

Supplementary Materials

SARS-CoV-2 Spike antibody levels indicate immuno-resilience against re-infection: a real-world study

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1.0 Supplemental material

1.1 Exclusion criteria

Exclusion criteria were as follows: linkage to more than one person in the claims database; invalid quantitative antibody test results; missing or inconsistent information on age and/or sex across the two data sources; a COVID-19 diagnosis or vaccination record 14 days prior and/or 7 days after the index date; a lack of healthcare activities in the claims database (defined as <2 records of medical or pharmacy claims during 365 days prior to the index date); and/or cases where the subject died within 7 days of the index date.

1.2 Additional sub-cohort details

Patients aged <65 years were compared with those aged 65 years and older. Subjects recorded as having an immunocompromised condition (as listed in **Supplemental Table 1d**) within 365 days prior to the index antibody test were defined as the immunocompromised cohort, and those without were the non-immunocompromised cohort. Individuals with a confirmed SARS-CoV-2 infection and/or vaccination in the claims data at least 14 days prior to the index antibody test were categorised as the infected and/or vaccinated cohort. This group included those with past infections and vaccinations up until 01 January 2020. The effects of prior infection and vaccinations on the SARS-CoV-2 antibody level were further characterised as the natural infection cohort (i.e. COVID-19-recovered and vaccine-naïve individuals) and vaccinated cohort (COVID-19-naïve and vaccinated individuals).

To understand the effect of emergent new variants on the predictive value of the determined antibody response, Delta and Omicron cohorts were defined according to the time periods when these SARS-CoV-2 variants were predominant: for Delta, between 28 June 2021 and 18 December 2021, and for Omicron, between 01 January 2022 and 23 June 2022 (CDCb 2022, Stærke et al 2022). Infections occurring before 27 June 2021 were omitted from the variant analysis because of absence or reduced dominance of Delta, as were those occurring between 19 December 2021 and 31 December 2021, which was classified as a transitional period between Delta and Omicron.

1.3 Statistical analysis

The baseline covariates of interest included age; gender; region; race and ethnicity; insurance plan; subjects' comorbidity (Charlson Comorbidity Index [CCI] score); immunocompromised conditions; past infection and vaccination status before the index antibody test; time from the most recent COVID-19 infection/vaccination event to the index date and seasonal variable for the index date.

2.0 Supplementary Tables

Supplemental Table 1a. Diagnosis codes to identify COVID-19 infection

Code	Description	Code Type	Comment
U07.1	COVID-19 Infections	ICD-10-CM	Confirmed cases (EFFECTIVE FROM APRIL 1, 2020)
J12.82	Pneumonia due to COVID-19	ICD-10-CM	Pneumonia case confirmed as due to COVID-19 (EFFECTIVE FROM JANUARY 1, 2021)
B97.29	Other coronavirus as the cause of diseases classified elsewhere	ICD-10-CM	Used as interim code to report confirmed cases of COVID-19 (ONLY UNTIL MARCH 31, 2020)

The Center for Disease Control and Prevention issued B97.29 from January 1, 2020 to March 31, 2020 and then U07.1 since April 1, 2020 and forward. However, in practice clinicians may use 2 codes interchangeably for COVID-19. In addition, literature suggested that B97.29 was not used frequently before COVID-19 and that it was rarely used without U07.1 during the COVID-19 pandemic.

Supplemental Table 1b. Codes of COVID-19 vaccination

Code	Description	Code Type	Manufacturer
2468235	SARS-CoV-2 (COVID-19) vaccine, mRNA-BNT162b2 0.1 MG/ML Injectable Suspension	RxCUI	Pfizer-BioNTech
2583743	SARS-CoV-2 (COVID-19) vaccine, mRNA-BNT162b2 0.05 MG/ML Injectable Suspension	RxCUI	Pfizer-BioNTech
2593847	SARS-CoV-2 (COVID-19) vaccine, mRNA-BNT162b2 0.1 MG/ML Injectable Suspension [Comirnaty]	RxCUI	Pfizer-BioNTech
59267-1000-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose	NDC11	Pfizer-BioNTech
59267-1000-02	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose	NDC11	Pfizer-BioNTech
59267-1000-03	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose	NDC11	Pfizer-BioNTech
91300	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, diluent reconstituted, for intramuscular use	CPT-4	Pfizer-BioNTech
0001A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, diluent reconstituted; first dose	CPT-4	Pfizer-BioNTech
0002A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, diluent reconstituted; second dose	CPT-4	Pfizer-BioNTech

0003A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, diluent reconstituted; third dose	CPT-4	Pfizer-BioNTech
0004A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, diluent reconstituted; booster dose	CPT-4	Pfizer-BioNTech
59267-1025-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-1025-03	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-1025-04	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
00069-2025-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
00069-2025-10	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
00069-2025-25	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
91305	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation, for intramuscular use	CPT-4	Pfizer-BioNTech

0051A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation; first dose	CPT-4	Pfizer-BioNTech
0052A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation; second dose	CPT-4	Pfizer-BioNTech
0053A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation; third dose	CPT-4	Pfizer-BioNTech
0054A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation; booster dose	CPT-4	Pfizer-BioNTech
59267-1055-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 10 mcg/0.2 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-1055-04	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 10 mcg/0.2 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
91307	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation, for intramuscular use	CPT-4	Pfizer-BioNTech

0071A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; first dose	CPT-4	Pfizer-BioNTech
0072A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; second dose	CPT-4	Pfizer-BioNTech
0073A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; third dose	CPT-4	Pfizer-BioNTech
0074A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; booster dose	CPT-4	Pfizer-BioNTech
59267-0078-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 3 mcg/0.2 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-0078-04	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 3 mcg/0.2 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
91308	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 3 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation, for intramuscular use	CPT-4	Pfizer-BioNTech

0081A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 3 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; first dose	CPT-4	Pfizer-BioNTech
0082A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 3 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; second dose	CPT-4	Pfizer-BioNTech
0083A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 3 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; third dose	CPT-4	Pfizer-BioNTech
59267-0304-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 30 mcg/0.3mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-0304-02	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 30 mcg/0.3mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-1404-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 30 mcg/0.3mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
59267-1404-02	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 30 mcg/0.3mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech

91312	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, bivalent spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation, for intramuscular use	CPT-4	Pfizer-BioNTech
0124A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, bivalent spike protein, preservative free, 30 mcg/0.3mL dosage, tris-sucrose formulation; booster dose	CPT-4	Pfizer-BioNTech
59267-0565-01	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 10 mcg/0.2 mL dose, tris-sucrose formulation	NDC11	Pfizer-BioNTech
91315	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, bivalent spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation, for intramuscular use	CPT-4	Pfizer-BioNTech
0154A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, bivalent spike protein, preservative free, 10 mcg/0.2mL dosage, diluent reconstituted, tris-sucrose formulation; booster dose	CPT-4	Pfizer-BioNTech
2470234	SARS-CoV-2 (COVID-19) vaccine, mRNA-1273 0.2 MG/ML Injectable Suspension	RxCUI	Moderna
2601552	SARS-CoV-2 (COVID-19) vaccine, mRNA-1273 0.2 MG/ML Injectable Suspension [Spikevax]	RxCUI	Moderna
2598700	SARS-CoV-2 (COVID-19) vaccine, mRNA-1273 0.1 MG/ML Injectable Suspension	RxCUI	Moderna
80777-0273-10	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna

80777-0273-99	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna
80777-0273-15	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna
80777-0273-98	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna
80777-0100-11	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna
80777-0100-99	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	NDC11	Moderna
91301	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 100 mcg/0.5mL dosage, for intramuscular use	CPT-4	Moderna
0011A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 100 mcg/0.5mL dosage; first dose	CPT-4	Moderna
0012A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 100 mcg/0.5mL dosage; second dose	CPT-4	Moderna
0013A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 100 mcg/0.5mL dosage; third dose	CPT-4	Moderna

91306	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.25mL dosage, for intramuscular use	CPT-4	Moderna
0064A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.25mL dosage; booster dose	CPT-4	Moderna
80777-0275-05	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 50 mcg/0.5 mL dose	NDC11	Moderna
80777-0275-99	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 50 mcg/0.5 mL dose	NDC11	Moderna
91309	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.5mL dosage, for intramuscular use	CPT-4	Moderna
0091A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.5mL dosage; first dose	CPT-4	Moderna
0092A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.5mL dosage; second dose	CPT-4	Moderna
0093A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.5mL dosage; third dose	CPT-4	Moderna

0094A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 50 mcg/0.5mL dosage; booster dose	CPT-4	Moderna
80777-0279-05	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, pediatric 25 mcg/0.25 mL dose	NDC11	Moderna
80777-0279-99	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, pediatric 25 mcg/0.25 mL dose	NDC11	Moderna
91311	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 25 mcg/0.25mL dosage, for intramuscular use	CPT-4	Moderna
0111A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 25 mcg/0.25mL dosage; first dose	CPT-4	Moderna
0112A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 25 mcg/0.25mL dosage; second dose	CPT-4	Moderna
0113A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, preservative free, 25 mcg/0.25mL dosage; third dose	CPT-4	Moderna
80777-0282-05	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 50 mcg/0.5 mL or 25mcg/0.25mL dose	NDC11	Moderna

80777-0282-99	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 50 mcg/0.5 mL or 25mcg/0.25mL dose	NDC11	Moderna
91313	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, bivalent, preservative free, 50 mcg/0.5mL dosage, for intramuscular use	CPT-4	Moderna
0134A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, bivalent, preservative free, 50 mcg/0.5mL dosage; booster dose	CPT-4	Moderna
91314	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, bivalent, preservative free, 25 mcg/0.25mL dosage, for intramuscular use	CPT-4	Moderna
0144A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus disease [COVID-19]) vaccine, mRNA-LNP, spike protein, bivalent, preservative free, 25 mcg/0.25mL dosage; booster dose	CPT-4	Moderna
2479835	COVID-19 vaccine, vector-nr, rS-Ad26, PF, 0.5 mL	RxCUI	Janssen
59676-0580-05	SARS-COV-2 (COVID-19) vaccine, vector non-replicating, recombinant spike protein-Ad26, preservative free, 0.5 mL	NDC11	Janssen
59676-0580-15	SARS-COV-2 (COVID-19) vaccine, vector non-replicating, recombinant spike protein-Ad26, preservative free, 0.5 mL	NDC11	Janssen
91303	Severe acute respiratory syndrome coronavirus 2 (SARSCoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, adenovirus type 26 (Ad26) vector, preservative free, 5x10 ¹⁰ viral particles/0.5 mL dosage, for intramuscular use	CPT-4	Janssen

0031A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, adenovirus type 26 (Ad26) vector, preservative free, 5x10 ¹⁰ viral particles/0.5mL dosage, single dose	CPT-4	Janssen
0034A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, adenovirus type 26 (Ad26) vector, preservative free, 5x10 ¹⁰ viral particles/0.5mL dosage, booster dose	CPT-4	Janssen
00310-1222-10	Covid-19 (Sars-Cov-2) Adenovirus Vac(Az) 0.5 MI Intramuscular Suspension	NDC11	AstraZeneca
00310-1222-15	Azd-1222 50000000000 {Vp}/.5MI Intramuscular Injection, Suspension	NDC11	AstraZeneca
91302	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, chimpanzee adenovirus Oxford 1 (ChAdOx1) vector, preservative free, 5x10 ¹⁰ viral particles/0.5mL dosage, for intramuscular use	CPT-4	AstraZeneca
0021A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, chimpanzee adenovirus Oxford 1 (ChAdOx1) vector, preservative free, 5x10 ¹⁰ viral particles/0.5mL dosage; first dose	CPT-4	AstraZeneca
0022A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, DNA, spike protein, chimpanzee adenovirus Oxford 1 (ChAdOx1) vector, preservative free, 5x10 ¹⁰ viral particles/0.5mL dosage; second dose	CPT-4	AstraZeneca

80631-0100-01	SARS-COV-2 (COVID-19) vaccine, subunit, recombinant spike protein-nanoparticle+Matrix-M1 Adjuvant, preservative free, 0.5mL dose	NDC11	Novavax
80631-0100-10	SARS-COV-2 (COVID-19) vaccine, subunit, recombinant spike protein-nanoparticle+Matrix-M1 Adjuvant, preservative free, 0.5mL dose	NDC11	Novavax
91304	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, recombinant spike protein nanoparticle, saponin-based adjuvant, preservative free, 5 mcg/0.5mL dosage, for intramuscular use	CPT-4	Novavax
0041A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, recombinant spike protein nanoparticle, saponin-based adjuvant, preservative free, 5 mcg/0.5mL dosage; first dose	CPT-4	Novavax
0042A	Immunization administration by intramuscular injection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (coronavirus disease [COVID-19]) vaccine, recombinant spike protein nanoparticle, saponin-based adjuvant, preservative free, 5 mcg/0.5mL dosage; second dose	CPT-4	Novavax

COVID-19, coronavirus disease; LNP, XXX; mRNA, messenger ribonucleic acid; SARS-CoV-2, severe-acute-respiratory-syndrome-related coronavirus

Supplemental Table 1c. Codes and coding algorithms for Charlson Comorbidity Index (CCI)¹

Comorbidities	ICD-10-CM	Score
Myocardial infarction	I21.x, I22.x, I25.2	1
Congestive heart failure	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, I50.x, P29.0	1
Peripheral vascular disease	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	1
Cerebrovascular disease	G45.x, G46.x, H34.0, I60.x-I69.x	1
Dementia	F00.x-F03.x, F05.1, G30.x, G31.1	1
Chronic pulmonary disease	I27.8, I27.9, J40.x-J47.x, J60.x-J67.x, J68.4, J70.1, J70.3	1
Rheumatic disease	M05.x, M06.x, M31.5, M32.x-M34.x, M35.1, M35.3, M36.0	1
Peptic ulcer disease	K25.x-K28.x	1
Mild liver disease	B18.x, K70.0-K70.3, K70.9, K71.3-K71.5, K71.7, K73.x, K74.x, K76.0, K76.2-K76.4, K76.8, K76.9, Z94.4	1
Diabetes without chronic complication	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9, O24	1
Diabetes with chronic complication	E10.2-E10.5, E10.7, E11.2-E11.5, E11.7, E12.2-E12.5, E12.7, E13.2-E13.5, E13.7, E14.2-E14.5, E14.7	2
Hemiplegia or paraplegia	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0-G83.4, G83.9	2
Renal disease	I12.0, I13.1, N03.2-N03.7, N05.2-N05.7, N18.x, N19.x, N25.0, Z49.0-Z49.2, Z94.0, Z99.2	2
Any malignancy, including lymphoma and leukemia, except malignant neoplasm of skin	C00.x-C26.x, C30.x-C34.x, C37.x-C41.x, C43.x, C45.x-C58.x, C60.x-C76.x, C81.x-C85.x, C88.x, C90.x-C97.x	2
Moderate or severe liver disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7	3
Metastatic solid tumor	C77.x-C80.x	6
AIDS/HIV	B20.x-B22.x, B24.x	6

¹ Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992; 45: 613-9.

Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining Comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005 Nov; 43(11): 1130-9.

Supplemental Table 1d. Codes of immunosuppressed status**Supplemental Table 1d (i). Reason for immunosuppressed status (Comorbidities)**

Comorbidities	Codes / List of Names
AIDS/HIV infection	ICD10: B20 ICD9: 042
Malignancy except malignant neoplasm of skin	ICD10: C76-C80, C00-C26, C30-C34, C37-C41, C43, C45-C58, C60-C76, C81-C85, C88, C90-C97 ICD9: 140-172, 174-195.8, 200-208, 238.6
Severe renal dysfunction	ICD10: N18.6 ICD9: 585.6
Immunodeficiency	ICD10: D84.9 ICD9: 279.3
Disorders involving immune mechanism	ICD10: D80-D89 ICD9: 279.0-279.9
Autoimmune disease (systemic)	ICD10: M35.9 ICD9: 710.9
Multiple sclerosis	ICD10: G35 ICD9: 340
Rheumatoid Arthritis	ICD10: M05.9 ICD9: 714.0
Psoriasis	ICD10: L40.9 ICD9: 696.1

Supplemental Table 1d (ii). Reason for immunosuppressed status (Active Procedures and History of Transplantation)

Conditions	Codes / List of Names
Solid organ/tissue transplant (incl. kidney, liver, pancreas, heart, and lung)	Kidney CPT codes: 50300, 50320, 50323, 50325, 50327, 50328, 50329, 50340, 50360, 50365, 50370, 50380, 50547 ICD-10 Procedure codes: 0TY00Z0, 0TY00Z1, 0TY10Z0, 0TY10Z1 Liver CPT codes: 47133, 47135, 47136, 47140, 47141, 47142, 47143, 47144, 47145, 47146, 47147, 47399 ICD-10 Procedure codes: 0FT00ZZ, 0FT04ZZ, 0FY00Z0, 0FY00Z1 Pancreas CPT codes: 48160, 48550, 48551, 48552, 48554, 48556 ICD-10 Procedure codes: 0FYG0Z0, 0FYG0Z1 Heart CPT codes: 33930, 33933, 33935, 33940, 33944, 33945 ICD-10 Procedure codes: 02YA0Z0, 02YA0Z1, 02YA0Z2 Lung/Lobar Lung CPT codes: 32850-32856, 33930, 33933, 33935, 0494T, 0495T, 0496T ICD-10 Procedure codes: 0BYC0Z0-0BYC0Z1, 0BYD0Z0-0BYD0Z1, 0BYF0Z0-0BYF0Z1, 0BYG0Z0-0BYG0Z1, 0BYH0Z0-0BYH0Z1, 0BYJ0Z0-0BYJ0Z1, 0BYK0Z0-0BYK0Z1, 0BYL0Z0-0BYL0Z1, 0BYM0Z0-0BYM0Z1
Blood, bone marrow, or hematopoietic stem-cell transplant (HSCT)	CPT codes: 38204, 38205, 38206, 38207-38215, 38230, 38232, 38240, 38241, 38243 ICD-10 Procedure codes: 30230G0-30243G0, 30230Y0-30243Y0, 30230G2-30243G4, 30230U2-30243U4, 30230X2-30243X4, 30230Y2-30243Y4
Dialysis	CPT codes: 90956, 90959, 90962, 90963-90970, 90989, 90993, 99512 ICD-10 Procedure codes: 5A1D00Z, 5A1D60Z, 3E1M39Z ICD-10-CM Diagnosis code: Z99.2
Solid organ transplant status (incl. kidney, liver, pancreas, heart, and lung)	ICD-10-CM: Z94.0-Z94.4, Z94.6, Z94.83
Bone marrow or HSCT status	ICD-10-CM: Z94.81, Z94.84

Supplemental Table 1d (iii). Treatment not for COVID-19 with potential immunosuppressive effects (i.e. historical treatment for medical conditions or current treatment for comorbidities)

Treatment	Codes / List of Names
Calcineurin Inhibitors	Cyclosporine Tacrolimus Voclosporine
Interleukin Inhibitors	Anakinra Basiliximab Benralizumab Brodalumab Canakinumab Daclizumab Dupilumab Guselkumab Ixekizumab Mepolizumab Reslizumab Rilonacept Risankizumab Sarilumab Satralizumab Secukinumab Siltuximab Tildrakizumab Tocilizumab Ustekinumab
TNF alpha Inhibitors	Adalimumab Certolizumab Etanercept Golimumab Infliximab
mTOR Inibitors	Sirolimus Everolimus
Antimetabolites	MPA MMF
Selective Immunosuppressants Biologics	Abatacept Alefcept ATG Belatacept BelimumabEfalizumab Inebilizumab Natalizumab Ocrelizumab Ofatumumab Omalizumab Rituximab (incl. all other CD20 drugs) Vedolizumab
Corticosteroids	Dexamethasone Methylprednisolone Prednisone Prednisolone

Miscellaneous	Azathioprine Baricitnib Cyclophosphamide Dimethyl fumarate Diroximel fumarate Fingolimod Ibritumomab lenalidomide Leflunomide Methotrexate Ozanimod Pomalidomide Siponimod Thalidomide
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Supplemental Table 2. Cumulative incidence rate of SARS-CoV-2 symptomatic and severe infection, by Anti-SARS-CoV-2 S levels

Anti-SARS-CoV-2 S level	No. Patient	No. Covid event	% Covid event	Cumulative Incidence Rate* (95% CI)
Symptomatic SARS-CoV-2 Infection				
< 0.8	22,790 (8.5%)	9,193 (25.2%)	40.30%	24.64 (24.14,25.15)
≥ 0.8				
to < 100	26,074 (9.7%)	4,224 (11.6%)	16.20%	7.54 (7.31,7.76)
≥ 100 to				
< 250	25,601 (9.5%)	3472 (9.5%)	13.60%	6.64 (6.42,6.86)
≥ 250				
to < 1,000	47,508 (17.7%)	6,541 (17.9%)	13.80%	6.56 (6.4,6.72)
≥ 1,000				
to < 2,500	39,641 (14.7%)	4,853 (13.3%)	12.20%	6.0 (5.83,6.16)
≥ 2,500	107,230 (39.9%)	8,215 (22.5%)	7.70%	4.19 (4.1,4.28)
Overall	268,844 (100%)	36,498 (100%)	13.60%	6.99 (6.92,7.06)
Severe SARS-CoV-2 Infection				
< 0.8	22,790 (8.5%)	939 (40.3%)	4.10%	1.76 (1.65,1.87)
≥ 0.8				
to < 100	26,074 (9.7%)	358 (15.4%)	1.40%	0.57 (0.51,0.63)
≥ 100 to				
< 250	25,601 (9.5%)	213 (9.1%)	0.80%	0.37 (0.32,0.42)
≥ 250				
to < 1,000	47,508 (17.7%)	288 (12.4%)	0.60%	0.26 (0.23,0.29)
≥ 1,000				
to < 2,500	39,641 (14.7%)	189 (8.1%)	0.50%	0.22 (0.18,0.25)
≥ 2,500	107,230 (39.9%)	344 (14.8%)	0.30%	0.17 (0.15,0.19)
Overall	268,844 (100%)	2,331 (100%)	0.90%	0.4 (0.39,0.42)

*Incidence rate presented as number of infections/10,000 person-days at risk

Supplemental Table 3: Baseline antibody levels and COVID outcomes by age group and immunocompromised conditions

Cohort	Age <65 (N=182,543)	Age 65 and over (N=86,301)	Immunocompromised (N=75,793)	Not Immunocompromised (N=193,051)
Anti-SARS-CoV-2 S Level				
Mean (SD)	2,480 (4830)	3330 (5880)	2,800 (5330)	2,730 (5160)
Median [Q1, Q3]	1,150 [169, ≥2,500]	1840 [330, ≥2,500]	1,300 [186, ≥2,500]	1,330 [214, ≥2,500]
Anti-SARS-CoV-2 S Categorical Level				
< 0.8	18,535 (10.2%)	4,255 (4.9%)	6,553 (8.6%)	16,237 (8.4%)
≥ 0.8 to < 100	19,032 (10.4%)	7,042 (8.2%)	8,178 (10.8%)	17,896 (9.3%)
≥ 100 to < 250	16,571 (9.1%)	9,030 (10.5%)	7,211 (9.5%)	18,390 (9.5%)
≥ 250 to < 1,000	32,707 (17.9%)	14,801 (17.2%)	12,859 (17.0%)	34,649 (17.9%)
≥ 1,000 to < 2,500	27,885 (15.3%)	11,756 (13.6%)	10,560 (13.9%)	29,081 (15.1%)
≥ 2,500	67,813 (37.1%)	39,417 (45.7%)	30,432 (40.2%)	76,798 (39.8%)
Primary outcome: COVID infection				
No	154,635 (84.7%)	77,711 (90.0%)	65,152 (86.0%)	167,194 (86.6%)
Yes	27,908 (15.3%)	8,590 (10.0%)	10,641 (14.0%)	25,857 (13.4%)
Secondary outcome: Severe COVID Infection				
No	181,316 (99.3%)	85,197 (98.7%)	74,826 (98.7%)	191,687 (99.3%)
Yes	1,227 (0.7%)	1,104 (1.3%)	967 (1.3%)	1,364 (0.7%)

Supplemental Table 4. Unweighted and weighted Hazard Ratios for SARS-CoV-2 symptomatic and severe infection by subgroup

Outcome	Unweighted			Weighted		
Anti-SARS-CoV-2 S Level	HR	95% CI	p-value	HR	95% CI	p-value
Immunocompromised Symptomatic Infection						
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.39	0.36, 0.42	<0.001	0.52	0.48, 0.56	<0.001
≥ 100 to < 2,500	0.32	0.31, 0.34	<0.001	0.42	0.40, 0.45	<0.001
≥ 2,500	0.22	0.21, 0.23	<0.001	0.29	0.27, 0.31	<0.001
Immunocompromised Severe Infection						
	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.4	0.33, 0.48	<0.001	0.42	0.33, 0.51	<0.001
≥ 100 to < 2,500	0.19	0.16, 0.22	<0.001	0.22	0.18, 0.26	<0.001
≥ 2,500	0.11	0.09, 0.13	<0.001	0.11	0.09, 0.14	<0.001
Non-immunocompromised symptomatic infection						
	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.27	0.26, 0.28	<0.001	0.44	0.42, 0.47	<0.001
≥ 100 to < 2,500	0.23	0.23, 0.24	<0.001	0.36	0.34, 0.38	<0.001
≥ 2,500	0.15	0.14, 0.16	<0.001	0.24	0.23, 0.26	<0.001
Non-immunocompromised severe infection						
	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.27	0.23, 0.32	<0.001	0.3	0.25, 0.37	<0.001
≥ 100 to < 2,500	0.13	0.12, 0.15	<0.001	0.14	0.12, 0.17	<0.001
≥ 2,500	0.08	0.07, 0.09	<0.001	0.08	0.07, 0.10	<0.001
Age 65 and over symptomatic infection						
	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.37	0.34, 0.40	<0.001	0.42	0.38, 0.47	<0.001
≥ 100 to < 2,500	0.26	0.25, 0.28	<0.001	0.31	0.29, 0.33	<0.001

≥ 2,500	0.2	0.18, 0.21	<0.001	0.21	0.19, 0.23	<0.001
Age 65 and over severe infection	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
≥ 0.8 to < 100	0.35	0.30, 0.42	<0.001	0.34	0.28, 0.42	<0.001
≥ 100 to < 2,500	0.12	0.11, 0.14	<0.001	0.15	0.12, 0.17	<0.001
≥ 2,500	0.07	0.06, 0.08	<0.001	0.08	0.07, 0.10	<0.001
Age under 65 years symptomatic infection	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
0.8 - 99	0.29	0.28, 0.31	<0.001	0.48	0.45, 0.51	<0.001
100 - 2499	0.27	0.26, 0.27	<0.001	0.4	0.39, 0.42	<0.001
≥ 2,500	0.17	0.16, 0.17	<0.001	0.28	0.26, 0.29	<0.001
Age under 65 years severe infection	HR	95% CI	p-value	HR	95% CI	p-value
< 0.8	—	—	n/a	—	—	n/a
0.8 - 99	0.24	0.20, 0.29	<0.001	0.34	0.28, 0.43	<0.001
100 - 2499	0.14	0.12, 0.16	<0.001	0.2	0.17, 0.24	<0.001
≥ 2,500	0.08	0.07, 0.10	<0.001	0.12	0.09, 0.14	<0.001

CI, Confidence Interval; HR, Hazard Ratio
Analyses conducted on the main study cohort, n=268,844

Supplemental Table 5: Demographic characteristics among continuously enrolled population

	Non-Reactive ^a (< 0.8 U/mL) (N=7,665)	Reactive ^b (0.8+ U/mL) (N=58,303)	Overall (N=65,968)	P-value
Age at Index Date				
Mean (SD)	44.5 (15.4)	49.6 (15.6)	49.0 (15.6)	<0.001
Median [Q1, Q3]	45.0 [35.0, 56.0]	52.0 [39.0, 61.0]	51.0 [38.0, 60.0]	
Age at Index Date - Category				
21 and under	660 (8.6%)	3,212 (5.5%)	3,872 (5.9%)	<0.001
22-45	3,174 (41.4%)	18,200 (31.2%)	21,374 (32.4%)	
46-55	1,780 (23.2%)	13,390 (23.0%)	15,170 (23.0%)	
56-64	1,541 (20.1%)	15,104 (25.9%)	16,645 (25.2%)	
65+	510 (6.7%)	8,397 (14.4%)	8,907 (13.5%)	
Gender				
Female	4,741 (61.9%)	36,008 (61.8%)	40,749 (61.8%)	0.988
Male	2,924 (38.1%)	22,295 (38.2%)	25,219 (38.2%)	
Race				
Asian	107 (1.4%)	2,302 (3.9%)	2,409 (3.7%)	<0.001
Black or African American	310 (4.0%)	2,228 (3.8%)	2,538 (3.8%)	
Other/Not Specified	3,277 (42.8%)	24,764 (42.5%)	28,041 (42.5%)	
White	3,971 (51.8%)	29,009 (49.8%)	32,980 (50.0%)	
Ethnicity				
Hispanic	721 (9.4%)	6,662 (11.4%)	7,383 (11.2%)	<0.001
Not Hispanic	3,216 (42.0%)	24,260 (41.6%)	27,476 (41.7%)	
Not Specified	3,728 (48.6%)	27,381 (47.0%)	31,109 (47.2%)	
Region				
Midwest	1,091 (14.2%)	5,160 (8.9%)	6,251 (9.5%)	<0.001
Northeast	2,937 (38.3%)	28,823 (49.4%)	31,760 (48.1%)	
South	2,349 (30.6%)	17,633 (30.2%)	19,982 (30.3%)	
West	1,288 (16.8%)	6,687 (11.5%)	7,975 (12.1%)	
Insurance Plan				
Commercial	5,765 (75.2%)	43,477 (74.6%)	49,242 (74.6%)	<0.001

Dual (Medicaid/Medicare)	56 (0.7%)	954 (1.6%)	1,010 (1.5%)	
Medicaid	1,617 (21.1%)	10,725 (18.4%)	12,342 (18.7%)	
Medicare	197 (2.6%)	2,883 (4.9%)	3,080 (4.7%)	
Other/Not Specified	30 (0.4%)	264 (0.5%)	294 (0.4%)	
Immunocompromised				
No	5,450 (71.1%)	38,874 (66.7%)	44,324 (67.2%)	<0.001
Yes	2,215 (28.9%)	19,429 (33.3%)	21,644 (32.8%)	
Charlson Comorbidity Index				
CCI 0 (none)	5,268 (68.7%)	34,612 (59.4%)	39,880 (60.5%)	<0.001
CCI 1-2 (mild)	1,748 (22.8%)	16,544 (28.4%)	18,292 (27.7%)	
CCI 3-4 (moderate)	400 (5.2%)	4,217 (7.2%)	4,617 (7.0%)	
CCI 5+ (severe)	249 (3.2%)	2,930 (5.0%)	3,179 (4.8%)	
Claims Records on Prior Infection and Vaccination				<0.001
Confirmed Records in Insurance Claims				
	1,118 (14.6%)	34,237 (58.7%)	35,355 (53.6%)	
Infected & Vaccinated	18 (0.2%)	2,973 (5.1%)	2,991 (4.5%)	
Natural-infection (No Vaccination)	826 (10.8%)	17,879 (30.7%)	18,705 (28.4%)	
Vaccinated (No Infection)	274 (3.6%)	13,385 (23.0%)	13,659 (20.7%)	
No Confirmed Record in Insurance Claims				
No infection or vacc record	6,547 (85.4%)	24,066 (41.3%)	30,613 (46.4%)	
Days from the most recent infection/vaccination to index date				
Mean (SD)	202 (149)	185 (130)	186 (130)	<0.001
Median [Q1, Q3]	170 [69.3, 304]	162 [83.0, 258]	162 [83.0, 259]	
Index_season				
2021 Apr-Jun	2,101 (27.4%)	5,821 (10.0%)	7,922 (12.0%)	<0.001
2021 Jul-Sep	3,595 (46.9%)	18,236 (31.3%)	21,831 (33.1%)	
2021 Oct-Dec	1,632 (21.3%)	21,350 (36.6%)	22,982 (34.8%)	
2022 Apr-Jun	269 (3.5%)	7,939 (13.6%)	8,208 (12.4%)	
2022 Jan-Mar	68 (0.9%)	4,957 (8.5%)	5,025 (7.6%)	

Primary outcome: Covid infection (within 365 days)				
No	4,148 (54.1%)	49,727 (85.3%)	53,875 (81.7%)	<0.001
Yes	3,517 (45.9%)	8,576 (14.7%)	12,093 (18.3%)	
Secondary outcome: Severe Covid Infection (within 365 days)				
No	7,384 (96.3%)	57,925 (99.4%)	65,309 (99.0%)	<0.001
Yes	281 (3.7%)	378 (0.6%)	659 (1.0%)	
^a Non-Reactive in the Anti-SARS-CoV-2 Assay; ^b Reactive in the Anti-SARS-CoV-2 Assay				

CCI, Charlson Comorbidity Index; SD, standard deviation; Q, quartile

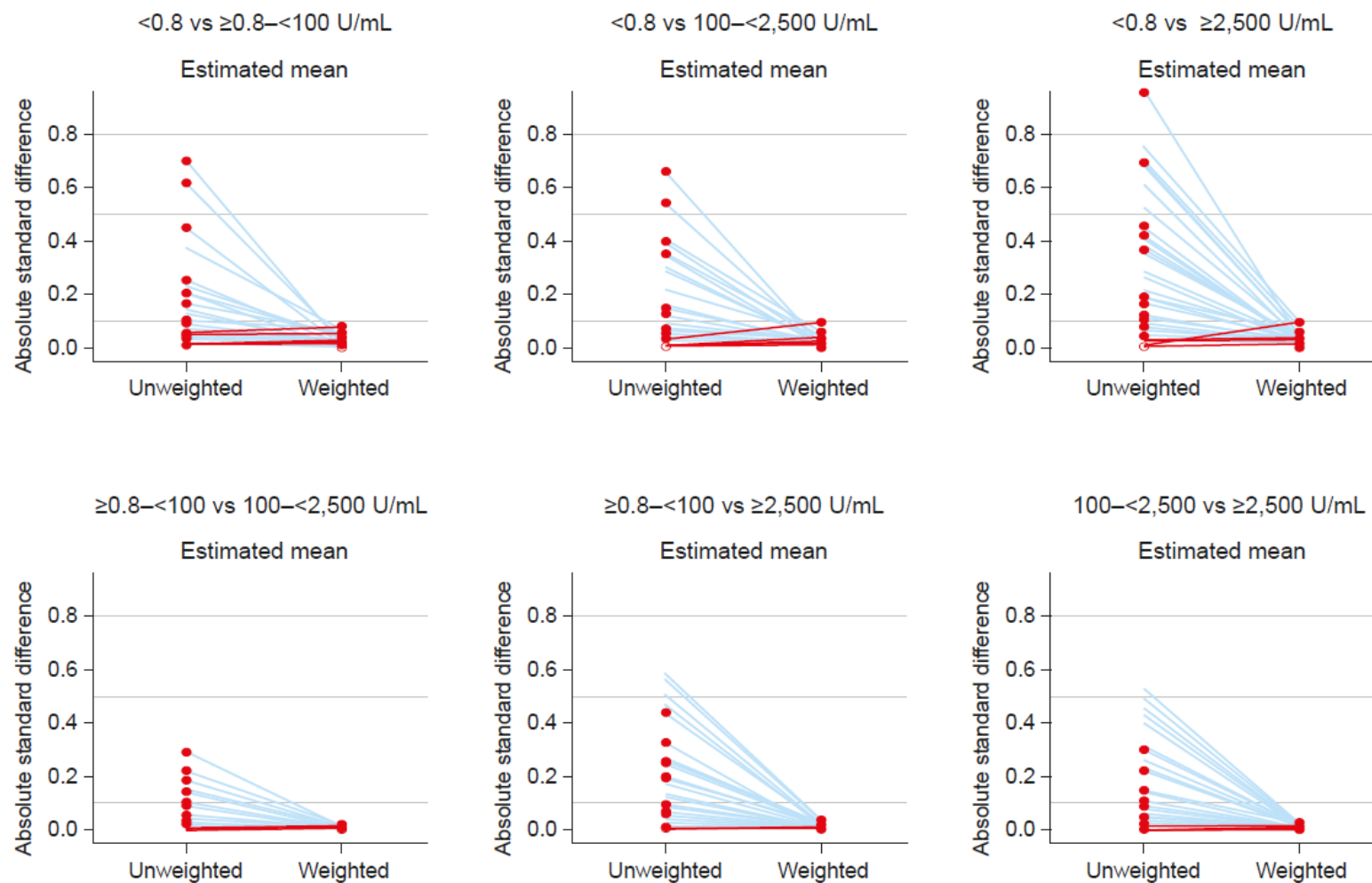
Supplemental Table 6: Unweighted and weighted Hazard Ratios for SARS-CoV-2 symptomatic and severe infection, among continuously enrolled population

	Unweighted			Weighted		
Characteristic	HR	95% CI	p-value	HR	95% CI	p-value
Symptomatic Infection						
Anti-SARS-CoV-2 S Level						
< 0.8	—	—		—	—	
≥ 0.8 to < 100	0.31	0.29, 0.33	<0.001	0.45	0.42, 0.49	<0.001
≥ 100 to < 2,500	0.27	0.26, 0.28	<0.001	0.36	0.33, 0.38	<0.001
≥ 2,500	0.18	0.17, 0.19	<0.001	0.24	0.22, 0.26	<0.001
Severe Infection						
Anti-SARS-CoV-2 S Level						
< 0.8	—	—		—	—	
≥ 0.8 to < 100	0.32	0.25, 0.40	<0.001	0.35	0.27, 0.47	<0.001
≥ 100 to < 2,500	0.19	0.16, 0.23	<0.001	0.2	0.15, 0.25	<0.001
≥ 2,500	0.11	0.09, 0.14	<0.001	0.1	0.07, 0.14	<0.001

CI, confidence interval; HR, hazard ratio; SARS-CoV-2 S, severe-acute-respiratory-syndrome-related coronavirus 2 spike protein

3.0 Supplementary Figures

Supplemental Figure 1. Pairwise absolute standard difference with and without inverse probability weighting



Data are shown for the main cohort of patients ($n = 268,844$).

Supplemental Figure 2. Anti-SARS-CoV-2 S distribution over time

