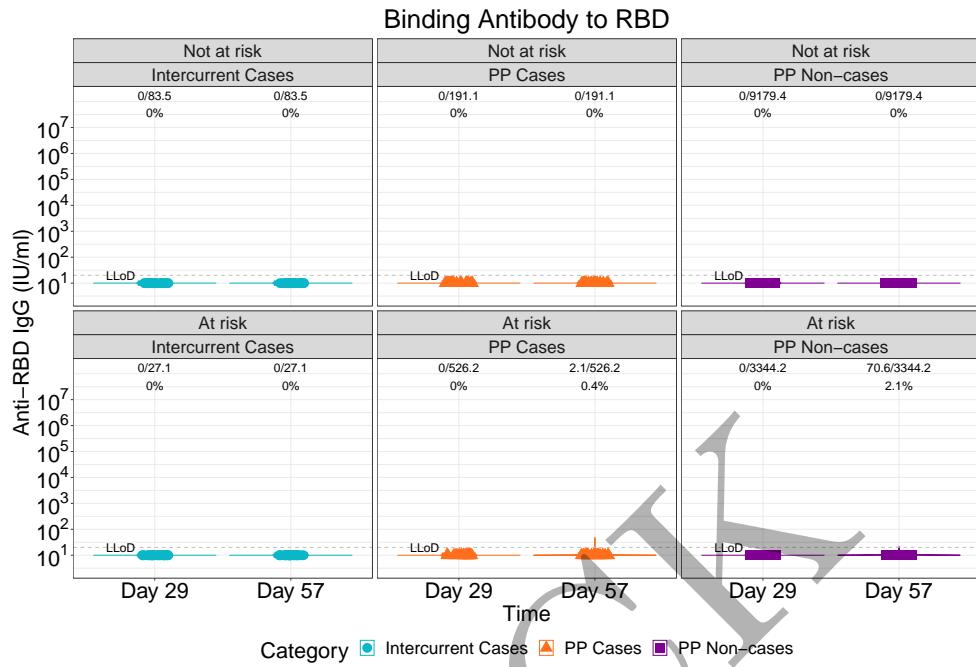


Figure 2.97: violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (2 timepoints)

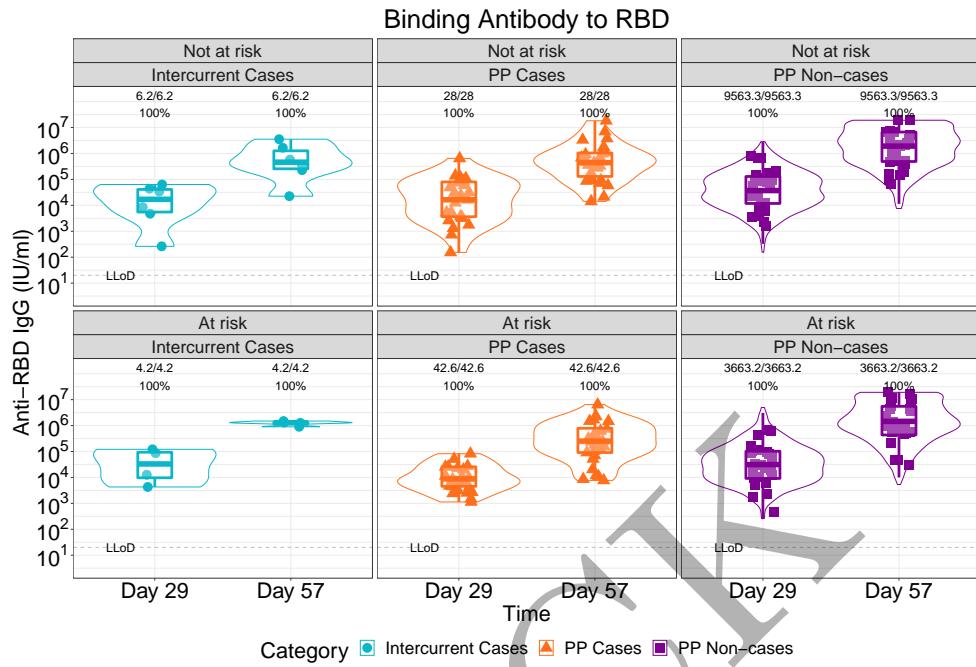


Figure 2.98: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (2 timepoints)

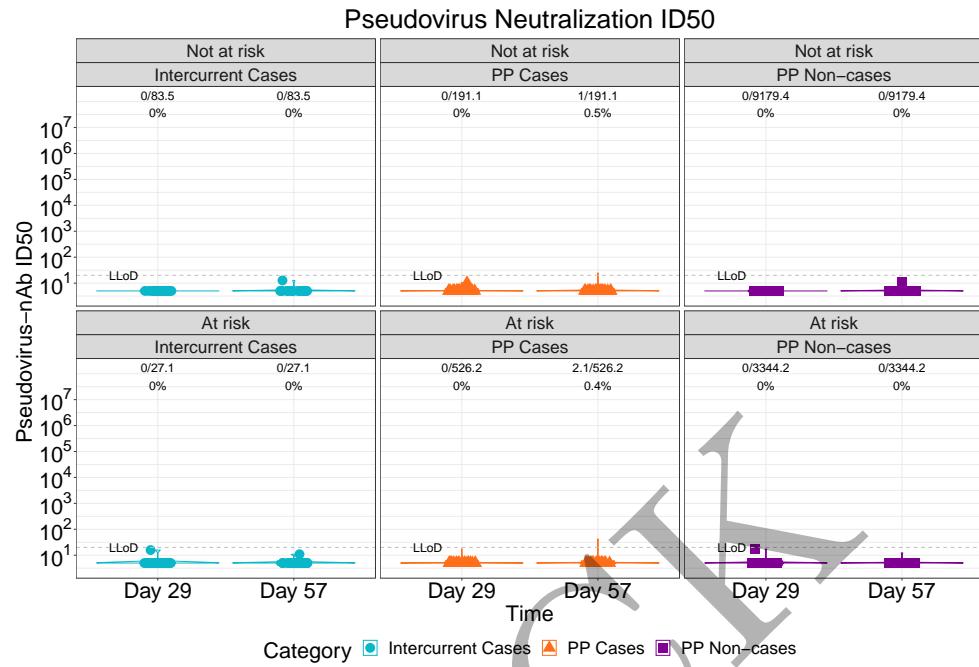


Figure 2.99: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (2 timepoints)

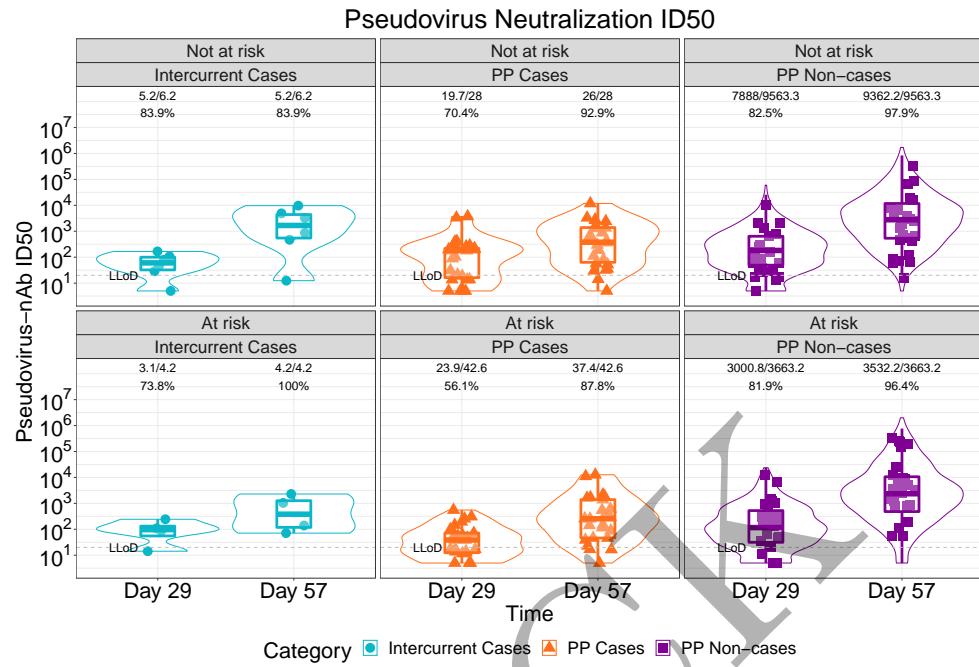


Figure 2.100: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (2 timepoints)

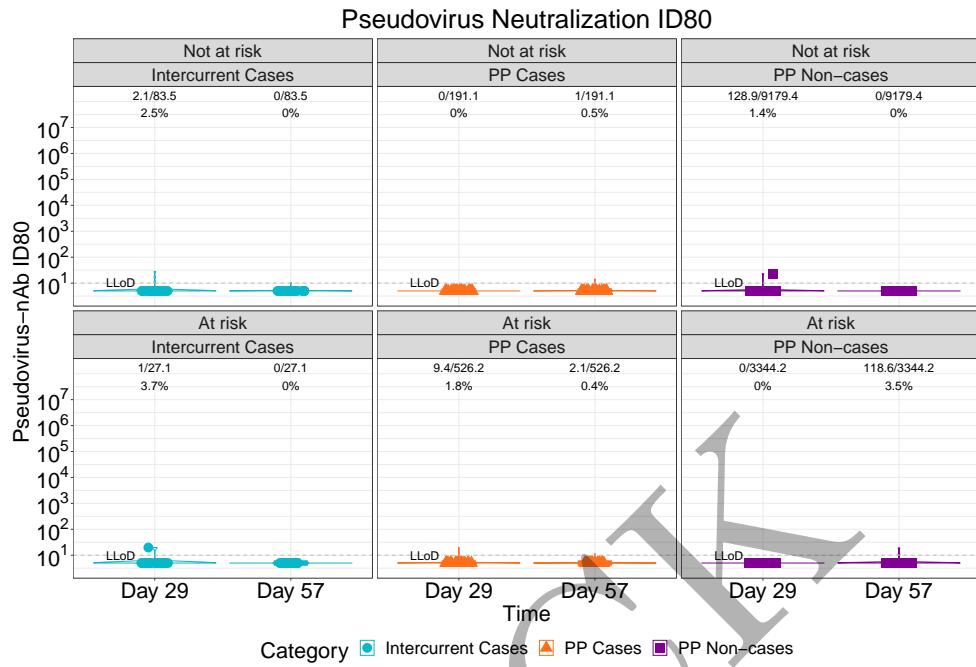


Figure 2.101: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (2 timepoints)

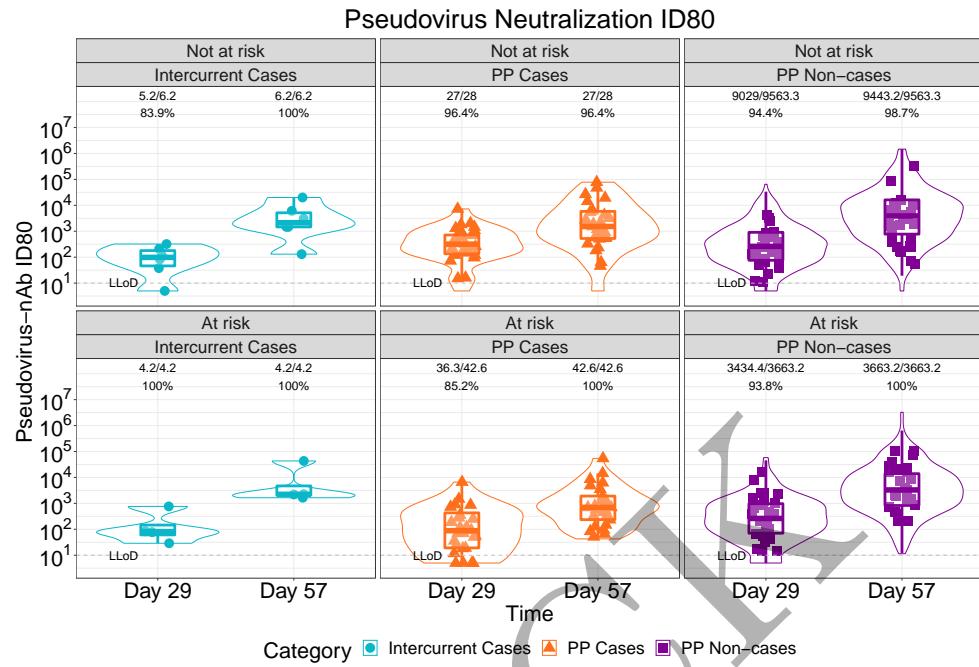


Figure 2.102: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (2 timepoints)

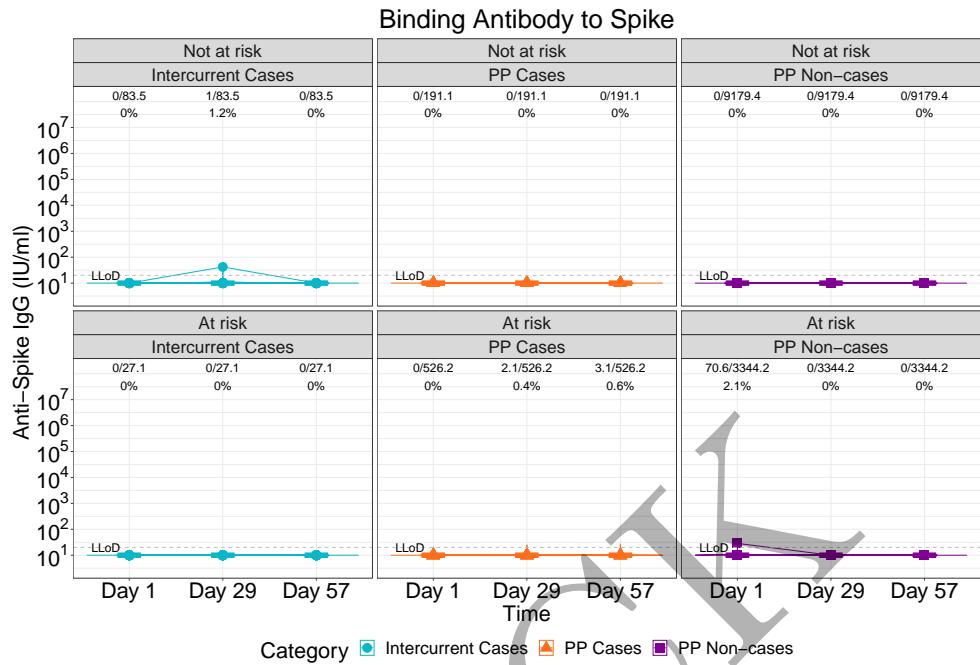


Figure 2.103: lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (3 timepoints)

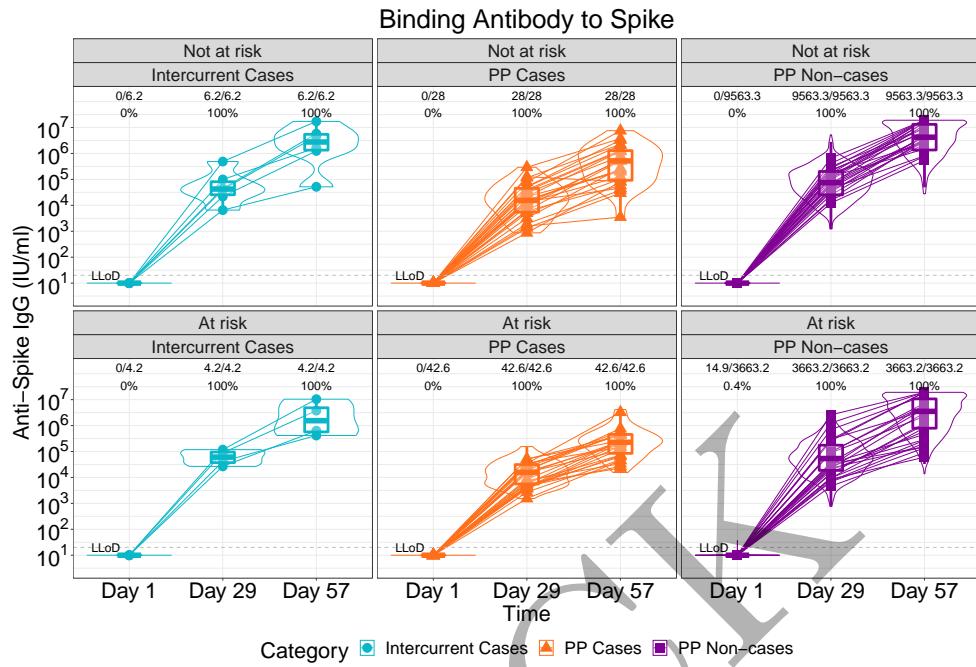


Figure 2.104: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (3 timepoints)

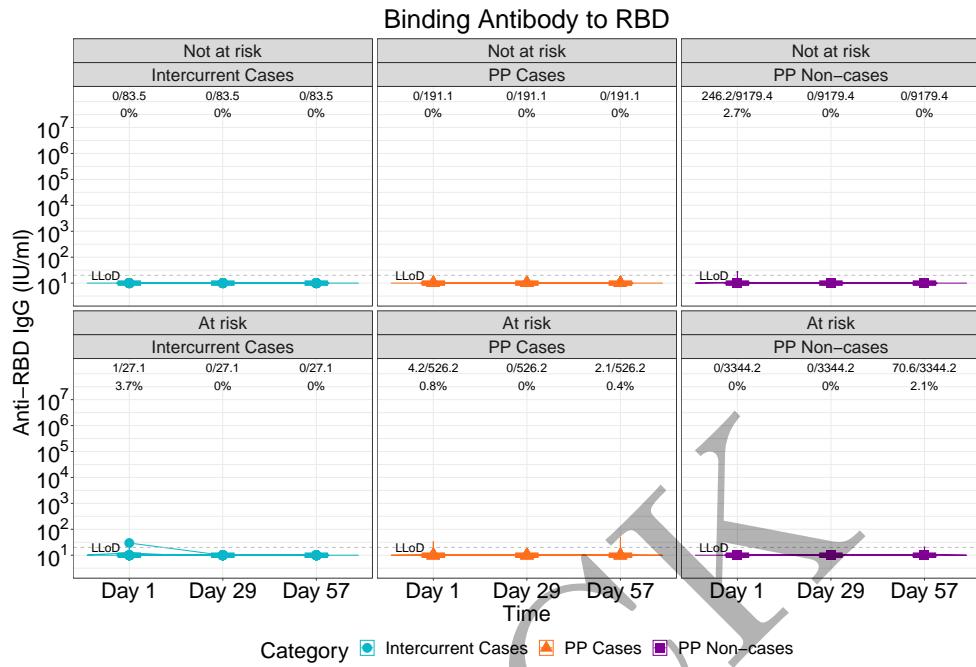


Figure 2.105: lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (3 timepoints)

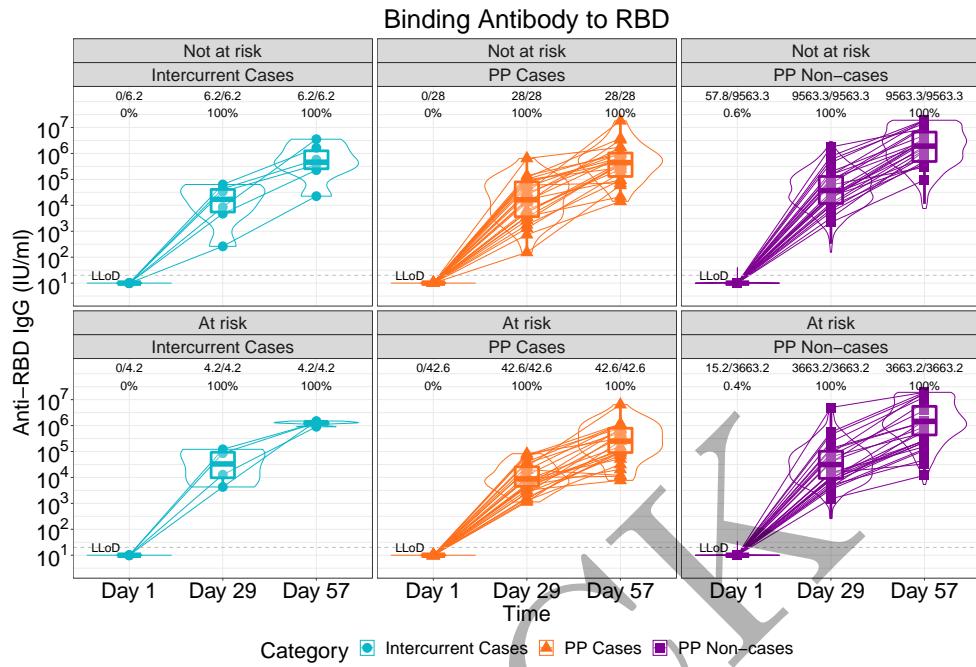


Figure 2.106: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (3 timepoints)

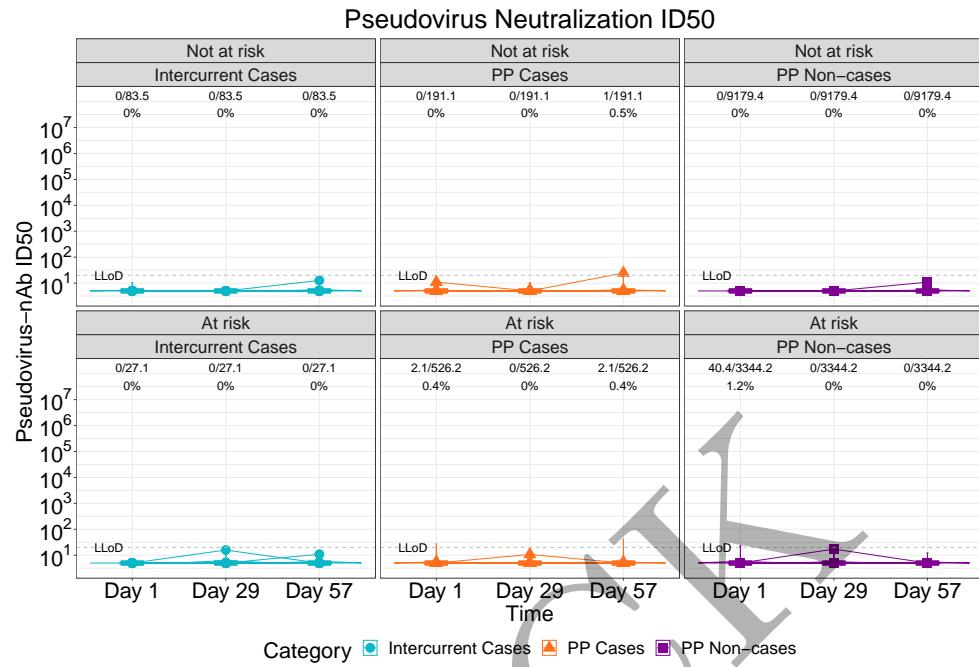


Figure 2.107: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (3 timepoints)

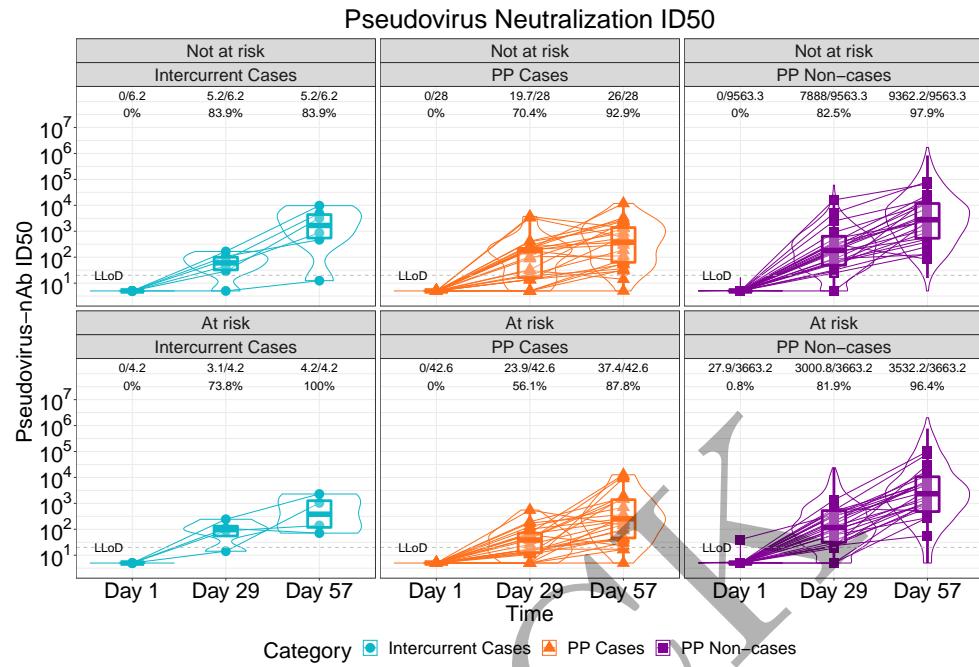


Figure 2.108: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (3 timepoints)

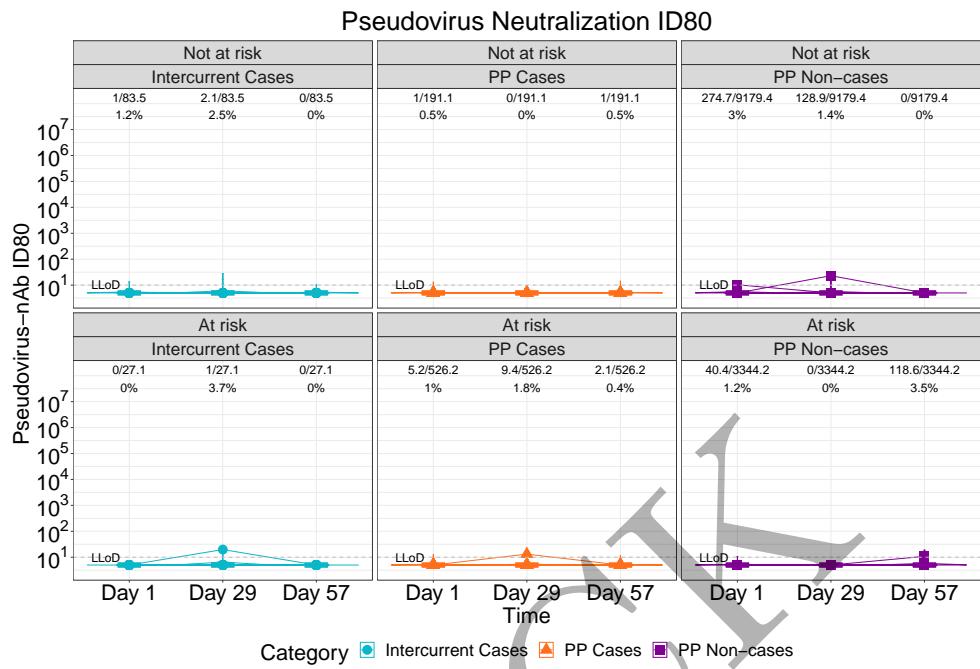


Figure 2.109: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (3 timepoints)

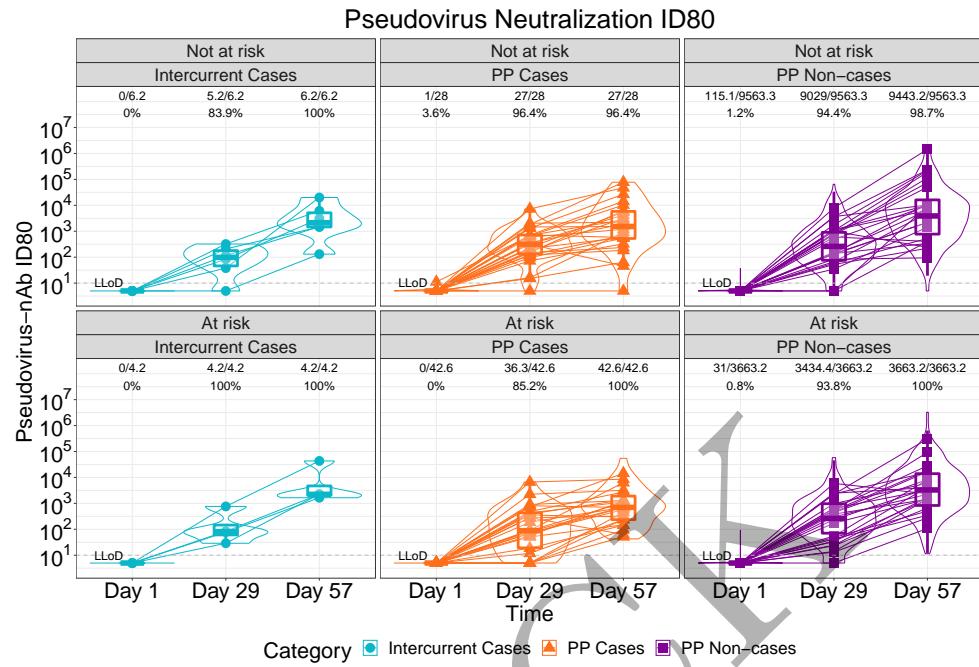


Figure 2.110: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (3 timepoints)

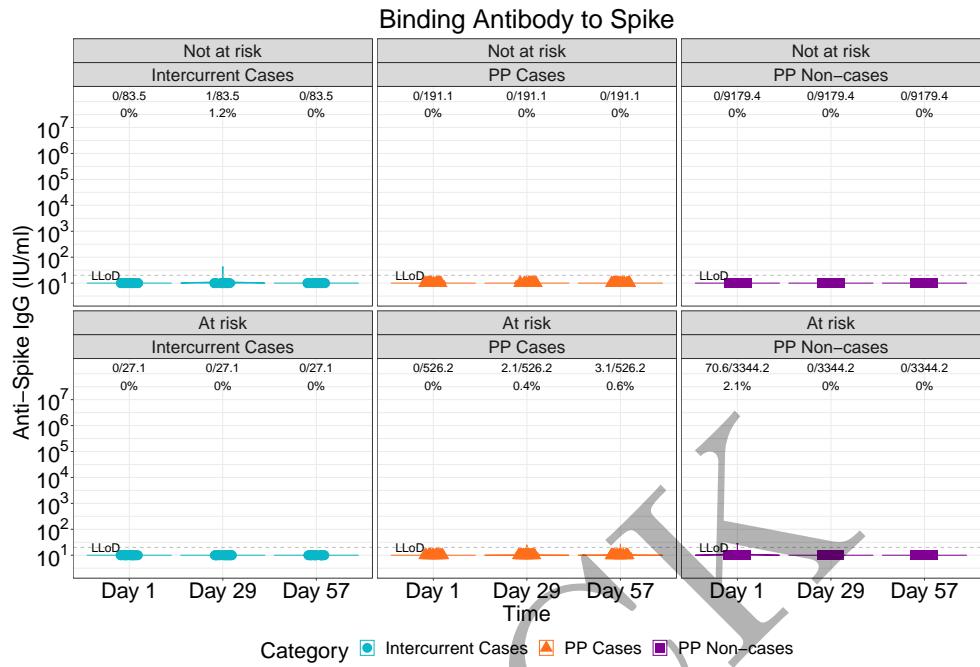


Figure 2.111: violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (3 timepoints)

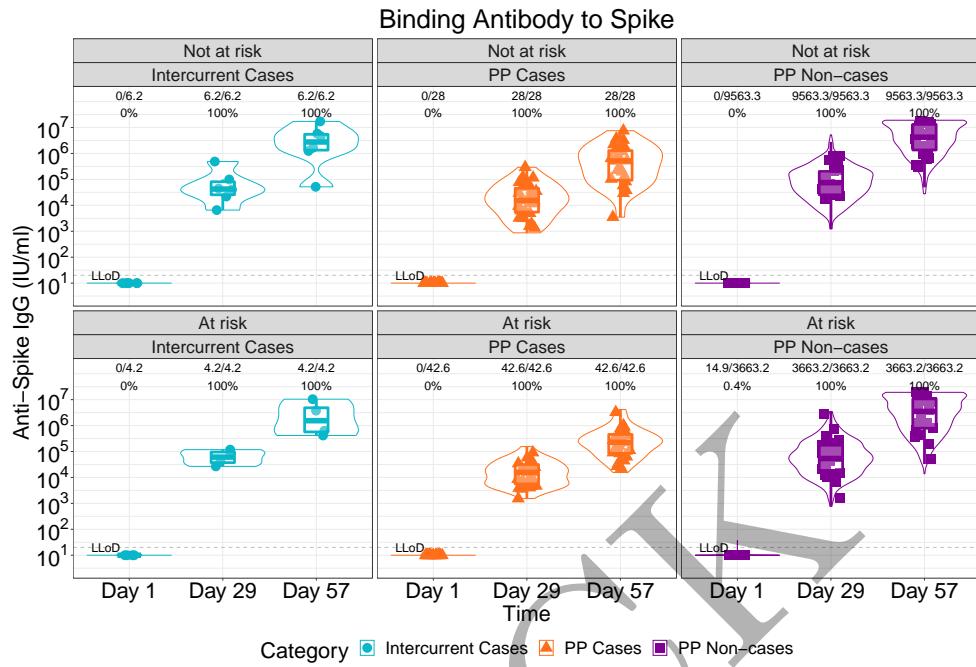


Figure 2.112: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (3 timepoints)

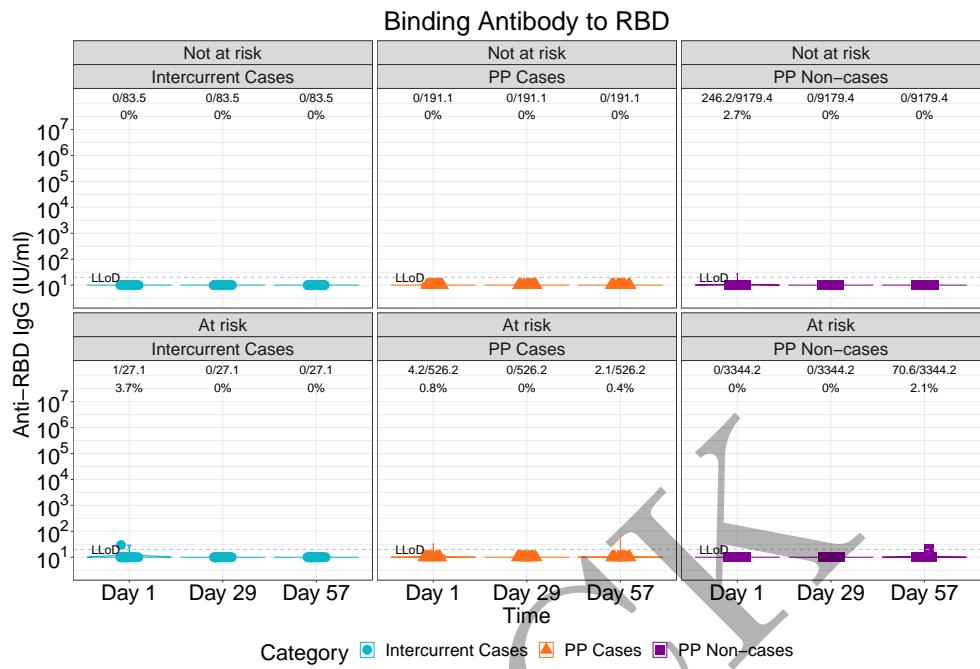


Figure 2.113: violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (3 timepoints)

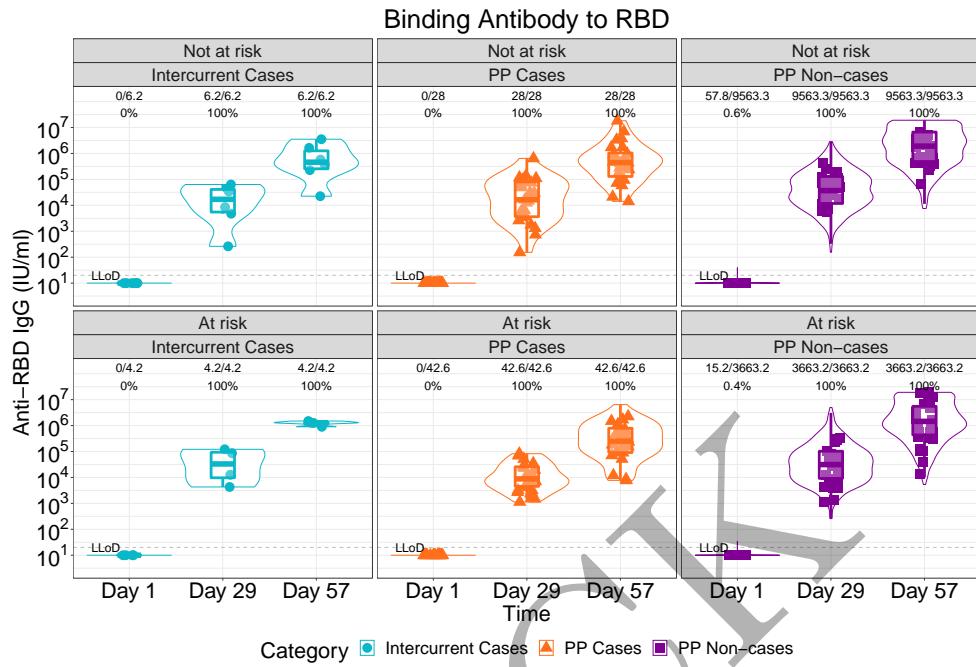


Figure 2.114: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (3 timepoints)

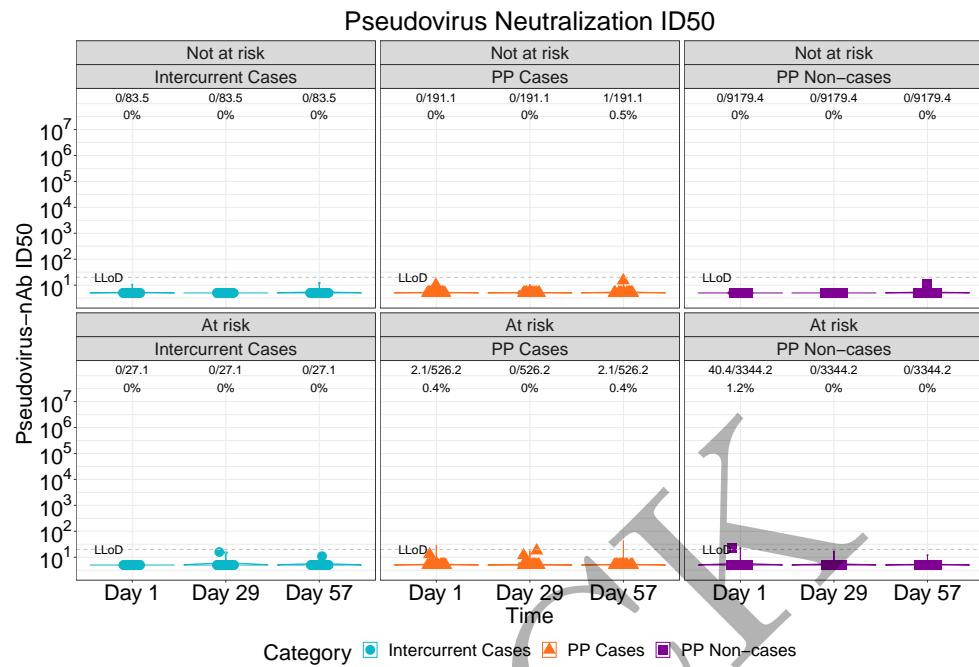


Figure 2.115: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (3 timepoints)

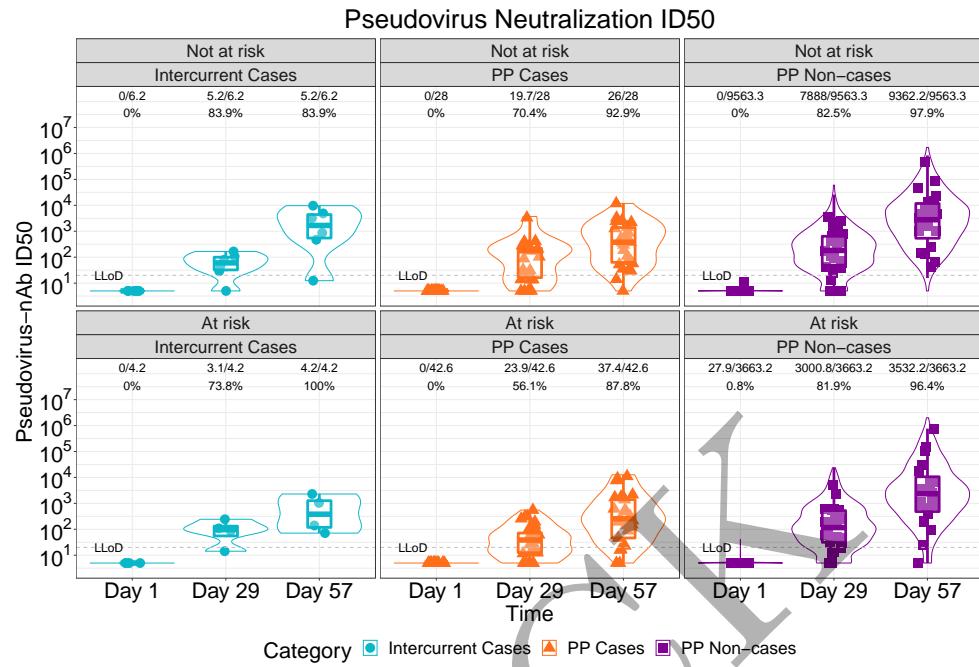


Figure 2.116: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (3 timepoints)

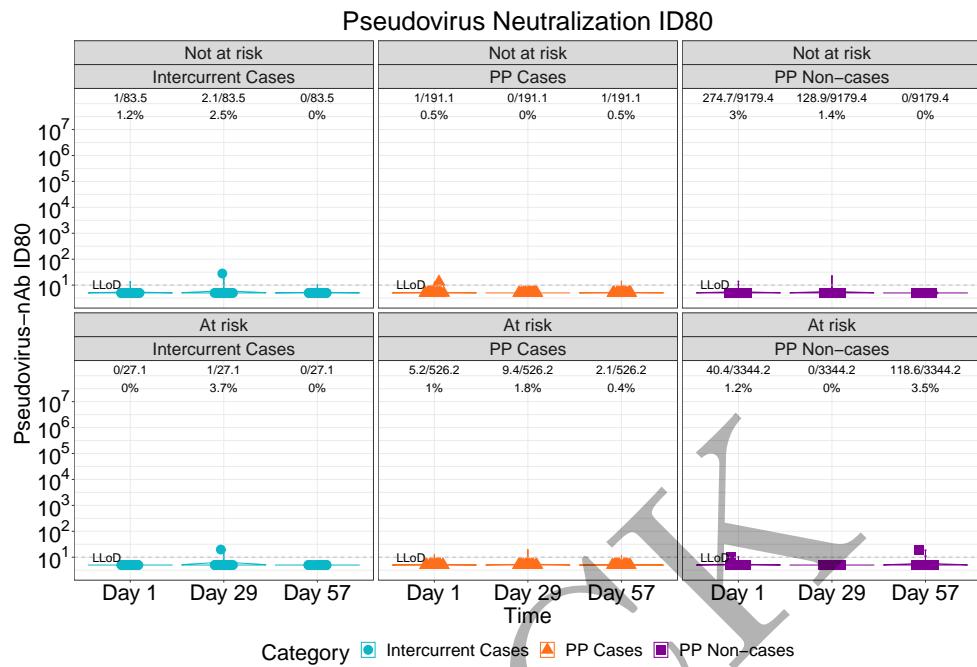


Figure 2.117: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (3 timepoints)

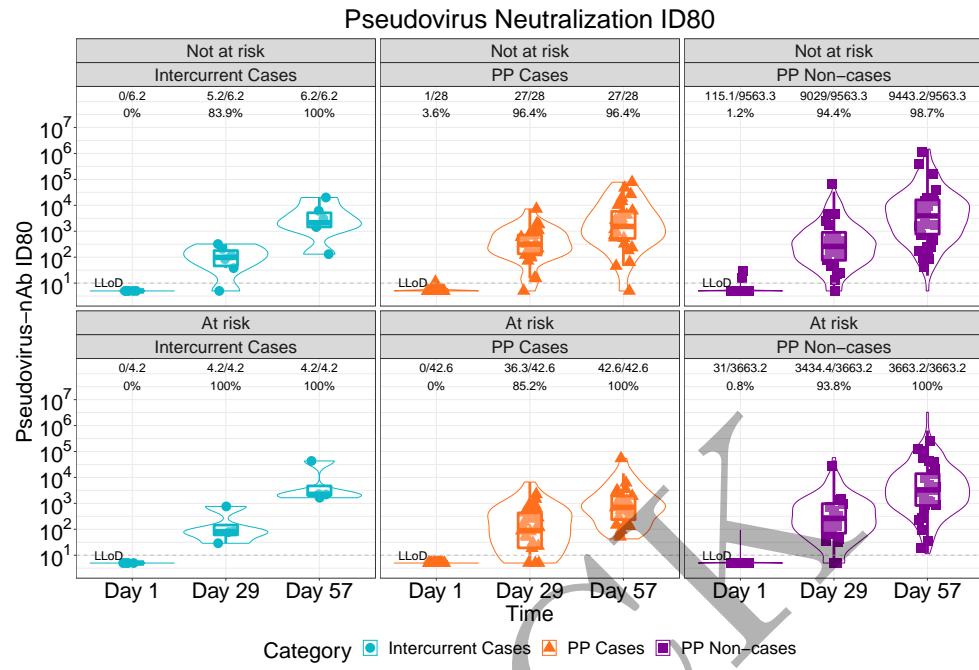


Figure 2.118: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (3 timepoints)



Figure 2.119: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (2 timepoints)

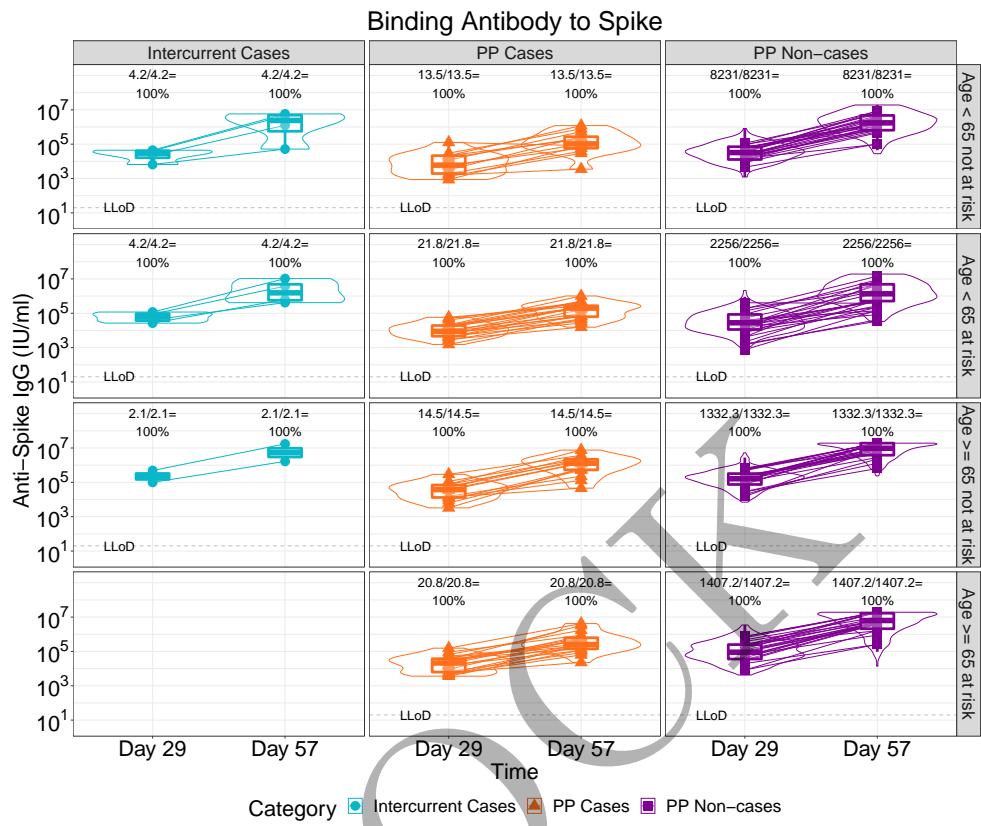


Figure 2.120: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (2 timepoints)

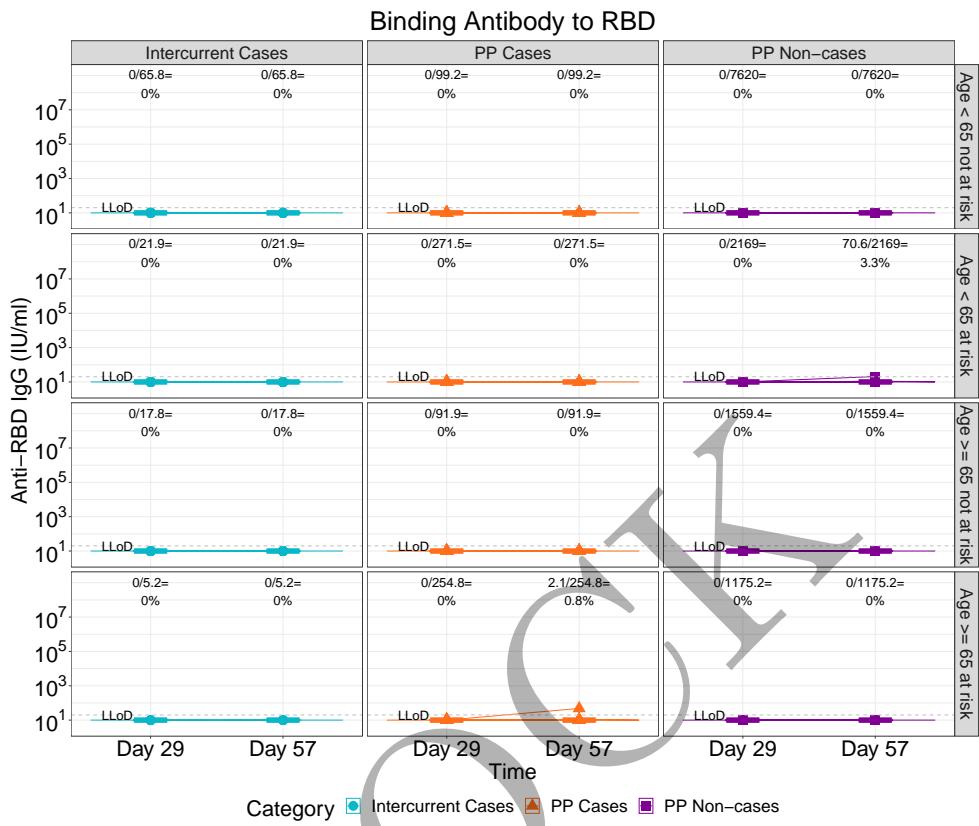


Figure 2.121: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (2 timepoints)

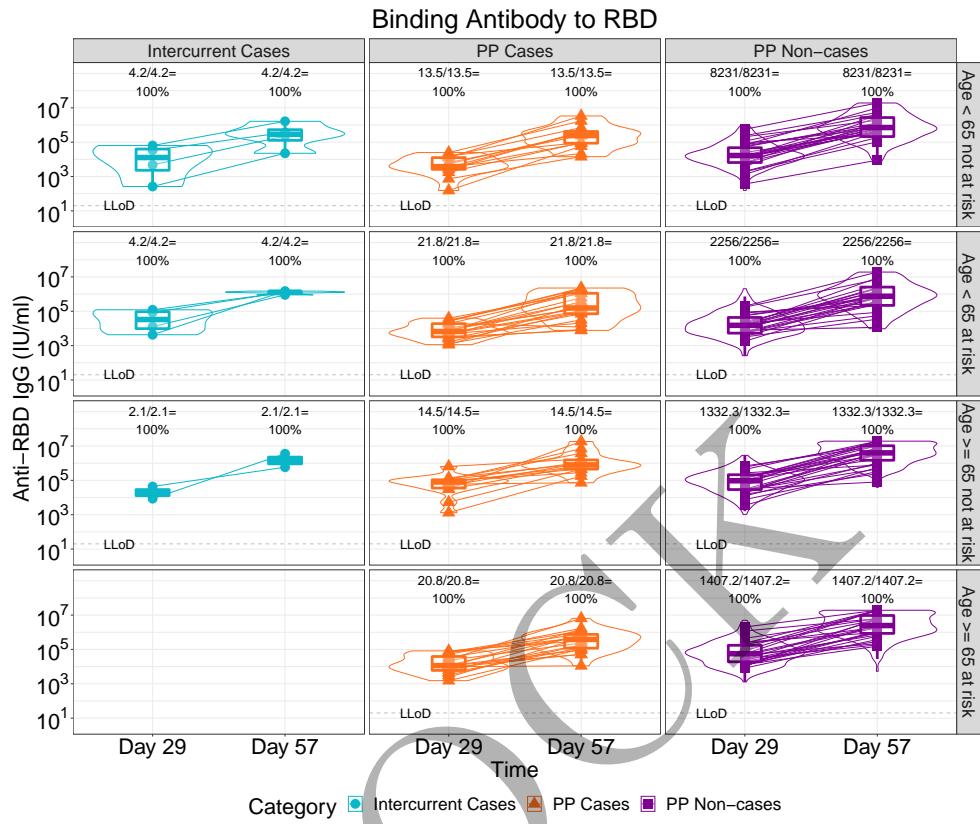


Figure 2.122: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (2 timepoints)

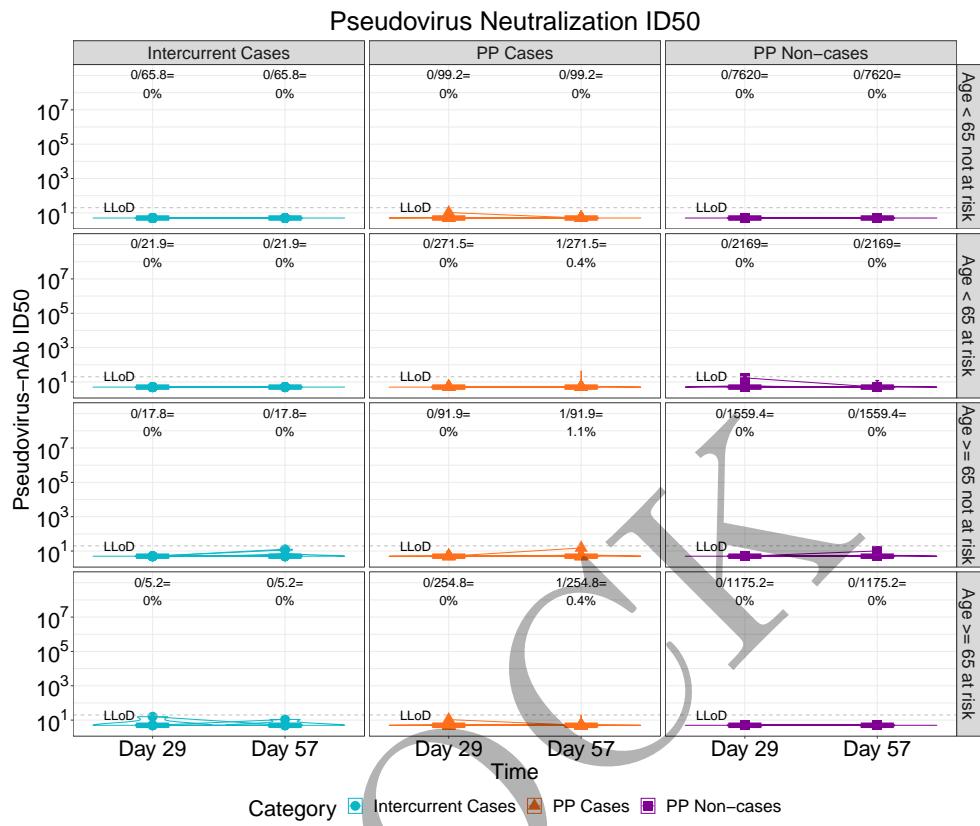


Figure 2.123: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (2 timepoints)

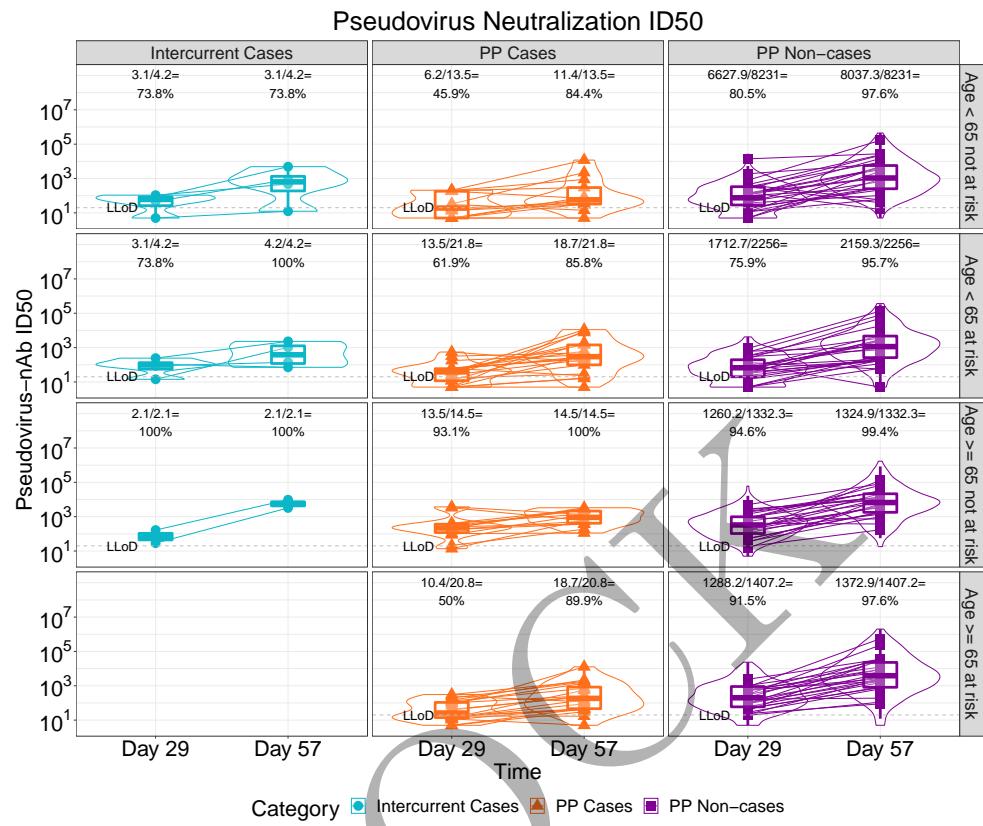


Figure 2.124: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (2 timepoints)



Figure 2.125: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (2 timepoints)

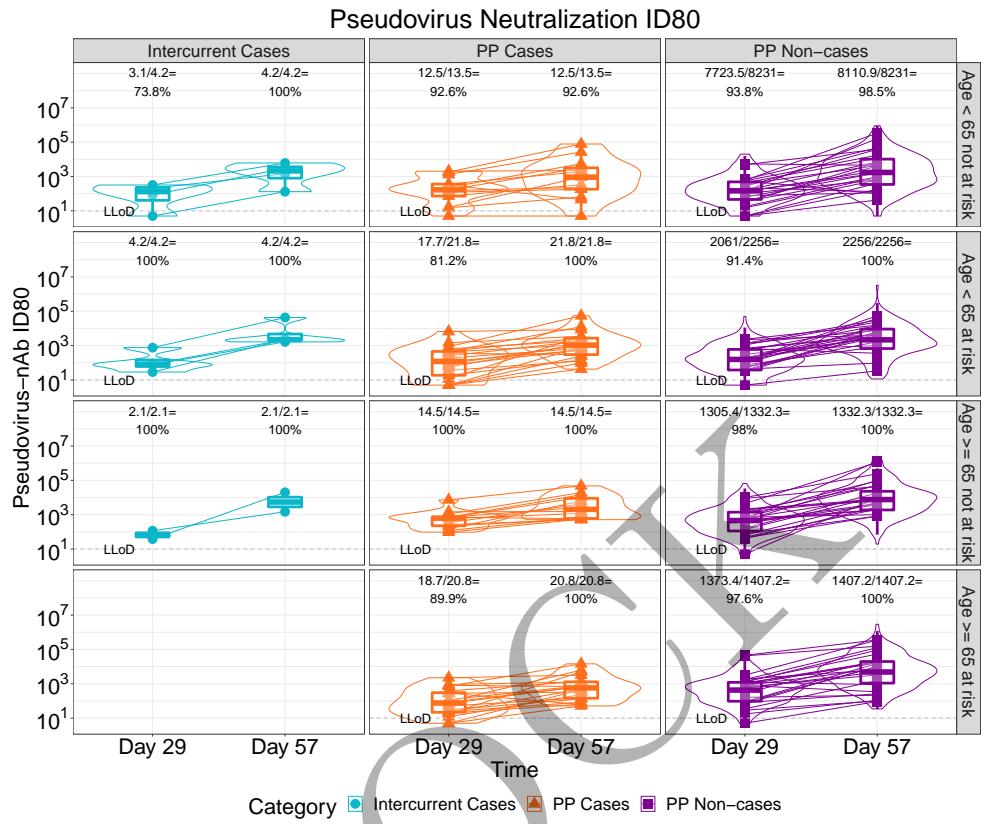


Figure 2.126: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (2 timepoints)

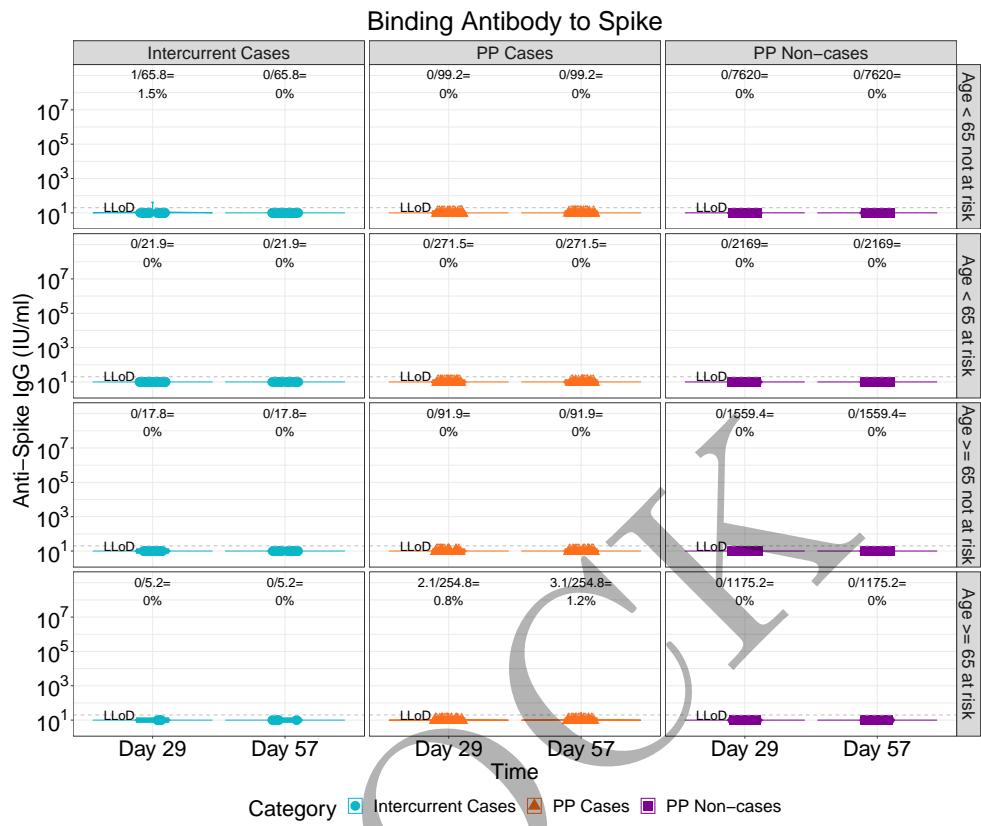


Figure 2.127: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (2 timepoints)

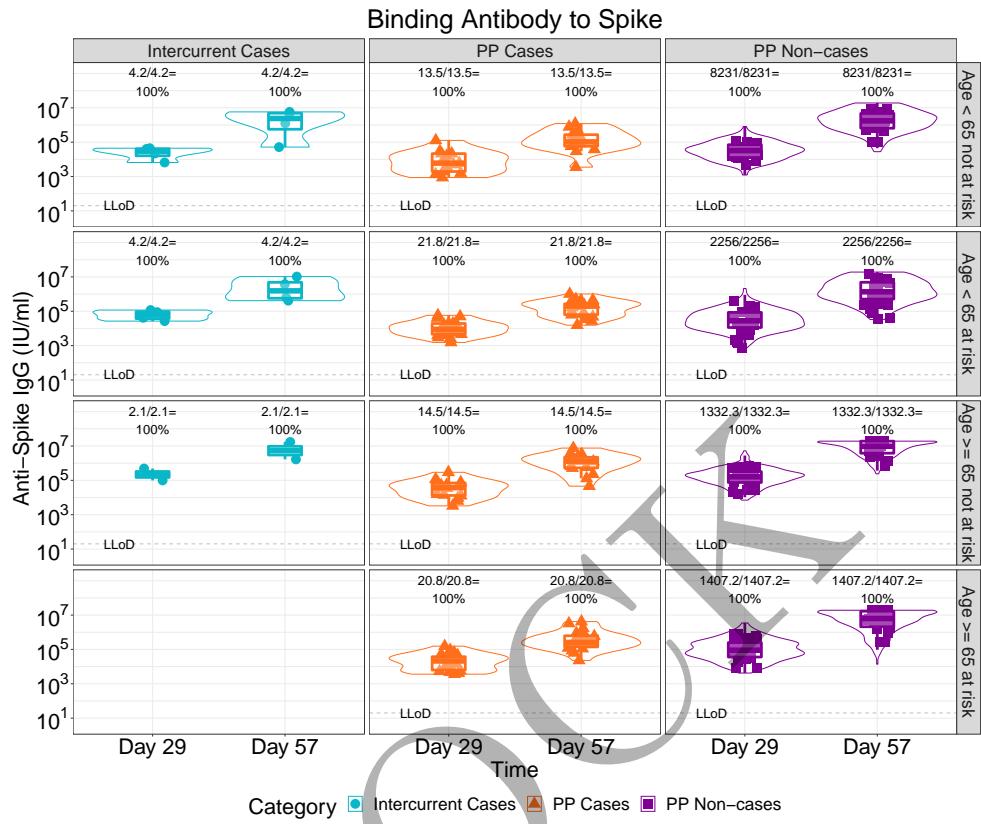


Figure 2.128: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (2 timepoints)

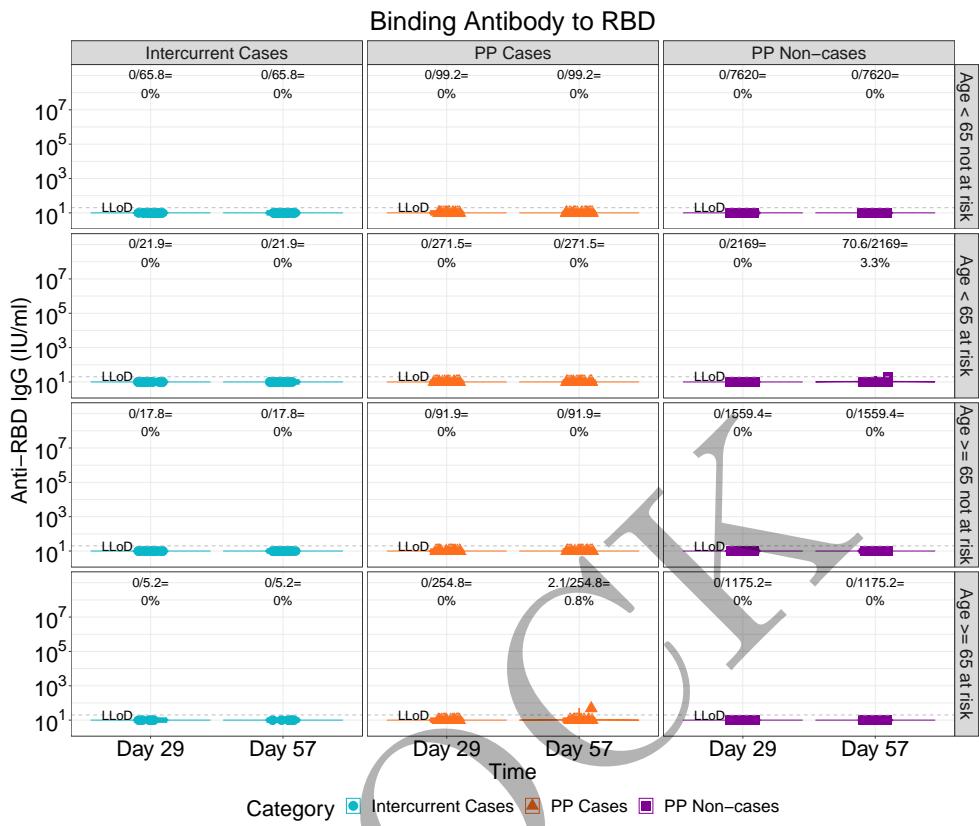


Figure 2.129: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (2 timepoints)

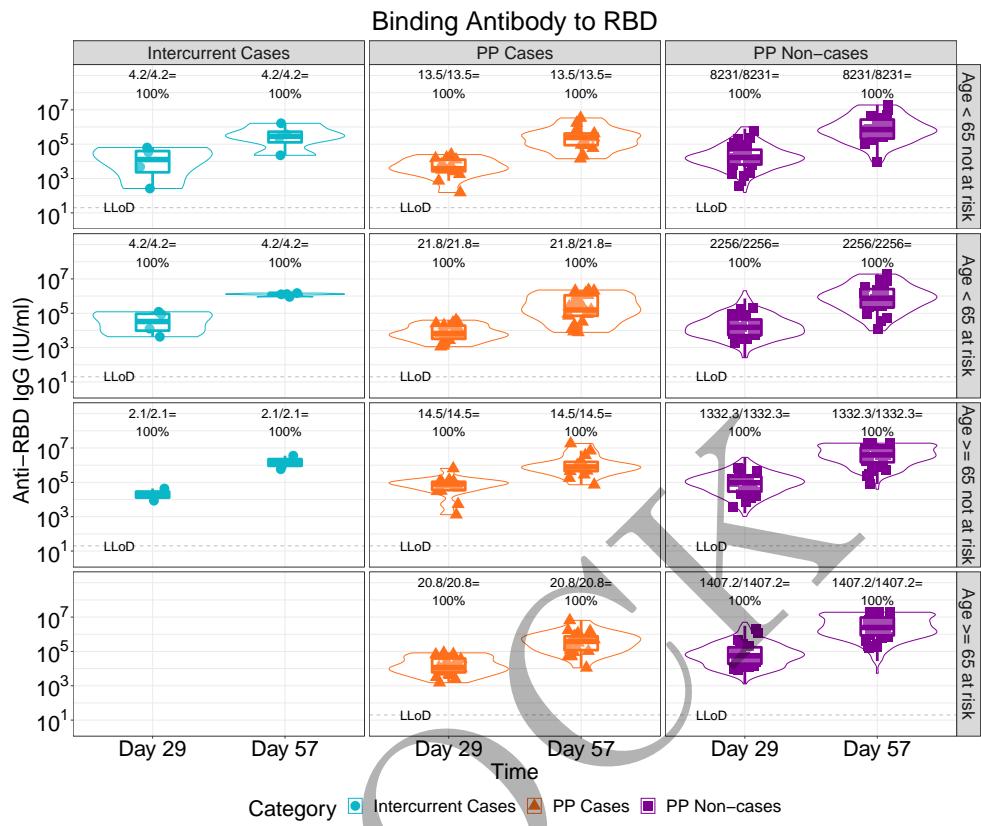


Figure 2.130: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (2 timepoints)

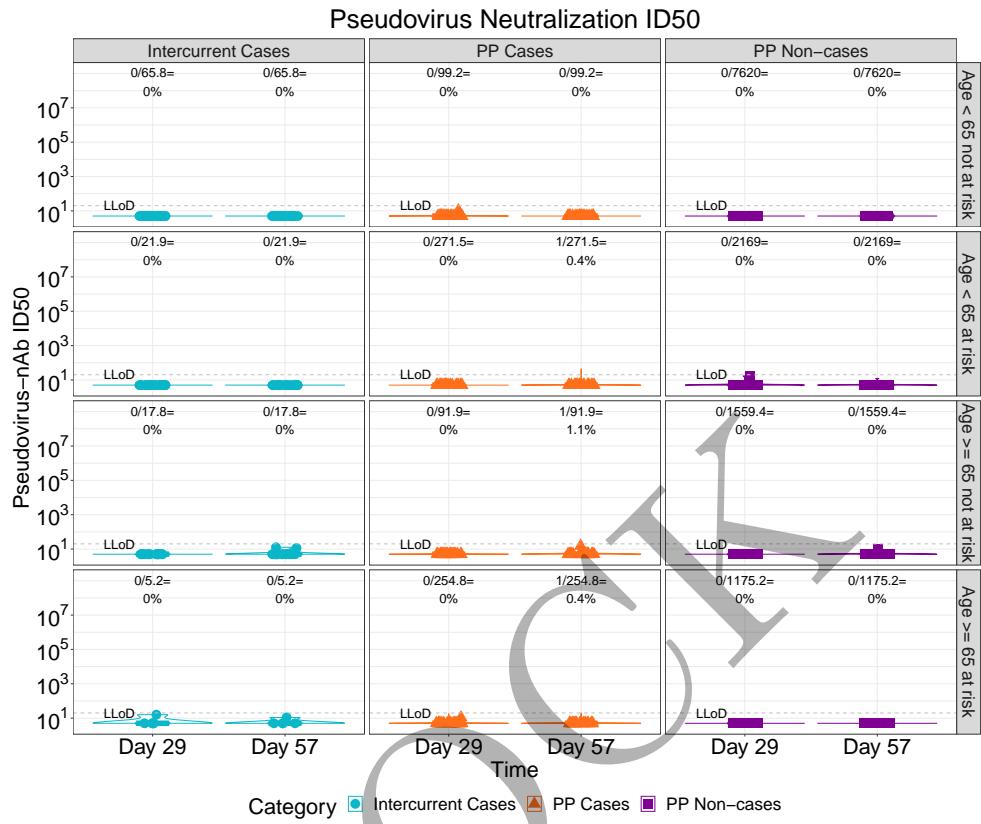


Figure 2.131: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (2 timepoints)

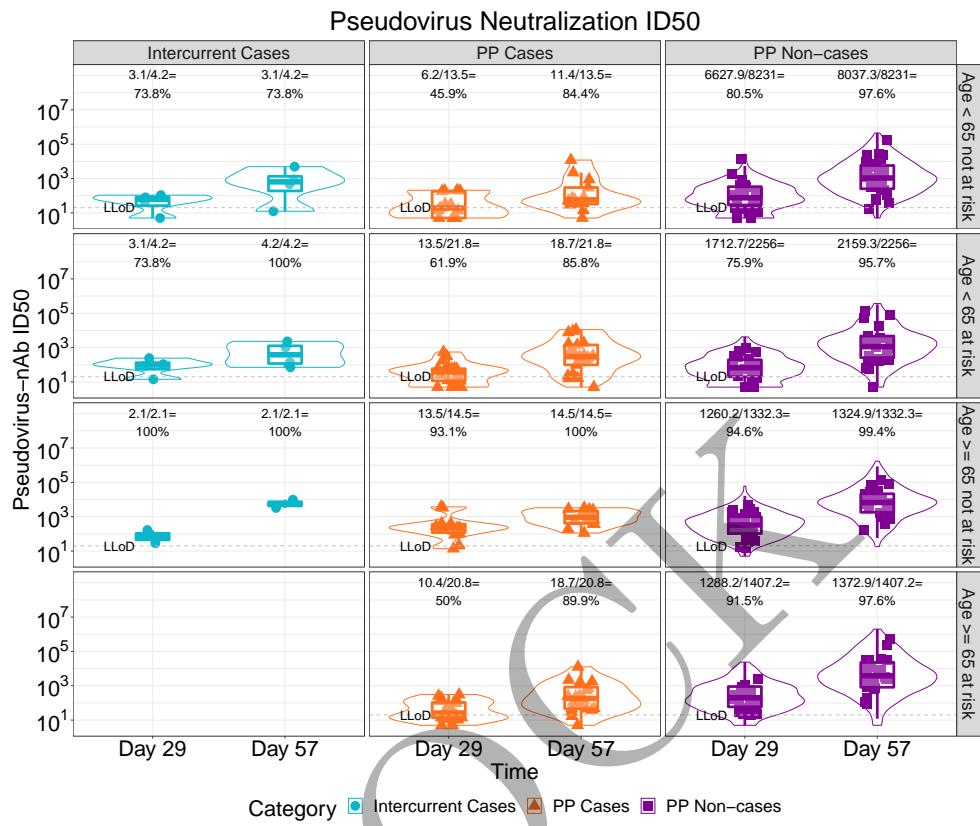


Figure 2.132: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (2 timepoints)

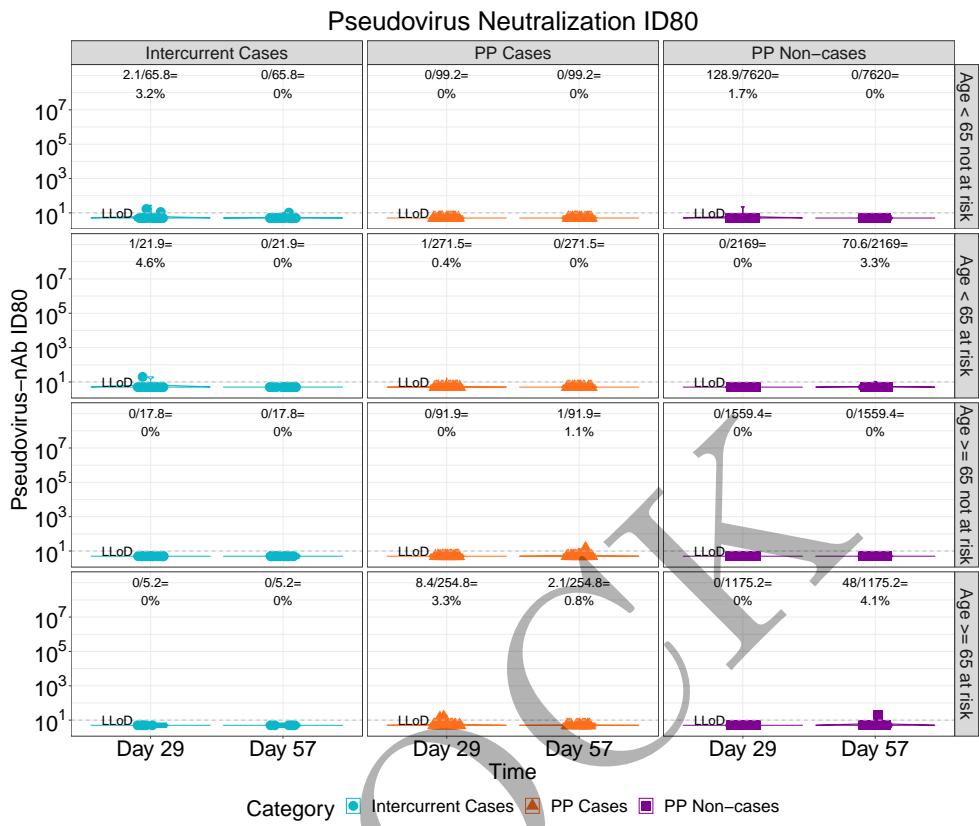


Figure 2.133: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (2 timepoints)

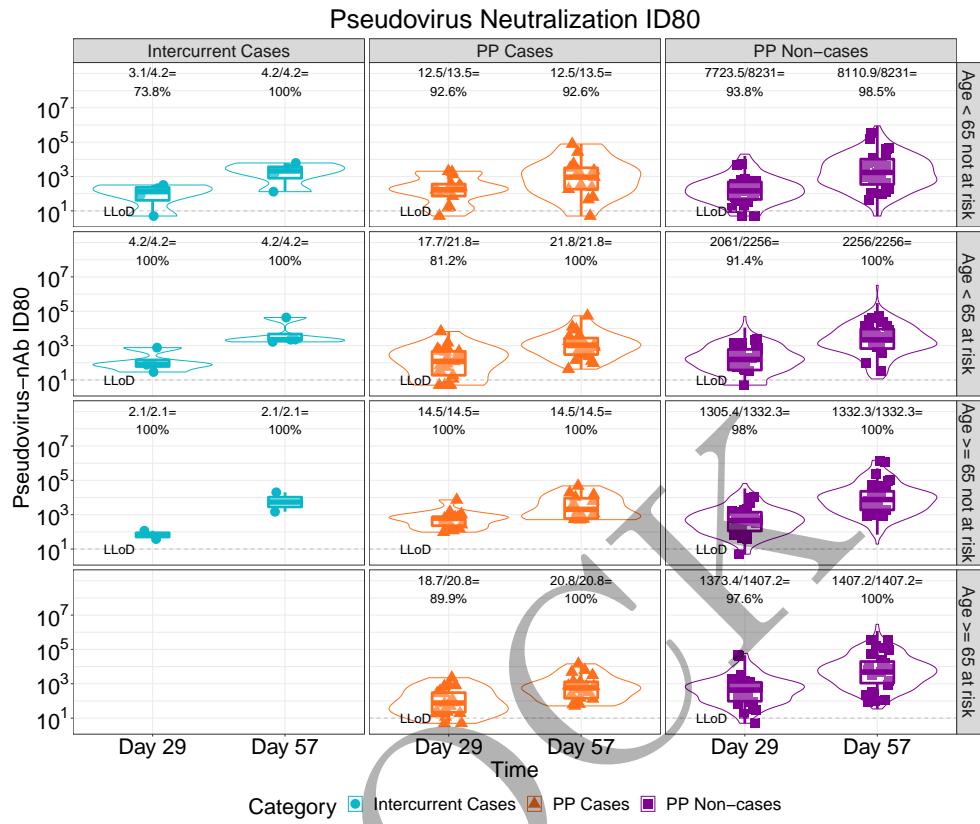


Figure 2.134: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (2 timepoints)

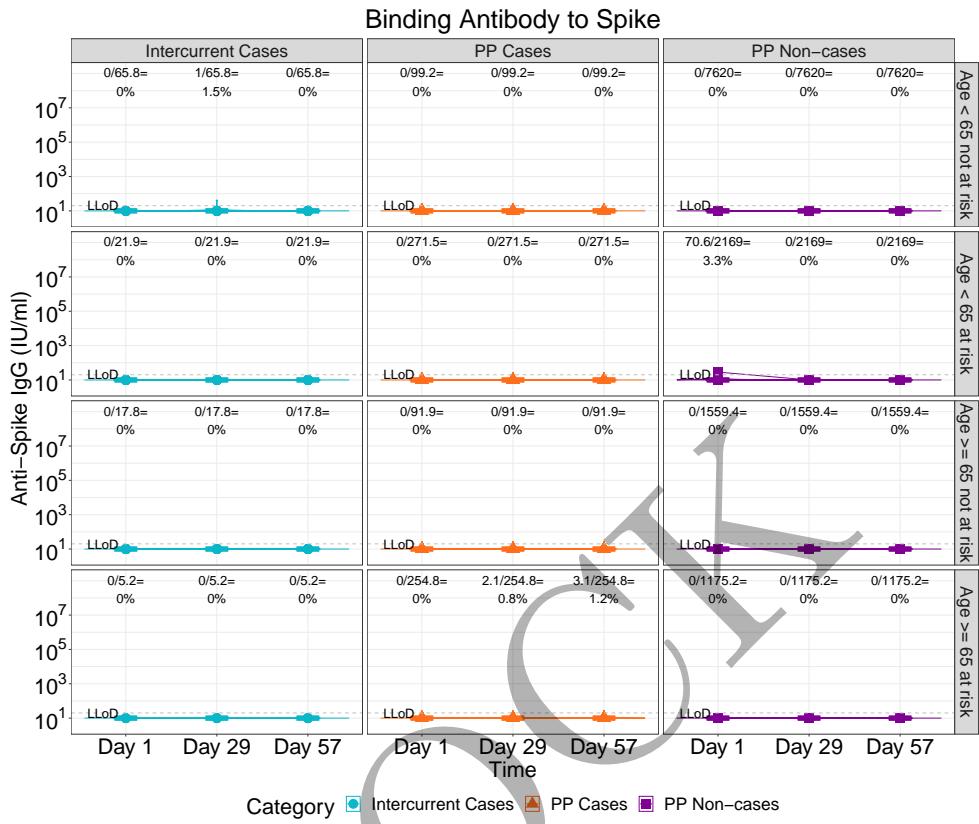


Figure 2.135: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (3 timepoints)



Figure 2.136: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (3 timepoints)



Figure 2.137: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (3 timepoints)

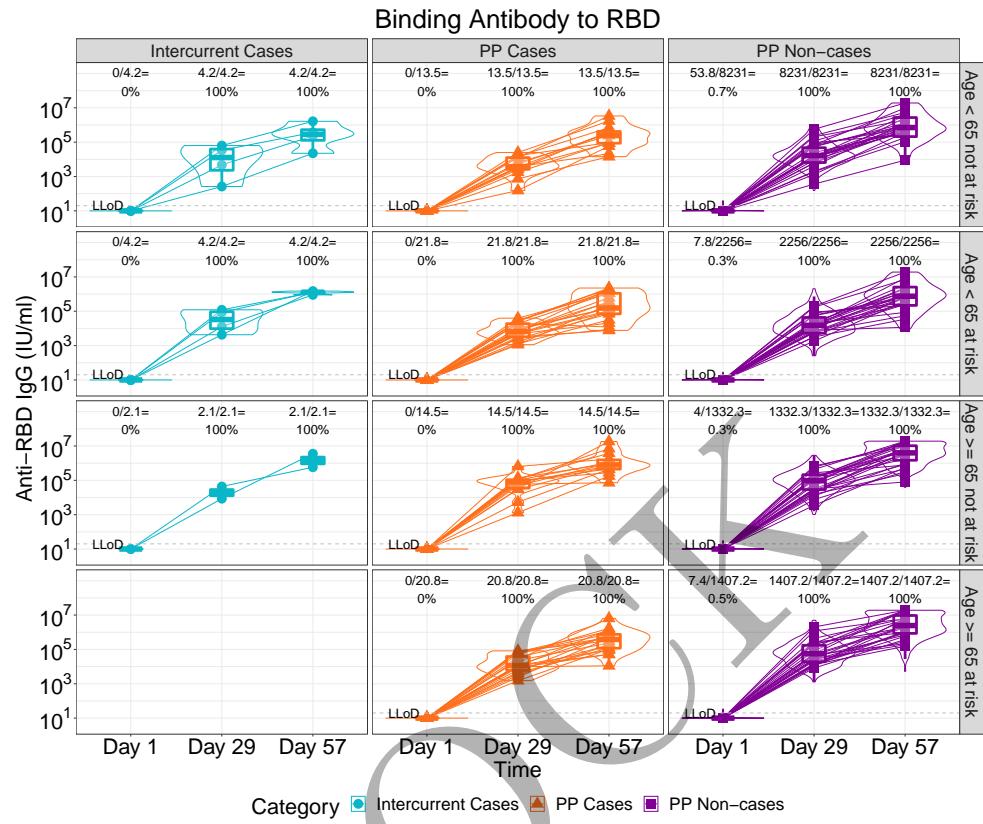


Figure 2.138: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (3 timepoints)



Figure 2.139: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (3 timepoints)

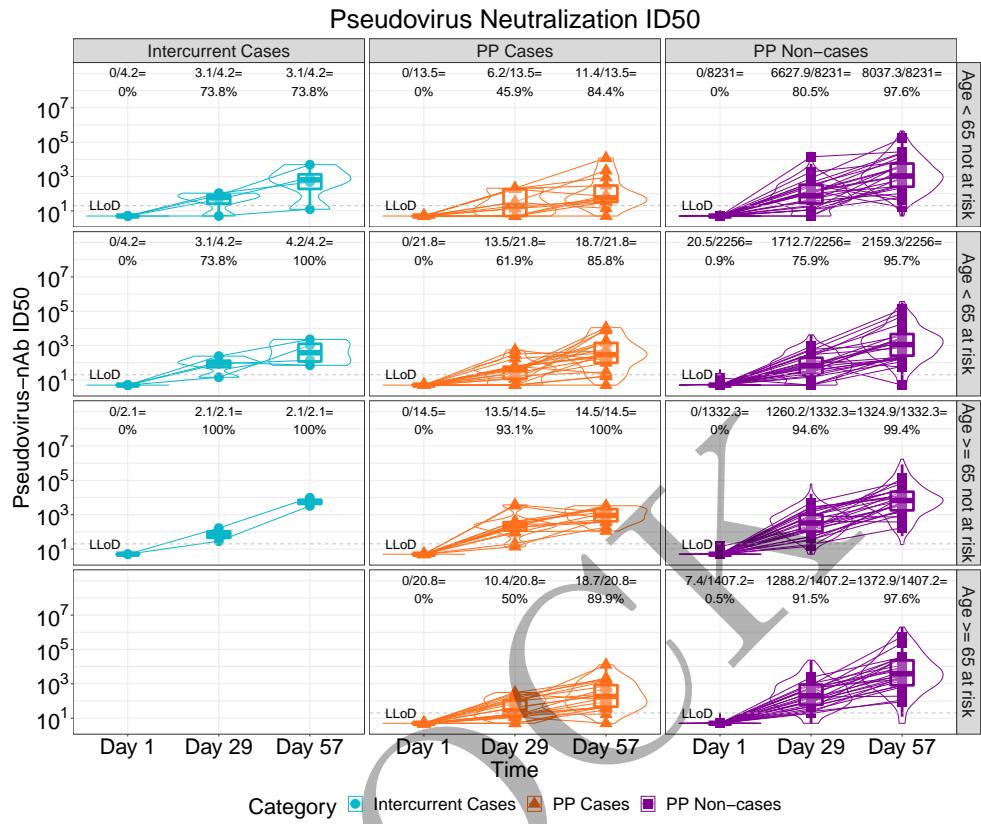


Figure 2.140: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (3 timepoints)

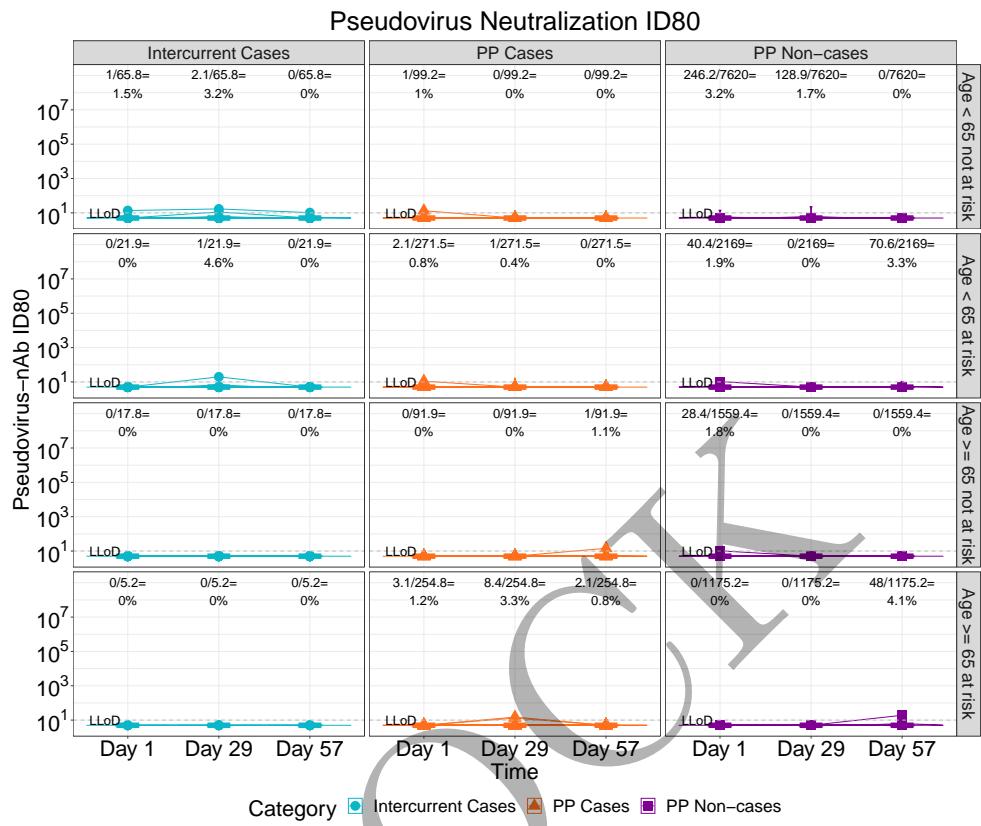


Figure 2.141: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (3 timepoints)

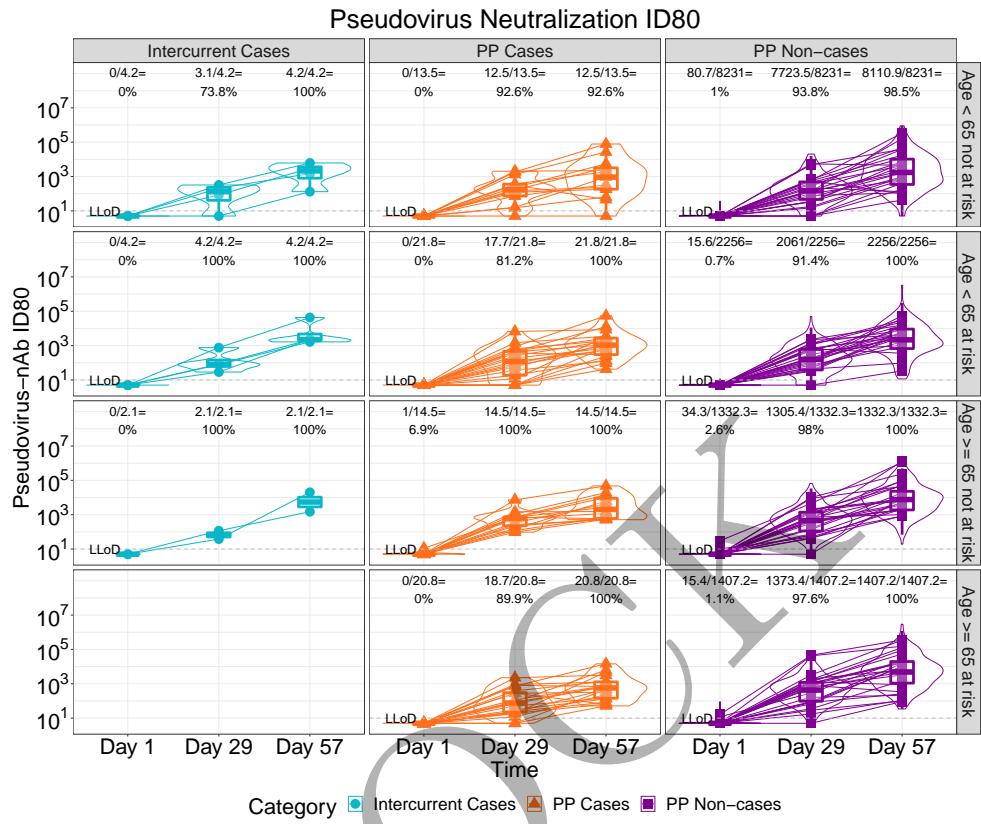


Figure 2.142: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (3 timepoints)

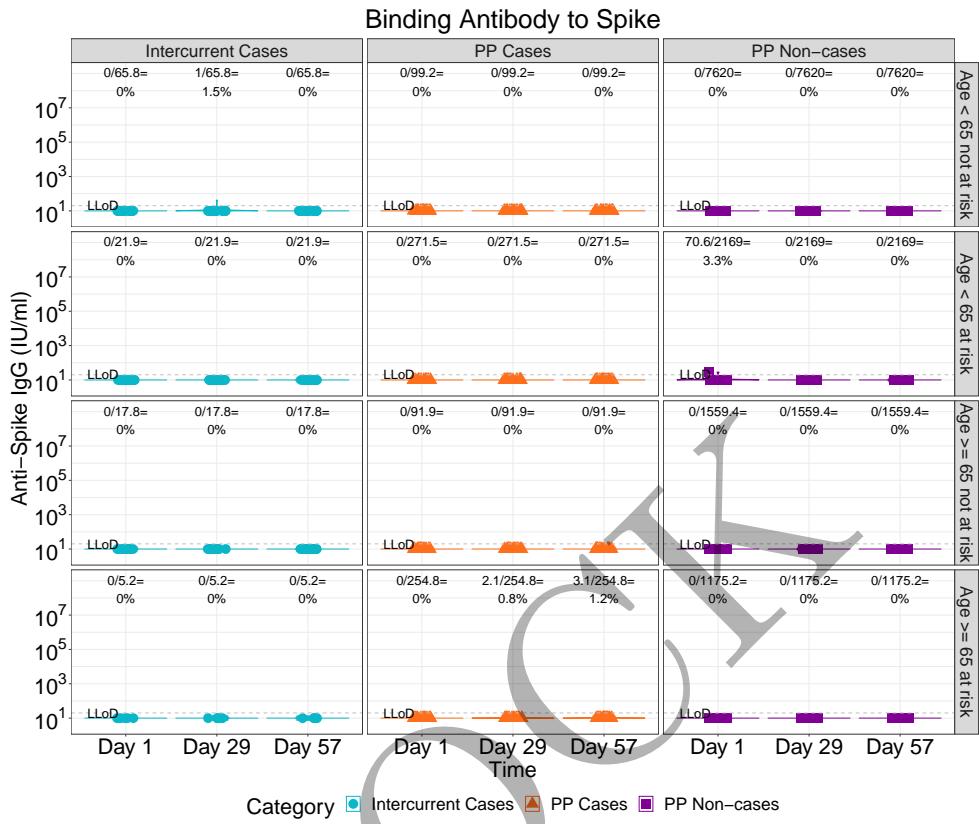


Figure 2.143: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (3 timepoints)

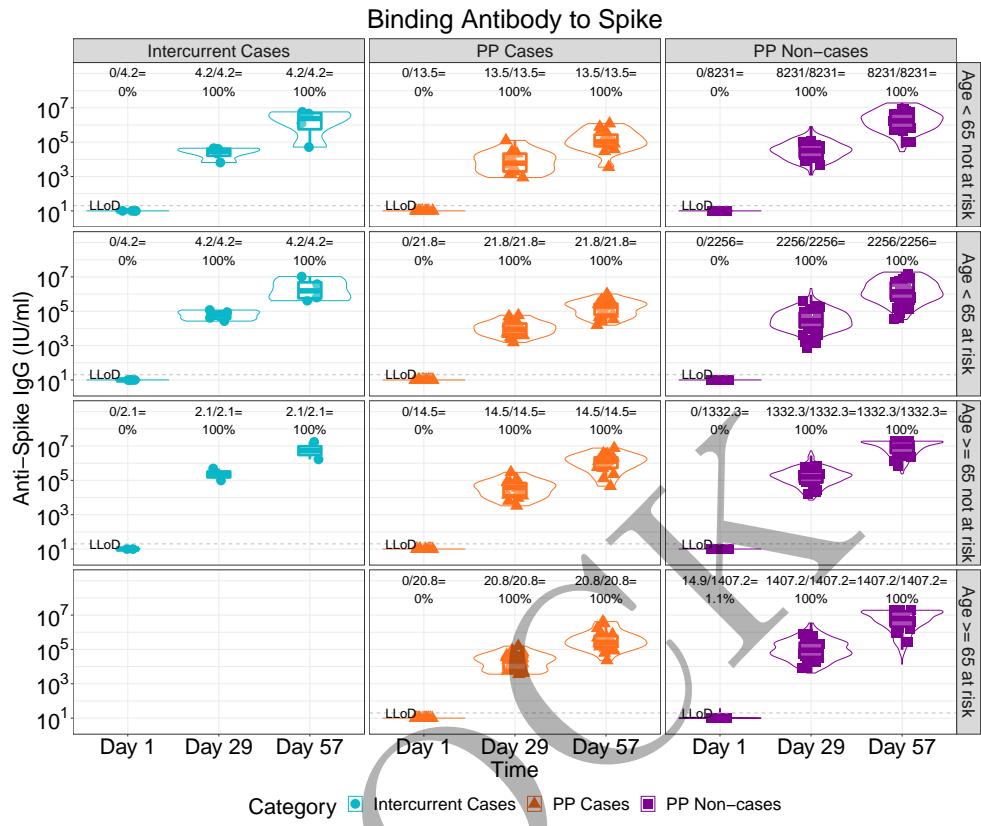


Figure 2.144: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (3 timepoints)

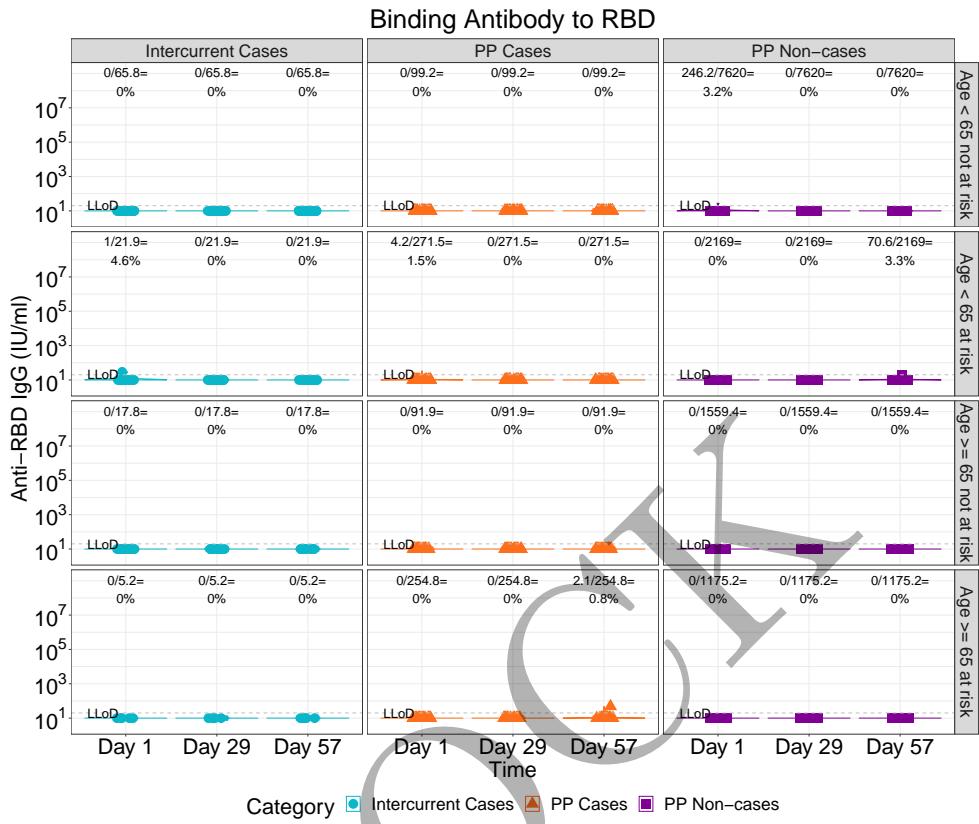


Figure 2.145: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (3 timepoints)

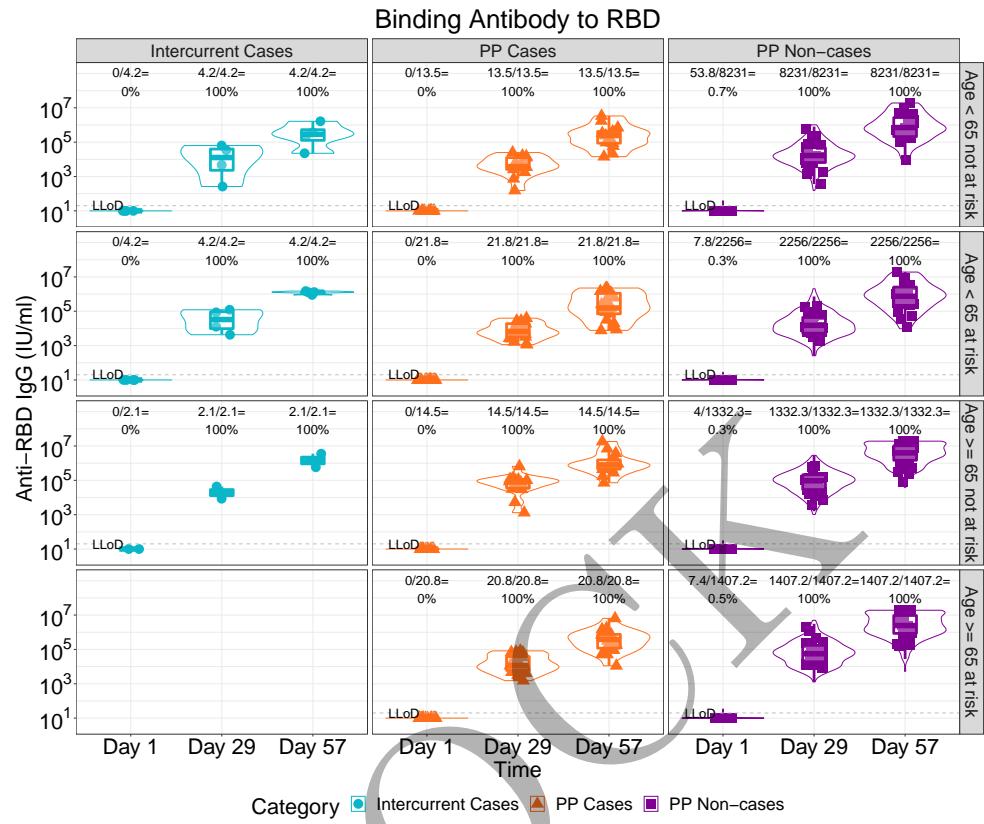


Figure 2.146: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (3 timepoints)

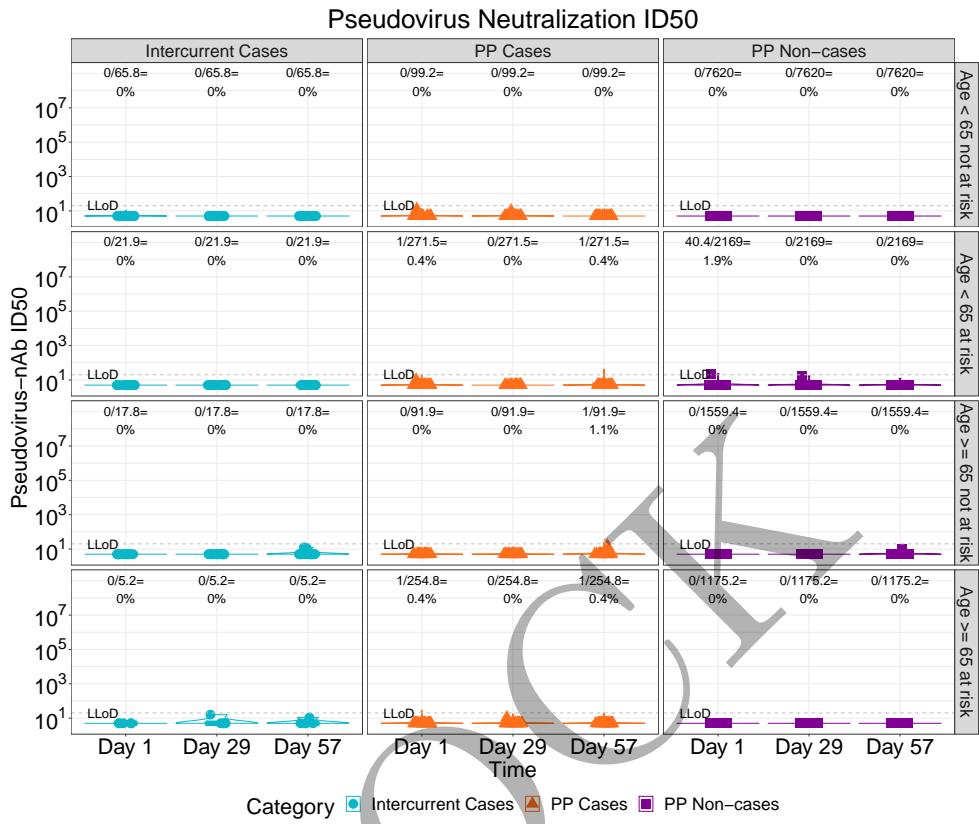


Figure 2.147: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (3 timepoints)

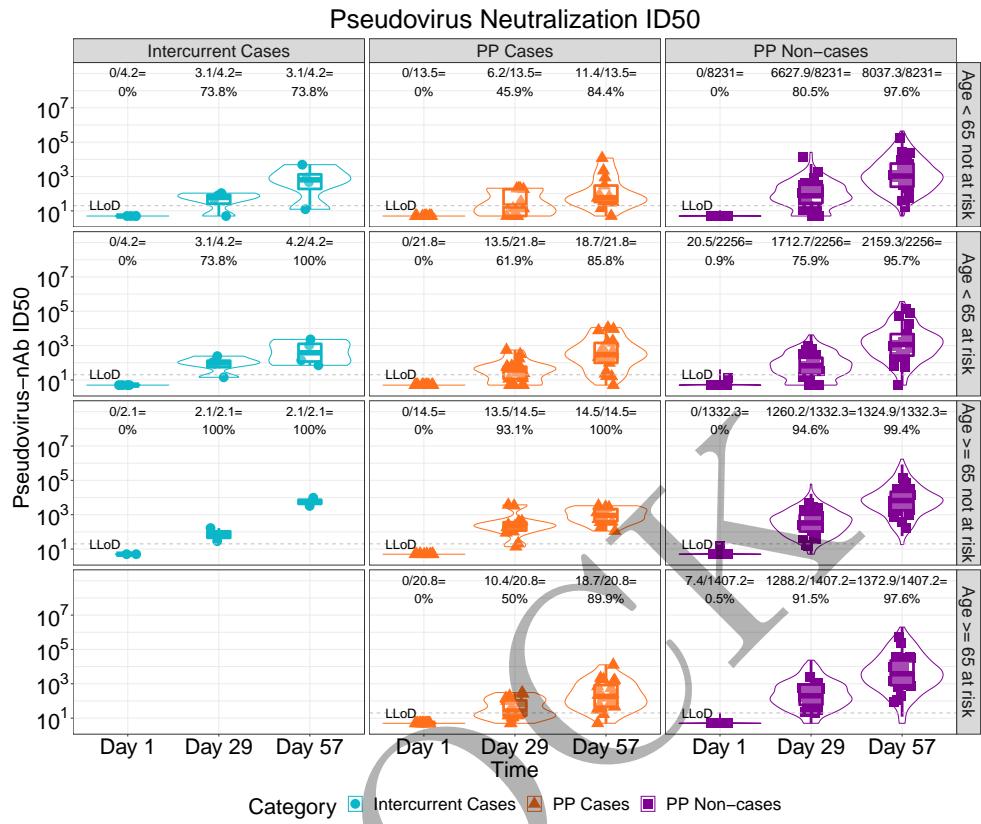


Figure 2.148: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (3 timepoints)

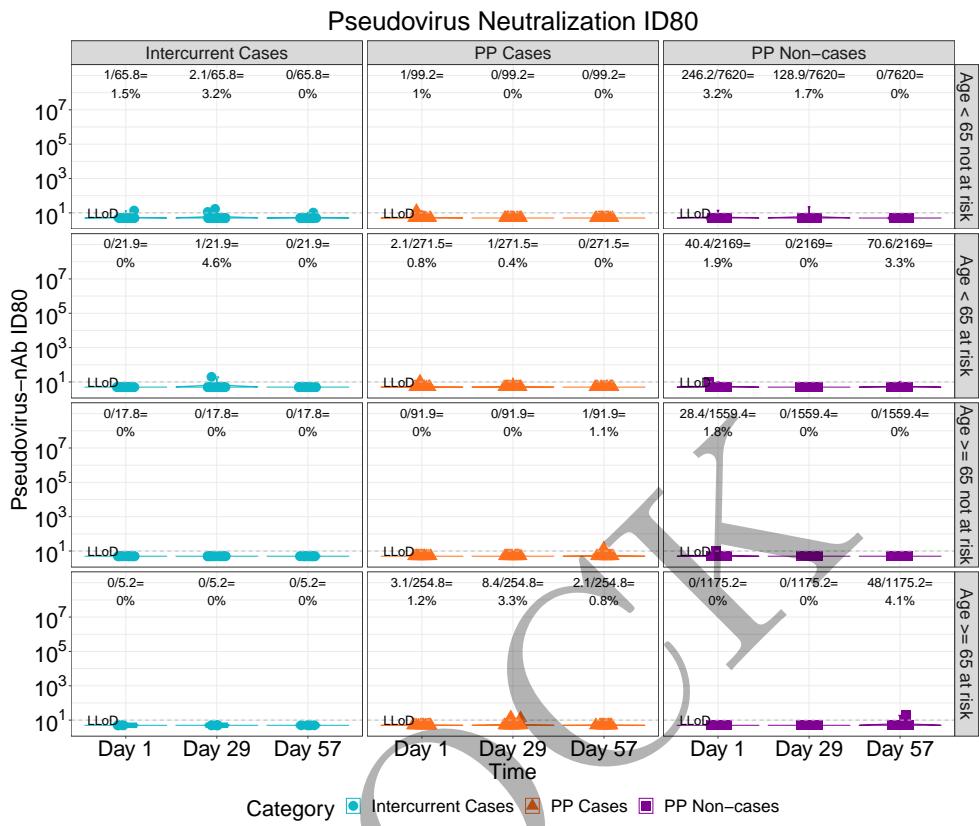


Figure 2.149: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (3 timepoints)

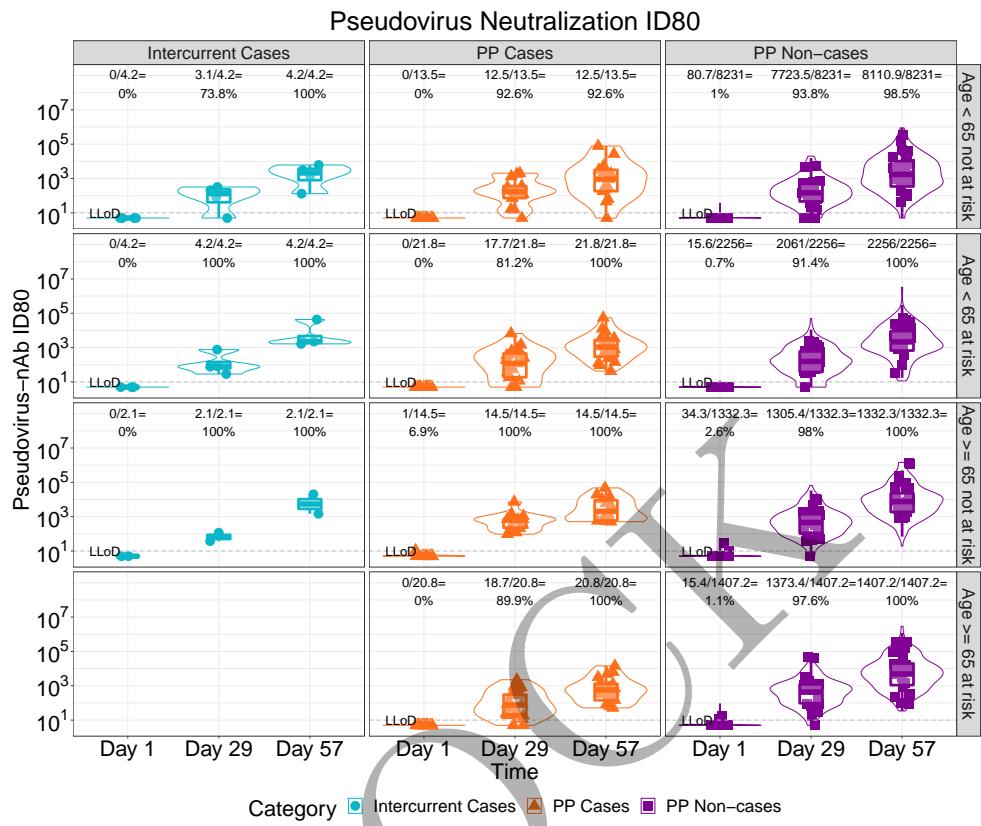


Figure 2.150: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (3 timepoints)

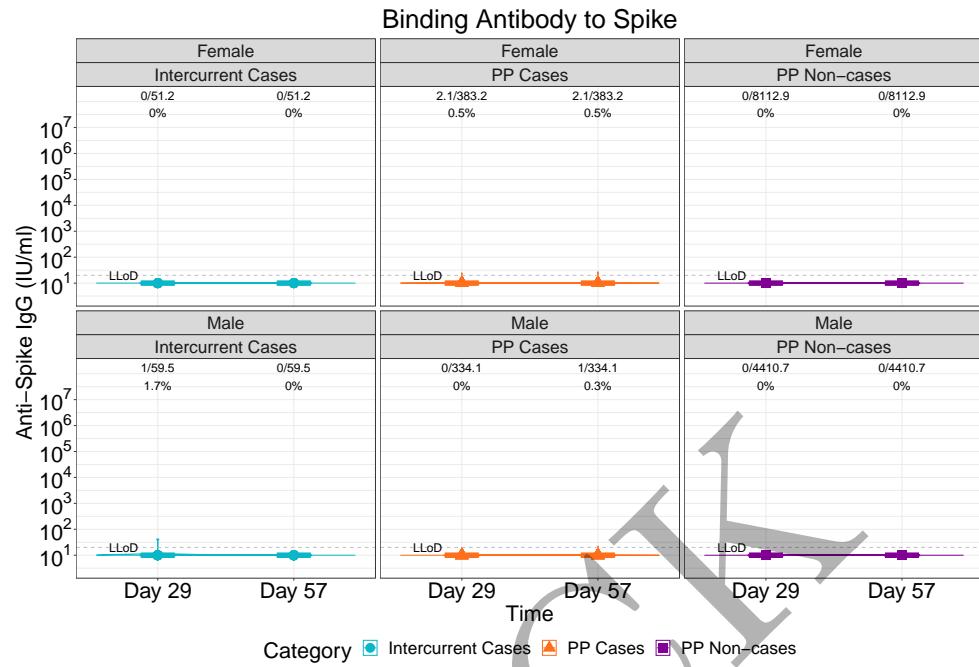


Figure 2.151: lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (2 timepoints)

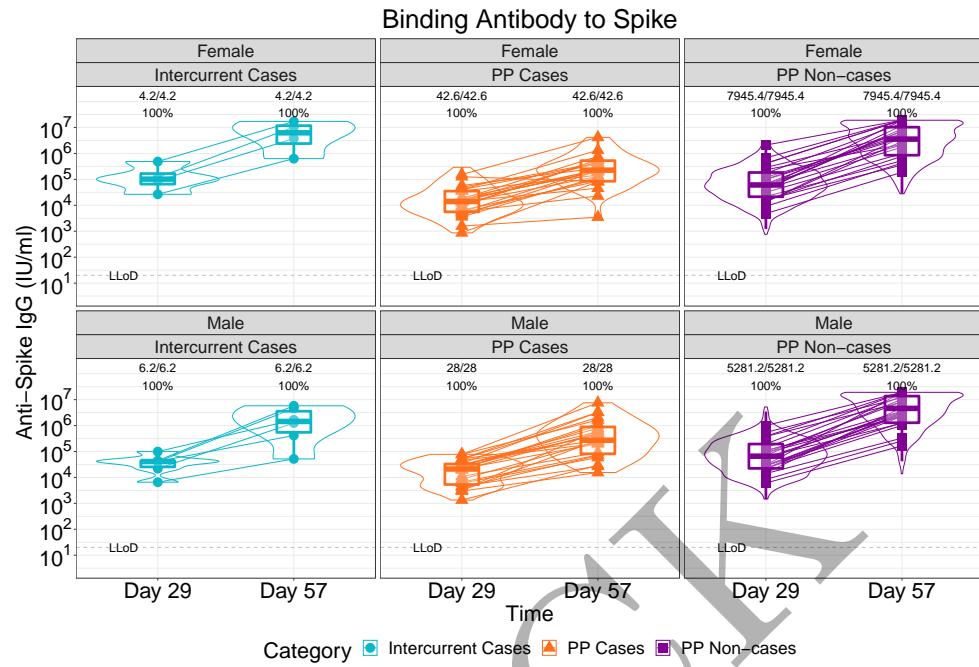


Figure 2.152: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

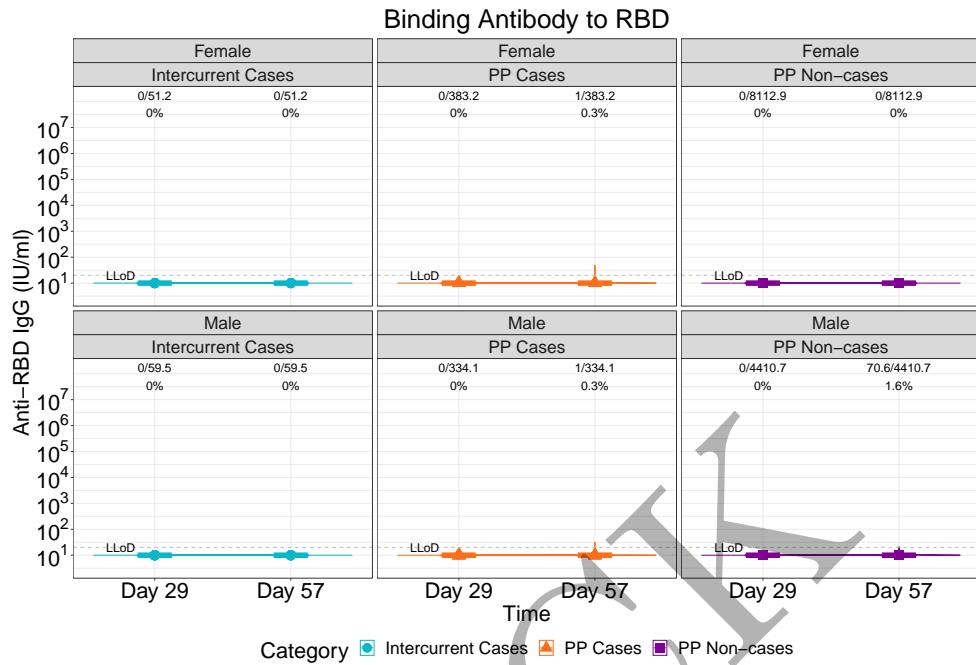


Figure 2.153: lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (2 timepoints)

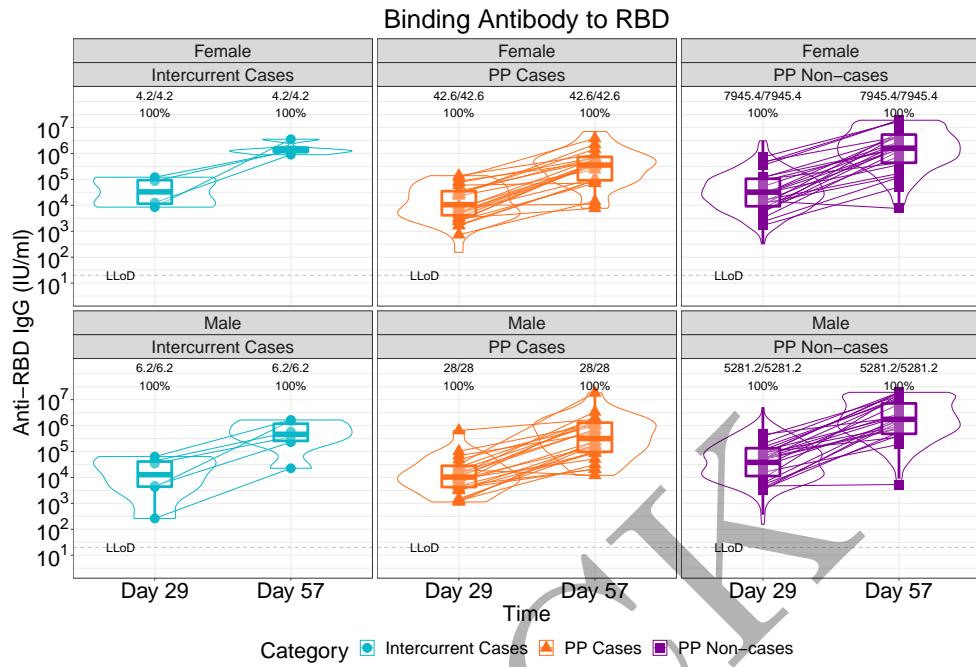


Figure 2.154: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

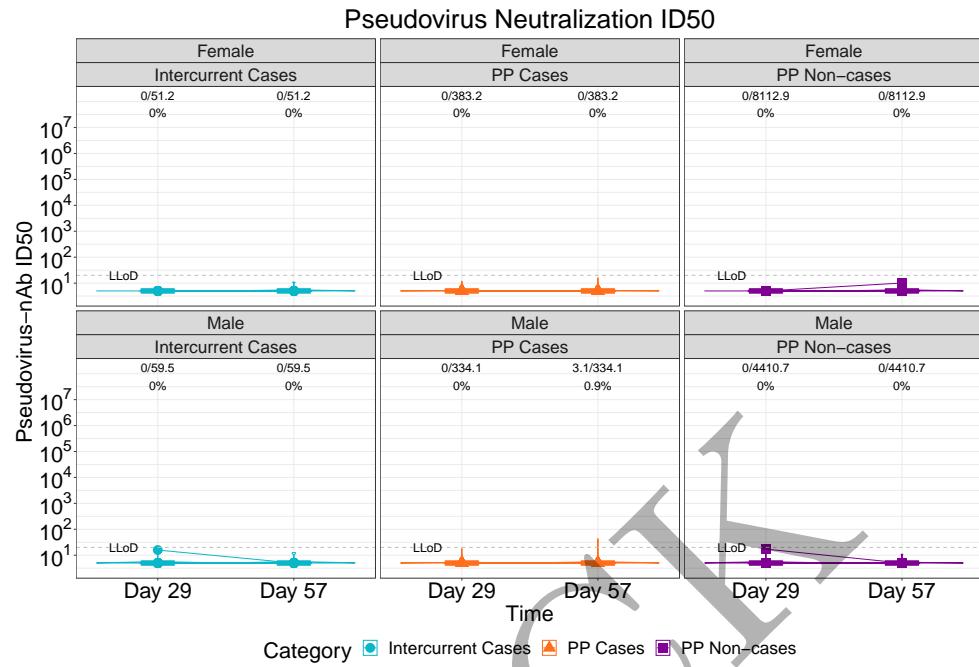


Figure 2.155: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (2 timepoints)

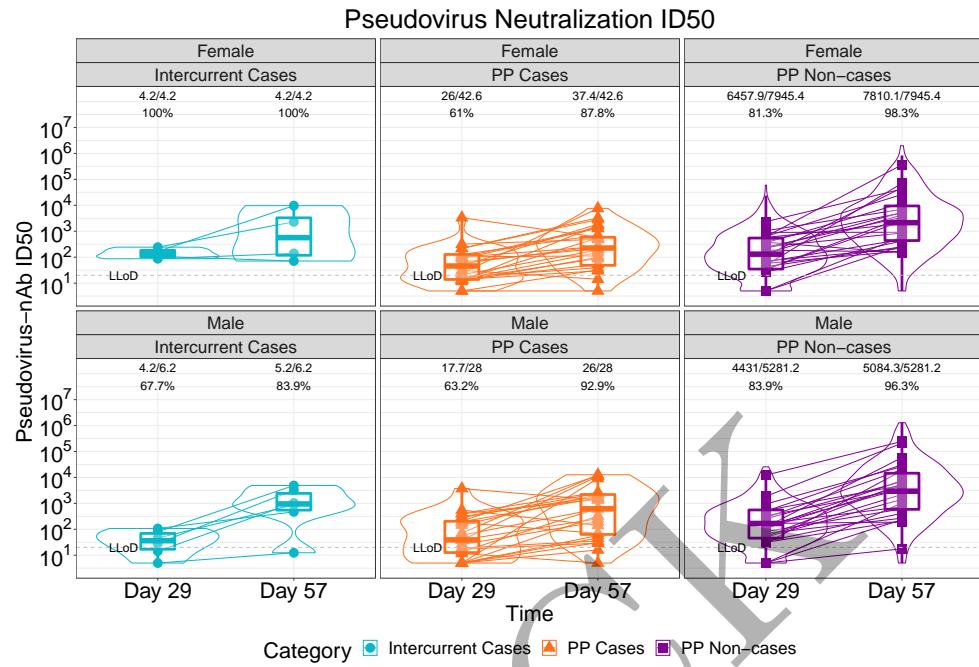


Figure 2.156: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

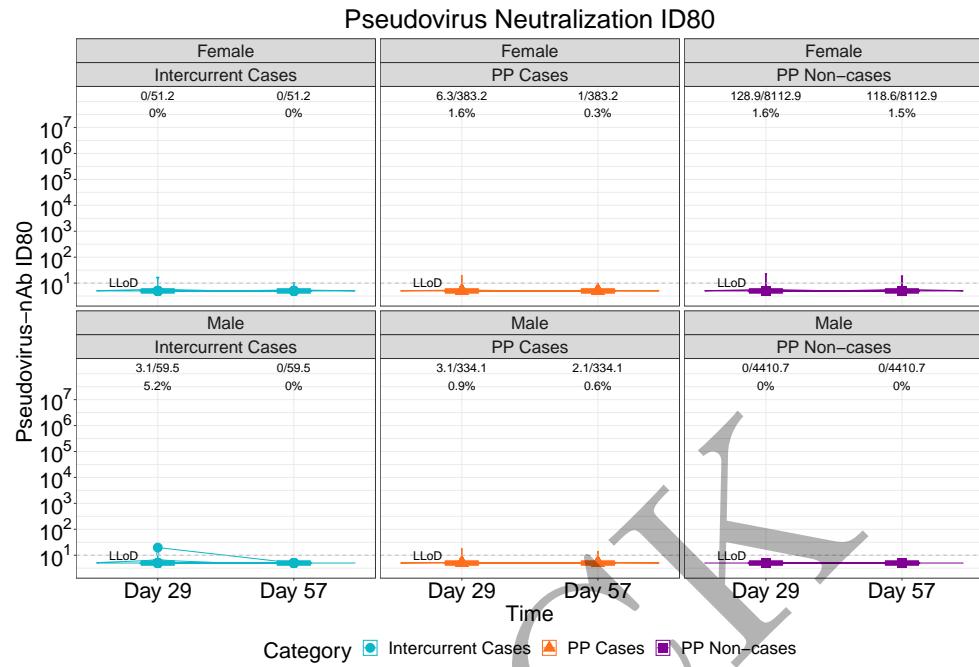


Figure 2.157: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (2 timepoints)

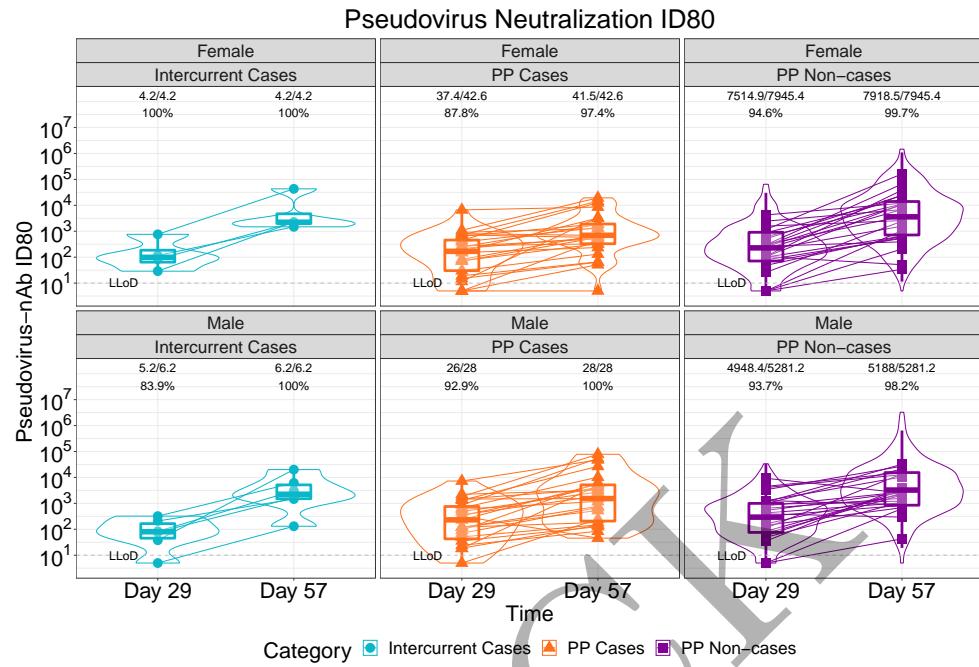


Figure 2.158: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

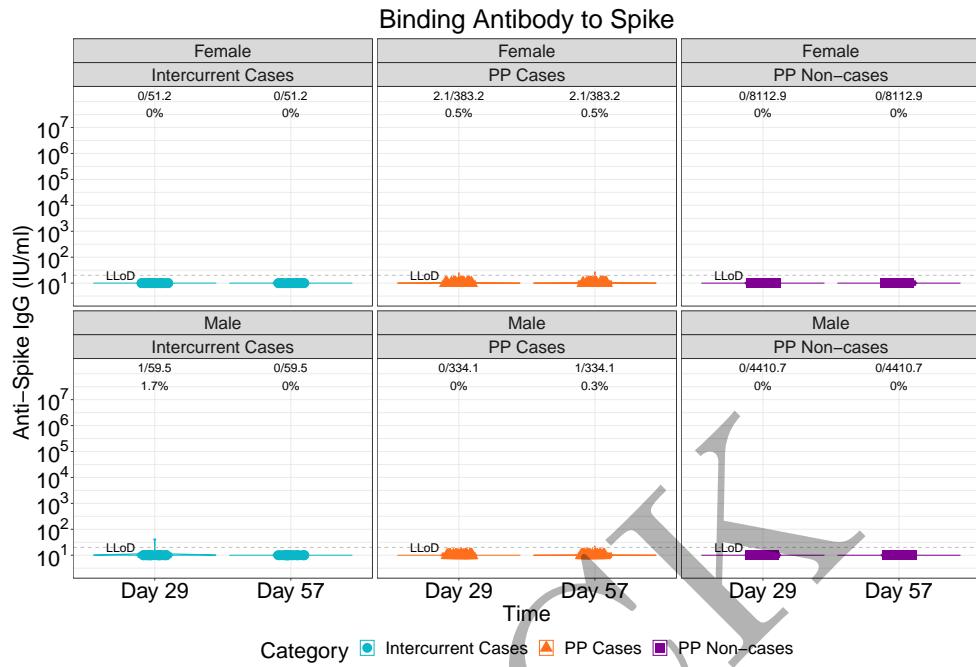


Figure 2.159: violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (2 timepoints)

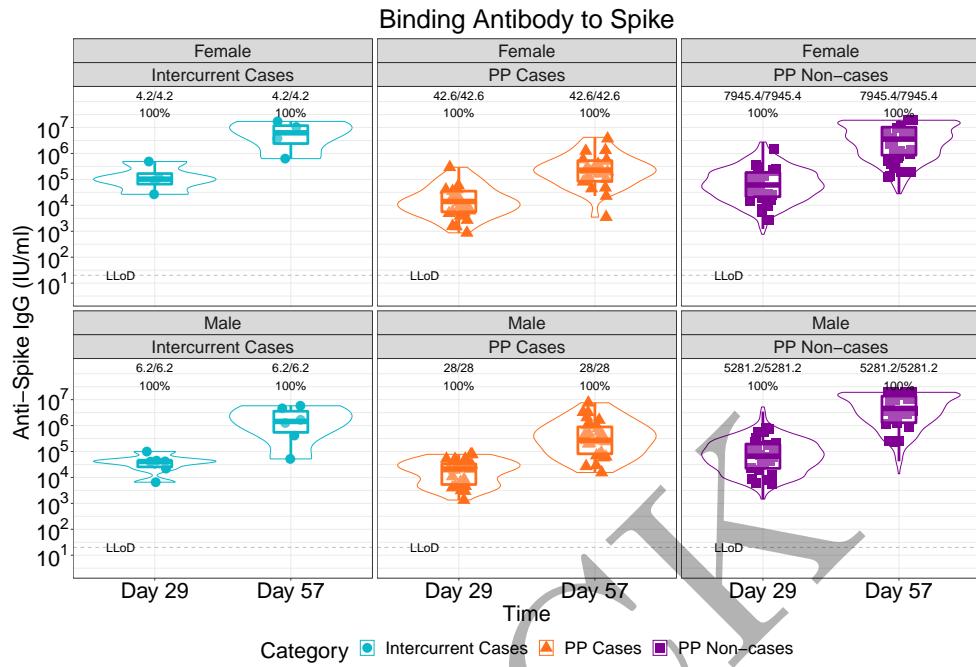


Figure 2.160: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

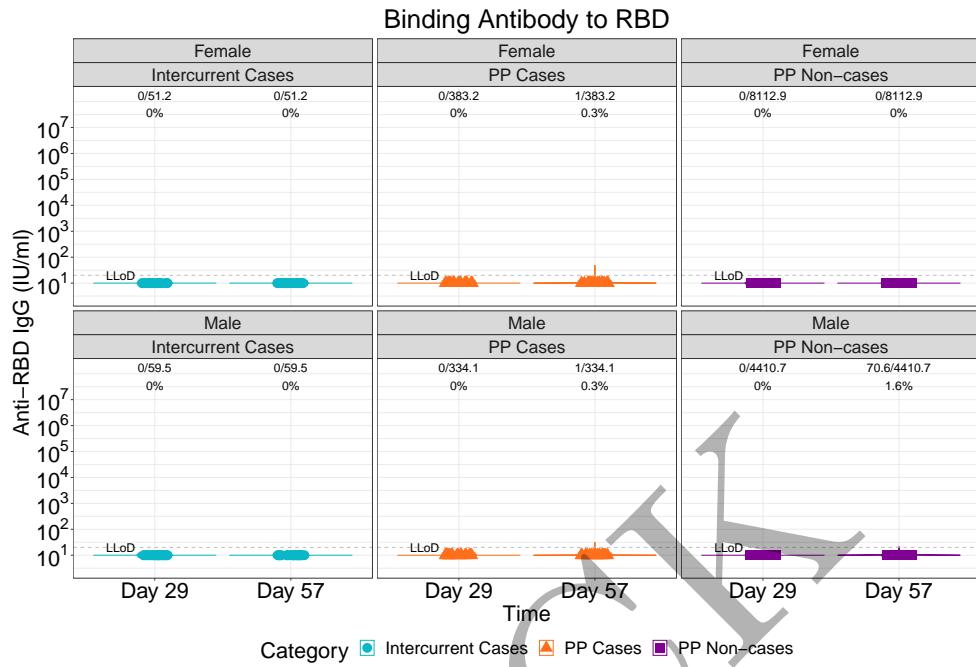


Figure 2.161: violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (2 timepoints)

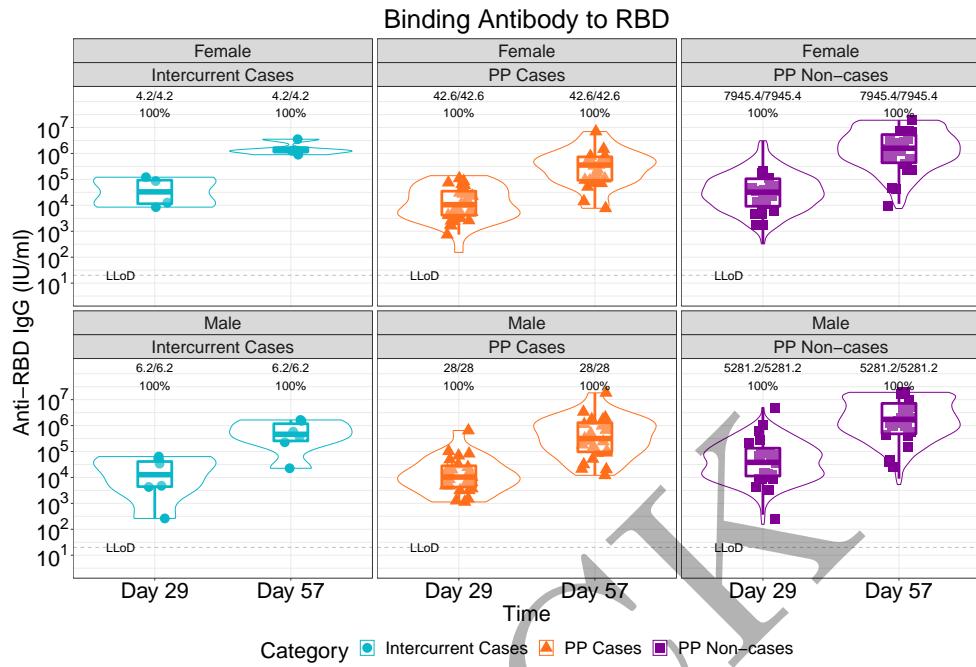


Figure 2.162: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

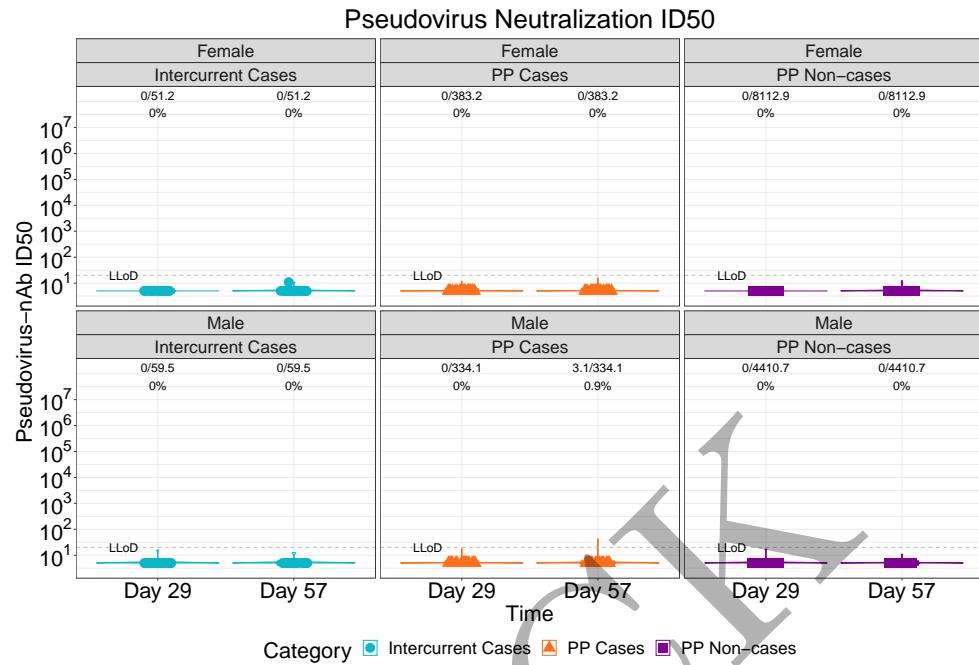


Figure 2.163: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (2 timepoints)

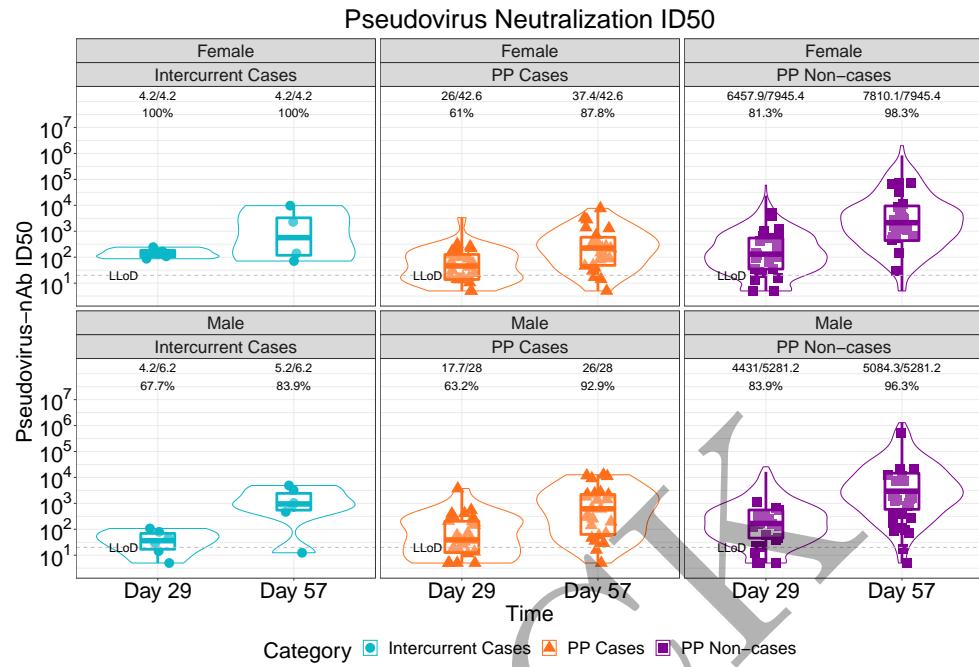


Figure 2.164: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

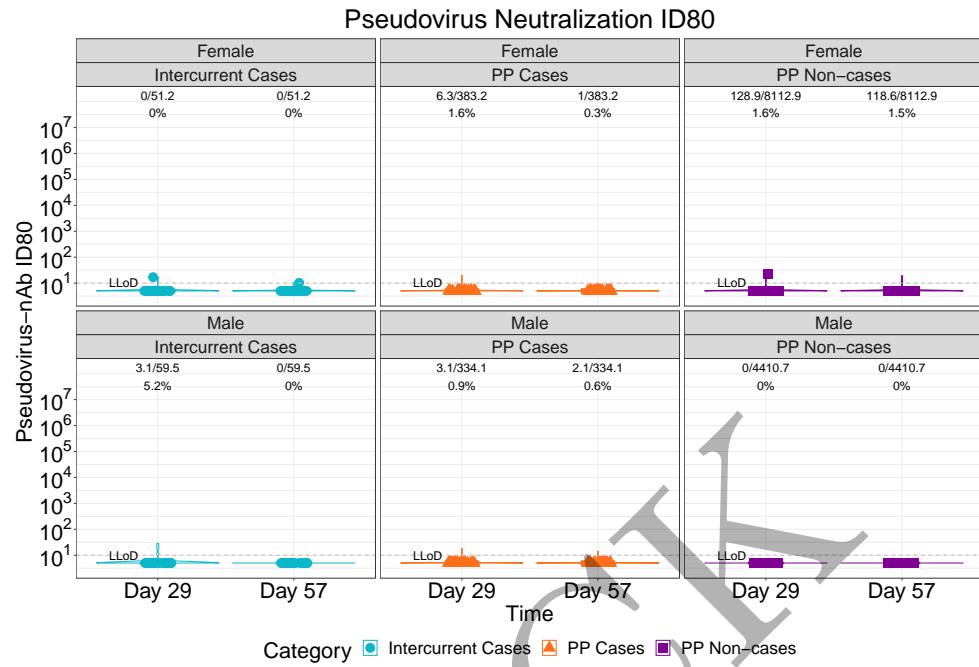


Figure 2.165: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (2 timepoints)

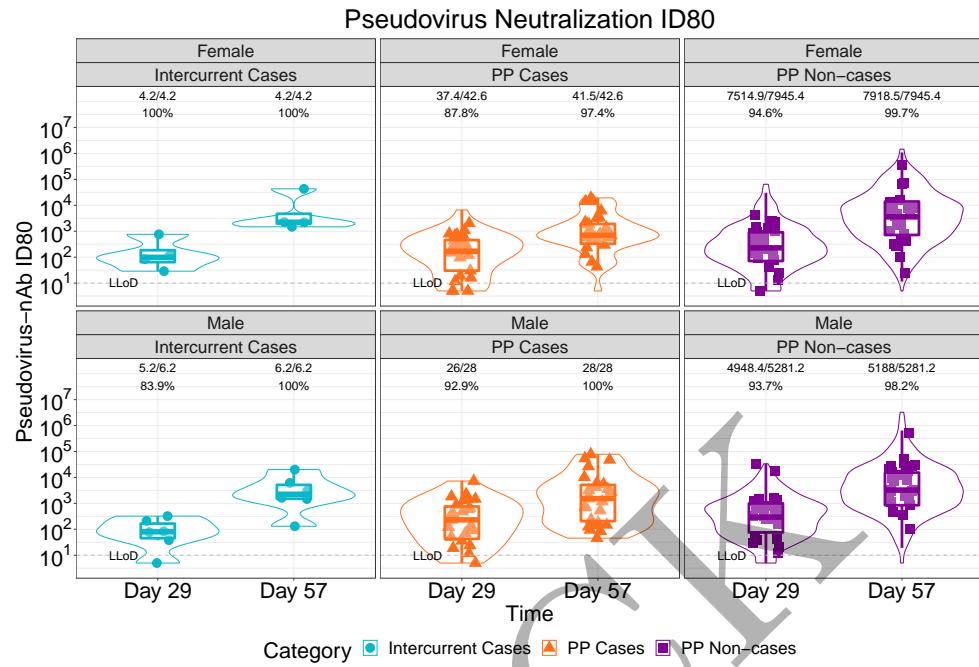


Figure 2.166: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (2 timepoints)

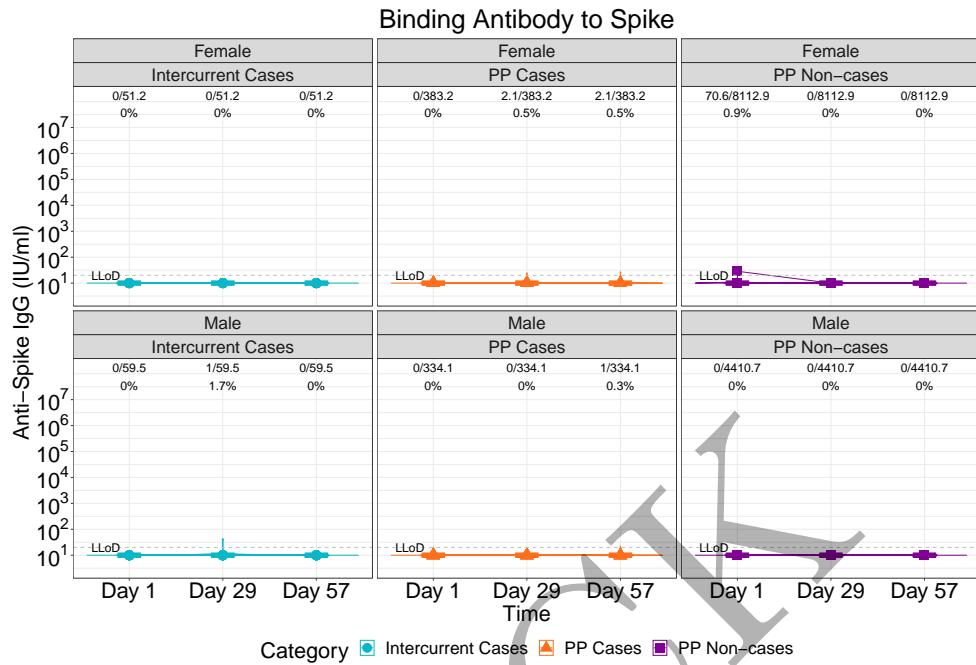


Figure 2.167: lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (3 timepoints)

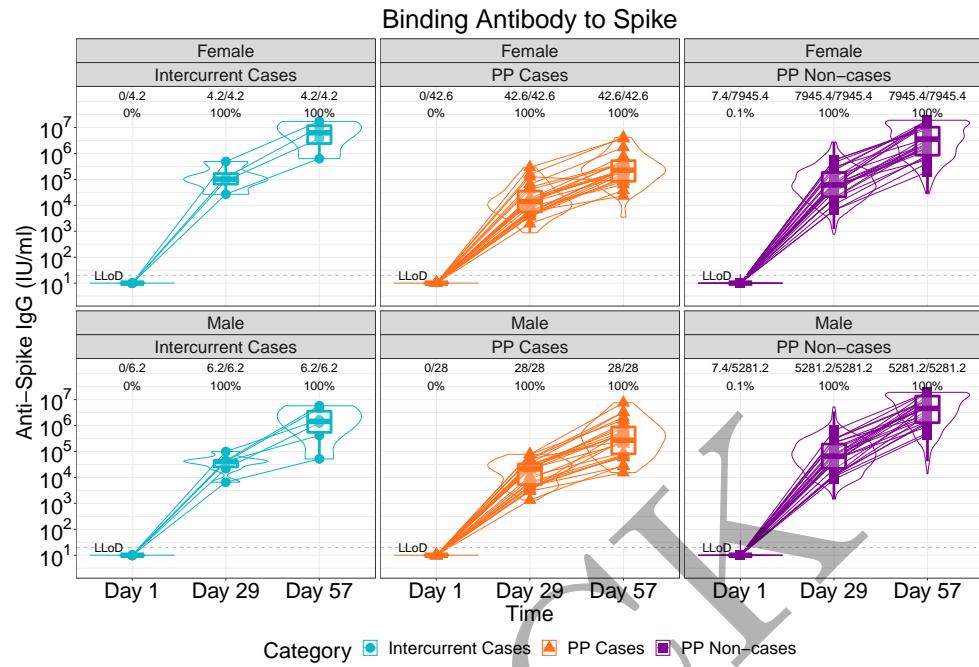


Figure 2.168: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

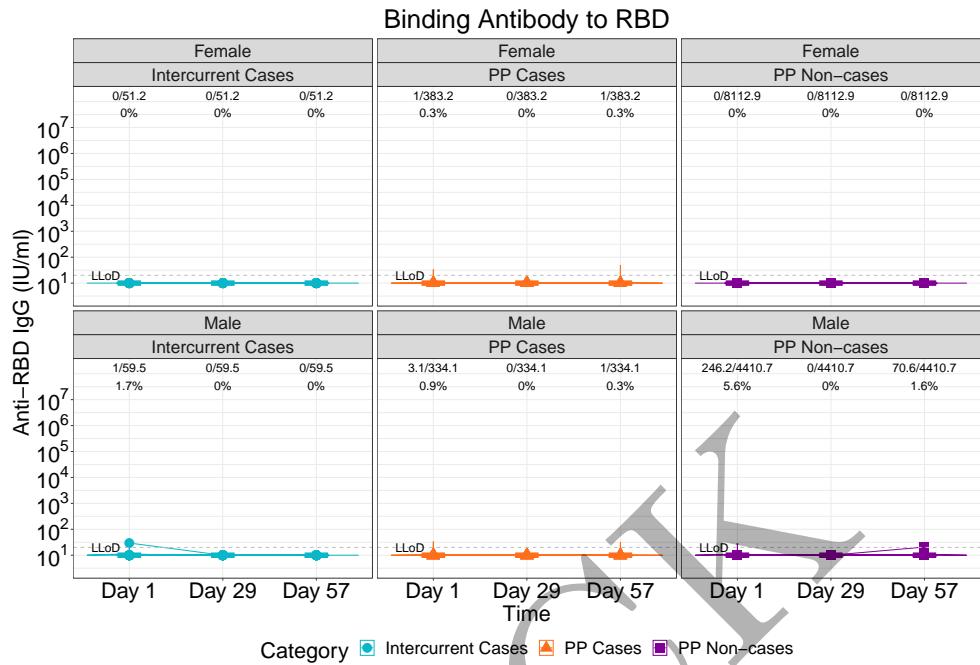


Figure 2.169: lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (3 timepoints)

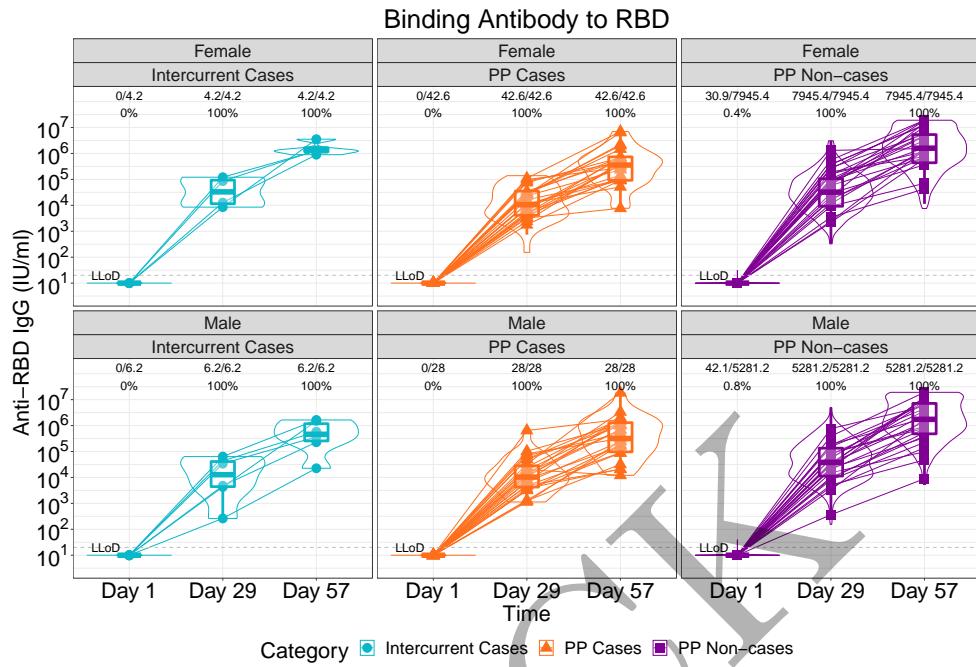


Figure 2.170: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

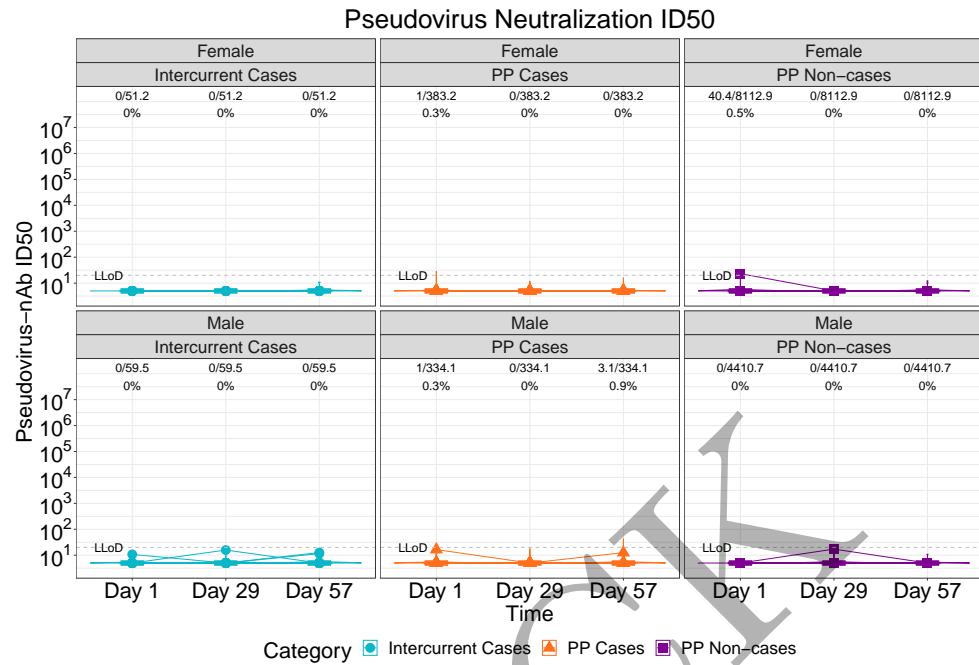


Figure 2.171: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (3 timepoints)

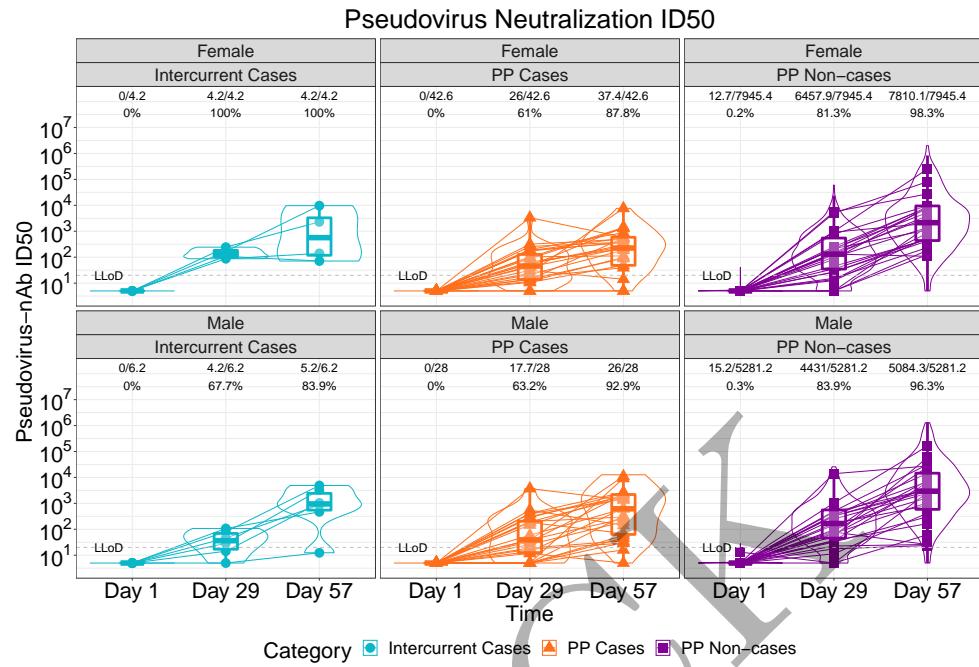


Figure 2.172: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

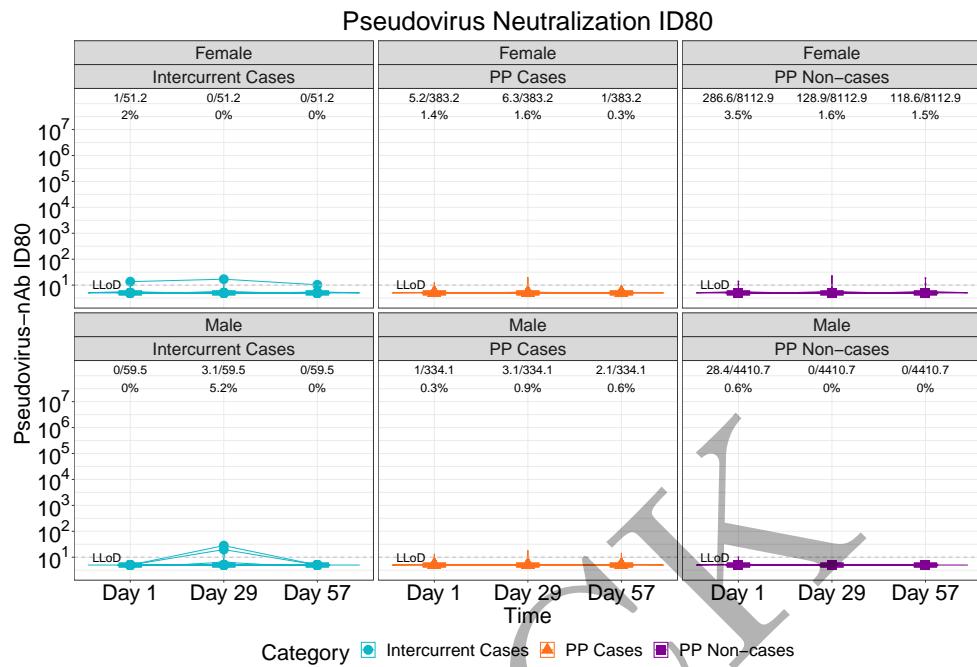


Figure 2.173: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (3 timepoints)

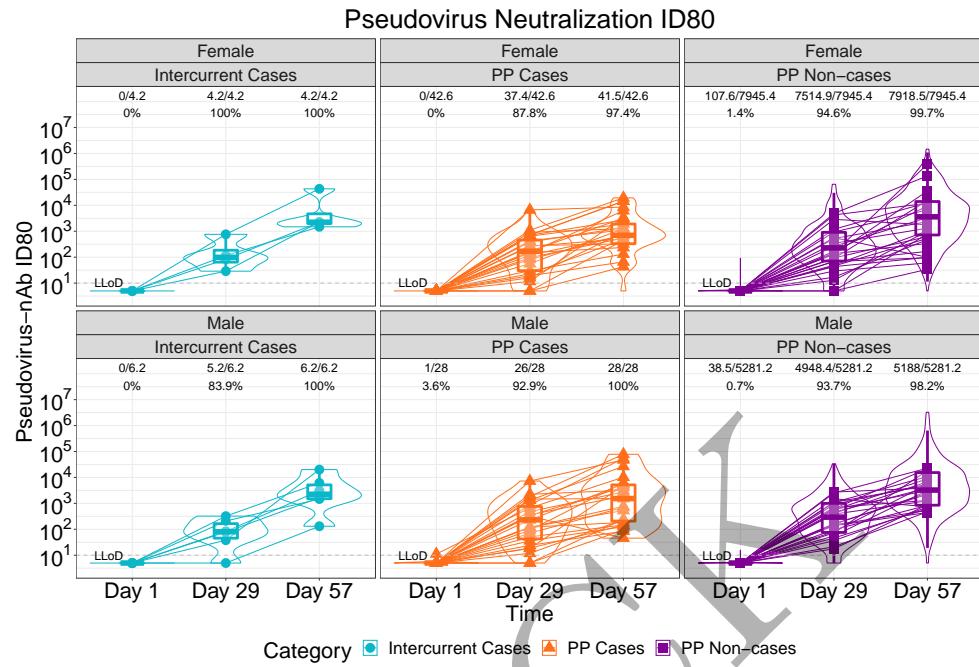


Figure 2.174: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

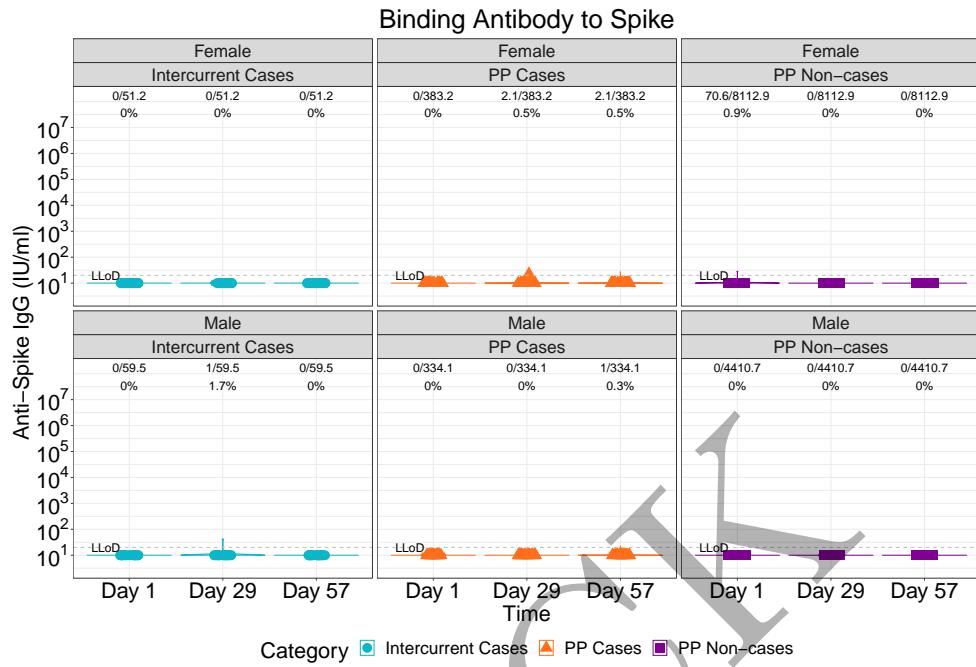


Figure 2.175: violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (3 timepoints)

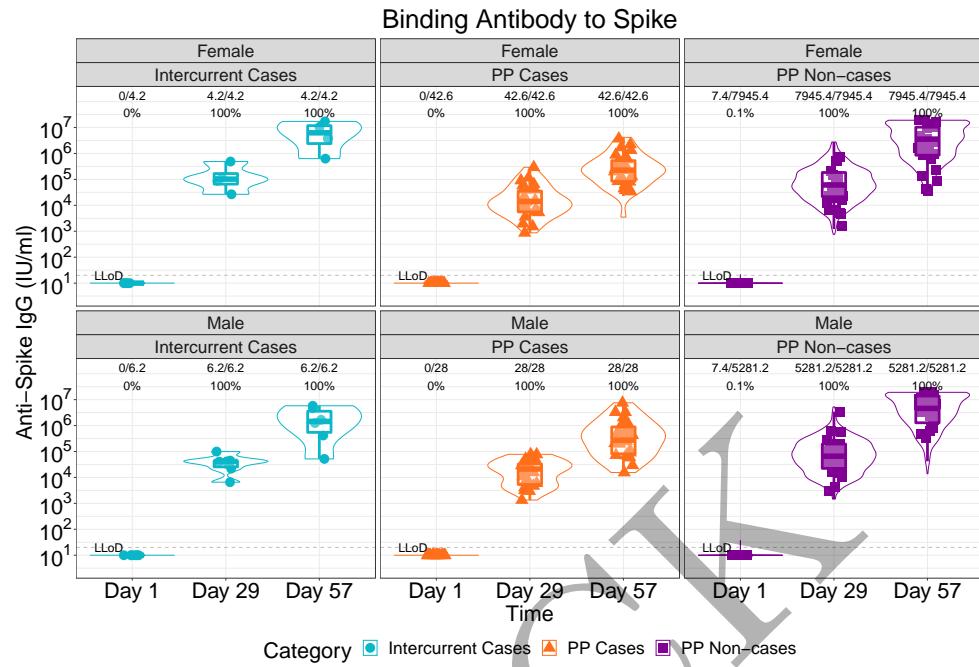


Figure 2.176: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

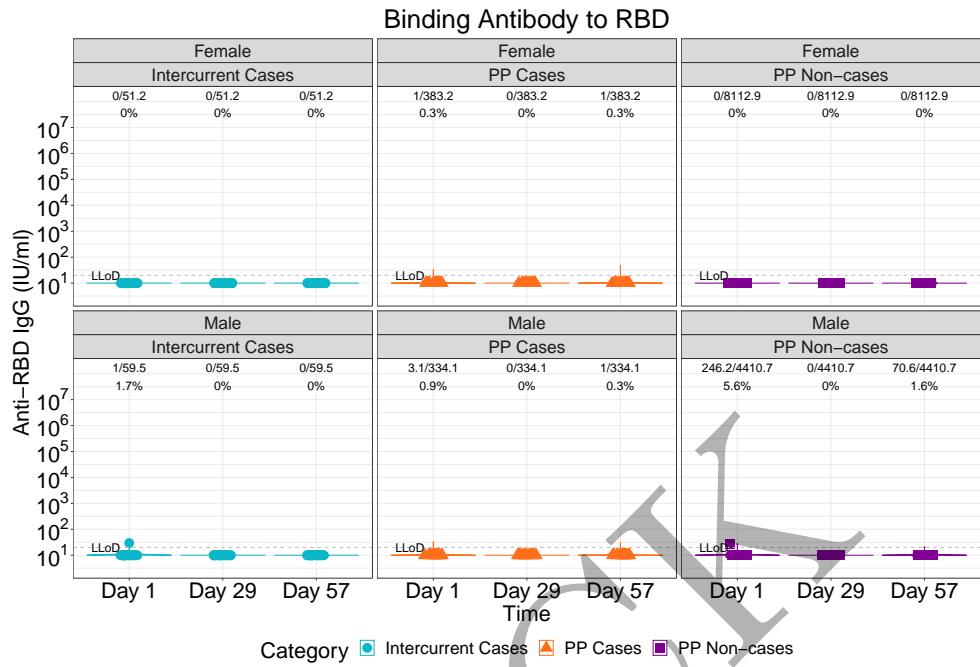


Figure 2.177: violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (3 timepoints)

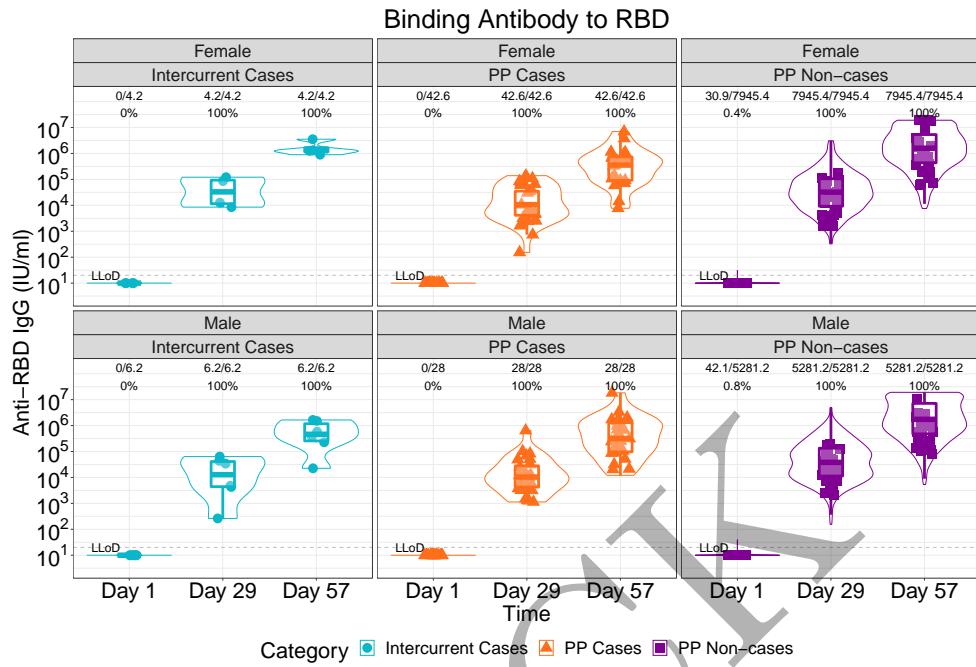


Figure 2.178: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

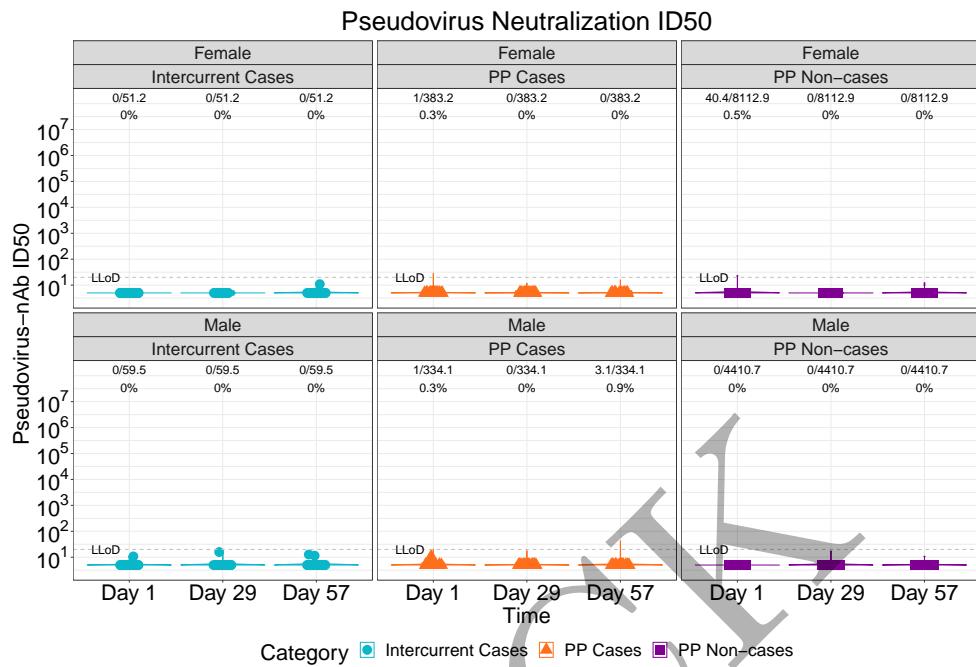


Figure 2.179: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (3 timepoints)

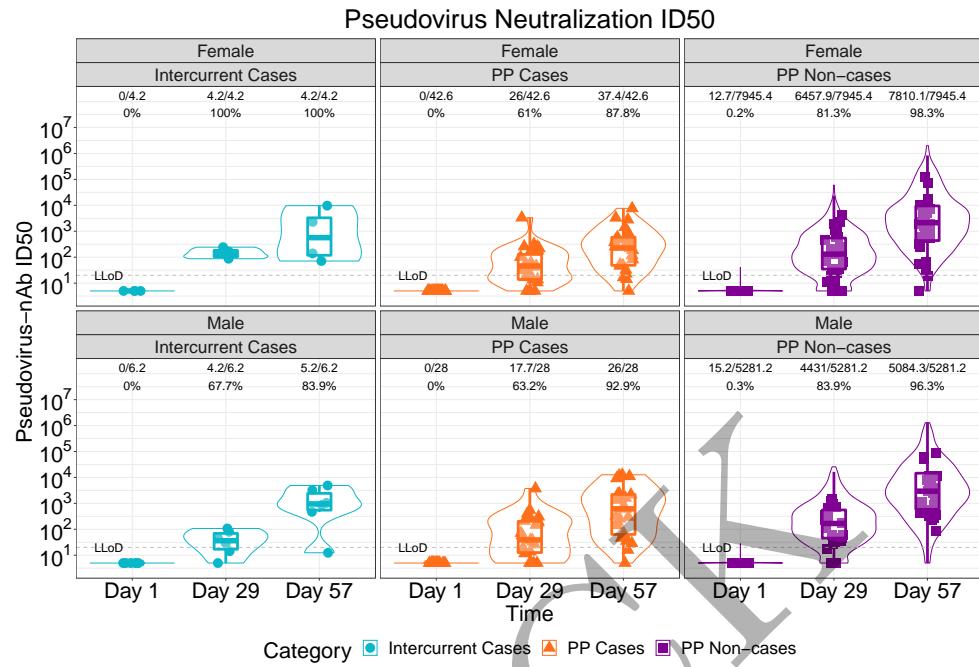


Figure 2.180: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (3 timepoints)

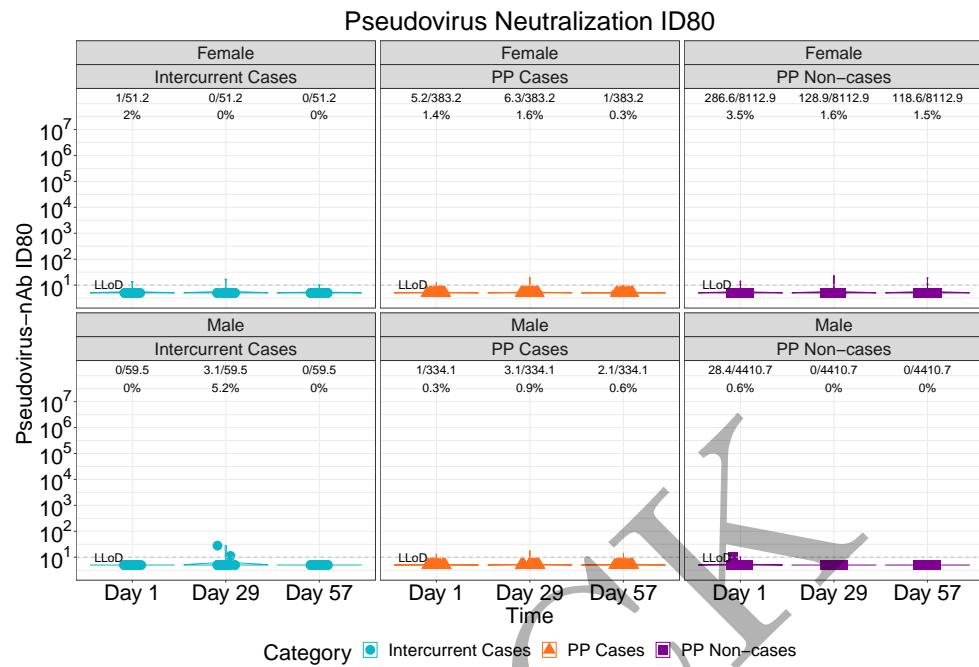


Figure 2.181: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (3 timepoints)

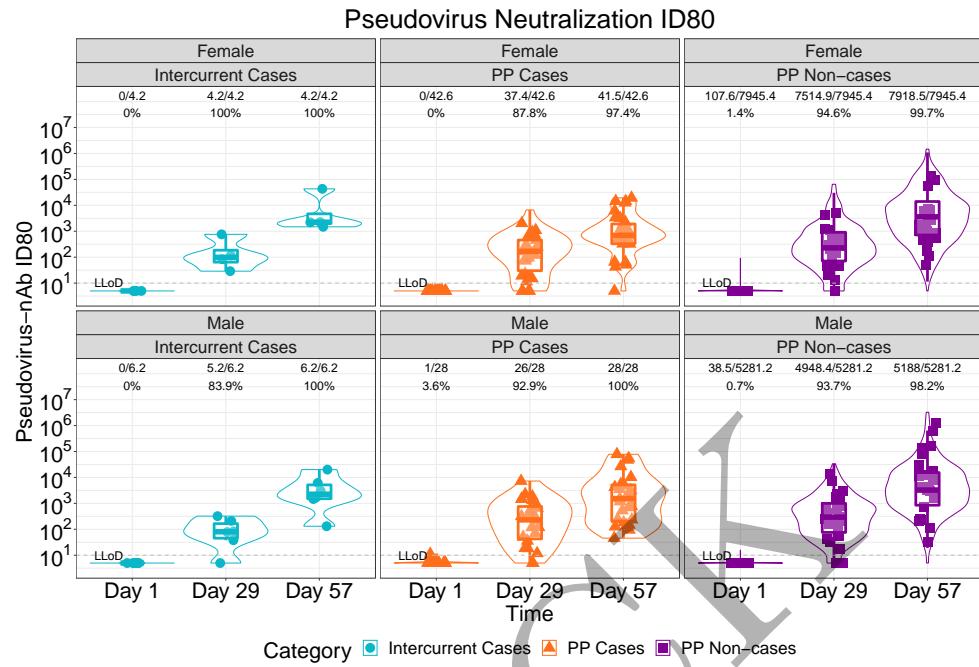


Figure 2.182: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (3 timepoints)



Figure 2.183: lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (2 timepoints)

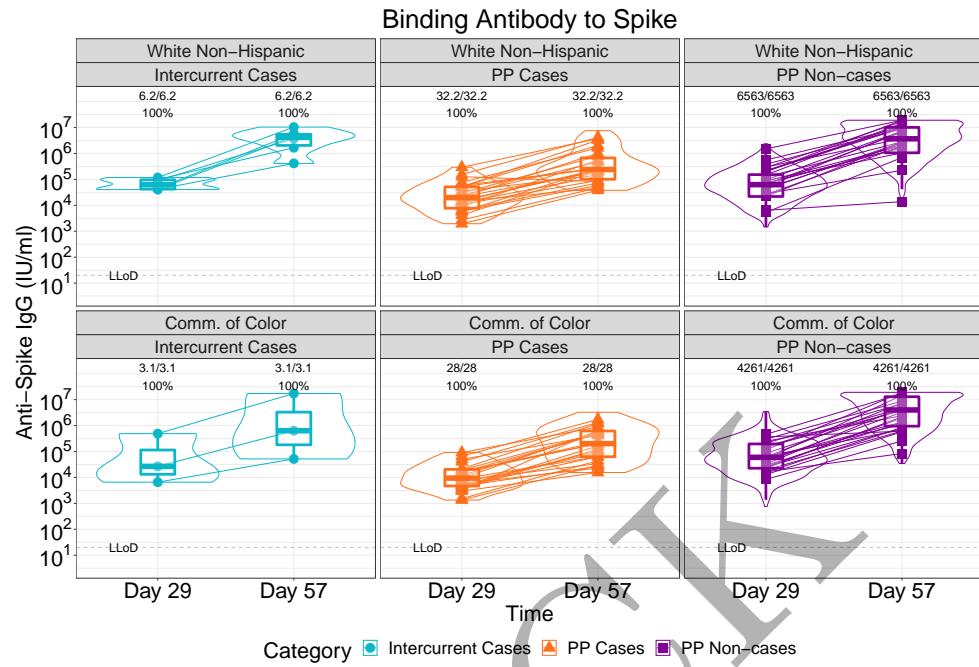


Figure 2.184: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (2 timepoints)

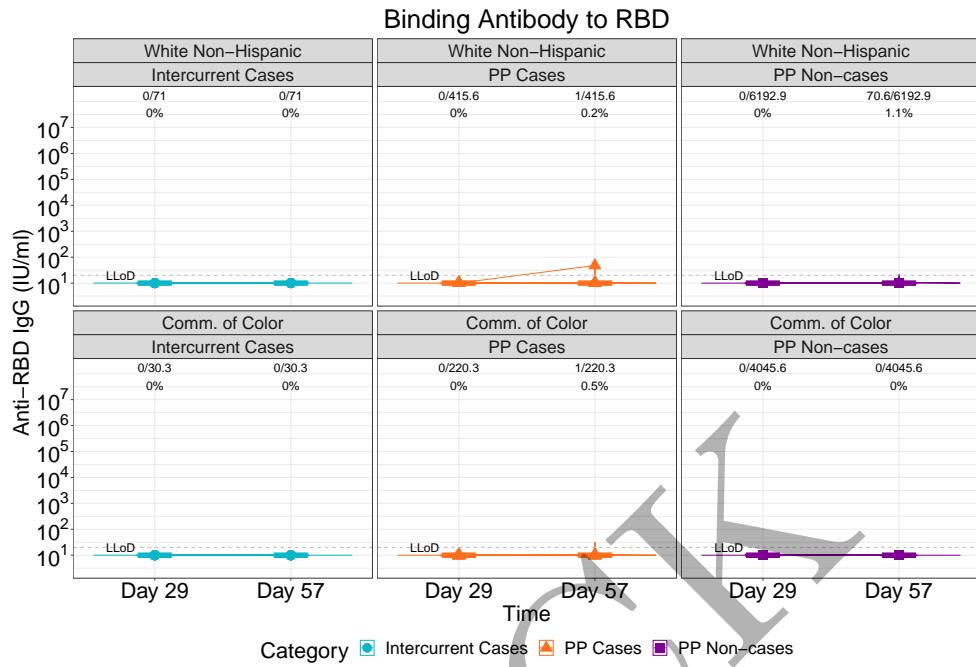


Figure 2.185: lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (2 timepoints)

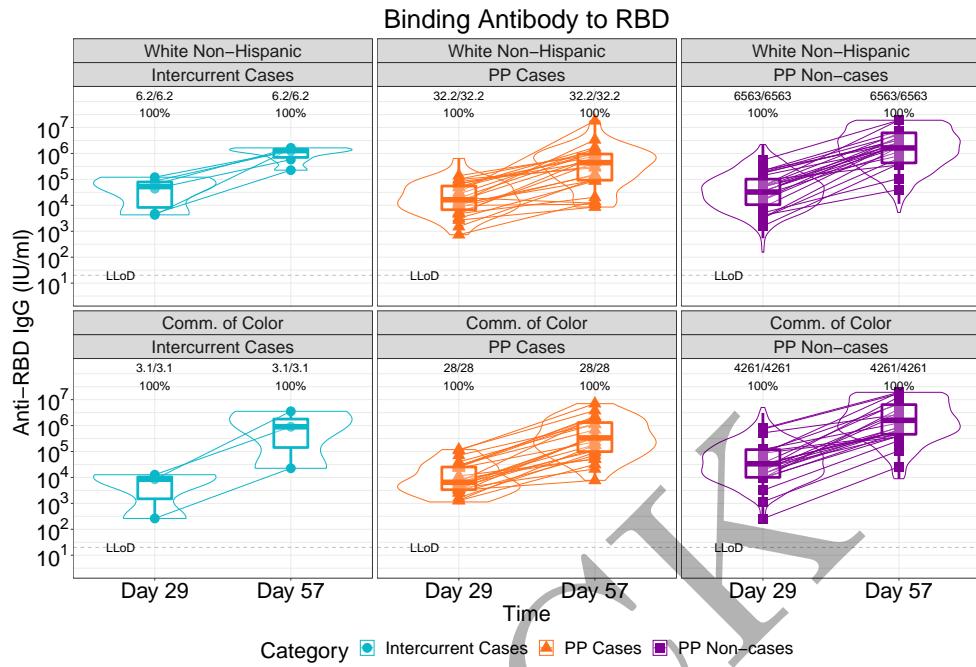


Figure 2.186: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (2 timepoints)

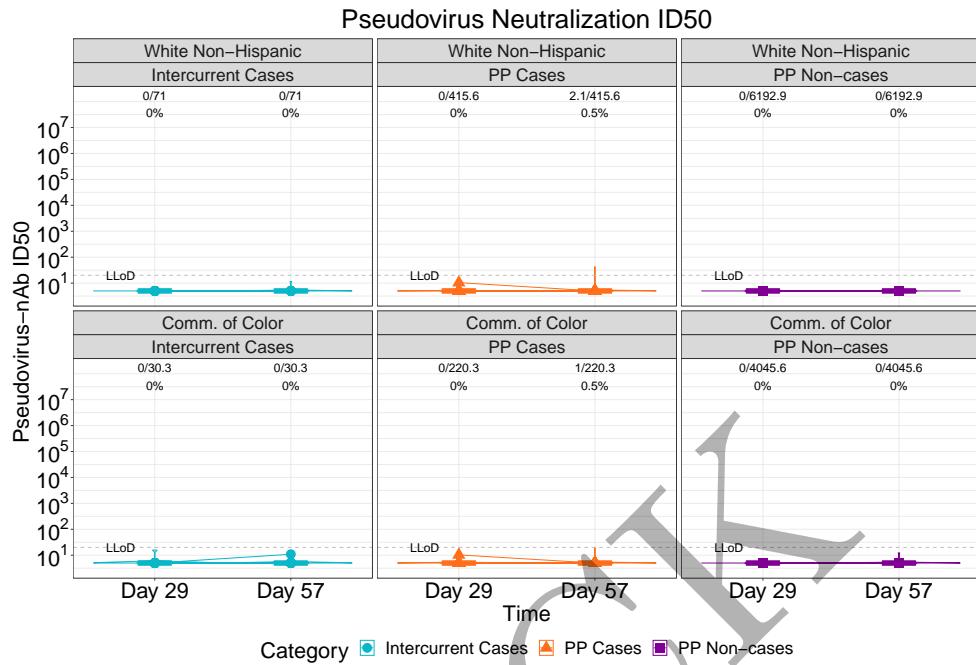


Figure 2.187: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (2 timepoints)

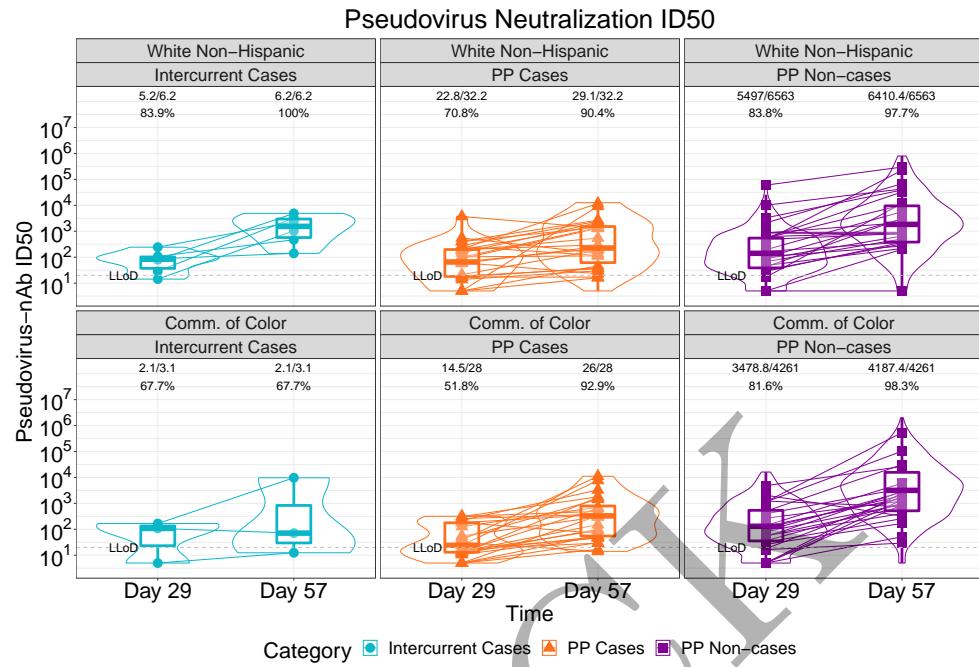


Figure 2.188: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (2 timepoints)

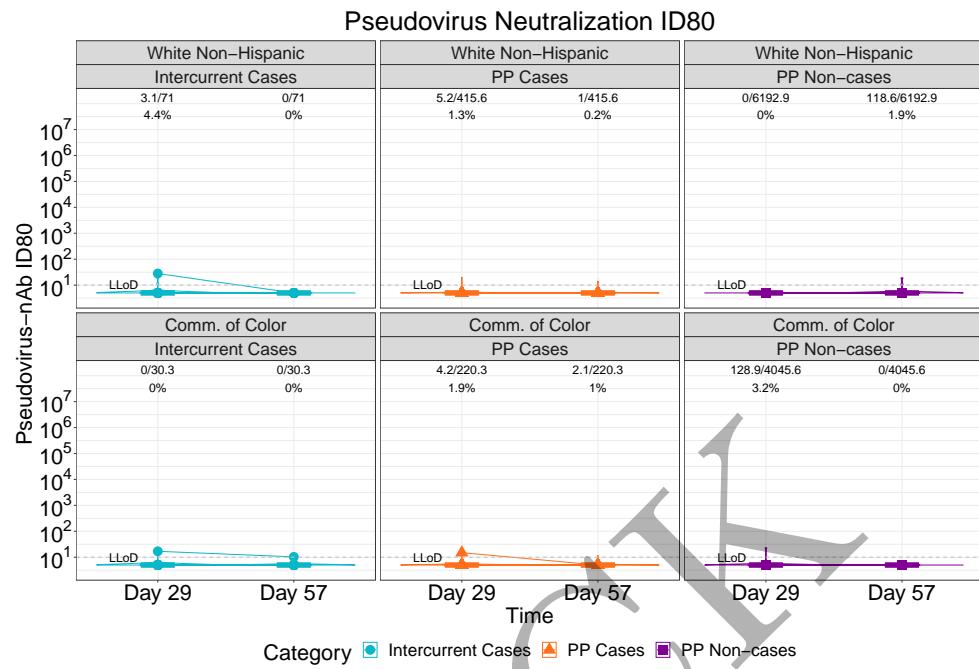


Figure 2.189: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (2 timepoints)

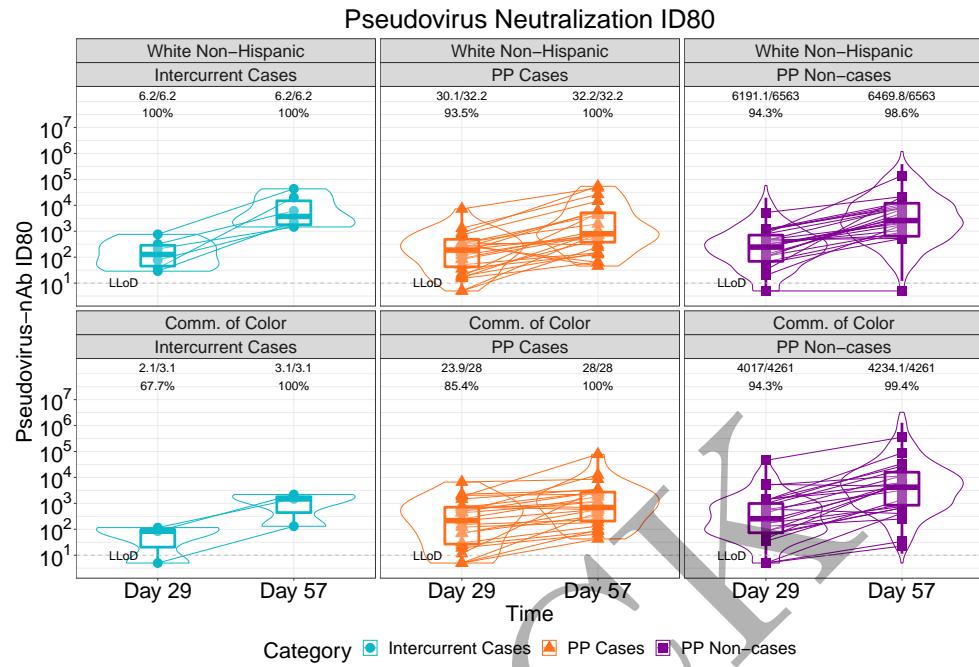


Figure 2.190: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (2 timepoints)

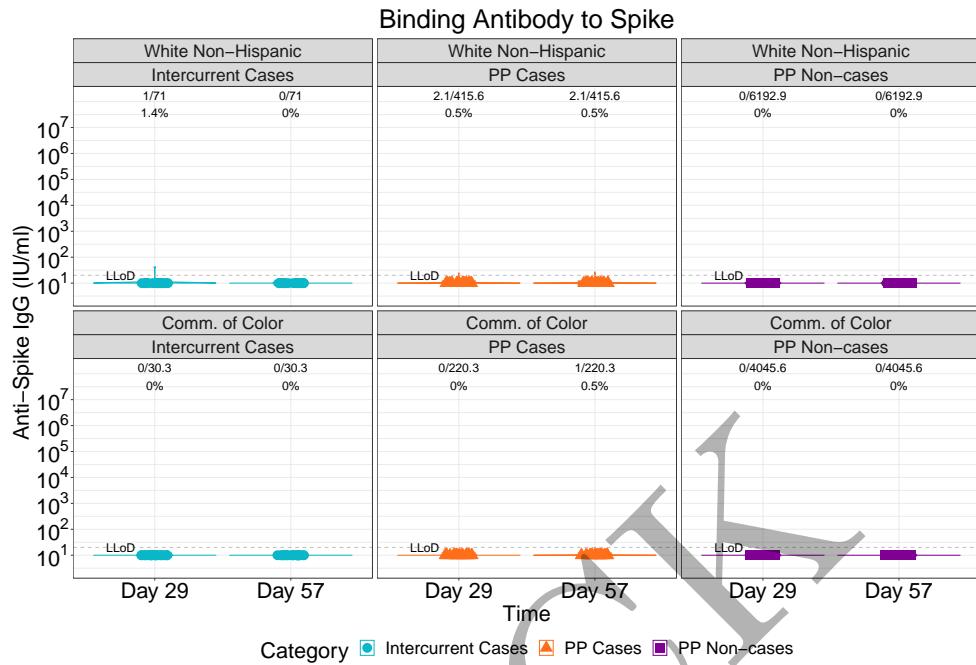


Figure 2.191: violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (2 timepoints)

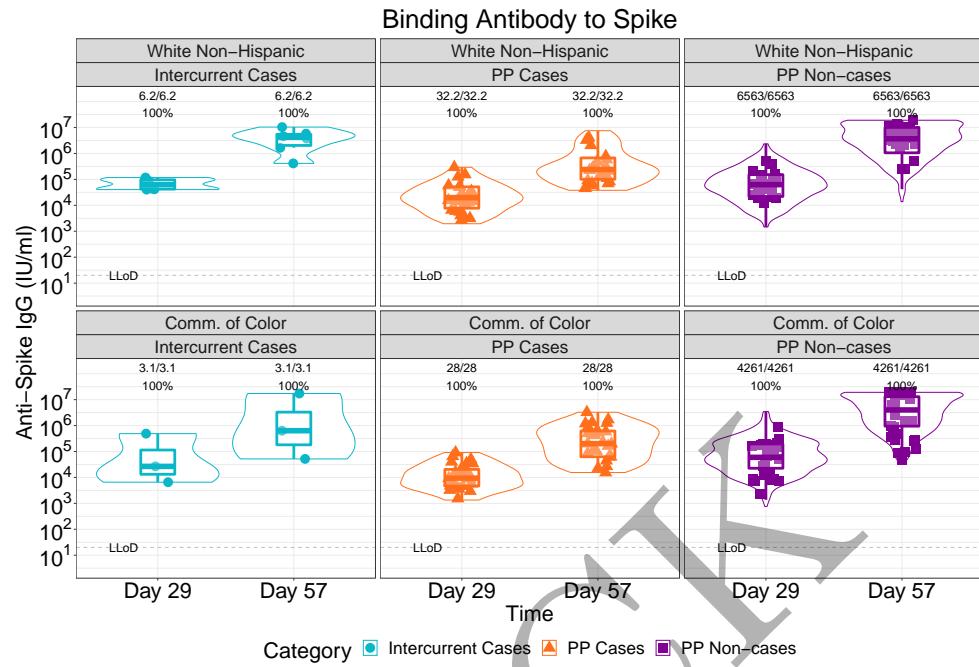


Figure 2.192: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (2 timepoints)

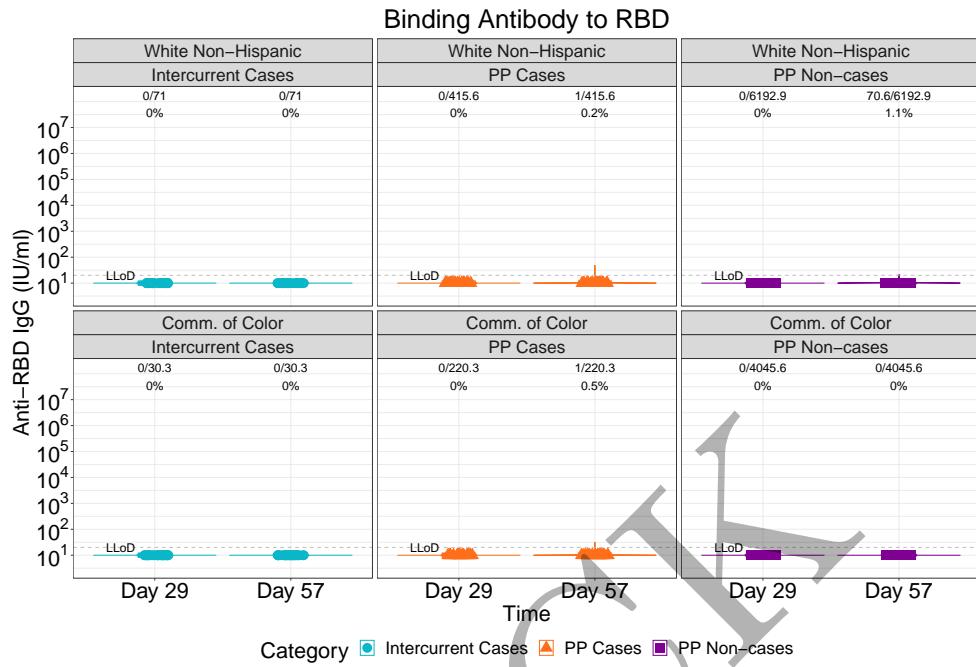


Figure 2.193: violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (2 timepoints)

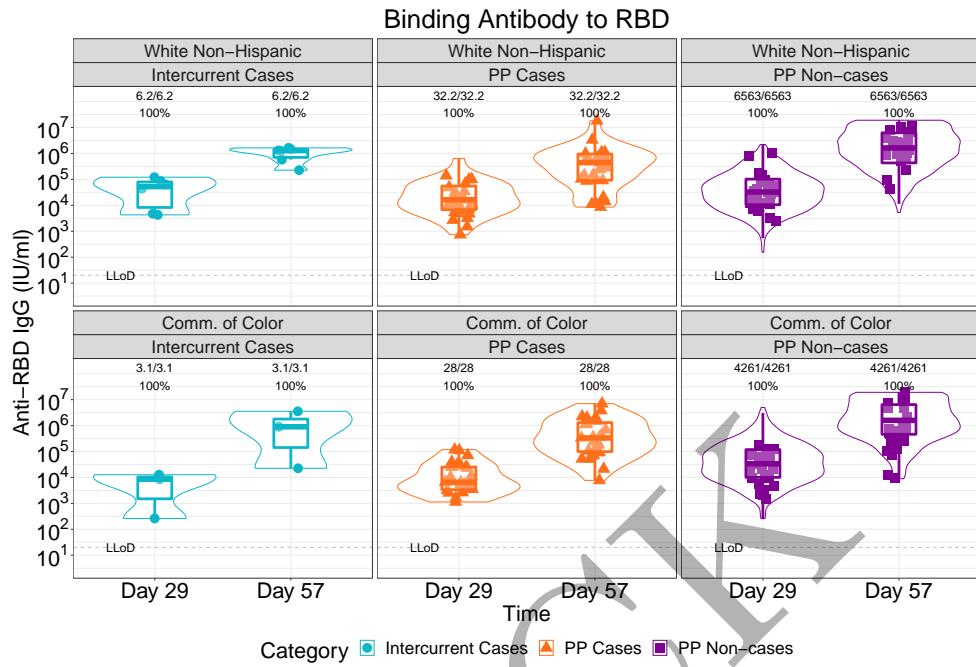


Figure 2.194: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (2 timepoints)

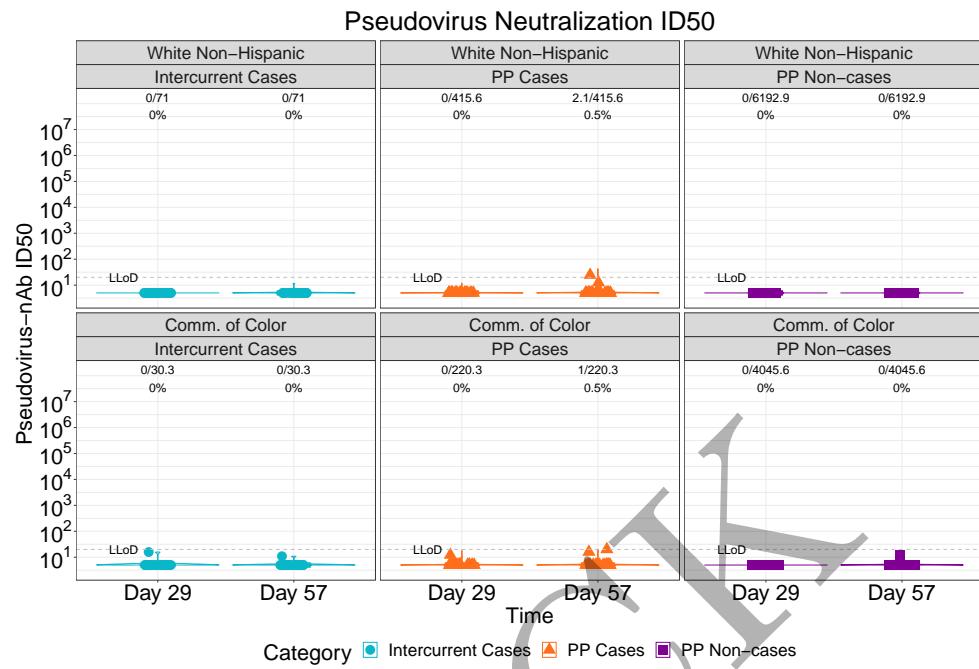


Figure 2.195: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (2 timepoints)

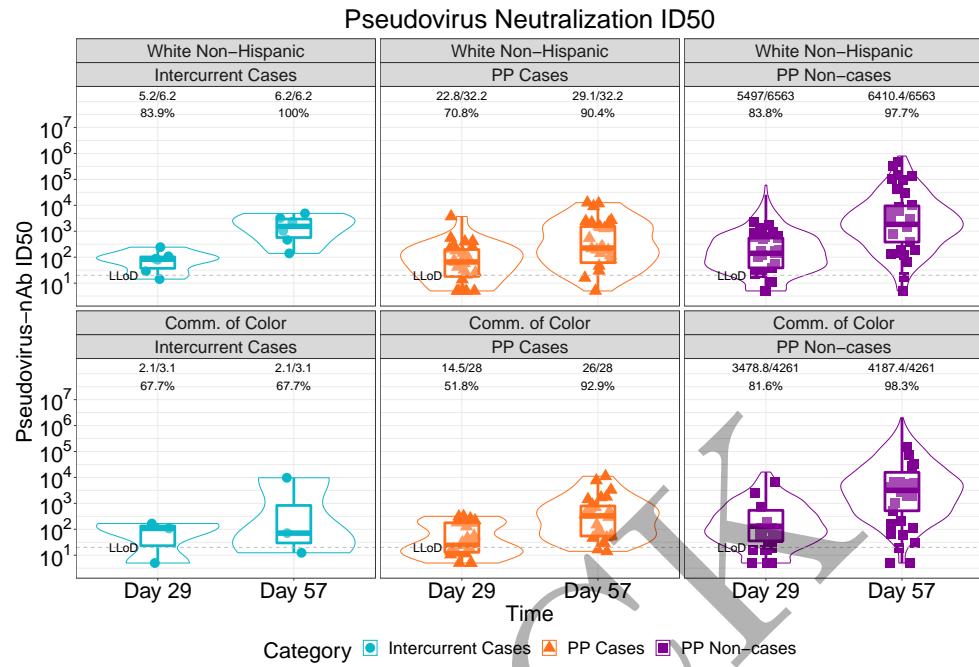


Figure 2.196: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (2 timepoints)

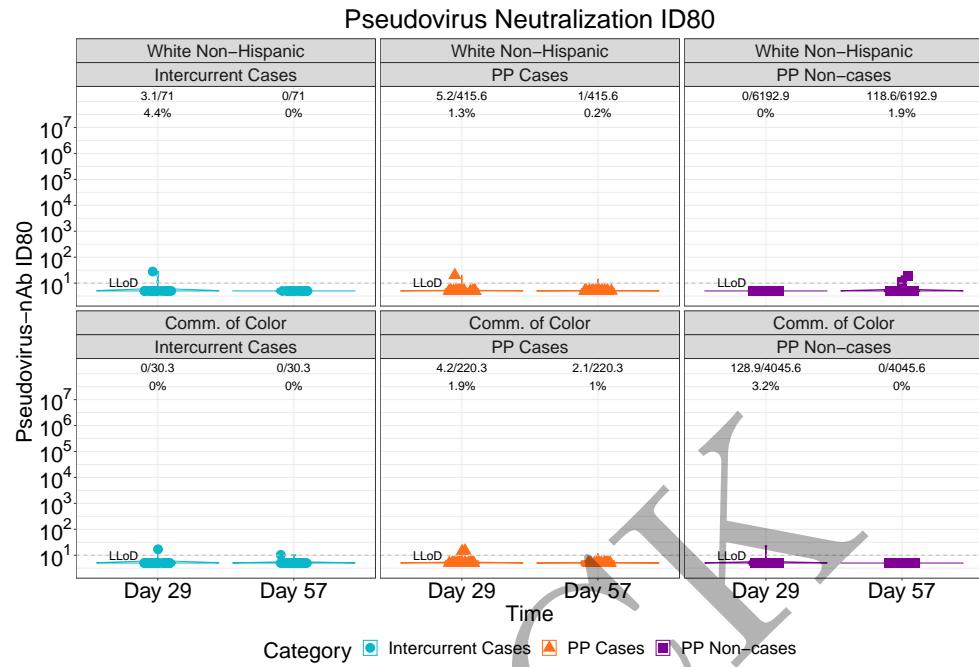


Figure 2.197: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (2 timepoints)

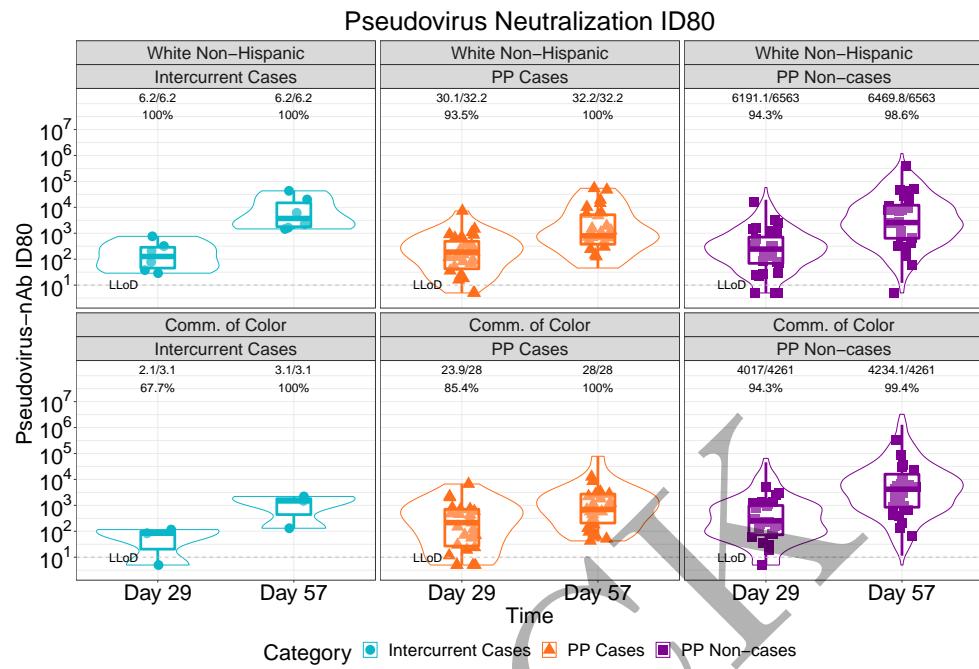


Figure 2.198: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (2 timepoints)

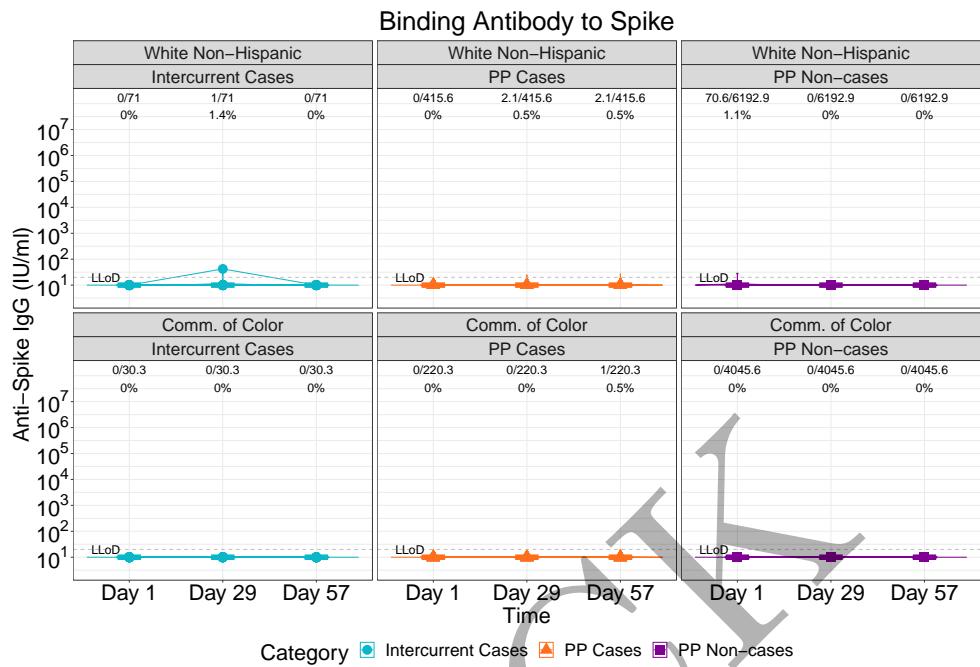


Figure 2.199: lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (3 timepoints)

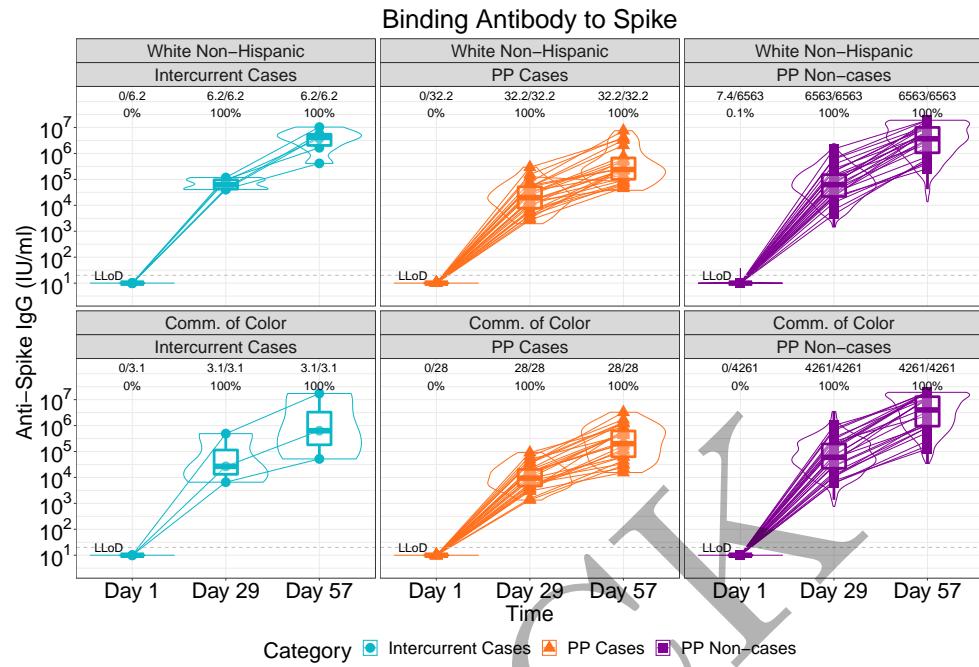


Figure 2.200: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (3 timepoints)

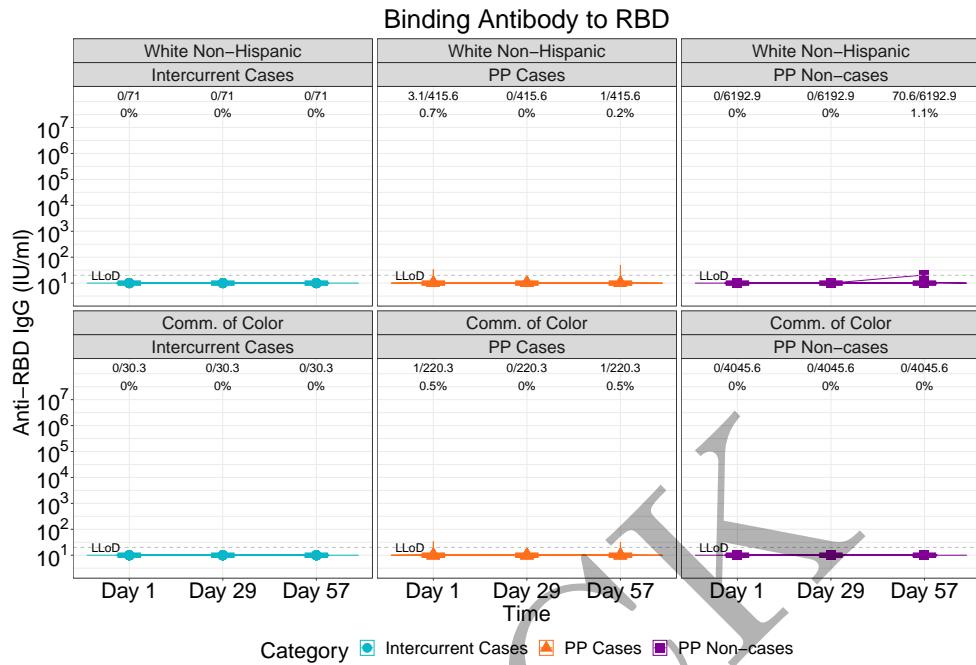


Figure 2.201: lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (3 timepoints)

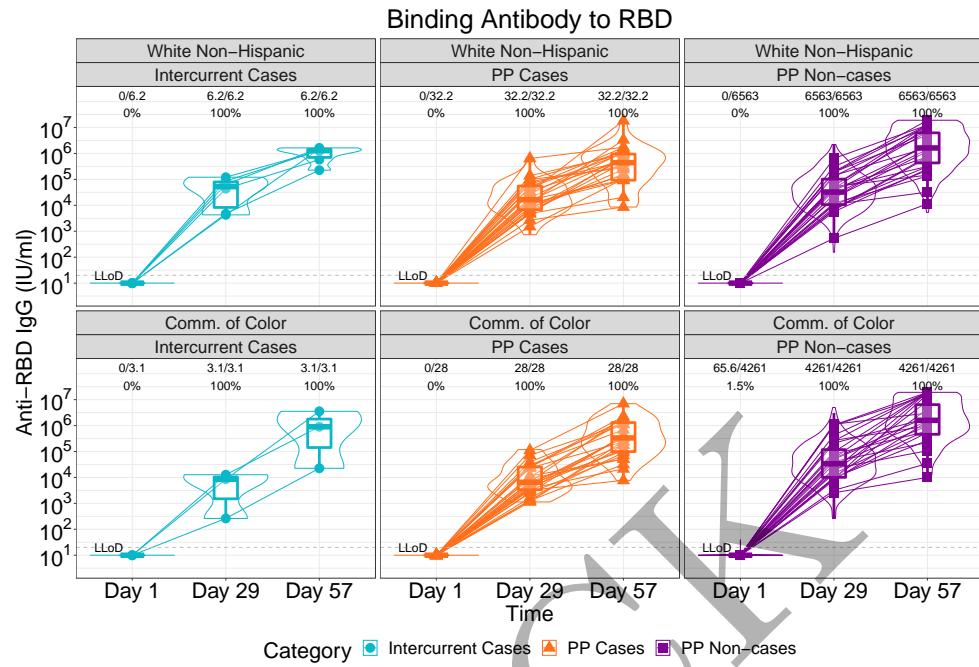


Figure 2.202: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (3 timepoints)

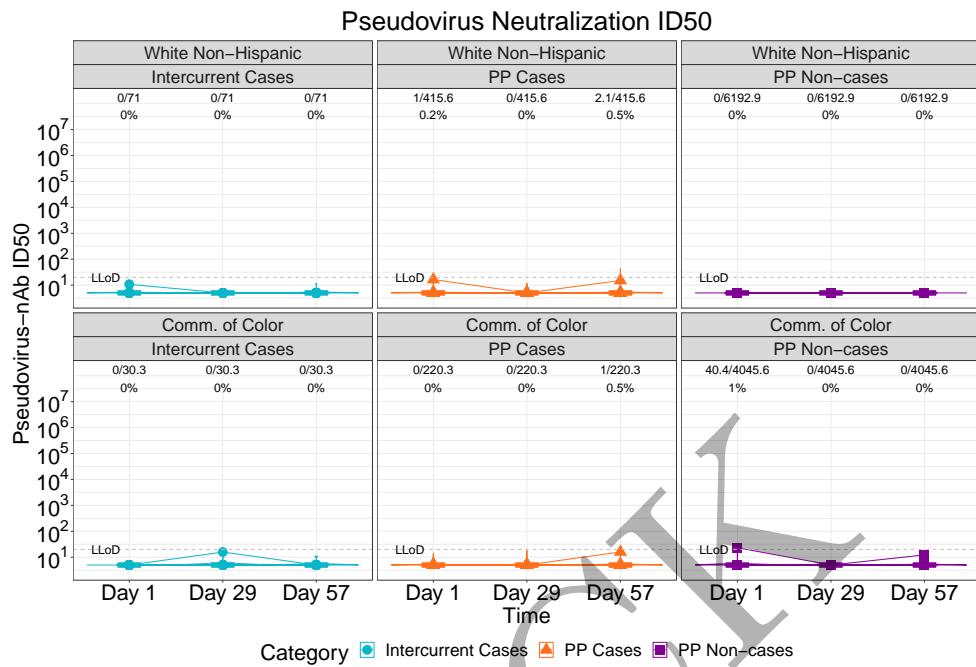


Figure 2.203: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (3 timepoints)

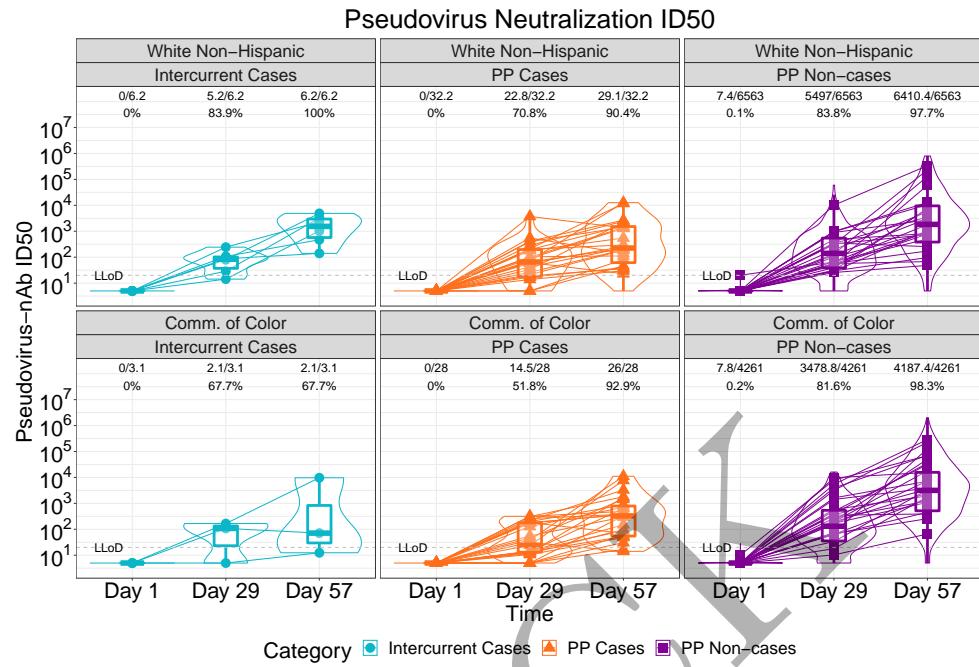


Figure 2.204: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (3 timepoints)

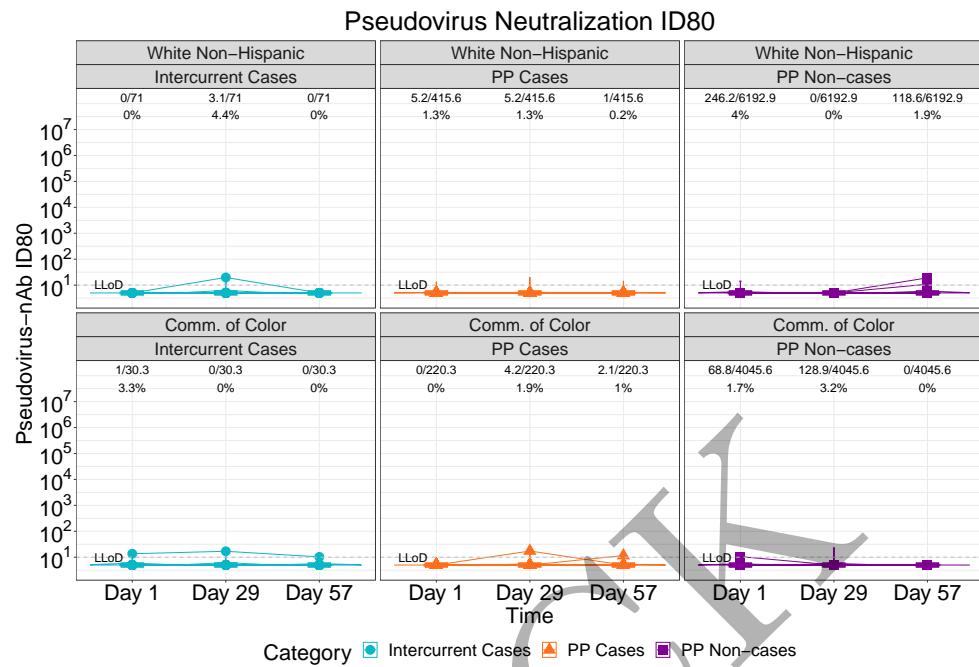


Figure 2.205: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (3 timepoints)

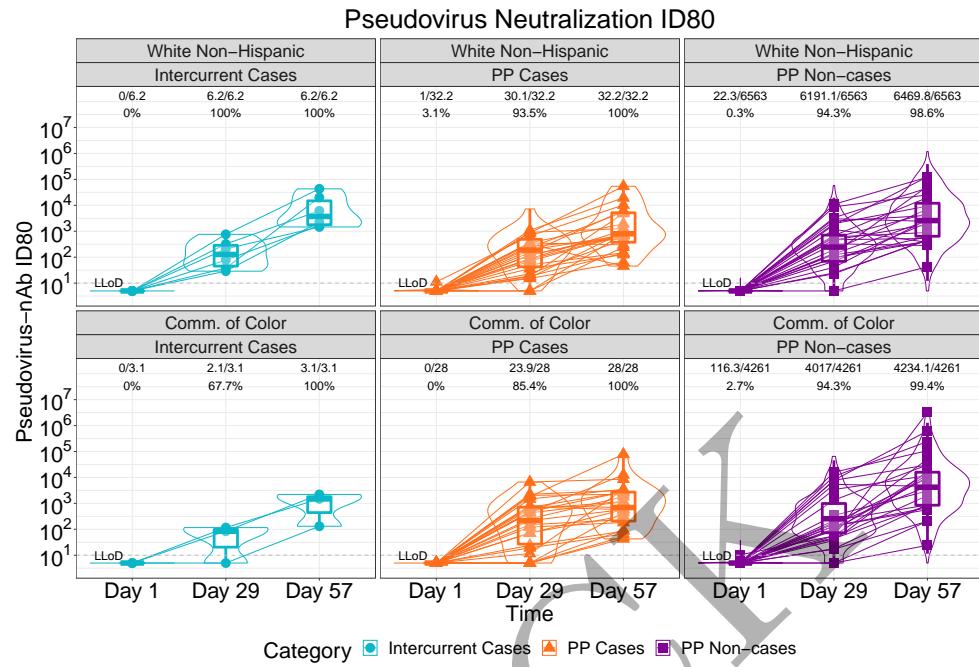


Figure 2.206: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (3 timepoints)

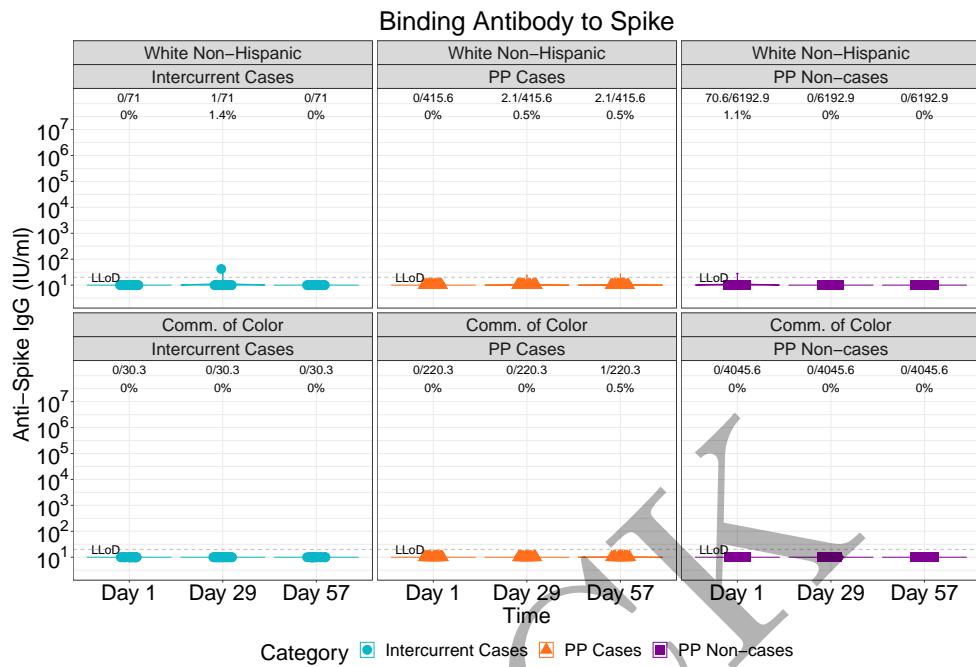


Figure 2.207: violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (3 timepoints)

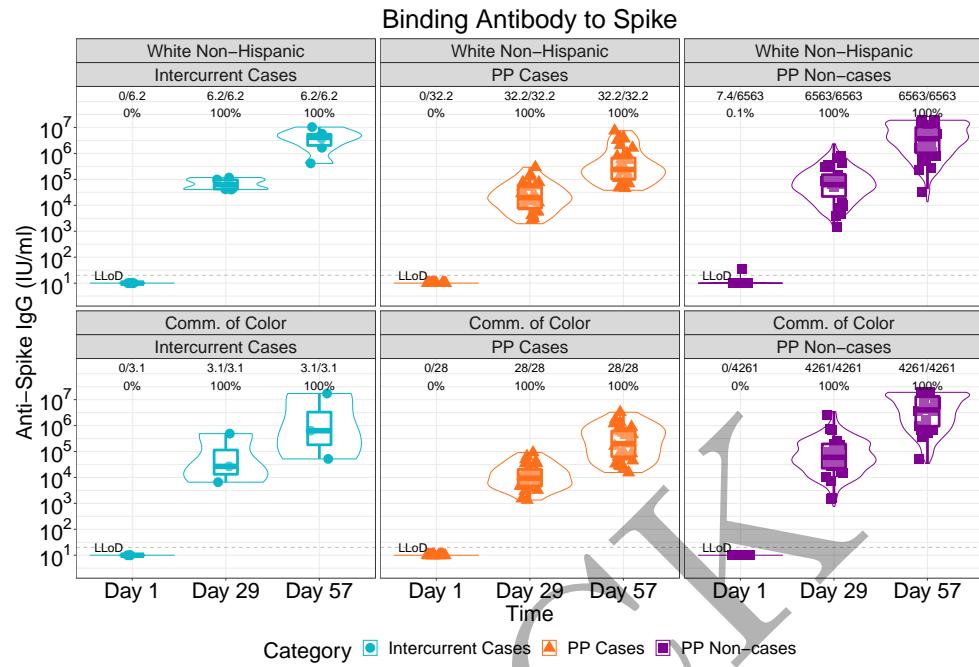


Figure 2.208: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (3 timepoints)

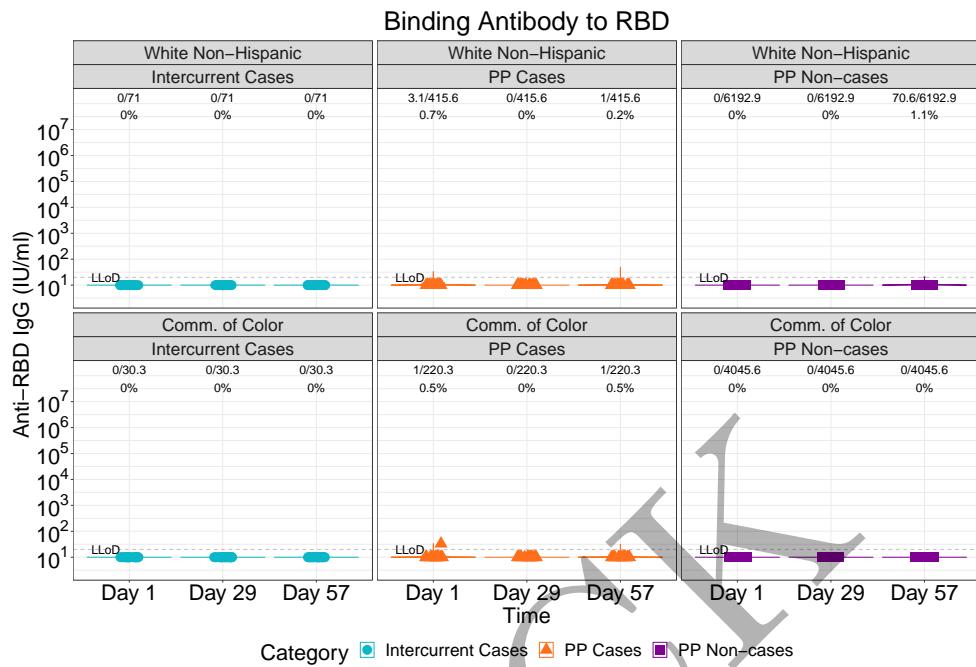


Figure 2.209: violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (3 timepoints)

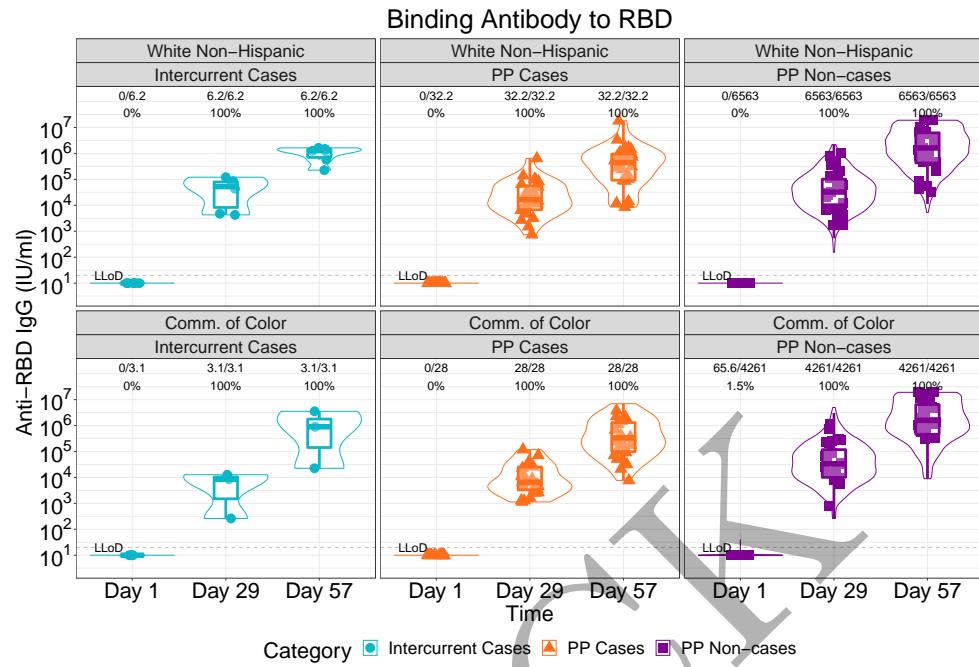


Figure 2.210: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (3 timepoints)

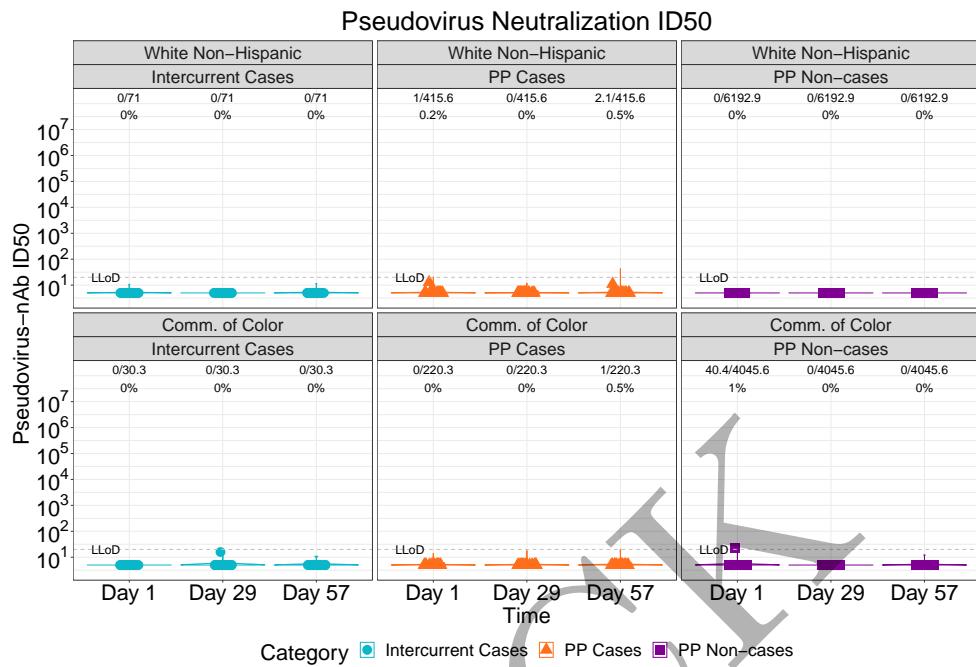


Figure 2.211: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (3 timepoints)

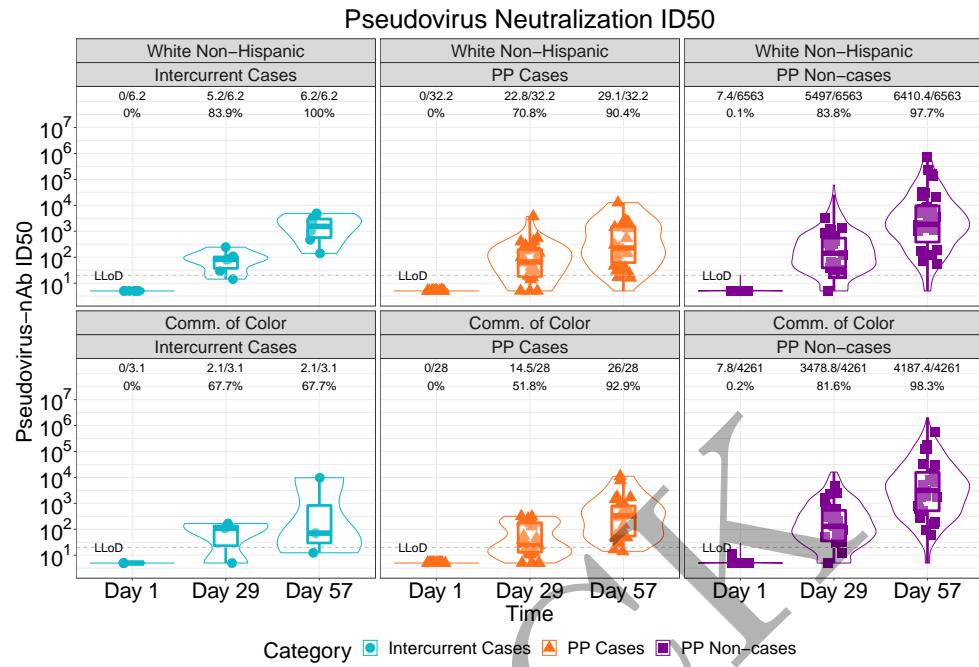


Figure 2.212: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (3 timepoints)

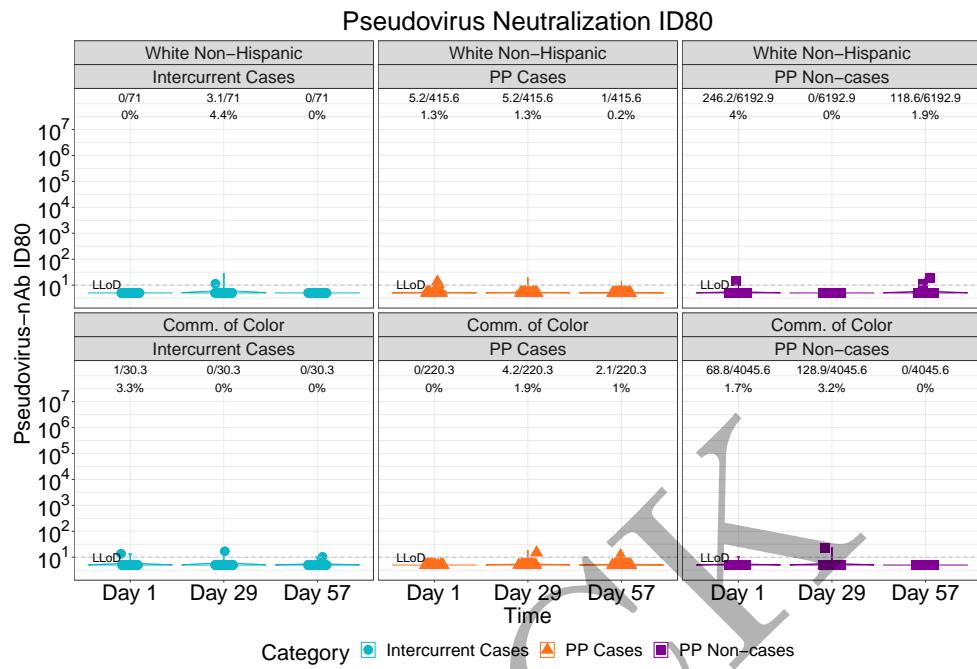


Figure 2.213: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (3 timepoints)

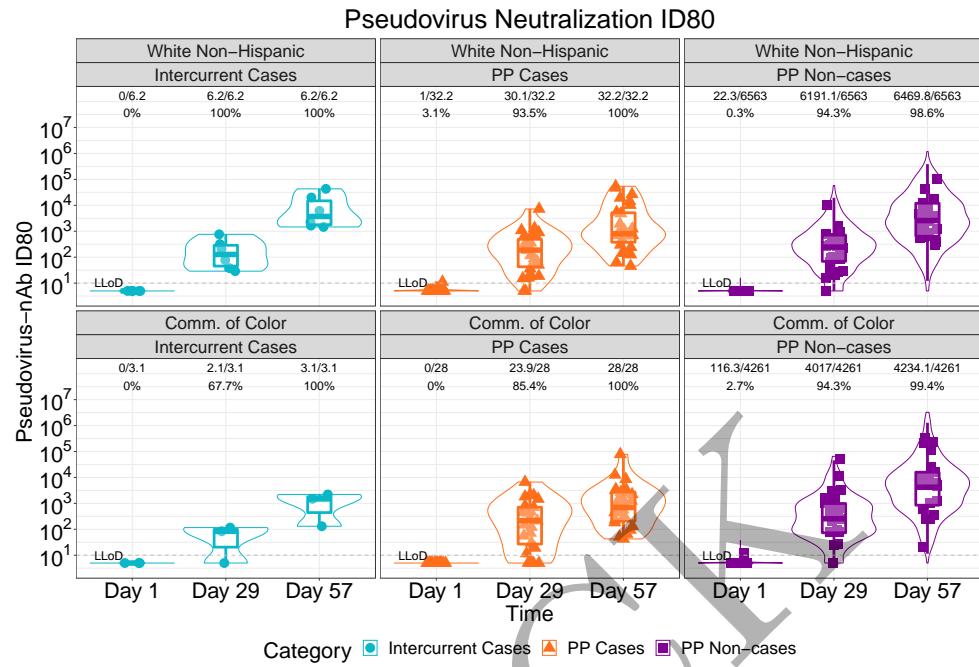


Figure 2.214: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (3 timepoints)

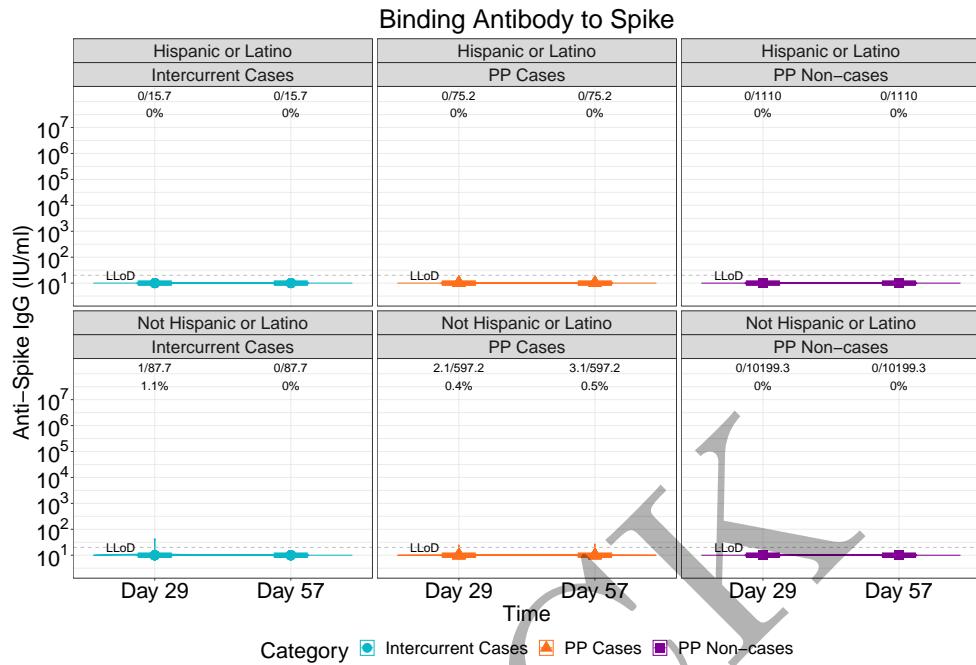


Figure 2.215: lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

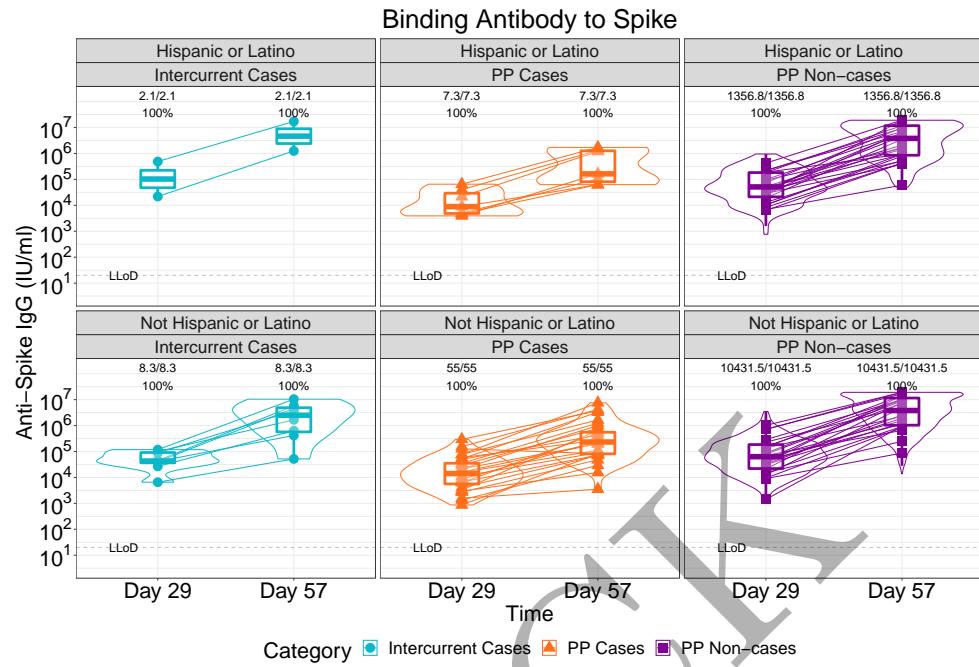


Figure 2.216: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

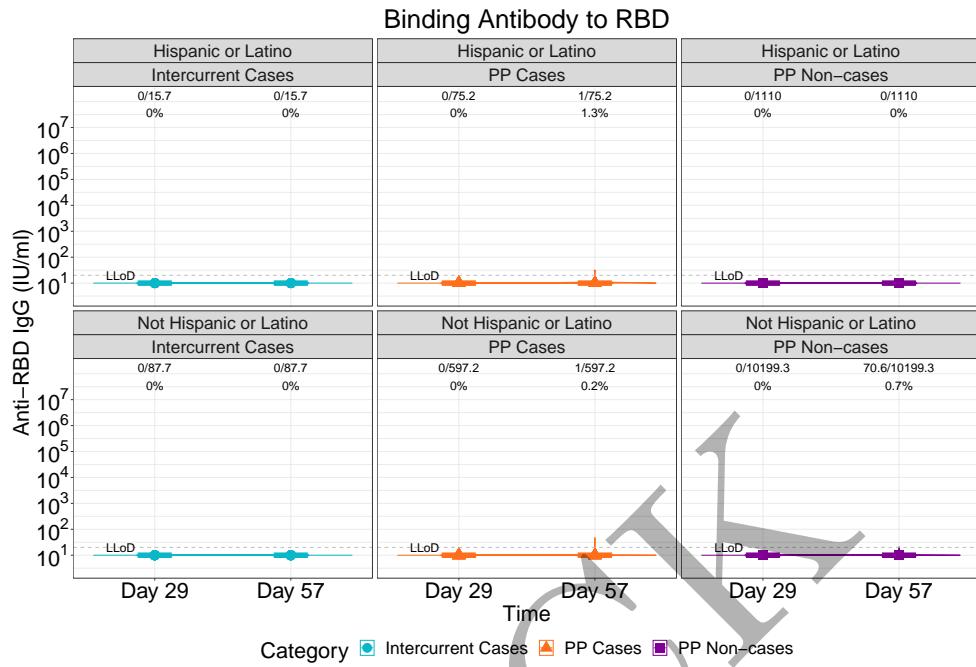


Figure 2.217: lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

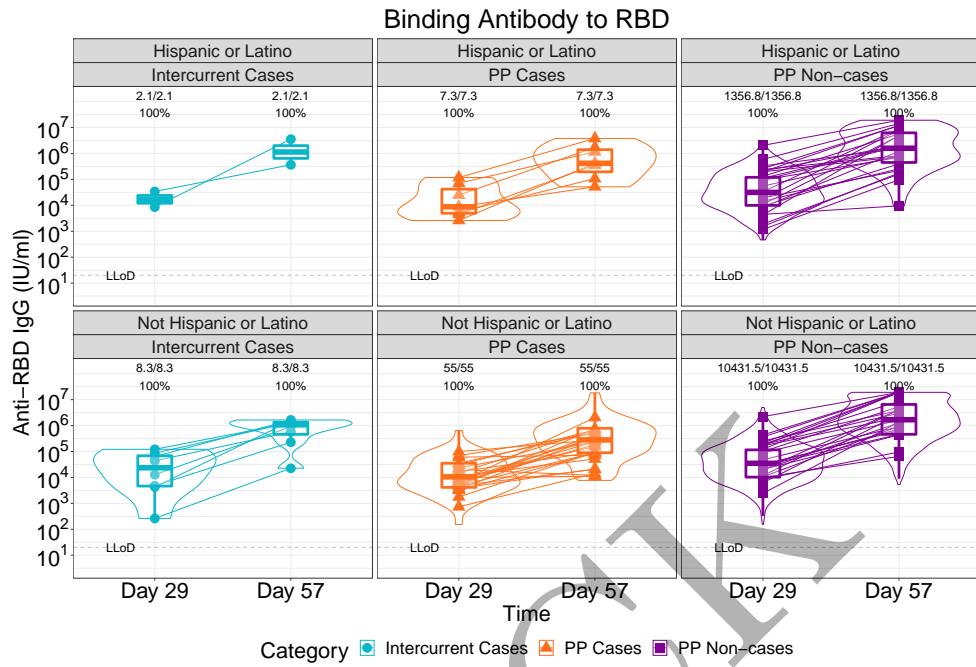


Figure 2.218: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

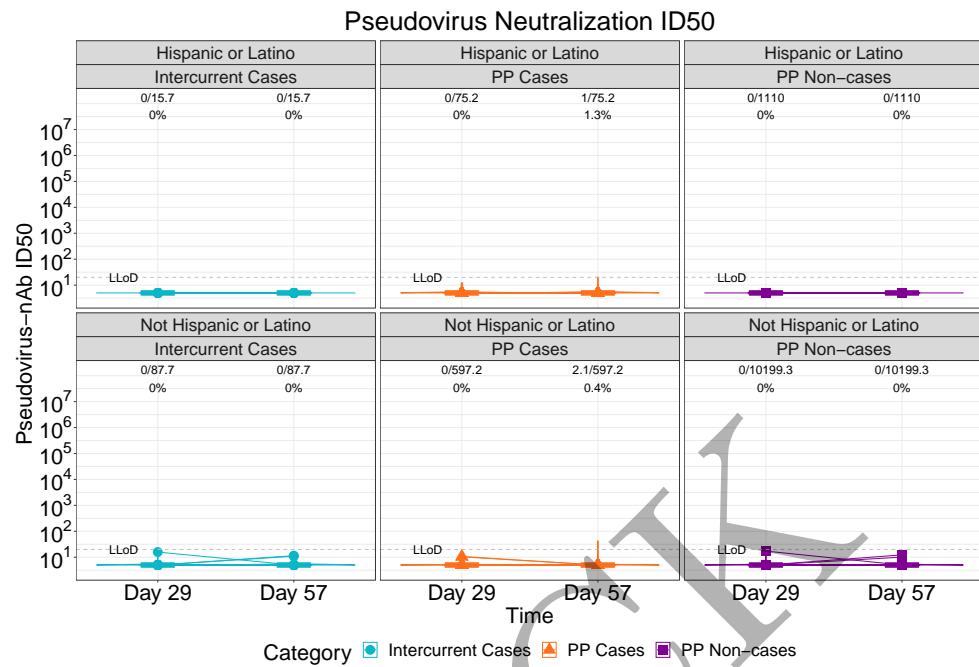


Figure 2.219: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

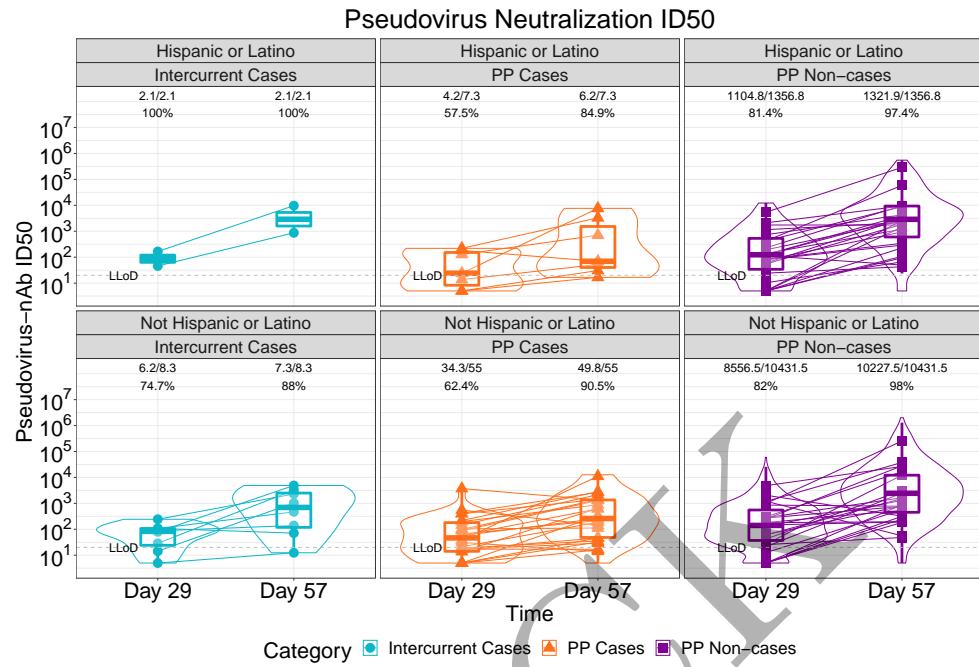


Figure 2.220: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

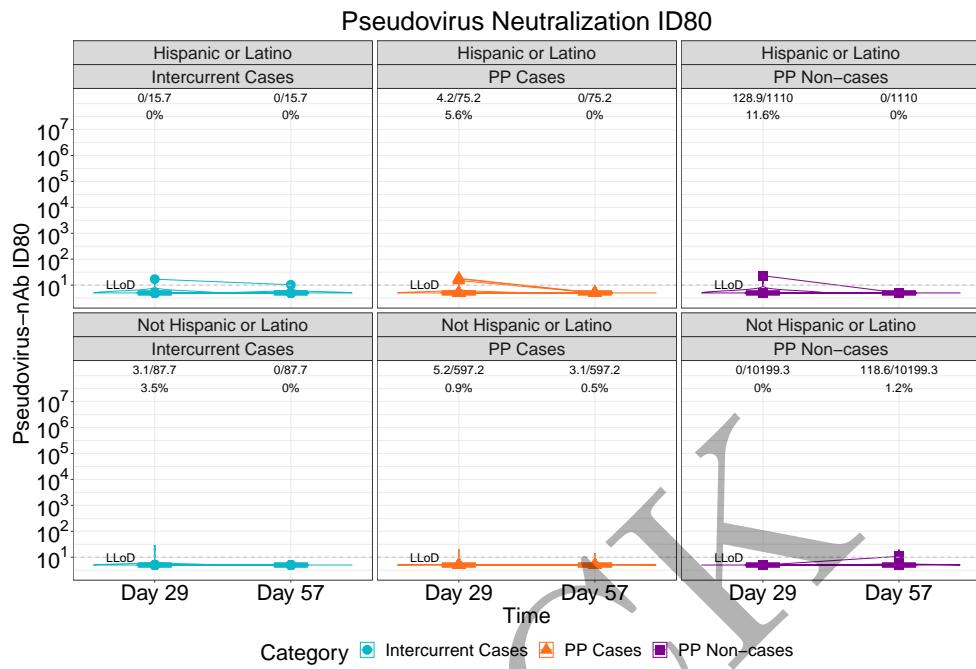


Figure 2.221: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

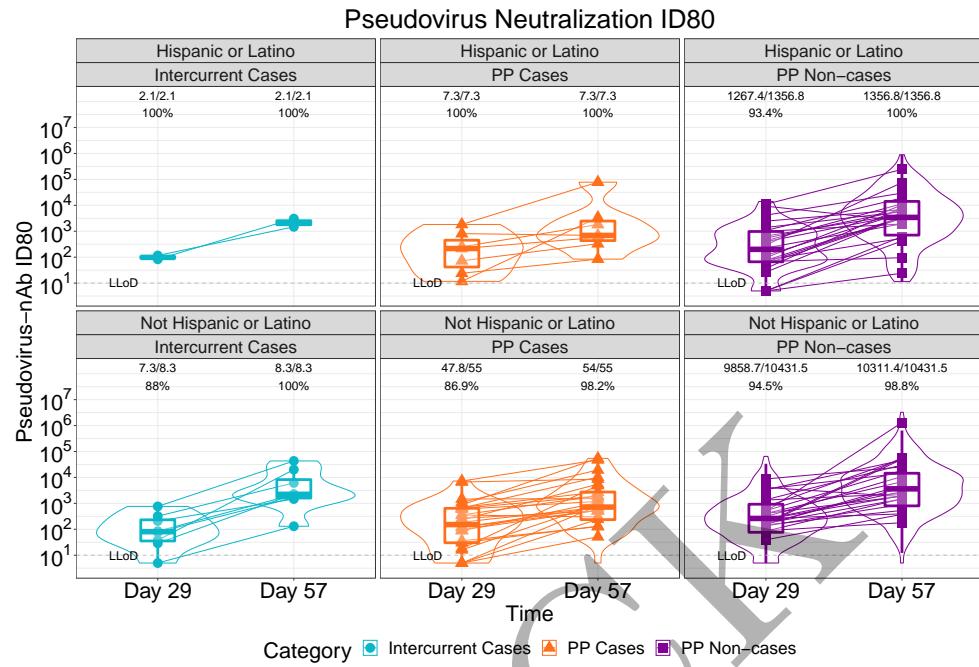


Figure 2.222: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

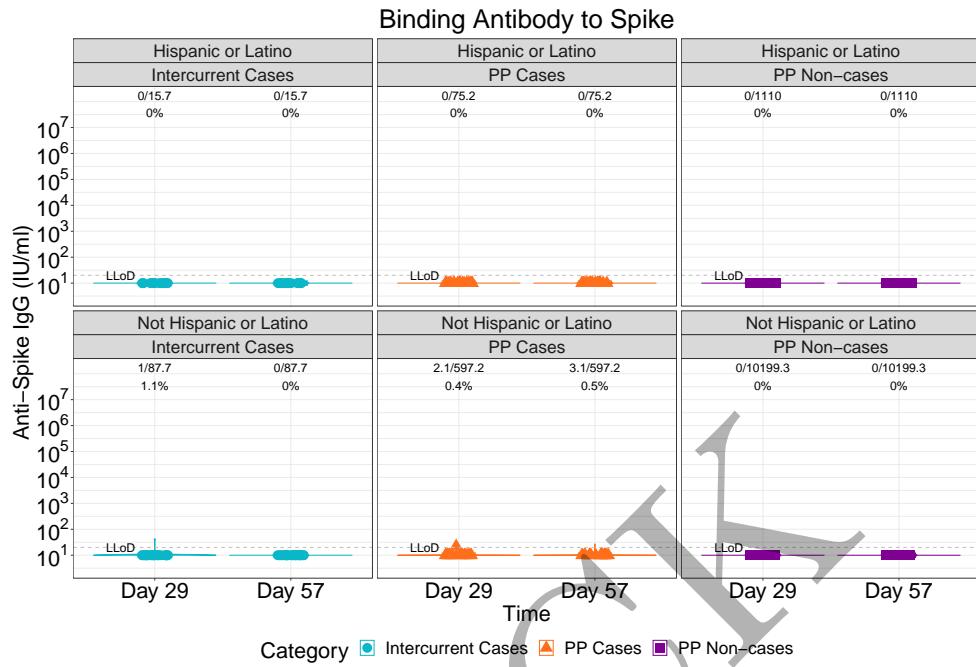


Figure 2.223: violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

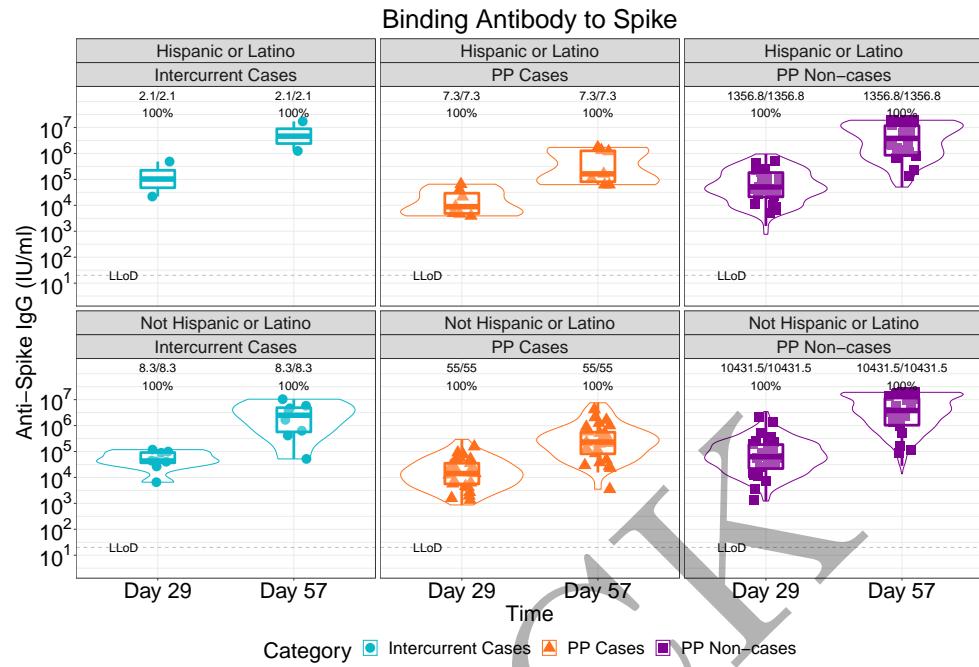


Figure 2.224: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

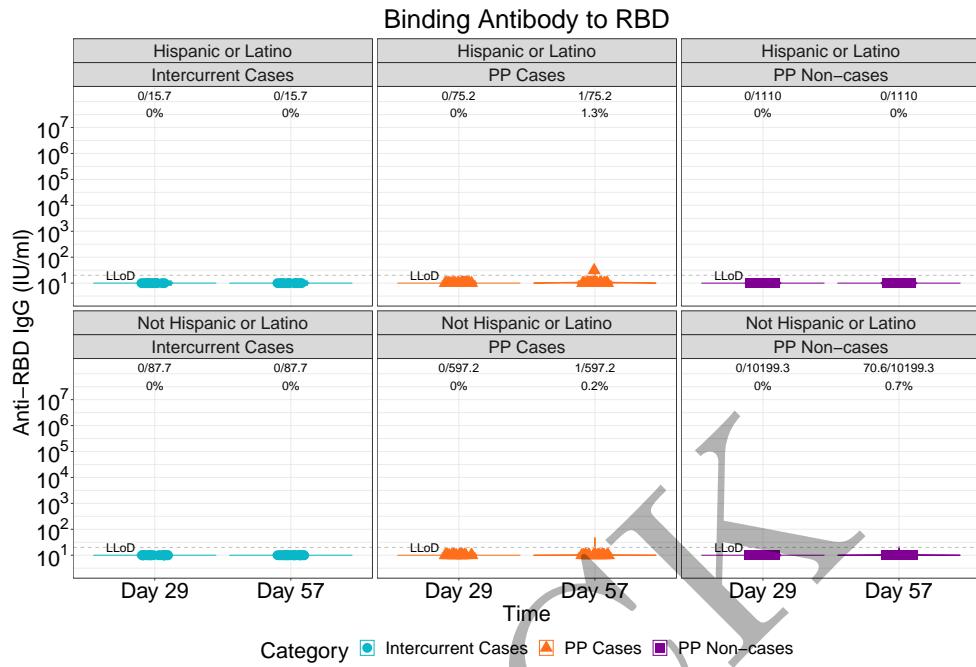


Figure 2.225: violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

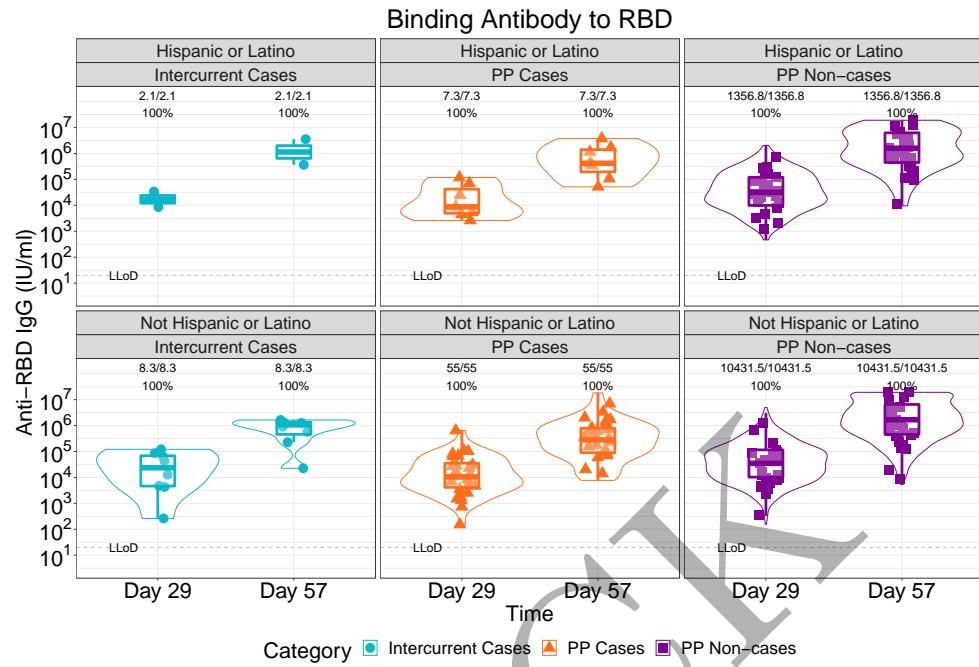


Figure 2.226: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

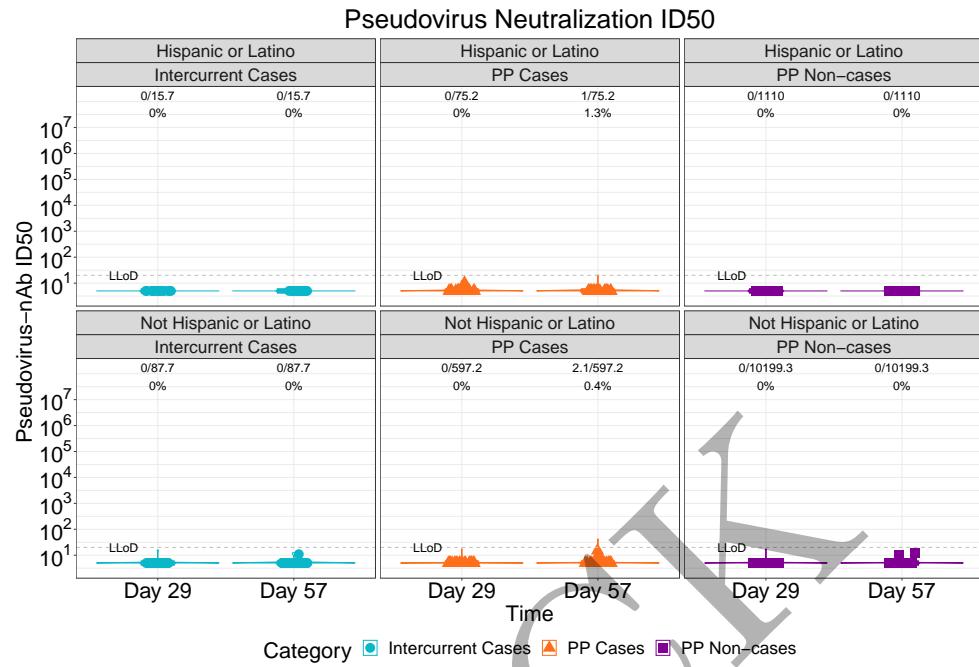


Figure 2.227: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

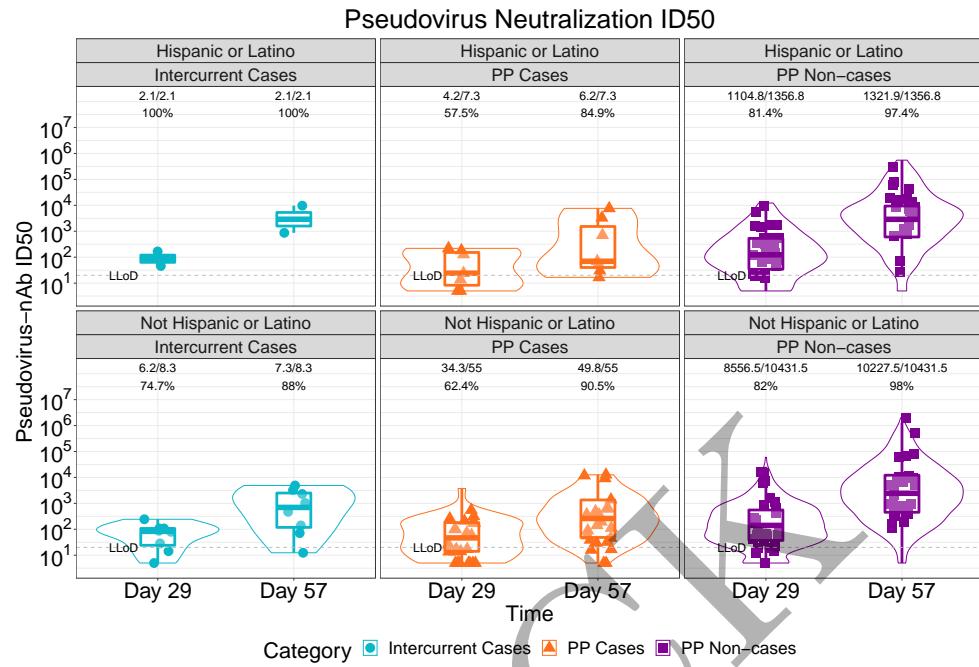


Figure 2.228: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)

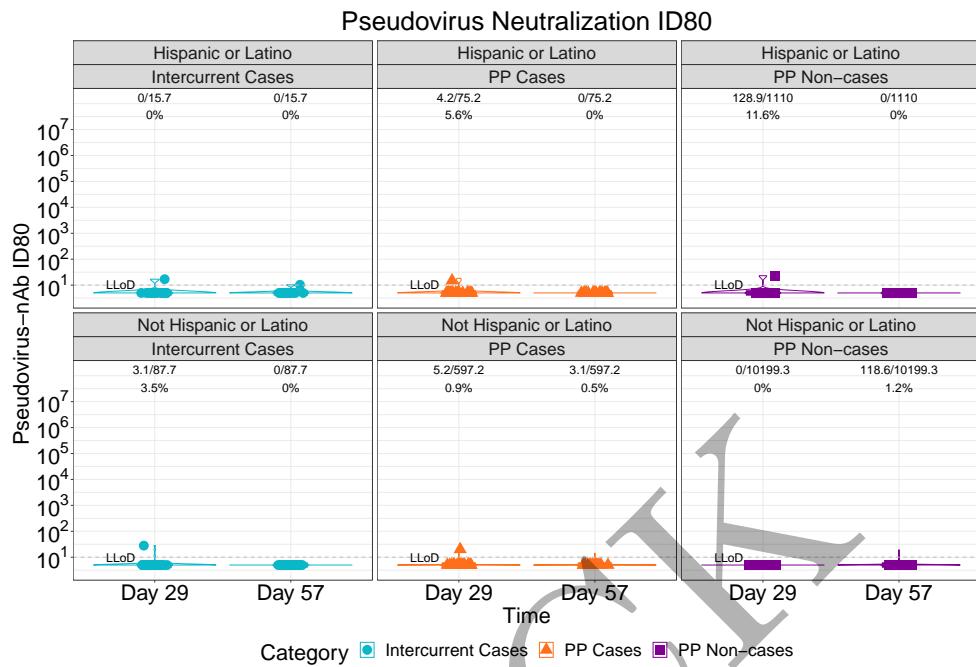


Figure 2.229: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (2 timepoints)

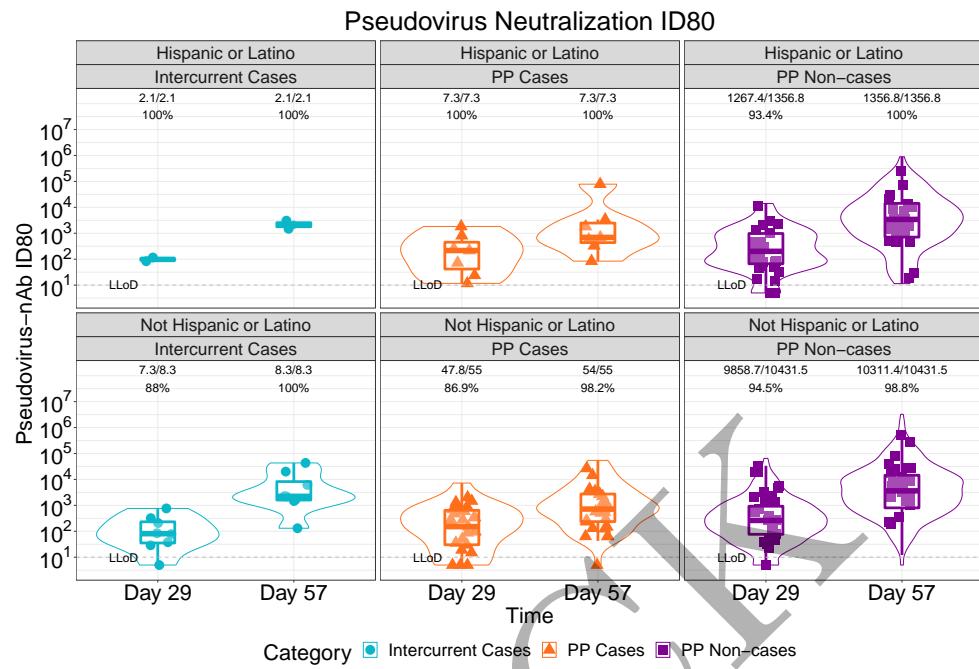


Figure 2.230: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (2 timepoints)



Figure 2.231: lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

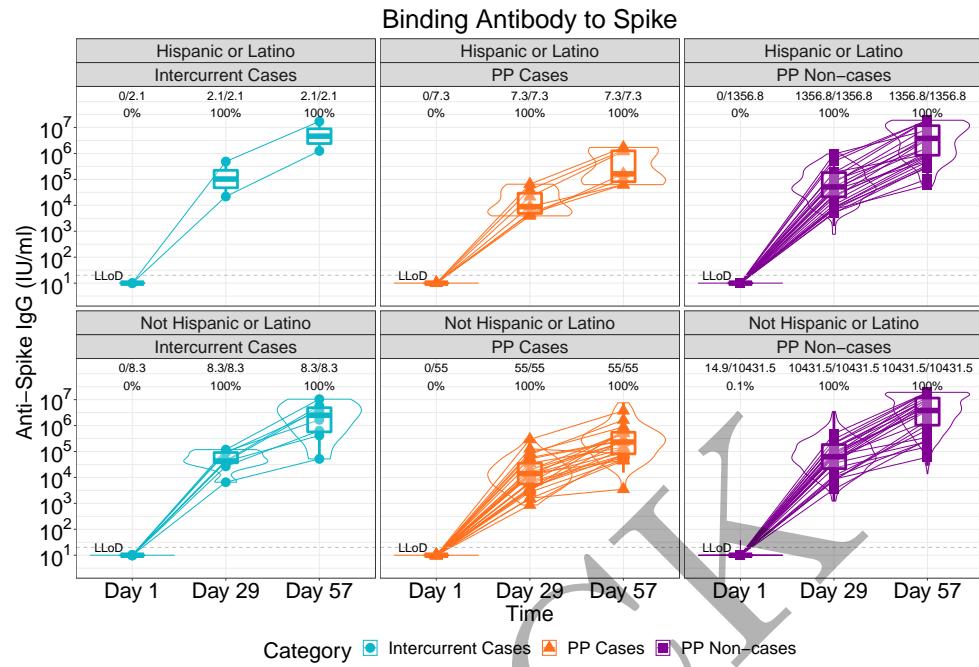


Figure 2.232: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

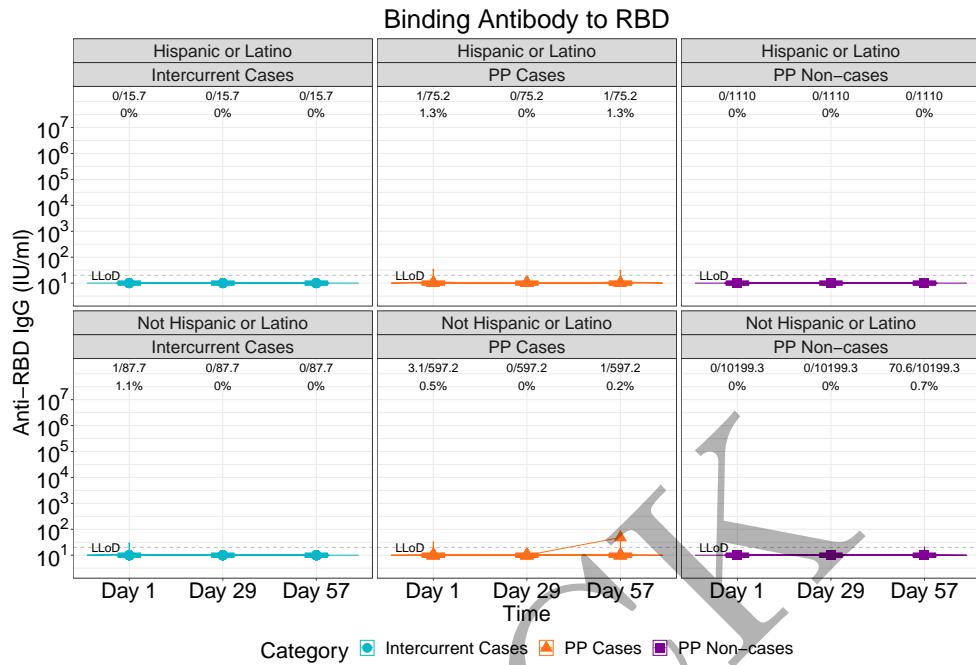


Figure 2.233: lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

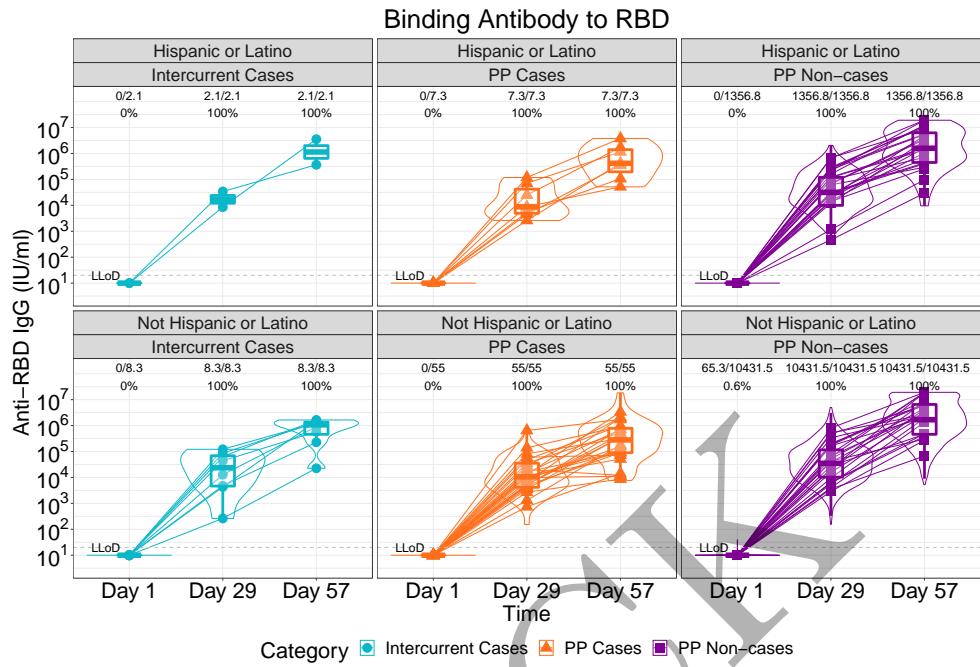


Figure 2.234: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

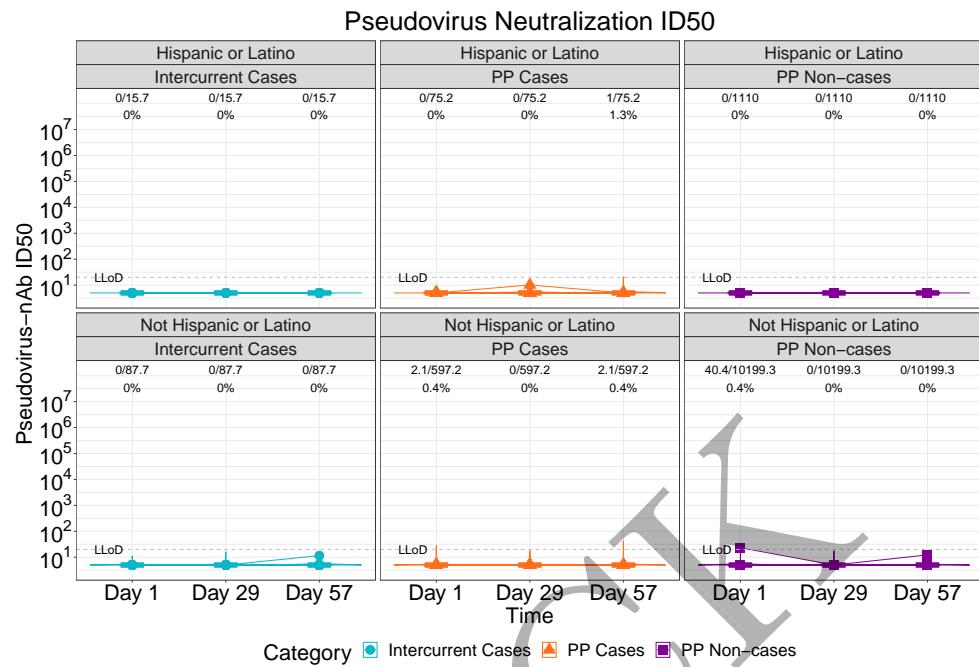


Figure 2.235: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

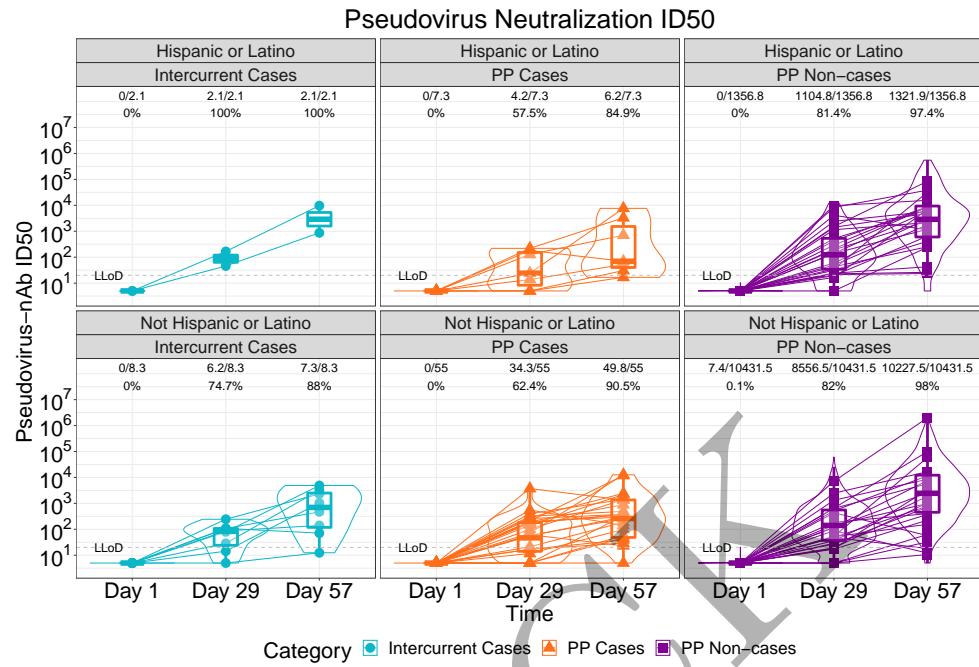


Figure 2.236: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

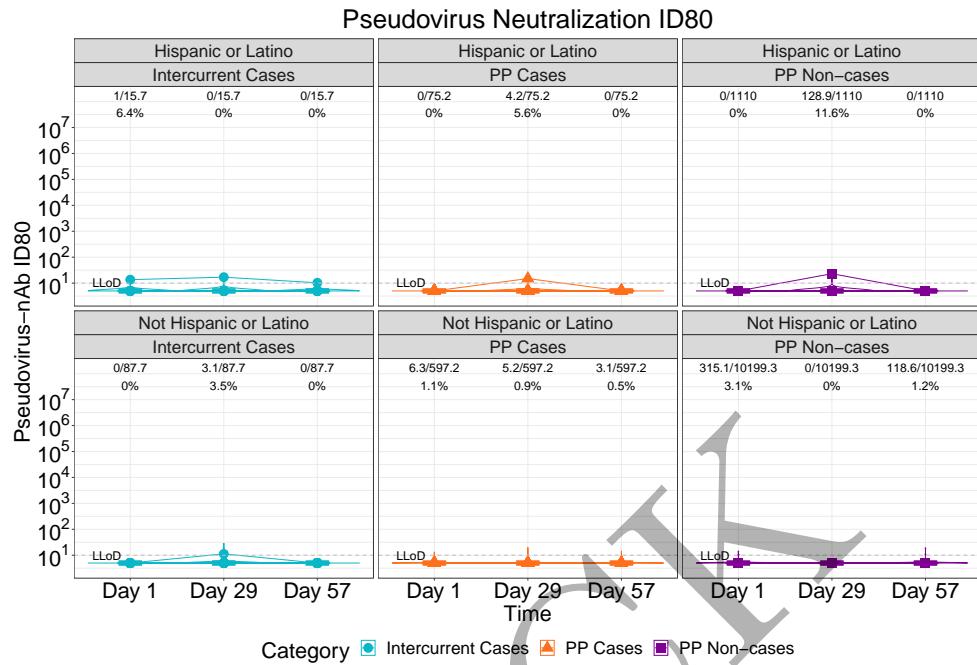


Figure 2.237: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

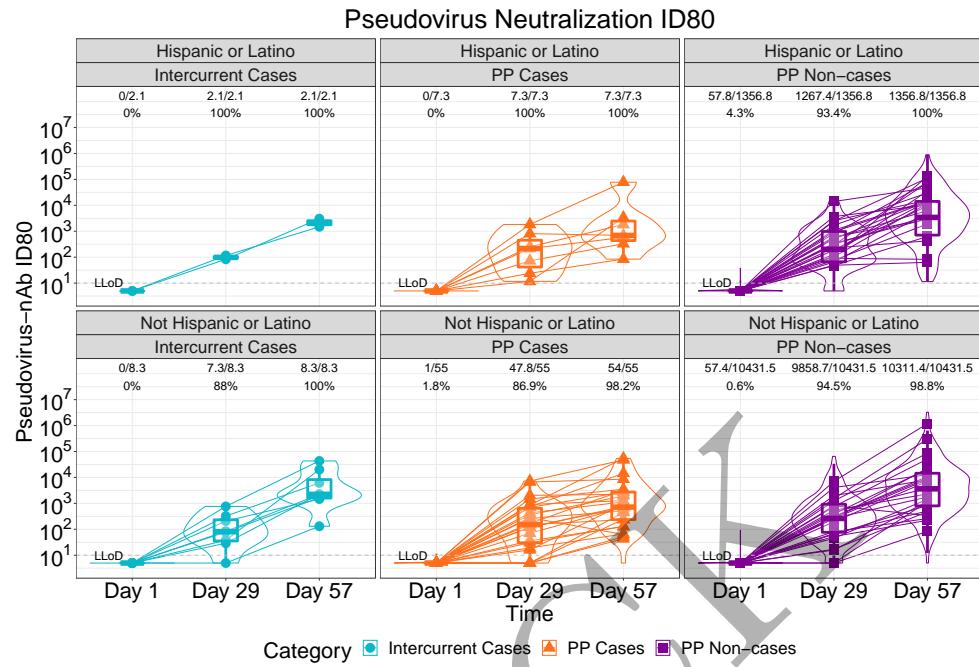


Figure 2.238: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

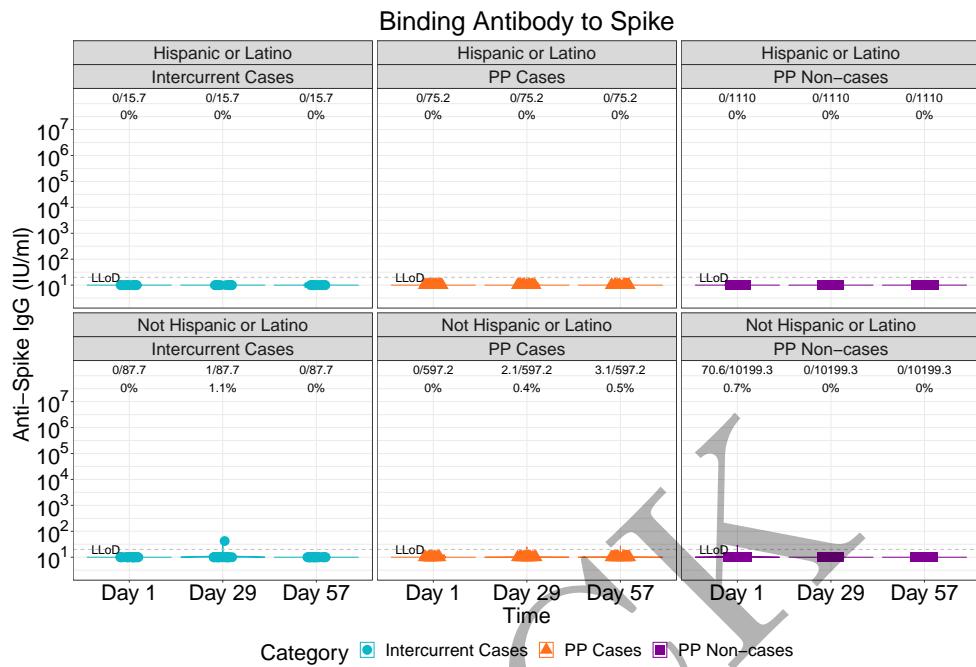


Figure 2.239: violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

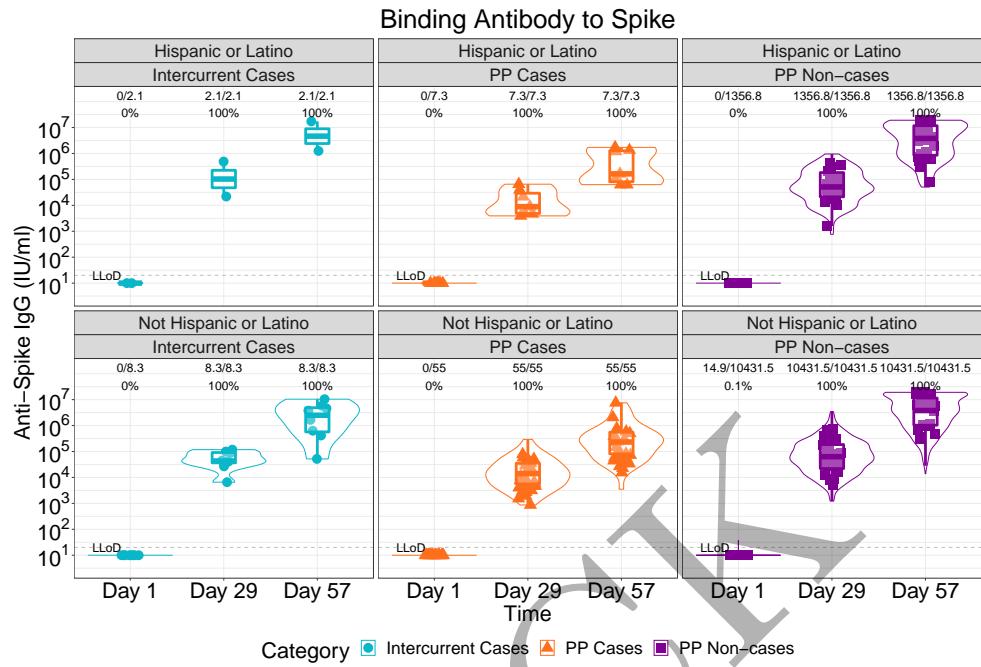


Figure 2.240: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

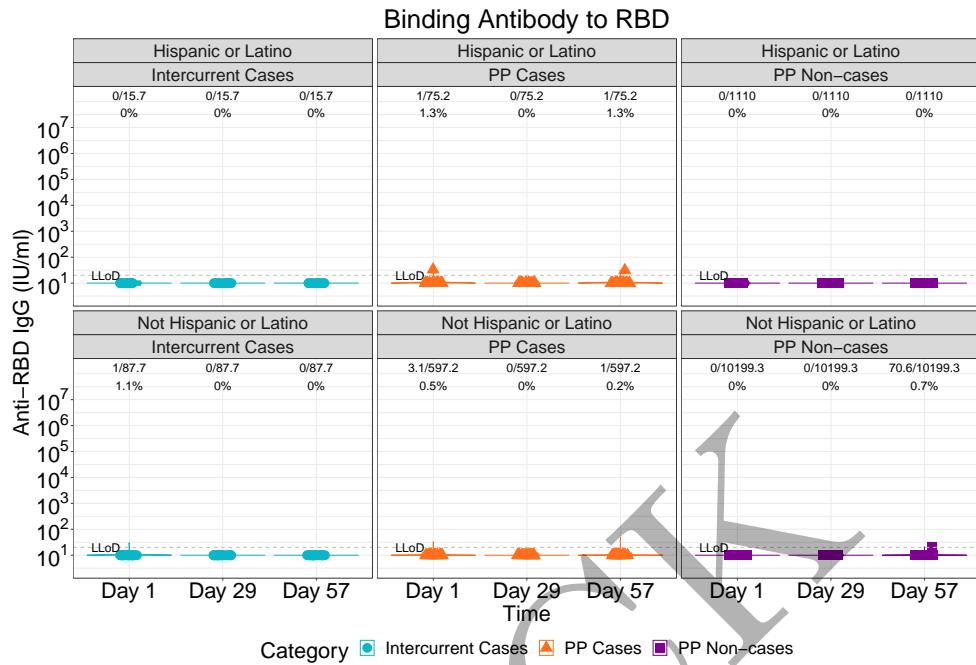


Figure 2.241: violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

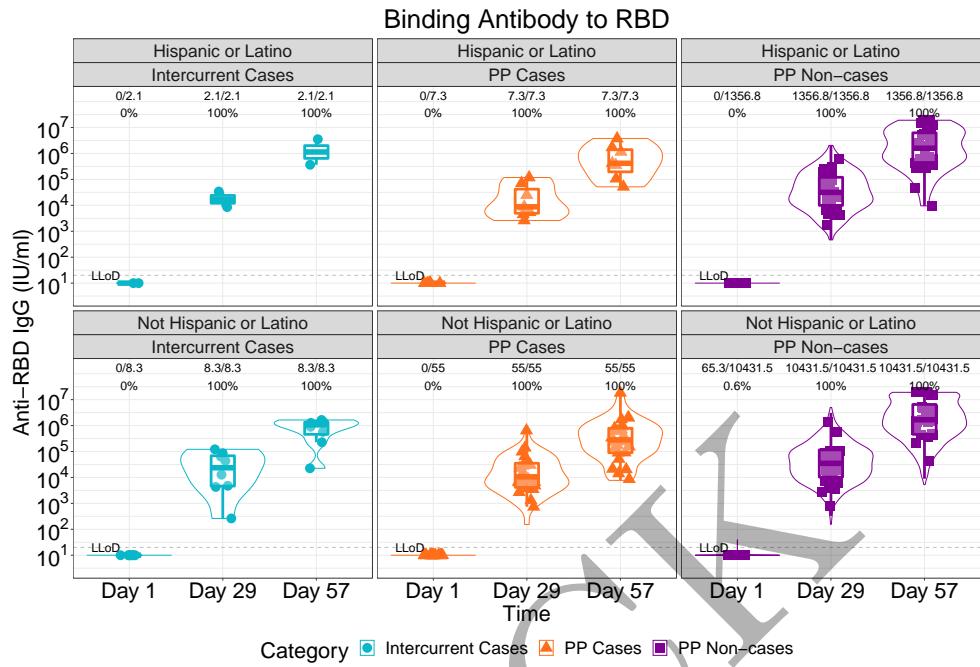


Figure 2.242: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

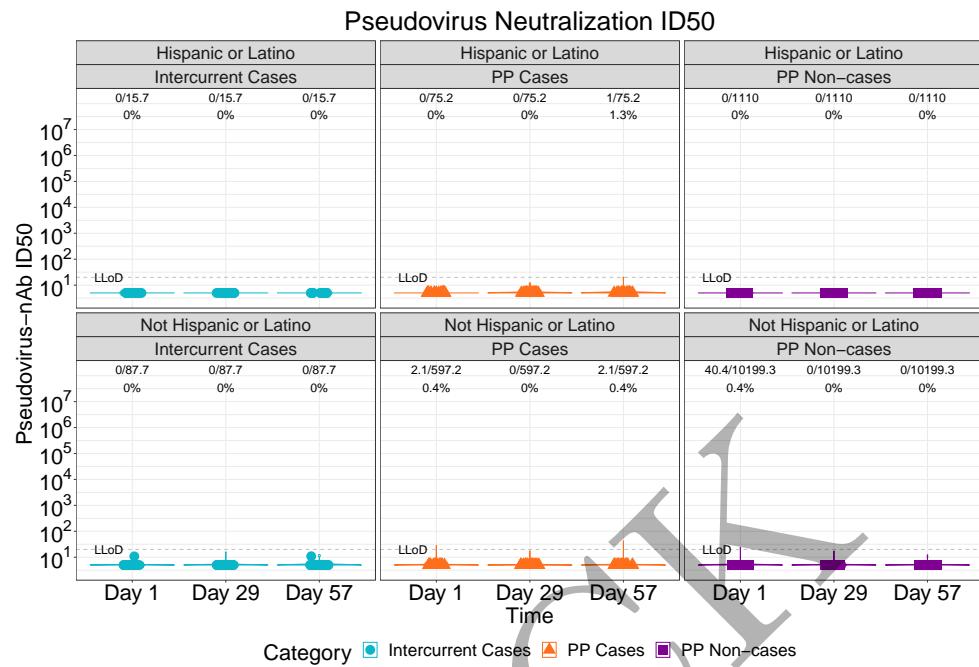


Figure 2.243: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

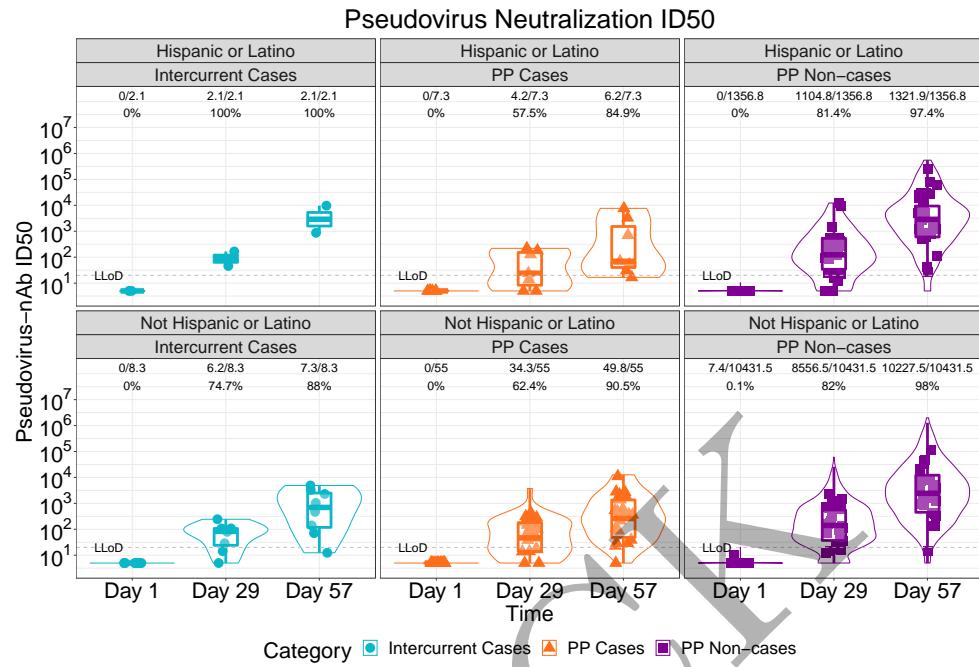


Figure 2.244: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

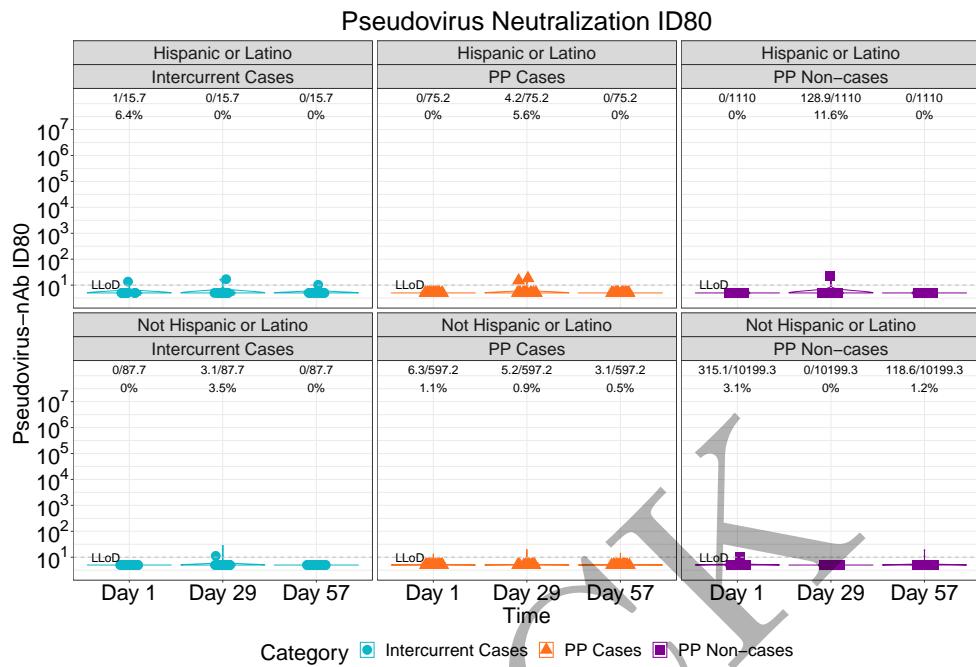


Figure 2.245: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (3 timepoints)

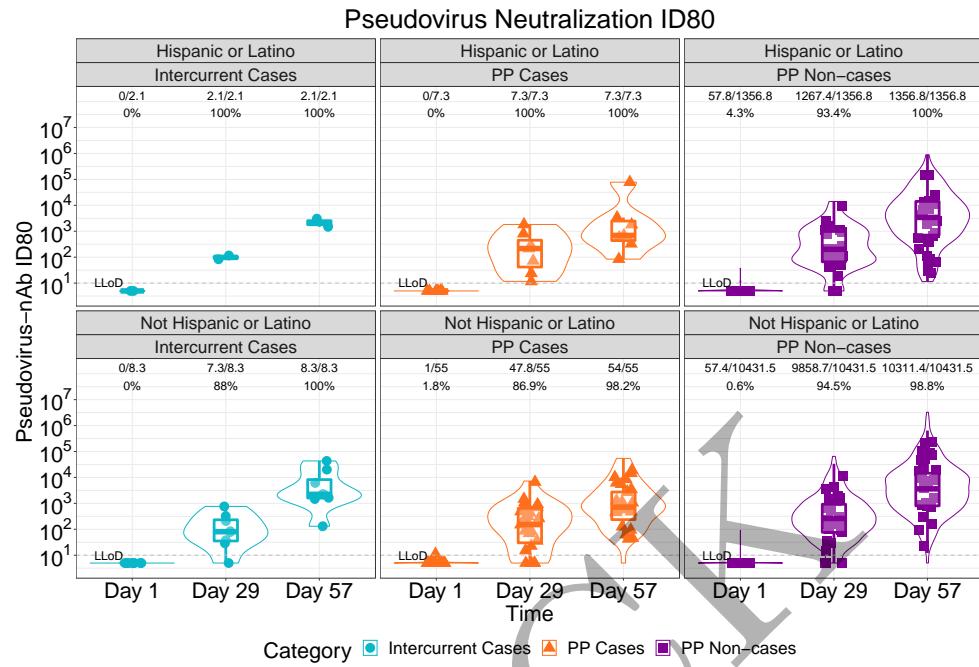


Figure 2.246: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (3 timepoints)

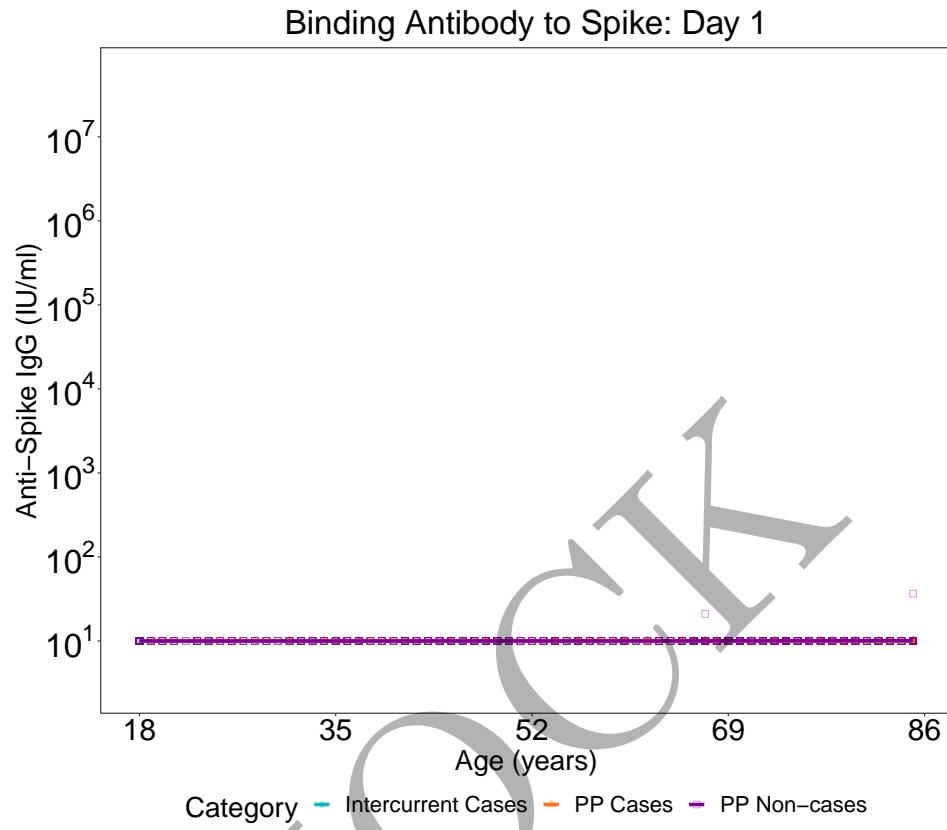


Figure 2.247: scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 1



Figure 2.248: scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 29

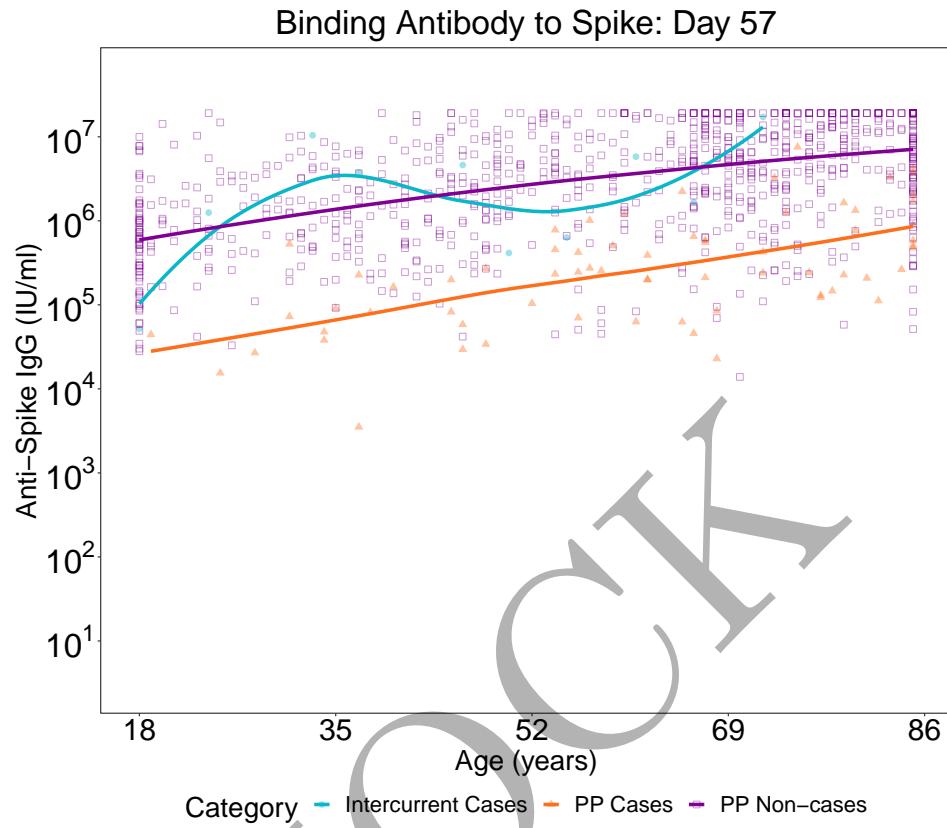


Figure 2.249: scatterplots of Binding Antibody to Spike: baseline negative vaccine arm at day 57



Figure 2.250: scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 1



Figure 2.251: scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 29

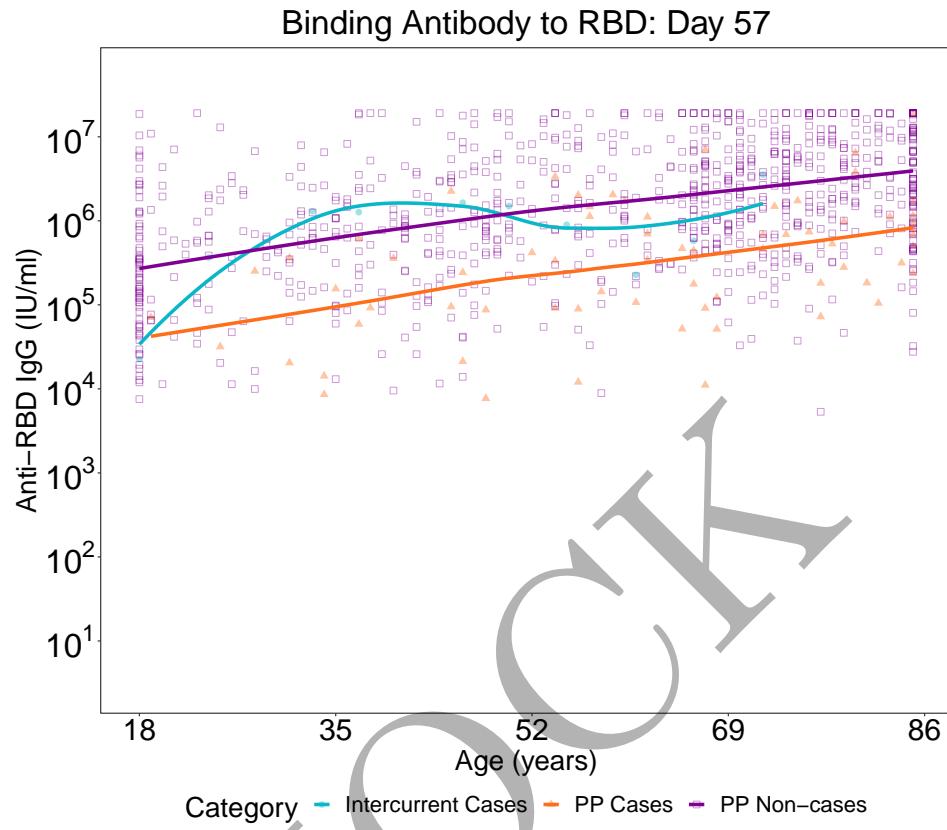


Figure 2.252: scatterplots of Binding Antibody to RBD: baseline negative vaccine arm at day 57

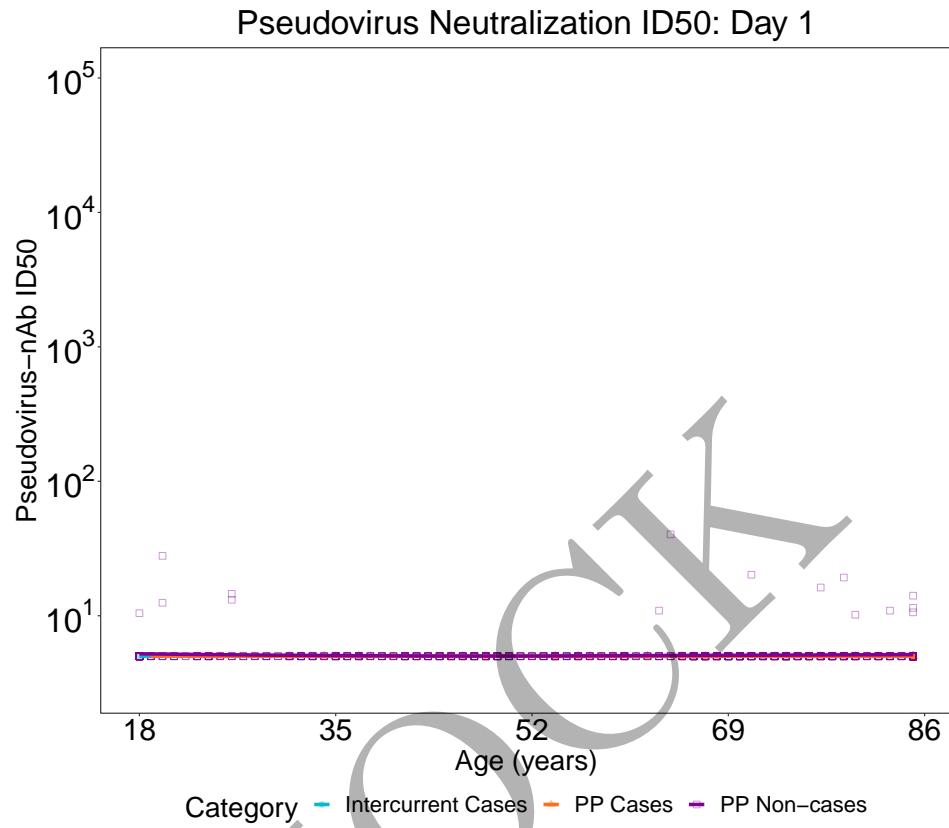


Figure 2.253: scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 1



Figure 2.254: scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 29



Figure 2.255: scatterplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm at day 57



Figure 2.256: scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 1



Figure 2.257: scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 29

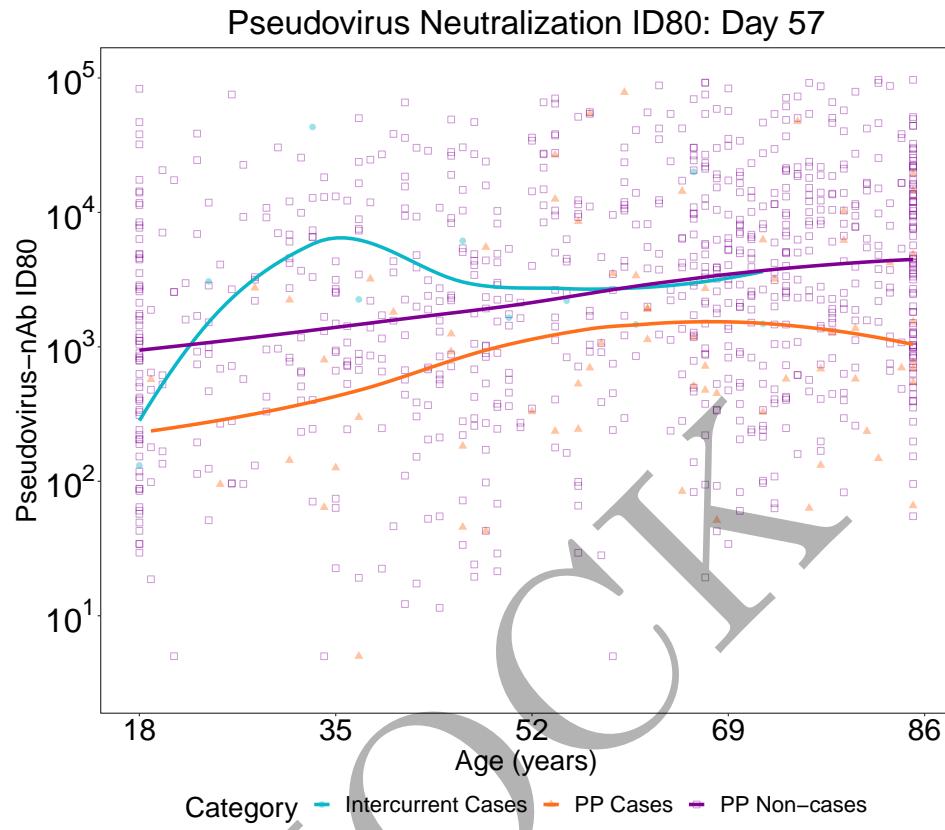


Figure 2.258: scatterplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm at day 57



Figure 2.259: scatterplots of Binding Antibody to Spike: by arm at day 1

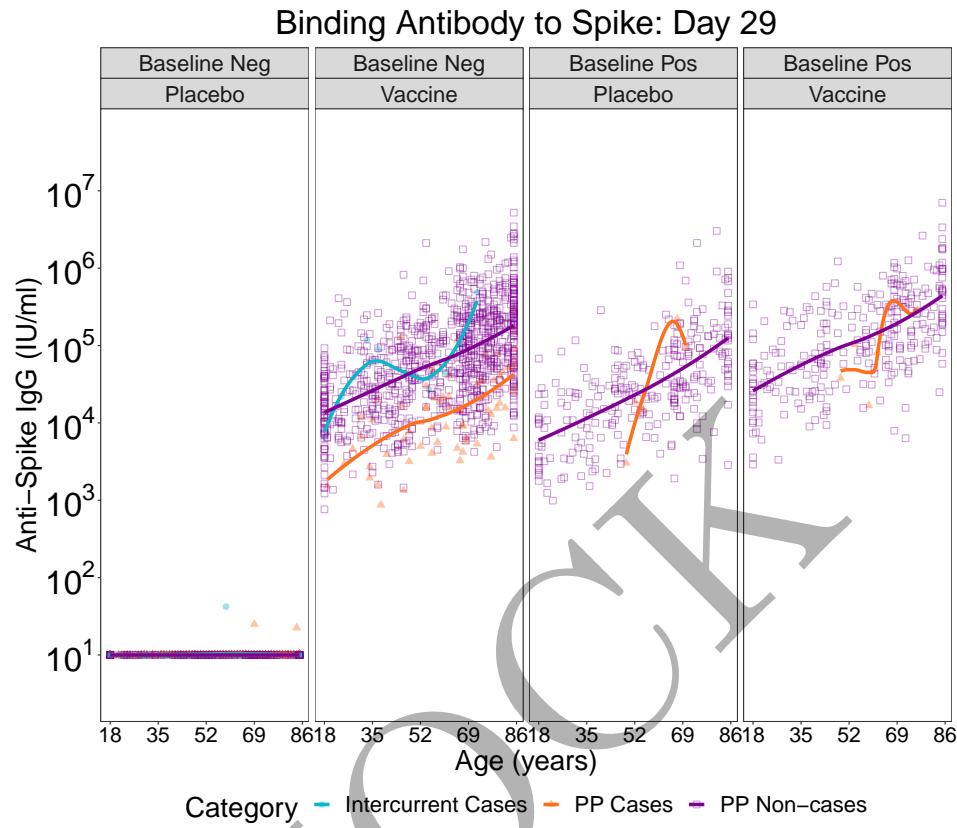


Figure 2.260: scatterplots of Binding Antibody to Spike: by arm at day 29

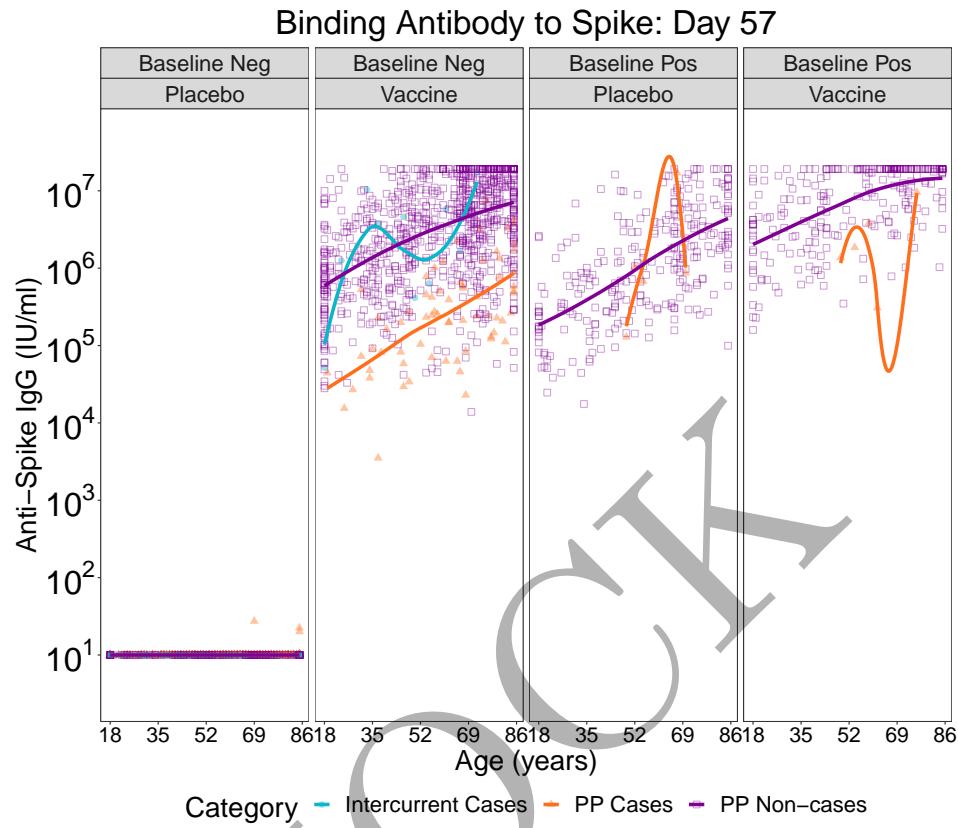


Figure 2.261: scatterplots of Binding Antibody to Spike: by arm at day 57

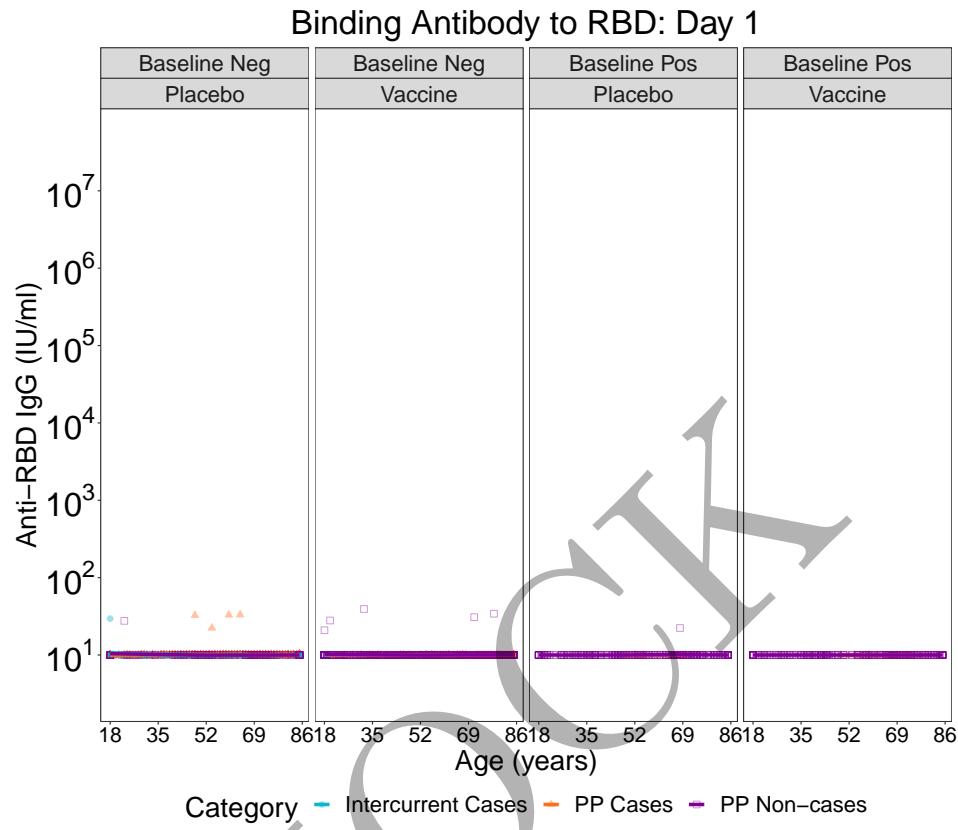


Figure 2.262: scatterplots of Binding Antibody to RBD: by arm at day 1



Figure 2.263: scatterplots of Binding Antibody to RBD: by arm at day 29

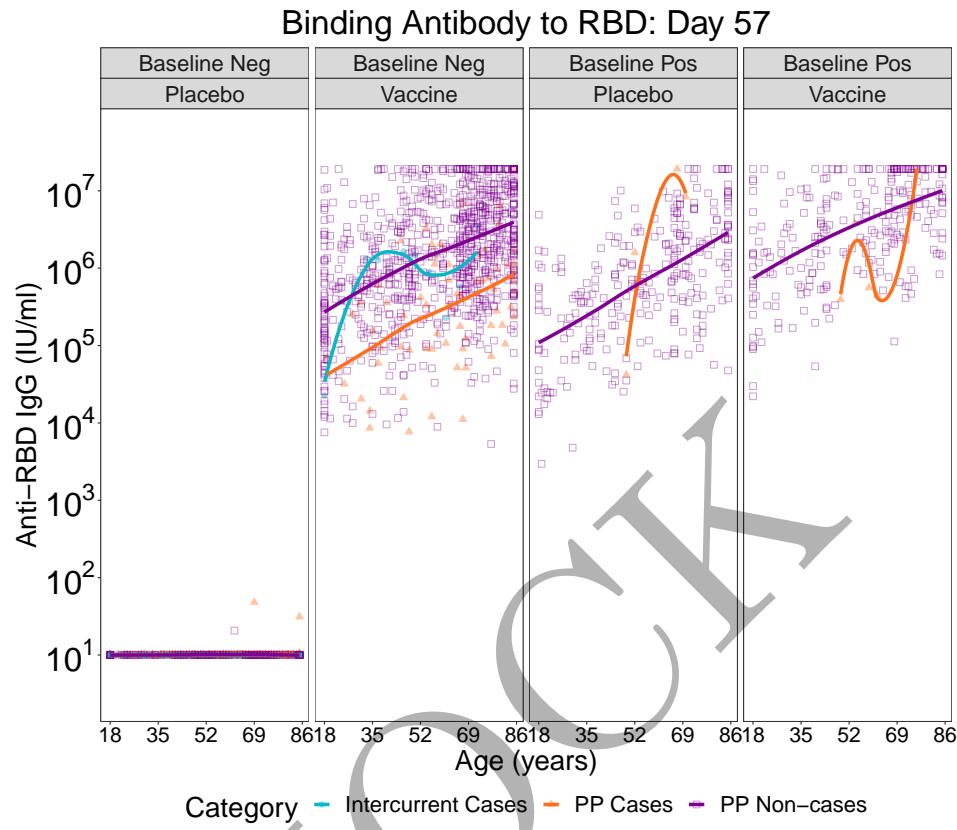


Figure 2.264: scatterplots of Binding Antibody to RBD: by arm at day 57



Figure 2.265: scatterplots of Pseudovirus Neutralization ID50: by arm at day 1



Figure 2.266: scatterplots of Pseudovirus Neutralization ID50: by arm at day 29

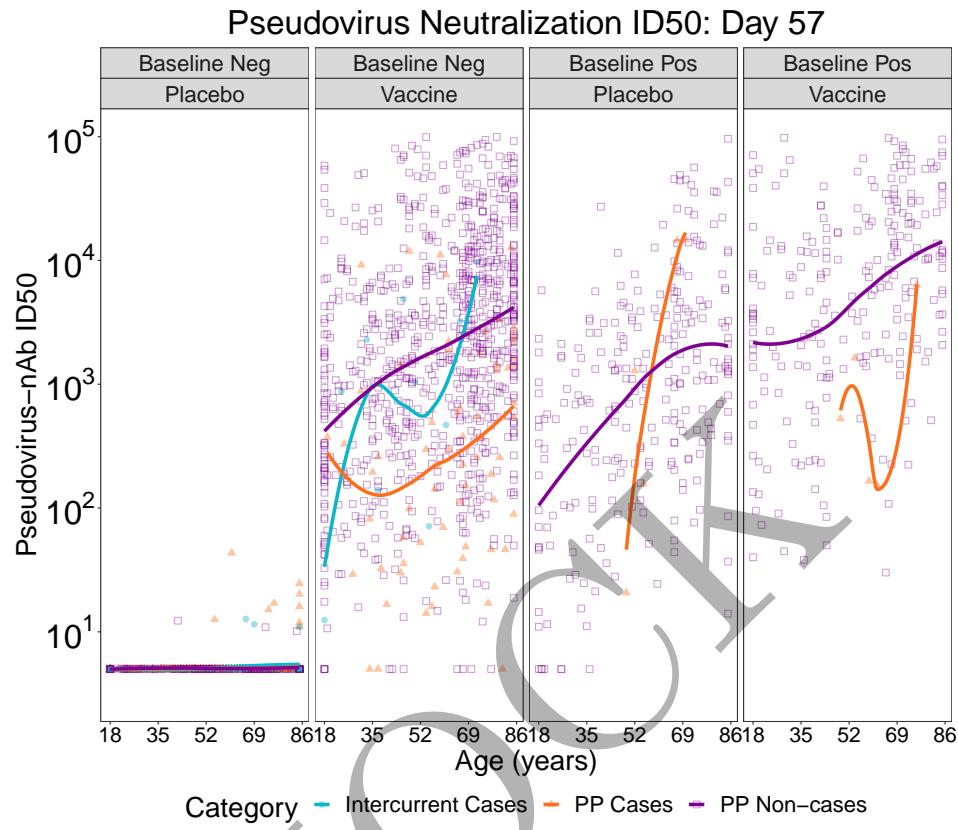


Figure 2.267: scatterplots of Pseudovirus Neutralization ID50: by arm at day 57

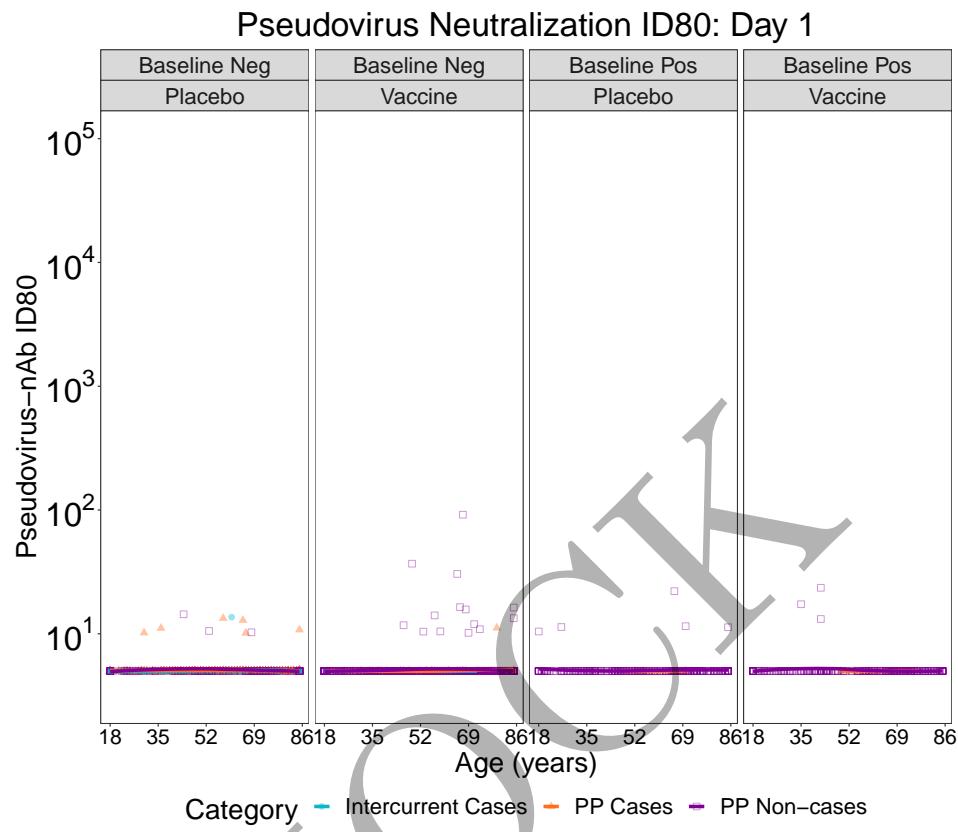


Figure 2.268: scatterplots of Pseudovirus Neutralization ID80: by arm at day 1

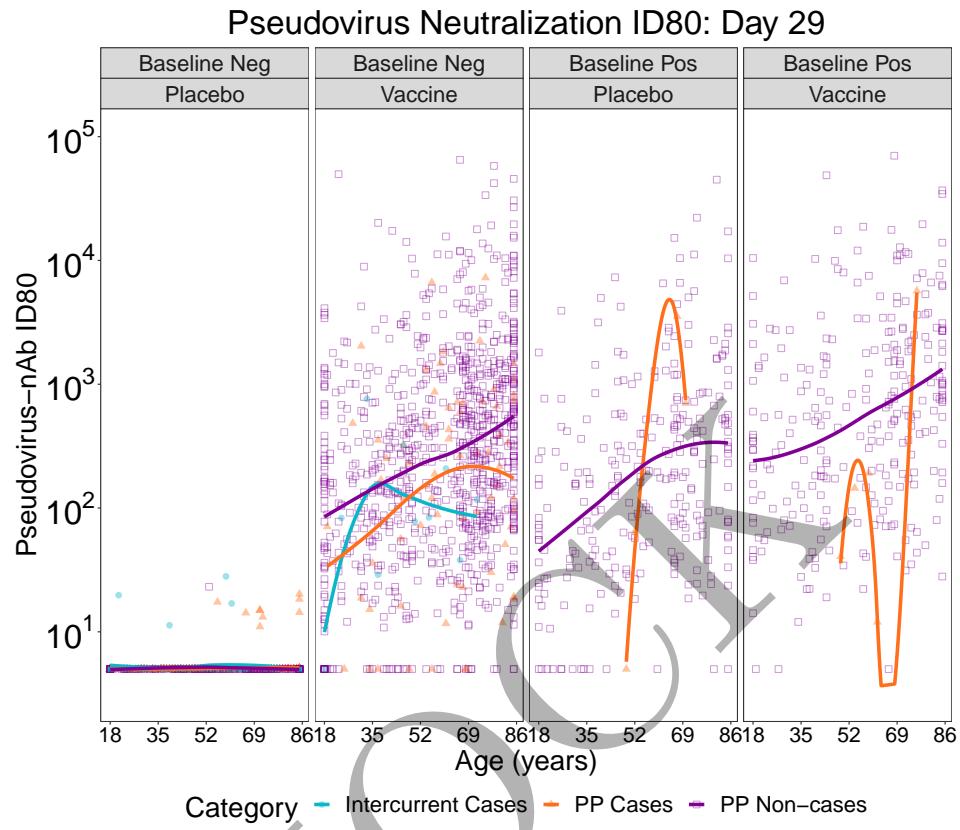


Figure 2.269: scatterplots of Pseudovirus Neutralization ID80: by arm at day 29



Figure 2.270: scatterplots of Pseudovirus Neutralization ID80: by arm at day 57

MOCK

Chapter 3

Day 57 Univariate CoR: Cox Models of Risk

The main regression model is the Cox proportional hazards model. All plots are made with Cox models fit unless specified otherwise.

3.1 Hazard ratios

Inference for Day 57 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group:
Hazard ratios per 10-fold increment in the marker*

Mock Immunologic Marker	No. cases / No. at-risk**	HR per 10-fold incr. Pt. Est.	95% CI	P-value (2-sided)	q-value	FWER
Anti Spike IgG (IU/ml)	70/13,295	0.09	(0.06-0.15)	<0.001	<0.001	<0.001
Anti RBD IgG (IU/ml)	70/13,295	0.27	(0.19-0.37)	<0.001	<0.001	<0.001
Pseudovirus-nAb ID50	70/13,295	0.30	(0.23-0.40)	<0.001	<0.001	<0.001
Pseudovirus-nAb ID80	70/13,295	0.49	(0.37-0.64)	<0.001	<0.001	<0.001

*Baseline covariates adjusted for: baseline risk score, at risk or not, community of color or not. Average follow-up time 172 days, maximum follow-up time 185 days.

**No. at-risk = number of per-protocol baseline negative vaccine recipients at-risk for COVID; no. cases = number of this cohort with an observed COVID endpoints starting 7 days post Day 57 visit.

Inference for Day 57 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group:
Hazard ratios for Middle vs. Upper tertile vs. Lower tertile*

Mock Immunologic Marker	Tertile	No. cases / No. at-risk**	Attack rate	Haz. Ratio Pt. Est.	95% CI	P-value (2-sided)	Overall P- value***	Overall q- value	Overall FWER
Anti Spike IgG (IU/ml)	Lower	58/4,434	0.0131	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	11/4,436	0.0025	0.10	(0.05-0.19)	<0.001			
	Upper	1/4,424	0.0002	0.00	(0.00-0.03)	<0.001			
Anti RBD IgG (IU/ml)	Lower	38/4,459	0.0085	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	27/4,397	0.0061	0.40	(0.23-0.70)	0.001			
	Upper	5/4,439	0.0011	0.05	(0.02-0.12)	<0.001			
Pseudovirus-nAb ID50	Lower	45/4,457	0.0101	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	21/4,364	0.0048	0.31	(0.17-0.56)	<0.001			
	Upper	5/4,475	0.0011	0.05	(0.02-0.12)	<0.001			
Pseudovirus-nAb ID80	Lower	35/4,443	0.0079	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	25/4,419	0.0057	0.47	(0.26-0.83)	0.010			
	Upper	10/4,433	0.0023	0.15	(0.07-0.33)	<0.001			
Placebo		719/13,359	0.0538						

*Baseline covariates adjusted for: baseline risk score, at risk or not, community of color or not. Average follow-up time 172 days, maximum follow-up time 185 days. Cutpoints: Anti Spike IgG (IU/ml) [6.03, 6.67), Anti RBD IgG (IU/ml) [5.65, 6.39), Pseudovirus-nAb ID50 [2.74, 3.56), Pseudovirus-nAb ID80 [2.9, 3.83).

**No. at-risk = number of per-protocol baseline negative vaccine recipients at-risk for COVID at 7 days post Day 57 visit; no. cases = number of this cohort with an observed COVID endpoints.

***Generalized Wald-test p-value of the null hypothesis that the hazard rate is constant across the Lower, Middle, and Upper tertile groups.

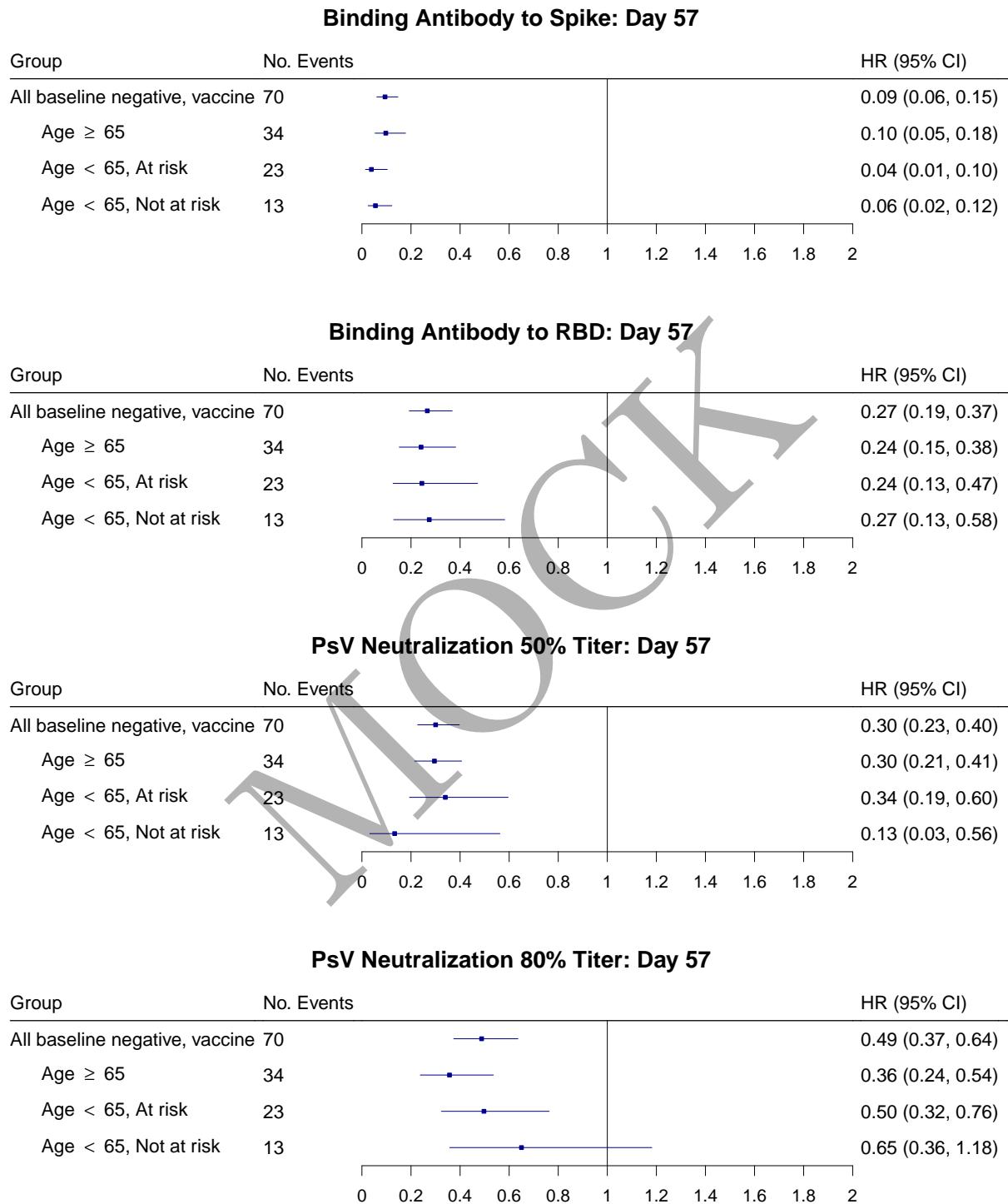


Figure 3.1: Forest plots of hazard ratios per 10-fold increase in the marker among baseline seronegative vaccine recipients and subgroups with 95% point-wise confidence intervals.

Binding Antibody to Spike: Day 57

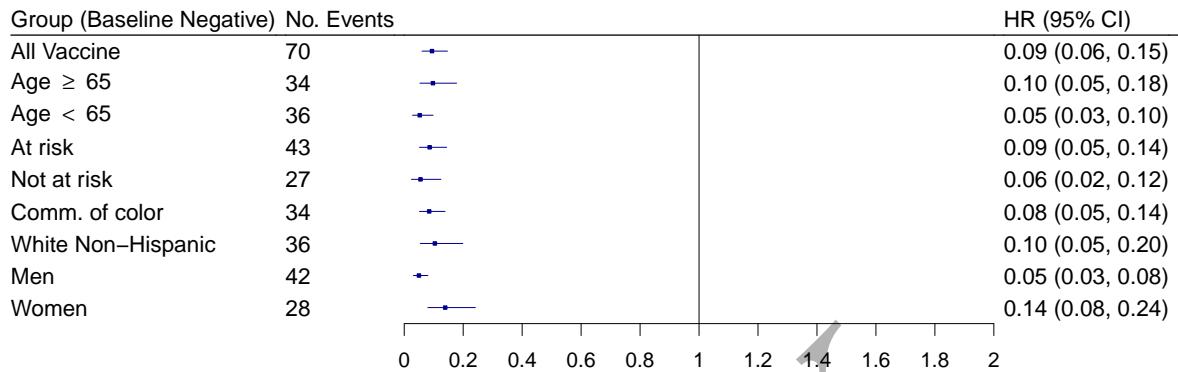


Figure 3.2: Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to spike markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

Binding Antibody to RBD: Day 57

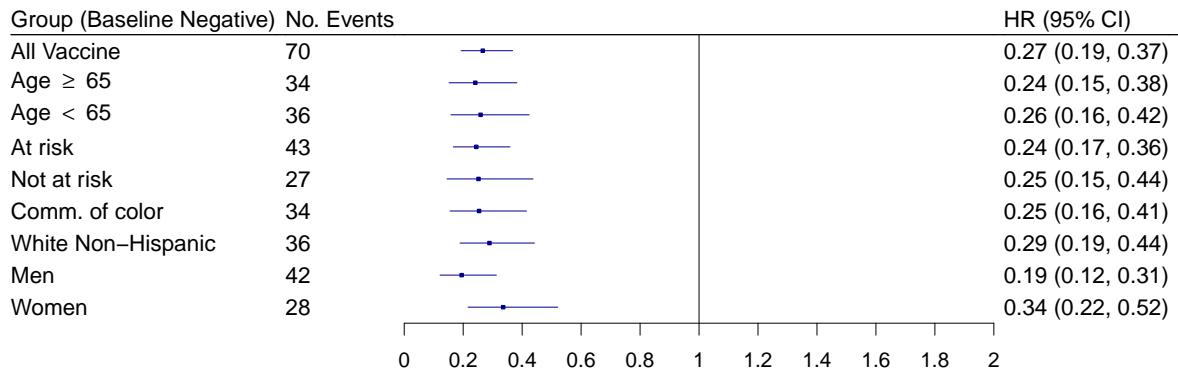


Figure 3.3: Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to RBD markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

PsV Neutralization 50% Titer: Day 57

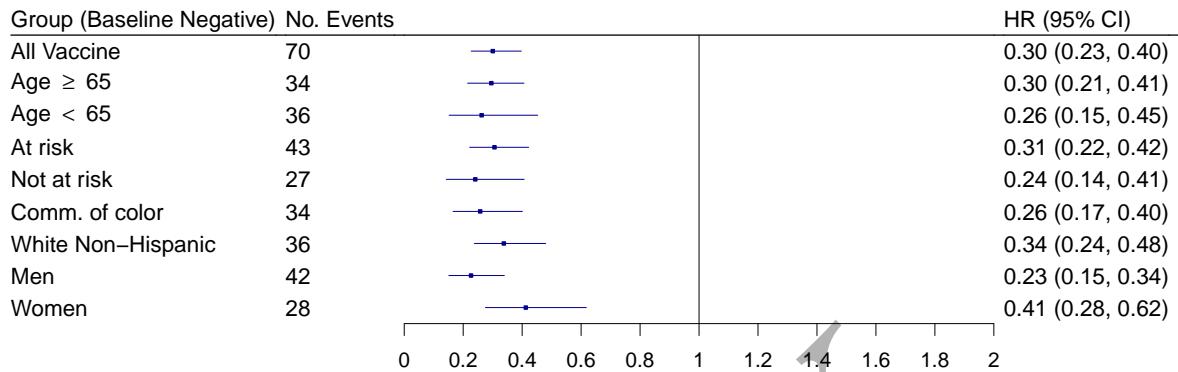


Figure 3.4: Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID50 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

PsV Neutralization 80% Titer: Day 57

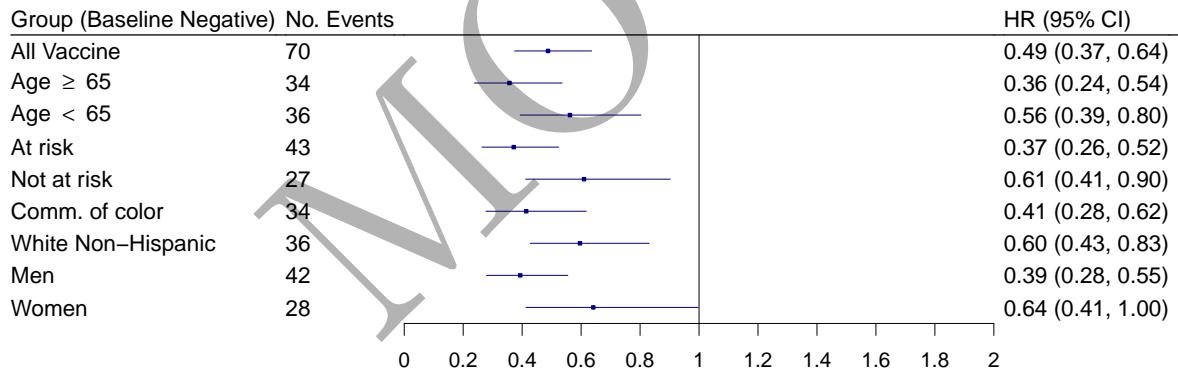


Figure 3.5: Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID80 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

3.2 Marginalized risk and controlled vaccine efficacy plots

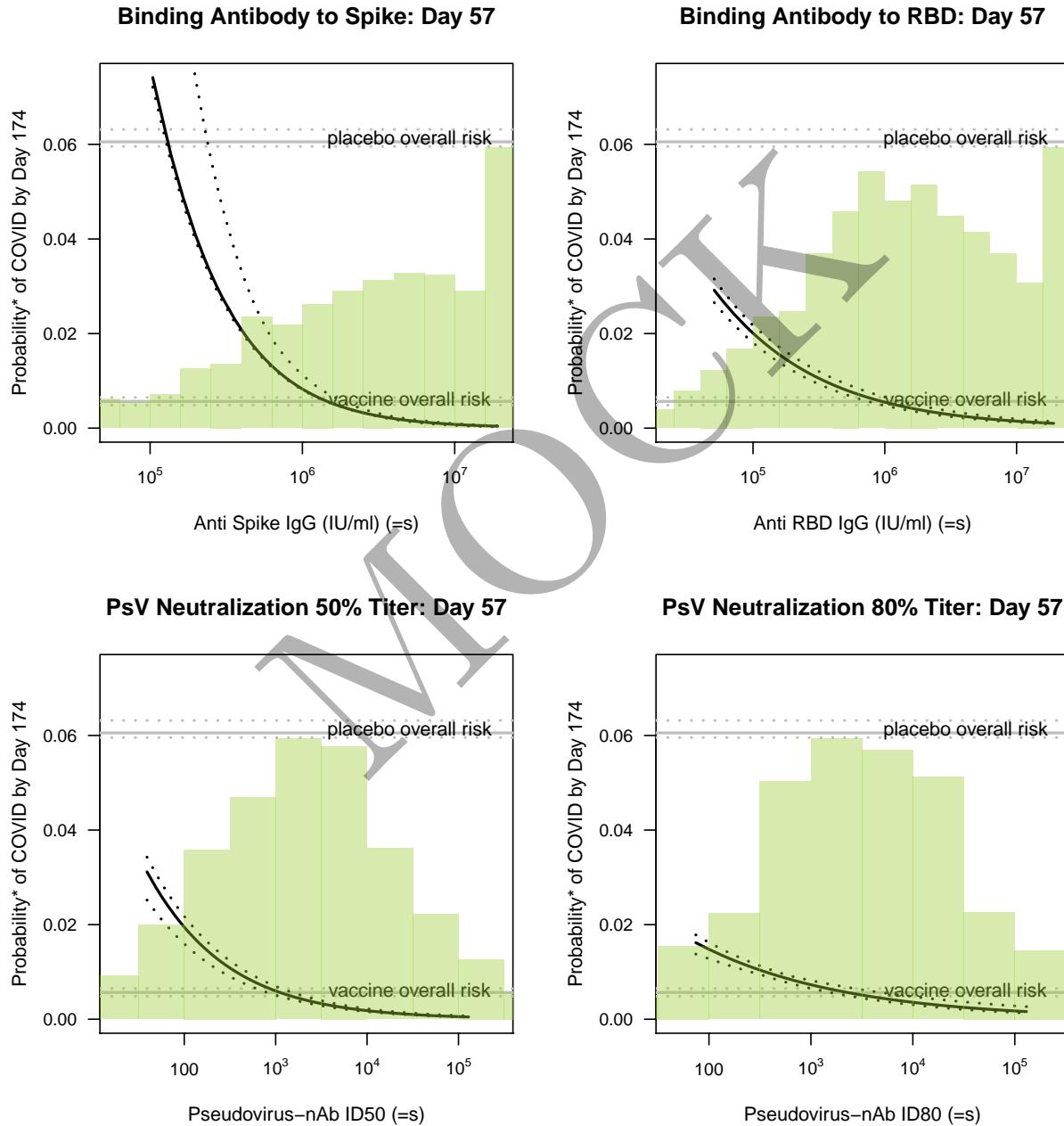


Figure 3.6: Marginalized cumulative risk by Day 174 as functions of Day 57 markers ($=s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 174 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

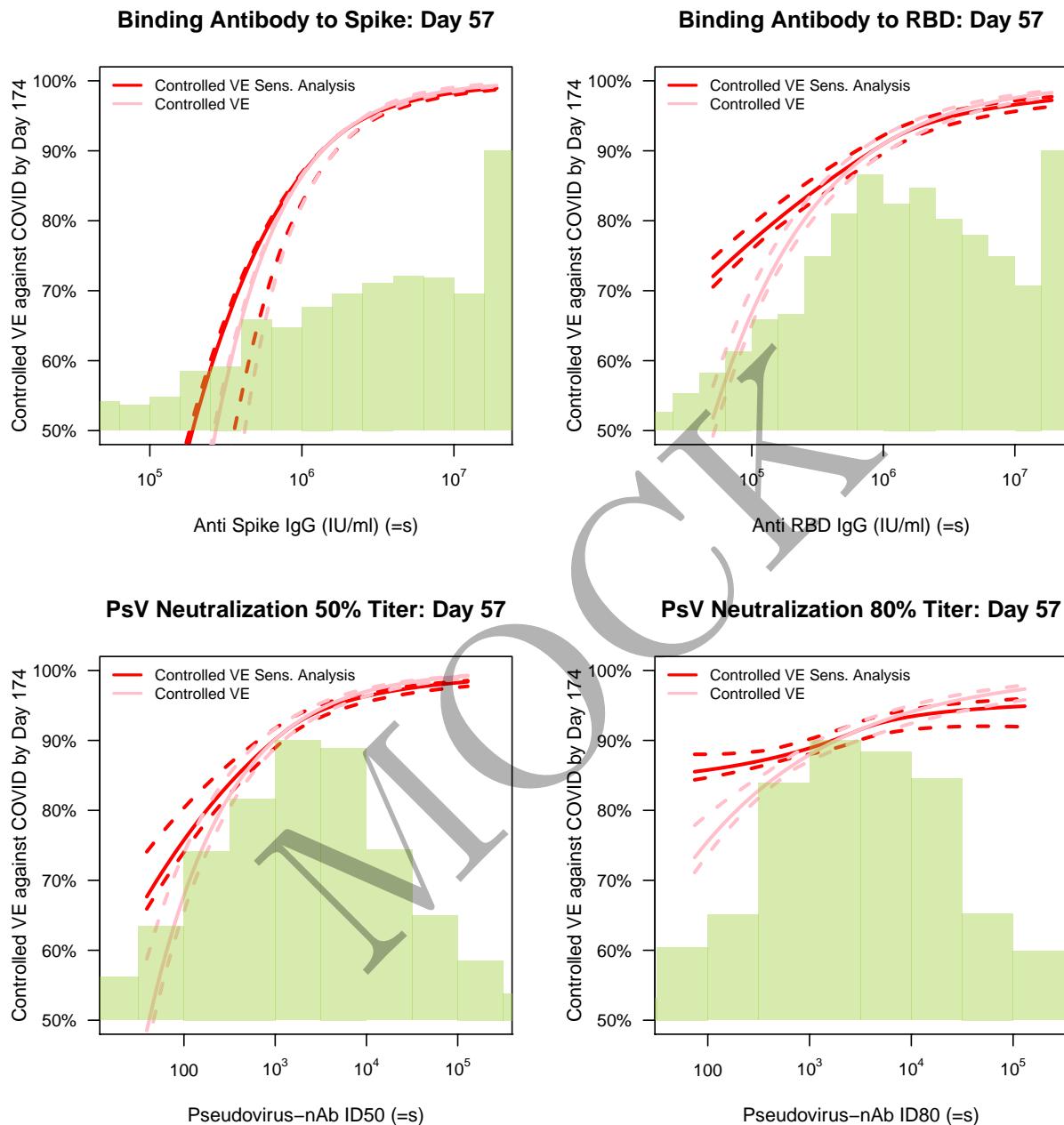


Figure 3.7: Controlled VE with sensitivity analysis as functions of Day 57 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

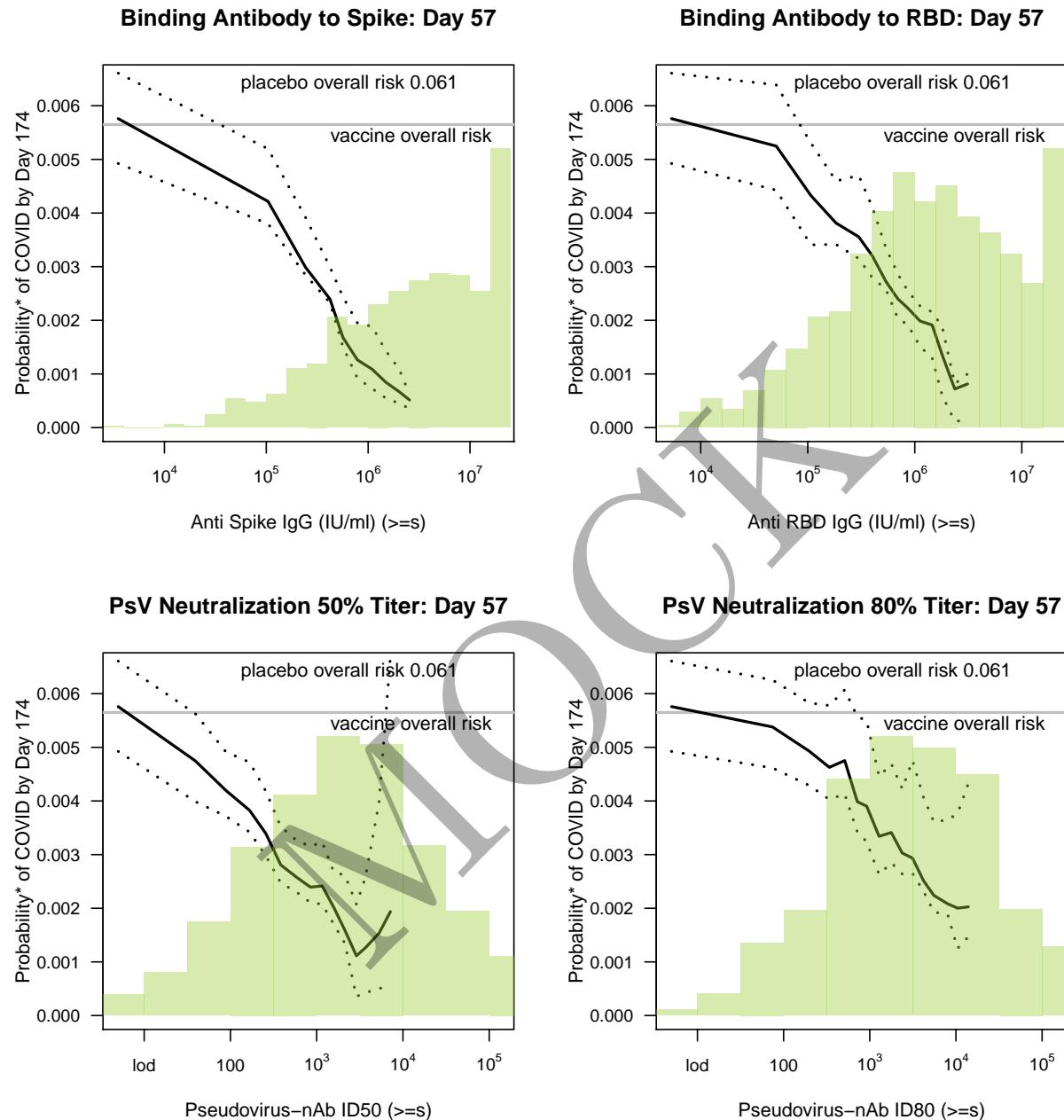


Figure 3.8: Marginalized cumulative risk by Day 174 as functions of Day 57 markers above a threshold ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 174 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

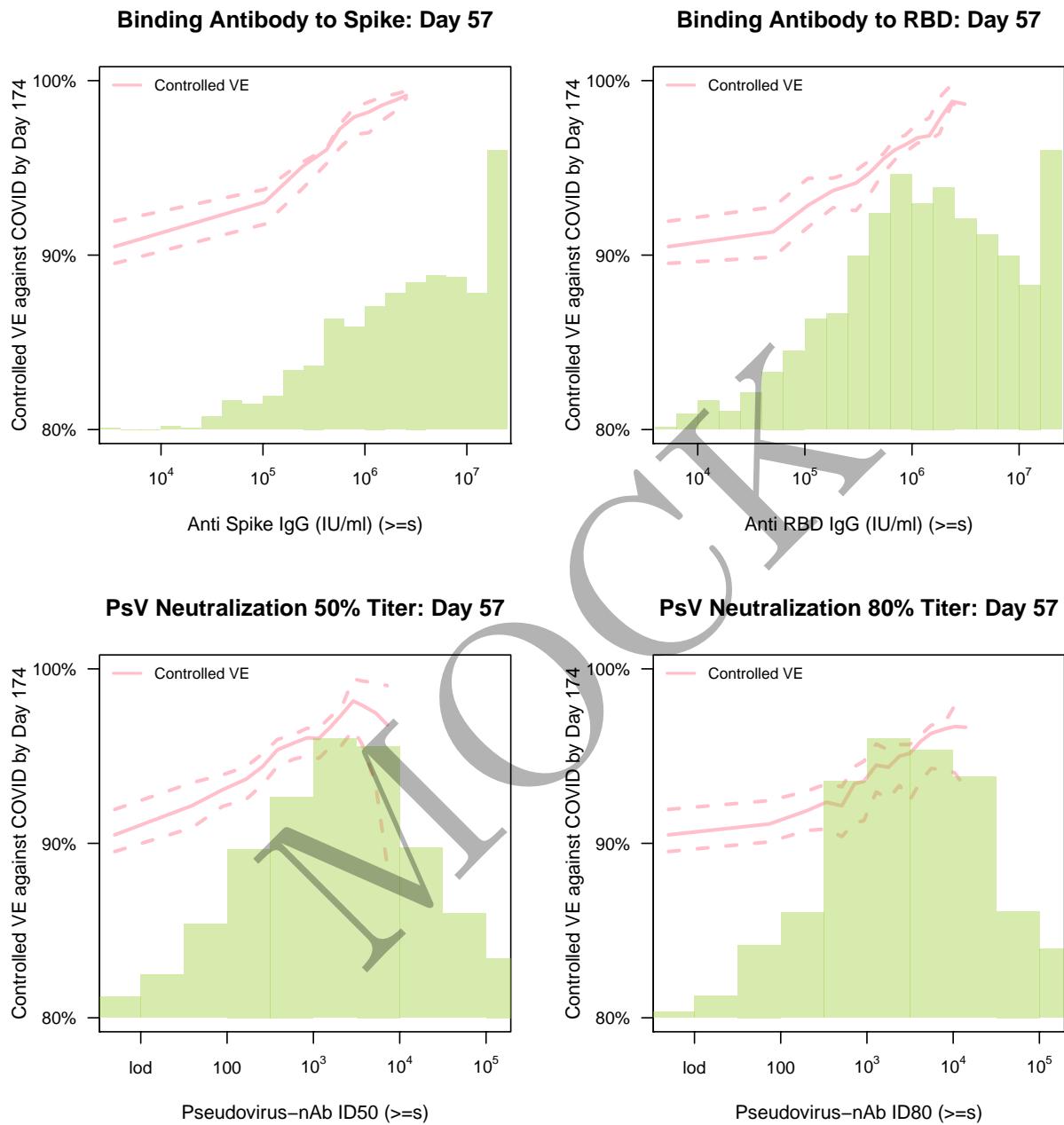


Figure 3.9: Controlled VE as functions of Day 57 markers ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

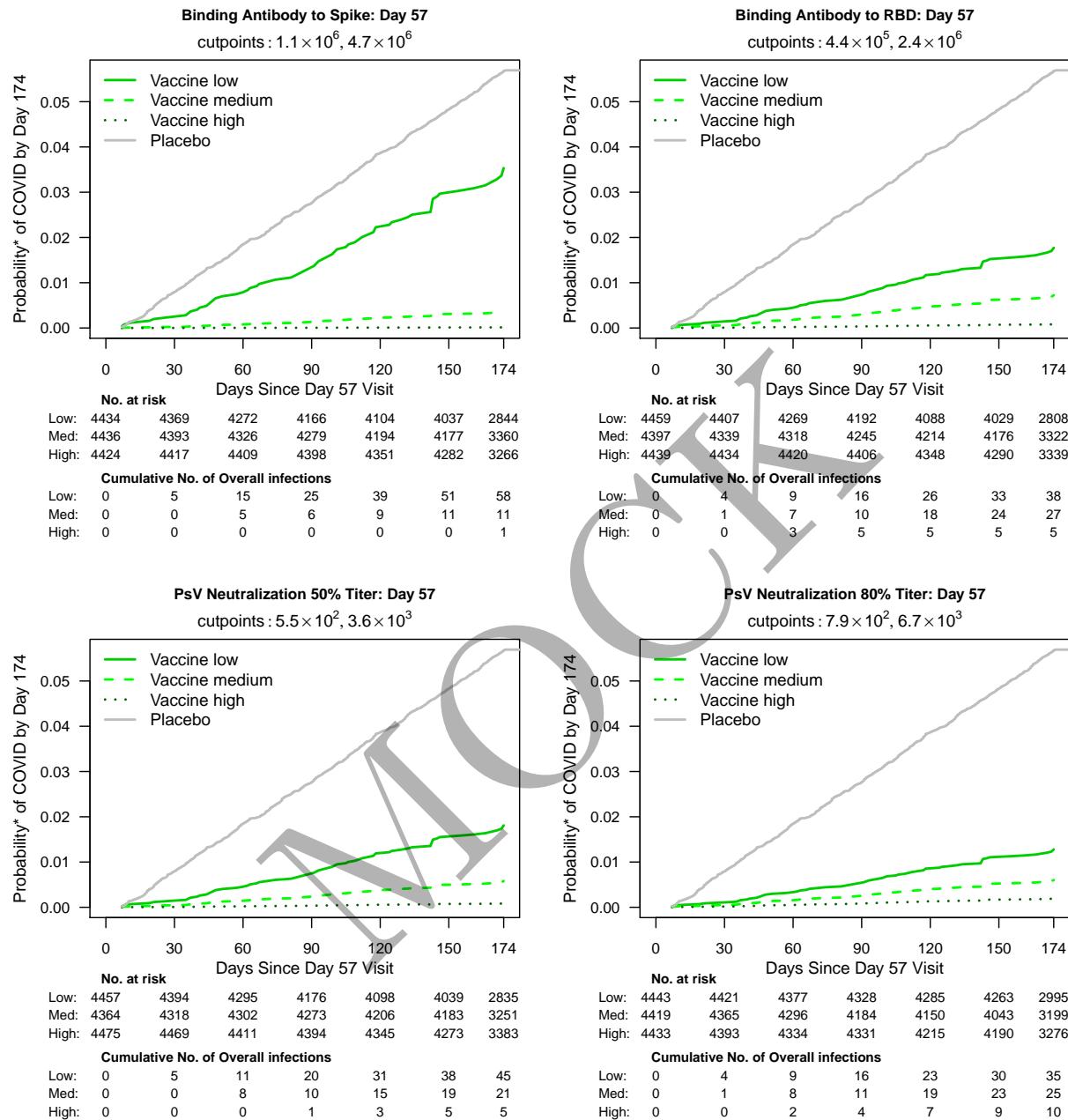


Figure 3.10: Marginalized cumulative incidence rate curves for trichotomized Day 57 markers among baseline seronegative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.

Chapter 4

Day 29 Univariate CoR: Cox Models of Risk

The main regression model is the Cox proportional hazards model. All plots are made with Cox models fit unless specified otherwise.

4.1 Hazard ratios

Inference for Day 29 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group:
Hazard ratios per 10-fold increment in the marker*

Mock Immunologic Marker	No. cases / No. at-risk**	HR per 10-fold incr. Pt. Est.	95% CI	P-value (2-sided)	q-value	FWER
Anti Spike IgG (IU/ml)	81/13,315	0.09	(0.05-0.17)	<0.001	<0.001	<0.001
Anti RBD IgG (IU/ml)	81/13,315	0.30	(0.21-0.43)	<0.001	<0.001	<0.001
Pseudovirus-nAb ID50	81/13,315	0.38	(0.28-0.52)	<0.001	<0.001	<0.001
Pseudovirus-nAb ID80	81/13,315	0.59	(0.43-0.81)	0.001	<0.001	<0.001

*Baseline covariates adjusted for: baseline risk score, at risk or not, community of color or not. Average follow-up time 200 days, maximum follow-up time 213 days.

**No. at-risk = number of per-protocol baseline negative vaccine recipients at-risk for COVID; no. cases = number of this cohort with an observed COVID endpoints starting 7 days post Day 29 visit.

Inference for Day 29 antibody marker covariate-adjusted correlates of risk of COVID in the vaccine group:
Hazard ratios for Middle vs. Upper tertile vs. Lower tertile*

Mock Immunologic Marker	Tertile	No. cases / No. at-risk**	Attack rate	Haz. Ratio Pt. Est.	95% CI	P-value (2-sided)	Overall P- value***	Overall q- value	Overall FWER
Anti Spike IgG (IU/ml)	Lower	49/4,460	0.0110	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	21/4,406	0.0048	0.24	(0.13-0.43)	<0.001			
	Upper	11/4,449	0.0025	0.06	(0.03-0.14)	<0.001			
Anti RBD IgG (IU/ml)	Lower	40/4,461	0.0090	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	21/4,412	0.0048	0.38	(0.22-0.68)	0.001			
	Upper	20/4,442	0.0045	0.19	(0.10-0.35)	<0.001			
Pseudovirus-nAb ID50	Lower	40/4,441	0.0090	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	30/4,429	0.0068	0.54	(0.32-0.92)	0.022			
	Upper	10/4,445	0.0022	0.14	(0.07-0.29)	<0.001			
Pseudovirus-nAb ID80	Lower	29/4,440	0.0065	1	N/A	N/A		0.077	
	Middle	28/4,434	0.0063	0.76	(0.43-1.35)	0.350			
	Upper	24/4,441	0.0054	0.50	(0.27-0.91)	0.024			
Placebo		828/13,380	0.0619						

*Baseline covariates adjusted for: baseline risk score, at risk or not, community of color or not. Average follow-up time 200 days, maximum follow-up time 213 days. Cutpoints: Anti Spike IgG (IU/ml) [4.35, 4.87], Anti RBD IgG (IU/ml) [4.05, 4.64], Pseudovirus-nAb ID50 [1.67, 2.39], Pseudovirus-nAb ID80 [1.92, 2.61].

**No. at-risk = number of per-protocol baseline negative vaccine recipients at-risk for COVID at 7 days post Day 29 visit; no. cases = number of this cohort with an observed COVID endpoints.

***Generalized Wald-test p-value of the null hypothesis that the hazard rate is constant across the Lower, Middle, and Upper tertile groups.

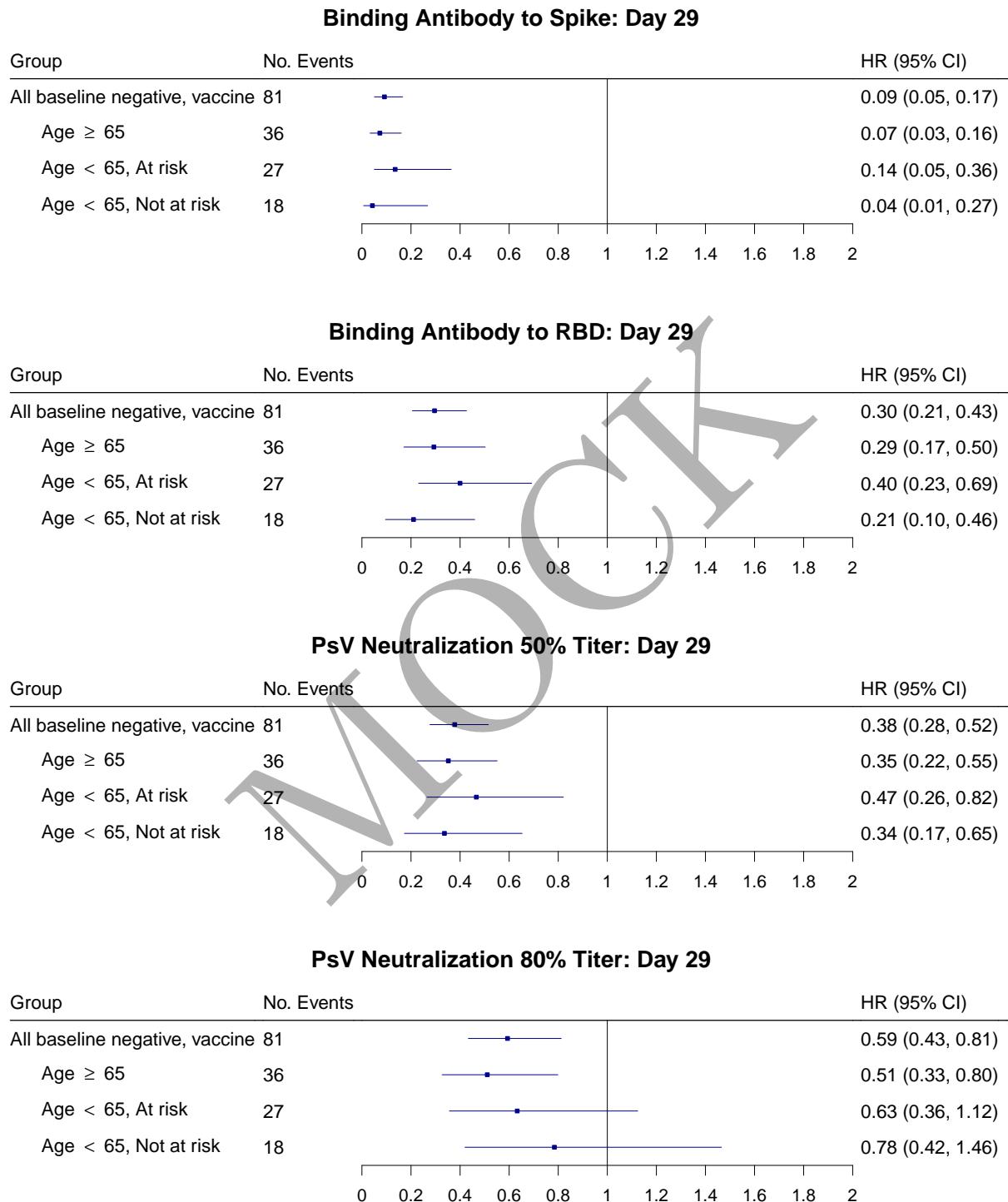


Figure 4.1: Forest plots of hazard ratios per 10-fold increase in the marker among baseline seronegative vaccine recipients and subgroups with 95% point-wise confidence intervals.

Binding Antibody to Spike: Day 29

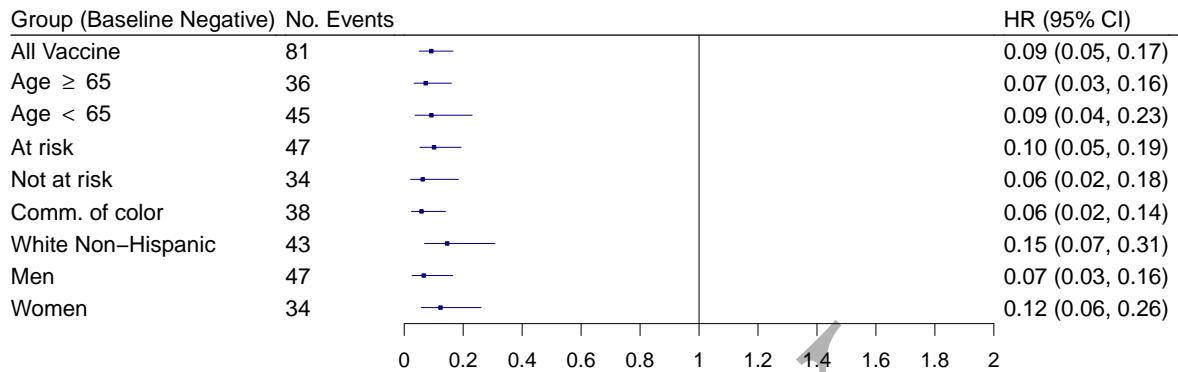


Figure 4.2: Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to spike markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

Binding Antibody to RBD: Day 29

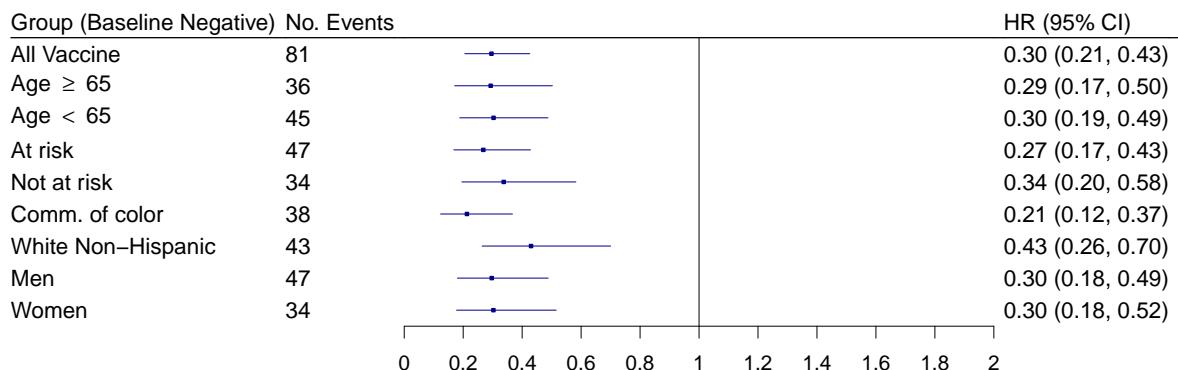


Figure 4.3: Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to RBD markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

PsV Neutralization 50% Titer: Day 29

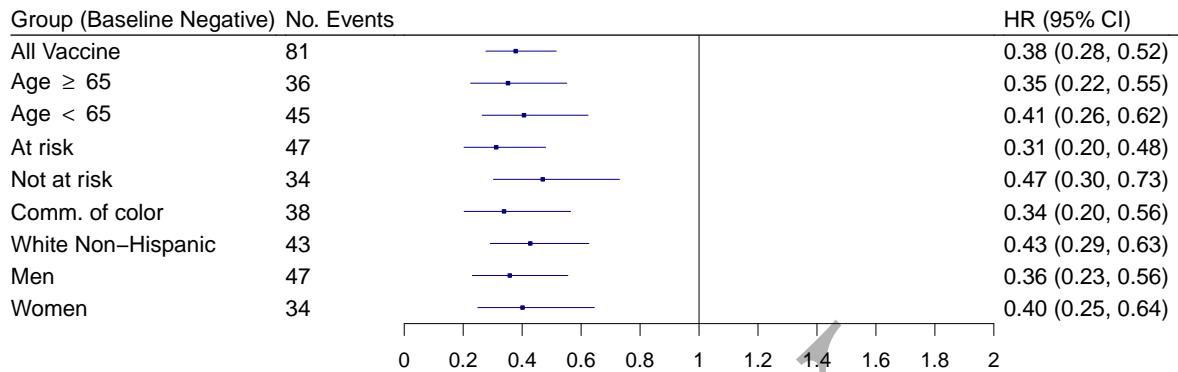


Figure 4.4: Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID50 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

PsV Neutralization 80% Titer: Day 29

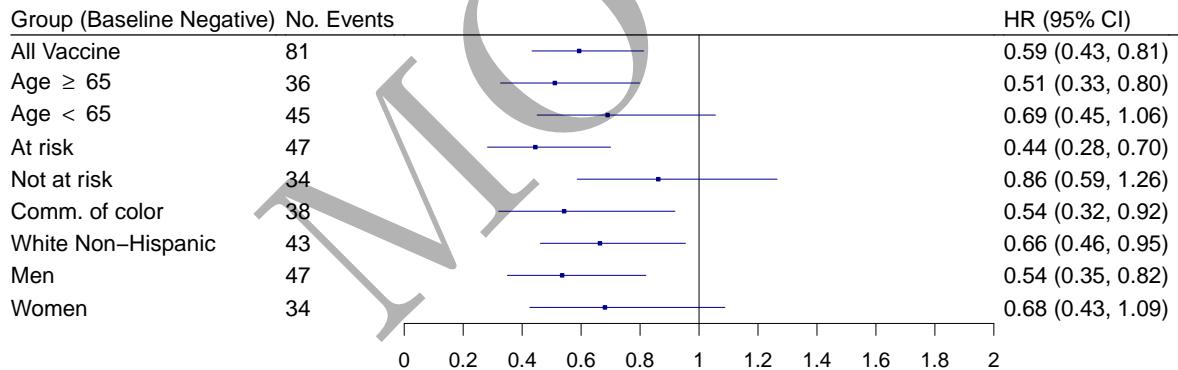


Figure 4.5: Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID80 markers among baseline seronegative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

4.2 Marginalized risk and controlled vaccine efficacy plots

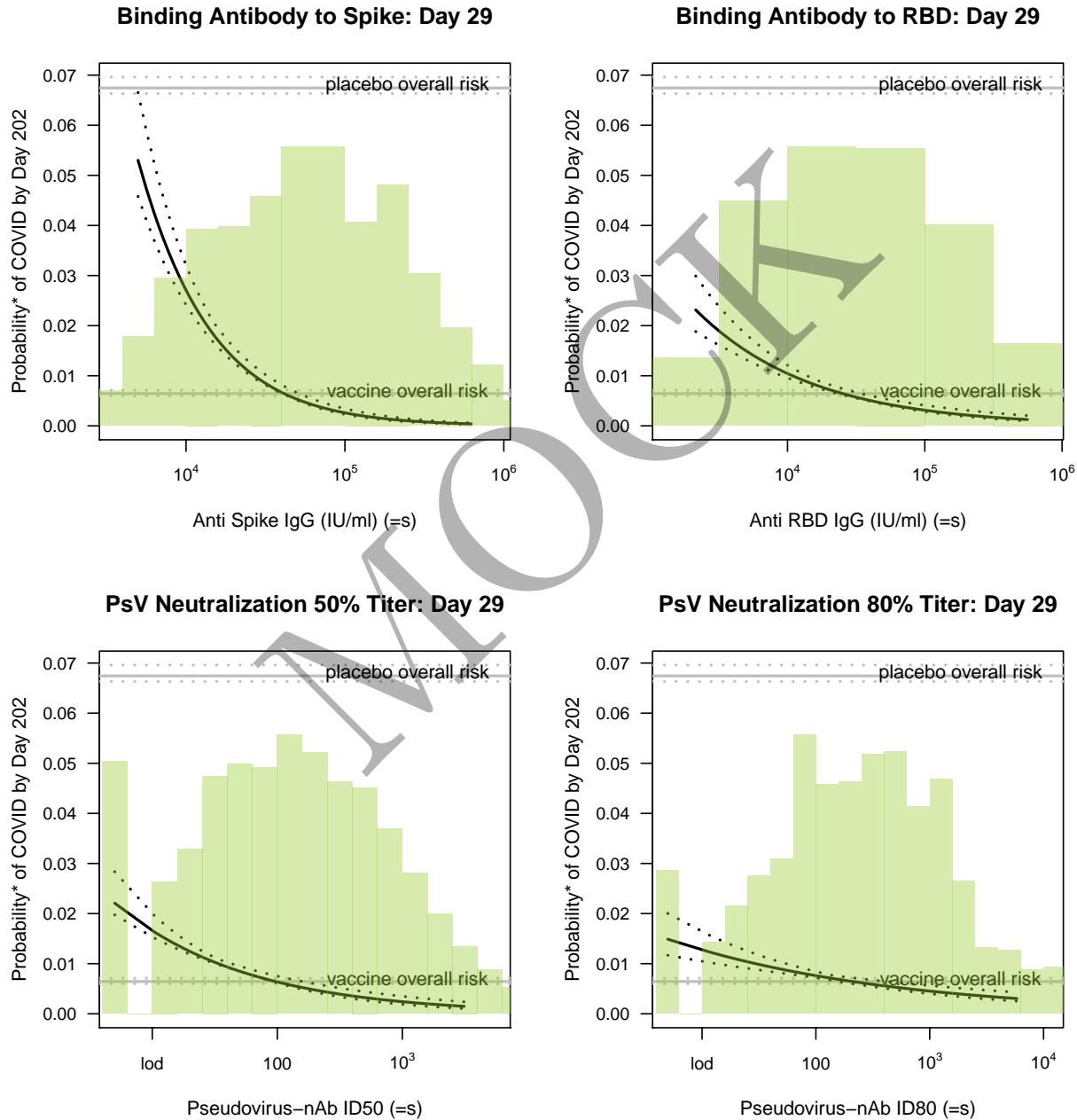


Figure 4.6: Marginalized cumulative risk by Day 202 as functions of Day 29 markers ($=s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 202 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

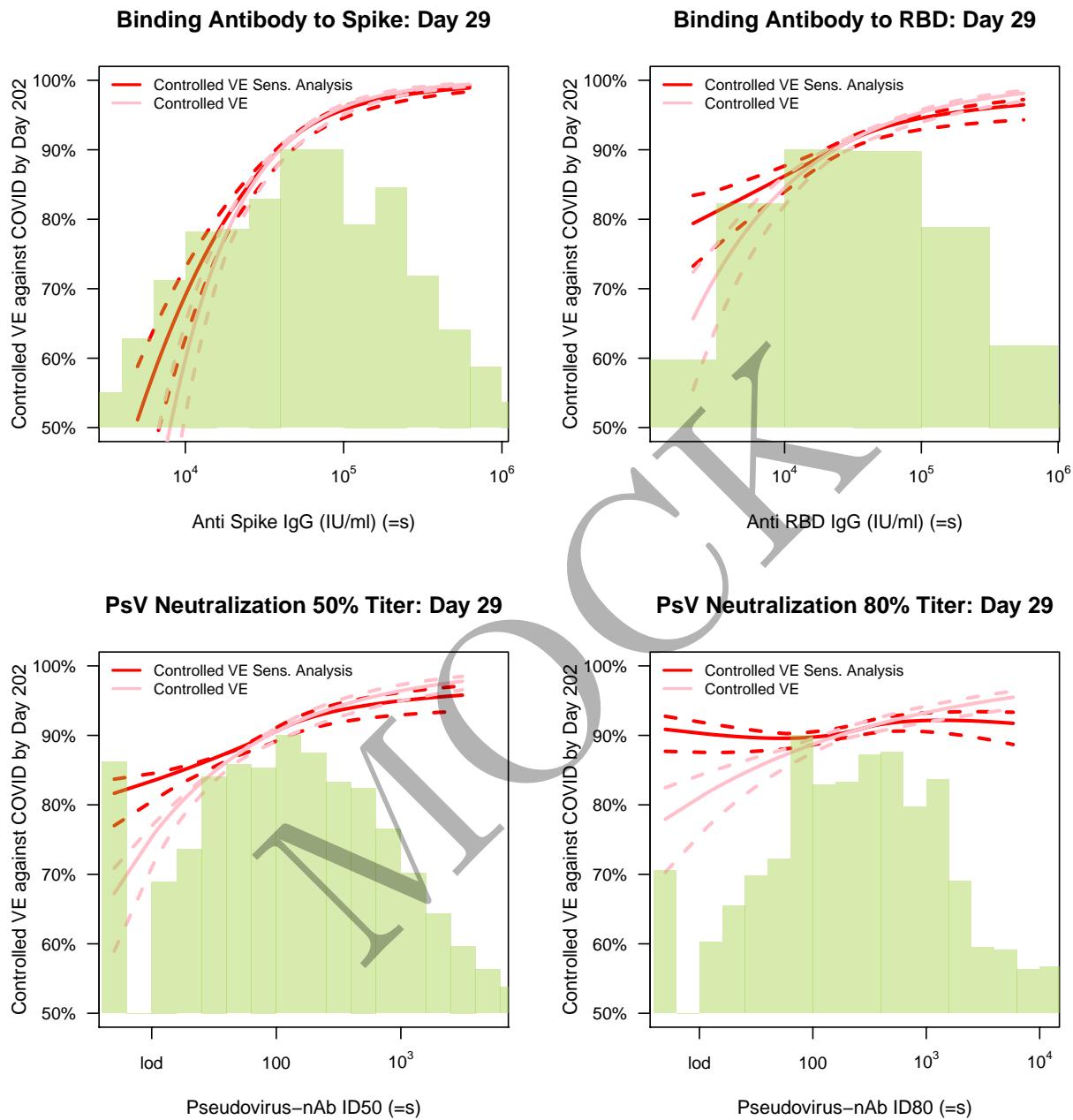


Figure 4.7: Controlled VE with sensitivity analysis as functions of Day 29 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

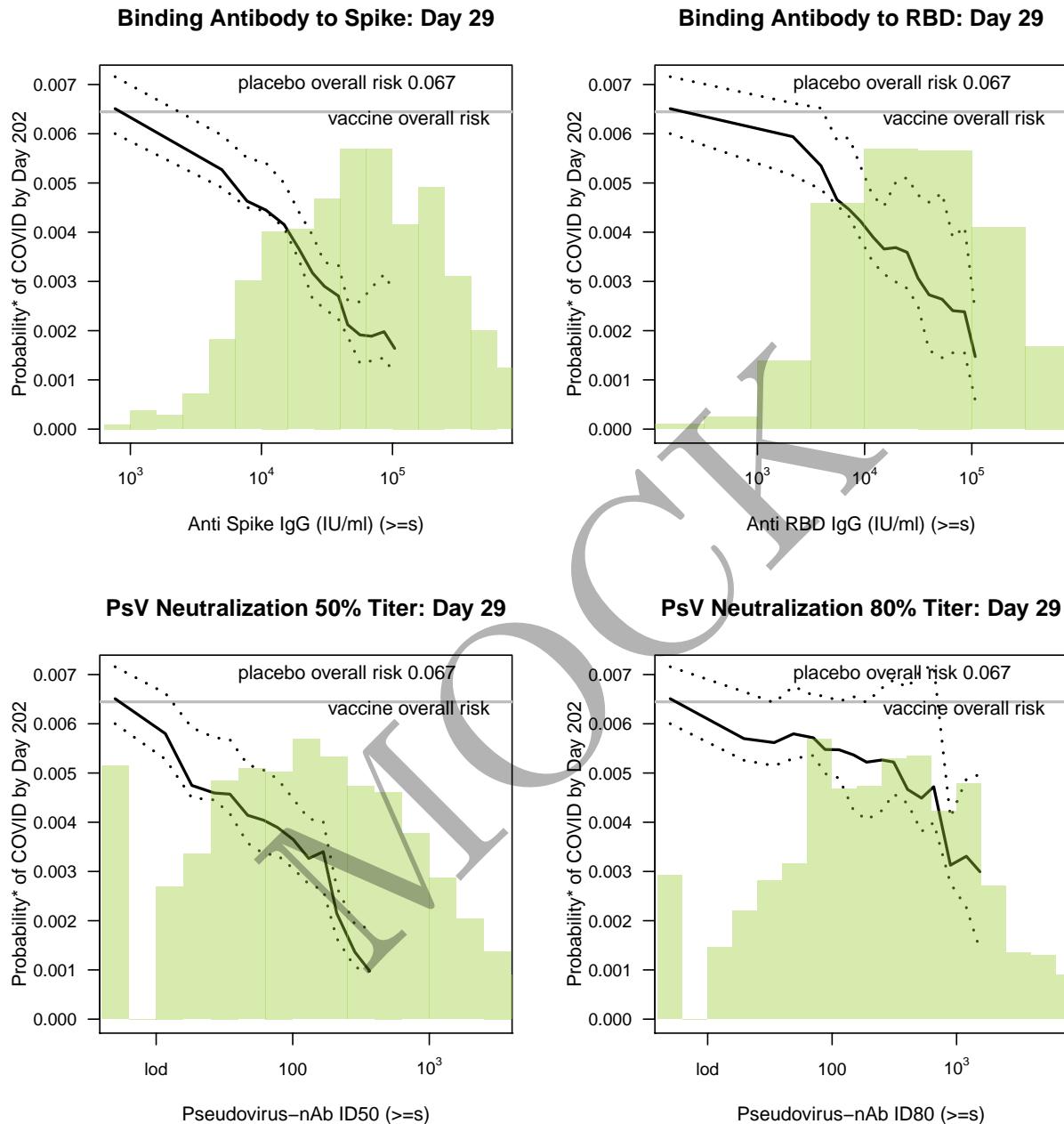


Figure 4.8: Marginalized cumulative risk by Day 202 as functions of Day 29 markers above a threshold ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 202 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

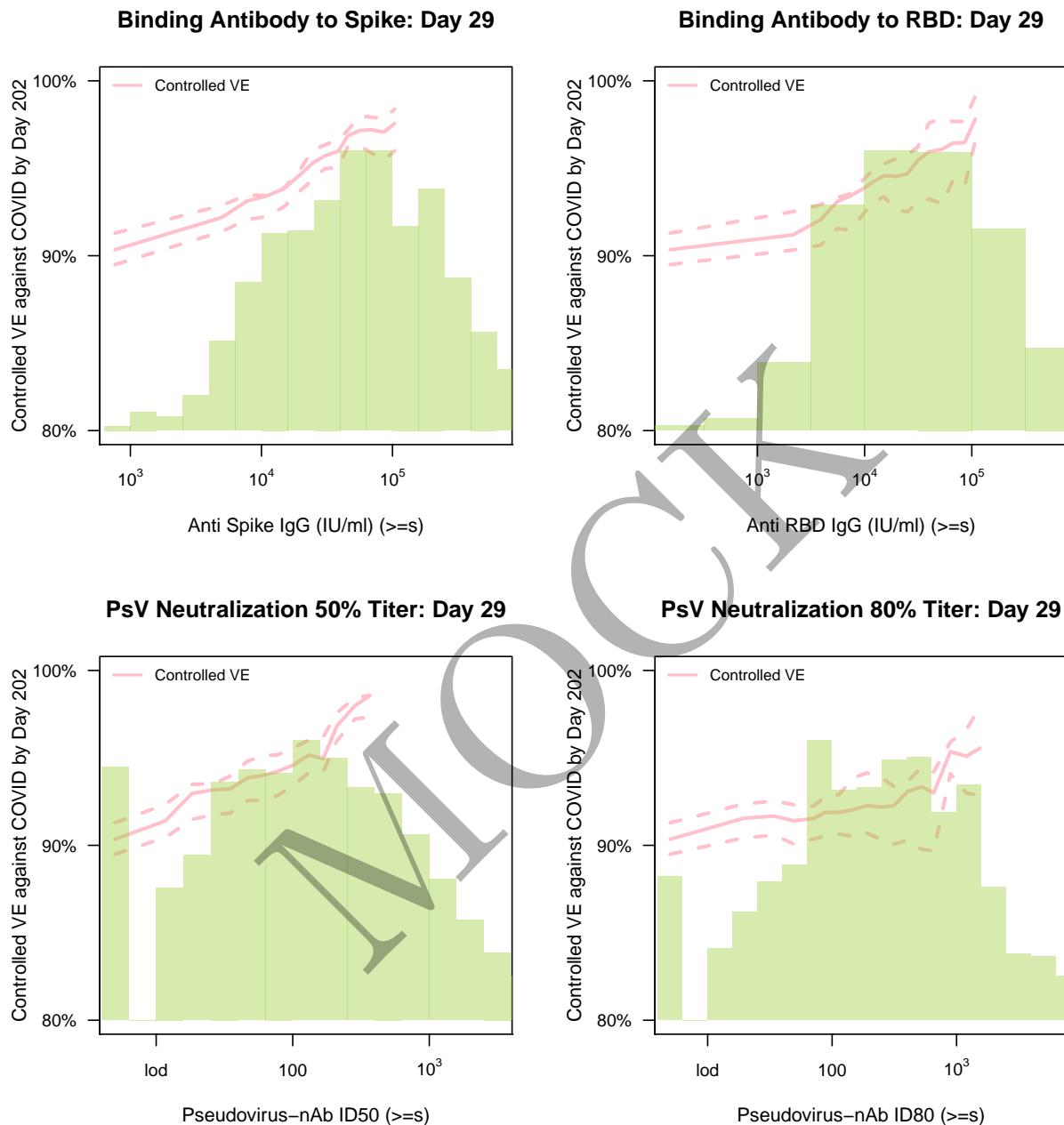


Figure 4.9: Controlled VE as functions of Day 29 markers ($\geq s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands. Histograms of the immunological markers in the vaccine arm are overlaid. lod: lower limit of detection.

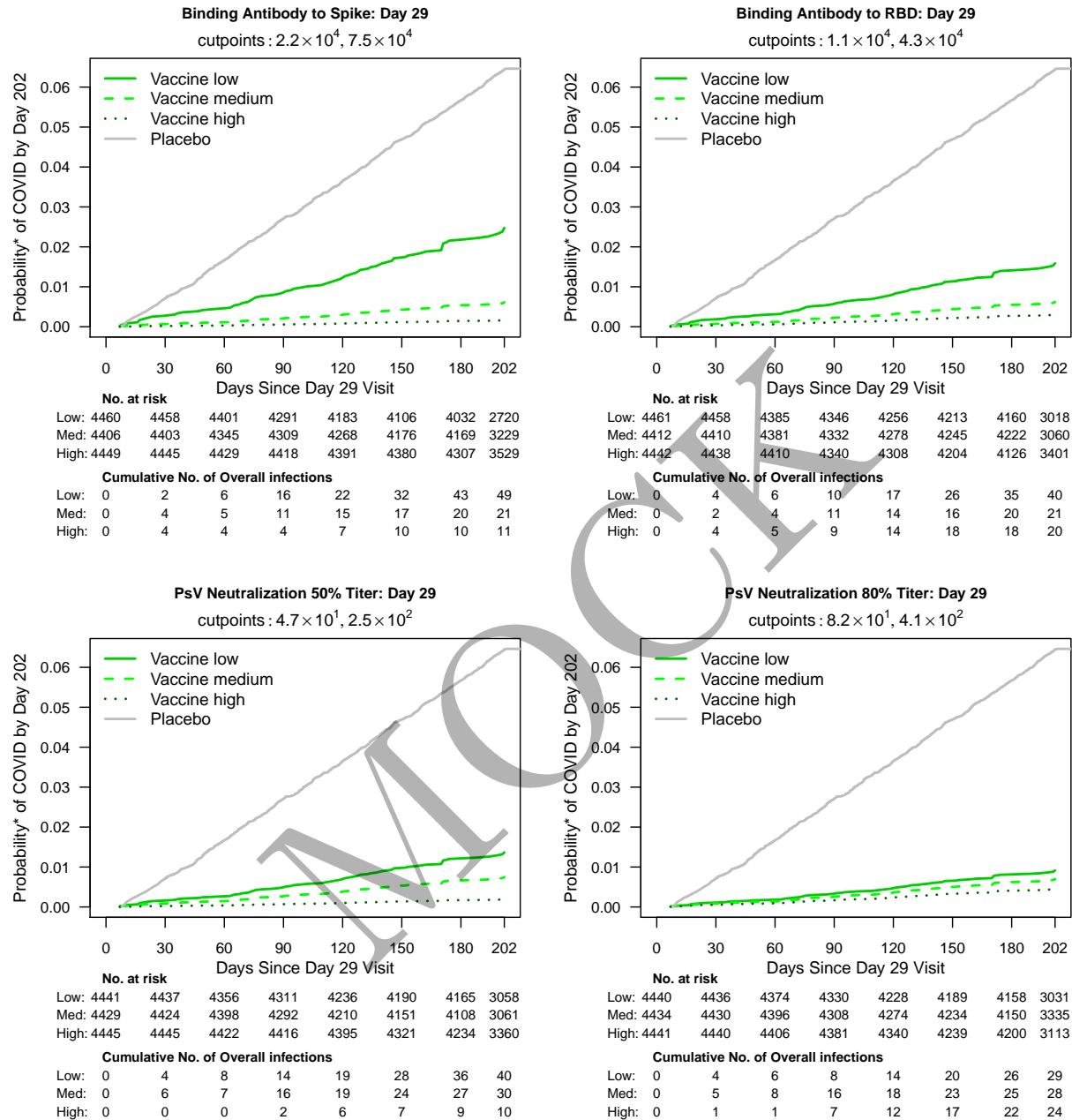


Figure 4.10: Marginalized cumulative incidence rate curves for trichotomized Day 29 markers among baseline seronegative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.

Chapter 5

Univariate CoR: Nonparametric Threshold Modeling

An extension of the unadjusted nonparametric threshold-searching approach developed in Donovan, Hudgens, and Gilbert (2019), the covariate-adjusted TMLE-based approach developed by van der Laan, Zhang, Gilbert (submitted) is used to estimate the so-called threshold-response function $E_X[E[Y | S \geq s, X, A = 1] | A = 1]$ for a range of thresholds s . Here, X is a set of baseline characteristics, $A = 1$ represents the vaccine group, S is the biomarker/immune-response/correlate of interest, and Y is the indicator of COVID disease before some time point t_f . This parameter can be viewed as a causal/covariate-adjusted version of the parameter $P(Y = 1 | S \geq s, A = 1)$. Intuitively, the threshold-response at a given threshold is the expected probability of obtaining COVID disease if one experiences a marker/immune-response value above that threshold. The threshold-response function is estimated for each of the four Day 57 antibody markers, in each case adjusting for the baseline covariates: baseline risk score, high risk indicator, and underrepresented minority status. A parametric learner, selected via cross-validation, is used for the covariate adjustment. A number of plots and tables are reported:

1. A plot and table with risk estimates and point-wise 95% confidence intervals
2. A plot and table with risk estimates and simultaneous 95% confidence bands
3. Monotone-corrected versions of 1 and 2.

A reverse cumulative distribution function curve estimated by the IPW NPMLE of the marker values is superimposed on the threshold-response plots and a dashed red line is added to mark the threshold value after which no more events are observed.

5.1 Plots and Tables with estimates and pointwise confidence interval for Day 57

MOCK

5.1.1 Day 57 Spike protein binding antibody

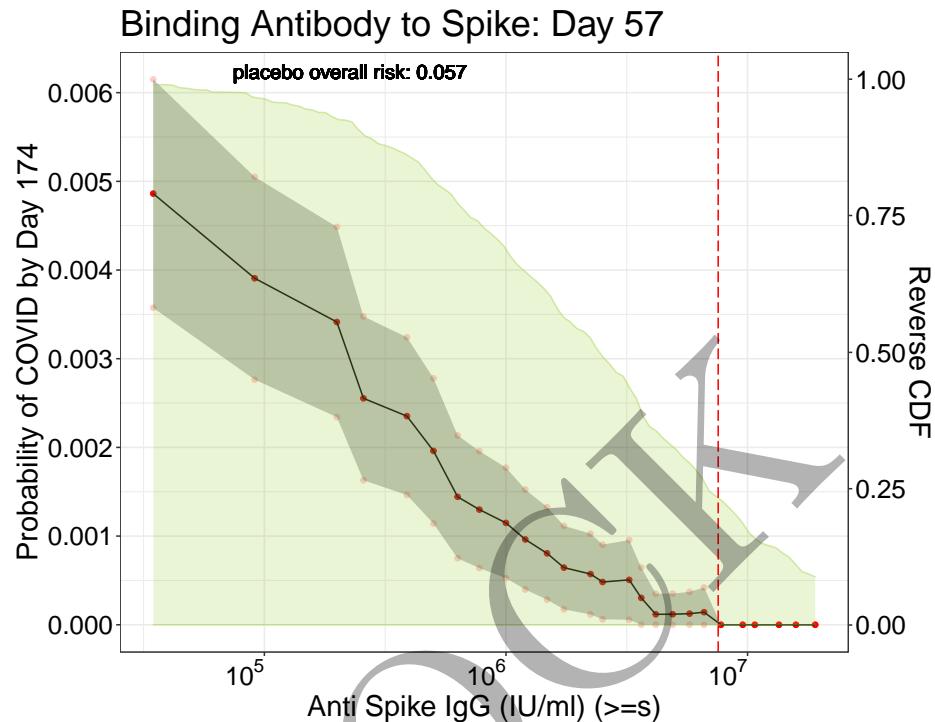


Figure 5.1: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.536	$3.44 * 10^4$	0.00486	0.00357	0.00615
5.413	$2.59 * 10^5$	0.00255	0.00163	0.00348
5.797	$6.27 * 10^5$	0.00144	0.00075	0.00214
5.996	$9.91 * 10^5$	0.00115	0.00053	0.00177
6.244	$1.75 * 10^6$	0.00064	0.00017	0.00112
6.508	$3.22 * 10^6$	0.00051	0.00006	0.00096
6.694	$4.94 * 10^6$	0.00012	0.00000	0.00035
6.820	$6.61 * 10^6$	0.00014	0.00000	0.00042
7.028	$1.07 * 10^7$	0.00000	0.00000	NA
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.1.2 Day 57 RBD binding antibody

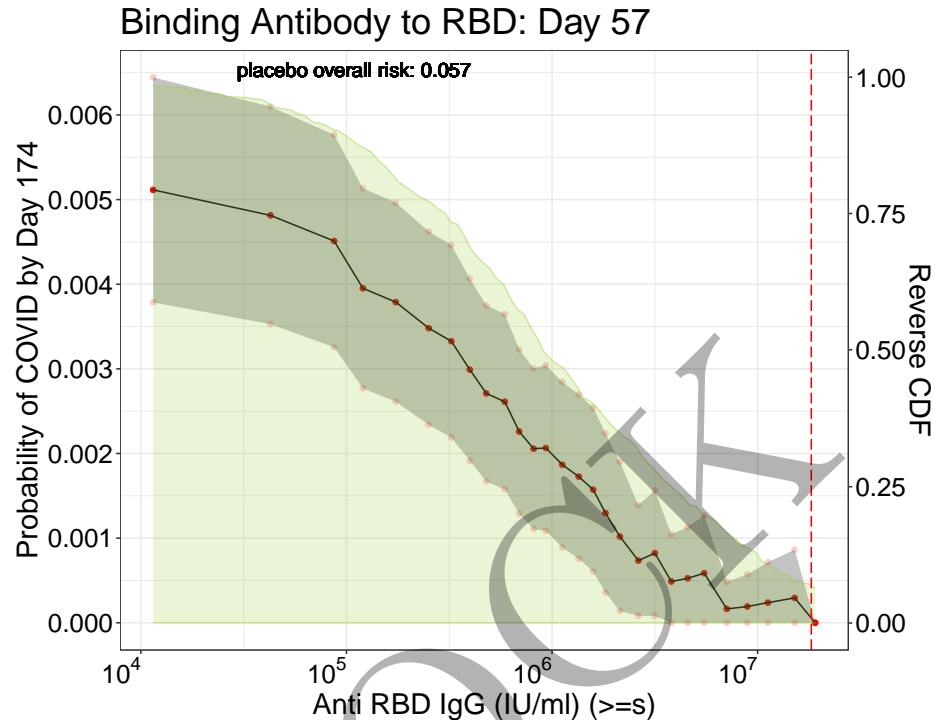


Figure 5.2: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.062	$1.15 * 10^4$	0.00511	0.00379	0.00644
5.085	$1.22 * 10^5$	0.00395	0.00277	0.00513
5.507	$3.21 * 10^5$	0.00333	0.00219	0.00446
5.771	$5.90 * 10^5$	0.00261	0.00158	0.00365
5.966	$9.25 * 10^5$	0.00207	0.00109	0.00304
6.195	$1.57 * 10^6$	0.00157	0.00061	0.00254
6.420	$2.63 * 10^6$	0.00073	0.00008	0.00139
6.664	$4.61 * 10^6$	0.00052	0.00000	0.00113
6.949	$8.89 * 10^6$	0.00019	0.00000	0.00057
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.1.3 Day 57 Pseudo virus-neutralizing antibody (50% titer)

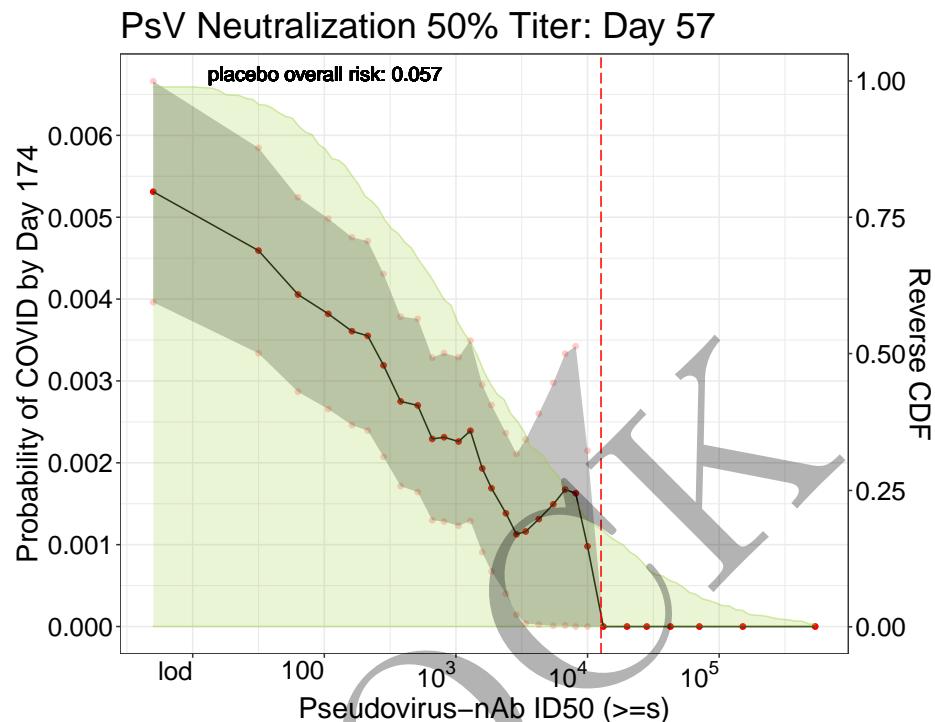


Figure 5.3: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	5.00 * 10 ⁰	0.00531	0.00396	0.00666
2.033	1.08 * 10 ²	0.00382	0.00266	0.00498
2.447	2.80 * 10 ²	0.00319	0.00207	0.00431
2.913	8.18 * 10 ²	0.00231	0.00128	0.00334
3.196	1.57 * 10 ³	0.00193	0.00091	0.00295
3.464	2.91 * 10 ³	0.00113	0.00014	0.00211
3.736	5.45 * 10 ³	0.00149	0.00001	0.00298
4.123	1.33 * 10 ⁴	0.00000	0.00000	NA
4.629	4.26 * 10 ⁴	0.00000	0.00000	NA
5.730	5.37 * 10 ⁵	0.00000	0.00000	NA

5.1.4 Day 57 Pseudo virus-neutralizing antibody (80% titer)

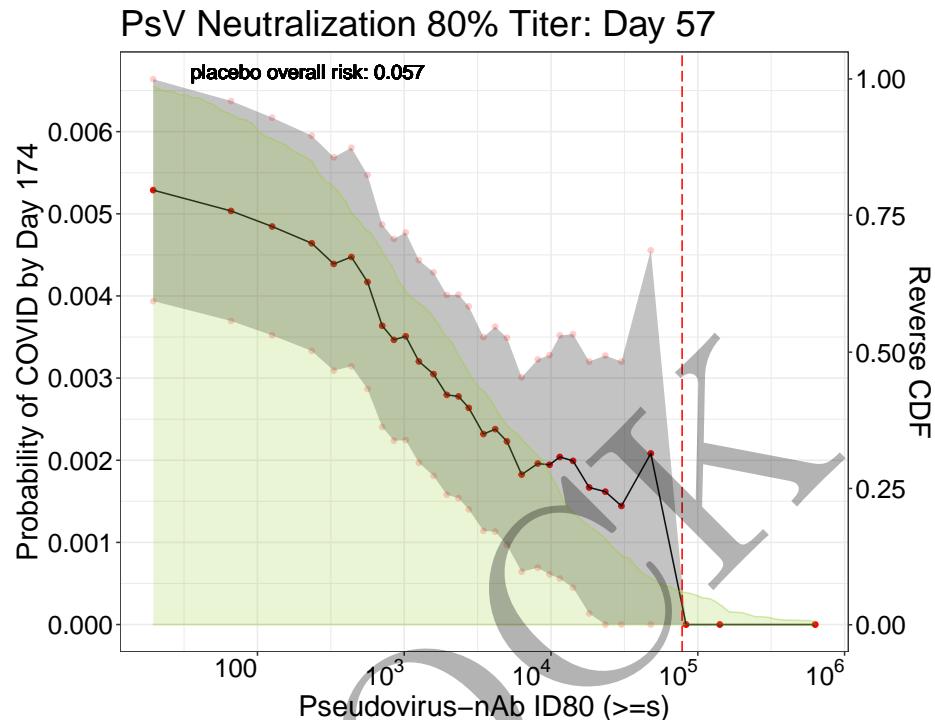


Figure 5.4: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.289	$1.95 * 10^1$	0.00529	0.00394	0.00664
2.368	$2.33 * 10^2$	0.00464	0.00333	0.00595
2.755	$5.69 * 10^2$	0.00417	0.00287	0.00547
3.104	$1.27 * 10^3$	0.00320	0.00197	0.00444
3.373	$2.36 * 10^3$	0.00278	0.00154	0.00402
3.624	$4.21 * 10^3$	0.00238	0.00113	0.00363
3.909	$8.11 * 10^3$	0.00196	0.00069	0.00323
4.259	$1.82 * 10^4$	0.00167	0.00014	0.00320
4.676	$4.74 * 10^4$	0.00208	0.00000	0.00455
5.796	$6.25 * 10^5$	0.00000	0.00000	NA

5.2 Plots and Tables with estimates and pointwise confidence intervals for Day 29

MOCK

5.2.1 Day 29 Spike protein antibody

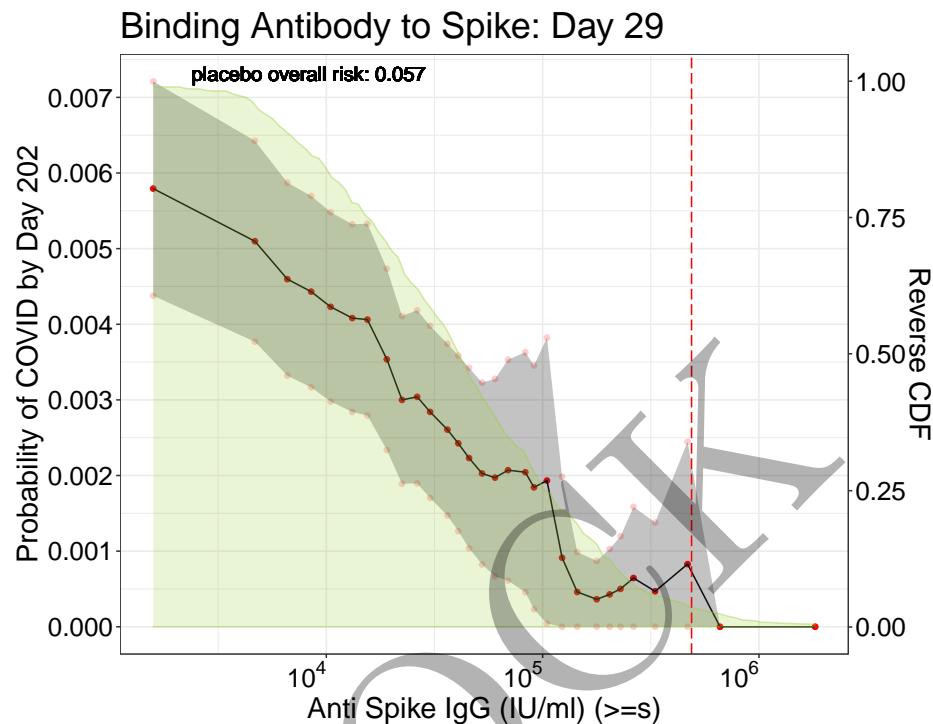


Figure 5.5: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
3.202	$1.59 * 10^3$	0.00579	0.00438	0.00721
3.926	$8.43 * 10^3$	0.00443	0.00317	0.00570
4.187	$1.54 * 10^4$	0.00406	0.00279	0.00533
4.478	$3.01 * 10^4$	0.00284	0.00170	0.00398
4.658	$4.55 * 10^4$	0.00223	0.00104	0.00342
4.841	$6.93 * 10^4$	0.00207	0.00061	0.00353
5.022	$1.05 * 10^5$	0.00193	0.00004	0.00382
5.310	$2.04 * 10^5$	0.00043	0.00000	0.00103
5.523	$3.33 * 10^5$	0.00047	0.00000	0.00138
6.259	$1.82 * 10^6$	0.00000	0.00000	NA

5.2.2 Day 29 RBD binding antibody

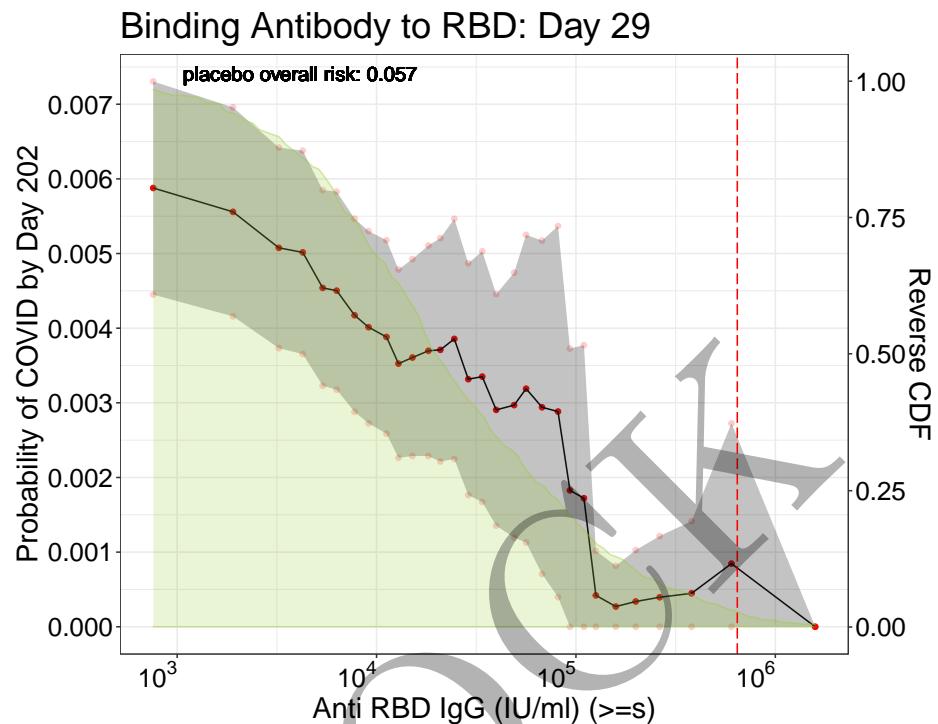


Figure 5.6: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.882	$7.62 * 10^2$	0.00588	0.00445	0.00731
3.628	$4.25 * 10^3$	0.00502	0.00365	0.00638
3.889	$7.74 * 10^3$	0.00417	0.00288	0.00547
4.180	$1.51 * 10^4$	0.00361	0.00229	0.00493
4.395	$2.48 * 10^4$	0.00386	0.00225	0.00547
4.603	$4.01 * 10^4$	0.00291	0.00135	0.00446
4.826	$6.70 * 10^4$	0.00294	0.00071	0.00517
5.105	$1.27 * 10^5$	0.00042	0.00000	0.00102
5.422	$2.64 * 10^5$	0.00040	0.00000	0.00122
6.197	$1.57 * 10^6$	0.00000	0.00000	NA

5.2.3 Day 29 Pseudo virus-neutralizing antibody (50% titer)

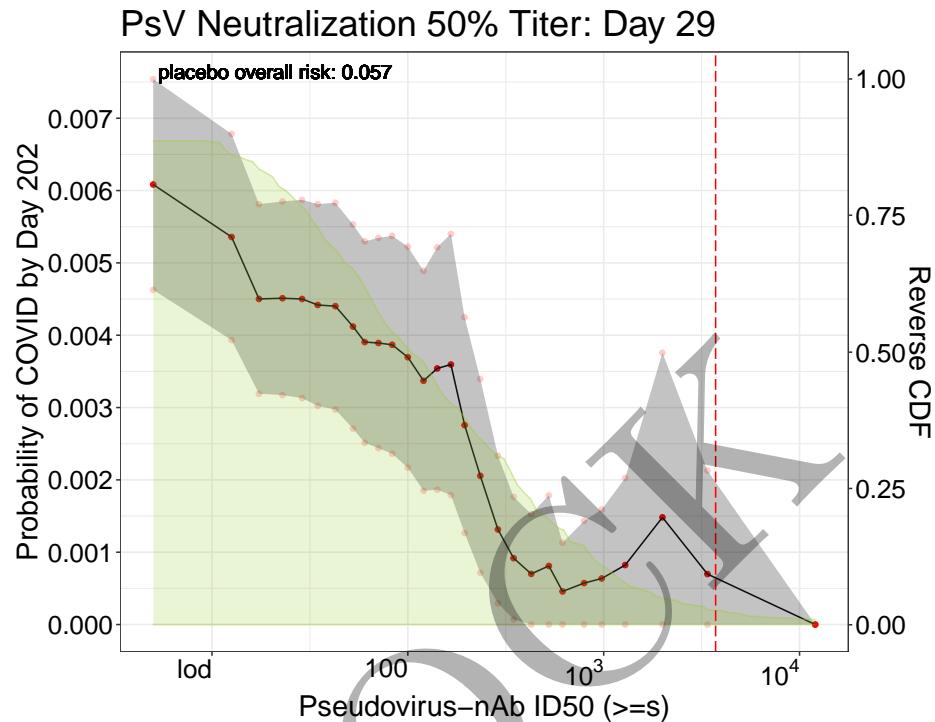


Figure 5.7: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00463	0.00754
1.363	$2.31 * 10^1$	0.00451	0.00317	0.00585
1.628	$4.25 * 10^1$	0.00440	0.00297	0.00583
1.848	$7.05 * 10^1$	0.00389	0.00244	0.00535
2.078	$1.20 * 10^2$	0.00337	0.00185	0.00489
2.293	$1.96 * 10^2$	0.00276	0.00126	0.00425
2.537	$3.44 * 10^2$	0.00092	0.00007	0.00177
2.791	$6.18 * 10^2$	0.00046	0.00000	0.00113
3.109	$1.29 * 10^3$	0.00082	0.00000	0.00203
4.080	$1.20 * 10^4$	0.00000	0.00000	NA

5.2.4 Day 29 Pseudo virus-neutralizing antibody (80% titer)

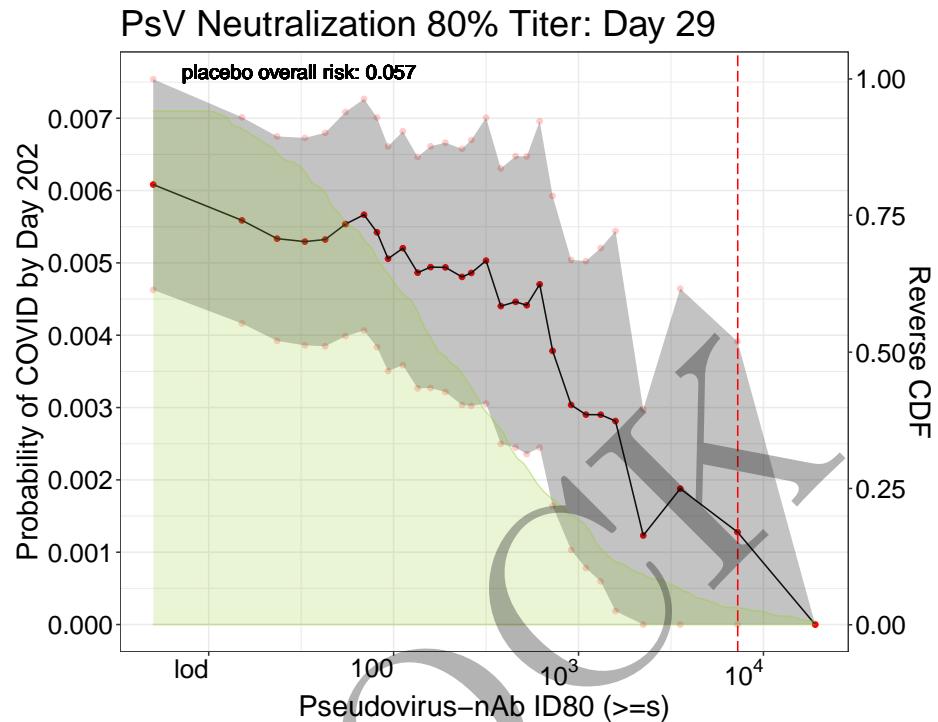


Figure 5.8: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00463	0.00754
1.525	$3.35 * 10^1$	0.00529	0.00386	0.00673
1.840	$6.92 * 10^1$	0.00567	0.00406	0.00727
2.049	$1.12 * 10^2$	0.00520	0.00359	0.00682
2.276	$1.89 * 10^2$	0.00494	0.00321	0.00666
2.583	$3.83 * 10^2$	0.00440	0.00250	0.00631
2.785	$6.10 * 10^2$	0.00470	0.00245	0.00696
3.039	$1.09 * 10^3$	0.00290	0.00078	0.00502
3.351	$2.24 * 10^3$	0.00123	0.00000	0.00298
4.285	$1.93 * 10^4$	0.00000	0.00000	NA

5.3 Plots and Tables with estimates and pointwise confidence interval for Day 57 (monotone-corrected)

MOCK

5.3.1 Day 57 Spike protein binding antibody

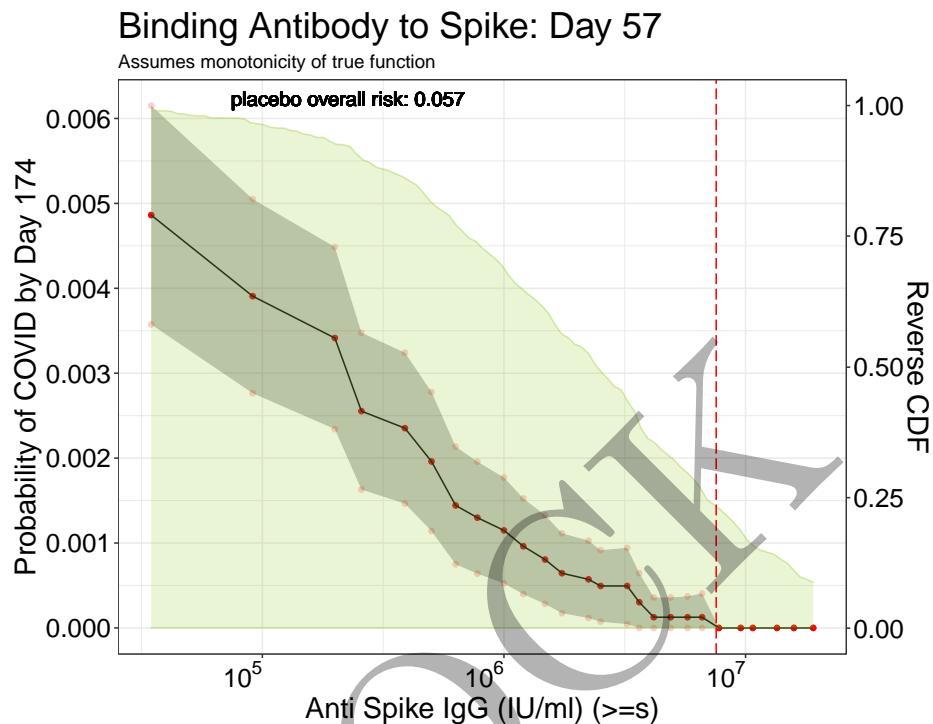


Figure 5.9: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
4.536	3.44 * 10 ⁴	0.00486	0.00357	0.00615
5.413	2.59 * 10 ⁵	0.00255	0.00163	0.00348
5.797	6.27 * 10 ⁵	0.00144	0.00075	0.00214
5.996	9.91 * 10 ⁵	0.00115	0.00053	0.00177
6.244	1.75 * 10 ⁶	0.00064	0.00017	0.00112
6.508	3.22 * 10 ⁶	0.00049	0.00005	0.00094
6.694	4.94 * 10 ⁶	0.00013	0.00000	0.00036
6.820	6.61 * 10 ⁶	0.00013	0.00000	0.00040
7.028	1.07 * 10 ⁷	0.00000	0.00000	NA
7.282	1.91 * 10 ⁷	0.00000	0.00000	NA

5.3.2 Day 57 RBD binding antibody

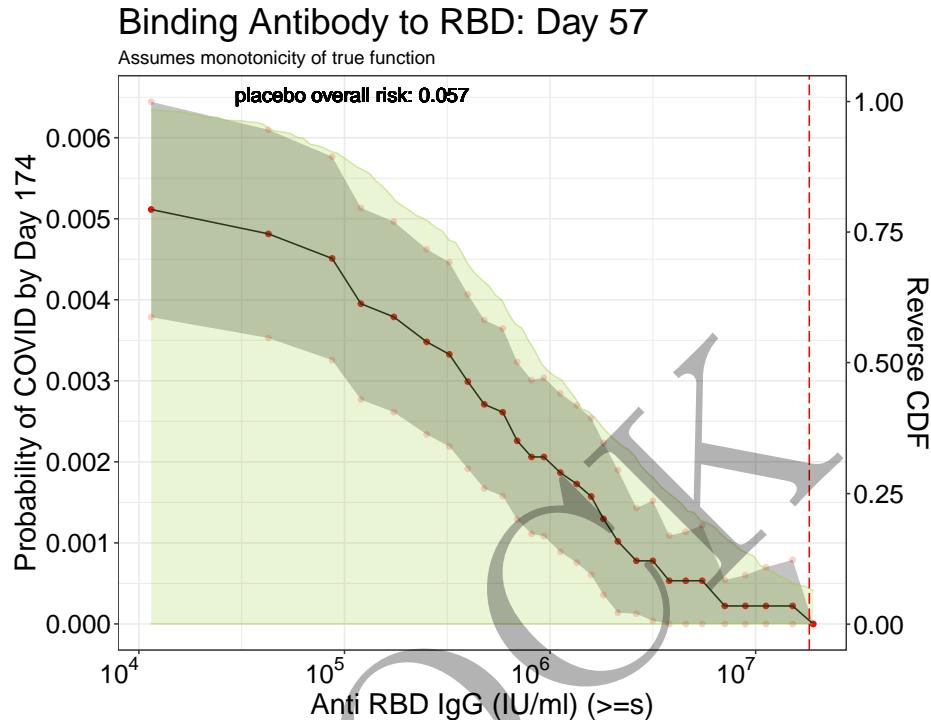


Figure 5.10: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.062	$1.15 * 10^4$	0.00511	0.00379	0.00644
5.085	$1.22 * 10^5$	0.00395	0.00277	0.00513
5.507	$3.21 * 10^5$	0.00333	0.00219	0.00446
5.771	$5.90 * 10^5$	0.00261	0.00158	0.00365
5.966	$9.25 * 10^5$	0.00206	0.00108	0.00304
6.195	$1.57 * 10^6$	0.00157	0.00061	0.00254
6.420	$2.63 * 10^6$	0.00078	0.00013	0.00143
6.664	$4.61 * 10^6$	0.00053	0.00000	0.00114
6.949	$8.89 * 10^6$	0.00022	0.00000	0.00060
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.3.3 Day 57 Pseudo virus-neutralizing antibody (50% titer)

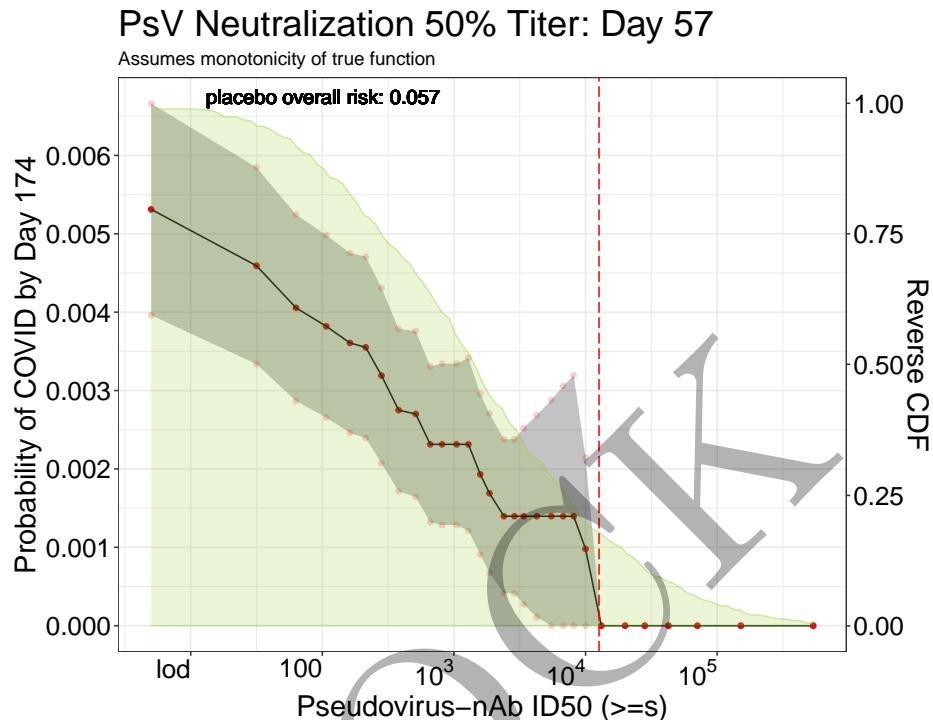


Figure 5.11: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00531	0.00396	0.00666
2.033	$1.08 * 10^2$	0.00382	0.00266	0.00498
2.447	$2.80 * 10^2$	0.00319	0.00207	0.00431
2.913	$8.18 * 10^2$	0.00231	0.00128	0.00334
3.196	$1.57 * 10^3$	0.00193	0.00091	0.00295
3.464	$2.91 * 10^3$	0.00140	0.00041	0.00238
3.736	$5.45 * 10^3$	0.00140	0.00000	0.00288
4.123	$1.33 * 10^4$	0.00000	0.00000	NA
4.629	$4.26 * 10^4$	0.00000	0.00000	NA
5.730	$5.37 * 10^5$	0.00000	0.00000	NA

5.3.4 Day 57 Pseudo virus-neutralizing antibody (80% titer)

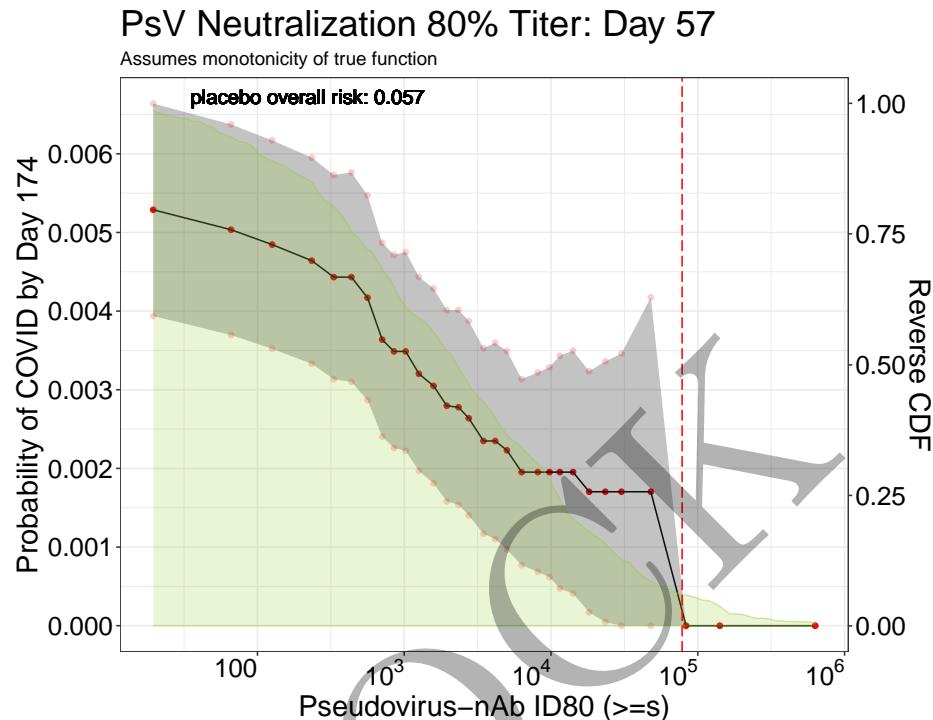


Figure 5.12: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.289	1.95×10^1	0.00529	0.00394	0.00664
2.368	2.33×10^2	0.00464	0.00333	0.00595
2.755	5.69×10^2	0.00417	0.00287	0.00547
3.104	1.27×10^3	0.00320	0.00197	0.00444
3.373	2.36×10^3	0.00278	0.00154	0.00402
3.624	4.21×10^3	0.00235	0.00110	0.00360
3.909	8.11×10^3	0.00195	0.00068	0.00322
4.259	1.82×10^4	0.00170	0.00017	0.00324
4.676	4.74×10^4	0.00170	0.00000	0.00418
5.796	6.25×10^5	0.00000	0.00000	NA

5.4 Plots and Tables with estimates and pointwise confidence intervals for Day 29 (monotone-corrected)

MOCK

5.4.1 Day 29 Spike protein antibody

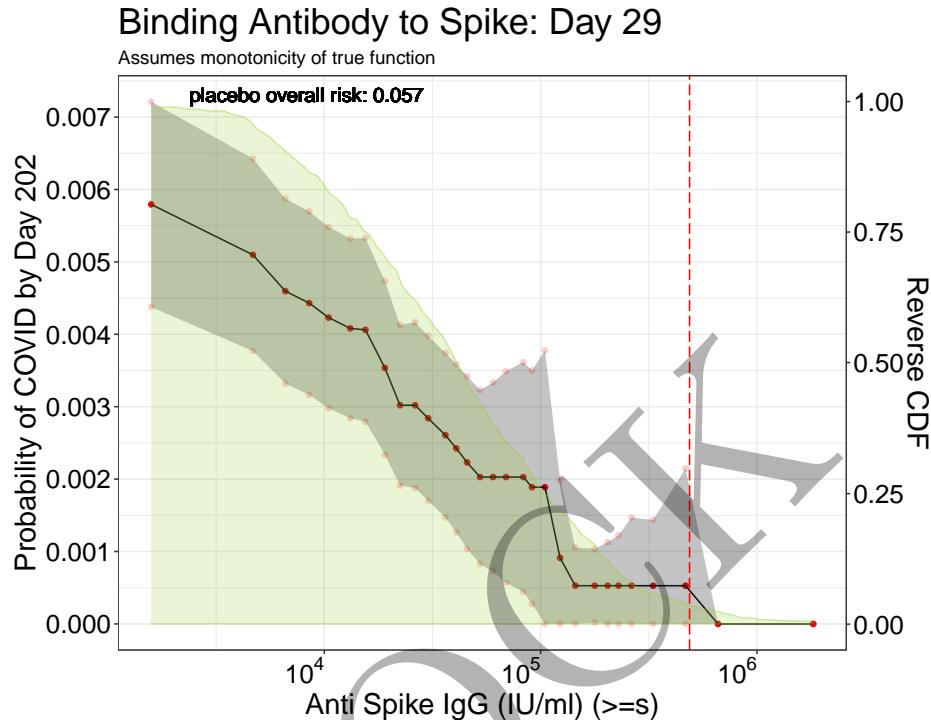


Figure 5.13: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
3.202	1.59×10^3	0.00579	0.00438	0.00721
3.926	8.43×10^3	0.00443	0.00317	0.00570
4.187	1.54×10^4	0.00406	0.00279	0.00533
4.478	3.01×10^4	0.00284	0.00170	0.00398
4.658	4.55×10^4	0.00223	0.00104	0.00342
4.841	6.93×10^4	0.00203	0.00057	0.00349
5.022	1.05×10^5	0.00189	0.00000	0.00378
5.310	2.04×10^5	0.00053	0.00000	0.00113
5.523	3.33×10^5	0.00053	0.00000	0.00144
6.259	1.82×10^6	0.00000	0.00000	NA

5.4.2 Day 29 RBD binding antibody

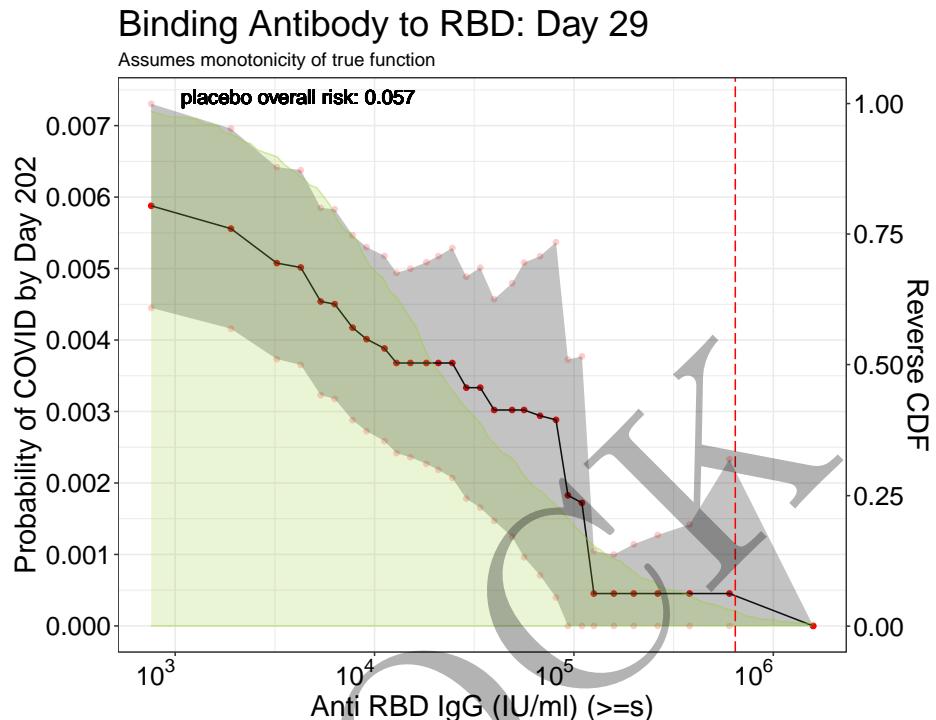


Figure 5.14: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.882	7.62×10^2	0.00588	0.00445	0.00731
3.628	4.25×10^3	0.00502	0.00365	0.00638
3.889	7.74×10^3	0.00417	0.00288	0.00547
4.180	1.51×10^4	0.00368	0.00236	0.00500
4.395	2.48×10^4	0.00368	0.00207	0.00529
4.603	4.01×10^4	0.00302	0.00147	0.00457
4.826	6.70×10^4	0.00294	0.00071	0.00517
5.105	1.27×10^5	0.00045	0.00000	0.00105
5.422	2.64×10^5	0.00045	0.00000	0.00127
6.197	1.57×10^6	0.00000	0.00000	NA

5.4.3 Day 29 Pseudo virus-neutralizing antibody (50% titer)

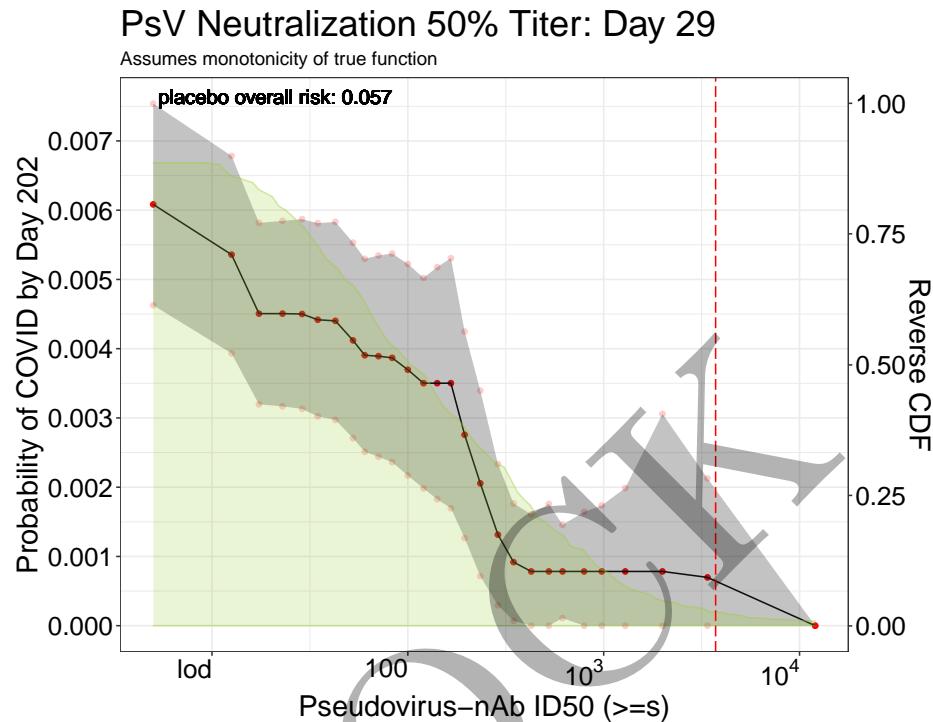


Figure 5.15: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00463	0.00754
1.363	$2.31 * 10^1$	0.00451	0.00317	0.00585
1.628	$4.25 * 10^1$	0.00440	0.00297	0.00583
1.848	$7.05 * 10^1$	0.00389	0.00244	0.00535
2.078	$1.20 * 10^2$	0.00350	0.00198	0.00502
2.293	$1.96 * 10^2$	0.00276	0.00126	0.00425
2.537	$3.44 * 10^2$	0.00092	0.00007	0.00177
2.791	$6.18 * 10^2$	0.00078	0.00011	0.00146
3.109	$1.29 * 10^3$	0.00078	0.00000	0.00199
4.080	$1.20 * 10^4$	0.00000	0.00000	NA

5.4.4 Day 29 Pseudo virus-neutralizing antibody (80% titer)

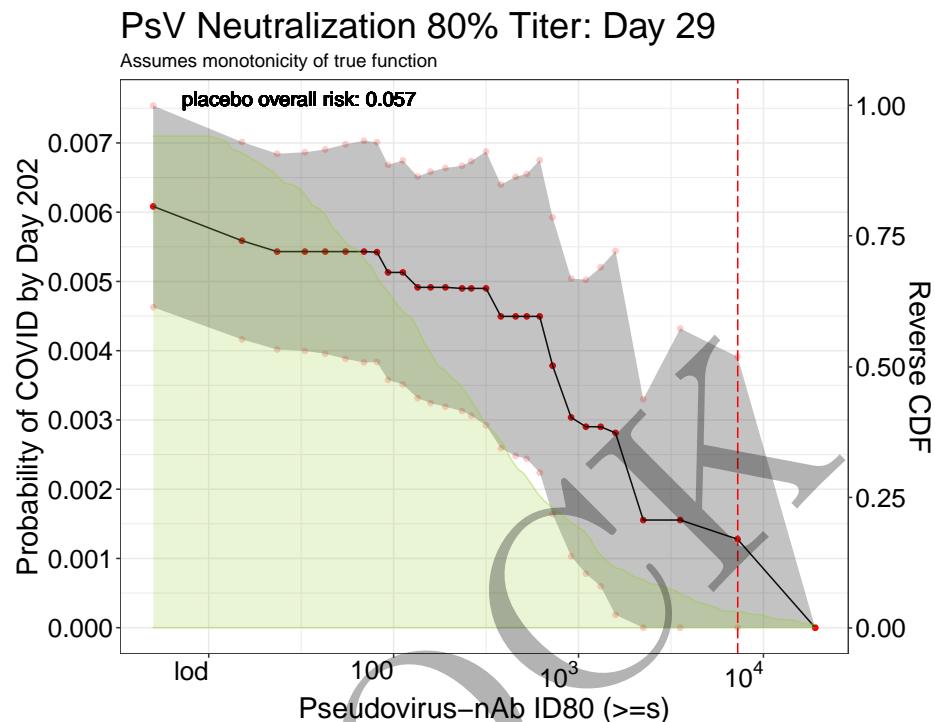


Figure 5.16: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00463	0.00754
1.525	$3.35 * 10^1$	0.00543	0.00400	0.00687
1.840	$6.92 * 10^1$	0.00543	0.00383	0.00703
2.049	$1.12 * 10^2$	0.00513	0.00351	0.00675
2.276	$1.89 * 10^2$	0.00491	0.00319	0.00664
2.583	$3.83 * 10^2$	0.00450	0.00259	0.00640
2.785	$6.10 * 10^2$	0.00450	0.00224	0.00675
3.039	$1.09 * 10^3$	0.00290	0.00078	0.00502
3.351	$2.24 * 10^3$	0.00155	0.00000	0.00330
4.285	$1.93 * 10^4$	0.00000	0.00000	NA

5.5 Plots and Tables with estimates and simultaneous confidence bands for Day 57

MOCK

5.5.1 Day 57 Spike protein binding antibody

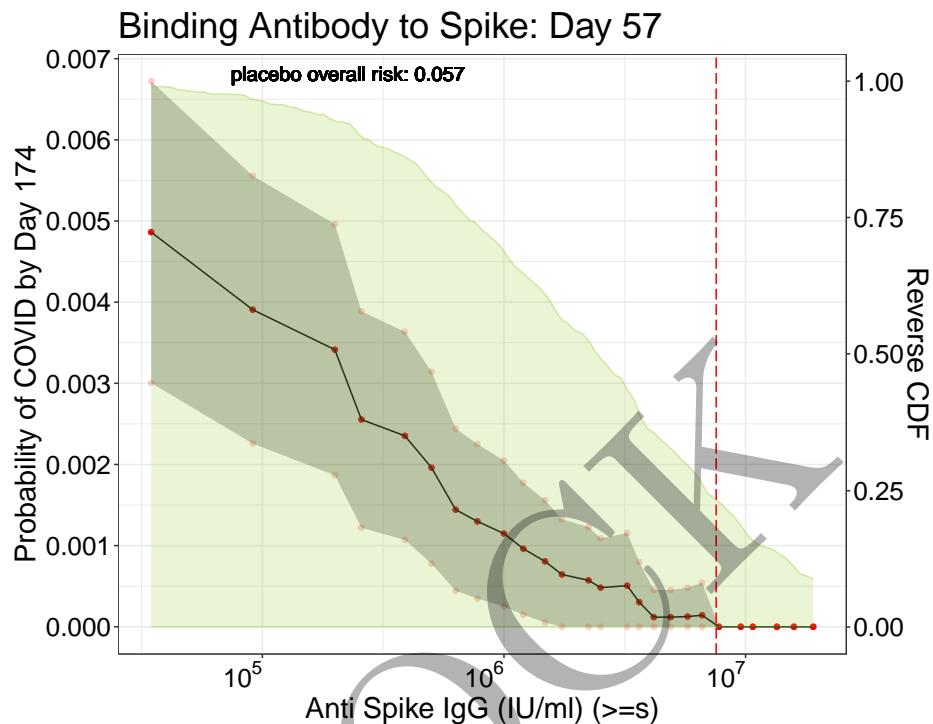


Figure 5.17: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.536	$3.44 * 10^4$	0.00486	0.00300	0.00672
5.413	$2.59 * 10^5$	0.00255	0.00122	0.00389
5.797	$6.27 * 10^5$	0.00144	0.00044	0.00244
5.996	$9.91 * 10^5$	0.00115	0.00025	0.00205
6.244	$1.75 * 10^6$	0.00064	0.00000	0.00132
6.508	$3.22 * 10^6$	0.00051	0.00000	0.00115
6.694	$4.94 * 10^6$	0.00012	0.00000	0.00045
6.820	$6.61 * 10^6$	0.00014	0.00000	0.00054
7.028	$1.07 * 10^7$	0.00000	0.00000	NA
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.5.2 Day 57 RBD binding antibody

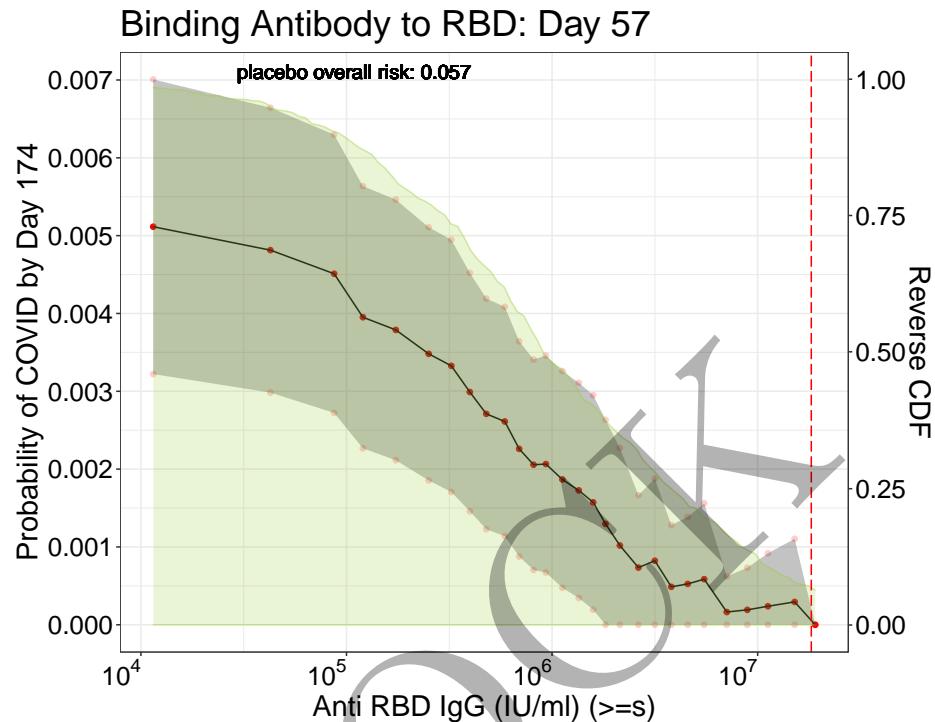


Figure 5.18: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.062	1.15×10^4	0.00511	0.00322	0.00701
5.085	1.22×10^5	0.00395	0.00227	0.00564
5.507	3.21×10^5	0.00333	0.00171	0.00495
5.771	5.90×10^5	0.00261	0.00114	0.00408
5.966	9.25×10^5	0.00207	0.00067	0.00346
6.195	1.57×10^6	0.00157	0.00020	0.00295
6.420	2.63×10^6	0.00073	0.00000	0.00167
6.664	4.61×10^6	0.00052	0.00000	0.00139
6.949	8.89×10^6	0.00019	0.00000	0.00073
7.282	1.91×10^7	0.00000	0.00000	NA

5.5.3 Day 57 Pseudo virus-neutralizing antibody (50% titer)

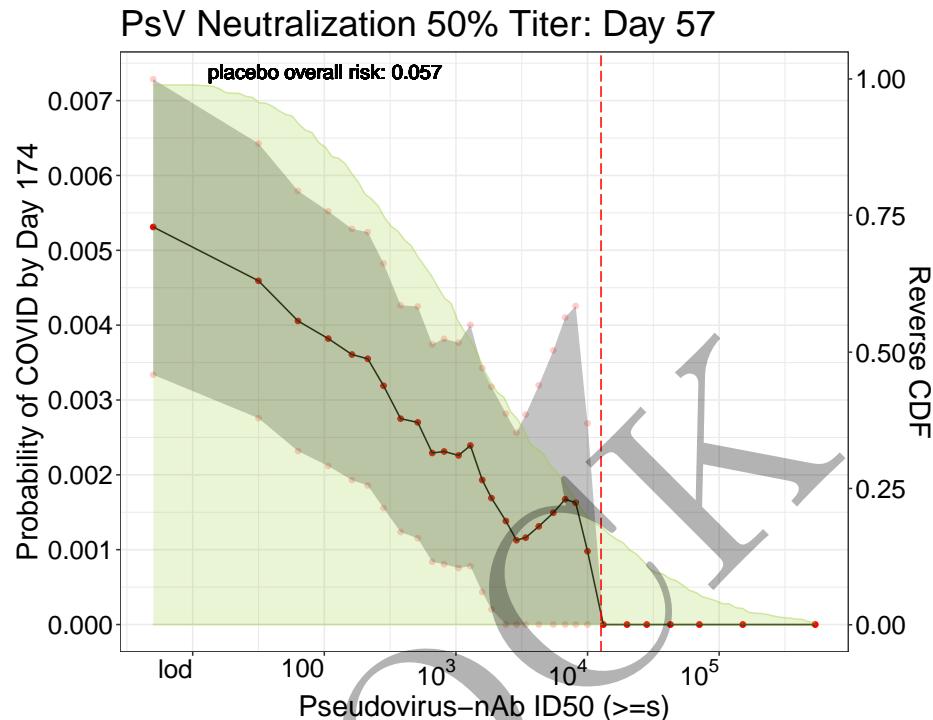


Figure 5.19: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	5.00 * 10 ⁰	0.00531	0.00334	0.00729
2.033	1.08 * 10 ²	0.00382	0.00212	0.00552
2.447	2.80 * 10 ²	0.00319	0.00156	0.00482
2.913	8.18 * 10 ²	0.00231	0.00081	0.00382
3.196	1.57 * 10 ³	0.00193	0.00044	0.00343
3.464	2.91 * 10 ³	0.00113	0.00000	0.00256
3.736	5.45 * 10 ³	0.00149	0.00000	0.00366
4.123	1.33 * 10 ⁴	0.00000	0.00000	NA
4.629	4.26 * 10 ⁴	0.00000	0.00000	NA
5.730	5.37 * 10 ⁵	0.00000	0.00000	NA

5.5.4 Day 57 Pseudo virus-neutralizing antibody (80% titer)

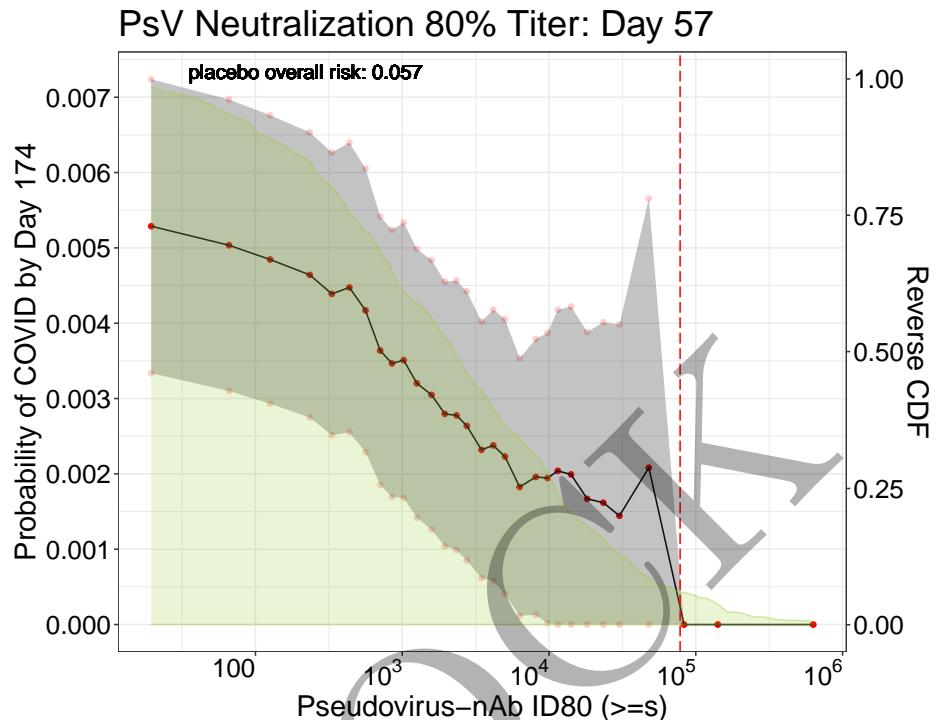


Figure 5.20: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.289	1.95×10^1	0.00529	0.00334	0.00724
2.368	2.33×10^2	0.00464	0.00275	0.00653
2.755	5.69×10^2	0.00417	0.00229	0.00605
3.104	1.27×10^3	0.00320	0.00142	0.00498
3.373	2.36×10^3	0.00278	0.00099	0.00457
3.624	4.21×10^3	0.00238	0.00058	0.00418
3.909	8.11×10^3	0.00196	0.00013	0.00379
4.259	1.82×10^4	0.00167	0.00000	0.00388
4.676	4.74×10^4	0.00208	0.00000	0.00565
5.796	6.25×10^5	0.00000	0.00000	NA

5.6 Plots and Tables with estimates and simultaneous confidence bands for Day 29

MOCK

5.6.1 Day 29 Spike protein antibody

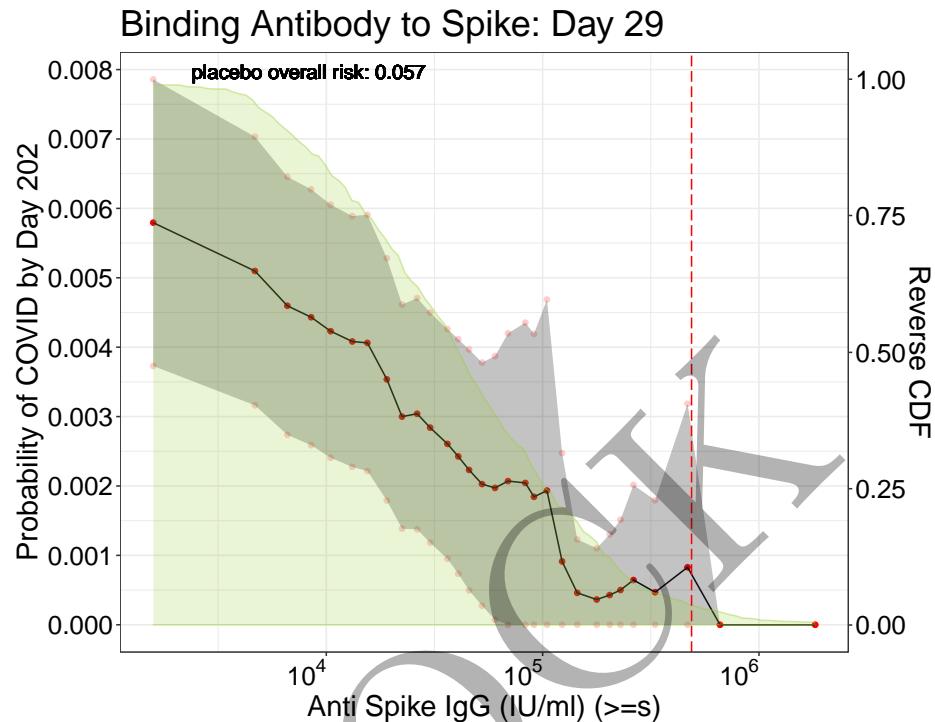


Figure 5.21: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
3.202	$1.59 * 10^3$	0.00579	0.00373	0.00786
3.926	$8.43 * 10^3$	0.00443	0.00259	0.00627
4.187	$1.54 * 10^4$	0.00406	0.00222	0.00591
4.478	$3.01 * 10^4$	0.00284	0.00118	0.00450
4.658	$4.55 * 10^4$	0.00223	0.00049	0.00397
4.841	$6.93 * 10^4$	0.00207	0.00000	0.00420
5.022	$1.05 * 10^5$	0.00193	0.00000	0.00469
5.310	$2.04 * 10^5$	0.00043	0.00000	0.00130
5.523	$3.33 * 10^5$	0.00047	0.00000	0.00179
6.259	$1.82 * 10^6$	0.00000	0.00000	NA

5.6.2 Day 29 RBD binding antibody

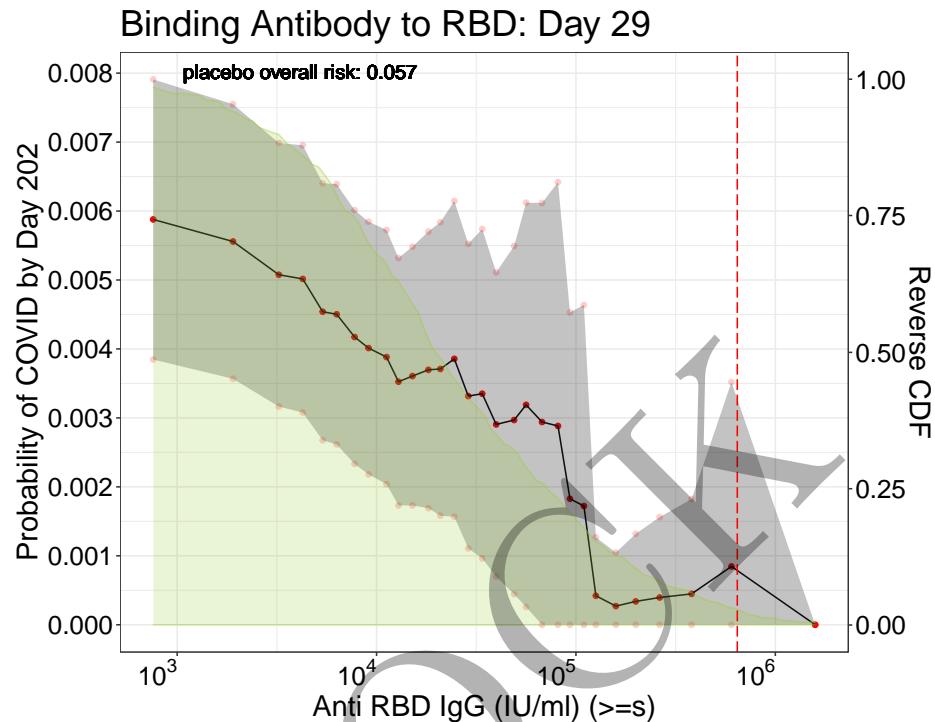


Figure 5.22: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.882	7.62×10^2	0.00588	0.00385	0.00791
3.628	4.25×10^3	0.00502	0.00308	0.00695
3.889	7.74×10^3	0.00417	0.00233	0.00601
4.180	1.51×10^4	0.00361	0.00173	0.00548
4.395	2.48×10^4	0.00386	0.00157	0.00615
4.603	4.01×10^4	0.00291	0.00070	0.00511
4.826	6.70×10^4	0.00294	0.00000	0.00612
5.105	1.27×10^5	0.00042	0.00000	0.00127
5.422	2.64×10^5	0.00040	0.00000	0.00156
6.197	1.57×10^6	0.00000	0.00000	NA

5.6.3 Day 29 Pseudo virus-neutralizing antibody (50% titer)

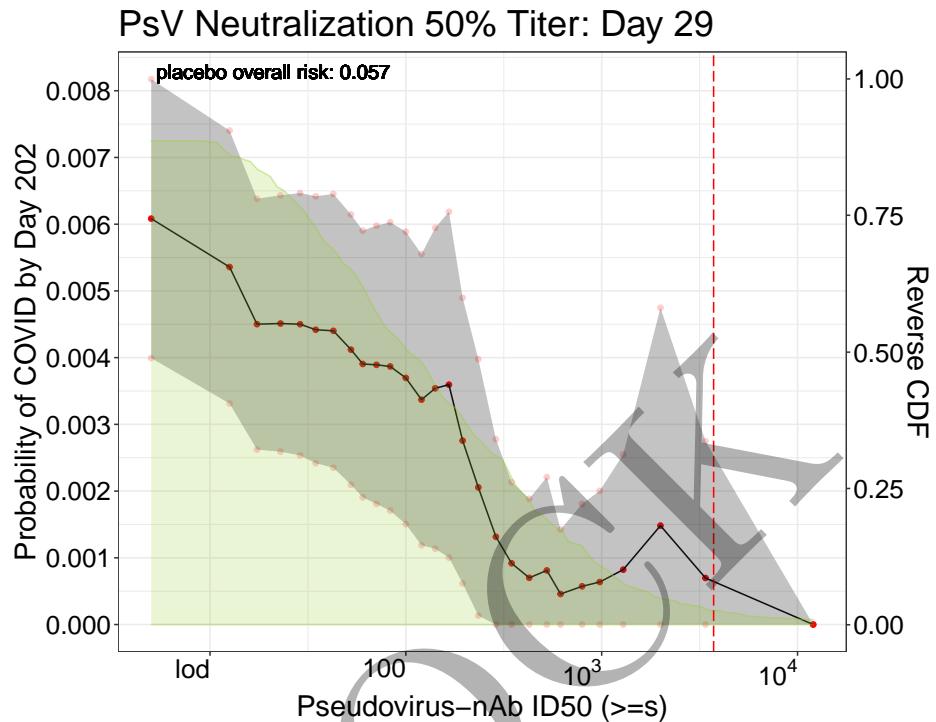


Figure 5.23: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00399	0.00817
1.363	$2.31 * 10^1$	0.00451	0.00259	0.00643
1.628	$4.25 * 10^1$	0.00440	0.00235	0.00645
1.848	$7.05 * 10^1$	0.00389	0.00181	0.00598
2.078	$1.20 * 10^2$	0.00337	0.00119	0.00555
2.293	$1.96 * 10^2$	0.00276	0.00062	0.00490
2.537	$3.44 * 10^2$	0.00092	0.00000	0.00213
2.791	$6.18 * 10^2$	0.00046	0.00000	0.00142
3.109	$1.29 * 10^3$	0.00082	0.00000	0.00255
4.080	$1.20 * 10^4$	0.00000	0.00000	NA

5.6.4 Day 29 Pseudo virus-neutralizing antibody (80% titer)

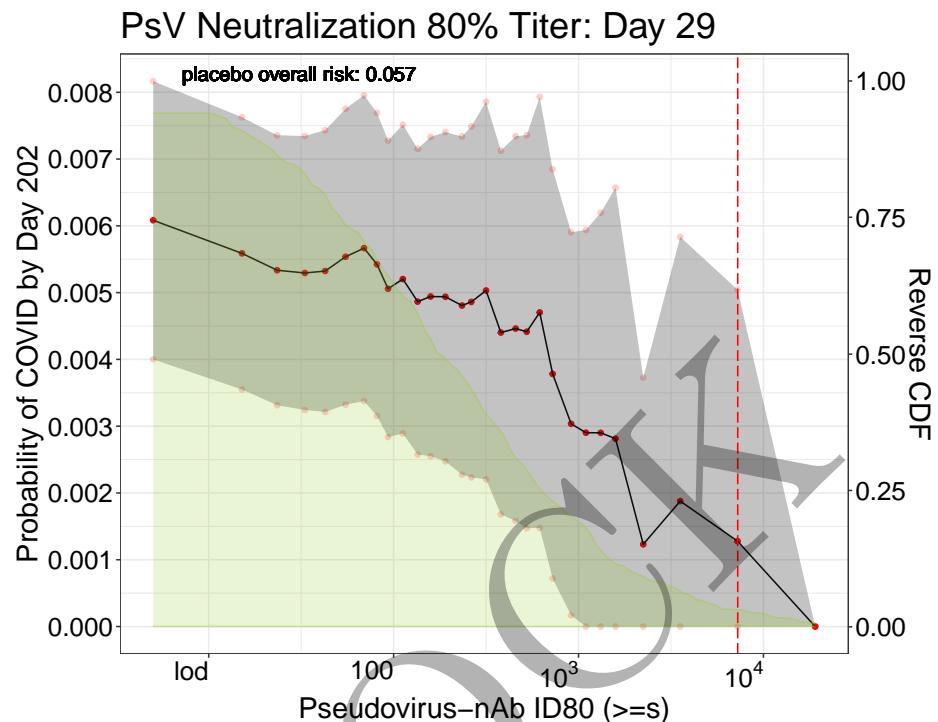


Figure 5.24: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	5.00×10^0	0.00608	0.00400	0.00817
1.525	3.35×10^1	0.00529	0.00324	0.00734
1.840	6.92×10^1	0.00567	0.00338	0.00796
2.049	1.12×10^2	0.00520	0.00289	0.00751
2.276	1.89×10^2	0.00494	0.00247	0.00740
2.583	3.83×10^2	0.00440	0.00168	0.00712
2.785	6.10×10^2	0.00470	0.00148	0.00793
3.039	1.09×10^3	0.00290	0.00000	0.00594
3.351	2.24×10^3	0.00123	0.00000	0.00373
4.285	1.93×10^4	0.00000	0.00000	NA

5.7 Plots and Tables with estimates and pointwise confidence interval for Day 57 (monotone-corrected)

MOCK

5.7.1 Day 57 Spike protein binding antibody

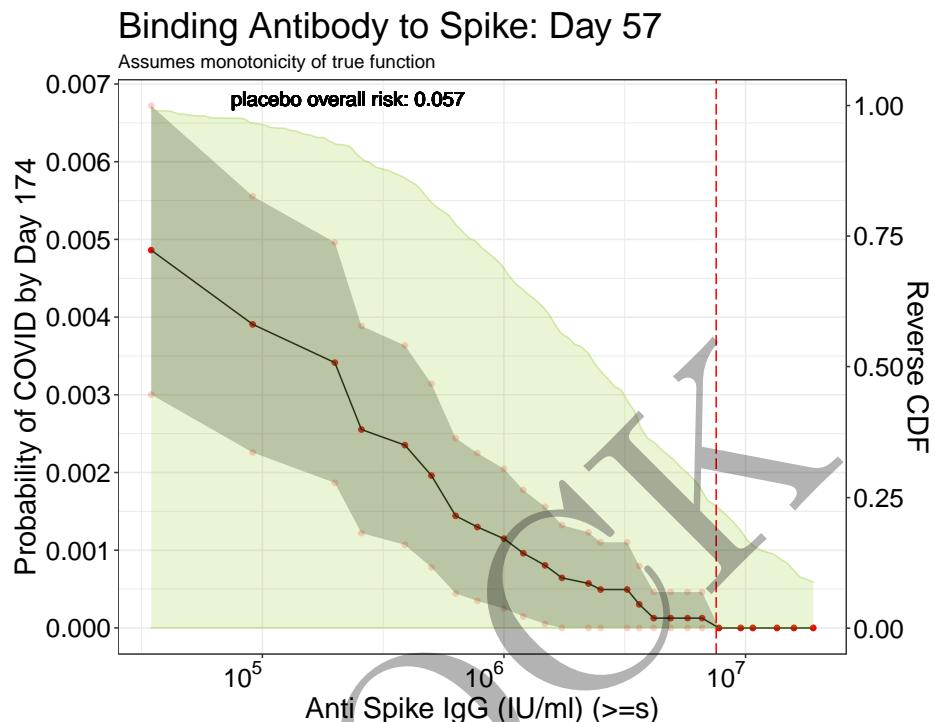


Figure 5.25: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.536	$3.44 * 10^4$	0.00486	0.00300	0.00672
5.413	$2.59 * 10^5$	0.00255	0.00122	0.00389
5.797	$6.27 * 10^5$	0.00144	0.00044	0.00244
5.996	$9.91 * 10^5$	0.00115	0.00025	0.00205
6.244	$1.75 * 10^6$	0.00064	0.00000	0.00132
6.508	$3.22 * 10^6$	0.00049	0.00000	0.00114
6.694	$4.94 * 10^6$	0.00013	0.00000	0.00046
6.820	$6.61 * 10^6$	0.00013	0.00000	0.00053
7.028	$1.07 * 10^7$	0.00000	0.00000	NA
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.7.2 Day 57 RBD binding antibody

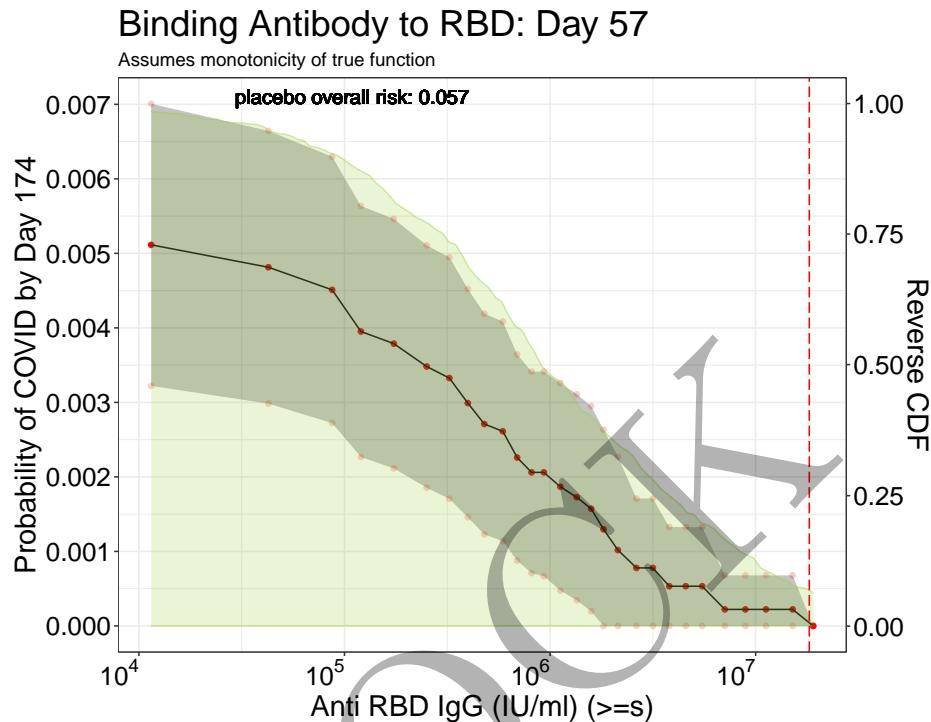


Figure 5.26: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
4.062	$1.15 * 10^4$	0.00511	0.00322	0.00701
5.085	$1.22 * 10^5$	0.00395	0.00227	0.00564
5.507	$3.21 * 10^5$	0.00333	0.00171	0.00495
5.771	$5.90 * 10^5$	0.00261	0.00114	0.00408
5.966	$9.25 * 10^5$	0.00206	0.00067	0.00345
6.195	$1.57 * 10^6$	0.00157	0.00020	0.00295
6.420	$2.63 * 10^6$	0.00078	0.00000	0.00171
6.664	$4.61 * 10^6$	0.00053	0.00000	0.00139
6.949	$8.89 * 10^6$	0.00022	0.00000	0.00076
7.282	$1.91 * 10^7$	0.00000	0.00000	NA

5.7.3 Day 57 Pseudo virus-neutralizing antibody (50% titer)

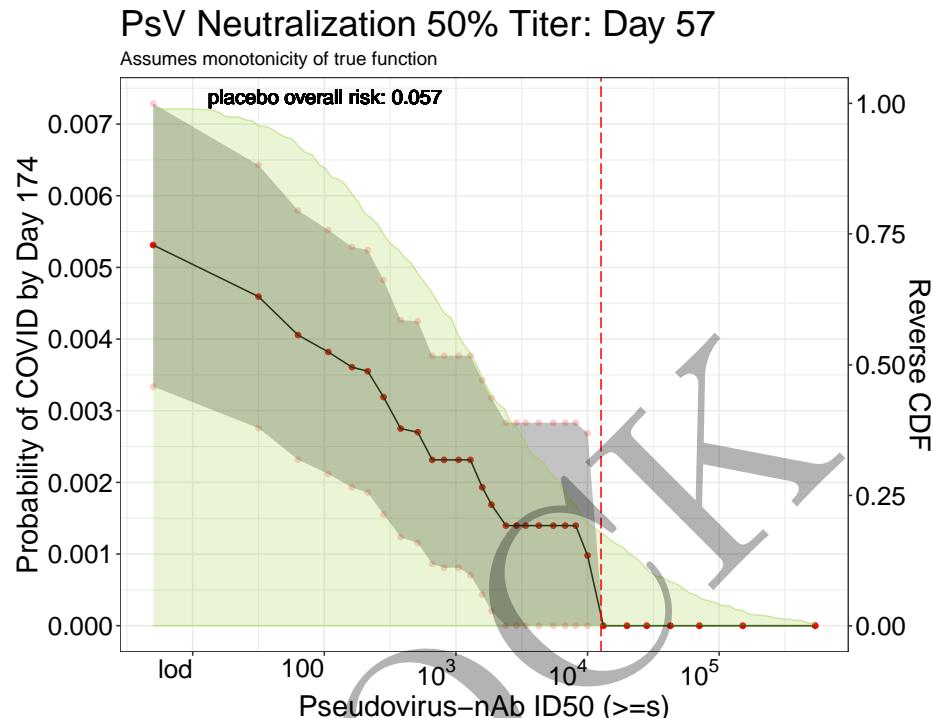


Figure 5.27: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00531	0.00334	0.00729
2.033	$1.08 * 10^2$	0.00382	0.00212	0.00552
2.447	$2.80 * 10^2$	0.00319	0.00156	0.00482
2.913	$8.18 * 10^2$	0.00231	0.00081	0.00382
3.196	$1.57 * 10^3$	0.00193	0.00044	0.00343
3.464	$2.91 * 10^3$	0.00140	0.00000	0.00283
3.736	$5.45 * 10^3$	0.00140	0.00000	0.00357
4.123	$1.33 * 10^4$	0.00000	0.00000	NA
4.629	$4.26 * 10^4$	0.00000	0.00000	NA
5.730	$5.37 * 10^5$	0.00000	0.00000	NA

5.7.4 Day 57 Pseudo virus-neutralizing antibody (80% titer)

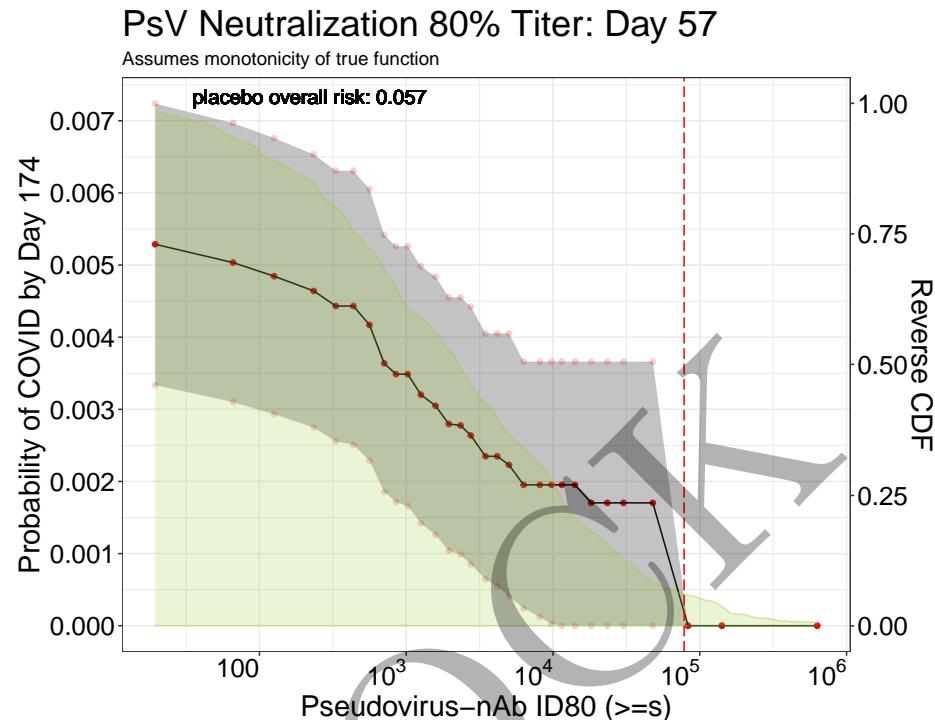


Figure 5.28: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.289	1.95×10^1	0.00529	0.00334	0.00724
2.368	2.33×10^2	0.00464	0.00275	0.00653
2.755	5.69×10^2	0.00417	0.00229	0.00605
3.104	1.27×10^3	0.00320	0.00142	0.00498
3.373	2.36×10^3	0.00278	0.00099	0.00457
3.624	4.21×10^3	0.00235	0.00055	0.00415
3.909	8.11×10^3	0.00195	0.00012	0.00378
4.259	1.82×10^4	0.00170	0.00000	0.00392
4.676	4.74×10^4	0.00170	0.00000	0.00527
5.796	6.25×10^5	0.00000	0.00000	NA

5.8 Plots and Tables with estimates and pointwise confidence intervals for Day 29 (monotone-corrected)

MOCK

5.8.1 Day 29 Spike protein antibody

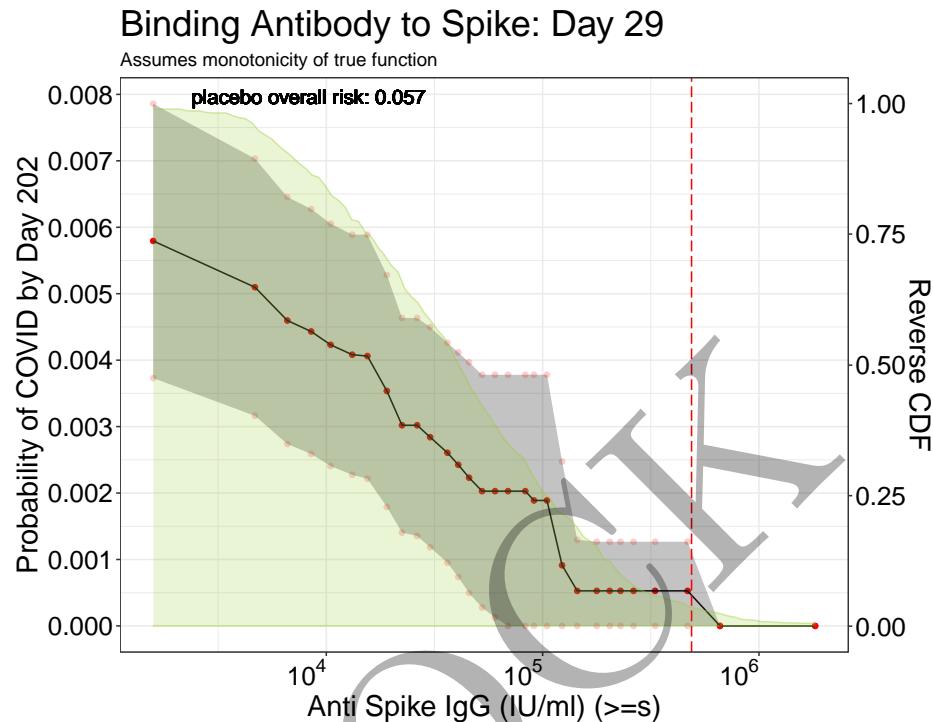


Figure 5.29: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
3.202	1.59×10^3	0.00579	0.00373	0.00786
3.926	8.43×10^3	0.00443	0.00259	0.00627
4.187	1.54×10^4	0.00406	0.00222	0.00591
4.478	3.01×10^4	0.00284	0.00118	0.00450
4.658	4.55×10^4	0.00223	0.00049	0.00397
4.841	6.93×10^4	0.00203	0.00000	0.00416
5.022	1.05×10^5	0.00189	0.00000	0.00464
5.310	2.04×10^5	0.00053	0.00000	0.00140
5.523	3.33×10^5	0.00053	0.00000	0.00185
6.259	1.82×10^6	0.00000	0.00000	NA

5.8.2 Day 29 RBD binding antibody

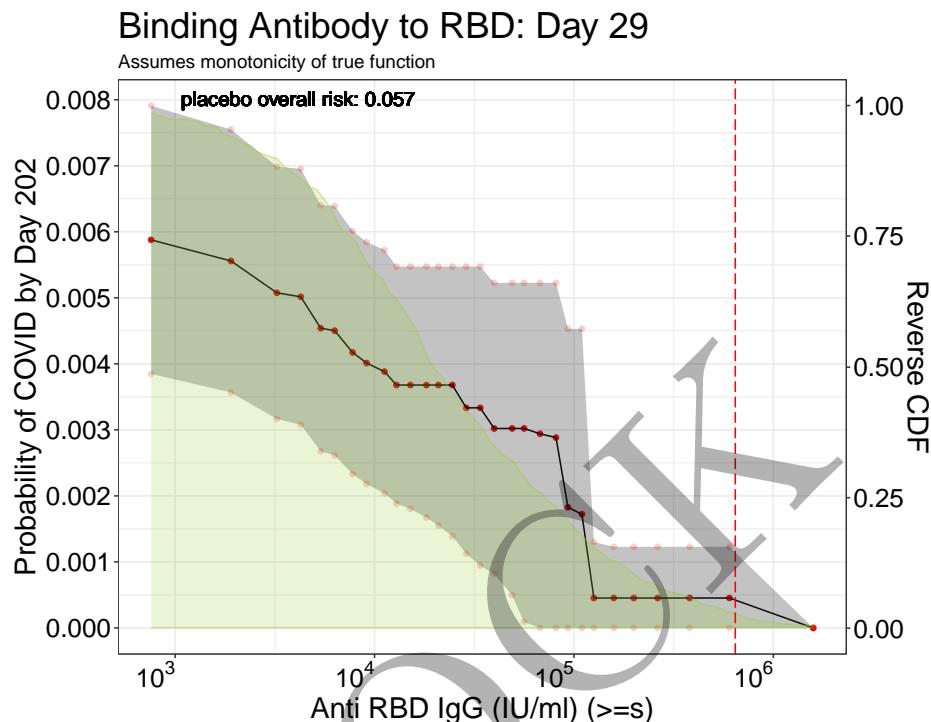


Figure 5.30: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.882	7.62×10^2	0.00588	0.00385	0.00791
3.628	4.25×10^3	0.00502	0.00308	0.00695
3.889	7.74×10^3	0.00417	0.00233	0.00601
4.180	1.51×10^4	0.00368	0.00180	0.00556
4.395	2.48×10^4	0.00368	0.00139	0.00597
4.603	4.01×10^4	0.00302	0.00082	0.00523
4.826	6.70×10^4	0.00294	0.00000	0.00612
5.105	1.27×10^5	0.00045	0.00000	0.00130
5.422	2.64×10^5	0.00045	0.00000	0.00162
6.197	1.57×10^6	0.00000	0.00000	NA

5.8.3 Day 29 Pseudo virus-neutralizing antibody (50% titer)

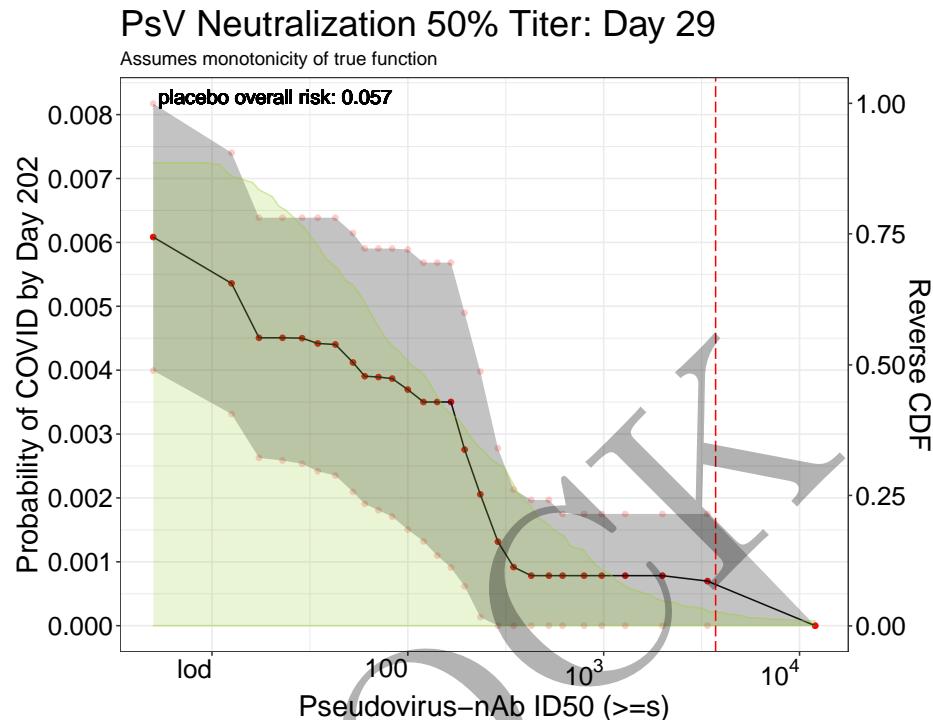


Figure 5.31: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	$5.00 * 10^0$	0.00608	0.00399	0.00817
1.363	$2.31 * 10^1$	0.00451	0.00259	0.00643
1.628	$4.25 * 10^1$	0.00440	0.00235	0.00645
1.848	$7.05 * 10^1$	0.00389	0.00181	0.00598
2.078	$1.20 * 10^2$	0.00350	0.00132	0.00568
2.293	$1.96 * 10^2$	0.00276	0.00062	0.00490
2.537	$3.44 * 10^2$	0.00092	0.00000	0.00213
2.791	$6.18 * 10^2$	0.00078	0.00000	0.00175
3.109	$1.29 * 10^3$	0.00078	0.00000	0.00251
4.080	$1.20 * 10^4$	0.00000	0.00000	NA

5.8.4 Day 29 Pseudo virus-neutralizing antibody (80% titer)

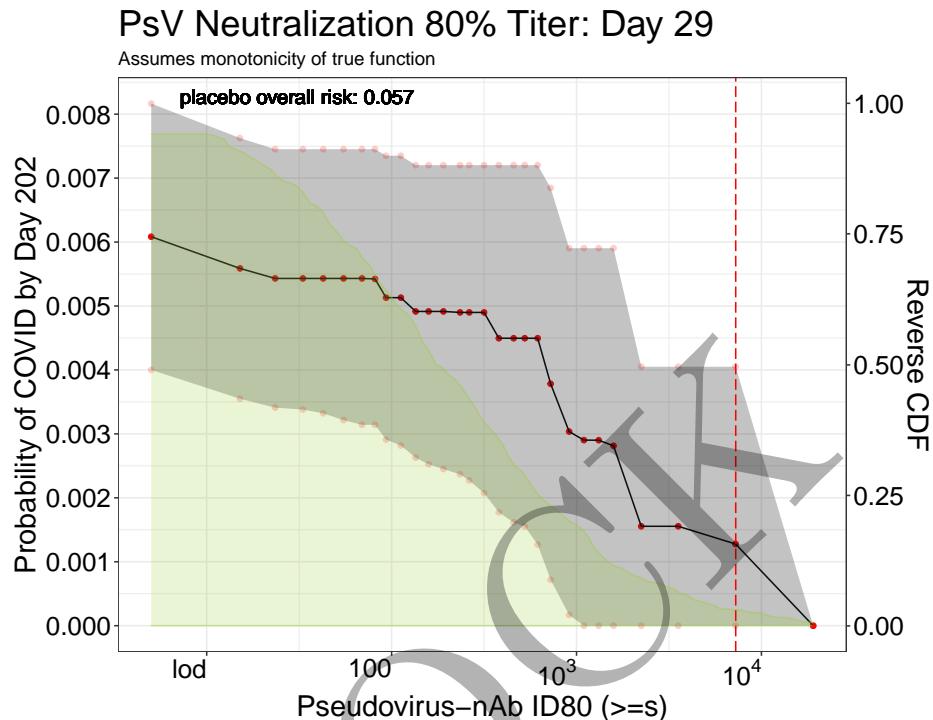


Figure 5.32: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table of monotone-corrected risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.699	5.00×10^0	0.00608	0.00400	0.00817
1.525	3.35×10^1	0.00543	0.00338	0.00748
1.840	6.92×10^1	0.00543	0.00314	0.00772
2.049	1.12×10^2	0.00513	0.00282	0.00744
2.276	1.89×10^2	0.00491	0.00245	0.00738
2.583	3.83×10^2	0.00450	0.00177	0.00722
2.785	6.10×10^2	0.00450	0.00127	0.00772
3.039	1.09×10^3	0.00290	0.00000	0.00594
3.351	2.24×10^3	0.00155	0.00000	0.00405
4.285	1.93×10^4	0.00000	0.00000	NA