Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.

eTable 1. *International Statistical Classification of Diseases, tenth revision* (ICD-10) codes of the included diseases

Disease	ICD-10 code
Autoimmune and autoinflammatory outcomes	
Alopecia areata	L63
Alopecia totalis	L630, L631
Psoriasis	L40
Vitiligo	L80
Anti-neutrophil cytoplasmic antibody-associated vasculitis	M301, M313, M317, M318
Behcet disease	M352
Crohn disease	K50
Ulcerative colitis	K51
Rheumatoid arthritis	M05, M06, M08
Adult-onset Still disease	M061
Polymyositis	M332
Systemic lupus erythematosus	M32
Systemic sclerosis	M34
Sjogren syndrome	M350
Ankylosing spondylitis	M45
Sarcoidosis	D86
Positive control outcomes	
Myocardial infarction	I21
Congestive heart failure	I50
Stroke	I60, I61, I62, I63
Negative control outcomes	
Epidermal cyst	L720
Tympanic membrane perforation	H72
Trauma of multiple site	T00
Chronic diseases that served as the covariates	
Hypertension	I10
Diabetes mellitus	E08, E09, E10, E11, E13
Dyslipidemia	E78
Chronic obstructive pulmonary disease	J44
Chronic kidney disease	N18
Mild liver disease	K73, K18
Atopic dermatitis	L20
Allergic rhinitis	J30
Asthma	J45
Hepatitis B virus infection	B180, B181, B191
Hepatitis C virus infection	B182, B192
Human immunodeficiency virus infection	B20

eMethods. The predefined covariates for inverse probability weighting

Age at the study index date, sex, income level, insurance type, area of residence, height, weight, body mass index, waist circumference, smoking status, average number of healthcare encounters per year, systolic blood pressure, diastolic blood pressure, serum levels of hemoglobin, fasting blood glucose, liver enzyme levels (aspartate aminotransferase, alanine transaminase, gamma-glutamyl transferase), and creatinine, COVID-19 vaccination status (more than one time vs. none) at index date, and personal histories of hypertension, diabetes mellitus, dyslipidemia, chronic obstructive pulmonary disease, chronic kidney disease, mild liver disease, atopic dermatitis, allergic rhinitis, asthma, hepatitis B and C infection, and human immunodeficiency virus infection.

eFigure 1. Cumulative incidence plot for all-cause mortality among patients with COVID-19 and controls
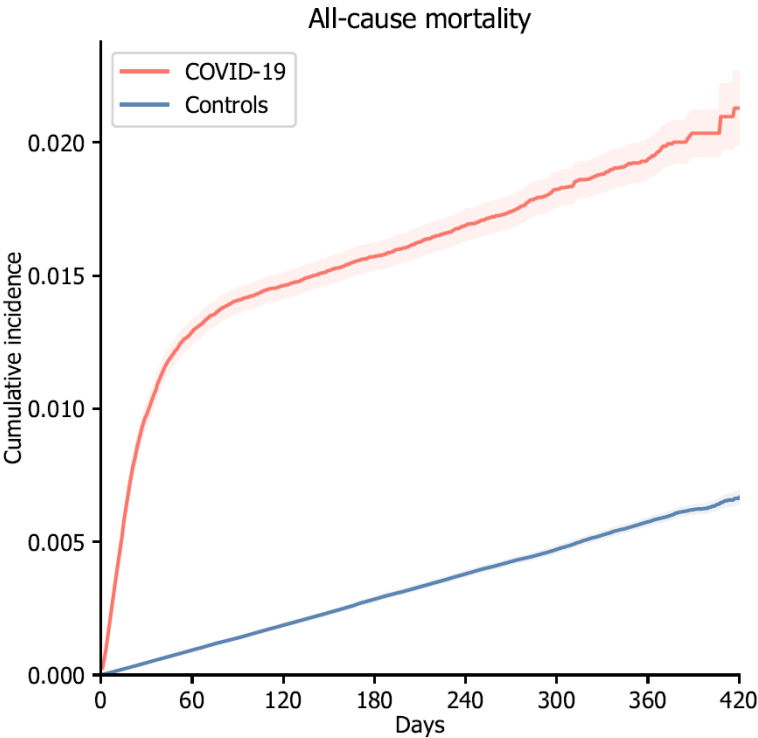
eFigure 2. Covariate balance after application of inverse probability weighting
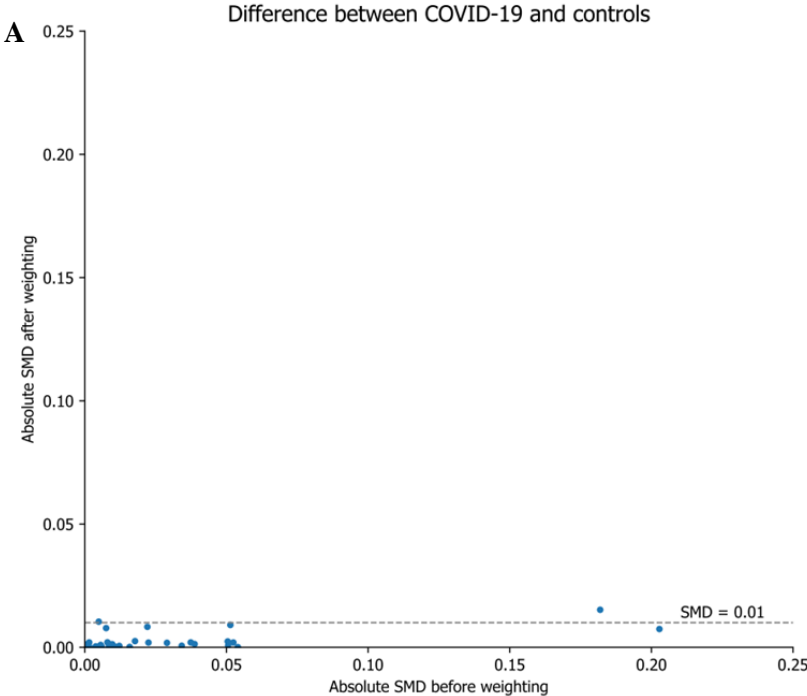
SMDs between individuals with COVID-19 and controls. Abbreviations: COVID-19, Coronavirus 2019; SMD, standardized mean difference.

eFigure 3. Cumulative incidences of autoinflammatory and autoimmune connective tissue disorders outcomes
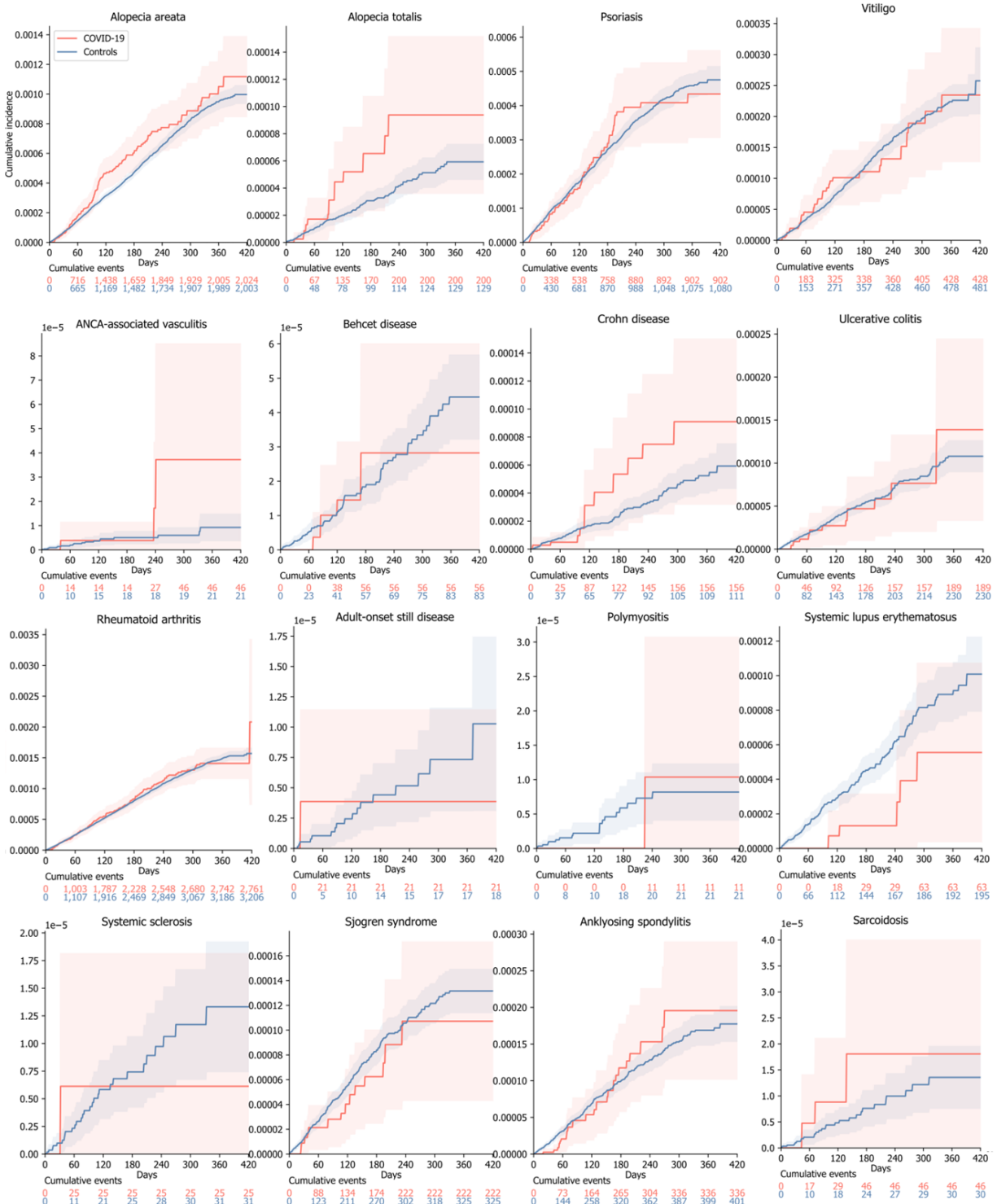

ANCA, anti-neutrophil cytoplasmic antibody

eTable 2. Sensitivity analysis: Demographic and clinical characteristics of individuals who underwent and who did not undergo general health examination

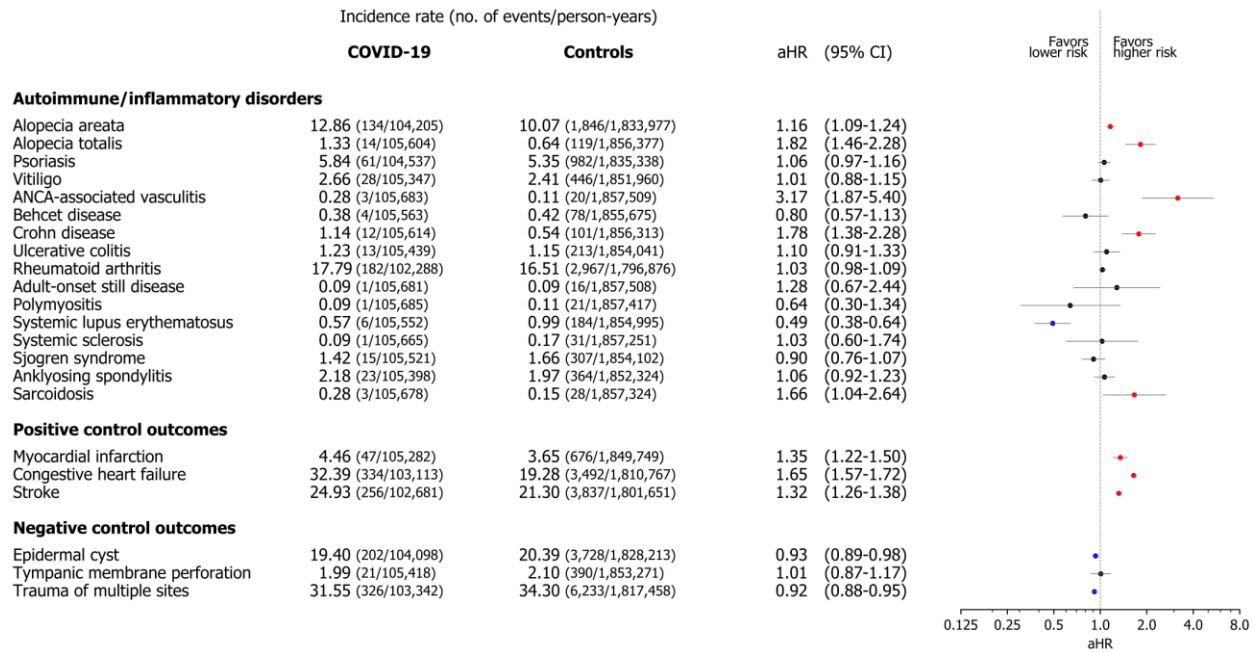|	Individuals who had GE (N=6,482,630)	Individuals who did not undergo GE (N=3,935,099)
Age, mean ± SD, y	52.04±15.61	24.76±19.02
≥40	4,875,146(75.2)	735,269(18.68)
18–39	1,607,460(24.8)	1,477,043(37.54)
<18	24(0.00)	1,722,787(43.78)
Female sex, n (%)	3,250,599(50.14)	1,794,011(45.59)
Insurance type, n (%)		
Standard	6,260,919(96.58)	3,744,567(95.16)
Medicaid	221,711(3.42)	190,532(4.84)
Income level, n (%)		
Highest	1,936,598(29.87)	1,333,489(33.89)
Higher	1,863,693(28.75)	1,109,109(28.19)
Lower	1,633,174(25.19)	832,628(21.16)
Lowest	1,013,520(15.63)	622,140(15.81)
No. of healthcare encounters per year, mean ± SD	15.06±16.73	11.08±11.76
COVID-19 positivity	354,527(5.47)	225,430(5.73)
COVID-19 vaccination status, n (%)		
Vaccinated at least 1 time	4,253,039(65.61)	1,304,263(33.14)
Non-vaccinated	2,229,591(34.39)	2,630,836(66.86)
Underlying disease, n (%)		
Hypertension	1,862,600(28.73)	252,363(6.41)
Diabetes mellitus	1,025,359(15.82)	137,762(3.50)
Dyslipidemia	2,504,551(38.63)	312,785(7.95)
Chronic obstructive pulmonary disease	99,476(1.53)	16,546(0.42)
Chronic kidney disease	72,701(1.12)	16,687(0.42)
Liver disease	179,135(2.76)	22,366(0.57)
Atopic dermatitis	72,465(1.12)	152,449(3.87)
Allergic rhinitis	315,292(4.86)	289,582(7.36)
Asthma	144,695(2.23)	134,343(3.41)
Hepatitis B	130,414(2.01)	14,075(0.36)
Hepatitis C	20,083(0.31)	2,957(0.08)
HIV infection	292(0.00)	148(0.00)

Abbreviations: GE, general health examination; HIV, human immunodeficiency virus

eTable 3. Sensitivity analysis: Demographic and clinical characteristics of individuals who survived at least 60 days post COVID-19 diagnosis and controls before and after weighting

	Pre-weighting			Post-weighting		
	COVID-19 (N= 192,854)	Control (N= 3,372,056)	Absolute standardized difference	COVID-19 (%)	Control (%)	Absolute standardized difference
Age, mean ± SD, y	49.89 ± 15.00	52.06 ± 15.62	0.1423	51.63 ± 65.58	51.85 ± 15.98	0.0143
Female sex, n (%)	95,023 (49.27)	1,692,429 (50.19)	0.0188	(49.87)	(50.16)	0.0059
Insurance type, n (%)			0.0039			0.0000
Standard	186,574 (96.74)	3,256,561 (96.57)		(97.26)	(97.08)	
Medicaid	6,280 (3.26)	115,495 (3.43)		(2.74)	(2.92)	
Income level, n (%)			0.0471			0.0080
Highest	53,512 (27.75)	1,009,728 (29.94)		(28.52)	(30.24)	
Higher	55,418 (28.74)	969,975 (28.77)		(29.58)	(29.06)	
Lower	52,930 (27.45)	848,159 (25.15)		(27.32)	(25.42)	
Lowest	30,300 (15.71)	525,457 (15.58)		(14.58)	(15.27)	
Area of residence, n (%)			0.1587			0.0116
Urban	101,303 (52.53)	1,503,271 (44.58)		(43.24)	(45.3)	
Rural	91,551 (47.47)	1,868,785 (55.42)		(56.76)	(54.70)	
COVID-19 vaccination status, n (%)			0.0547			0.0039
Vaccinated at least 1 time	57,598 (29.87)	1,385,341 (41.08)		(37.30)	(40.48)	
Non-vaccinated	135,256 (70.13)	1,986,715 (58.92)		(62.70)	(59.52)	
General health examination data, mean ± SD						
Height, cm	165.00 ± 9.32	164.20 ± 9.36	0.0865	164.40 ± 39.99	164.30 ± 9.60	0.0081
Weight, cm	66.93 ± 13.69	65.61 ± 13.30	0.0981	65.81 ± 56.32	65.68 ± 13.71	0.0092
Body mass index, kg/m²	24.44 ± 3.76	24.20 ± 4.09	0.0612	24.23 ± 15.47	24.21 ± 4.26	0.0061
Waist circumference, cm	81.81 ± 11.13	81.37 ± 11.66	0.0396	81.44 ± 45.14	81.37 ± 11.84	0.0062
Smoking, n (%)			0.0130			0.0038
Current smoker	37,544 (19.47)	638,947 (18.95)		(19.24)	(18.98)	
Ex-smoker	30,759 (15.95)	596,142 (17.68)		(18.95)	(17.49)	
Never smoker	124,551 (64.58)	2,136,967 (63.37)		(61.81)	(63.53)	
Systolic blood pressure, mmHg	122.40 ± 14.95	123.00 ± 15.04	0.0362	122.90 ± 64.80	122.90 ± 15.47	0.0003
Diastolic blood pressure, mmHg	75.88 ± 10.38	75.90 ± 10.20	0.0018	75.90 ± 44.30	75.90 ± 10.49	0.0002
Hemoglobin, g/dL	14.24 ± 1.59	14.20 ± 1.59	0.0248	14.20 ± 6.77	14.20 ± 1.64	0.0035
Fasting serum glucose, mmol/L	100.90 ± 25.46	101.30 ± 25.22	0.0148	101.20 ± 109.90	101.30 ± 25.93	0.0028
Aspartate aminotransferase, U/L	26.59 ± 25.99	26.49 ± 24.07	0.0041	26.64 ± 102.00	26.50 ± 25.98	0.0055
Alanine transaminase, U/L	26.66 ± 28.42	26.16 ± 27.90	0.0177	26.50 ± 157.50	26.18 ± 28.71	0.0114
Gamma-glutamyl transferase, U/L	37.29 ± 50.67	36.51 ± 50.94	0.0159	36.68 ± 209.5	36.55 ± 52.58	0.0026
Creatinine, mg/dL	0.86 ± 0.62	0.86 ± 0.53	0.0045	0.86 ± 2.24	0.86 ± 0.55	0.0004
Underlying disease, n (%)						
Hypertension	50,341 (26.1)	959,304 (28.45)	0.0520	(24.77)	(28.38)	0.0043
Diabetes mellitus	28,911 (14.99)	527,236 (15.64)	0.0176	(13.64)	(15.61)	0.0037
Dyslipidemia	70,442 (36.53)	1,291,408 (38.3)	0.0363	(34.66)	(38.33)	0.0052
Chronic obstructive pulmonary disease	2,325 (1.21)	51,209 (1.52)	0.0271	(1.13)	(1.48)	0.0002
Chronic kidney disease	1,888 (0.98)	36,593 (1.09)	0.0110	(0.82)	(1.08)	0.0026
Liver disease	5,061 (2.62)	91,496 (2.71)	0.0050	(2.49)	(2.71)	0.0032
Atopic dermatitis	2,136 (1.11)	37,101 (1.1)	0.0004	(1.07)	(1.10)	0.0010
Allergic rhinitis	9,531 (4.94)	163,240 (4.84)	0.0054	(4.76)	(4.86)	0.0007
Asthma	4,123 (2.14)	74,762 (2.22)	0.0051	(2.00)	(2.21)	0.0013
Hepatitis B	3,717 (1.93)	67,555 (2)	0.0052	(1.90)	(2.01)	0.0009
Hepatitis C	651 (0.34)	10,349 (0.31)	0.0058	(0.28)	(0.31)	0.0017
HIV infection	13 (0.01)	155 (0.0)	0.0024	(0.01)	(0.00)	0.0006

Abbreviations, COVID-19, Coronavirus 2019; HIV, human immunodeficiency virus

eFigure 4. Sensitivity analyses: risks of incident autoimmune and autoinflammatory disease outcomes in individuals survived by 60 days post COVID-19 diagnosis and the control cohort

	Incidence rate (no. of events/person-years)		aHR	(95% CI)	
	COVID-19	**Controls**			
Autoimmune/inflammatory disorders					
Alopecia areata	12.86 (134/104,205)	10.07 (1,846/1,833,977)	1.16	(1.09-1.24)	
Alopecia totalis	1.33 (14/105,604)	0.64 (119/1,856,377)	1.82	(1.46-2.28)	
Psoriasis	5.84 (61/104,537)	5.35 (982/1,835,338)	1.06	(0.97-1.16)	
Vitiligo	2.66 (28/105,347)	2.41 (446/1,851,960)	1.01	(0.88-1.15)	
ANCA-associated vasculitis	0.28 (3/105,683)	0.11 (20/1,857,509)	3.17	(1.87-5.40)	
Behcet disease	0.38 (4/105,563)	0.42 (78/1,855,675)	0.80	(0.57-1.13)	
Crohn disease	1.14 (12/105,614)	0.54 (101/1,856,313)	1.78	(1.38-2.28)	
Ulcerative colitis	1.23 (13/105,439)	1.15 (213/1,854,041)	1.10	(0.91-1.33)	
Rheumatoid arthritis	17.79 (182/102,288)	16.51 (2,967/1,796,876)	1.03	(0.98-1.09)	
Adult-onset still disease	0.09 (1/105,681)	0.09 (16/1,857,508)	1.28	(0.67-2.44)	
Polymyositis	0.09 (1/105,685)	0.11 (21/1,857,417)	0.64	(0.30-1.34)	
Systemic lupus erythematosus	0.57 (6/105,552)	0.99 (184/1,854,995)	0.49	(0.38-0.64)	
Systemic sclerosis	0.09 (1/105,665)	0.17 (31/1,857,251)	1.03	(0.60-1.74)	
Sjogren syndrome	1.42 (15/105,521)	1.66 (307/1,854,102)	0.90	(0.76-1.07)	
Anklyosing spondylitis	2.18 (23/105,398)	1.97 (364/1,852,324)	1.06	(0.92-1.23)	
Sarcoidosis	0.28 (3/105,678)	0.15 (28/1,857,324)	1.66	(1.04-2.64)	
Positive control outcomes					
Myocardial infarction	4.46 (47/105,282)	3.65 (676/1,849,749)	1.35	(1.22-1.50)	
Congestive heart failure	32.39 (334/103,113)	19.28 (3,492/1,810,767)	1.65	(1.57-1.72)	
Stroke	24.93 (256/102,681)	21.30 (3,837/1,801,651)	1.32	(1.26-1.38)	
Negative control outcomes					
Epidermal cyst	19.40 (202/104,098)	20.39 (3,728/1,828,213)	0.93	(0.89-0.98)	
Tympanic membrane perforation	1.99 (21/105,418)	2.10 (390/1,853,271)	1.01	(0.87-1.17)	
Trauma of multiple sites	31.55 (326/103,342)	34.30 (6,233/1,817,458)	0.92	(0.88-0.95)	

The forest plot depicts aHRs and 95% CIs in individuals with COVID-19 compared with controls. The hazard estimates were adjusted for all 32 covariates used for the inverse probability of treatment weighting. For each analysis, individuals who had already been diagnosed with the target outcome at the index date or before were excluded.

Abbreviations: COVID-19, coronavirus disease 2019; aHR, adjusted hazard ratio; CI, confidence interval.

eFigure 5. Sensitivity analysis: risks of incident autoimmune and autoinflammatory disease outcomes in COVID-19 cohort and the control cohort, adjusted for area of residency (urban vs rural) status only

	Incidence rate (no. of events/person-years)				
	COVID-19	**Controls**	aHR	(95% CI)	
Autoimmune/inflammatory disorders					
Alopecia areata	11.79 (135/114,542)	9.48 (1,907/2,012,295)	1.18	(1.11-1.25)	
Alopecia totalis	1.21 (14/116,054)	0.60 (123/2,036,903)	1.82	(1.46-2.27)	
Psoriasis	5.40 (62/114,856)	5.09 (1,025/2,013,810)	0.98	(0.90-1.07)	
Vitiligo	2.59 (30/115,768)	2.30 (467/2,032,049)	1.02	(0.90-1.16)	
ANCA-associated vasculitis	0.26 (3/116,137)	0.10 (21/2,038,149)	2.59	(1.55-4.34)	
Behcet disease	0.34 (4/116,008)	0.38 (78/2,036,137)	0.82	(0.58-1.14)	
Crohn disease	1.03 (12/116,063)	0.52 (106/2,036,833)	1.68	(1.31-2.14)	
Ulcerative colitis	1.12 (13/115,873)	1.07 (218/2,034,322)	1.03	(0.85-1.25)	
Rheumatoid arthritis	16.92 (190/112,321)	15.56 (3,068/1,971,486)	1.00	(0.95-1.05)	
Adult-onset still disease	0.09 (1/116,137)	0.08 (17/2,038,152)	1.26	(0.67-2.36)	
Polymyositis	0.09 (1/116,141)	0.10 (21/2,038,049)	0.59	(0.28-1.24)	
Systemic lupus erythematosus	0.52 (6/115,992)	0.92 (188/2,035,386)	0.47	(0.36-0.61)	
Systemic sclerosis	0.09 (1/116,119)	0.15 (31/2,037,867)	0.89	(0.53-1.51)	
Sjogren syndrome	1.29 (15/115,956)	1.53 (312/2,034,400)	0.80	(0.67-0.94)	
Anklyosing spondylitis	1.99 (23/115,821)	1.86 (379/2,032,445)	0.99	(0.86-1.15)	
Sarcoidosis	0.26 (3/116,132)	0.14 (29/2,037,948)	1.69	(1.07-2.67)	
Positive control outcomes					
Myocardial infarction	4.15 (48/115,684)	3.38 (685/2,029,628)	1.20	(1.08-1.33)	
Congestive heart failure	31.10 (352/113,190)	18.02 (3,580/1,986,762)	1.47	(1.41-1.53)	
Stroke	24.24 (273/112,637)	20.15 (3,983/1,976,716)	1.15	(1.10-1.20)	
Negative control outcomes					
Epidermal cyst	18.45 (211/114,386)	19.99 (4,010/2,005,922)	0.90	(0.86-0.94)	
Tympanic membrane perforation	1.99 (23/115,847)	2.06 (418/2,033,487)	0.93	(0.81-1.07)	
Trauma of multiple sites	30.47 (346/113,544)	33.65 (6,709/1,993,987)	0.88	(0.85-0.91)	

The forest plot depicts aHRs and 95% CIs in individuals with COVID-19 compared with controls. Abbreviations: COVID-19, coronavirus disease 2019; aHR, adjusted hazard ratio; CI, confidence interval.