

COVID-19 Correlates of Risk Analysis Report
MockCOVE Study

USG COVID-19 Response Biostatistics Team

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Chapter 1

Disclaimers

- The data presented in the analysis originated from the Moderna Sponsored mRNA-1273-P301 clinical study and are provided to NIAID in accordance with Clinical Trial Agreement between the parties. The study was funded in part by BARDA under Government Contract No. 75A50120C00034
- The preliminary immunogenicity data presented here do not reflect the Sponsors statistical analysis plan and therefore should not be interpreted as a protocol defined read-out of the clinical study.
- These data are not to be disclosed without written permission of Moderna.

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Chapter 2

Summary Tables

2.1 Demographic and Clinical Characteristics at Baseline in the Baseline SARS-CoV-2 Negative Per-Protocol Cohort

Table 1. Demographic and Clinical Characteristics at Baseline in the Baseline SARS-CoV-2 Negative Per-Protocol Cohort

Characteristics	Vaccine (N = 747)	Placebo (N = 138)	Total (N = 885)
Age			
Age < 65	357 (47.8%)	72 (52.2%)	429 (48.5%)
Age ≥ 65	390 (52.2%)	66 (47.8%)	456 (51.5%)
Mean (Range)	58.5 (18.0, 85.0)	58.3 (18.0, 85.0)	58.5 (18.0, 85.0)
BMI			
Mean ± SD	29.7 ± 6.6	31.4 ± 6.3	30.0 ± 6.6
Risk for Severe Covid-19			
At-risk	381 (51.0%)	71 (51.4%)	452 (51.1%)
Not at-risk	366 (49.0%)	67 (48.6%)	433 (48.9%)
Age, Risk for Severe Covid-19			
Age < 65 At-risk	185 (24.8%)	36 (26.1%)	221 (25.0%)
Age < 65 Not at-risk	172 (23.0%)	36 (26.1%)	208 (23.5%)
Age ≥ 65	390 (52.2%)	66 (47.8%)	456 (51.5%)
Sex			
Female	427 (57.2%)	75 (54.3%)	502 (56.7%)
Male	320 (42.8%)	63 (45.7%)	383 (43.3%)
Hispanic or Latino ethnicity			
Hispanic or Latino	99 (13.3%)	20 (14.5%)	119 (13.4%)
Not Hispanic or Latino	623 (83.4%)	113 (81.9%)	736 (83.2%)
Not reported and unknown	25 (3.3%)	5 (3.6%)	30 (3.4%)
Race			
White	397 (53.1%)	74 (53.6%)	471 (53.2%)
Black or African American	184 (24.6%)	40 (29.0%)	224 (25.3%)
Asian	56 (7.5%)	10 (7.2%)	66 (7.5%)
American Indian or Alaska Native	16 (2.1%)	2 (1.4%)	18 (2.0%)
Native Hawaiian or Other Pacific Islander	17 (2.3%)	2 (1.4%)	19 (2.1%)

(continued)

Characteristics	Vaccine (N = 747)	Placebo (N = 138)	Total (N = 885)
Multiracial	57 (7.6%)	8 (5.8%)	65 (7.3%)
Other	16 (2.1%)	1 (0.7%)	17 (1.9%)
Not reported and unknown	4 (0.5%)	1 (0.7%)	5 (0.6%)
White Non-Hispanic	370 (49.5%)	63 (45.7%)	433 (48.9%)
Communities of Color	377 (50.5%)	75 (54.3%)	452 (51.1%)

This table summarizes the random subcohort, which was randomly sampled from the per-protocol cohort. The sampling was stratified by 24 strata defined by enrollment characteristics: Assigned treatment arm × Baseline SARS-CoV-2 naïve vs. non-naïve status (defined by serostatus and NAAT testing) × Randomization strata (Age < 65 and at-risk, Age < 65 and not at-risk, Age ≥ 65) × Communities of color (Yes/No) defined by White Non-Hispanic vs. all others (following the primary COVE trial paper).

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2.2 Demographic and Clinical Characteristics at Baseline in the Baseline SARS-CoV-2 Positive Per-Protocol Cohort

Table 2. Demographic and Clinical Characteristics at Baseline in the Baseline SARS-CoV-2 Positive Per-Protocol Cohort

Characteristics	Vaccine (N = 234)	Placebo (N = 241)	Total (N = 475)
Age			
Age < 65	114 (48.7%)	120 (49.8%)	234 (49.3%)
Age ≥ 65	120 (51.3%)	121 (50.2%)	241 (50.7%)
Mean (Range)	58.3 (18.0, 85.0)	56.3 (18.0, 85.0)	57.3 (18.0, 85.0)
BMI			
Mean ± SD	29.7 ± 7.5	30.0 ± 6.6	29.9 ± 7.0
Risk for Severe Covid-19			
At-risk	111 (47.4%)	117 (48.5%)	228 (48.0%)
Not at-risk	123 (52.6%)	124 (51.5%)	247 (52.0%)
Age, Risk for Severe Covid-19			
Age < 65 At-risk	56 (23.9%)	59 (24.5%)	115 (24.2%)
Age < 65 Not at-risk	58 (24.8%)	61 (25.3%)	119 (25.1%)
Age ≥ 65	120 (51.3%)	121 (50.2%)	241 (50.7%)
Sex			
Female	139 (59.4%)	133 (55.2%)	272 (57.3%)
Male	95 (40.6%)	108 (44.8%)	203 (42.7%)
Hispanic or Latino ethnicity			
Hispanic or Latino	31 (13.2%)	34 (14.1%)	65 (13.7%)
Not Hispanic or Latino	194 (82.9%)	201 (83.4%)	395 (83.2%)
Not reported and unknown	9 (3.8%)	6 (2.5%)	15 (3.2%)
Race			
White	126 (53.8%)	129 (53.5%)	255 (53.7%)
Black or African American	58 (24.8%)	45 (18.7%)	103 (21.7%)
Asian	19 (8.1%)	27 (11.2%)	46 (9.7%)
American Indian or Alaska Native	10 (4.3%)	7 (2.9%)	17 (3.6%)
Native Hawaiian or Other Pacific Islander	4 (1.7%)	2 (0.8%)	6 (1.3%)
Multiracial	10 (4.3%)	16 (6.6%)	26 (5.5%)
Other	7 (3.0%)	13 (5.4%)	20 (4.2%)
Not reported and unknown		2 (0.8%)	2 (0.4%)
White Non-Hispanic	118 (50.4%)	121 (50.2%)	239 (50.3%)
Communities of Color	116 (49.6%)	120 (49.8%)	236 (49.7%)

This table summarizes the random subcohort, which was randomly sampled from the per-protocol cohort. The sampling was stratified by 24 strata defined by enrollment characteristics: Assigned treatment arm × Baseline SARS-CoV-2 naïve vs. non-naïve status (defined by serostatus and NAAT testing) × Randomization strata (Age < 65 and at-risk, Age < 65 and not at-risk, Age ≥ 65) × Communities of color (Yes/No) defined by White Non-Hispanic vs. all others (following the primary COVE trial paper).

2.3 Sample Sizes of Baseline Strata for Correlates of Risk Analysis

Table 3. Sample Sizes of Baseline Strata for Correlates of Risk Analysis

Per-protocol Cases and Non-Cases (Moderna Trial)																		
	Baseline SARS-CoV-2 Negative									Baseline SARS-CoV-2 Positive								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Vaccine																		
Day 29 Cases	8	18	6	2	7	0	3	12	3	0	0	0	0	0	1	2	0	0
Day 57 Cases	8	18	4	2	7	0	1	9	3	0	0	0	0	0	1	2	0	0
Non-Cases	153	235	69	78	106	35	67	105	39	48	72	26	24	32	12	23	35	11
Placebo																		
Day 29 Cases	141	329	77	48	109	31	87	243	55	0	1	1	0	1	0	1	1	0
Day 57 Cases	132	306	72	37	93	27	61	198	42	0	1	1	0	1	0	1	1	0
Non-Cases	21	34	9	16	16	2	16	18	3	43	77	32	19	39	16	22	38	9

Demographic covariate strata:

- | | |
|----------------------------------|--------------------------------------|
| 1. Age \geq 65 Minority | 6. Age < 65 At-risk Unknown |
| 2. Age \geq 65 Non-Minority | 7. Age < 65 Not At-risk Minority |
| 3. Age \geq 65 Unknown | 8. Age < 65 Not At-risk Non-Minority |
| 4. Age < 65 At-risk Minority | 9. Age < 65 Not At-risk Unknown |
| 5. Age < 65 At-risk Non-Minority | |

Minority includes Blacks or African Americans, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders.

Non-Minority includes all other races with observed race (Asian, Multiracial, White, Other) and observed ethnicity Not Hispanic or Latino.

Unknown includes unknown, unreported race or ethnicity.

Cases for Day 29 marker correlates analyses are per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 29 study visit. Cases for Day 57 marker correlates analyses are per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 57 study visit. Non-cases are per-protocol participants sampled into the random subcohort with no COVID primary endpoint up to the time of data cut and no evidence of SARS-CoV-2 infection up to six days post Day 57 visit.

The table shows the numbers of cases sampled into the subcohort within baseline covariate strata.

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

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

Visit	Marker	Baseline SARS-CoV-2 Negative Vaccine Recipients						Comparison	
		Cases*		Non-Cases/Control		Resp Rate Difference	GMTR/GMCR		
N	Resp rate	N	Resp rate	GMT/GMC					
Day 29	Pseudovirus-nAb ID80	59	35.6/60 = 59.3% (46.2%, 71.3%)	21.18 (17.33, 25.87)	744	6530.6/11070 = 59.0% (54.4%, 63.4%)	25.97 (23.98, 28.13)	0 (-0.14, 0.13)	0.82 (0.66, 1.01)
Day 29	Pseudovirus-nAb ID50	59	53.9/60 = 89.8% (78.9%, 95.4%)	16.19 (12.51, 20.95)	744	9932/11070 = 89.7% (86.2%, 92.4%)	17.35 (15.85, 18.99)	0 (-0.11, 0.07)	0.93 (0.71, 1.23)
Day 29	Anti RBD IgG (IU/ml)	59	60/60 = 100.0% (100.0%, 100.0%)	456.66 (292.67, 712.53)	744	10896.8/11070 = 98.4% (96.6%, 99.3%)	473.53 (412.98, 542.96)	0.02 (0.01, 0.03)	0.96 (0.61, 1.54)
Day 29	Anti Spike IgG (IU/ml)	59	60/60 = 100.0% (100.0%, 100.0%)	236.57 (169.47, 330.25)	744	10981.5/11070 = 99.2% (97.7%, 99.7%)	266.03 (238.38, 296.89)	0.01 (0, 0.02)	0.89 (0.63, 1.26)
Day 29	Anti N IgG (IU/ml)	59	35.6/60 = 59.3% (46.2%, 71.3%)	39.18 (24.94, 61.55)	744	6848.9/11070 = 61.9% (57.3%, 66.2%)	36.77 (31.08, 43.49)	-0.03 (-0.16, 0.1)	1.07 (0.66, 1.73)
Day 57	Pseudovirus-nAb ID80	52	52/52 = 100.0% (100.0%, 100.0%)	408.70 (310.06, 538.71)	744	11065/11065 = 100.0% (100.0%, 100.0%)	564.67 (511.70, 623.12)	0 (0, 0)	0.72 (0.54, 0.97)
Day 57	Pseudovirus-nAb ID50	52	52/52 = 100.0% (100.0%, 100.0%)	320.14 (230.41, 444.83)	744	11065/11065 = 100.0% (100.0%, 100.0%)	427.25 (383.62, 475.84)	0 (0, 0)	0.75 (0.53, 1.06)
Day 57	Anti RBD IgG (IU/ml)	52	52/52 = 100.0% (100.0%, 100.0%)	3325.76 (2232.06, 4955.38)	744	11045.2/11065 = 99.8% (98.7%, 100.0%)	3599.25 (3171.86, 4084.22)	0 (0, 0.01)	0.92 (0.61, 1.40)
Day 57	Anti Spike IgG (IU/ml)	52	52/52 = 100.0% (100.0%, 100.0%)	1847.33 (1337.98, 2550.57)	744	11065/11065 = 100.0% (100.0%, 100.0%)	2668.40 (2364.64, 3011.17)	0 (0, 0)	0.69 (0.49, 0.98)

Day	Anti N IgG (IU/ml)	52	$37/52 = 71.2\%$ (57.2%, 82.0%)	71.78 (43.87, 117.44)	744	$8998.4/11065 = 81.3\%$ (77.3%, 84.8%)	110.30 (94.07, 129.33)	-0.1 (-0.25, 0.01)	0.65 (0.39, 1.09)
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Cases for Day 29 marker correlates analyses are baseline negative per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 29 study visit. Cases for Day 57 marker correlates analyses 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.

N is the number of cases sampled into the subcohort within baseline covariate strata.

The denominator in Resp Rate is the number of participants in the whole per-protocol cohort within baseline covariate strata, calculated using inverse probability weighting.



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

Table 5. 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	3	3.3/5 = 66.7% (0.6%, 99.8%)	28.17 (20.25, 39.20)	234	904.7/1218.1 = 74.3% (66.3%, 80.9%)	51.20 (44.64, 58.73)	-0.08 (-0.74, 0.27)	0.55 (0.38, 0.79)
Day 29	Pseudovirus-nAb ID50	3	5/5 = 100.0% (100.0%, 100.0%)	37.31 (35.33, 39.40)	234	1159.7/1218.1 = 95.2% (89.2%, 97.9%)	32.70 (28.11, 38.04)	0.05 (0.02, 0.11)	1.14 (0.97, 1.34)
Day 29	Anti RBD IgG (IU/ml)	3	5/5 = 100.0% (100.0%, 100.0%)	622.59 (124.89, 3103.56)	234	1213.5/1218.1 = 99.6% (97.3%, 99.9%)	823.96 (640.00, 1060.79)	0 (0, 0.03)	0.76 (0.15, 3.84)
Day 29	Anti Spike IgG (IU/ml)	3	5/5 = 100.0% (100.0%, 100.0%)	180.93 (156.70, 208.91)	234	1209.6/1218.1 = 99.3% (95.1%, 99.9%)	474.27 (397.60, 565.71)	0.01 (0, 0.05)	0.38 (0.30, 0.48)
Day 29	Anti N IgG (IU/ml)	3	5/5 = 100.0% (100.0%, 100.0%)	220.52 (99.97, 486.42)	234	928.1/1218.1 = 76.2% (68.6%, 82.4%)	70.68 (55.09, 90.70)	0.24 (0.18, 0.31)	3.12 (1.36, 7.15)
Day 57	Pseudovirus-nAb ID80	3	5/5 = 100.0% (100.0%, 100.0%)	1156.48 (486.62, 2748.44)	233	1229/1229 = 100.0% (100.0%, 100.0%)	1559.92 (1333.89, 1824.26)	0 (0, 0)	0.74 (0.31, 1.79)
Day 57	Pseudovirus-nAb ID50	3	5/5 = 100.0% (100.0%, 100.0%)	493.08 (319.26, 761.53)	233	1229/1229 = 100.0% (100.0%, 100.0%)	1227.59 (1000.73, 1505.88)	0 (0, 0)	0.40 (0.25, 0.65)
Day 57	Anti RBD IgG (IU/ml)	3	5/5 = 100.0% (100.0%, 100.0%)	15558.50 (14386.64, 16825.81)	233	1229/1229 = 100.0% (100.0%, 100.0%)	8619.19 (7266.78, 10223.28)	0 (0, 0)	1.81 (1.50, 2.18)
Day 57	Anti Spike IgG (IU/ml)	3	5/5 = 100.0% (100.0%, 100.0%)	4871.27 (3719.87, 6379.06)	233	1229/1229 = 100.0% (100.0%, 100.0%)	5665.25 (4956.22, 6475.72)	0 (0, 0)	0.86 (0.64, 1.16)

Day 57	Anti N IgG (IU/ml)	3	$5/5 = 100.0\%$ (100.0%, 100.0%)	293.21 (150.76, 570.25)	233	$1182.5/1229 = 96.2\%$ (90.6%, 98.5%)	248.12 (202.53, 303.97)	0.04 (0.01, 0.09)	1.18 (0.59, 2.37)
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The SAP does not specify correlates analyses in baseline positive vaccine recipients. This table summarizes descriptively the same information for baseline positive vaccine recipients that was summarized for baseline negative vaccine recipients. Cases for Day 29 markers are baseline positive per-protocol vaccine recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 29 study visit. Cases for Day 57 markers 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 positive per-protocol vaccine recipients sampled into the random subcohort with no COVID-19 endpoint diagnosis by the time of data-cut.

N is the number of cases sampled into the subcohort within baseline covariate strata.

The denominator in Resp Rate is the number of participants in the whole per-protocol cohort within baseline covariate strata, calculated using inverse probability weighting.



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

Table 6. Antibody levels in the baseline SARS-CoV-2 positive per-protocol cohort (placebo recipients)

Visit	Marker	Baseline SARS-CoV-2 Positive Placebo 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 3/5 = 60.0% (10.6%, 95.0%)	19.58 (9.63, 39.79)	238	442.9/1121 = 39.5% (32.4%, 47.1%)	20.38 (17.86, 23.27)	0.2 (-0.29, 0.56)	0.96 (0.47, 1.98)	
Day 29	Pseudovirus-nAb ID50	5 2/5 = 40.0% (5.0%, 89.4%)	4.46 (1.50, 13.28)	238	896.5/1121 = 80.0% (72.4%, 85.9%)	11.68 (9.90, 13.77)	-0.4 (-0.75, 0.1)	0.38 (0.13, 1.15)	
Day 29	Anti RBD IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	498.48 (77.45, 3208.22)	238	1060/1121 = 94.6% (88.4%, 97.5%)	306.92 (232.82, 404.62)	0.05 (0.02, 0.12)	1.62 (0.25, 10.67)	
Day 29	Anti Spike IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	266.06 (74.76, 946.84)	238	1085.9/1121 = 96.9% (91.9%, 98.8%)	170.13 (136.41, 212.19)	0.03 (0.01, 0.08)	1.56 (0.43, 5.67)	
Day 29	Anti N IgG (IU/ml)	5 3/5 = 60.0% (10.6%, 95.0%)	11.78 (2.03, 68.41)	238	603/1121 = 53.8% (45.9%, 61.5%)	26.96 (20.32, 35.77)	0.06 (-0.44, 0.42)	0.44 (0.07, 2.60)	
Day 57	Pseudovirus-nAb ID80	5 5/5 = 100.0% (100.0%, 100.0%)	288.29 (114.87, 723.51)	238	1119/1119 = 100.0% (100.0%, 100.0%)	462.73 (395.43, 541.48)	0 (0, 0)	0.62 (0.24, 1.58)	
Day 57	Pseudovirus-nAb ID50	5 5/5 = 100.0% (100.0%, 100.0%)	629.06 (128.64, 3076.16)	238	1119/1119 = 100.0% (100.0%, 100.0%)	313.97 (258.96, 380.65)	0 (0, 0)	2.00 (0.40, 9.91)	
Day 57	Anti RBD IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	1704.47 (253.44, 11462.91)	238	1119/1119 = 100.0% (100.0%, 100.0%)	2656.74 (2066.29, 3415.92)	0 (0, 0)	0.64 (0.09, 4.39)	
Day 57	Anti Spike IgG (IU/ml)	5 5/5 = 100.0% (100.0%, 100.0%)	1648.06 (332.52, 8168.38)	238	1119/1119 = 100.0% (100.0%, 100.0%)	1953.05 (1538.23, 2479.73)	0 (0, 0)	0.84 (0.17, 4.26)	
Day 57	Anti N IgG (IU/ml)	5 3/5 = 60.0% (10.6%, 95.0%)	49.66 (3.50, 703.93)	238	865.3/1119 = 77.3% (69.5%, 83.6%)	94.81 (70.11, 128.23)	-0.17 (-0.67, 0.19)	0.52 (0.04, 7.55)	

(continued)

Visit	Marker	N	Resp rate	GMT/GMC	N	Resp rate	GMT/GMC	Resp Rate Difference	GMTR/GMCR
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The SAP does not specify correlates analyses in baseline positive placebo recipients. This table summarizes descriptively the same information for baseline positive placebo recipients that was summarized for baseline negative and positive vaccine recipients. Cases for Day 29 markers are baseline positive per-protocol placebo recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 29 study visit. Cases for Day 57 markers are baseline positive per-protocol placebo recipients with the symptomatic infection COVID-19 primary endpoint diagnosed starting 7 days after the Day 57 study visit. Non-cases/Controls are baseline positive per-protocol placebo recipients sampled into the random subcohort with no COVID-19 endpoint diagnosis by the time of data-cut.

N is the number of cases sampled into the subcohort within baseline covariate strata.

The denominator in Resp Rate is the number of participants in the whole per-protocol cohort within baseline covariate strata, calculated using inverse probability weighting.

MOCK

Chapter 3

Graphical Descriptions of Antibody Marker Data

3.1 Boxplots

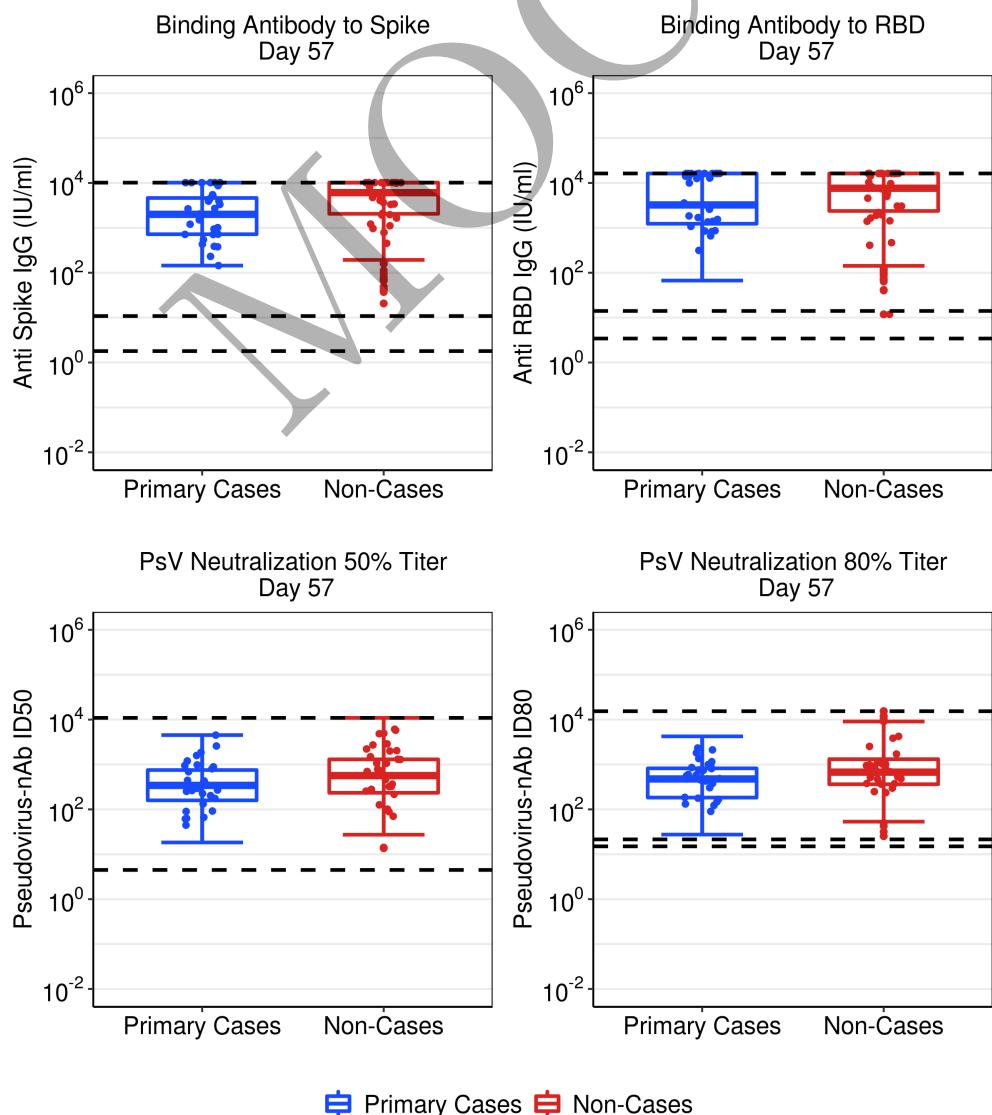


Figure 3.1: Boxplots of D57 Ab markers: vaccine arm. The three dashed lines in each figure are ULOQ, LLOQ, and LLOD, from top to bottom respectively.

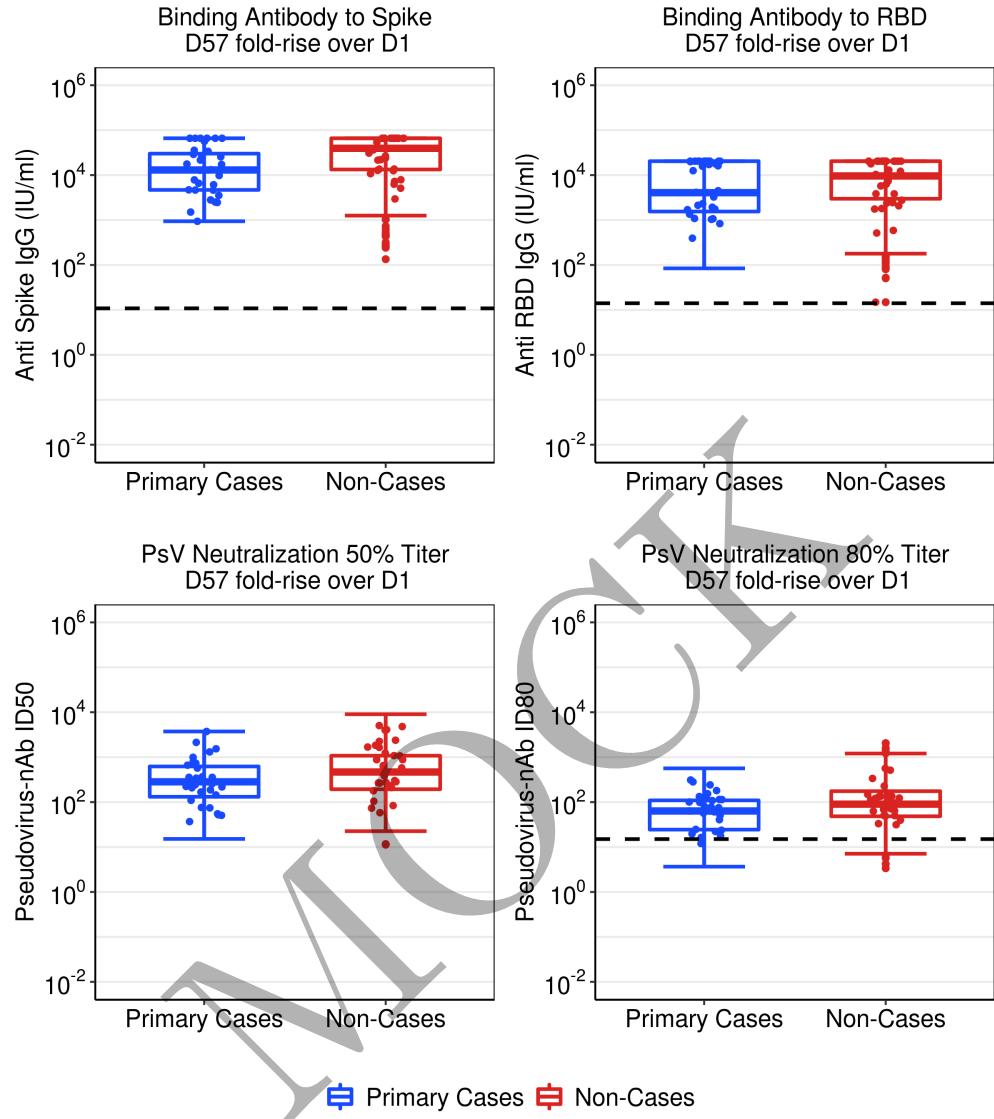


Figure 3.2: Boxplots of D57 fold-rise over D1 Ab markers: vaccine arm.

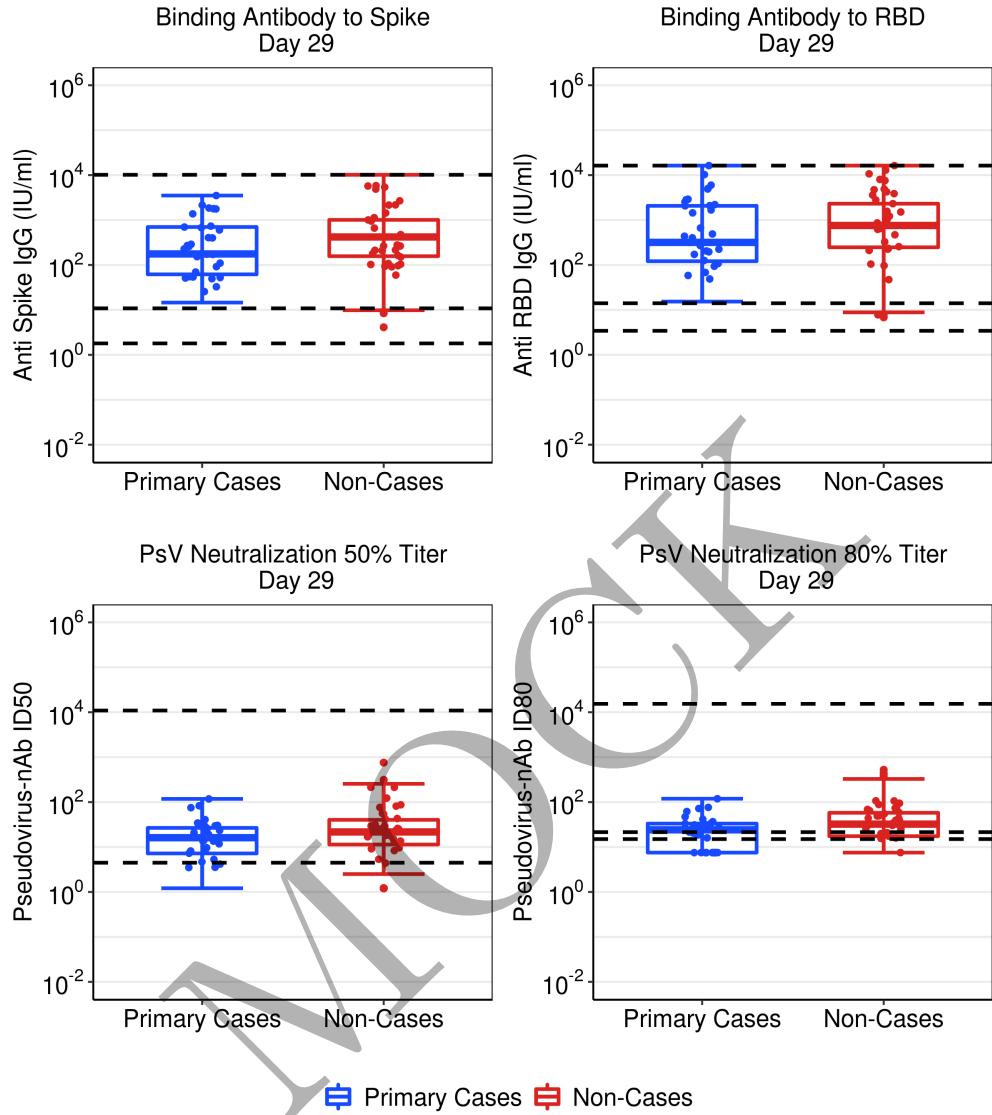


Figure 3.3: Boxplots of D29 Ab markers: vaccine arm. The three dashed lines in each figure are ULOQ, LLOQ, and LLOD, from top to bottom respectively.

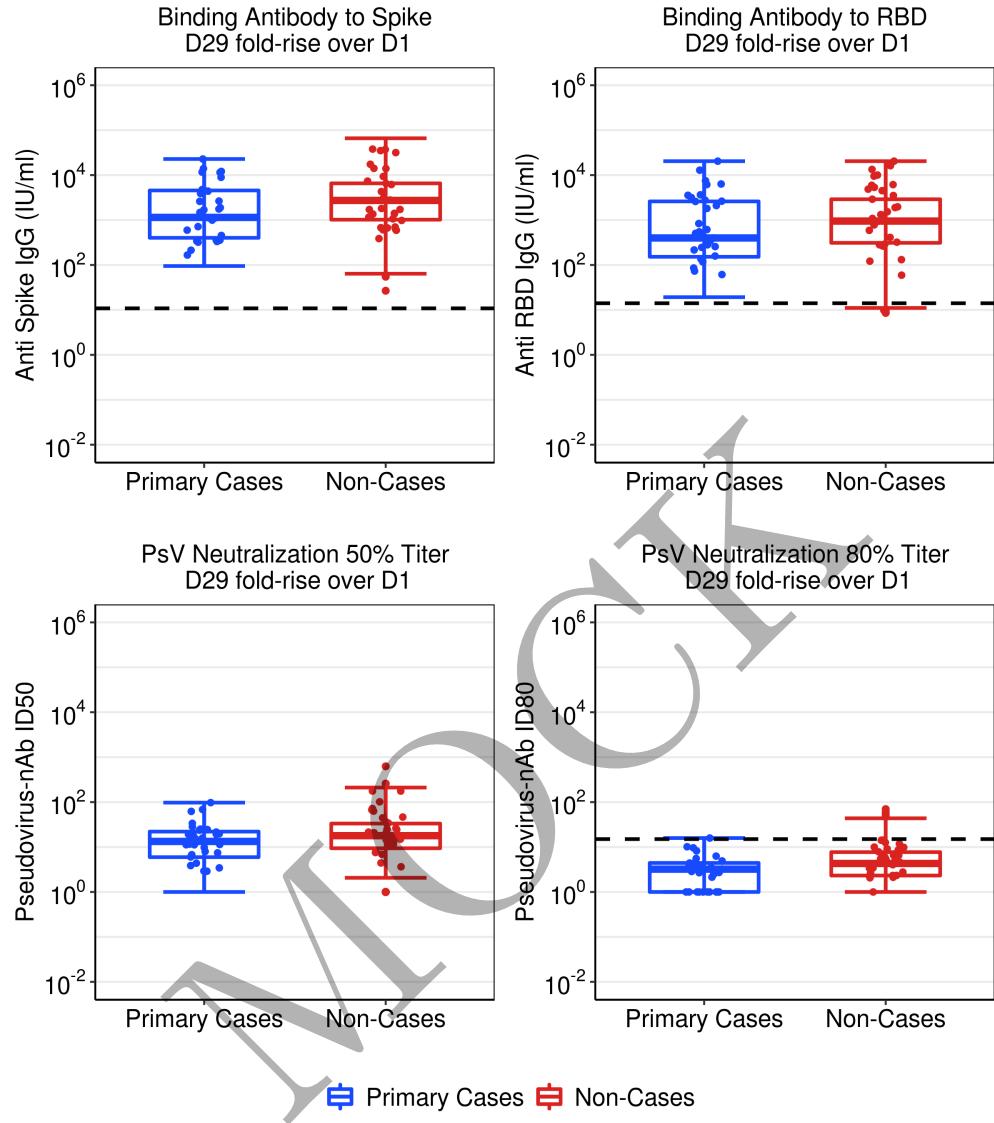


Figure 3.4: Boxplots of D29 fold-rise over D1 Ab markers: vaccine arm.

3.2 Weighted RCDF plots

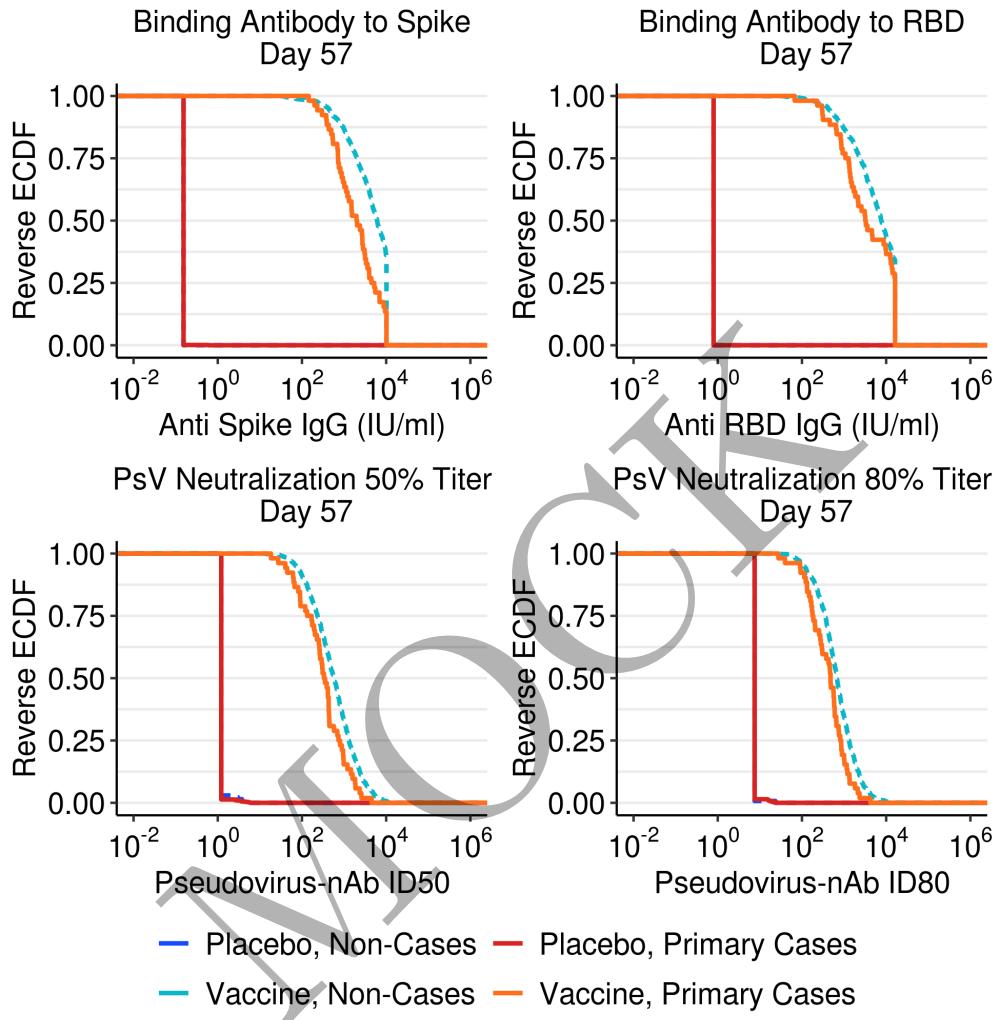


Figure 3.5: RCDF plots for D57 Ab markers by treatment arm.

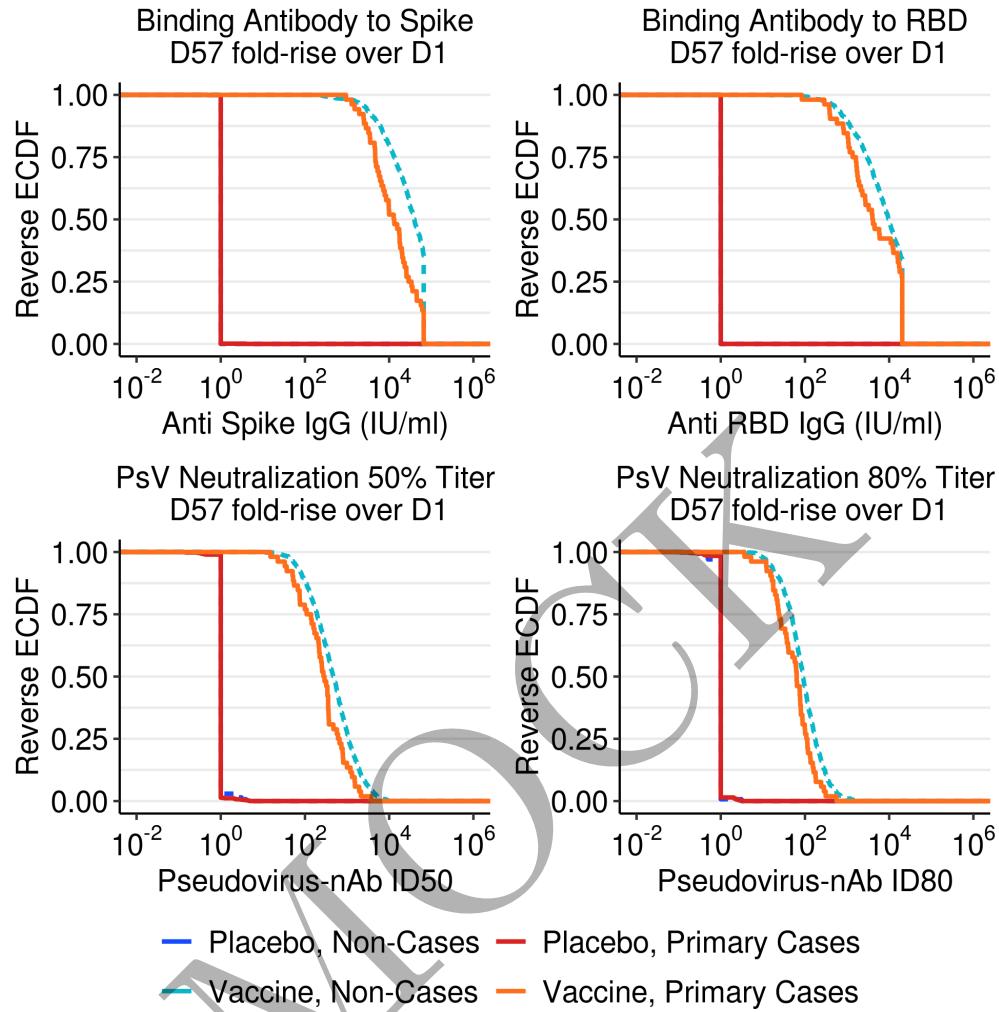


Figure 3.6: RCDF plots for D57 fold-rise over D1 Ab markers by treatment arm.

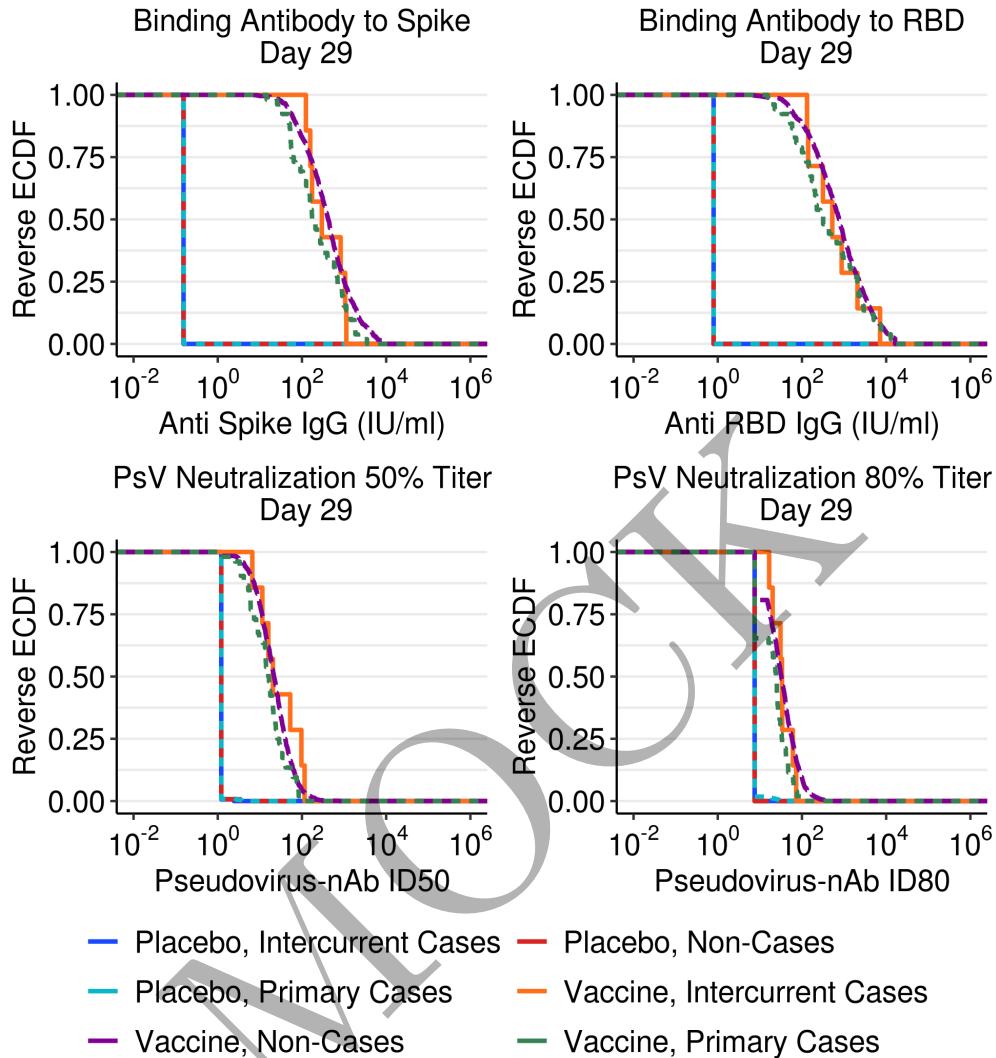


Figure 3.7: RCDF plots for D29 Ab markers by treatment arm.

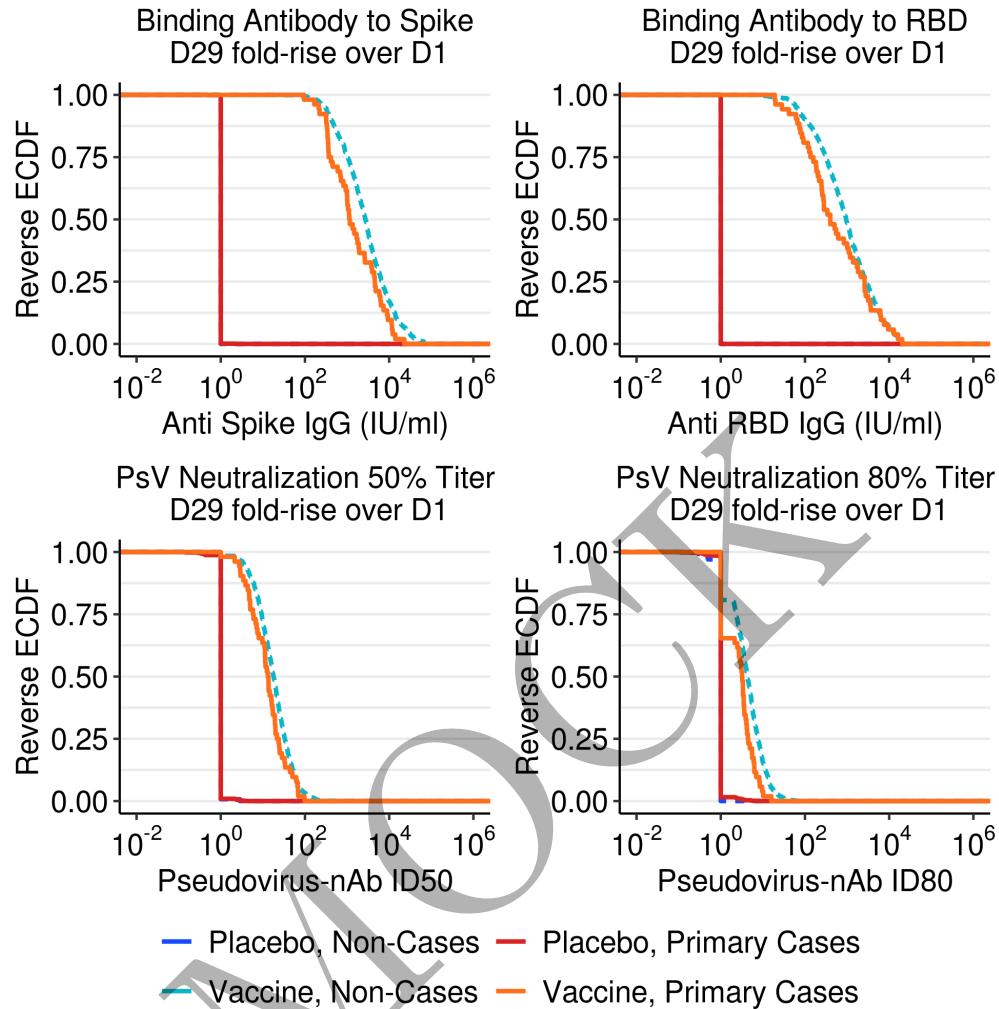


Figure 3.8: RCDF plots for D29 fold-rise over D1 Ab markers by treatment arm.

3.3 Weighted RCDF plots of threshold correlate concentration for vaccine efficacy

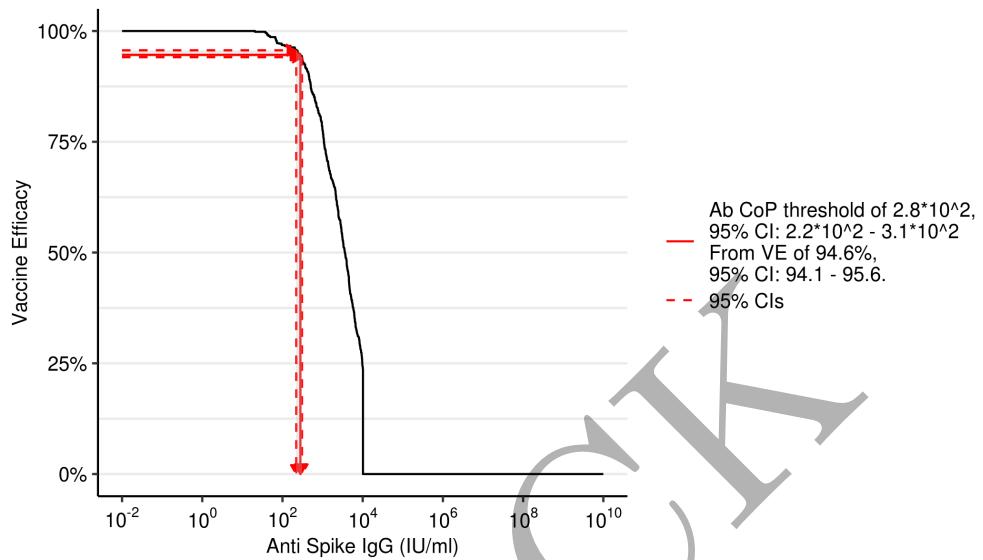


Figure 3.9: Marker RCDF of D57 anti-Spike binding Ab: vaccine arm

3.3. WEIGHTED RCDF PLOTS OF THRESHOLD CORRELATE CONCENTRATION FOR VACCINE EFFICACY53

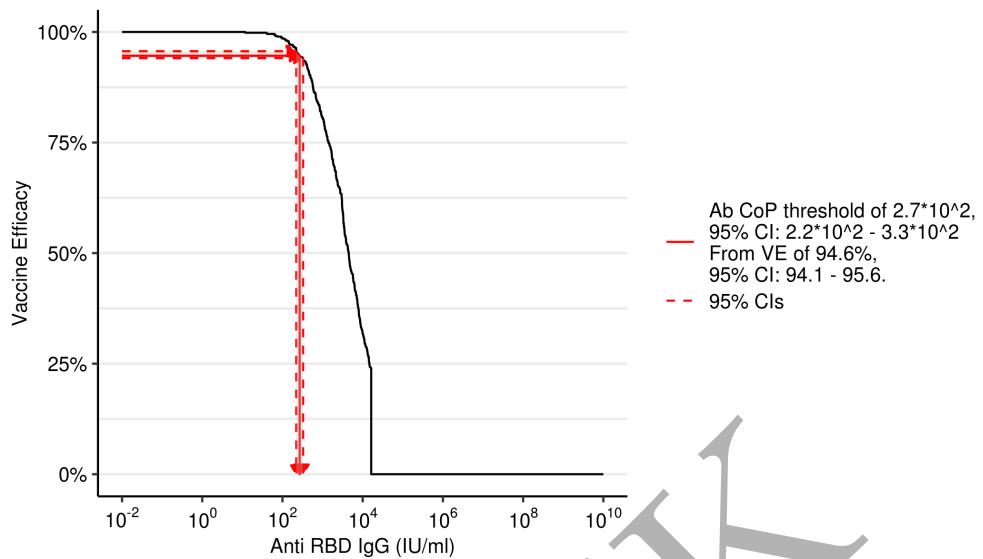


Figure 3.10: Marker RCDF of D57 anti-RBD binding Ab: vaccine arm

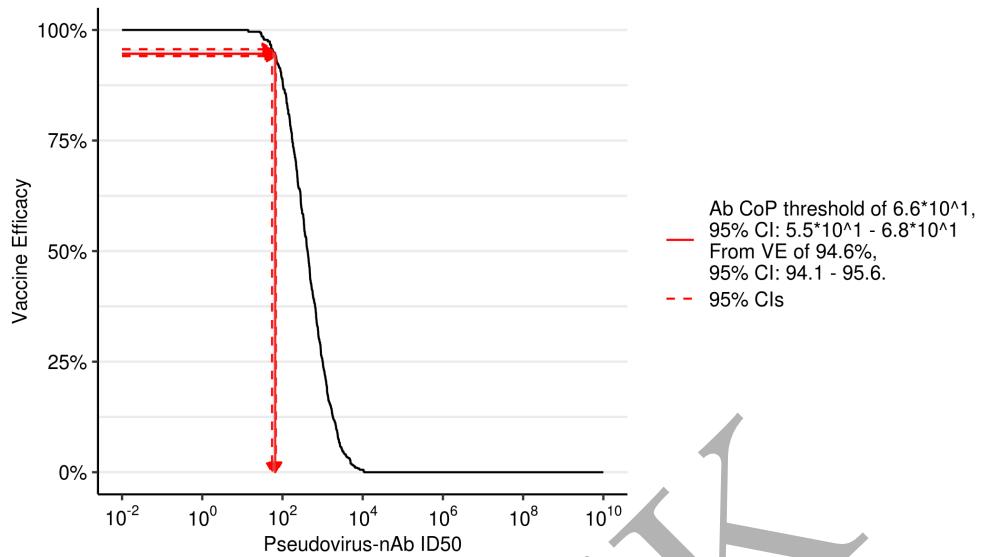


Figure 3.11: Marker RCDF of D57 PsV-nAb ID50: vaccine arm

3.3. WEIGHTED RCDF PLOTS OF THRESHOLD CORRELATE CONCENTRATION FOR VACCINE EFFICACY55

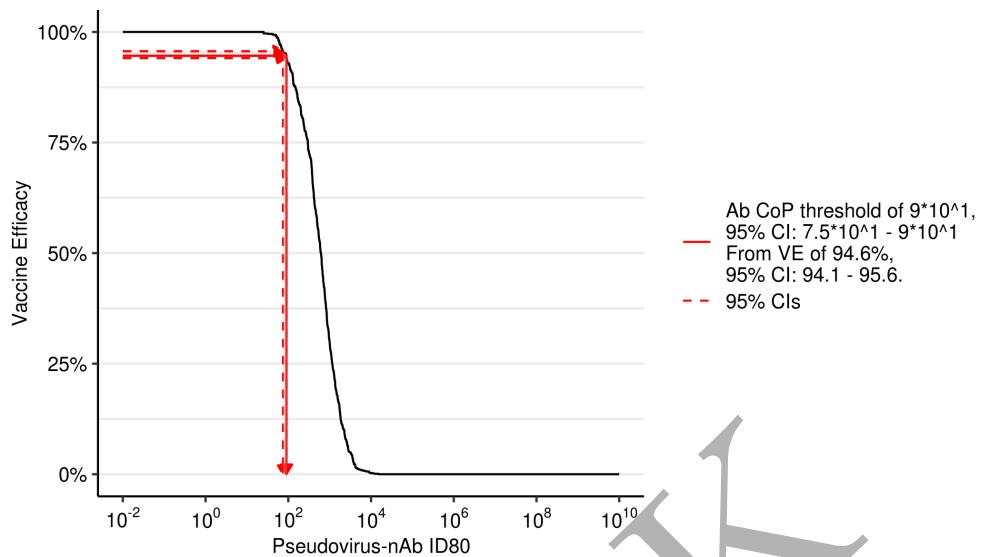


Figure 3.12: Marker RCDF of D57 PsV-nAb ID80: vaccine arm

3.4 Spaghetti plots

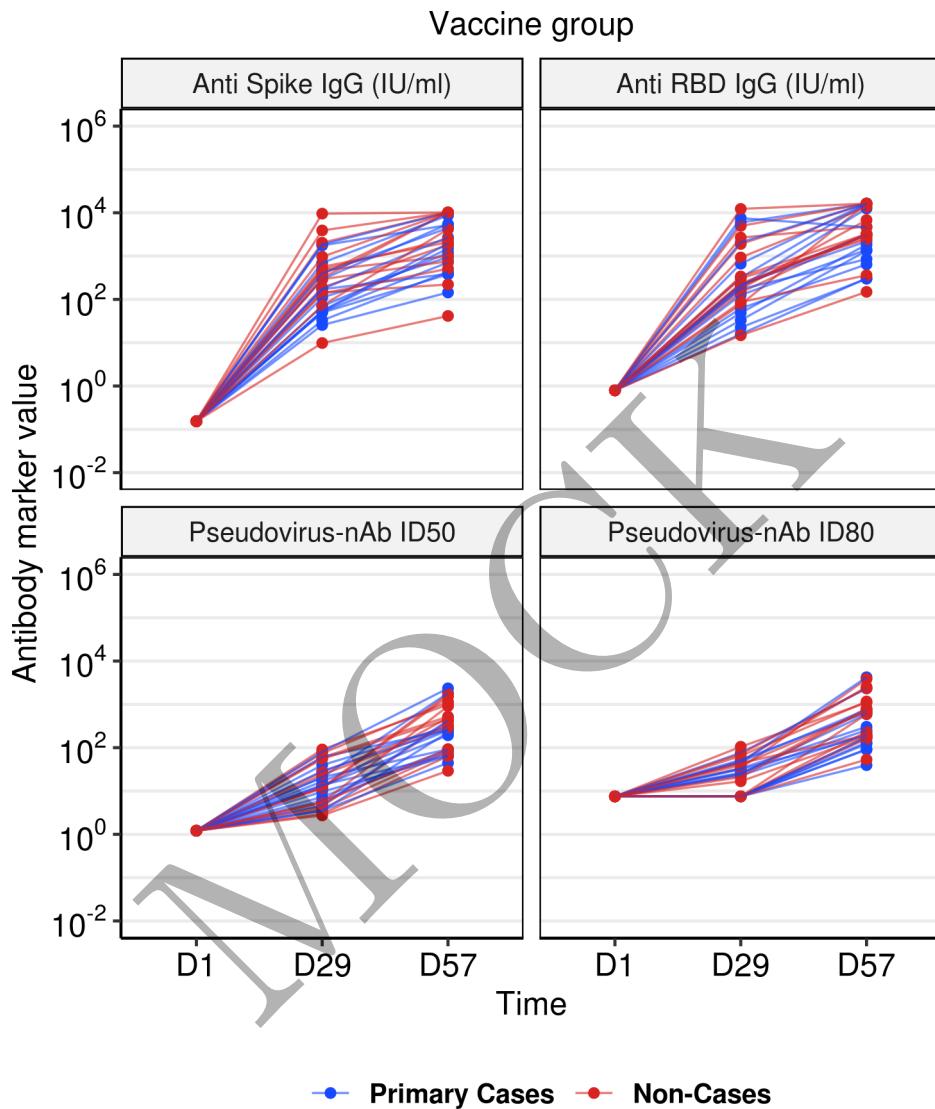


Figure 3.13: Spaghetti Plots of Marker Trajectory: vaccine arm

3.5 Violin and line plots

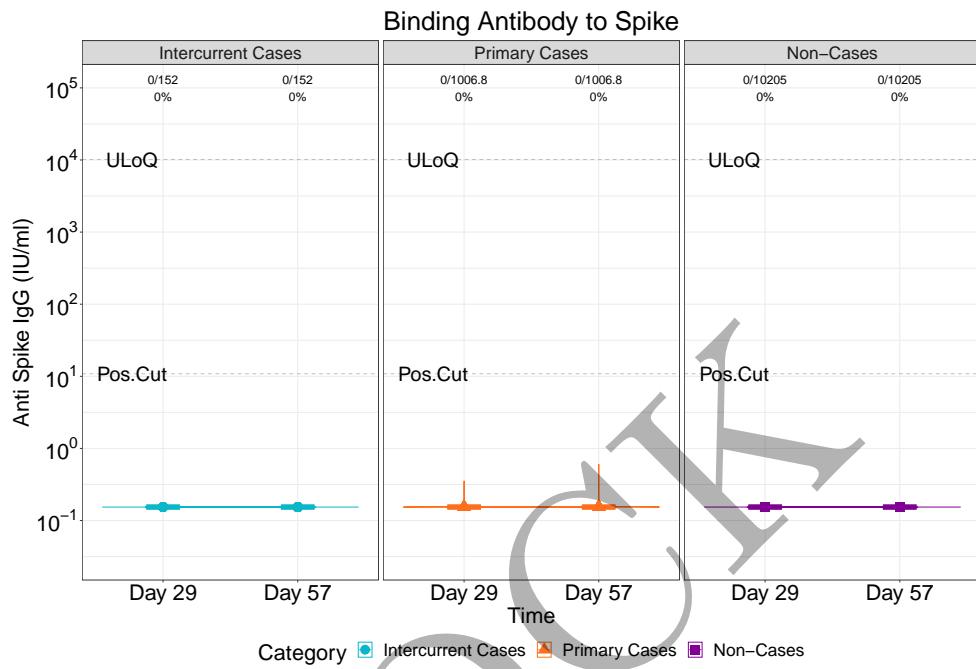


Figure 3.14: lineplots of Binding Antibody to Spike: baseline negative placebo arm (version 1)

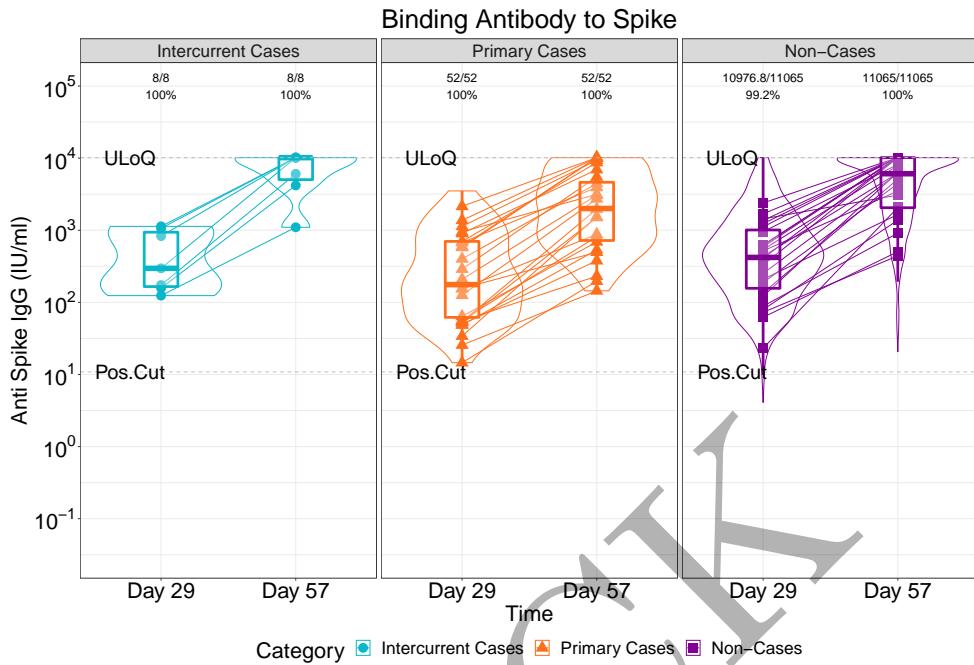


Figure 3.15: lineplots of Binding Antibody to Spike: baseline negative vaccine arm (version 1)

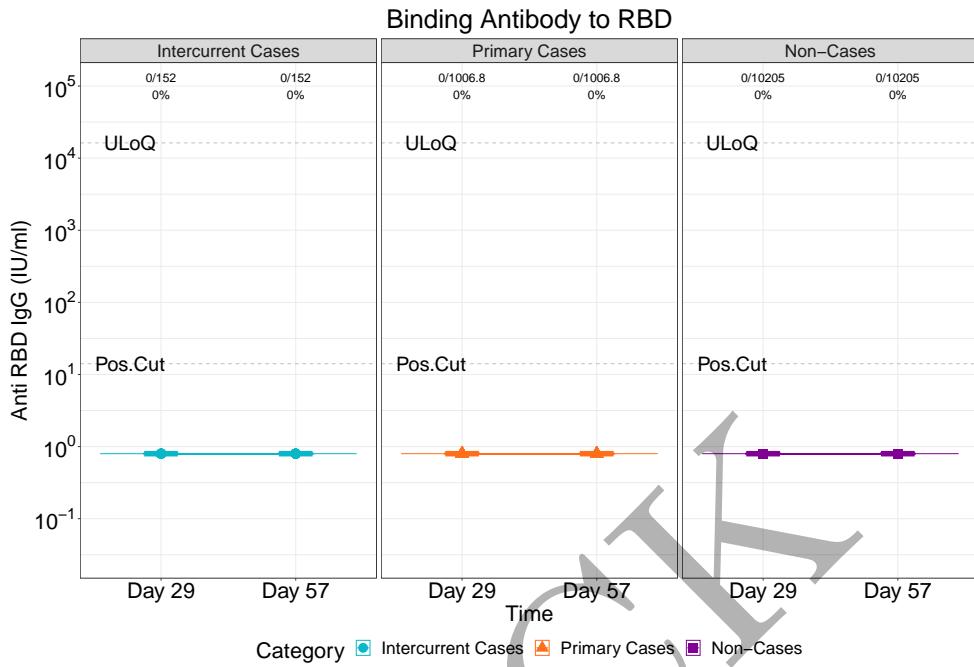


Figure 3.16: lineplots of Binding Antibody to RBD: baseline negative placebo arm (version 1)

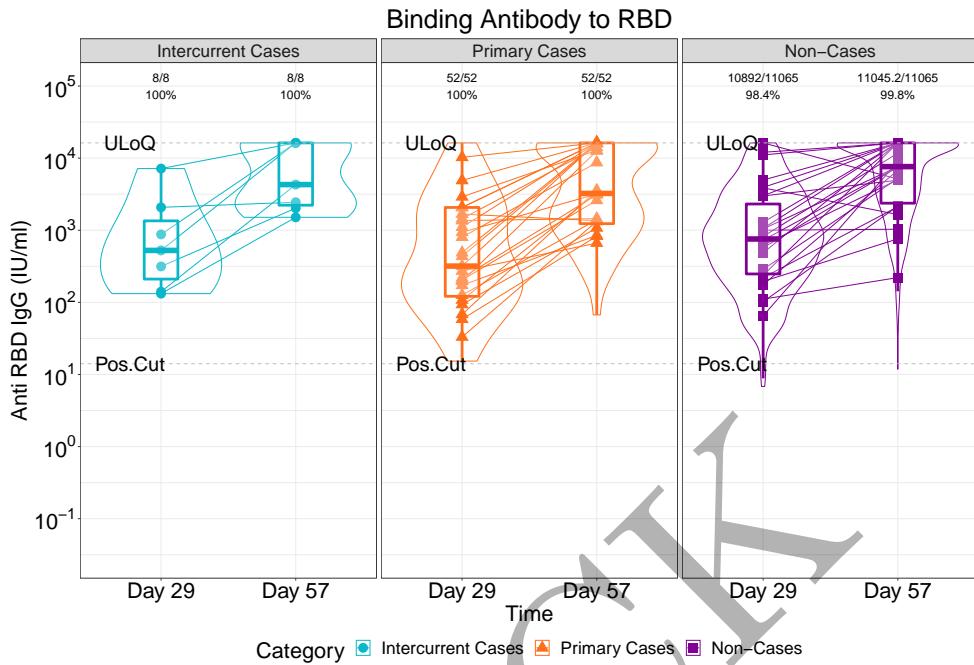


Figure 3.17: lineplots of Binding Antibody to RBD: baseline negative vaccine arm (version 1)

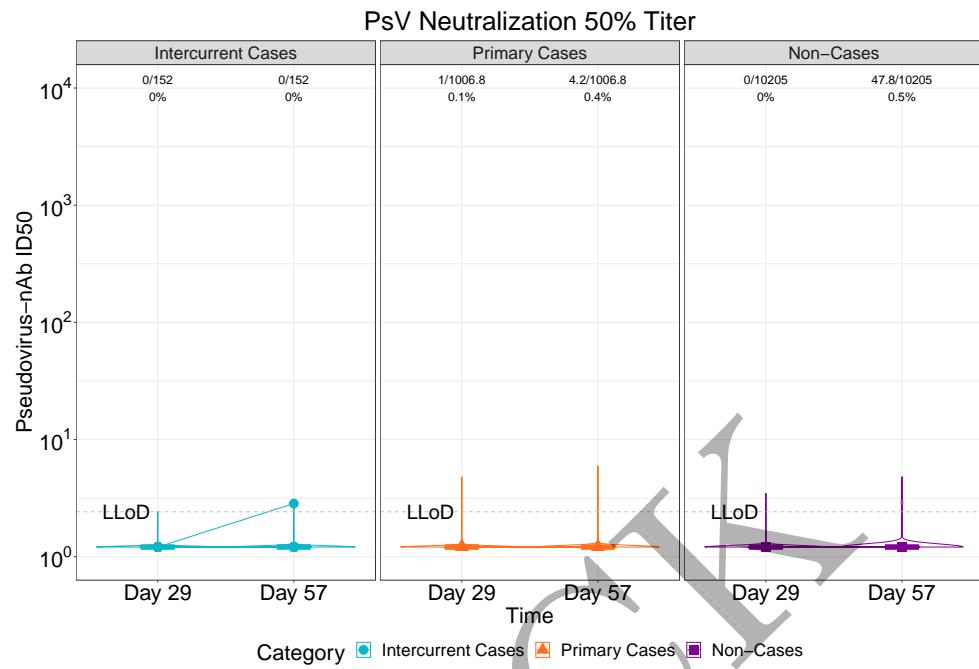


Figure 3.18: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (version 1)

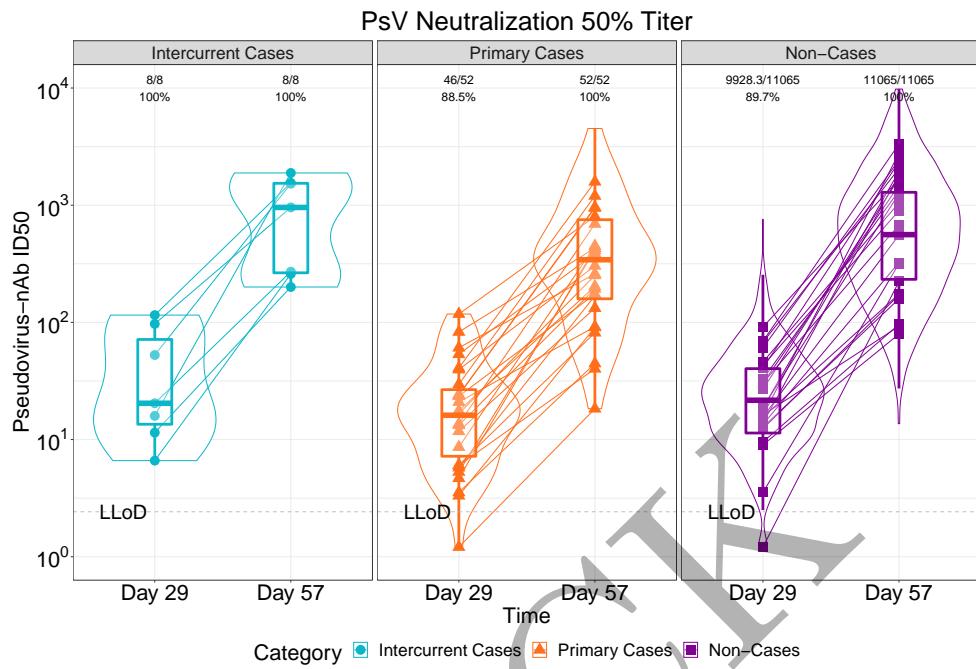


Figure 3.19: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (version 1)

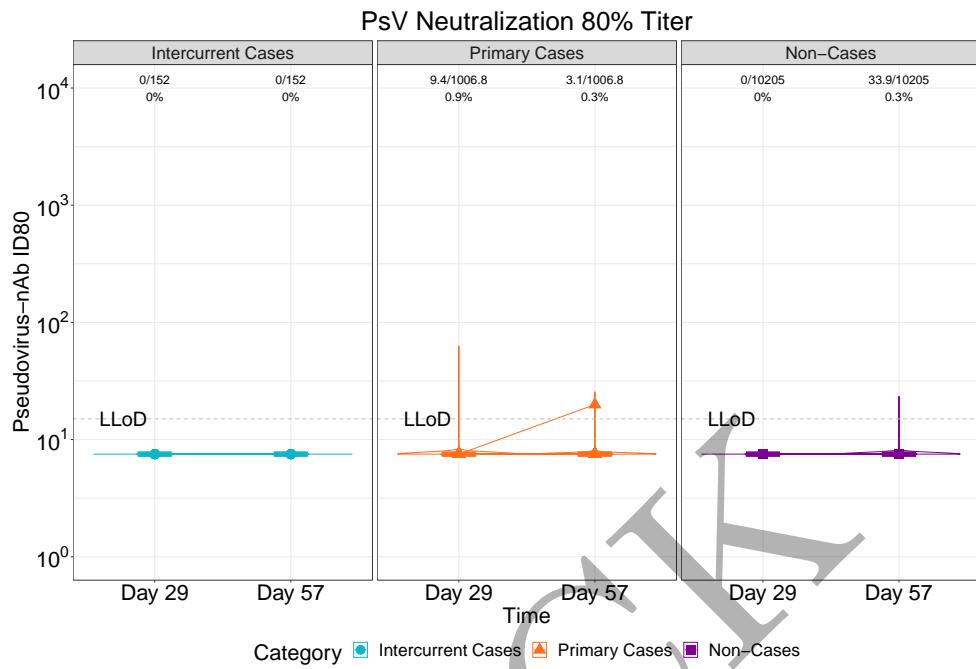


Figure 3.20: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (version 1)

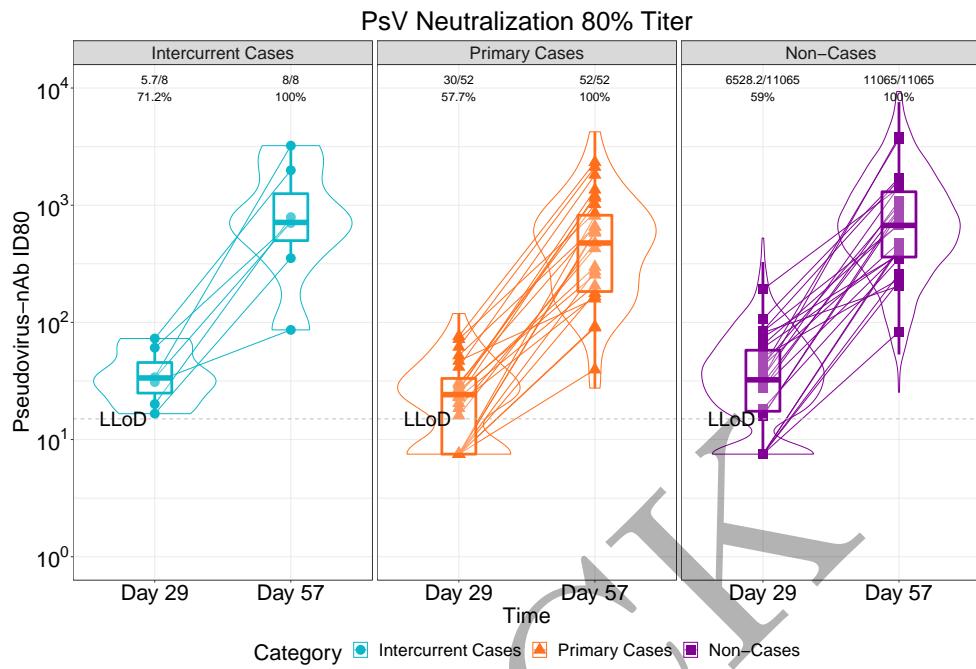


Figure 3.21: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (version 1)

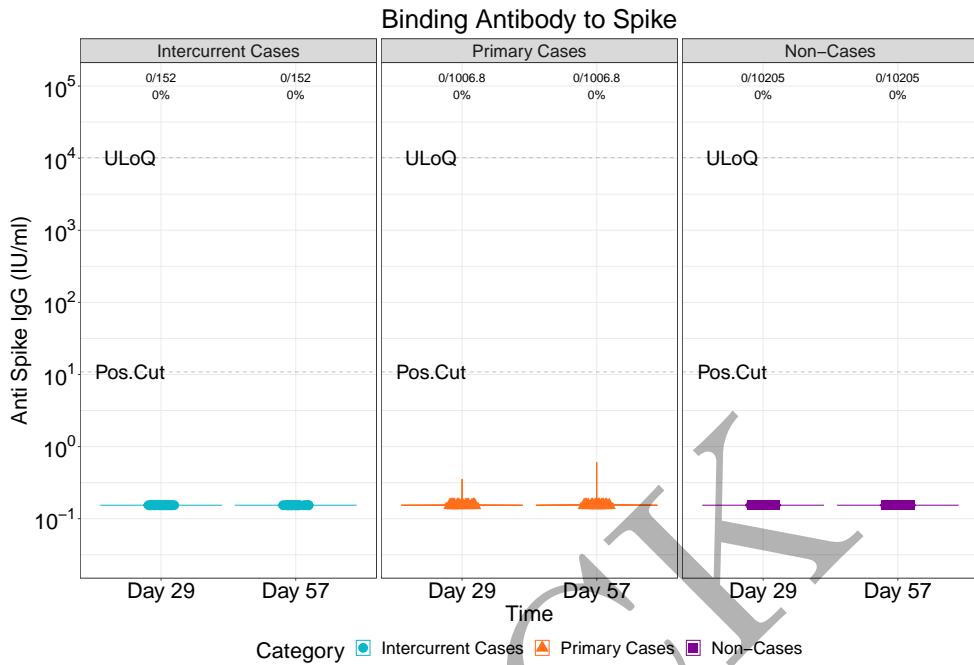


Figure 3.22: violinplots of Binding Antibody to Spike: baseline negative placebo arm (version 1)

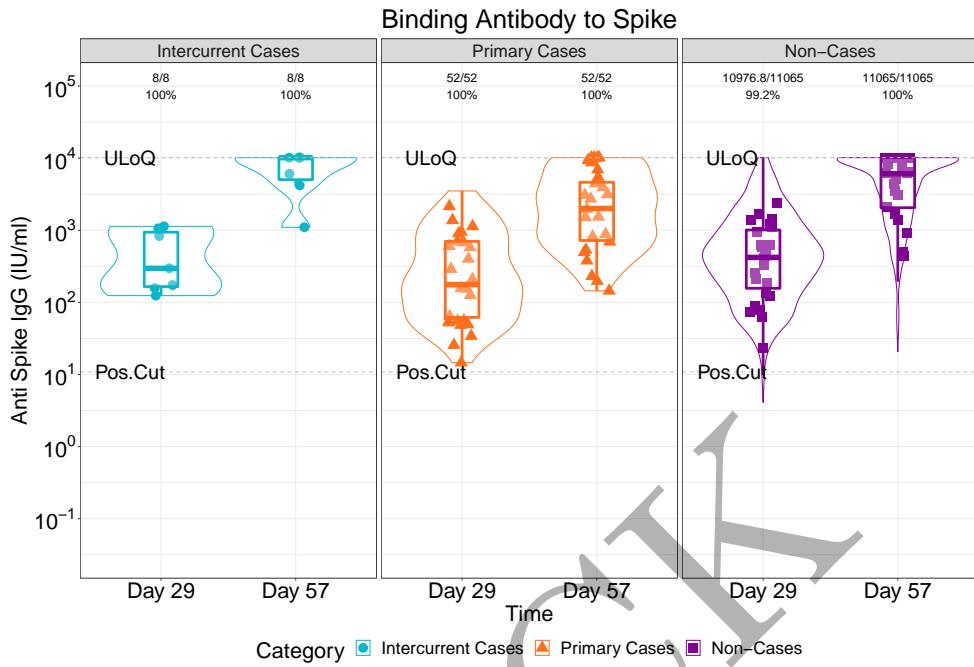


Figure 3.23: violinplots of Binding Antibody to Spike: baseline negative vaccine arm (version 1)

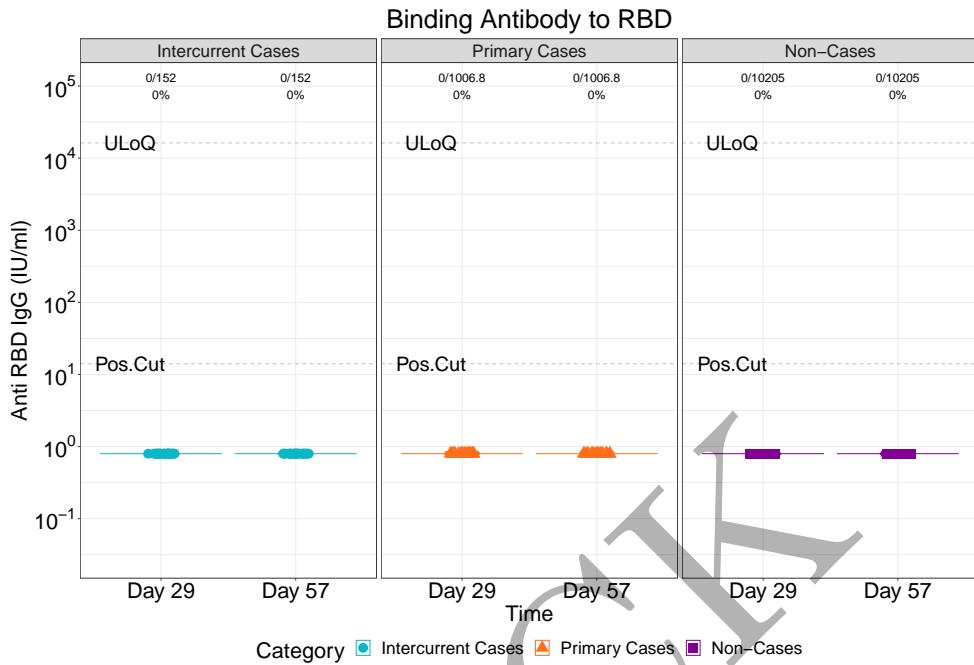


Figure 3.24: violinplots of Binding Antibody to RBD: baseline negative placebo arm (version 1)

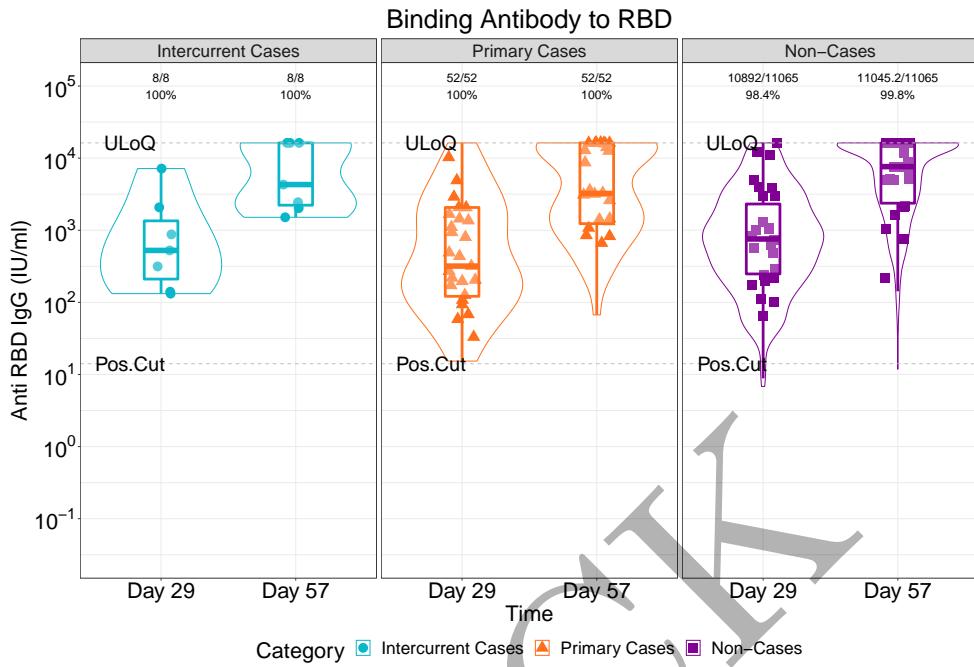


Figure 3.25: violinplots of Binding Antibody to RBD: baseline negative vaccine arm (version 1)

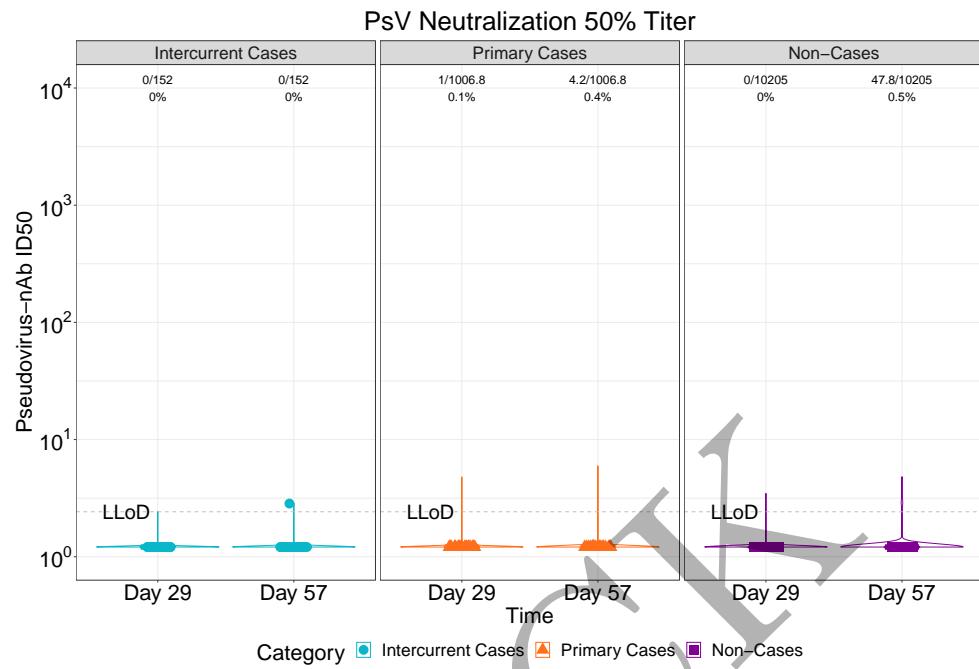


Figure 3.26: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (version 1)

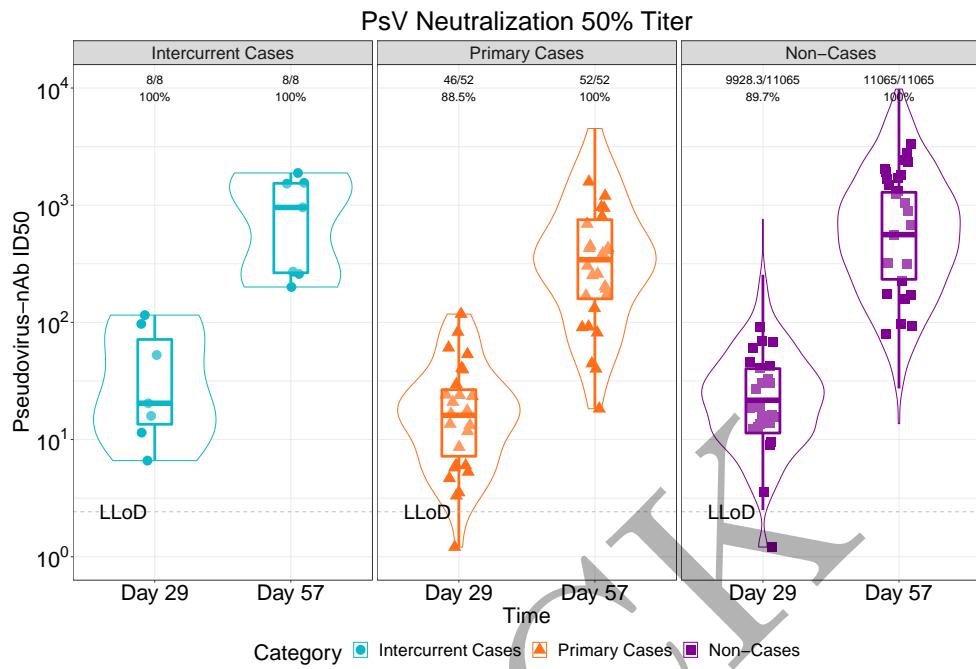


Figure 3.27: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (version 1)

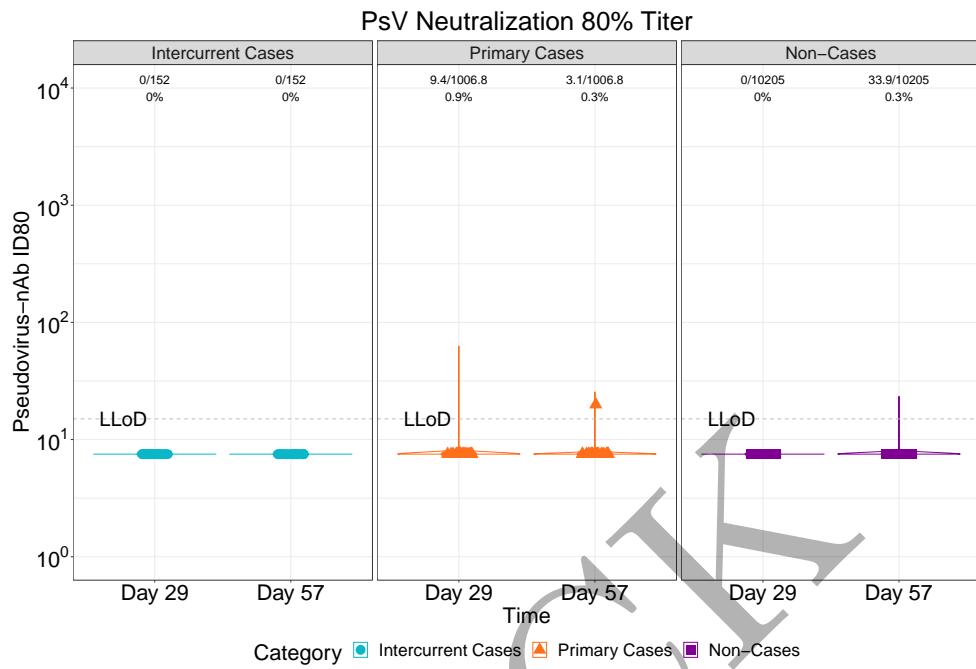


Figure 3.28: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (version 1)

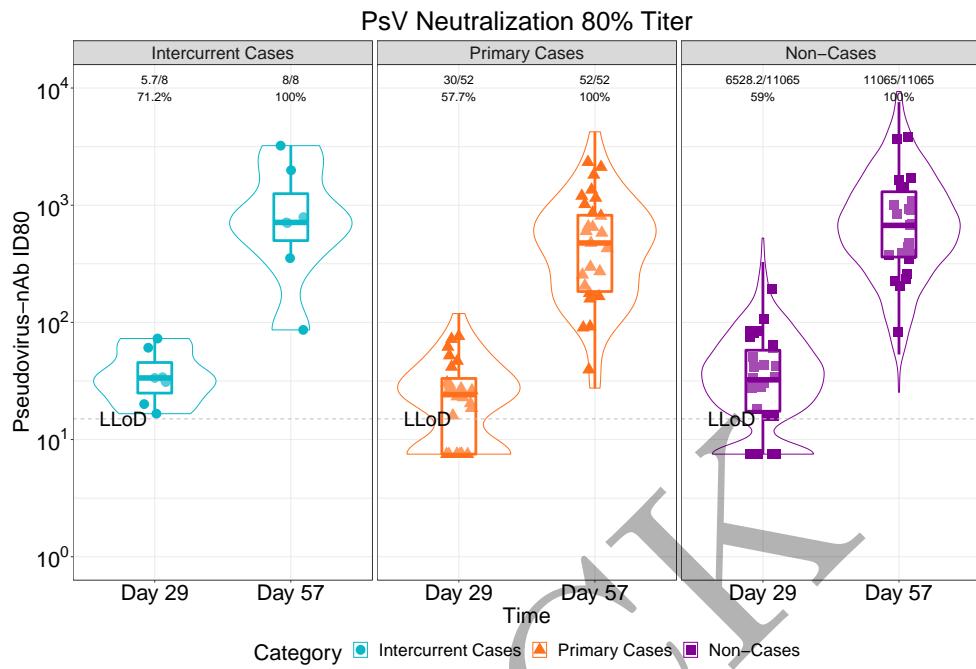


Figure 3.29: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (version 1)

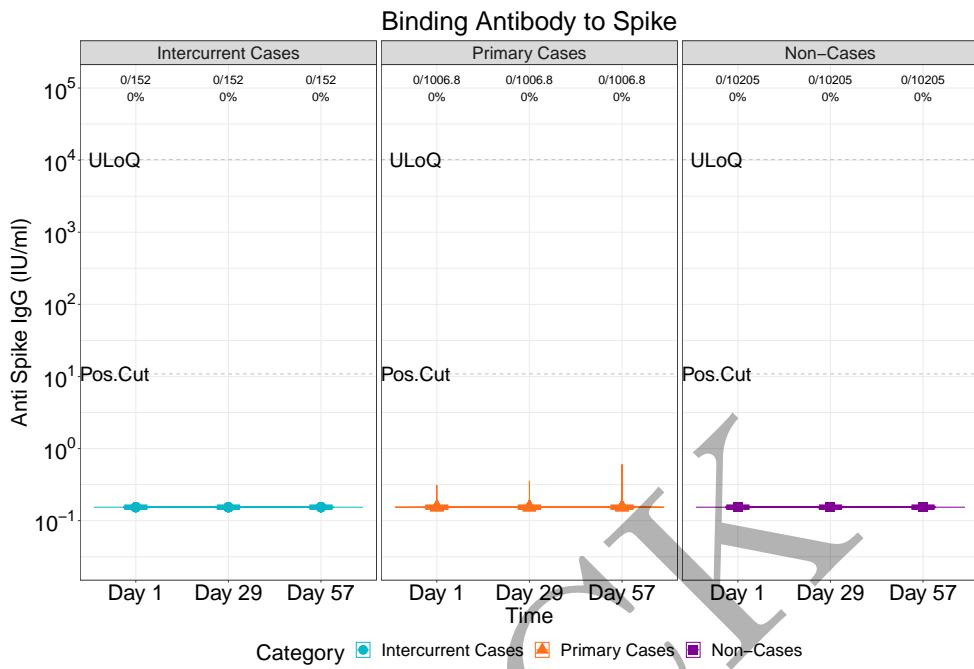


Figure 3.30: lineplots of Binding Antibody to Spike: baseline negative placebo arm (version 2)

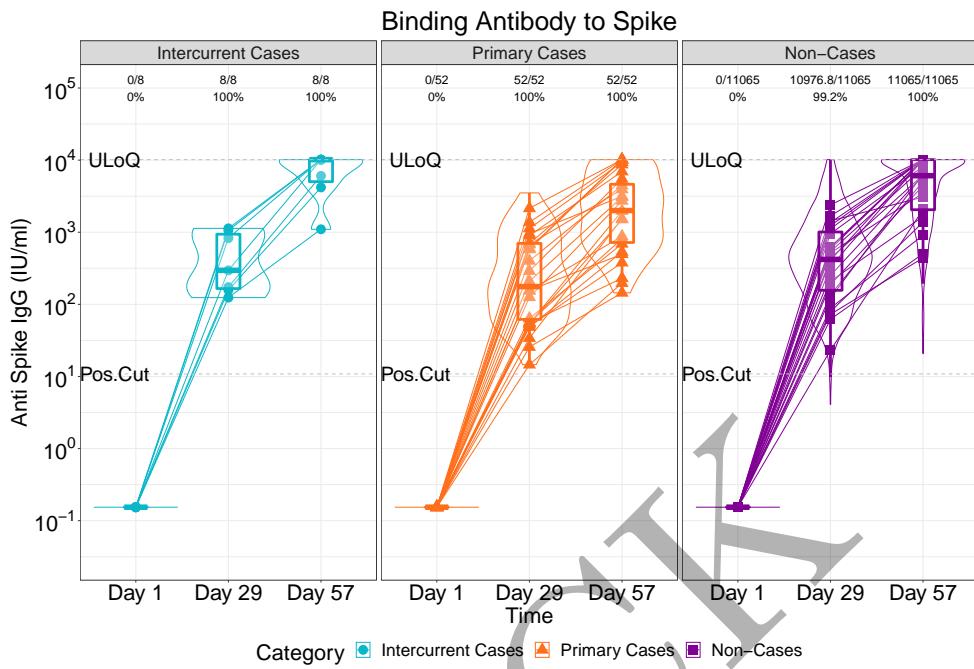


Figure 3.31: lineplots of Binding Antibody to Spike: baseline negative vaccine arm (version 2)

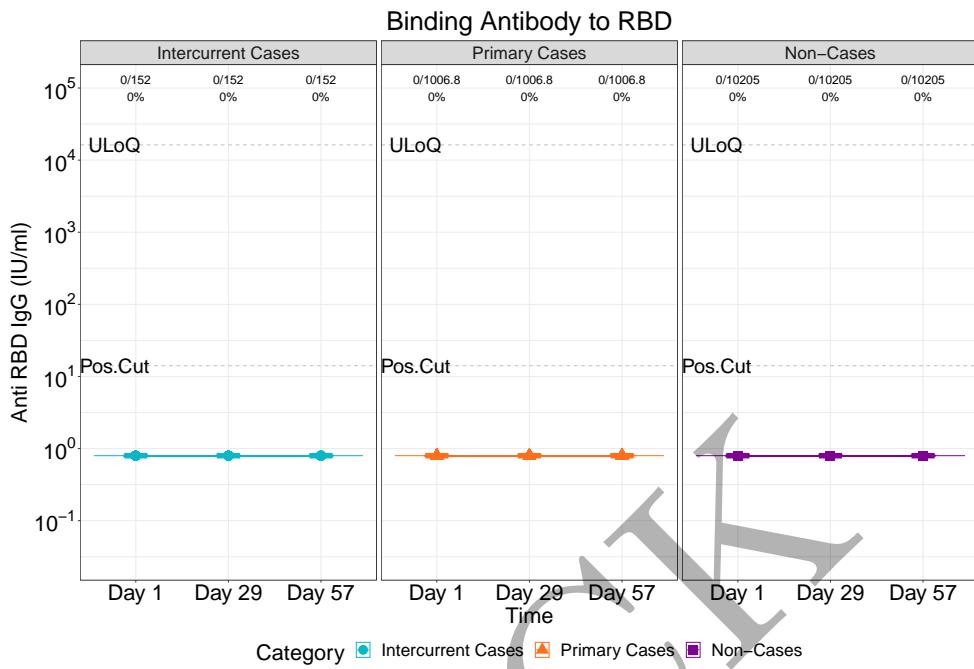


Figure 3.32: lineplots of Binding Antibody to RBD: baseline negative placebo arm (version 2)

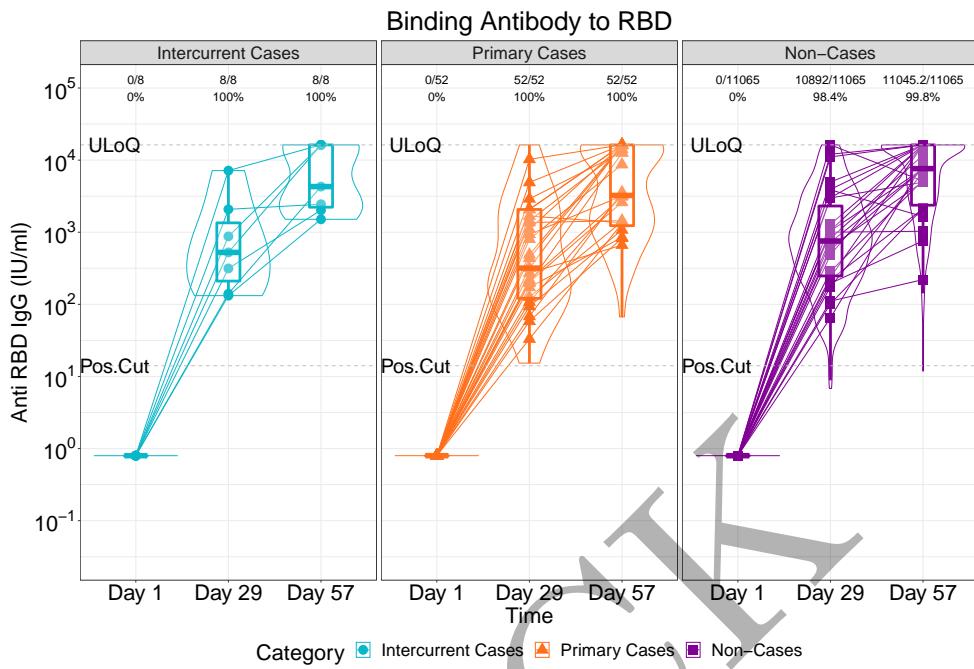


Figure 3.33: lineplots of Binding Antibody to RBD: baseline negative vaccine arm (version 2)

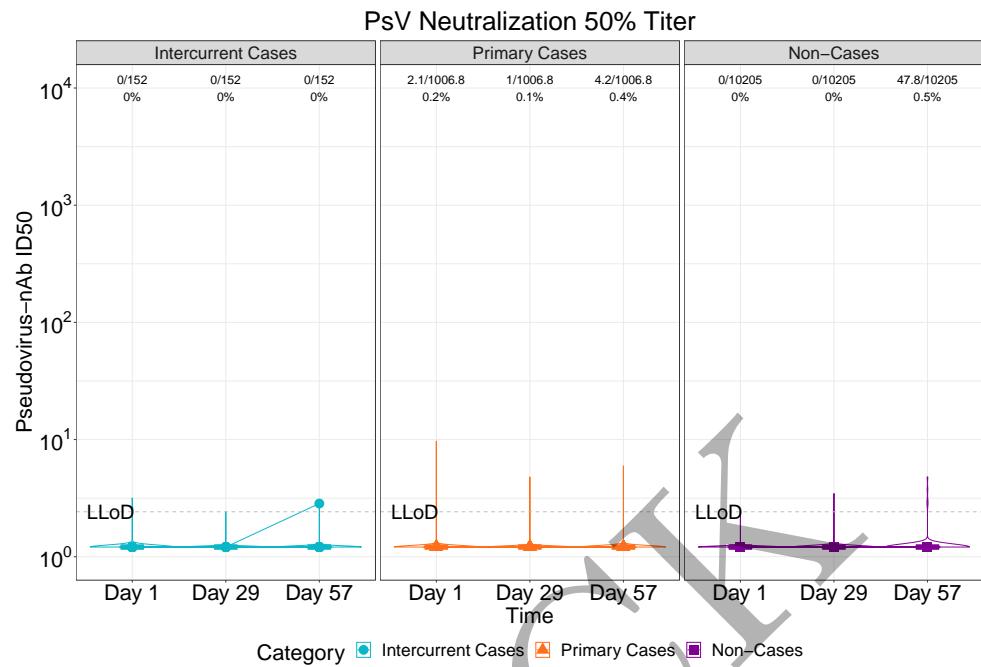


Figure 3.34: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (version 2)

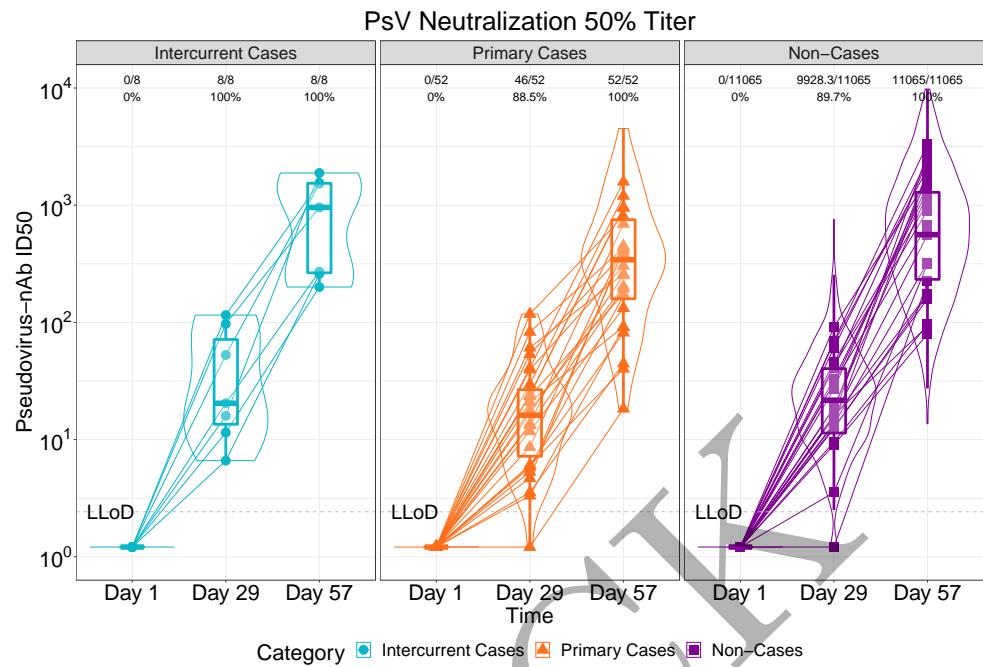


Figure 3.35: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (version 2)

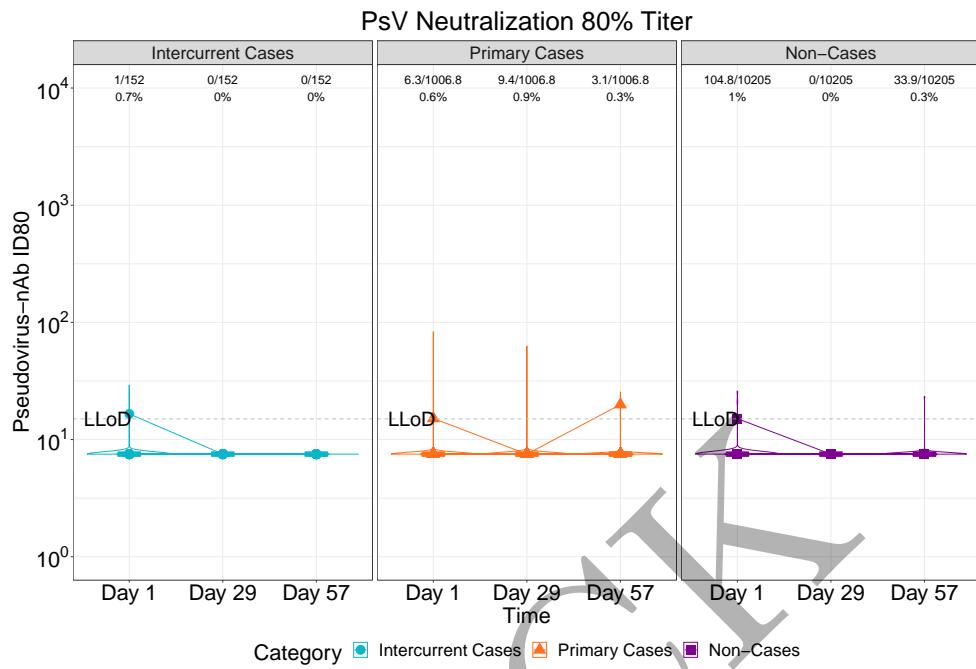


Figure 3.36: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (version 2)

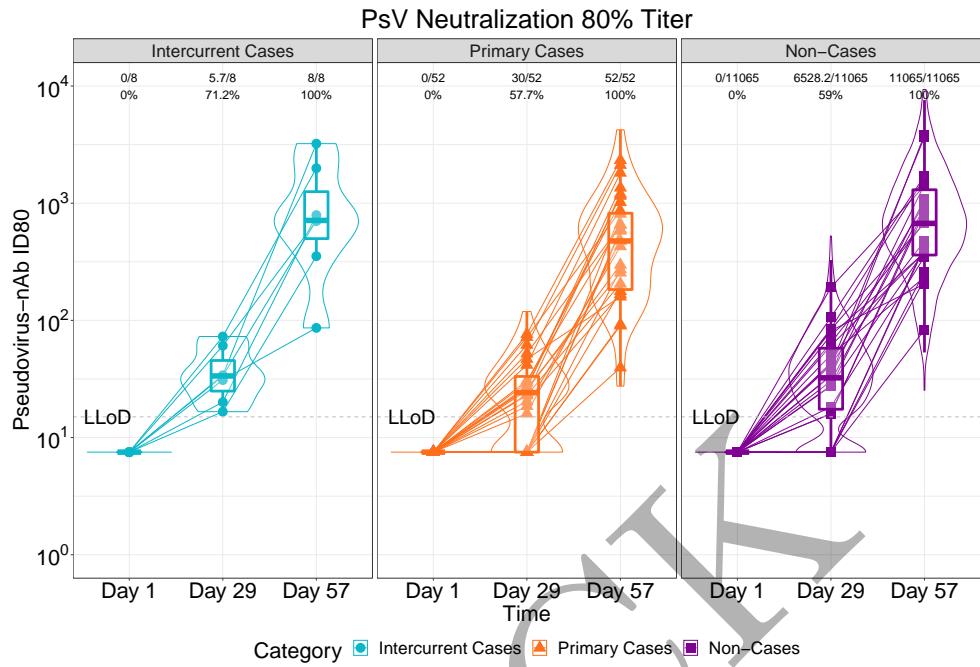


Figure 3.37: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (version 2)

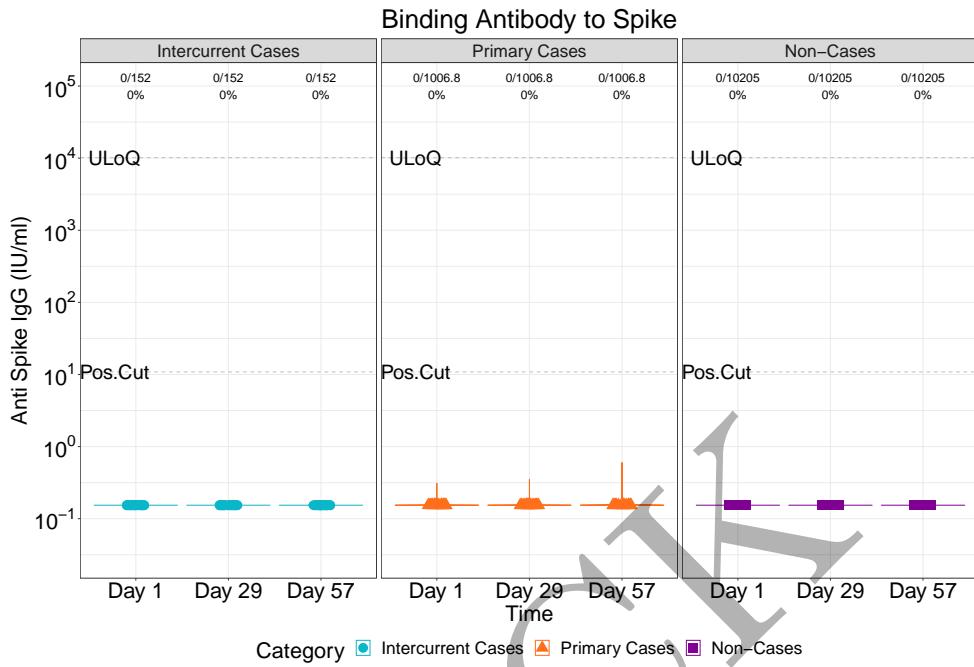


Figure 3.38: violinplots of Binding Antibody to Spike: baseline negative placebo arm (version 2)

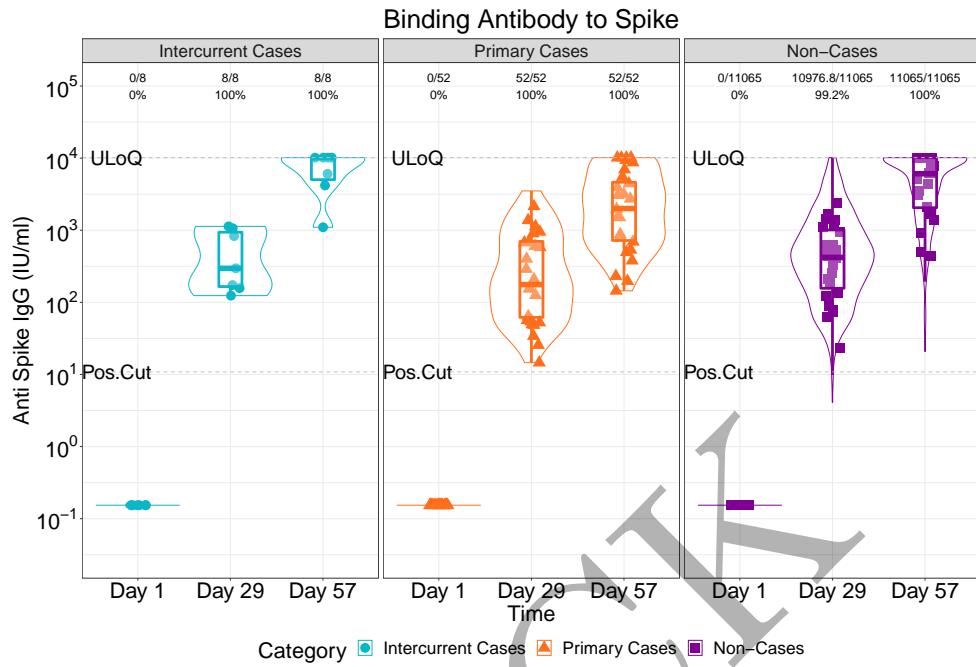


Figure 3.39: violinplots of Binding Antibody to Spike: baseline negative vaccine arm (version 2)

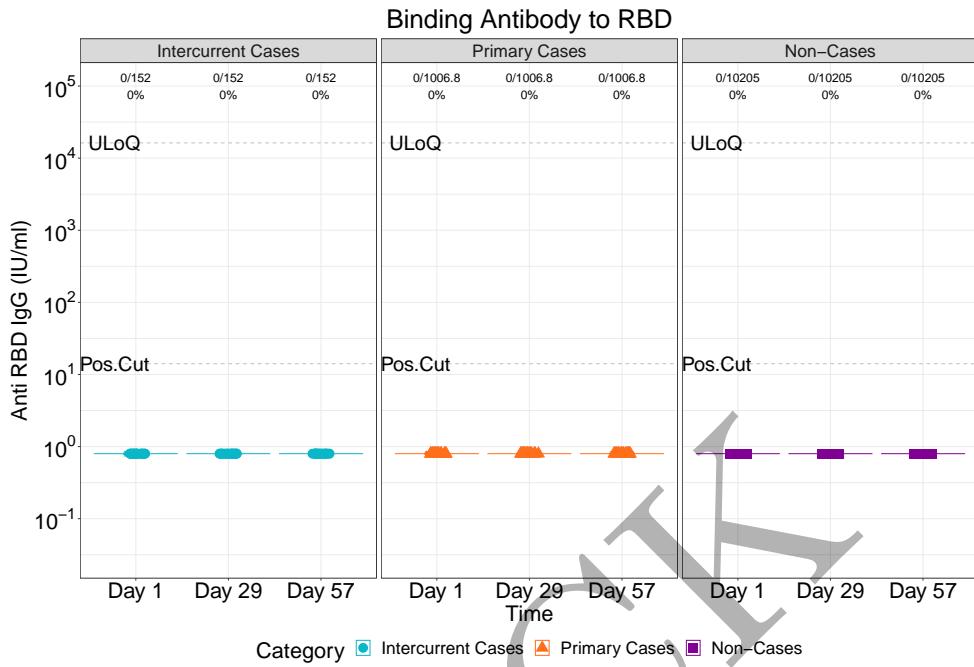


Figure 3.40: violinplots of Binding Antibody to RBD: baseline negative placebo arm (version 2)

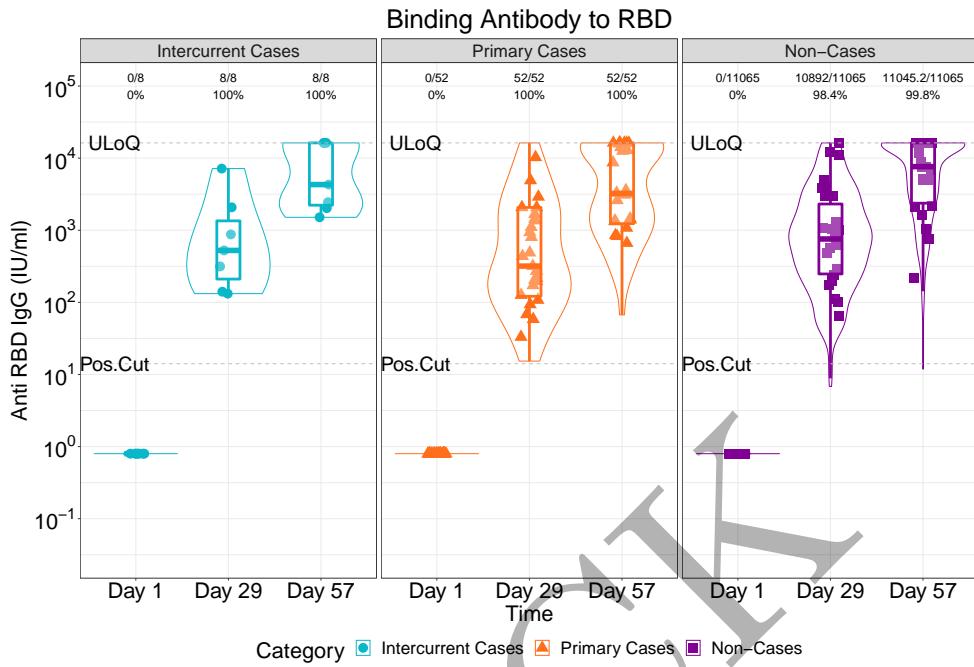


Figure 3.41: violinplots of Binding Antibody to RBD: baseline negative vaccine arm (version 2)

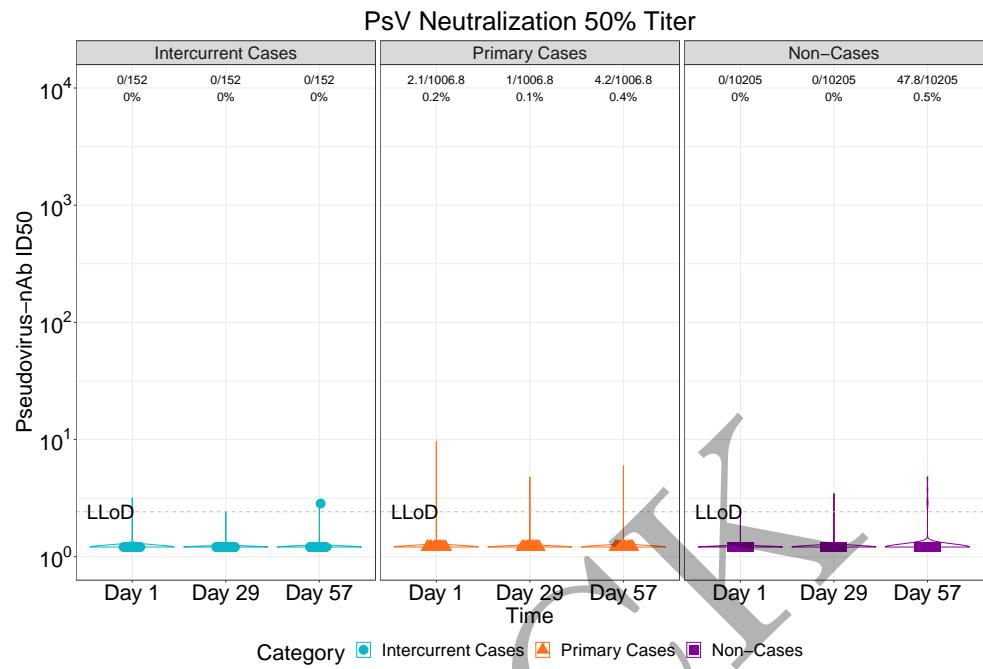


Figure 3.42: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm (version 2)

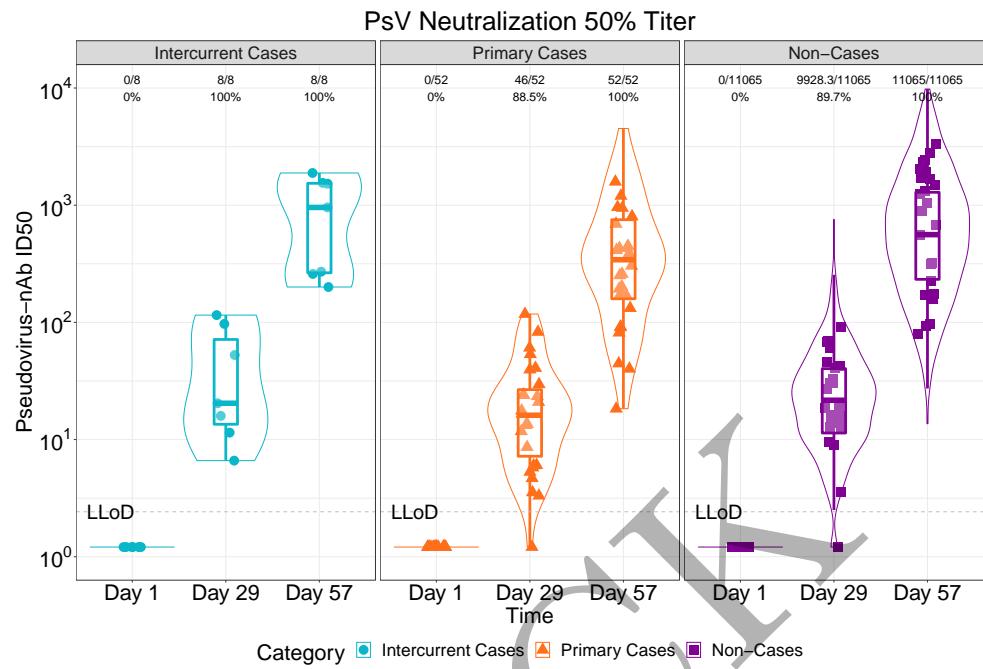


Figure 3.43: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm (version 2)

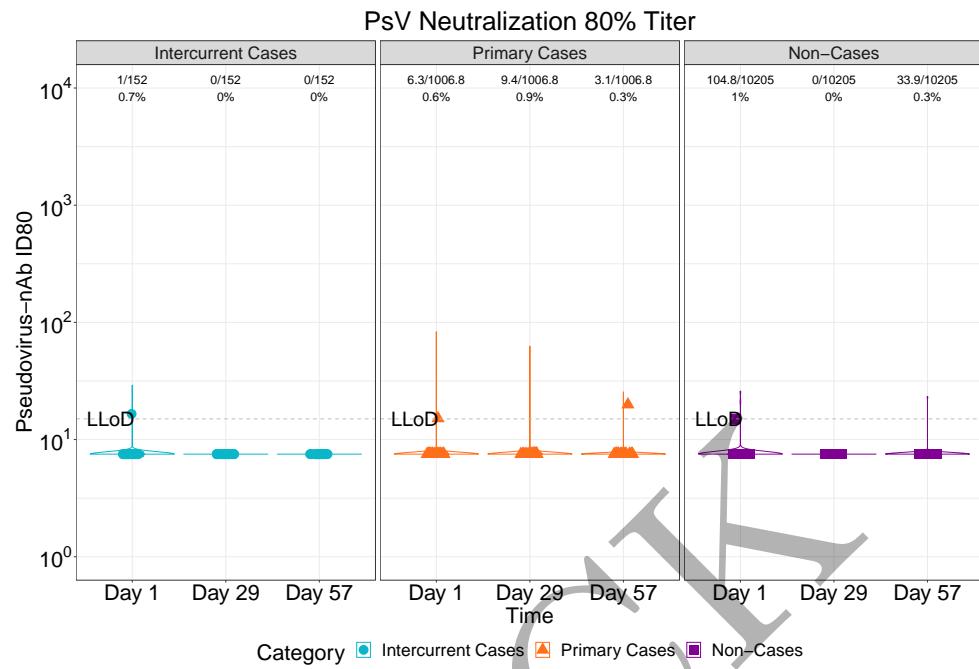


Figure 3.44: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm (version 2)

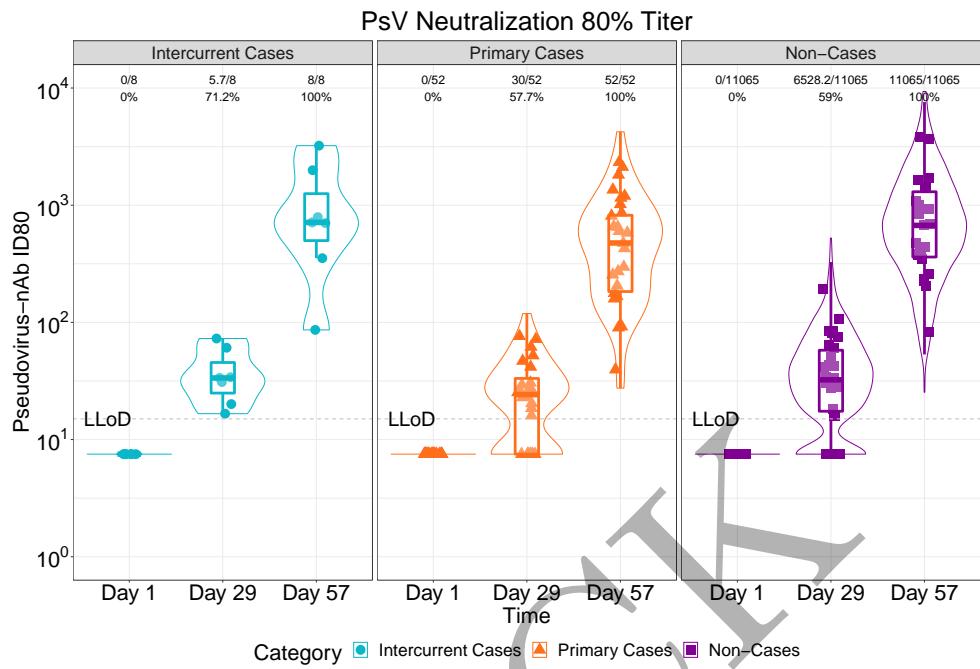


Figure 3.45: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm (version 2)

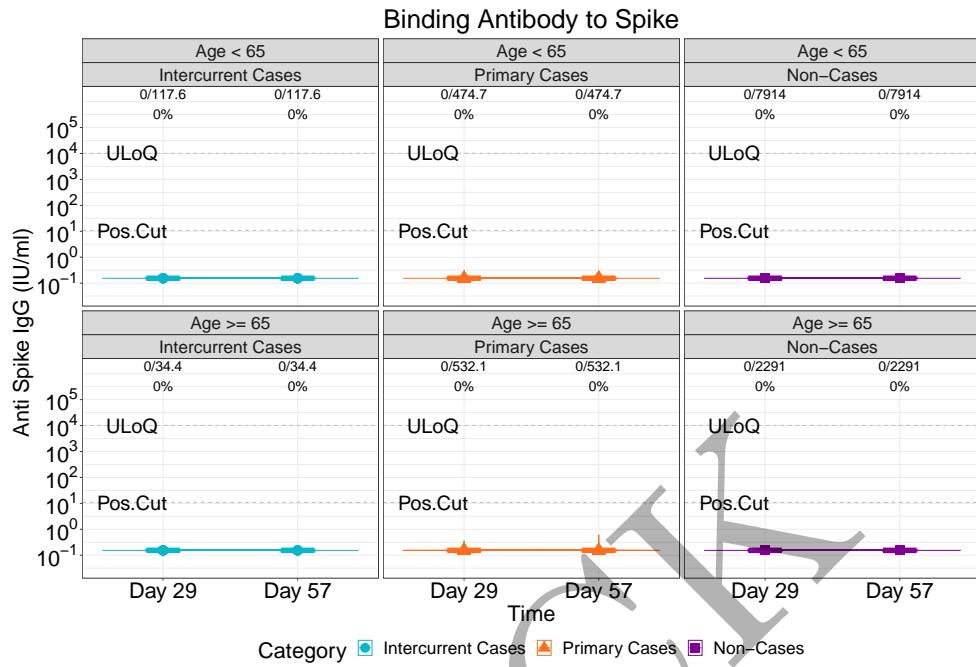


Figure 3.46: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (version 1)

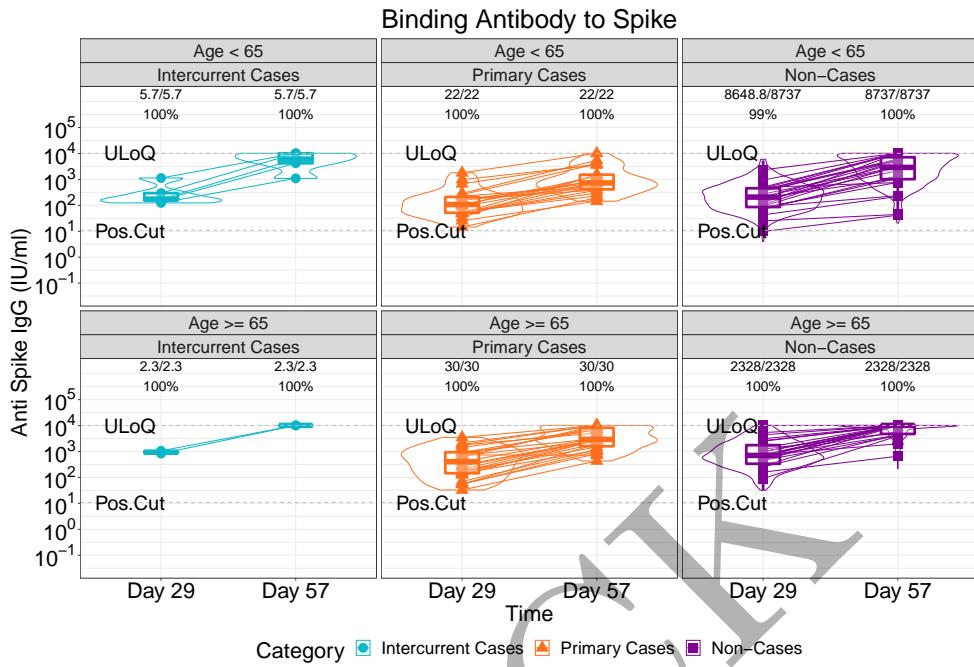


Figure 3.47: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (version 1)

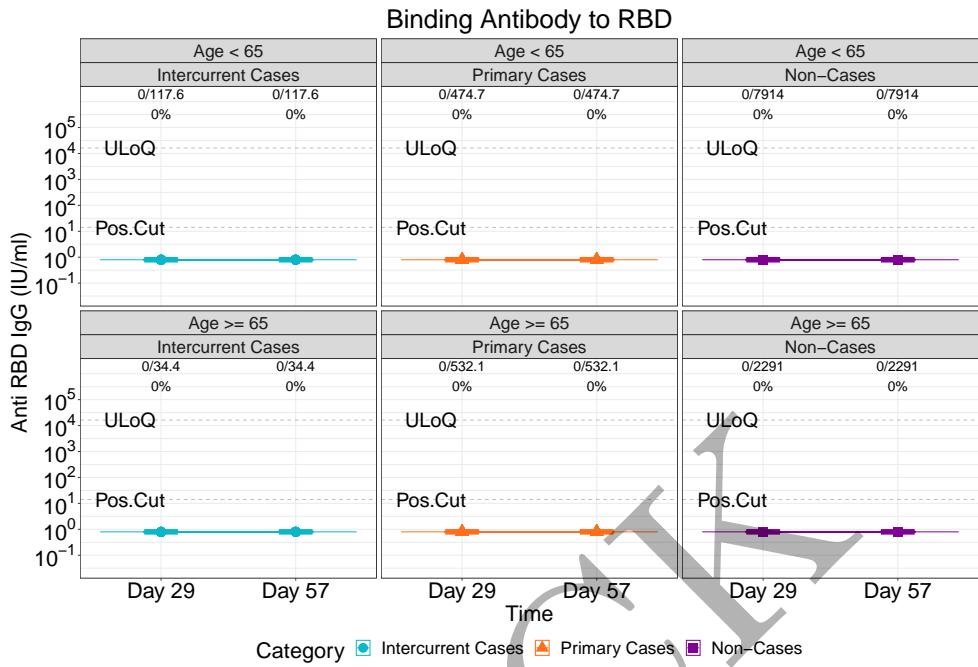


Figure 3.48: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (version 1)

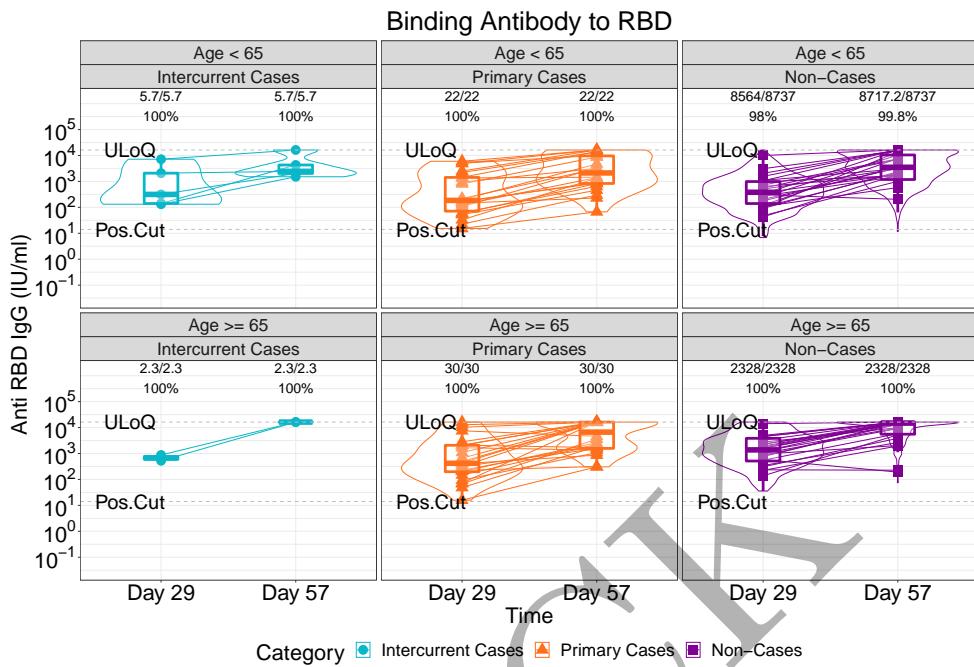


Figure 3.49: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (version 1)

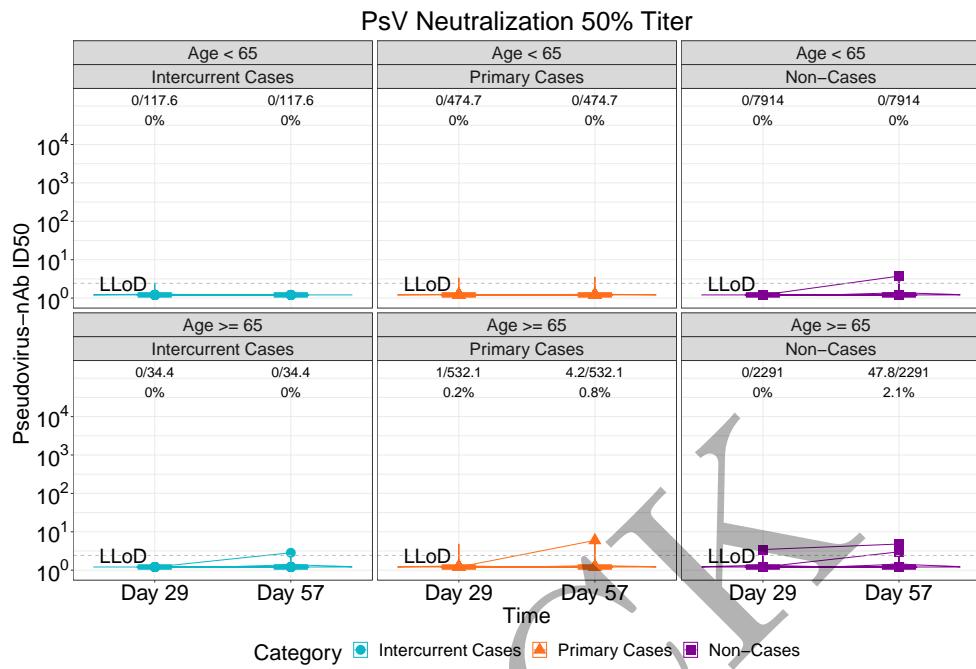


Figure 3.50: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (version 1)

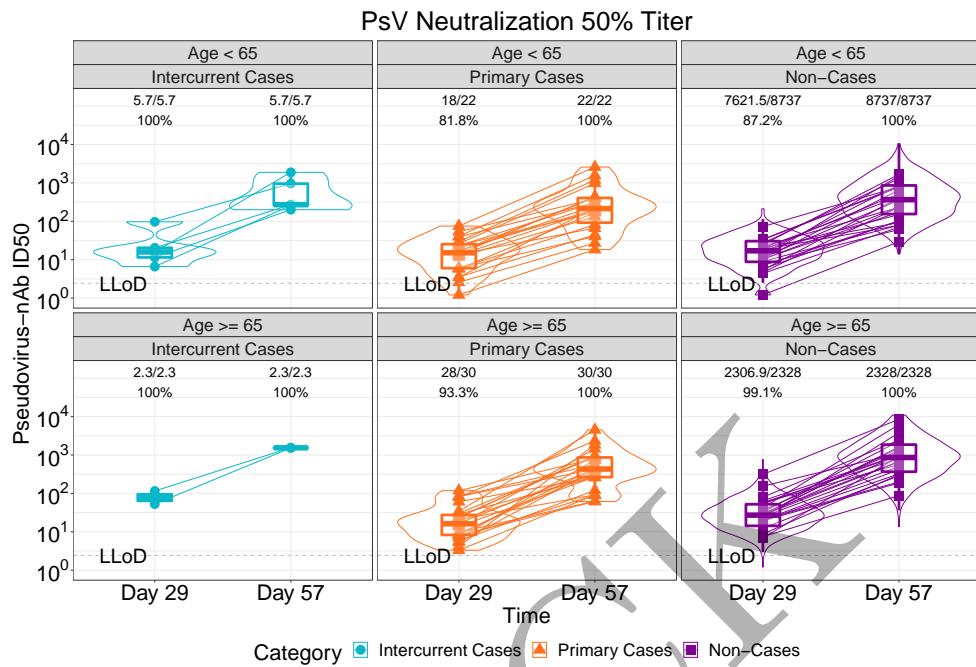


Figure 3.51: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (version 1)

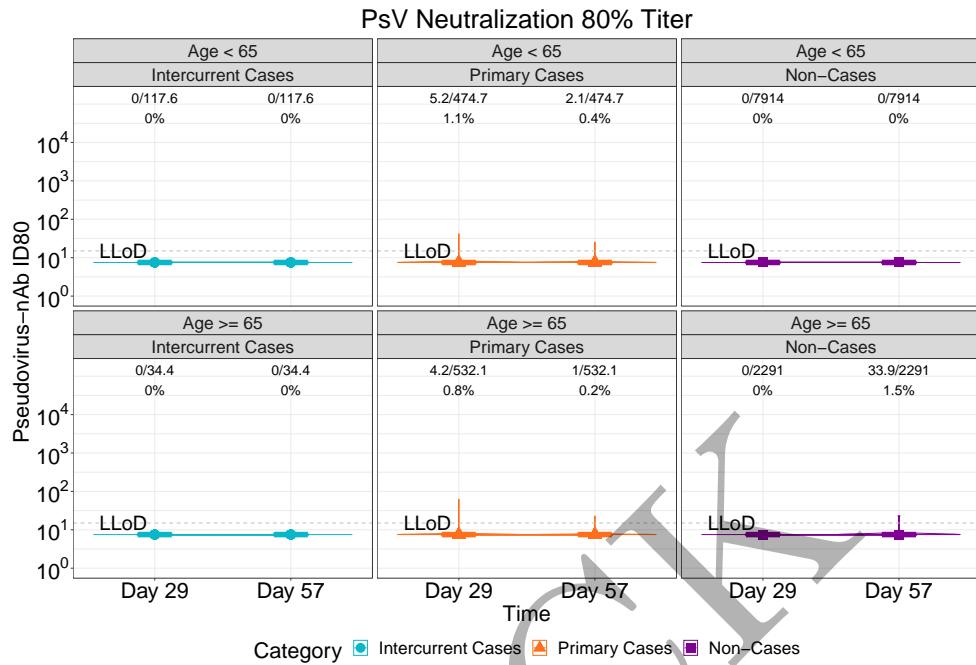


Figure 3.52: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (version 1)

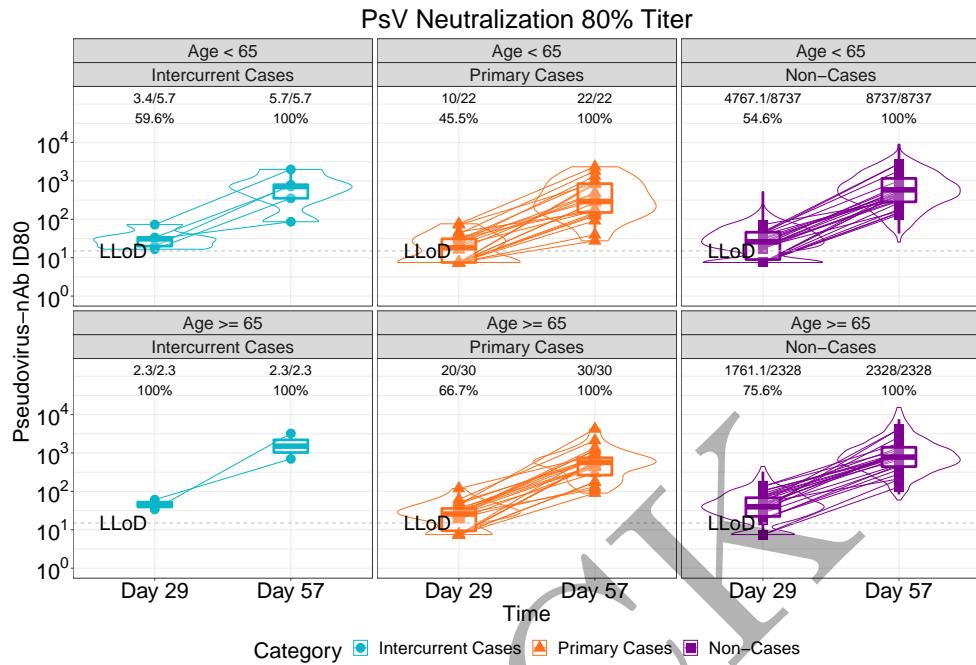


Figure 3.53: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (version 1)

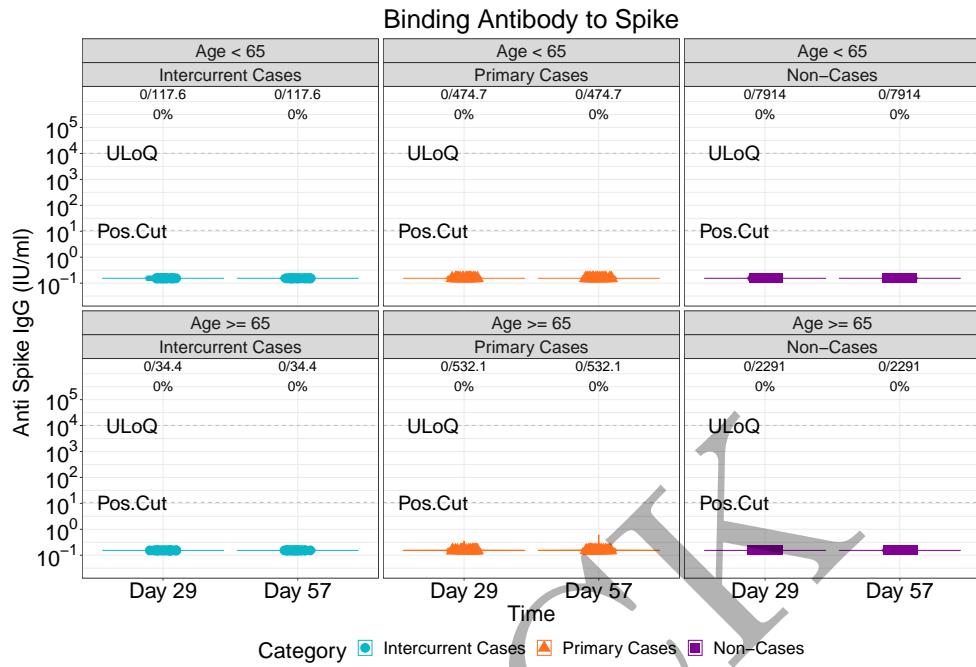


Figure 3.54: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (version 1)

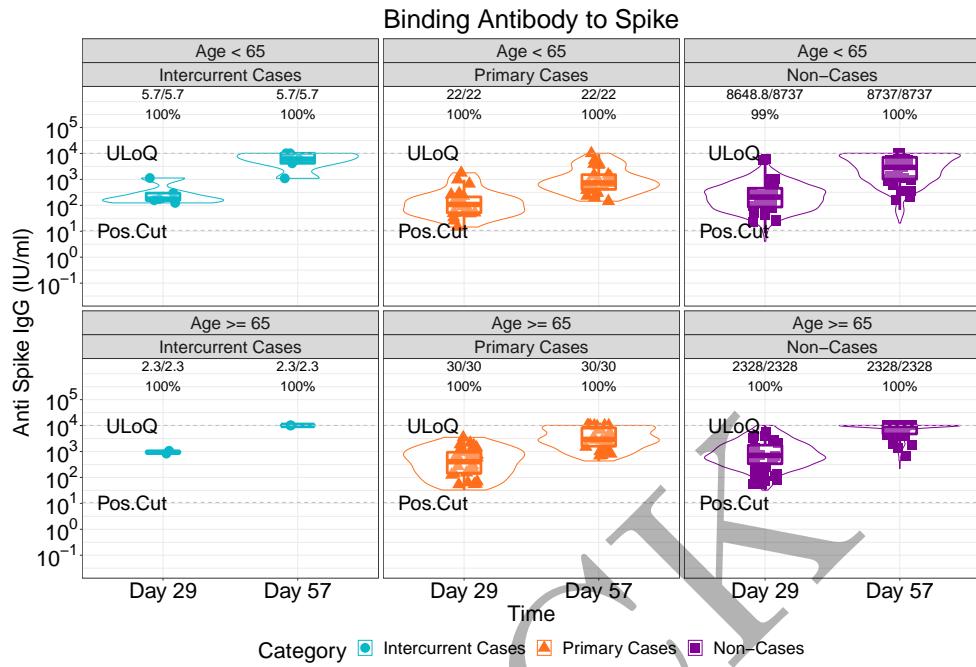


Figure 3.55: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (version 1)

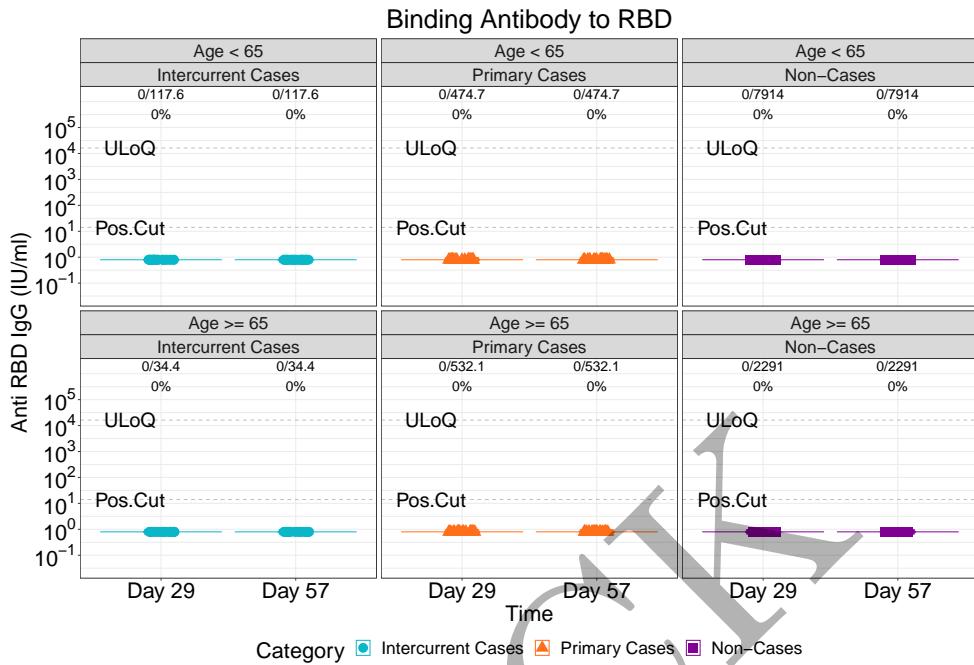


Figure 3.56: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (version 1)

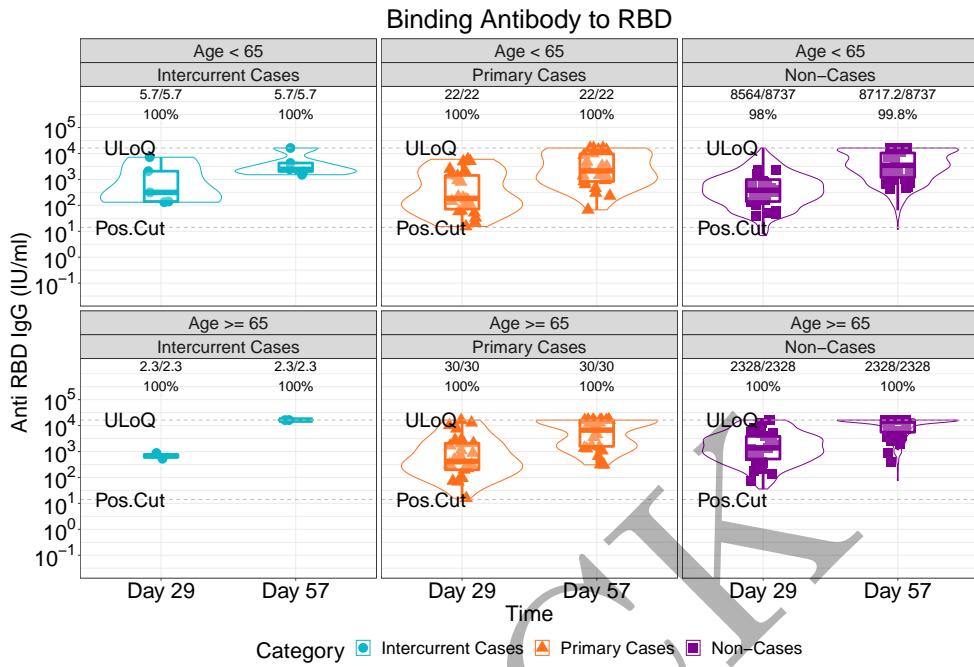


Figure 3.57: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (version 1)

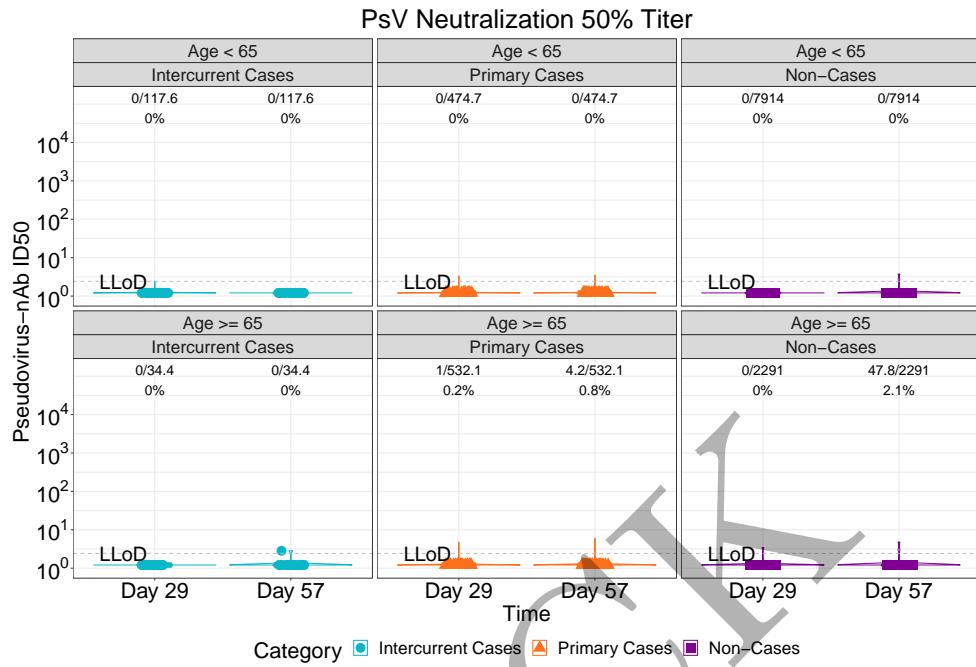


Figure 3.58: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (version 1)

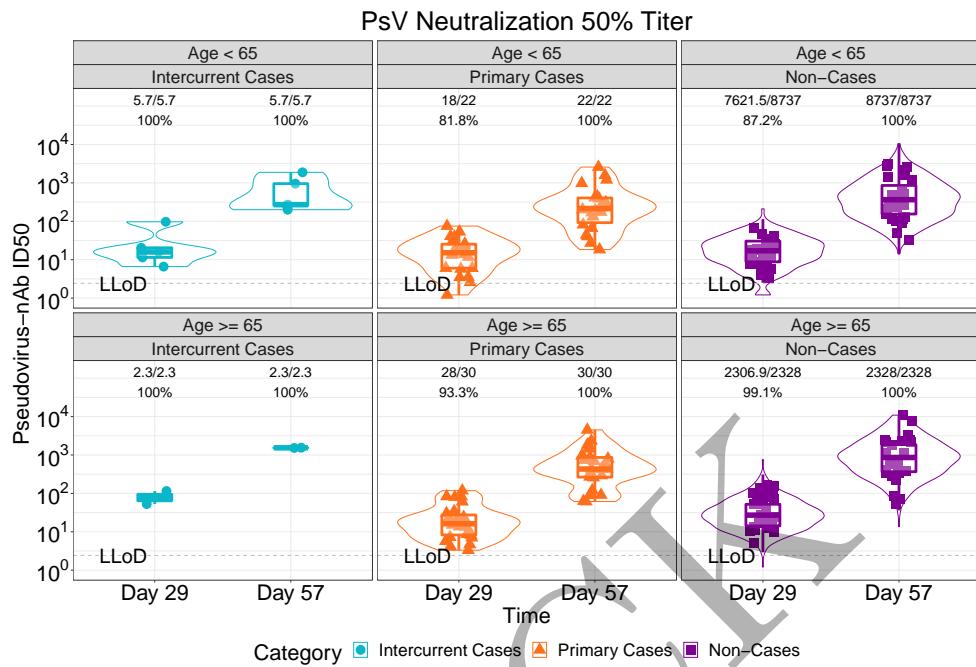


Figure 3.59: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (version 1)

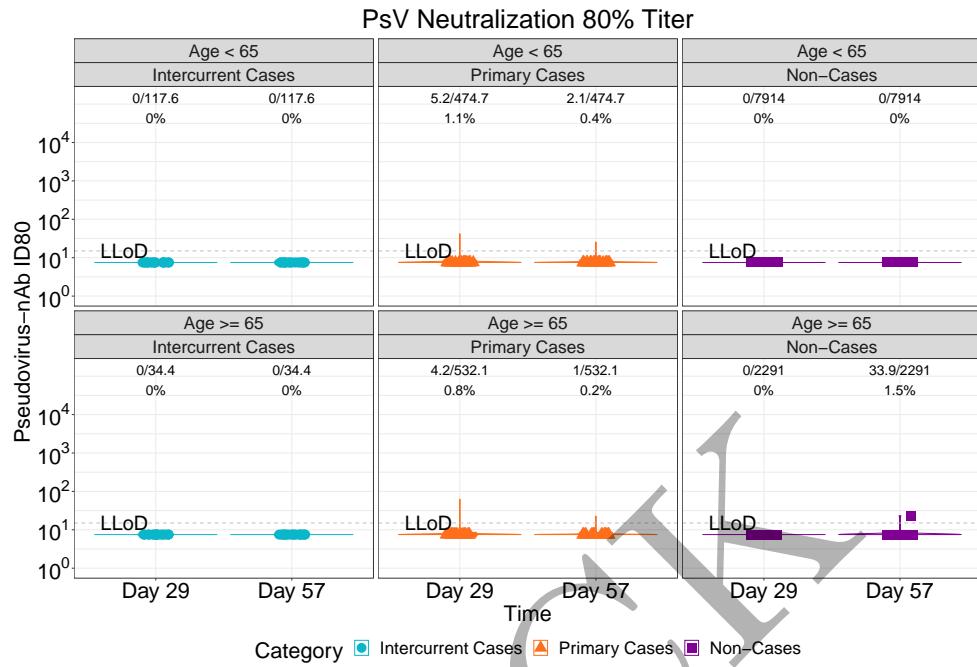


Figure 3.60: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (version 1)

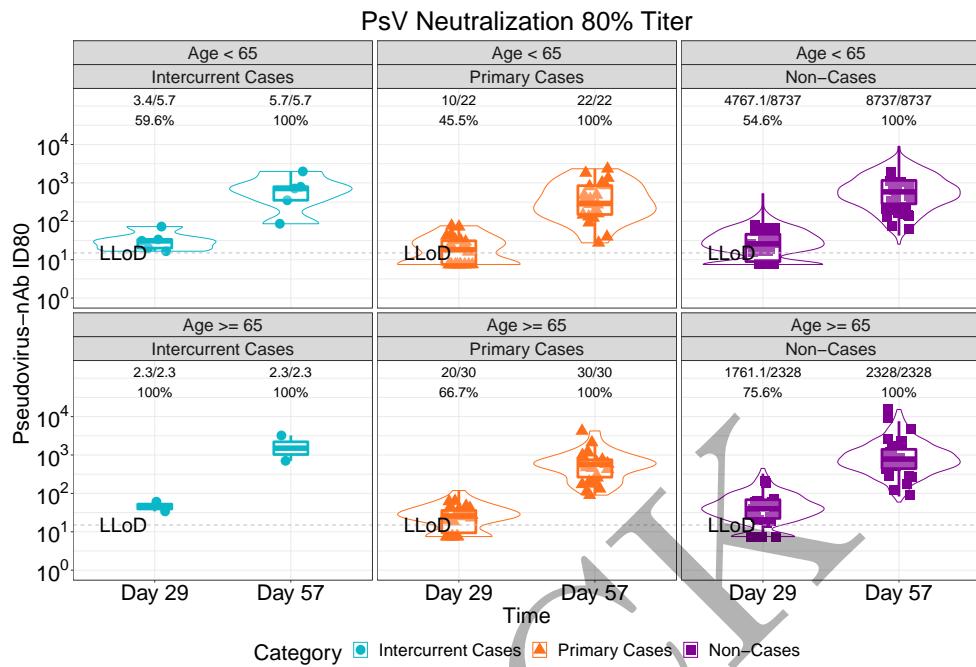


Figure 3.61: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (version 1)

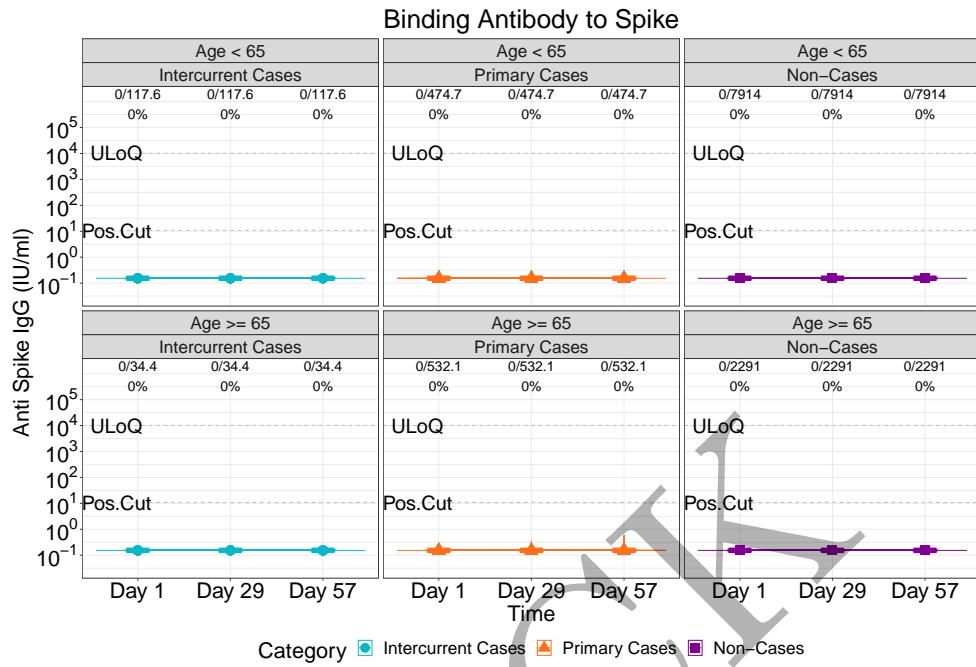


Figure 3.62: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age (version 2)

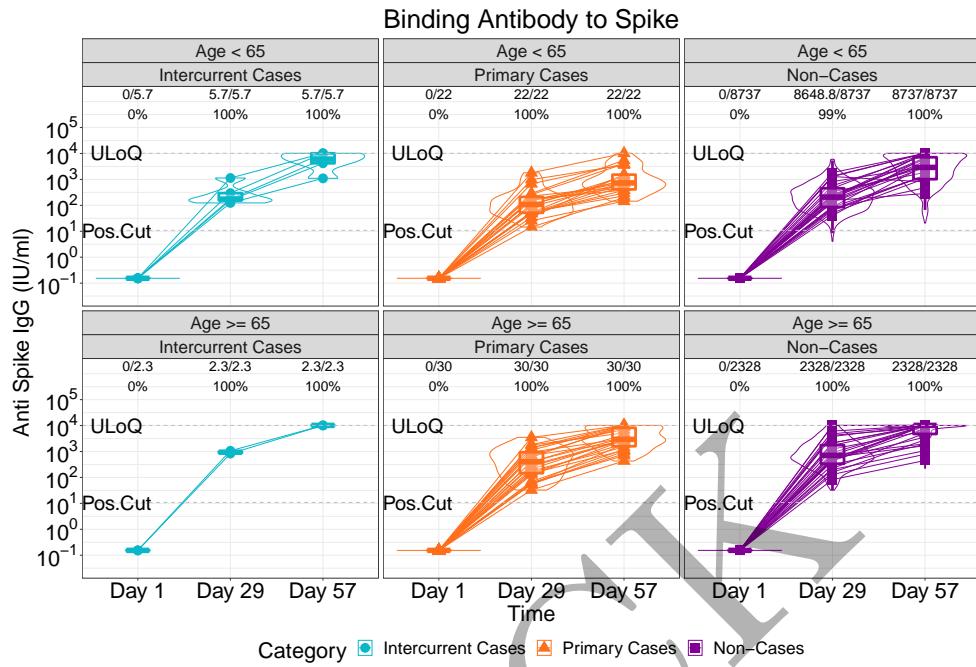


Figure 3.63: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age (version 2)

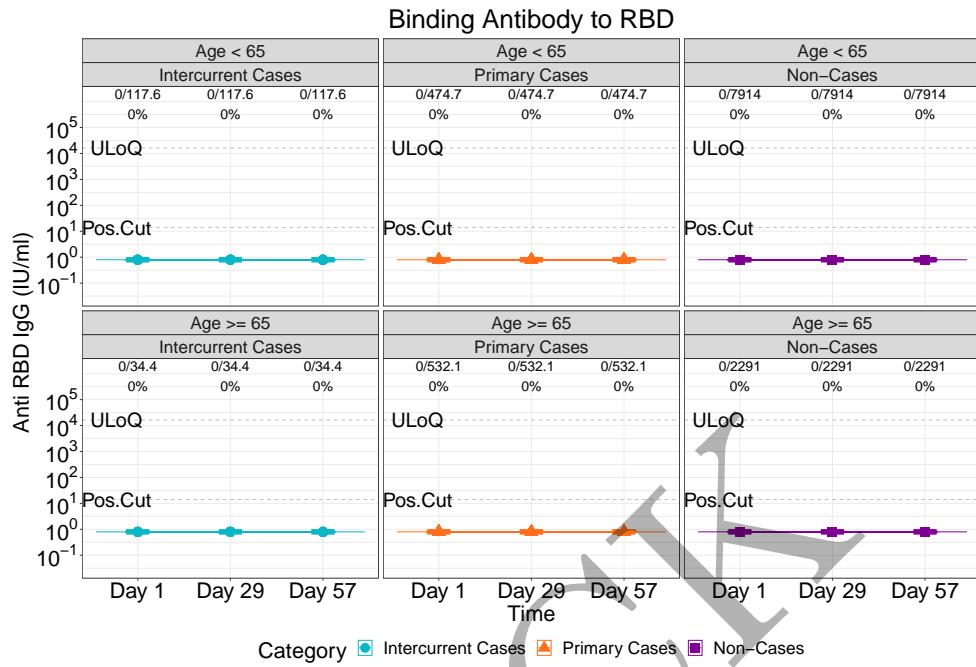


Figure 3.64: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age (version 2)

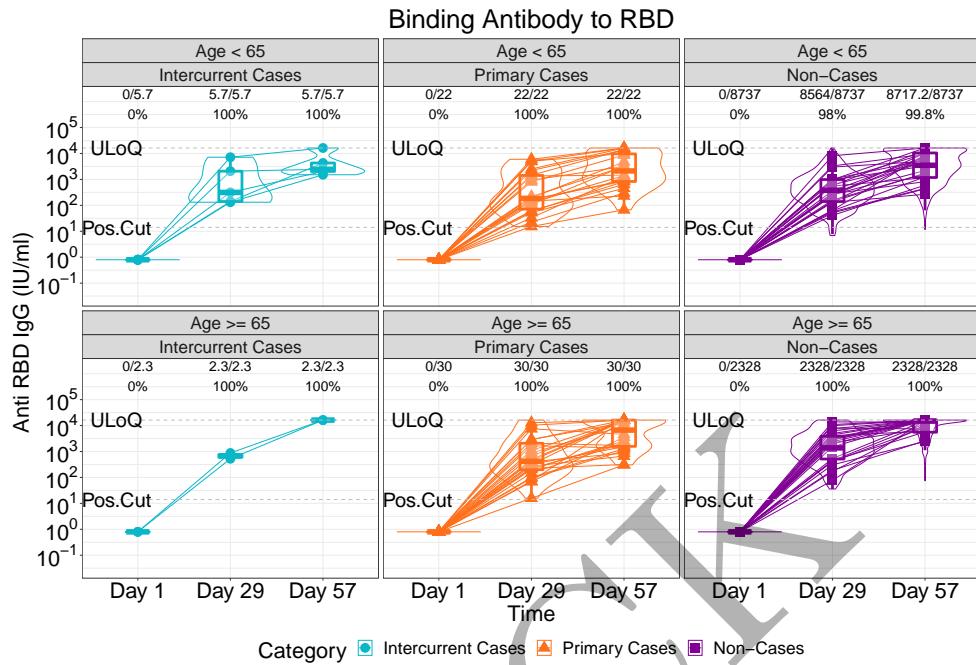


Figure 3.65: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age (version 2)

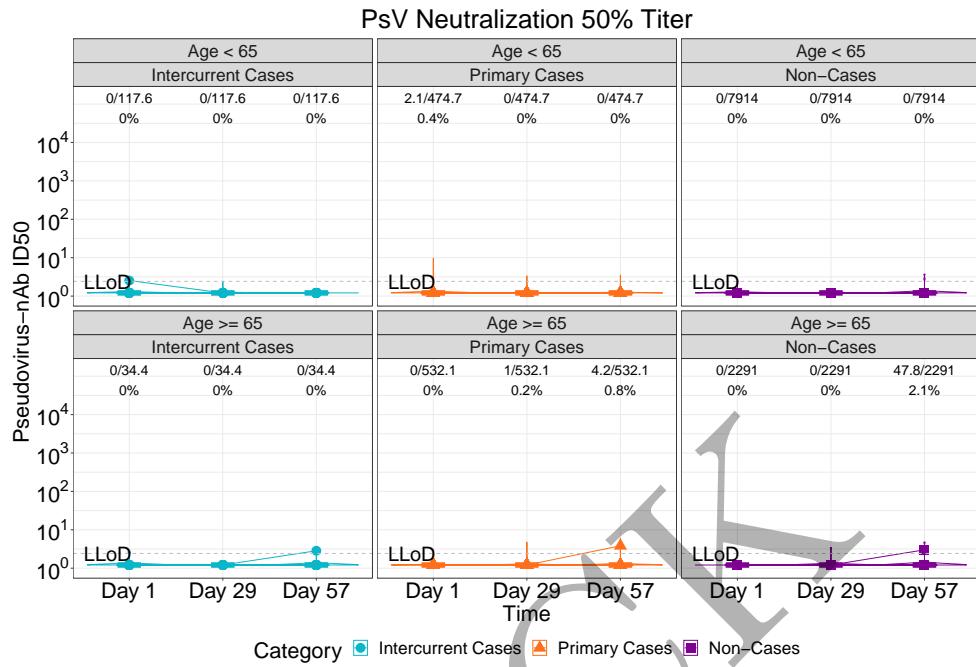


Figure 3.66: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (version 2)

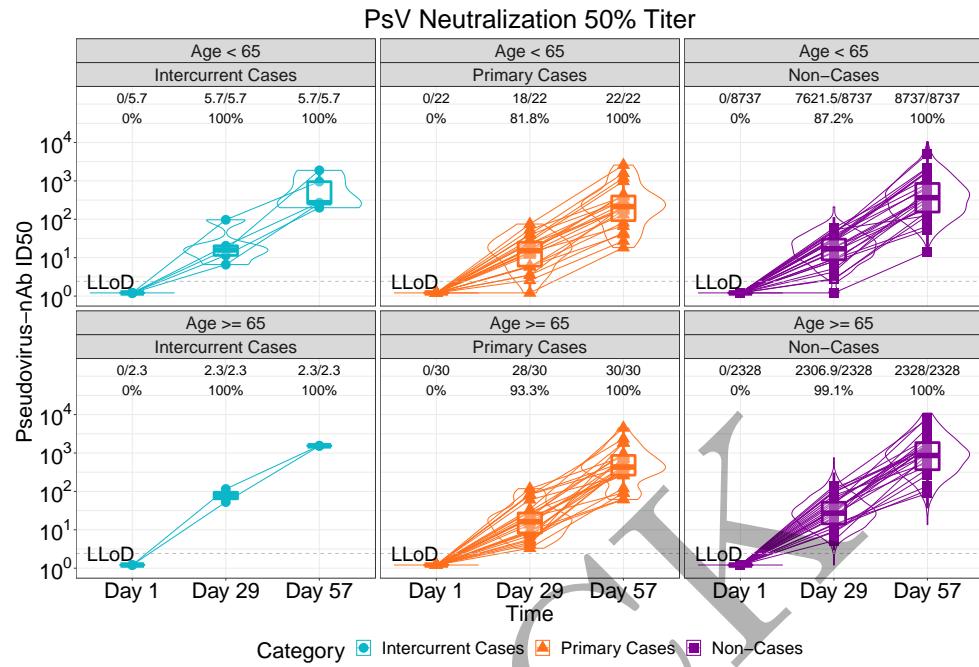


Figure 3.67: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (version 2)

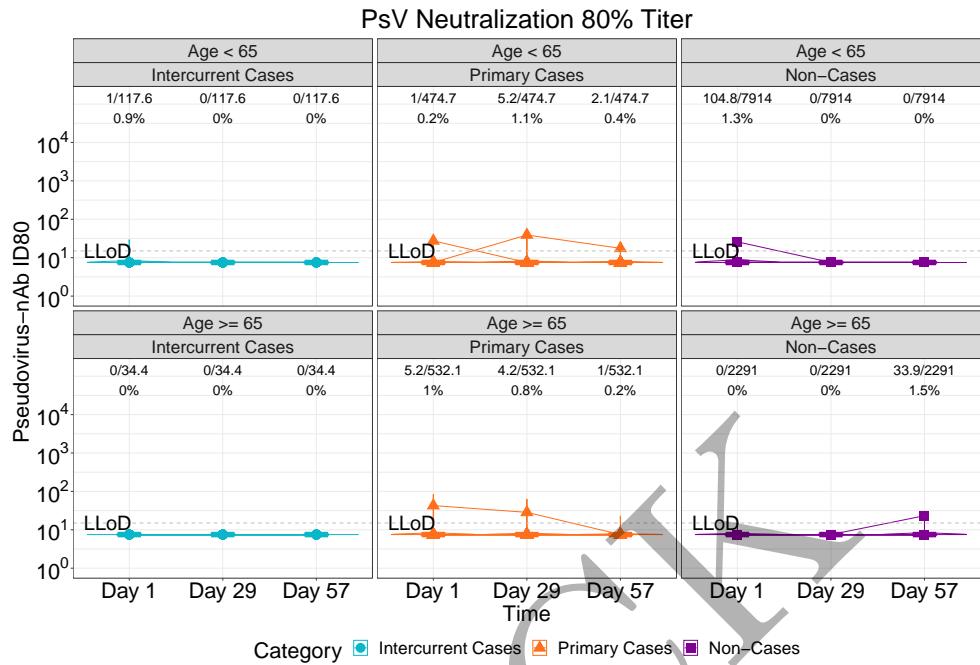


Figure 3.68: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (version 2)

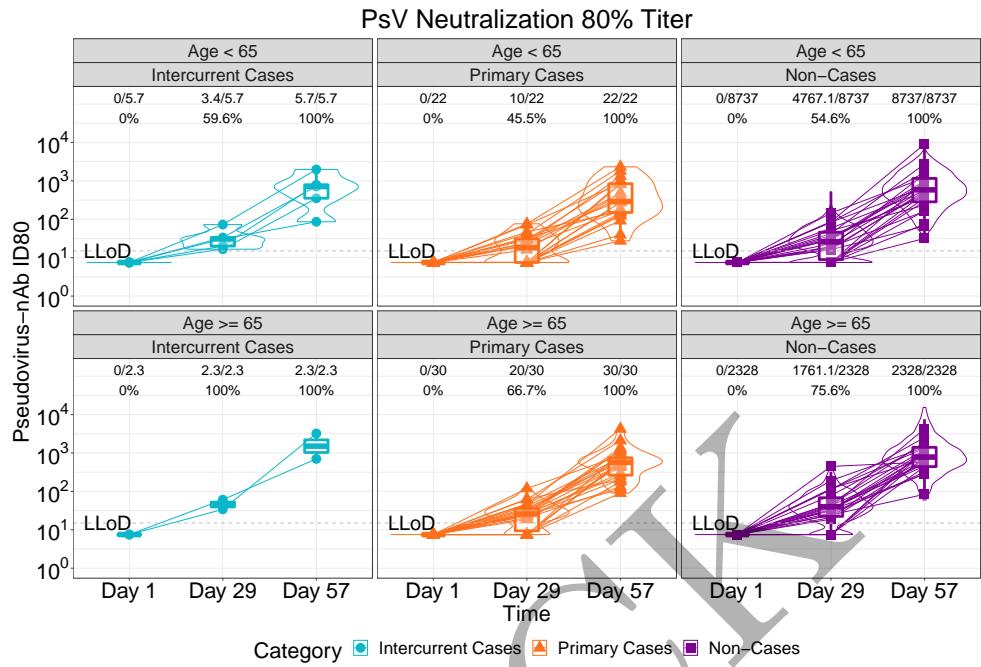


Figure 3.69: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (version 2)

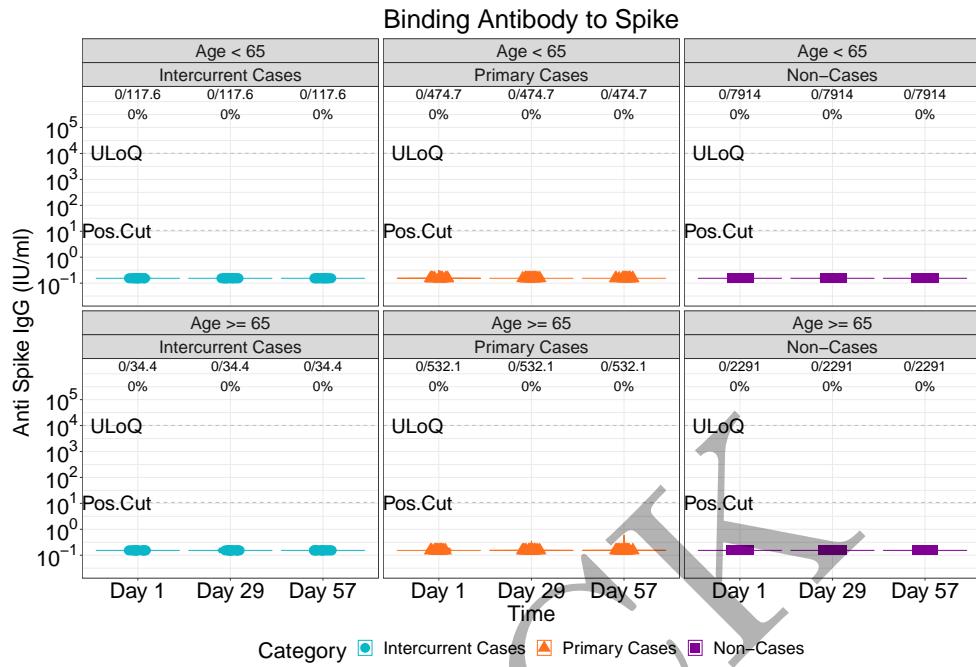


Figure 3.70: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age (version 2)

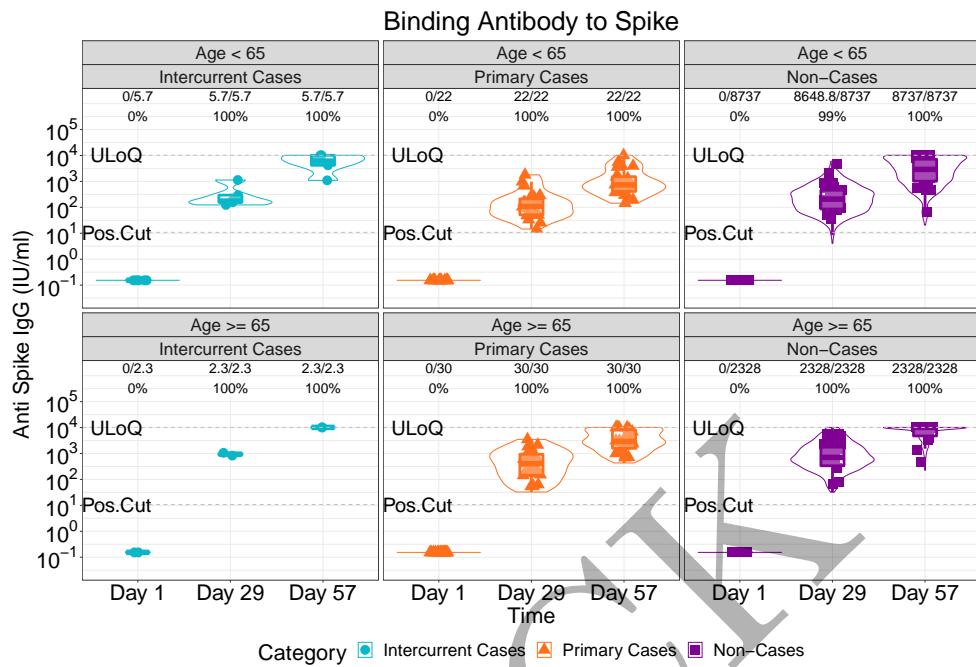


Figure 3.71: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age (version 2)

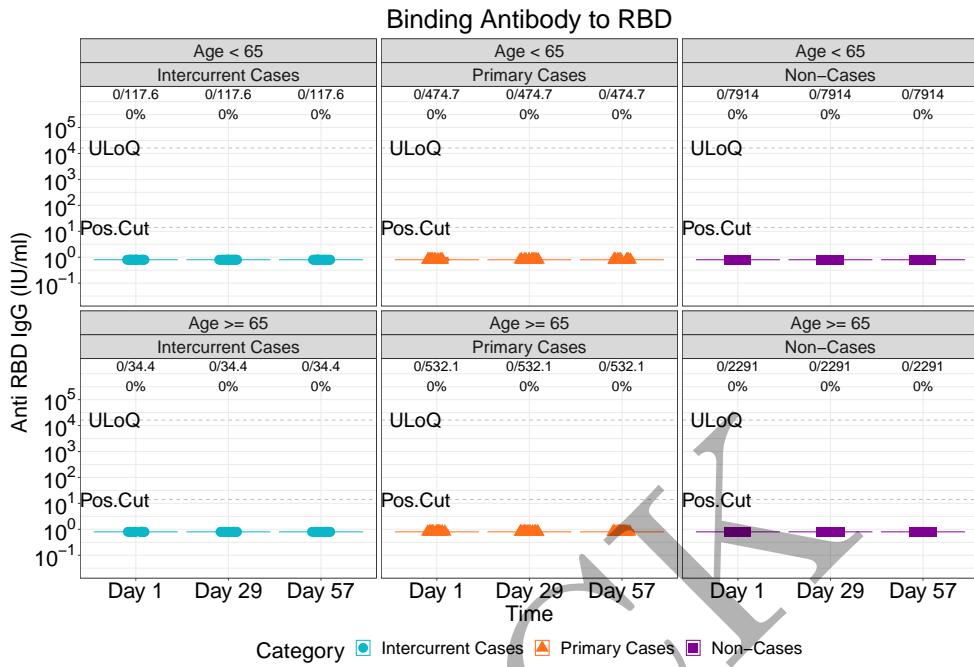


Figure 3.72: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age (version 2)

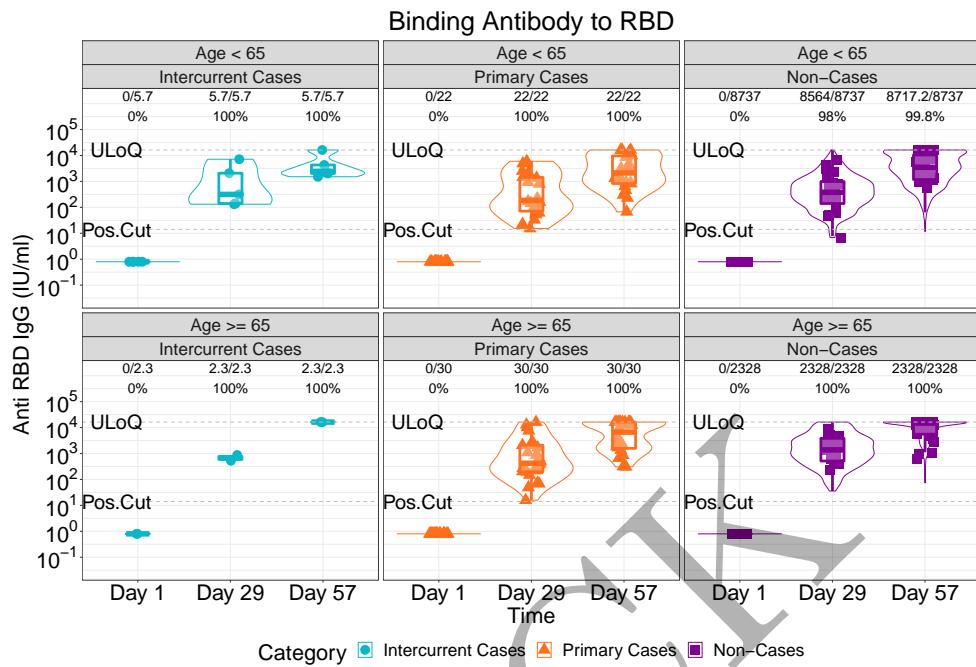


Figure 3.73: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age (version 2)

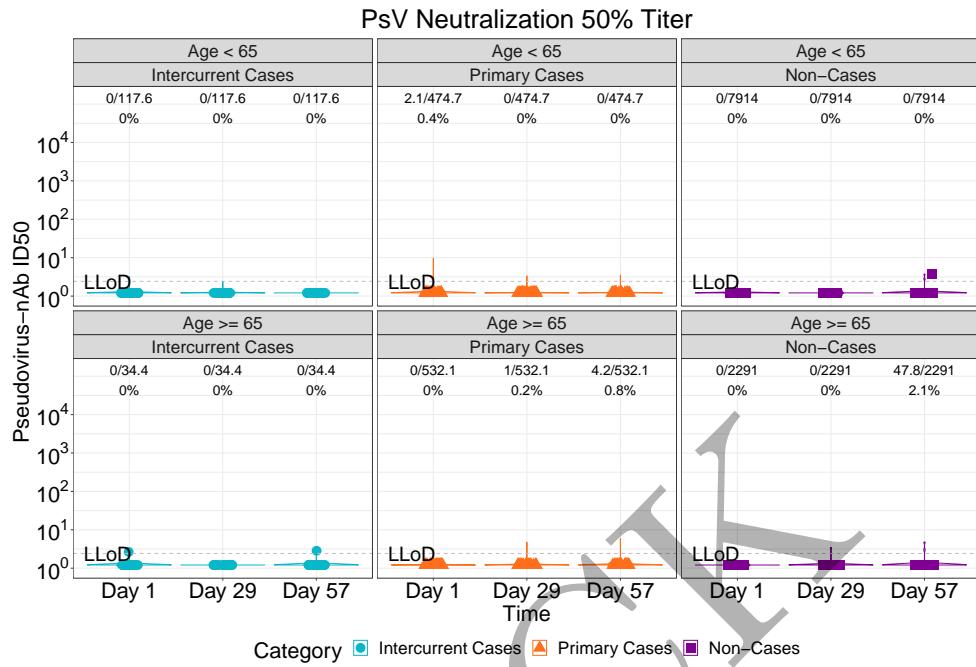


Figure 3.74: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age (version 2)

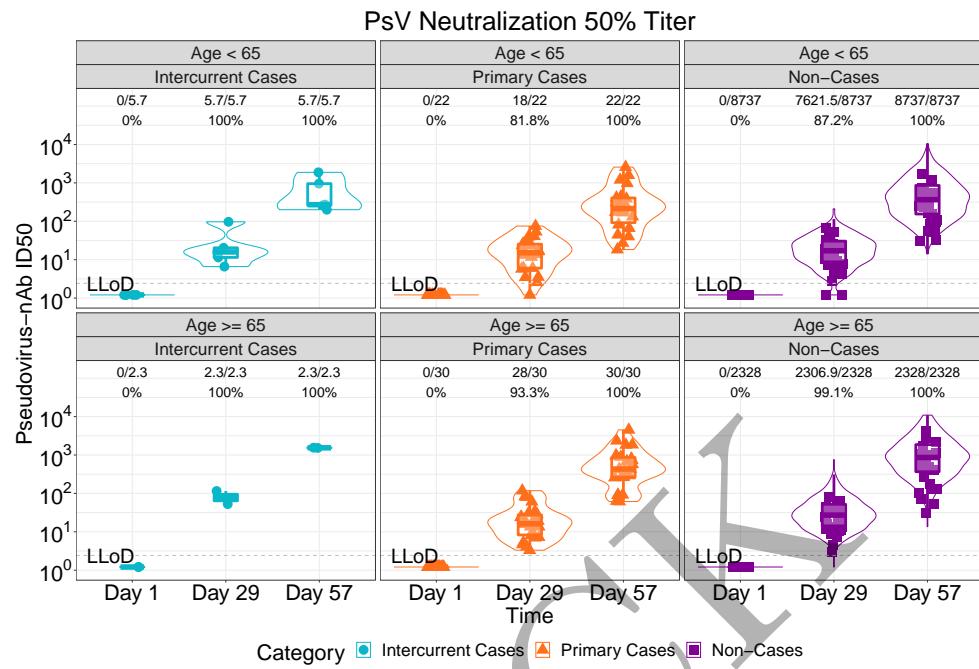


Figure 3.75: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age (version 2)

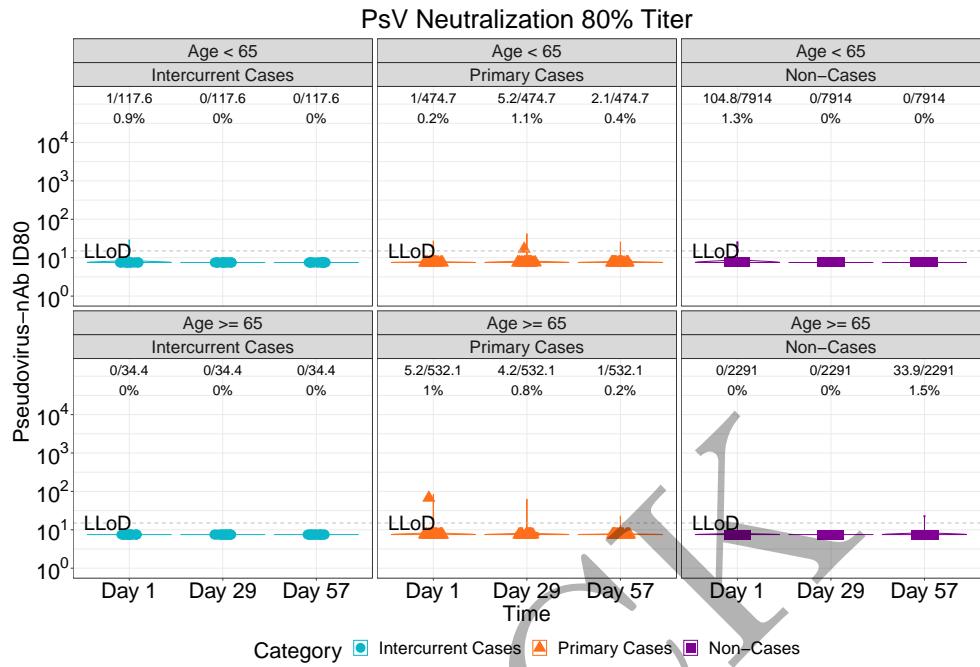


Figure 3.76: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age (version 2)

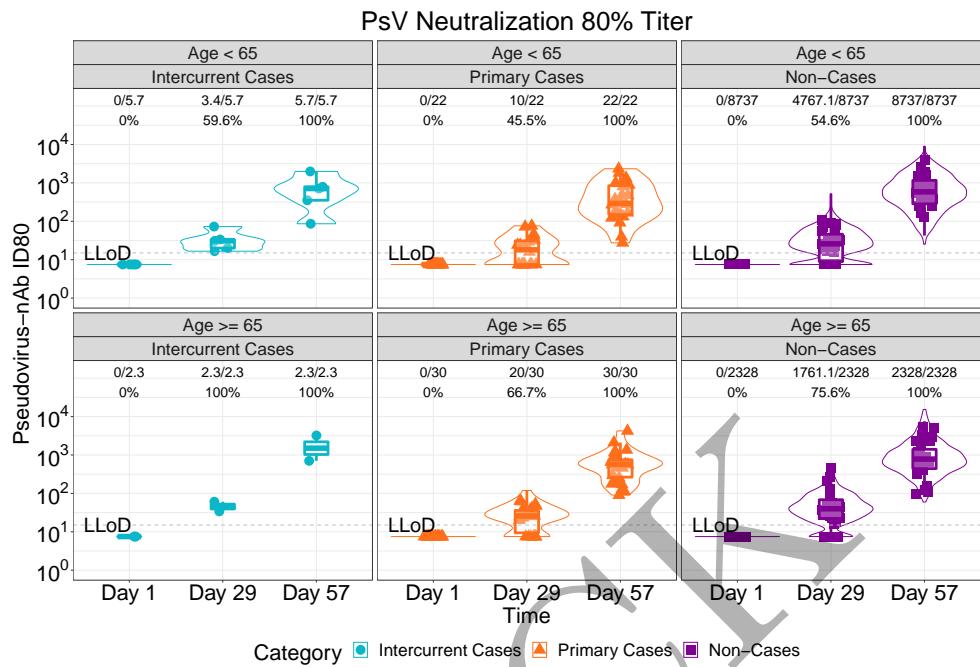


Figure 3.77: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age (version 2)

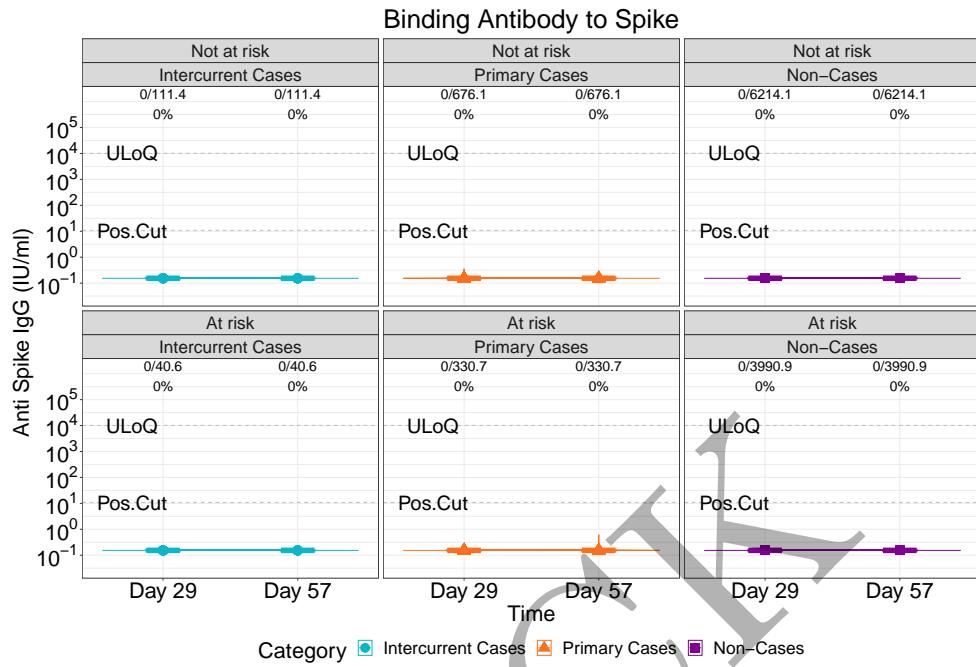


Figure 3.78: lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (version 1)

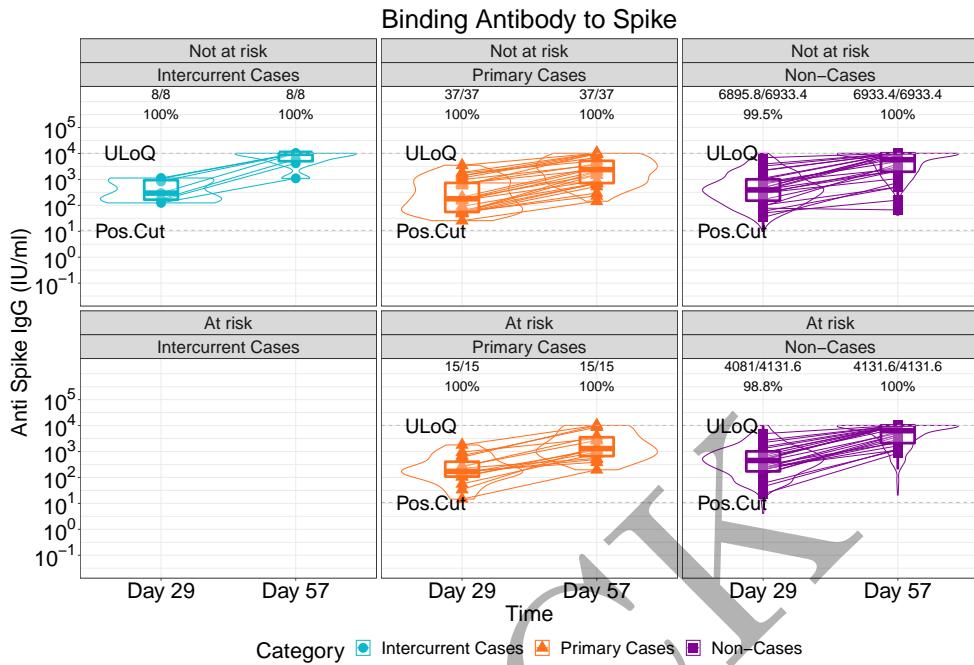


Figure 3.79: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (version 1)

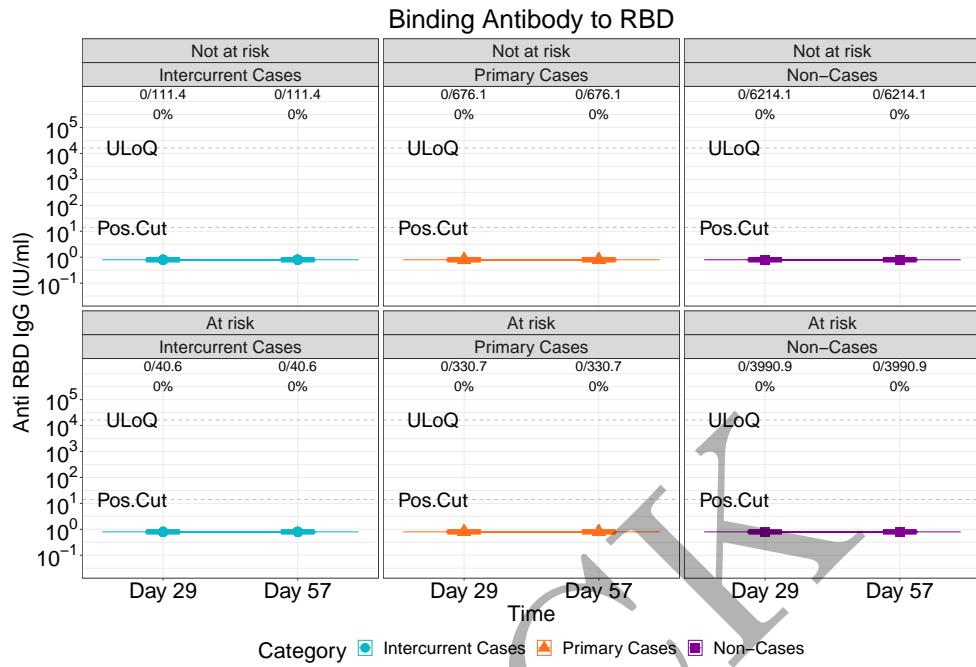


Figure 3.80: lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (version 1)

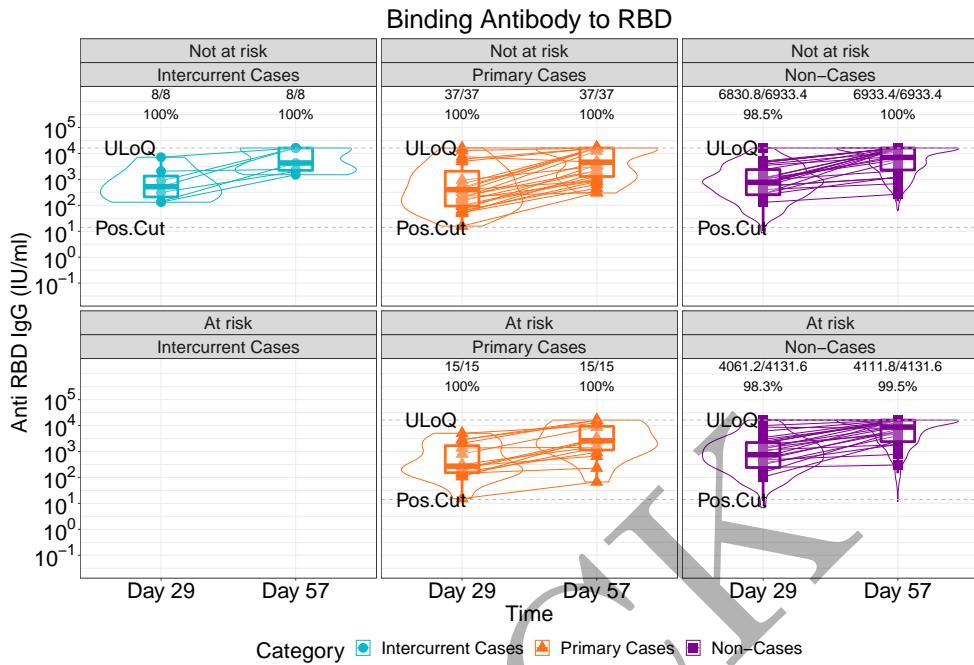


Figure 3.81: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (version 1)

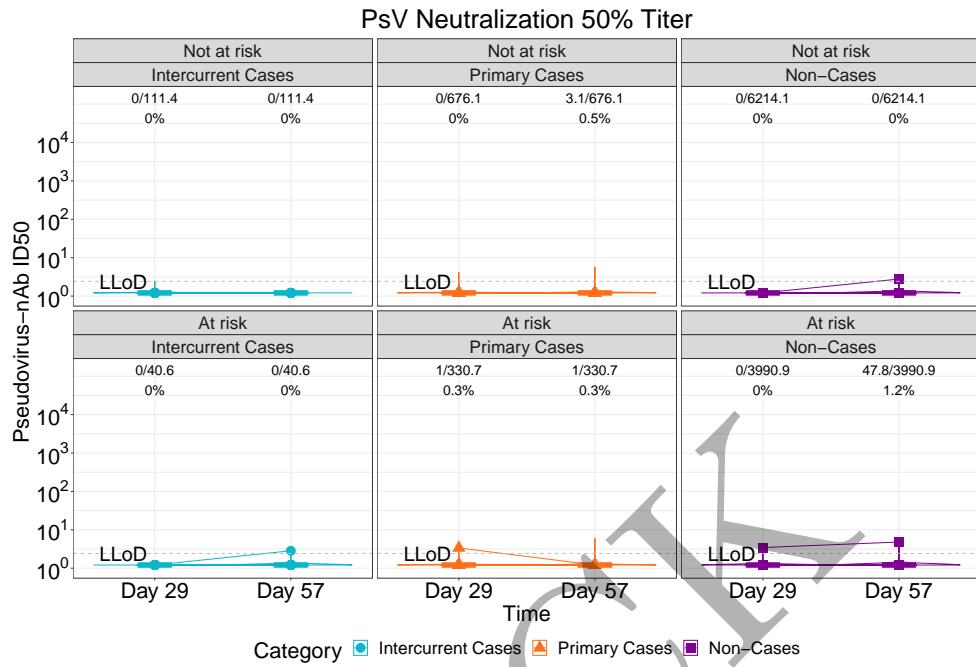


Figure 3.82: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (version 1)

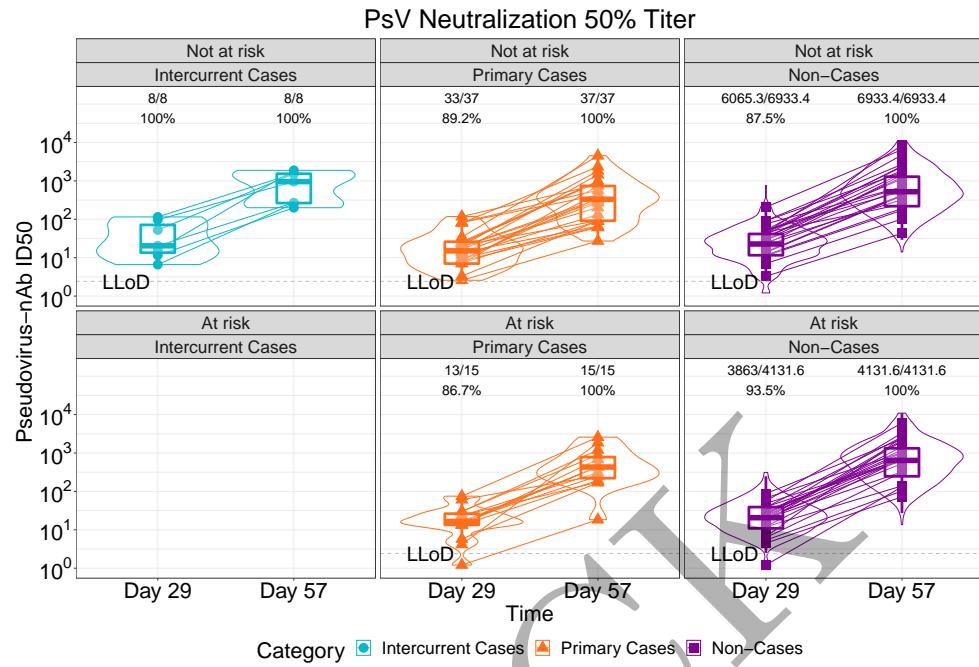


Figure 3.83: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (version 1)

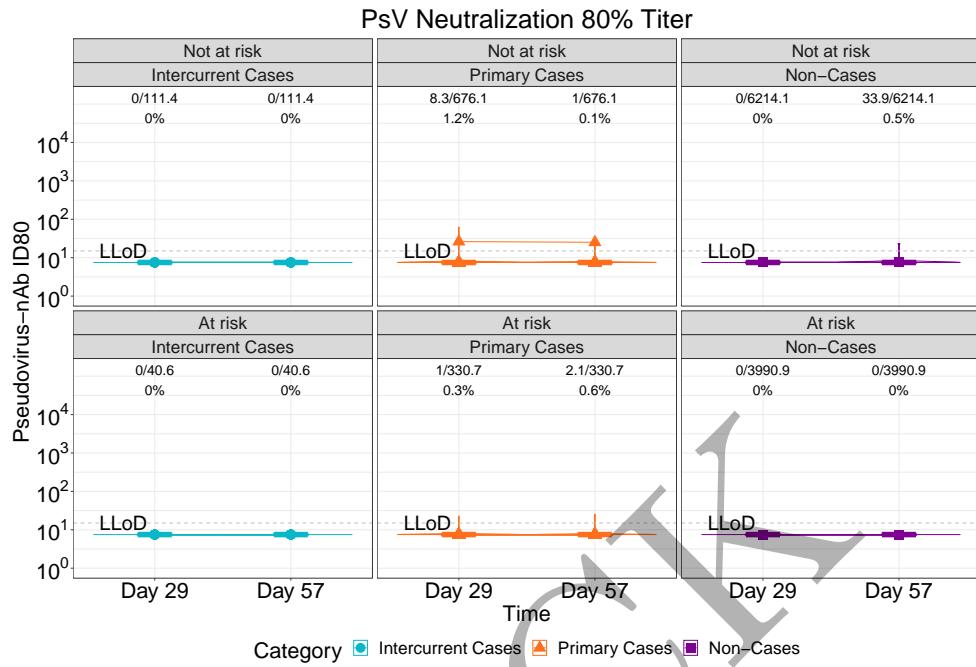


Figure 3.84: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (version 1)

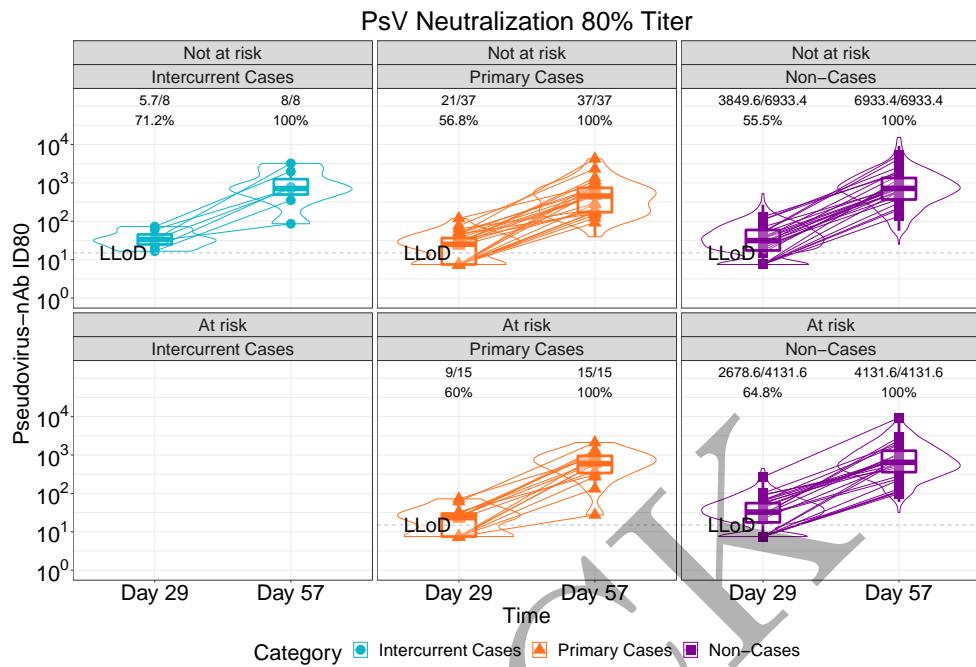


Figure 3.85: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (version 1)

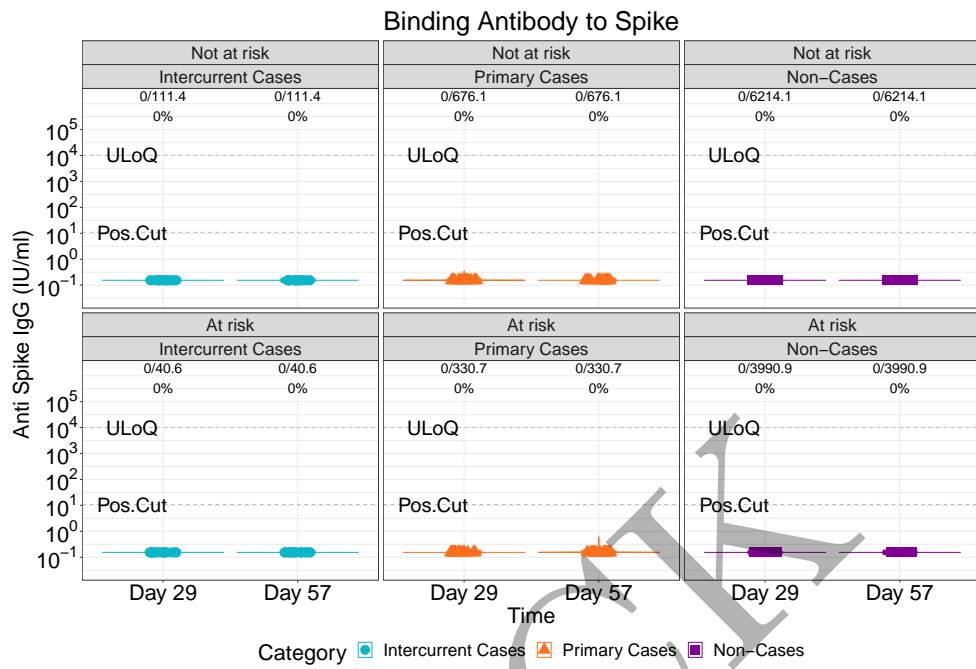


Figure 3.86: violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (version 1)

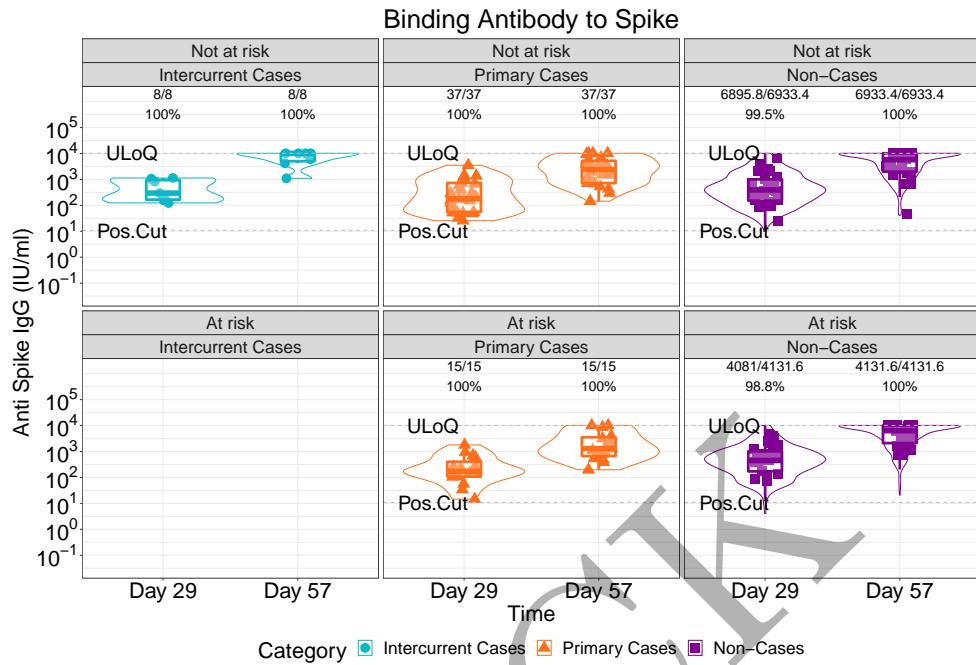


Figure 3.87: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (version 1)

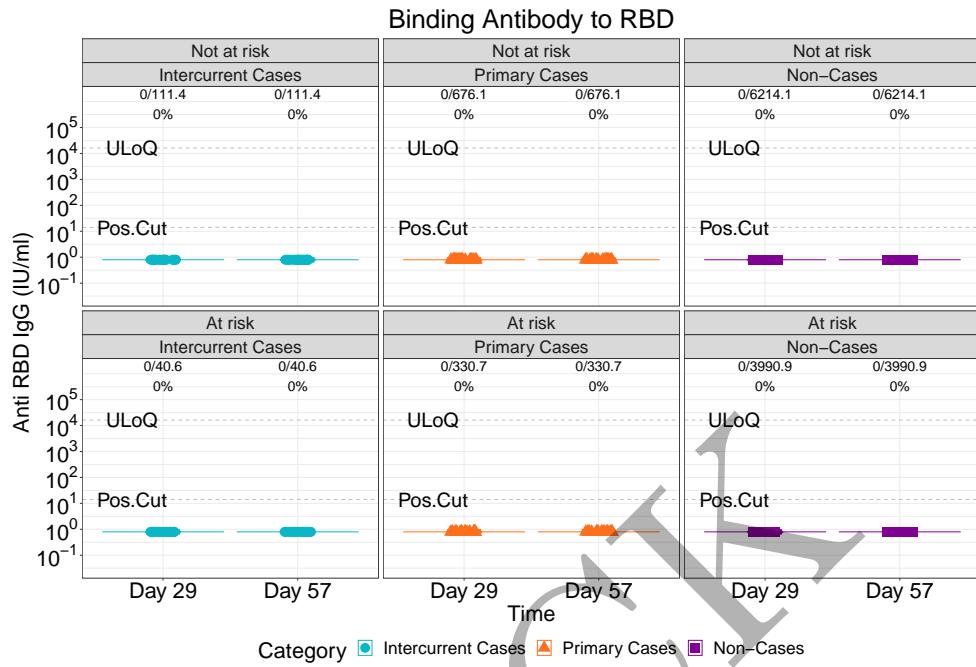


Figure 3.88: violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (version 1)

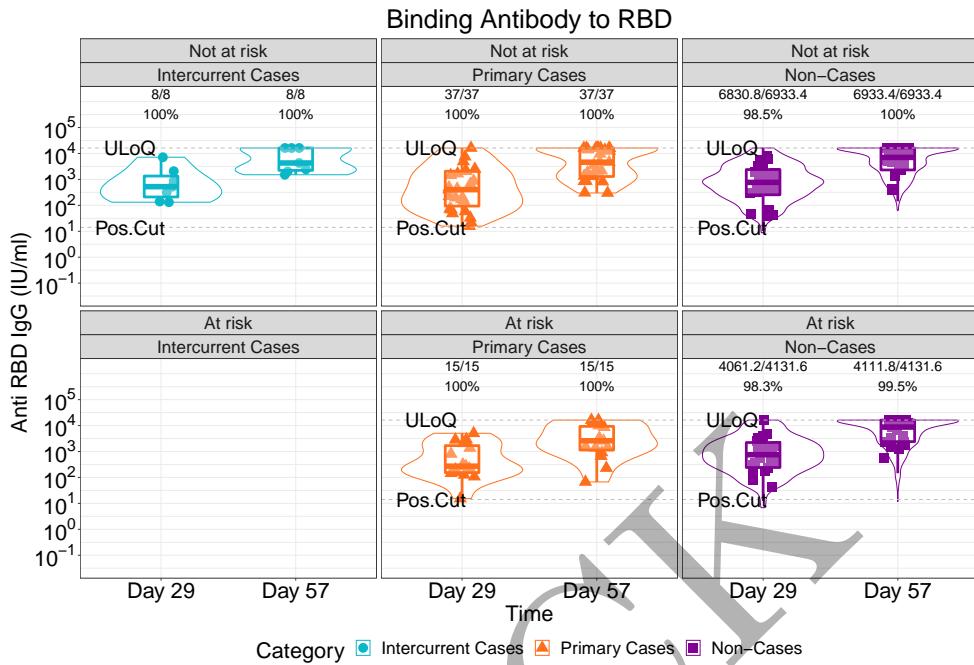


Figure 3.89: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (version 1)

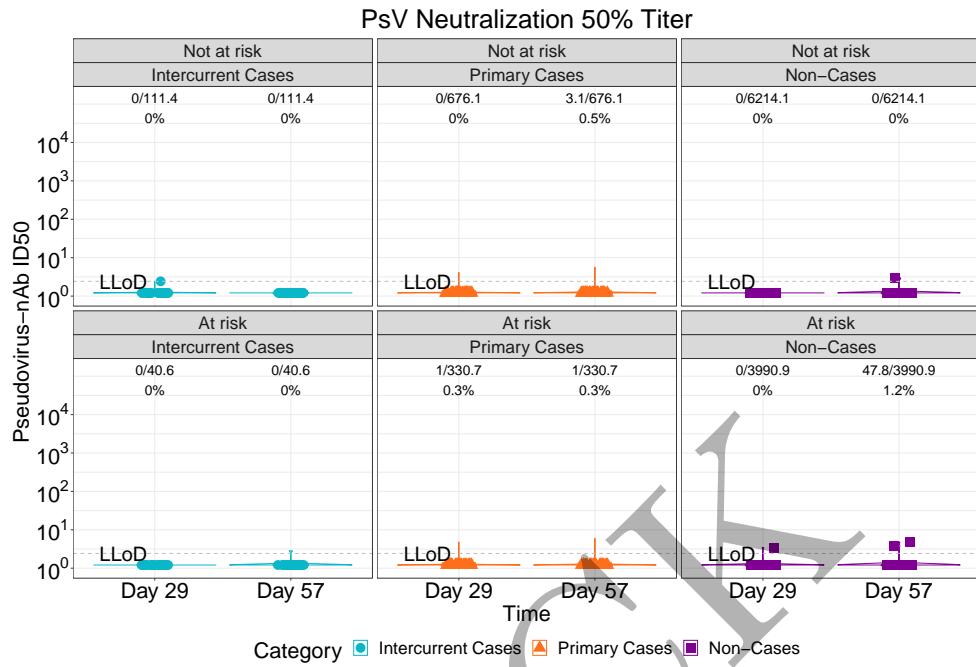


Figure 3.90: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (version 1)

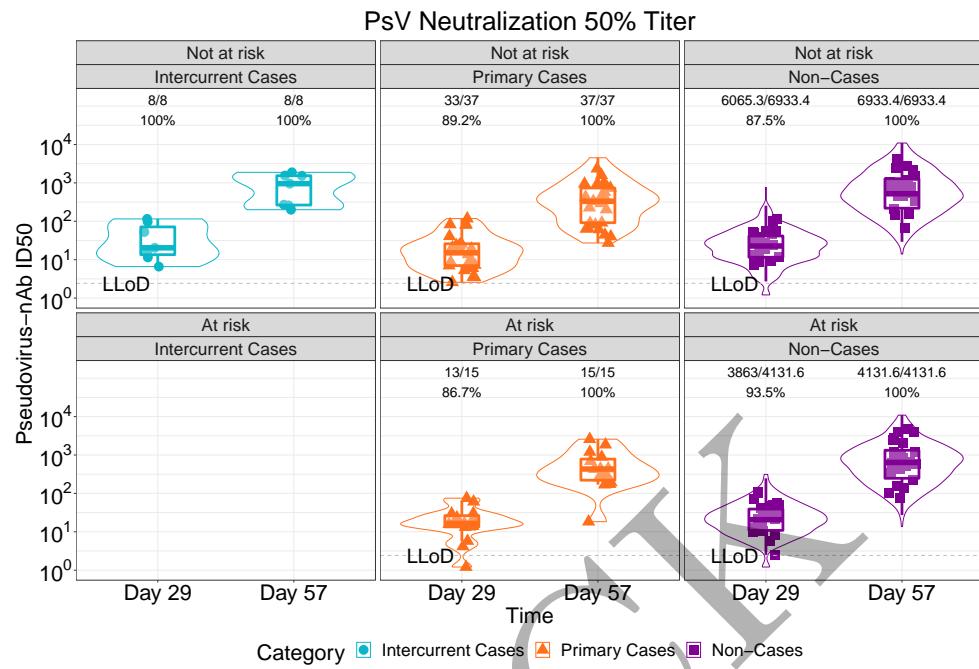


Figure 3.91: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (version 1)

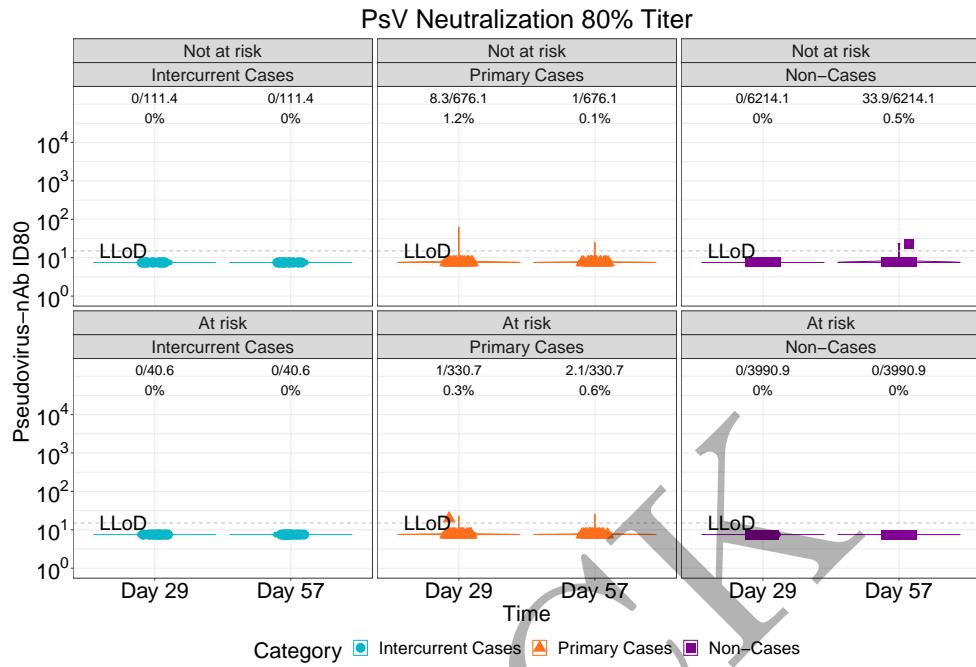


Figure 3.92: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (version 1)

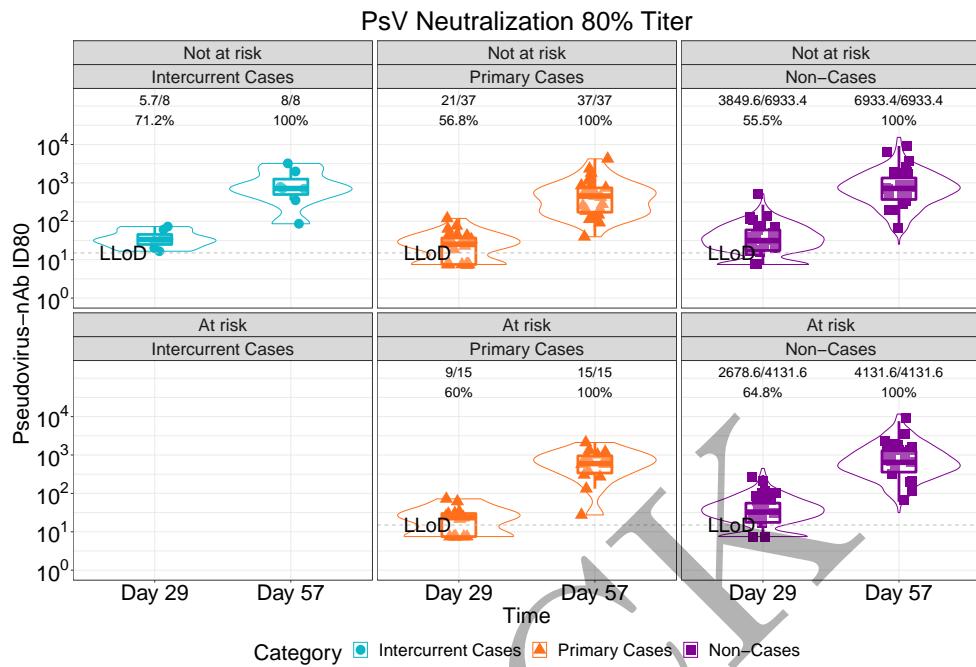


Figure 3.93: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (version 1)

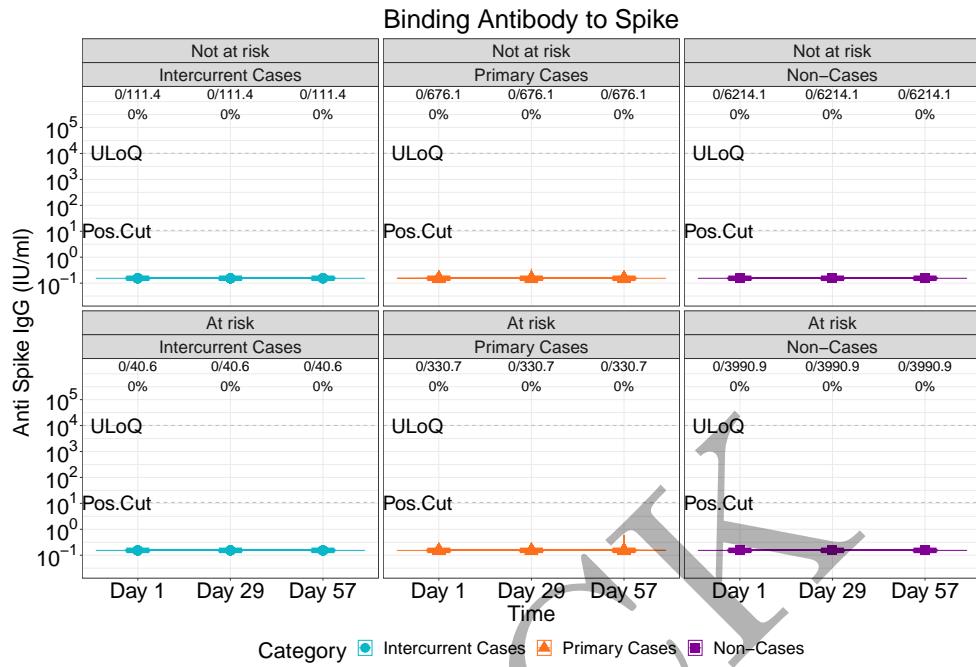


Figure 3.94: lineplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (version 2)

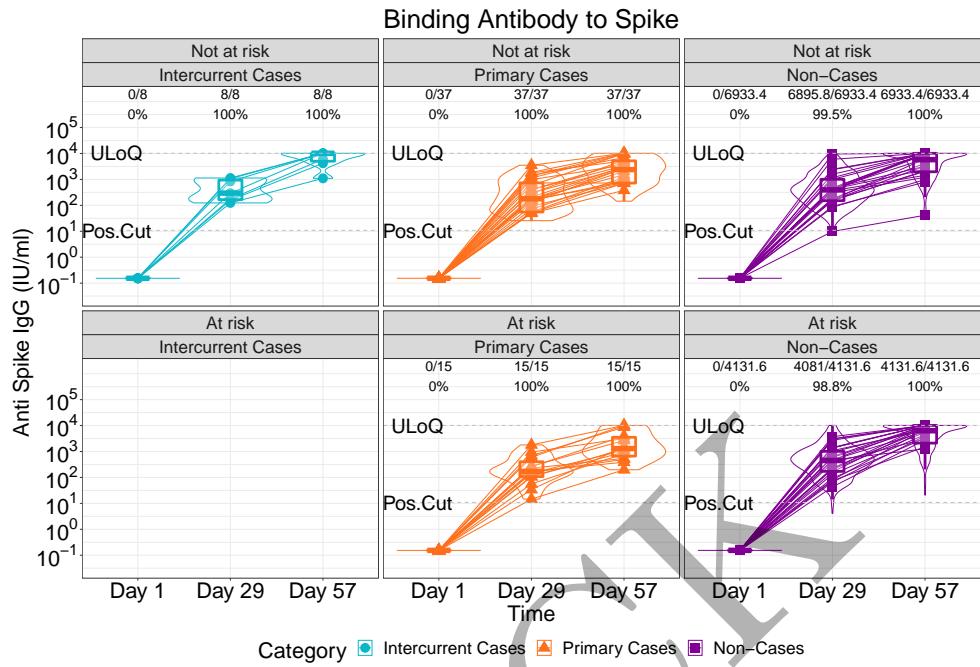


Figure 3.95: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (version 2)

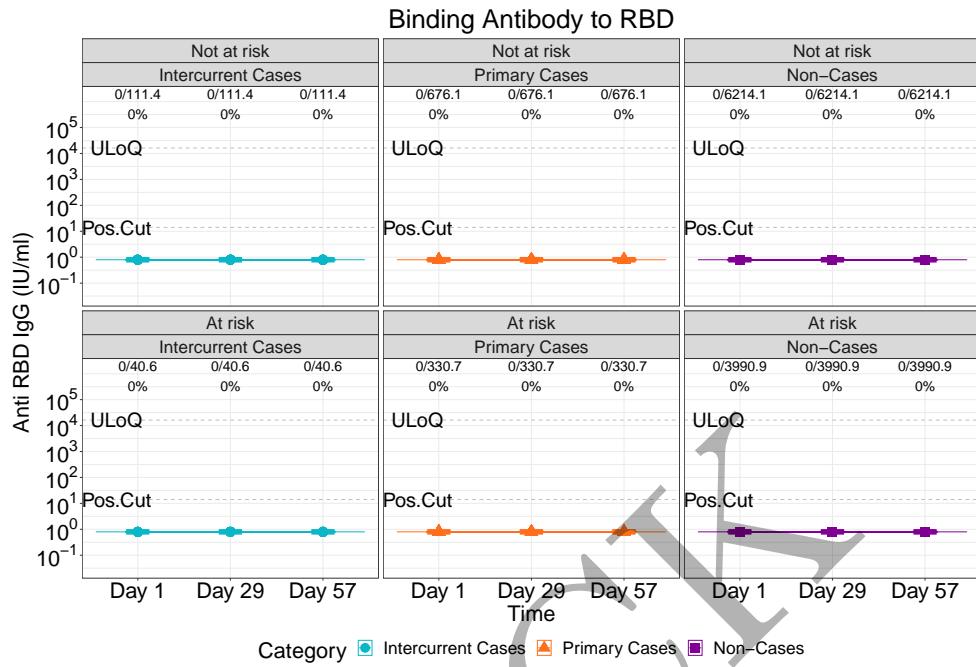


Figure 3.96: lineplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (version 2)

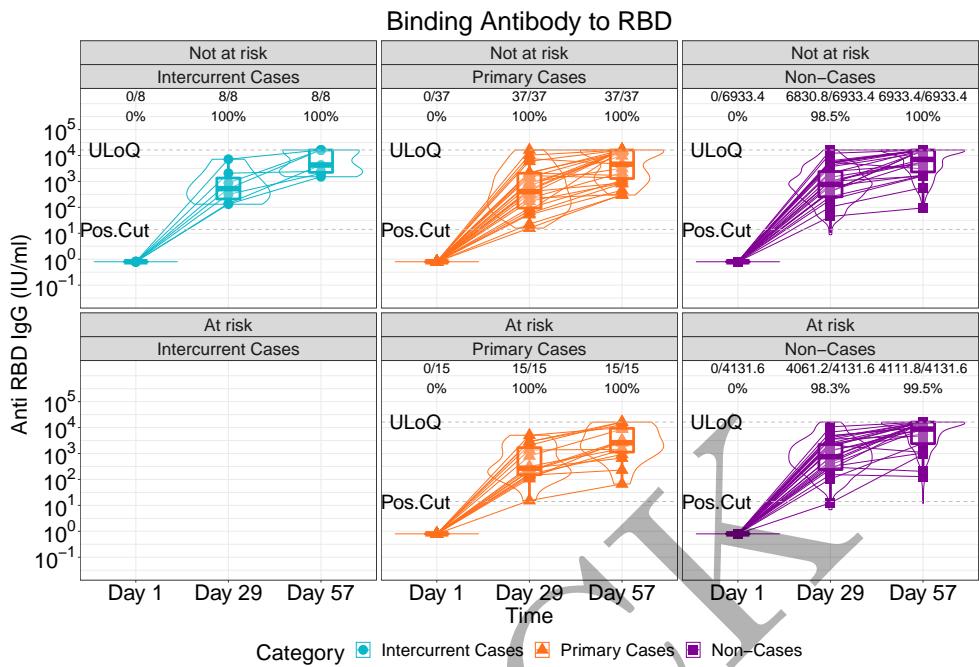


Figure 3.97: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (version 2)

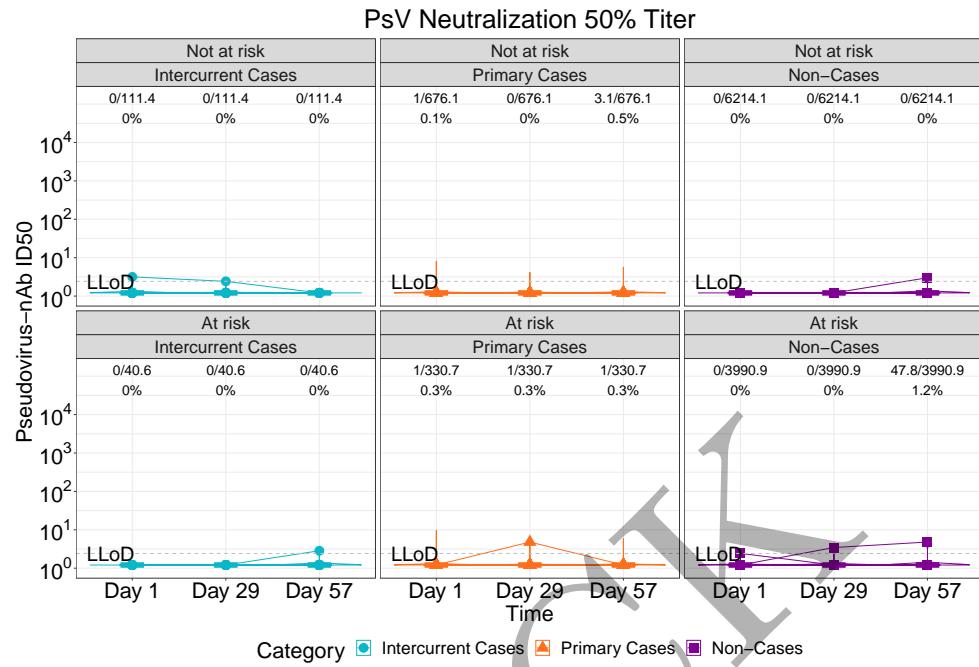


Figure 3.98: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (version 2)

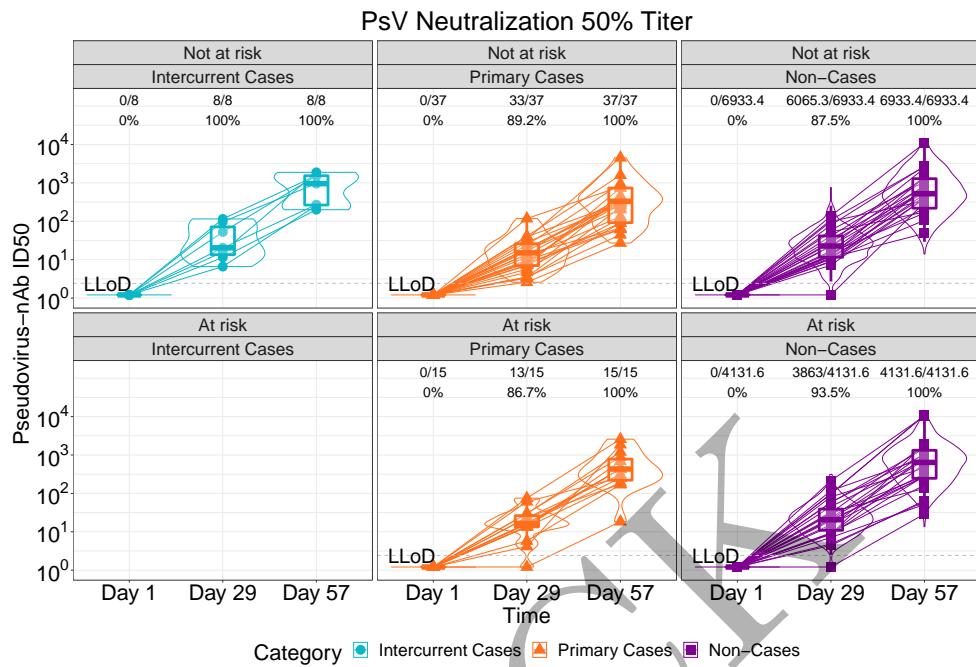


Figure 3.99: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (version 2)

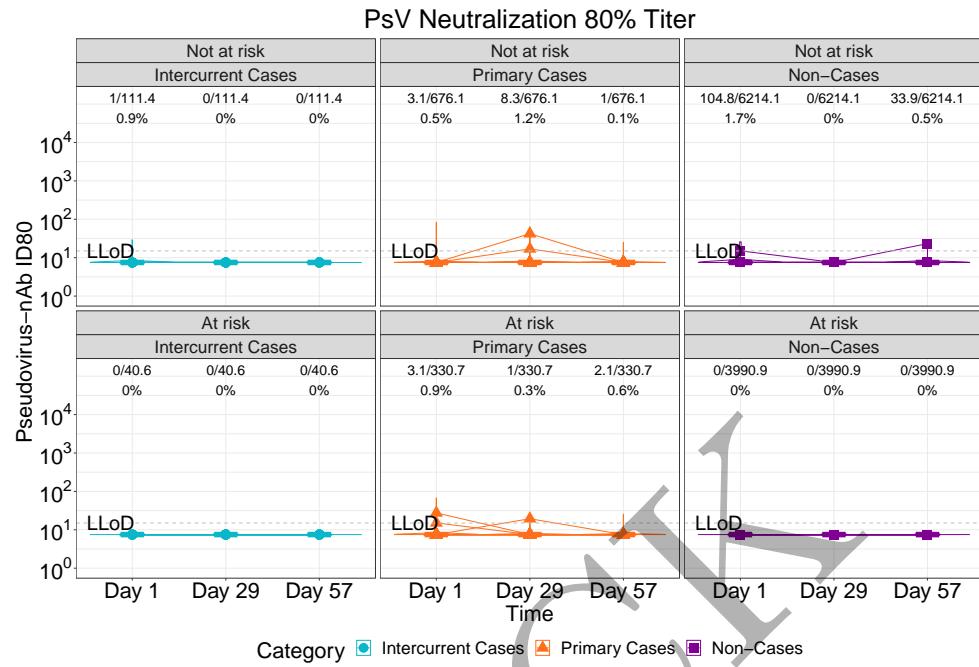


Figure 3.100: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (version 2)

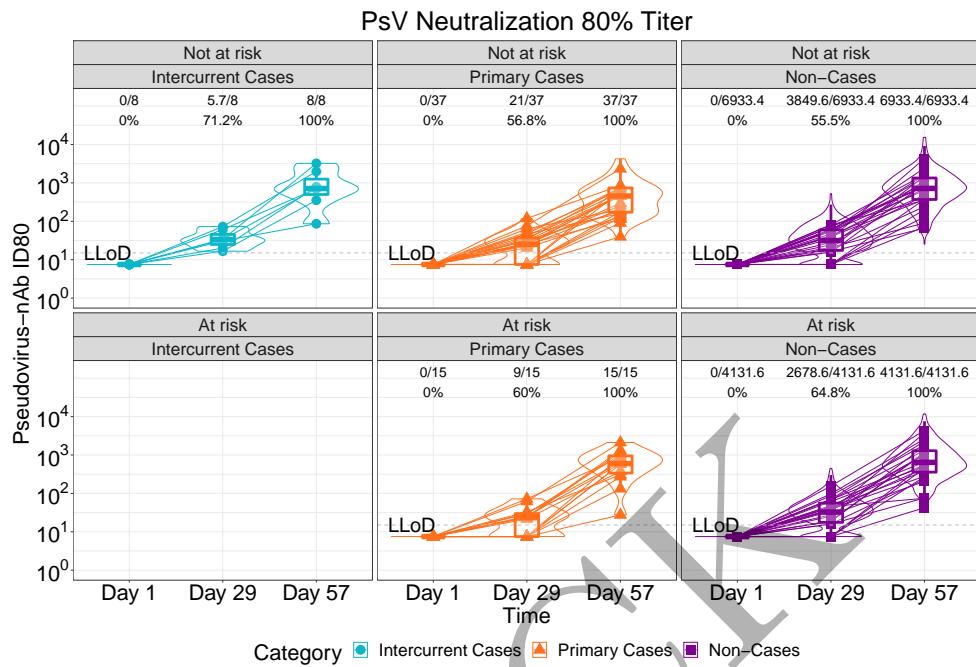


Figure 3.101: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (version 2)

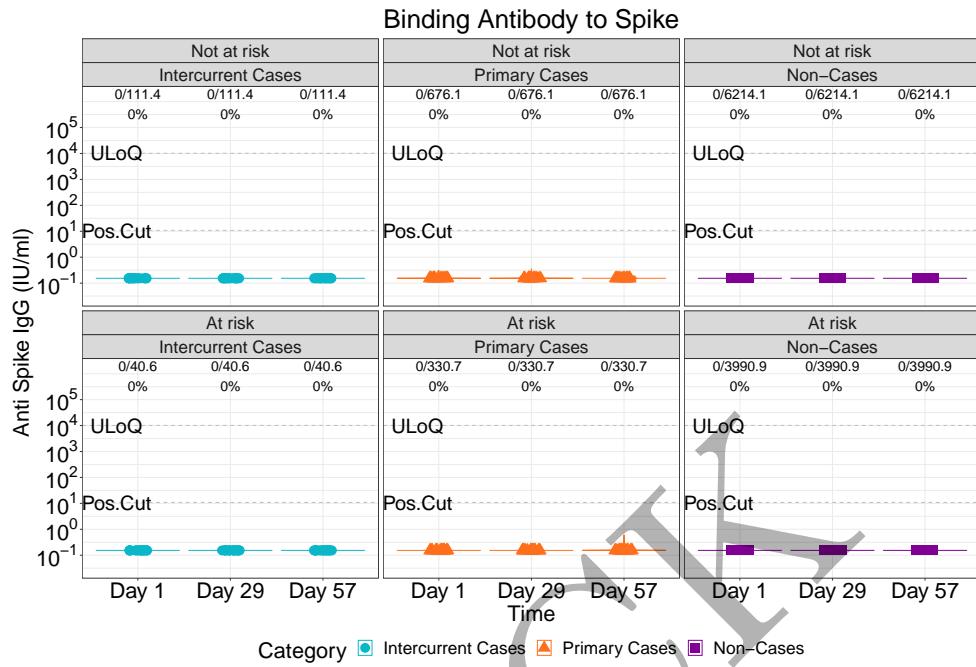


Figure 3.102: violinplots of Binding Antibody to Spike: baseline negative placebo arm by risk condition (version 2)

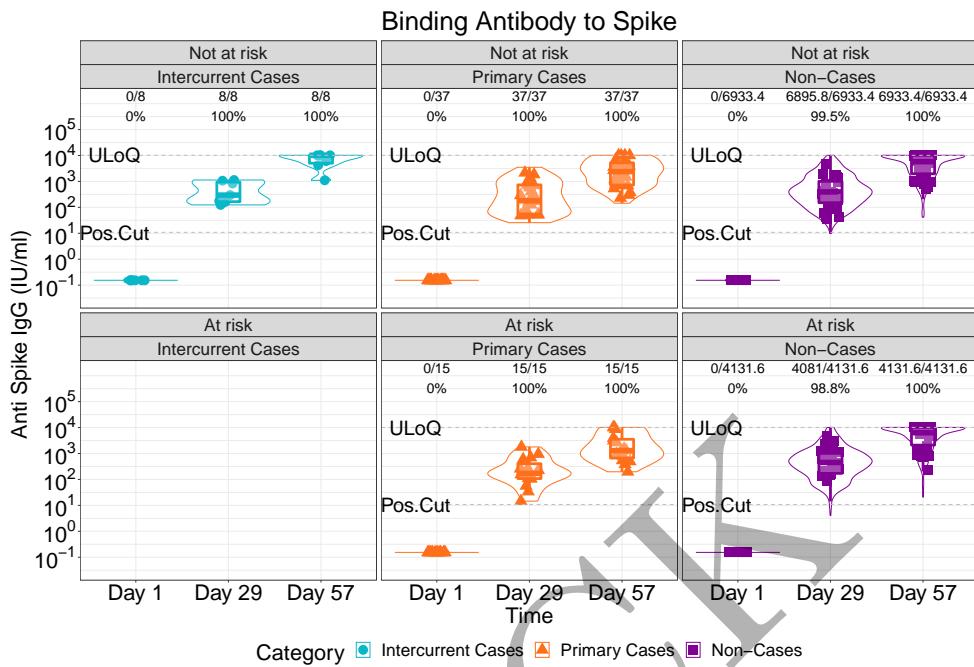


Figure 3.103: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by risk condition (version 2)

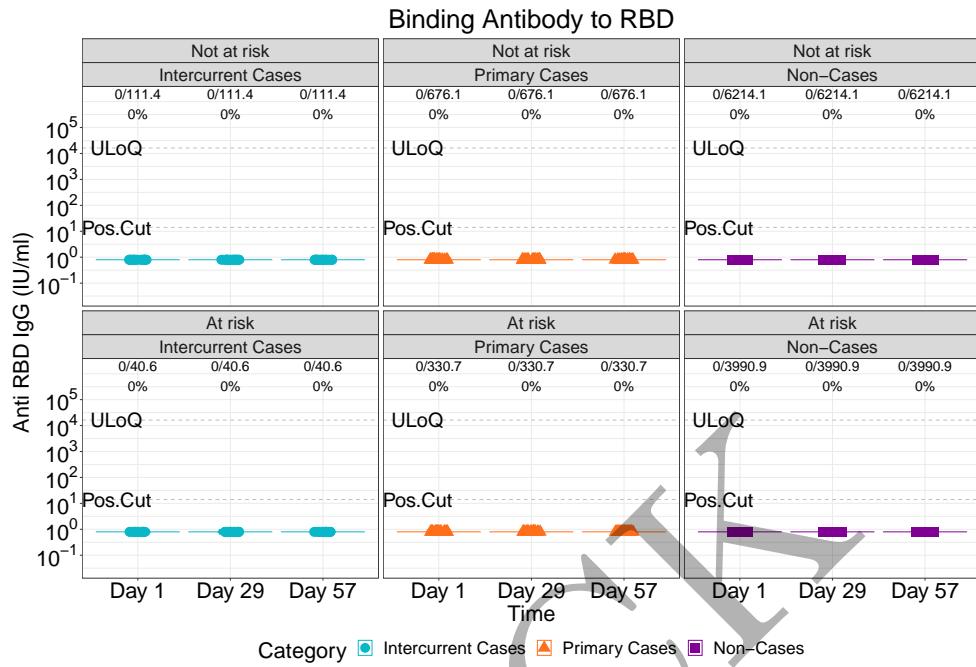


Figure 3.104: violinplots of Binding Antibody to RBD: baseline negative placebo arm by risk condition (version 2)

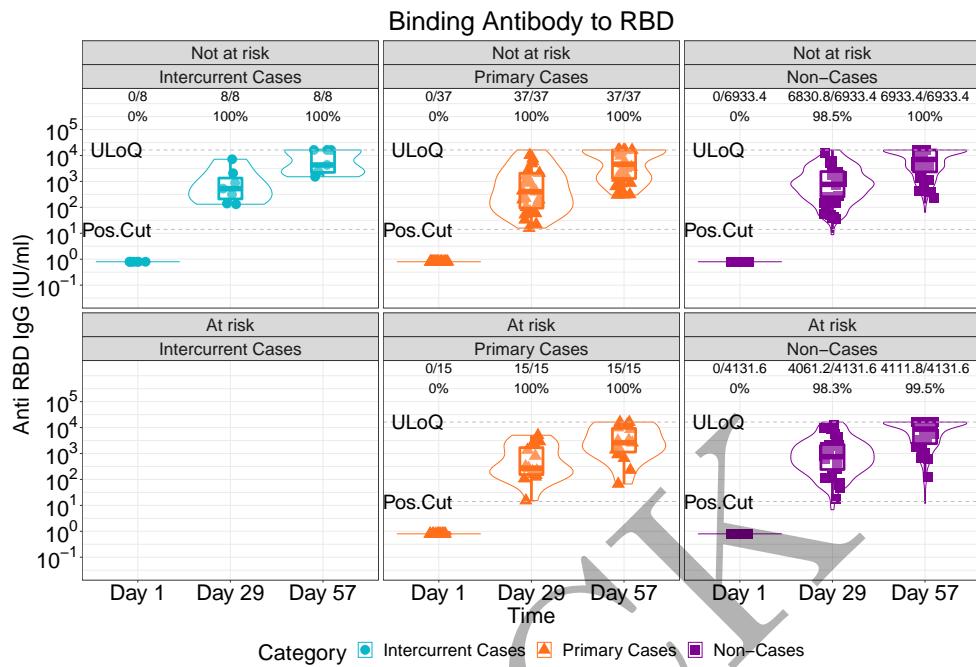


Figure 3.105: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by risk condition (version 2)

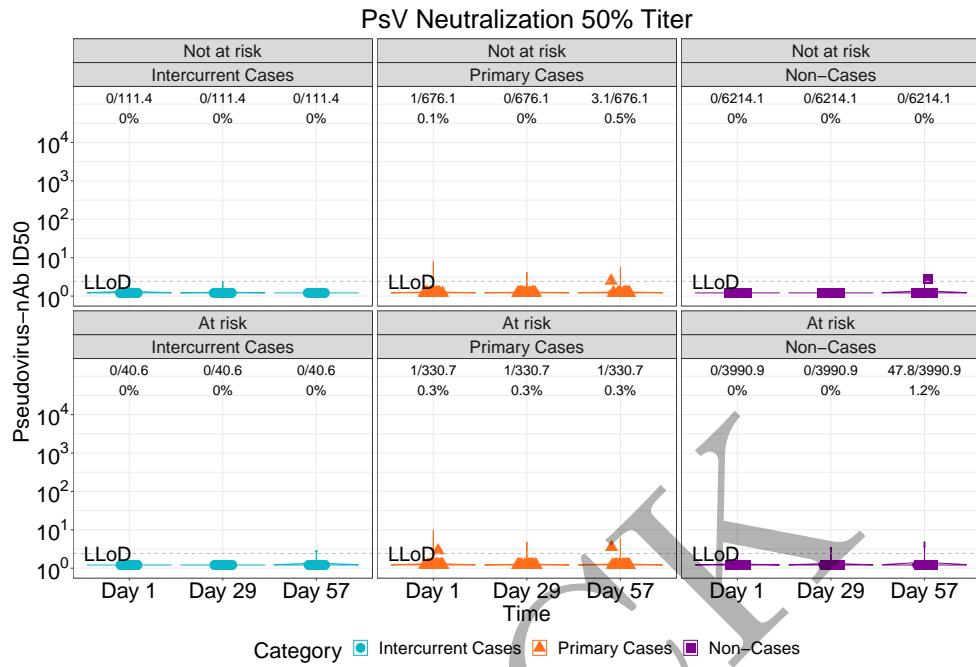


Figure 3.106: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by risk condition (version 2)

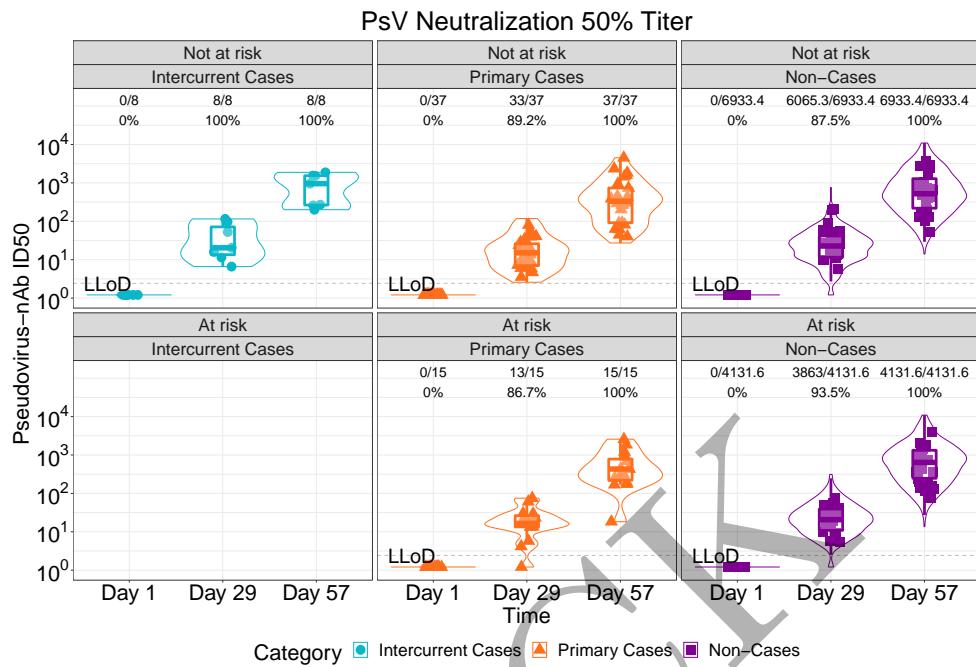


Figure 3.107: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by risk condition (version 2)

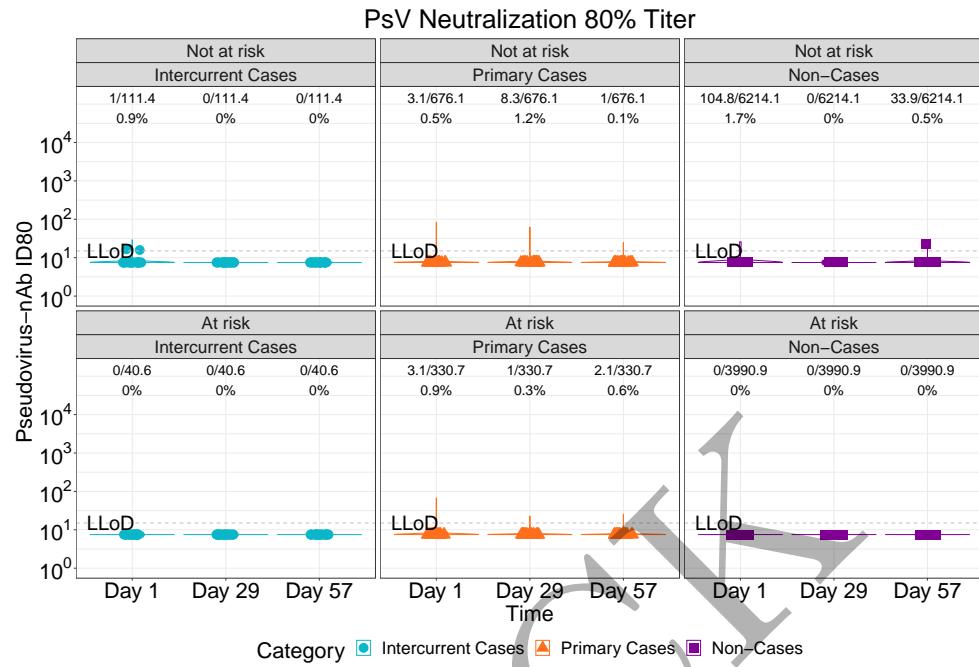


Figure 3.108: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by risk condition (version 2)

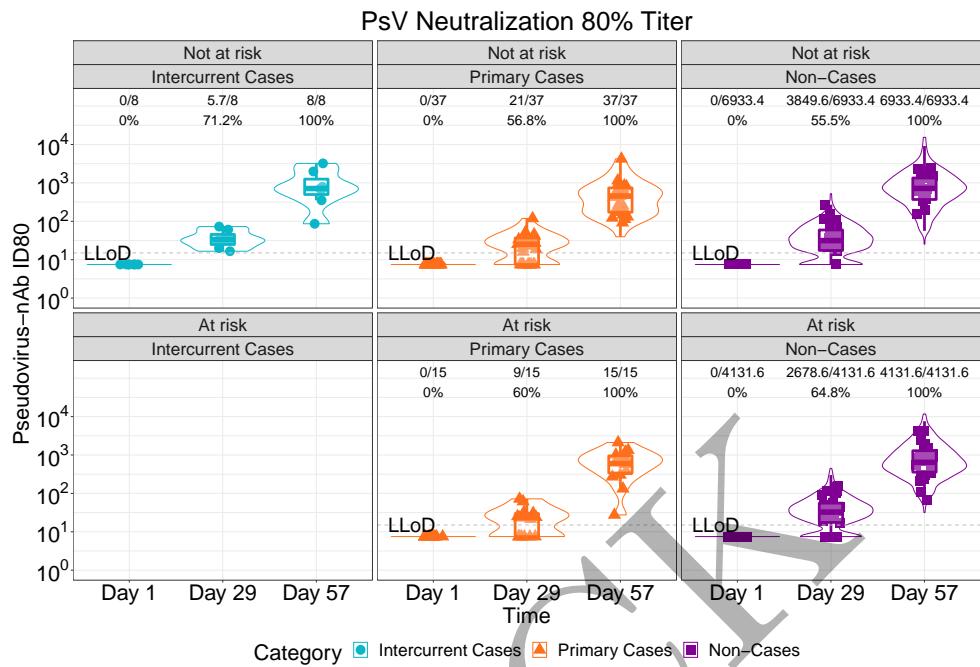


Figure 3.109: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by risk condition (version 2)

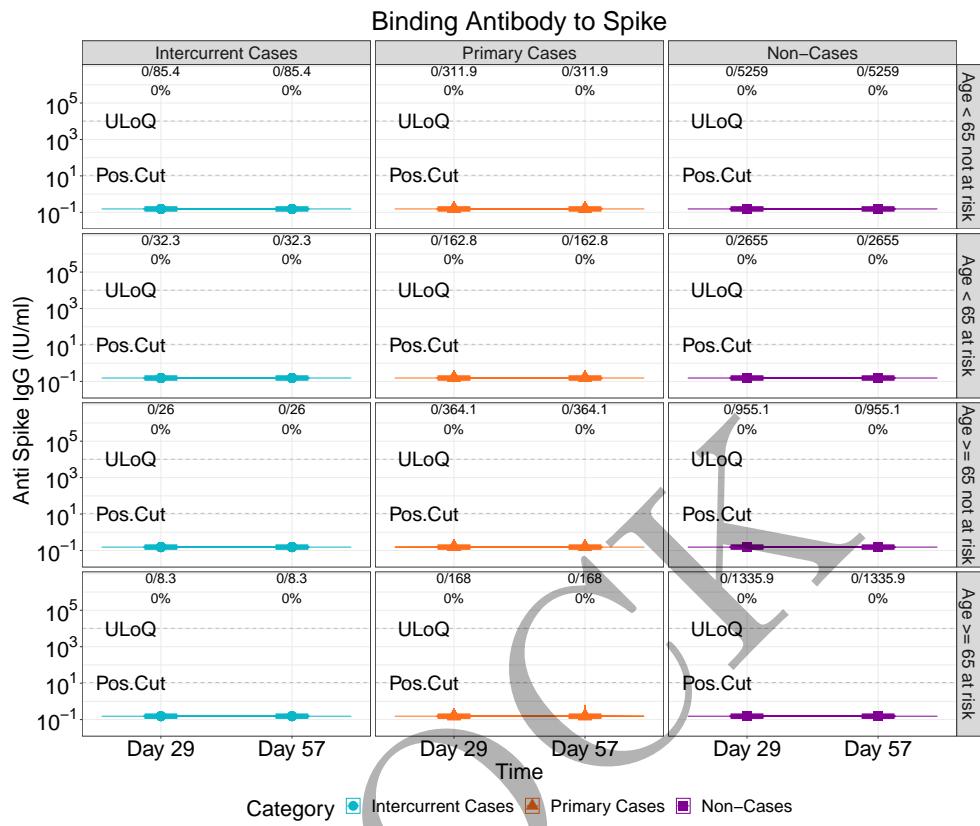


Figure 3.110: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (version 1)

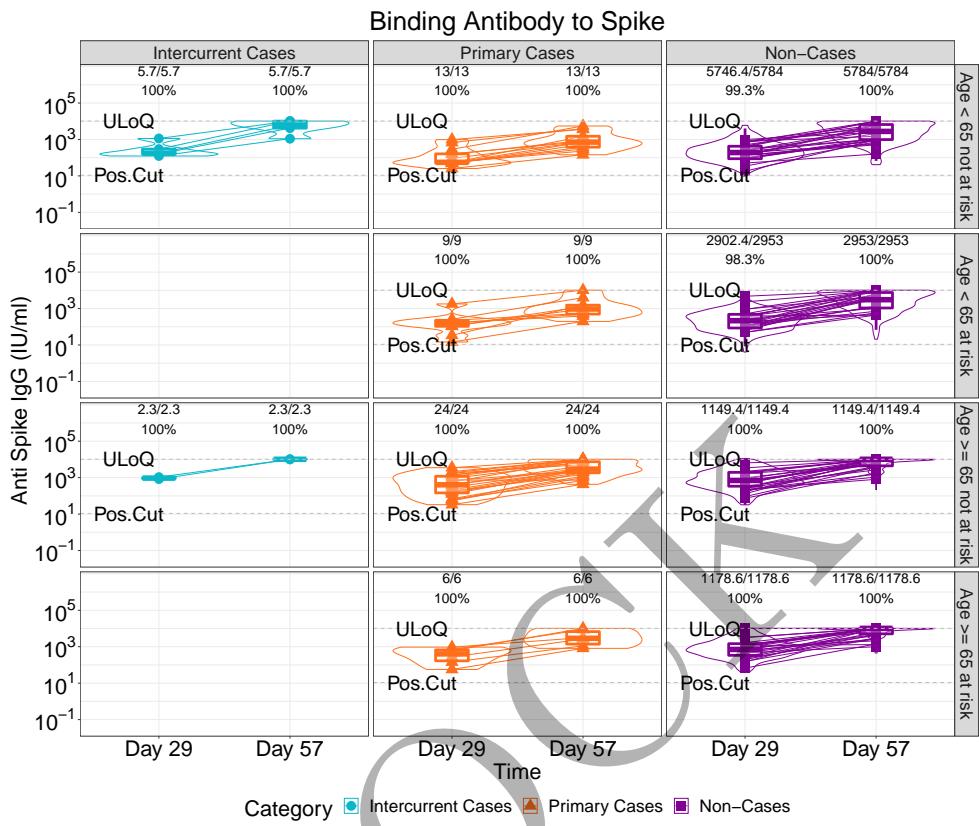


Figure 3.111: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (version 1)

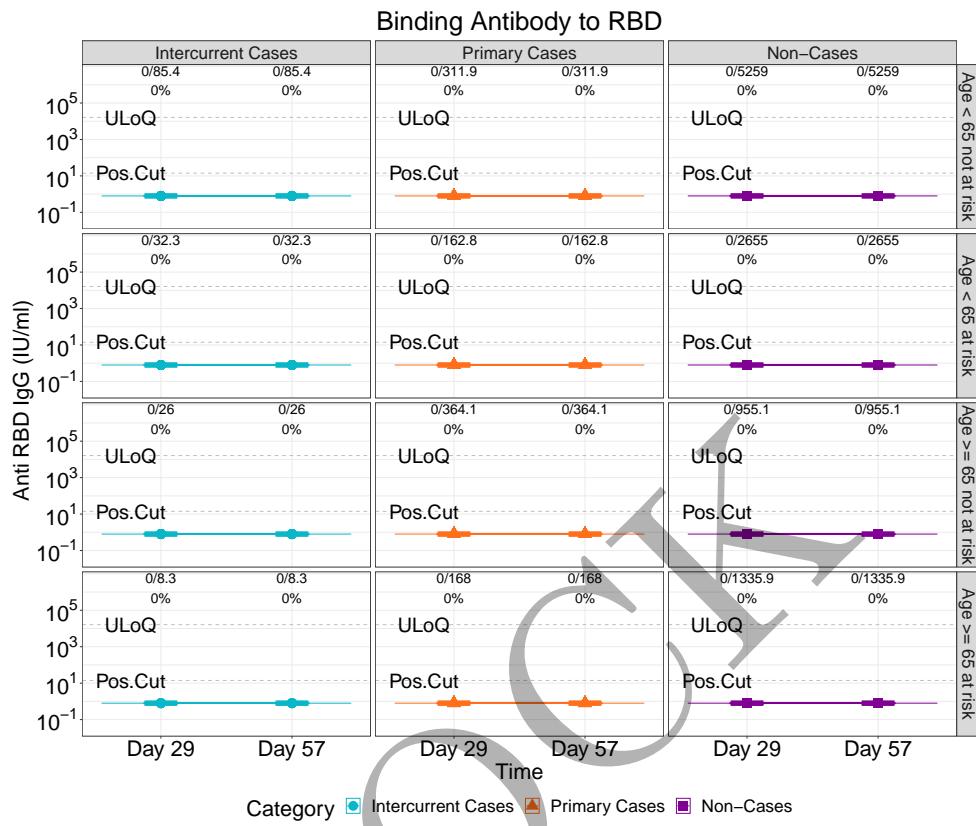


Figure 3.112: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (version 1)

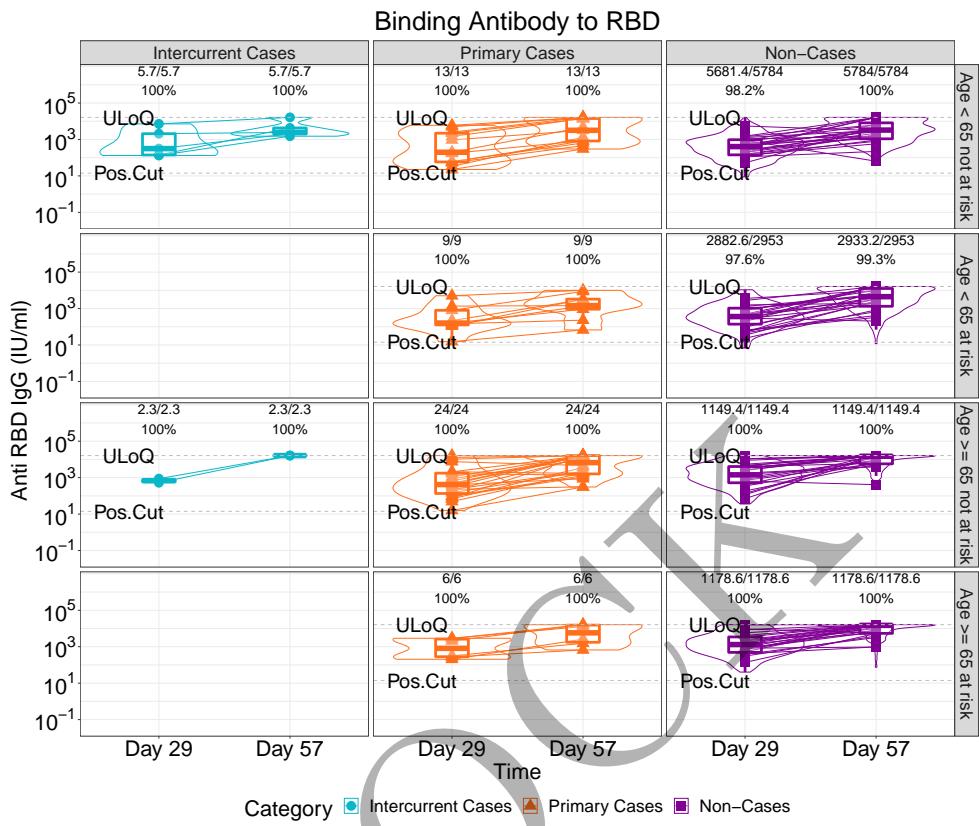


Figure 3.113: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (version 1)

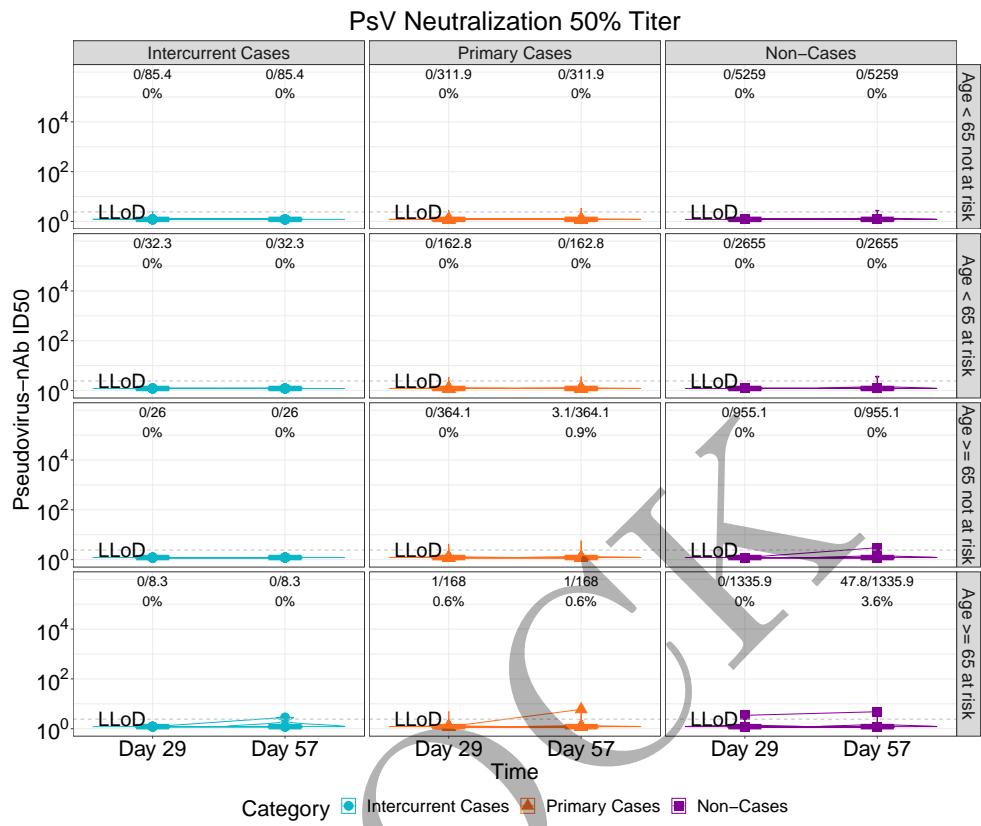


Figure 3.114: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (version 1)

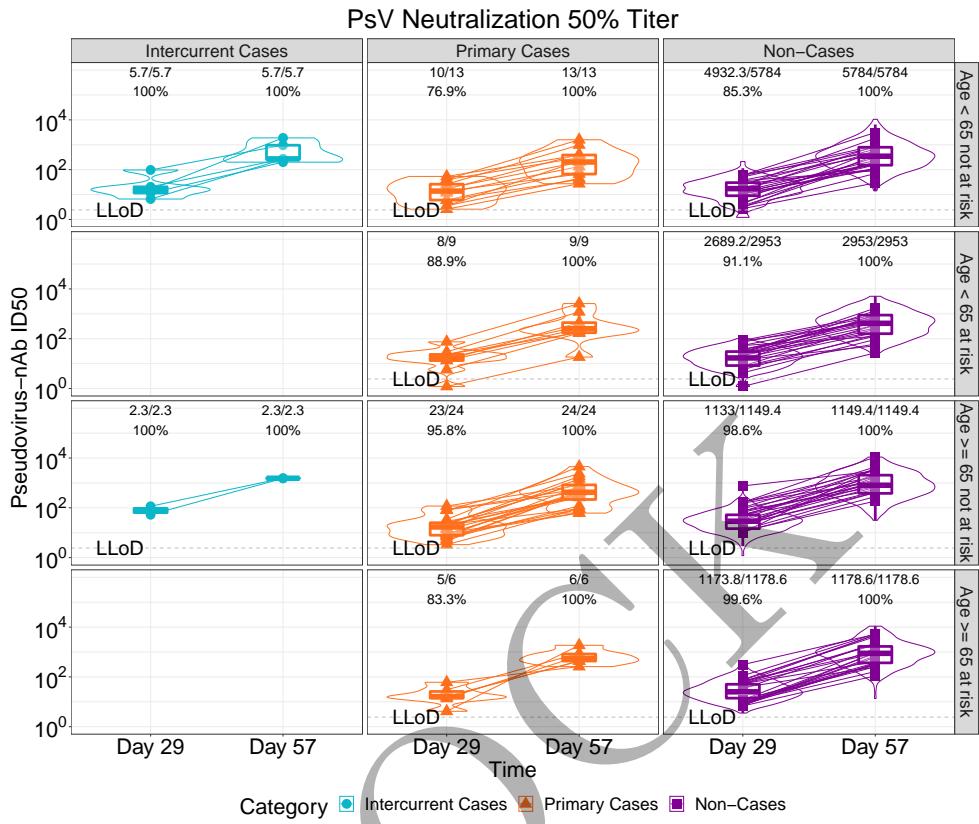


Figure 3.115: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by age and risk condition (version 1)

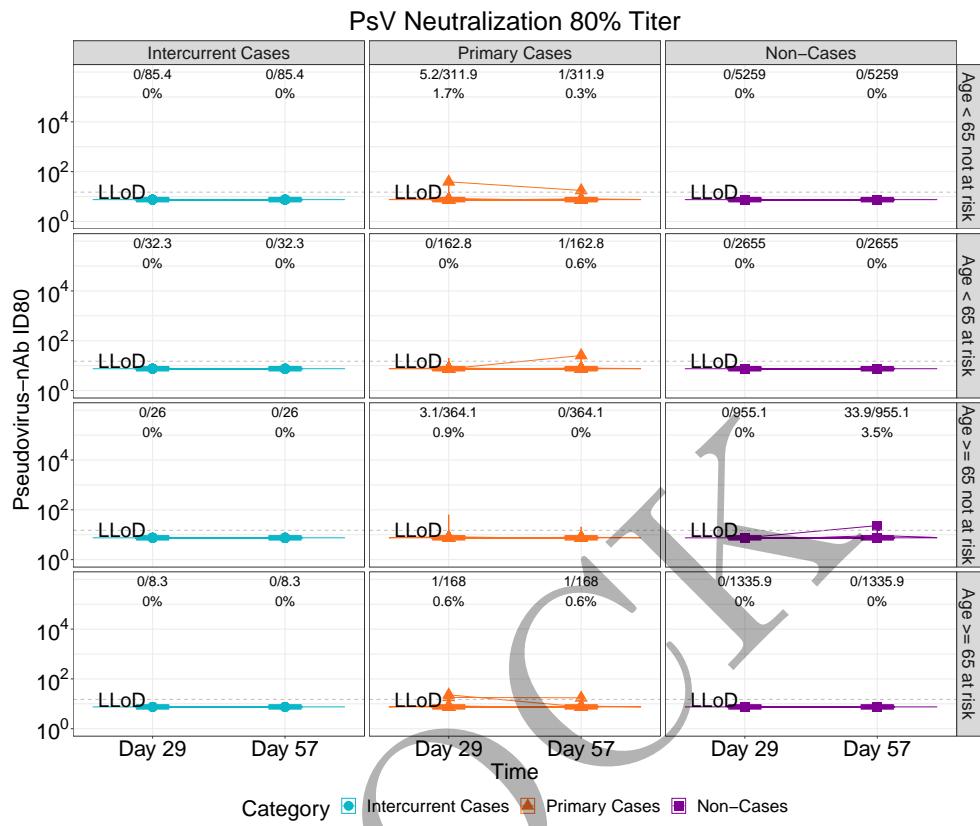


Figure 3.116: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (version 1)

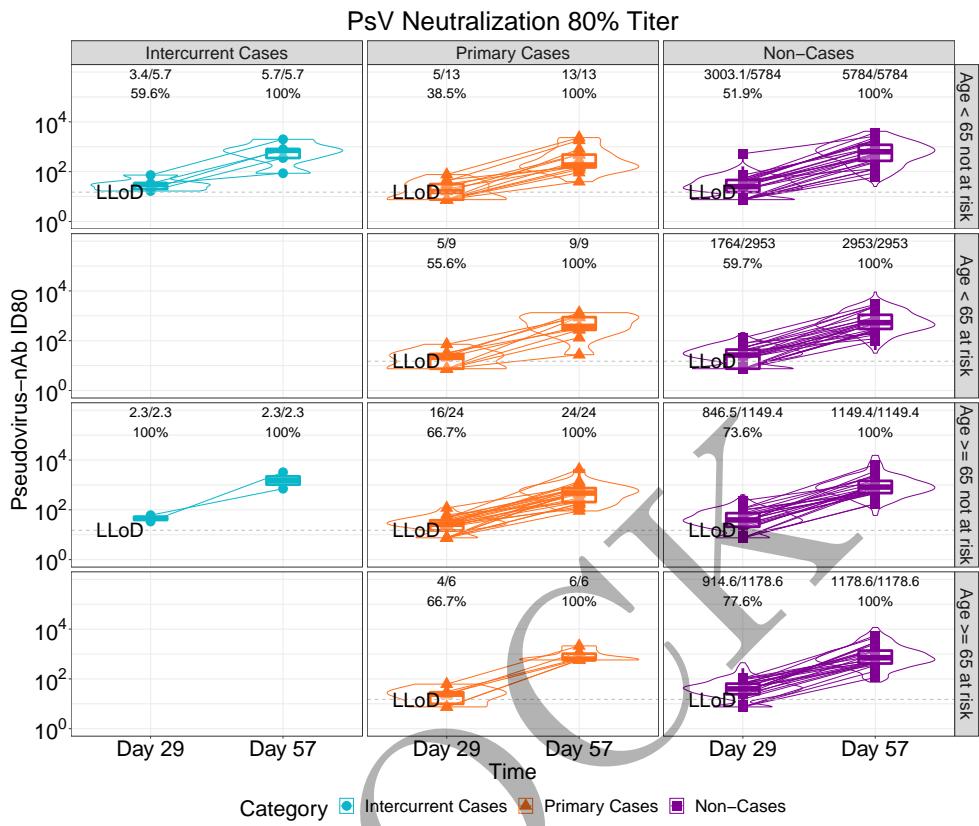


Figure 3.117: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (version 1)

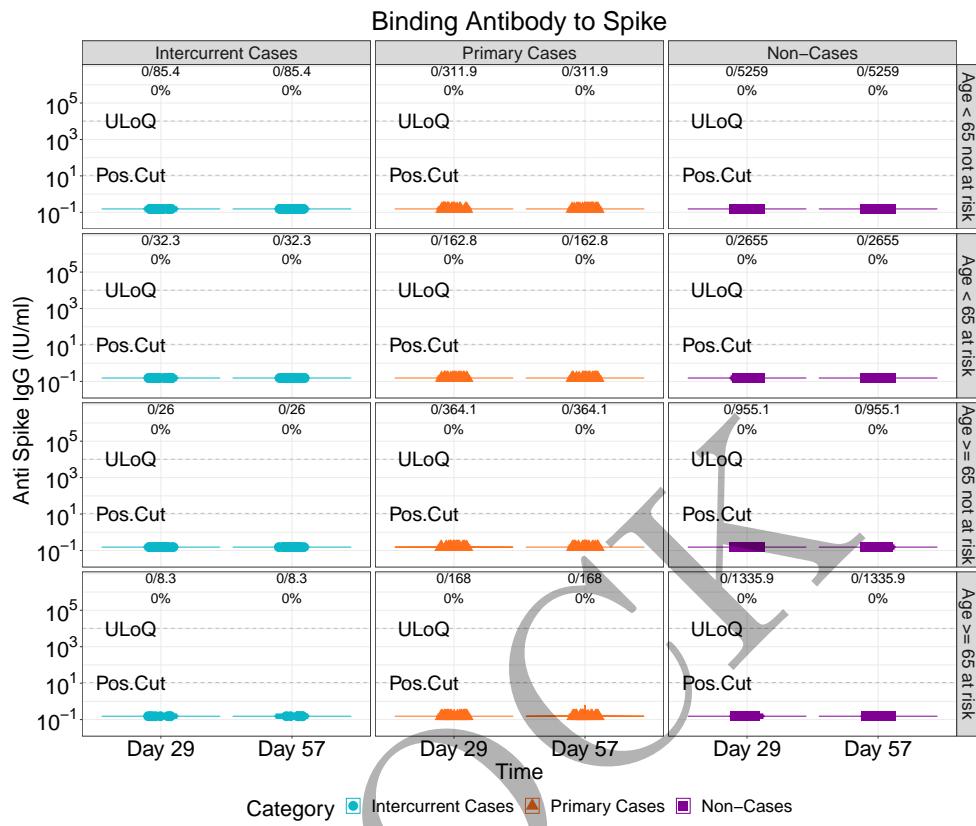


Figure 3.118: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (version 1)

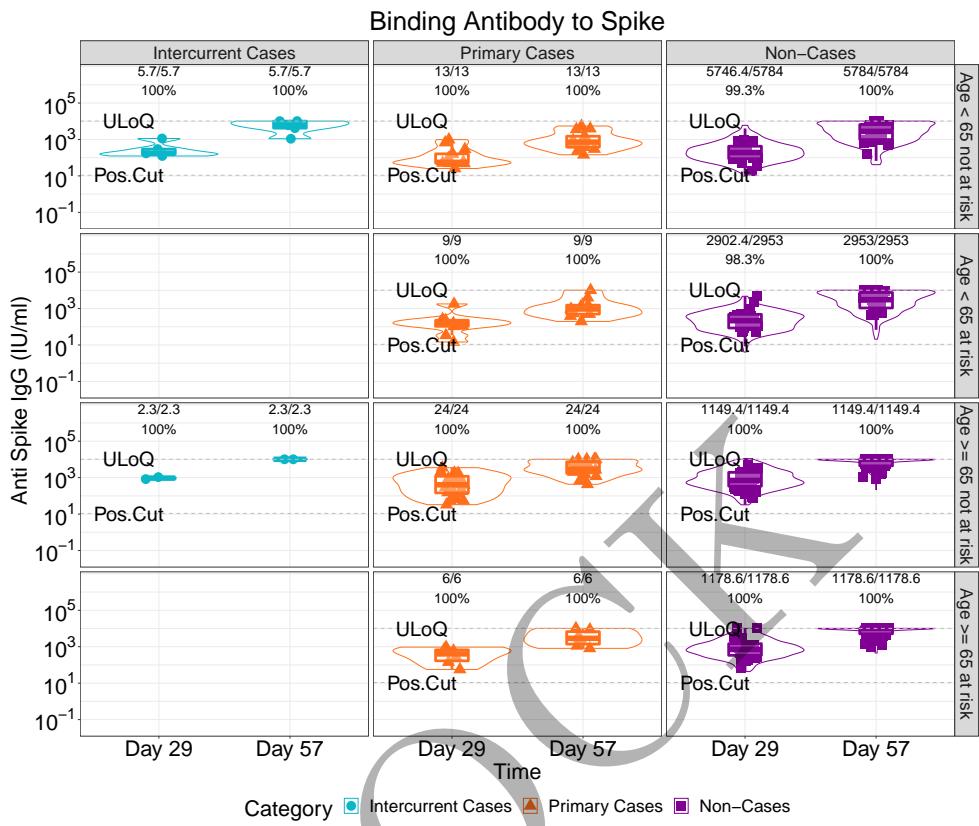


Figure 3.119: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (version 1)

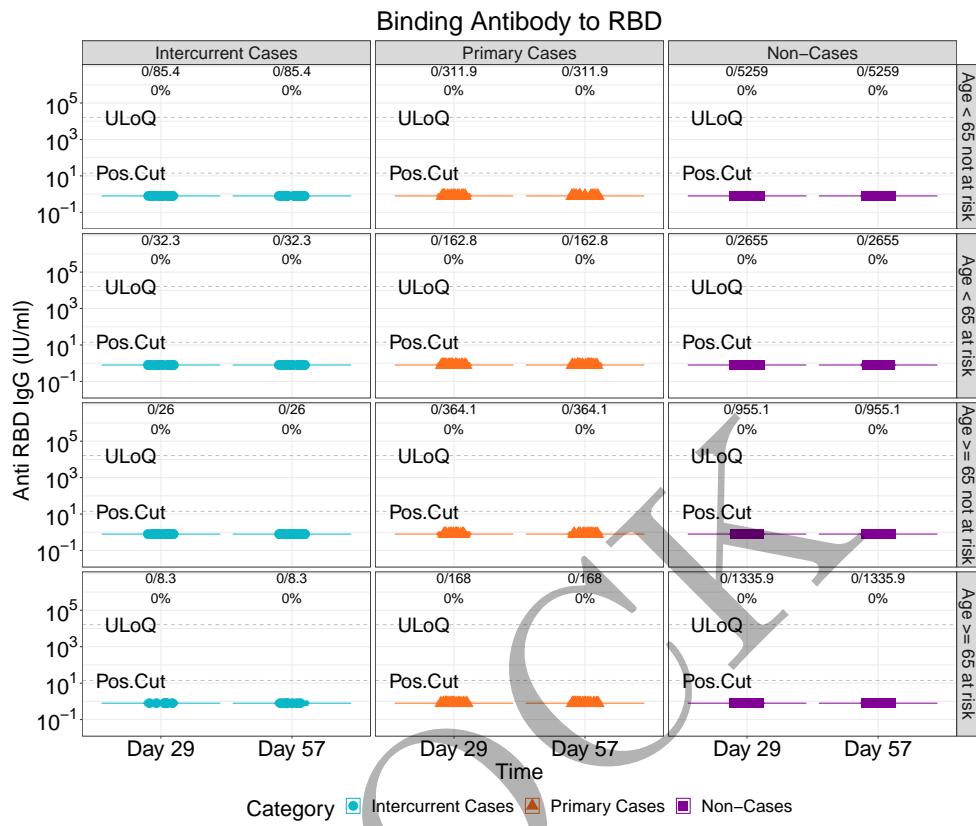


Figure 3.120: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (version 1)

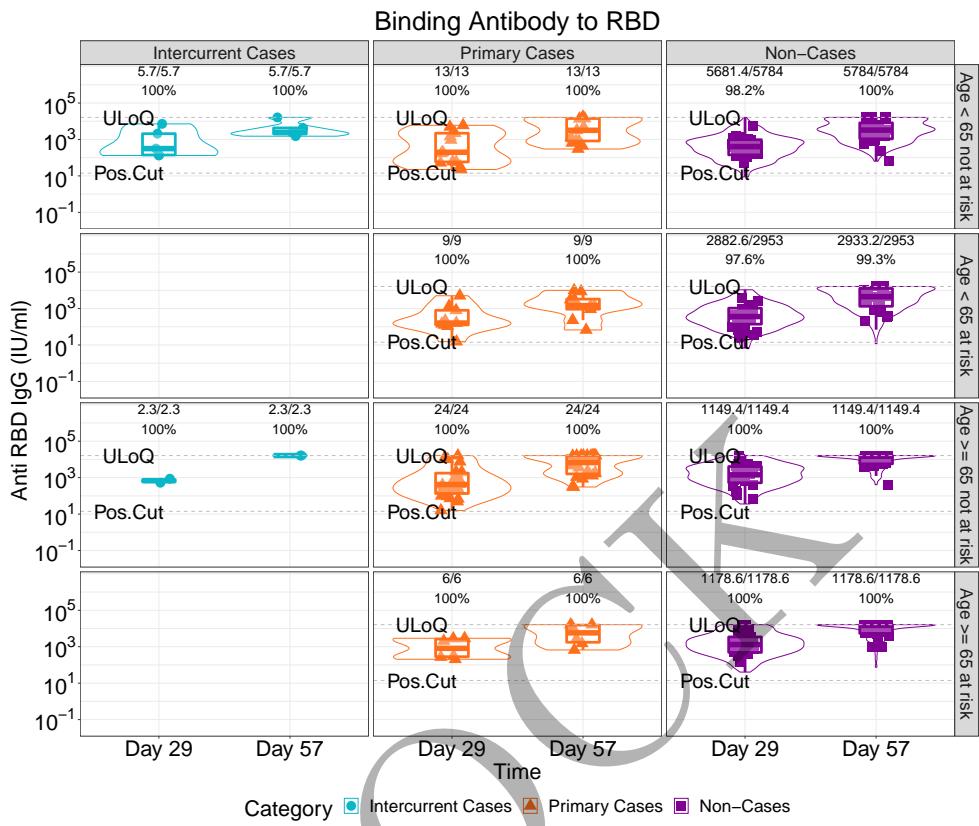


Figure 3.121: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (version 1)

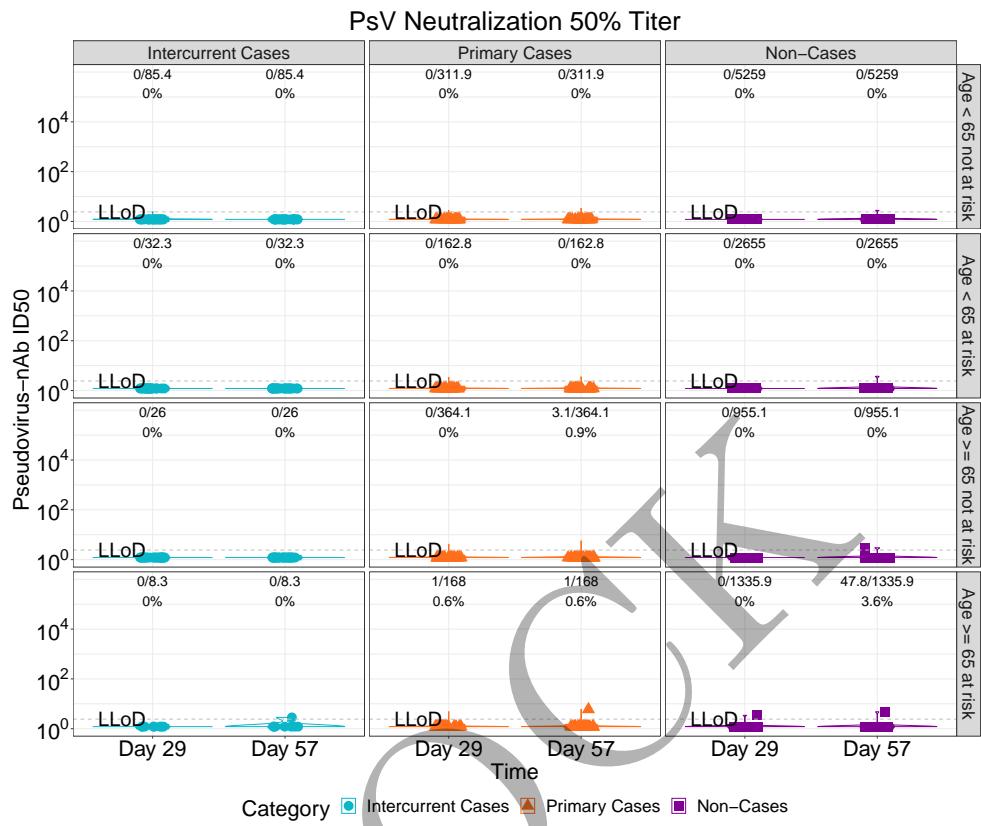


Figure 3.122: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (version 1)

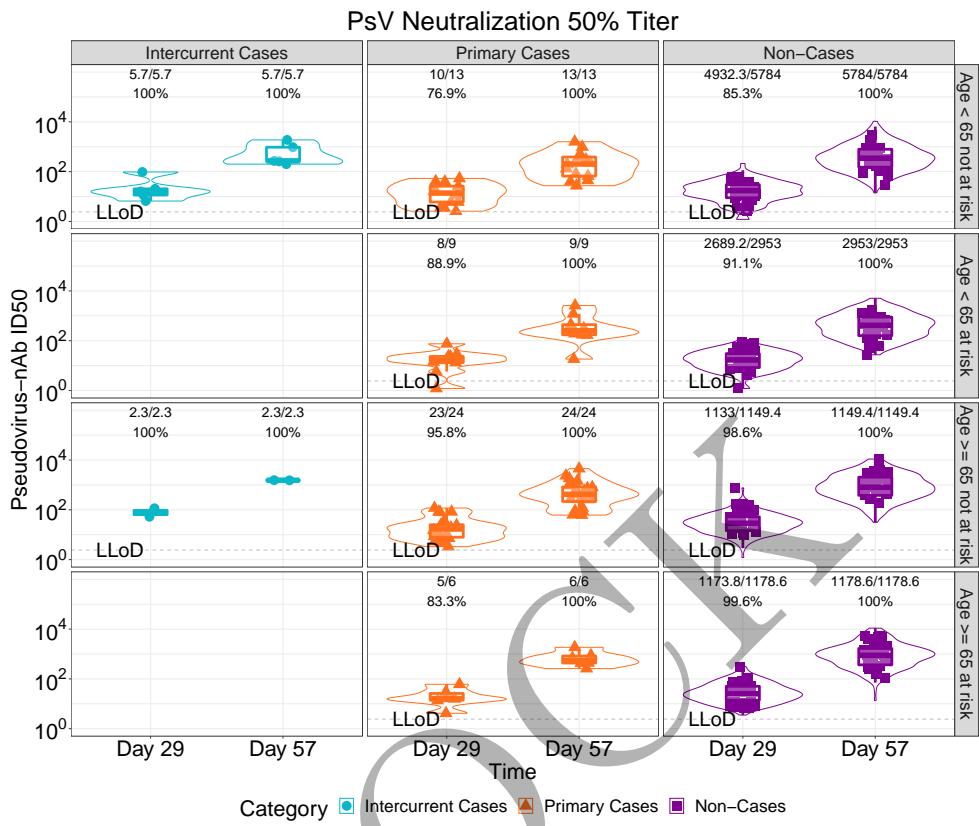


Figure 3.123: violinplots of Pseudovirus Neutralization ID₅₀: baseline negative vaccine arm by age and risk condition (version 1)

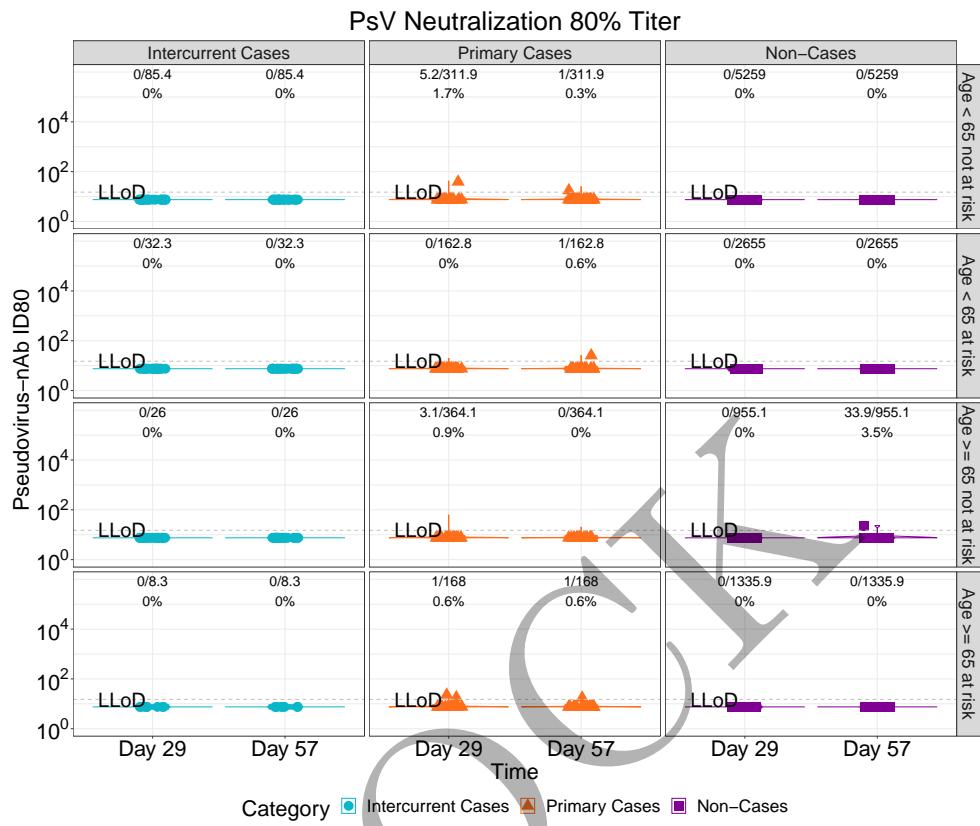


Figure 3.124: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (version 1)

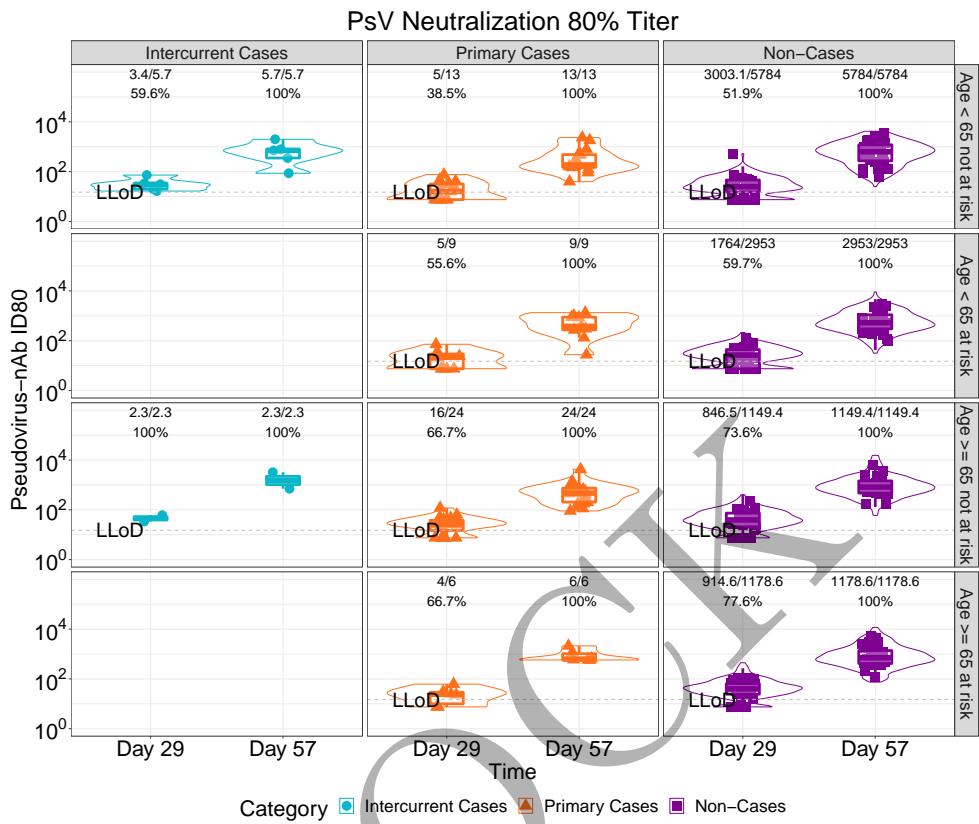


Figure 3.125: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (version 1)

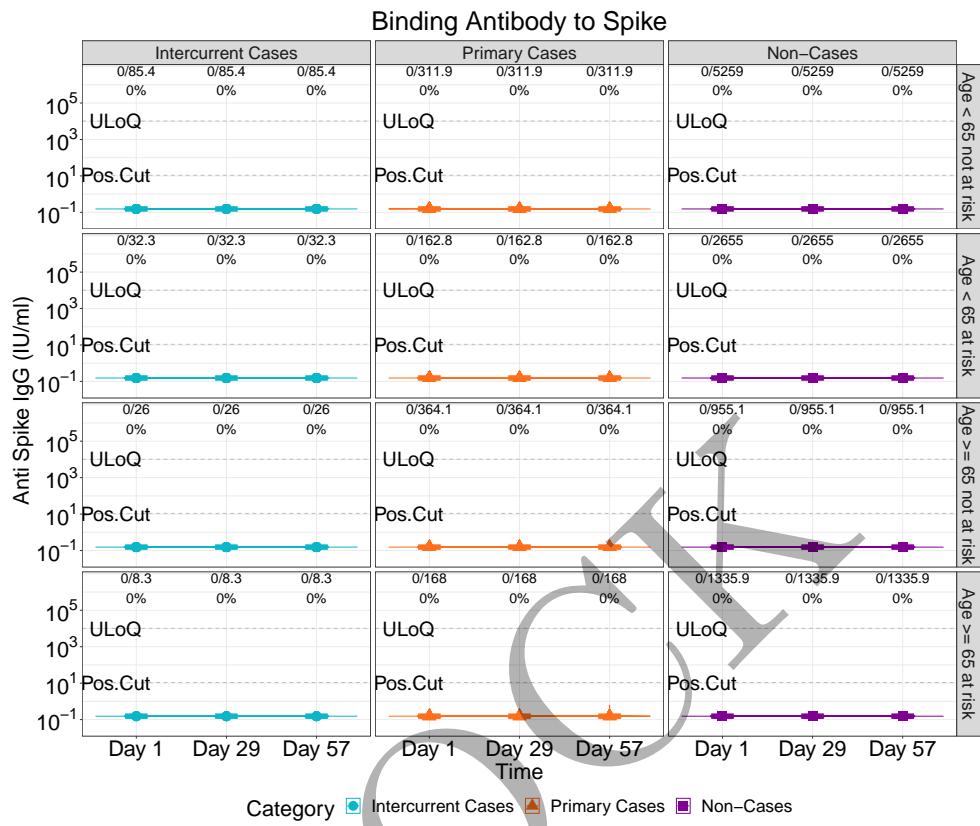


Figure 3.126: lineplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (version 2)

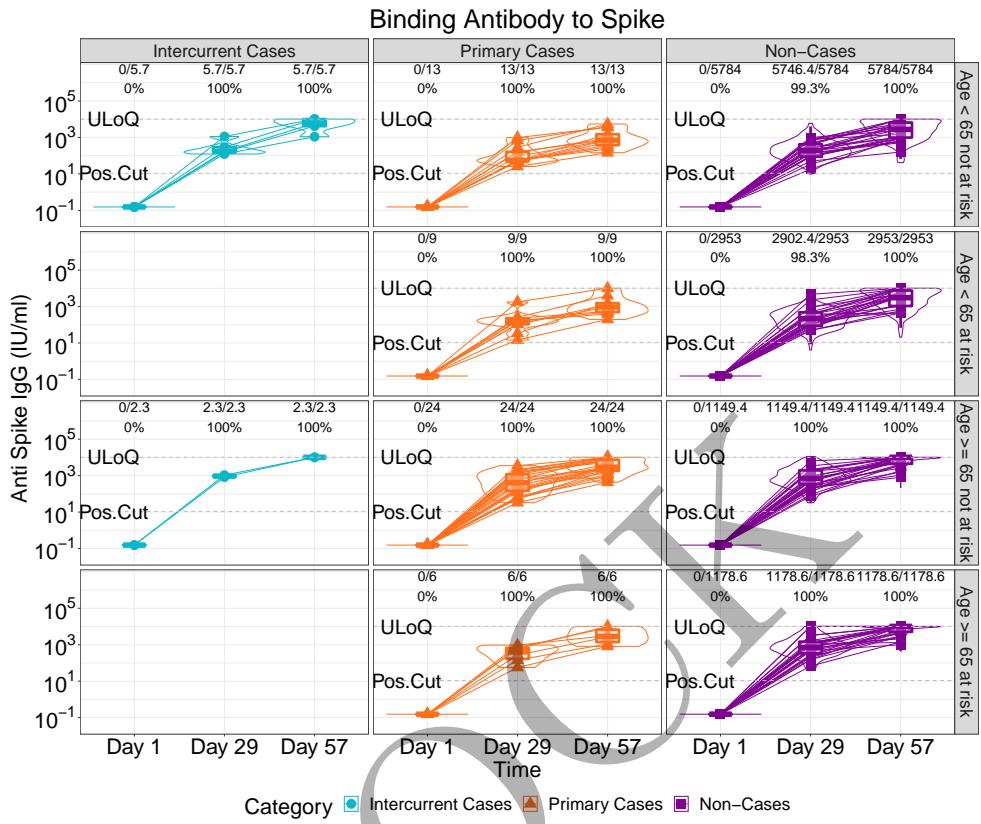


Figure 3.127: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (version 2)

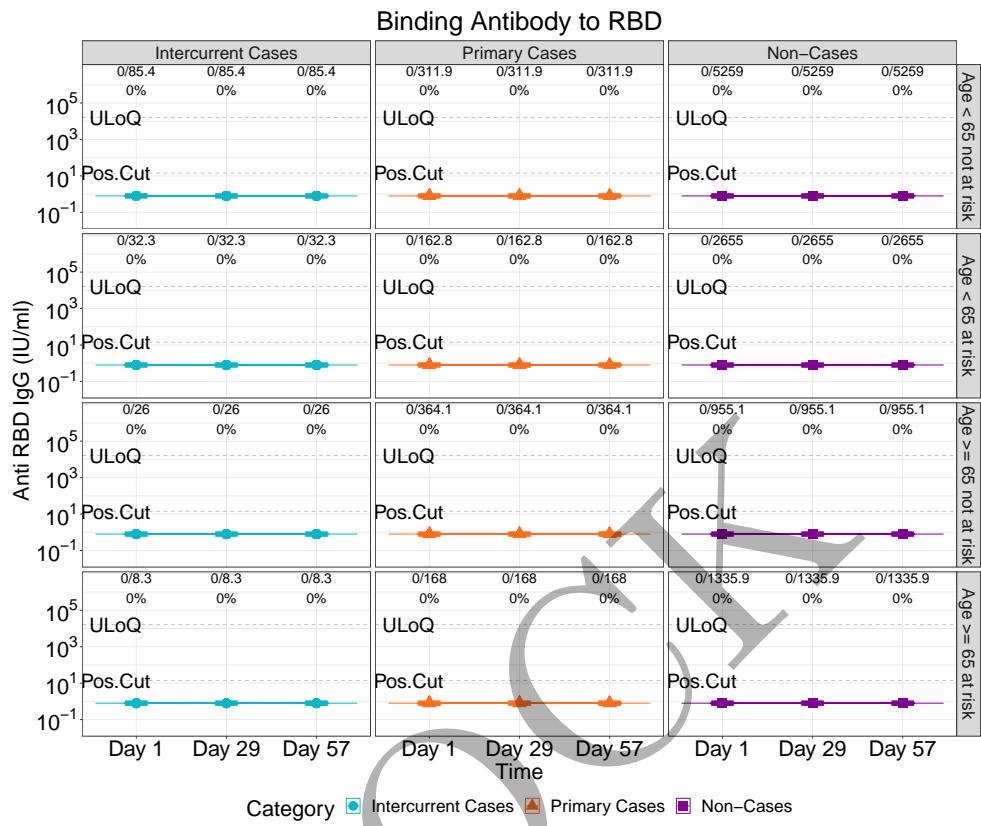


Figure 3.128: lineplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (version 2)

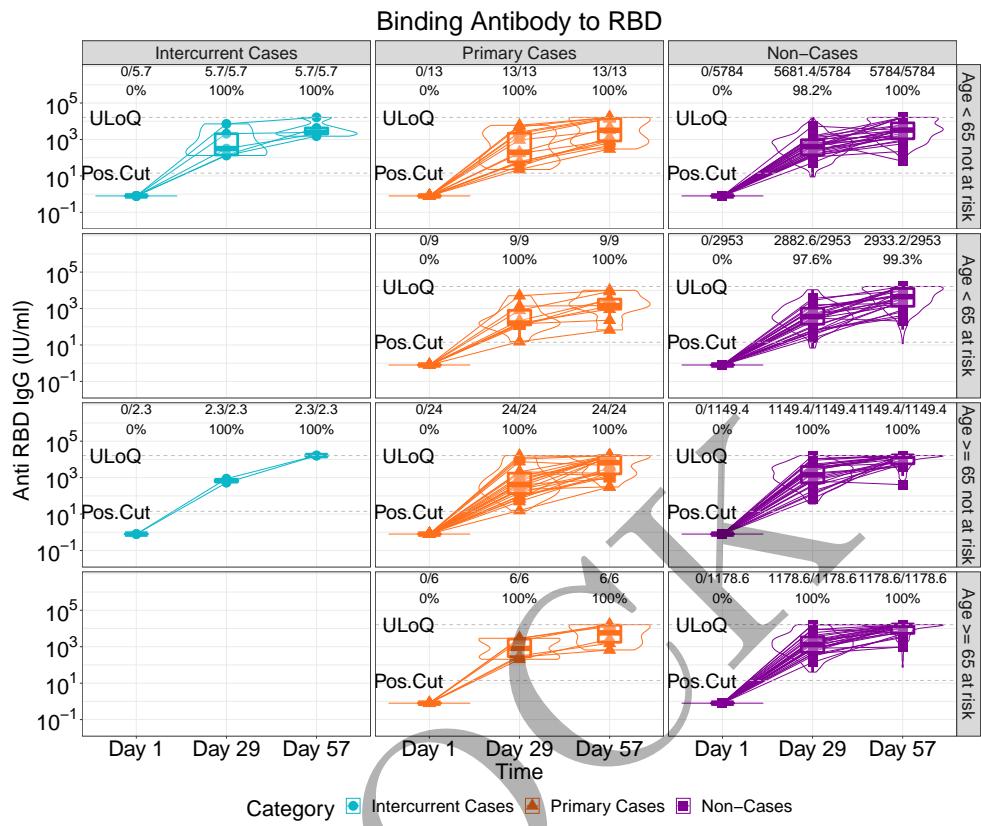


Figure 3.129: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (version 2)

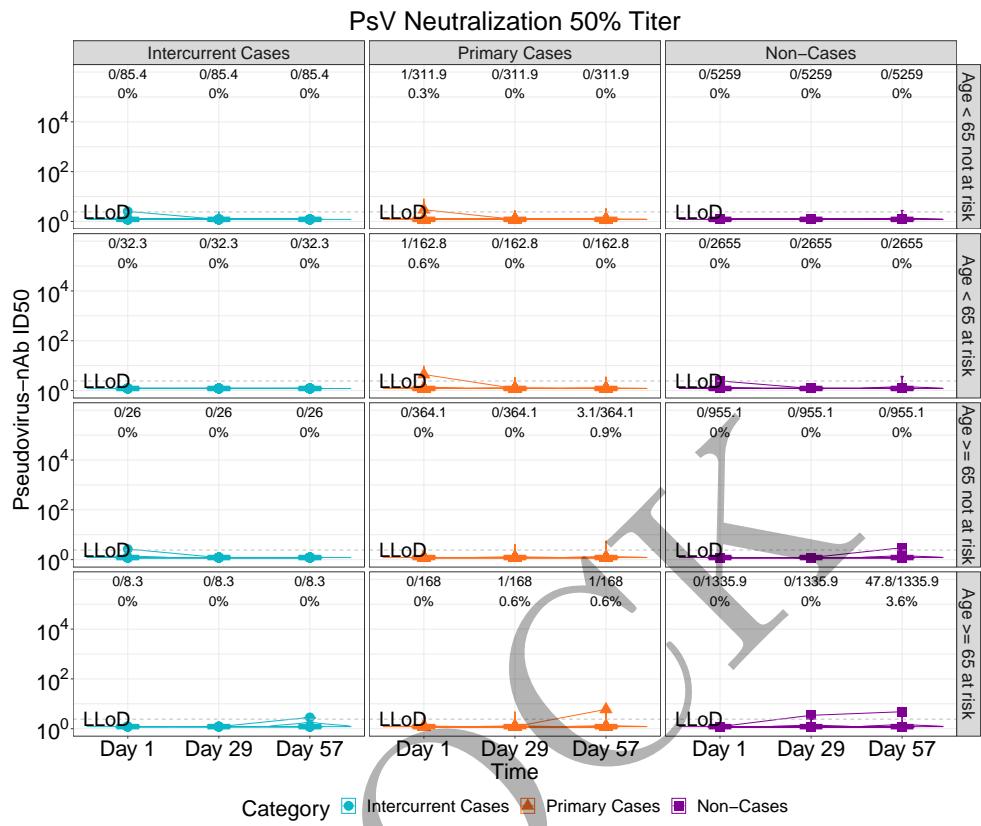


Figure 3.130: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (version 2)

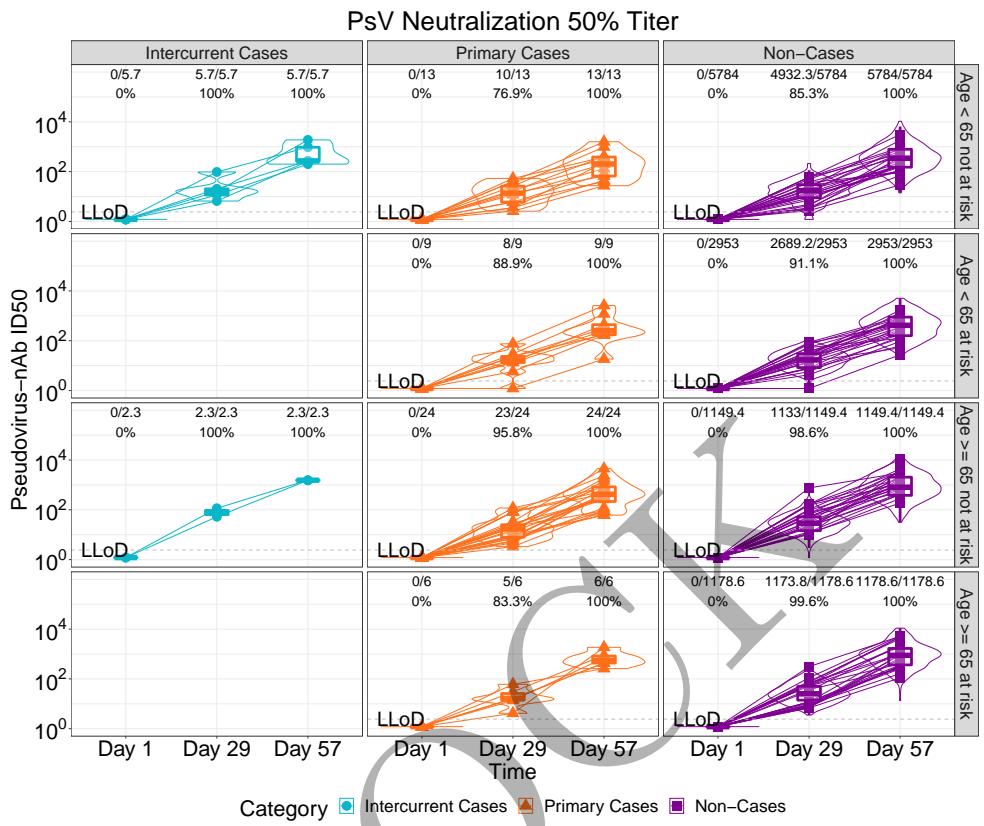


Figure 3.131: lineplots of Pseudovirus Neutralization ID₅₀: baseline negative vaccine arm by age and risk condition (version 2)

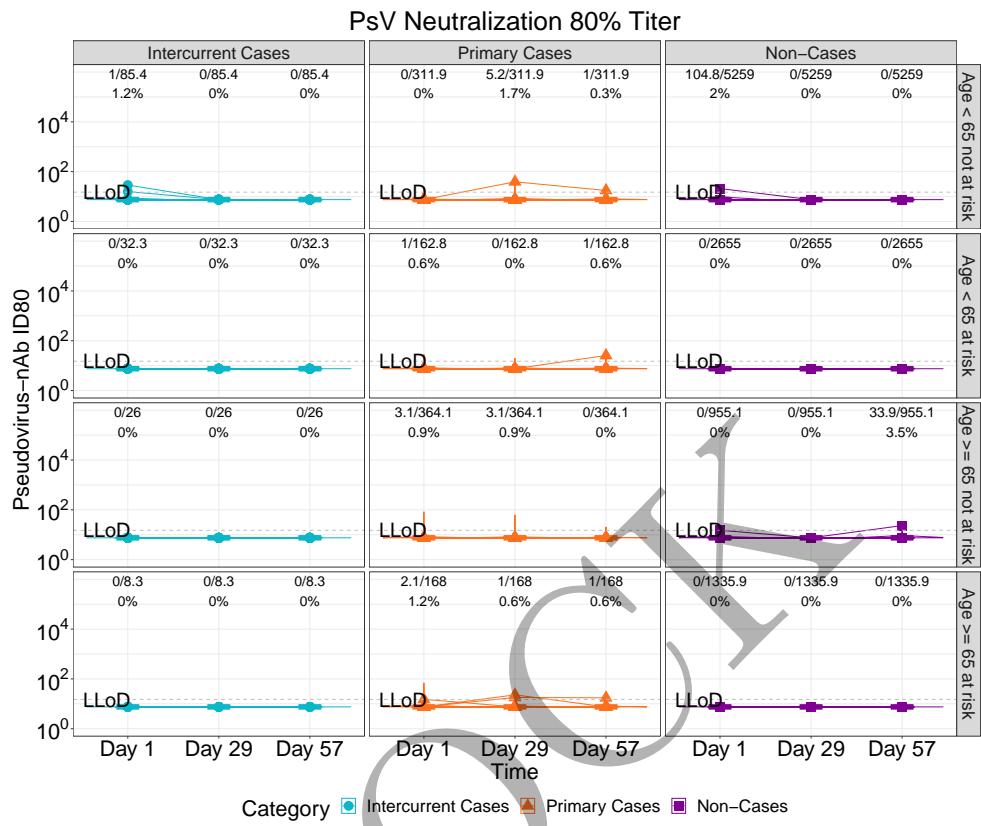


Figure 3.132: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (version 2)

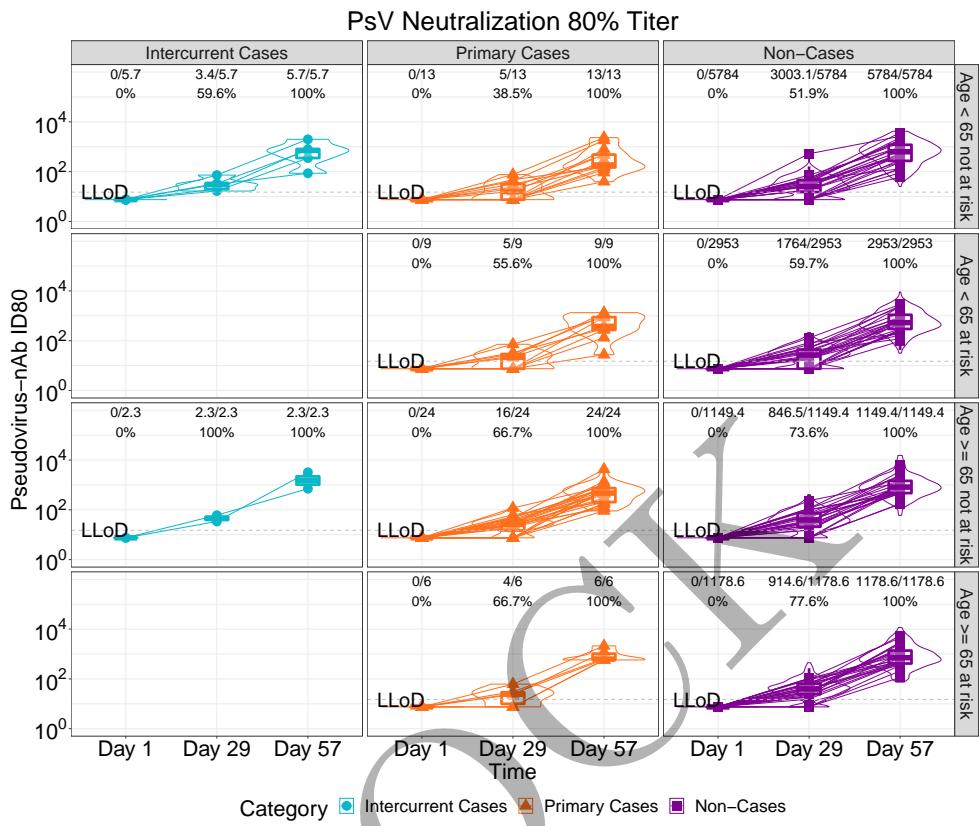


Figure 3.133: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (version 2)

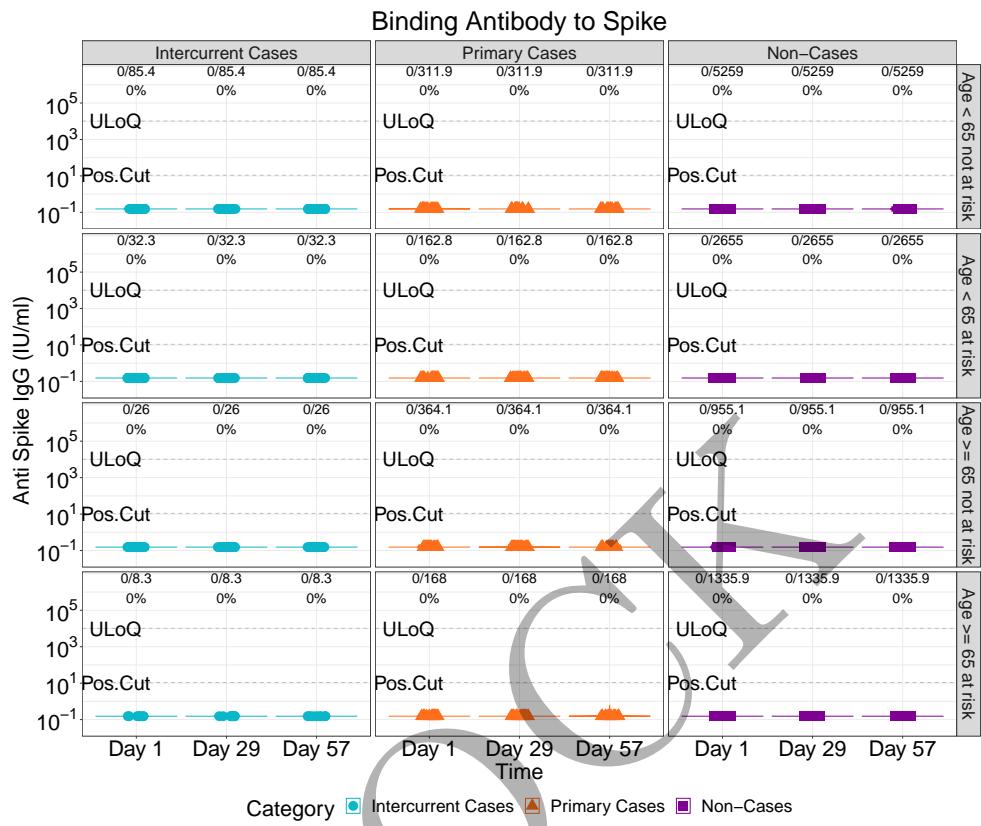


Figure 3.134: violinplots of Binding Antibody to Spike: baseline negative placebo arm by age and risk condition (version 2)

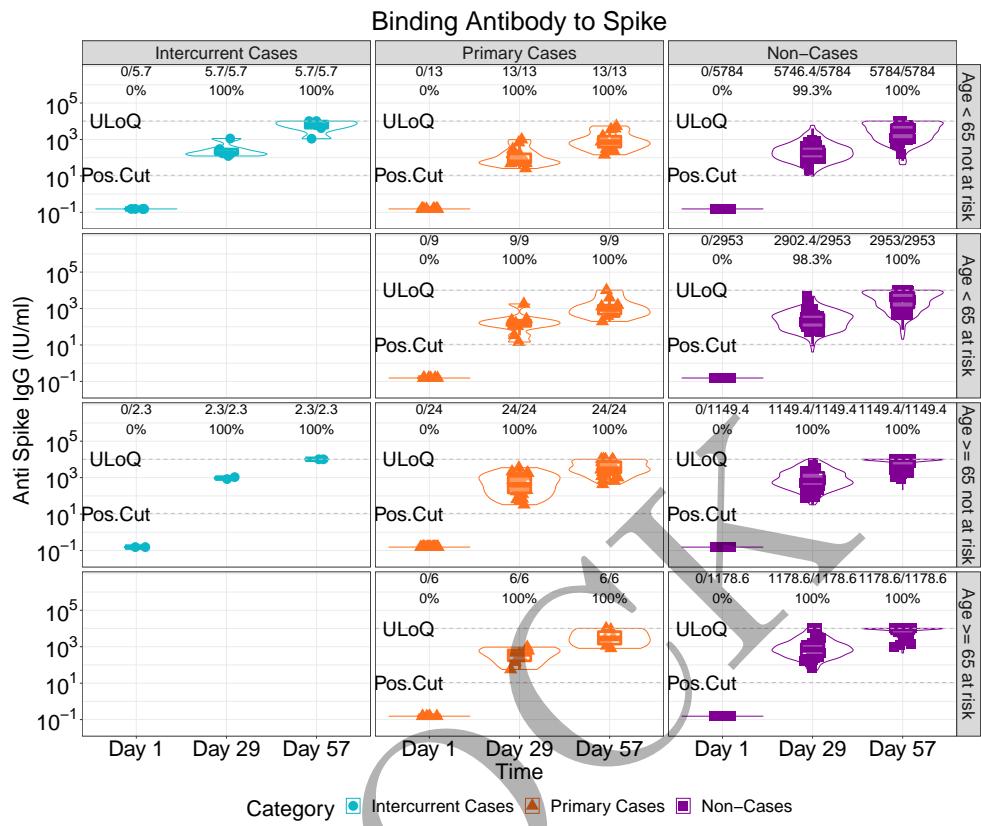


Figure 3.135: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by age and risk condition (version 2)

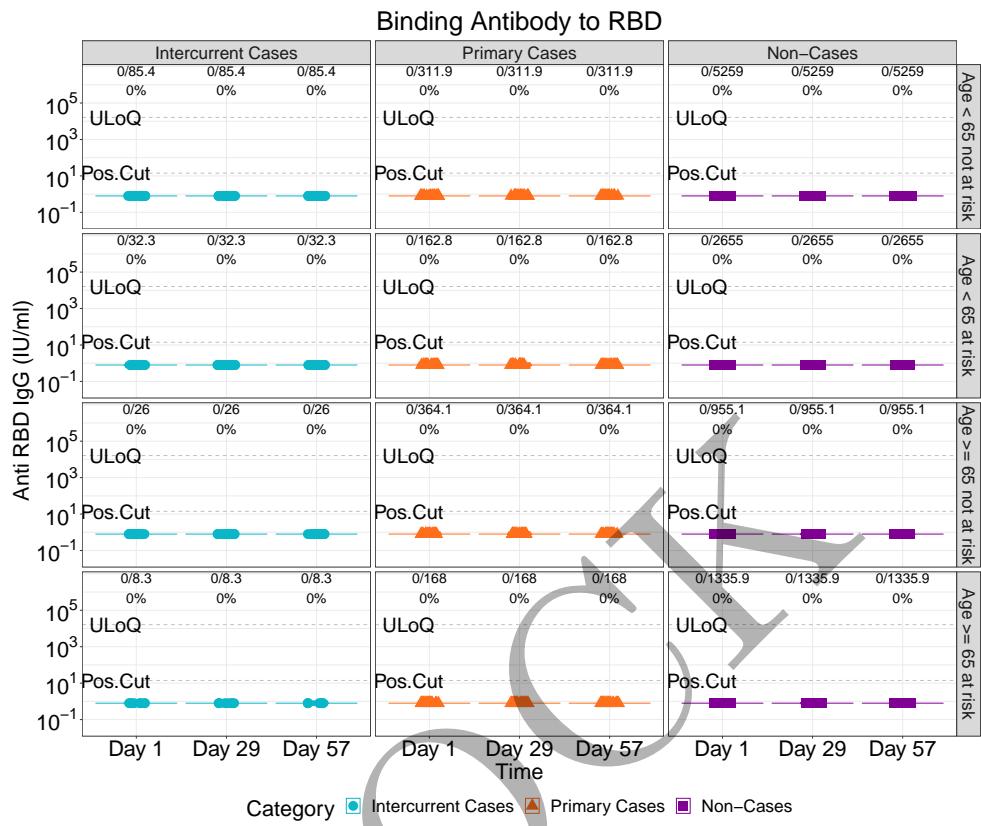


Figure 3.136: violinplots of Binding Antibody to RBD: baseline negative placebo arm by age and risk condition (version 2)

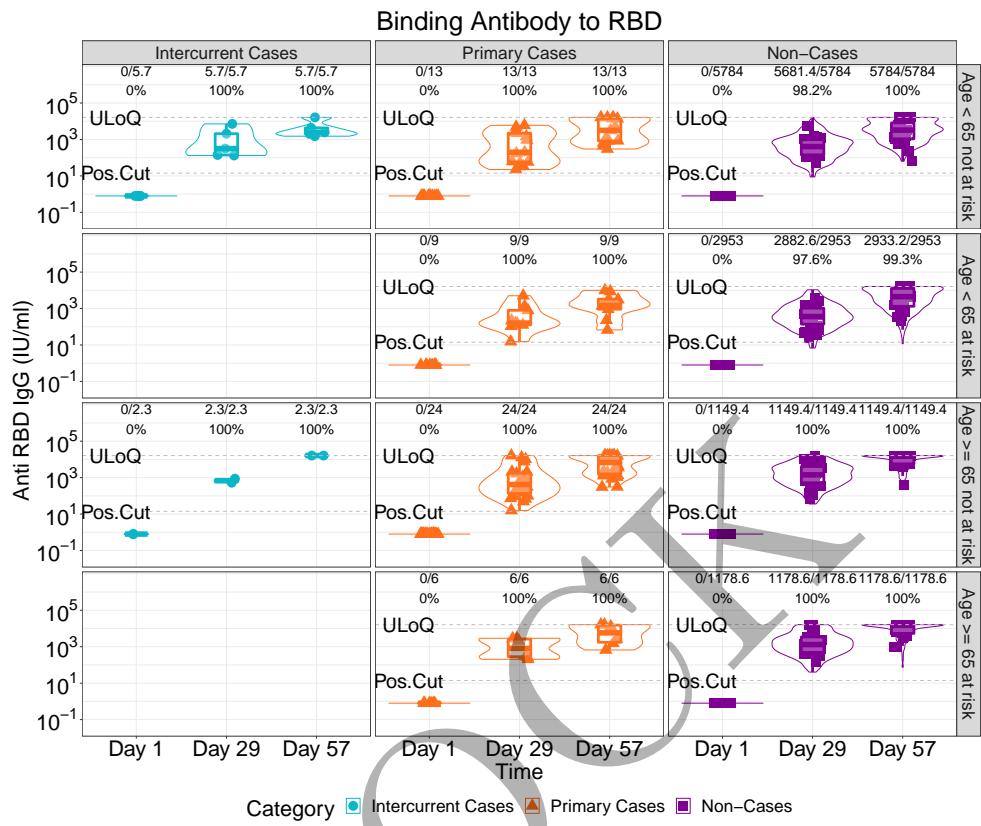


Figure 3.137: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by age and risk condition (version 2)

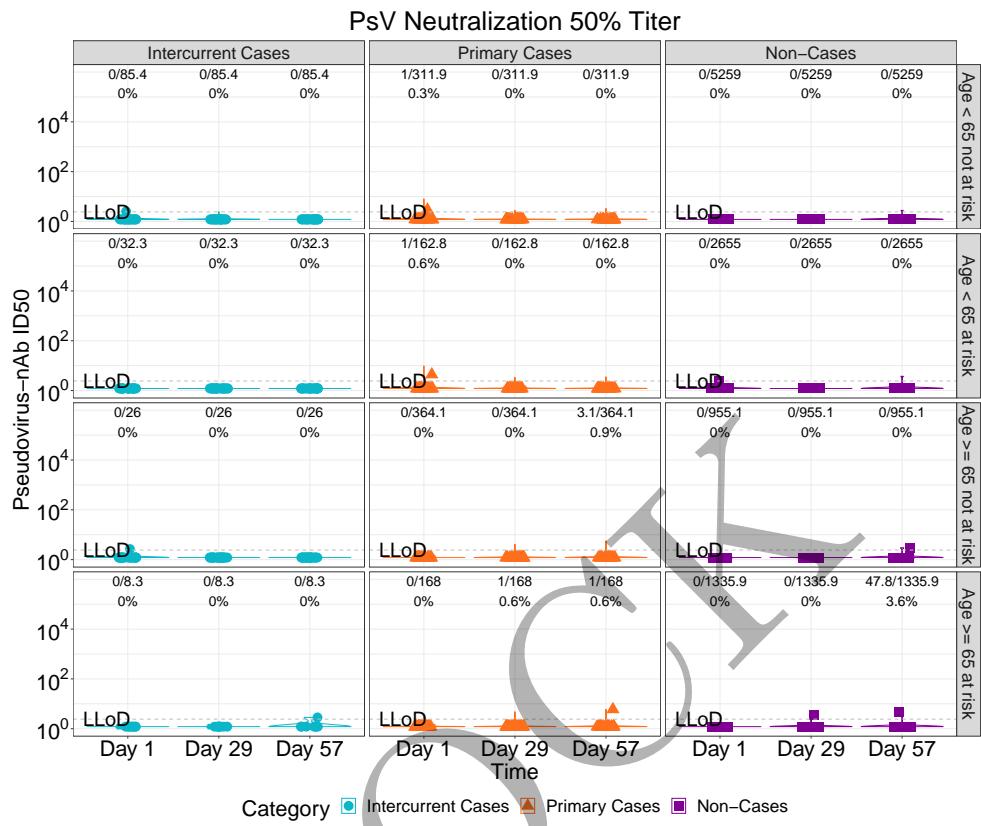


Figure 3.138: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by age and risk condition (version 2)

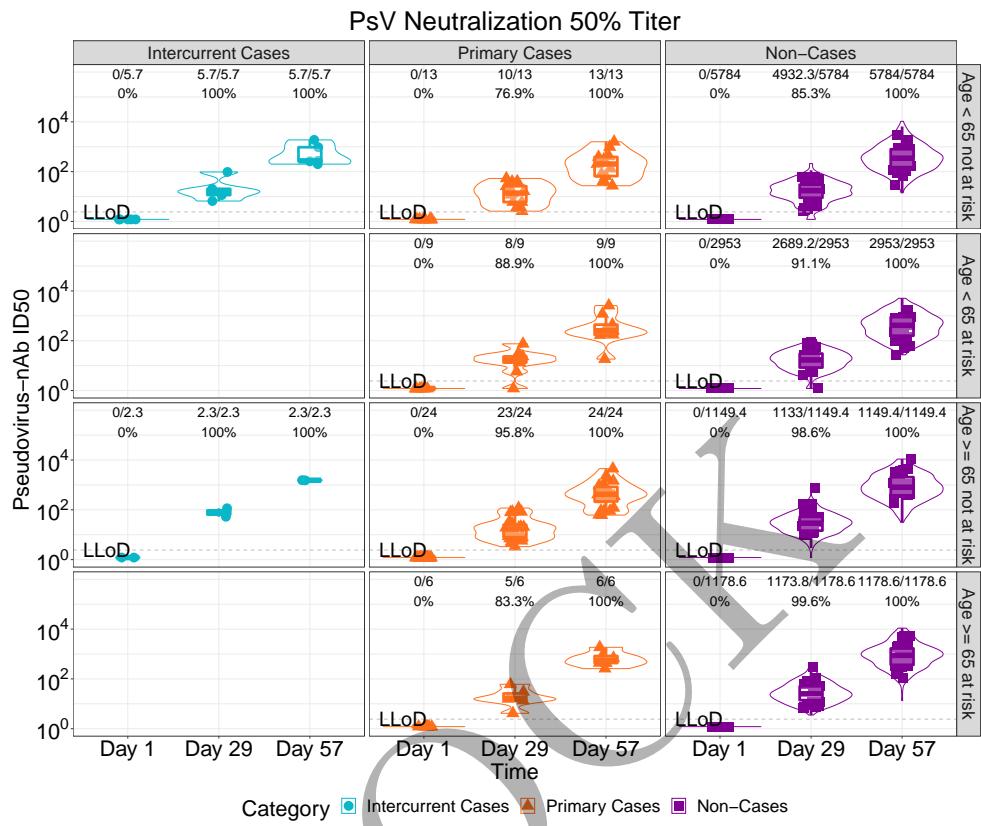


Figure 3.139: violinplots of Pseudovirus Neutralization ID₅₀: baseline negative vaccine arm by age and risk condition (version 2)

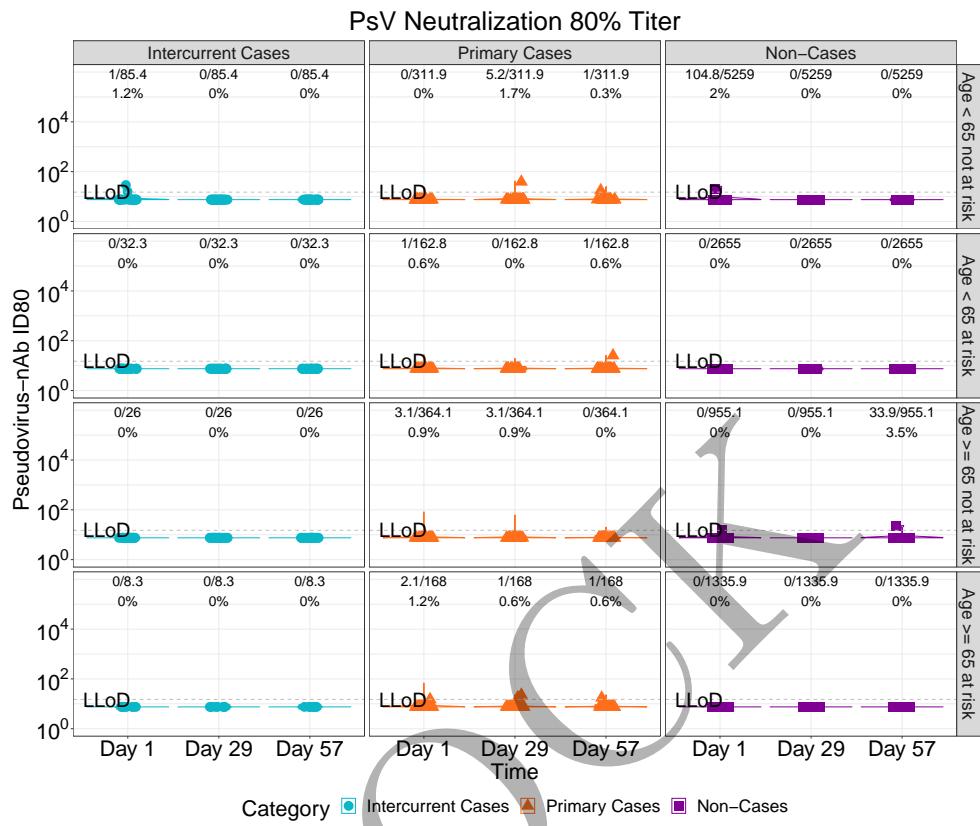


Figure 3.140: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by age and risk condition (version 2)

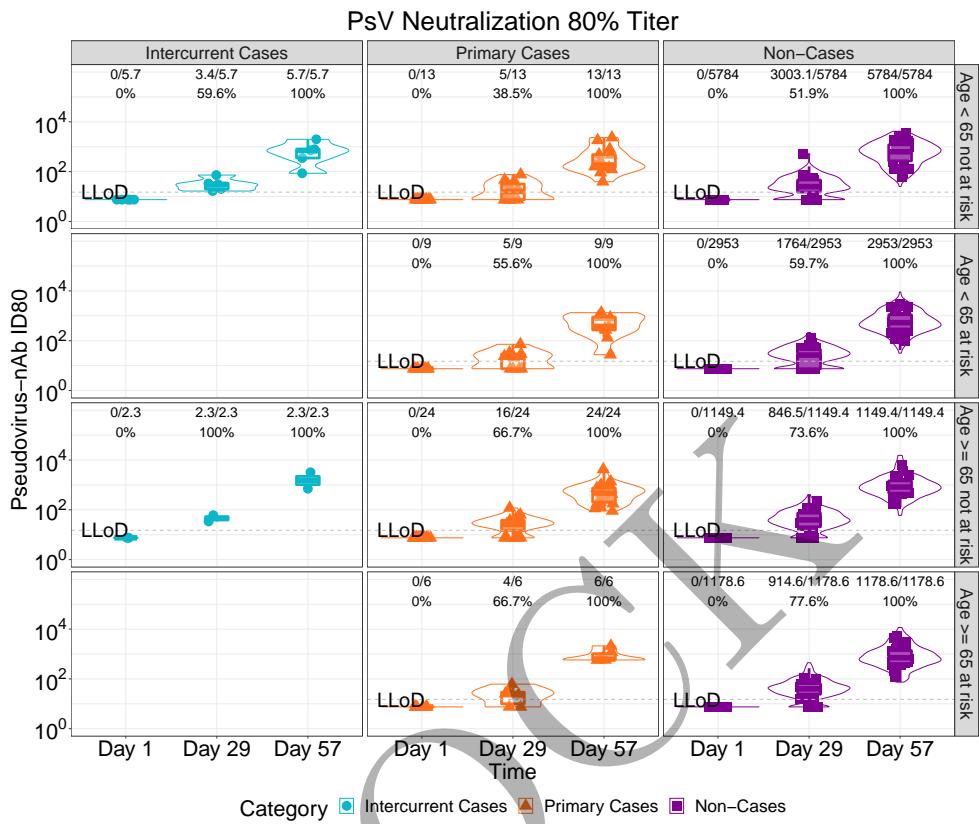


Figure 3.141: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by age and risk condition (version 2)

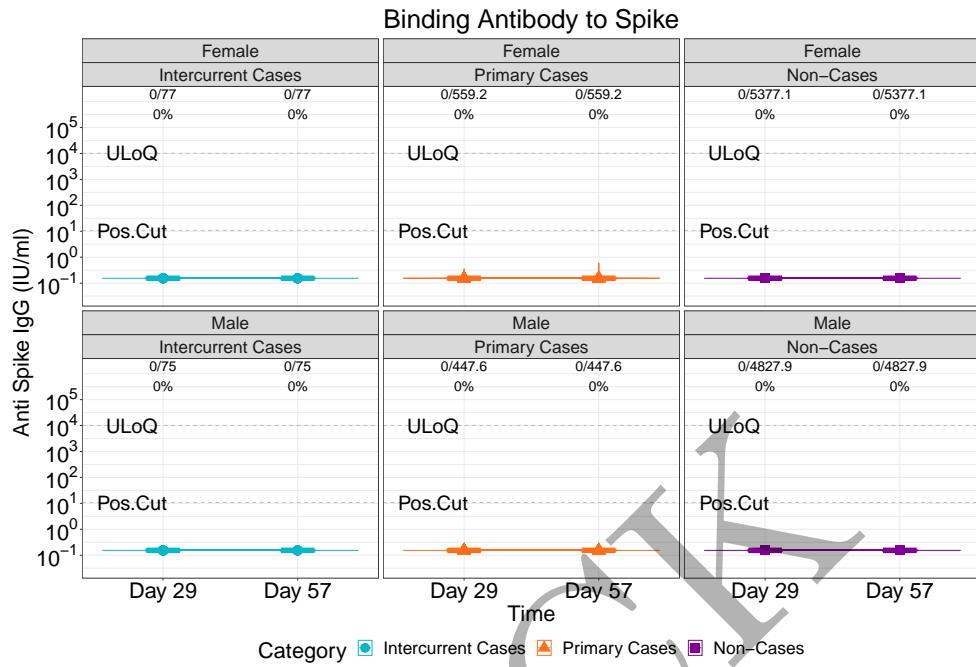


Figure 3.142: lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (version 1)

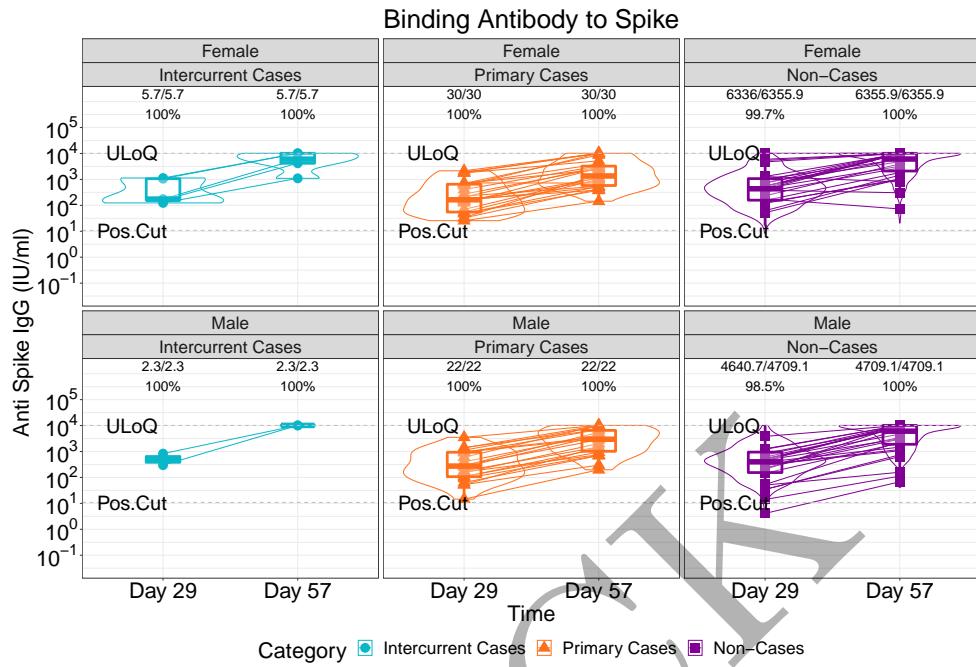


Figure 3.143: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (version 1)

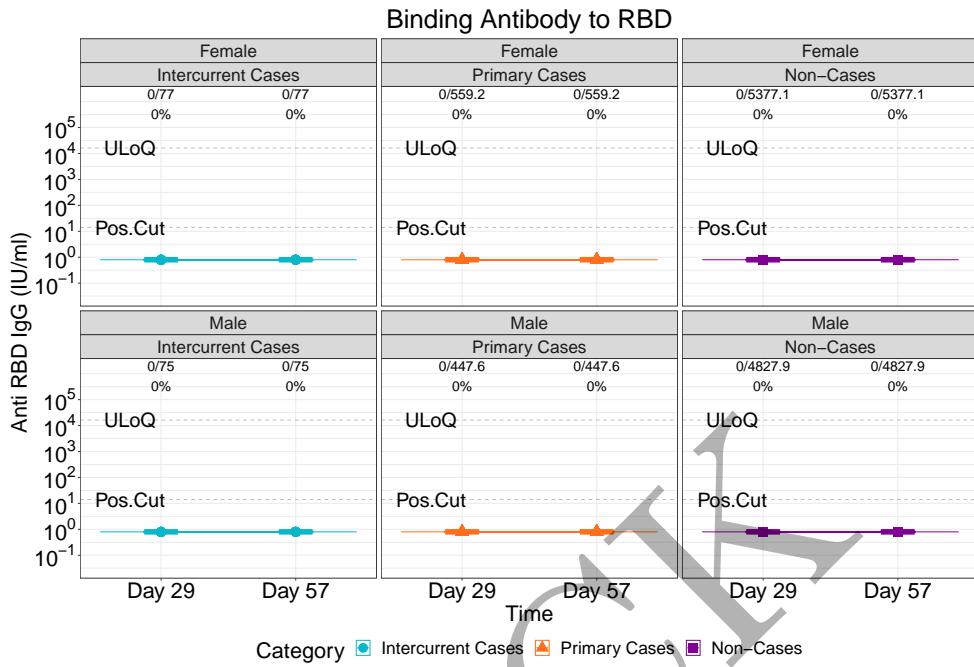


Figure 3.144: lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (version 1)

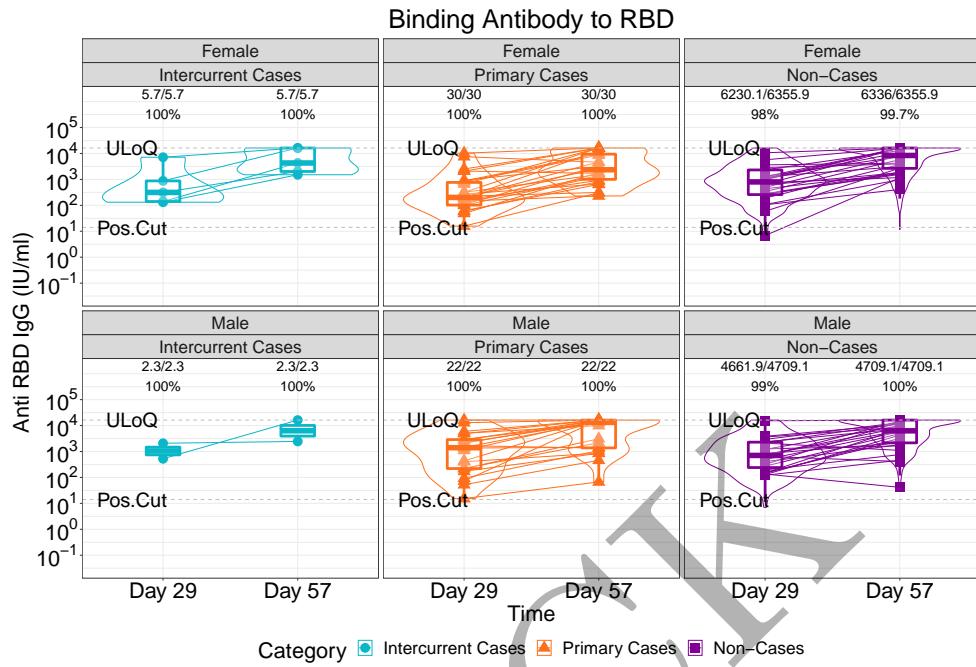


Figure 3.145: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (version 1)

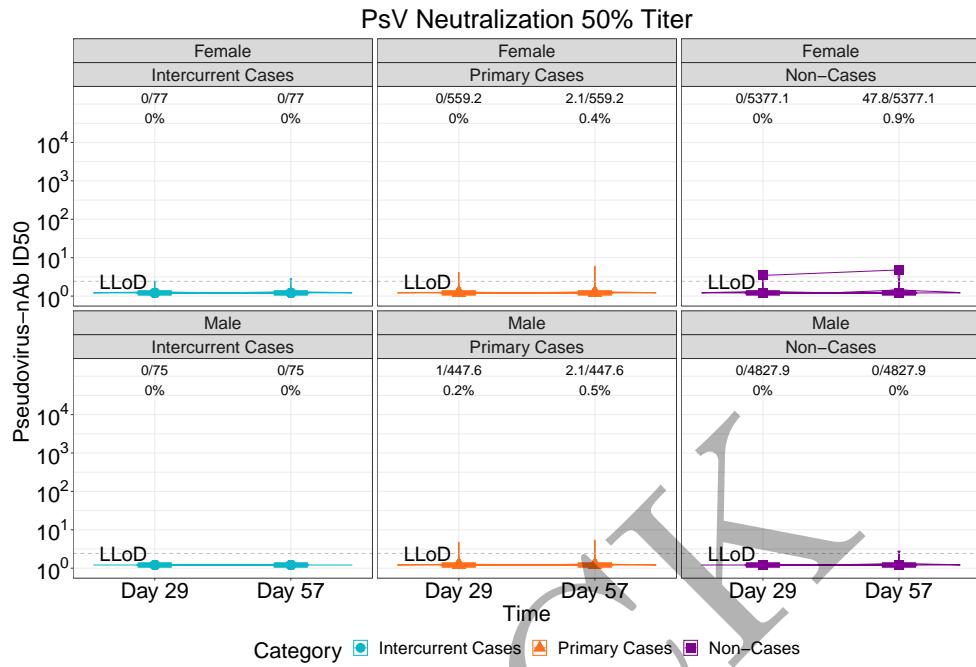


Figure 3.146: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (version 1)

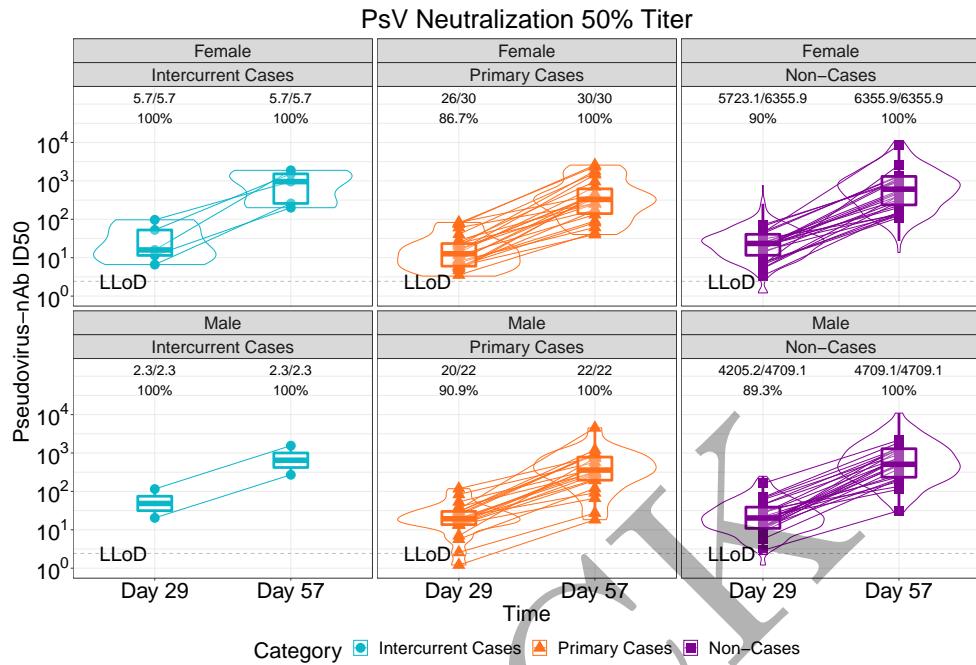


Figure 3.147: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (version 1)

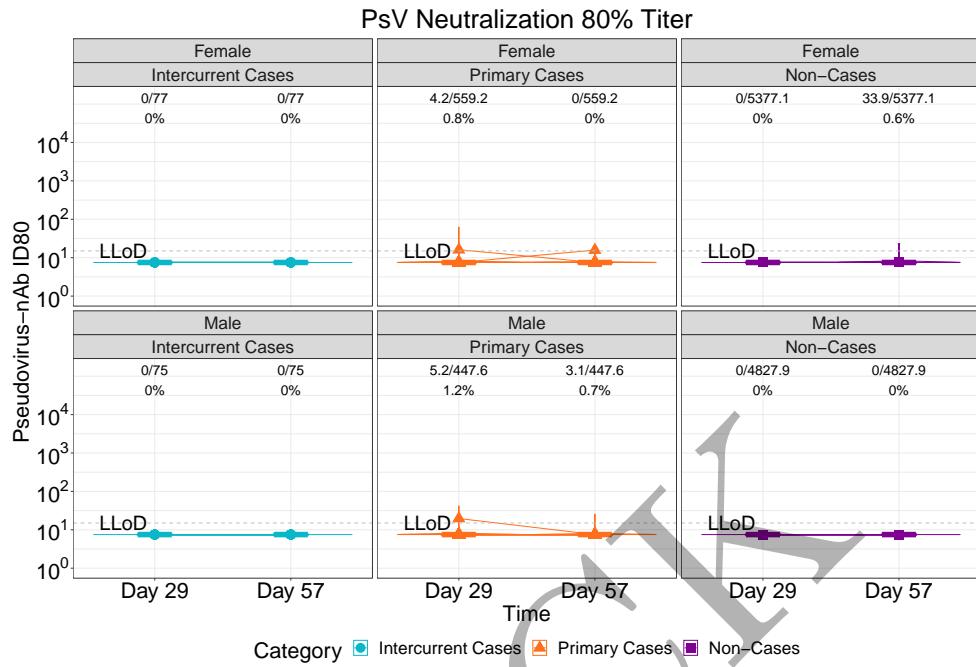


Figure 3.148: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (version 1)

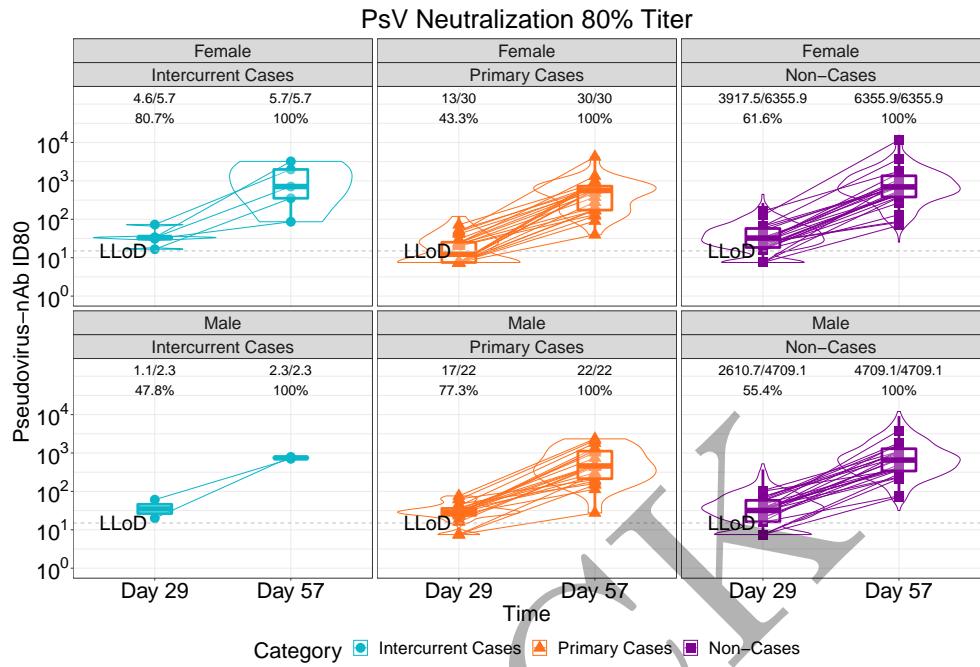


Figure 3.149: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (version 1)

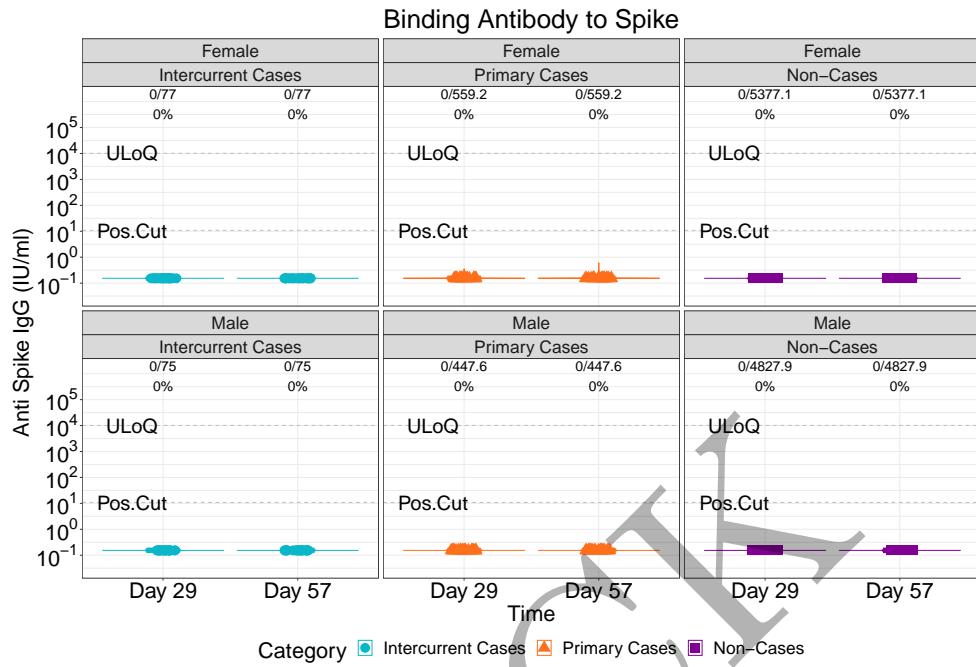


Figure 3.150: violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (version 1)

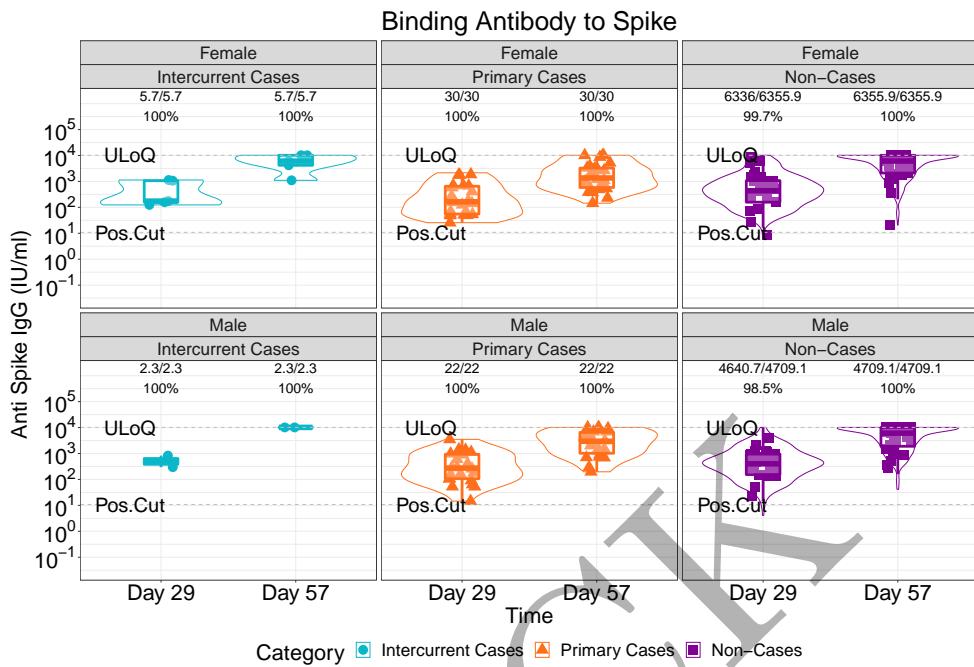


Figure 3.151: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (version 1)

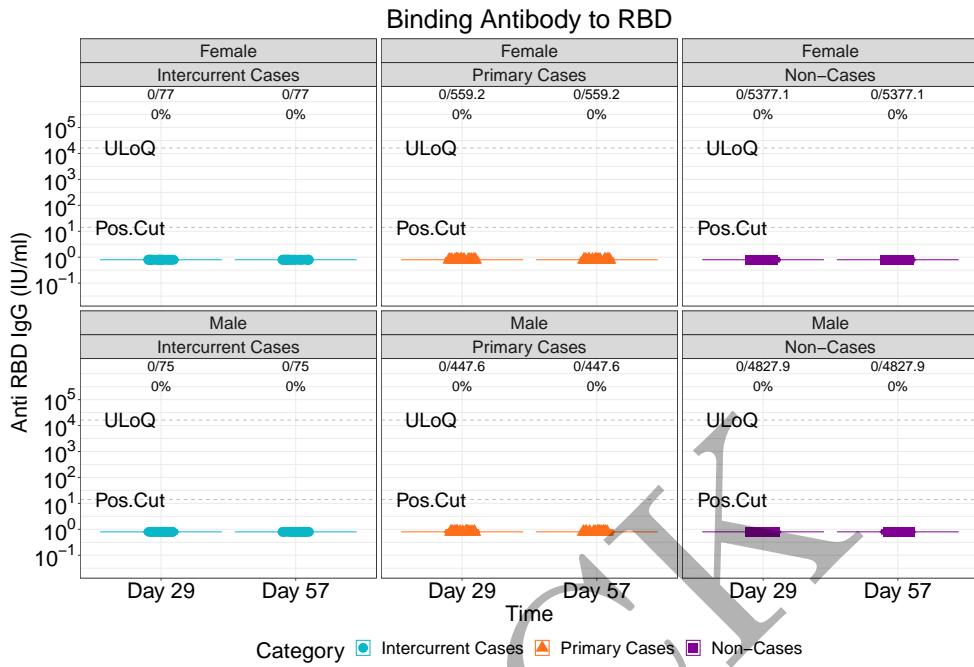


Figure 3.152: violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (version 1)

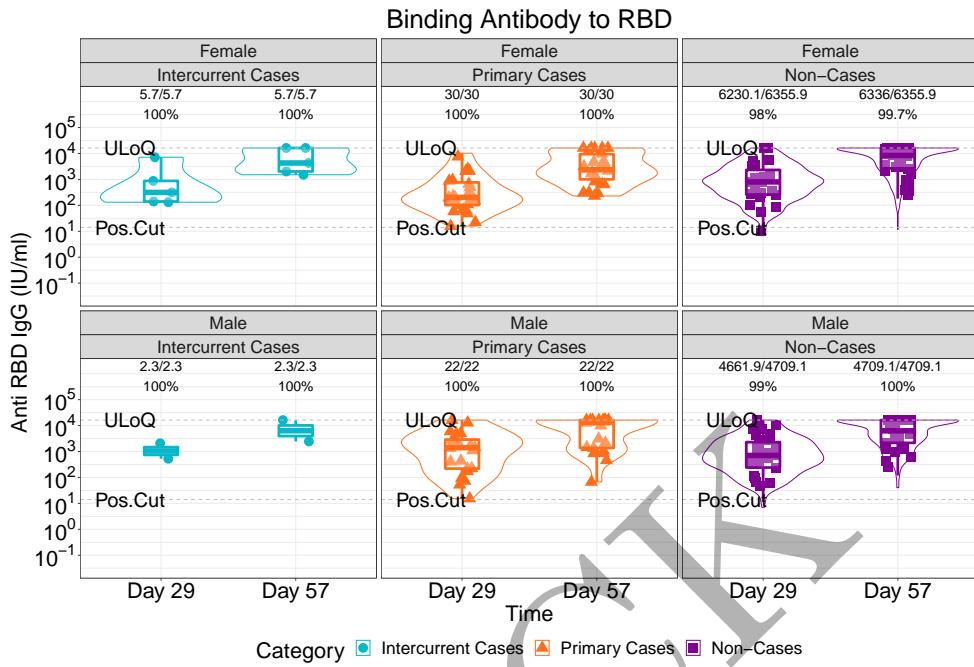


Figure 3.153: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (version 1)

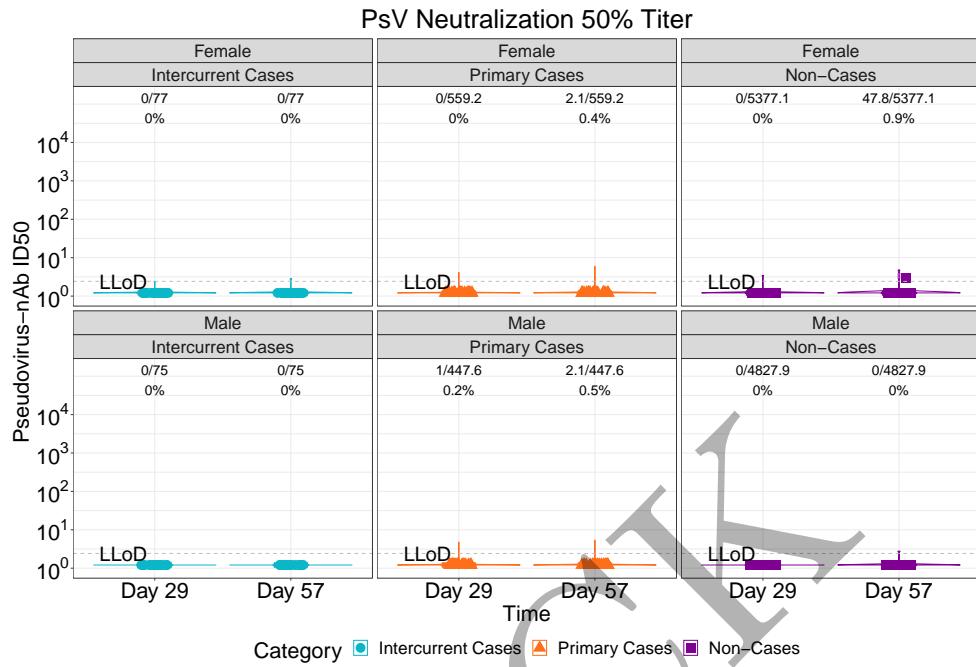


Figure 3.154: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (version 1)

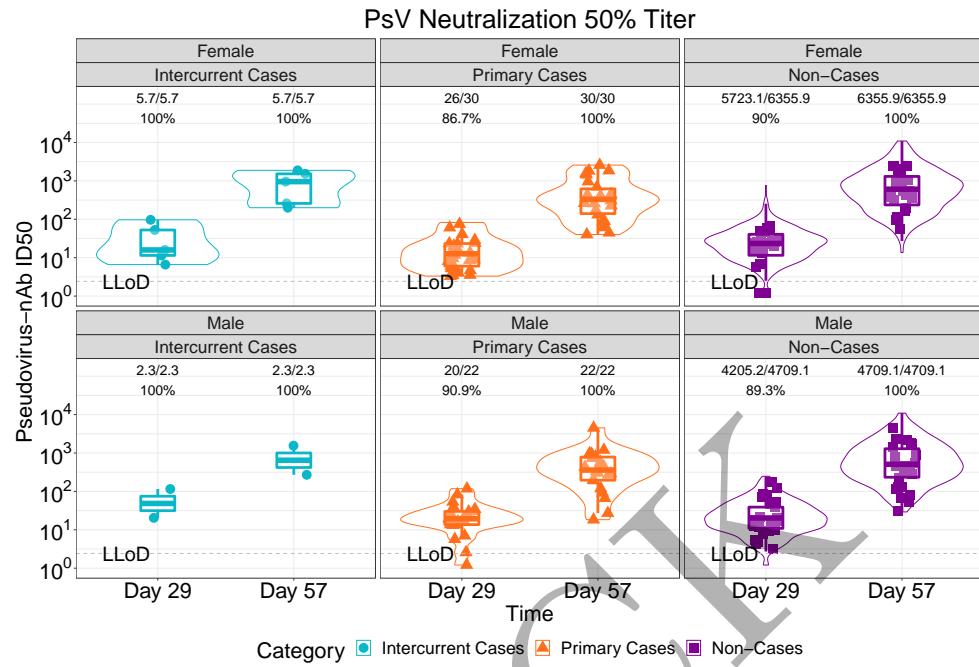


Figure 3.155: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (version 1)

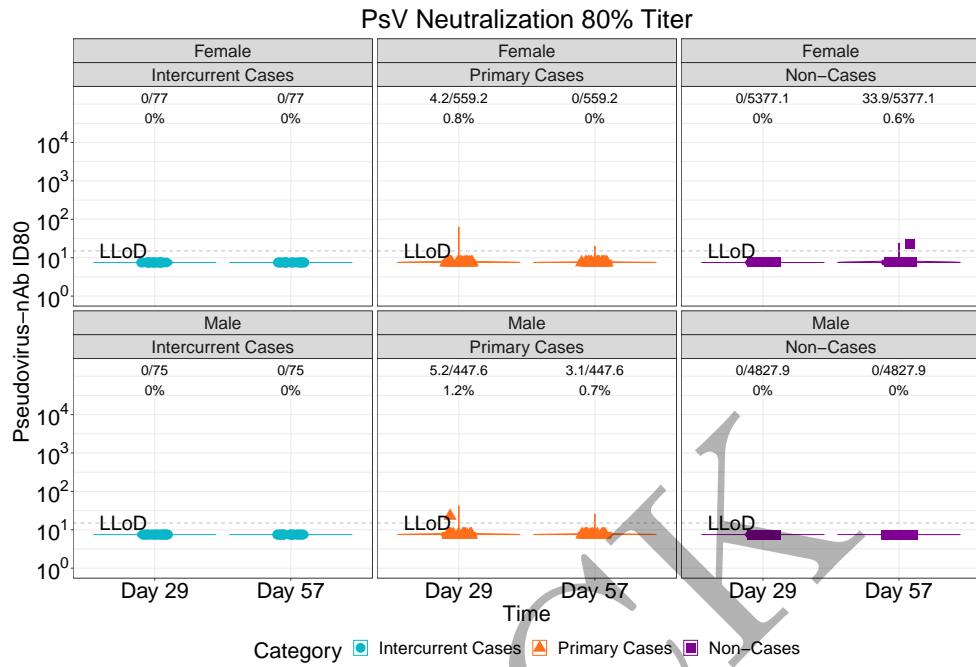


Figure 3.156: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (version 1)

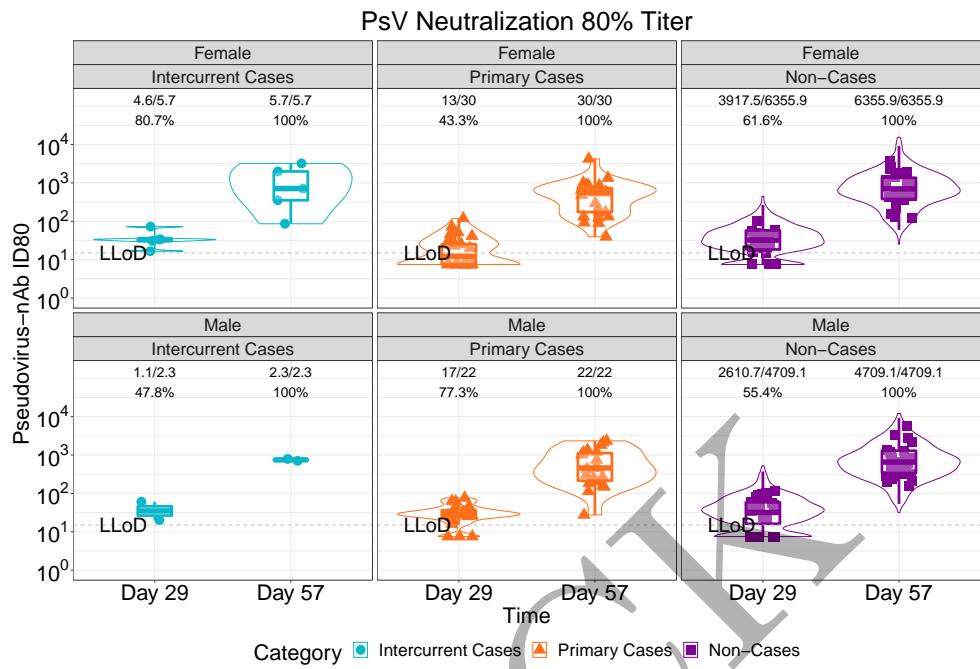


Figure 3.157: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (version 1)

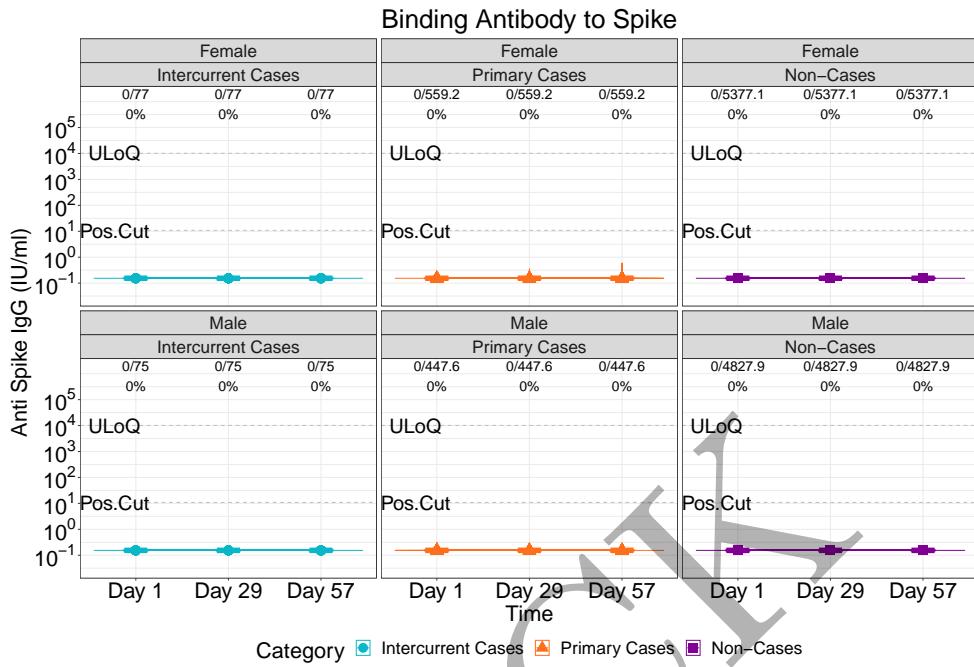


Figure 3.158: lineplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (version 2)

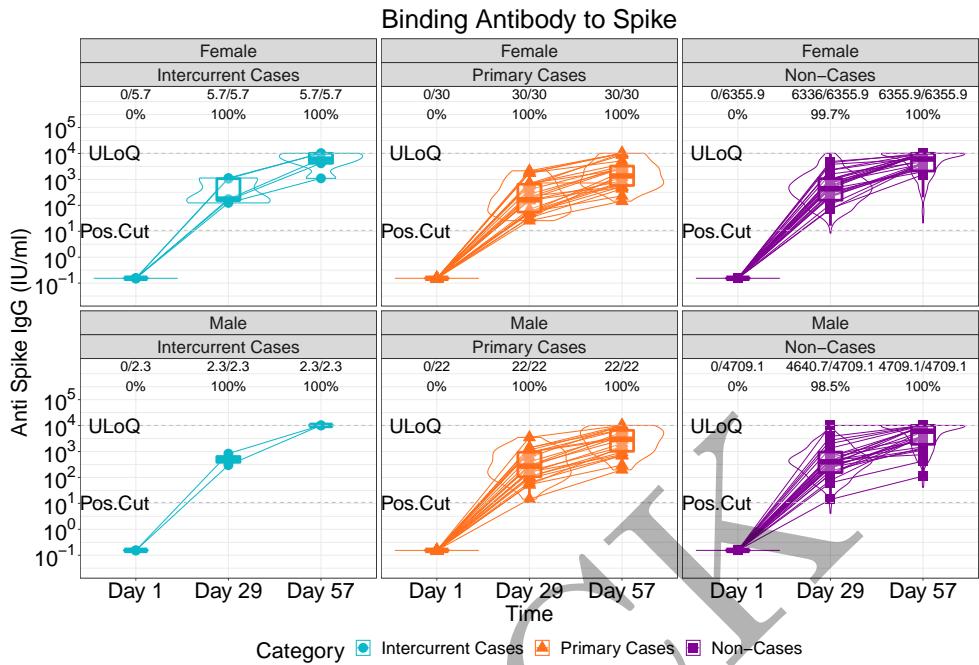


Figure 3.159: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (version 2)

Binding Antibody to RBD



Figure 3.160: lineplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (version 2)

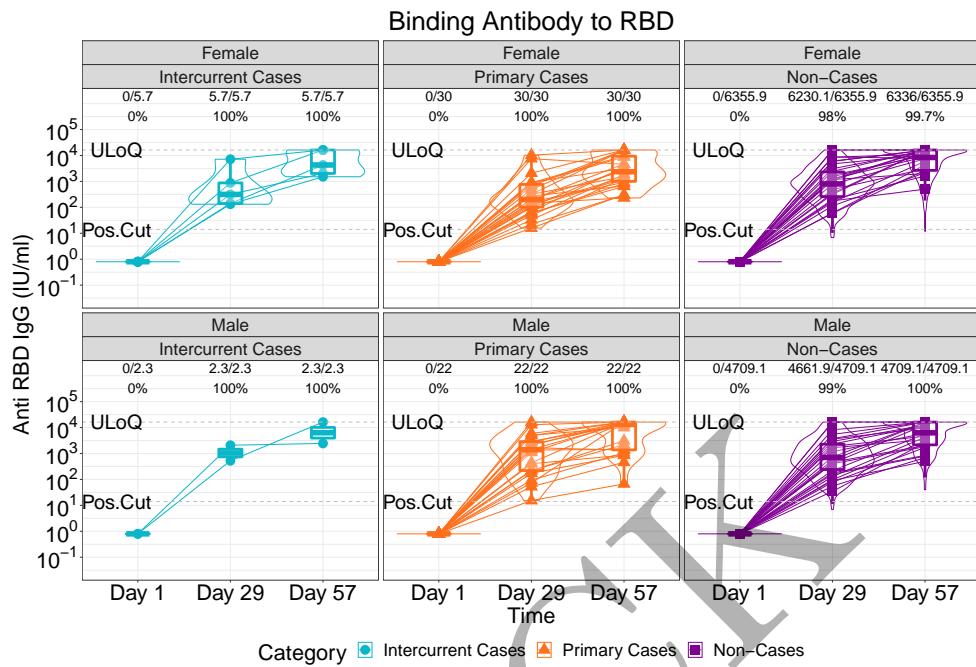


Figure 3.161: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (version 2)

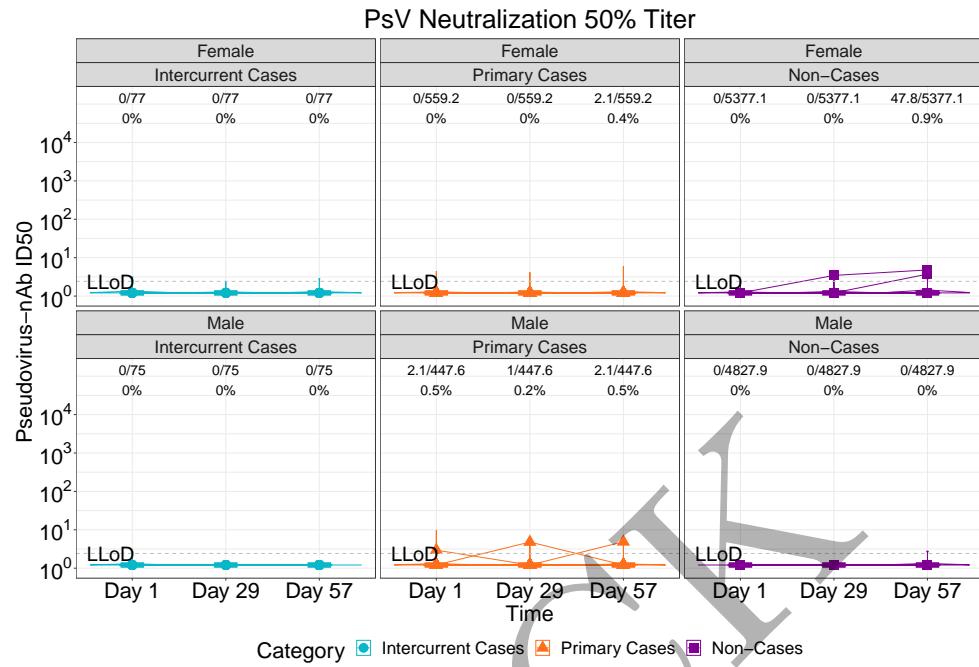


Figure 3.162: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (version 2)

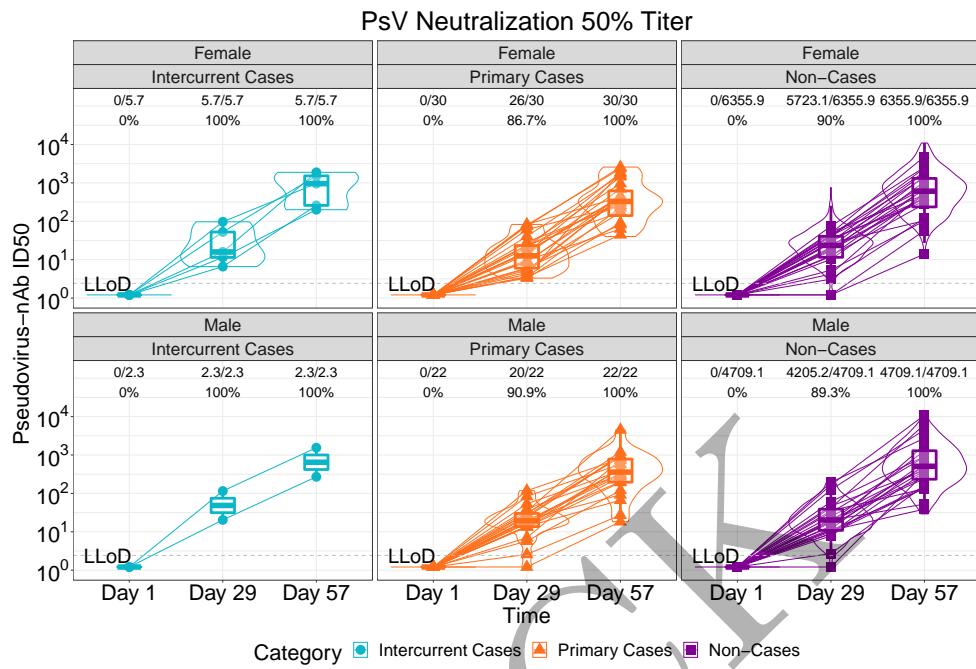


Figure 3.163: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (version 2)

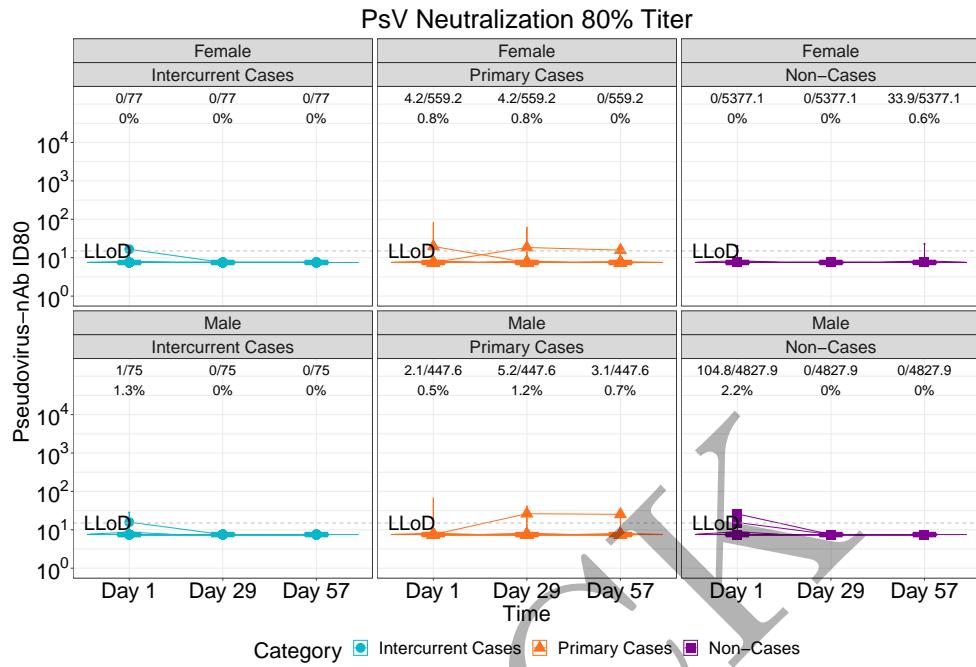


Figure 3.164: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (version 2)

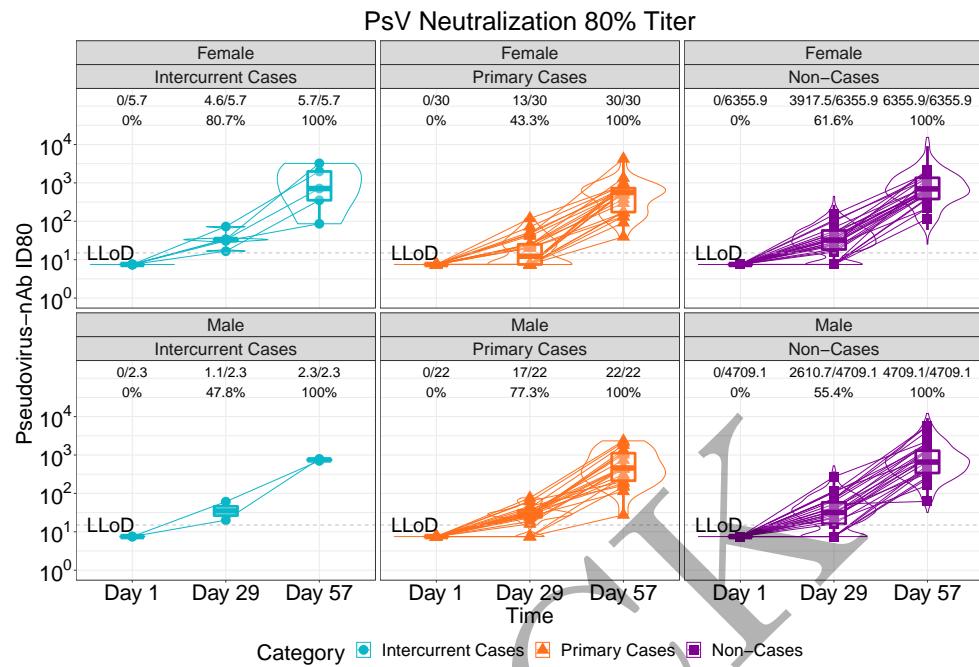


Figure 3.165: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (version 2)

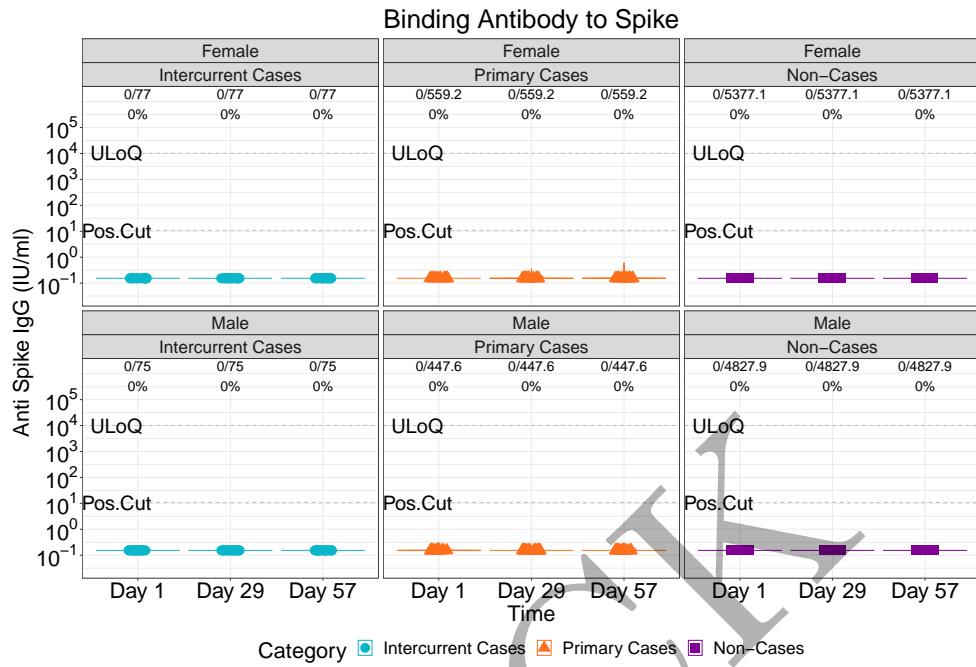


Figure 3.166: violinplots of Binding Antibody to Spike: baseline negative placebo arm by sex assigned at birth (version 2)

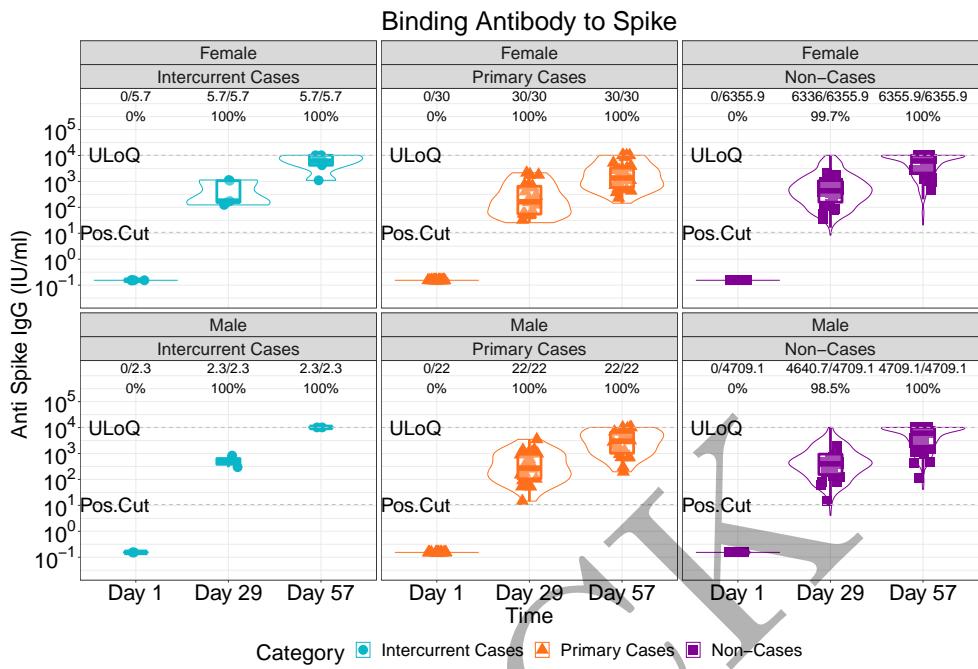


Figure 3.167: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by sex assigned at birth (version 2)

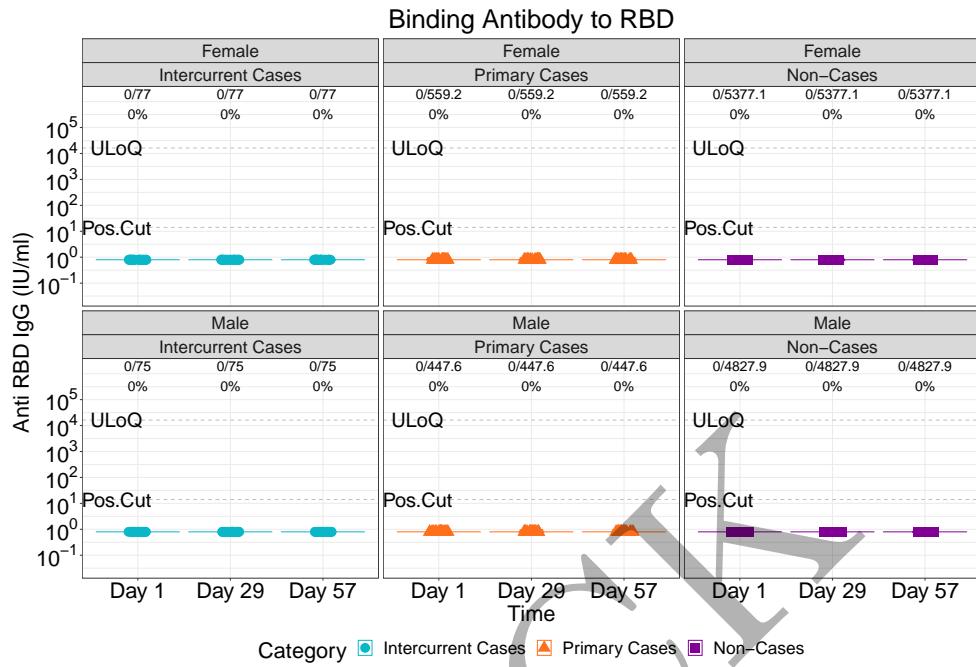


Figure 3.168: violinplots of Binding Antibody to RBD: baseline negative placebo arm by sex assigned at birth (version 2)

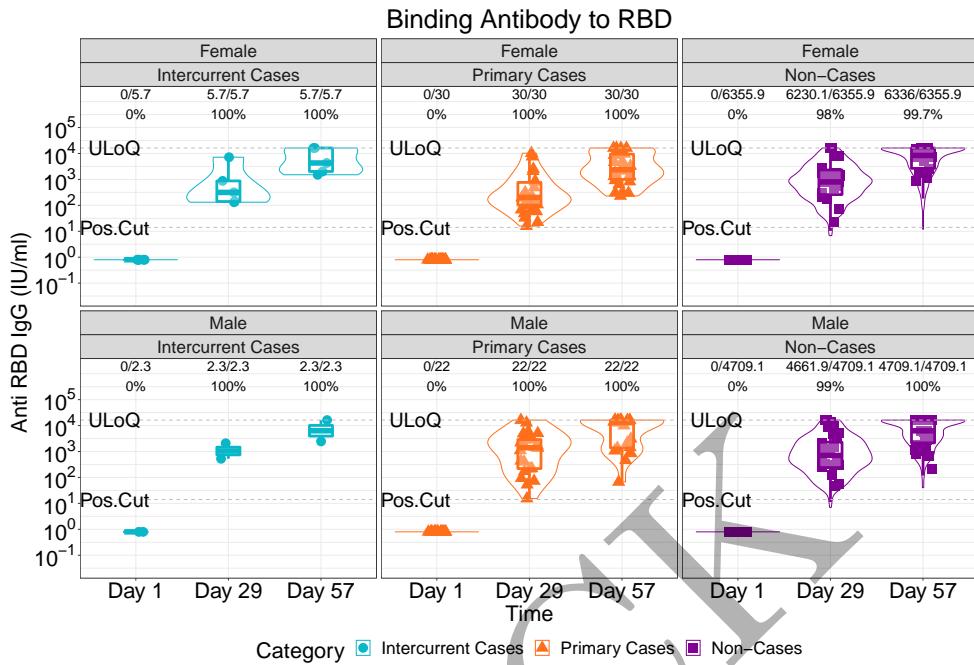


Figure 3.169: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by sex assigned at birth (version 2)

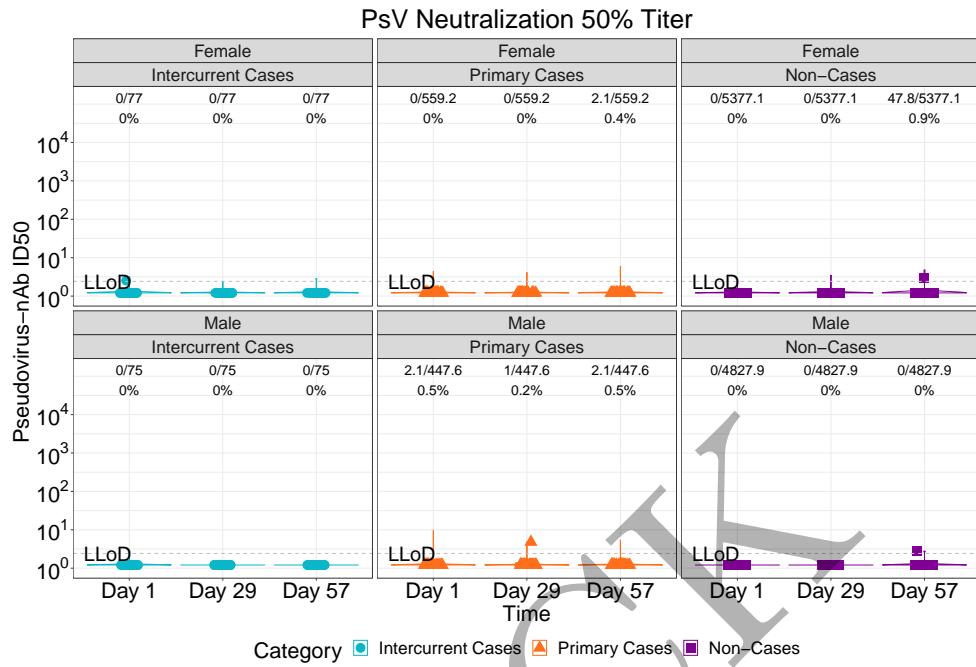


Figure 3.170: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by sex assigned at birth (version 2)

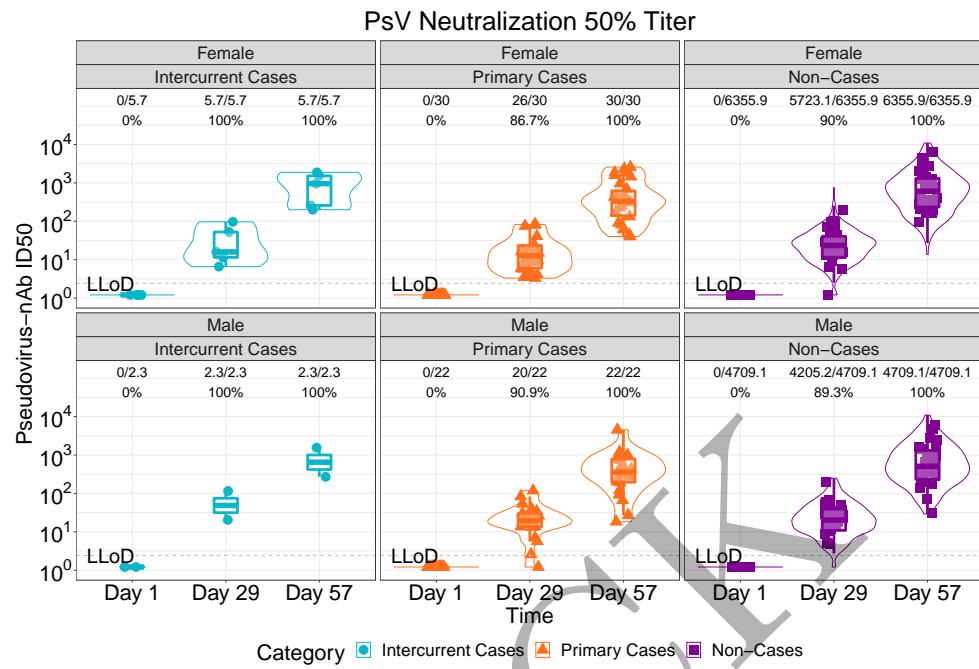


Figure 3.171: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by sex assigned at birth (version 2)

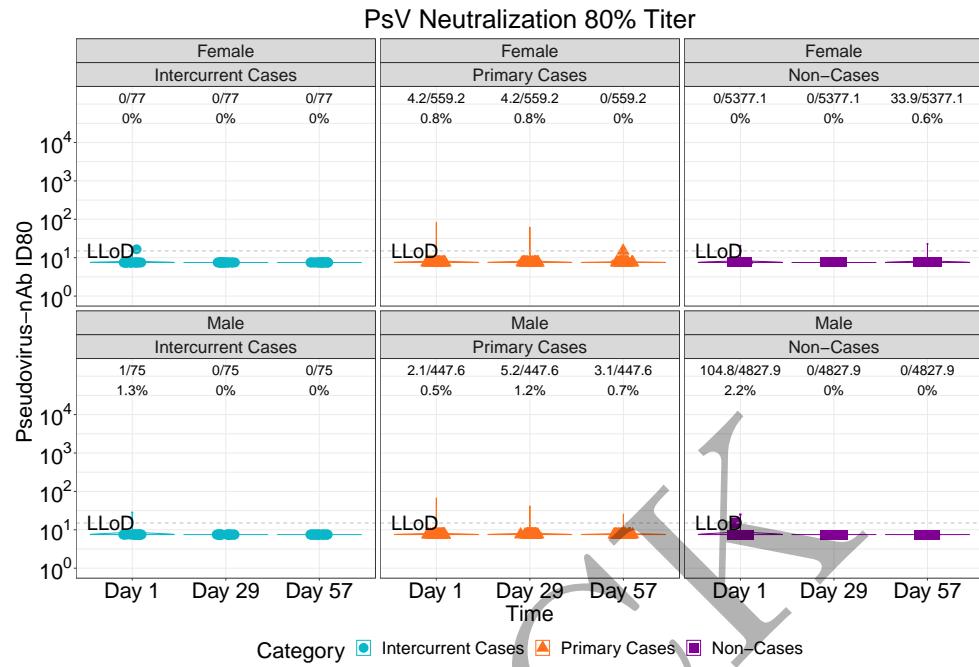


Figure 3.172: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by sex assigned at birth (version 2)

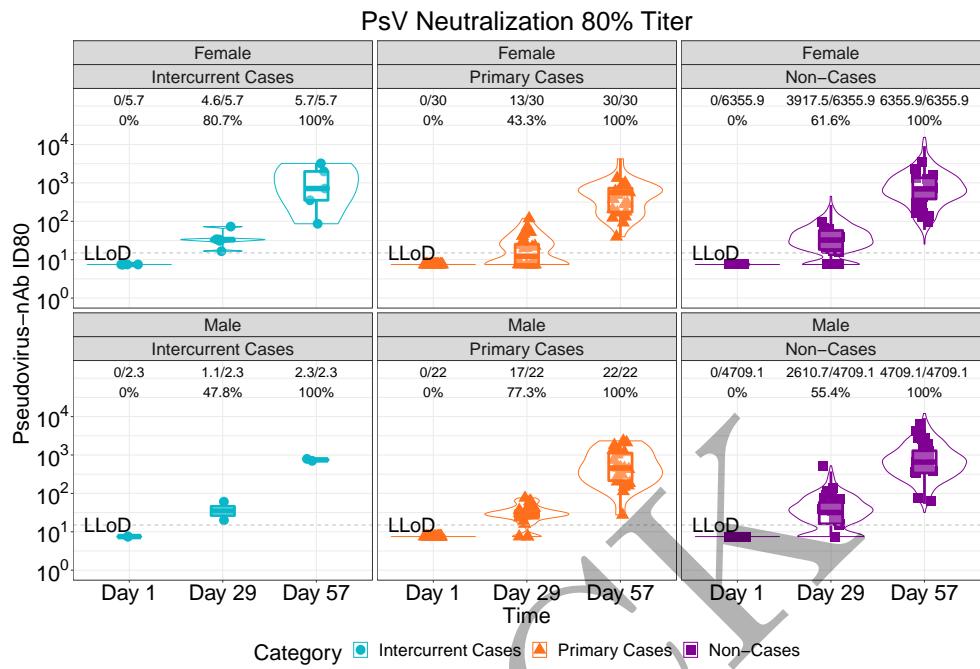


Figure 3.173: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by sex assigned at birth (version 2)

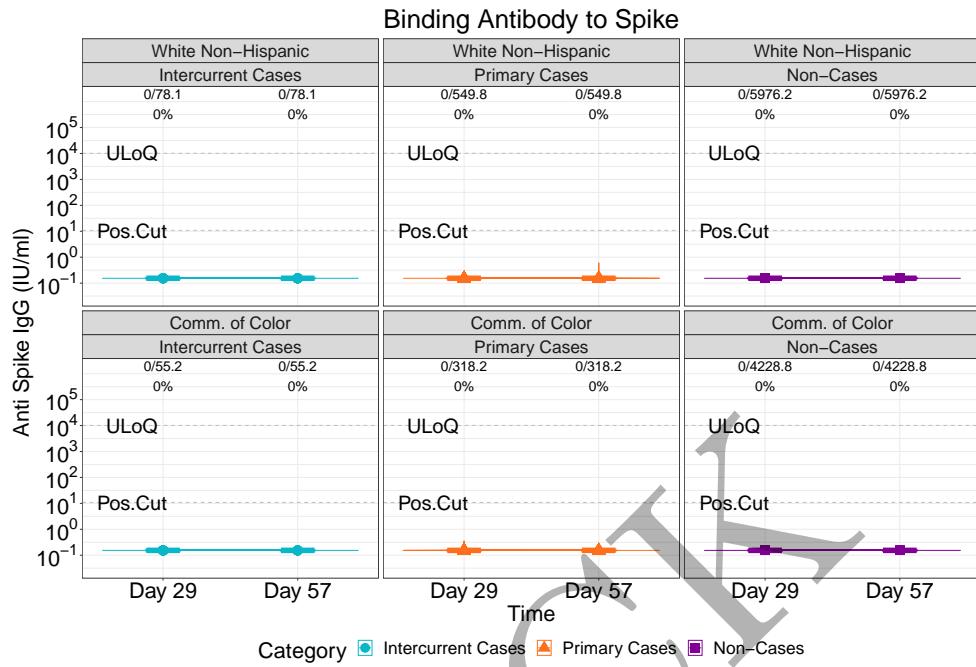


Figure 3.174: lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (version 1)

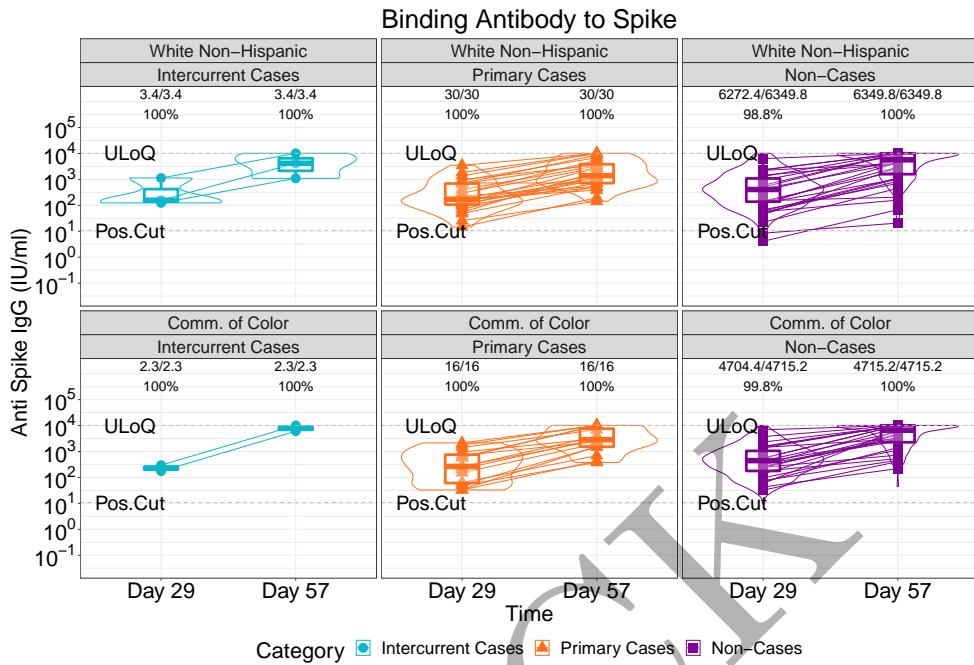


Figure 3.175: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (version 1)

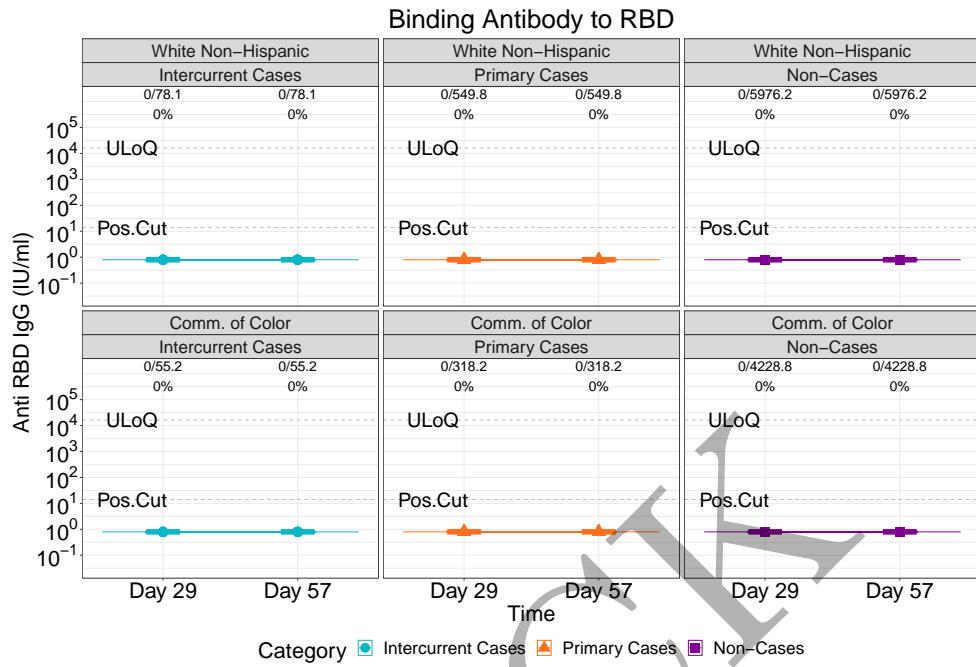


Figure 3.176: lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (version 1)

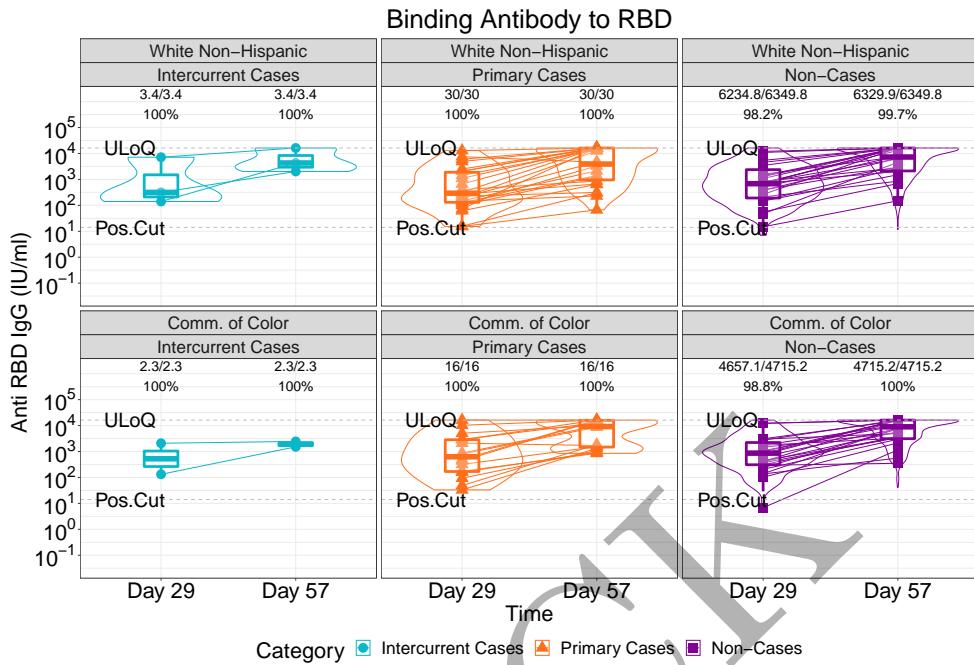


Figure 3.177: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (version 1)

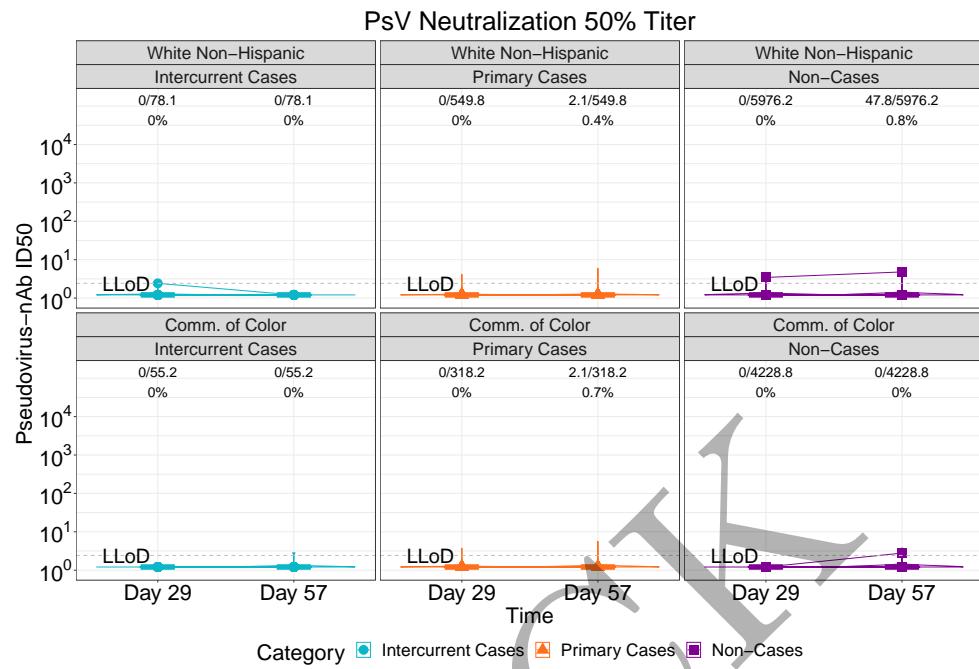


Figure 3.178: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (version 1)

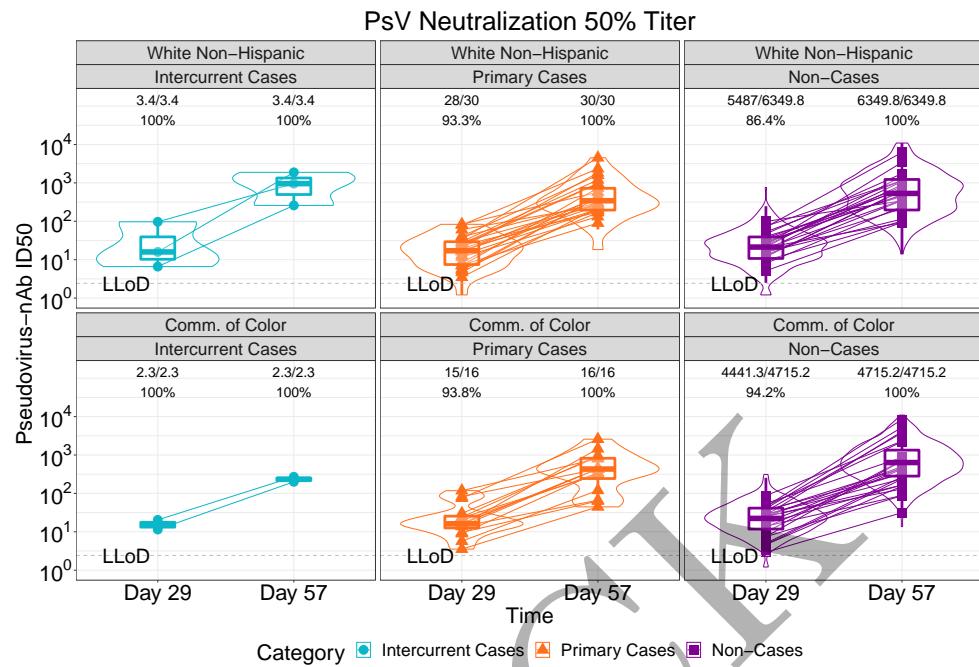


Figure 3.179: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (version 1)

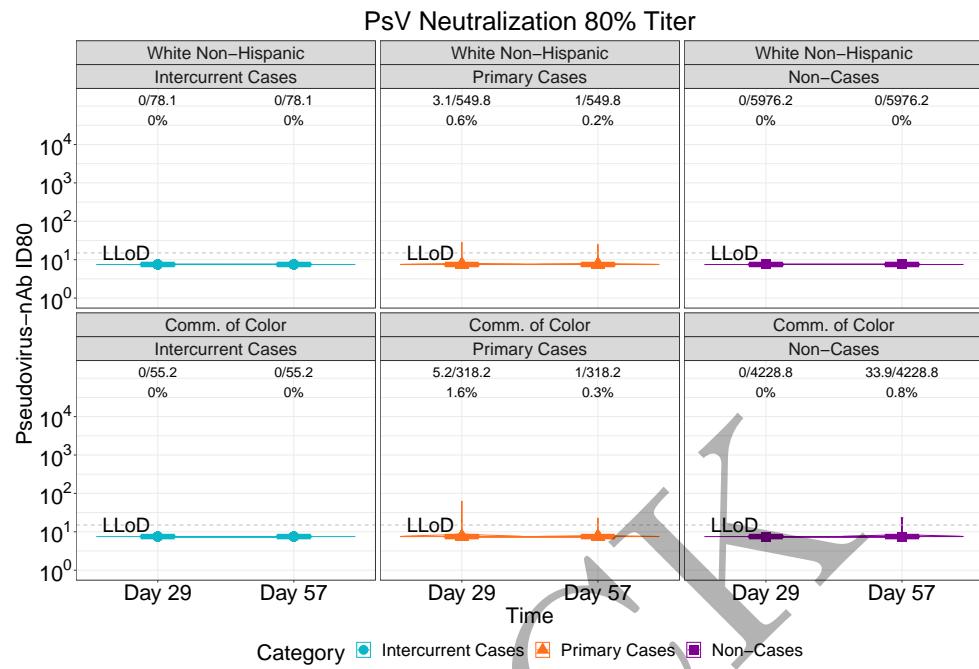


Figure 3.180: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (version 1)

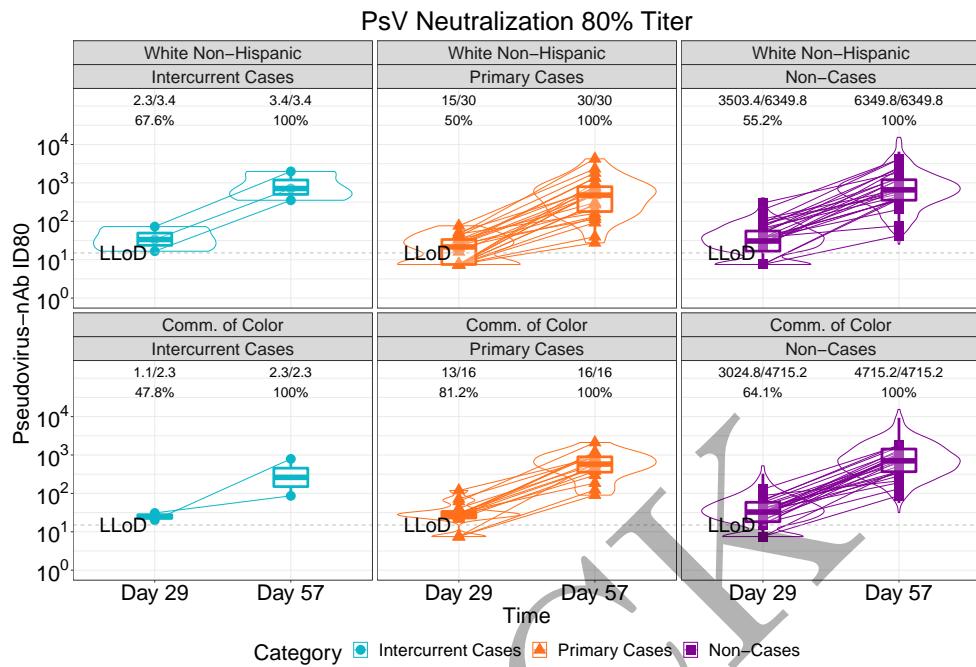


Figure 3.181: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (version 1)

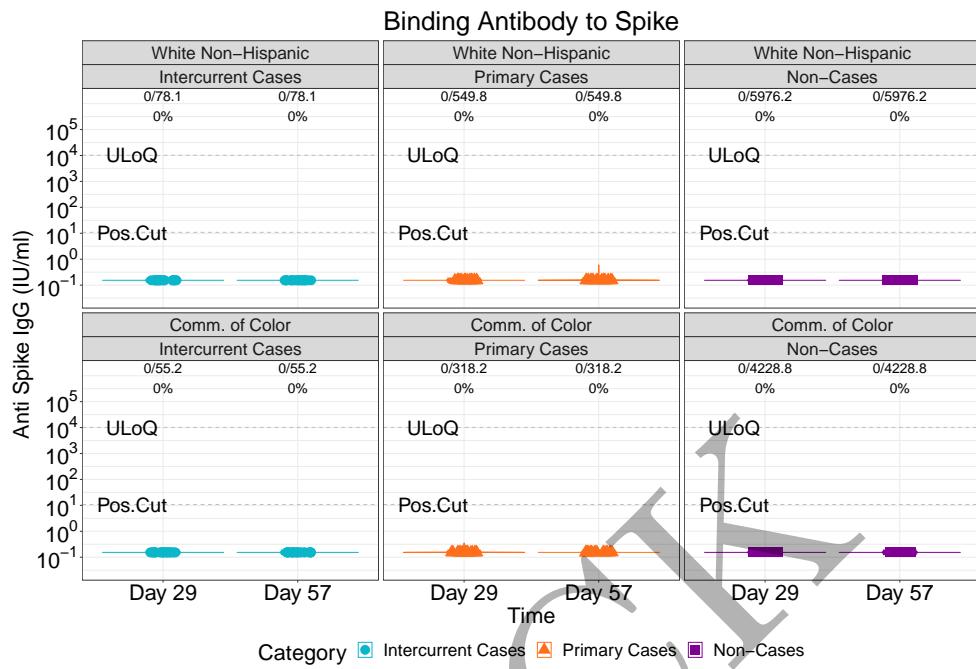


Figure 3.182: violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (version 1)

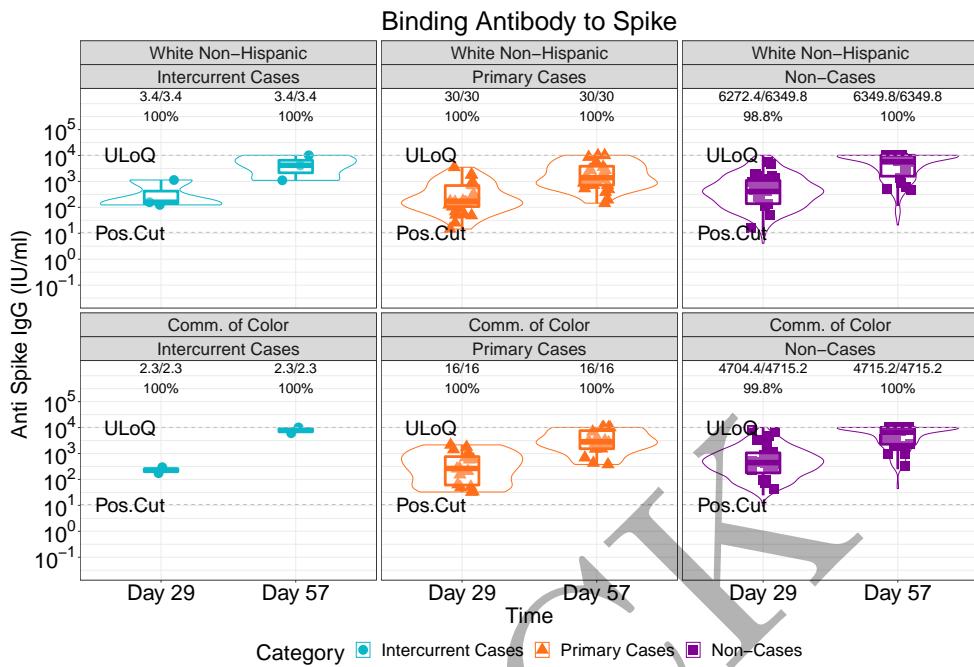


Figure 3.183: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (version 1)

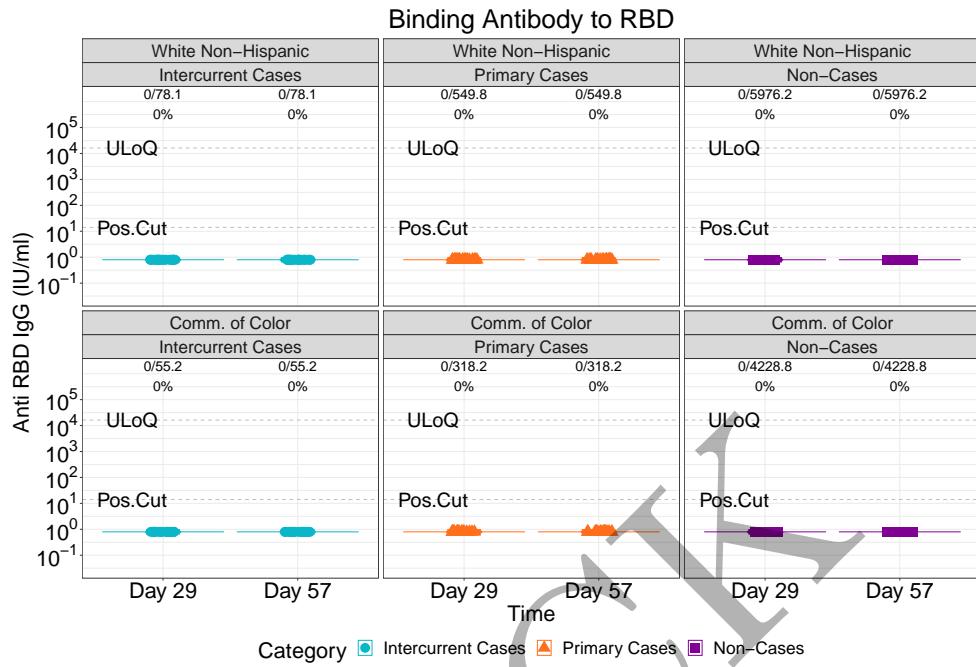


Figure 3.184: violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (version 1)

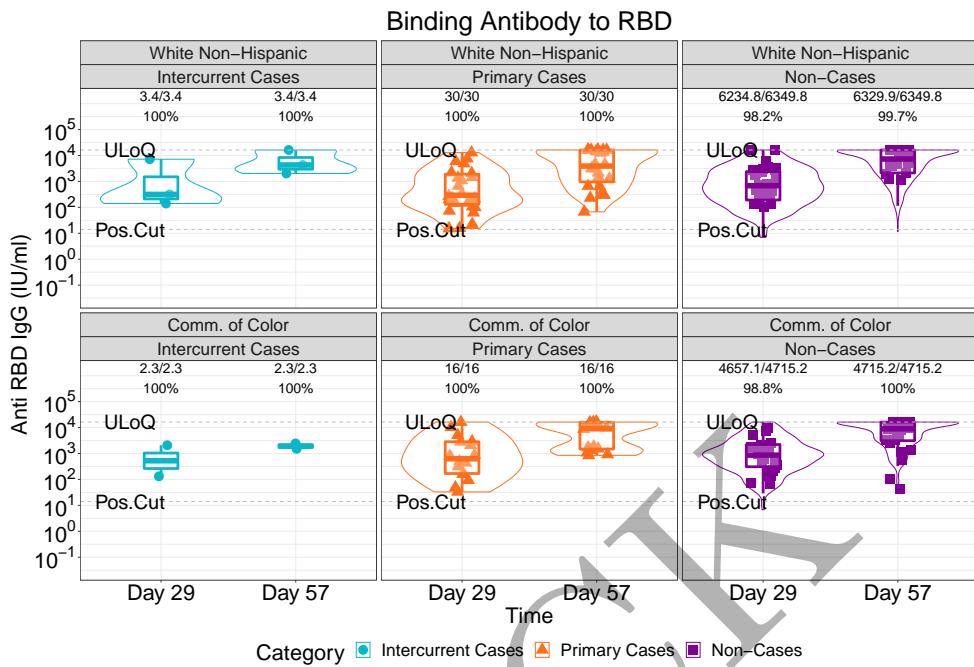


Figure 3.185: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (version 1)

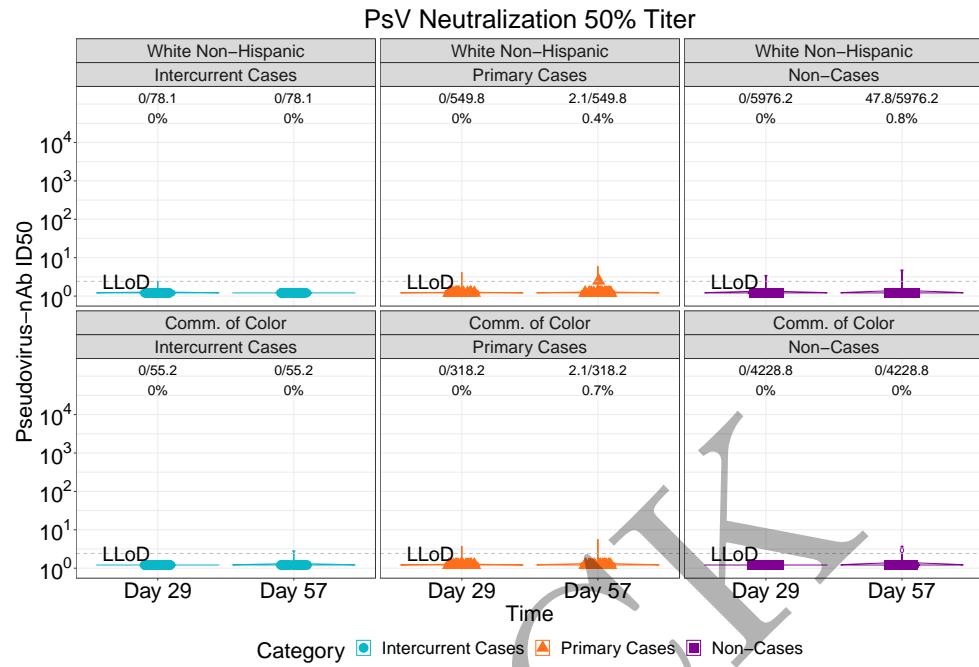


Figure 3.186: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (version 1)

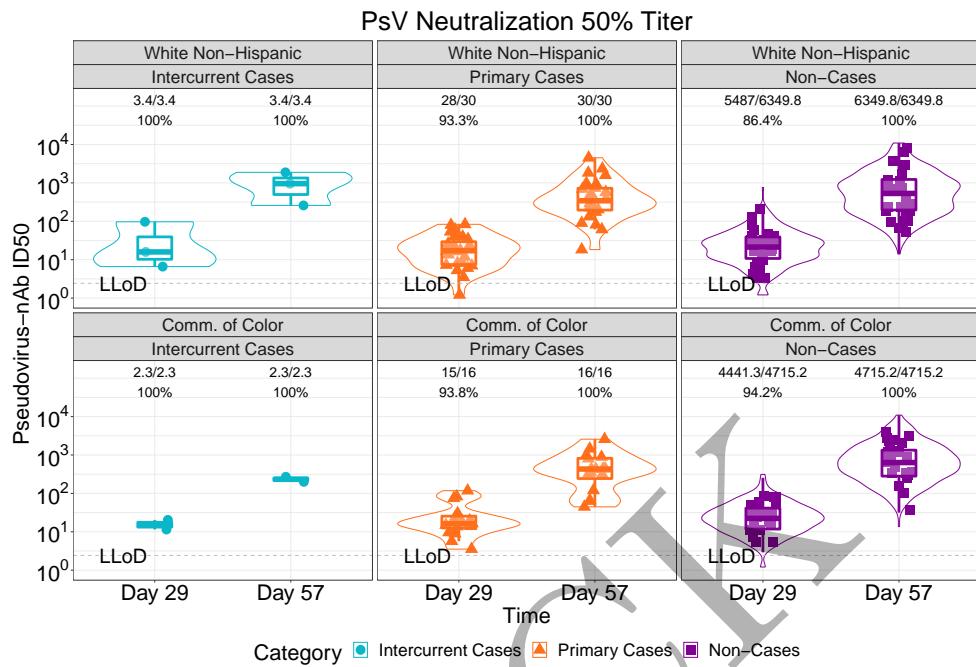


Figure 3.187: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (version 1)

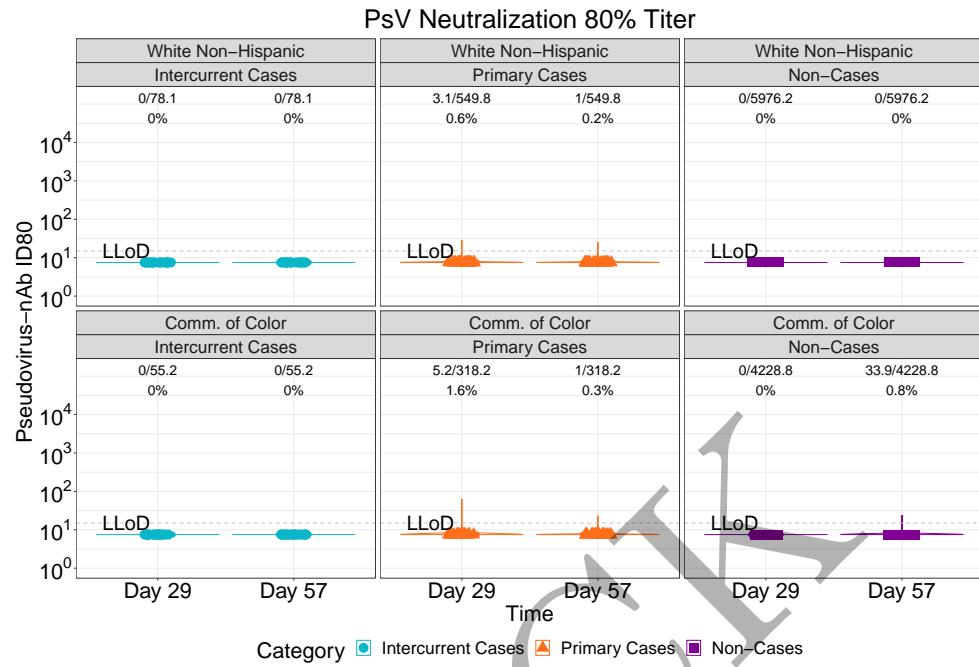


Figure 3.188: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (version 1)

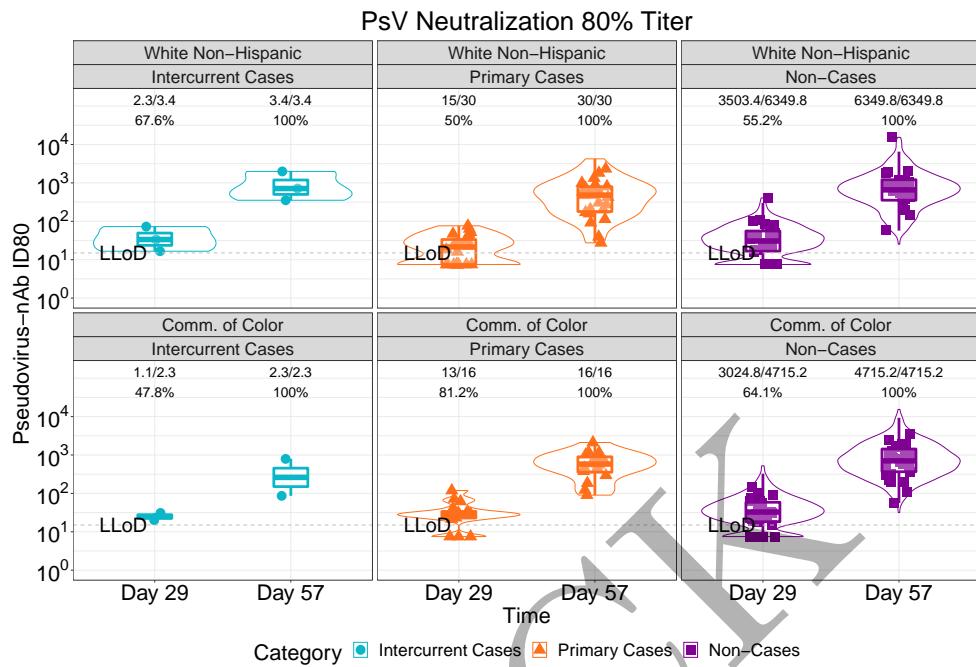


Figure 3.189: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (version 1)

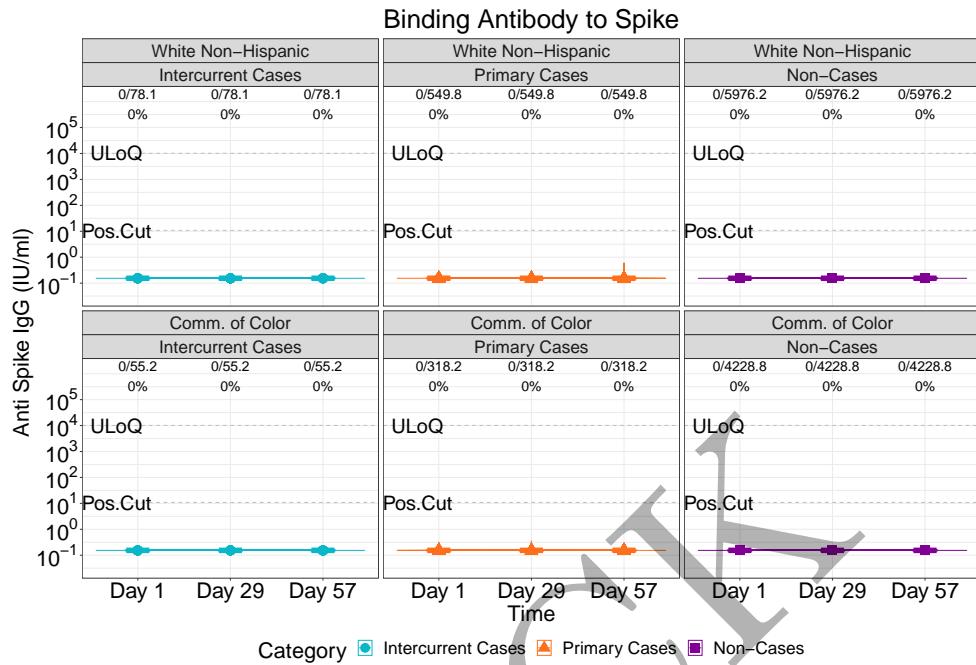


Figure 3.190: lineplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (version 2)

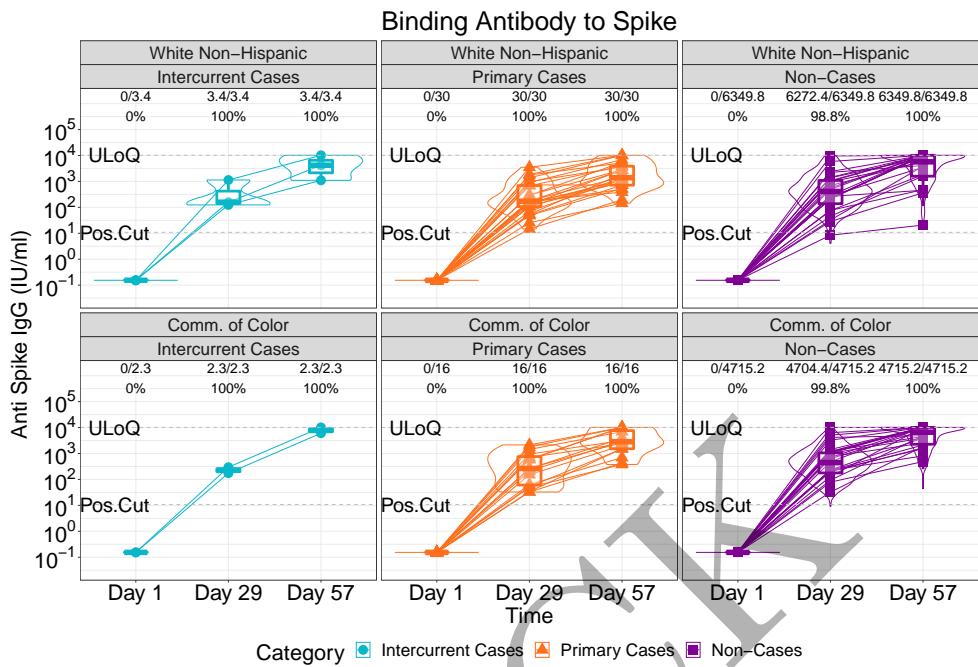


Figure 3.191: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (version 2)

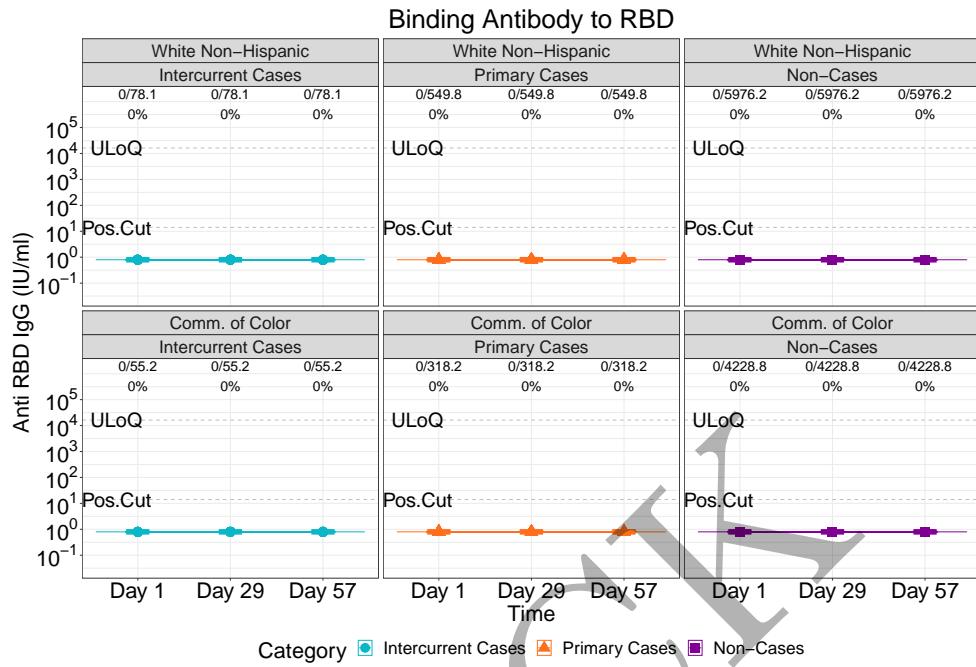


Figure 3.192: lineplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (version 2)

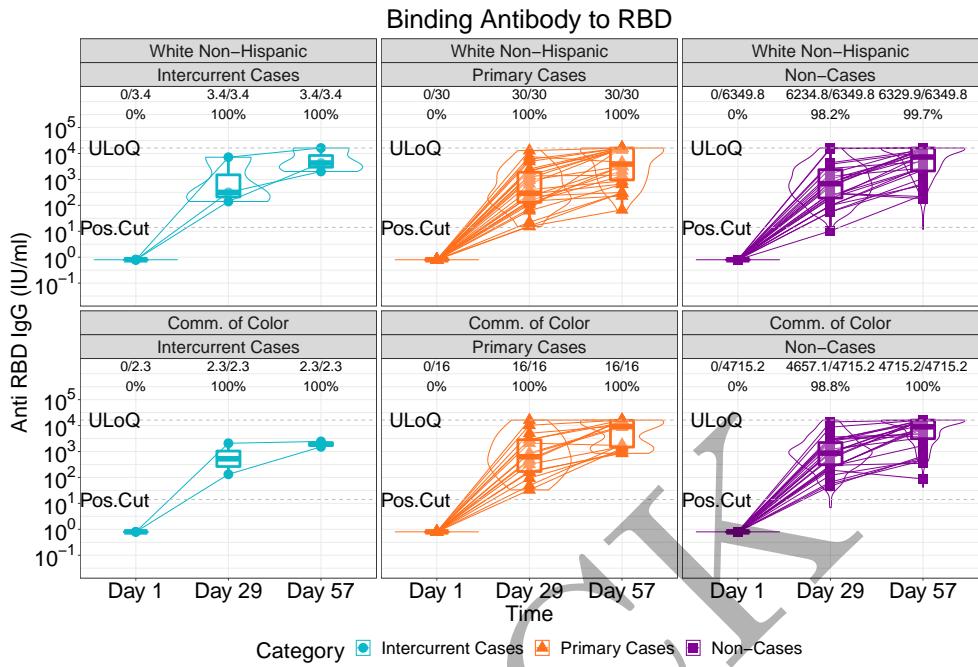


Figure 3.193: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (version 2)

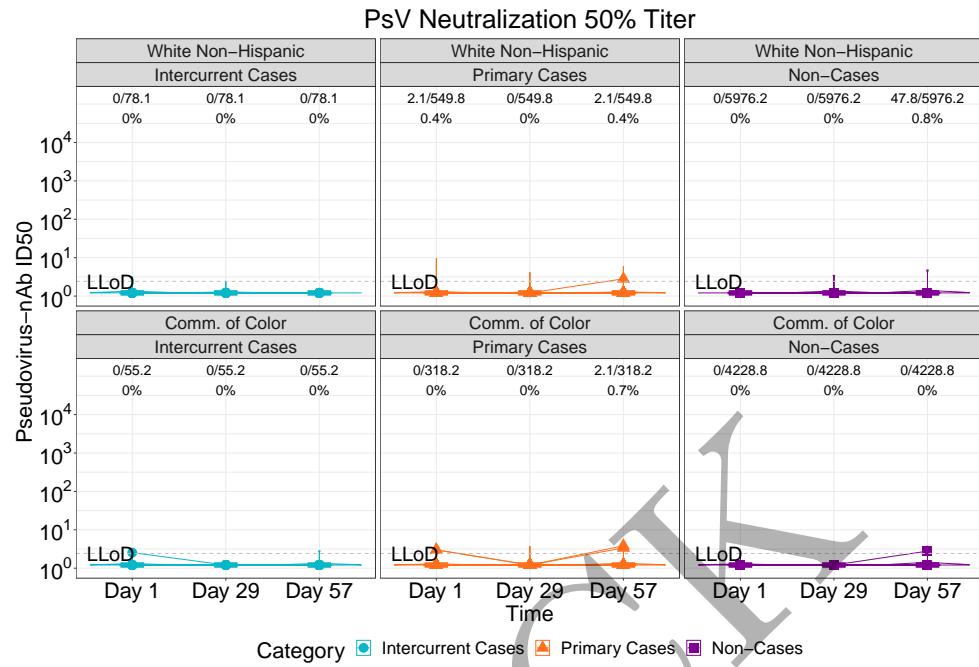


Figure 3.194: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (version 2)

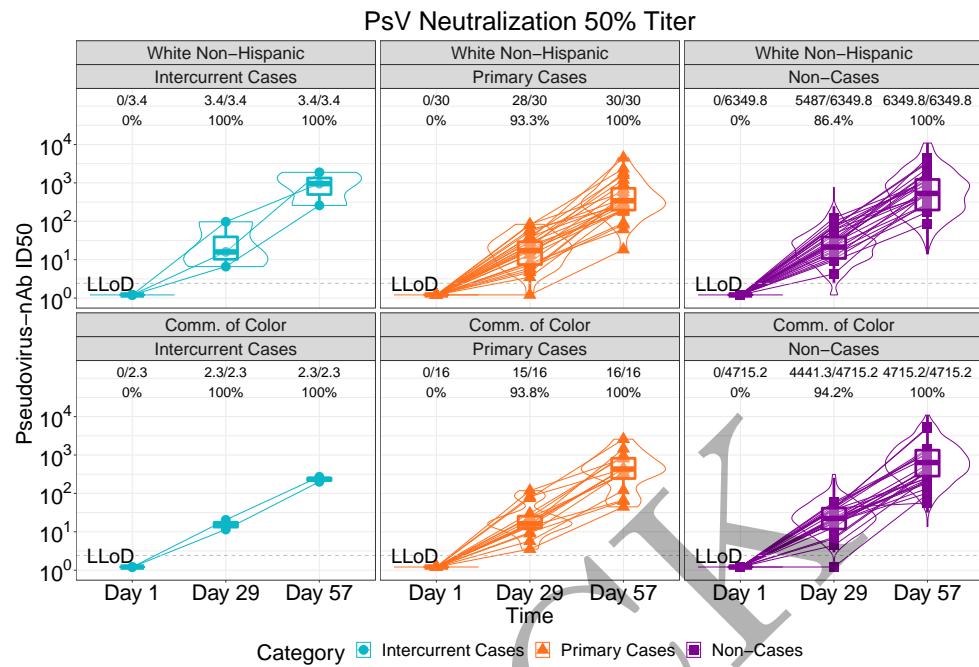


Figure 3.195: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (version 2)

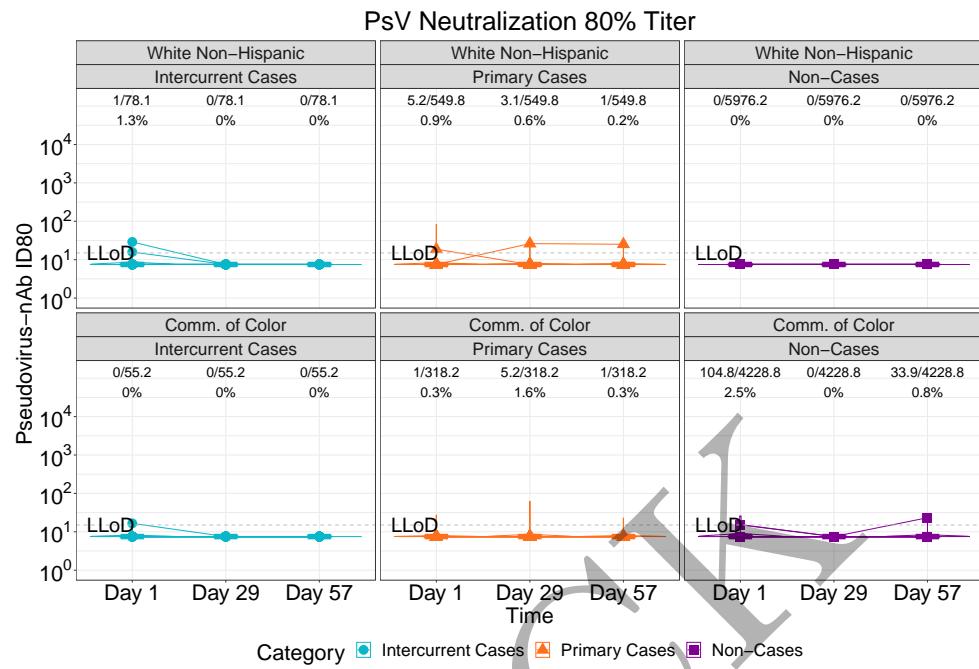


Figure 3.196: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (version 2)

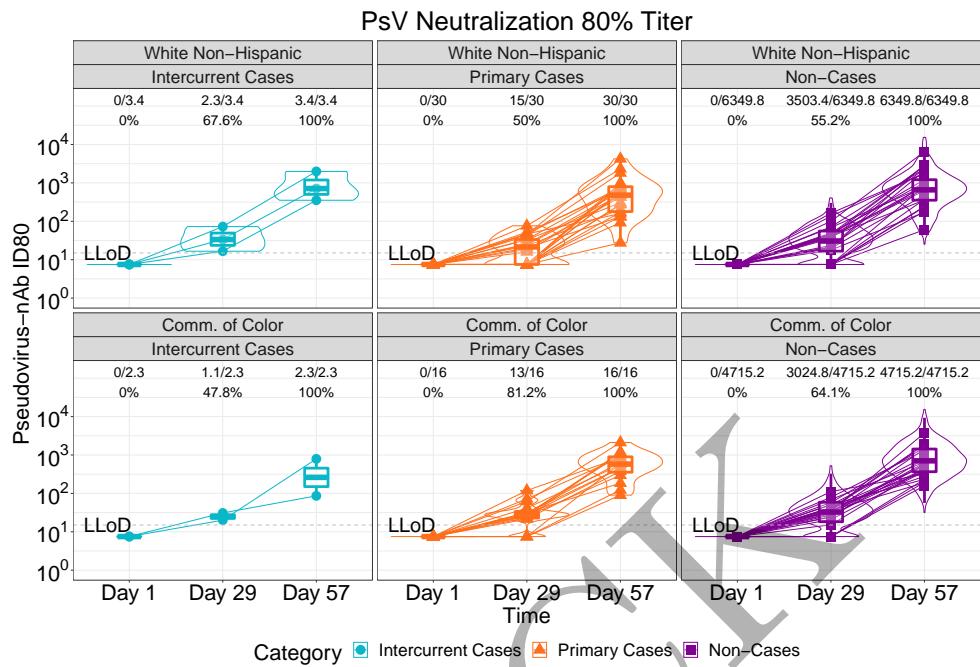


Figure 3.197: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (version 2)

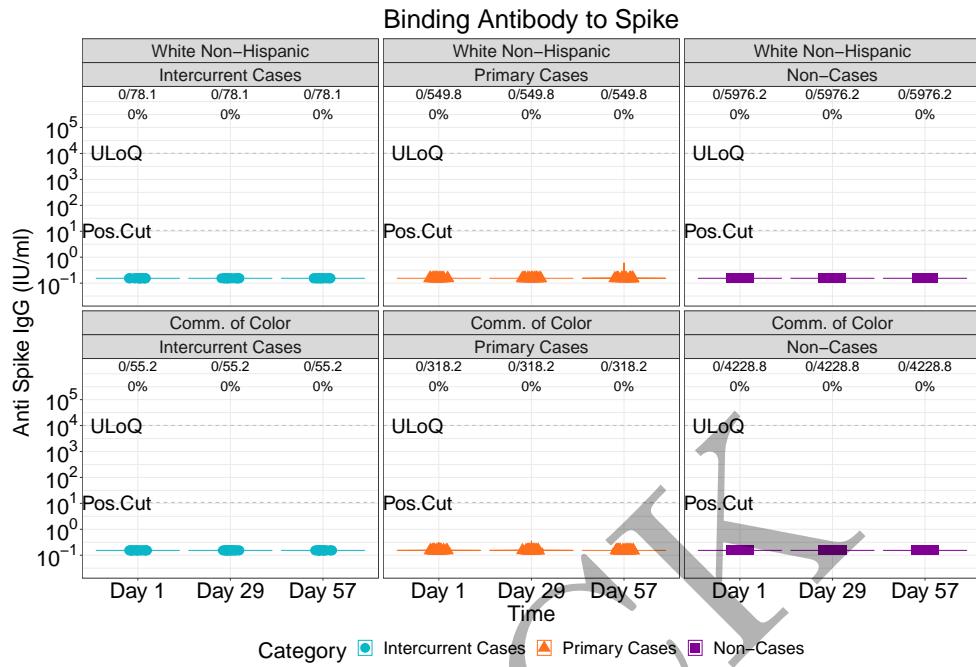


Figure 3.198: violinplots of Binding Antibody to Spike: baseline negative placebo arm by race and ethnic group (version 2)

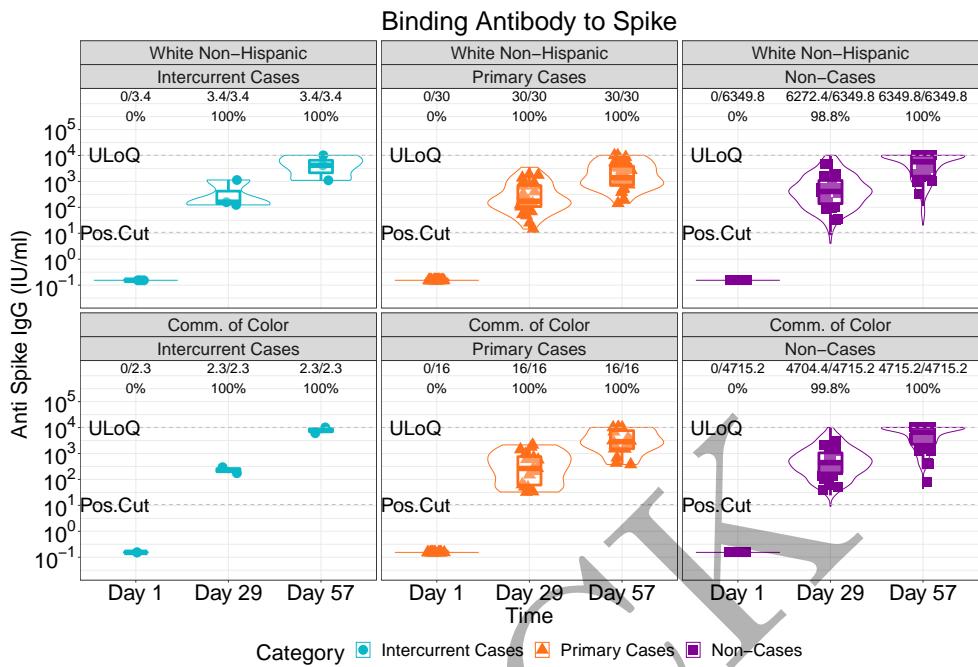


Figure 3.199: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by race and ethnic group (version 2)

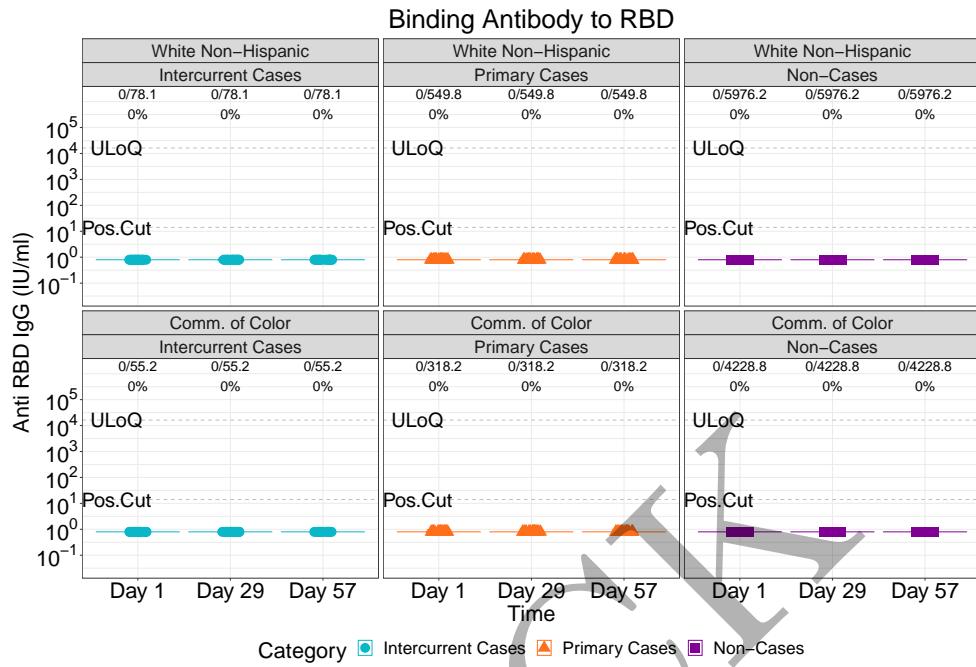


Figure 3.200: violinplots of Binding Antibody to RBD: baseline negative placebo arm by race and ethnic group (version 2)

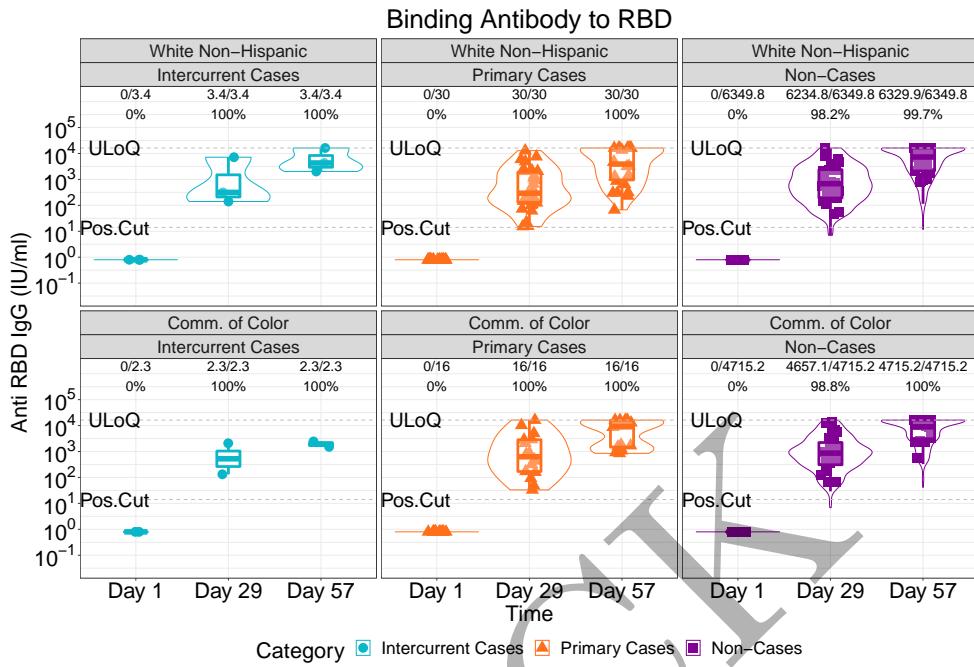


Figure 3.201: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by race and ethnic group (version 2)

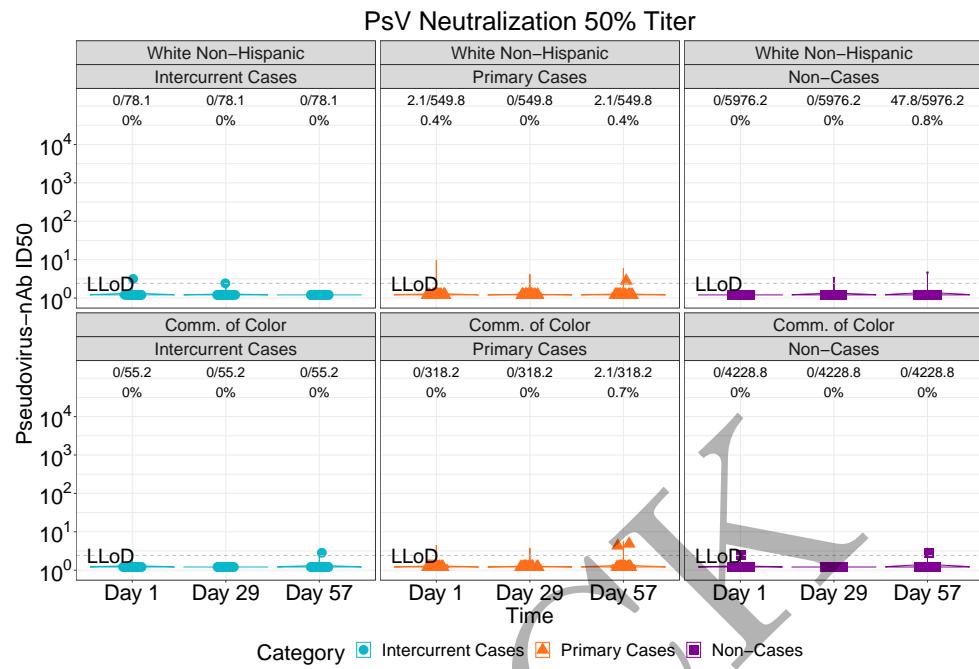


Figure 3.202: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by race and ethnic group (version 2)

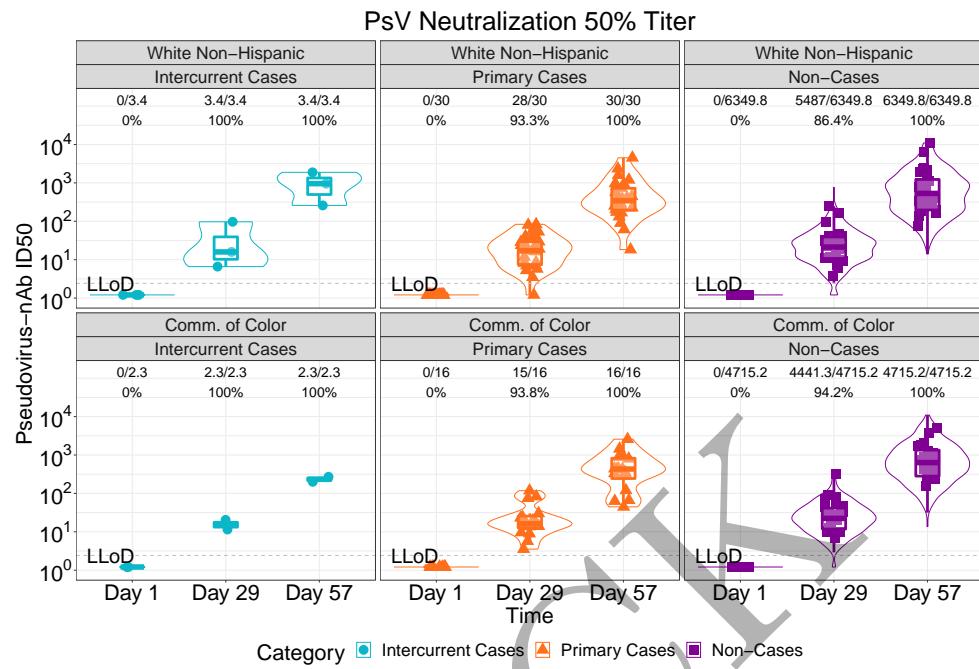


Figure 3.203: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by race and ethnic group (version 2)

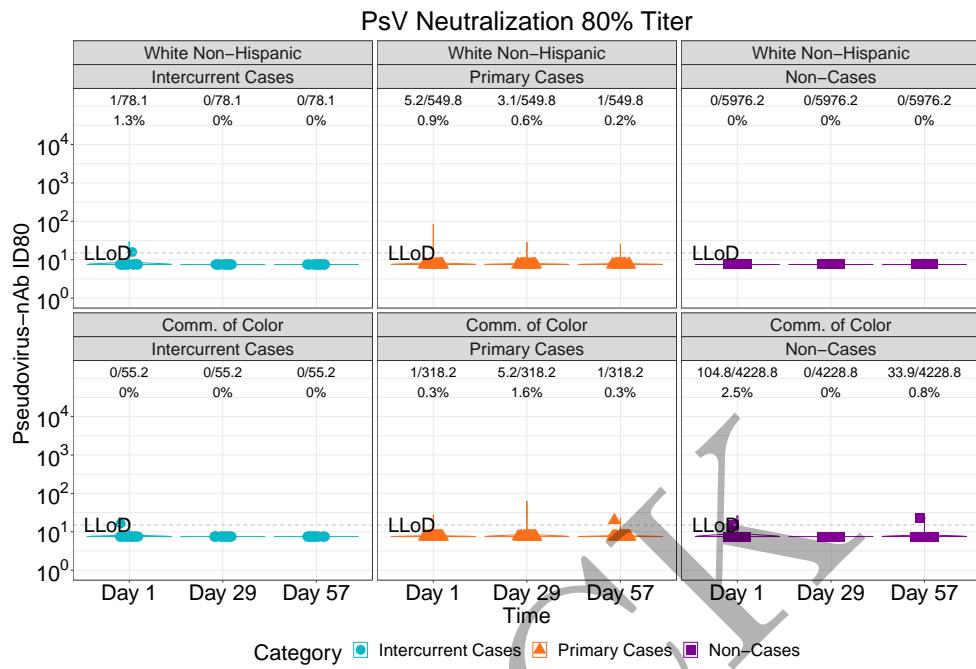


Figure 3.204: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by race and ethnic group (version 2)

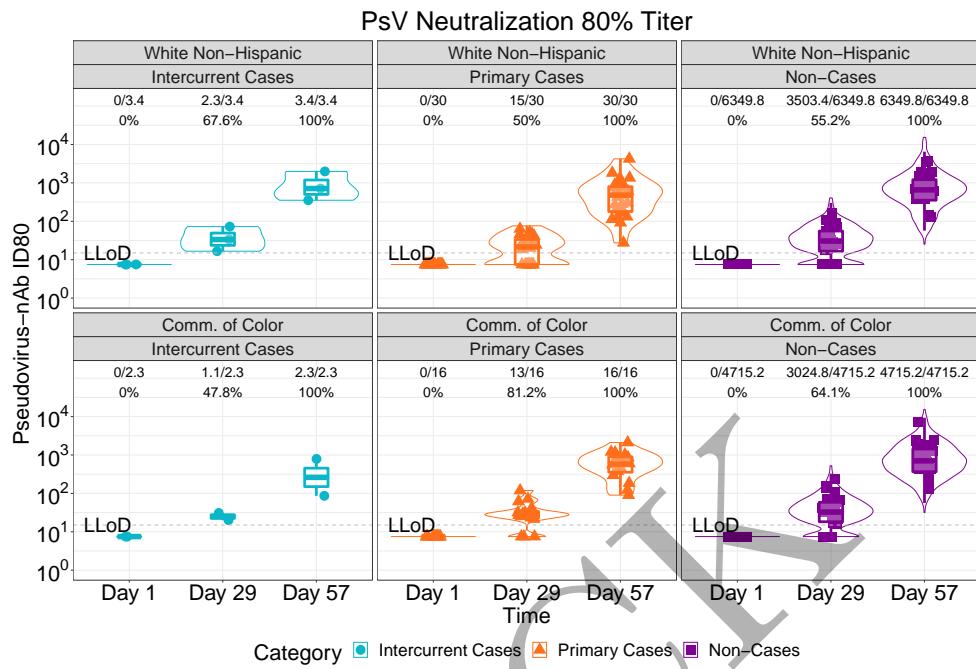


Figure 3.205: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by race and ethnic group (version 2)

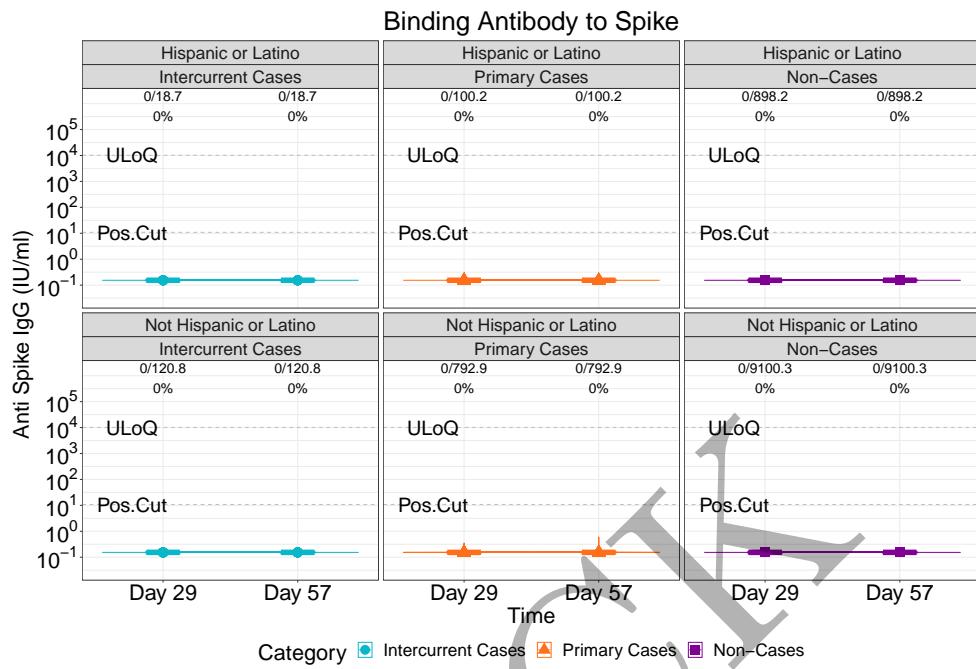


Figure 3.206: lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

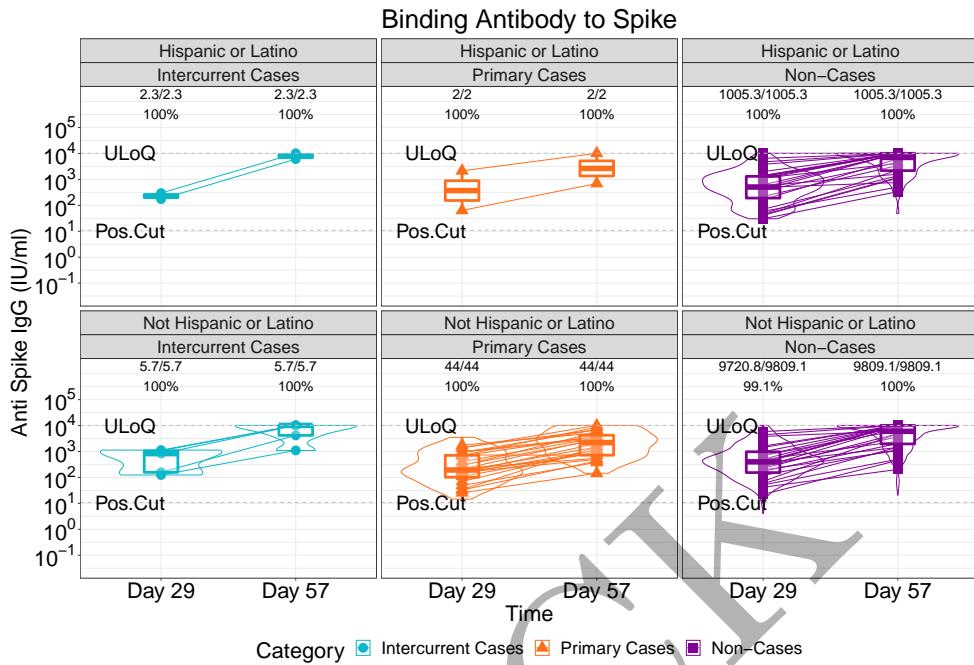


Figure 3.207: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

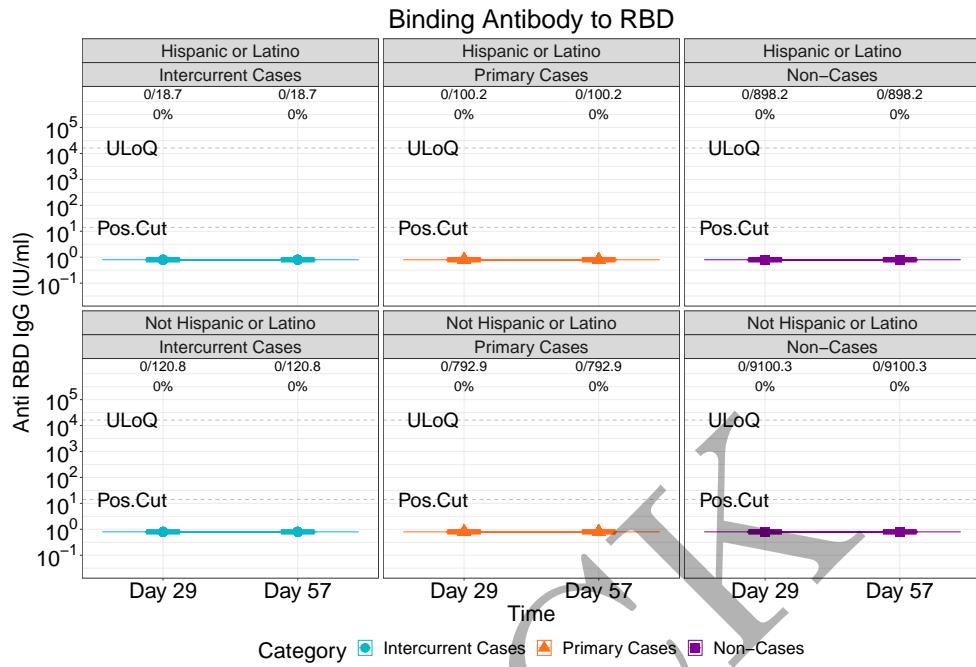


Figure 3.208: lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

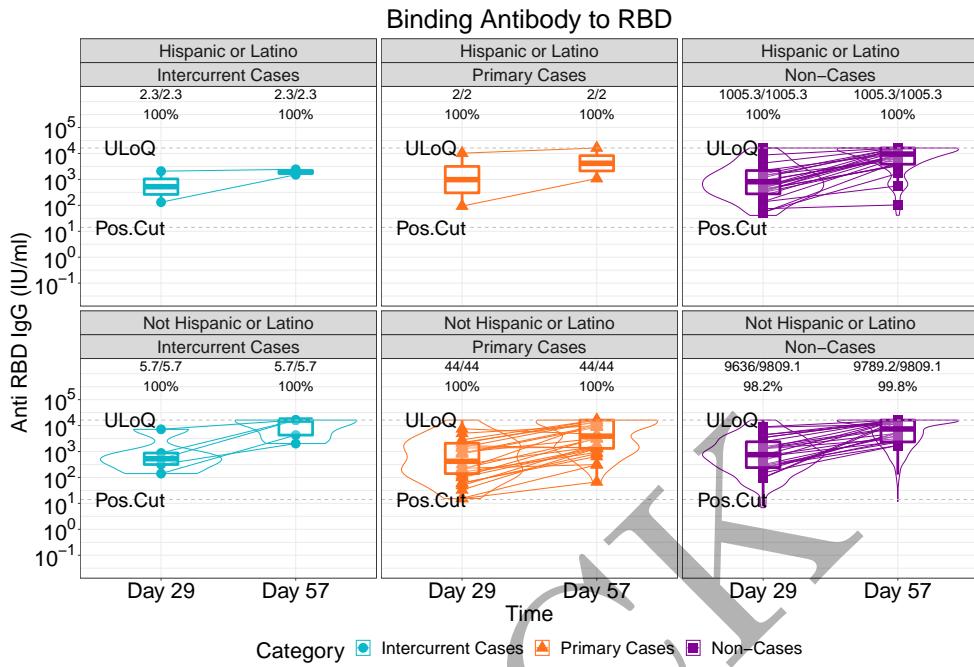


Figure 3.209: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

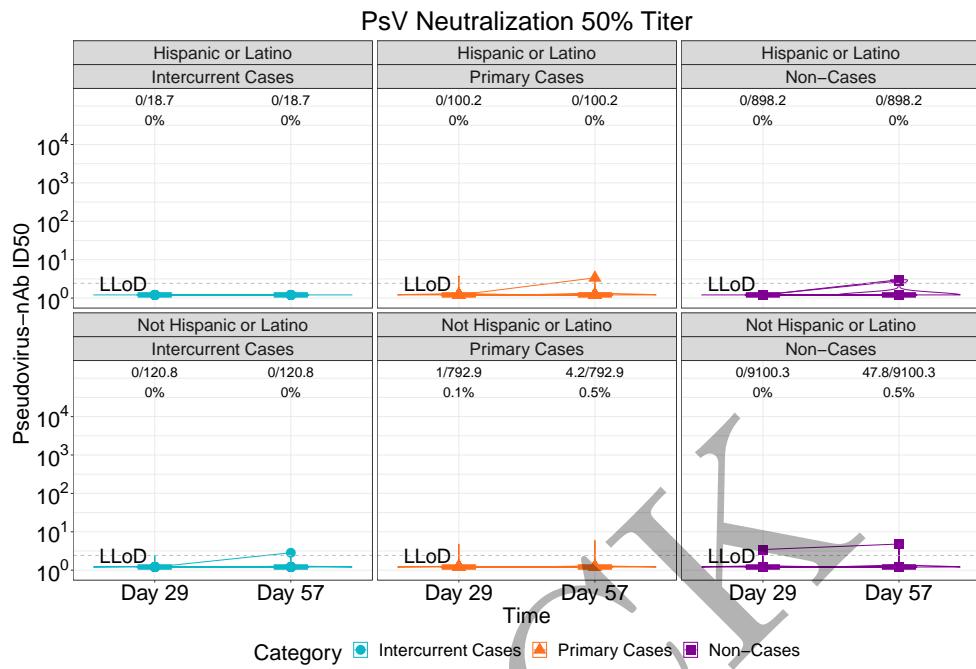


Figure 3.210: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

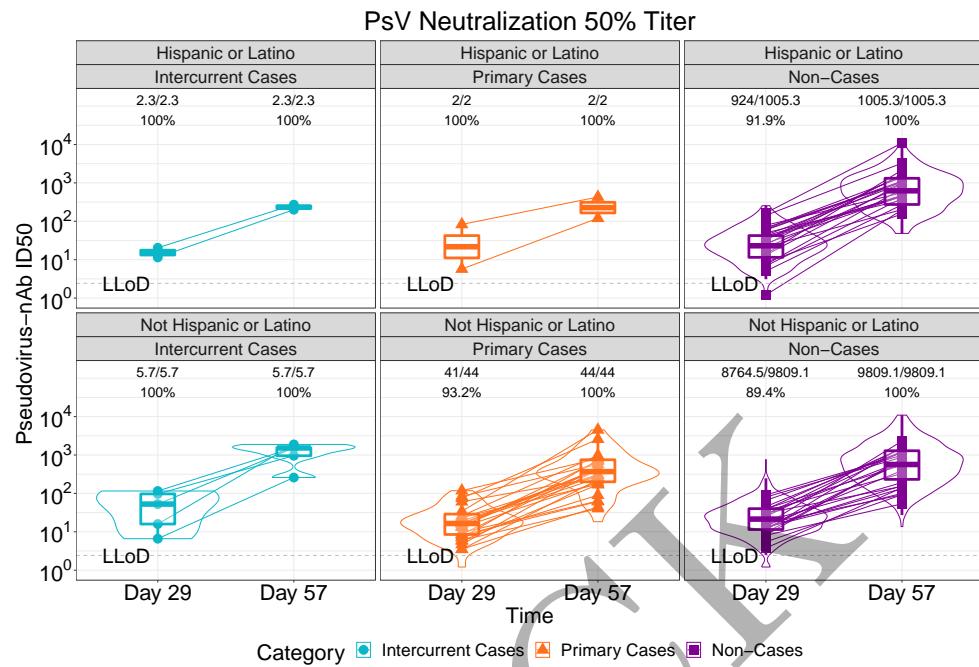


Figure 3.211: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

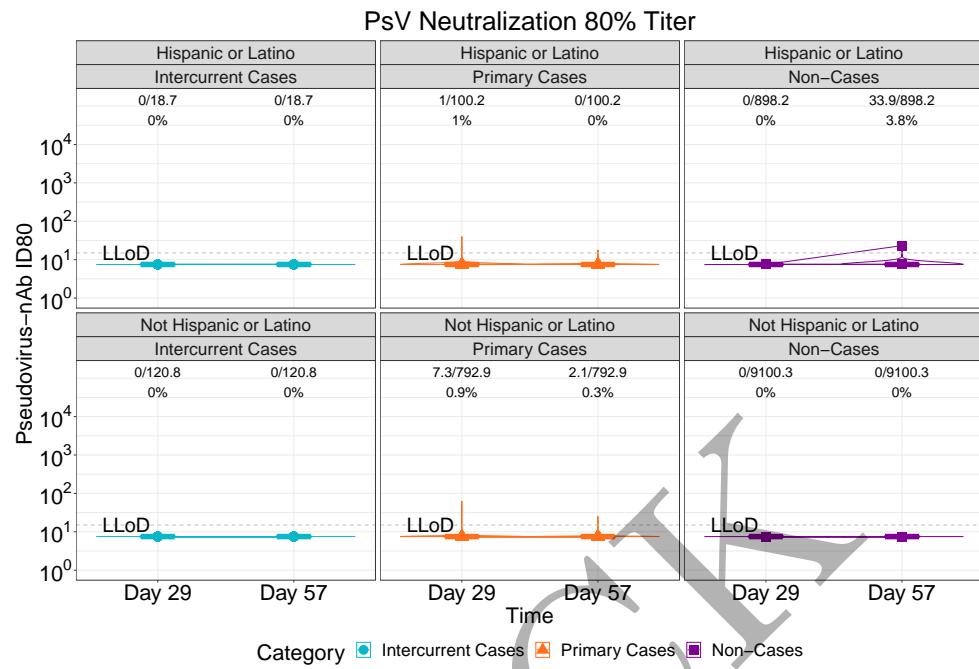


Figure 3.212: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

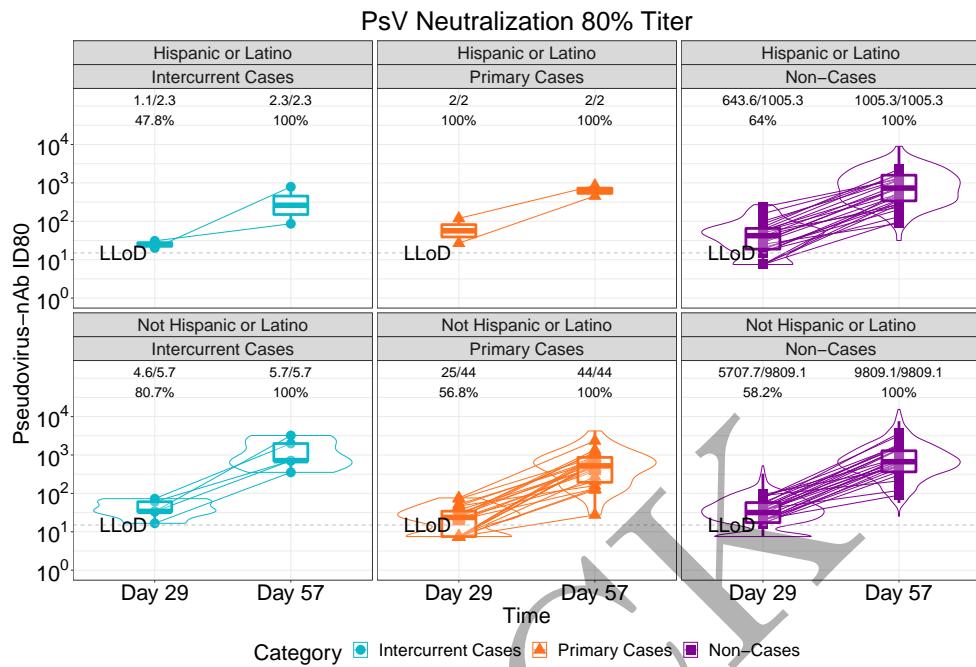


Figure 3.213: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

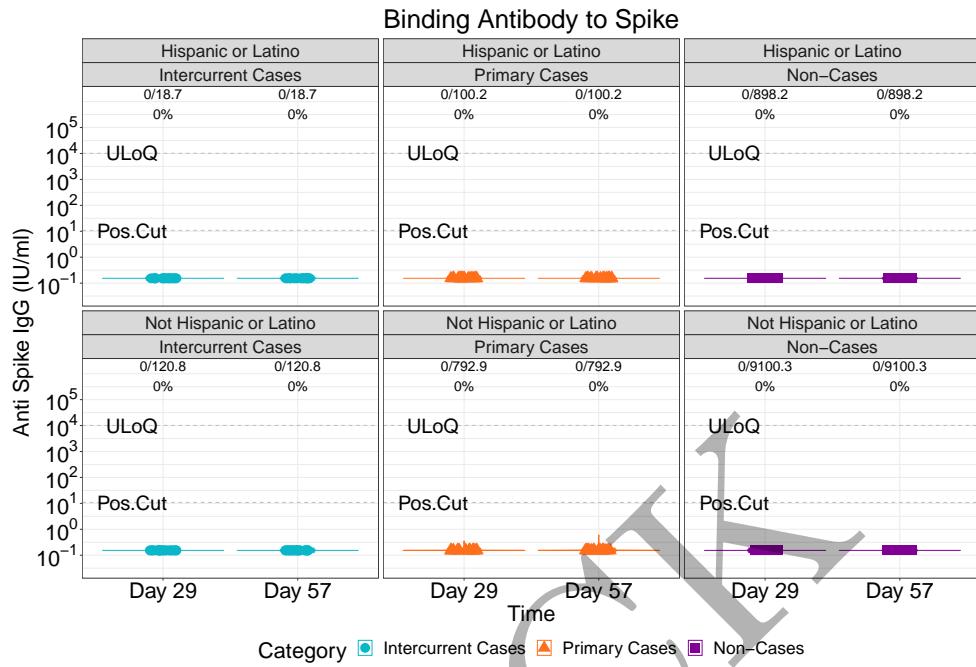


Figure 3.214: violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

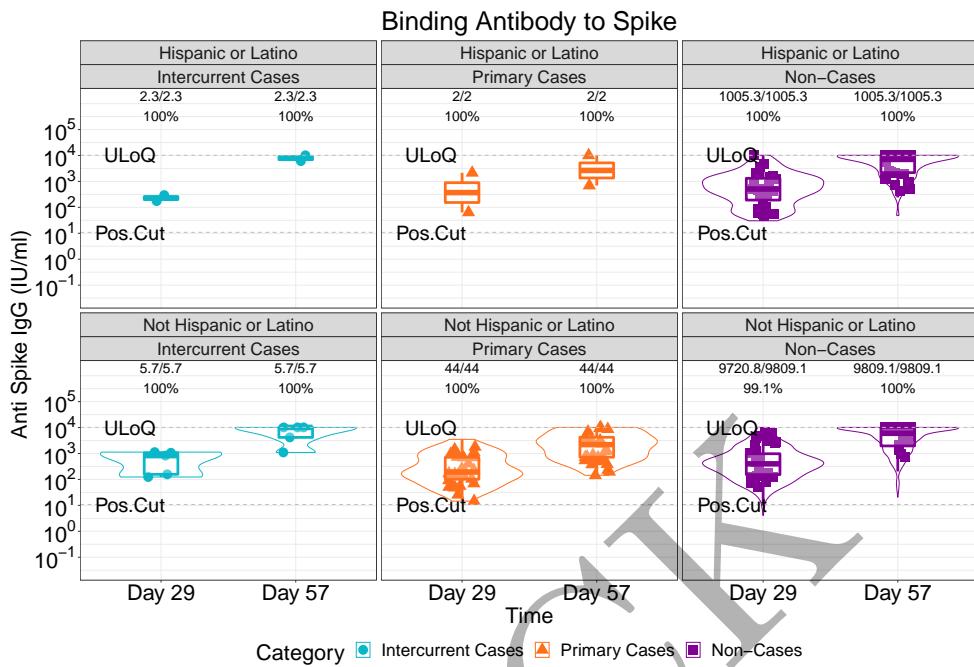


Figure 3.215: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

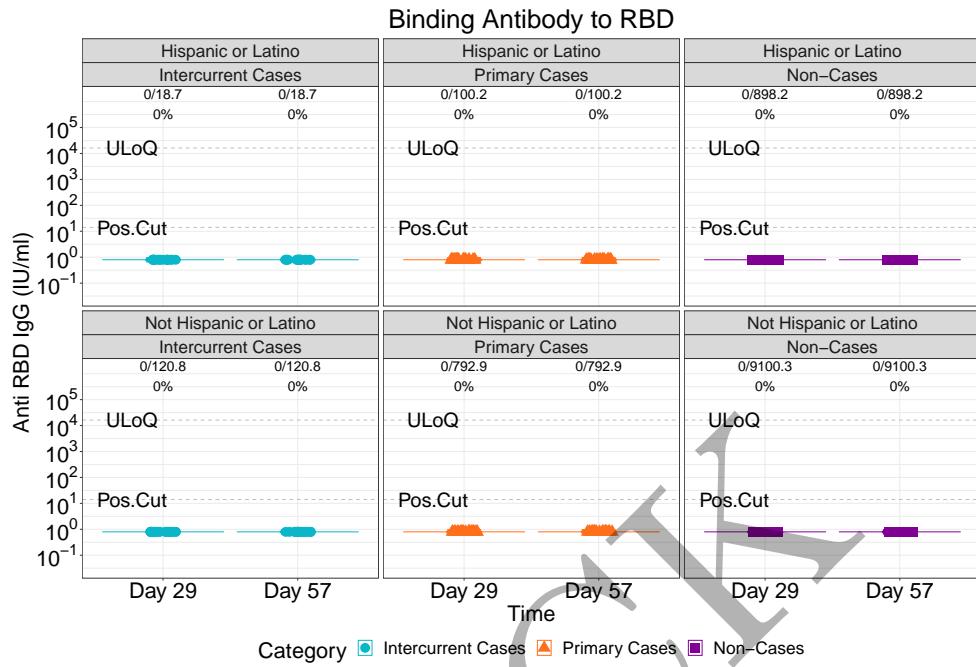


Figure 3.216: violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

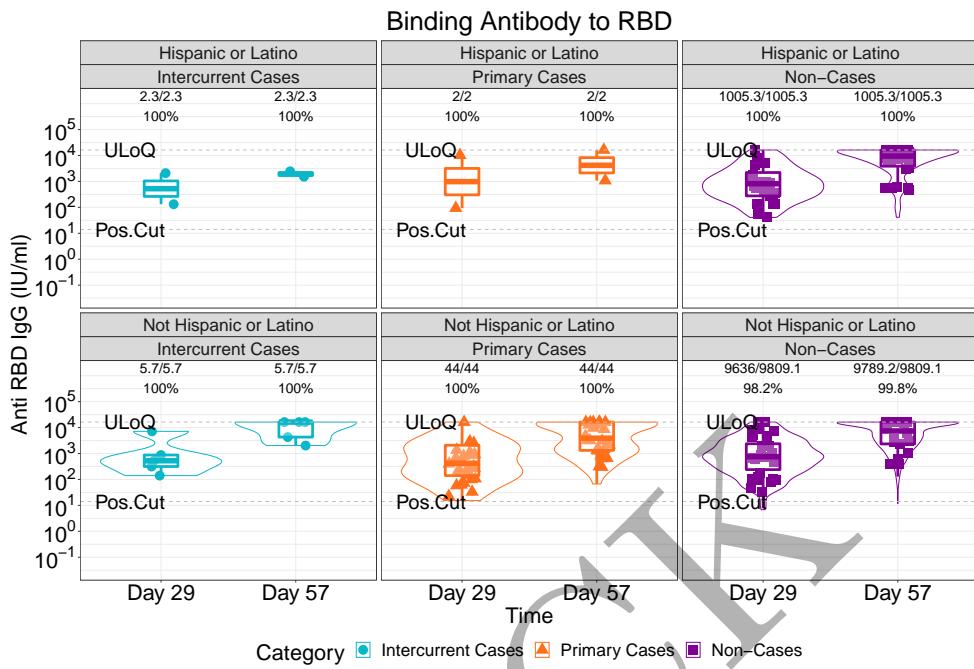


Figure 3.217: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

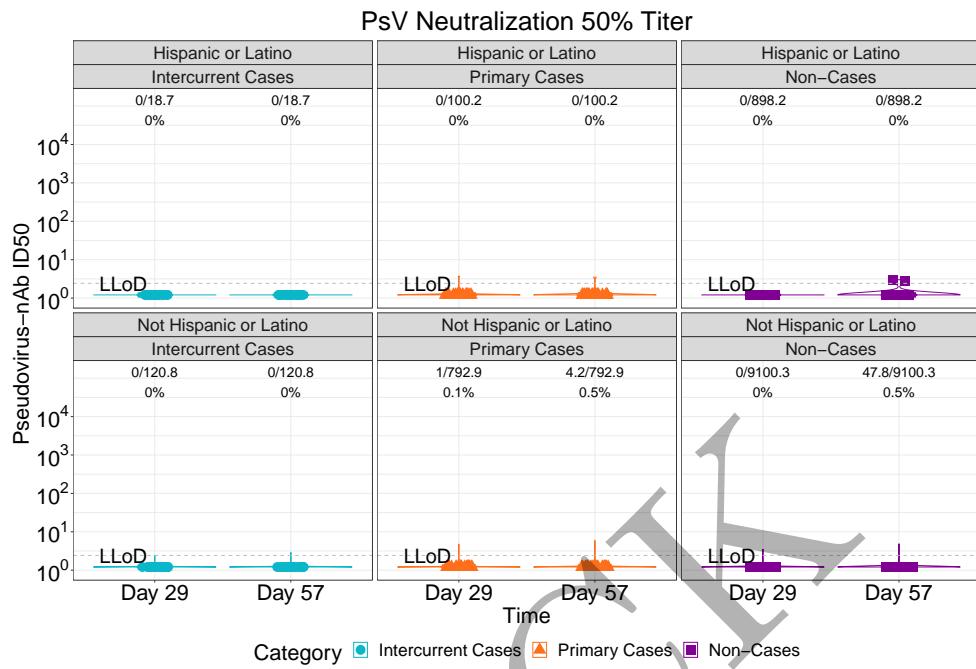


Figure 3.218: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

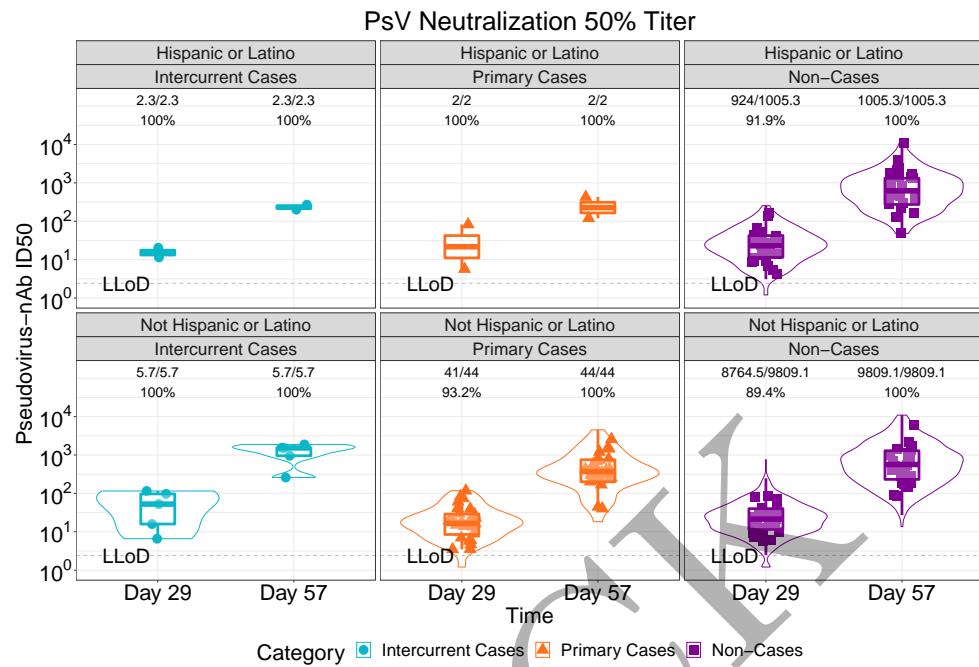


Figure 3.219: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

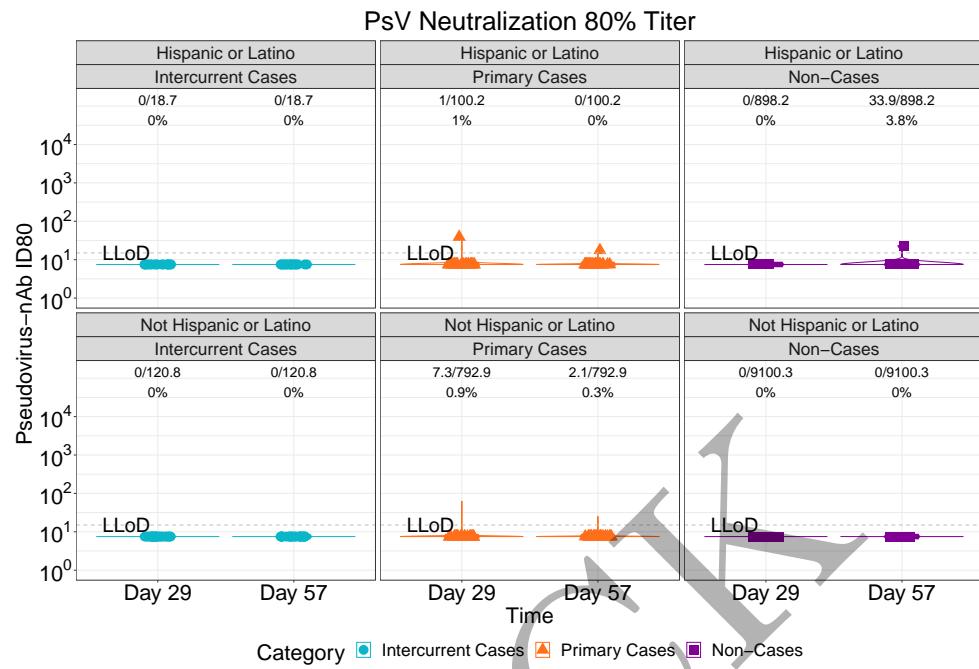


Figure 3.220: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 1)

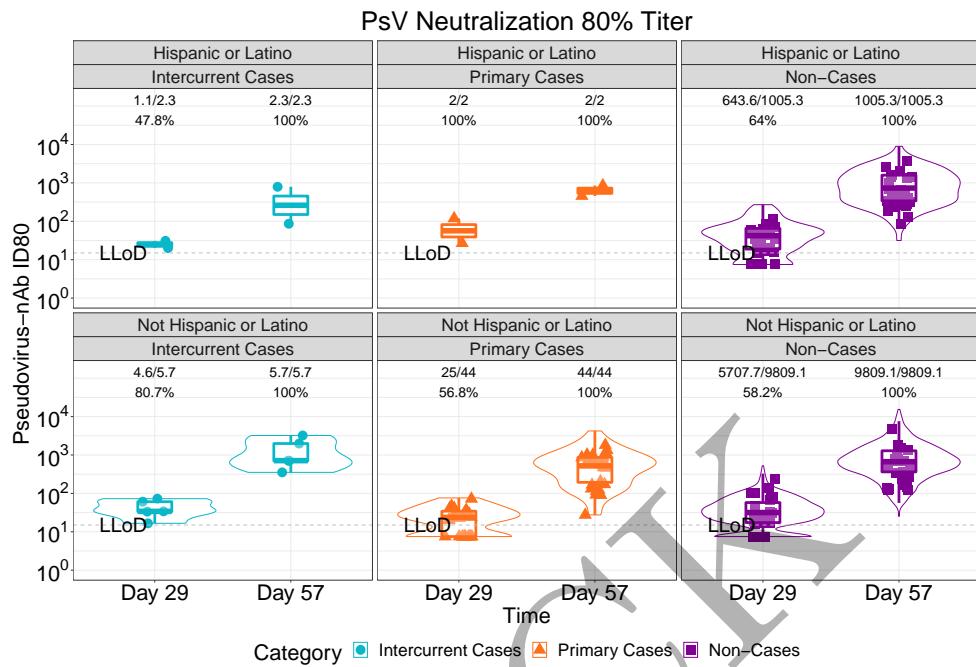


Figure 3.221: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 1)

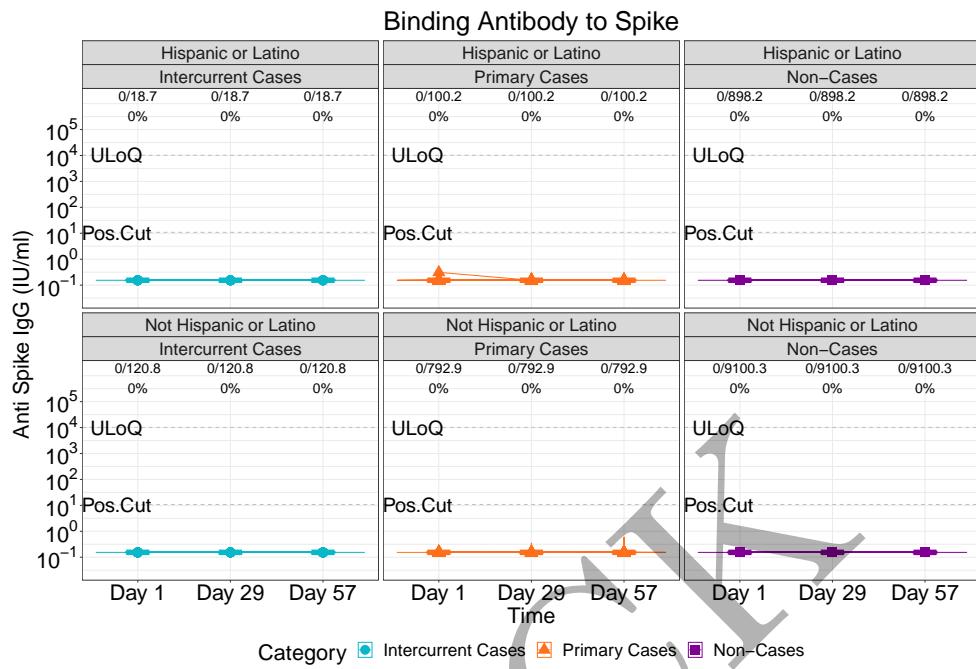


Figure 3.222: lineplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

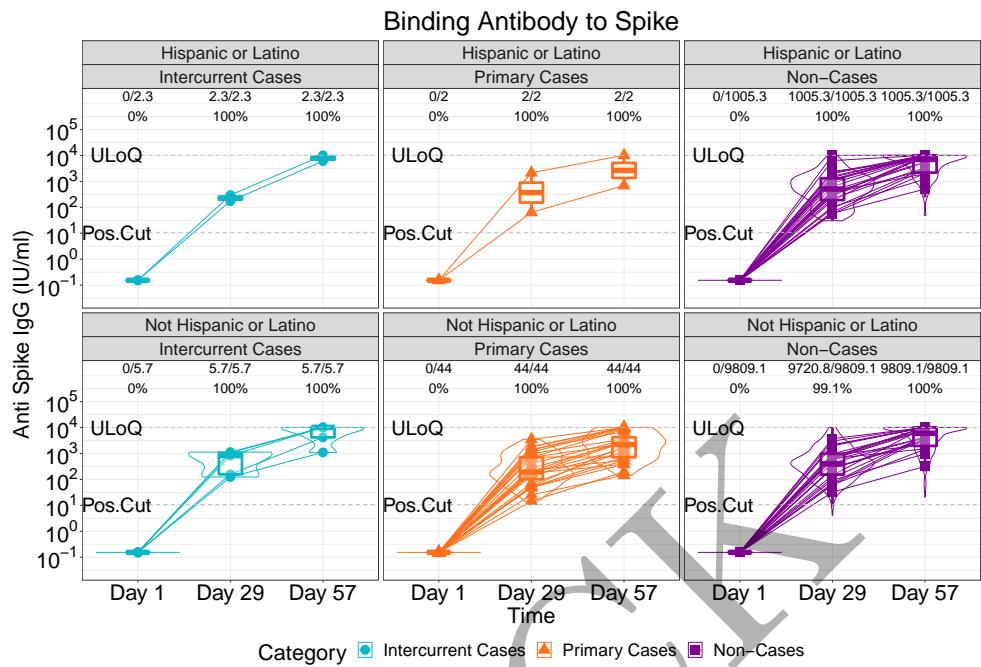


Figure 3.223: lineplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

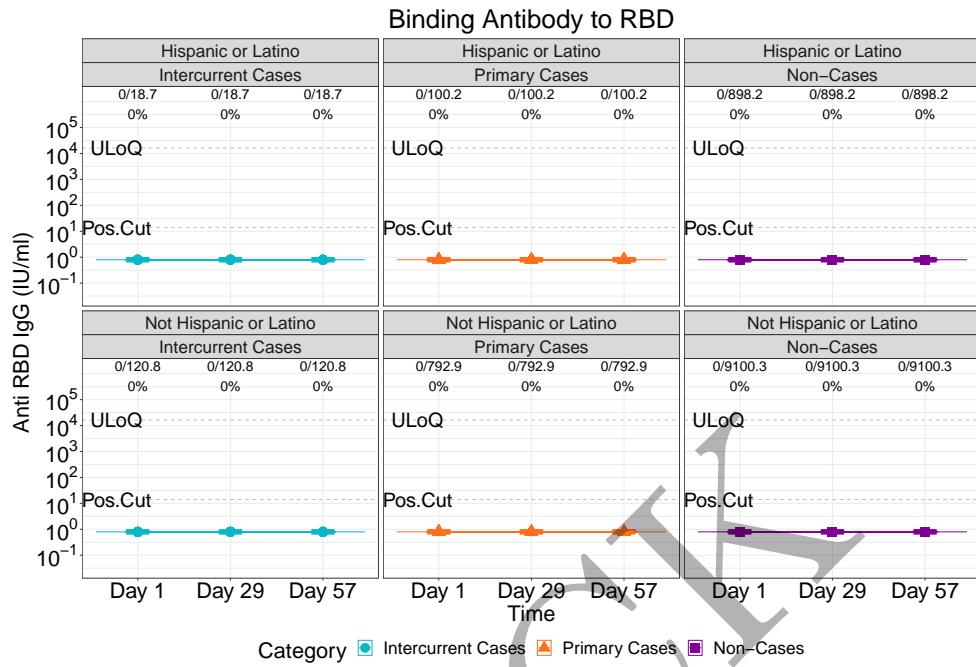


Figure 3.224: lineplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

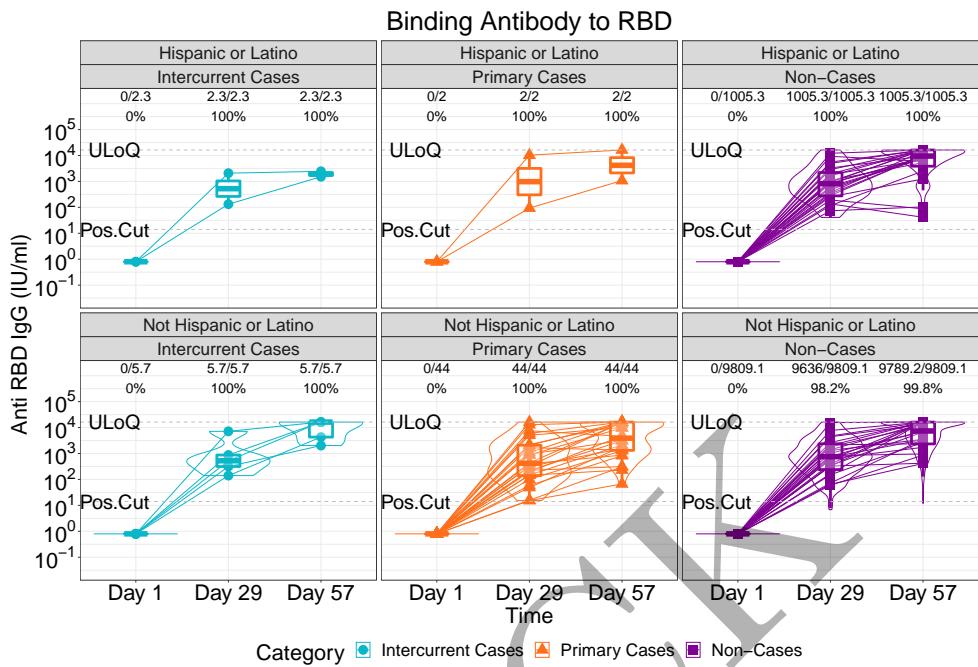


Figure 3.225: lineplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

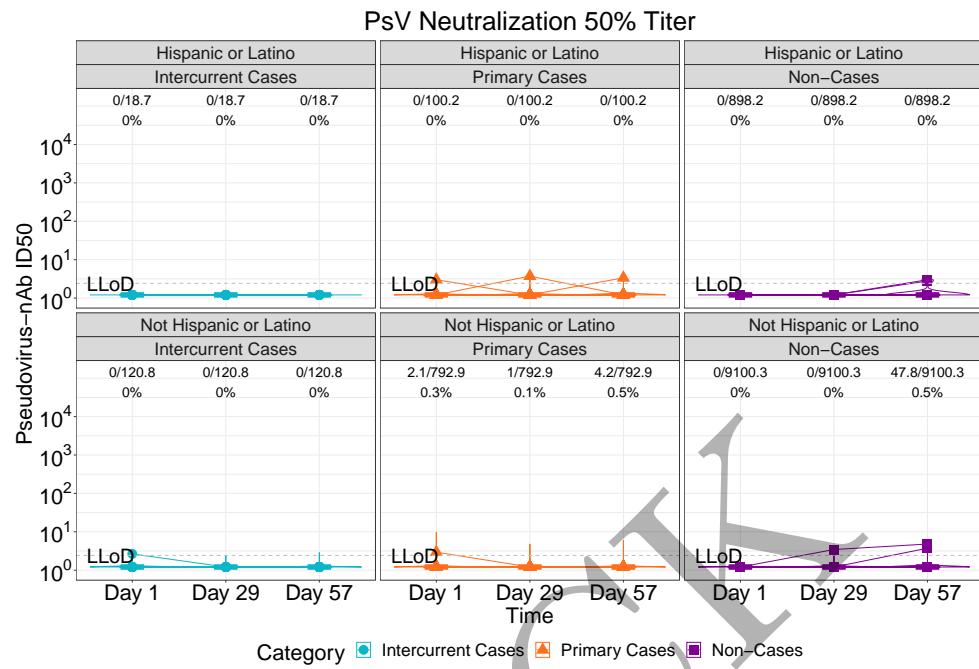


Figure 3.226: lineplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

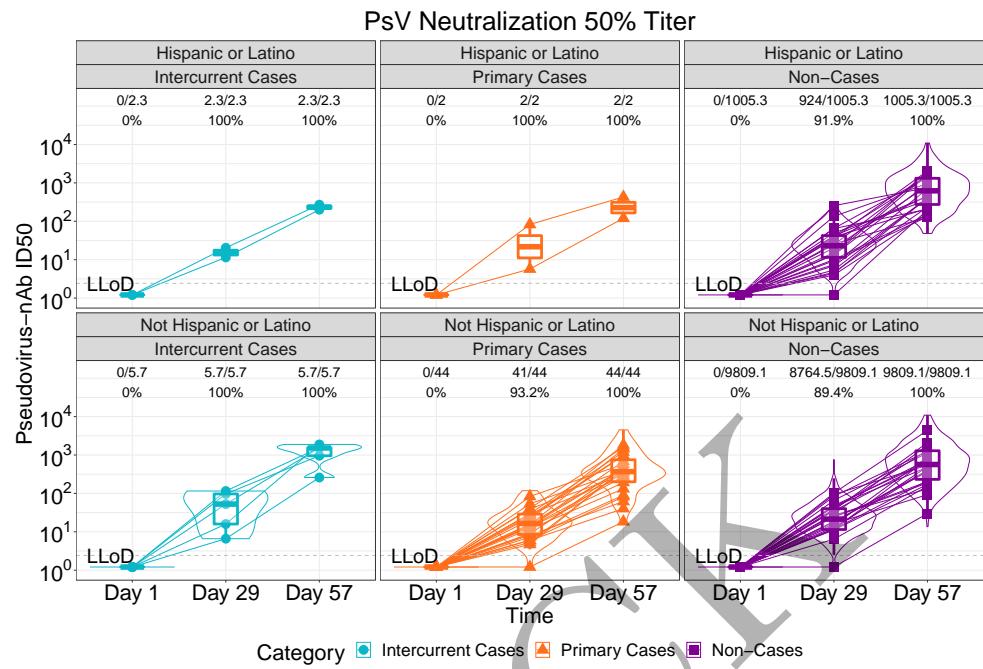


Figure 3.227: lineplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

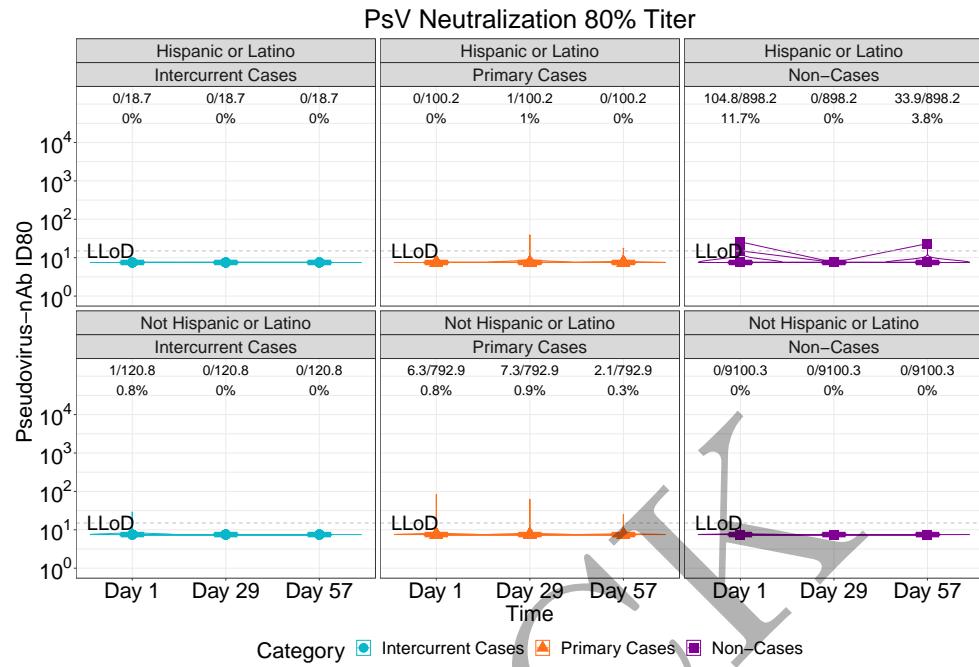


Figure 3.228: lineplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

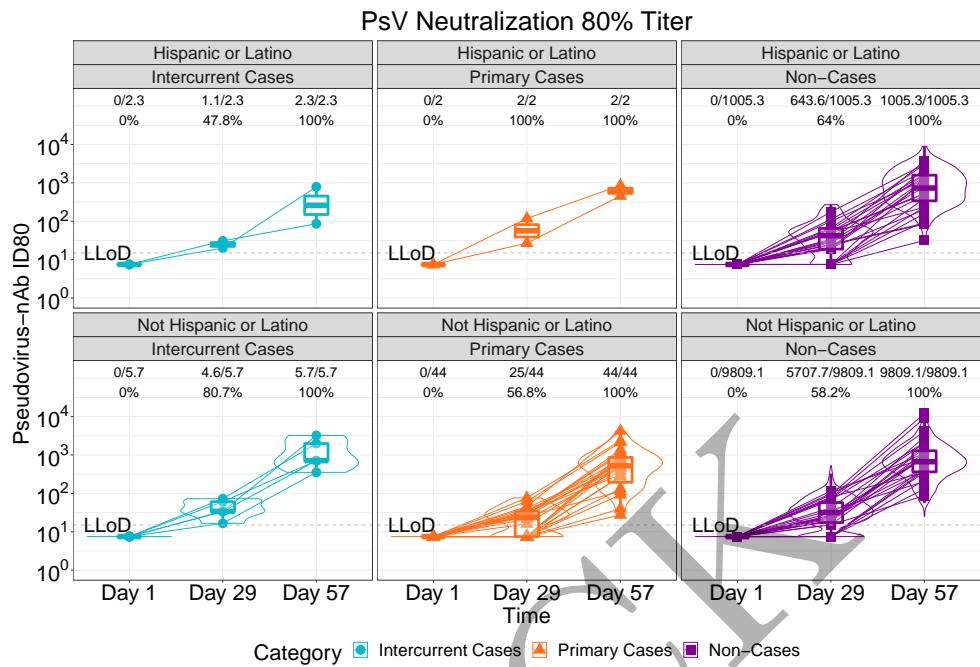


Figure 3.229: lineplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

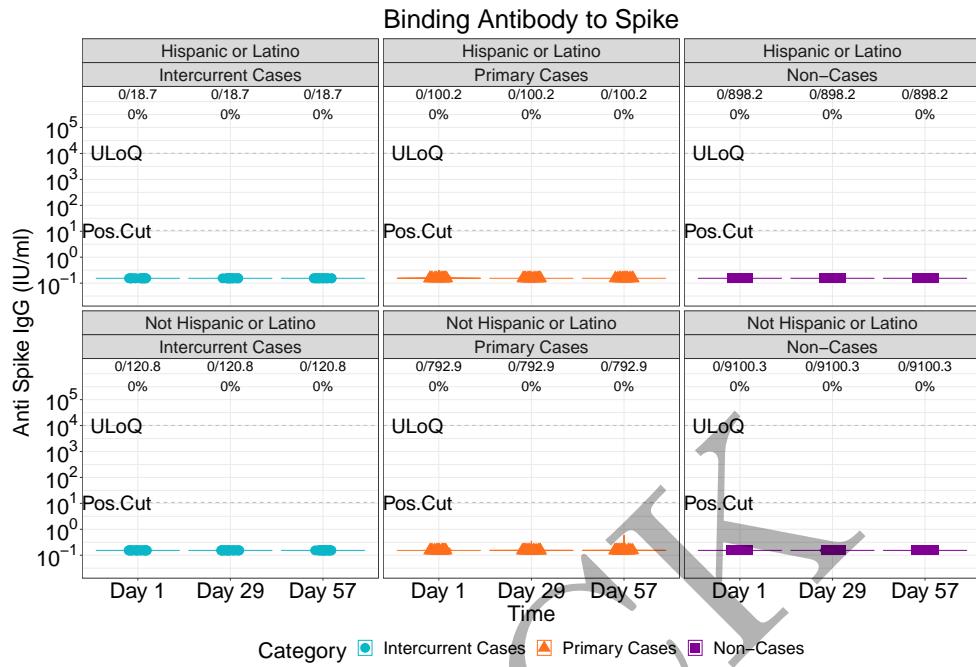


Figure 3.230: violinplots of Binding Antibody to Spike: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

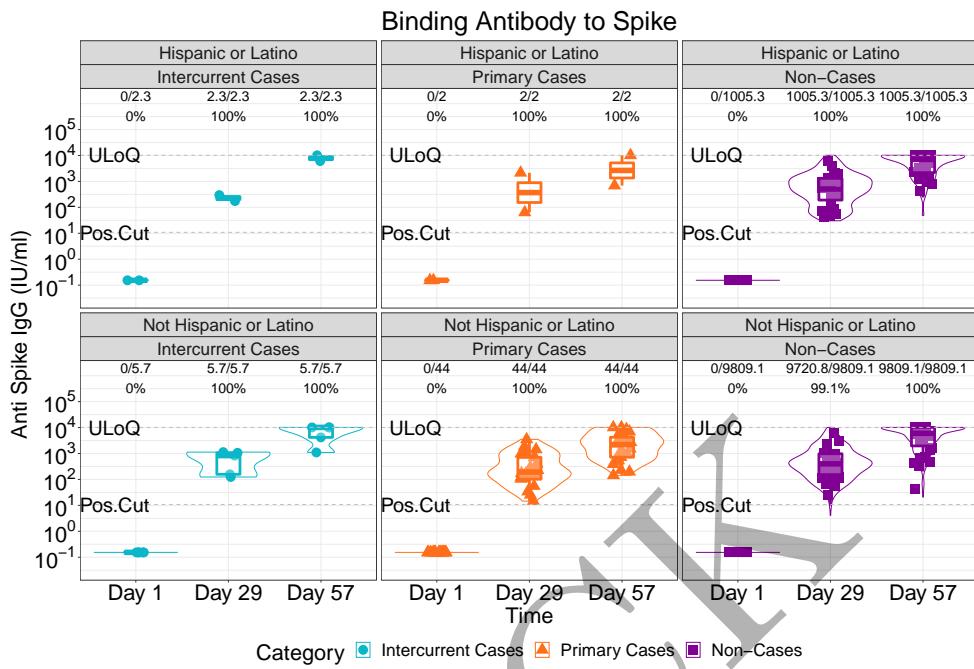


Figure 3.231: violinplots of Binding Antibody to Spike: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

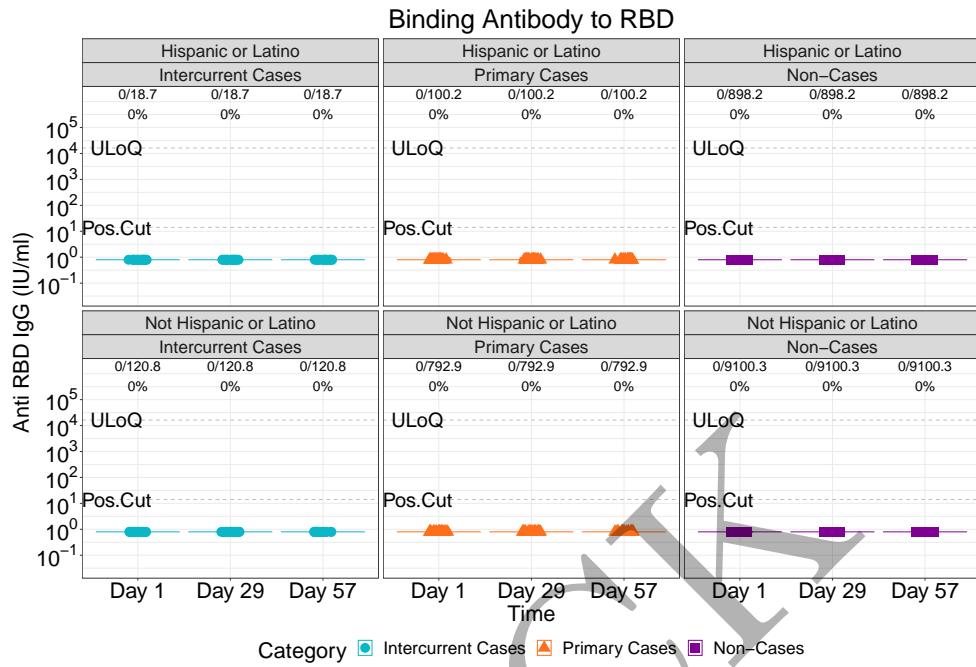


Figure 3.232: violinplots of Binding Antibody to RBD: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

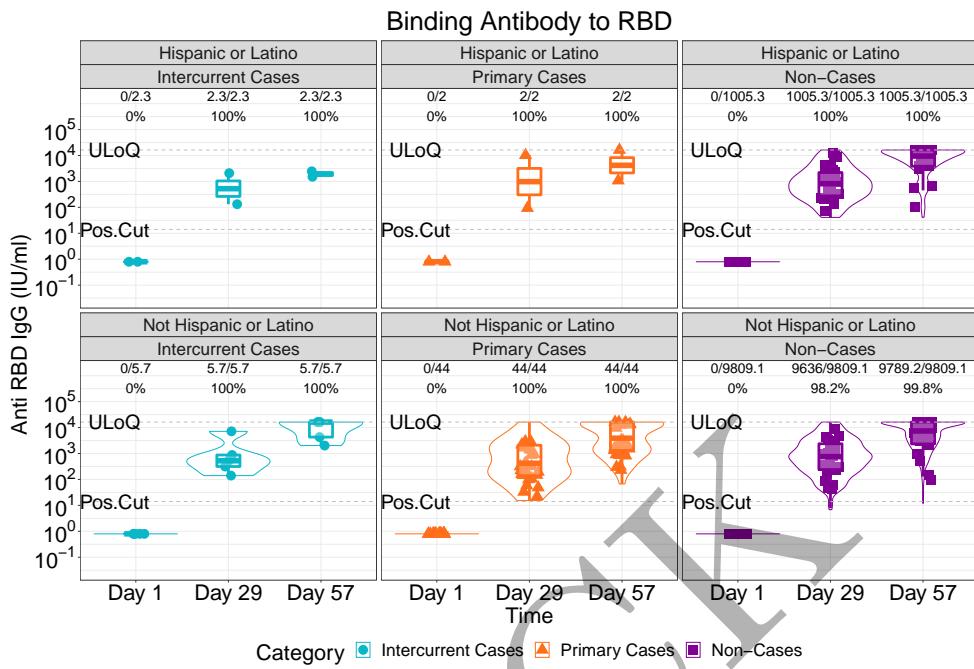


Figure 3.233: violinplots of Binding Antibody to RBD: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

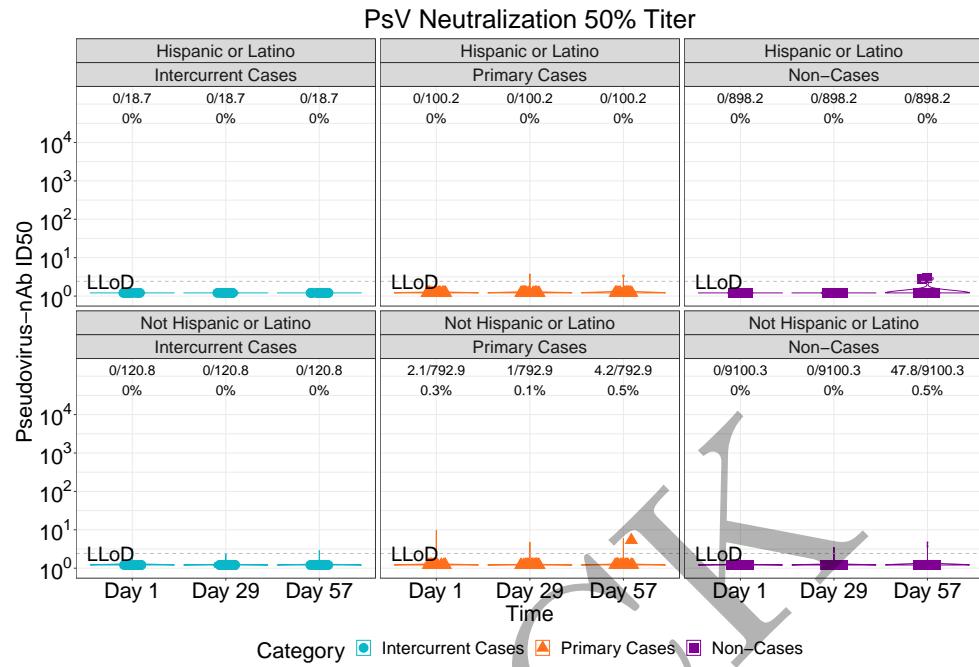


Figure 3.234: violinplots of Pseudovirus Neutralization ID50: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

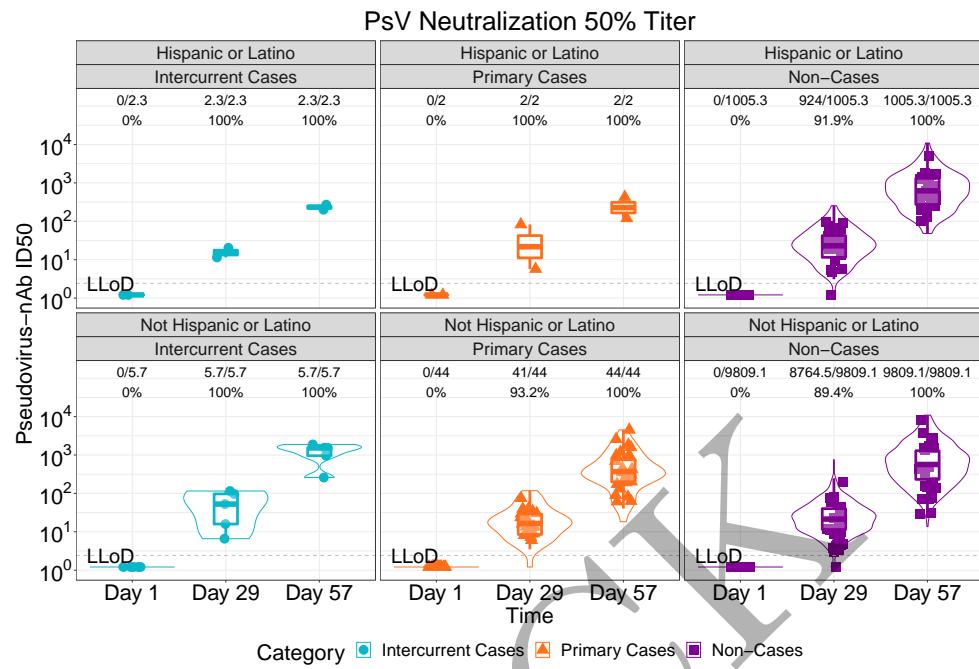


Figure 3.235: violinplots of Pseudovirus Neutralization ID50: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

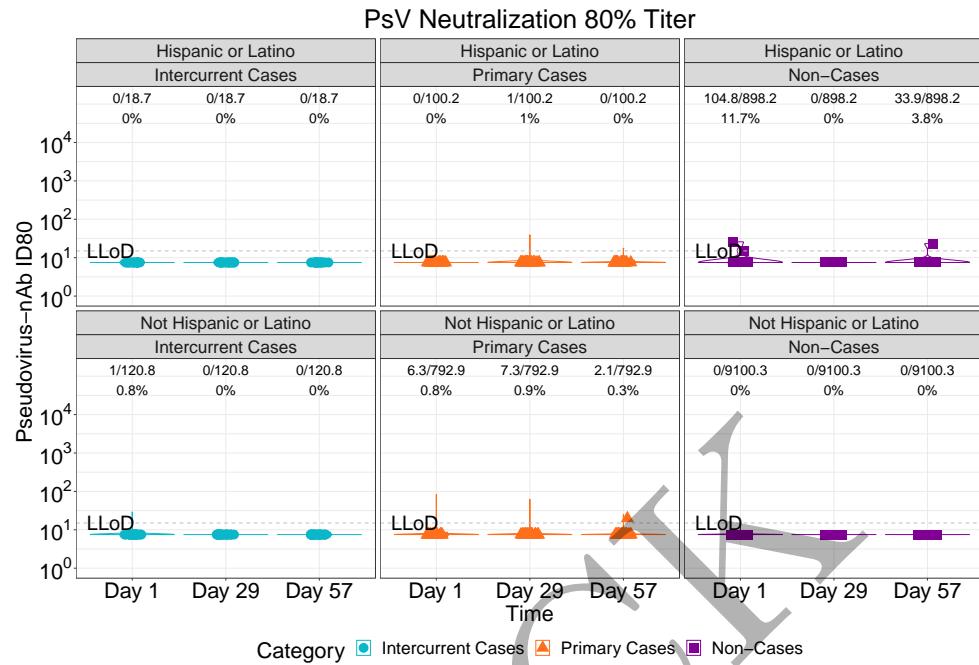


Figure 3.236: violinplots of Pseudovirus Neutralization ID80: baseline negative placebo arm by dichotomous classification of race and ethnic group (version 2)

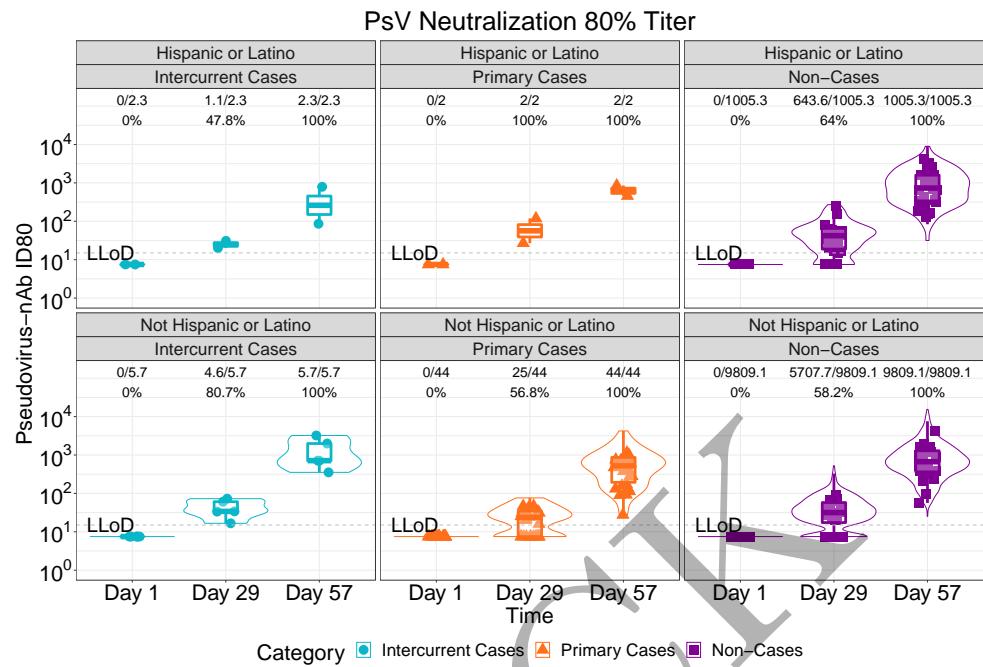


Figure 3.237: violinplots of Pseudovirus Neutralization ID80: baseline negative vaccine arm by dichotomous classification of race and ethnic group (version 2)

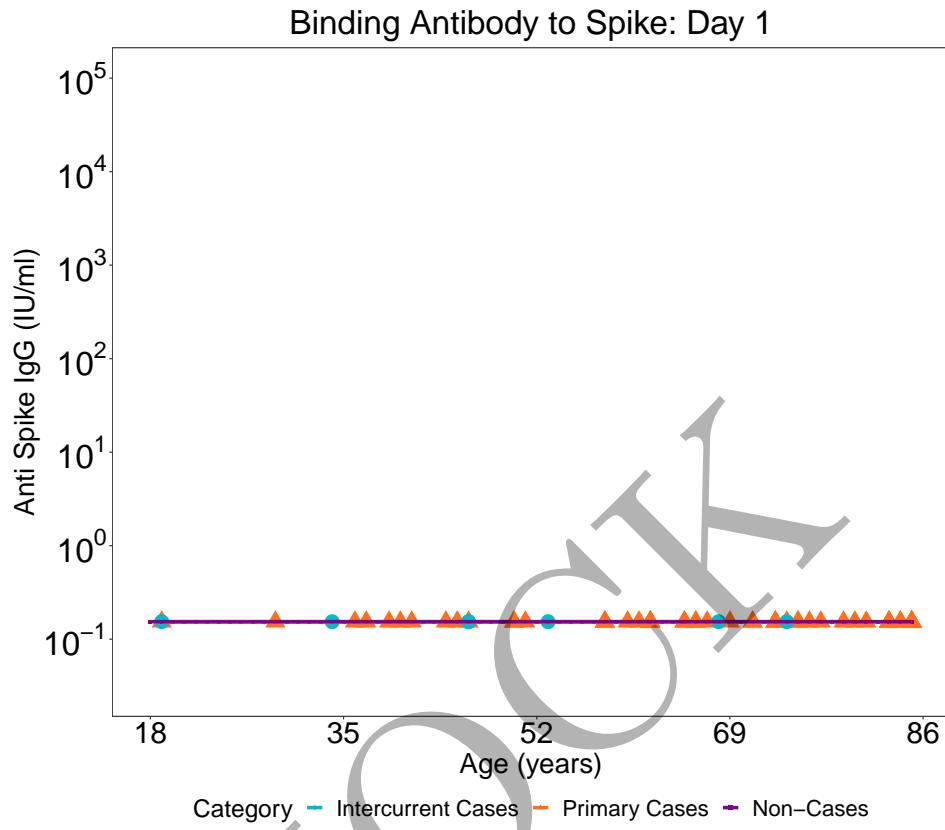


Figure 3.238: scatterplots of Binding Antibody to Spike vs Age: baseline negative vaccine arm at day 1

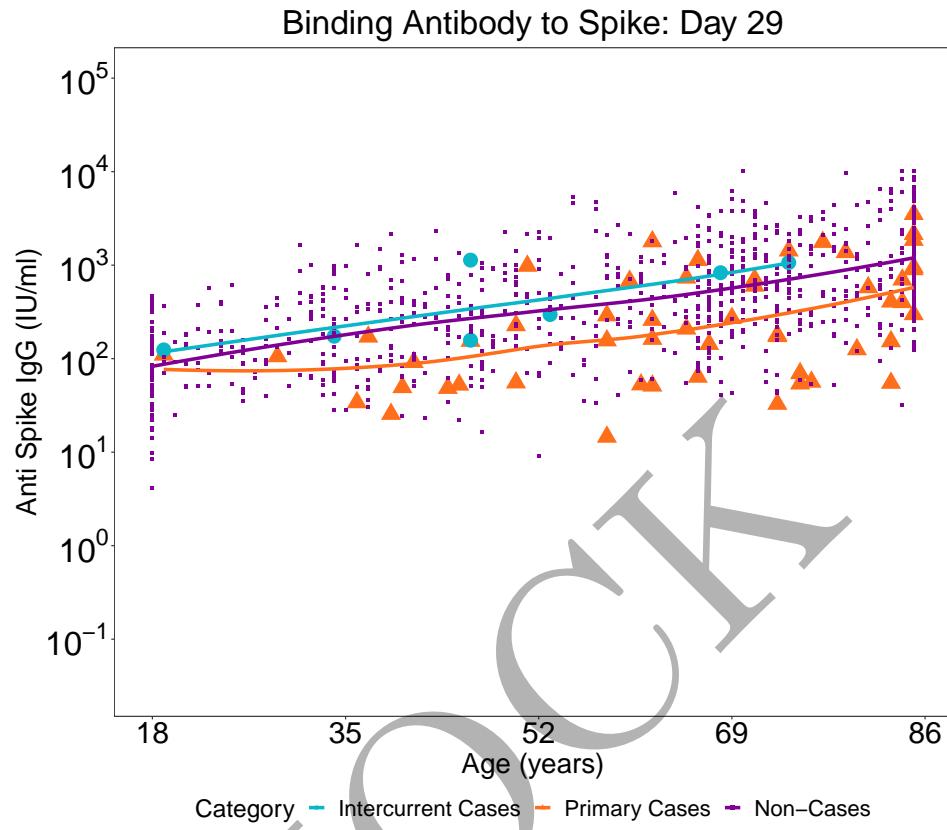


Figure 3.239: scatterplots of Binding Antibody to Spike vs Age: baseline negative vaccine arm at day 29

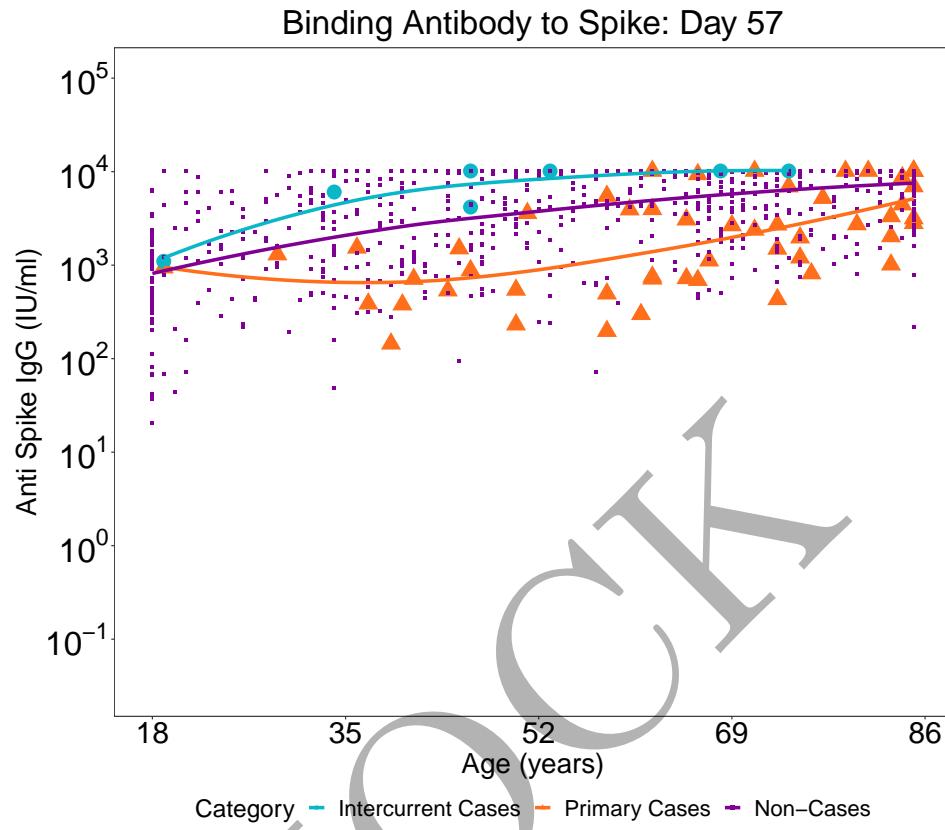


Figure 3.240: scatterplots of Binding Antibody to Spike vs Age: baseline negative vaccine arm at day 57

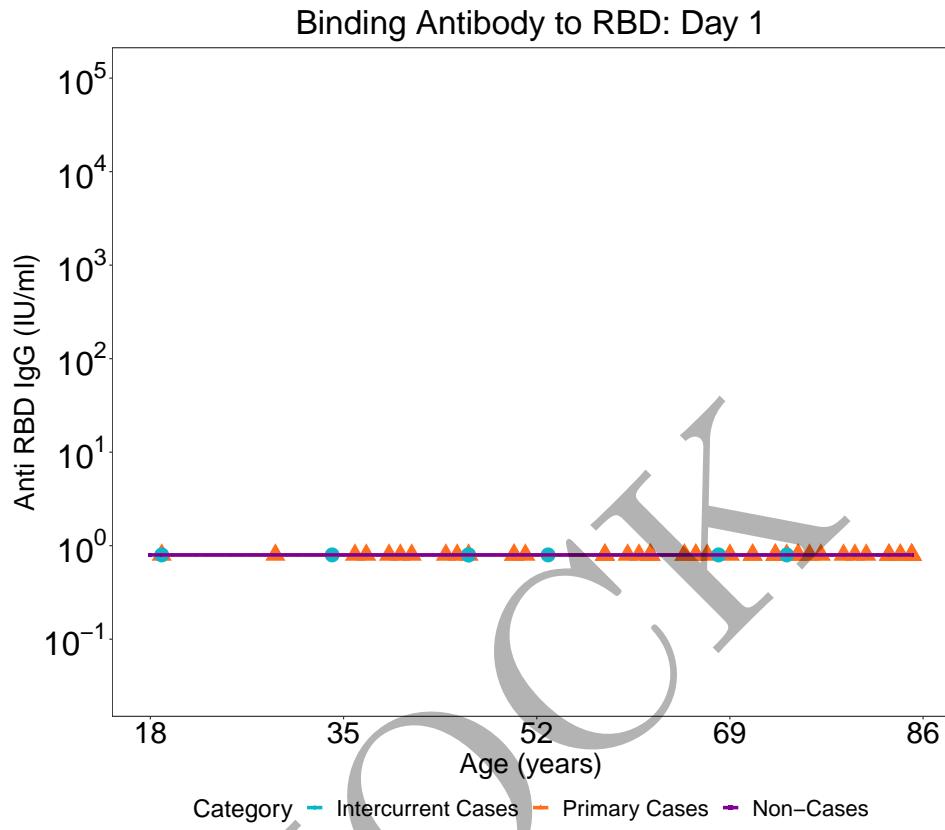


Figure 3.241: scatterplots of Binding Antibody to RBD vs Age: baseline negative vaccine arm at day 1

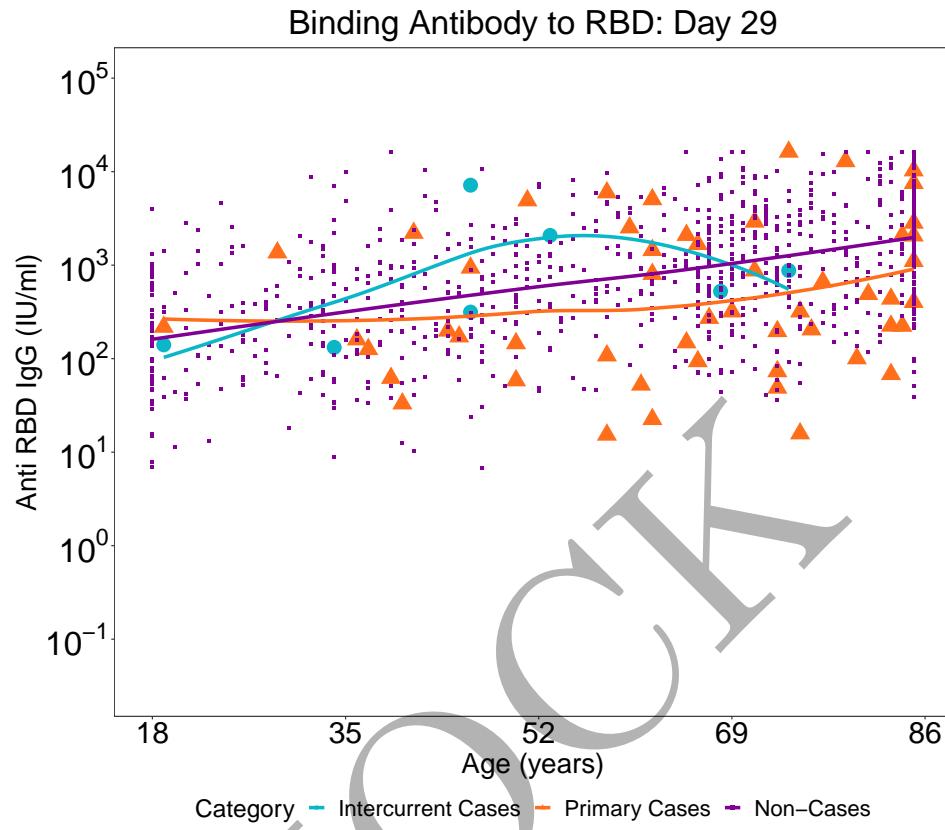


Figure 3.242: scatterplots of Binding Antibody to RBD vs Age: baseline negative vaccine arm at day 29

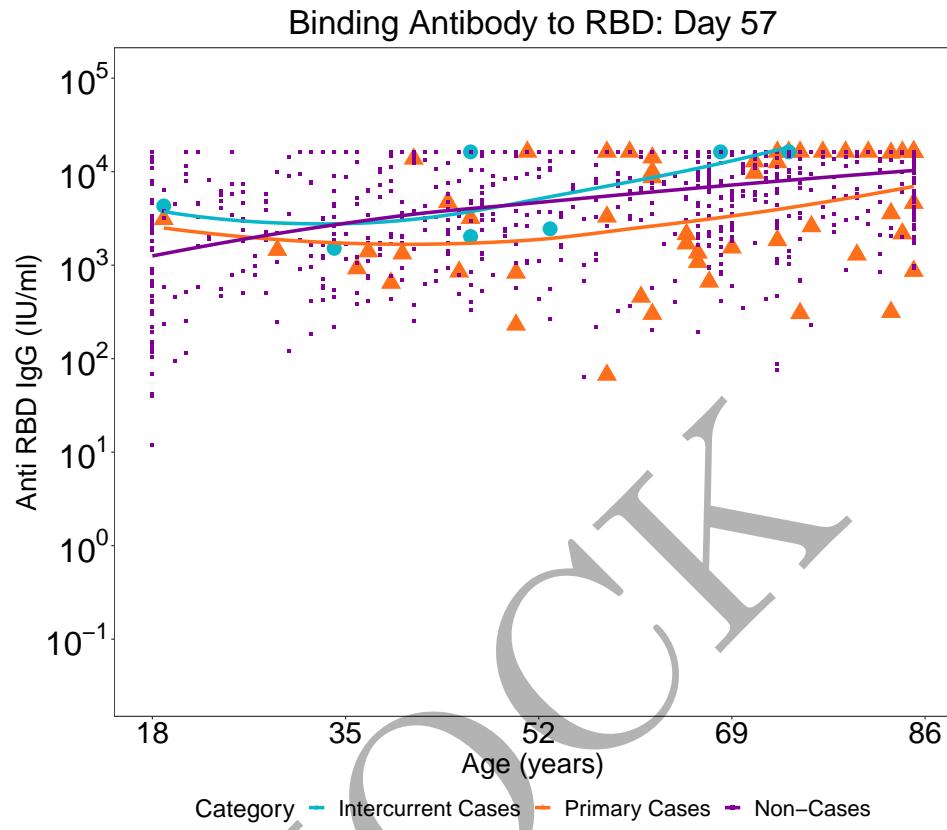


Figure 3.243: scatterplots of Binding Antibody to RBD vs Age: baseline negative vaccine arm at day 57

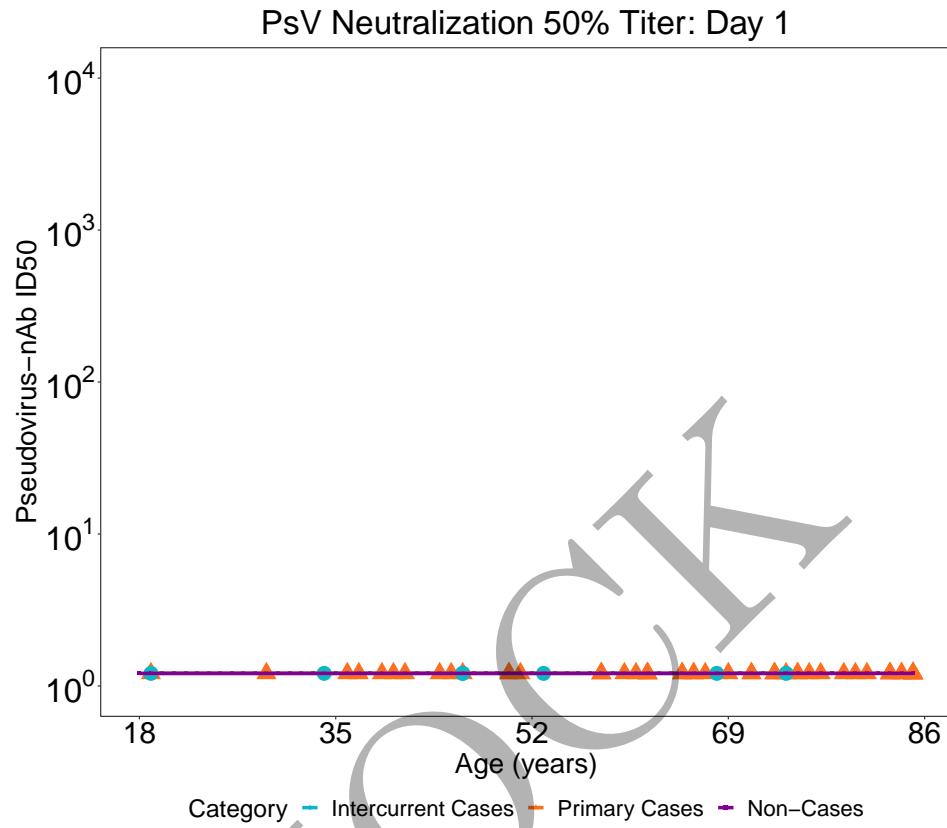


Figure 3.244: scatterplots of Pseudovirus Neutralization ID50 vs Age: baseline negative vaccine arm at day 1

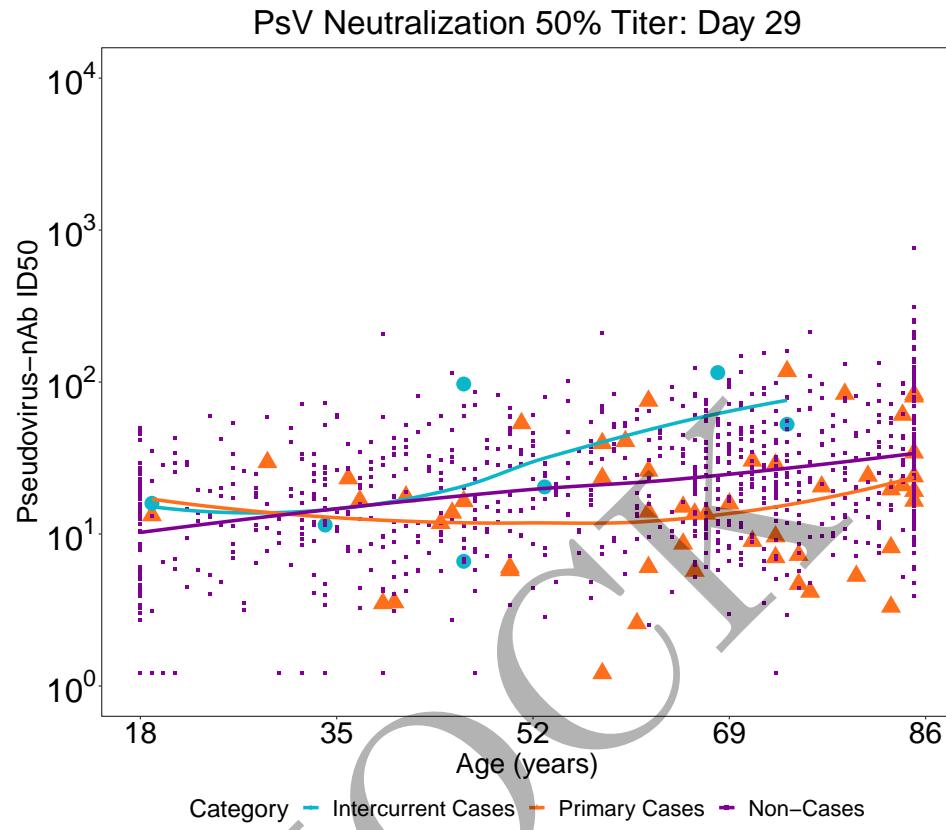


Figure 3.245: scatterplots of Pseudovirus Neutralization ID₅₀ vs Age: baseline negative vaccine arm at day 29

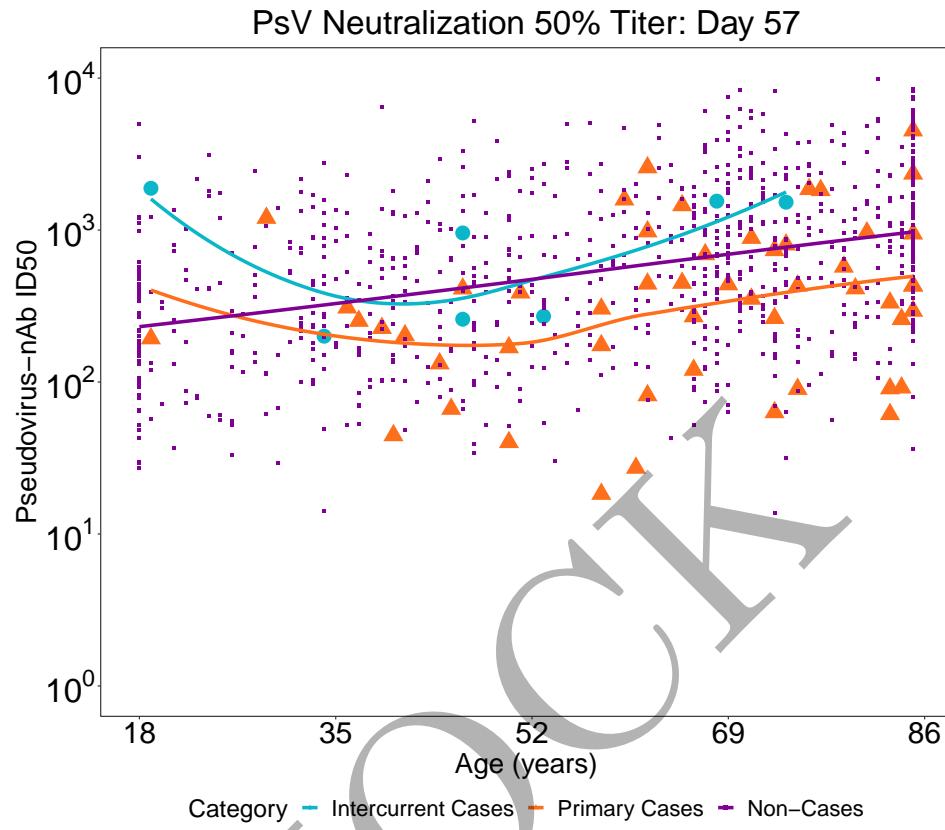


Figure 3.246: scatterplots of Pseudovirus Neutralization ID₅₀ vs Age: baseline negative vaccine arm at day 57

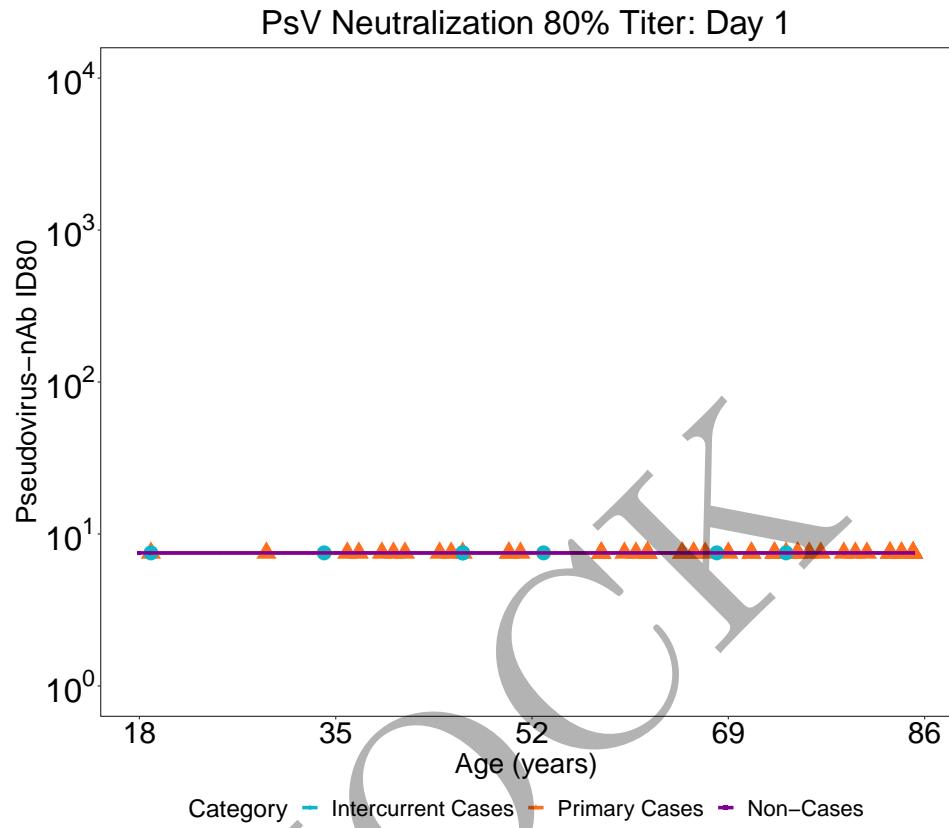


Figure 3.247: scatterplots of Pseudovirus Neutralization ID80 vs Age: baseline negative vaccine arm at day 1

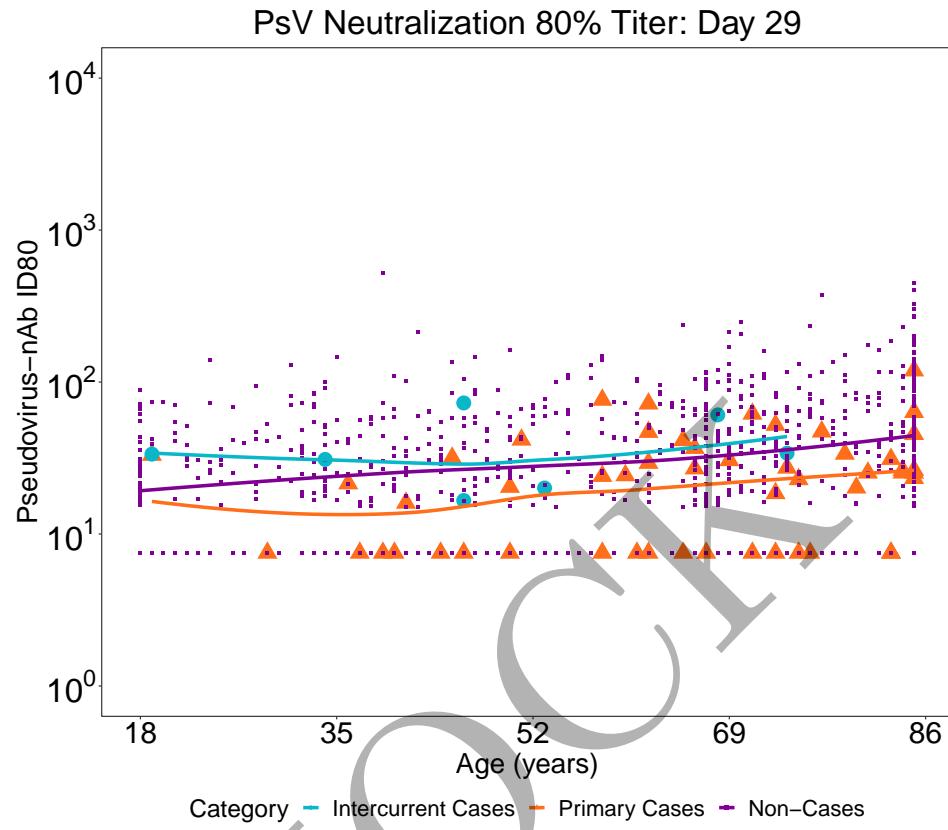


Figure 3.248: scatterplots of Pseudovirus Neutralization ID80 vs Age: baseline negative vaccine arm at day 29

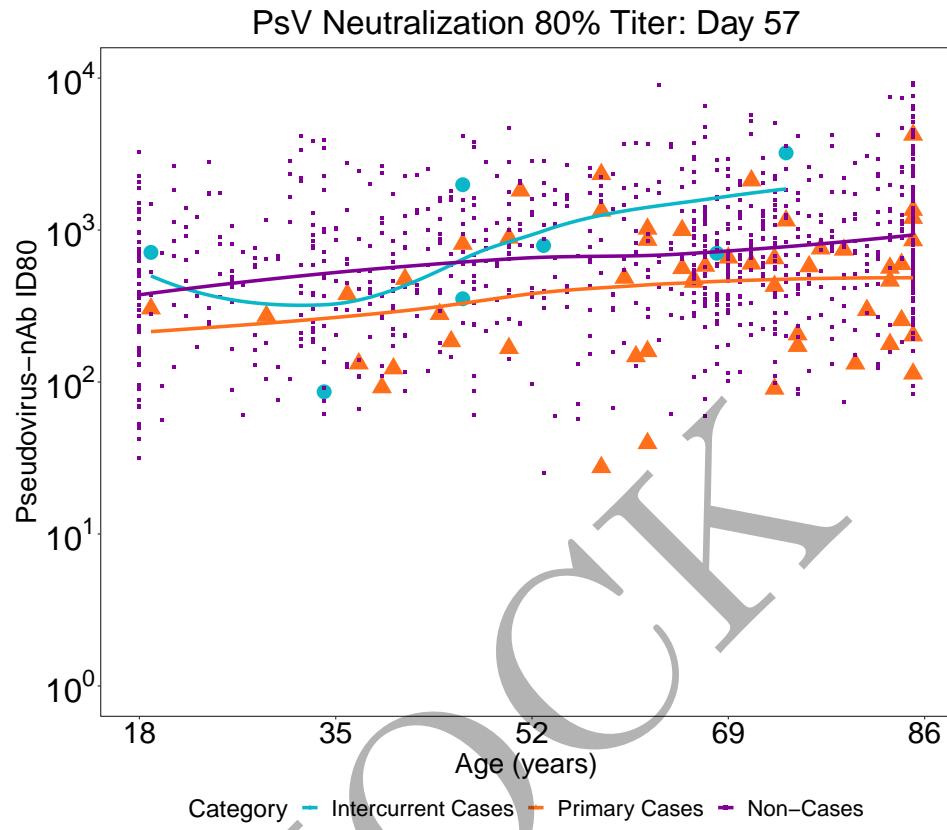


Figure 3.249: scatterplots of Pseudovirus Neutralization ID80 vs Age: baseline negative vaccine arm at day 57

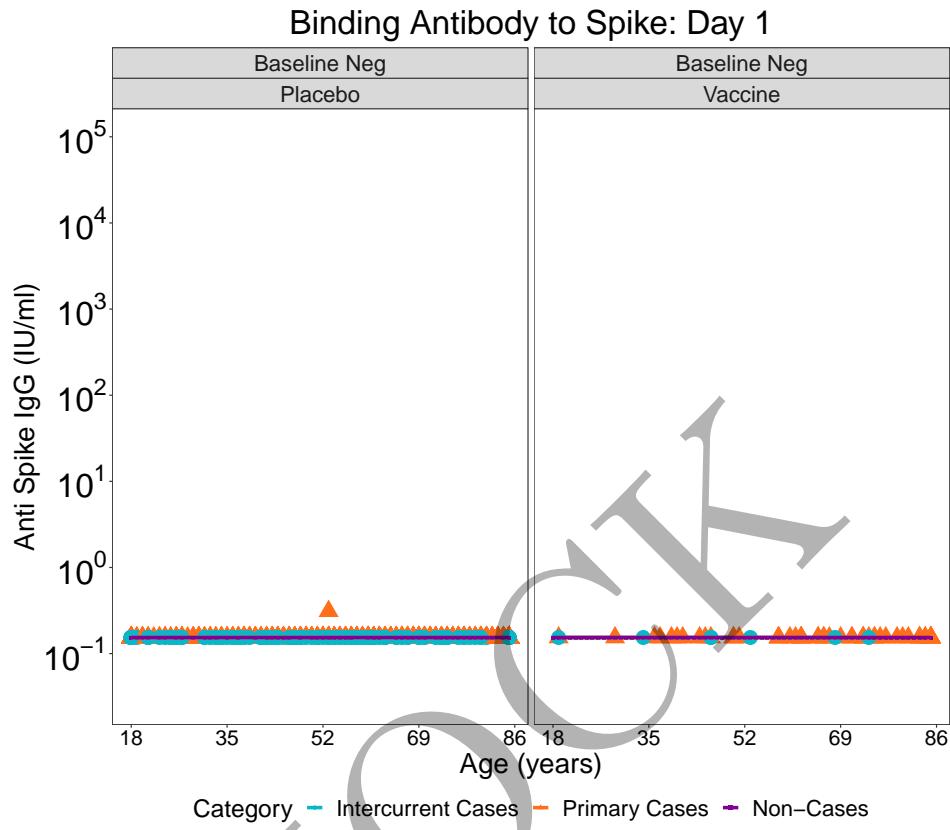


Figure 3.250: scatterplots of Binding Antibody to Spike vs Age: by arm at day 1

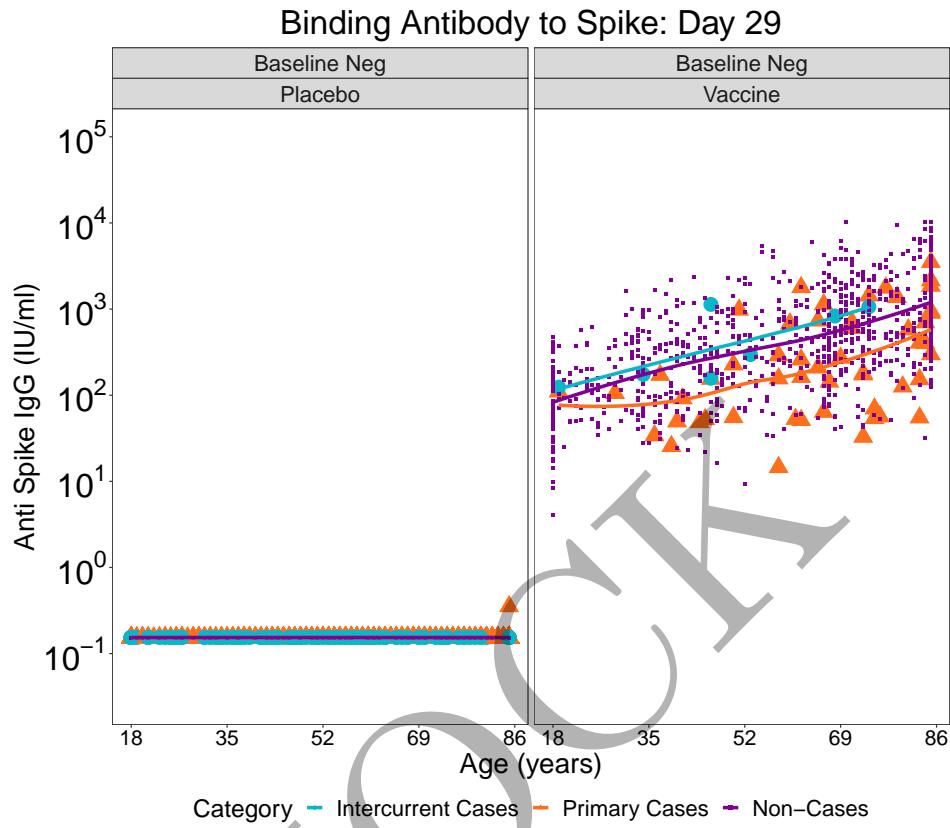


Figure 3.251: scatterplots of Binding Antibody to Spike vs Age: by arm at day 29

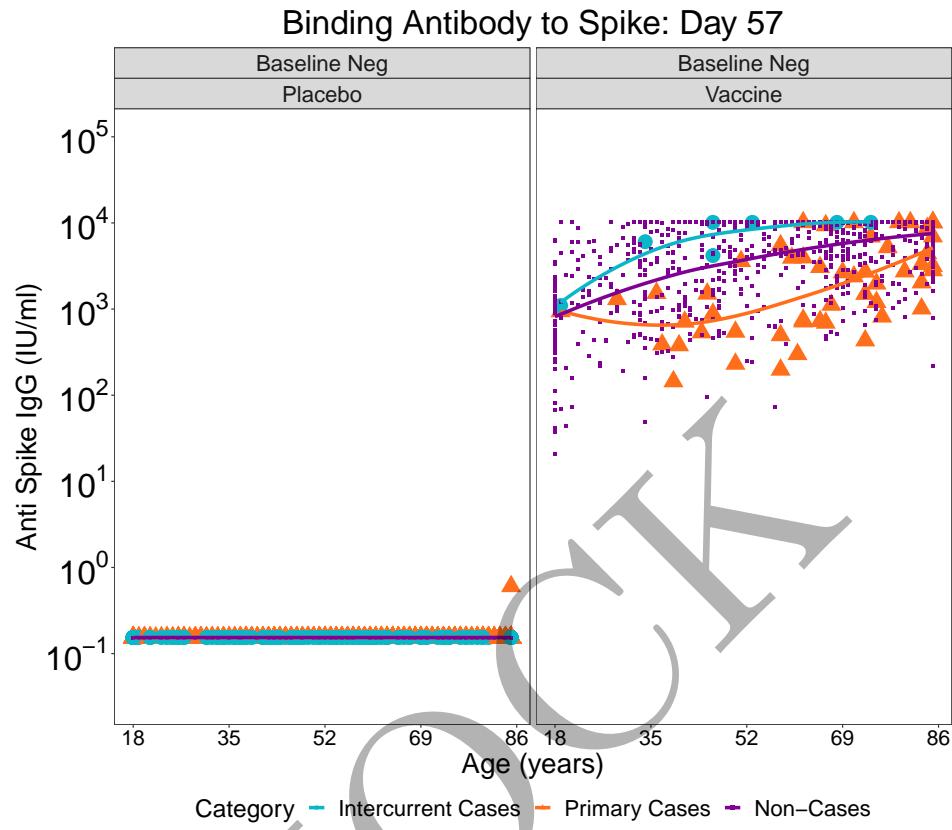


Figure 3.252: scatterplots of Binding Antibody to Spike vs Age: by arm at day 57

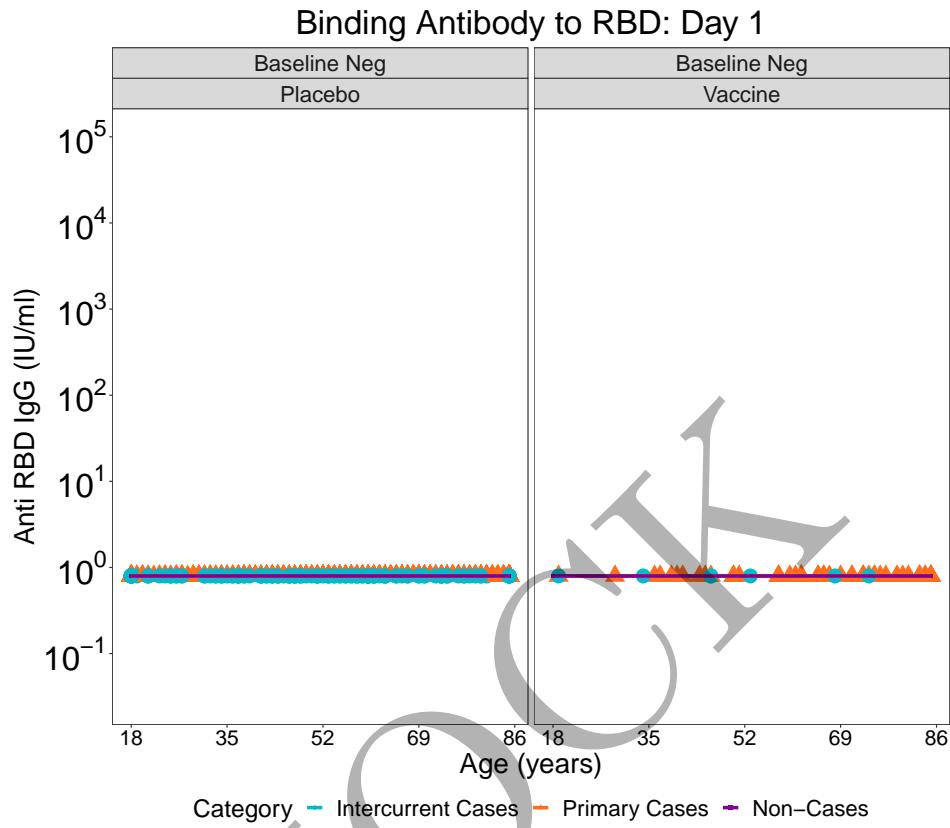


Figure 3.253: scatterplots of Binding Antibody to RBD vs Age: by arm at day 1

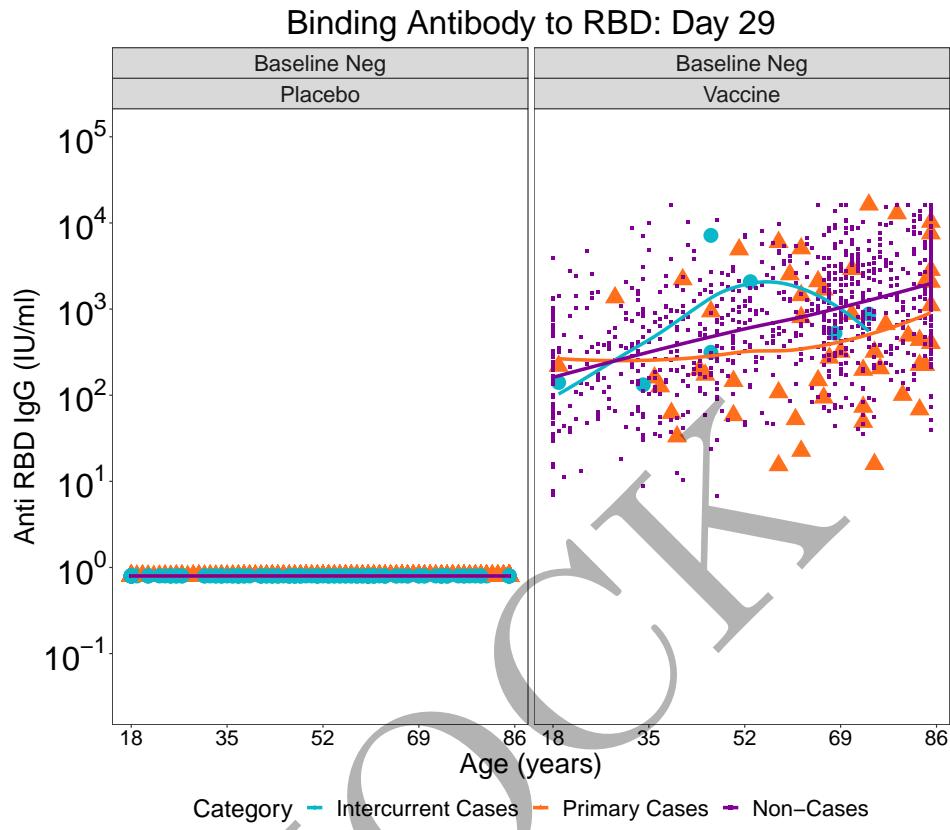


Figure 3.254: scatterplots of Binding Antibody to RBD vs Age: by arm at day 29

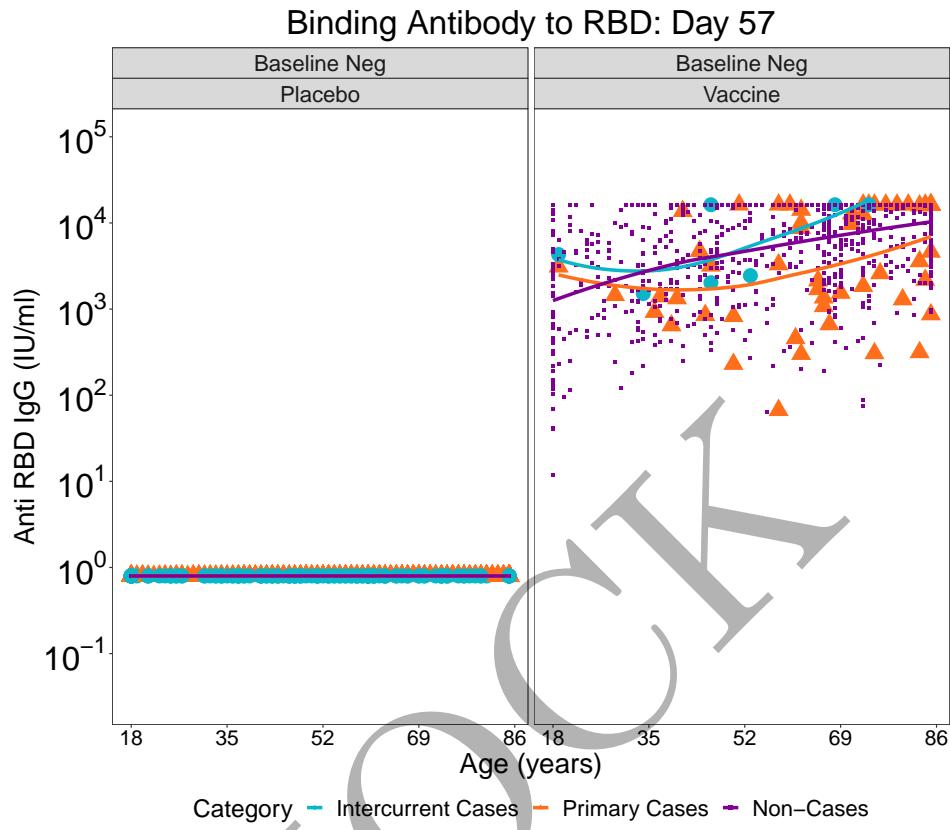


Figure 3.255: scatterplots of Binding Antibody to RBD vs Age: by arm at day 57

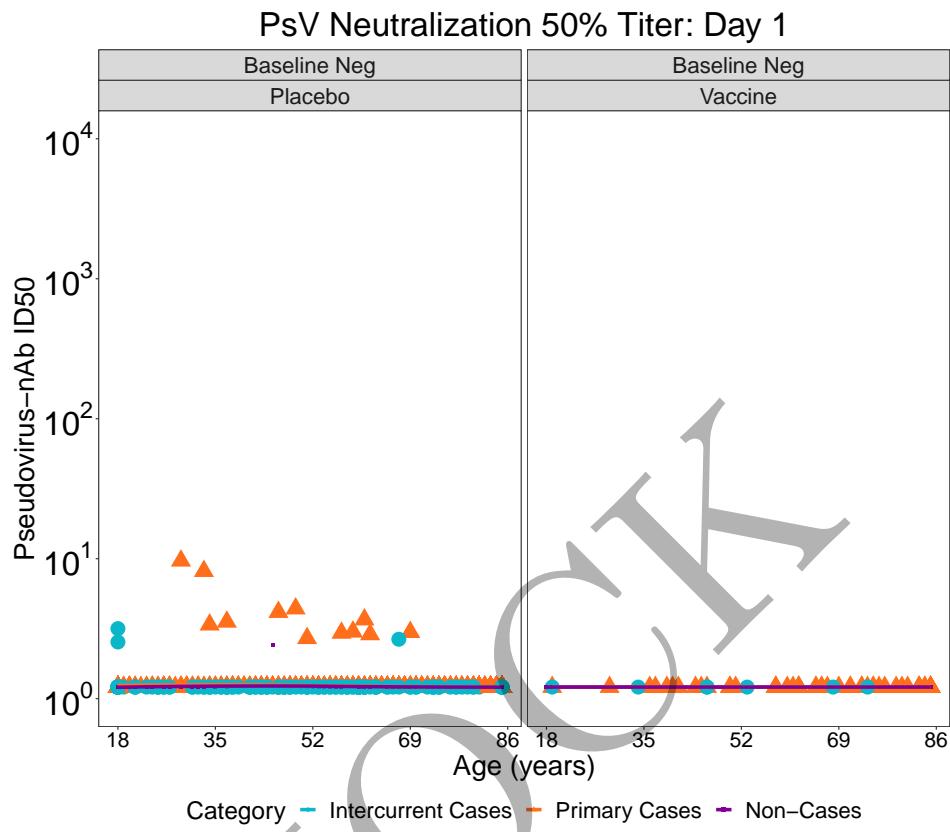


Figure 3.256: scatterplots of Pseudovirus Neutralization ID50 vs Age vs Age: by arm at day 1

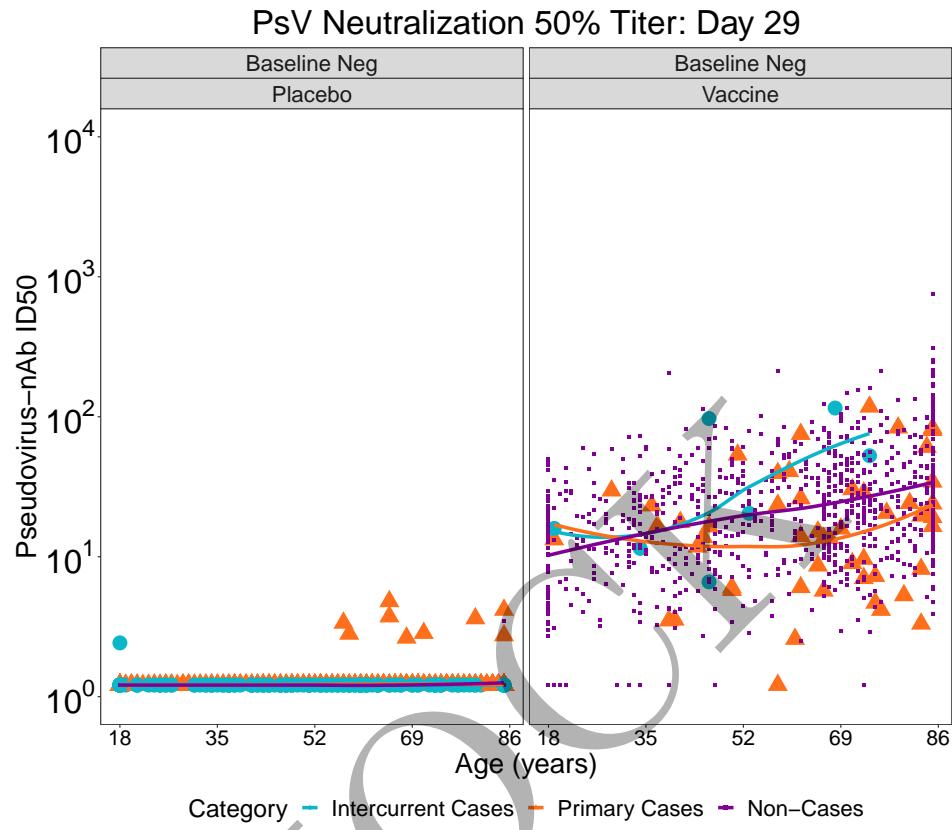


Figure 3.257: scatterplots of Pseudovirus Neutralization ID50 vs Age vs Age: by arm at day 29

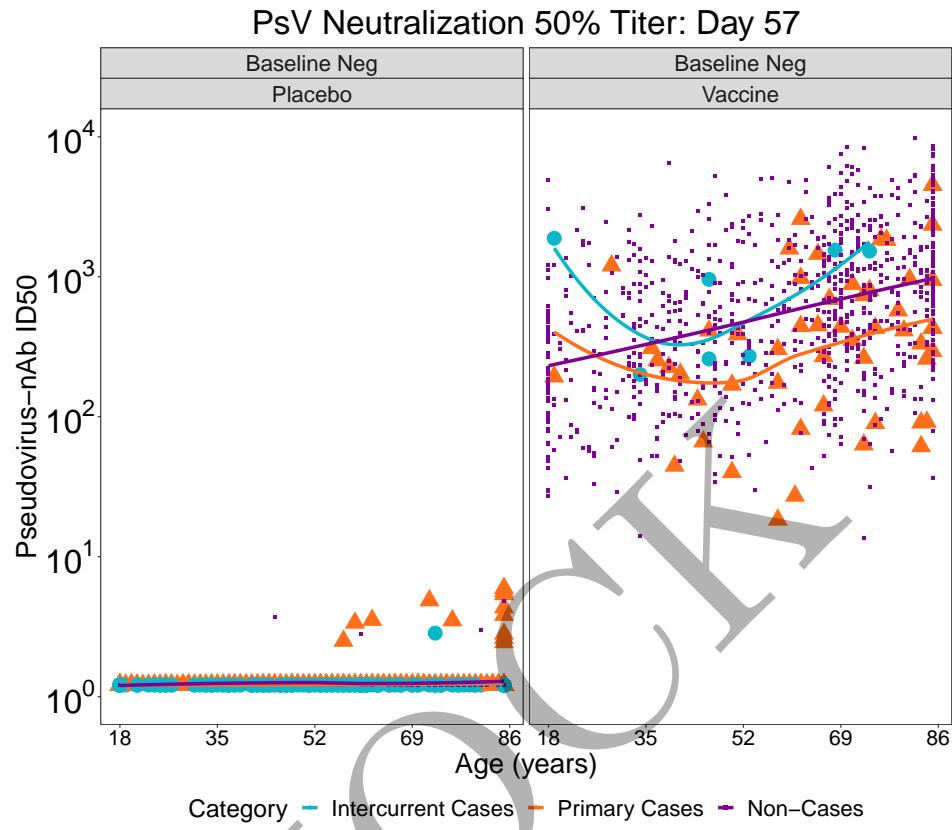


Figure 3.258: scatterplots of Pseudovirus Neutralization ID50 vs Age: by arm at day 57

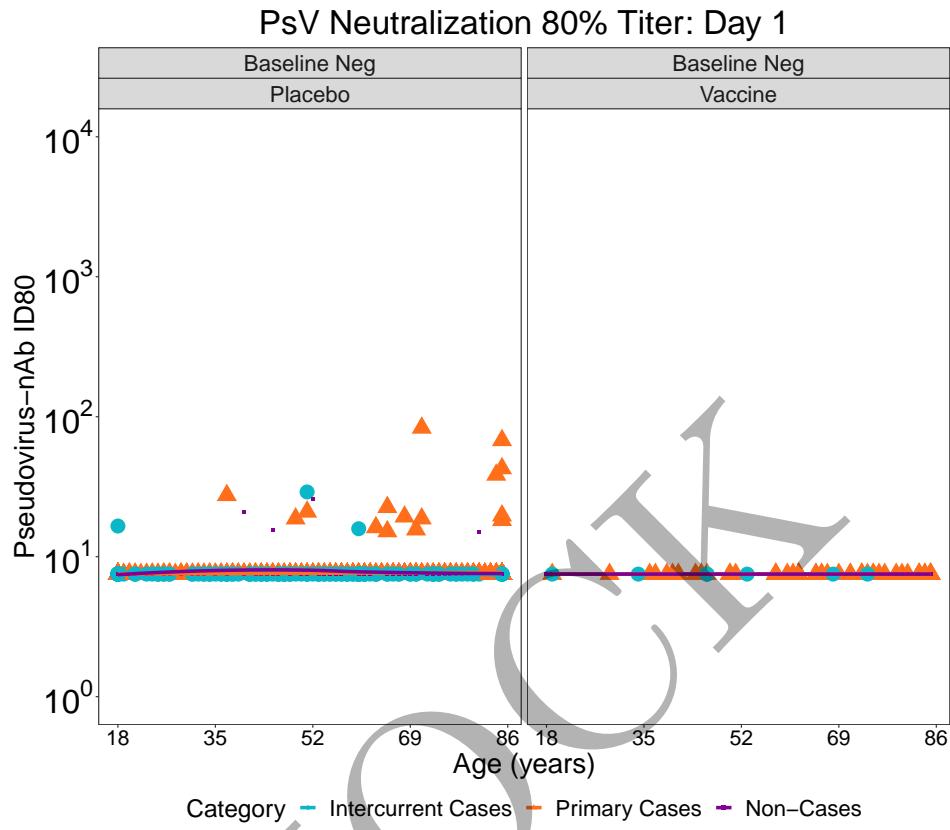


Figure 3.259: scatterplots of Pseudovirus Neutralization ID80 vs Age: by arm at day 1

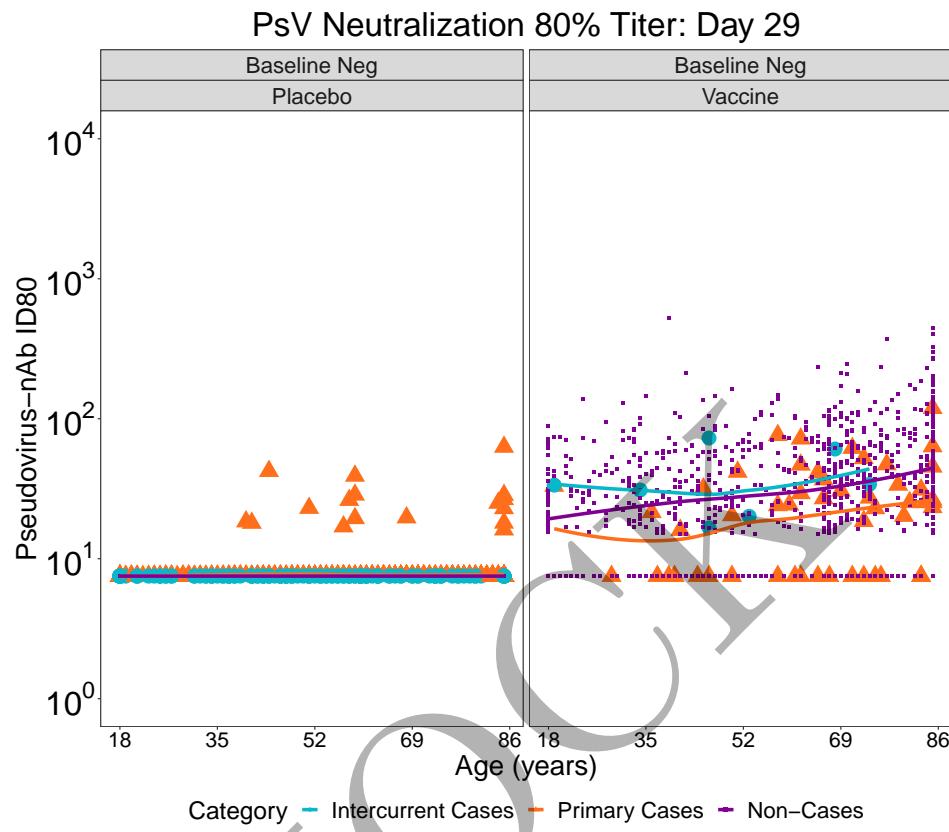


Figure 3.260: scatterplots of Pseudovirus Neutralization ID80 vs Age: by arm at day 29

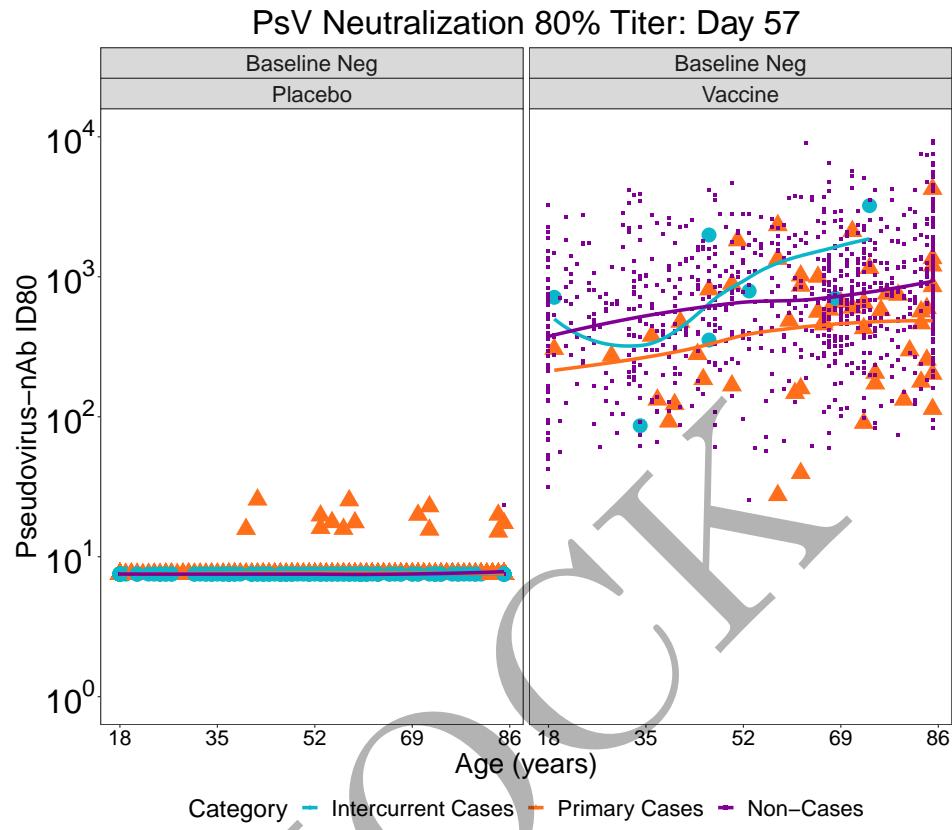


Figure 3.261: scatterplots of Pseudovirus Neutralization ID80 vs Age: by arm at day 57

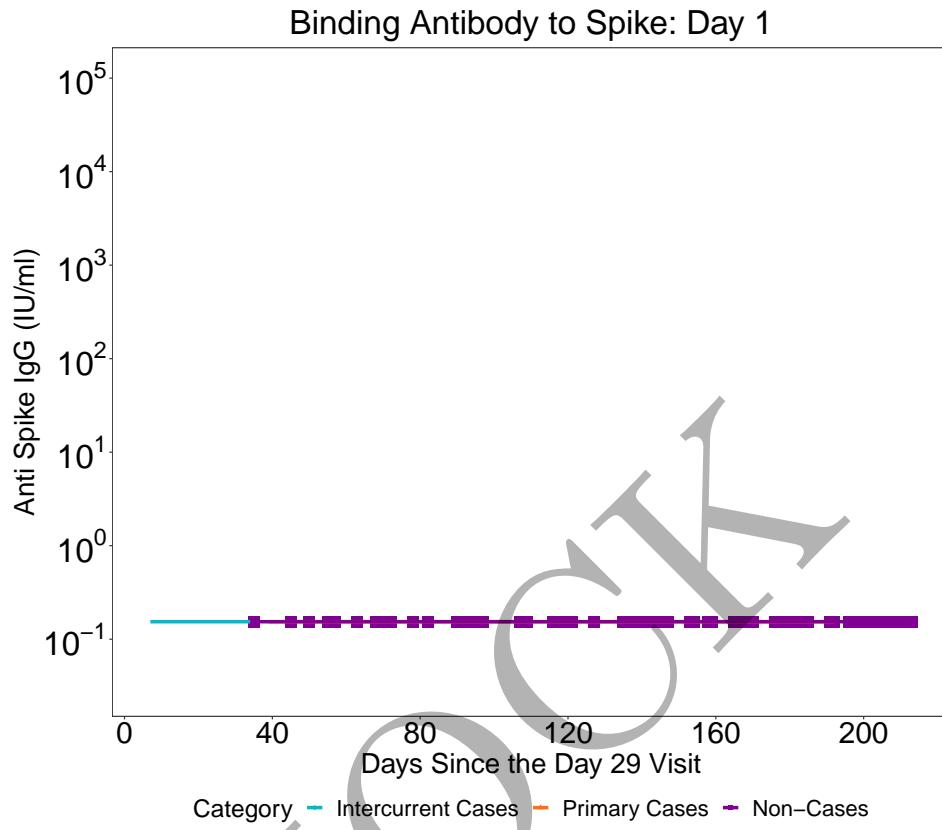


Figure 3.262: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 1

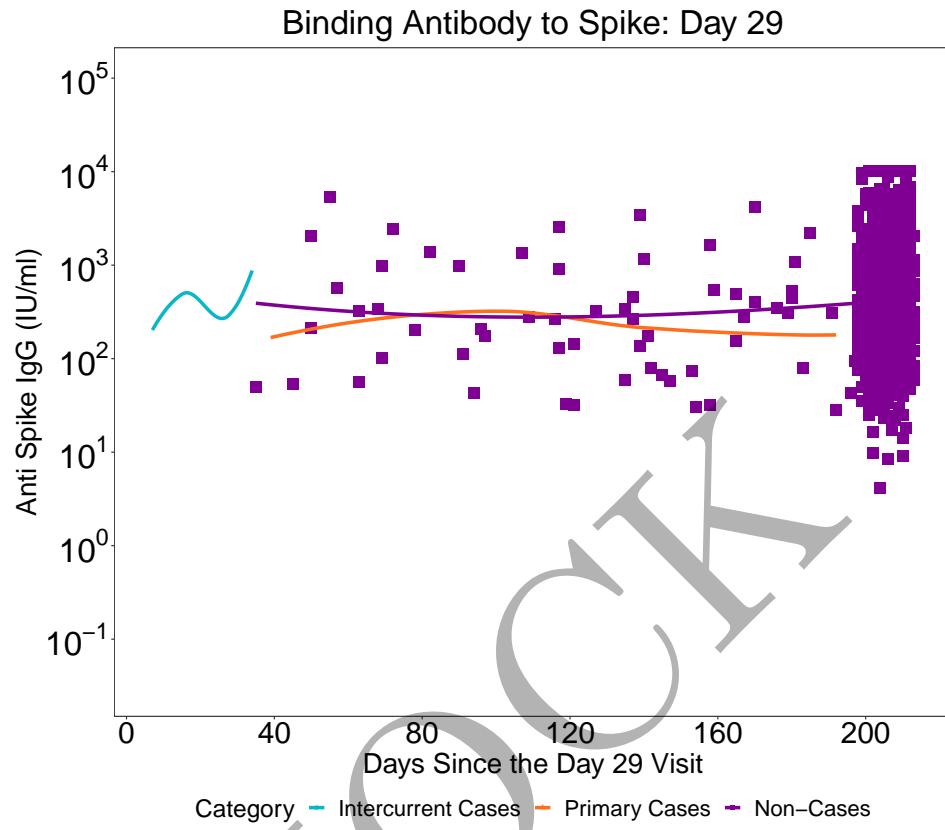


Figure 3.263: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 29

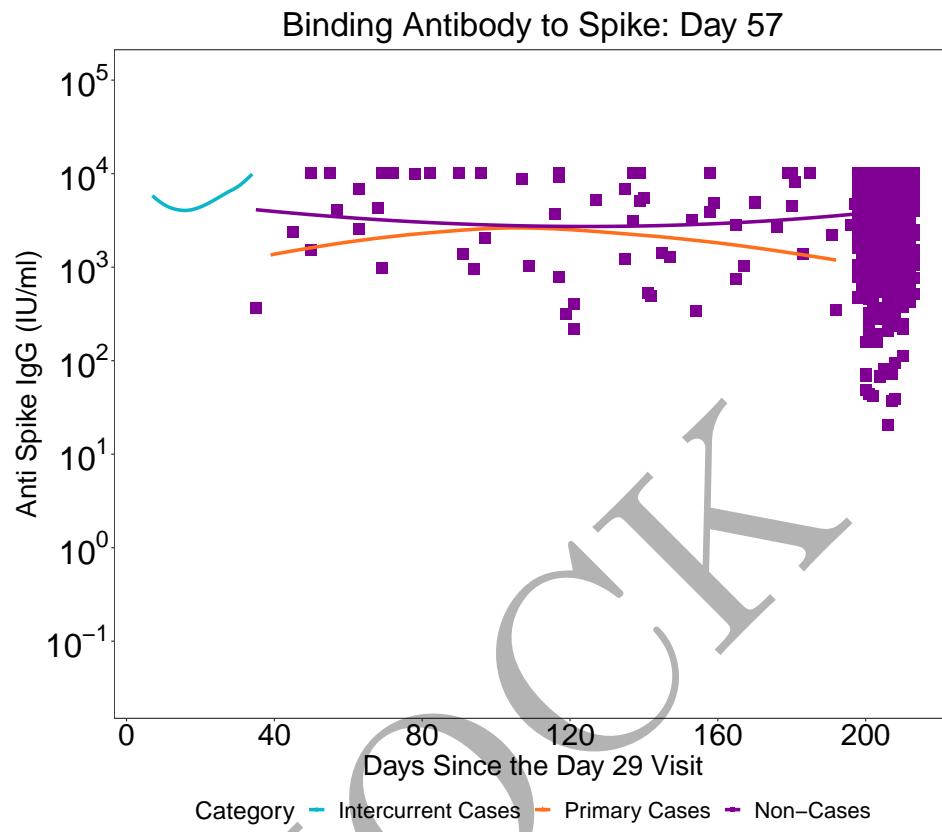


Figure 3.264: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 57

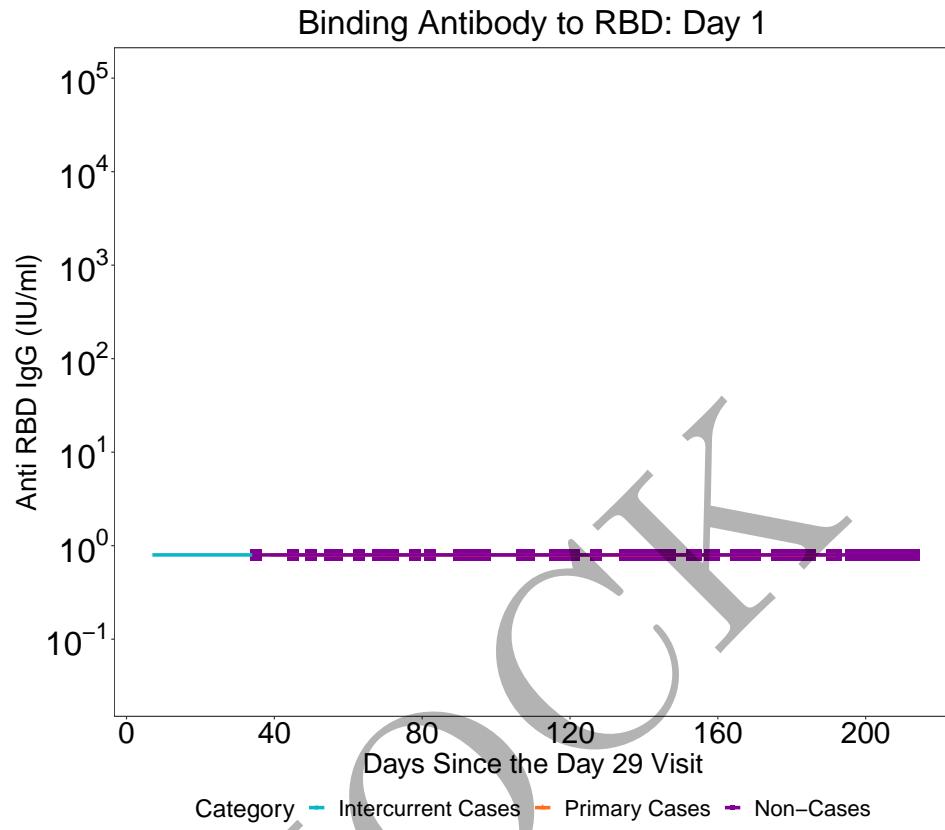


Figure 3.265: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 1

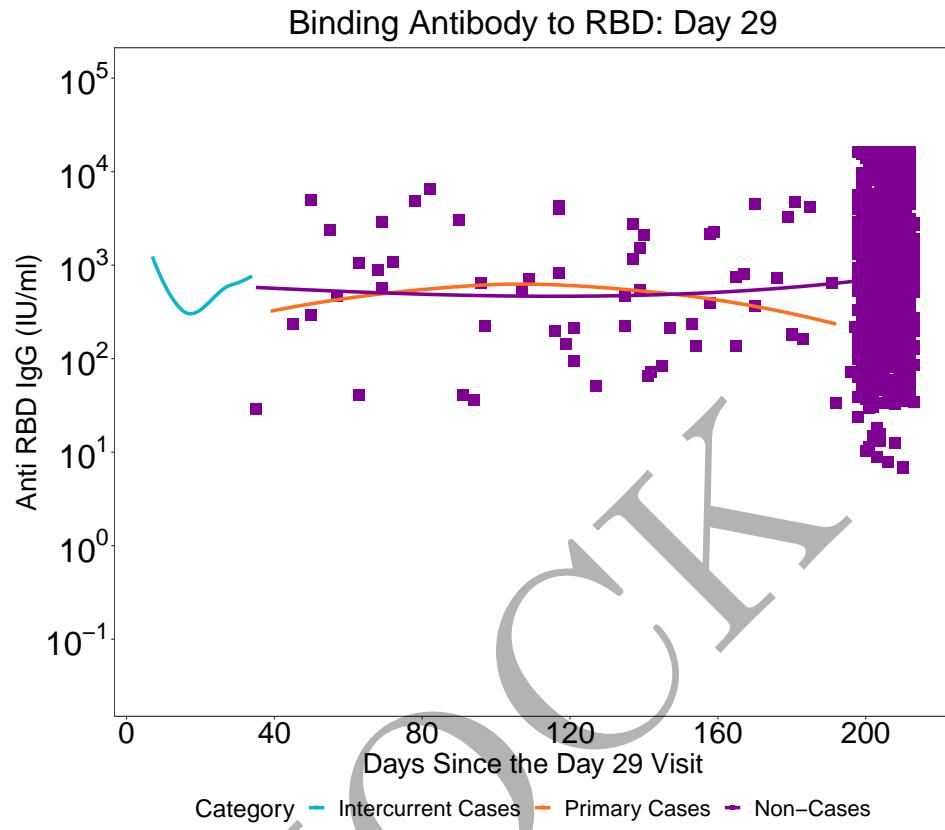


Figure 3.266: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 29

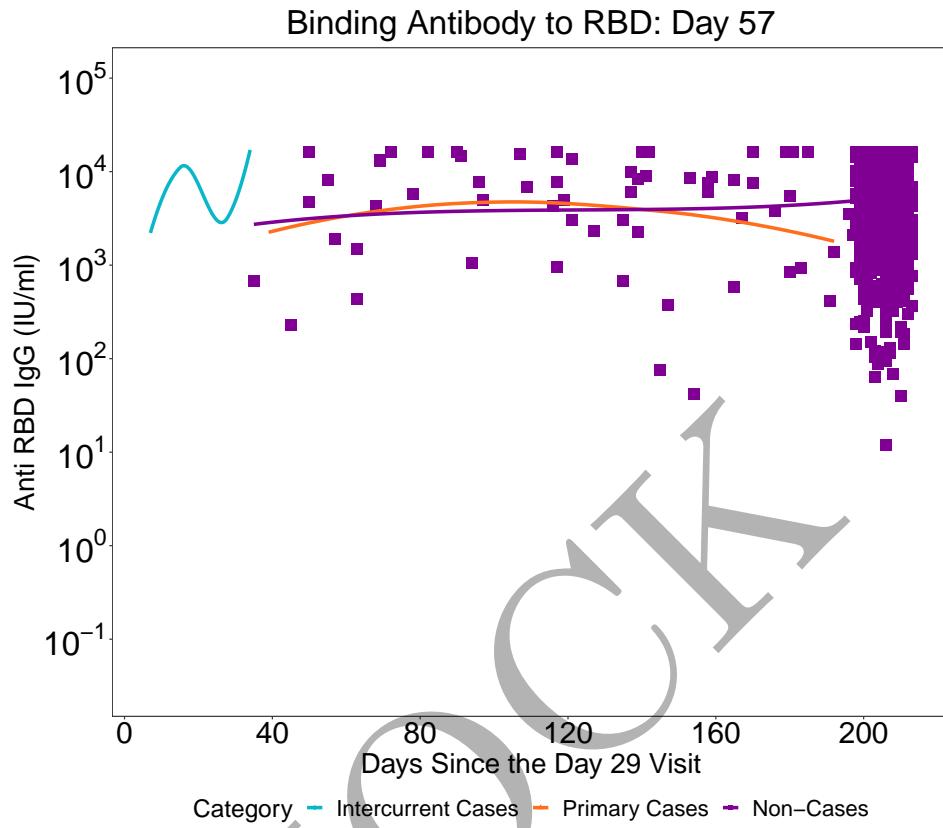


Figure 3.267: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 57

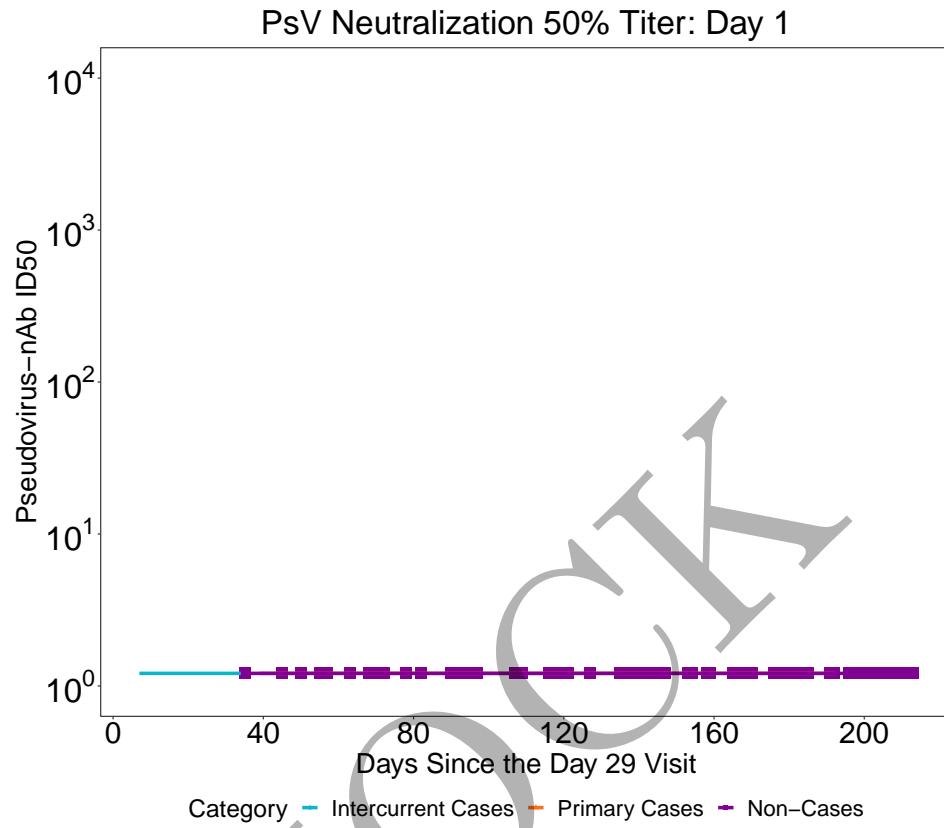


Figure 3.268: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 1

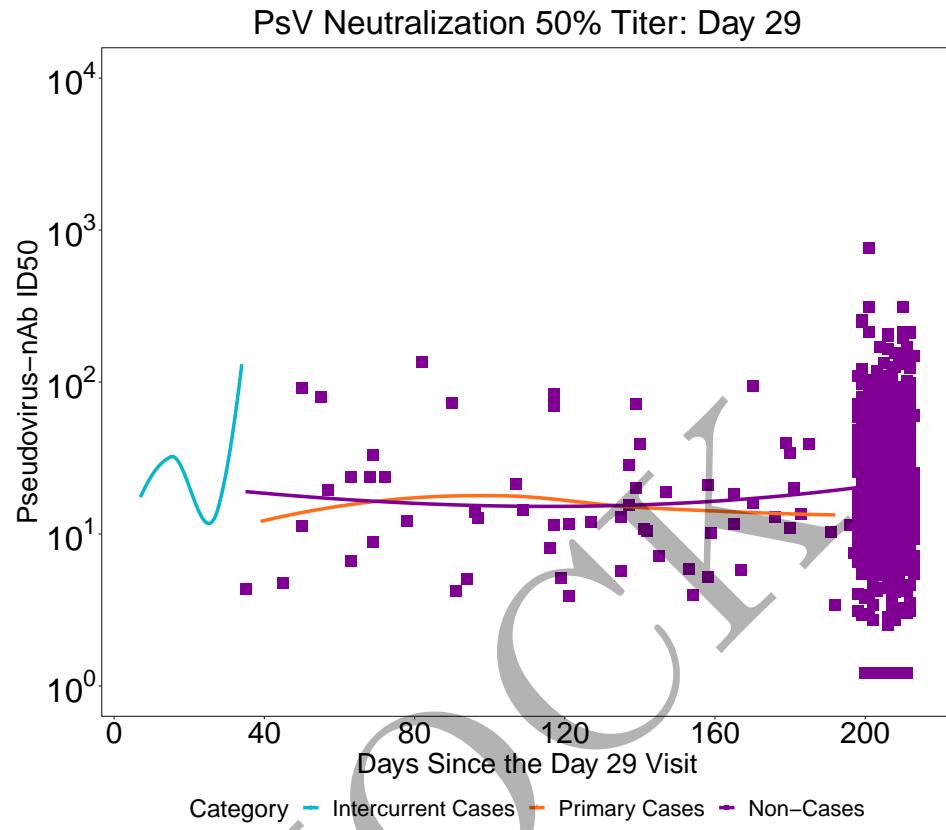


Figure 3.269: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 29

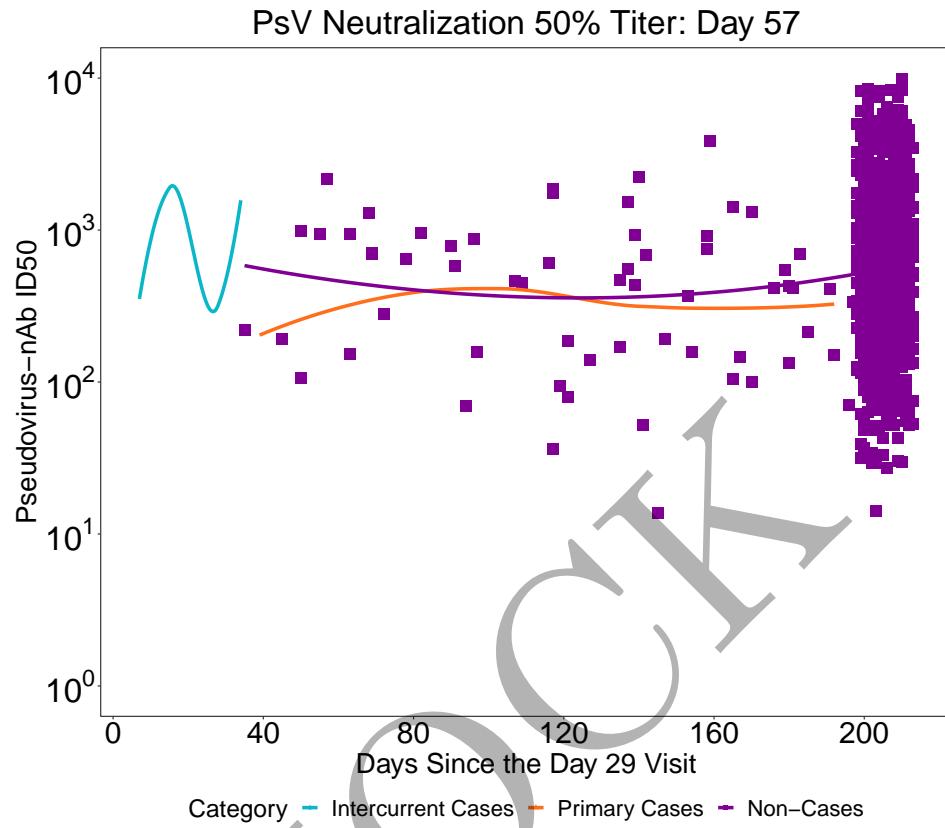


Figure 3.270: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 57

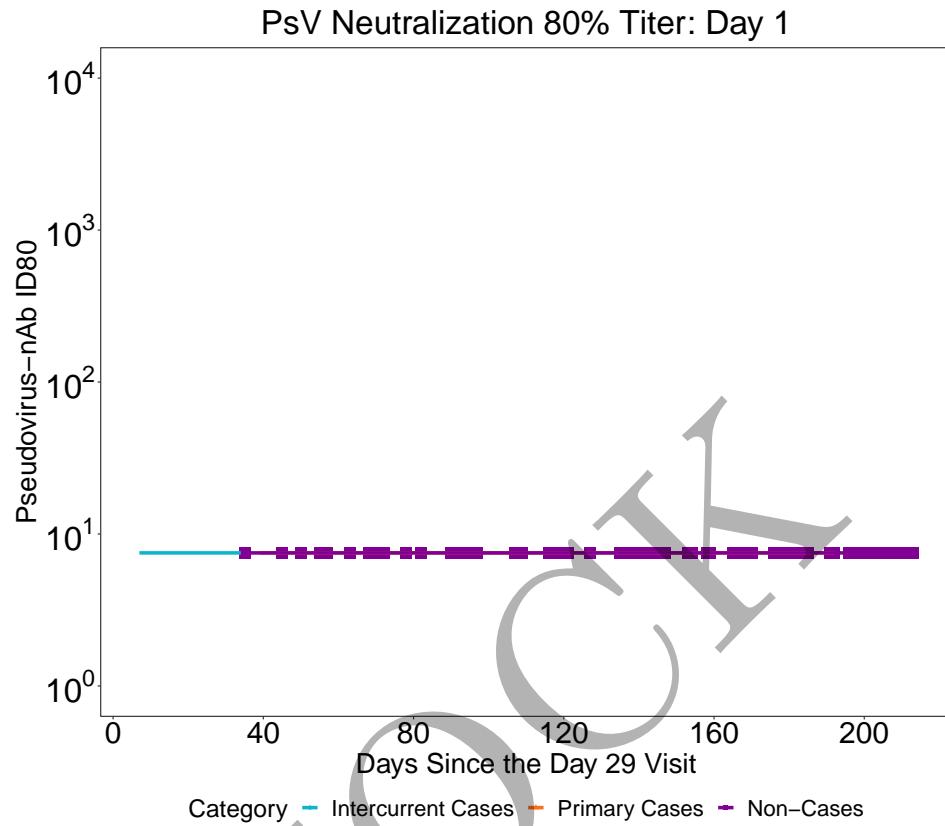


Figure 3.271: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 1

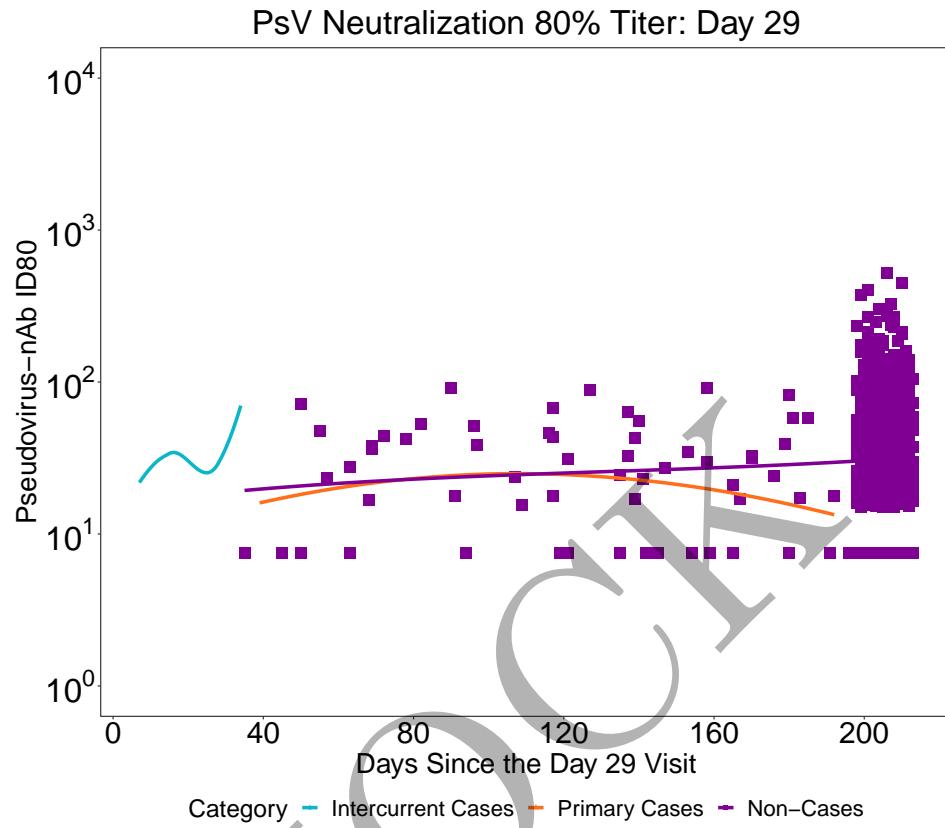


Figure 3.272: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 29

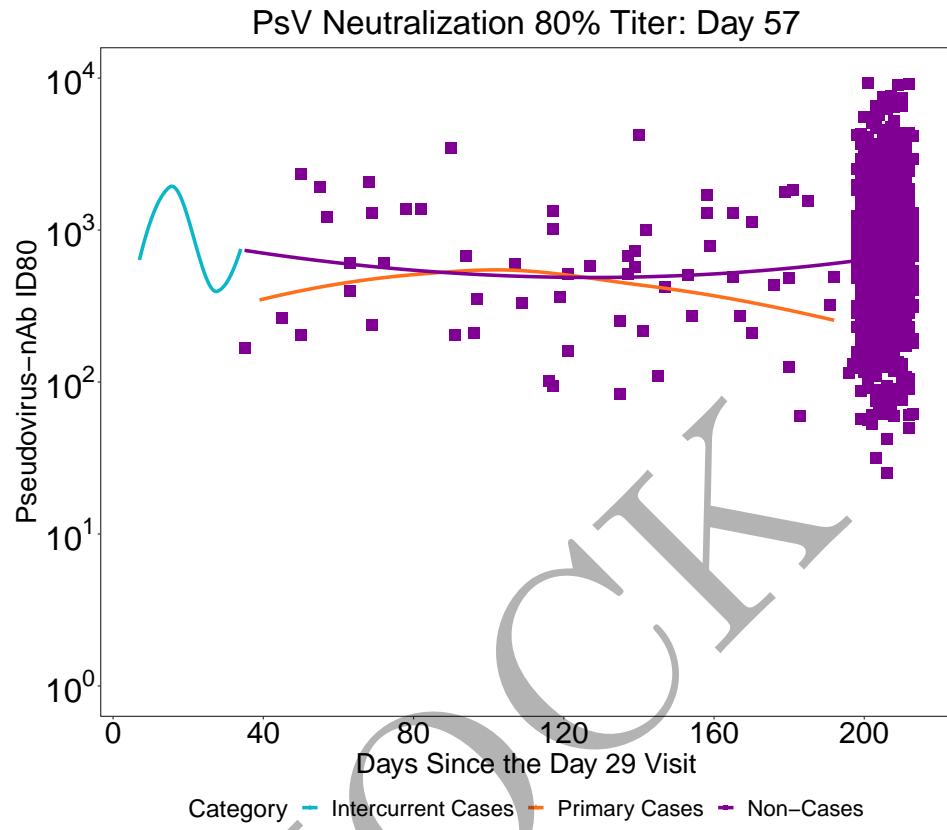


Figure 3.273: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: baseline negative vaccine arm at day 57

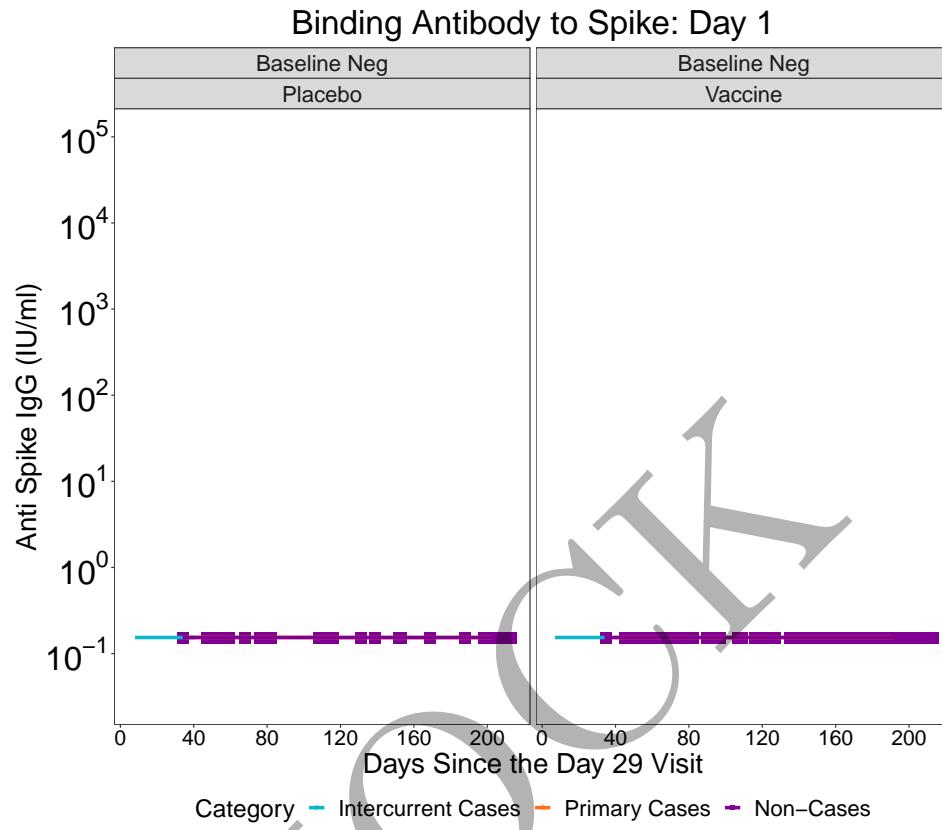


Figure 3.274: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: by arm at day 1

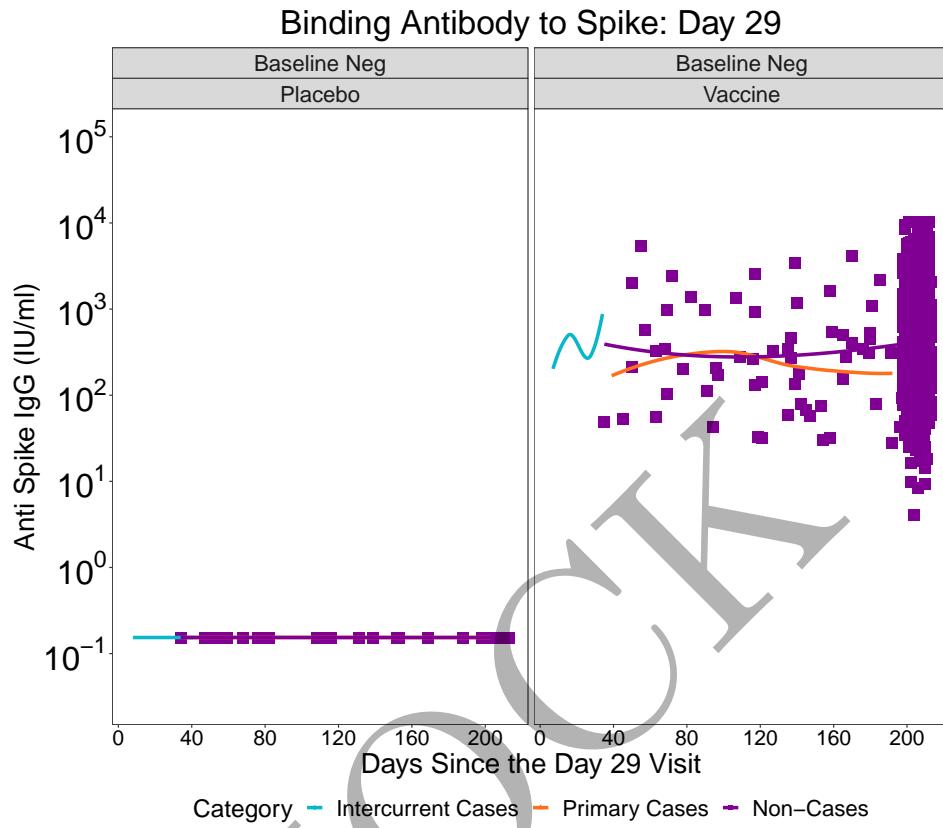


Figure 3.275: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: by arm at day 29

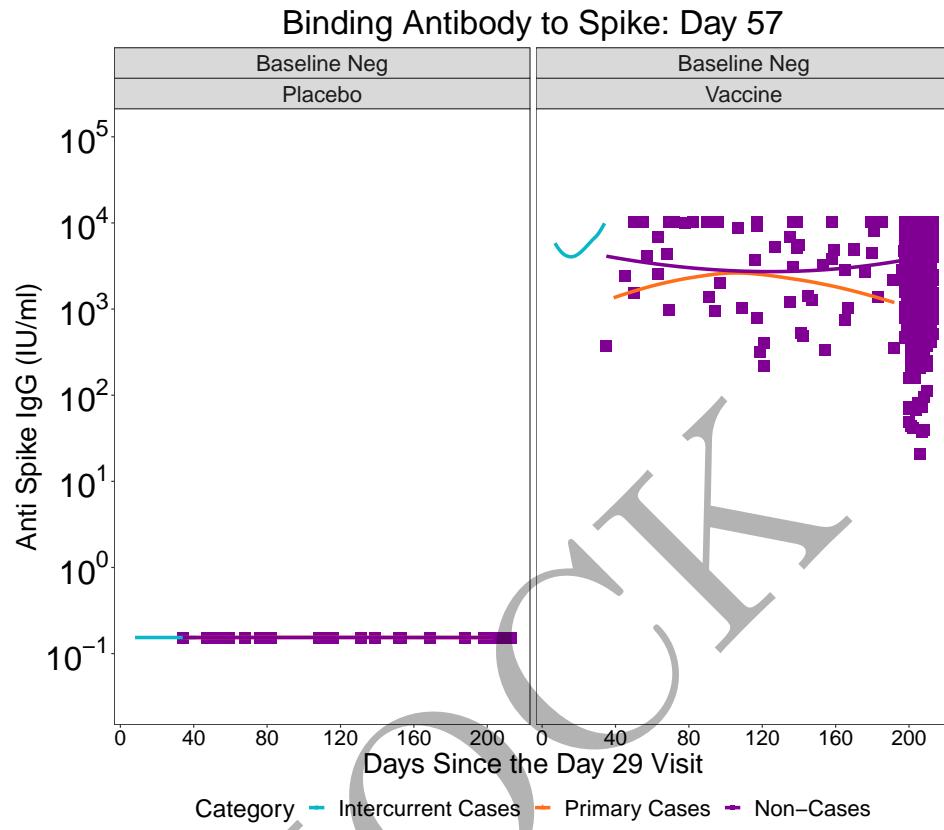


Figure 3.276: scatterplots of Binding Antibody to Spike vs Days Since the Day 29 Visit: by arm at day 57

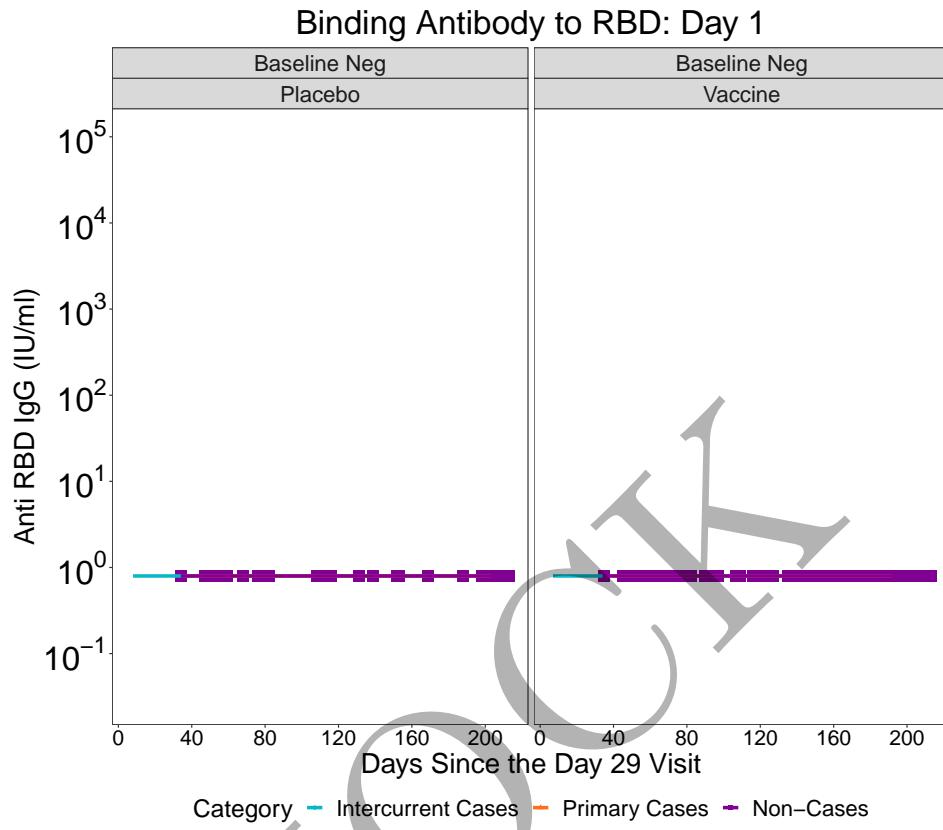


Figure 3.277: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: by arm at day 1

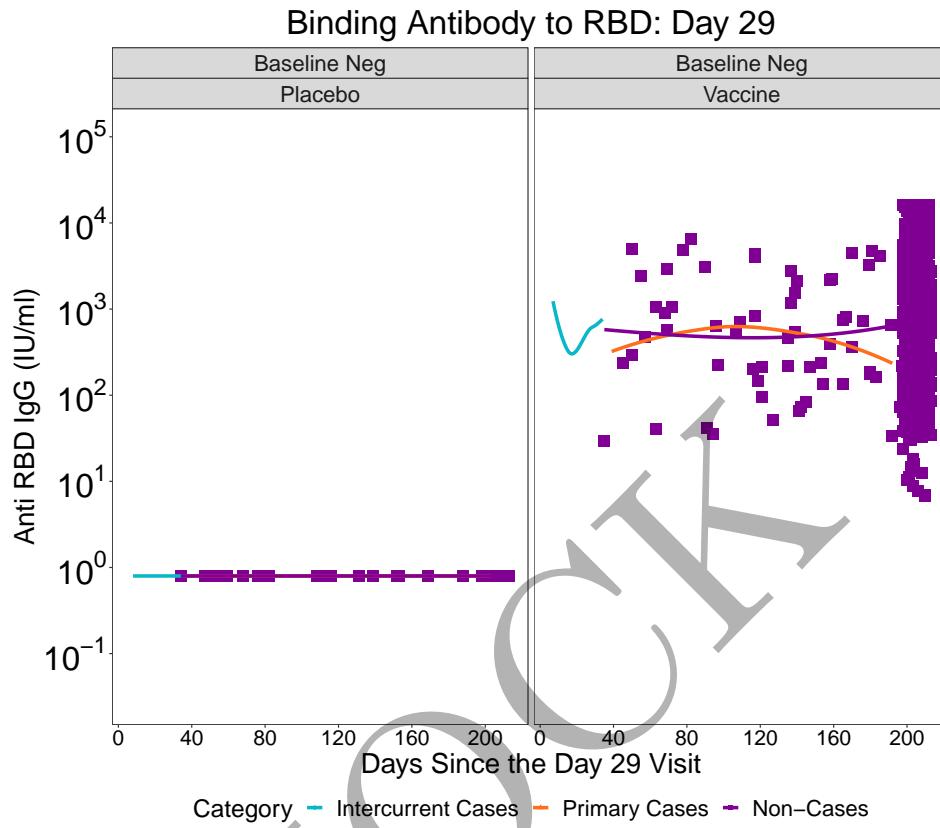


Figure 3.278: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: by arm at day 29

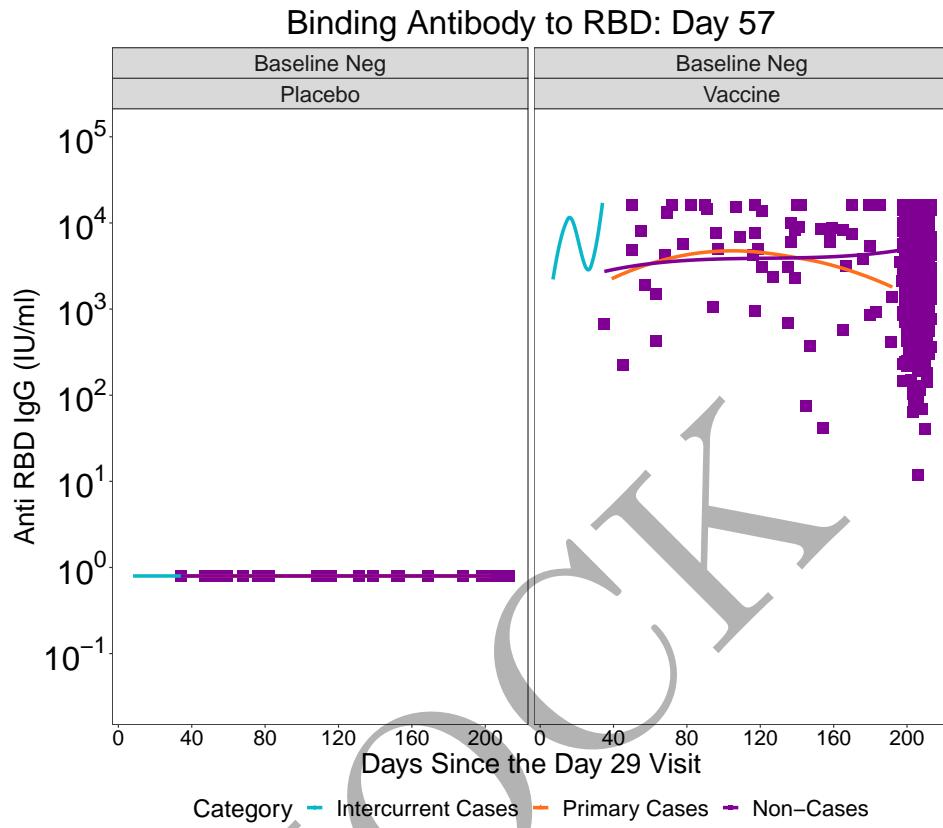


Figure 3.279: scatterplots of Binding Antibody to RBD vs Days Since the Day 29 Visit: by arm at day 57

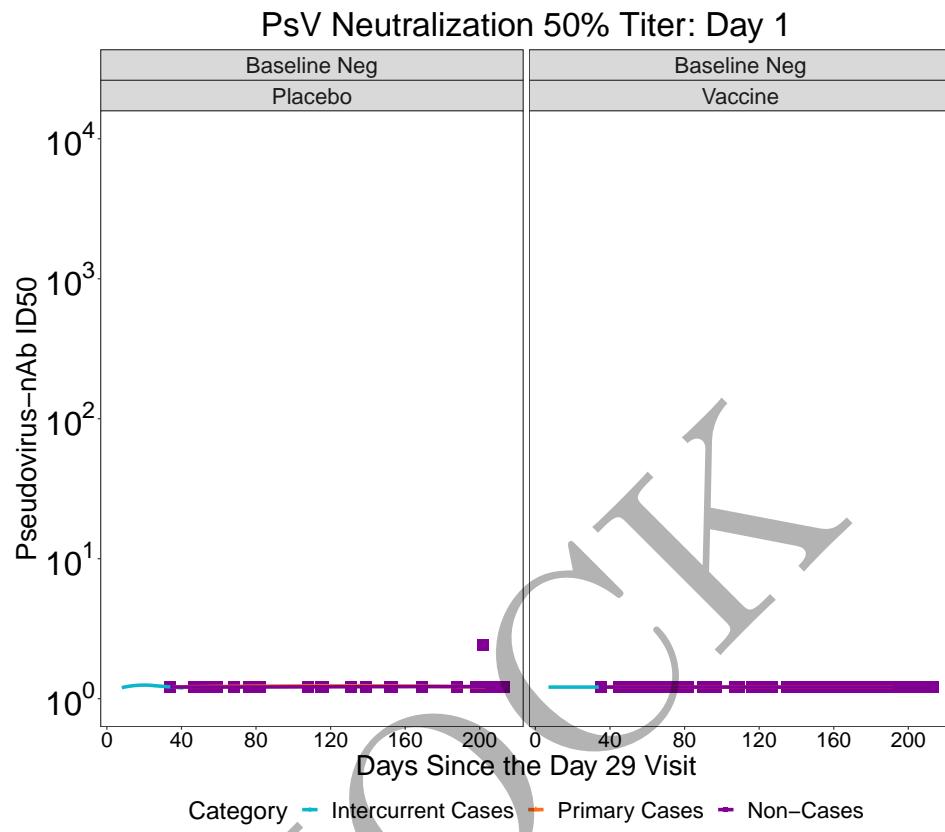


Figure 3.280: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit vs Days Since the Day 29 Visit: by arm at day 1

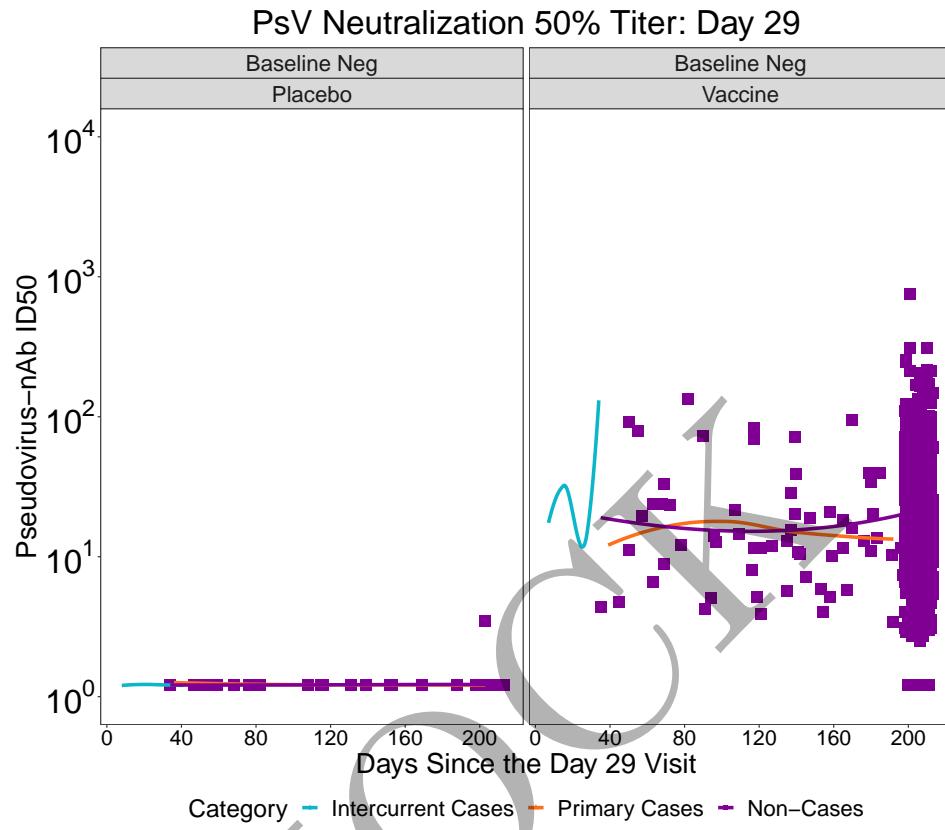


Figure 3.281: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit vs Days Since the Day 29 Visit: by arm at day 29

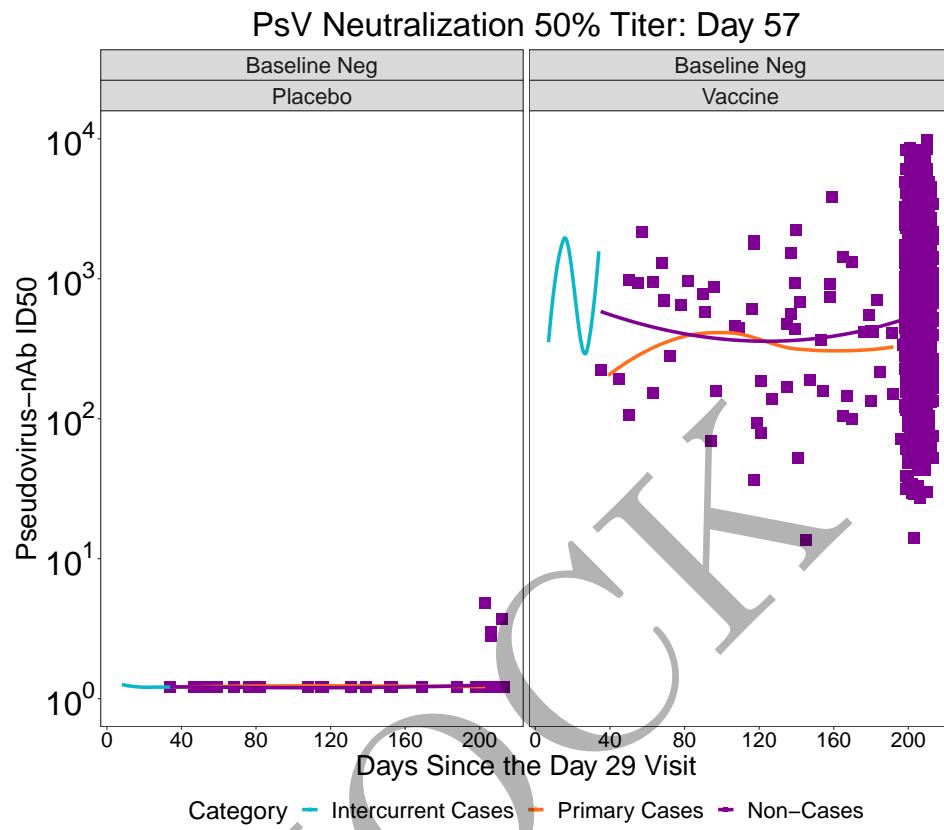


Figure 3.282: scatterplots of Pseudovirus Neutralization ID50 vs Days Since the Day 29 Visit: by arm at day 57

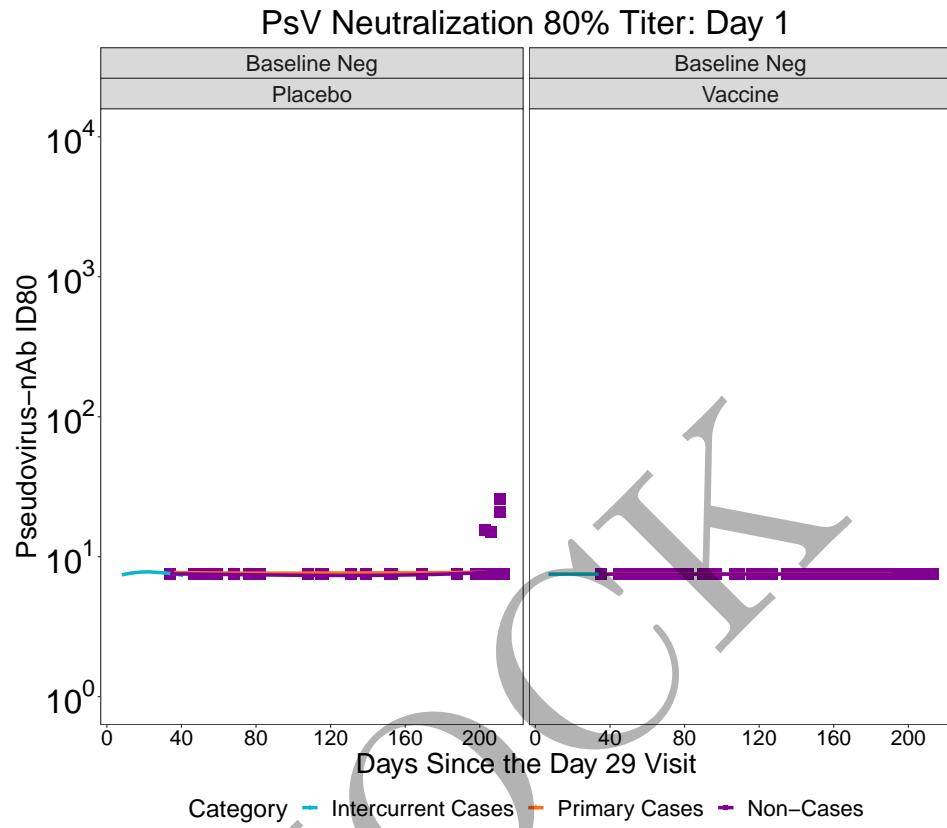


Figure 3.283: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: by arm at day 1

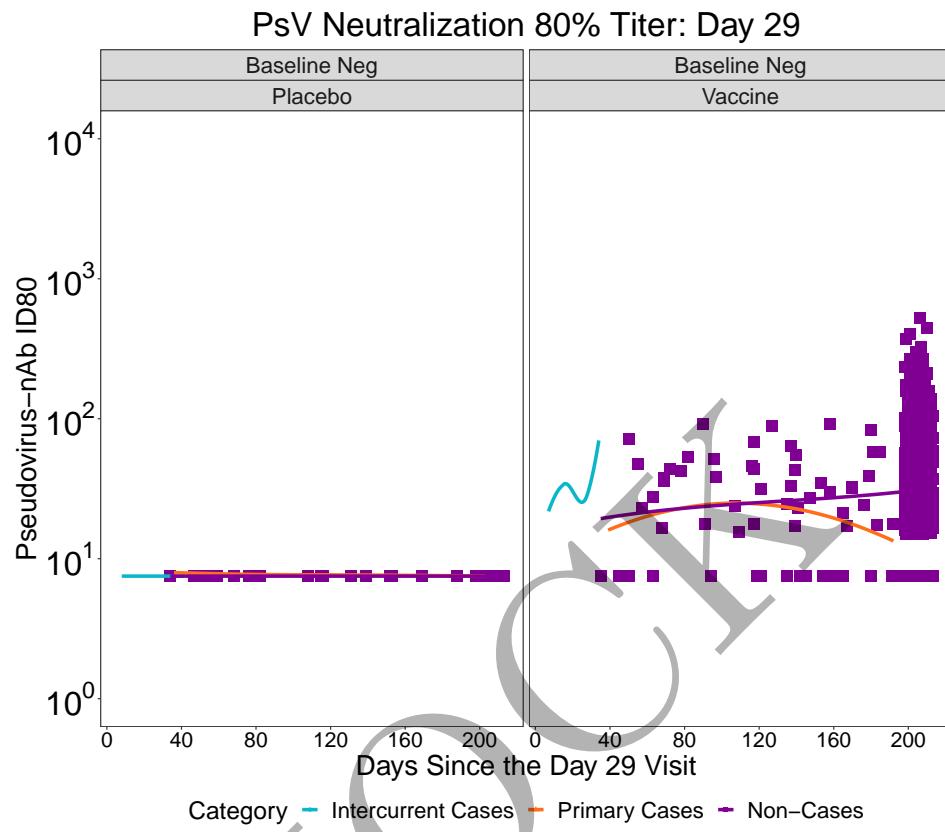


Figure 3.284: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: by arm at day 29

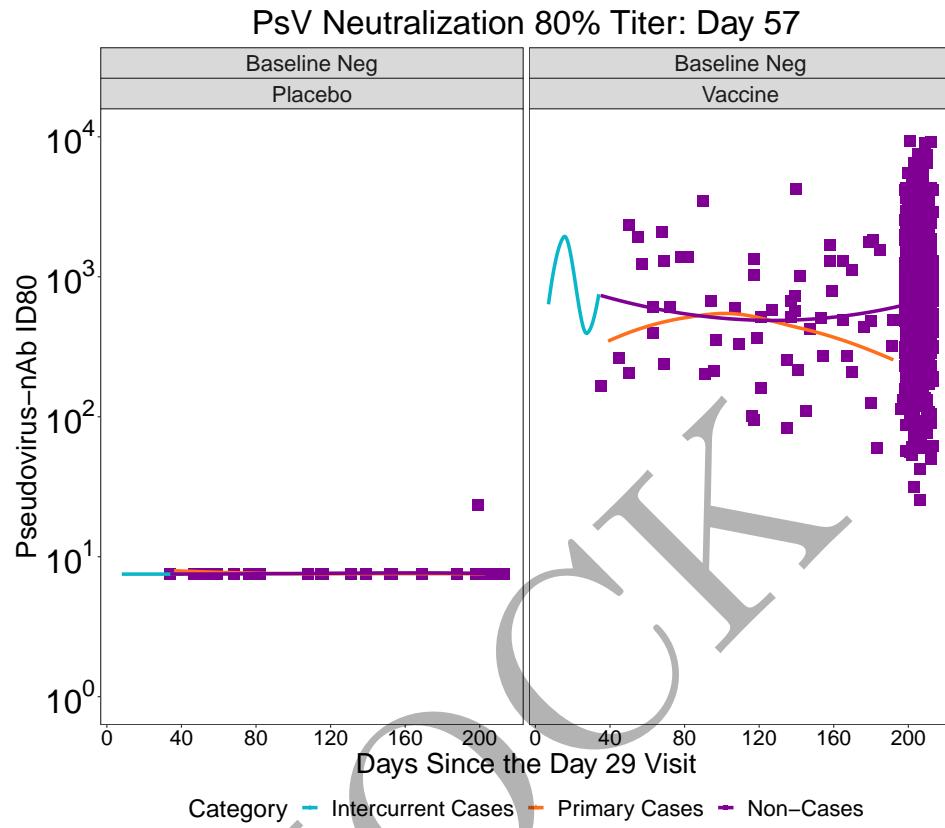


Figure 3.285: scatterplots of Pseudovirus Neutralization ID80 vs Days Since the Day 29 Visit: by arm at day 57

Chapter 4

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.

4.1 Hazard ratios

Table 4.1: 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*

MockCOVE 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)	52/11,117	0.21	(0.12-0.37)	<0.001	<0.001	<0.001
Anti RBD IgG (IU/ml)	52/11,117	0.43	(0.25-0.74)	0.003	<0.001	<0.001
Pseudovirus-nAb ID50	52/11,117	0.32	(0.17-0.60)	<0.001	<0.001	<0.001
Pseudovirus-nAb ID80	52/11,117	0.35	(0.19-0.64)	<0.001	<0.001	<0.001

*Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not. Maximum failure event time 164 days.

**No. at-risk = estimated number in the population for analysis: baseline negative per-protocol vaccine recipients not experiencing the COVID endpoint through 6 days post Day 57 visit; no. cases = number of this cohort with an observed COVID endpoint.

***q-value and FWER (family-wide error rate) are computed over the set of p-values both for quantitative markers and categorical markers using the Westfall and Young permutation method (5 replicates).

Table 4.2: 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*

MockCOVE Immunologic Marker	Tertile	No. cases / No. at-risk**	Attack rate	Pt. Est.	Haz. Ratio 95% CI	P-value (2-sided)	Overall P- value***	Overall q- value †	Overall FWER
Anti Spike IgG (IU/ml)	Lower	27/4,235	0.0064	1	N/A	N/A	<0.001	<0.001	<0.001
	Middle	18/4,243	0.0042	0.30	(0.16-0.59)	<0.001			
	Upper	7/2,638	0.0027	0.08	(0.03-0.21)	<0.001			
Anti RBD IgG (IU/ml)	Lower	24/4,242	0.0057	1	N/A	N/A	0.003	<0.001	<0.001
	Middle	14/4,209	0.0033	0.33	(0.15-0.71)	0.005			
	Upper	14/2,666	0.0053	0.29	(0.13-0.64)	0.002			
Pseudovirus-nAb ID50	Lower	18/3,697	0.0049	1	N/A	N/A	0.036	<0.001	<0.001
	Middle	20/3,701	0.0054	0.80	(0.39-1.64)	0.546			
	Upper	14/3,719	0.0038	0.36	(0.16-0.82)	0.015			
Pseudovirus-nAb ID80	Lower	22/3,724	0.0059	1	N/A	N/A	0.009	<0.001	<0.001
	Middle	20/3,707	0.0054	0.66	(0.35-1.27)	0.217			
	Upper	10/3,687	0.0027	0.29	(0.13-0.64)	0.002			
Placebo		953/11,217	0.0850						

*Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not. Maximum failure event time 164 days. Cutpoints: Anti Spike IgG (IU/ml) [3.34, 4.01], Anti RBD IgG (IU/ml) [3.48, 4.21], Pseudovirus-nAb ID50 [2.37, 2.86], Pseudovirus-nAb ID80 [2.58, 2.96], all on the log10 scale.

**No. at-risk = estimated number in the population for analysis: baseline negative per-protocol vaccine recipients not experiencing the COVID endpoint through 6 days post Day 57 visit; no. cases = number of this cohort with an observed COVID endpoint.

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

† q-value and FWER (family-wide error rate) are computed over the set of p-values both for quantitative markers and categorical markers using the Westfall and Young permutation method (5 replicates).

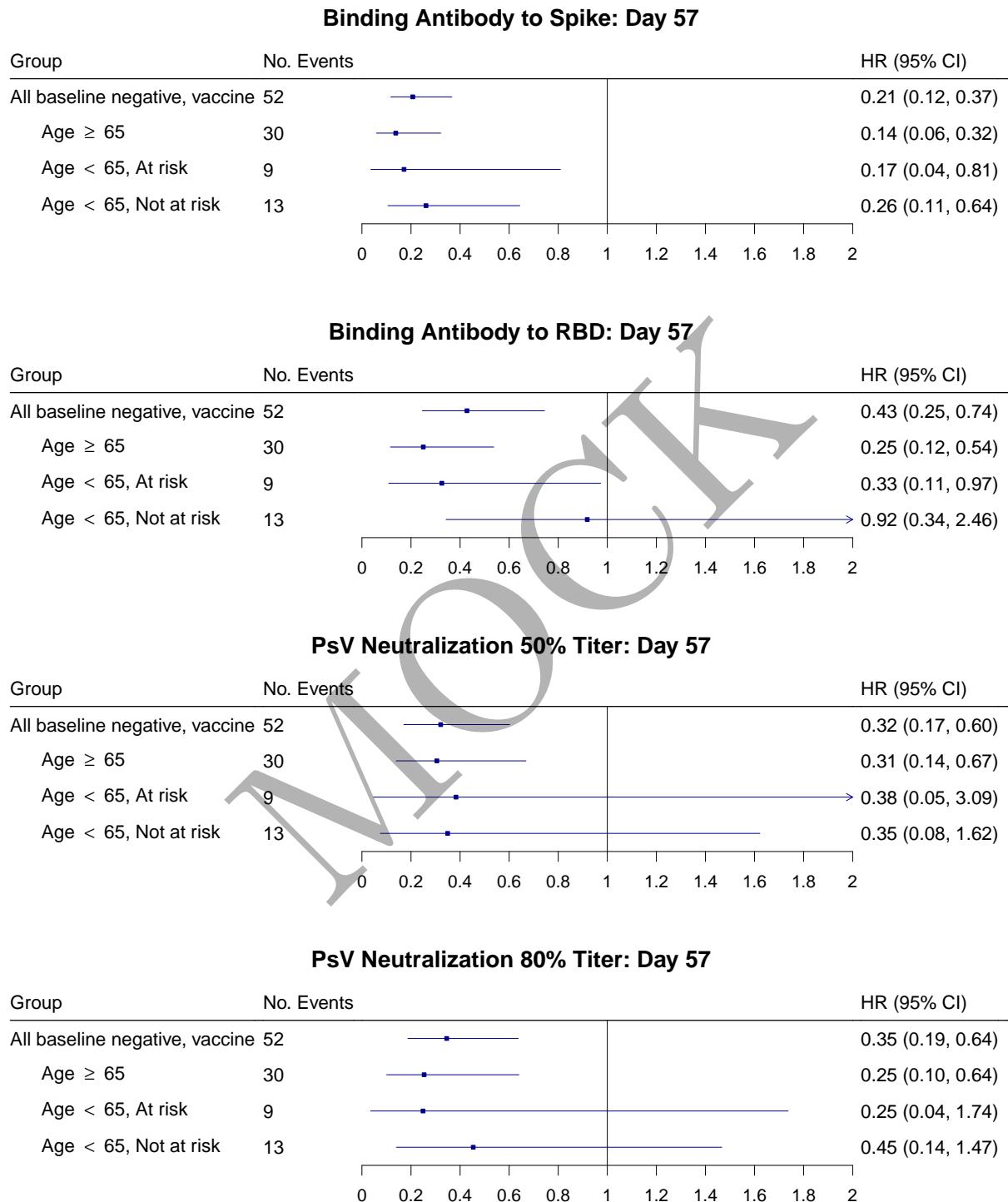


Figure 4.1: Forest plots of hazard ratios per 10-fold increase in the marker among baseline negative vaccine recipients and subgroups with 95% point-wise confidence intervals.

Binding Antibody to Spike: Day 57

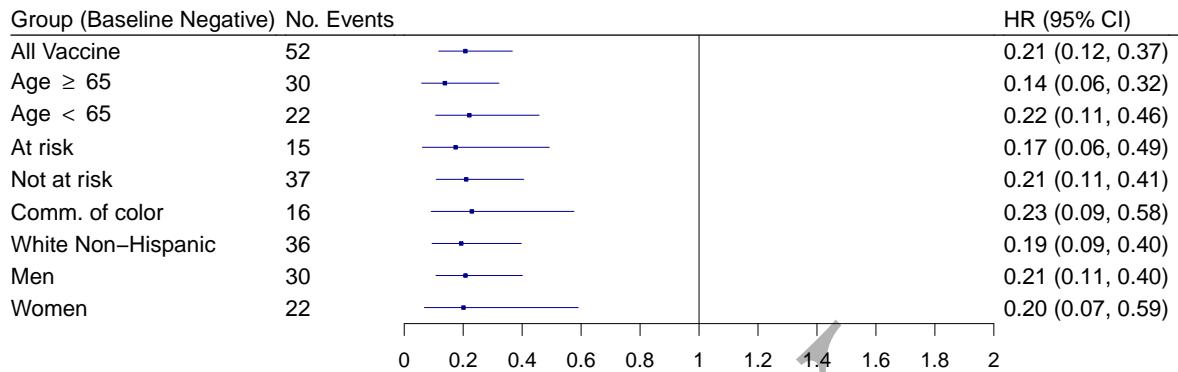


Figure 4.2: Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to spike markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

Binding Antibody to RBD: Day 57

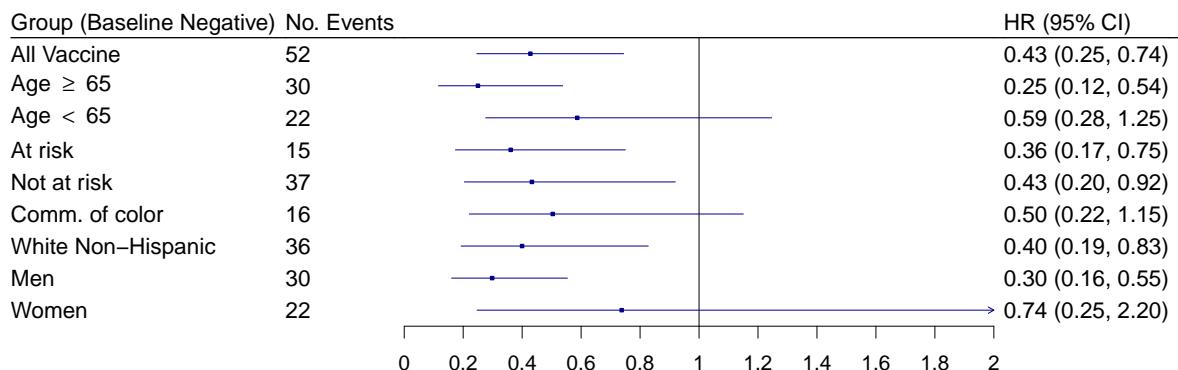


Figure 4.3: Forest plots of hazard ratios per 10-fold increase in the Day 57 binding Ab to RBD markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

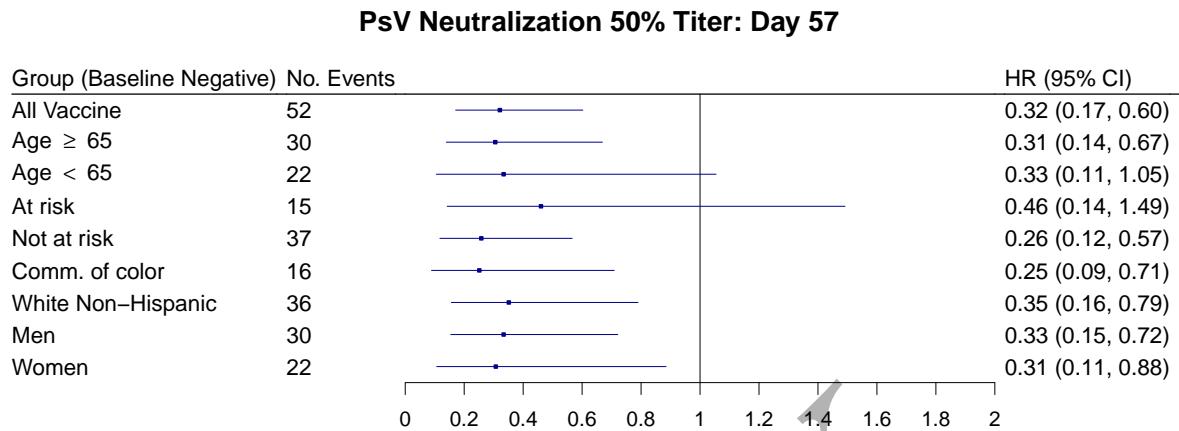


Figure 4.4: Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID50 markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

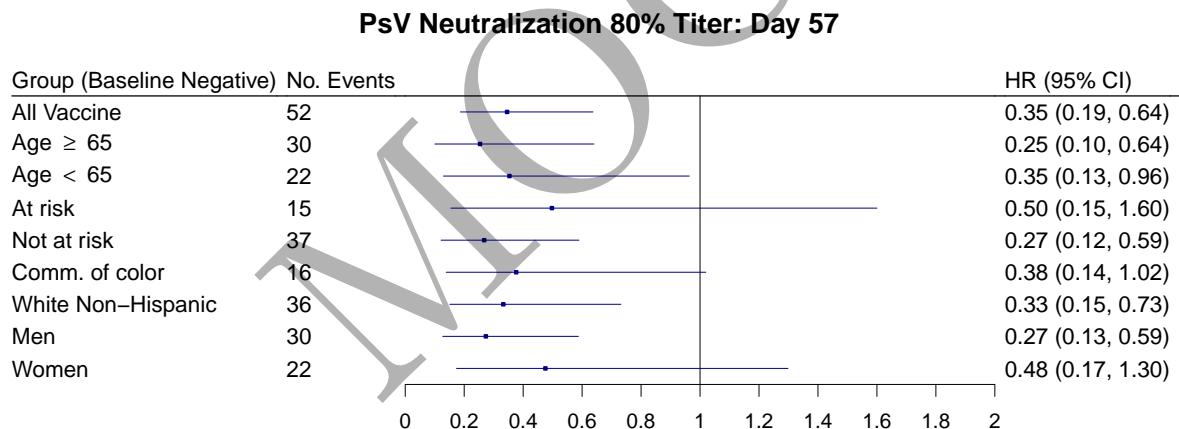


Figure 4.5: Forest plots of hazard ratios per 10-fold increase in the Day 57 pseudo neut ID80 markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

4.2 Marginalized risk and controlled vaccine efficacy plots

MOCK

Table 4.3: Analysis of Day 57 markers (upper vs. lower tertile) as a CoR and a controlled risk CoP.

	marginalized risk		controlled risk			
	ratio $RR_M(0, 1)$	Point Est.	ratio $RR_C(0, 1)^1$	Point Est.	e(0,1) ²	95% CI UL
	95% CI		95% CI	Point Est.	95% CI	UL
Anti Spike IgG (IU/ml)	0.09	0.05–0.14	0.11	0.07–0.18	22.8	14.2
Anti RBD IgG (IU/ml)	0.29	0.27–0.38	0.39	0.36–0.51	6.3	4.7
Pseudovirus-nAb ID50	0.37	0.25–0.48	0.49	0.33–0.65	4.9	3.5
Pseudovirus-nAb ID80	0.29	0.13–0.66	0.39	0.18–0.88	6.3	2.4

¹Conservative (upper bound) estimate assuming unmeasured confounding at level $RR_{UD}(0, 1) = RR_{EU}(0, 1) = 2$ and thus $B(0, 1) = 4/3$.

²E-values are computed for upper tertile ($s = 1$) vs. lower tertile ($s = 0$) biomarker subgroups after controlling for baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not; UL = upper limit.

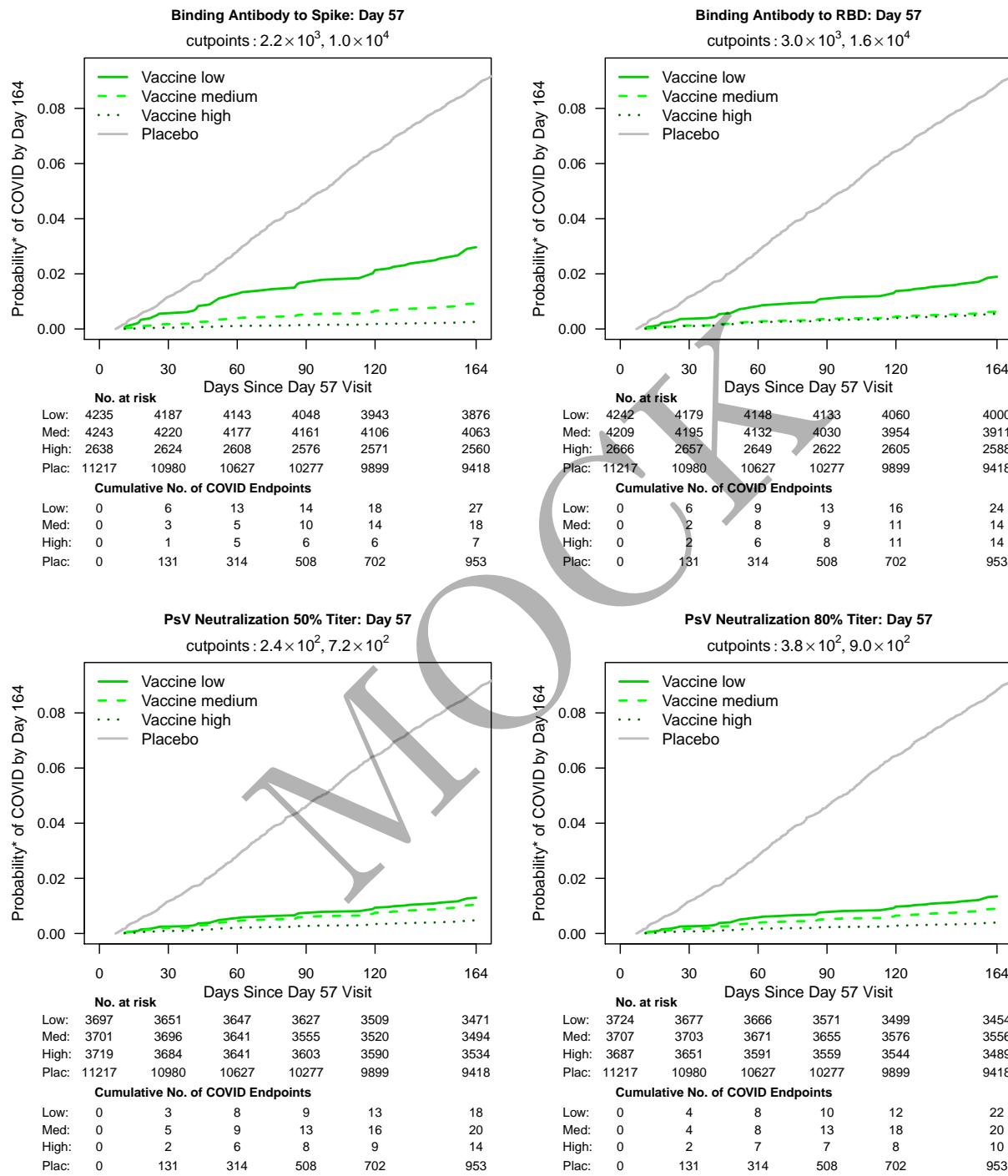


Figure 4.6: Marginalized cumulative incidence rate curves for trichotomized Day 57 markers among baseline negative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.

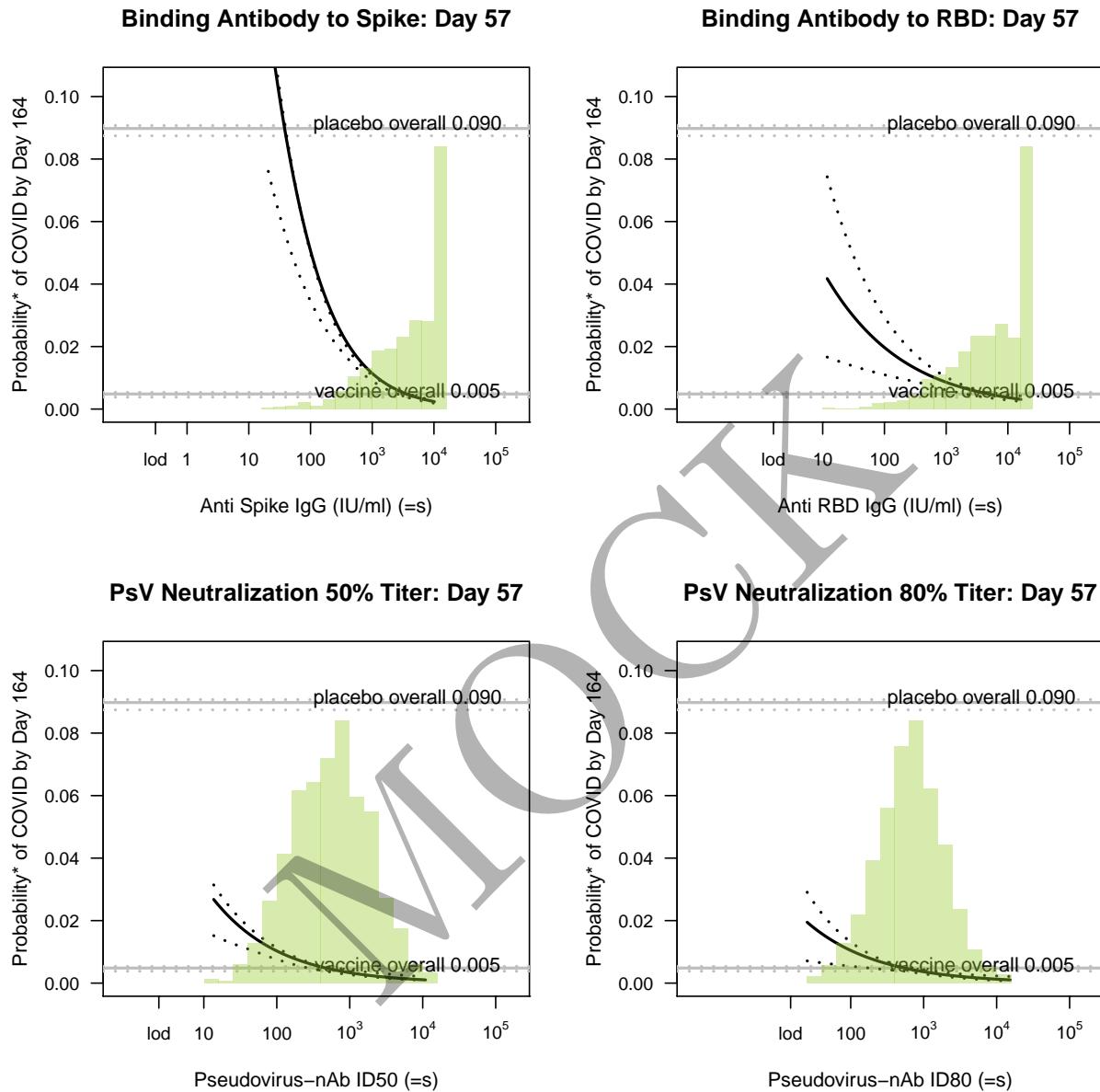


Figure 4.7: Marginalized cumulative risk by Day 164 as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 164 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

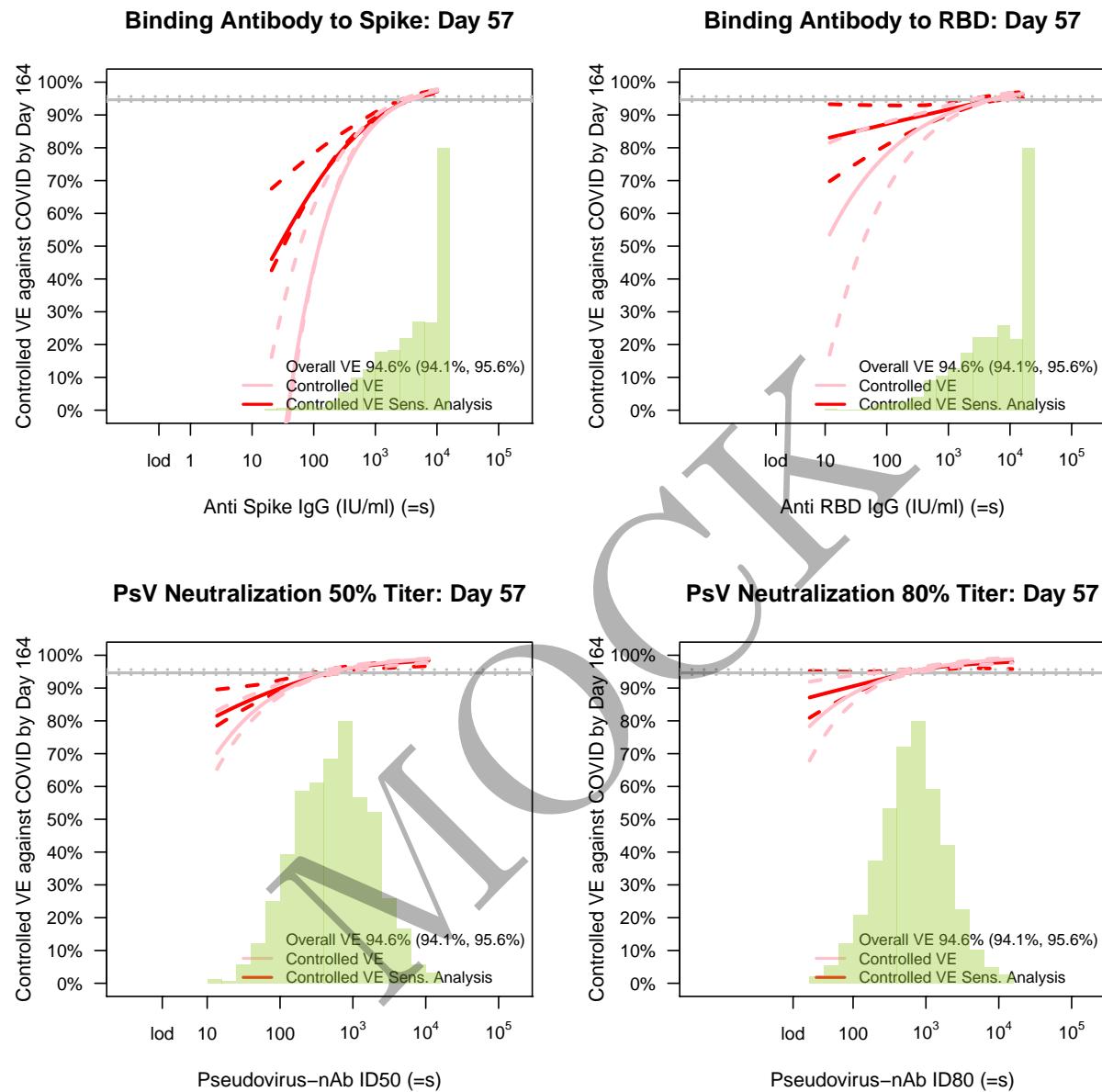


Figure 4.8: Controlled VE with sensitivity analysis as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

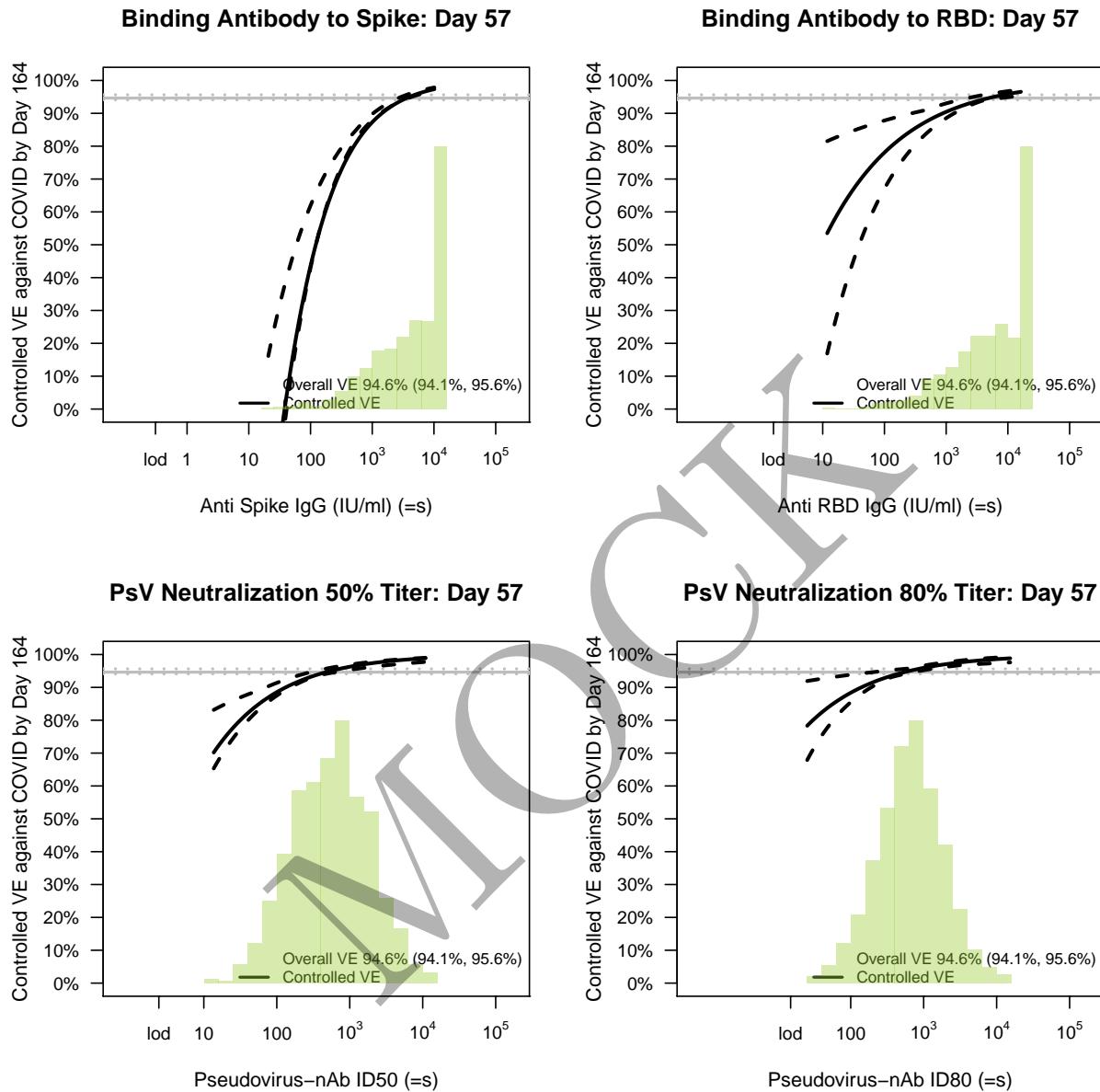


Figure 4.9: Controlled VE with sensitivity analysis as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

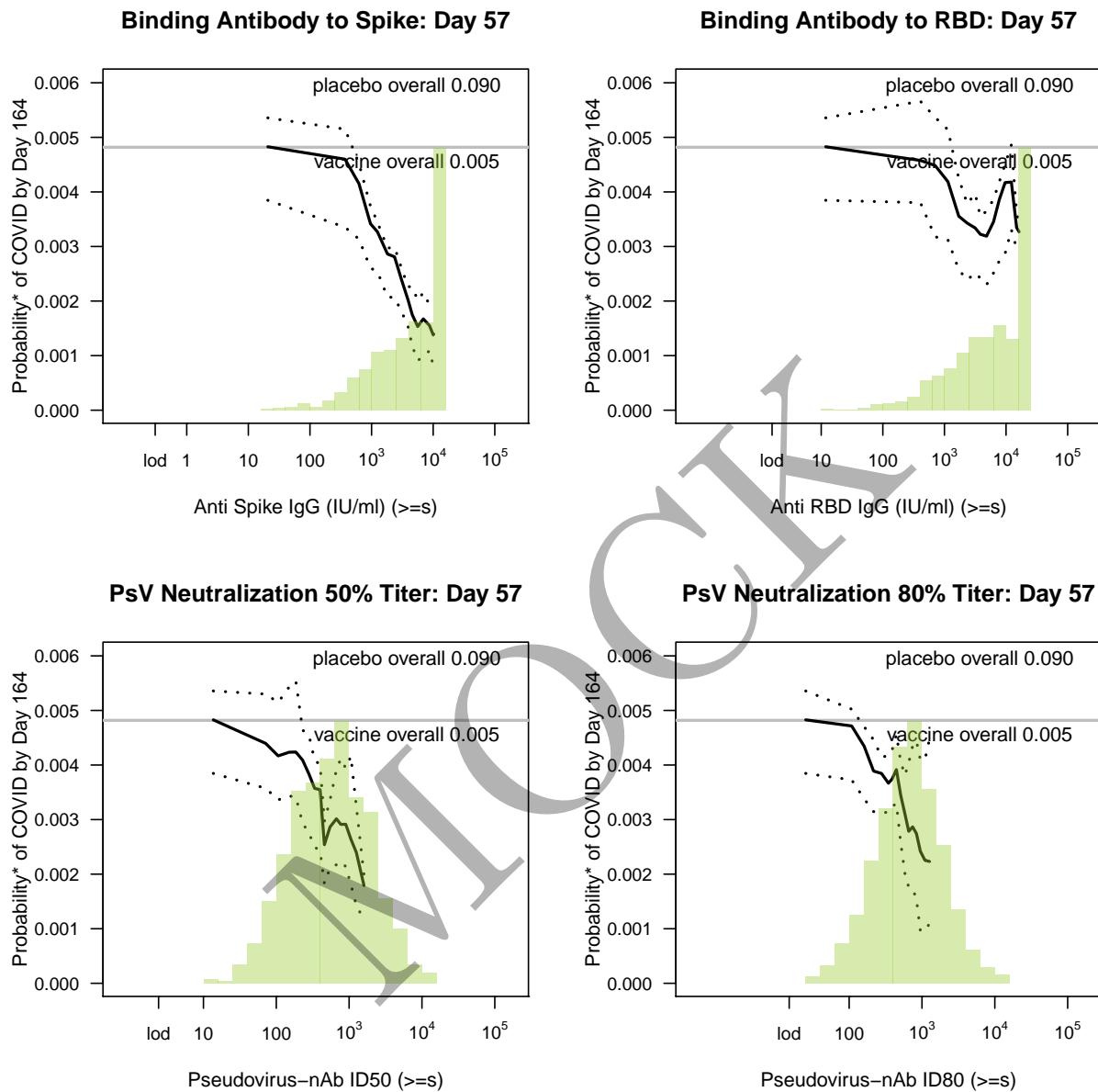


Figure 4.10: Marginalized cumulative risk by Day 164 as functions of Day 57 markers above a threshold ($\geq s$) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required, 5 replicates). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 164 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. $l_{od} = 0.3, 1.6, 2.4, 15$ for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

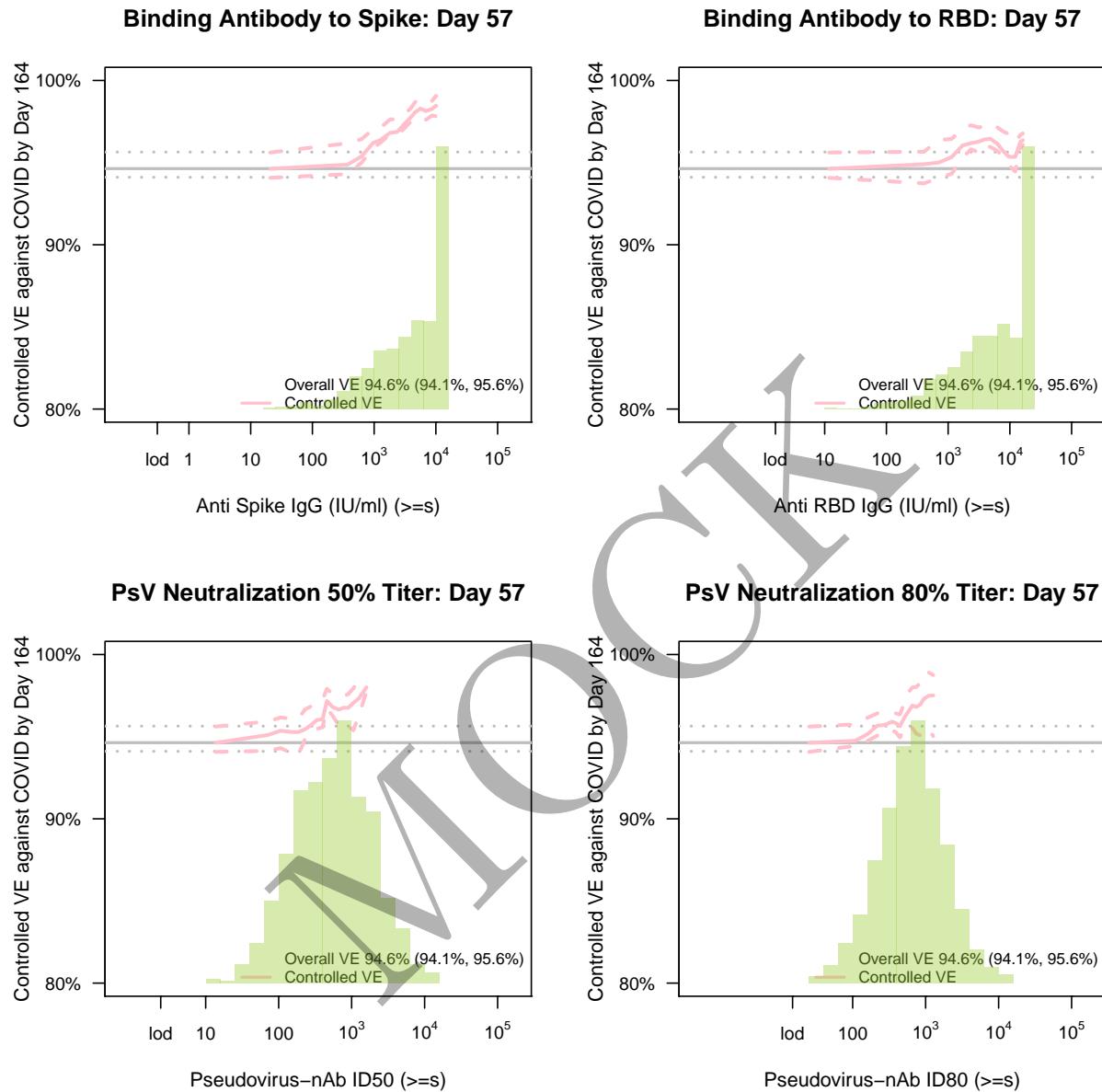


Figure 4.11: Controlled VE as functions of Day 57 markers ($\geq s$) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

Table 4.4: Marginalized cumulative risk by Day 164 as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

	Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80
s	Estimate	s	Estimate	s	Estimate	s	Estimate
20.7	.1251 (.0761,.1297)	11.8	.0417 (.0166,.0743)	13.7	.0268 (.0152,.0314)	25.3	.0195 (.0071,.0291)
500	.0181 (.0141,.0166)	500	.0110 (.0077,.0141)	113	.0097 (.0072,.0106)	166	.0083 (.0049,.0098)
653	.0152 (.0119,.0141)	763	.0095 (.0067,.0116)	150	.0084 (.0063,.0092)	216	.0074 (.0046,.0084)
960	.0117 (.0092,.0111)	1000	.0086 (.0061,.0103)	191	.0075 (.0057,.0081)	285	.0065 (.0044,.0072)
1000	.0114 (.0090,.0108)	1139	.0082 (.0059,.0097)	330	.0057 (.0044,.0061)	440	.0053 (.0040,.0058)
1297	.0096 (.0076,.0092)	1817	.0069 (.0050,.0078)	454	.0049 (.0038,.0054)	500	.0050 (.0039,.0055)
2957	.0055 (.0044,.0056)	3607	.0054 (.0040,.0057)	500	.0047 (.0037,.0052)	581	.0047 (.0038,.0052)
4553	.0041 (.0033,.0044)	6262	.0044 (.0033,.0050)	673	.0041 (.0032,.0048)	749	.0042 (.0034,.0048)
6937	.0031 (.0025,.0035)	9688	.0037 (.0029,.0046)	909	.0035 (.0028,.0043)	958	.0037 (.0030,.0044)
10145	.0024 (.0019,.0028)	15353	.0032 (.0025,.0042)	1000	.0033 (.0027,.0042)	1000	.0036 (.0030,.0043)
10156	.0024 (.0019,.0028)	16269	.0031 (.0024,.0042)	1491	.0027 (.0022,.0037)	1452	.0031 (.0025,.0038)
10156	.0024 (.0019,.0028)	16269	.0031 (.0024,.0042)	2027	.0024 (.0020,.0034)	1840	.0028 (.0022,.0035)
10156	.0024 (.0019,.0028)	16269	.0031 (.0024,.0042)	2440	.0022 (.0018,.0032)	2349	.0025 (.0019,.0032)
10156	.0024 (.0019,.0028)	16269	.0031 (.0024,.0042)	10919	.0010 (.0009,.0020)	15368	.0010 (.0006,.0021)

Table 4.5: Controlled VE as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80	
s	Estimate	s	Estimate	s	Estimate	s	Estimate
20.7	-0.3935 (-0.4817,.1615)	11.8	.5350 (.1689,.8152)	13.7	.7018 (.6532,.8314)	25.3	.7832 (.6788,.9193)
500	.7986 (.8099,.8409)	500	.8771 (.8420,.9124)	113	.8922 (.8829,.9183)	166	.9075 (.8918,.9442)
653	.8312 (.8424,.8654)	763	.8945 (.8700,.9236)	150	.9060 (.8990,.9278)	216	.9181 (.9072,.9471)
960	.8694 (.8761,.8951)	1000	.9044 (.8853,.9301)	191	.9164 (.9109,.9352)	285	.9278 (.9209,.9501)
1000	.8729 (.8792,.8978)	1139	.9088 (.8920,.9331)	330	.9360 (.9330,.9494)	440	.9408 (.9360,.9544)
1297	.8932 (.8971,.9137)	1817	.9231 (.9130,.9426)	454	.9452 (.9404,.9562)	500	.9442 (.9389,.9556)
2957	.9387 (.9377,.9502)	3607	.9401 (.9366,.9543)	500	.9478 (.9422,.9581)	581	.9479 (.9422,.9569)
4553	.9542 (.9513,.9628)	6262	.9511 (.9443,.9619)	673	.9548 (.9473,.9633)	749	.9536 (.9471,.9613)
6937	.9656 (.9617,.9720)	9688	.9583 (.9488,.9670)	909	.9610 (.9520,.9680)	958	.9586 (.9514,.9655)
10145	.9734 (.9691,.9787)	15353	.9648 (.9532,.9718)	1000	.9628 (.9533,.9694)	1000	.9594 (.9521,.9663)
10156	.9734 (.9692,.9787)	16269	.9655 (.9538,.9723)	1491	.9694 (.9588,.9744)	1452	.9658 (.9579,.9721)
10156	.9734 (.9692,.9787)	16269	.9655 (.9538,.9723)	2027	.9737 (.9625,.9778)	1840	.9693 (.9612,.9752)
10156	.9734 (.9692,.9787)	16269	.9655 (.9538,.9723)	2440	.9760 (.9645,.9796)	2349	.9726 (.9642,.9781)
10156	.9734 (.9692,.9787)	16269	.9655 (.9538,.9723)	10919	.9885 (.9774,.9901)	15368	.9885 (.9759,.9928)
209.7	.6456 (.6525,.7431)	26.4	.6483 (.4079,.8420)	(,)	(,)	(,)	(,)
1459	.9013 (.9043,.9200)	877	.8998 (.8781,.9271)	136	.9012 (.8934,.9244)	136	.8988 (.8787,.9420)
3972	.9498 (.9474,.9592)	5855	.9498 (.9435,.9610)	560	.9506 (.9442,.9601)	644	.9503 (.9443,.9585)

Table 4.6: Controlled VE with sensitivity analysis as functions of Day 57 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80	
s	Estimate	s	Estimate	s	Estimate	s	Estimate
20.7	.4603 (.4261,.6752)	11.8	.8310 (.6978,.9328)	13.7	.8152 (.7852,.8956)	25.3	.8713 (.8094,.9521)
500	.8387 (.8478,.8726)	500	.9035 (.8759,.9312)	113	.9037 (.8954,.9270)	166	.9178 (.9038,.9504)
653	.8583 (.8677,.8870)	763	.9115 (.8909,.9359)	150	.9131 (.9066,.9332)	216	.9242 (.9142,.9511)
960	.8835 (.8895,.9064)	1000	.9166 (.8999,.9391)	191	.9207 (.9155,.9385)	285	.9308 (.9242,.9522)
1000	.8860 (.8917,.9083)	1139	.9190 (.9041,.9406)	330	.9367 (.9338,.9500)	440	.9413 (.9365,.9547)
1297	.9008 (.9044,.9198)	1817	.9278 (.9184,.9462)	454	.9453 (.9404,.9562)	500	.9443 (.9391,.9557)
2957	.9389 (.9380,.9504)	3607	.9407 (.9372,.9547)	500	.9478 (.9422,.9581)	581	.9479 (.9422,.9569)
4553	.9541 (.9512,.9626)	6262	.9510 (.9442,.9618)	673	.9546 (.9470,.9631)	749	.9533 (.9468,.9610)
6937	.9646 (.9606,.9712)	9688	.9575 (.9478,.9663)	909	.9602 (.9509,.9673)	958	.9576 (.9503,.9647)
10145	.9716 (.9670,.9772)	15353	.9627 (.9505,.9701)	1000	.9617 (.9520,.9685)	1000	.9583 (.9508,.9654)
10156	.9716 (.9670,.9772)	16269	.9632 (.9507,.9705)	1491	.9674 (.9559,.9727)	1452	.9634 (.9549,.9701)
10156	.9716 (.9670,.9772)	16269	.9632 (.9507,.9705)	2027	.9709 (.9584,.9754)	1840	.9660 (.9570,.9725)
10156	.9716 (.9670,.9772)	16269	.9632 (.9507,.9705)	2440	.9728 (.9598,.9768)	2349	.9684 (.9587,.9747)
10156	.9716 (.9670,.9772)	16269	.9632 (.9507,.9705)	10919	.9833 (.9671,.9856)	15368	.9798 (.9580,.9875)
209.7	.6456 (.6525,.7431)	26.4	.6483 (.4079,.8420)	(,)	(,)	(,)	(,)
1459	.9013 (.9043,.9200)	877	.8998 (.8781,.9271)	136	.9012 (.8934,.9244)	136	.8988 (.8787,.9420)
3972	.9498 (.9474,.9592)	5855	.9498 (.9435,.9610)	560	.9506 (.9442,.9601)	644	.9503 (.9443,.9585)

Chapter 5

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.

5.1 Hazard ratios

Table 5.1: 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*

MockCOVE 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)	60/11,157	0.30	(0.17-0.54)	<0.001	<0.001	<0.001
Anti RBD IgG (IU/ml)	60/11,157	0.50	(0.30-0.85)	0.010	<0.001	<0.001
Pseudovirus-nAb ID50	60/11,157	0.43	(0.21-0.85)	0.016	<0.001	<0.001
Pseudovirus-nAb ID80	60/11,157	0.35	(0.19-0.68)	0.002	<0.001	<0.001

*Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not. Maximum failure event time 192 days.

**No. at-risk = estimated number in the population for analysis: baseline negative per-protocol vaccine recipients not experiencing the COVID endpoint through 6 days post Day 29 visit; no. cases = number of this cohort with an observed COVID endpoint.

***q-value and FWER (family-wide error rate) are computed over the set of p-values both for quantitative markers and categorical markers using the Westfall and Young permutation method (5 replicates).

Table 5.2: 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*

MockCOVE Immunologic Marker	Tertile	No. cases / No. at-risk**	Attack rate	Pt. Est.	Haz. Ratio 95% CI	P-value (2-sided)	Overall P- value***	Overall q- value †	Overall FWER
Anti Spike IgG (IU/ml)	Lower	20/3,702	0.0054	1	N/A	N/A	0.004	<0.001	<0.001
	Middle	19/3,705	0.0051	0.57	(0.28-1.16)	0.120			
	Upper	20/3,750	0.0053	0.26	(0.11-0.57)	<0.001			
Anti RBD IgG (IU/ml)	Lower	26/3,722	0.0070	1	N/A	N/A	0.001	<0.001	<0.001
	Middle	13/3,740	0.0035	0.33	(0.16-0.67)	0.002			
	Upper	20/3,695	0.0054	0.29	(0.14-0.61)	0.001			
Pseudovirus-nAb ID50	Lower	20/3,690	0.0054	1	N/A	N/A	0.053	<0.001	<0.001
	Middle	23/3,749	0.0061	0.97	(0.50-1.90)	0.938			
	Upper	16/3,718	0.0043	0.45	(0.21-0.96)	0.038			
Pseudovirus-nAb ID80	Lower	20/3,754	0.0053	1	N/A	N/A	0.028	<0.001	<0.001
	Middle	26/3,719	0.0070	1.15	(0.61-2.17)	0.675			
	Upper	13/3,685	0.0035	0.45	(0.21-0.96)	0.038			
Placebo		1112/11,426	0.0973						

*Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not. Maximum failure event time 192 days. Cutpoints: Anti Spike IgG (IU/ml) [2.14, 2.65], Anti RBD IgG (IU/ml) [2.37, 2.98], Pseudovirus-nAb ID50 [1.07, 1.45], Pseudovirus-nAb ID80 [1.26, 1.61], all on the log10 scale.

**No. at-risk = estimated number in the population for analysis: baseline negative per-protocol vaccine recipients not experiencing the COVID endpoint through 6 days post Day 29 visit; no. cases = number of this cohort with an observed COVID endpoint.

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

† q-value and FWER (family-wide error rate) are computed over the set of p-values both for quantitative markers and categorical markers using the Westfall and Young permutation method (5 replicates).

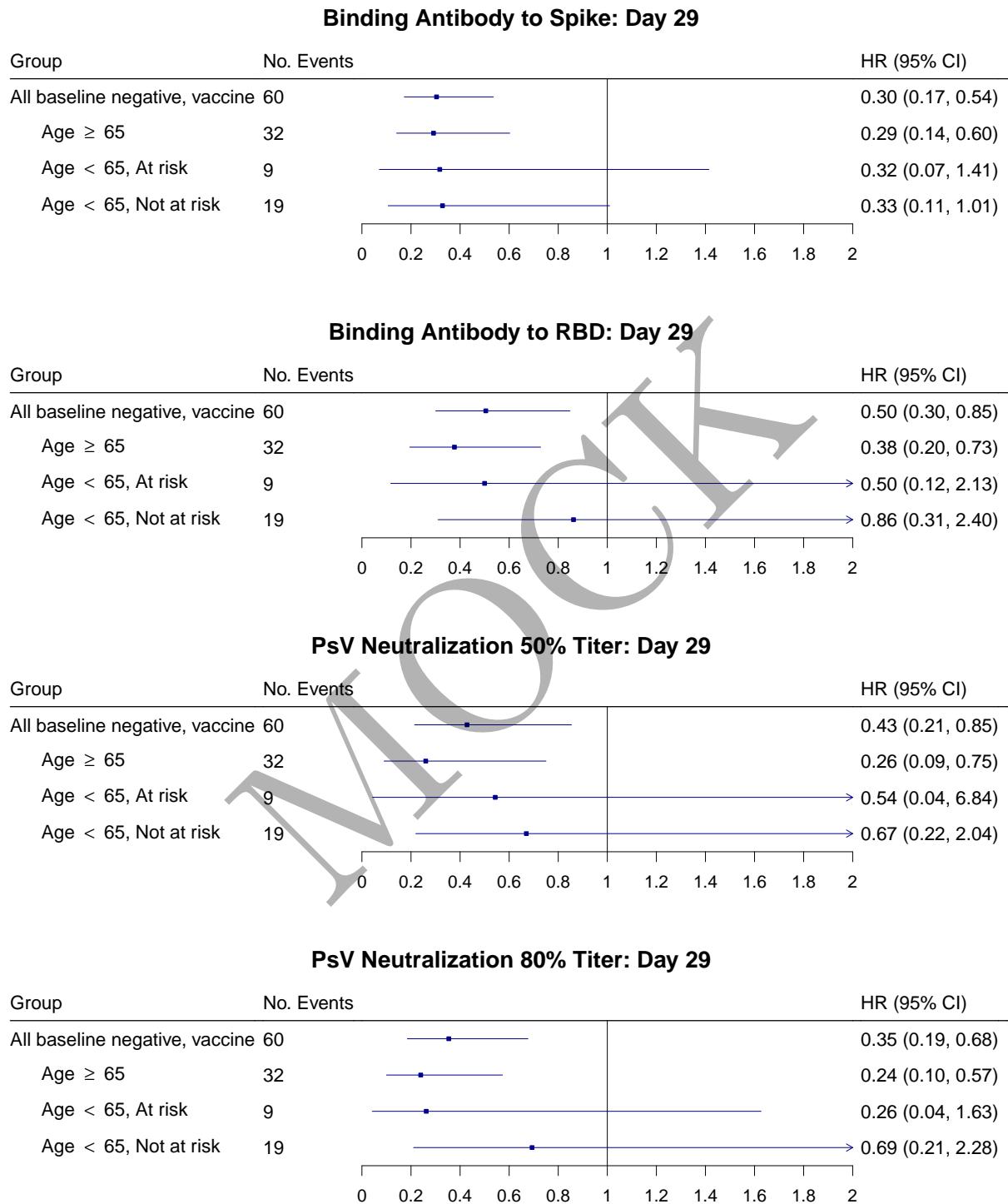


Figure 5.1: Forest plots of hazard ratios per 10-fold increase in the marker among baseline negative vaccine recipients and subgroups with 95% point-wise confidence intervals.

Binding Antibody to Spike: Day 29

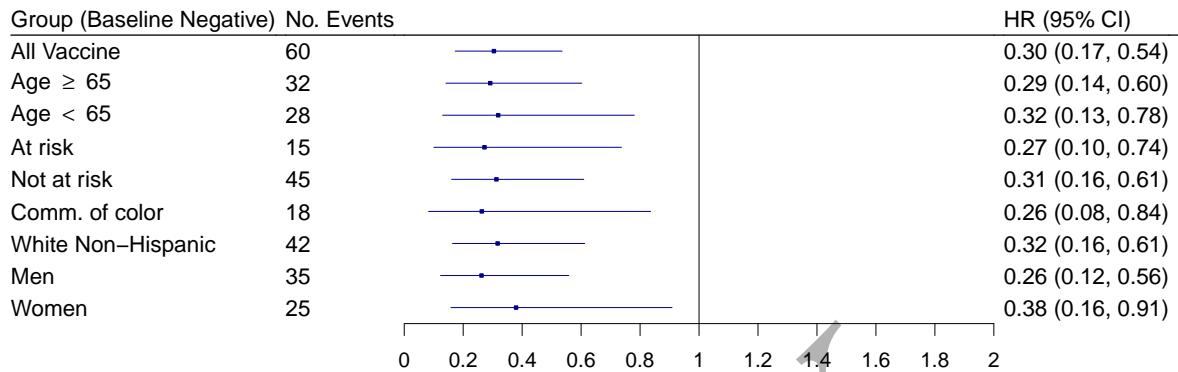


Figure 5.2: Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to spike markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

Binding Antibody to RBD: Day 29

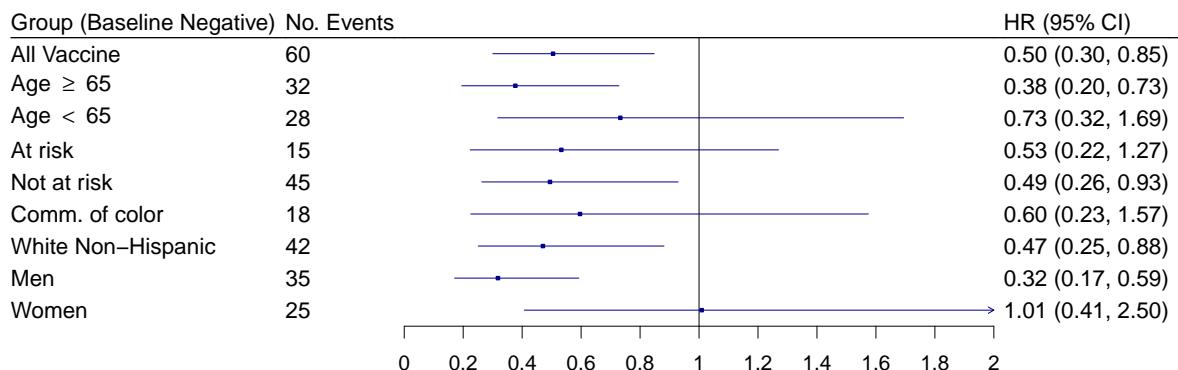


Figure 5.3: Forest plots of hazard ratios per 10-fold increase in the Day 29 binding Ab to RBD markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

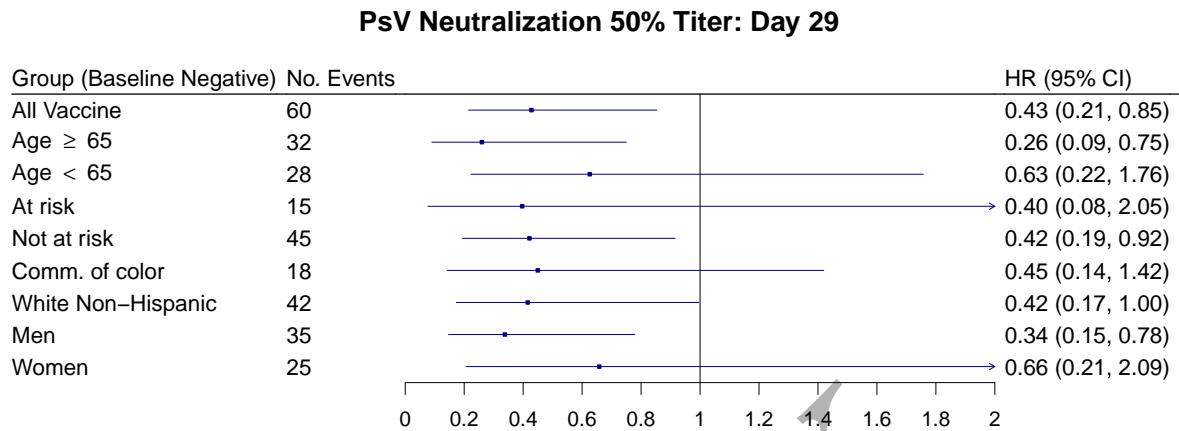


Figure 5.4: Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID50 markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

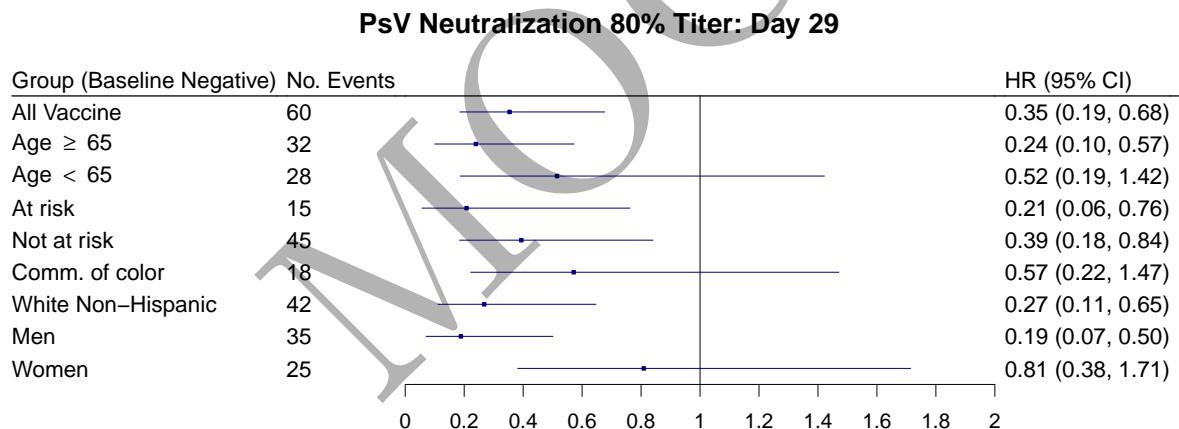


Figure 5.5: Forest plots of hazard ratios per 10-fold increase in the Day 29 pseudo neut ID80 markers among baseline negative vaccine recipients (top row) and eight subpopulations (row 2-9) with 95% point-wise confidence intervals.

5.2 Marginalized risk and controlled vaccine efficacy plots

MOCK

Table 5.3: Analysis of Day 29 markers (upper vs. lower tertile) as a CoR and a controlled risk CoP.

	marginalized risk		controlled risk			
	ratio $RR_M(0,1)$	Point Est. 95% CI	ratio $RR_C(0,1)^1$	Point Est. 95% CI	e(0,1) ²	Point Est. 95% CI UL
Anti Spike IgG (IU/ml)	0.26	0.13–0.70	0.35	0.17–0.94	7.2	2.2
Anti RBD IgG (IU/ml)	0.29	0.17–0.50	0.39	0.23–0.67	6.3	3.4
Pseudovirus-nAb ID50	0.45	0.28–0.65	0.61	0.37–0.87	3.8	2.4
Pseudovirus-nAb ID80	0.45	0.30–0.84	0.60	0.40–1.13	3.9	1.7

¹Conservative (upper bound) estimate assuming unmeasured confounding at level $RR_{UD}(0,1) = RR_{EU}(0,1) = 2$ and thus $B(0,1) = 4/3$.

²E-values are computed for upper tertile ($s = 1$) vs. lower tertile ($s = 0$) biomarker subgroups after controlling for baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not; UL = upper limit.

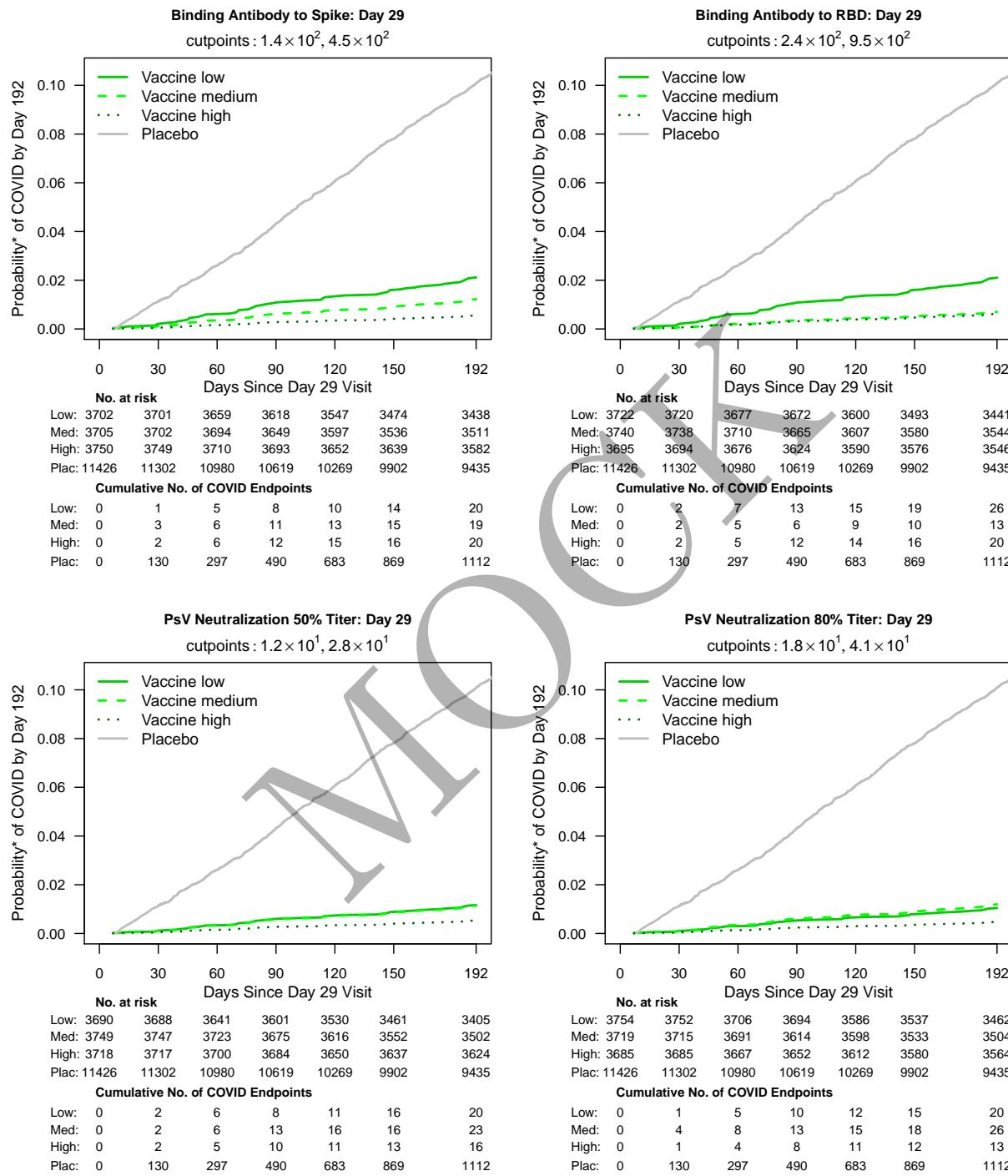


Figure 5.6: Marginalized cumulative incidence rate curves for trichotomized Day 29 markers among baseline negative vaccine recipients. The gray line is the overall cumulative incidence rate curve in the placebo arm.

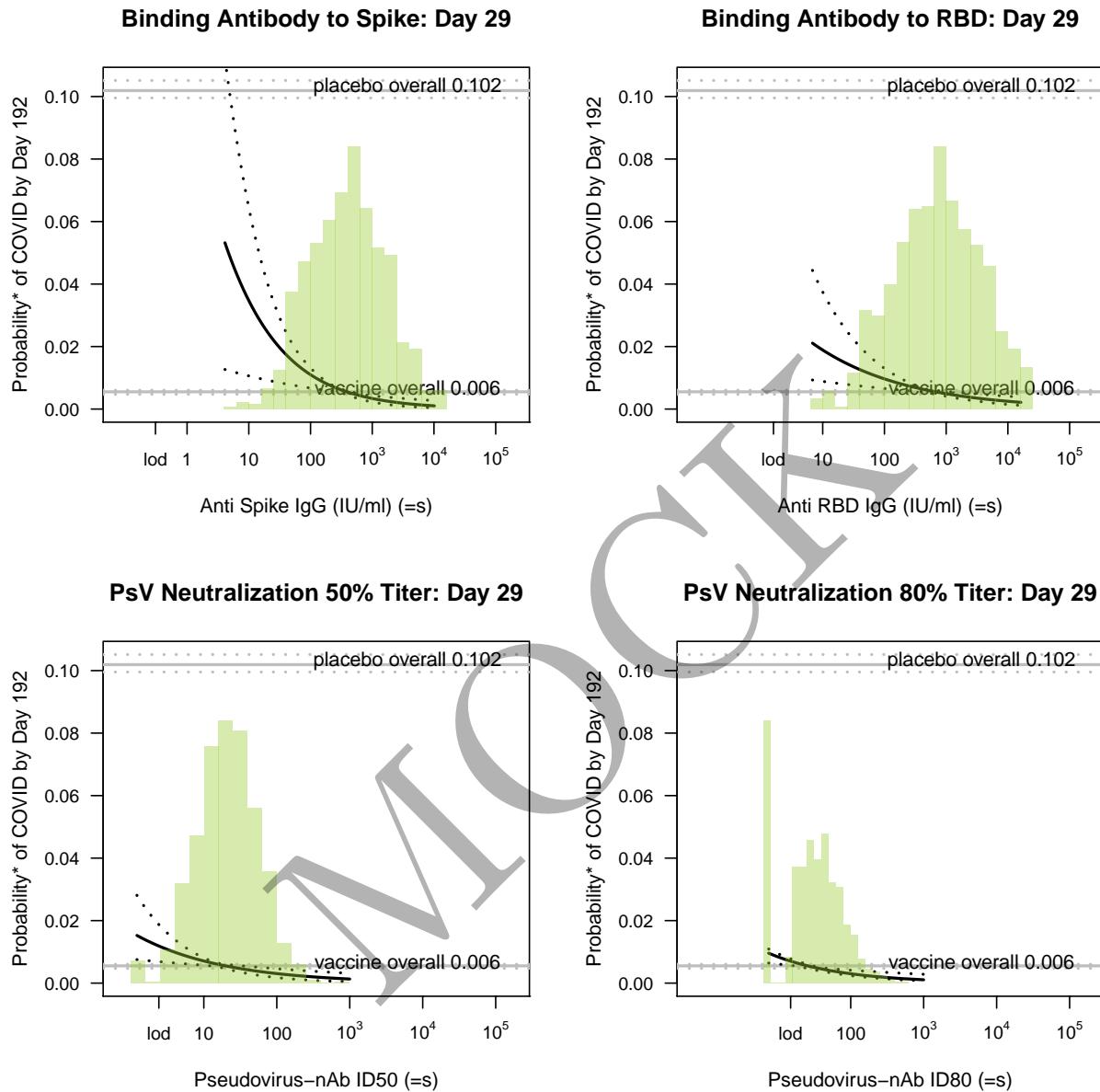


Figure 5.7: Marginalized cumulative risk by Day 192 as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). The horizontal lines indicate the overall cumulative risk of the placebo and vaccine arms by Day 192 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

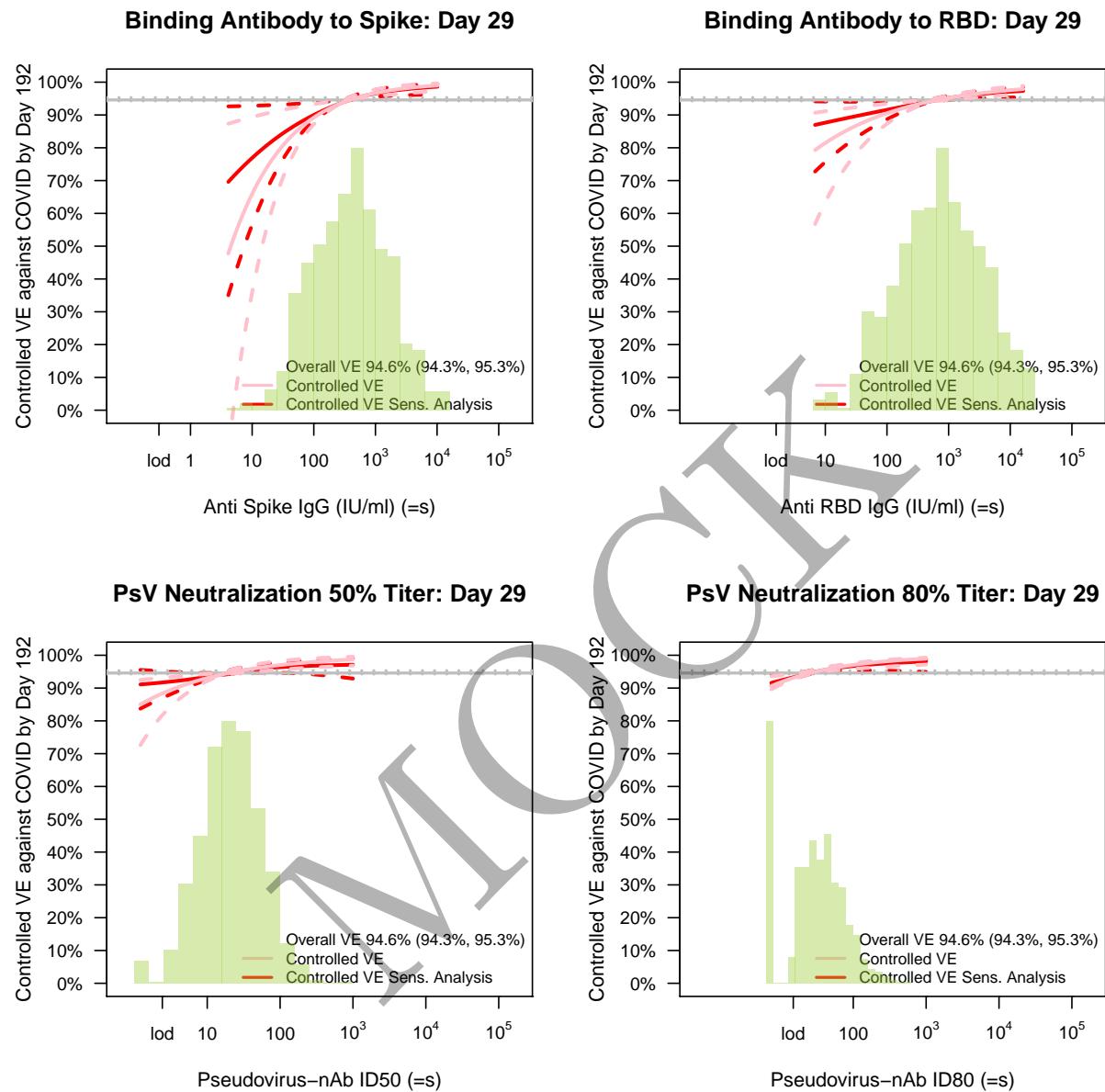


Figure 5.8: Controlled VE with sensitivity analysis as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. Iod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

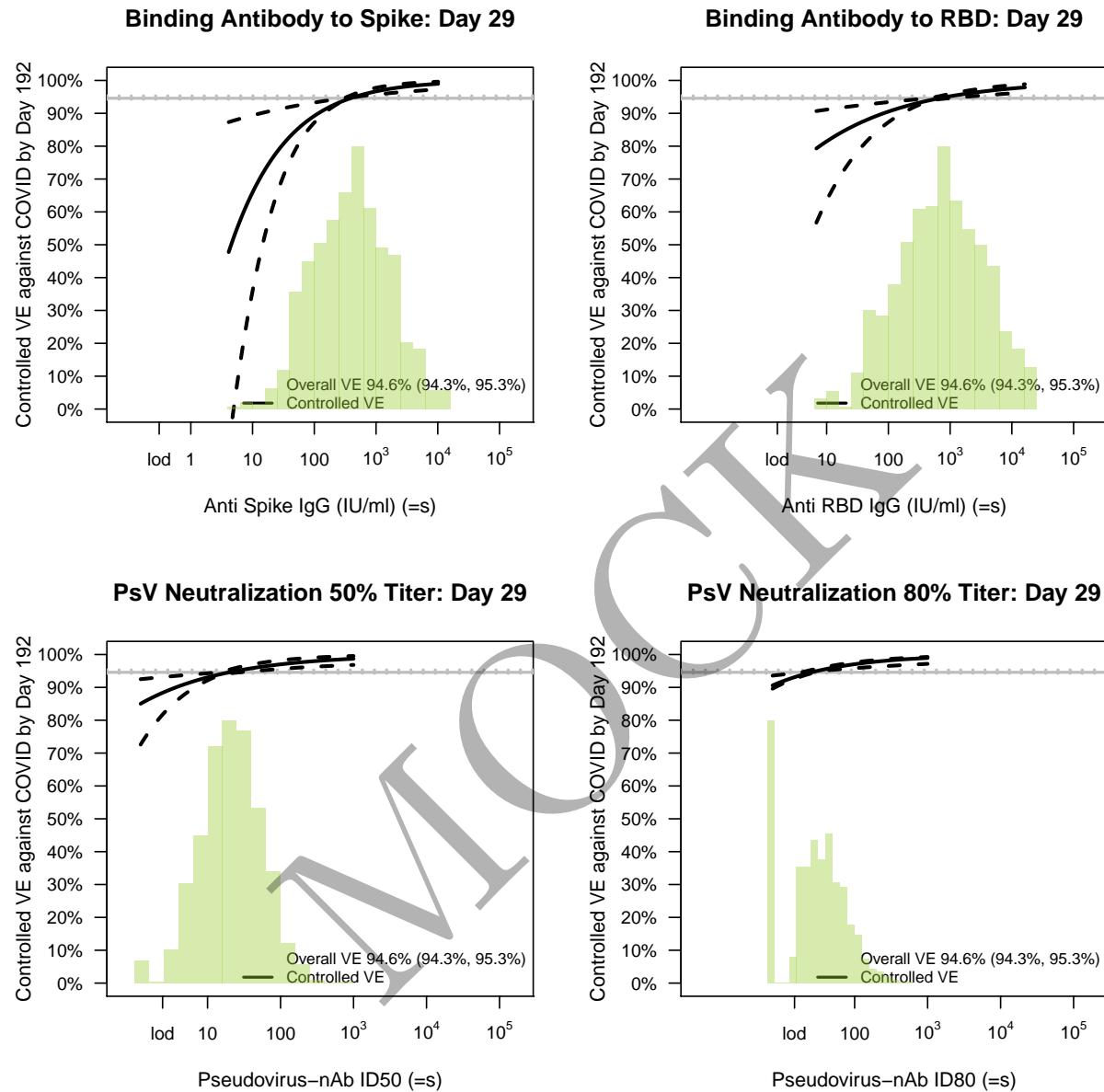


Figure 5.9: Controlled VE with sensitivity analysis as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. $\text{Iod} = 0.3, 1.6, 2.4, 15$ for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

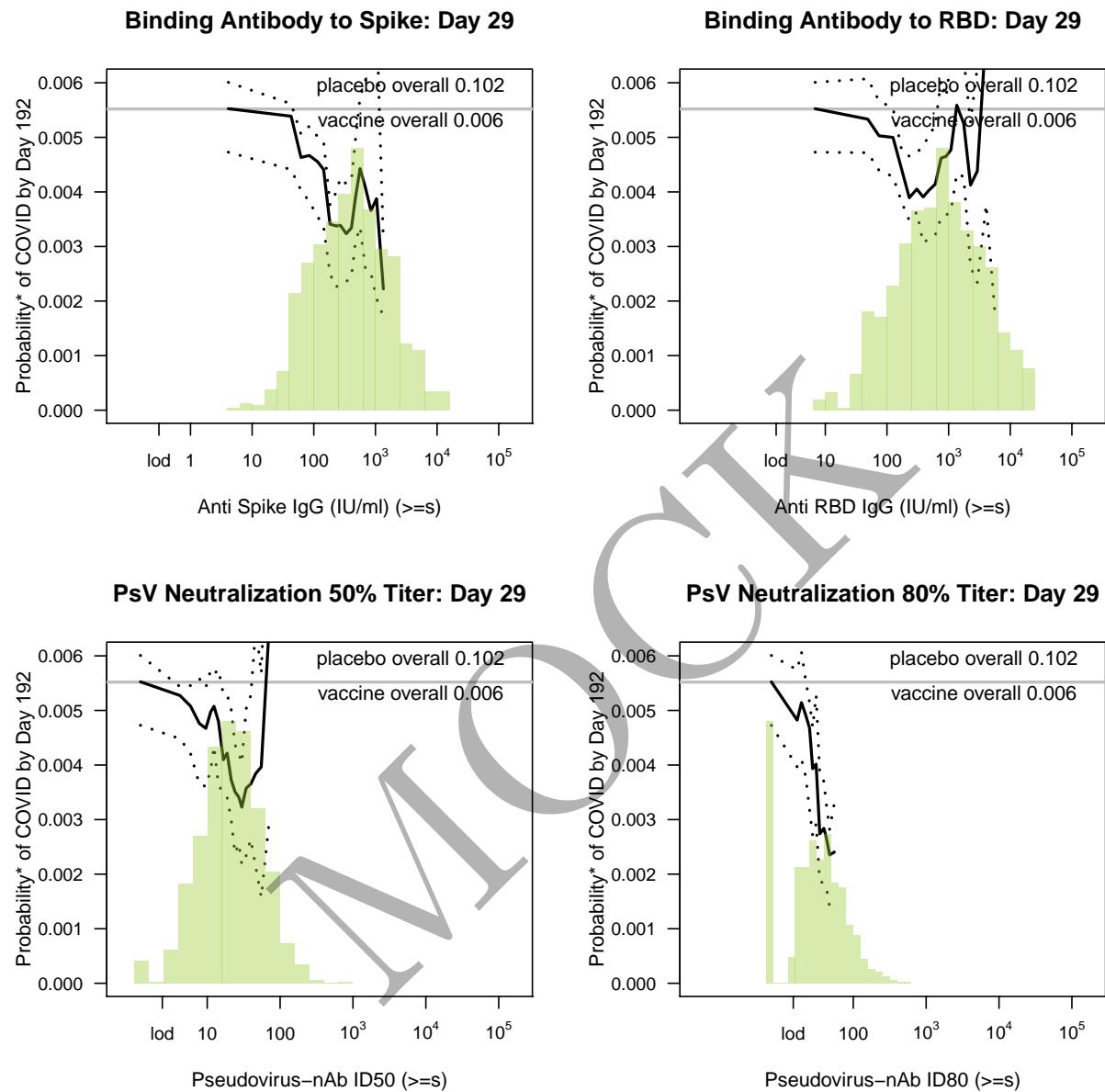


Figure 5.10: Marginalized cumulative risk by Day 192 as functions of Day 29 markers above a threshold ($\geq s$) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (at least 5 cases are required, 5 replicates). The horizontal lines indicate the overall cumulative risk of the vaccine arm by Day 192 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. $l_{od} = 0.3, 1.6, 2.4, 15$ for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

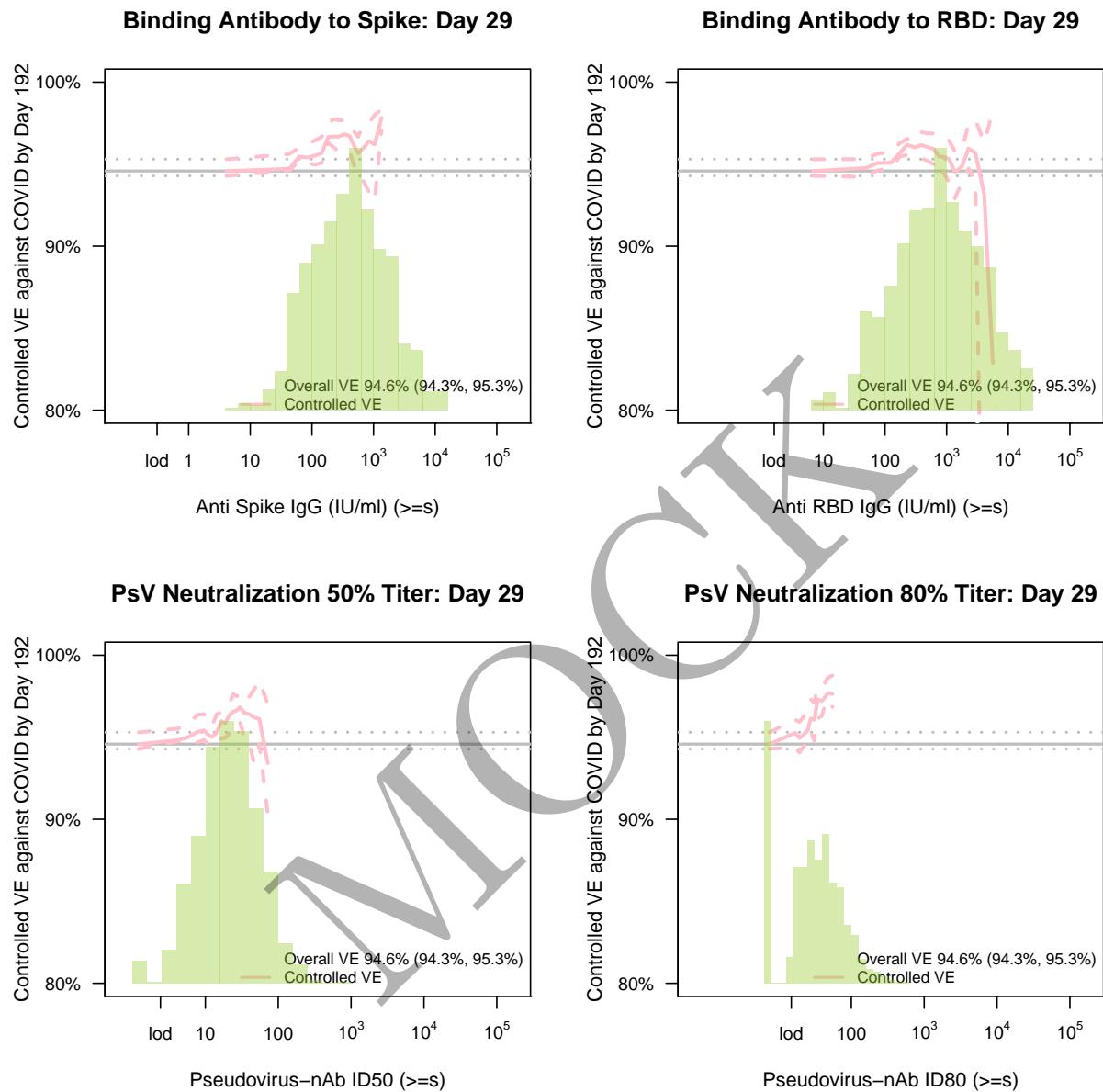


Figure 5.11: Controlled VE as functions of Day 29 markers ($\geq s$) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates). Histograms of the immunological markers in the vaccine arm are overlaid. $l_{od} = 0.3, 1.6, 2.4, 15$ for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

Table 5.4: Marginalized cumulative risk by Day 192 as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

	Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80
s	Estimate	s	Estimate	s	Estimate	s	Estimate
4.1	.0532 (.0127,.1122)	6.8	.0211 (.0093,.0444)	1.2	.0153 (.0075,.0281)	7.5	.0096 (.0064,.0109)
64	.0138 (.0073,.0178)	78	.0104 (.0068,.0146)	6	.0085 (.0061,.0109)	8	.0096 (.0064,.0109)
84	.0120 (.0069,.0147)	125	.0090 (.0064,.0117)	8	.0078 (.0059,.0094)	8	.0096 (.0064,.0109)
121	.0100 (.0065,.0116)	188	.0080 (.0061,.0097)	10	.0072 (.0057,.0082)	15	.0070 (.0056,.0077)
224	.0073 (.0057,.0077)	376	.0065 (.0055,.0070)	14	.0063 (.0054,.0067)	22	.0059 (.0051,.0065)
333	.0060 (.0051,.0062)	500	.0060 (.0053,.0063)	19	.0056 (.0048,.0061)	28	.0054 (.0045,.0058)
475	.0050 (.0039,.0053)	603	.0057 (.0050,.0061)	24	.0051 (.0041,.0058)	35	.0048 (.0041,.0052)
500	.0048 (.0038,.0052)	912	.0050 (.0042,.0057)	30	.0047 (.0036,.0056)	43	.0044 (.0037,.0048)
693	.0041 (.0030,.0046)	1000	.0049 (.0041,.0057)	45	.0041 (.0028,.0052)	63	.0037 (.0030,.0045)
1000	.0034 (.0022,.0043)	1395	.0044 (.0036,.0054)	55	.0038 (.0025,.0051)	74	.0034 (.0028,.0044)
1294	.0030 (.0018,.0040)	2891	.0036 (.0026,.0049)	71	.0035 (.0022,.0049)	90	.0031 (.0025,.0042)
1785	.0025 (.0014,.0038)	4073	.0032 (.0023,.0047)	500	.0017 (.0007,.0035)	500	.0015 (.0011,.0032)
2228	.0022 (.0012,.0036)	5444	.0030 (.0020,.0045)	757	.0014 (.0005,.0033)	524	.0014 (.0010,.0031)
10156	.0010 (.0004,.0027)	16269	.0022 (.0012,.0038)	1000	.0013 (.0004,.0032)	1000	.0011 (.0007,.0028)

Table 5.5: Controlled VE as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

	Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80
s	Estimate	s	Estimate	s	Estimate	s	Estimate
4.1	.4777 (-0.1157,.8732)	6.8	.7930 (.5673,.9069)	1.2	.8503 (.7259,.9249)	7.5	.9060 (.8960,.9358)
64	.8646 (.8252,.9265)	78	.8981 (.8572,.9320)	6	.9164 (.8934,.9389)	8	.9060 (.8960,.9358)
84	.8824 (.8561,.9305)	125	.9113 (.8855,.9360)	8	.9239 (.9086,.9409)	8	.9060 (.8960,.9358)
121	.9018 (.8869,.9352)	188	.9212 (.9053,.9392)	10	.9298 (.9200,.9426)	15	.9315 (.9267,.9433)
224	.9284 (.9256,.9427)	376	.9358 (.9316,.9445)	14	.9386 (.9351,.9458)	22	.9417 (.9383,.9496)
333	.9415 (.9407,.9492)	500	.9409 (.9397,.9468)	19	.9447 (.9418,.9524)	28	.9474 (.9448,.9548)
475	.9513 (.9495,.9609)	603	.9441 (.9419,.9502)	24	.9496 (.9445,.9589)	35	.9527 (.9501,.9597)
500	.9525 (.9506,.9624)	912	.9505 (.9454,.9578)	30	.9537 (.9465,.9642)	43	.9569 (.9522,.9636)
693	.9599 (.9541,.9706)	1000	.9518 (.9461,.9594)	45	.9600 (.9500,.9718)	63	.9636 (.9551,.9699)
1000	.9667 (.9573,.9777)	1395	.9563 (.9485,.9646)	55	.9628 (.9516,.9749)	74	.9662 (.9563,.9723)
1294	.9709 (.9594,.9817)	2891	.9648 (.9535,.9741)	71	.9661 (.9536,.9785)	90	.9692 (.9578,.9750)
1785	.9753 (.9619,.9856)	4073	.9682 (.9556,.9780)	500	.9834 (.9654,.9933)	500	.9857 (.9682,.9895)
2228	.9780 (.9635,.9878)	5444	.9708 (.9574,.9808)	757	.9858 (.9672,.9948)	524	.9860 (.9685,.9898)
10156	.9899 (.9729,.9962)	16269	.9789 (.9634,.9886)	1000	.9872 (.9684,.9956)	1000	.9895 (.9717,.9926)
9.8	.6557 (.3499,.8933)	(,)	(,)	(,)	(,)	(,)	(,)
113	.8986 (.8818,.9344)	84	.9003 (.8623,.9326)	4	.8997 (.8567,.9349)	8	.9060 (.8960,.9358)
468	.9509 (.9492,.9604)	889	.9501 (.9452,.9574)	24	.9496 (.9445,.9589)	31	.9501 (.9477,.9573)

Table 5.6: Controlled VE with sensitivity analysis as functions of Day 29 markers (=s) among baseline negative vaccine recipients with 95% bootstrap point-wise confidence intervals (5 replicates).

	Anti Spike IgG (IU/ml)		Anti RBD IgG (IU/ml)		Pseudovirus-nAb ID50		Pseudovirus-nAb ID80
s	Estimate	s	Estimate	s	Estimate	s	Estimate
4.1	.6960 (.3506,.9262)	6.8	.8697 (.7276,.9414)	1.2	.9111 (.8372,.9554)	7.5	.9158 (.9069,.9425)
64	.8803 (.8455,.9350)	78	.9116 (.8762,.9410)	6	.9272 (.9072,.9468)	8	.9158 (.9069,.9425)
84	.8928 (.8689,.9366)	125	.9193 (.8959,.9418)	8	.9307 (.9168,.9462)	8	.9158 (.9069,.9425)
121	.9074 (.8933,.9389)	188	.9259 (.9109,.9428)	10	.9339 (.9246,.9459)	15	.9332 (.9286,.9447)
224	.9295 (.9267,.9435)	376	.9369 (.9327,.9455)	14	.9397 (.9363,.9468)	22	.9419 (.9386,.9498)
333	.9416 (.9408,.9493)	500	.9413 (.9401,.9472)	19	.9448 (.9419,.9525)	28	.9474 (.9448,.9548)
475	.9512 (.9494,.9608)	603	.9442 (.9420,.9503)	24	.9495 (.9444,.9589)	35	.9524 (.9498,.9595)
500	.9524 (.9505,.9623)	912	.9504 (.9454,.9577)	30	.9530 (.9458,.9636)	43	.9562 (.9513,.9630)
693	.9593 (.9534,.9702)	1000	.9517 (.9460,.9593)	45	.9577 (.9470,.9702)	63	.9617 (.9527,.9683)
1000	.9655 (.9557,.9769)	1395	.9558 (.9479,.9642)	55	.9594 (.9472,.9727)	74	.9637 (.9531,.9703)
1294	.9692 (.9570,.9806)	2891	.9628 (.9508,.9726)	71	.9614 (.9471,.9755)	90	.9660 (.9534,.9725)
1785	.9731 (.9584,.9843)	4073	.9654 (.9517,.9760)	500	.9697 (.9366,.9877)	500	.9782 (.9515,.9840)
2228	.9754 (.9592,.9864)	5444	.9674 (.9524,.9785)	757	.9706 (.9322,.9892)	524	.9785 (.9514,.9843)
10156	.9862 (.9628,.9947)	16269	.9733 (.9537,.9856)	1000	.9712 (.9289,.9901)	1000	.9813 (.9492,.9868)
9.8	.6557 (.3499,.8933)	(,)	(,)	(,)	(,)	(,)	(,)
113	.8986 (.8818,.9344)	84	.9003 (.8623,.9326)	4	.8997 (.8567,.9349)	8	.9060 (.8960,.9358)
468	.9509 (.9492,.9604)	889	.9501 (.9452,.9574)	24	.9496 (.9445,.9589)	31	.9501 (.9477,.9573)

Chapter 6

Univariate CoR: Nonparametric Threshold Modeling ($>= s$)

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.

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

MOCK

6.1.1 Day 57 Spike protein binding antibody

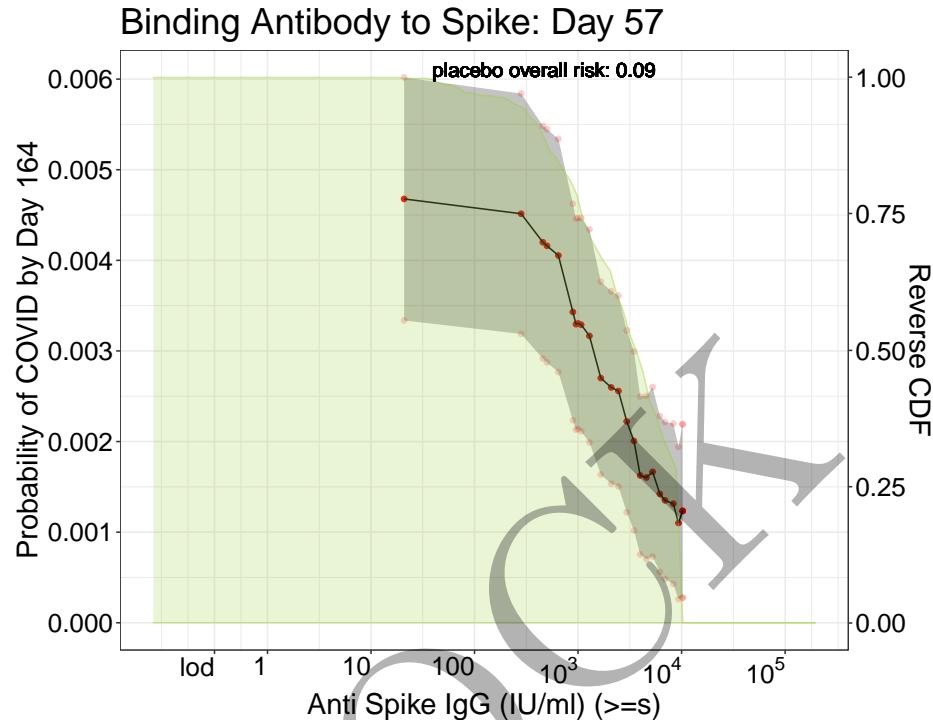


Figure 6.1: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.1: 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
1.316	$2.07 * 10^1$	0.00468	0.00334	0.00602
2.699	$5.00 * 10^2$	0.00416	0.00287	0.00545
2.815	$6.53 * 10^2$	0.00405	0.00277	0.00534
2.982	$9.59 * 10^2$	0.00330	0.00213	0.00446
3.000	$1.00 * 10^3$	0.00330	0.00214	0.00447
3.113	$1.30 * 10^3$	0.00317	0.00199	0.00434
3.471	$2.96 * 10^3$	0.00222	0.00122	0.00323
3.658	$4.55 * 10^3$	0.00160	0.00070	0.00250
3.841	$6.93 * 10^3$	0.00135	0.00048	0.00222
4.006	$1.01 * 10^4$	0.00124	0.00028	0.00220
4.007	$1.02 * 10^4$	0.00123	0.00028	0.00219
4.007	$1.02 * 10^4$	0.00123	0.00028	0.00219
4.007	$1.02 * 10^4$	0.00123	0.00028	0.00219

6.1.2 Day 57 RBD binding antibody

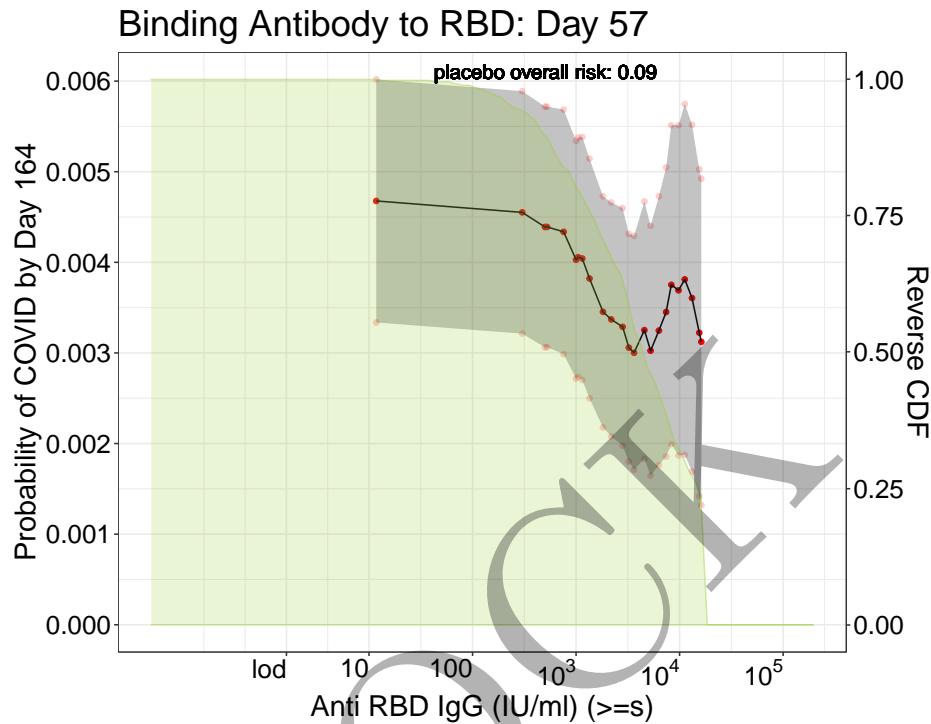


Figure 6.2: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.2: 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
1.073	$1.18 * 10^1$	0.00468	0.00334	0.00602
2.699	$5.00 * 10^2$	0.00439	0.00306	0.00572
2.882	$7.62 * 10^2$	0.00434	0.00299	0.00569
3.000	$1.00 * 10^3$	0.00403	0.00272	0.00534
3.056	$1.14 * 10^3$	0.00404	0.00270	0.00538
3.259	$1.82 * 10^3$	0.00345	0.00218	0.00473
3.557	$3.61 * 10^3$	0.00300	0.00171	0.00429
3.797	$6.27 * 10^3$	0.00325	0.00176	0.00473
3.986	$9.68 * 10^3$	0.00369	0.00187	0.00551
4.186	$1.53 * 10^4$	0.00322	0.00142	0.00503
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492

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

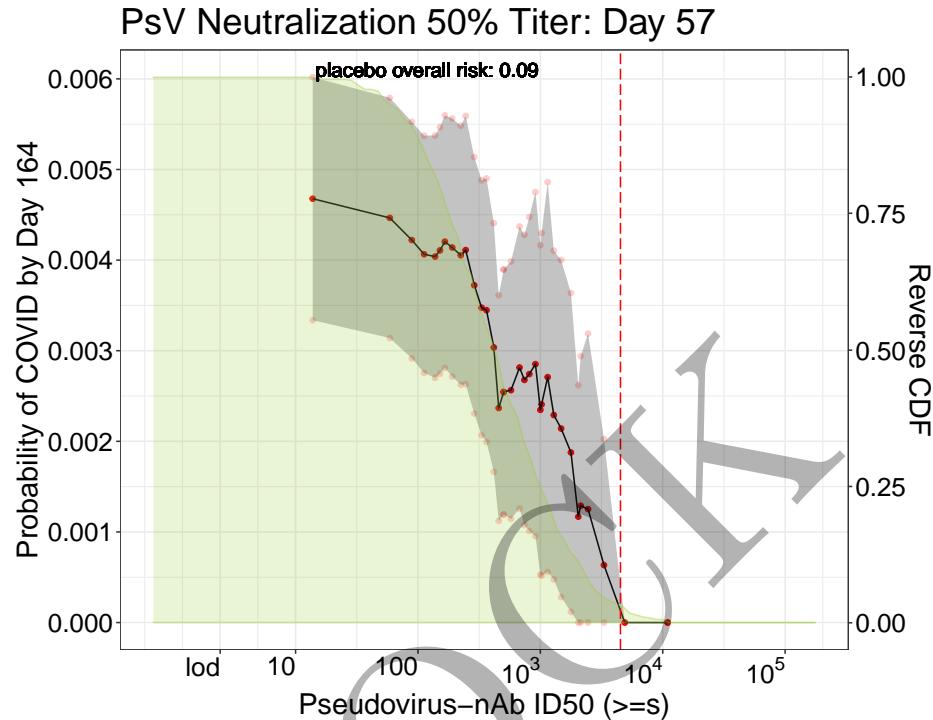


Figure 6.3: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.3: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.135	$1.36 * 10^1$	0.00468	0.00334	0.00602
2.055	$1.14 * 10^2$	0.00406	0.00276	0.00537
2.177	$1.50 * 10^2$	0.00411	0.00275	0.00547
2.281	$1.91 * 10^2$	0.00414	0.00271	0.00556
2.519	$3.30 * 10^2$	0.00347	0.00207	0.00488
2.657	$4.54 * 10^2$	0.00237	0.00112	0.00361
2.699	$5.00 * 10^2$	0.00255	0.00119	0.00390
2.828	$6.73 * 10^2$	0.00281	0.00126	0.00437
2.959	$9.10 * 10^2$	0.00285	0.00095	0.00475
3.000	$1.00 * 10^3$	0.00235	0.00053	0.00416
3.174	$1.49 * 10^3$	0.00214	0.00028	0.00400
3.307	$2.03 * 10^3$	0.00117	0.00000	0.00262
3.387	$2.44 * 10^3$	0.00125	0.00000	0.00319
4.038	$1.09 * 10^4$	0.00000	0.00000	NA

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

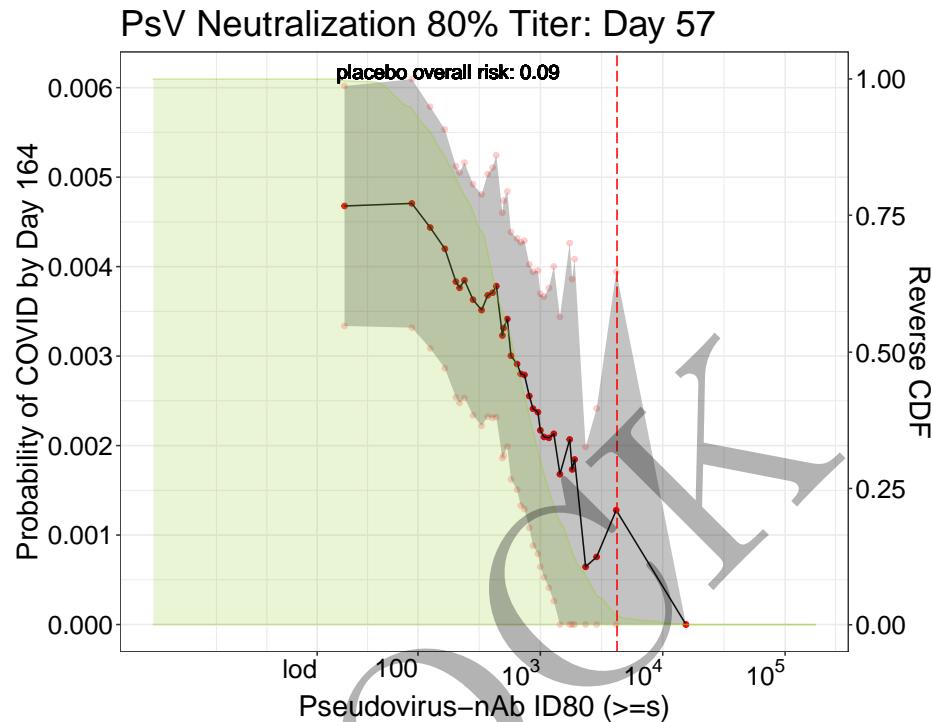


Figure 6.4: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.4: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.403	$2.53 * 10^1$	0.00468	0.00334	0.00602
2.220	$1.66 * 10^2$	0.00420	0.00286	0.00553
2.335	$2.16 * 10^2$	0.00376	0.00248	0.00505
2.455	$2.85 * 10^2$	0.00363	0.00234	0.00492
2.644	$4.41 * 10^2$	0.00378	0.00232	0.00524
2.699	$5.00 * 10^2$	0.00331	0.00189	0.00474
2.764	$5.81 * 10^2$	0.00300	0.00162	0.00439
2.874	$7.48 * 10^2$	0.00279	0.00129	0.00429
2.981	$9.57 * 10^2$	0.00237	0.00079	0.00396
3.000	$1.00 * 10^3$	0.00217	0.00064	0.00370
3.162	$1.45 * 10^3$	0.00168	0.00000	0.00344
3.265	$1.84 * 10^3$	0.00173	0.00000	0.00386
3.371	$2.35 * 10^3$	0.00065	0.00000	0.00198
4.187	$1.54 * 10^4$	0.00000	0.00000	NA

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

MOCK

6.2.1 Day 29 Spike protein antibody

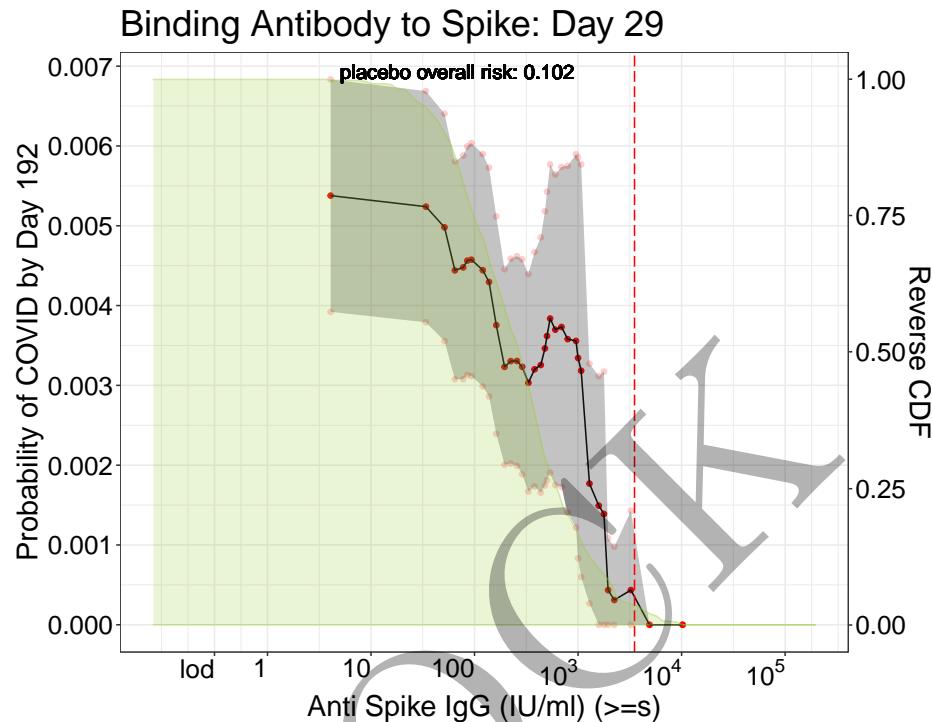


Figure 6.5: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.5: 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
0.613	$4.10 * 10^0$	0.00538	0.00392	0.00683
1.805	$6.38 * 10^1$	0.00444	0.00308	0.00580
1.927	$8.45 * 10^1$	0.00456	0.00313	0.00600
2.081	$1.21 * 10^2$	0.00444	0.00299	0.00590
2.351	$2.24 * 10^2$	0.00330	0.00202	0.00459
2.522	$3.33 * 10^2$	0.00303	0.00167	0.00440
2.677	$4.75 * 10^2$	0.00346	0.00174	0.00518
2.699	$5.00 * 10^2$	0.00362	0.00181	0.00543
2.841	$6.93 * 10^2$	0.00373	0.00173	0.00574
3.000	$1.00 * 10^3$	0.00334	0.00083	0.00585
3.112	$1.29 * 10^3$	0.00177	0.00027	0.00327
3.252	$1.79 * 10^3$	0.00139	0.00000	0.00317
3.348	$2.23 * 10^3$	0.00031	0.00000	0.00098
4.007	$1.02 * 10^4$	0.00000	0.00000	NA

6.2.2 Day 29 RBD binding antibody

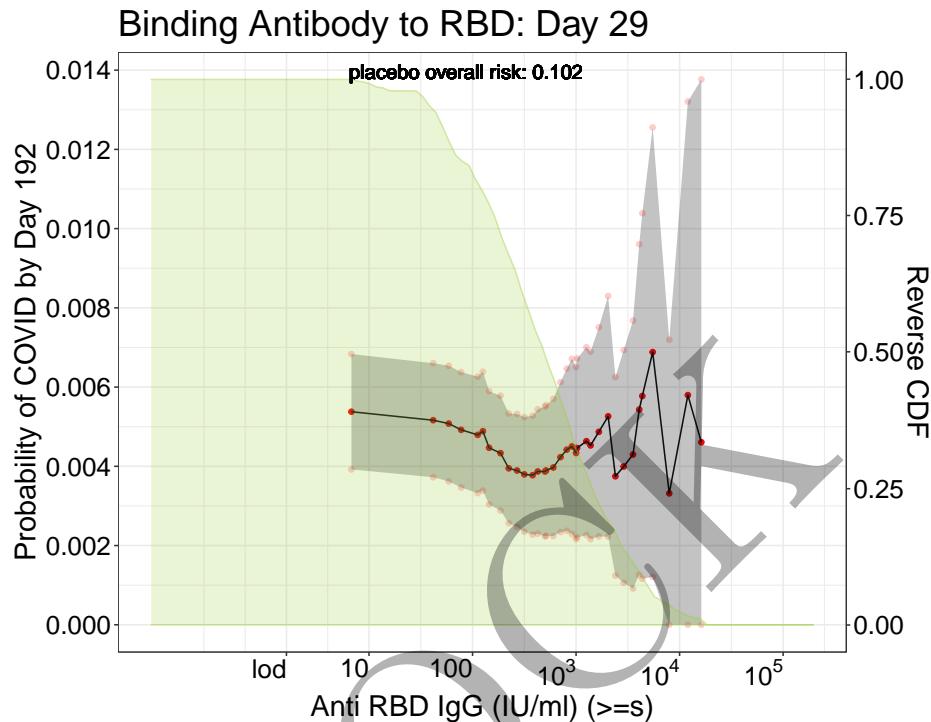


Figure 6.6: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.6: 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
0.834	$6.82 * 10^0$	0.00538	0.00392	0.00683
1.892	$7.80 * 10^1$	0.00492	0.00346	0.00638
2.098	$1.25 * 10^2$	0.00489	0.00339	0.00639
2.273	$1.87 * 10^2$	0.00433	0.00288	0.00578
2.575	$3.76 * 10^2$	0.00378	0.00227	0.00528
2.699	$5.00 * 10^2$	0.00387	0.00223	0.00551
2.780	$6.03 * 10^2$	0.00397	0.00224	0.00570
2.960	$9.12 * 10^2$	0.00450	0.00229	0.00671
3.000	$1.00 * 10^3$	0.00434	0.00216	0.00651
3.144	$1.39 * 10^3$	0.00453	0.00216	0.00689
3.461	$2.89 * 10^3$	0.00400	0.00106	0.00693
3.610	$4.07 * 10^3$	0.00543	0.00126	0.00961
3.736	$5.45 * 10^3$	0.00688	0.00121	0.01256
4.211	$1.63 * 10^4$	0.00461	0.00000	0.01465

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

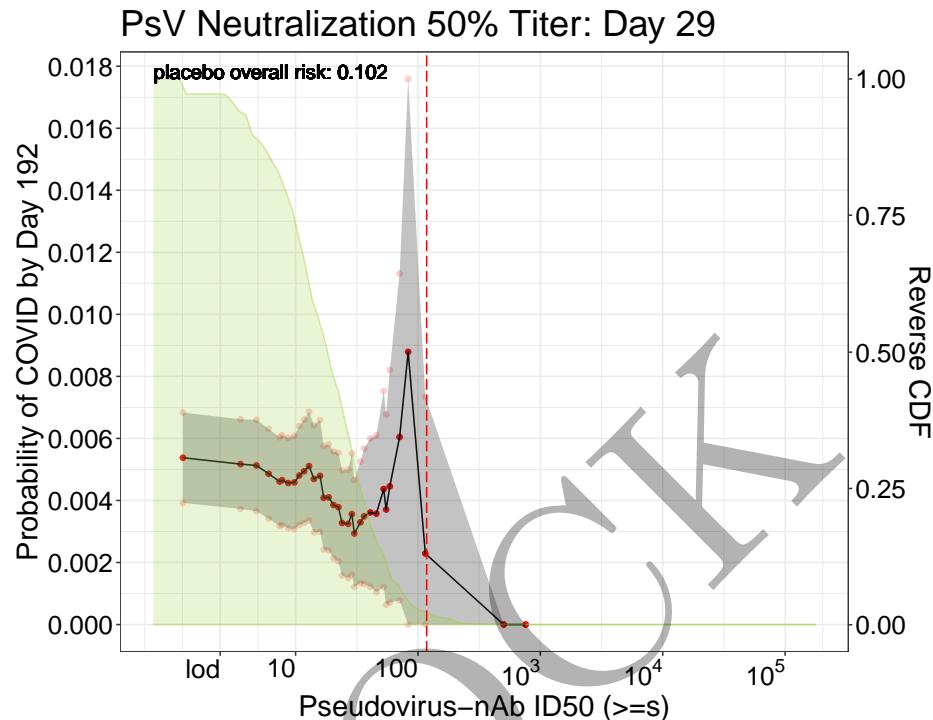


Figure 6.7: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.7: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.083	1.21×10^0	0.00538	0.00392	0.00683
0.779	6.01×10^0	0.00486	0.00341	0.00631
0.892	7.80×10^0	0.00465	0.00321	0.00610
0.988	9.73×10^0	0.00458	0.00308	0.00608
1.147	1.40×10^1	0.00469	0.00297	0.00642
1.271	1.87×10^1	0.00410	0.00239	0.00581
1.382	2.41×10^1	0.00327	0.00158	0.00497
1.481	3.03×10^1	0.00294	0.00121	0.00466
1.656	4.53×10^1	0.00357	0.00104	0.00610
1.741	5.51×10^1	0.00371	0.00065	0.00677
1.852	7.11×10^1	0.00605	0.00078	0.01131
2.699	5.00×10^2	0.00000	0.00000	NA
2.879	7.57×10^2	0.00000	0.00000	NA
2.879	7.57×10^2	0.00000	0.00000	NA

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

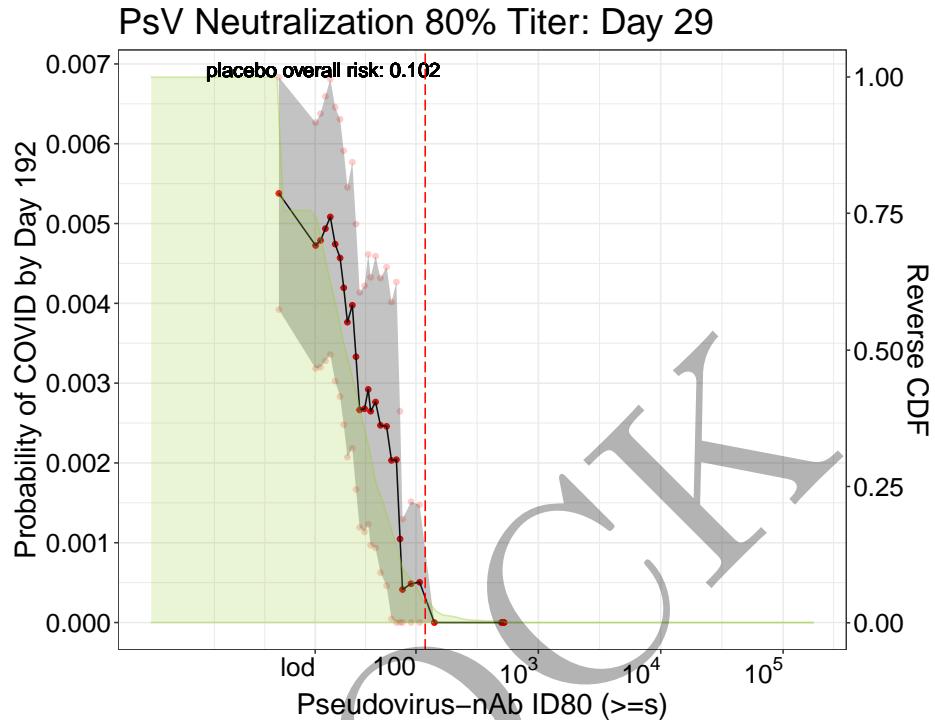


Figure 6.8: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.8: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
1.183	$1.52 * 10^1$	0.00473	0.00318	0.00627
1.339	$2.18 * 10^1$	0.00474	0.00303	0.00646
1.440	$2.75 * 10^1$	0.00376	0.00207	0.00545
1.541	$3.48 * 10^1$	0.00266	0.00119	0.00414
1.632	$4.29 * 10^1$	0.00265	0.00097	0.00433
1.796	$6.25 * 10^1$	0.00203	0.00005	0.00402
1.868	$7.38 * 10^1$	0.00105	0.00000	0.00265
1.956	$9.04 * 10^1$	0.00049	0.00000	0.00151
2.699	$5.00 * 10^2$	0.00000	0.00000	NA
2.719	$5.24 * 10^2$	0.00000	0.00000	NA
2.719	$5.24 * 10^2$	0.00000	0.00000	NA

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

MOCK

6.3.1 Day 57 Spike protein binding antibody

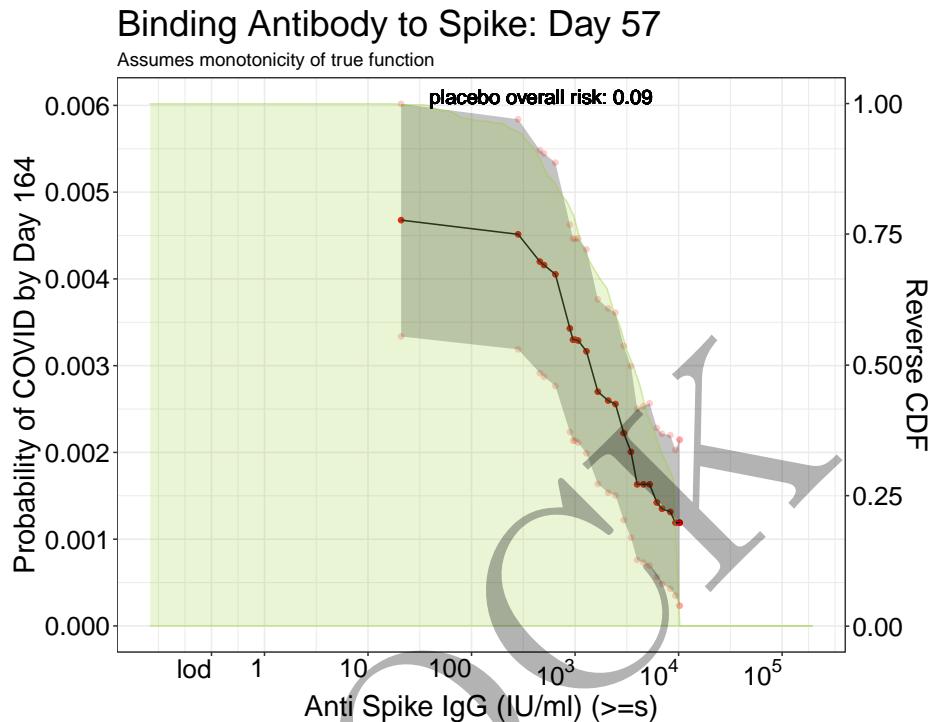


Figure 6.9: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.9: Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
1.316	2.07 * 10 ¹	0.00468	0.00334	0.00602
2.699	5.00 * 10 ²	0.00416	0.00287	0.00545
2.815	6.53 * 10 ²	0.00405	0.00277	0.00534
2.982	9.59 * 10 ²	0.00330	0.00214	0.00446
3.000	1.00 * 10 ³	0.00330	0.00213	0.00446
3.113	1.30 * 10 ³	0.00317	0.00199	0.00434
3.471	2.96 * 10 ³	0.00222	0.00122	0.00323
3.658	4.55 * 10 ³	0.00163	0.00073	0.00253
3.841	6.93 * 10 ³	0.00135	0.00048	0.00222
4.006	1.01 * 10 ⁴	0.00119	0.00023	0.00215
4.007	1.02 * 10 ⁴	0.00119	0.00024	0.00214
4.007	1.02 * 10 ⁴	0.00119	0.00024	0.00214
4.007	1.02 * 10 ⁴	0.00119	0.00024	0.00214

6.3.2 Day 57 RBD binding antibody

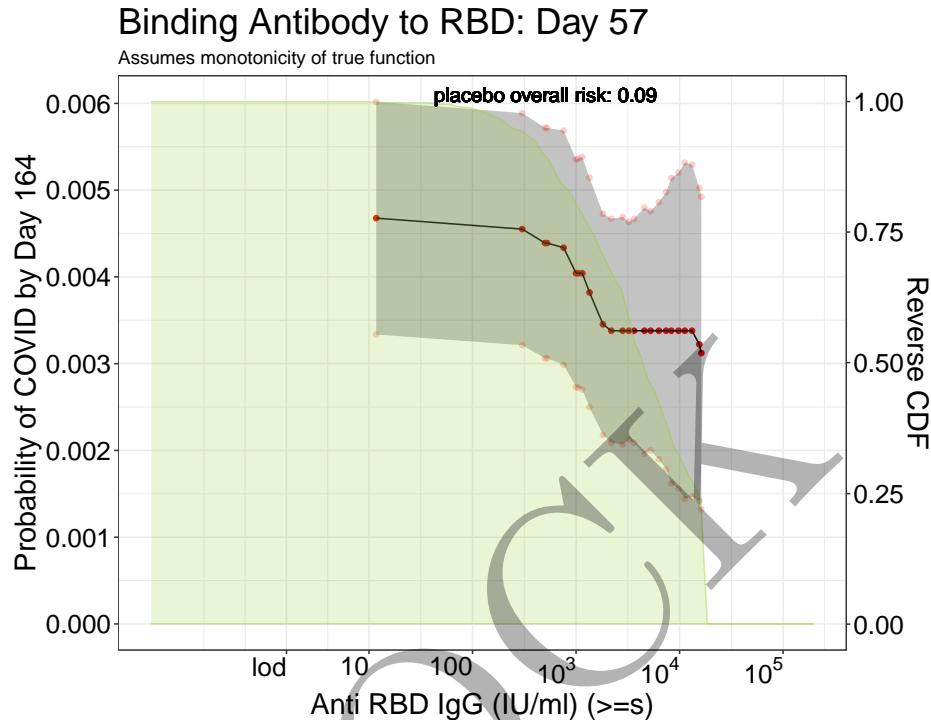


Figure 6.10: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.10: 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
1.073	$1.18 * 10^1$	0.00468	0.00334	0.00602
2.699	$5.00 * 10^2$	0.00439	0.00306	0.00572
2.882	$7.62 * 10^2$	0.00434	0.00299	0.00569
3.000	$1.00 * 10^3$	0.00404	0.00273	0.00535
3.056	$1.14 * 10^3$	0.00404	0.00270	0.00538
3.259	$1.82 * 10^3$	0.00345	0.00218	0.00473
3.557	$3.61 * 10^3$	0.00338	0.00209	0.00467
3.797	$6.27 * 10^3$	0.00338	0.00190	0.00486
3.986	$9.68 * 10^3$	0.00338	0.00156	0.00520
4.186	$1.53 * 10^4$	0.00322	0.00142	0.00503
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492
4.211	$1.63 * 10^4$	0.00312	0.00132	0.00492

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

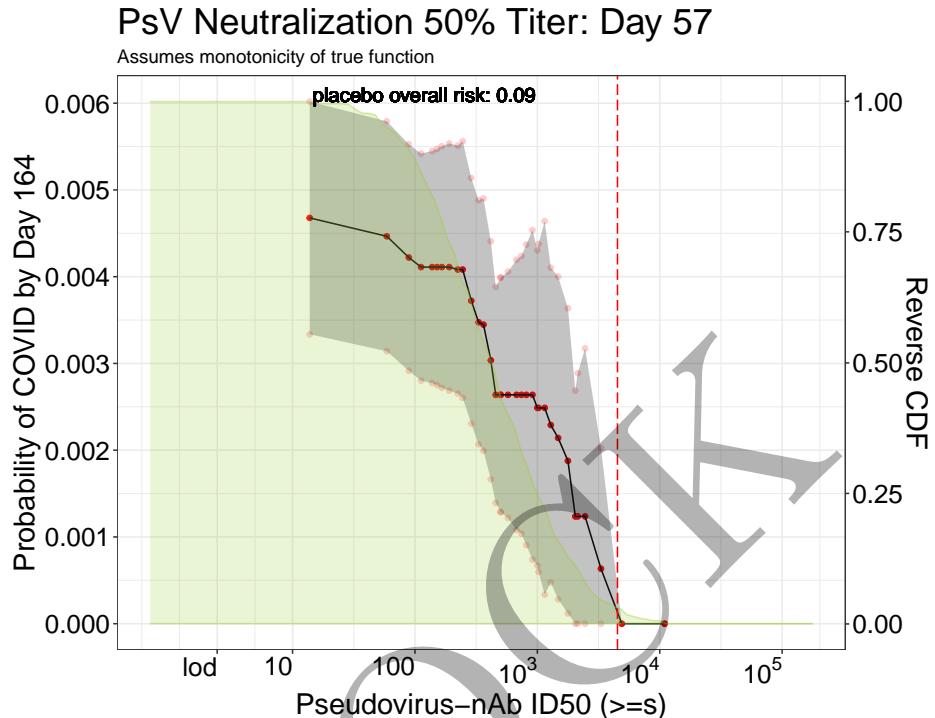


Figure 6.11: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.11: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.135	$1.36 * 10^1$	0.00468	0.00334	0.00602
2.055	$1.14 * 10^2$	0.00411	0.00280	0.00542
2.177	$1.50 * 10^2$	0.00411	0.00275	0.00547
2.281	$1.91 * 10^2$	0.00411	0.00269	0.00554
2.519	$3.30 * 10^2$	0.00347	0.00207	0.00488
2.657	$4.54 * 10^2$	0.00264	0.00139	0.00388
2.699	$5.00 * 10^2$	0.00264	0.00129	0.00399
2.828	$6.73 * 10^2$	0.00264	0.00108	0.00420
2.959	$9.10 * 10^2$	0.00264	0.00074	0.00454
3.000	$1.00 * 10^3$	0.00249	0.00067	0.00430
3.174	$1.49 * 10^3$	0.00214	0.00028	0.00400
3.307	$2.03 * 10^3$	0.00124	0.00000	0.00269
3.387	$2.44 * 10^3$	0.00124	0.00000	0.00317
4.038	$1.09 * 10^4$	0.00000	0.00000	NA

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

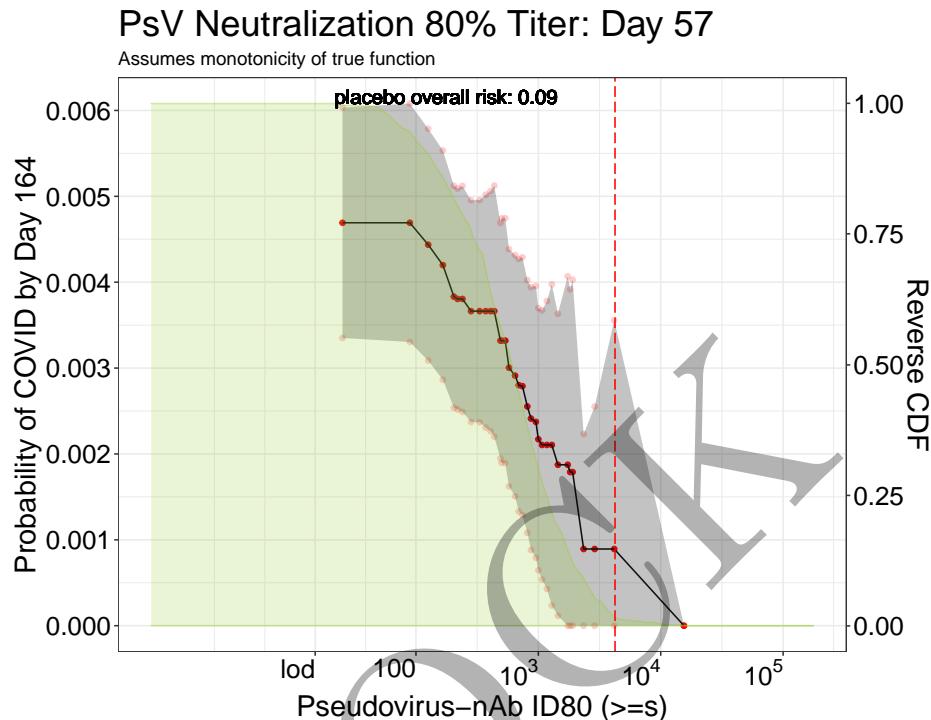


Figure 6.12: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.12: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.403	$2.53 * 10^1$	0.00469	0.00335	0.00603
2.220	$1.66 * 10^2$	0.00420	0.00286	0.00553
2.335	$2.16 * 10^2$	0.00380	0.00252	0.00509
2.455	$2.85 * 10^2$	0.00366	0.00237	0.00495
2.644	$4.41 * 10^2$	0.00366	0.00220	0.00513
2.699	$5.00 * 10^2$	0.00332	0.00190	0.00474
2.764	$5.81 * 10^2$	0.00300	0.00162	0.00439
2.874	$7.48 * 10^2$	0.00279	0.00129	0.00429
2.981	$9.57 * 10^2$	0.00237	0.00079	0.00396
3.000	$1.00 * 10^3$	0.00217	0.00064	0.00370
3.162	$1.45 * 10^3$	0.00187	0.00012	0.00363
3.265	$1.84 * 10^3$	0.00179	0.00000	0.00392
3.371	$2.35 * 10^3$	0.00089	0.00000	0.00223
4.187	$1.54 * 10^4$	0.00000	0.00000	NA

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

MOCK

6.4.1 Day 29 Spike protein antibody

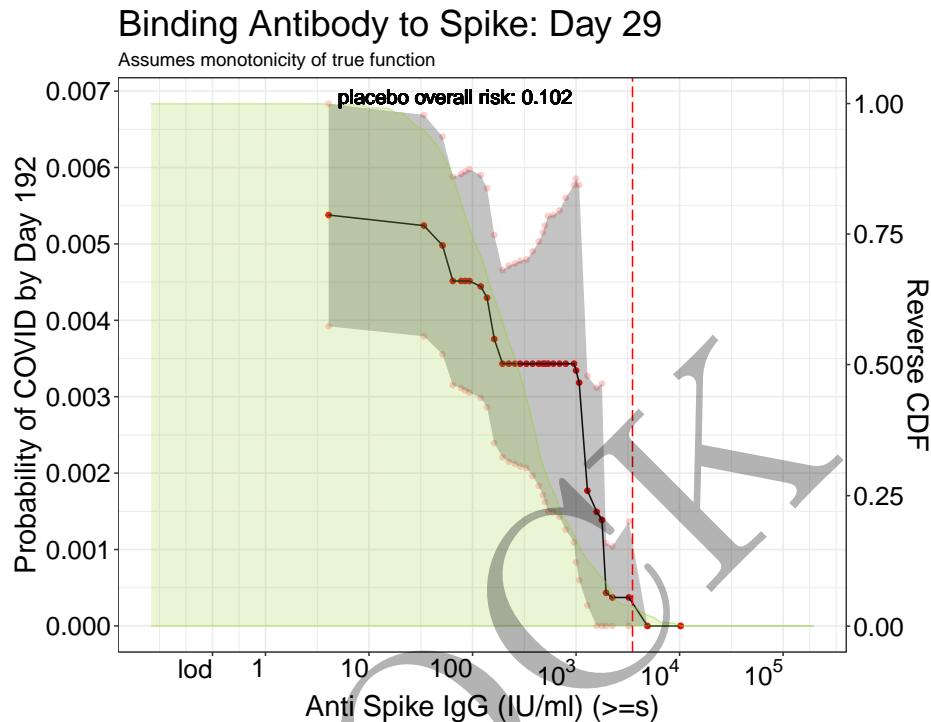


Figure 6.13: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.13: 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
0.613	4.10×10^0	0.00538	0.00392	0.00683
1.805	6.38×10^1	0.00451	0.00315	0.00588
1.927	8.45×10^1	0.00451	0.00308	0.00595
2.081	1.21×10^2	0.00444	0.00299	0.00590
2.351	2.24×10^2	0.00343	0.00215	0.00472
2.522	3.33×10^2	0.00343	0.00207	0.00480
2.677	4.75×10^2	0.00343	0.00171	0.00515
2.699	5.00×10^2	0.00343	0.00162	0.00524
2.841	6.93×10^2	0.00343	0.00143	0.00544
3.000	1.00×10^3	0.00334	0.00083	0.00585
3.112	1.29×10^3	0.00177	0.00027	0.00327
3.252	1.79×10^3	0.00139	0.00000	0.00317
3.348	2.23×10^3	0.00037	0.00000	0.00104
4.007	1.02×10^4	0.00000	0.00000	NA

6.4.2 Day 29 RBD binding antibody

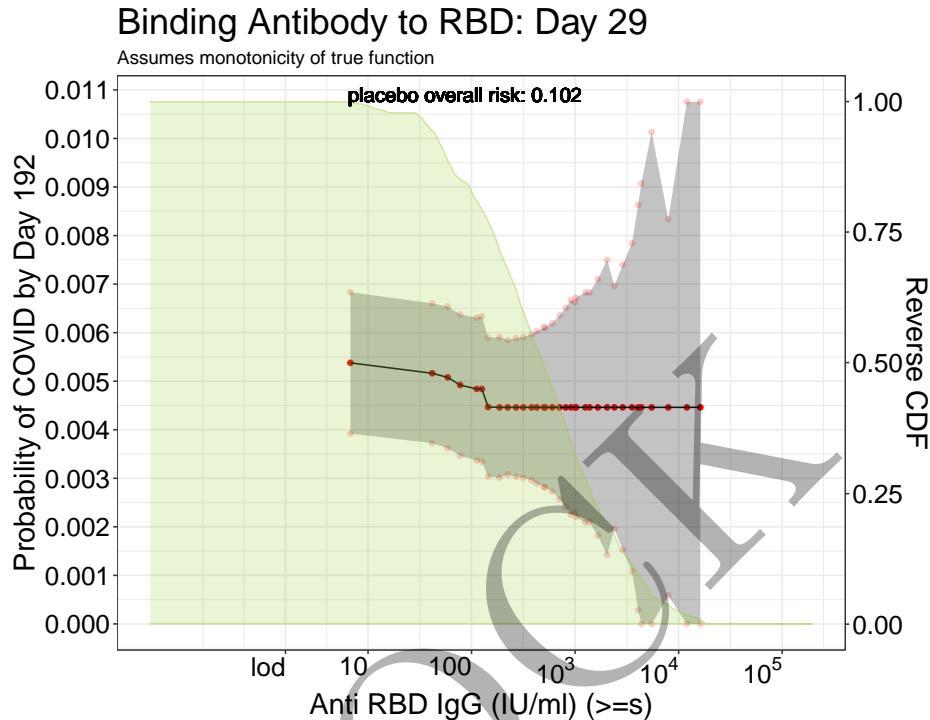


Figure 6.14: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.14: 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
0.834	$6.82 * 10^0$	0.00538	0.00392	0.00683
1.892	$7.80 * 10^1$	0.00492	0.00346	0.00638
2.098	$1.25 * 10^2$	0.00484	0.00334	0.00634
2.273	$1.87 * 10^2$	0.00446	0.00301	0.00591
2.575	$3.76 * 10^2$	0.00446	0.00296	0.00596
2.699	$5.00 * 10^2$	0.00446	0.00282	0.00610
2.780	$6.03 * 10^2$	0.00446	0.00273	0.00619
2.960	$9.12 * 10^2$	0.00446	0.00225	0.00667
3.000	$1.00 * 10^3$	0.00446	0.00229	0.00663
3.144	$1.39 * 10^3$	0.00446	0.00209	0.00683
3.461	$2.89 * 10^3$	0.00446	0.00152	0.00740
3.610	$4.07 * 10^3$	0.00446	0.00029	0.00864
3.736	$5.45 * 10^3$	0.00446	0.00000	0.01013
4.211	$1.63 * 10^4$	0.00446	0.00000	0.01450

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

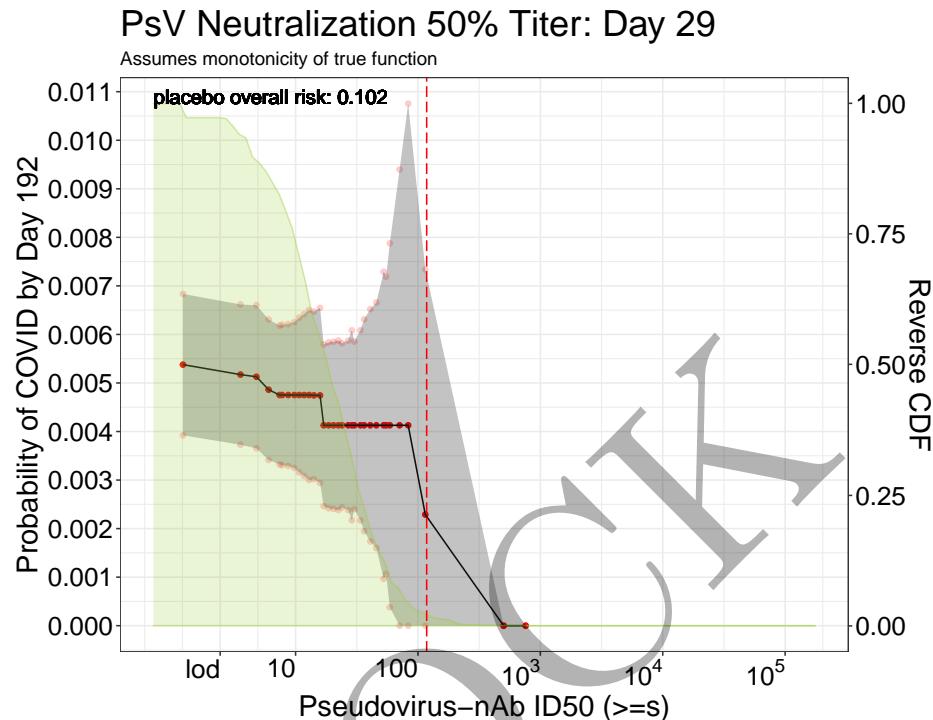


Figure 6.15: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.15: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.083	1.21×10^0	0.00538	0.00392	0.00683
0.779	6.01×10^0	0.00486	0.00341	0.00631
0.892	7.80×10^0	0.00475	0.00330	0.00620
0.988	9.73×10^0	0.00475	0.00325	0.00625
1.147	1.40×10^1	0.00474	0.00302	0.00647
1.271	1.87×10^1	0.00413	0.00242	0.00584
1.382	2.41×10^1	0.00413	0.00244	0.00582
1.481	3.03×10^1	0.00413	0.00240	0.00585
1.656	4.53×10^1	0.00413	0.00160	0.00666
1.741	5.51×10^1	0.00413	0.00107	0.00719
1.852	7.11×10^1	0.00413	0.00000	0.00940
2.699	5.00×10^2	0.00000	0.00000	NA
2.879	7.57×10^2	0.00000	0.00000	NA
2.879	7.57×10^2	0.00000	0.00000	NA

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

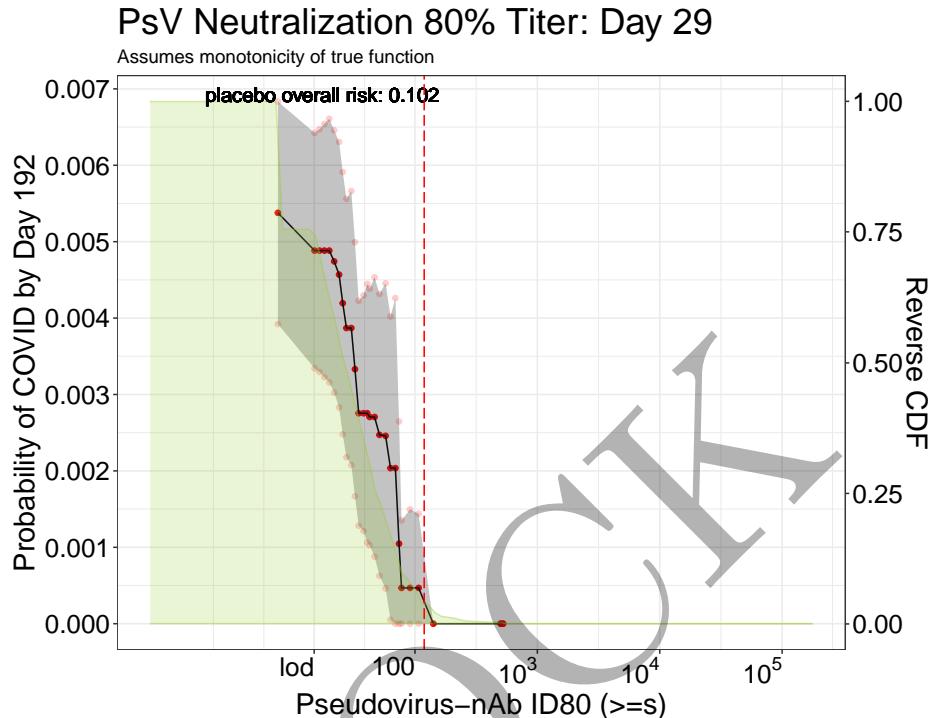


Figure 6.16: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.16: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
0.876	$7.52 * 10^0$	0.00538	0.00392	0.00683
1.183	$1.52 * 10^1$	0.00488	0.00334	0.00642
1.339	$2.18 * 10^1$	0.00474	0.00303	0.00646
1.440	$2.75 * 10^1$	0.00387	0.00218	0.00556
1.541	$3.48 * 10^1$	0.00275	0.00128	0.00423
1.632	$4.29 * 10^1$	0.00271	0.00103	0.00438
1.796	$6.25 * 10^1$	0.00204	0.00005	0.00402
1.868	$7.38 * 10^1$	0.00105	0.00000	0.00265
1.956	$9.04 * 10^1$	0.00047	0.00000	0.00150
2.699	$5.00 * 10^2$	0.00000	0.00000	NA
2.719	$5.24 * 10^2$	0.00000	0.00000	NA
2.719	$5.24 * 10^2$	0.00000	0.00000	NA

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

MOCK

6.5.1 Day 57 Spike protein binding antibody

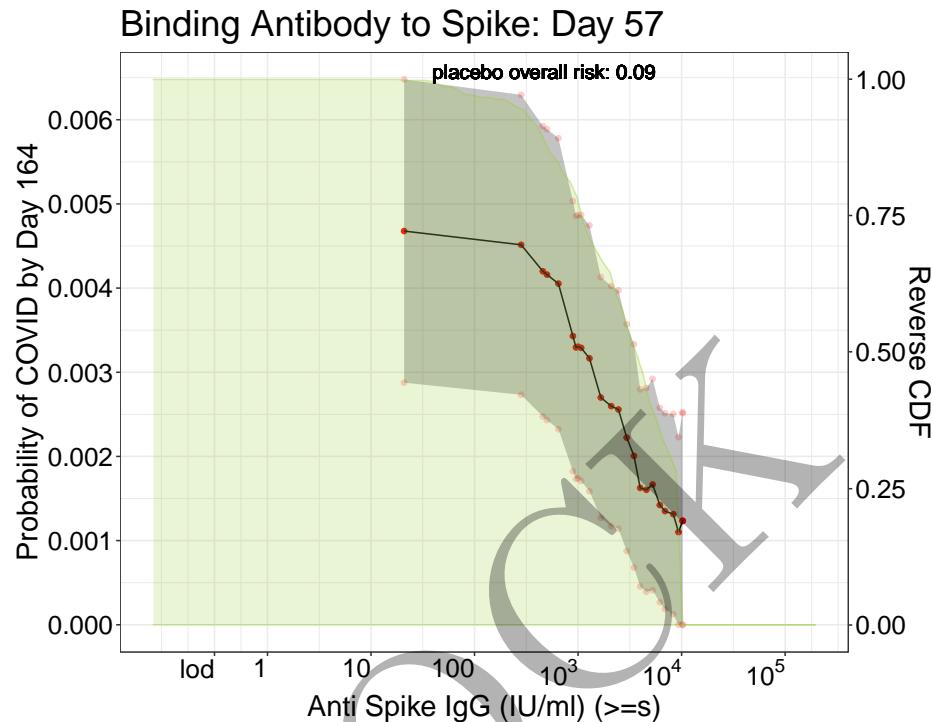


Figure 6.17: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.17: 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
1.316	$2.07 * 10^1$	0.00468	0.00288	0.00648
2.699	$5.00 * 10^2$	0.00416	0.00243	0.00589
2.815	$6.53 * 10^2$	0.00405	0.00232	0.00578
2.982	$9.59 * 10^2$	0.00330	0.00173	0.00486
3.000	$1.00 * 10^3$	0.00330	0.00174	0.00487
3.113	$1.30 * 10^3$	0.00317	0.00159	0.00474
3.471	$2.96 * 10^3$	0.00222	0.00088	0.00357
3.658	$4.55 * 10^3$	0.00160	0.00039	0.00281
3.841	$6.93 * 10^3$	0.00135	0.00019	0.00251
4.006	$1.01 * 10^4$	0.00124	0.00000	0.00252
4.007	$1.02 * 10^4$	0.00123	0.00000	0.00251
4.007	$1.02 * 10^4$	0.00123	0.00000	0.00251
4.007	$1.02 * 10^4$	0.00123	0.00000	0.00251

6.5.2 Day 57 RBD binding antibody

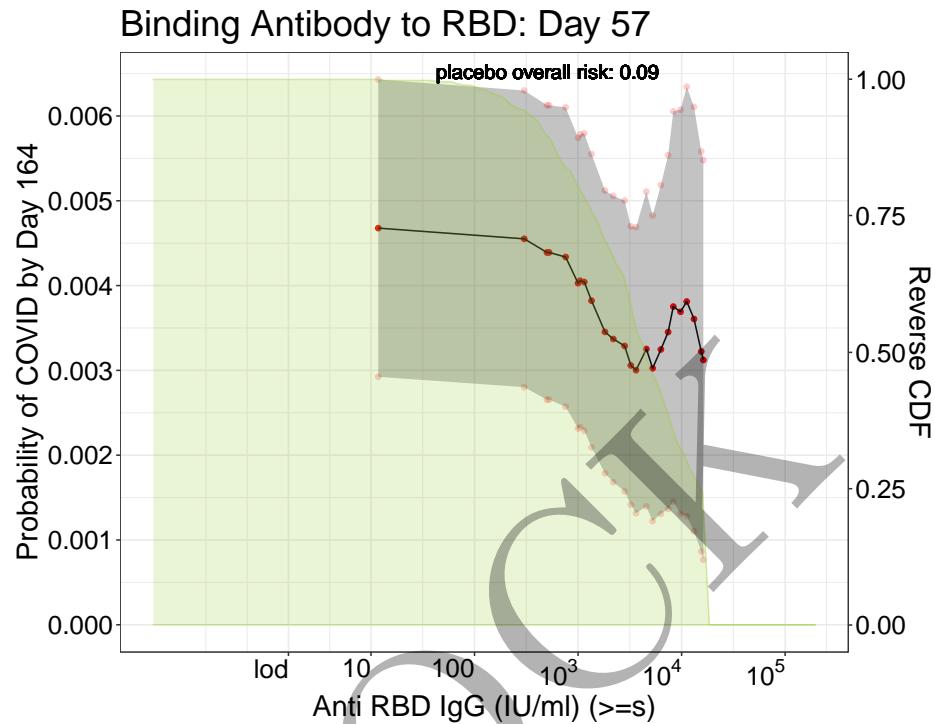


Figure 6.18: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.18: 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
1.073	$1.18 * 10^1$	0.00468	0.00292	0.00643
2.699	$5.00 * 10^2$	0.00439	0.00265	0.00613
2.882	$7.62 * 10^2$	0.00434	0.00257	0.00610
3.000	$1.00 * 10^3$	0.00403	0.00231	0.00574
3.056	$1.14 * 10^3$	0.00404	0.00229	0.00579
3.259	$1.82 * 10^3$	0.00345	0.00179	0.00512
3.557	$3.61 * 10^3$	0.00300	0.00132	0.00469
3.797	$6.27 * 10^3$	0.00325	0.00131	0.00518
3.986	$9.68 * 10^3$	0.00369	0.00131	0.00607
4.186	$1.53 * 10^4$	0.00322	0.00086	0.00558
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548

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

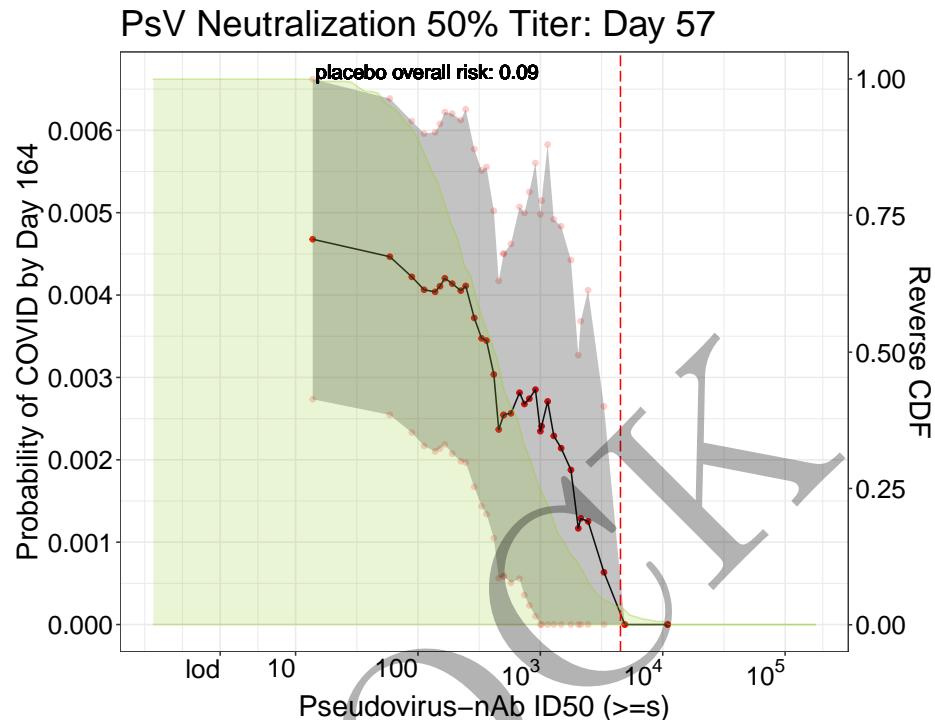


Figure 6.19: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.19: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.135	$1.36 * 10^1$	0.00468	0.00273	0.00662
2.055	$1.14 * 10^2$	0.00406	0.00217	0.00596
2.177	$1.50 * 10^2$	0.00411	0.00214	0.00608
2.281	$1.91 * 10^2$	0.00414	0.00207	0.00620
2.519	$3.30 * 10^2$	0.00347	0.00144	0.00551
2.657	$4.54 * 10^2$	0.00237	0.00056	0.00417
2.699	$5.00 * 10^2$	0.00255	0.00059	0.00451
2.828	$6.73 * 10^2$	0.00281	0.00056	0.00507
2.959	$9.10 * 10^2$	0.00285	0.00010	0.00560
3.000	$1.00 * 10^3$	0.00235	0.00000	0.00498
3.174	$1.49 * 10^3$	0.00214	0.00000	0.00484
3.307	$2.03 * 10^3$	0.00117	0.00000	0.00327
3.387	$2.44 * 10^3$	0.00125	0.00000	0.00406
4.038	$1.09 * 10^4$	0.00000	0.00000	NA

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

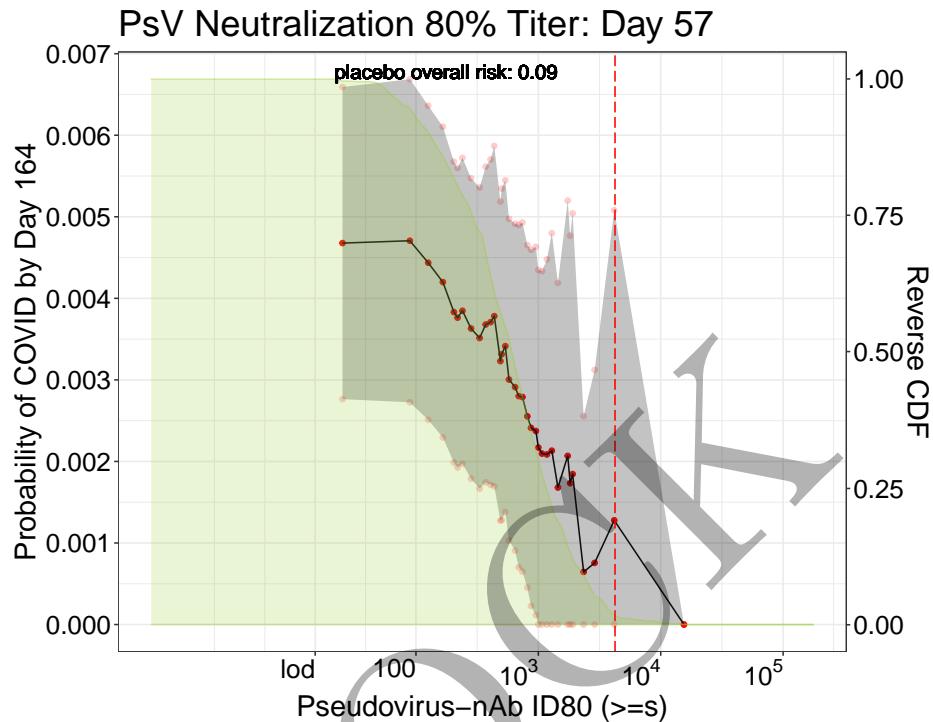


Figure 6.20: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.20: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.403	$2.53 * 10^1$	0.00468	0.00276	0.00659
2.220	$1.66 * 10^2$	0.00420	0.00229	0.00610
2.335	$2.16 * 10^2$	0.00376	0.00193	0.00560
2.455	$2.85 * 10^2$	0.00363	0.00179	0.00547
2.644	$4.41 * 10^2$	0.00378	0.00169	0.00587
2.699	$5.00 * 10^2$	0.00331	0.00128	0.00535
2.764	$5.81 * 10^2$	0.00300	0.00103	0.00498
2.874	$7.48 * 10^2$	0.00279	0.00065	0.00493
2.981	$9.57 * 10^2$	0.00237	0.00012	0.00463
3.000	$1.00 * 10^3$	0.00217	0.00000	0.00435
3.162	$1.45 * 10^3$	0.00168	0.00000	0.00419
3.265	$1.84 * 10^3$	0.00173	0.00000	0.00477
3.371	$2.35 * 10^3$	0.00065	0.00000	0.00256
4.187	$1.54 * 10^4$	0.00000	0.00000	NA

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

MOCK

6.6.1 Day 29 Spike protein antibody

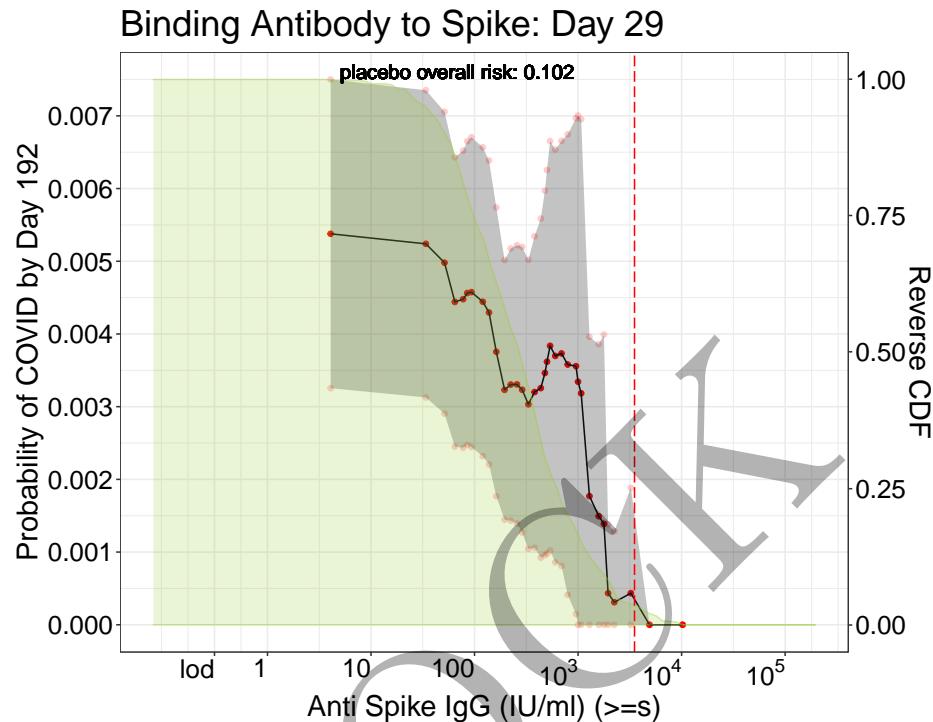


Figure 6.21: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.21: 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
0.613	4.10×10^0	0.00538	0.00325	0.00750
1.805	6.38×10^1	0.00444	0.00245	0.00643
1.927	8.45×10^1	0.00456	0.00247	0.00665
2.081	1.21×10^2	0.00444	0.00232	0.00657
2.351	2.24×10^2	0.00330	0.00143	0.00518
2.522	3.33×10^2	0.00303	0.00104	0.00502
2.677	4.75×10^2	0.00346	0.00096	0.00597
2.699	5.00×10^2	0.00362	0.00098	0.00626
2.841	6.93×10^2	0.00373	0.00081	0.00666
3.000	1.00×10^3	0.00334	0.00000	0.00700
3.112	1.29×10^3	0.00177	0.00000	0.00396
3.252	1.79×10^3	0.00139	0.00000	0.00399
3.348	2.23×10^3	0.00031	0.00000	0.00129
4.007	1.02×10^4	0.00000	0.00000	NA

6.6.2 Day 29 RBD binding antibody

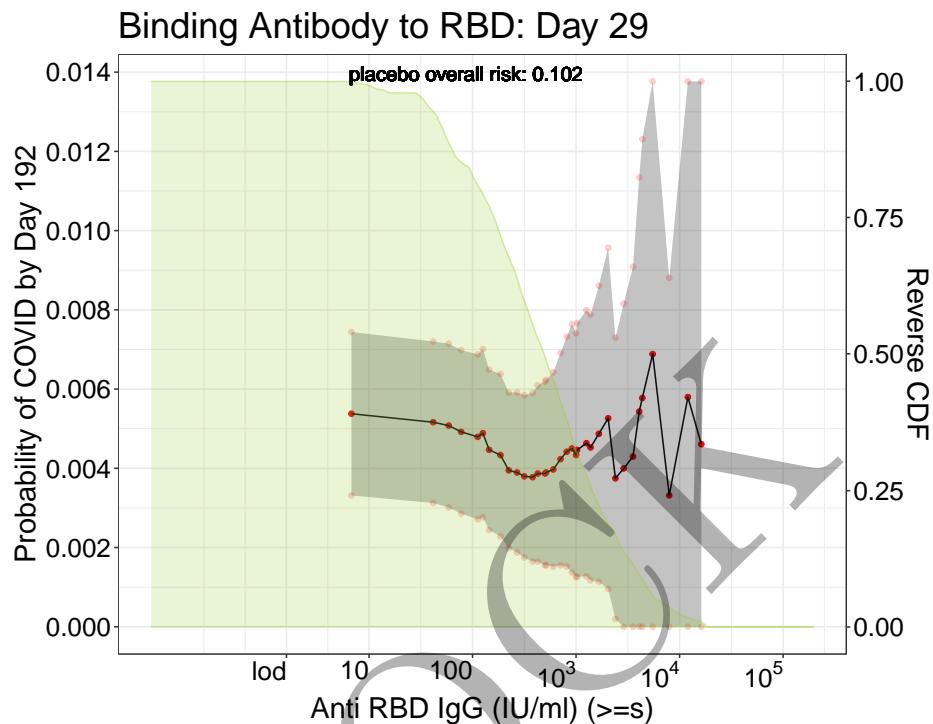


Figure 6.22: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.22: 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
0.834	$6.82 * 10^0$	0.00538	0.00332	0.00744
1.892	$7.80 * 10^1$	0.00492	0.00286	0.00698
2.098	$1.25 * 10^2$	0.00489	0.00276	0.00701
2.273	$1.87 * 10^2$	0.00433	0.00228	0.00638
2.575	$3.76 * 10^2$	0.00378	0.00165	0.00590
2.699	$5.00 * 10^2$	0.00387	0.00155	0.00619
2.780	$6.03 * 10^2$	0.00397	0.00152	0.00642
2.960	$9.12 * 10^2$	0.00450	0.00137	0.00763
3.000	$1.00 * 10^3$	0.00434	0.00126	0.00741
3.144	$1.39 * 10^3$	0.00453	0.00118	0.00788
3.461	$2.89 * 10^3$	0.00400	0.00000	0.00816
3.610	$4.07 * 10^3$	0.00543	0.00000	0.01135
3.736	$5.45 * 10^3$	0.00688	0.00000	0.01492
4.211	$1.63 * 10^4$	0.00461	0.00000	0.01883

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

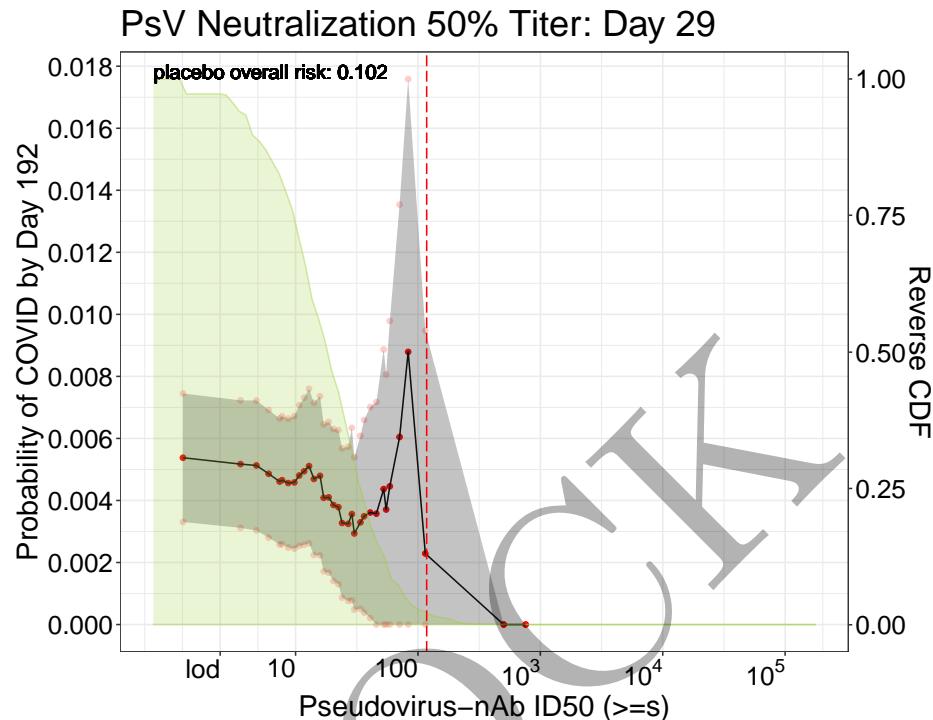


Figure 6.23: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.23: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.083	$1.21 * 10^0$	0.00538	0.00331	0.00745
0.779	$6.01 * 10^0$	0.00486	0.00280	0.00692
0.892	$7.80 * 10^0$	0.00465	0.00259	0.00671
0.988	$9.73 * 10^0$	0.00458	0.00244	0.00672
1.147	$1.40 * 10^1$	0.00469	0.00224	0.00715
1.271	$1.87 * 10^1$	0.00410	0.00167	0.00653
1.382	$2.41 * 10^1$	0.00327	0.00087	0.00568
1.481	$3.03 * 10^1$	0.00294	0.00048	0.00539
1.656	$4.53 * 10^1$	0.00357	0.00000	0.00717
1.741	$5.51 * 10^1$	0.00371	0.00000	0.00806
1.852	$7.11 * 10^1$	0.00605	0.00000	0.01354
2.699	$5.00 * 10^2$	0.00000	0.00000	NA
2.879	$7.57 * 10^2$	0.00000	0.00000	NA
2.879	$7.57 * 10^2$	0.00000	0.00000	NA

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

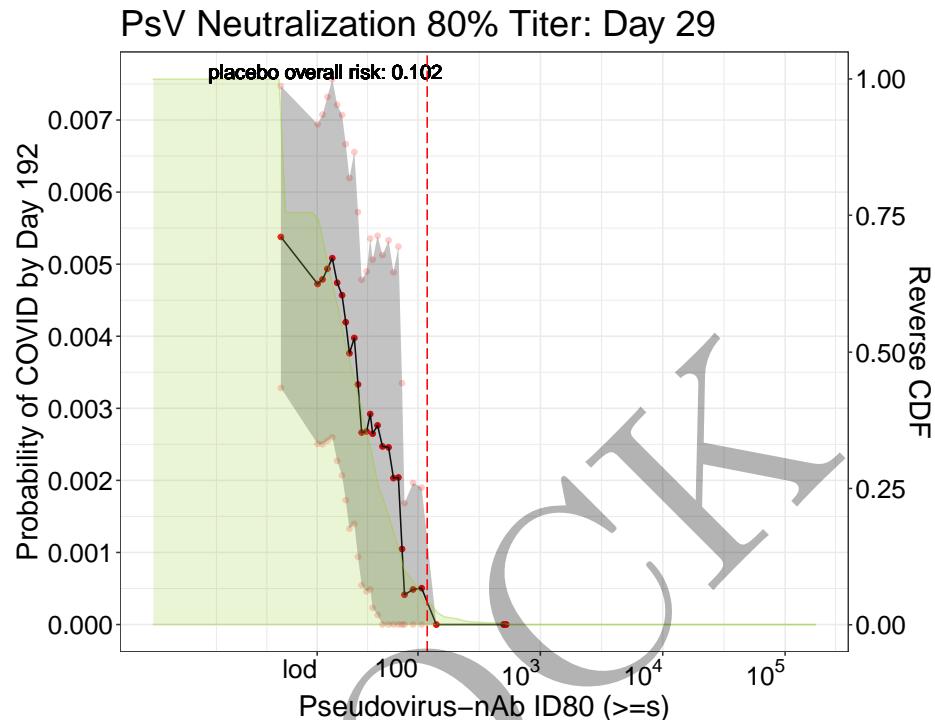


Figure 6.24: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed.

Table 6.24: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
0.876	7.52 * 10 ⁰	0.00538	0.00328	0.00747
0.876	7.52 * 10 ⁰	0.00538	0.00328	0.00747
0.876	7.52 * 10 ⁰	0.00538	0.00328	0.00747
1.183	1.52 * 10 ¹	0.00473	0.00251	0.00694
1.339	2.18 * 10 ¹	0.00474	0.00227	0.00721
1.440	2.75 * 10 ¹	0.00376	0.00133	0.00620
1.541	3.48 * 10 ¹	0.00266	0.00055	0.00478
1.632	4.29 * 10 ¹	0.00265	0.00023	0.00506
1.796	6.25 * 10 ¹	0.00203	0.00000	0.00489
1.868	7.38 * 10 ¹	0.00105	0.00000	0.00335
1.956	9.04 * 10 ¹	0.00049	0.00000	0.00196
2.699	5.00 * 10 ²	0.00000	0.00000	NA
2.719	5.24 * 10 ²	0.00000	0.00000	NA
2.719	5.24 * 10 ²	0.00000	0.00000	NA

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

MOCK

6.7.1 Day 57 Spike protein binding antibody

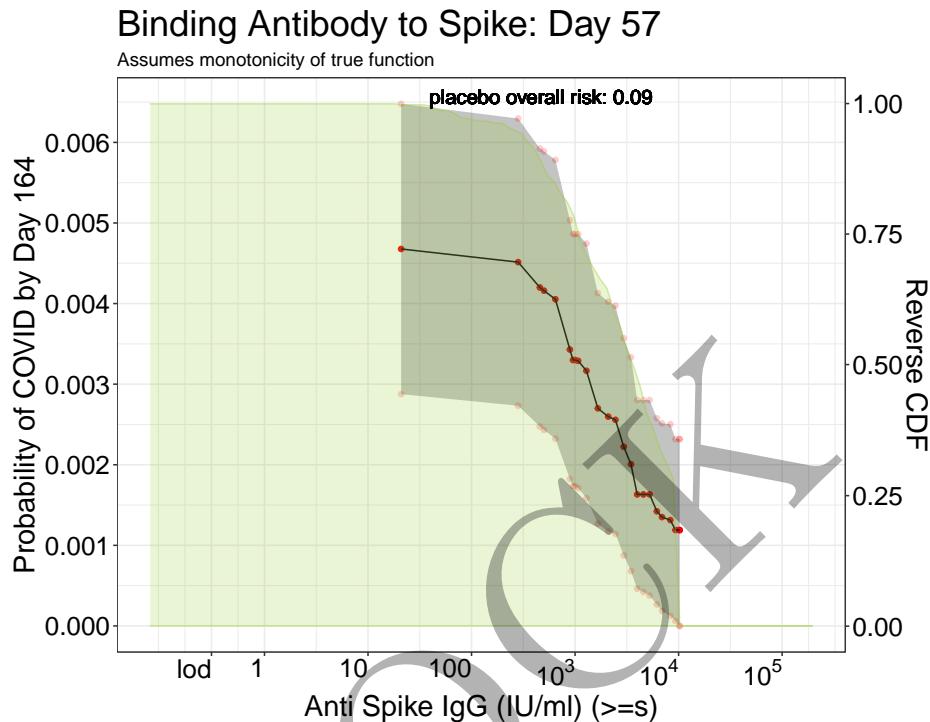


Figure 6.25: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.25: Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
1.316	2.07×10^1	0.00468	0.00288	0.00648
2.699	5.00×10^2	0.00416	0.00243	0.00589
2.815	6.53×10^2	0.00405	0.00232	0.00578
2.982	9.59×10^2	0.00330	0.00174	0.00486
3.000	1.00×10^3	0.00330	0.00174	0.00486
3.113	1.30×10^3	0.00317	0.00159	0.00474
3.471	2.96×10^3	0.00222	0.00088	0.00357
3.658	4.55×10^3	0.00163	0.00042	0.00284
3.841	6.93×10^3	0.00135	0.00019	0.00251
4.006	1.01×10^4	0.00119	0.00000	0.00248
4.007	1.02×10^4	0.00119	0.00000	0.00247
4.007	1.02×10^4	0.00119	0.00000	0.00247
4.007	1.02×10^4	0.00119	0.00000	0.00247

6.7.2 Day 57 RBD binding antibody

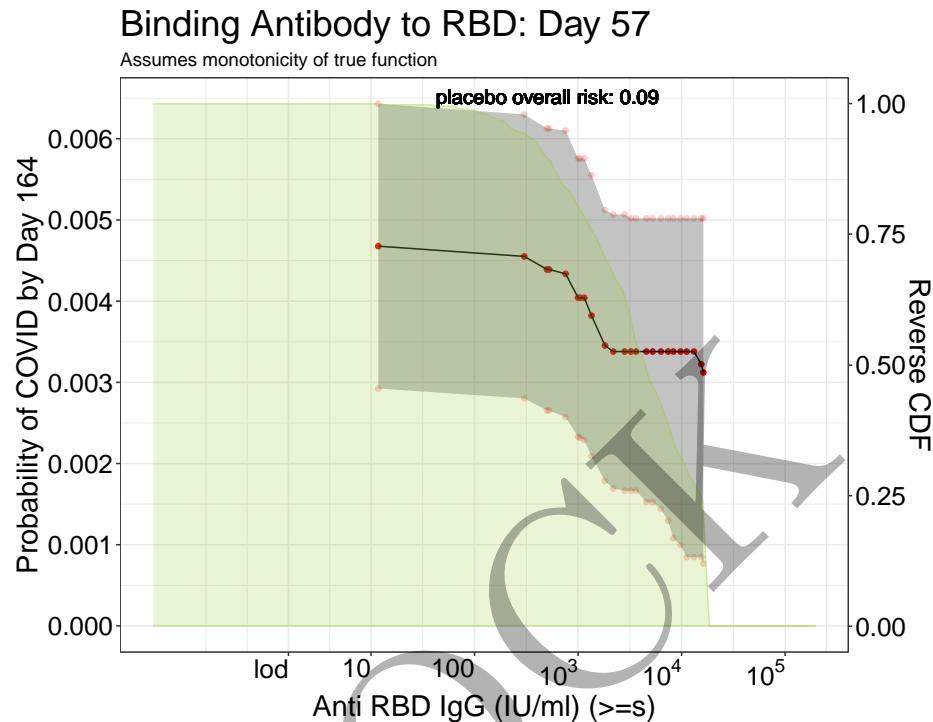


Figure 6.26: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.26: 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
1.073	$1.18 * 10^1$	0.00468	0.00292	0.00643
2.699	$5.00 * 10^2$	0.00439	0.00265	0.00613
2.882	$7.62 * 10^2$	0.00434	0.00257	0.00610
3.000	$1.00 * 10^3$	0.00404	0.00233	0.00576
3.056	$1.14 * 10^3$	0.00404	0.00229	0.00579
3.259	$1.82 * 10^3$	0.00345	0.00179	0.00512
3.557	$3.61 * 10^3$	0.00338	0.00169	0.00507
3.797	$6.27 * 10^3$	0.00338	0.00144	0.00532
3.986	$9.68 * 10^3$	0.00338	0.00100	0.00576
4.186	$1.53 * 10^4$	0.00322	0.00086	0.00558
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548
4.211	$1.63 * 10^4$	0.00312	0.00077	0.00548

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

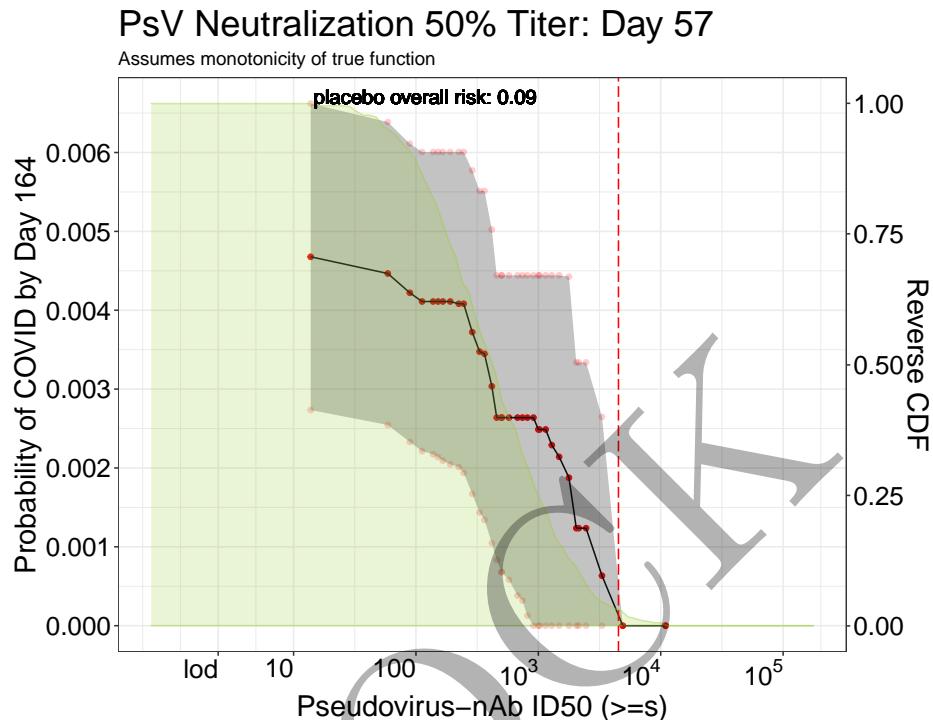


Figure 6.27: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.27: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.135	$1.36 * 10^1$	0.00468	0.00273	0.00662
2.055	$1.14 * 10^2$	0.00411	0.00221	0.00601
2.177	$1.50 * 10^2$	0.00411	0.00214	0.00608
2.281	$1.91 * 10^2$	0.00411	0.00205	0.00617
2.519	$3.30 * 10^2$	0.00347	0.00144	0.00551
2.657	$4.54 * 10^2$	0.00264	0.00083	0.00444
2.699	$5.00 * 10^2$	0.00264	0.00068	0.00460
2.828	$6.73 * 10^2$	0.00264	0.00038	0.00489
2.959	$9.10 * 10^2$	0.00264	0.00000	0.00539
3.000	$1.00 * 10^3$	0.00249	0.00000	0.00512
3.174	$1.49 * 10^3$	0.00214	0.00000	0.00484
3.307	$2.03 * 10^3$	0.00124	0.00000	0.00334
3.387	$2.44 * 10^3$	0.00124	0.00000	0.00404
4.038	$1.09 * 10^4$	0.00000	0.00000	NA

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

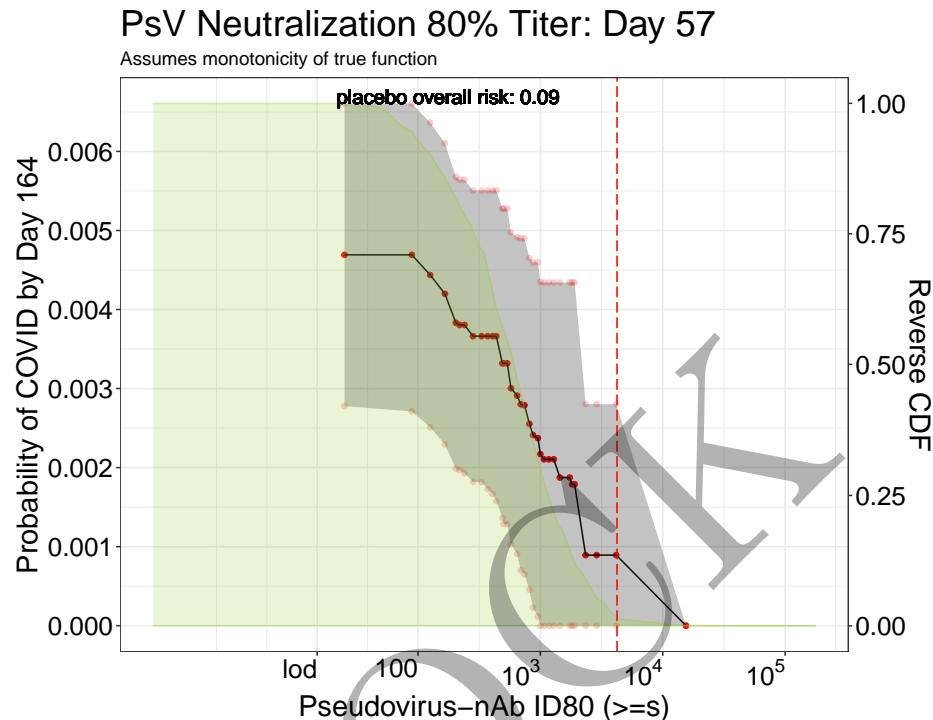


Figure 6.28: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.28: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.403	2.53×10^1	0.00469	0.00278	0.00661
2.220	1.66×10^2	0.00420	0.00229	0.00610
2.335	2.16×10^2	0.00380	0.00197	0.00564
2.455	2.85×10^2	0.00366	0.00182	0.00551
2.644	4.41×10^2	0.00366	0.00158	0.00575
2.699	5.00×10^2	0.00332	0.00129	0.00535
2.764	5.81×10^2	0.00300	0.00103	0.00498
2.874	7.48×10^2	0.00279	0.00065	0.00493
2.981	9.57×10^2	0.00237	0.00012	0.00463
3.000	1.00×10^3	0.00217	0.00000	0.00435
3.162	1.45×10^3	0.00187	0.00000	0.00438
3.265	1.84×10^3	0.00179	0.00000	0.00482
3.371	2.35×10^3	0.00089	0.00000	0.00280
4.187	1.54×10^4	0.00000	0.00000	NA

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

MOCK

6.8.1 Day 29 Spike protein antibody

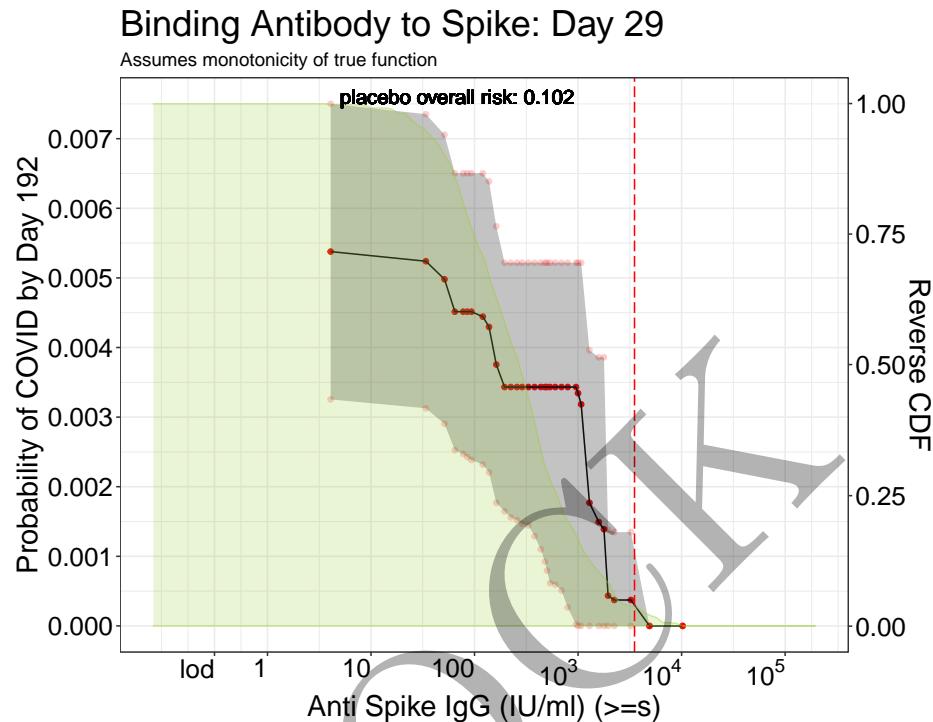


Figure 6.29: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.29: 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
0.613	4.10×10^0	0.00538	0.00325	0.00750
1.805	6.38×10^1	0.00451	0.00253	0.00650
1.927	8.45×10^1	0.00451	0.00243	0.00660
2.081	1.21×10^2	0.00444	0.00232	0.00657
2.351	2.24×10^2	0.00343	0.00156	0.00530
2.522	3.33×10^2	0.00343	0.00144	0.00542
2.677	4.75×10^2	0.00343	0.00093	0.00594
2.699	5.00×10^2	0.00343	0.00079	0.00607
2.841	6.93×10^2	0.00343	0.00051	0.00636
3.000	1.00×10^3	0.00334	0.00000	0.00700
3.112	1.29×10^3	0.00177	0.00000	0.00396
3.252	1.79×10^3	0.00139	0.00000	0.00399
3.348	2.23×10^3	0.00037	0.00000	0.00135
4.007	1.02×10^4	0.00000	0.00000	NA

6.8.2 Day 29 RBD binding antibody

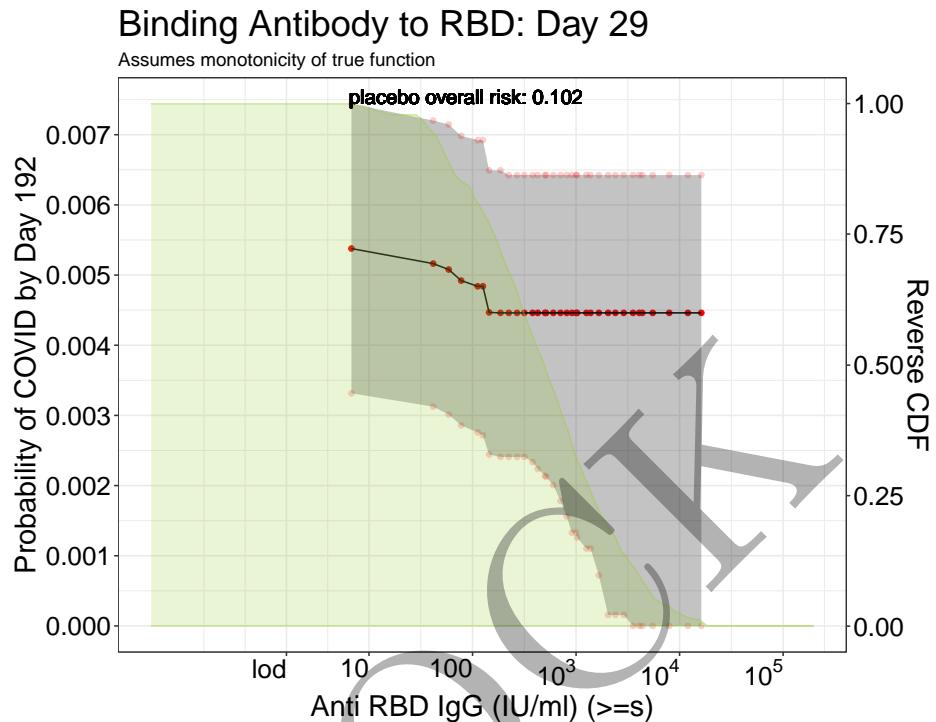


Figure 6.30: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.30: 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
0.834	$6.82 * 10^0$	0.00538	0.00332	0.00744
1.892	$7.80 * 10^1$	0.00492	0.00286	0.00698
2.098	$1.25 * 10^2$	0.00484	0.00272	0.00696
2.273	$1.87 * 10^2$	0.00446	0.00241	0.00651
2.575	$3.76 * 10^2$	0.00446	0.00233	0.00659
2.699	$5.00 * 10^2$	0.00446	0.00214	0.00678
2.780	$6.03 * 10^2$	0.00446	0.00201	0.00692
2.960	$9.12 * 10^2$	0.00446	0.00133	0.00759
3.000	$1.00 * 10^3$	0.00446	0.00139	0.00754
3.144	$1.39 * 10^3$	0.00446	0.00111	0.00781
3.461	$2.89 * 10^3$	0.00446	0.00030	0.00862
3.610	$4.07 * 10^3$	0.00446	0.00000	0.01037
3.736	$5.45 * 10^3$	0.00446	0.00000	0.01250
4.211	$1.63 * 10^4$	0.00446	0.00000	0.01868

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

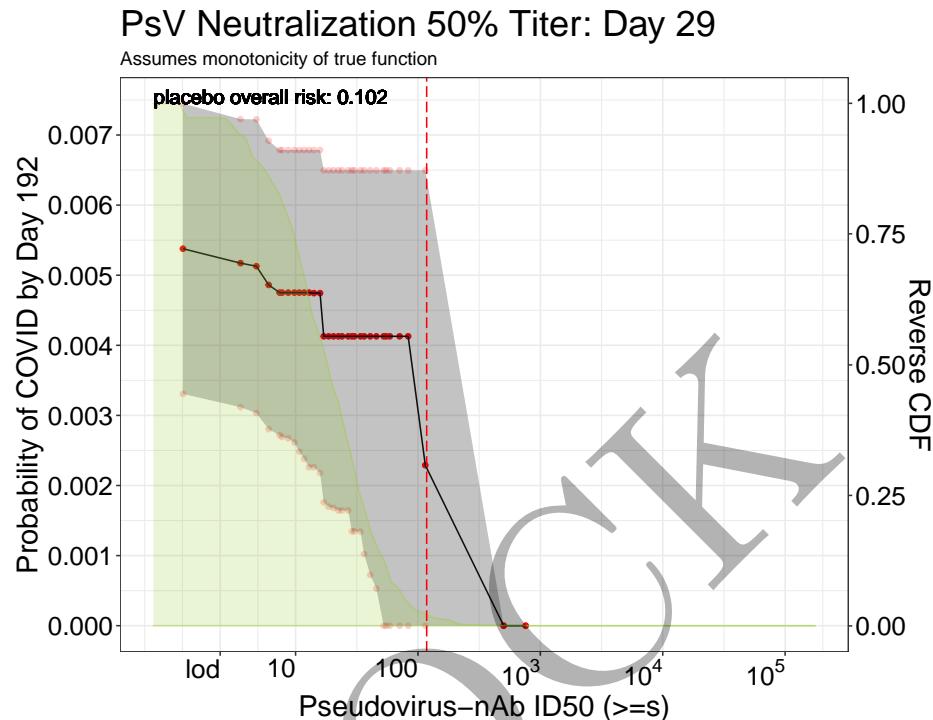


Figure 6.31: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.31: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.083	$1.21 * 10^0$	0.00538	0.00331	0.00745
0.779	$6.01 * 10^0$	0.00486	0.00280	0.00692
0.892	$7.80 * 10^0$	0.00475	0.00269	0.00681
0.988	$9.73 * 10^0$	0.00475	0.00261	0.00689
1.147	$1.40 * 10^1$	0.00474	0.00229	0.00720
1.271	$1.87 * 10^1$	0.00413	0.00170	0.00656
1.382	$2.41 * 10^1$	0.00413	0.00172	0.00653
1.481	$3.03 * 10^1$	0.00413	0.00167	0.00658
1.656	$4.53 * 10^1$	0.00413	0.00053	0.00773
1.741	$5.51 * 10^1$	0.00413	0.00000	0.00848
1.852	$7.11 * 10^1$	0.00413	0.00000	0.01162
2.699	$5.00 * 10^2$	0.00000	0.00000	NA
2.879	$7.57 * 10^2$	0.00000	0.00000	NA
2.879	$7.57 * 10^2$	0.00000	0.00000	NA

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

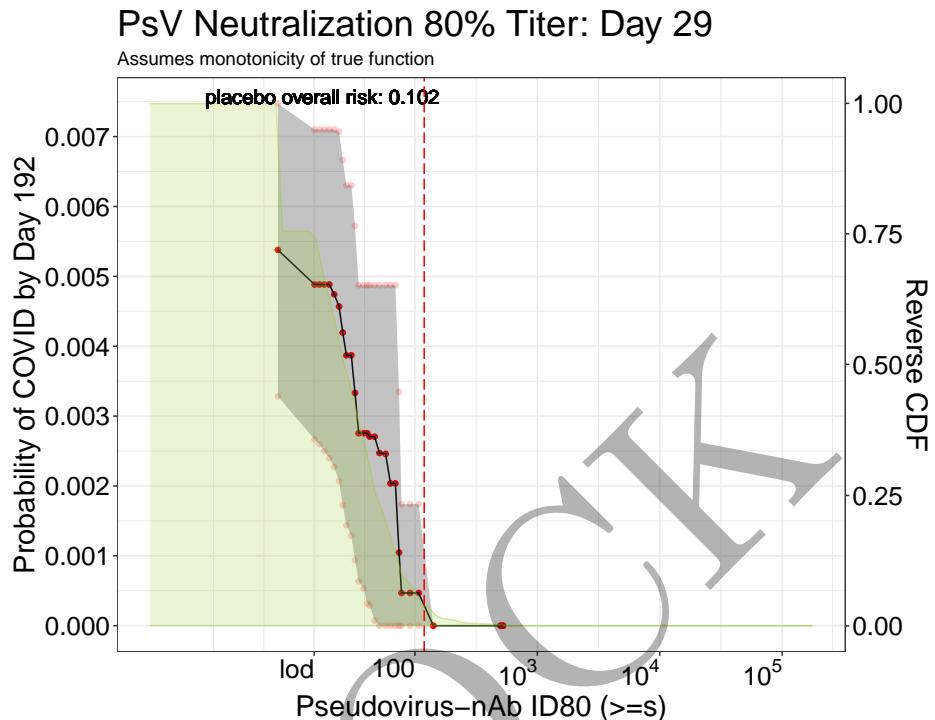


Figure 6.32: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The dashed red line marks the threshold after which no more COVID events are observed. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 6.32: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.876	7.52×10^0	0.00538	0.00328	0.00747
0.876	7.52×10^0	0.00538	0.00328	0.00747
0.876	7.52×10^0	0.00538	0.00328	0.00747
1.183	1.52×10^1	0.00488	0.00267	0.00710
1.339	2.18×10^1	0.00474	0.00227	0.00721
1.440	2.75×10^1	0.00387	0.00144	0.00630
1.541	3.48×10^1	0.00275	0.00064	0.00487
1.632	4.29×10^1	0.00271	0.00029	0.00512
1.796	6.25×10^1	0.00204	0.00000	0.00489
1.868	7.38×10^1	0.00105	0.00000	0.00335
1.956	9.04×10^1	0.00047	0.00000	0.00195
2.699	5.00×10^2	0.00000	0.00000	NA
2.719	5.24×10^2	0.00000	0.00000	NA
2.719	5.24×10^2	0.00000	0.00000	NA

MOCK

Chapter 7

Univariate CoR: Nonparametric Threshold Modeling ($\leq s$)

The same methodology as the previous section is apply to estimate the “below” threshold-response function $E_{W|A=1}[Y = 1 | A = 1, X, S \leq s]$.

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

7.1.1 Day 57 Spike protein binding antibody

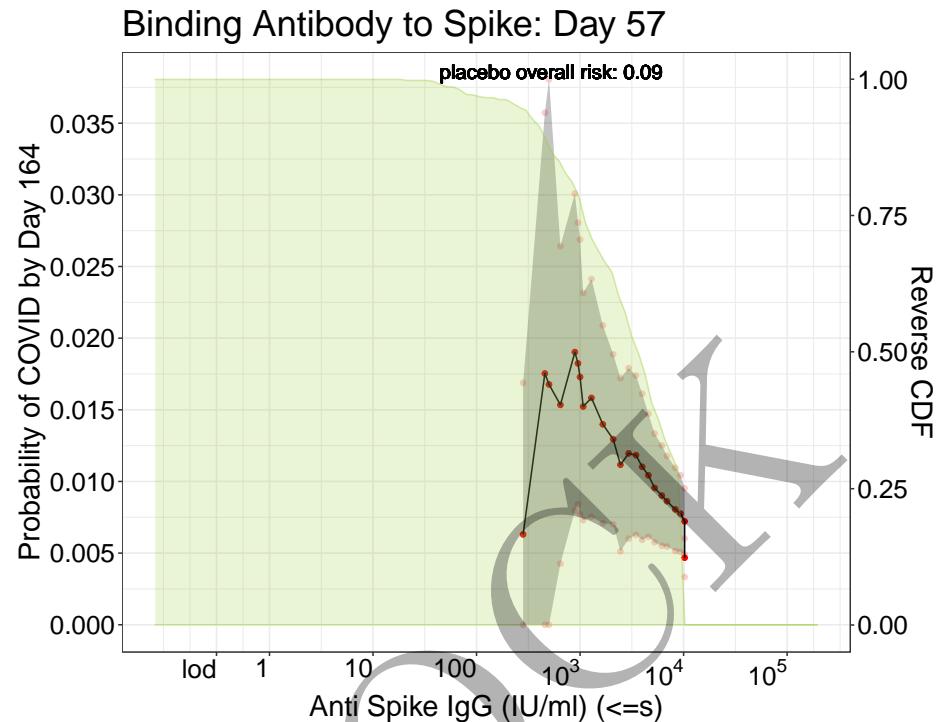


Figure 7.1: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.

Table 7.1: 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
2.450	$2.82 * 10^2$	0.00630	0.00000	0.01688
2.699	$5.00 * 10^2$	0.01677	0.00000	0.04605
2.815	$6.53 * 10^2$	0.01534	0.00427	0.02642
2.982	$9.59 * 10^2$	0.01824	0.00841	0.02806
3.000	$1.00 * 10^3$	0.01729	0.00770	0.02688
3.113	$1.30 * 10^3$	0.01583	0.00753	0.02413
3.471	$2.96 * 10^3$	0.01196	0.00601	0.01791
3.658	$4.55 * 10^3$	0.01043	0.00614	0.01471
3.841	$6.93 * 10^3$	0.00862	0.00546	0.01178
4.006	$1.01 * 10^4$	0.00721	0.00491	0.00952
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602

7.1.2 Day 57 RBD binding antibody

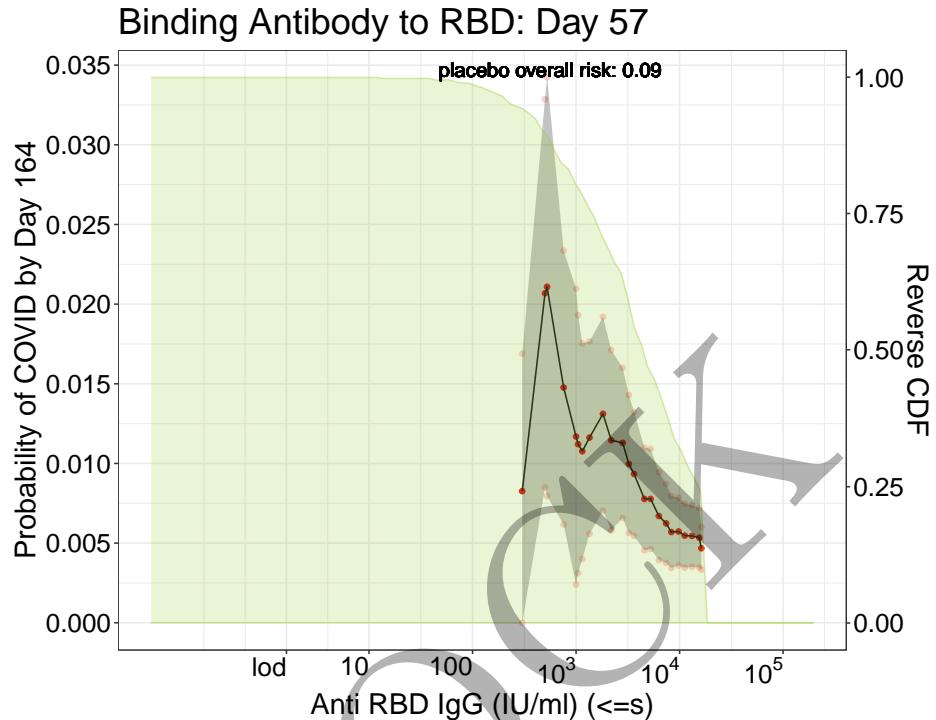


Figure 7.2: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals.

Table 7.2: 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
2.478	$3.01 * 10^2$	0.00826	0.00000	0.01689
2.699	$5.00 * 10^2$	0.02068	0.00850	0.03286
2.882	$7.62 * 10^2$	0.01476	0.00617	0.02336
3.000	$1.00 * 10^3$	0.01169	0.00241	0.02097
3.056	$1.14 * 10^3$	0.01076	0.00400	0.01753
3.259	$1.82 * 10^3$	0.01311	0.00703	0.01920
3.557	$3.61 * 10^3$	0.00934	0.00546	0.01322
3.797	$6.27 * 10^3$	0.00670	0.00394	0.00946
3.986	$9.68 * 10^3$	0.00573	0.00359	0.00786
4.186	$1.53 * 10^4$	0.00534	0.00348	0.00720
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602

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

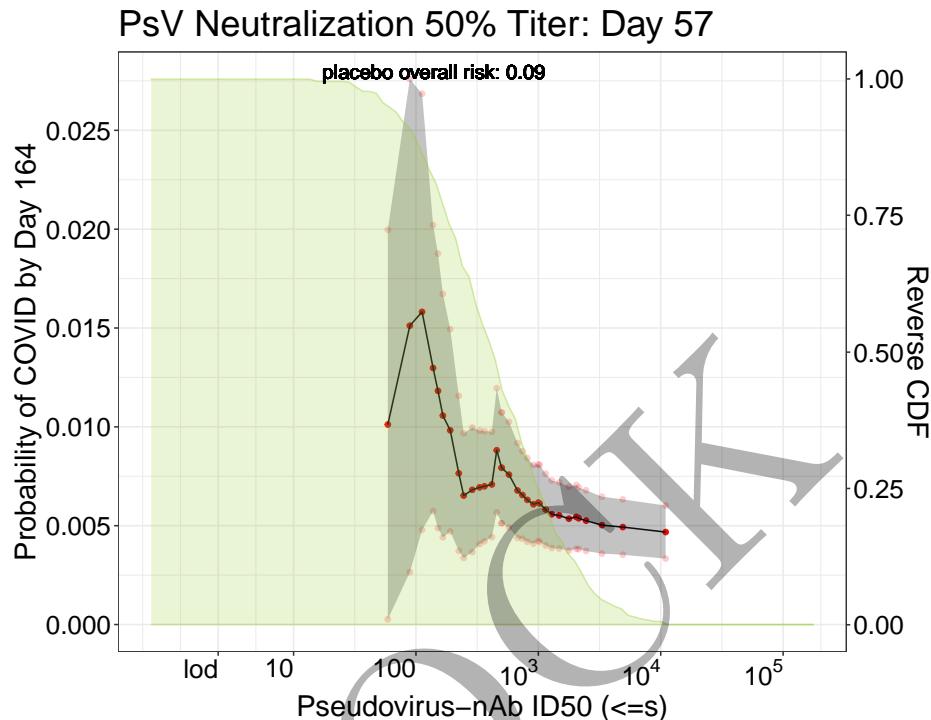


Figure 7.3: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

Table 7.3: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.765	$5.82 * 10^1$	0.01012	0.00026	0.01997
2.055	$1.14 * 10^2$	0.01582	0.00478	0.02685
2.177	$1.50 * 10^2$	0.01182	0.00488	0.01876
2.281	$1.91 * 10^2$	0.00982	0.00471	0.01494
2.519	$3.30 * 10^2$	0.00694	0.00407	0.00981
2.657	$4.54 * 10^2$	0.00882	0.00568	0.01196
2.699	$5.00 * 10^2$	0.00793	0.00513	0.01073
2.828	$6.73 * 10^2$	0.00678	0.00438	0.00918
2.959	$9.10 * 10^2$	0.00608	0.00409	0.00807
3.000	$1.00 * 10^3$	0.00617	0.00423	0.00810
3.174	$1.49 * 10^3$	0.00552	0.00384	0.00719
3.307	$2.03 * 10^3$	0.00544	0.00383	0.00706
3.387	$2.44 * 10^3$	0.00526	0.00372	0.00679
4.038	$1.09 * 10^4$	0.00468	0.00334	0.00602

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

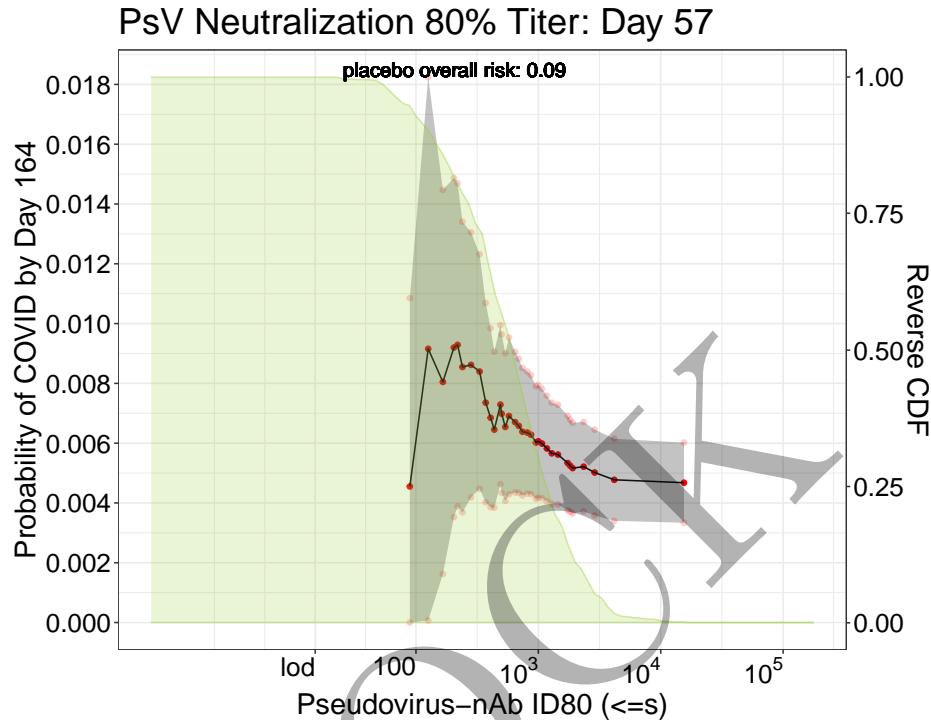


Figure 7.4: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

Table 7.4: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.954	8.99 * 10 ¹	0.00455	0.00000	0.01085
2.220	1.66 * 10 ²	0.00805	0.00162	0.01447
2.335	2.16 * 10 ²	0.00929	0.00388	0.01469
2.455	2.85 * 10 ²	0.00862	0.00419	0.01305
2.644	4.41 * 10 ²	0.00645	0.00384	0.00906
2.699	5.00 * 10 ²	0.00699	0.00433	0.00964
2.764	5.81 * 10 ²	0.00691	0.00429	0.00953
2.874	7.48 * 10 ²	0.00638	0.00425	0.00852
2.981	9.57 * 10 ²	0.00602	0.00414	0.00791
3.000	1.00 * 10 ³	0.00606	0.00418	0.00795
3.162	1.45 * 10 ³	0.00562	0.00395	0.00728
3.265	1.84 * 10 ³	0.00525	0.00371	0.00678
3.371	2.35 * 10 ³	0.00521	0.00372	0.00671
4.187	1.54 * 10 ⁴	0.00468	0.00334	0.00602

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

MOCK

7.2.1 Day 29 Spike protein antibody

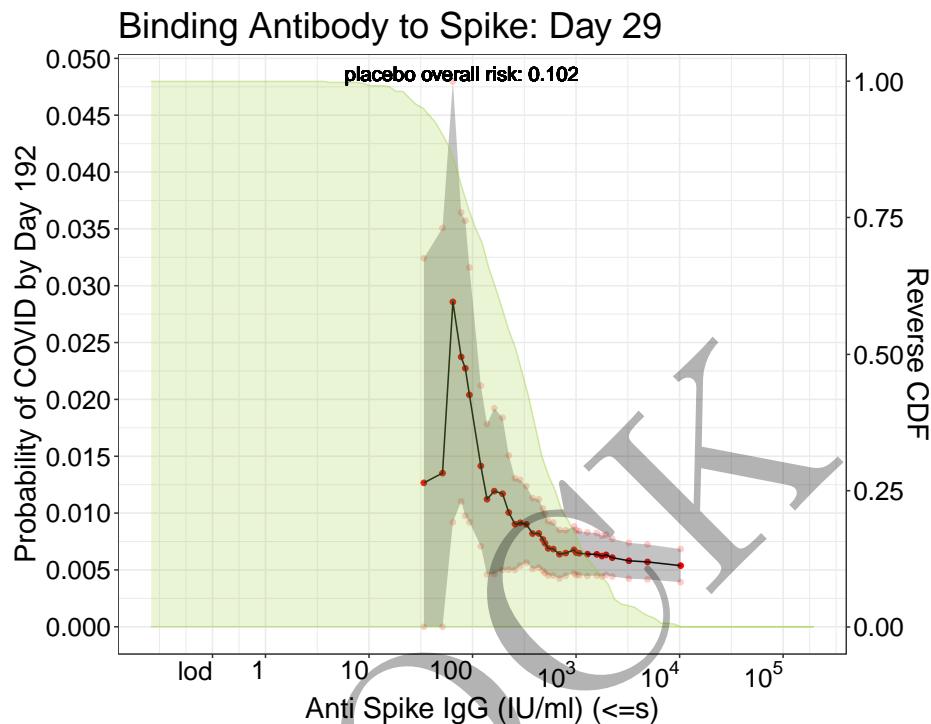


Figure 7.5: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals.

Table 7.5: 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
1.532	$3.40 * 10^1$	0.01266	0.00000	0.03241
1.805	$6.38 * 10^1$	0.02858	0.00918	0.04797
1.927	$8.45 * 10^1$	0.02273	0.00975	0.03572
2.081	$1.21 * 10^2$	0.01415	0.00708	0.02121
2.351	$2.24 * 10^2$	0.01005	0.00502	0.01507
2.522	$3.33 * 10^2$	0.00901	0.00564	0.01237
2.677	$4.75 * 10^2$	0.00768	0.00493	0.01042
2.699	$5.00 * 10^2$	0.00734	0.00473	0.00996
2.841	$6.93 * 10^2$	0.00638	0.00424	0.00852
3.000	$1.00 * 10^3$	0.00653	0.00455	0.00851
3.112	$1.29 * 10^3$	0.00639	0.00447	0.00830
3.252	$1.79 * 10^3$	0.00622	0.00443	0.00801
3.348	$2.23 * 10^3$	0.00608	0.00442	0.00774
4.007	$1.02 * 10^4$	0.00538	0.00392	0.00683

7.2.2 Day 29 RBD binding antibody

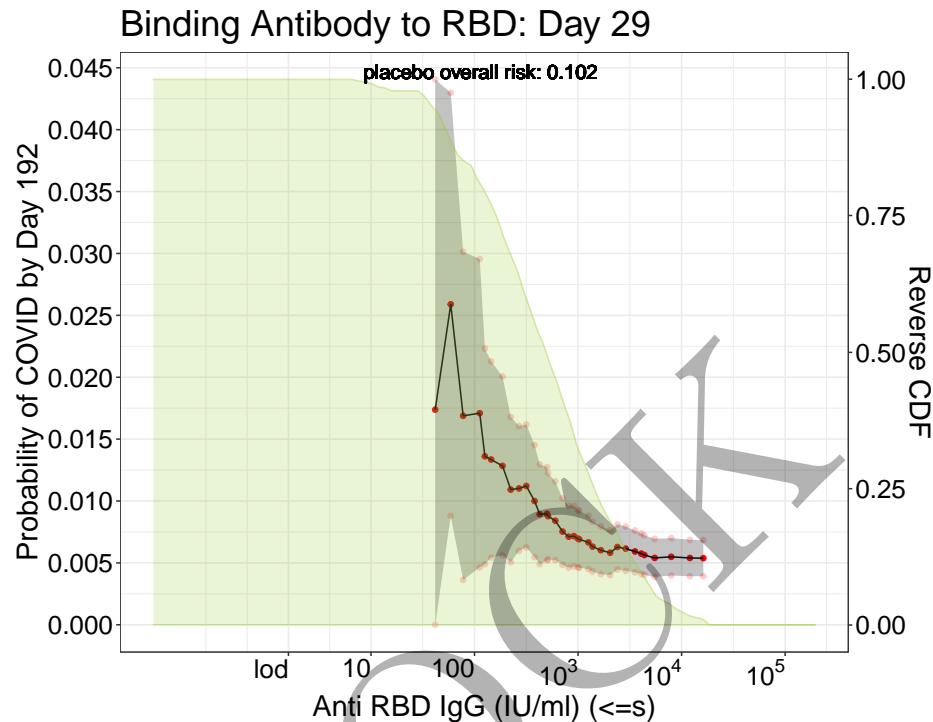


Figure 7.6: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals.

Table 7.6: 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
1.620	$4.17 * 10^1$	0.01738	0.00000	0.04406
1.892	$7.80 * 10^1$	0.01688	0.00363	0.03013
2.098	$1.25 * 10^2$	0.01361	0.00489	0.02232
2.273	$1.87 * 10^2$	0.01284	0.00561	0.02006
2.575	$3.76 * 10^2$	0.00999	0.00546	0.01453
2.699	$5.00 * 10^2$	0.00897	0.00519	0.01274
2.780	$6.03 * 10^2$	0.00840	0.00523	0.01158
2.960	$9.12 * 10^2$	0.00716	0.00471	0.00961
3.000	$1.00 * 10^3$	0.00696	0.00465	0.00926
3.144	$1.39 * 10^3$	0.00631	0.00430	0.00833
3.461	$2.89 * 10^3$	0.00615	0.00436	0.00794
3.610	$4.07 * 10^3$	0.00575	0.00411	0.00739
3.736	$5.45 * 10^3$	0.00540	0.00386	0.00694
4.211	$1.63 * 10^4$	0.00538	0.00392	0.00683

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

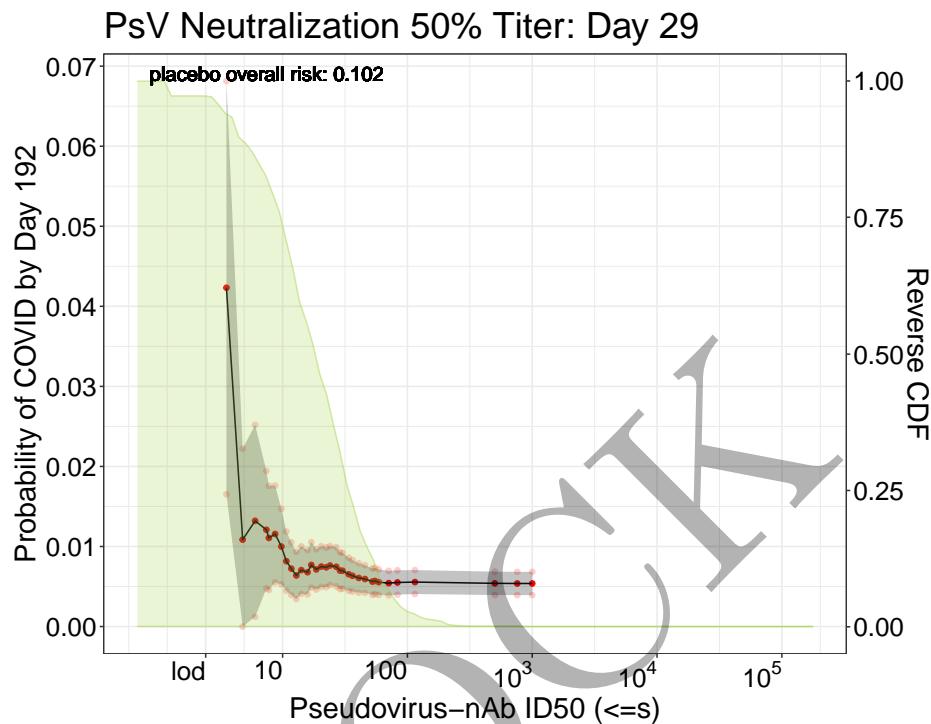


Figure 7.7: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

Table 7.7: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
0.548	3.53 * 10 ⁰	0.04232	0.01652	0.06812
0.779	6.01 * 10 ⁰	0.01320	0.00122	0.02518
0.892	7.80 * 10 ⁰	0.01106	0.00455	0.01757
0.988	9.73 * 10 ⁰	0.00999	0.00527	0.01472
1.147	1.40 * 10 ¹	0.00705	0.00407	0.01002
1.271	1.87 * 10 ¹	0.00714	0.00462	0.00966
1.382	2.41 * 10 ¹	0.00762	0.00518	0.01006
1.481	3.03 * 10 ¹	0.00697	0.00474	0.00920
1.656	4.53 * 10 ¹	0.00594	0.00421	0.00766
1.741	5.51 * 10 ¹	0.00569	0.00405	0.00733
1.852	7.11 * 10 ¹	0.00542	0.00389	0.00696
2.699	5.00 * 10 ²	0.00540	0.00394	0.00685
2.879	7.57 * 10 ²	0.00538	0.00392	0.00683
3.000	1.00 * 10 ³	0.00538	0.00392	0.00683

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

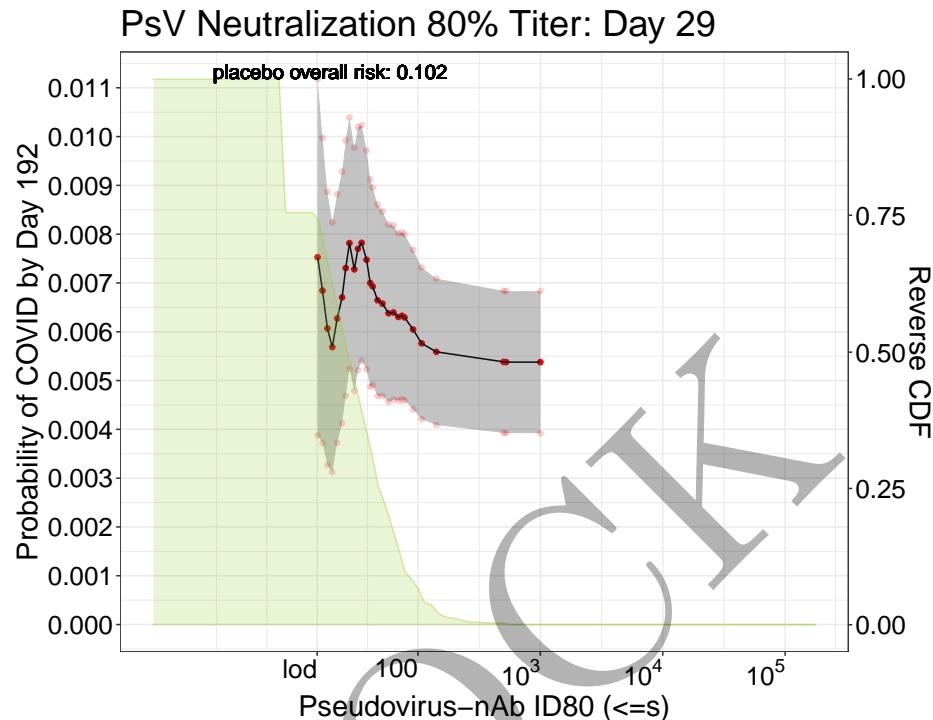


Figure 7.8: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

Table 7.8: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals.

log ₁₀ -Threshold	Threshold	Risk estimate	CI left	CI right
1.183	1.52 * 10 ¹	0.00753	0.00388	0.01118
1.183	1.52 * 10 ¹	0.00753	0.00388	0.01118
1.183	1.52 * 10 ¹	0.00753	0.00388	0.01118
1.183	1.52 * 10 ¹	0.00753	0.00388	0.01118
1.339	2.18 * 10 ¹	0.00627	0.00372	0.00882
1.440	2.75 * 10 ¹	0.00782	0.00524	0.01039
1.541	3.48 * 10 ¹	0.00782	0.00541	0.01024
1.632	4.29 * 10 ¹	0.00693	0.00491	0.00895
1.796	6.25 * 10 ¹	0.00640	0.00461	0.00818
1.868	7.38 * 10 ¹	0.00633	0.00462	0.00804
1.956	9.04 * 10 ¹	0.00605	0.00441	0.00768
2.699	5.00 * 10 ²	0.00538	0.00393	0.00684
2.719	5.24 * 10 ²	0.00538	0.00392	0.00683
3.000	1.00 * 10 ³	0.00538	0.00392	0.00683

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

MOCK

7.3.1 Day 57 Spike protein binding antibody

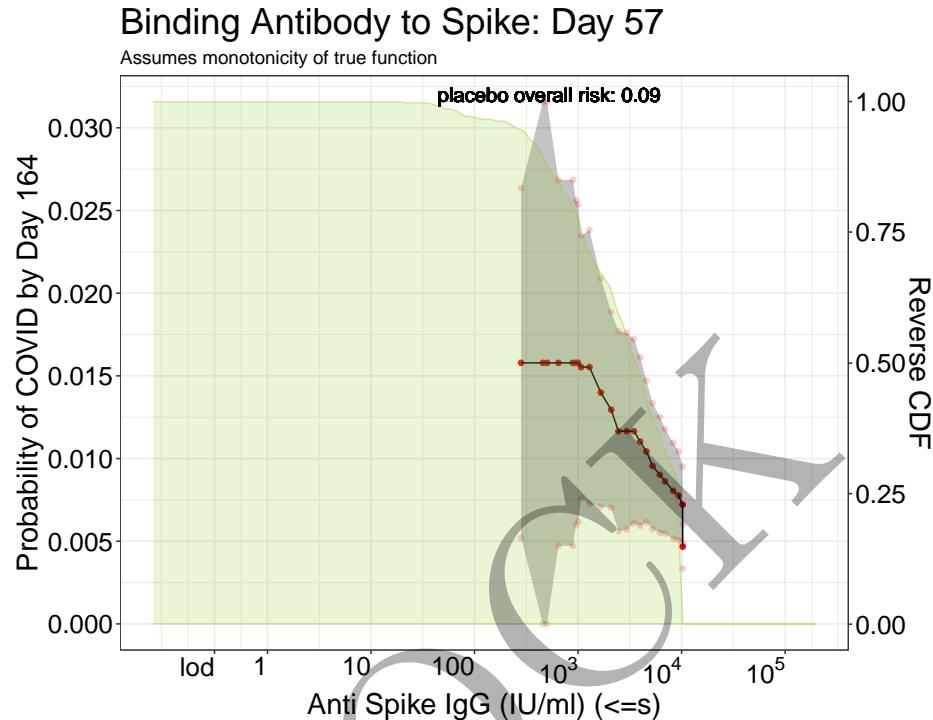


Figure 7.9: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.9: Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with pointwise 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.450	$2.82 * 10^2$	0.01579	0.00521	0.02636
2.699	$5.00 * 10^2$	0.01579	0.00000	0.04506
2.815	$6.53 * 10^2$	0.01579	0.00471	0.02686
2.982	$9.59 * 10^2$	0.01579	0.00596	0.02561
3.000	$1.00 * 10^3$	0.01579	0.00620	0.02538
3.113	$1.30 * 10^3$	0.01553	0.00723	0.02383
3.471	$2.96 * 10^3$	0.01165	0.00570	0.01760
3.658	$4.55 * 10^3$	0.01043	0.00614	0.01471
3.841	$6.93 * 10^3$	0.00862	0.00546	0.01178
4.006	$1.01 * 10^4$	0.00721	0.00491	0.00952
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602
4.007	$1.02 * 10^4$	0.00468	0.00334	0.00602

7.3.2 Day 57 RBD binding antibody

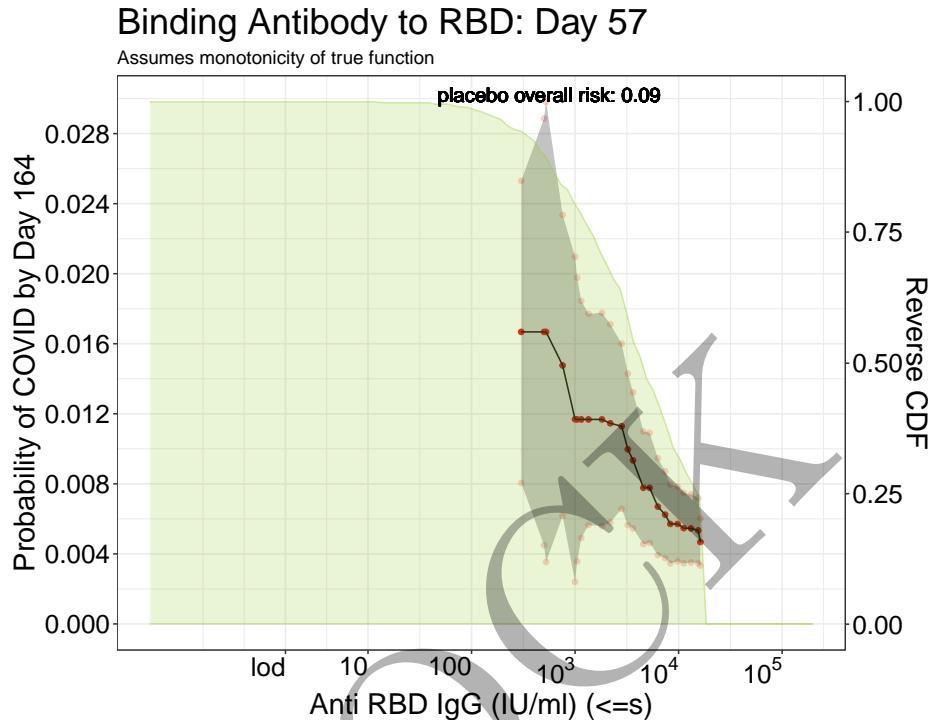


Figure 7.10: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.10: 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
2.478	$3.01 * 10^2$	0.01668	0.00805	0.02531
2.699	$5.00 * 10^2$	0.01668	0.00450	0.02886
2.882	$7.62 * 10^2$	0.01476	0.00617	0.02336
3.000	$1.00 * 10^3$	0.01169	0.00241	0.02097
3.056	$1.14 * 10^3$	0.01168	0.00491	0.01844
3.259	$1.82 * 10^3$	0.01168	0.00559	0.01777
3.557	$3.61 * 10^3$	0.00934	0.00546	0.01322
3.797	$6.27 * 10^3$	0.00670	0.00394	0.00946
3.986	$9.68 * 10^3$	0.00571	0.00358	0.00784
4.186	$1.53 * 10^4$	0.00534	0.00348	0.00720
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602
4.211	$1.63 * 10^4$	0.00468	0.00334	0.00602

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

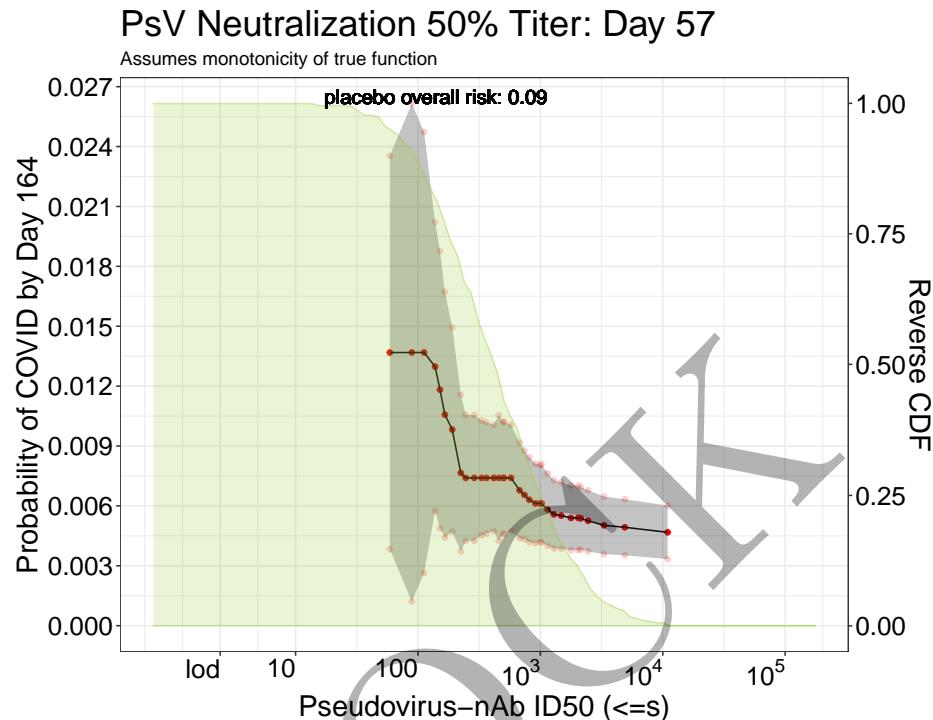


Figure 7.11: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.11: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.765	$5.82 * 10^1$	0.01368	0.00383	0.02354
2.055	$1.14 * 10^2$	0.01368	0.00265	0.02472
2.177	$1.50 * 10^2$	0.01182	0.00488	0.01876
2.281	$1.91 * 10^2$	0.00982	0.00471	0.01494
2.519	$3.30 * 10^2$	0.00740	0.00453	0.01027
2.657	$4.54 * 10^2$	0.00740	0.00426	0.01054
2.699	$5.00 * 10^2$	0.00740	0.00460	0.01020
2.828	$6.73 * 10^2$	0.00678	0.00438	0.00918
2.959	$9.10 * 10^2$	0.00612	0.00413	0.00812
3.000	$1.00 * 10^3$	0.00612	0.00419	0.00806
3.174	$1.49 * 10^3$	0.00552	0.00384	0.00719
3.307	$2.03 * 10^3$	0.00540	0.00378	0.00702
3.387	$2.44 * 10^3$	0.00526	0.00372	0.00679
4.038	$1.09 * 10^4$	0.00468	0.00334	0.00602

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

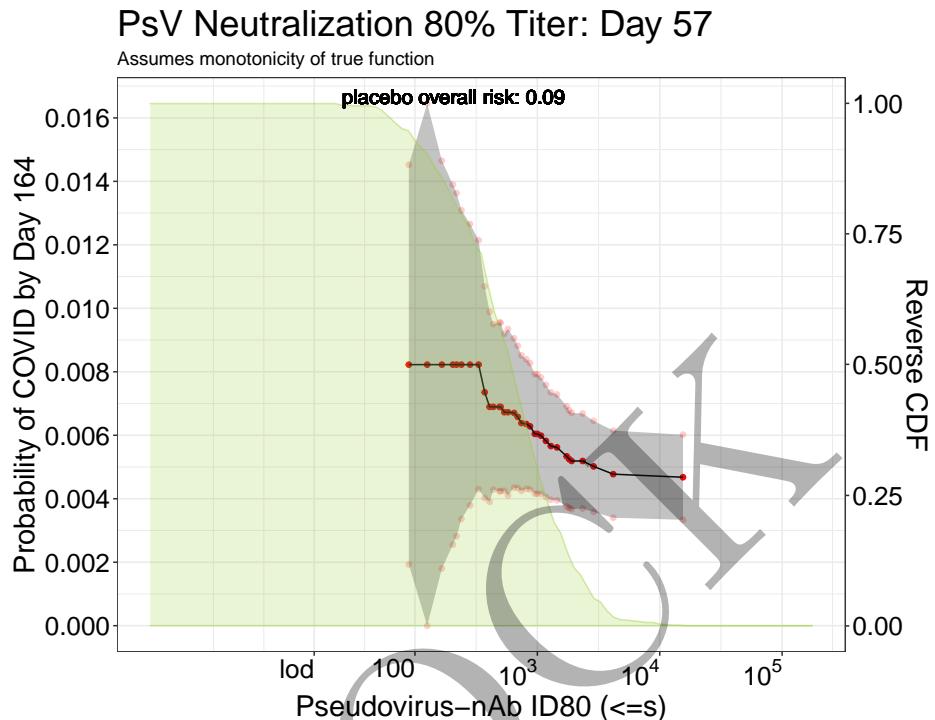


Figure 7.12: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.12: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.954	$8.99 * 10^1$	0.00823	0.00193	0.01452
2.220	$1.66 * 10^2$	0.00823	0.00180	0.01465
2.335	$2.16 * 10^2$	0.00823	0.00282	0.01363
2.455	$2.85 * 10^2$	0.00823	0.00379	0.01266
2.644	$4.41 * 10^2$	0.00689	0.00429	0.00950
2.699	$5.00 * 10^2$	0.00689	0.00424	0.00955
2.764	$5.81 * 10^2$	0.00673	0.00410	0.00935
2.874	$7.48 * 10^2$	0.00638	0.00425	0.00852
2.981	$9.57 * 10^2$	0.00604	0.00416	0.00793
3.000	$1.00 * 10^3$	0.00604	0.00416	0.00793
3.162	$1.45 * 10^3$	0.00562	0.00395	0.00728
3.265	$1.84 * 10^3$	0.00525	0.00371	0.00678
3.371	$2.35 * 10^3$	0.00519	0.00369	0.00669
4.187	$1.54 * 10^4$	0.00468	0.00334	0.00602

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

MOCK

7.4.1 Day 29 Spike protein antibody

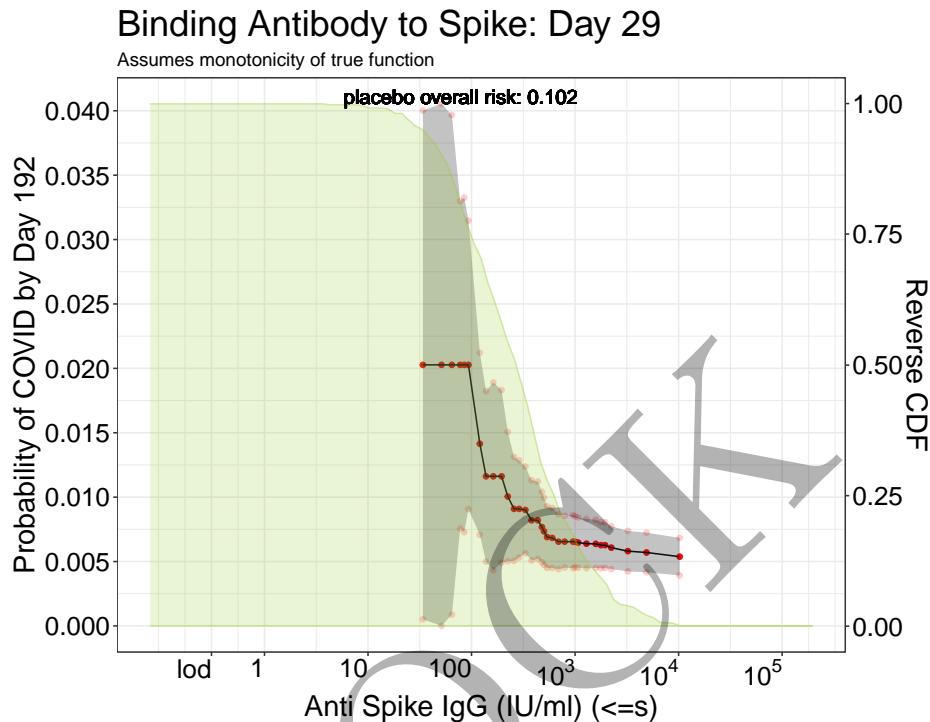


Figure 7.13: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.13: 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
1.532	$3.40 * 10^1$	0.02027	0.00052	0.04002
1.805	$6.38 * 10^1$	0.02027	0.00088	0.03966
1.927	$8.45 * 10^1$	0.02027	0.00728	0.03326
2.081	$1.21 * 10^2$	0.01415	0.00708	0.02121
2.351	$2.24 * 10^2$	0.01005	0.00502	0.01507
2.522	$3.33 * 10^2$	0.00901	0.00564	0.01237
2.677	$4.75 * 10^2$	0.00768	0.00493	0.01042
2.699	$5.00 * 10^2$	0.00734	0.00473	0.00996
2.841	$6.93 * 10^2$	0.00654	0.00440	0.00868
3.000	$1.00 * 10^3$	0.00653	0.00455	0.00851
3.112	$1.29 * 10^3$	0.00639	0.00447	0.00830
3.252	$1.79 * 10^3$	0.00627	0.00448	0.00806
3.348	$2.23 * 10^3$	0.00608	0.00442	0.00774
4.007	$1.02 * 10^4$	0.00538	0.00392	0.00683

7.4.2 Day 29 RBD binding antibody

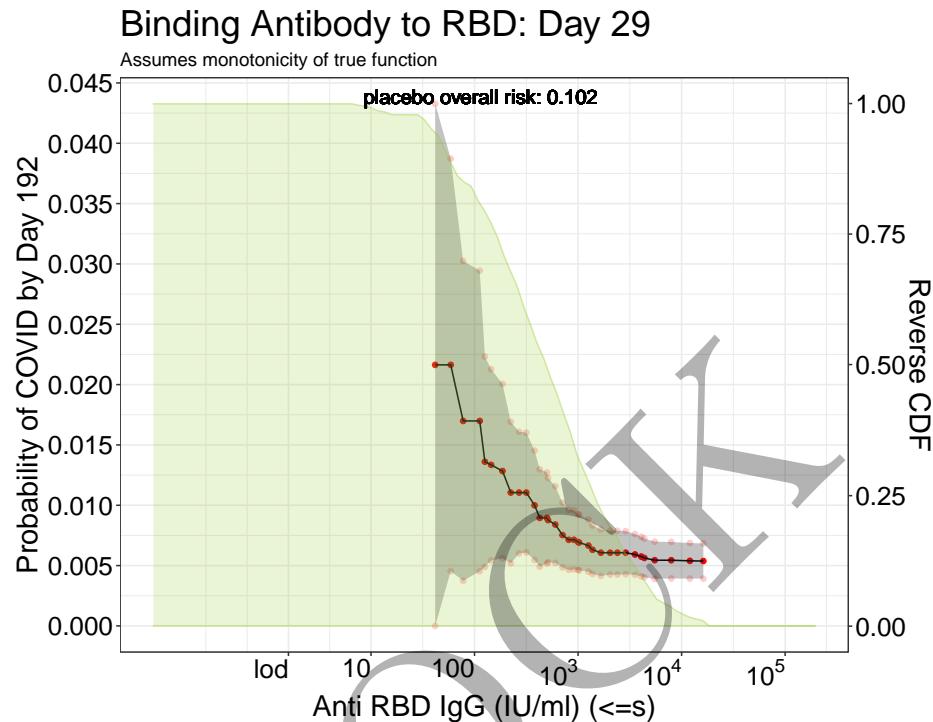


Figure 7.14: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.14: 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
1.620	$4.17 * 10^1$	0.02164	0.00000	0.04831
1.892	$7.80 * 10^1$	0.01699	0.00374	0.03024
2.098	$1.25 * 10^2$	0.01361	0.00489	0.02232
2.273	$1.87 * 10^2$	0.01284	0.00561	0.02006
2.575	$3.76 * 10^2$	0.00999	0.00546	0.01453
2.699	$5.00 * 10^2$	0.00895	0.00517	0.01272
2.780	$6.03 * 10^2$	0.00840	0.00523	0.01158
2.960	$9.12 * 10^2$	0.00714	0.00469	0.00959
3.000	$1.00 * 10^3$	0.00696	0.00465	0.00926
3.144	$1.39 * 10^3$	0.00631	0.00430	0.00833
3.461	$2.89 * 10^3$	0.00607	0.00428	0.00786
3.610	$4.07 * 10^3$	0.00575	0.00411	0.00739
3.736	$5.45 * 10^3$	0.00545	0.00391	0.00698
4.211	$1.63 * 10^4$	0.00538	0.00392	0.00683

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

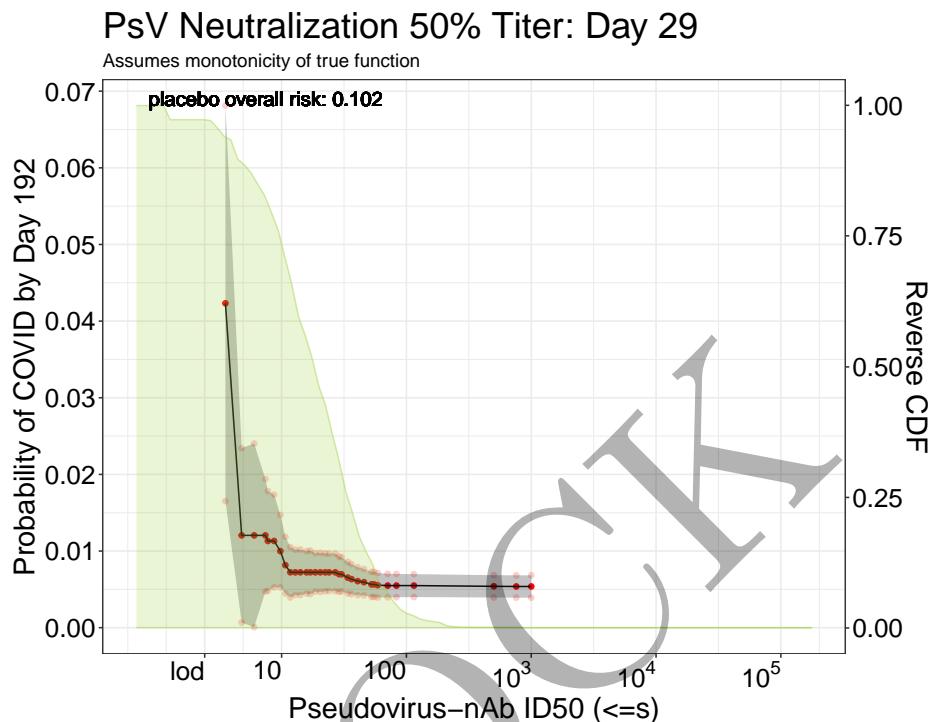


Figure 7.15: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.15: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.548	$3.53 * 10^0$	0.04232	0.01652	0.06812
0.779	$6.01 * 10^0$	0.01205	0.00006	0.02403
0.892	$7.80 * 10^0$	0.01131	0.00480	0.01782
0.988	$9.73 * 10^0$	0.00999	0.00527	0.01472
1.147	$1.40 * 10^1$	0.00722	0.00425	0.01020
1.271	$1.87 * 10^1$	0.00722	0.00470	0.00974
1.382	$2.41 * 10^1$	0.00722	0.00478	0.00967
1.481	$3.03 * 10^1$	0.00697	0.00474	0.00920
1.656	$4.53 * 10^1$	0.00594	0.00421	0.00766
1.741	$5.51 * 10^1$	0.00565	0.00401	0.00730
1.852	$7.11 * 10^1$	0.00549	0.00396	0.00703
2.699	$5.00 * 10^2$	0.00540	0.00394	0.00685
2.879	$7.57 * 10^2$	0.00538	0.00392	0.00683
3.000	$1.00 * 10^3$	0.00538	0.00392	0.00683

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

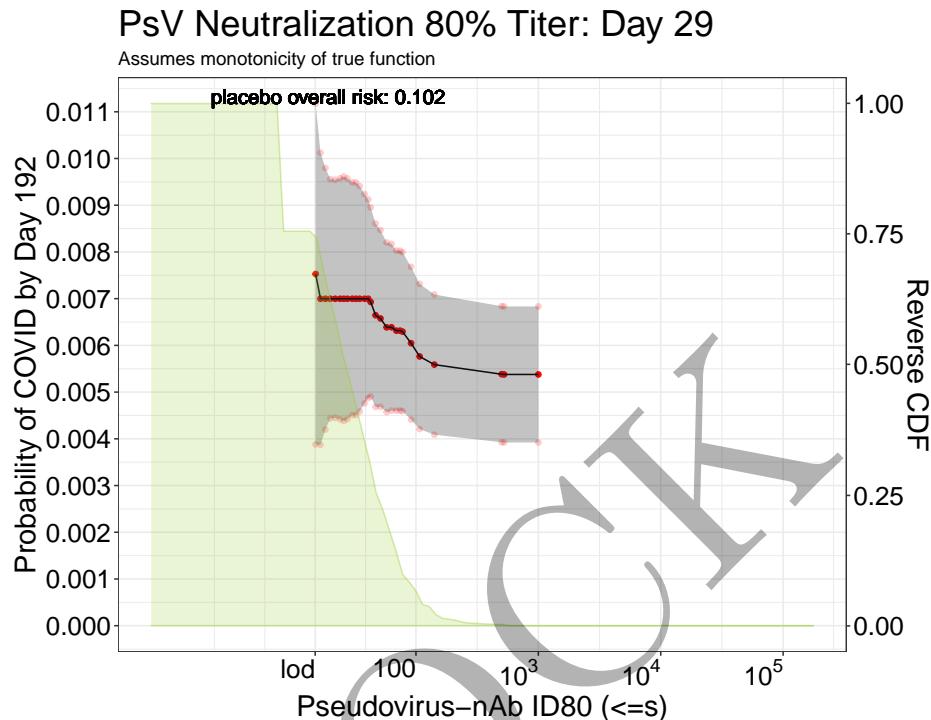


Figure 7.16: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with pointwise 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.16: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.183	$1.52 * 10^1$	0.00753	0.00388	0.01118
1.183	$1.52 * 10^1$	0.00753	0.00388	0.01118
1.183	$1.52 * 10^1$	0.00753	0.00388	0.01118
1.183	$1.52 * 10^1$	0.00753	0.00388	0.01118
1.339	$2.18 * 10^1$	0.00700	0.00445	0.00955
1.440	$2.75 * 10^1$	0.00700	0.00442	0.00957
1.541	$3.48 * 10^1$	0.00700	0.00458	0.00941
1.632	$4.29 * 10^1$	0.00693	0.00491	0.00895
1.796	$6.25 * 10^1$	0.00639	0.00460	0.00817
1.868	$7.38 * 10^1$	0.00631	0.00460	0.00803
1.956	$9.04 * 10^1$	0.00605	0.00441	0.00768
2.699	$5.00 * 10^2$	0.00538	0.00393	0.00684
2.719	$5.24 * 10^2$	0.00538	0.00392	0.00683
3.000	$1.00 * 10^3$	0.00538	0.00392	0.00683

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

MOCK

7.5.1 Day 57 Spike protein binding antibody

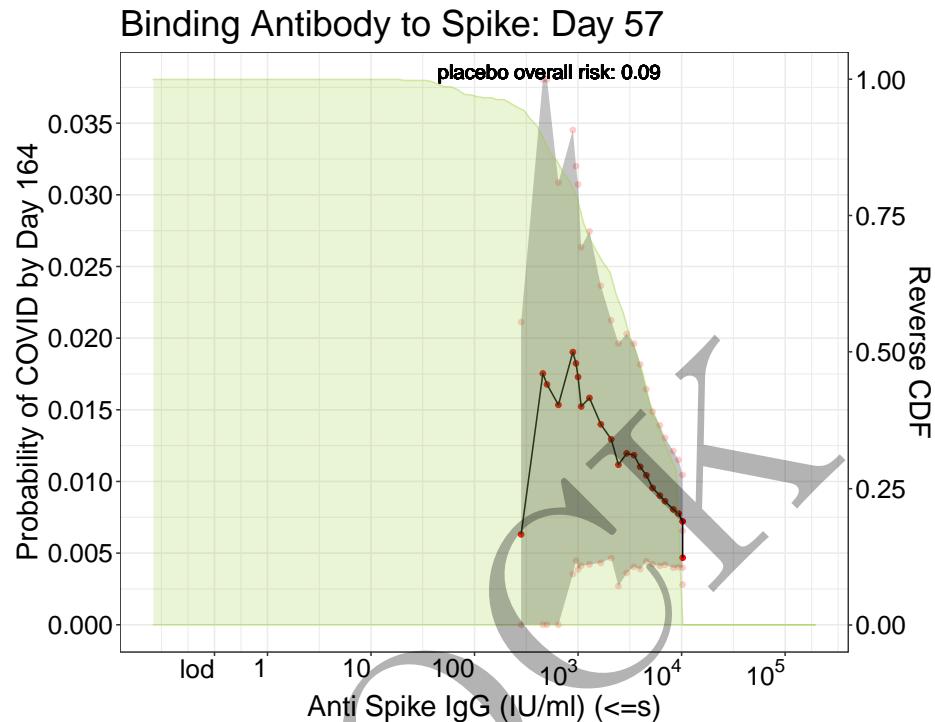


Figure 7.17: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.

Table 7.17: 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
2.450	2.82 * 10 ²	0.00630	0.00000	0.02112
2.699	5.00 * 10 ²	0.01677	0.00000	0.05779
2.815	6.53 * 10 ²	0.01534	0.00000	0.03086
2.982	9.59 * 10 ²	0.01824	0.00447	0.03200
3.000	1.00 * 10 ³	0.01729	0.00385	0.03073
3.113	1.30 * 10 ³	0.01583	0.00421	0.02745
3.471	2.96 * 10 ³	0.01196	0.00362	0.02030
3.658	4.55 * 10 ³	0.01043	0.00442	0.01643
3.841	6.93 * 10 ³	0.00862	0.00419	0.01305
4.006	1.01 * 10 ⁴	0.00721	0.00398	0.01045
4.007	1.02 * 10 ⁴	0.00468	0.00280	0.00656
4.007	1.02 * 10 ⁴	0.00468	0.00280	0.00656
4.007	1.02 * 10 ⁴	0.00468	0.00280	0.00656

7.5.2 Day 57 RBD binding antibody

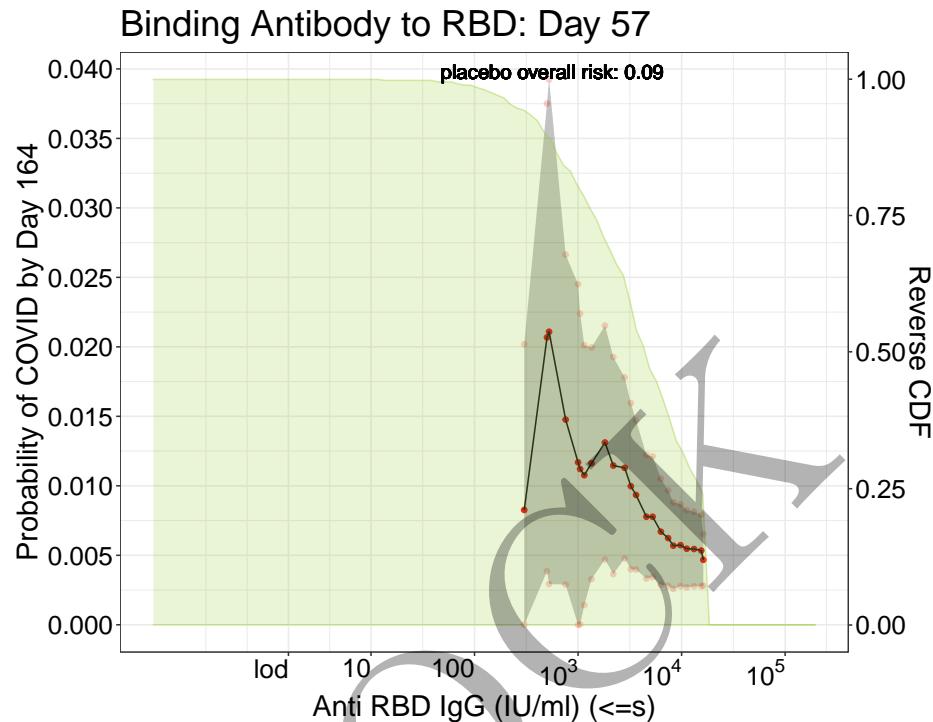


Figure 7.18: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals.

Table 7.18: 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
2.478	$3.01 * 10^2$	0.00826	0.00000	0.02019
2.699	$5.00 * 10^2$	0.02068	0.00385	0.03751
2.882	$7.62 * 10^2$	0.01476	0.00289	0.02664
3.000	$1.00 * 10^3$	0.01169	0.00000	0.02451
3.056	$1.14 * 10^3$	0.01076	0.00142	0.02011
3.259	$1.82 * 10^3$	0.01311	0.00470	0.02153
3.557	$3.61 * 10^3$	0.00934	0.00397	0.01471
3.797	$6.27 * 10^3$	0.00670	0.00288	0.01051
3.986	$9.68 * 10^3$	0.00573	0.00278	0.00868
4.186	$1.53 * 10^4$	0.00534	0.00277	0.00791
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653

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

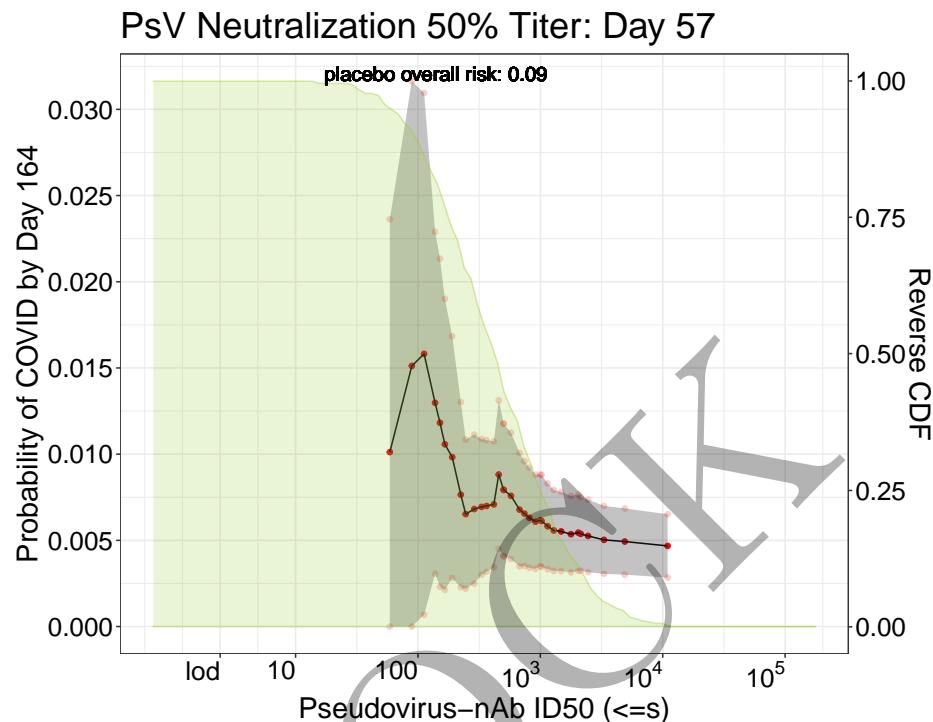


Figure 7.19: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

Table 7.19: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.765	$5.82 * 10^1$	0.01012	0.00000	0.02363
2.055	$1.14 * 10^2$	0.01582	0.00069	0.03095
2.177	$1.50 * 10^2$	0.01182	0.00230	0.02134
2.281	$1.91 * 10^2$	0.00982	0.00281	0.01684
2.519	$3.30 * 10^2$	0.00694	0.00300	0.01088
2.657	$4.54 * 10^2$	0.00882	0.00451	0.01312
2.699	$5.00 * 10^2$	0.00793	0.00409	0.01177
2.828	$6.73 * 10^2$	0.00678	0.00349	0.01007
2.959	$9.10 * 10^2$	0.00608	0.00335	0.00881
3.000	$1.00 * 10^3$	0.00617	0.00352	0.00882
3.174	$1.49 * 10^3$	0.00552	0.00322	0.00781
3.307	$2.03 * 10^3$	0.00544	0.00323	0.00766
3.387	$2.44 * 10^3$	0.00526	0.00315	0.00736
4.038	$1.09 * 10^4$	0.00468	0.00284	0.00652

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

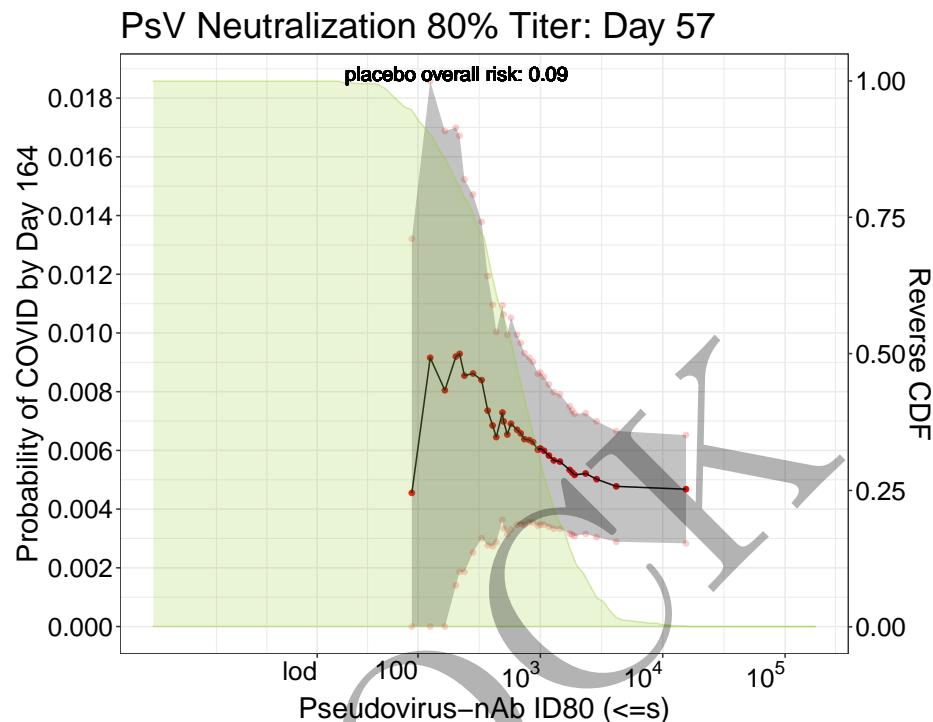


Figure 7.20: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

Table 7.20: Table of risk estimates for a range of thresholds of Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.954	$8.99 * 10^1$	0.00455	0.00000	0.01321
2.220	$1.66 * 10^2$	0.00805	0.00000	0.01688
2.335	$2.16 * 10^2$	0.00929	0.00186	0.01672
2.455	$2.85 * 10^2$	0.00862	0.00252	0.01471
2.644	$4.41 * 10^2$	0.00645	0.00287	0.01004
2.699	$5.00 * 10^2$	0.00699	0.00334	0.01063
2.764	$5.81 * 10^2$	0.00691	0.00330	0.01052
2.874	$7.48 * 10^2$	0.00638	0.00345	0.00932
2.981	$9.57 * 10^2$	0.00602	0.00343	0.00861
3.000	$1.00 * 10^3$	0.00606	0.00347	0.00865
3.162	$1.45 * 10^3$	0.00562	0.00333	0.00791
3.265	$1.84 * 10^3$	0.00525	0.00313	0.00736
3.371	$2.35 * 10^3$	0.00521	0.00316	0.00727
4.187	$1.54 * 10^4$	0.00468	0.00283	0.00652

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

MOCK

7.6.1 Day 29 Spike protein antibody

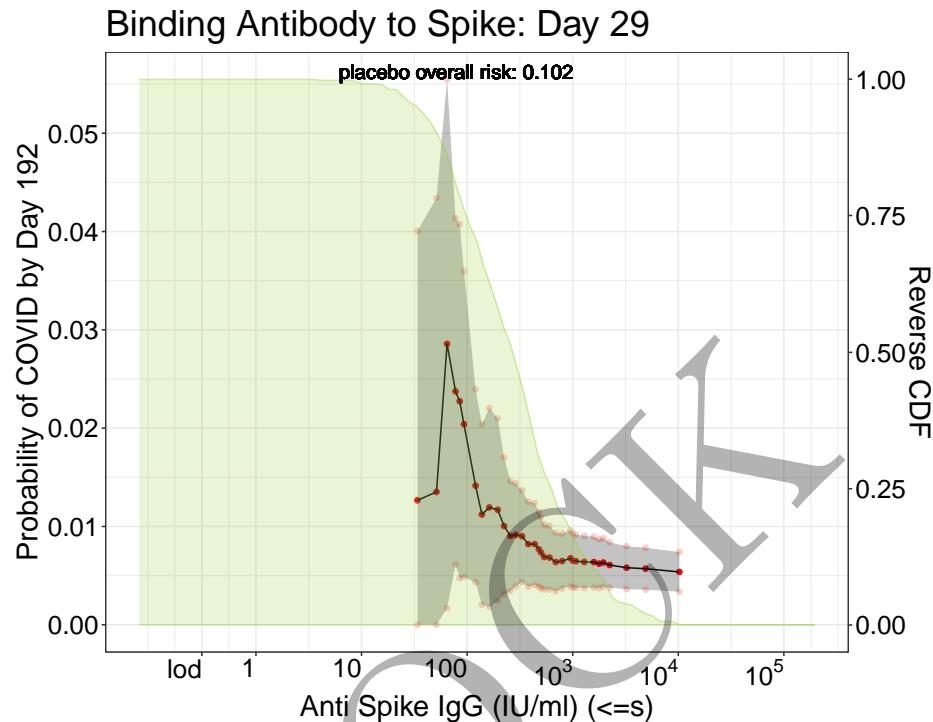


Figure 7.21: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals.

Table 7.21: 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
1.532	$3.40 * 10^1$	0.01266	0.00000	0.04005
1.805	$6.38 * 10^1$	0.02858	0.00168	0.05547
1.927	$8.45 * 10^1$	0.02273	0.00473	0.04074
2.081	$1.21 * 10^2$	0.01415	0.00434	0.02395
2.351	$2.24 * 10^2$	0.01005	0.00308	0.01702
2.522	$3.33 * 10^2$	0.00901	0.00434	0.01367
2.677	$4.75 * 10^2$	0.00768	0.00387	0.01148
2.699	$5.00 * 10^2$	0.00734	0.00372	0.01097
2.841	$6.93 * 10^2$	0.00638	0.00342	0.00934
3.000	$1.00 * 10^3$	0.00653	0.00379	0.00927
3.112	$1.29 * 10^3$	0.00639	0.00373	0.00905
3.252	$1.79 * 10^3$	0.00622	0.00373	0.00870
3.348	$2.23 * 10^3$	0.00608	0.00377	0.00838
4.007	$1.02 * 10^4$	0.00538	0.00336	0.00740

7.6.2 Day 29 RBD binding antibody

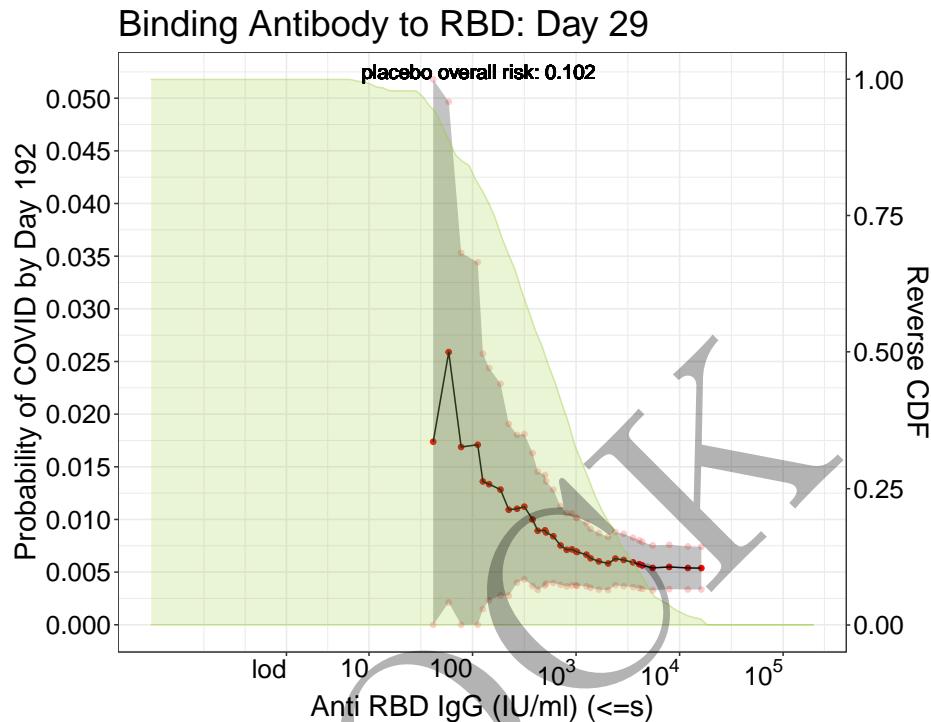


Figure 7.22: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals.

Table 7.22: 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
1.620	$4.17 * 10^1$	0.01738	0.00000	0.05449
1.892	$7.80 * 10^1$	0.01688	0.00000	0.03532
2.098	$1.25 * 10^2$	0.01361	0.00148	0.02573
2.273	$1.87 * 10^2$	0.01284	0.00279	0.02288
2.575	$3.76 * 10^2$	0.00999	0.00369	0.01630
2.699	$5.00 * 10^2$	0.00897	0.00372	0.01422
2.780	$6.03 * 10^2$	0.00840	0.00398	0.01282
2.960	$9.12 * 10^2$	0.00716	0.00375	0.01057
3.000	$1.00 * 10^3$	0.00696	0.00374	0.01017
3.144	$1.39 * 10^3$	0.00631	0.00352	0.00911
3.461	$2.89 * 10^3$	0.00615	0.00366	0.00864
3.610	$4.07 * 10^3$	0.00575	0.00347	0.00803
3.736	$5.45 * 10^3$	0.00540	0.00326	0.00754
4.211	$1.63 * 10^4$	0.00538	0.00335	0.00740

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

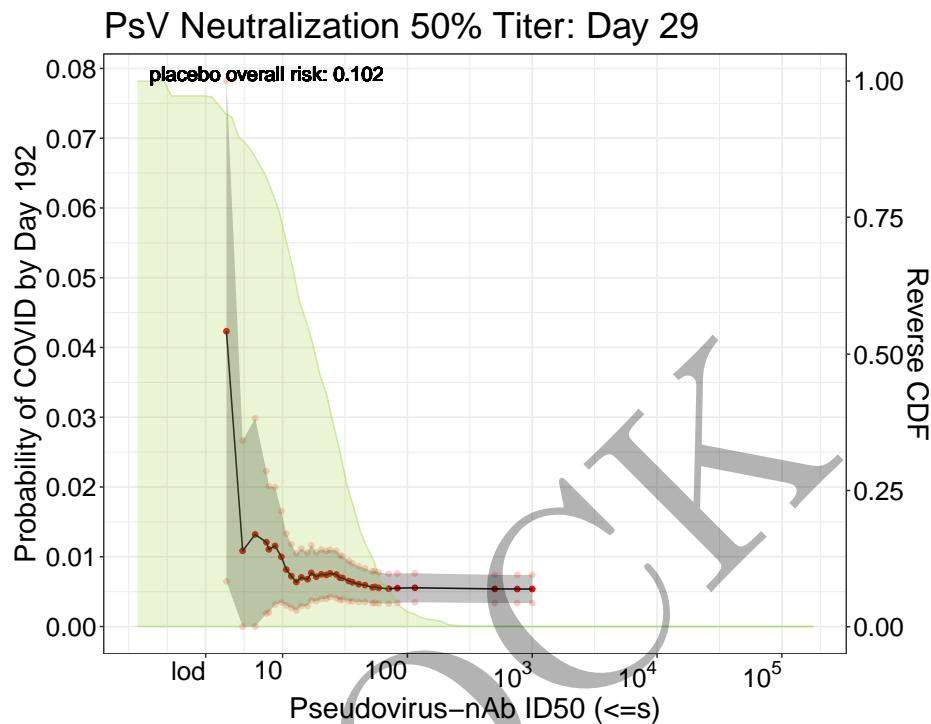


Figure 7.23: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

Table 7.23: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.548	$3.53 * 10^0$	0.04232	0.00647	0.07817
0.779	$6.01 * 10^0$	0.01320	0.00000	0.02985
0.892	$7.80 * 10^0$	0.01106	0.00202	0.02011
0.988	$9.73 * 10^0$	0.00999	0.00343	0.01655
1.147	$1.40 * 10^1$	0.00705	0.00292	0.01118
1.271	$1.87 * 10^1$	0.00714	0.00364	0.01064
1.382	$2.41 * 10^1$	0.00762	0.00423	0.01101
1.481	$3.03 * 10^1$	0.00697	0.00387	0.01007
1.656	$4.53 * 10^1$	0.00594	0.00354	0.00834
1.741	$5.51 * 10^1$	0.00569	0.00341	0.00797
1.852	$7.11 * 10^1$	0.00542	0.00329	0.00755
2.699	$5.00 * 10^2$	0.00540	0.00337	0.00742
2.879	$7.57 * 10^2$	0.00538	0.00335	0.00740
3.000	$1.00 * 10^3$	0.00538	0.00335	0.00740

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

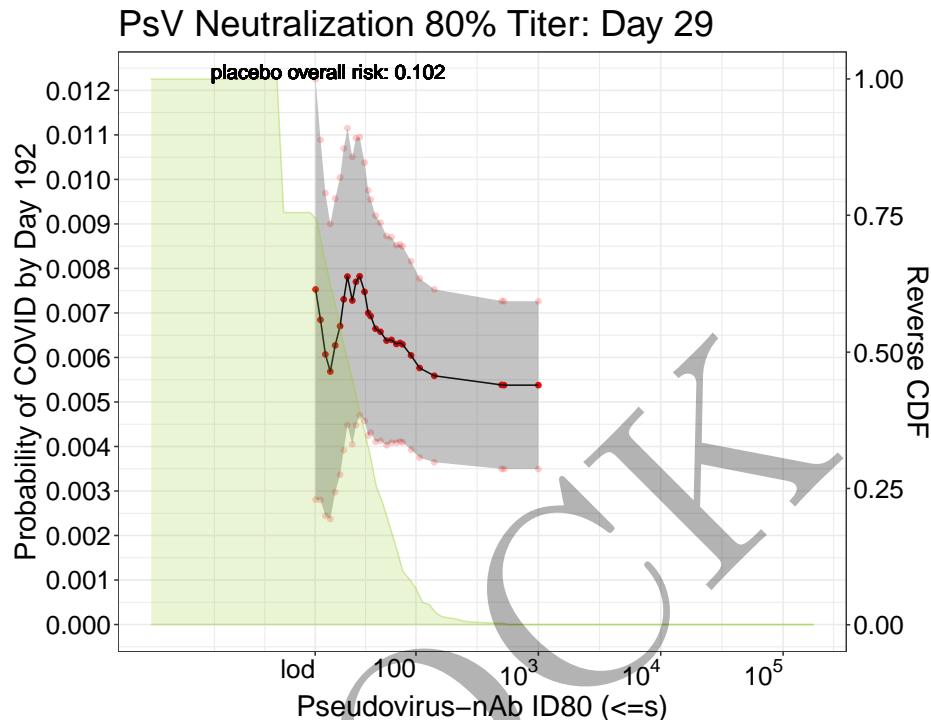


Figure 7.24: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

Table 7.24: Table of risk estimates for a range of thresholds of Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.339	$2.18 * 10^1$	0.00627	0.00297	0.00957
1.440	$2.75 * 10^1$	0.00782	0.00448	0.01115
1.541	$3.48 * 10^1$	0.00782	0.00470	0.01095
1.632	$4.29 * 10^1$	0.00693	0.00431	0.00955
1.796	$6.25 * 10^1$	0.00640	0.00409	0.00870
1.868	$7.38 * 10^1$	0.00633	0.00411	0.00854
1.956	$9.04 * 10^1$	0.00605	0.00393	0.00816
2.699	$5.00 * 10^2$	0.00538	0.00350	0.00727
2.719	$5.24 * 10^2$	0.00538	0.00349	0.00726
3.000	$1.00 * 10^3$	0.00538	0.00349	0.00726

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

MOCK

7.7.1 Day 57 Spike protein binding antibody

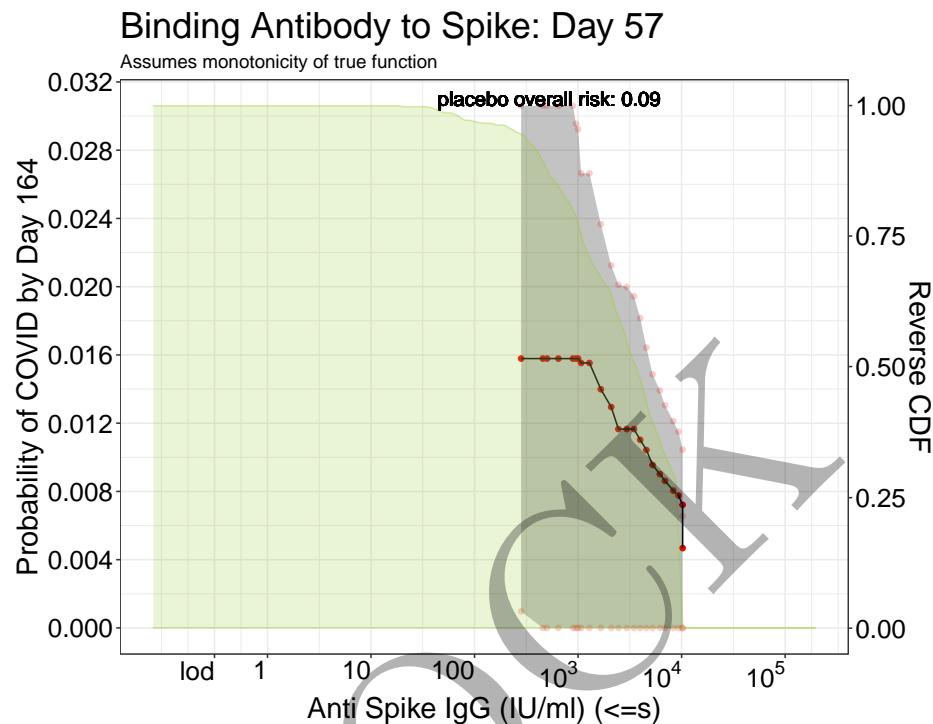


Figure 7.25: Adjusted threshold-response function for a range of thresholds of the Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.25: Table of monotone-corrected risk estimates for a range of thresholds of Day 57 Spike protein binding antibody levels with simultaneous 95% confidence intervals.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
2.450	$2.82 * 10^2$	0.01579	0.00097	0.03060
2.699	$5.00 * 10^2$	0.01579	0.00000	0.05681
2.815	$6.53 * 10^2$	0.01579	0.00027	0.03130
2.982	$9.59 * 10^2$	0.01579	0.00202	0.02955
3.000	$1.00 * 10^3$	0.01579	0.00235	0.02922
3.113	$1.30 * 10^3$	0.01553	0.00391	0.02715
3.471	$2.96 * 10^3$	0.01165	0.00331	0.01999
3.658	$4.55 * 10^3$	0.01043	0.00442	0.01643
3.841	$6.93 * 10^3$	0.00862	0.00419	0.01305
4.006	$1.01 * 10^4$	0.00721	0.00398	0.01045
4.007	$1.02 * 10^4$	0.00468	0.00280	0.00656
4.007	$1.02 * 10^4$	0.00468	0.00280	0.00656
4.007	$1.02 * 10^4$	0.00468	0.00280	0.00656

7.7.2 Day 57 RBD binding antibody

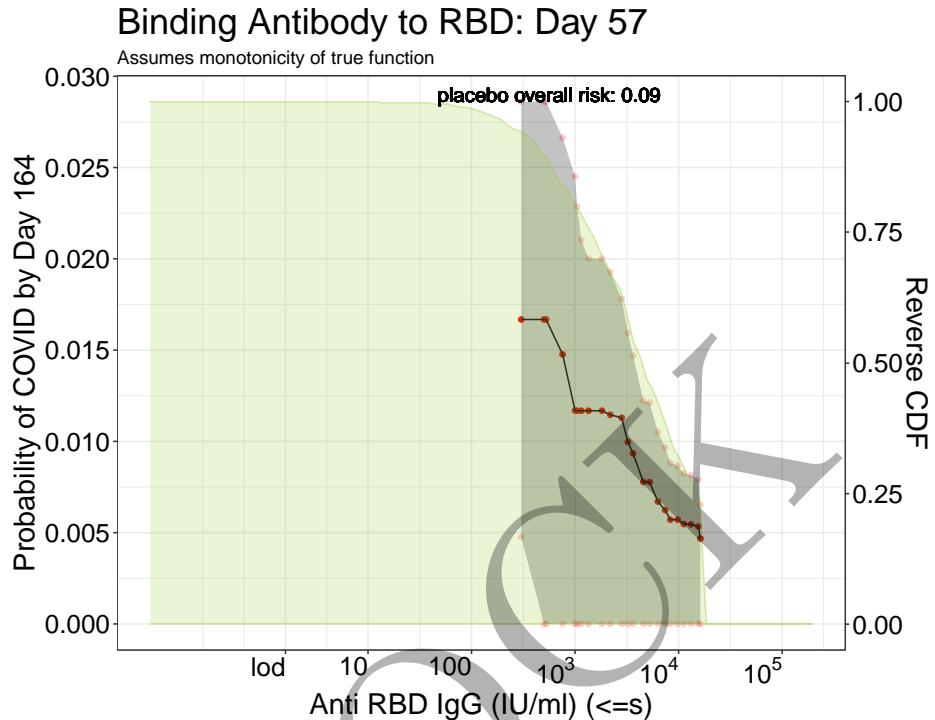


Figure 7.26: Adjusted threshold-response function for a range of thresholds of the Day 57 RBD binding antibody levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.26: 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
2.478	$3.01 * 10^2$	0.01668	0.00475	0.02860
2.699	$5.00 * 10^2$	0.01668	0.00000	0.03351
2.882	$7.62 * 10^2$	0.01476	0.00289	0.02664
3.000	$1.00 * 10^3$	0.01169	0.00000	0.02451
3.056	$1.14 * 10^3$	0.01168	0.00233	0.02103
3.259	$1.82 * 10^3$	0.01168	0.00326	0.02009
3.557	$3.61 * 10^3$	0.00934	0.00397	0.01471
3.797	$6.27 * 10^3$	0.00670	0.00288	0.01051
3.986	$9.68 * 10^3$	0.00571	0.00276	0.00866
4.186	$1.53 * 10^4$	0.00534	0.00277	0.00791
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653
4.211	$1.63 * 10^4$	0.00468	0.00282	0.00653

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

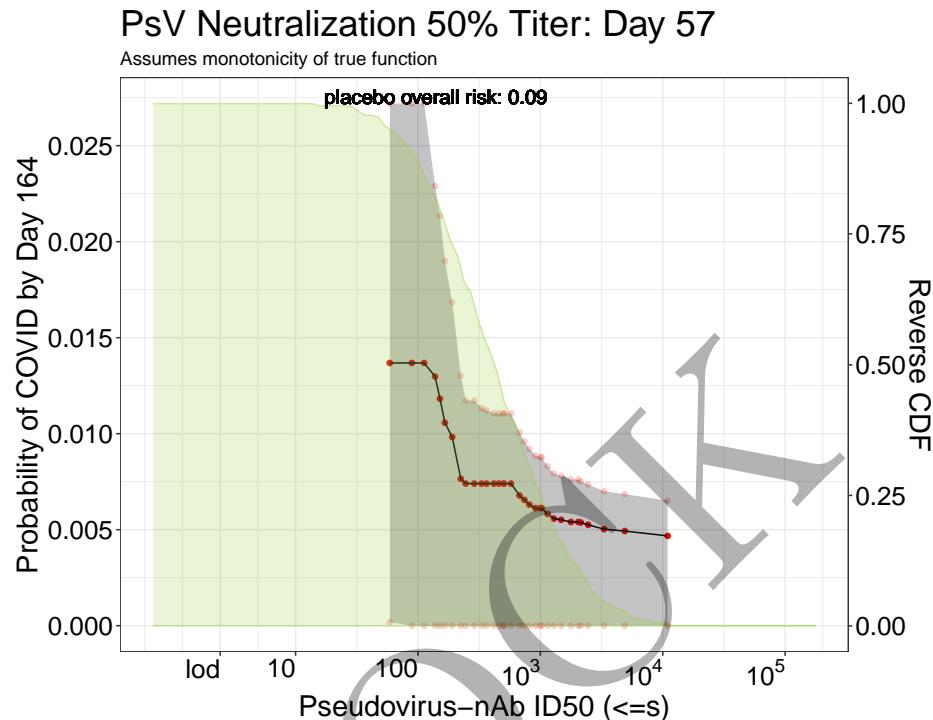


Figure 7.27: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.27: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.765	$5.82 * 10^1$	0.01368	0.00017	0.02719
2.055	$1.14 * 10^2$	0.01368	0.00000	0.02881
2.177	$1.50 * 10^2$	0.01182	0.00230	0.02134
2.281	$1.91 * 10^2$	0.00982	0.00281	0.01684
2.519	$3.30 * 10^2$	0.00740	0.00346	0.01134
2.657	$4.54 * 10^2$	0.00740	0.00310	0.01171
2.699	$5.00 * 10^2$	0.00740	0.00356	0.01124
2.828	$6.73 * 10^2$	0.00678	0.00349	0.01007
2.959	$9.10 * 10^2$	0.00612	0.00339	0.00885
3.000	$1.00 * 10^3$	0.00612	0.00347	0.00877
3.174	$1.49 * 10^3$	0.00552	0.00322	0.00781
3.307	$2.03 * 10^3$	0.00540	0.00319	0.00761
3.387	$2.44 * 10^3$	0.00526	0.00315	0.00736
4.038	$1.09 * 10^4$	0.00468	0.00284	0.00652

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

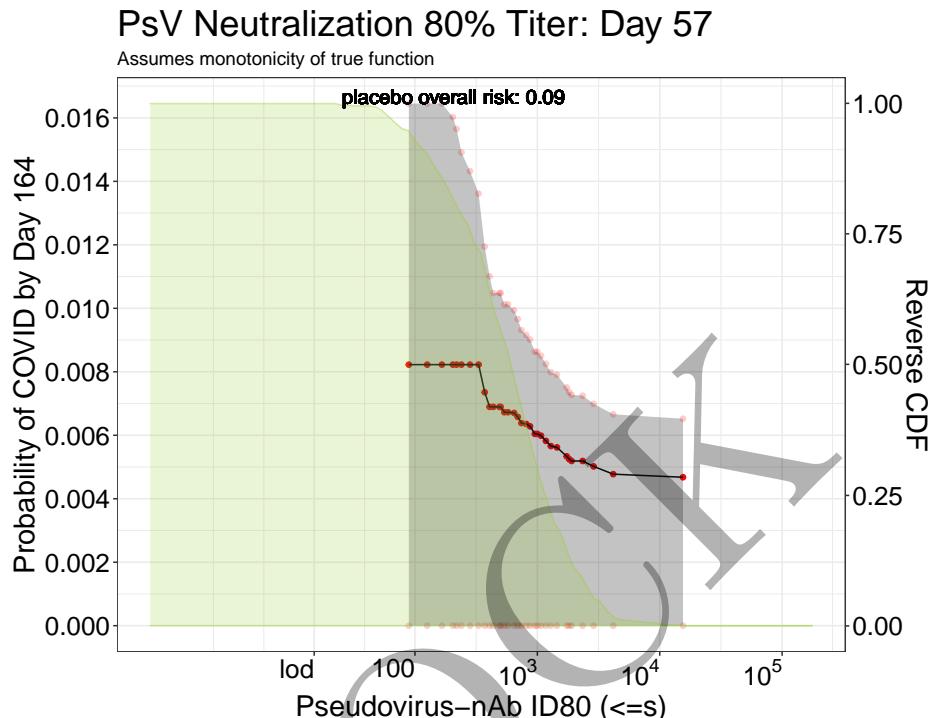


Figure 7.28: Adjusted threshold-response function for a range of thresholds of the Day 57 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.28: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.954	$8.99 * 10^1$	0.00823	0.00000	0.01688
2.220	$1.66 * 10^2$	0.00823	0.00000	0.01706
2.335	$2.16 * 10^2$	0.00823	0.00080	0.01565
2.455	$2.85 * 10^2$	0.00823	0.00213	0.01432
2.644	$4.41 * 10^2$	0.00689	0.00331	0.01048
2.699	$5.00 * 10^2$	0.00689	0.00325	0.01054
2.764	$5.81 * 10^2$	0.00673	0.00312	0.01033
2.874	$7.48 * 10^2$	0.00638	0.00345	0.00932
2.981	$9.57 * 10^2$	0.00604	0.00345	0.00863
3.000	$1.00 * 10^3$	0.00604	0.00345	0.00863
3.162	$1.45 * 10^3$	0.00562	0.00333	0.00791
3.265	$1.84 * 10^3$	0.00525	0.00313	0.00736
3.371	$2.35 * 10^3$	0.00519	0.00313	0.00725
4.187	$1.54 * 10^4$	0.00468	0.00283	0.00652

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

MOCK

7.8.1 Day 29 Spike protein antibody

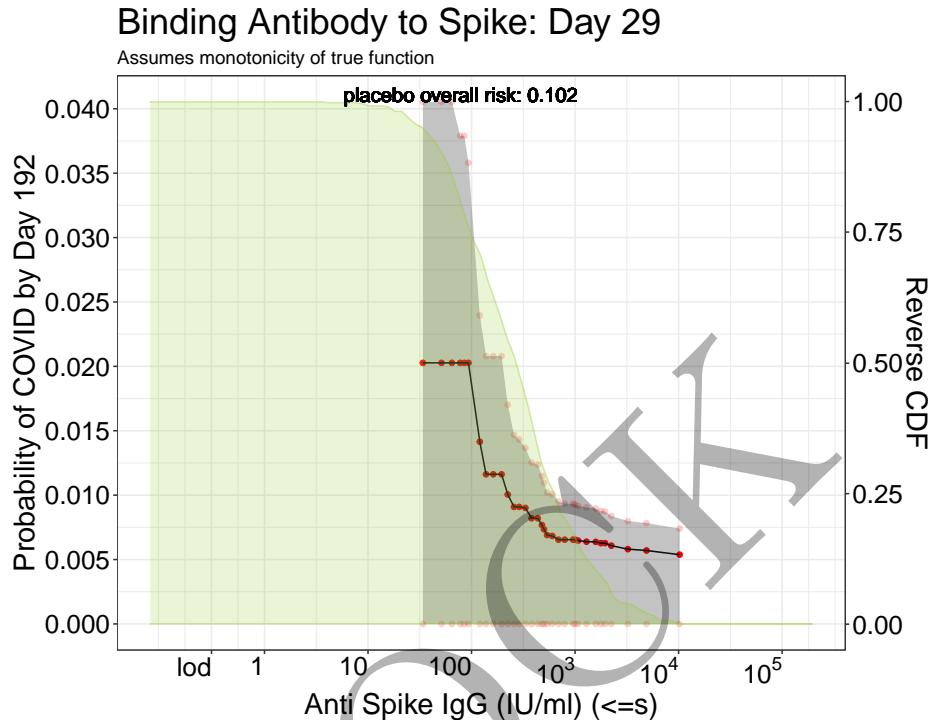


Figure 7.29: Adjusted threshold-response function for a range of thresholds of the Day 29 Spike protein antibody levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.29: 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
1.532	$3.40 * 10^1$	0.02027	0.00000	0.04766
1.805	$6.38 * 10^1$	0.02027	0.00000	0.04716
1.927	$8.45 * 10^1$	0.02027	0.00226	0.03828
2.081	$1.21 * 10^2$	0.01415	0.00434	0.02395
2.351	$2.24 * 10^2$	0.01005	0.00308	0.01702
2.522	$3.33 * 10^2$	0.00901	0.00434	0.01367
2.677	$4.75 * 10^2$	0.00768	0.00387	0.01148
2.699	$5.00 * 10^2$	0.00734	0.00372	0.01097
2.841	$6.93 * 10^2$	0.00654	0.00358	0.00951
3.000	$1.00 * 10^3$	0.00653	0.00379	0.00927
3.112	$1.29 * 10^3$	0.00639	0.00373	0.00905
3.252	$1.79 * 10^3$	0.00627	0.00379	0.00875
3.348	$2.23 * 10^3$	0.00608	0.00377	0.00838
4.007	$1.02 * 10^4$	0.00538	0.00336	0.00740

7.8.2 Day 29 RBD binding antibody

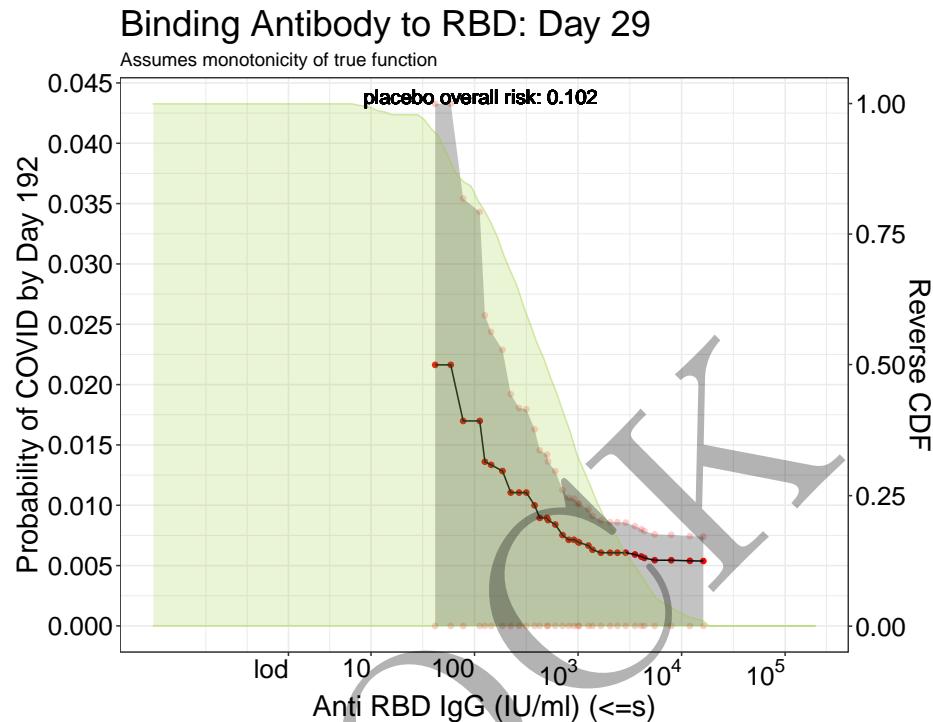


Figure 7.30: Adjusted threshold-response function for a range of thresholds of the Day 29 RBD binding antibody levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.30: 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
1.620	$4.17 * 10^1$	0.02164	0.00000	0.05875
1.892	$7.80 * 10^1$	0.01699	0.00000	0.03542
2.098	$1.25 * 10^2$	0.01361	0.00148	0.02573
2.273	$1.87 * 10^2$	0.01284	0.00279	0.02288
2.575	$3.76 * 10^2$	0.00999	0.00369	0.01630
2.699	$5.00 * 10^2$	0.00895	0.00370	0.01420
2.780	$6.03 * 10^2$	0.00840	0.00398	0.01282
2.960	$9.12 * 10^2$	0.00714	0.00373	0.01055
3.000	$1.00 * 10^3$	0.00696	0.00374	0.01017
3.144	$1.39 * 10^3$	0.00631	0.00352	0.00911
3.461	$2.89 * 10^3$	0.00607	0.00358	0.00856
3.610	$4.07 * 10^3$	0.00575	0.00347	0.00803
3.736	$5.45 * 10^3$	0.00545	0.00331	0.00759
4.211	$1.63 * 10^4$	0.00538	0.00335	0.00740

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

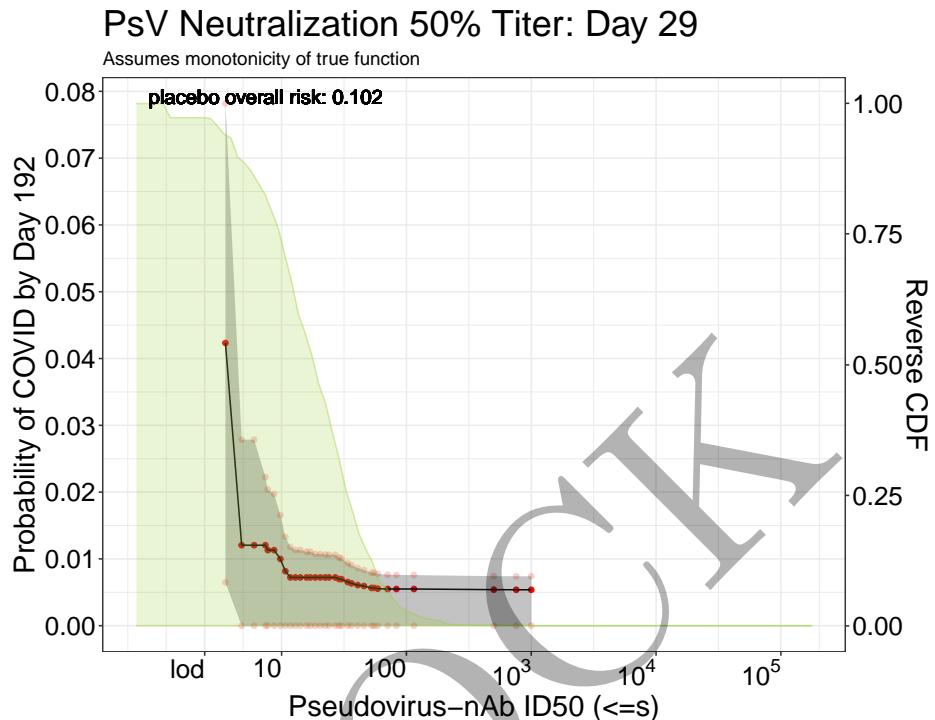


Figure 7.31: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (50% titer) levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.31: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
0.548	$3.53 * 10^0$	0.04232	0.00647	0.07817
0.779	$6.01 * 10^0$	0.01205	0.00000	0.02870
0.892	$7.80 * 10^0$	0.01131	0.00227	0.02036
0.988	$9.73 * 10^0$	0.00999	0.00343	0.01655
1.147	$1.40 * 10^1$	0.00722	0.00309	0.01135
1.271	$1.87 * 10^1$	0.00722	0.00372	0.01073
1.382	$2.41 * 10^1$	0.00722	0.00383	0.01062
1.481	$3.03 * 10^1$	0.00697	0.00387	0.01007
1.656	$4.53 * 10^1$	0.00594	0.00354	0.00834
1.741	$5.51 * 10^1$	0.00565	0.00337	0.00794
1.852	$7.11 * 10^1$	0.00549	0.00336	0.00763
2.699	$5.00 * 10^2$	0.00540	0.00337	0.00742
2.879	$7.57 * 10^2$	0.00538	0.00335	0.00740
3.000	$1.00 * 10^3$	0.00538	0.00335	0.00740

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

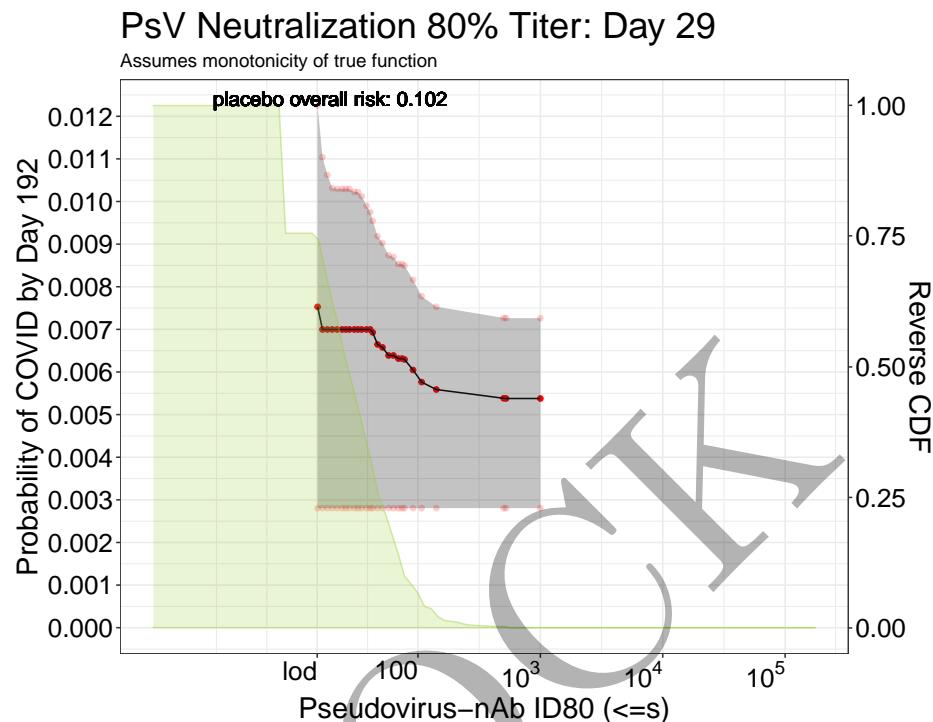


Figure 7.32: Adjusted threshold-response function for a range of thresholds of the Day 29 Pseudo virus-neutralizing antibody (80% titer) levels with simultaneous 95% confidence intervals. The estimates and confidence intervals are adjusted using the assumption that the true threshold-response is nonincreasing.

Table 7.32: 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.

\log_{10} -Threshold	Threshold	Risk estimate	CI left	CI right
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.183	$1.52 * 10^1$	0.00753	0.00281	0.01225
1.339	$2.18 * 10^1$	0.00700	0.00370	0.01030
1.440	$2.75 * 10^1$	0.00700	0.00366	0.01033
1.541	$3.48 * 10^1$	0.00700	0.00387	0.01012
1.632	$4.29 * 10^1$	0.00693	0.00431	0.00955
1.796	$6.25 * 10^1$	0.00639	0.00408	0.00870
1.868	$7.38 * 10^1$	0.00631	0.00410	0.00853
1.956	$9.04 * 10^1$	0.00605	0.00393	0.00816
2.699	$5.00 * 10^2$	0.00538	0.00350	0.00727
2.719	$5.24 * 10^2$	0.00538	0.00349	0.00726
3.000	$1.00 * 10^3$	0.00538	0.00349	0.00726

Chapter 8

Day 57 Univariate CoR: Nonlinear modeling

To explore nonlinear association and threshold modeling, we fit smoothing spline models using the mgcv R package and two-phase models using the chngpt R package.

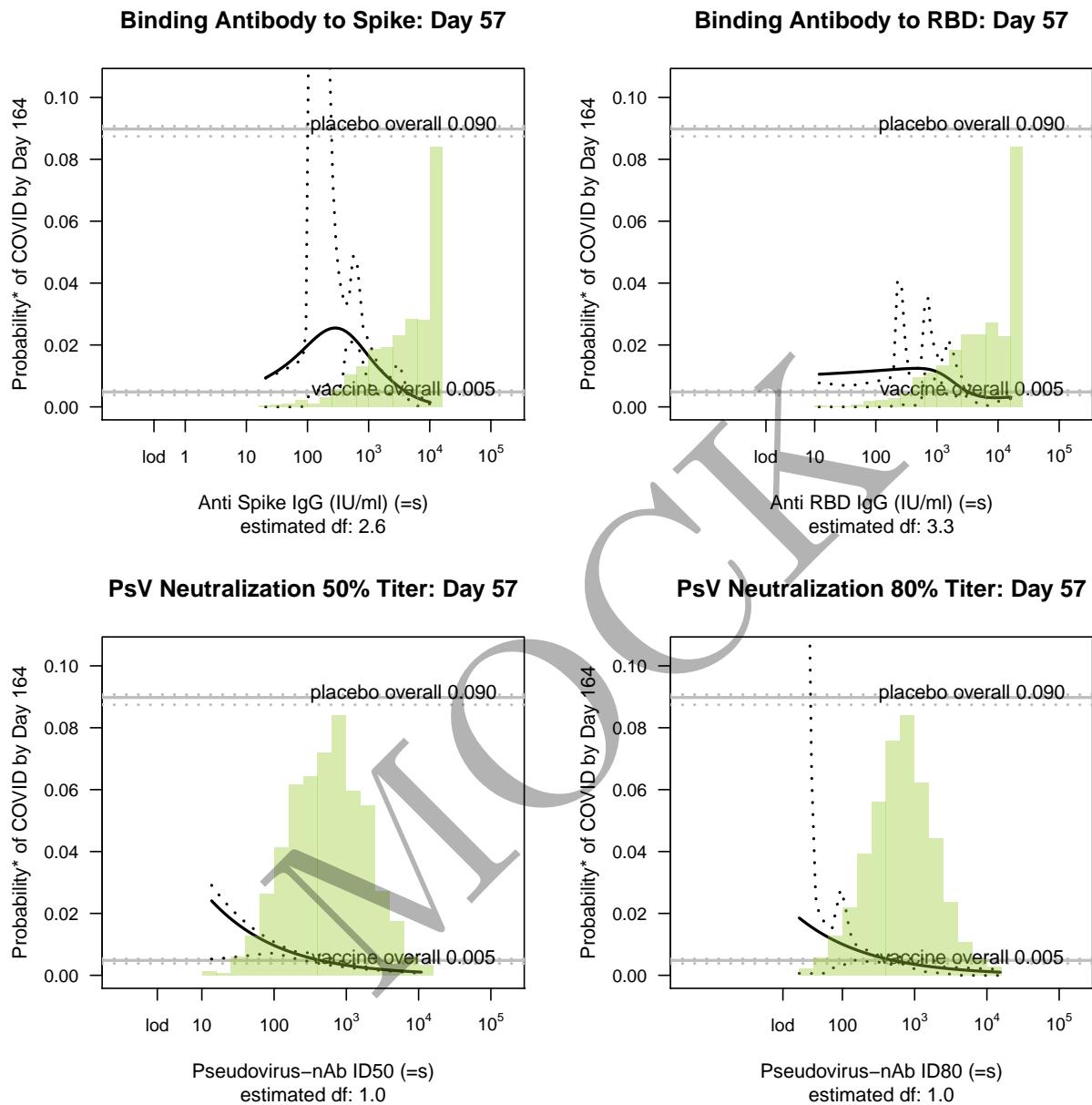


Figure 8.1: Marginalized risk as functions of Day 57 markers ($=s$) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates) as modeled by GAM with automatic smoothness estimation. Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization criterion for being at heightened risk of COVID (yes or no), community of color or not. The horizontal lines indicate the overall cumulative risk of the vaccine and placebo arms by Day 164 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

Chapter 9

Day 29 Univariate CoR: Nonlinear modeling

To explore nonlinear association and threshold modeling, we fit smoothing spline models using the mgcv R package and two-phase models using the chngpt R package.

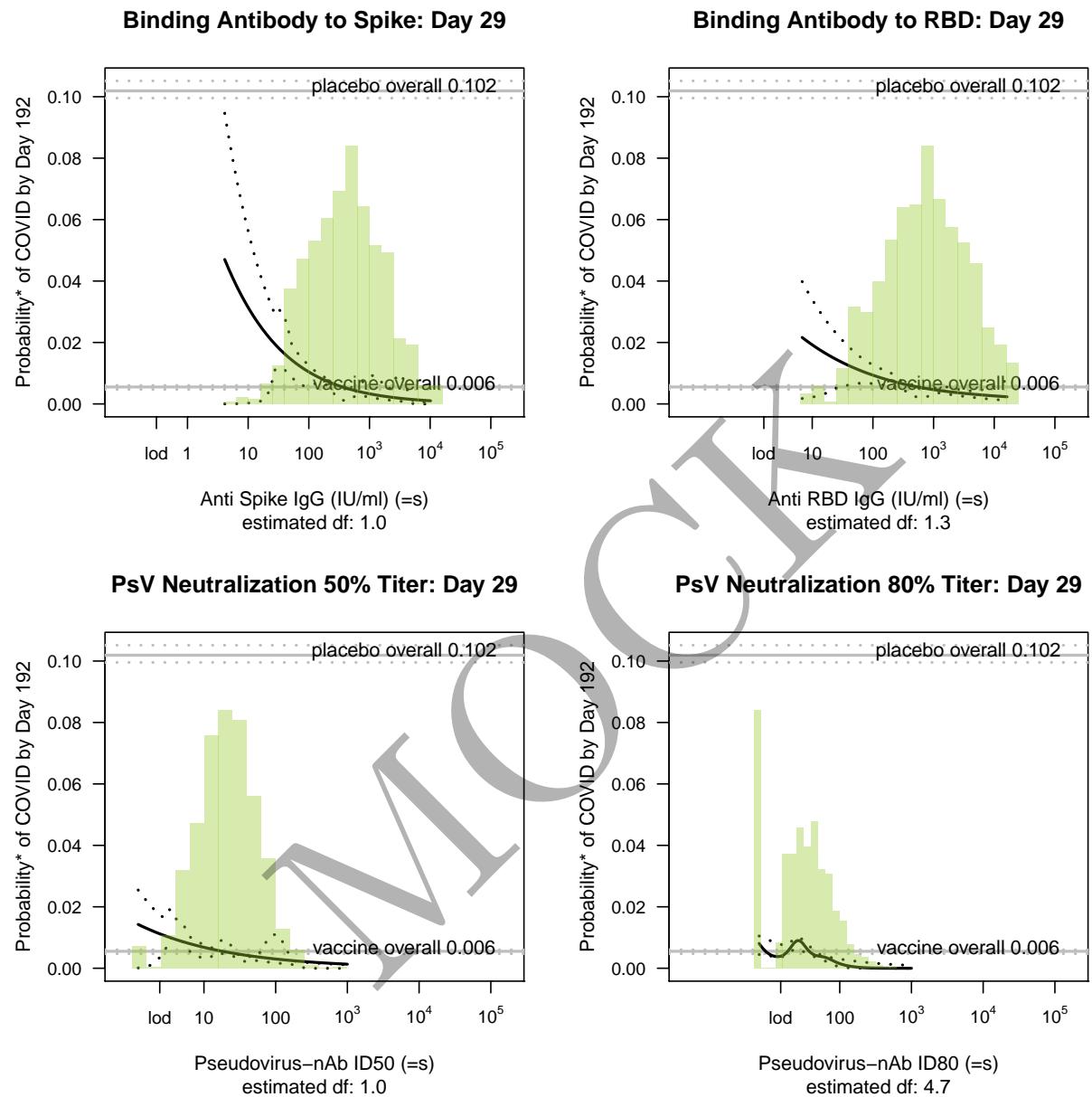


Figure 9.1: Marginalized risk as functions of Day 29 markers (=s) among baseline seronegative vaccine recipients with 95% bootstrap point-wise confidence bands (5 replicates) as modeled by GAM with automatic smoothness estimation. Baseline covariates adjusted for: baseline risk score, meeting the protocol randomization stratification criterion for being at heightened risk of COVID (yes or no), community of color or not. The horizontal lines indicate the overall cumulative risk of the vaccine and placebo arms by Day 192 and its 95% point-wise confidence interval. Histograms of the immunological markers in the vaccine arm are overlaid. lod = 0.3, 1.6, 2.4, 15 for bAb Spike, bAb RBD, PsV nAb ID50, PsV nAb ID80, respectively.

Chapter 10

Mediators of Vaccine Efficacy

Table 10.1: Table of mediation effect estimates for quantitative markers with 95% confidence intervals.
Direct VE = VE comparing vaccine vs. placebo with marker set to distribution in placebo.

Indirect VE = VE in vaccinated comparing observed marker vs. hypothetical marker under placebo.

Prop. mediated = fraction of total risk reduction from vaccine attributed to antibody response.

Time	Assay	Direct VE	Indirect VE	Prop. mediated
Day 29	PsV Neutralization 80% Titer	0.906 (0.846, 0.942)	0.407 (0.079, 0.618)	0.181 (0.029, 0.333)

Table 10.2: Table of mediation effect estimates for tertile markers with 95% confidence intervals.

Direct VE = VE comparing vaccine vs. placebo with marker set to distribution in placebo.

Indirect VE = VE in vaccinated comparing observed marker vs. hypothetical marker under placebo.

Prop. mediated = fraction of total risk reduction from vaccine attributed to antibody response.

Time	Assay	Direct VE	Indirect VE	Prop. mediated
Day 29	PsV Neutralization 80% Titer	0.914 (0.869, 0.943)	0.350 (0.050, 0.555)	0.149 (0.019, 0.279)

Table 10.3: All learner-screen combinations (13 in total) used as input to the Superlearner.

Learner	Screen
SL.mean	all
SL.glm	all
SL.glm	glmnet
SL.glm	univar_logistic_pval
SL.glm	highcor_random

Table 10.4: All variable sets (10 in total) with immunological markers for which Superlearner was run.

Variable Set Name	Variables included in the set
1_baselineRiskFactors	Baseline risk factors only (Reference model)
2_varset_bAbSpike	Baseline risk factors + bAb anti-Spike markers
3_varset_bAbRBD	Baseline risk factors + bAb anti-RBD markers
4_varset_pnabID50	Baseline risk factors + p-nAb ID50 markers
5_varset_pnabID80	Baseline risk factors + p-nAb ID80 markers
6_varset_bAb_pnabID50	Baseline risk factors + bAb markers + p-nAb ID50 markers
7_varset_bAb_pnabID80	Baseline risk factors + bAb markers + p-nAb ID80 markers
8_varset_bAb_combScores	Baseline risk factors + bAb markers + combination scores across the five markers [PCA1, PCA2, FSDAM1/FSDAM2 (the first two components of nonlinear PCA), and the maximum signal diversity score]
9_varset_allMarkers	Baseline risk factors + all individual markers
10_varset_allMarkers_combScores	Baseline risk factors + all individual markers + all combination scores (Full model)

Note:

Baseline risk factors include risk score, HighRiskInd and MinorityInd variables.

Table 10.5: Superlearner performance across all 10 variable sets sorted by weighted CV-AUC performance.

Variable set	CV-AUC (95% CI)
2_varset_bAbSpike	0.831 [0.750, 0.911]
7_varset_bAb_pnabID80	0.824 [0.742, 0.906]
6_varset_bAb_pnabID50	0.824 [0.742, 0.906]
9_varset_allMarkers	0.821 [0.739, 0.904]
8_varset_bAb_combScores	0.820 [0.737, 0.903]
10_varset_allMarkers_combScores	0.819 [0.737, 0.902]
4_varset_pnabID50	0.779 [0.695, 0.864]
5_varset_pnabID80	0.770 [0.686, 0.854]
3_varset_bAbRBD	0.767 [0.685, 0.849]
1_baselineRiskFactors	0.753 [0.672, 0.833]

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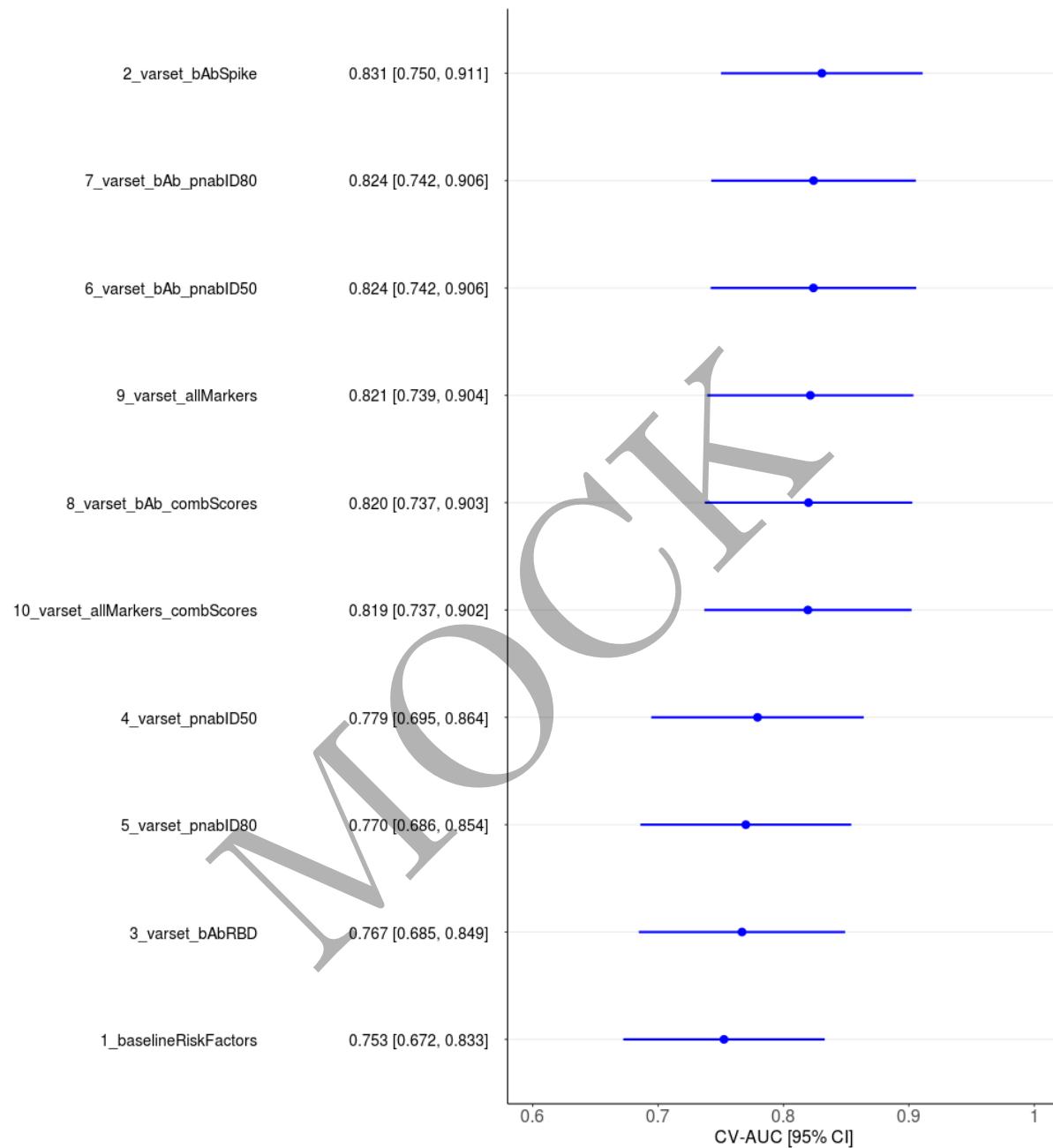


Figure 10.1: Forest plot showing Superlearner performance (weighted CV-AUC with 95% CI) across all 10 variable sets.

Chapter 11

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Appendix

Forest plots, ROC curves and predicted probability plots are shown for each variable set.

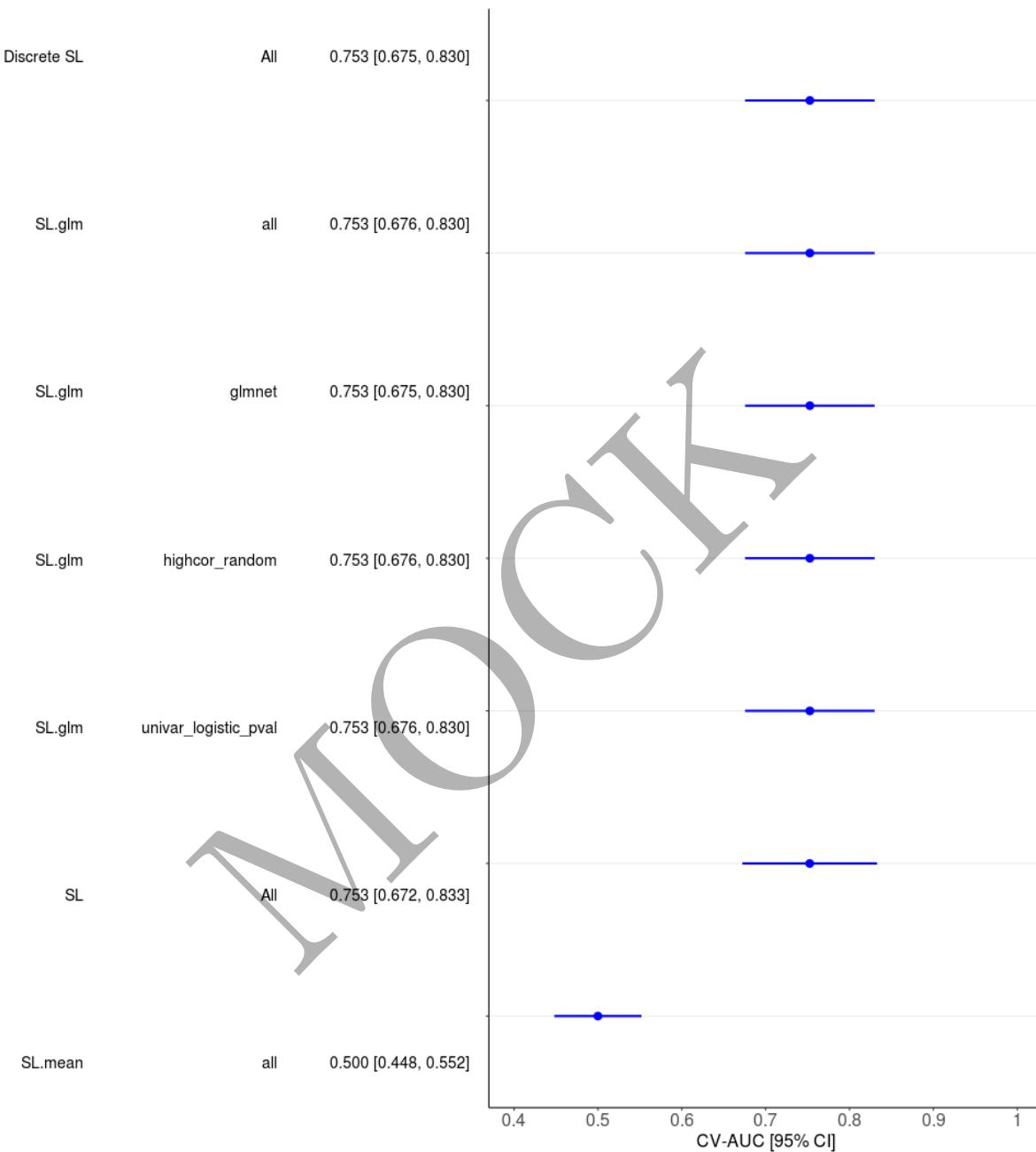


Figure 11.1: 1_baselineRiskFactors: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

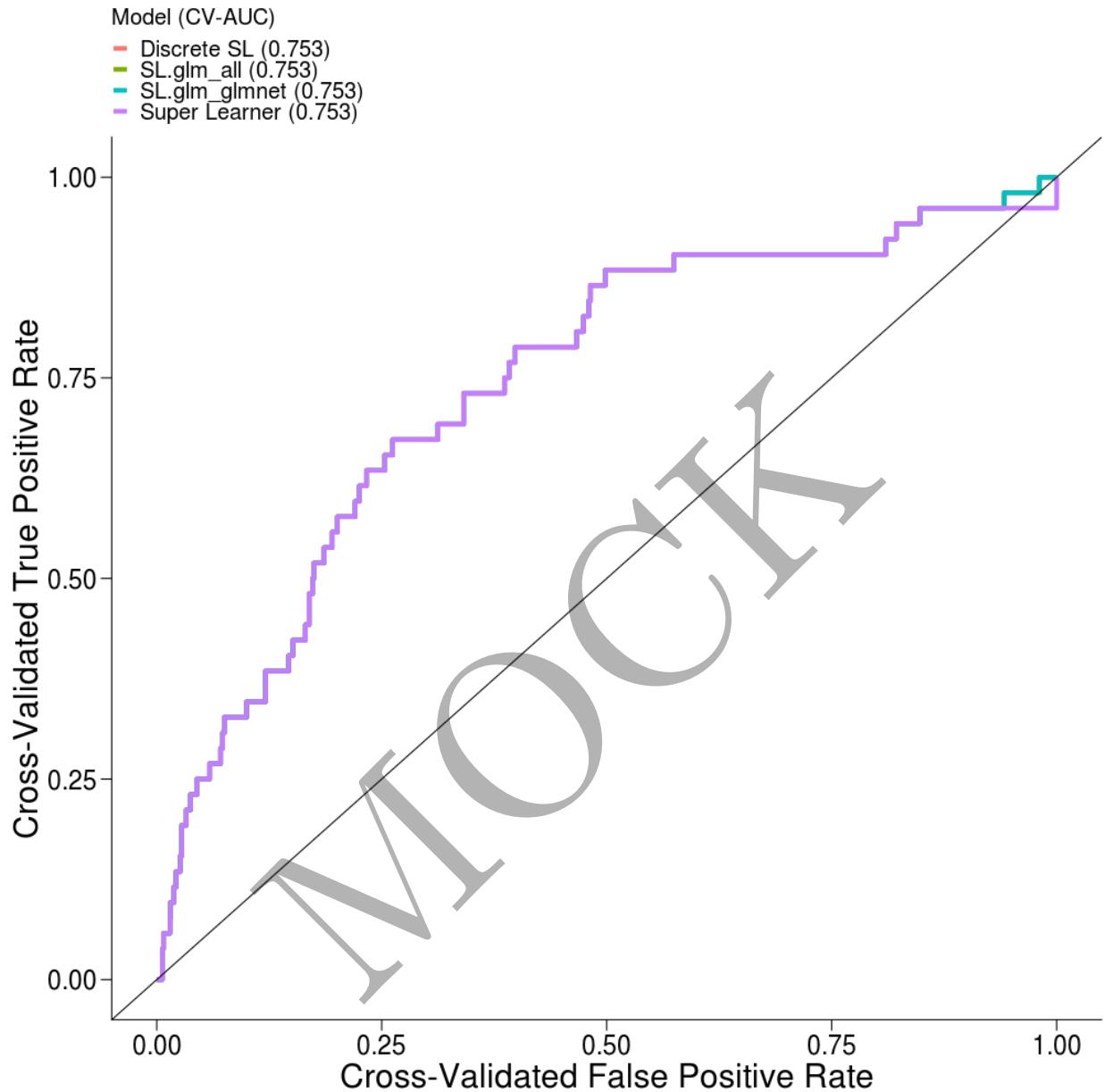


Figure 11.2: 1_baselineRiskFactors: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

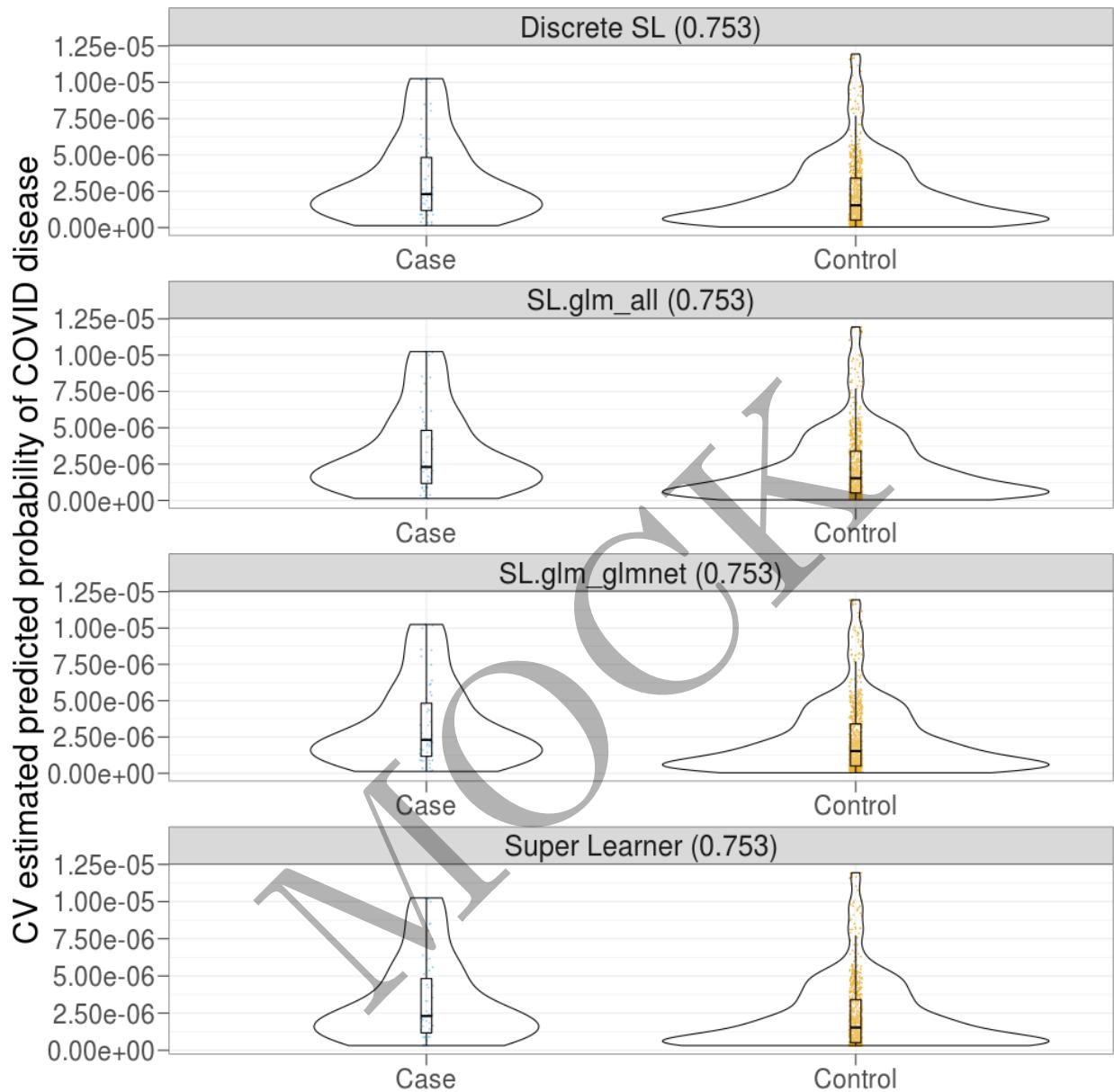


Figure 11.3: 1_baselineRiskFactors: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

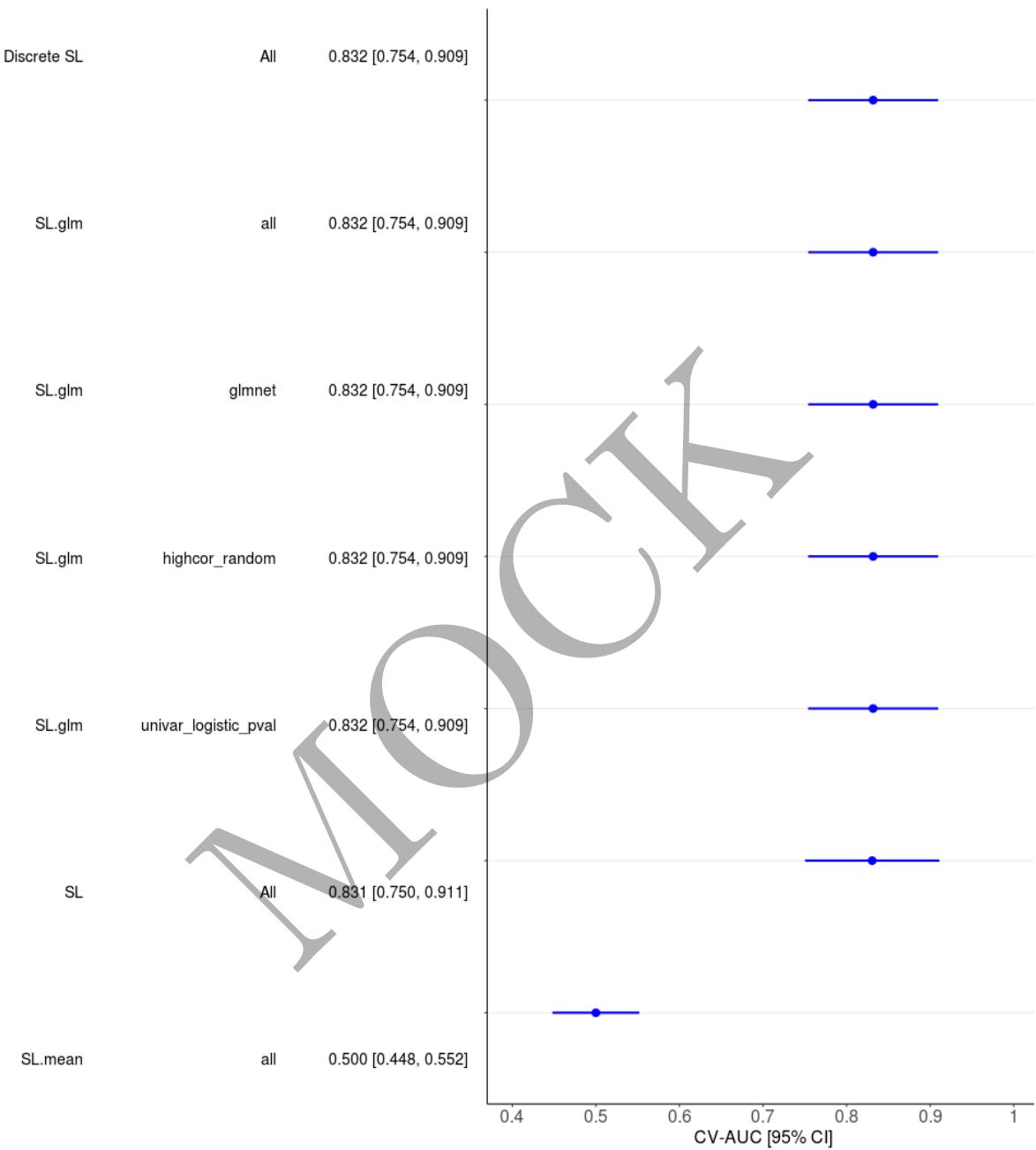


Figure 11.4: 2_varset_bAbSpike: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

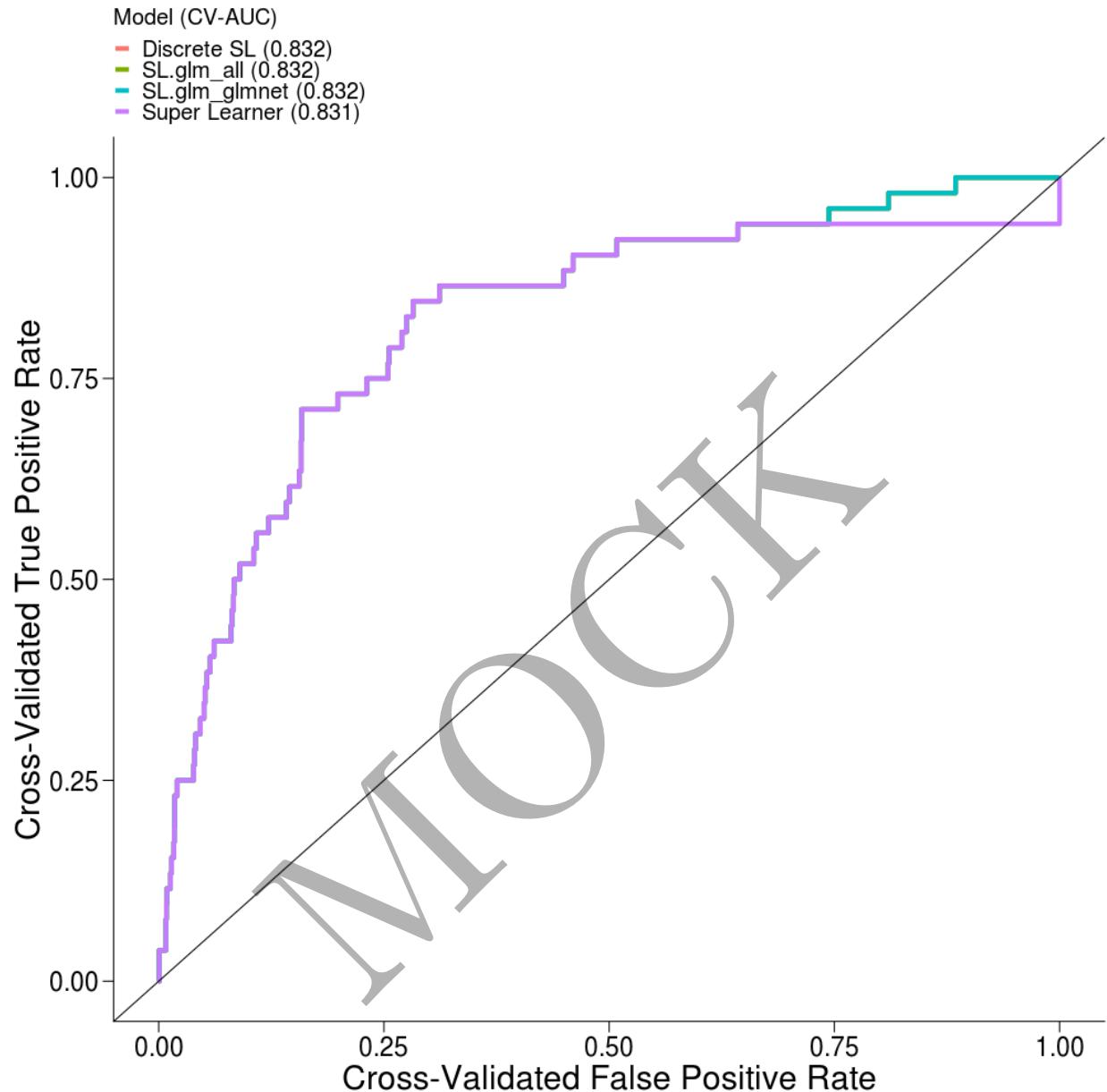


Figure 11.5: 2_varset_bAbSpike: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

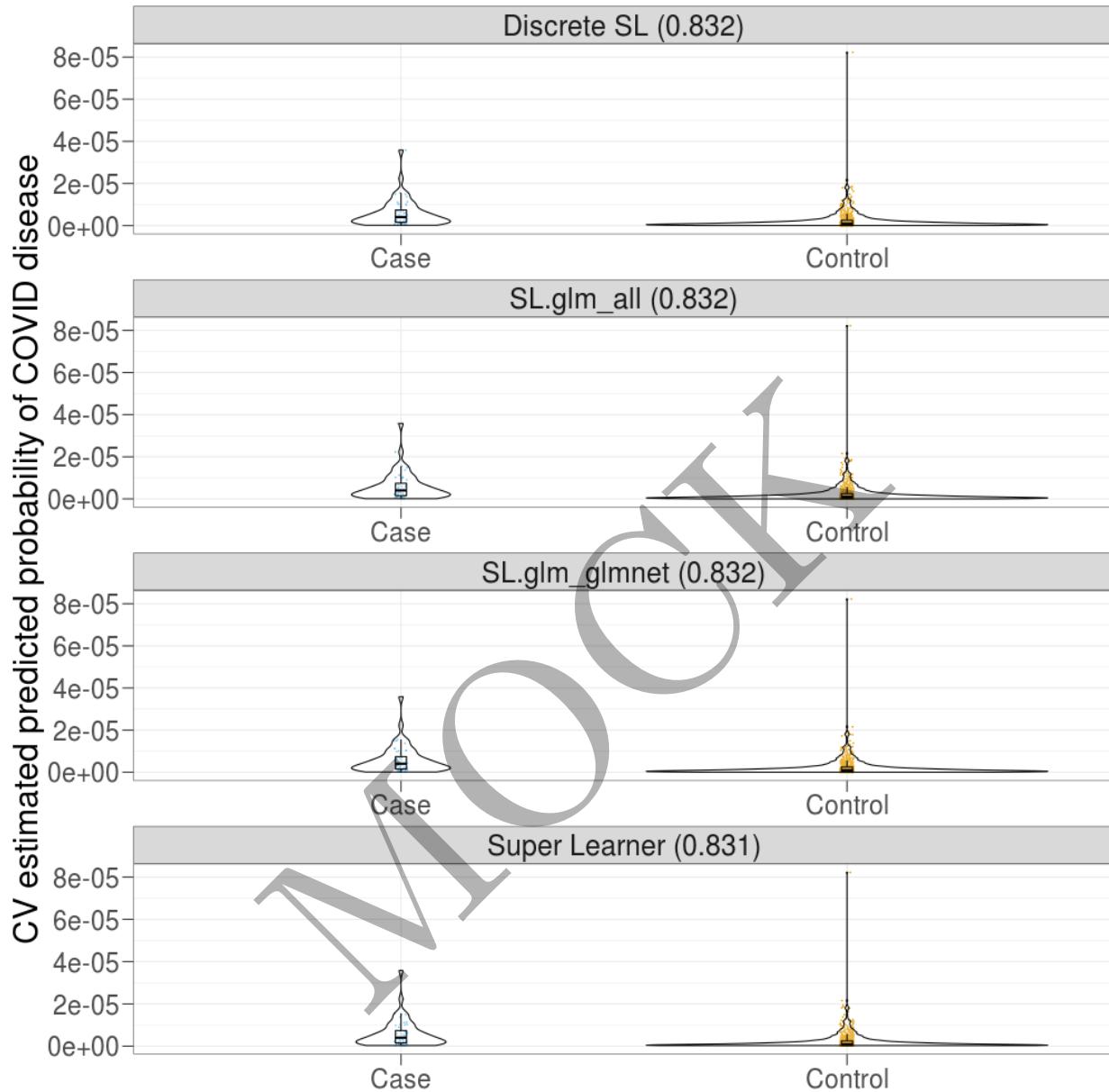


Figure 11.6: 2_varset_bAbSpike: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

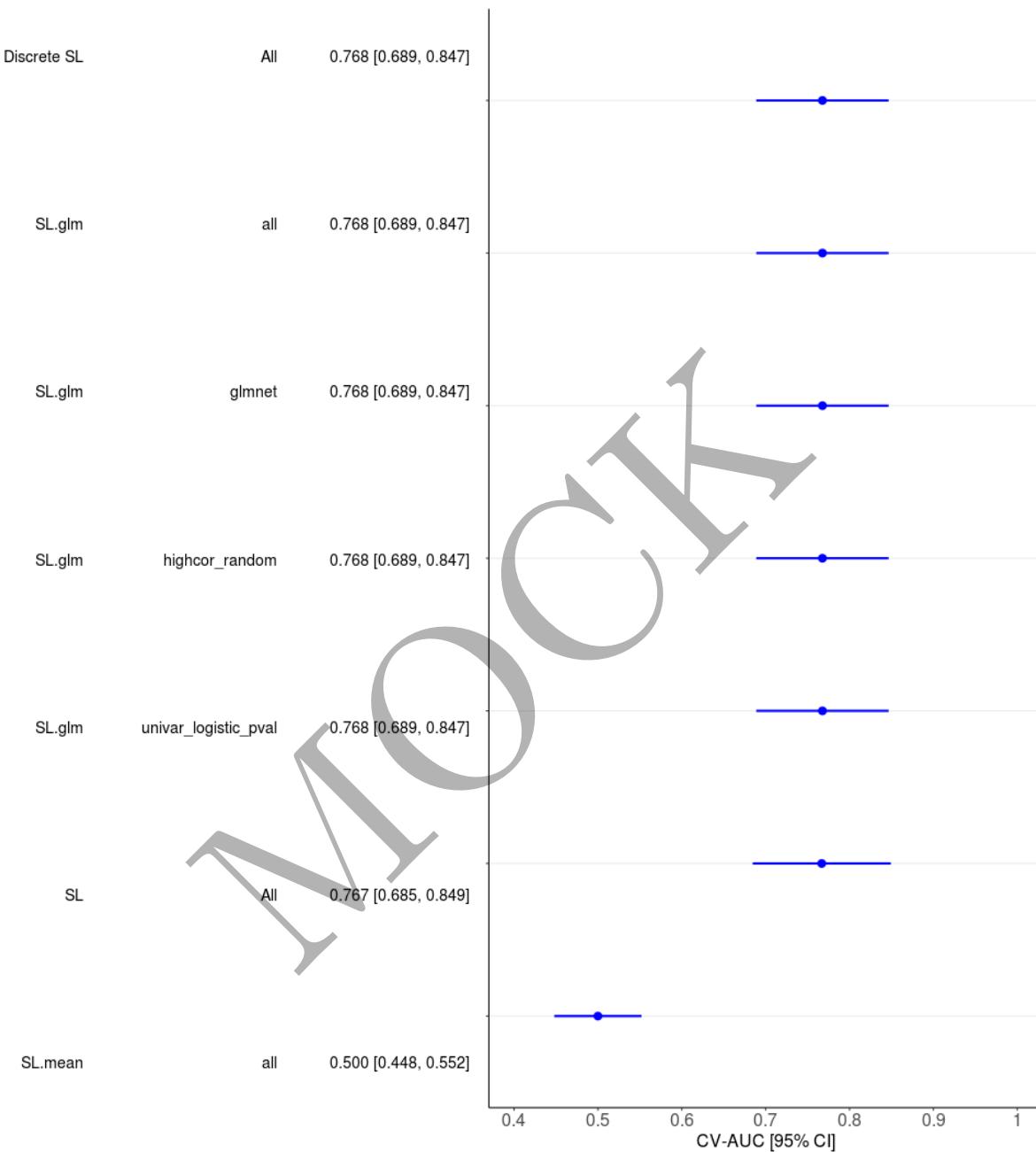


Figure 11.7: 3_varset_bAbRBD: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

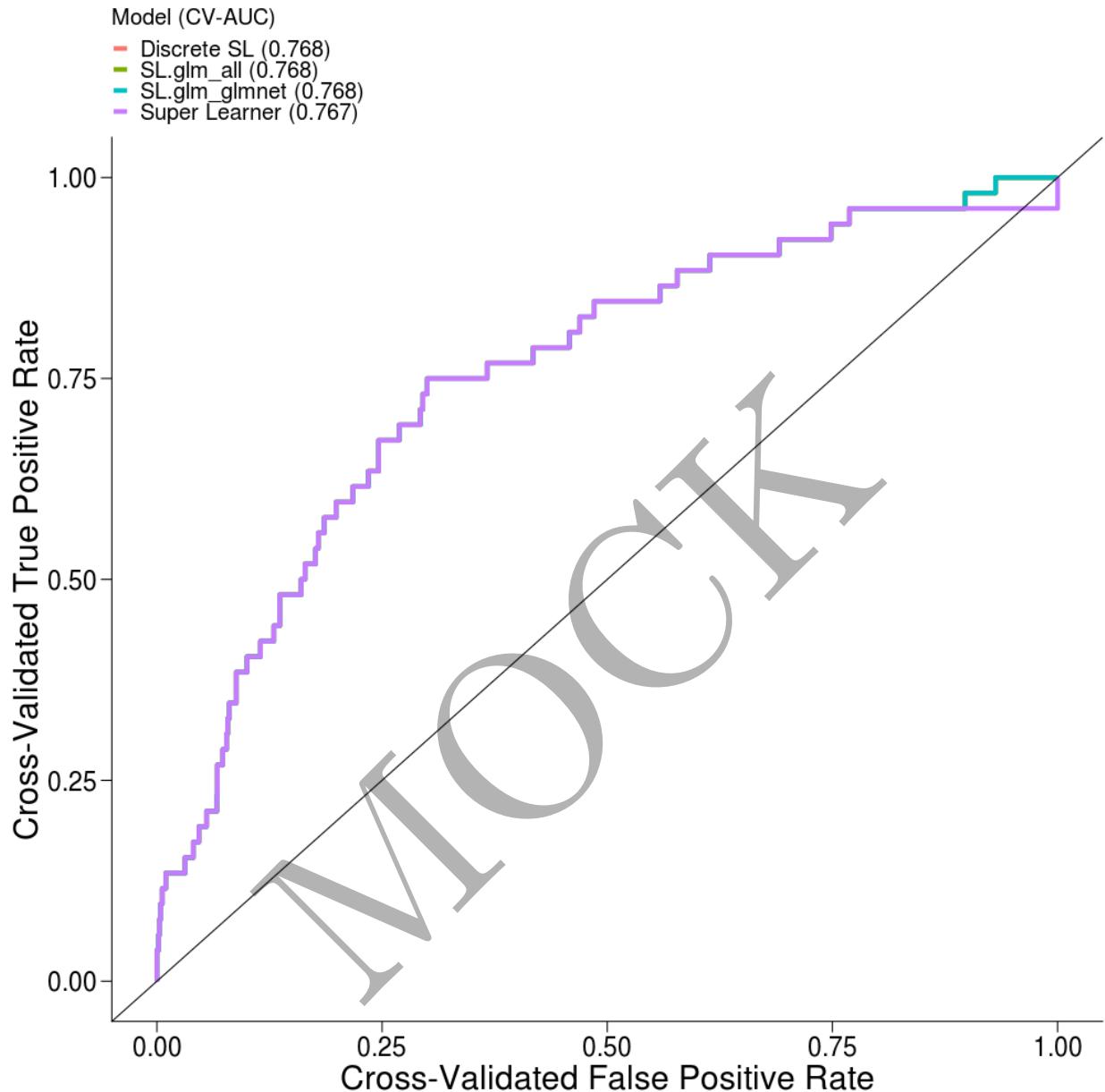


Figure 11.8: 3_varset_bAbRBD: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

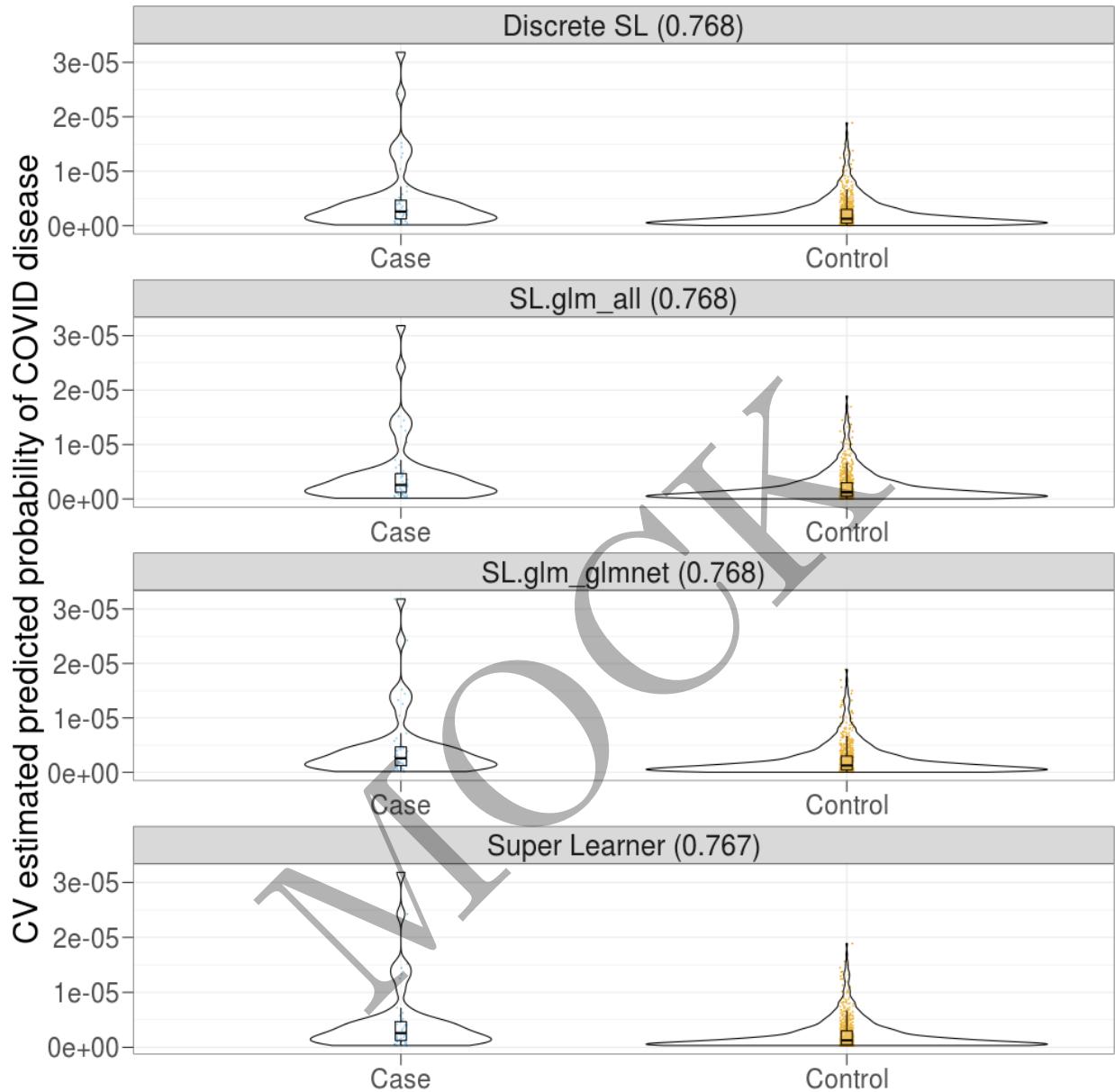


Figure 11.9: 3_varset_bAbRBD: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

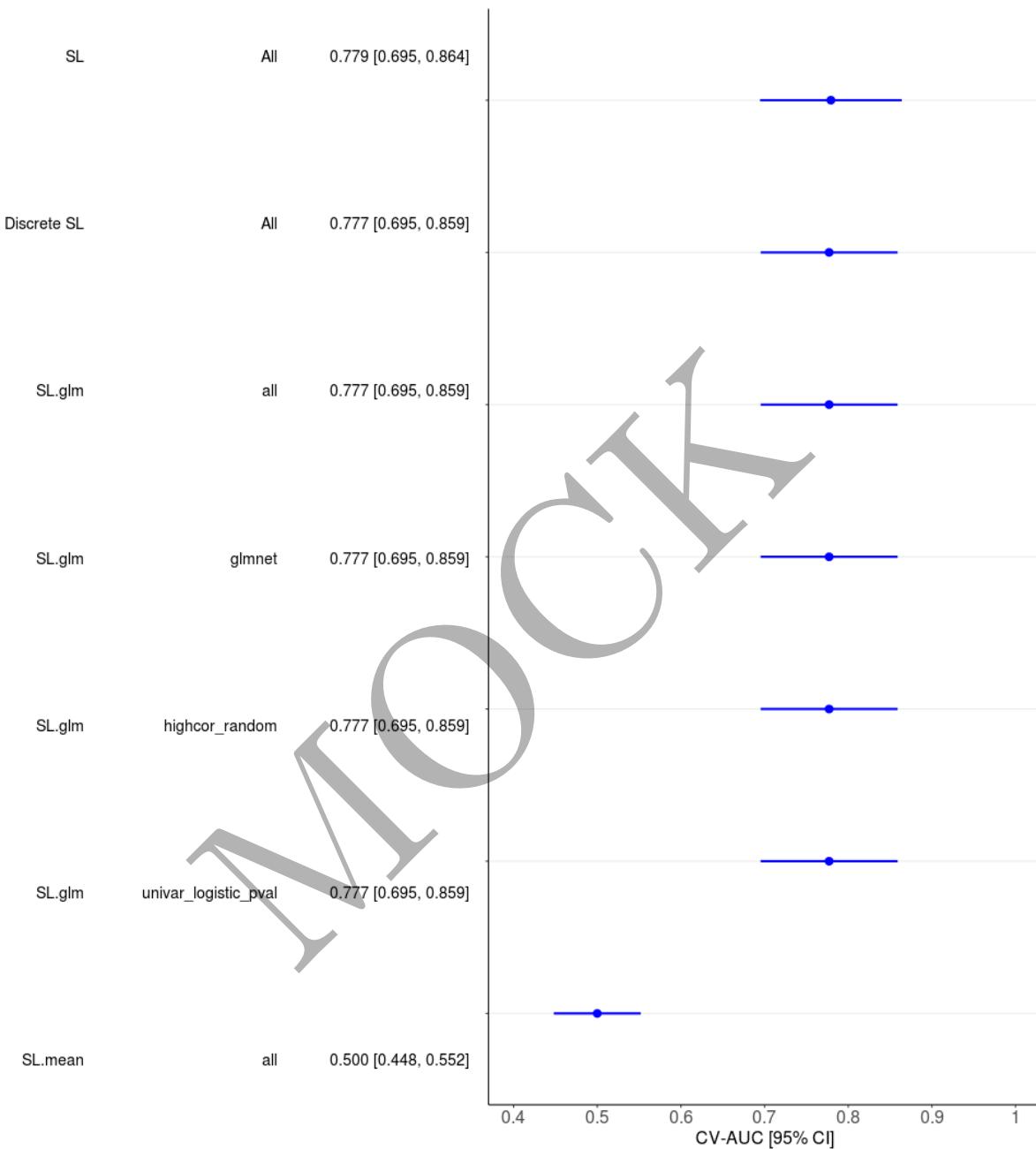


Figure 11.10: 4_varset_pnabID50: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

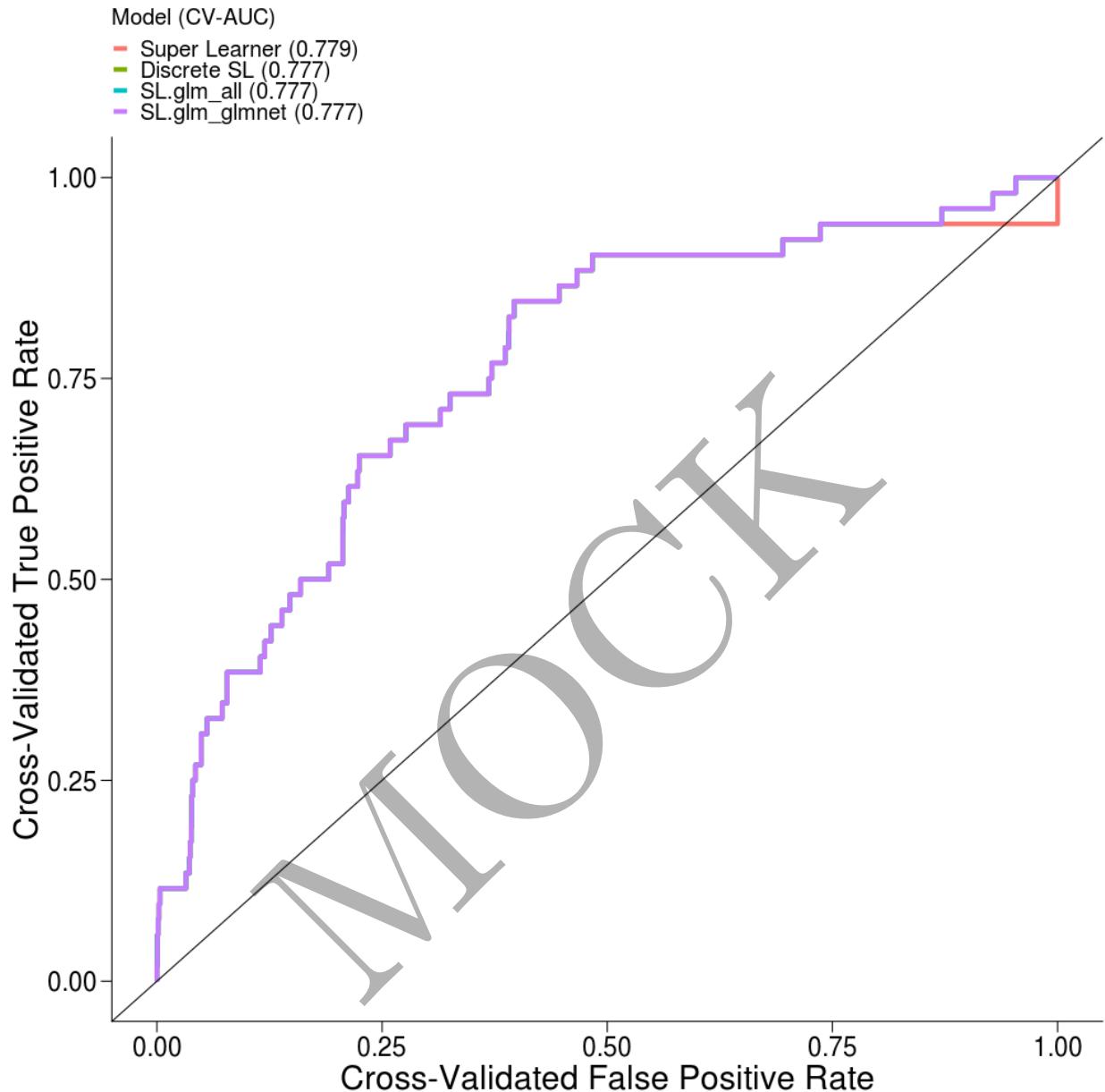


Figure 11.11: 4_varset_pnabID50: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

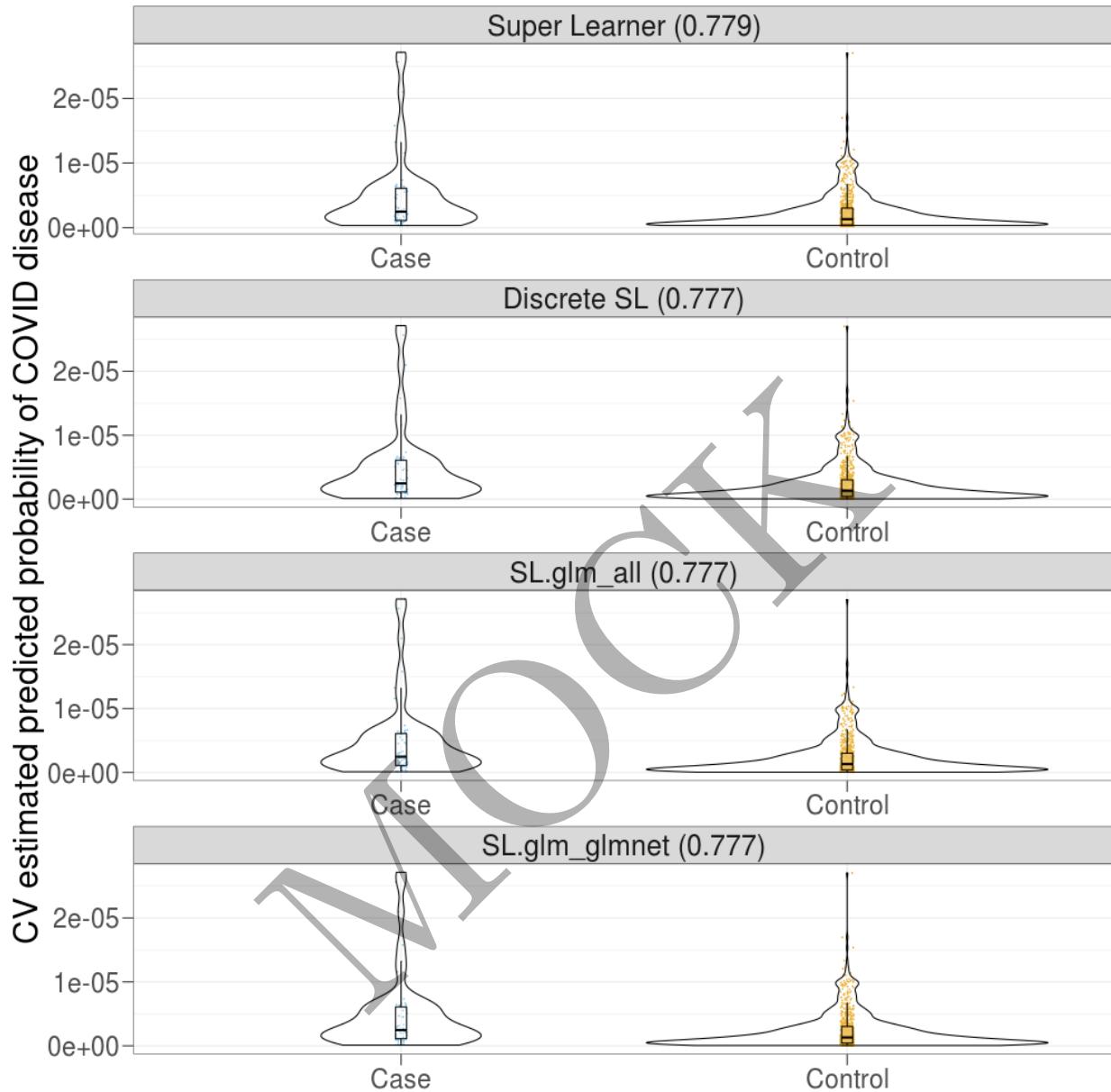


Figure 11.12: 4_varset_pnabID50: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

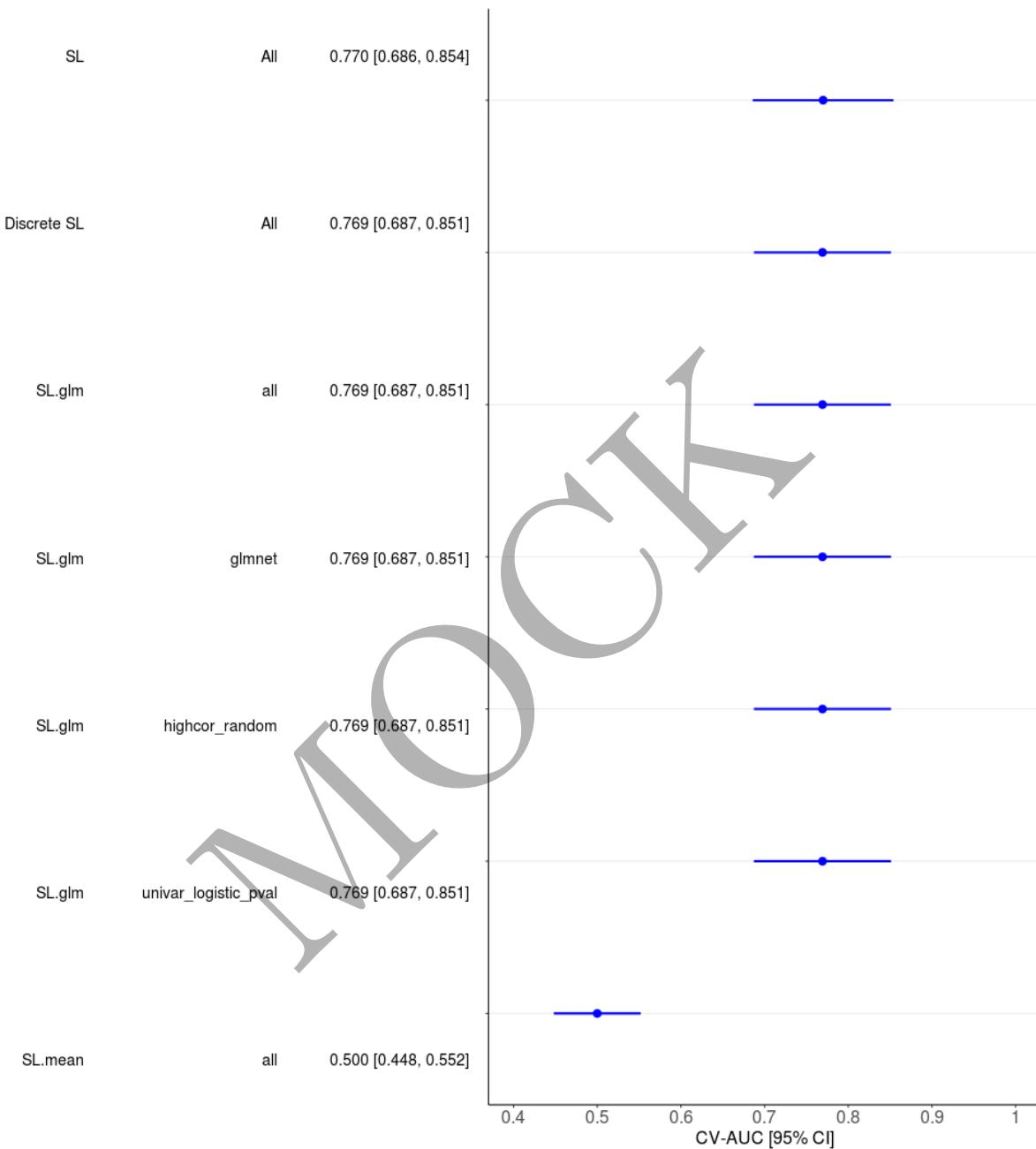


Figure 11.13: 5_varset_pnabID80: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

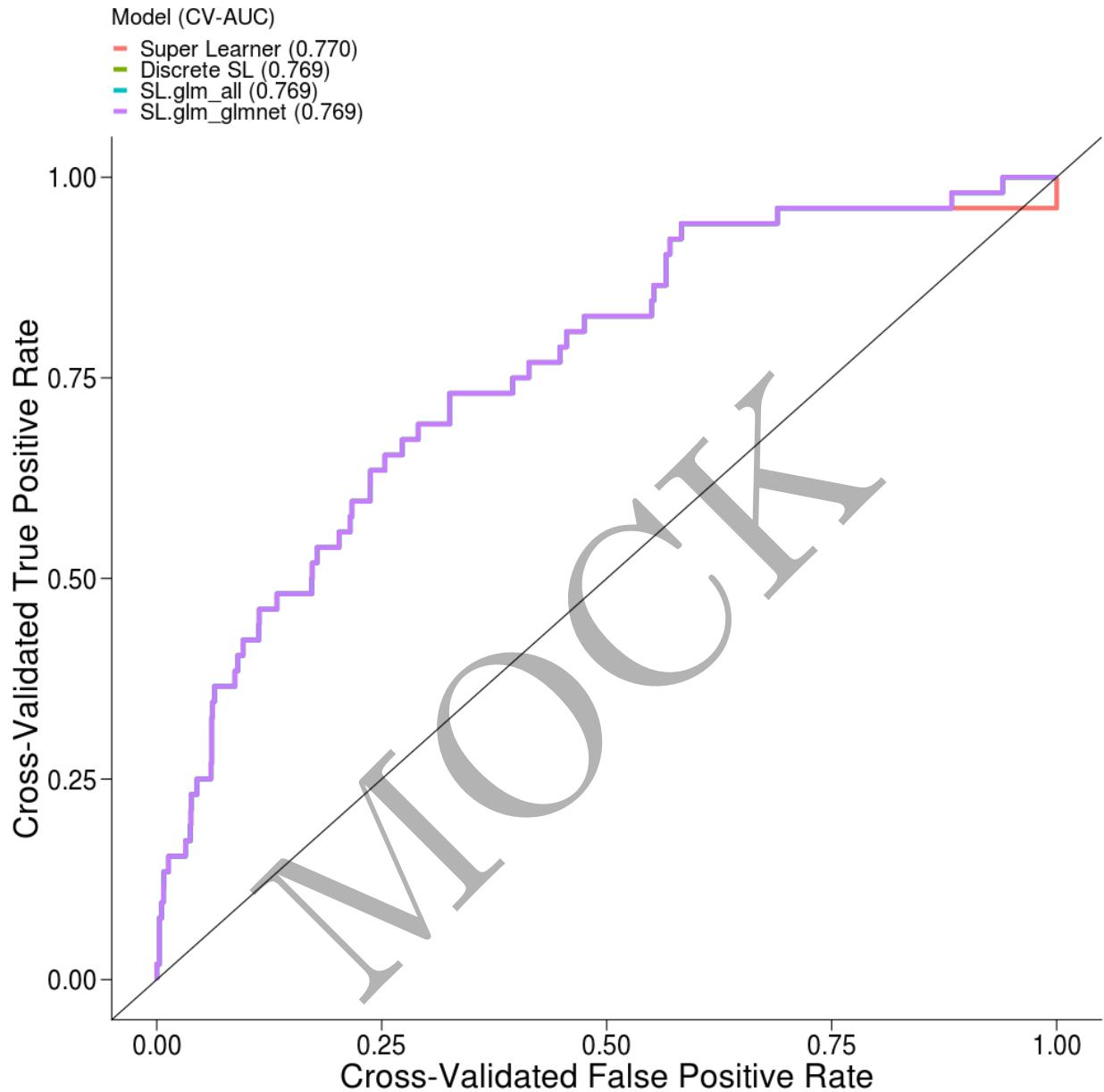


Figure 11.14: 5_varset_pnabID80: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

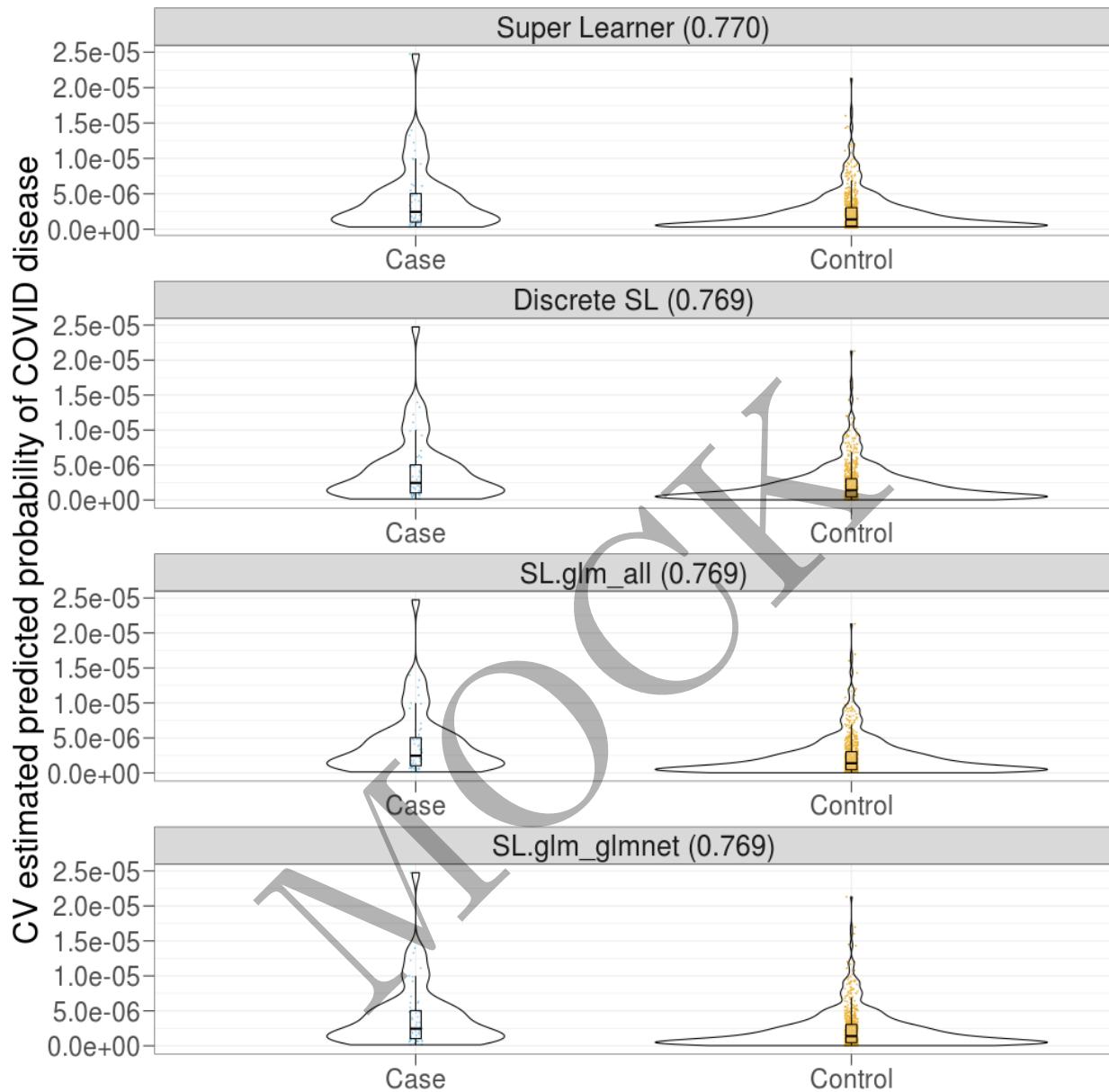


Figure 11.15: 5_varset_pnabID80: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

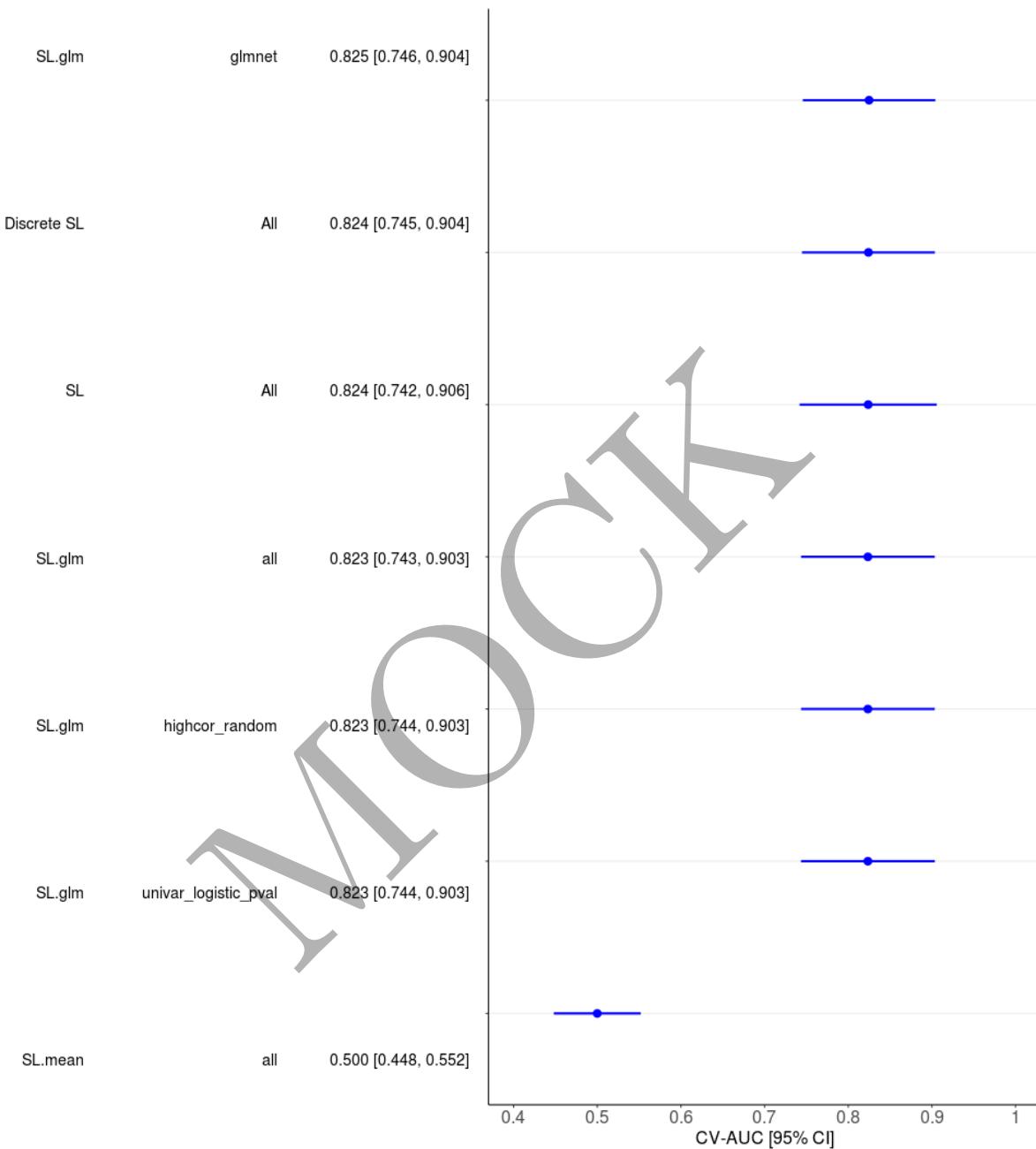


Figure 11.16: 6_varset_bAb_pnabID50: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

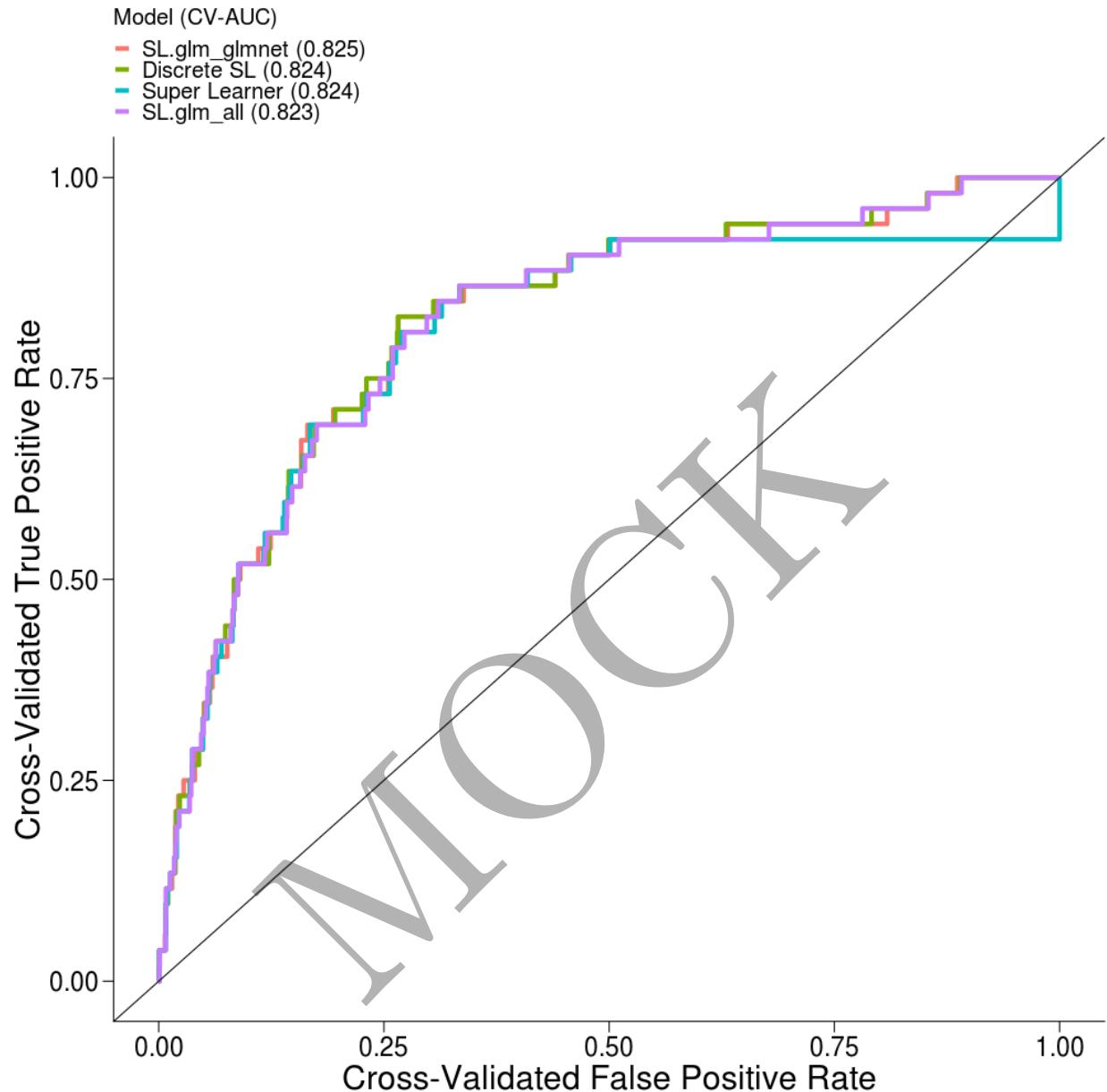


Figure 11.17: 6_varset_bAb_pnabID50: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

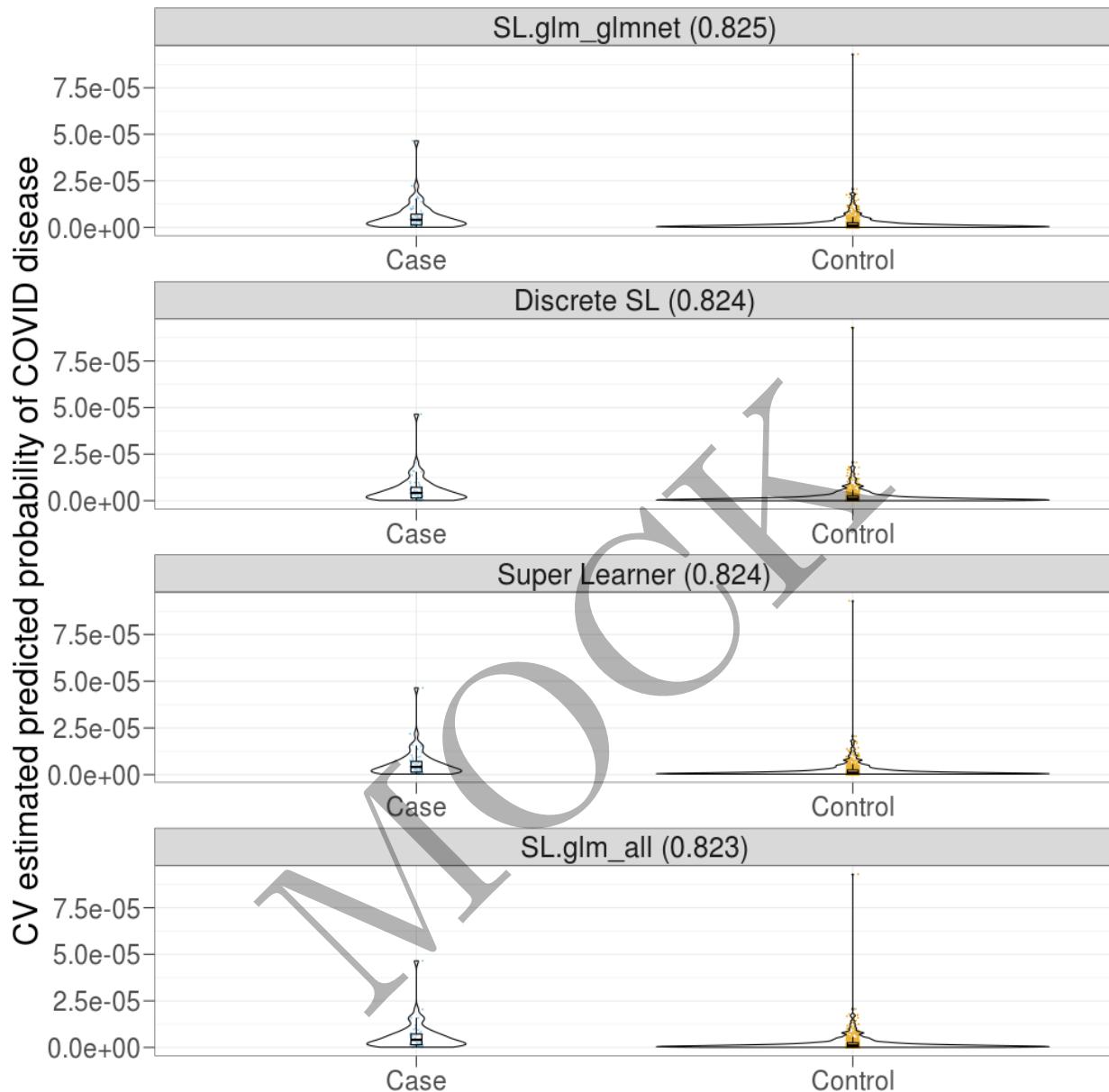


Figure 11.18: 6_varset_bAb_pnabID50: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

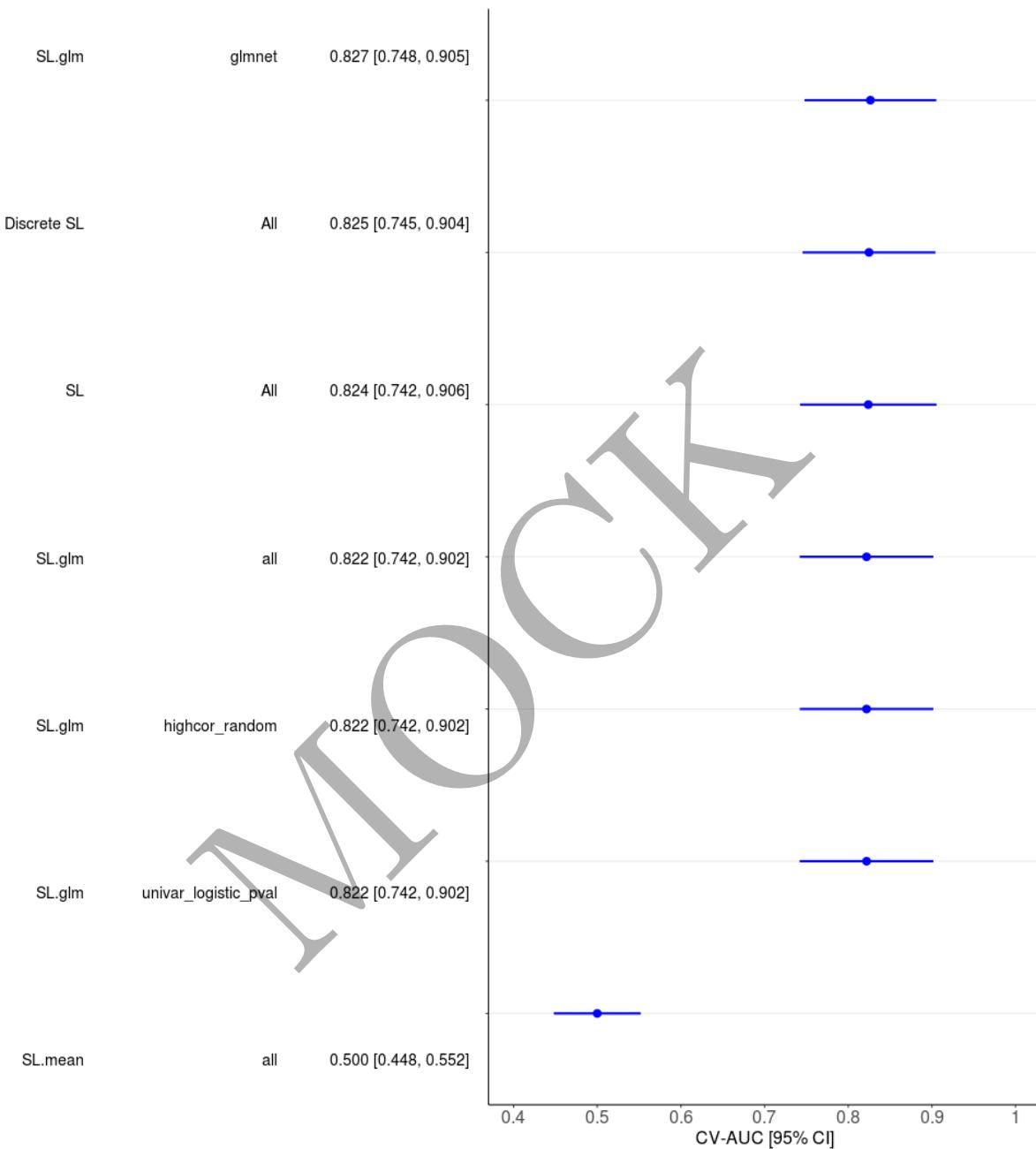


Figure 11.19: 7_varset_bAb_pnabID80: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

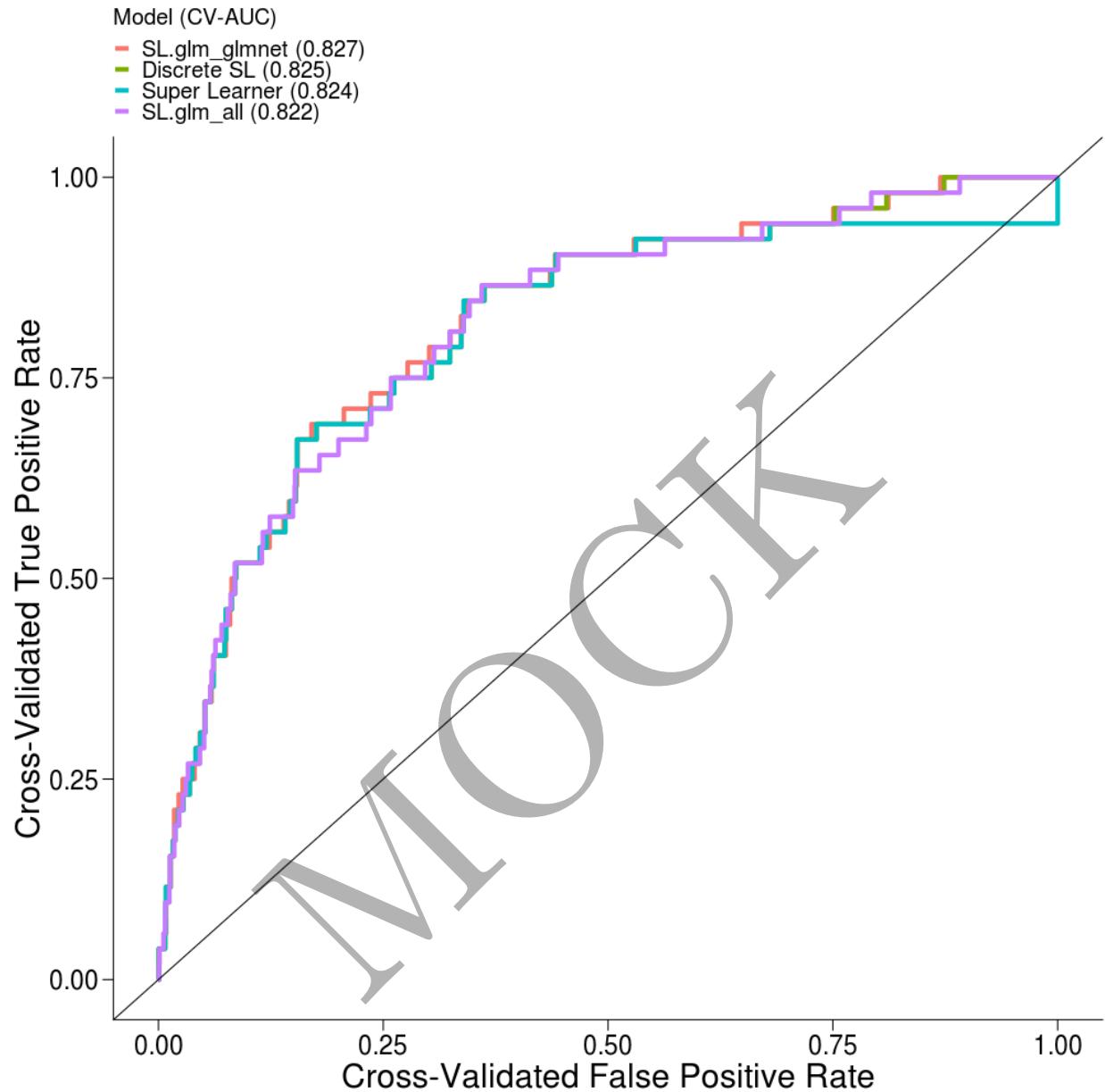


Figure 11.20: 7_varset_bAb_pnabID80: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

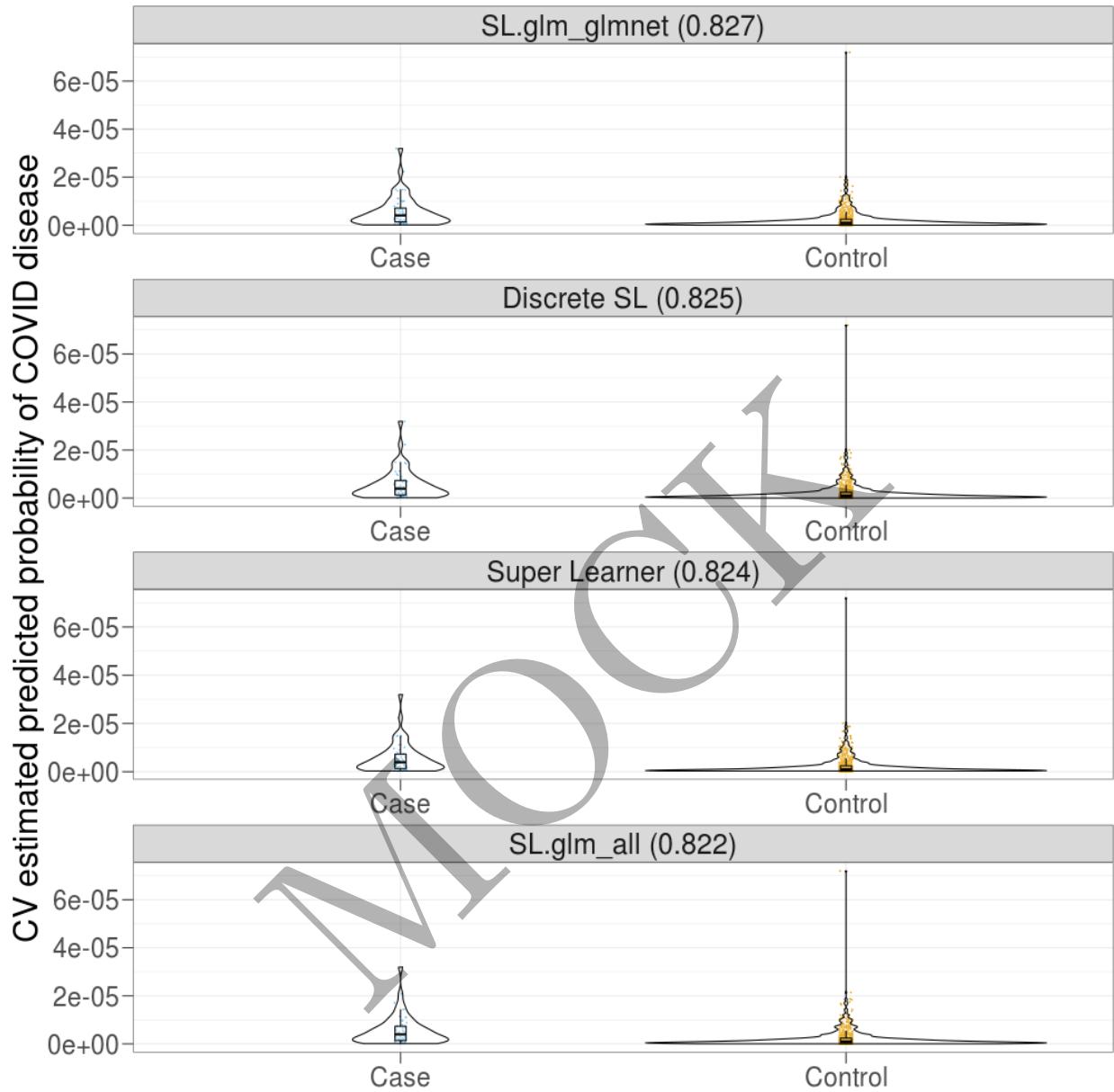


Figure 11.21: 7_varset_bAb_pnabID80: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

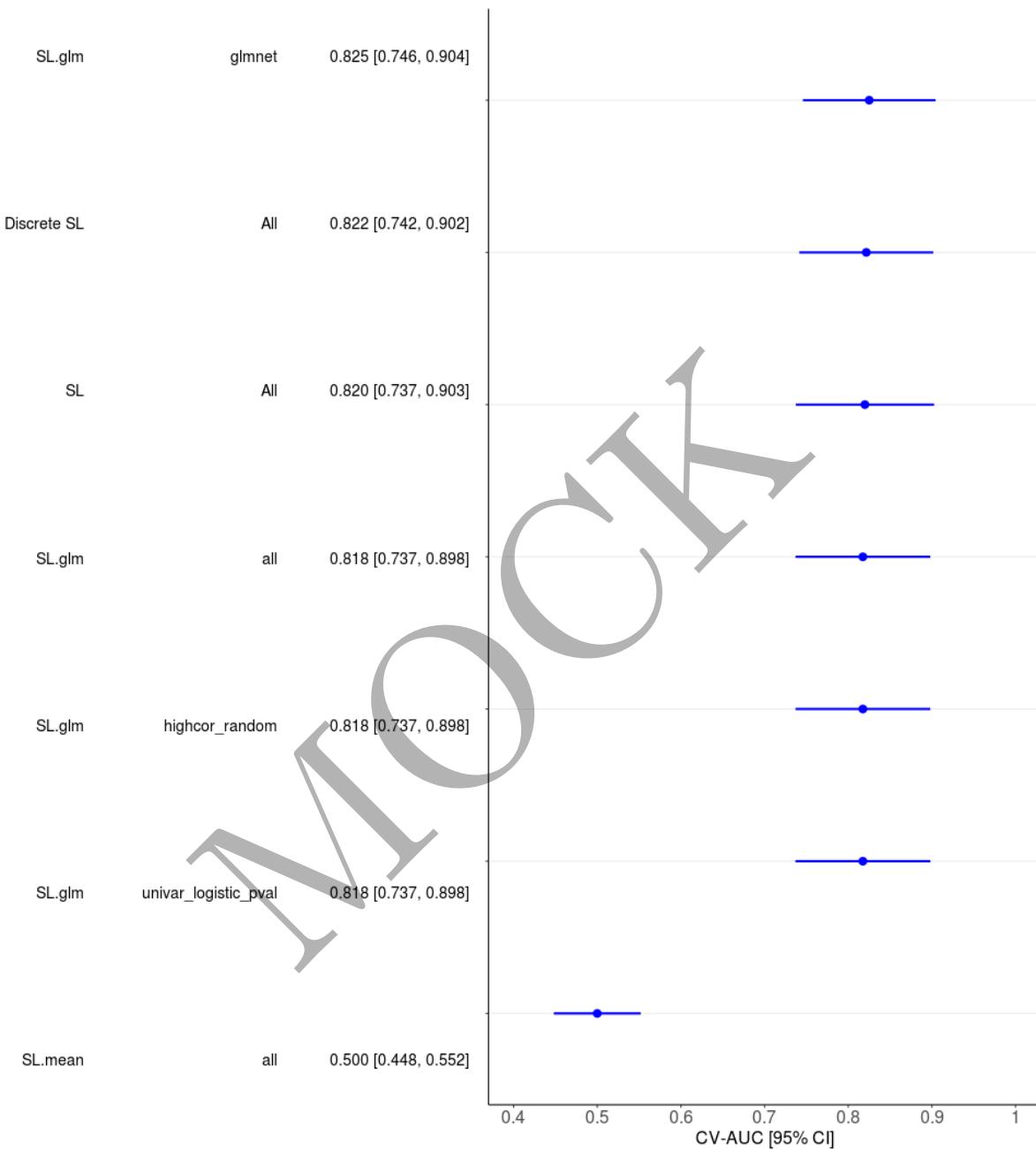


Figure 11.22: 8_varset_bAb_combScores: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

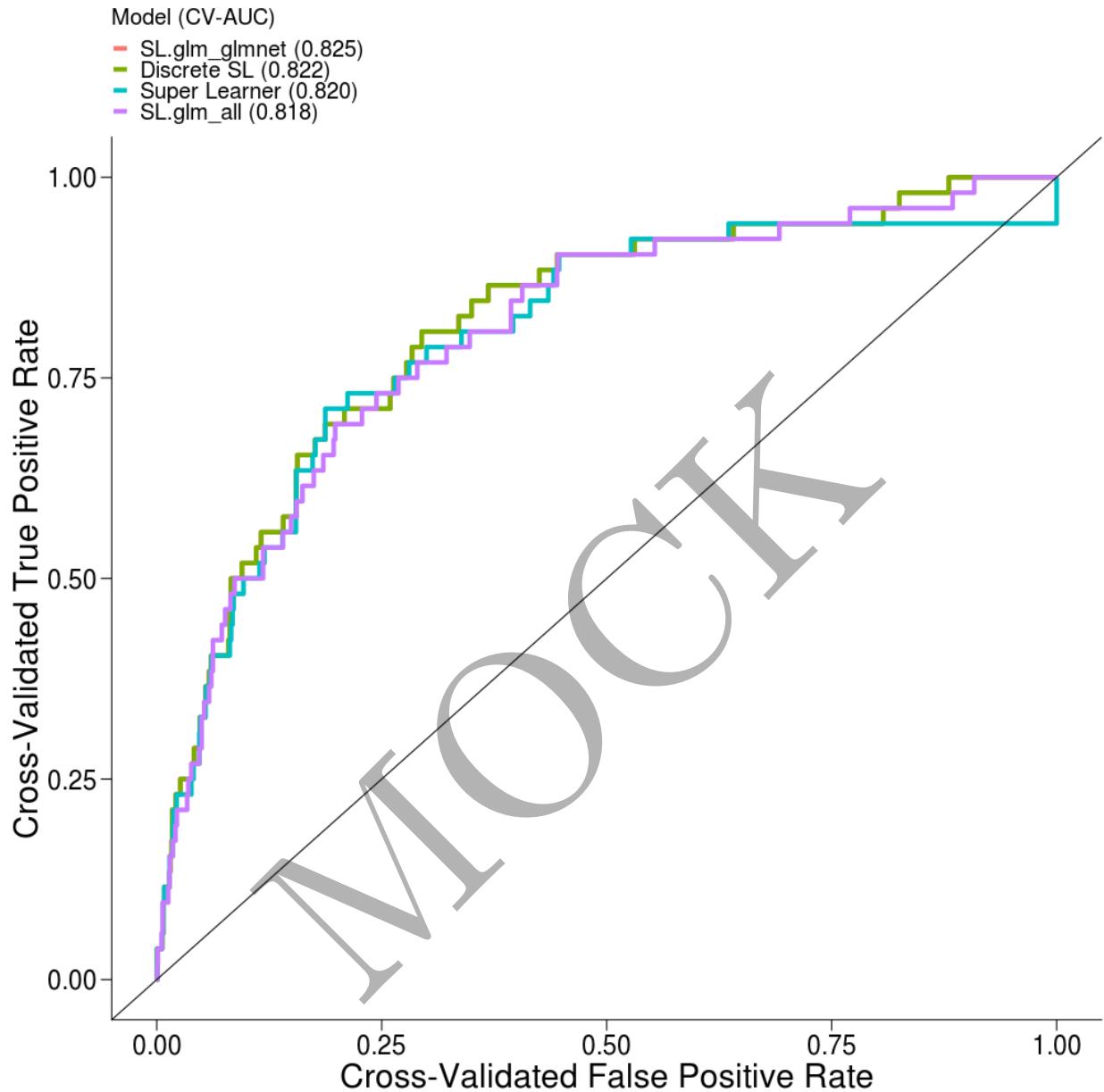


Figure 11.23: 8_varset_bAb_combScores: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

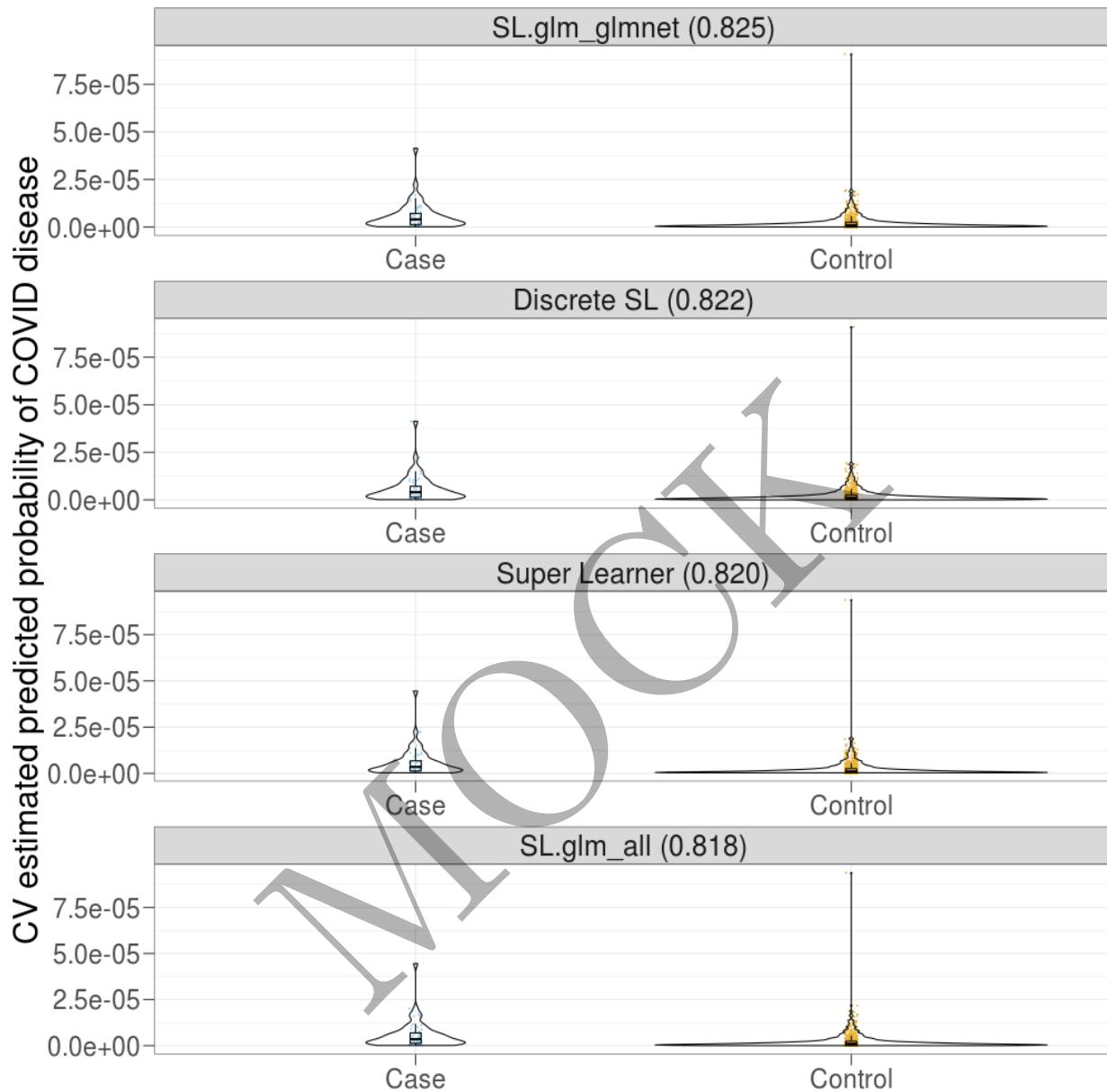


Figure 11.24: 8_varset_bAb_combScores: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

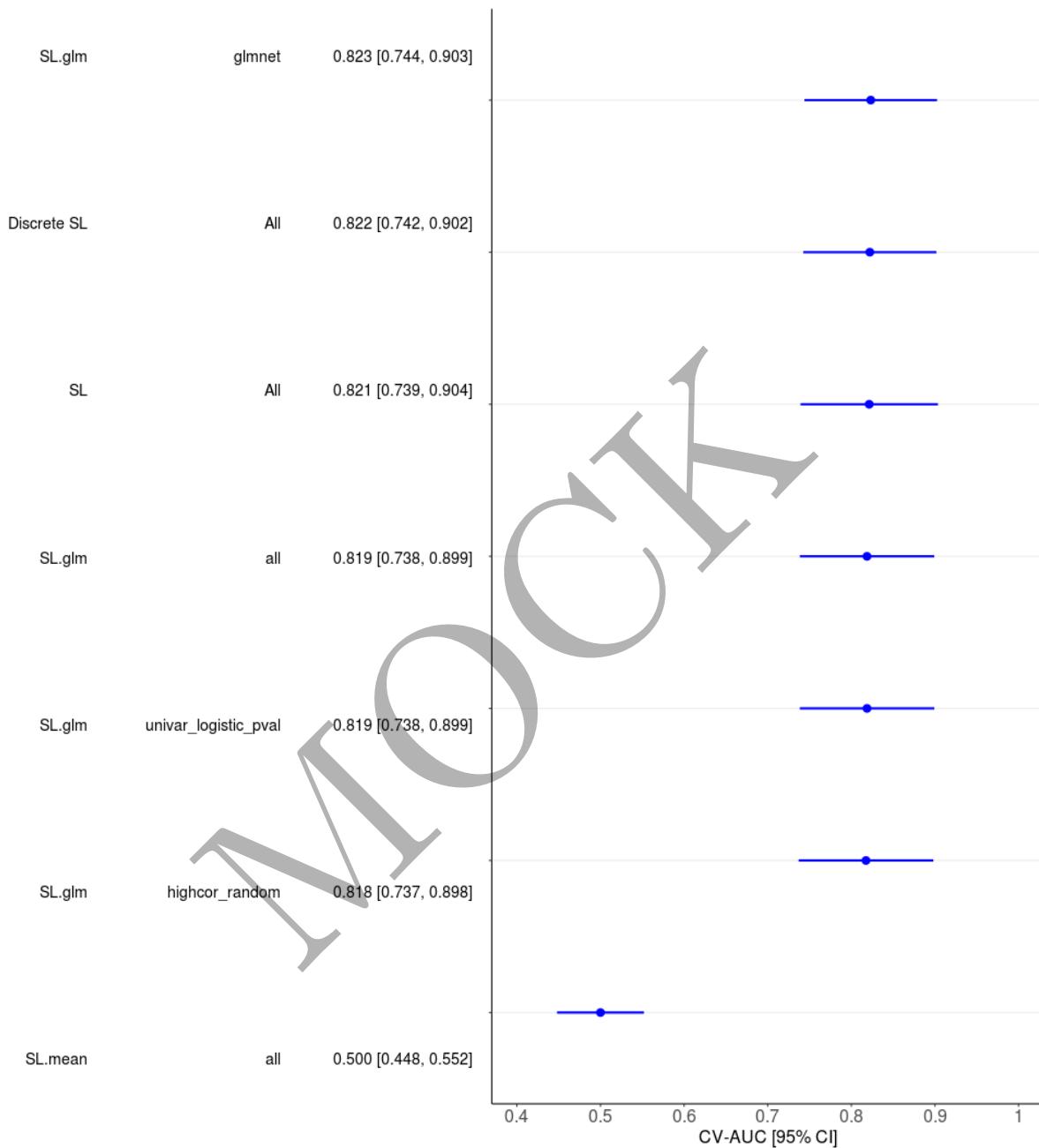


Figure 11.25: 9_varset_allMarkers: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

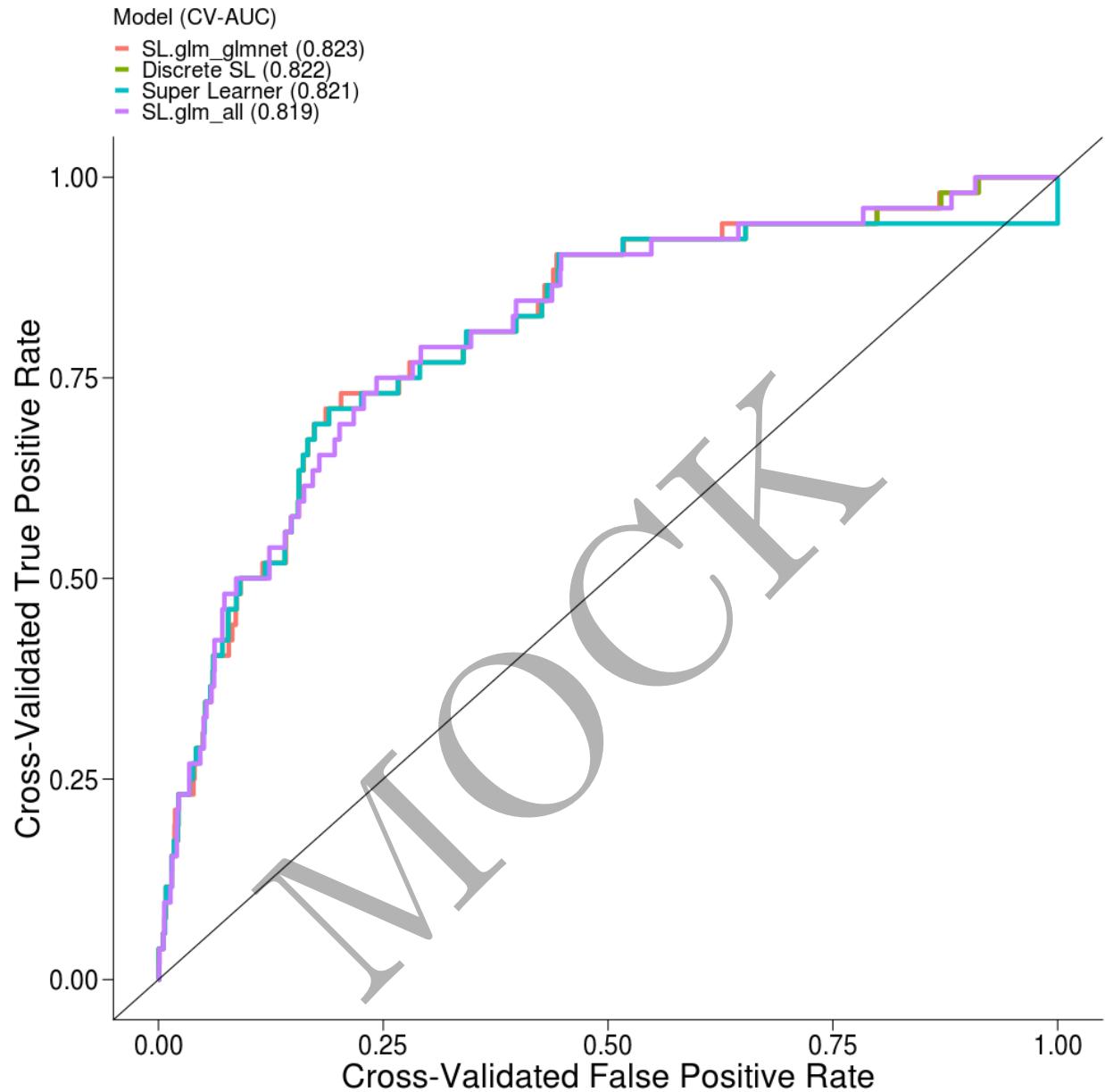


Figure 11.26: 9_varset_allMarkers: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

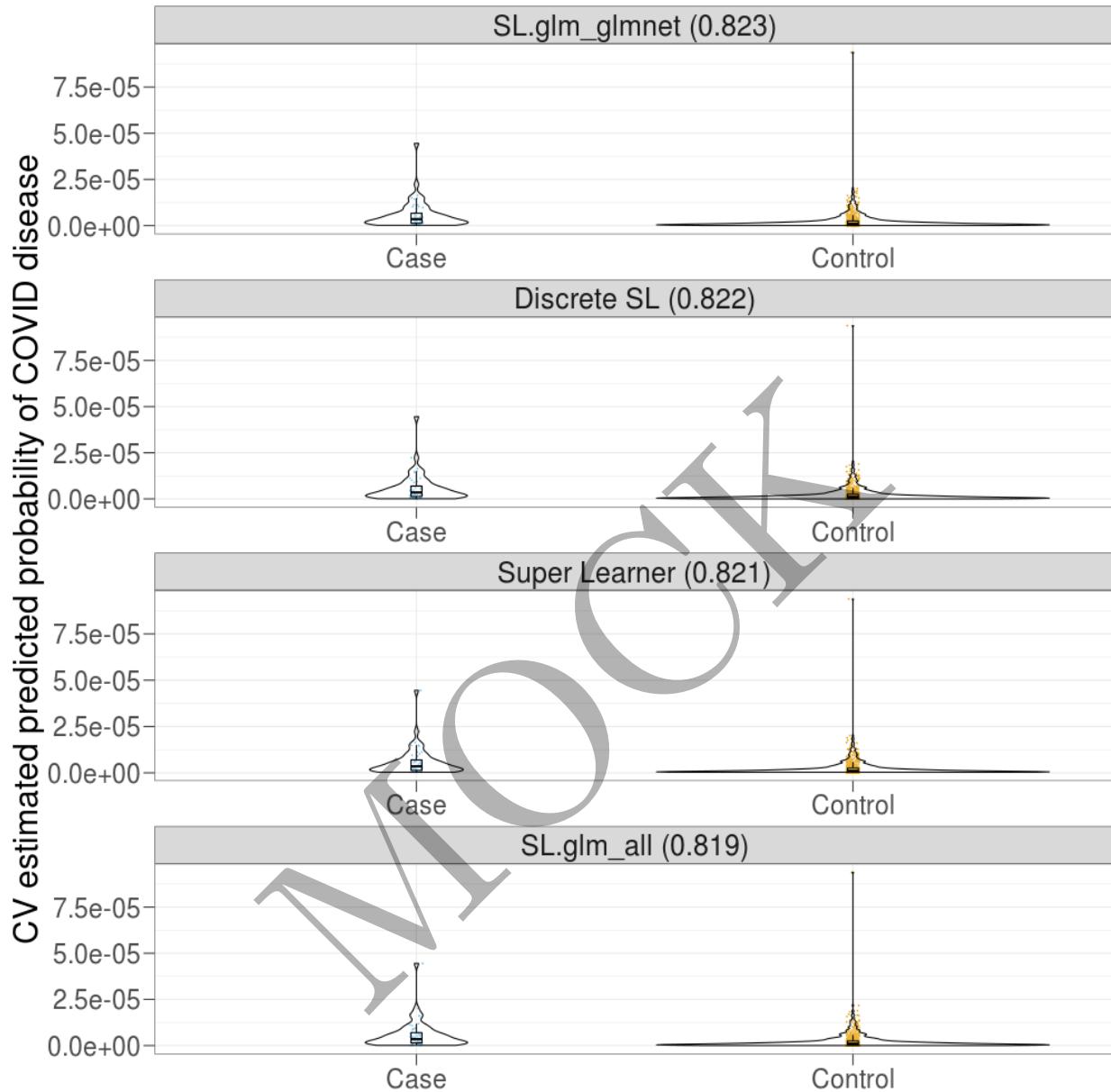


Figure 11.27: 9_varset_allMarkers: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

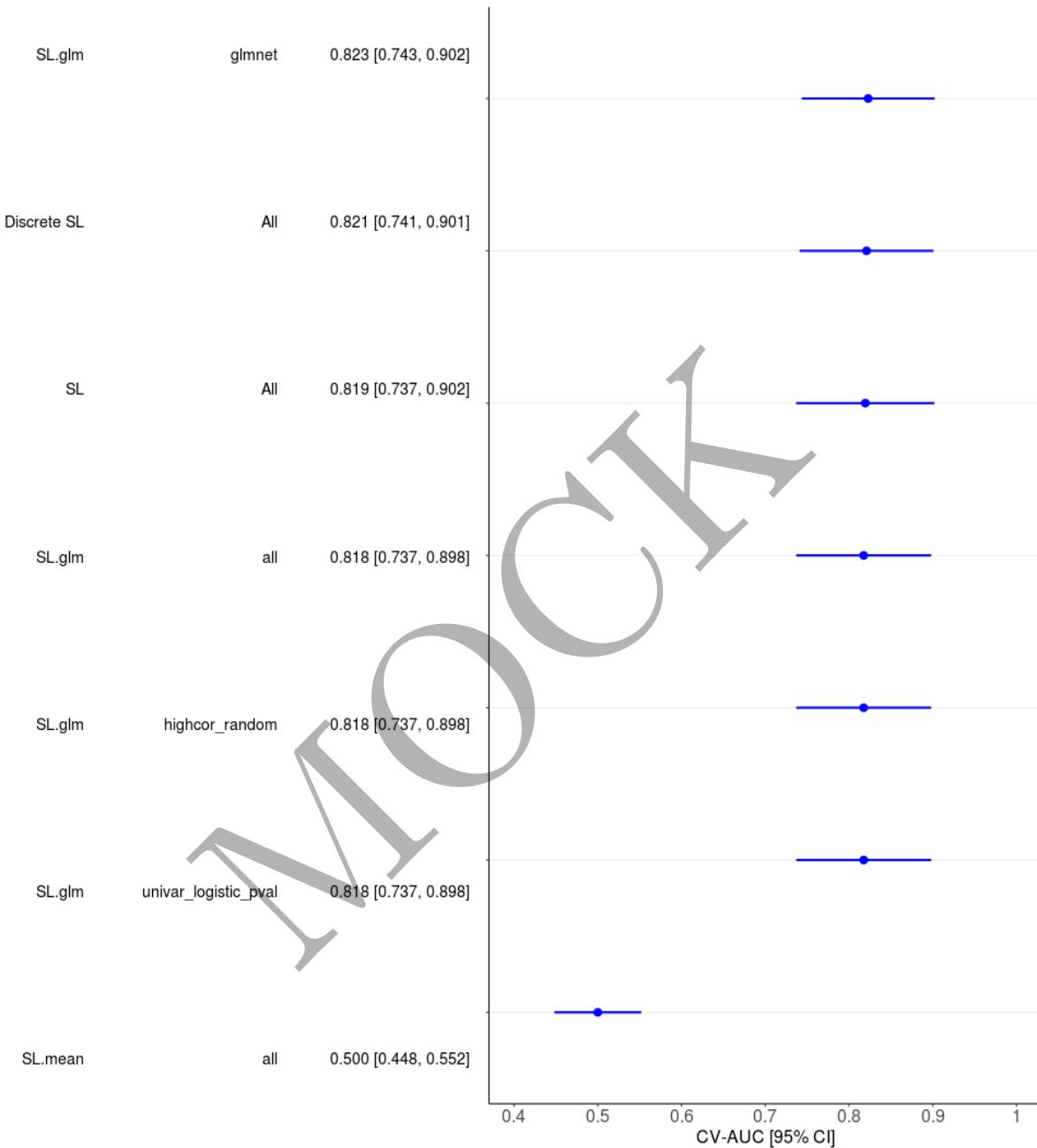


Figure 11.28: 10_varset_allMarkers_combScores: Weighted CV-AUC (95% CI) of algorithms for predicting COVID-19 disease status starting 7 days after Day 57.

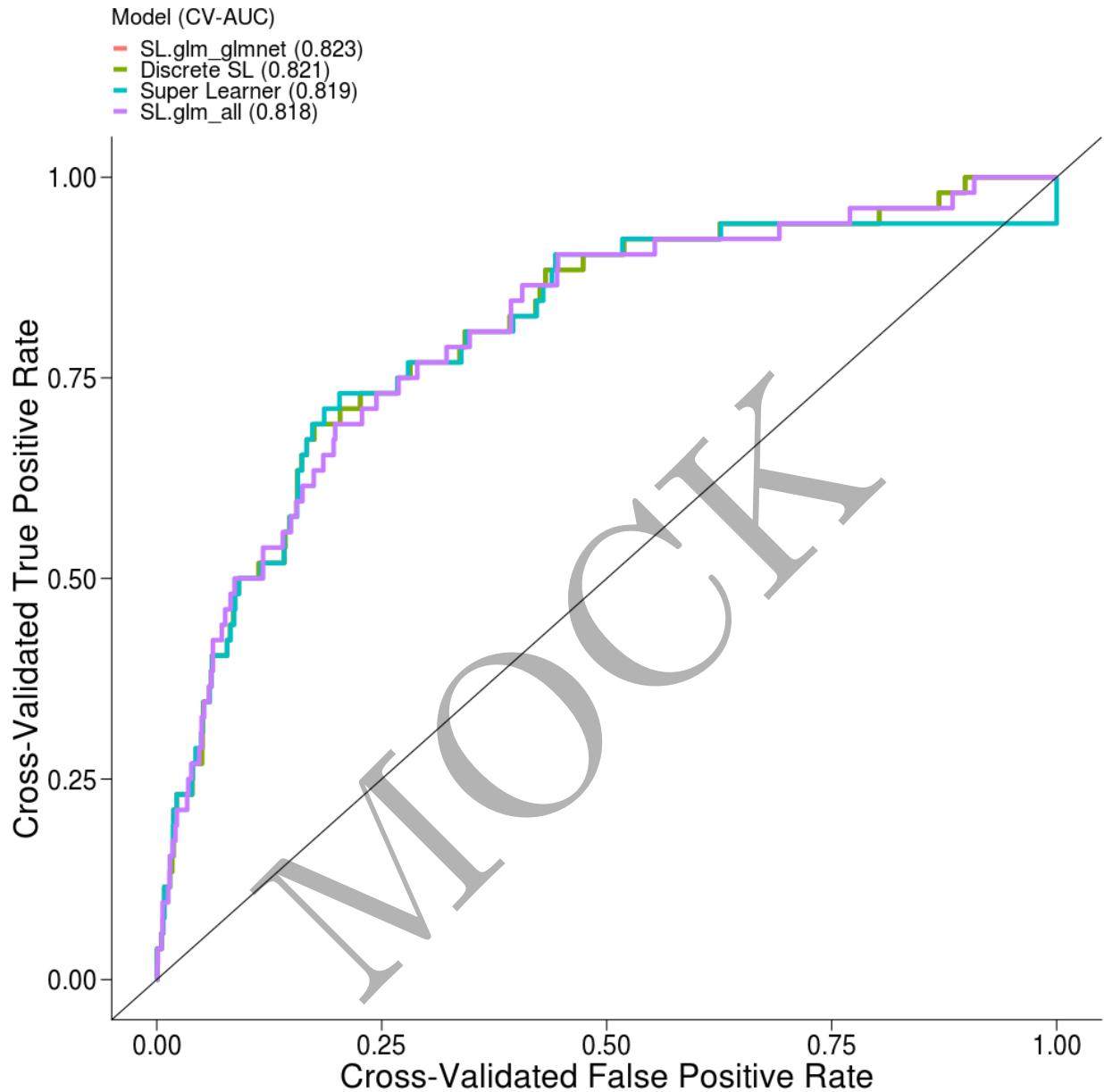


Figure 11.29: 10_varset_allMarkers_combScores: Weighted CV-AUC ROC curves of top two individual learners along with Superlearner and discrete-SL.

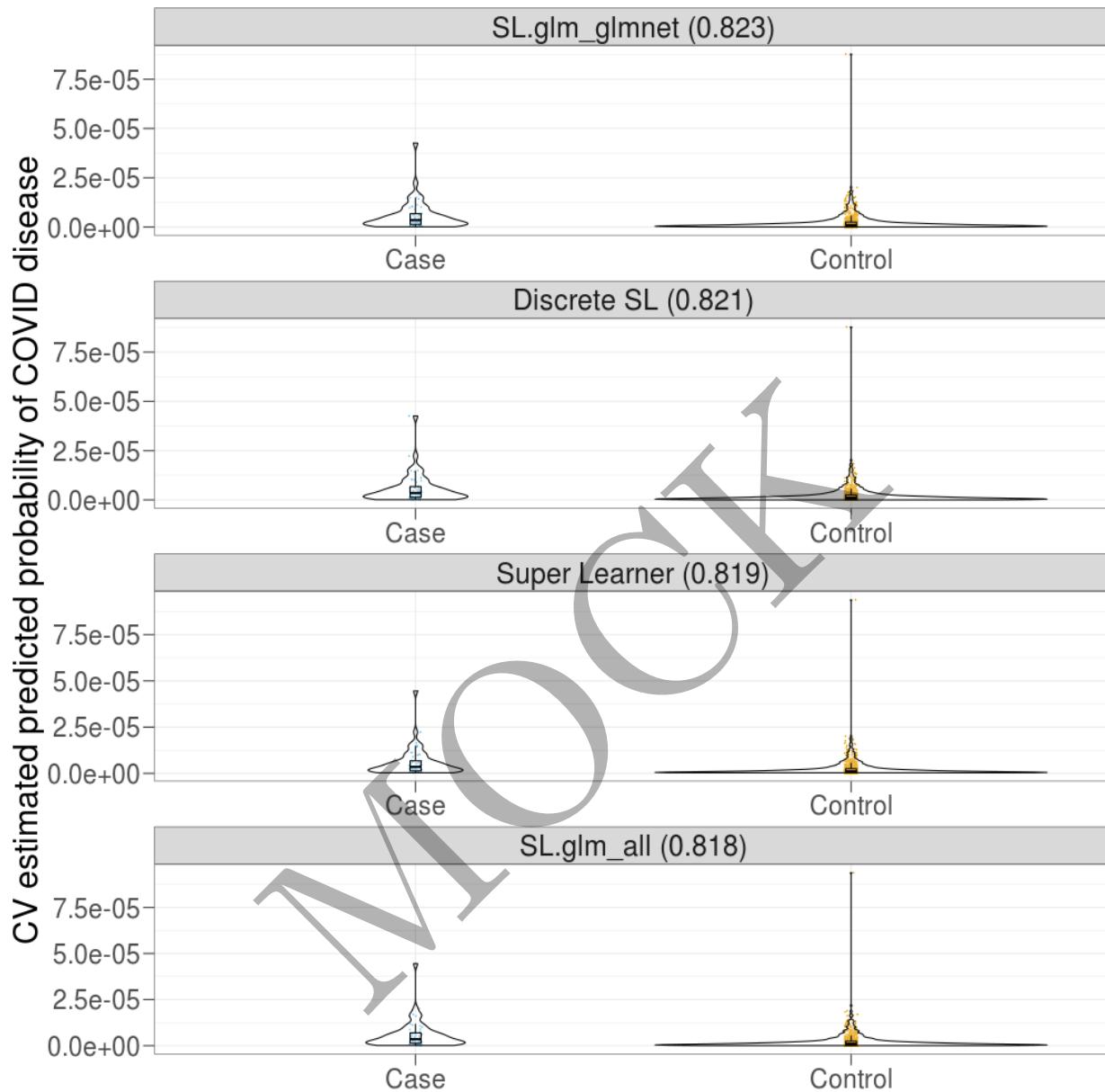


Figure 11.30: 10_varset_allMarkers_combScores: Weighted prediction probability plots of top two individual learners along with Superlearner and discrete-SL.

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Chapter 12

Appendix

- This report was built from the [CoVPN/correlates_reporting](#) repository with commit hash 2e9c7143db31974a77fd3ac901c52cfe3f17c731. A diff of the changes introduced by that commit may be viewed at https://github.com/CoVPN/correlates_reporting/commit/2e9c7143db31974a77fd3ac901c52cfe3f17c731
- The sha256 hash sum of the raw input file, “COVID_VEtiral_practicedata_primarystage1.csv”: 83d0f55d1745ffd42be124d8f9ec9a9903abcc13cd22f95e537542a08b41300a
- The sha256 hash sum of the processed file, “moderna_mock_data_processed.csv”: 28964ce20cfcd70a621aff9df412c42b11