

# THE LANCET

## Rheumatology

### Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed.  
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Supplement to: Shin Y H, Shin J II, Moon S Y, et al. Autoimmune inflammatory rheumatic diseases and COVID-19 outcomes in South Korea: a nationwide cohort study. *Lancet Rheumatol* 2021; published online June 18. [https://doi.org/10.1016/S2665-9913\(21\)00151-X](https://doi.org/10.1016/S2665-9913(21)00151-X).

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**Table S1.** Sensitivity analyses and justification.

Sensitivity analysis (1 to 10)	Cohort	Justification
1. Risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD, IA, or CTD	Matched cohort A, B, C	<ul style="list-style-type: none"><li>- Main results</li><li>- Social-economic status, body mass index, physical activity, cigarette smoking, and consuming alcoholic drinks can affect the COVID-19 and AIRD. We consider these covariates by linking the national general health examination results.</li><li>- Matching covariates were selected for age; sex; region of residence; resident of a skilled nursing facility; a history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; household income ; smoking; alcoholic drinks; body mass index; sufficient aerobic activity; and current use of aspirin, metformin, and statin</li></ul>
2. Subgroup analysis of the risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD stratified by DMARD and	Matched cohort A	<ul style="list-style-type: none"><li>- To investigate the association of COVID-19-related outcomes by current use of DMARD and systemic steroid.</li></ul>

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systemic steroid

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3. Risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD, IA, or CTD	Matched cohort D, E, F	<p>- We constructed an original dataset without linking the general health examination records to obtain a large sample number.</p> <p>- Matching covariates were selected for age; sex; region of residence; resident of a skilled nursing facility; a history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; and current use of aspirin, metformin, and statin</p>
4. Subgroup analysis of the risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD stratified by DMARD and systemic steroid	Matched cohort D	<p>- To investigate the association of COVID-19-related outcomes by current use of DMARD and systemic steroid.</p>
5. Risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD	Full-unmatched cohort	<p>- Propensity score matching can introduce unintended bias into the estimation. We repeated the main analysis by analysis from unmatched subjects.</p>
7. Risk of positive SARS-CoV-2 test, severe COVID-19	Matched cohort G, H, I	<p>- To avoid overmatching issues, we selected the matching covariates in</p>

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outcomes, or COVID-19-related death in patients with  
AIRD, IA, or CTD

matched A, B, C by using the DAG approach. DAGs can be used to  
select covariates for support causal interpretation.

- Matching covariates were selected for age; sex; region of residence;  
resident of a skilled nursing facility.

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8. Risk of positive SARS-CoV-2 test, severe COVID-19  
outcomes, or COVID-19-related death in patients with  
AIRD, IA, or CTD

Matched cohort J, K, L

- To avoid overmatching issues, we selected the matching covariates in  
matched D, E, F by using the DAG approach. DAGs can be used to  
select covariates for support causal interpretation.

- Matching covariates were selected for age; sex; region of residence;  
resident of a skilled nursing facility; household income ; smoking;  
alcoholic drinks; body mass index.

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AIRD, autoimmune inflammatory rheumatic disease; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease;

DMARD, disease-modifying antirheumatic drug; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

**Table S2.** Baseline covariates of patients who underwent the SARS-CoV-2 test in the nationwide cohort.

Characteristics	Entire cohort	AIRD	AIRD	
			IA	CTD
Total, n (%)	212,678	11,766	10,038	2875
Age, years, n (%)				
20-39	78,372 (36.9)	1590 (13.5)	1247 (12.4)	581 (20.2)
40-59	63,057 (29.7)	3303 (28.1)	2772 (27.6)	950 (33.0)
≥ 60	71,249 (33.5)	6873 (58.4)	6019 (60.0)	1344 (46.8)
Sex, n (%)				
Male	100,038 (47.0)	4284 (36.4)	3647 (36.3)	905 (31.5)
Female	112,640 (53.0)	7482 (63.6)	6391 (63.7)	1970 (68.5)
Region of residence, n (%)				

Seoul Capital Area	97,733 (46.0)	5410 (46.0)	4527 (45.1)	1433 (49.8)
Daegu/Gyeongbuk area	39,063 (18.4)	2150 (18.3)	1925 (19.2)	431(15.0)
Other area	75,882 (35.7)	4206 (35.8)	3586 (35.7)	1011 (35.2)
Resident of a skilled nursing facility, n (%)	13,015 (6.1)	1045 (8.9)	898 (9.0)	190 (6.6)
History of diabetes mellitus, n (%)	44,845 (21.1)	4890 (41.6)	4257 (42.4)	1072 (37.3)
History of cardiovascular disease, n (%)	40,526 (19.1)	4640 (39.4)	3956 (39.4)	1126 (39.2)
History of cerebrovascular disease, n (%)	25,991 (12.2)	2784 (23.7)	2420 (24.1)	586 (20.4)
History of COPD, n (%)	25,081 (11.8)	2841 (24.2)	2435 (24.3)	667 (23.2)
History of hypertension, n (%)	68,817 (32.4)	6706 (57.0)	5801 (57.8)	1502 (52.2)
History of chronic kidney disease, n (%)	18,561 (8.7)	2306 (19.6)	1900 (18.9)	651 (22.6)
Current use of aspirin, n (%)	17,551 (8.3)	1722 (14.6)	1490 (14.8)	398 (13.8)
Current use of metformin, n (%)	19,687 (9.3)	1734 (14.7)	1538 (15.3)	316 (11.0)
Current use of statin, n (%)	42,695 (20.1)	4294 (36.5)	3759 (37.5)	891 (31.0)



Current use of systemic steroid, n (%)	26,048 (12.2)	2808 (23.9)	2992 (29.8)	1404 (48.8)
Current use of DMARDs, n (%)	7713			
Methotrexate–leflunomide–azathioprine, n (%)	12,503 (5.9)	5243 (44.6)	4592 (45.7)	1921 (66.8)
Sulfasalazine, n (%)	716 (0.3)	652 (5.5)	636 (6.3)	153 (5.3)
Antimalarials, n (%)	11749 (5.5)	2620 (22.2)	2257 (22.5)	1196 (41.6)
Anti-TNF-alpha agent, n (%)	1448 (0.7)	752 (6.4)	685 (6.8)	203 (7.1)
Other biologics, n (%)	2160 (1.0)	529 (4.5)	490 (4.9)	121 (4.2)

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AIRD, autoimmune inflammatory rheumatic disease; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease; DMARD, disease-modifying antirheumatic drug; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; TNF; tumor necrosis factor.

**Table S3.** 3:1 propensity score-matched covariates and aOR (95% CI) of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD, IA, or CTD.

Characteristics	Matched cohort D			Matched cohort E			Matched cohort F		
	None	AIRD	SMD	None	IA**	SMD	None	CTD**	SMD
Total, n (%)	34,343	11,698		29,578	9991		8352	2832	
Age, years, n (%)			0.022			0.014			0.023
20-39	4352 (12.7)	1559 (13.3)		3541 (12.0)	1237 (12.4)		1552 (18.6)	547 (19.3)	
40-59	9475 (27.6)	3276 (28.0)		8062 (27.3)	2750 (27.5)		2744 (32.9)	942 (33.3)	
≥ 60	20,516 (59.7)	6863 (58.7)		17,975 (60.8)	6004 (60.1)		4056 (48.6)	1343 (47.4)	
Sex, n (%)			0.019			0.013			0.007
Male	12,894 (37.5)	4284 (36.6)		10,976 (37.1)	3646 (36.5)		2691 (32.2)	903 (31.9)	
Female	21,449 (62.5)	7414 (63.4)		18,602 (62.9)	6345 (63.5)		5661 (67.8)	1929 (68.1)	

Region of residence, n (%)			0.004			0.002			0.018
Seoul Capital Area	15,808 (46.0)	5377 (46.0)		13,389(45.3)	4505 (45.1)		4242 (50.8)	1417 (50.0)	
Daegu/Gyeongbuk area	6348 (18.5)	2132 (18.2)		5593 (18.9)	1910 (19.1)		1241 (14.9)	417 (14.7)	
Other area	12,187 (35.5)	4189 (35.8)		10,596 (35.8)	3576 (35.8)		2869 (34.4)	998 (35.2)	
Resident of a skilled nursing facility, n (%)	2992(8.7)	1044 (8.9)	0.008	2623 (8.9)	897 (9.0)	0.004	546 (6.5)	190 (6.7)	0.007
History of diabetes mellitus, n (%)	14,130 (41.1)	4868 (41.6)	0.010	12,395 (41.9)	4230 (42.3)	0.010	3097 (37.1)	1058 (37.4)	0.006
History of cardiovascular disease, n (%)	13,323 (38.8)	4599 (39.3)	0.012	11,460 (38.8)	3929 (39.3)	0.013	3199 (38.3)	1096 (38.7)	0.009
History of cerebrovascular disease, n (%)	8089 (23.6)	2771 (23.7)	0.004	6994 (23.7)	2408 (24.1)	0.012	1634 (19.6)	566 (20.0)	0.012
History of COPD, n (%)	7838 (22.8)	2796 (23.9)	0.029	6793 (23.0)	2398 (24.0)	0.028	1871 (22.4)	651 (23.0)	0.016
History of hypertension, n (%)	19,649 (57.2)	6676 (57.1)	0.003	17,188 (58.1)	5782 (57.9)	0.005	4314 (51.7)	1469 (51.9)	0.005
History of chronic kidney disease, n (%)	6377 (18.6)	2266 (19.4)	0.024	5255 (17.8)	1876 (18.8)	0.030	1769 (21.2)	624 (22.0)	0.024
Current use of aspirin, n (%)	4892 (14.2)	1707 (14.6)	0.011	4288 (14.5)	1480 (14.8)	0.010	1048 (12.6)	380 (13.4)	0.028
Current use of metformin, n (%)	5049 (14.7)	1731 (14.8)	0.003	4481 (15.2)	1538 (15.4)	0.008	920 (11.0)	315 (11.1)	0.004

Current use of statin, n (%)	12,459 (36.3)	4264 (36.5)	0.004	10,967(37.1)	3733 (37.4)	0.006	2577 (30.9)	868 (30.7)	0.005
COVID-19, n (%)	1345 (3.9)	527 (4.5)		1156 (3.9)	457 (4.6)		298 (3.6)	127 (4.5)	
Minimally aOR* (95% CI)	1.0 (ref)	<b>1.16 (1.02-1.31)</b>		1.0 (ref)	<b>1.18 (1.06-1.32)</b>		1.0 (ref)	<b>1.26 (1.03-1.57)</b>	
Fully aOR <sup>§</sup> (95% CI)	1.0 (ref)	<b>1.21 (1.06-1.39)</b>		1.0 (ref)	<b>1.22 (1.09-1.38)</b>		1.0 (ref)	<b>1.28 (1.03-1.61)</b>	
Severe COVID-19‡, n (%)	391 (1.1)	165 (1.4)		349 (1.2)	144 (1.4)		85 (1.0)	44 (1.6)	
Minimally aOR* (95% CI)	1.0 (ref)	<b>1.21 (1.02-1.45)</b>		1.0 (ref)	<b>1.22 (1.01-1.49)</b>		1.0 (ref)	<b>1.54 (1.07-2.21)</b>	
Fully aOR <sup>§</sup> (95% CI)	1.0 (ref)	<b>1.24 (1.04-1.49)</b>		1.0 (ref)	<b>1.23 (1.02-1.50)</b>		1.0 (ref)	<b>1.55 (1.08-2.22)</b>	
COVID-19-related death, n (%)	55 (0.2)	30 (0.3)		45 (0.2)	27 (0.3)		13 (0.2)	9 (0.3)	
Minimally aOR* (95% CI)	1.0 (ref)	<b>1.62 (1.03-2.51)</b>		1.0 (ref)	<b>1.79 (1.10-2.88)</b>		1.0 (ref)	2.05 (0.89-4.80)	
Fully aOR <sup>§</sup> (95% CI)	1.0 (ref)	<b>1.62 (1.03-2.53)</b>		1.0 (ref)	<b>1.80 (1.10-2.89)</b>		1.0 (ref)	2.06 (0.89-4.83)	

An SMD <0.1 indicates no major imbalance. All SMD values were <0.03 in the propensity score-matched cohorts.

Data in bold indicate significant differences ( $P < 0.05$ ).

aOR, adjusted odds ratio; AIRD, autoimmune inflammatory rheumatic disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease; DMARD, disease-modifying antirheumatic drug; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; SMD, standardized mean difference.

\*Minimally adjusted: adjustment for age (20-39, 40-59, and  $\geq 60$  years) and sex.

§Fully adjusted: adjustment for age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other area); resident of a skilled nursing facility; history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; and current use of aspirin, metformin, and statin

‡ Requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

\*\* Includes 1125 patients who had both inflammatory arthritis and connective tissue disease.

**Table S4.** Propensity-score-matched subgroup analysis of aOR (95% CI) of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD stratified by DMARD and systemic steroid (matched cohort D).

Events	Factors	N (%)	Adjusted OR (95% CI)
COVID-19	Treated without DMARD	210/4444 (4.7)	1.0 (ref)*
	Treated with DMARD	317/7254 (4.4)	0.91 (0.72-1.17)
COVID-19	Treated without systemic steroid	382/8901 (4.3)	1.0 (ref)‡
	Treated with systemic steroid (any dose)	145/2797 (5.2)	1.21 (0.93-1.57)
	Treated with systemic steroid ( $\geq 10$ mg/day)	58/920 (6.3)	<b>1.50 (1.05-2.15)</b>
Severe COVID-19§	Treated without DMARD	60/4444 (1.4)	1.0 (ref)*
	Treated with DMARD	105/7254 (1.5)	1.10 (0.77-1.57)*\
Severe COVID-19§	Treated without systemic steroid	116/8901 (1.3)	1.0 (ref)‡
	Treated with systemic steroid (any dose)	49/2797 (1.8)	1.34 (0.90-1.91)
	Treated with systemic steroid ( $\geq 10$ mg/day)	23/920 (2.5)	<b>1.95 (1.13-3.35)</b>
COVID-19-related death	Treated without DMARD	10/4444 (2.3)	1.0 (ref)*
	Treated with DMARD	20/7254 (2.8)	1.24 (0.59-2.65)

COVID-19-related death	Treated without systemic steroid	18/8901 (0.2)	1.0 (ref) <sup>‡</sup>
	Treated with systemic steroid (any dose)	12/2797 (0.4)	2.14 (0.99-4.50)
	Treated with systemic steroid ( $\geq 10$ mg/day)	6/920 (0.7)	<b>3.26 (1.20-8.28)</b>

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Data in bold indicate significant differences ( $P < 0.05$ ).

aOR, adjusted odds ratio; AIRD, autoimmune inflammatory rheumatic disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; DMARD, disease-modifying antirheumatic drug; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

\*Risk factors were adjusted for age (20-39, 40-59, and  $\geq 60$  years); sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other area); resident of a skilled nursing facility; history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; and current use of aspirin, metformin, statin, and systemic steroid.

<sup>‡</sup>Risk factors were adjusted for age (20-39, 40-59, and  $\geq 60$  years); sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other area); resident of a skilled nursing facility; history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; and current use of aspirin, metformin, and statin and DMARD.

<sup>§</sup> Requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

**Table S5.** 3:1 propensity score-matched covariates selected by DAGs and aOR (95% CI) of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD, IA, or CTD in the Korean nationwide cohort linked with the general health examination records.

Characteristics	Matched cohort G			Matched cohort H			Matched cohort I		
	None	AIRD	SMD	None	IA	SMD	None	CTD	SMD
Total, n (%)	24,782	8286		21,342	7132		5854	1952	
Matched covariates selected by DAGs									
Age, years, n (%)			0.001			<0.001			0.003
20-39	2341 (9.45)	782 (9.4)		1865 (8.8)	622 (8.7)		771(13.2)	255 (13.1)	
40-59	7775 (31.4)	2592 (31.3)		6607 (31.0)	2206 (30.9)		2155 (36.8)	719 (36.8)	
≥ 60	14,666 (59.2)	4912 (59.3)		12,870 (60.3)	4304 (60.4)		2928 (50.0)	978 (50.1)	
Sex, n (%)			0.002			0.001			<0.001
Male	9130 (36.8)	3044 (36.7)		7848 (36.8)	2618 (36.7)		1875 (32.0)	625 (32.0)	



Female	15,652 (63.2)	5242 (63.3)		13,494 (63.2)	4514 (63.3)		3979 (68.0)	1327 (68.0)
Region of residence, n (%)			0.001			<0.001		0.002
Seoul Capital Area	10,888 (43.9)	3640 (43.9)		9204 (43.1)	3071 (43.1)		2790 (47.7)	927 (47.5)
Daegu/Gyeongbuk area	4811 (19.4)	1617 (19.5)		4347 (20.4)	1462 (20.5)		918 (15.7)	310 (15.9)
Other area	9083 (36.7)	3029 (36.6)		7791 (36.5)	2599 (36.4)		2146 (36.7)	715 (36.6)
Resident of a skilled nursing facility, n (%)	1775 (7.2)	601 (7.3)	0.003	1498 (7.0)	515(7.2)	0.008	345 (5.9)	116 (5.9)
Household income, n (%)			0.002					<0.001
Low (0–39 percentile)	8854 (35.7)	2973 (35.9)		7644 (35.8)	2569 (36.0)		2054 (35.1)	685 (35.1)
Middle (40–79 percentile)	8547 (34.5)	2848 (34.4)		7383 (34.6)	2460 (34.5)		2017 (34.5)	673 (34.5)
High (80–100 percentile)	7381 (29.8)	2465 (29.8)		6315 (29.6)	2103 (29.5)		1783 (30.5)	594 (30.4)
Smoking, n (%)			0.002			0.003		0.003
Never smoker	17,840 (72.0)	5953 (71.8)		15,378 (72.1)	5129 (71.9)		4408 (75.3)	1468 (75.2)

Ex-smoker	3964 (16.0)	1336 (16.1)	3361 (15.8)	1128 (15.8)	895 (15.3)	298 (15.3)
Current smoker	2978 (12.0)	997 (12.0)	2603 (12.2)	875 (12.3)	551 (9.4)	186 (9.5)
Alcoholic drinks, days per week, n (%)			0.005		0.004	0.001
<1	18,989 (76.6)	6341 (76.5)	16,463 (77.1)	5502 (77.2)	4457 (76.1)	1485 (76.1)
1–2	4487 (18.1)	1494 (18.0)	3738 (17.5)	1239 (17.4)	1147 (19.6)	383 (19.6)
3–4	890 (3.6)	304 (3.7)	761 (3.6)	257 (3.6)	183 (3.1)	62 (3.2)
≥5	416 (1.7)	147 (1.8)	380 (1.8)	134 (1.9)	67 (1.1)	22 (1.1)
Body mass index, kg/m <sup>2</sup> , n (%)			0.006		0.009	0.006
<25	15,886 (64.1)	5297 (63.9)	13,553 (63.5)	4507 (63.2)	4131 (70.6)	1373 (70.3)
25–30	7444 (30.0)	2490 (30.1)	6527 (30.6)	2186 (30.7)	1466 (25.0)	491 (25.2)
≥30	1452 (5.9)	499 (6.0)	1262 (5.9)	439 (6.2)	257 (4.4)	88 (4.5)
Unmatched covariates						

History of diabetes mellitus, n (%)	7401 (29.9)	3434 (41.4)	6528 (30.6)	3001 (42.1)	1526 (26.1)	751 (38.5)
History of cardiovascular disease, n (%)	6570 (26.5)	3130 (37.8)	5725 (26.8)	2677 (37.5)	1392(23.8)	743 (38.1)
History of cerebrovascular disease, n (%)	4318 (17.4)	1878 (22.7)	3830 (18.0)	1636 (22.9)	924 (15.8)	392 (20.1)
History of COPD, n (%)	3974 (16.0)	2000 (24.1)	3523 (16.5)	1710 (24.0)	839 (14.3)	481 (24.6)
History of hypertension, n (%)	11,671 (47.1)	4649 (56.1)	10,117 (47.4)	4041 (56.7)	2390 (40.8)	1014 (52.0)
History of chronic kidney disease, n (%)	2736 (11.0)	1472 (17.8)	2343 (11.0)	1236 (17.3)	590 (10.1)	399 (20.4)
Current use of aspirin, n (%)	3185 (12.9)	1209 (14.6)	2738 (12.8)	1044 (14.6)	652 (11.1)	282 (14.5)
Current use of metformin, n (%)	3506 (14.2)	1256 (15.2)	3100 (14.5)	1114 (15.6)	692 (11.8)	234 (12.0)
Current use of statin, n (%)	8044 (32.5)	3223 (38.9)	7057 (33.1)	2833 (39.7)	1593 (27.2)	658 (33.7)
Sufficient aerobic activity, n (%)	11,934 (48.2)	4096 (49.4)	10,238 (48.0)	3521 (49.4)	2829 (48.3)	983 (50.4)
COVID-19, n (%)	1024 (3.7)	365 (4.4)	816 (3.8)	327 (4.6)	191 (3.3)	84 (4.3)
Fully aOR <sup>s</sup> (95% CI)	1.0 (ref)	<b>1.21 (1.07-1.38)</b>	1.0 (ref)	<b>1.21 (1.06-1.39)</b>	1.0 (ref)	<b>1.35 (1.04-1.76)</b>
Severe COVID-19 <sup>‡</sup> , n (%)	315 (1.1)	127 (1.5)	240 (1.1)	103 (1.4)	51 (0.9)	30 (1.5)

Fully aOR <sup>§</sup> (95% CI)	1.0 (ref)	<b>1.38 (1.12-1.68)</b>	1.0 (ref)	<b>1.30 (1.03-1.65)</b>	1.0 (ref)	<b>1.78 (1.14-2.82)</b>
COVID-19-related death, n (%)	46 (0.2)	24 (0.3)	32 (0.2)	20 (0.3)	11 (0.2)	7 (0.4)
Fully aOR <sup>§</sup> (95% CI)	1.0 (ref)	<b>1.77 (1.06-2.90)</b>	1.0 (ref)	<b>1.89 (1.06-3.34)</b>	1.0 (ref)	1.93 (0.72-4.96)

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An SMD <0.1 indicates no major imbalance. All SMD values were <0.01 in the propensity score-matched cohort.

Data in bold indicate significant differences ( $P < 0.05$ ).

aOR, adjusted odds ratio; AIRD, autoimmune inflammatory rheumatic disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease; DAGs, directed acyclic graphs; DMARD, disease-modifying antirheumatic drug; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; SMD, standardized mean difference.

\*Minimally adjusted: adjustment for age (20-39, 40-59, and  $\geq 60$  years) and sex.

§Fully adjusted: adjustment for age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other area); resident of a skilled nursing facility; history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1-2, 3-4,  $\geq 5$  days per week);

body mass index (< 25, 25-30, and  $\geq 30$  kg/m<sup>2</sup>); sufficient aerobic activity; and current use of aspirin, metformin, and statin

‡ Requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

**Table S6.** 3:1 propensity score-matched covariates selected by DAGs and aOR (95% CI) of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients with AIRD, IA, or CTD in the Korean nationwide cohort.

Characteristics	Matched cohort J			Matched cohort K			Matched cohort L		
	None	AIRD	SMD	None	IA	SMD	None	CTD	SMD
Total, n (%)	35,298	11,766		30,114	10,038		8625	2875	
Matched covariates selected by DAGs									
Age, years, n (%)			<0.001			<0.001			<0.001
20-39	4770 (13.5)	1590(13.5)		3741 (12.4)	1247 (12.4)		1743 (20.2)	581 (20.2)	
40-59	9909 (28.1)	3303(28.1)		8316 (27.6)	2772 (27.6)		2850 (33.0)	950 (33.0)	
≥ 60	20,619 (58.4)	6873(58.41)		18,057 (60.0)	6019(60.0)		4032 (46.8)	1344 (46.8)	
Sex, n (%)			<0.001			<0.001			<0.001
Male	12,852 (36.4)	4284 (36.4)		10,941 (36.3)	3647 (36.3)		2715 (31.5)	905 (31.5)	

Female	22,446 (63.6)	7482 (63.6)		19,173 (63.7)	6391 (63.7)		5910 (68.5)	1970 (68.5)	
Region of residence, n (%)			<0.001			<0.001			<0.001
Seoul Capital Area	16,230 (46.0)	5410 (46.0)		13,581 (45.1)	4527 (45.1)		4299 (49.8)	1433 (49.8)	
Daegu/Gyeongbuk area	6450 (18.3)	2150 (18.3)		5775 (19.2)	1925 (19.2)		1293 (15.0)	431 (15.0)	
Other area	12,618 (35.8)	4206 (35.8)		10,758 (35.7)	3586 (35.7)		3033 (35.2)	1011 (35.2)	
Resident of a skilled nursing facility, n (%)	3135 (8.9)	1045 (8.9)	<0.001	2694 (9.0)	898 (9.0)	<0.001	570 (6.6)	190 (6.6)	<0.001
Unmatched covariates									
History of diabetes mellitus, n (%)	10,407 (29.5)	4890 (41.6)		9082 (30.2)	4257 (42.4)		2433 (28.2)	1072 (37.3)	
History of cardiovascular disease, n (%)	9678 (27.4)	4640 (39.4)		8494 (28.2)	3956 (39.4)		2186 (25.3)	1126 (39.2)	
History of cerebrovascular disease, n (%)	6546 (18.5)	2784 (23.7)		5785 (19.2)	2420 (24.1)		1508 (17.5)	586 (20.4)	
History of COPD, n (%)	5527 (15.7)	2841 (24.2)		4877 (16.2)	2435 (24.3)		1394 (16.2)	667 (23.2)	
History of hypertension, n (%)	16,575 (47.0)	6706 (57.0)		14,494 (48.1)	5801 (57.8)		3595 (41.7)	1502 (52.2)	
History of chronic kidney disease, n (%)	4186 (11.9)	2306 (19.6)		3635 (12.1)	1900 (18.9)		1003 (11.6)	651 (22.6)	

Current use of aspirin, n (%)	4432 (12.6)	1722 (14.6)	3917 (13.0)	1490 (14.8)	957 (11.1)	398 (13.8)
Current use of metformin, n (%)	4612 (13.1)	1734 (14.7)	4016 (13.3)	1538 (15.3)	1058 (12.3)	316(11.0)
Current use of statin, n (%)	10,380 (29.4)	4294 (36.5)	9092 (30.2)	3759 (37.5)	2266 (26.3)	891 (31.0)
COVID-19, n (%)	1288 (3.7)	530 (4.5)	1136 (3.8)	457 (4.6)	290 (3.4)	127 (4.4)
Fully aOR* (95% CI)	1.0 (ref)	<b>1.20 (1.02-1.38)</b>	1.0 (ref)	<b>1.19 (1.02-1.42)</b>	1.0 (ref)	<b>1.31 (1.05-1.62)</b>
Severe COVID-19 <sup>§</sup> , n (%)	388 (1.1)	168 (1.4)	327 (1.1)	144 (1.4)	79 (0.9)	40 (1.4)
Fully aOR* (95% CI)	1.0 (ref)	<b>1.26 (1.03-1.54)</b>	1.0 (ref)	<b>1.35 (1.14-1.62)</b>	1.0 (ref)	<b>1.56 (1.08-2.28)</b>
COVID-19-related death, n (%)	51 (0.1)	31 (0.3)	42 (0.1)	27 (0.3)	12 (0.1)	9 (0.3)
Fully aOR* (95% CI)	1.0 (ref)	<b>1.73 (1.05-2.78)</b>	1.0 (ref)	<b>1.90 (1.20-2.99)</b>	1.0 (ref)	2.23 (0.91-5.35)

An SMD <0.1 indicates no major imbalance. All SMD values were <0.001 in the propensity score-matched cohort.

Data in bold indicate significant differences ( $P < 0.05$ ).



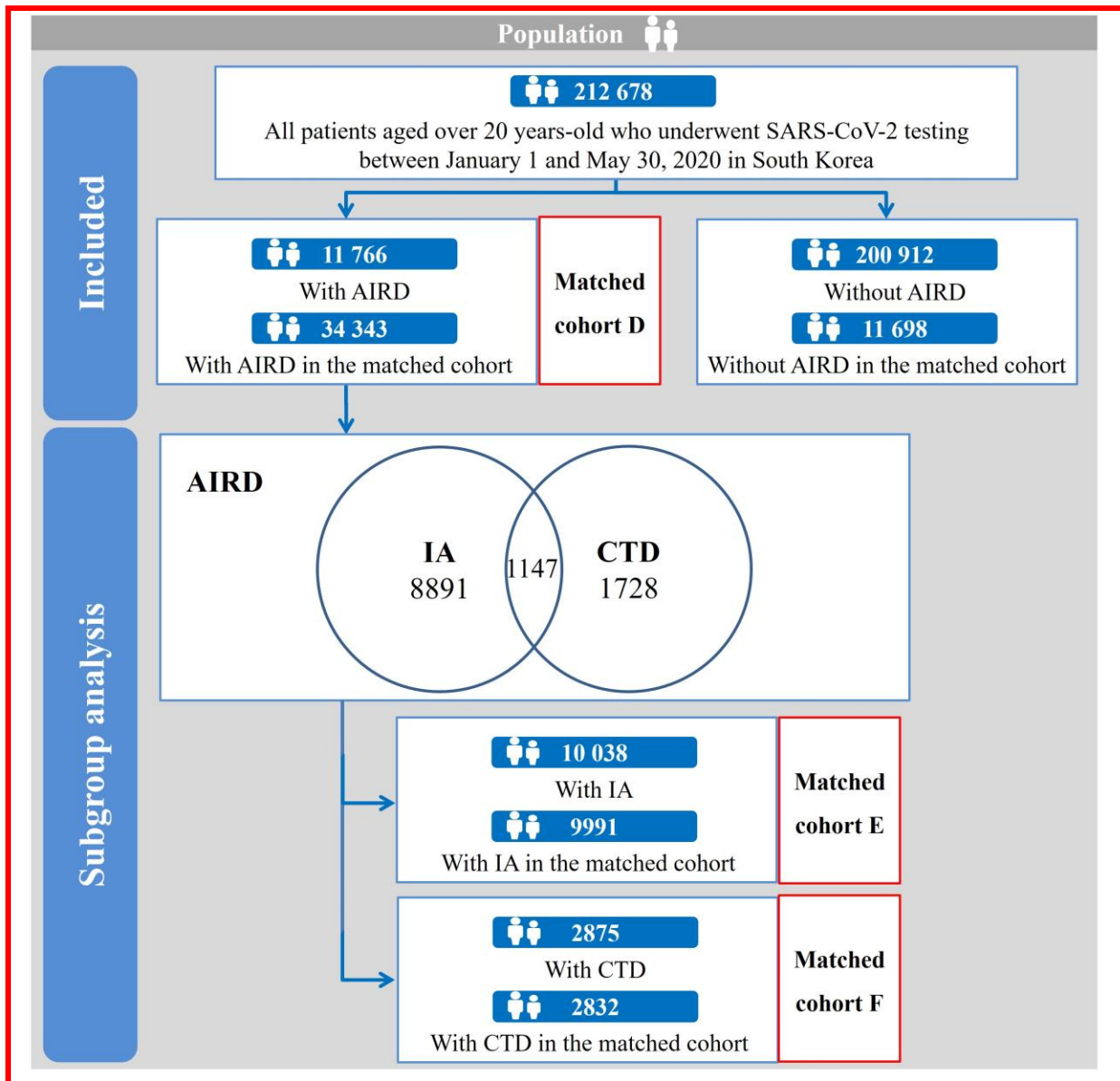
aOR, adjusted odds ratio; AIRD, autoimmune inflammatory rheumatic disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CTD, connective tissue disease; DAGs, directed acyclic graphs; DMARD, disease-modifying antirheumatic drug; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; SMD, standardized mean difference.

\*Fully adjusted: adjustment for age (20-39, 40-59, and  $\geq 60$  years); sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other area); resident of a skilled nursing facility; history of diabetes mellitus, cardiovascular disease, cerebrovascular disease, COPD, hypertension, and chronic kidney disease; and current use of aspirin, metformin, and statin

§ Requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

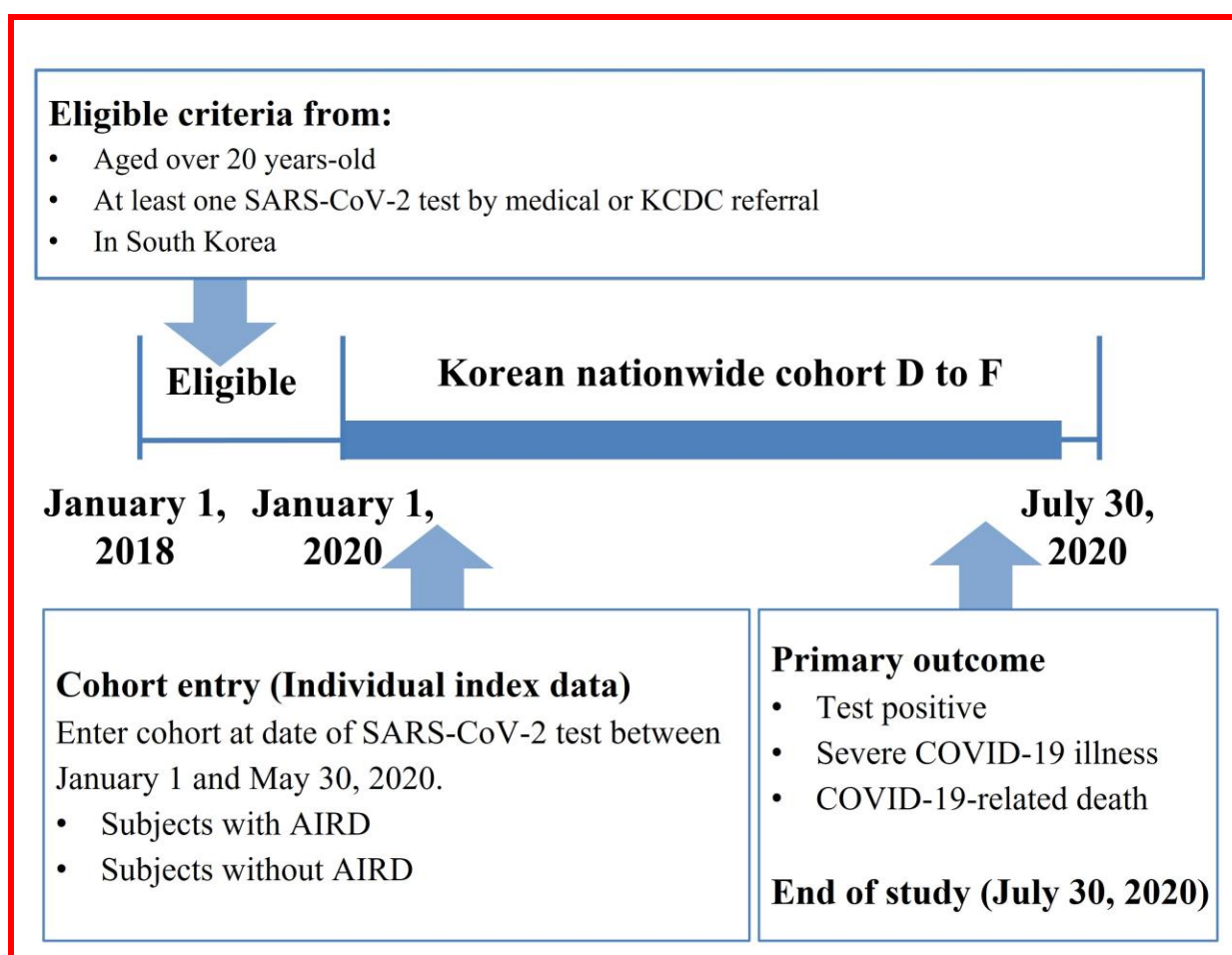
**Figure S1.** Disposition of patients in the Korean nationwide cohort without linking the general health examination records (matched cohorts D-F)

AIRD, autoimmune inflammatory rheumatic disease; CTD, connective tissue disease; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

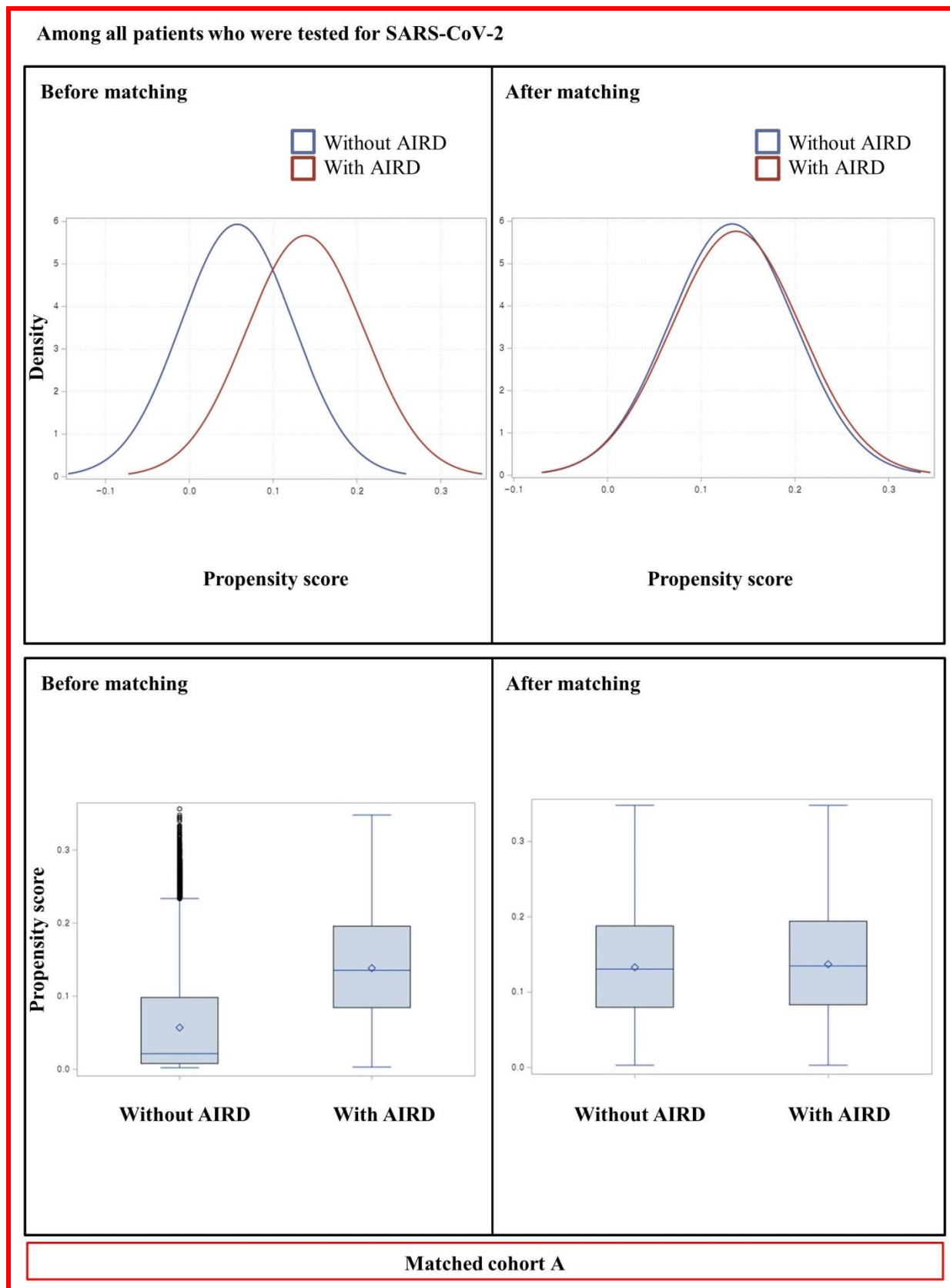


**Figure S2.** Flowchart showing the study enrollment in the Korean nationwide cohort without linking the general health examination records (matched cohorts D-F)

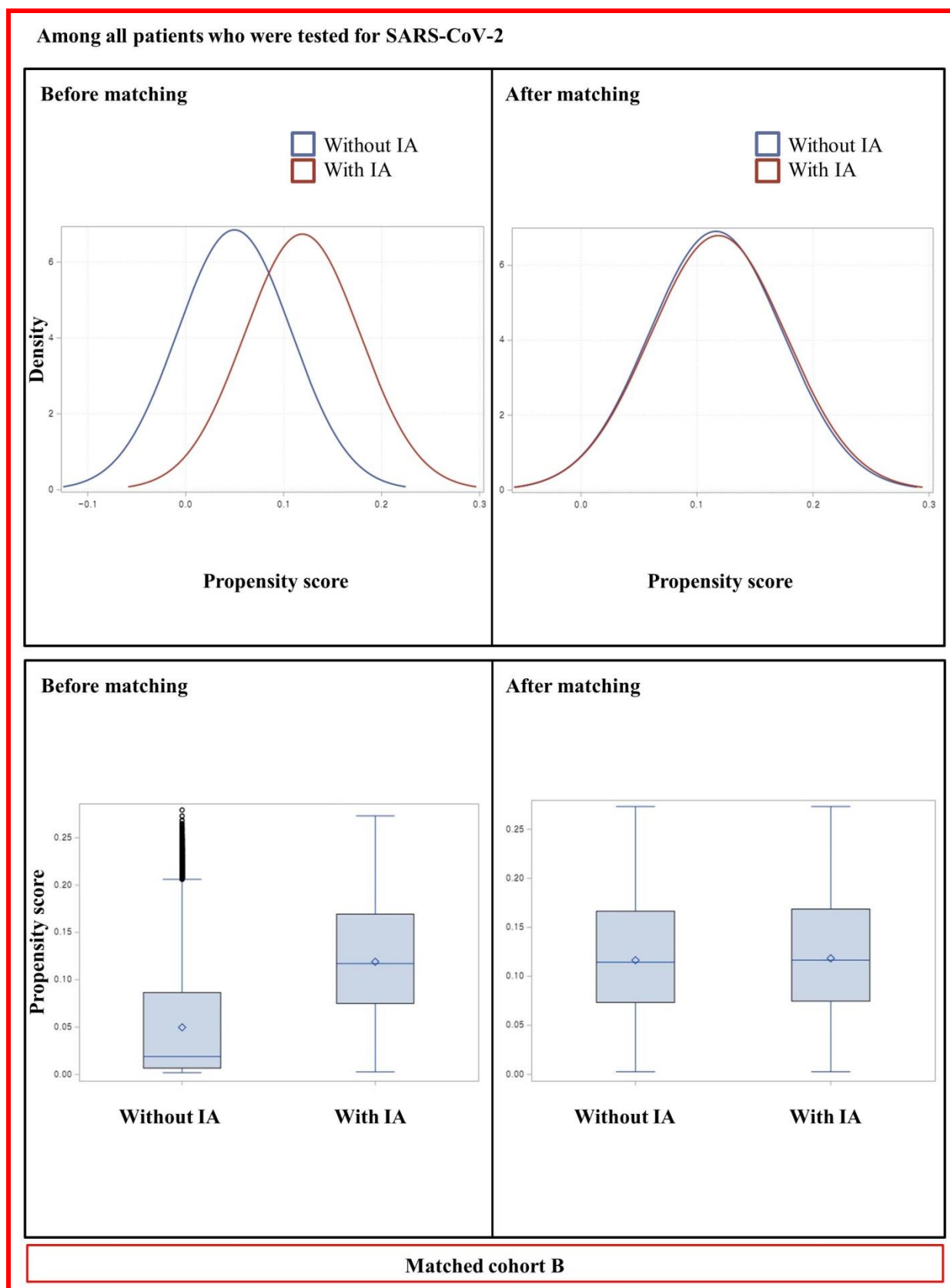
AIRD, autoimmune inflammatory rheumatic disease; CTD, connective tissue disease; IA, inflammatory arthritis; KCDC, Korea Centers for Disease Control; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



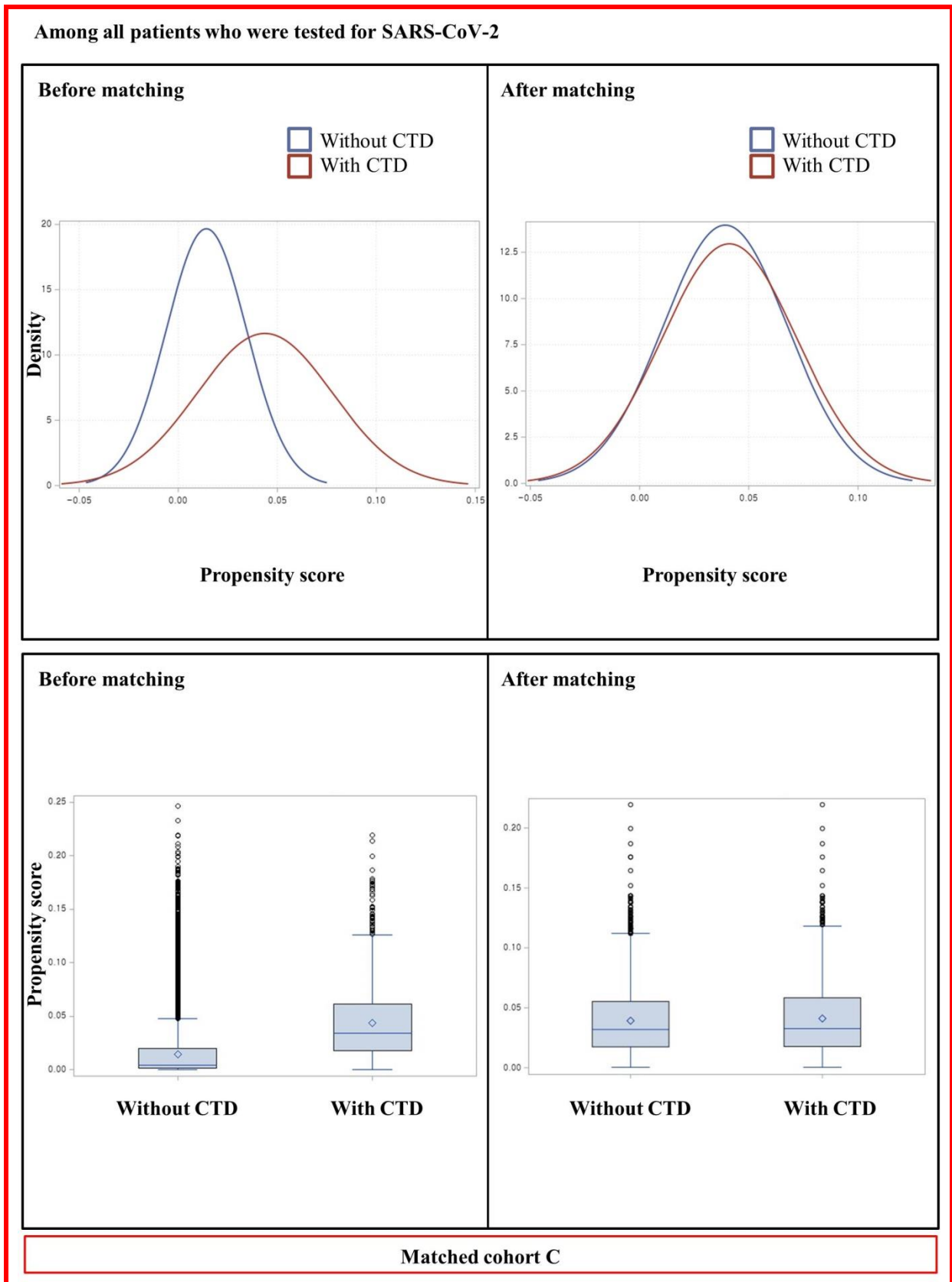
**Figure S3.** The density and distribution of propensity scores before and after matching in matched cohort A



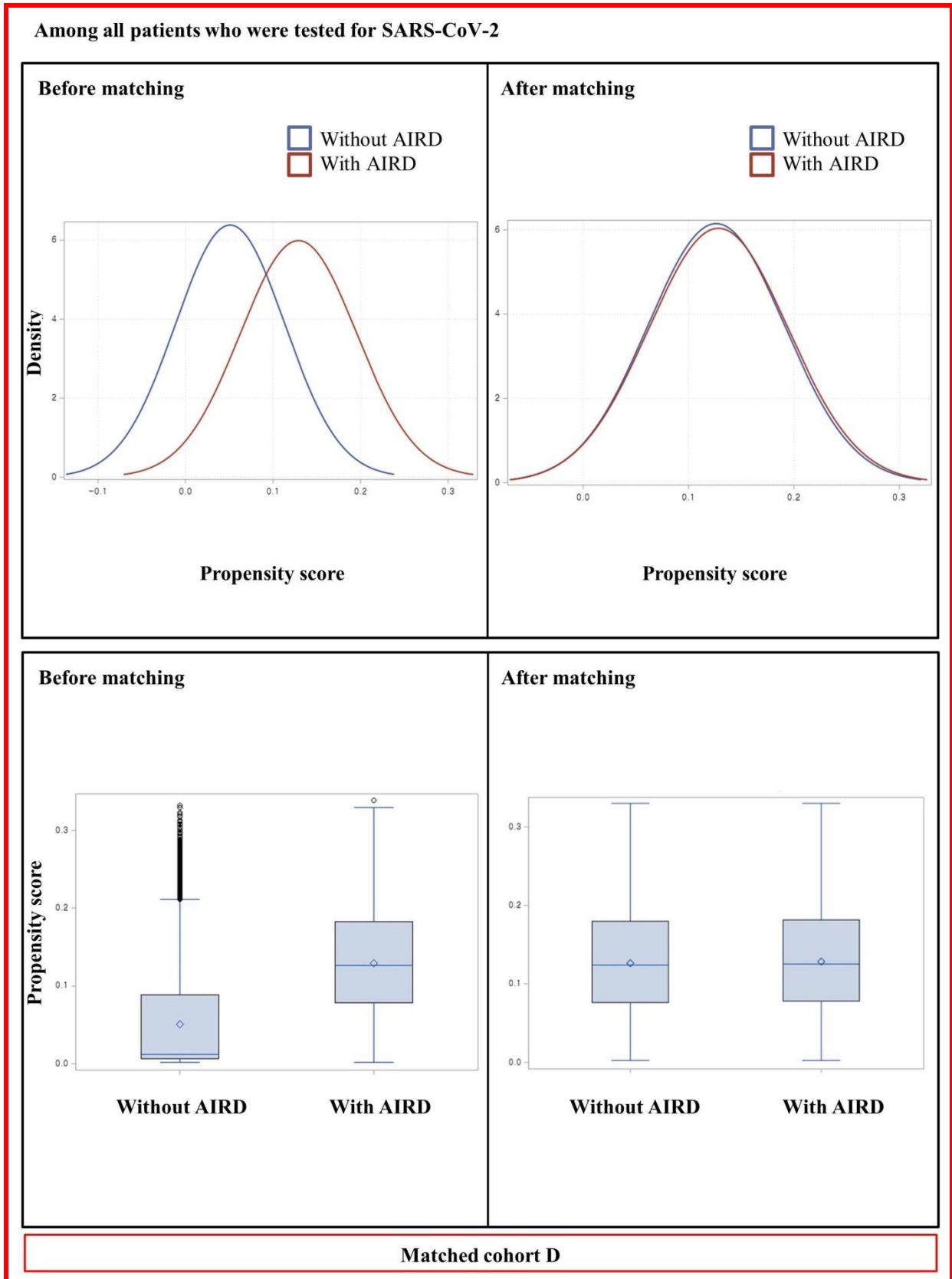
**Figure S4.** The density and distribution of propensity scores before and after matching in matched cohort B



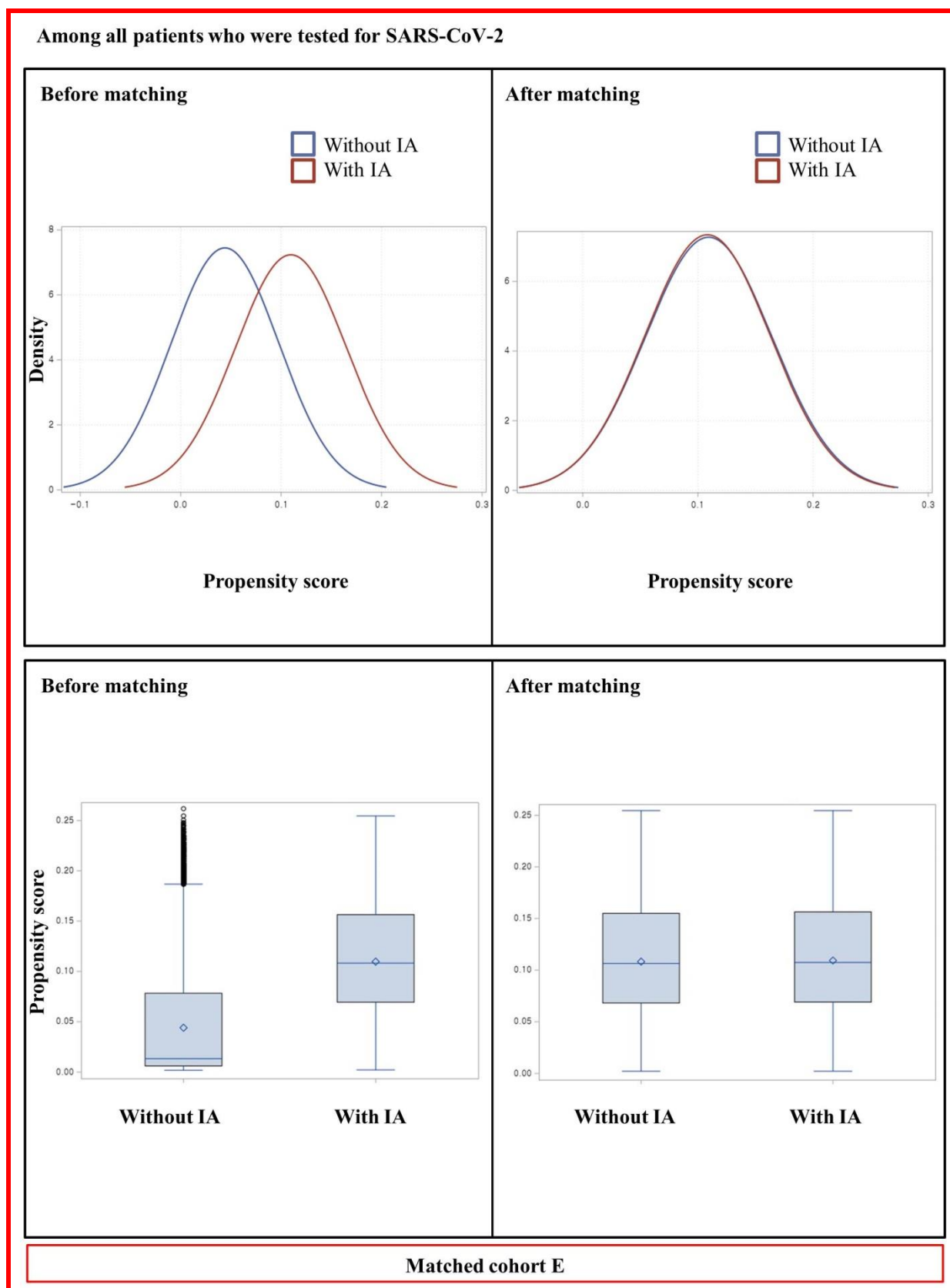
**Figure S5.** The density and distribution of propensity scores before and after matching in matched cohort C



**Figure S6.** The density and distribution of propensity scores before and after matching in matched cohort D

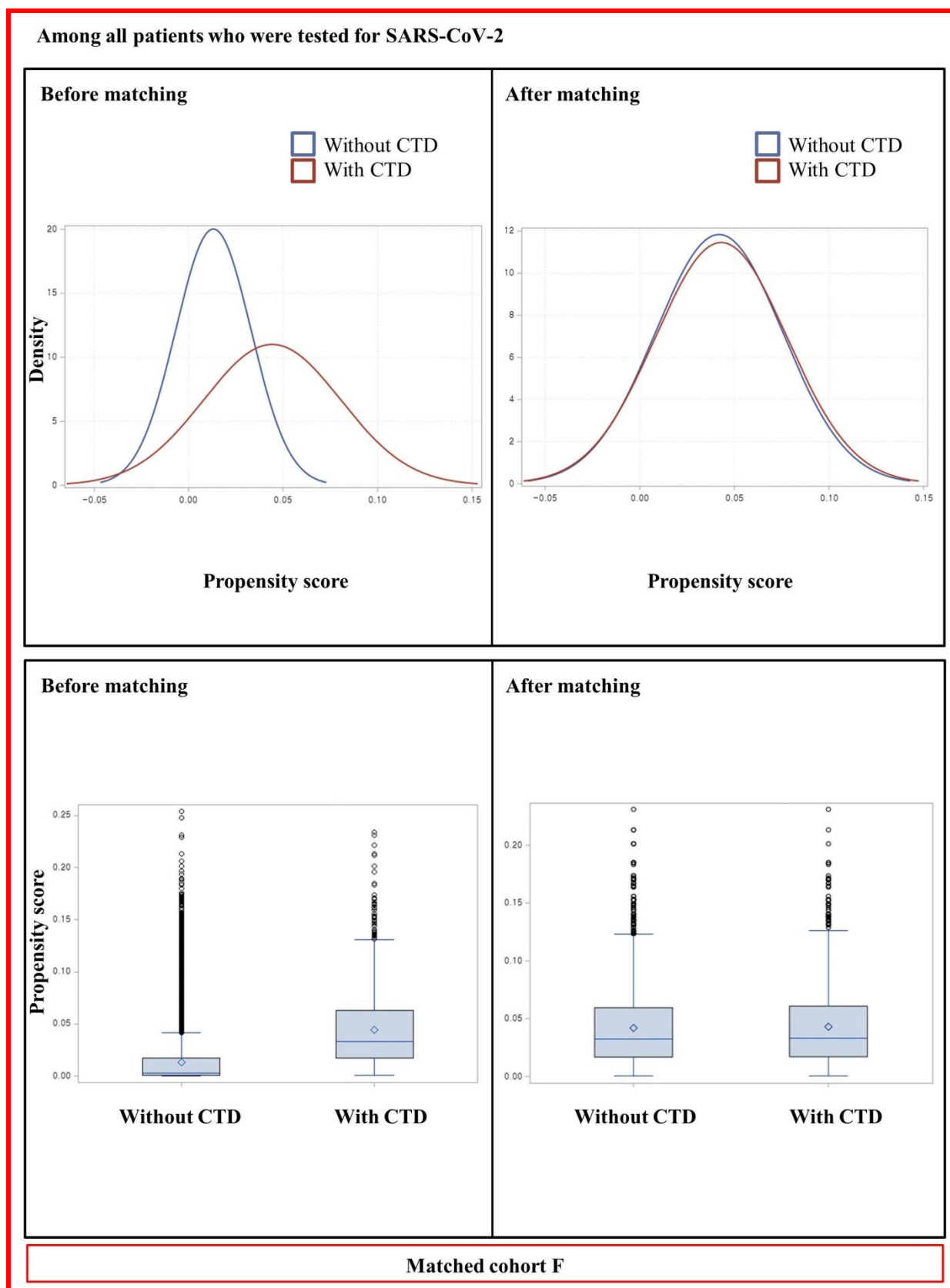


**Figure S7.** The density and distribution of propensity scores before and after matching in matched cohort E

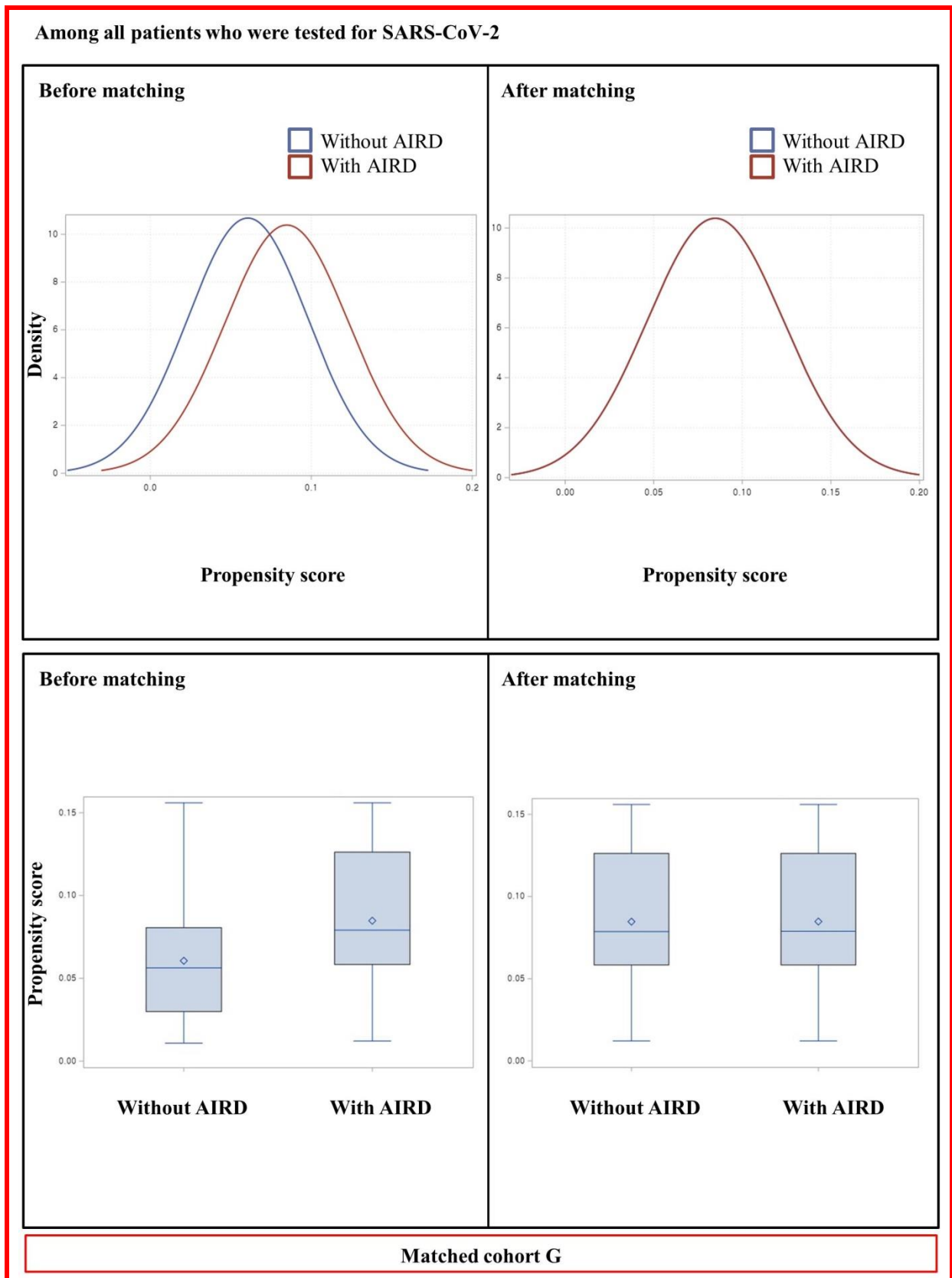




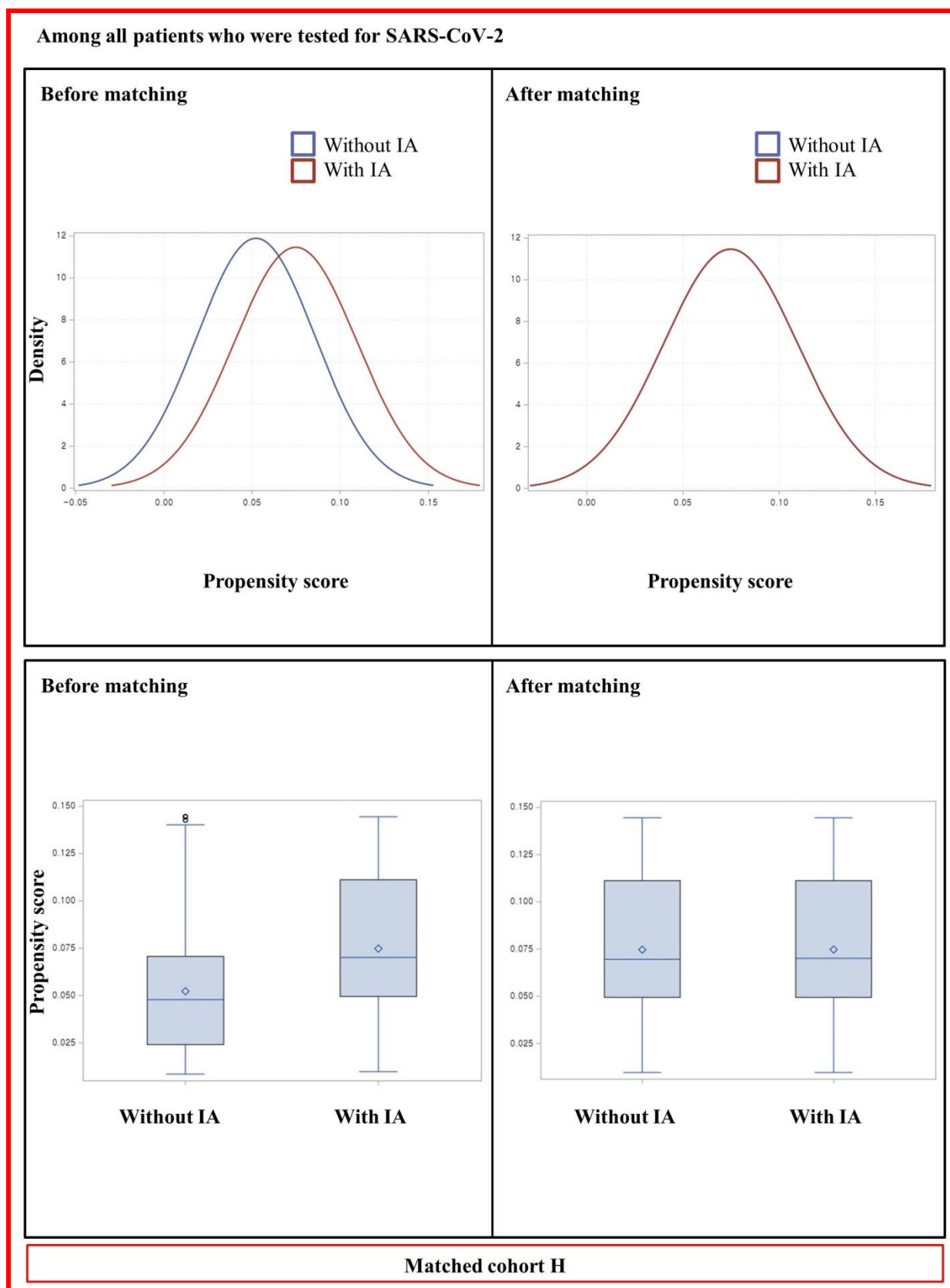
**Figure S8.** The density and distribution of propensity scores before and after matching in matched cohort F



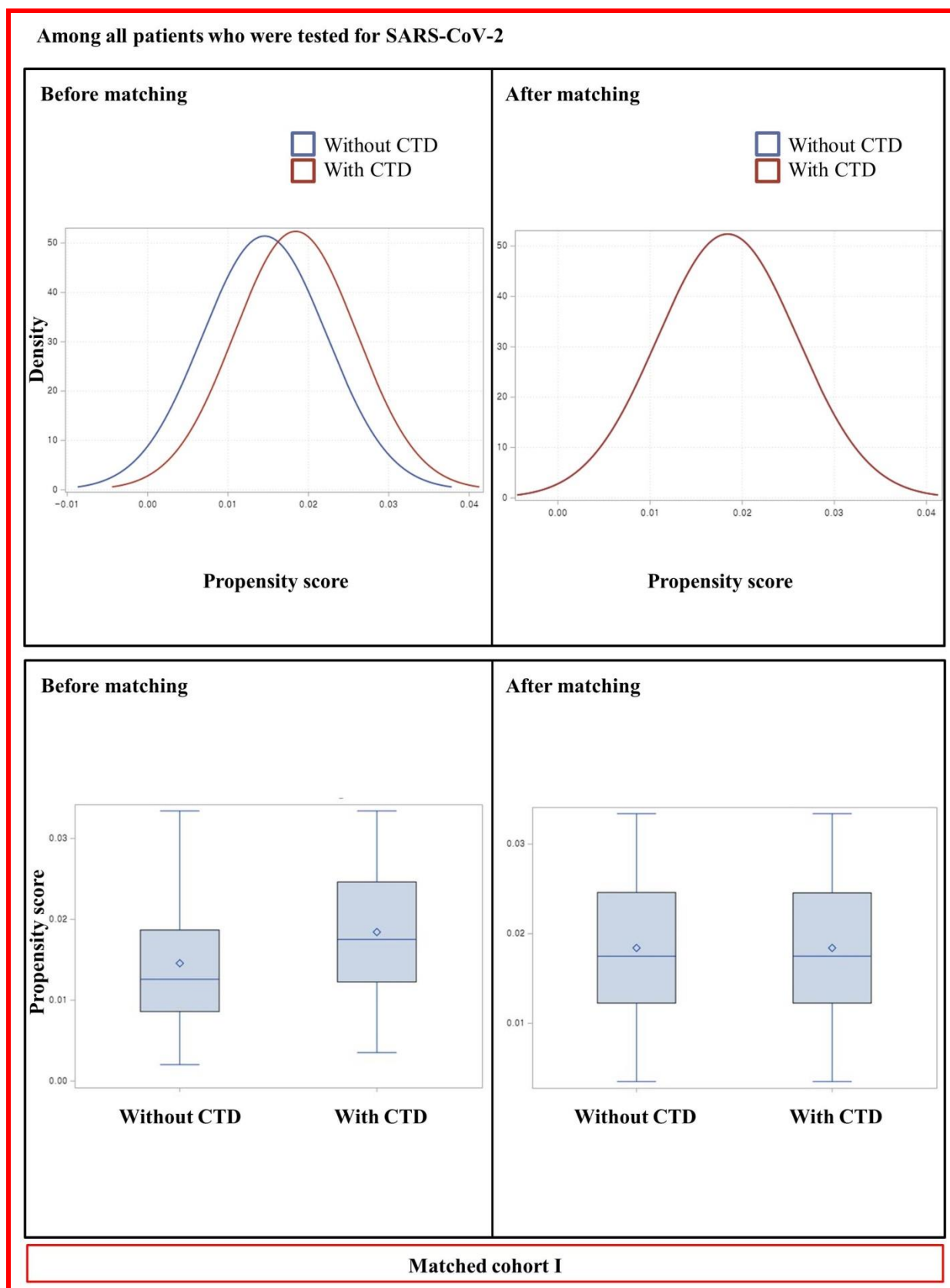
**Figure S9.** The density and distribution of propensity scores before and after matching in matched cohort G. After matching, the two curves overlap completely.



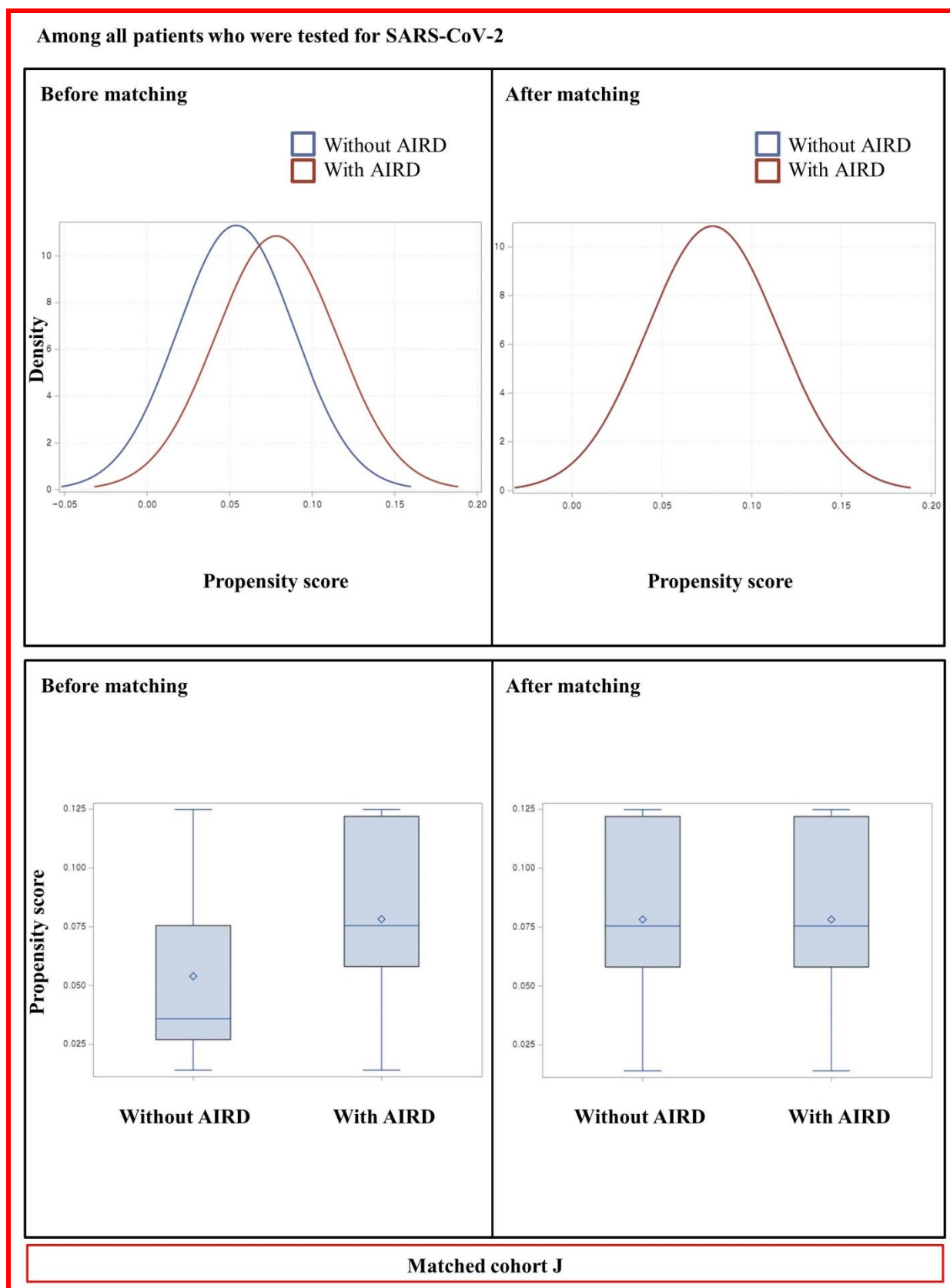
**Figure S10.** The density and distribution of propensity scores before and after matching in matched cohort H. After matching, the two curves overlap completely.



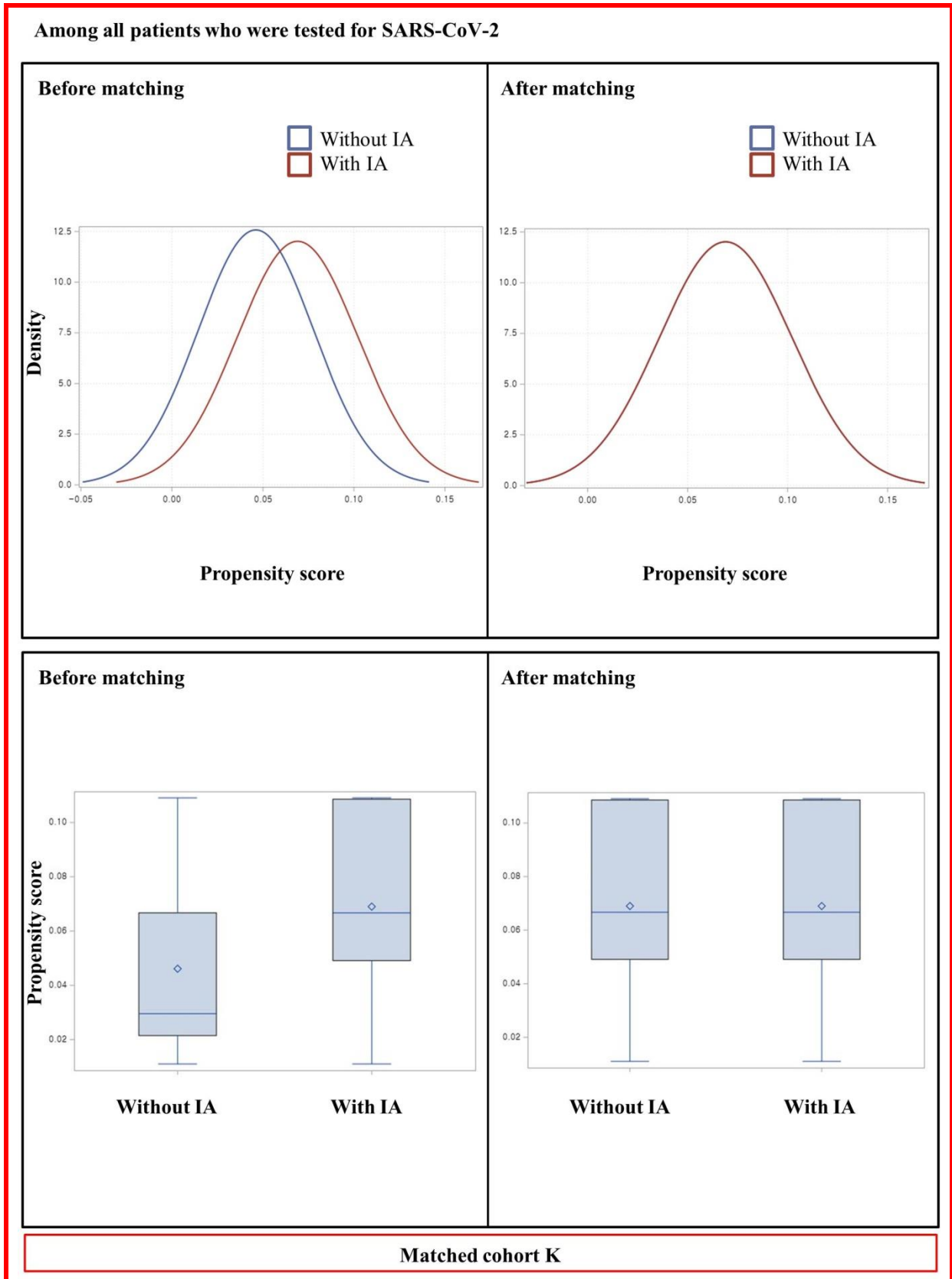
**Figure S11.** The density and distribution of propensity scores before and after matching in matched cohort I. After matching, the two curves overlap completely.



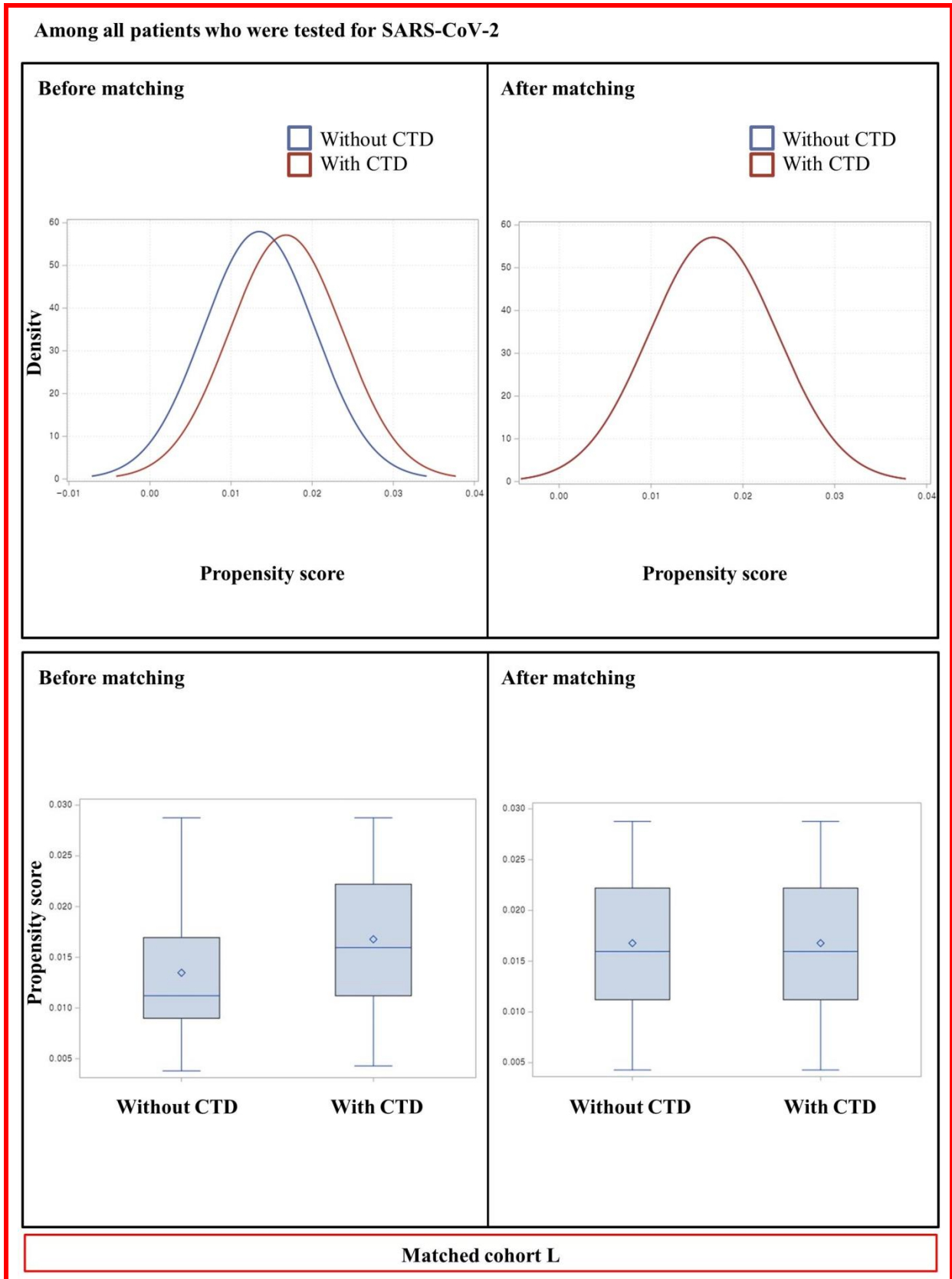
**Figure S12.** The density and distribution of propensity scores before and after matching in matched cohort J. After matching, the two curves overlap completely.



**Figure S13.** The density and distribution of propensity scores before and after matching in matched cohort K. After matching, the two curves overlap completely.

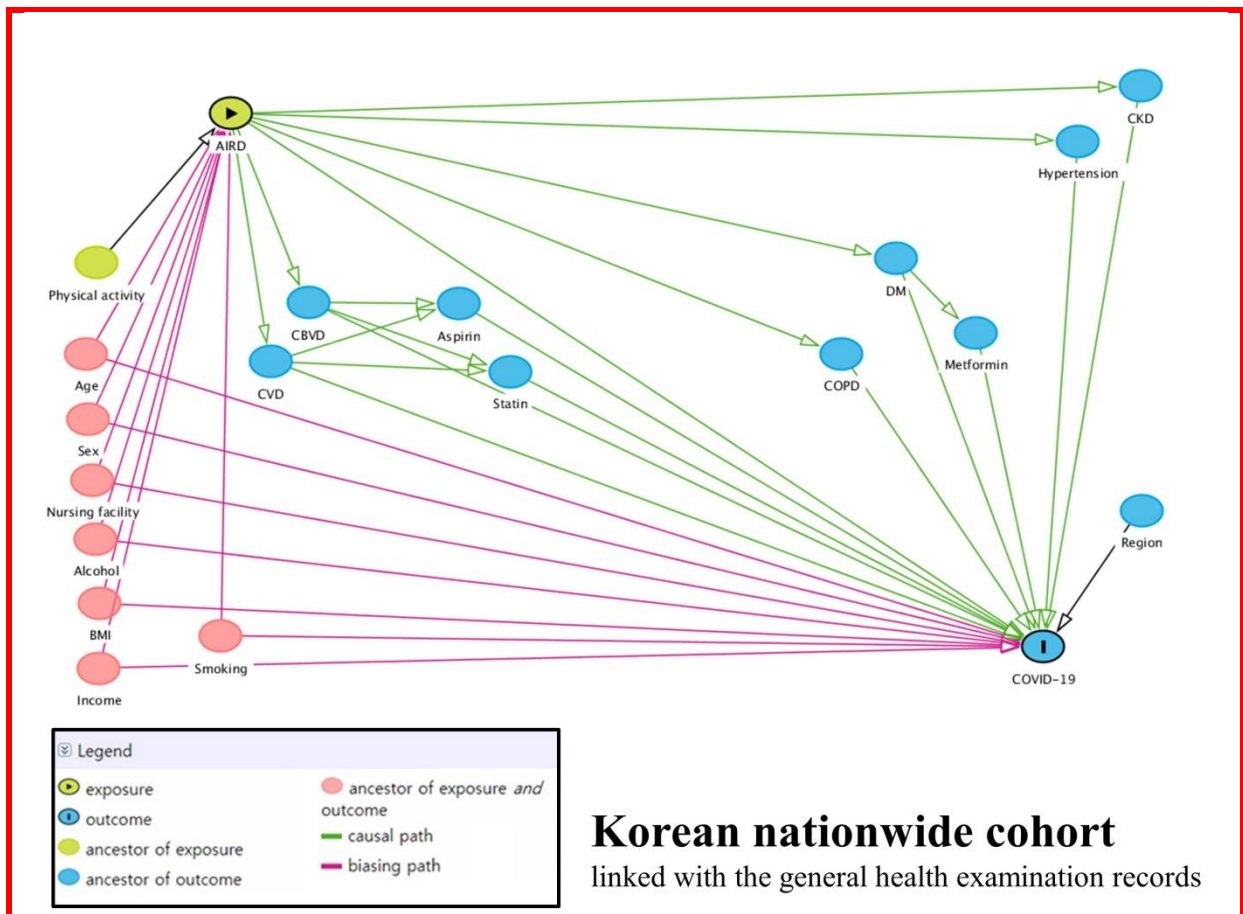


**Figure S14.** The density and distribution of propensity scores before and after matching in matched cohort L. After matching, the two curves overlap completely.



**Figure S15.** Directed acyclic graph demonstrating the implicitly assumed causal association between AIRD (“exposure”) and risk of COVID-19 (“outcome”) in the Korean nationwide cohort linked to the general health examination records before matching. Confounders, potential mediators, and exposure-outcome associations are indicated.

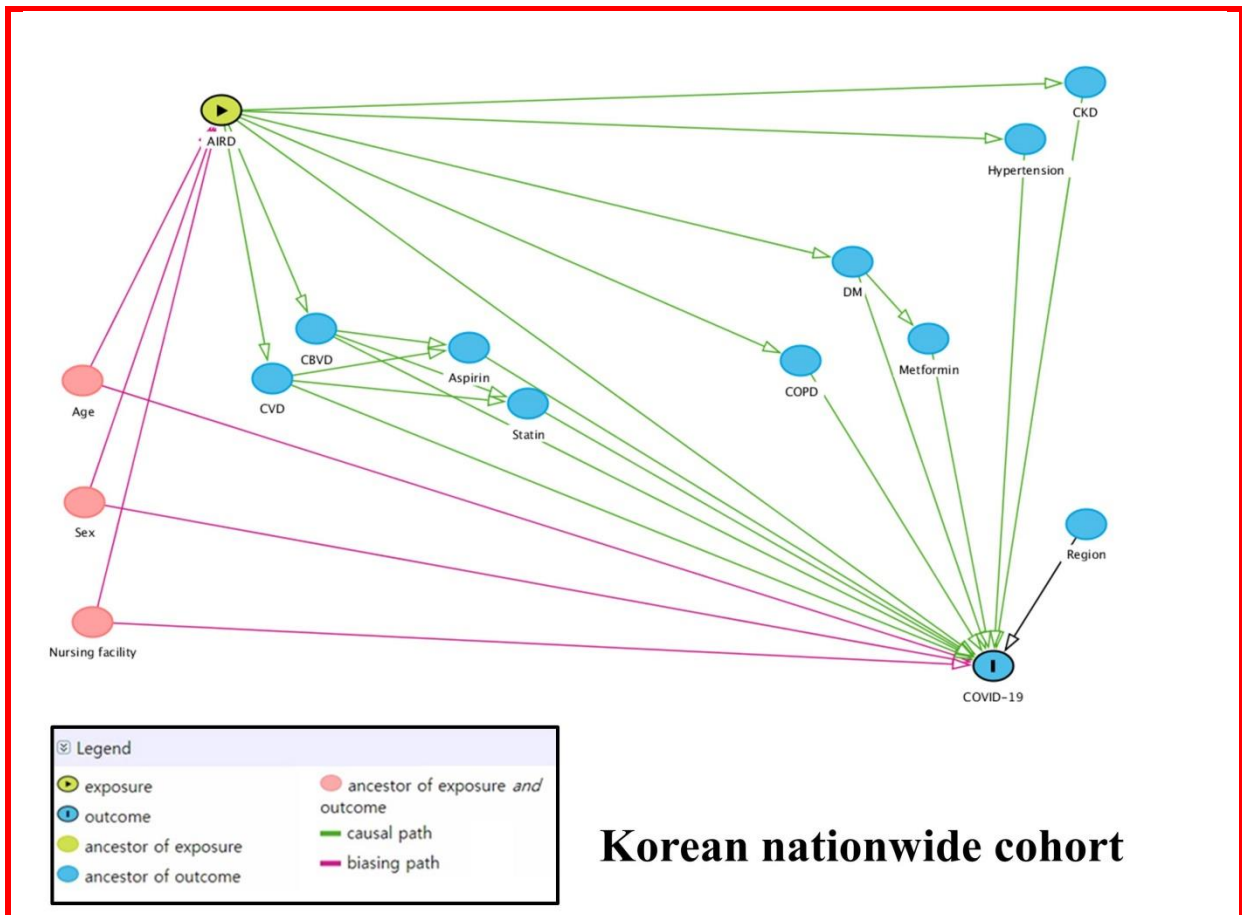
AIRD, autoimmune inflammatory rheumatic disease; BMI, body mass index; CBVD, Cerebrovascular disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; DM, Diabetes Mellitus





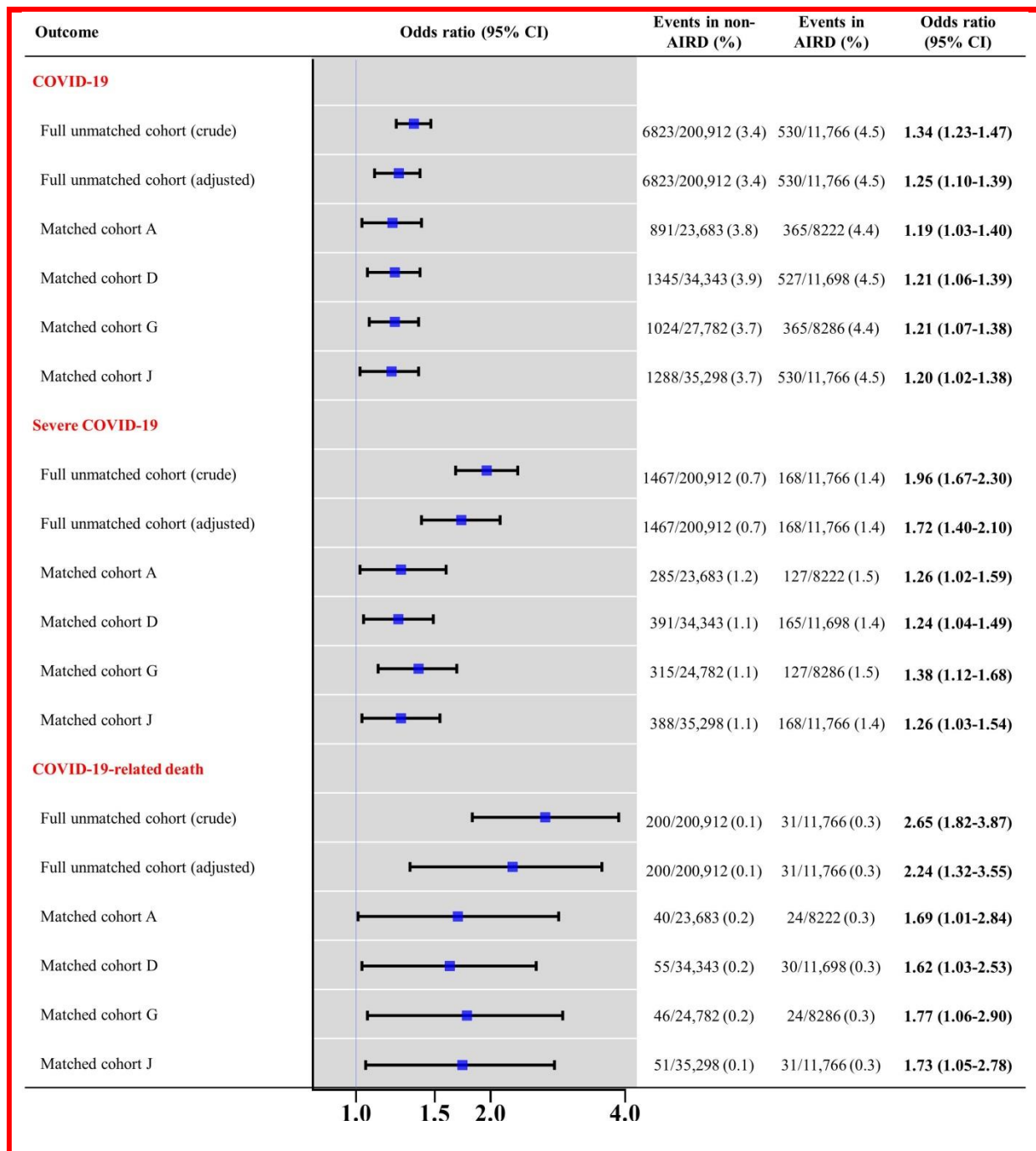
**Figure S16.** Directed acyclic graph showing the implicitly assumed causal association between AIRD (“exposure”) and risk of COVID-19 (“outcome”) in the Korean nationwide cohort without linking the general health examination records before matching. Confounders, potential mediators, and exposure-outcome associations are indicated.

AIRD, autoimmune inflammatory rheumatic disease; CBVD, Cerebrovascular disease; CKD, Chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; DM, Diabetes Mellitus



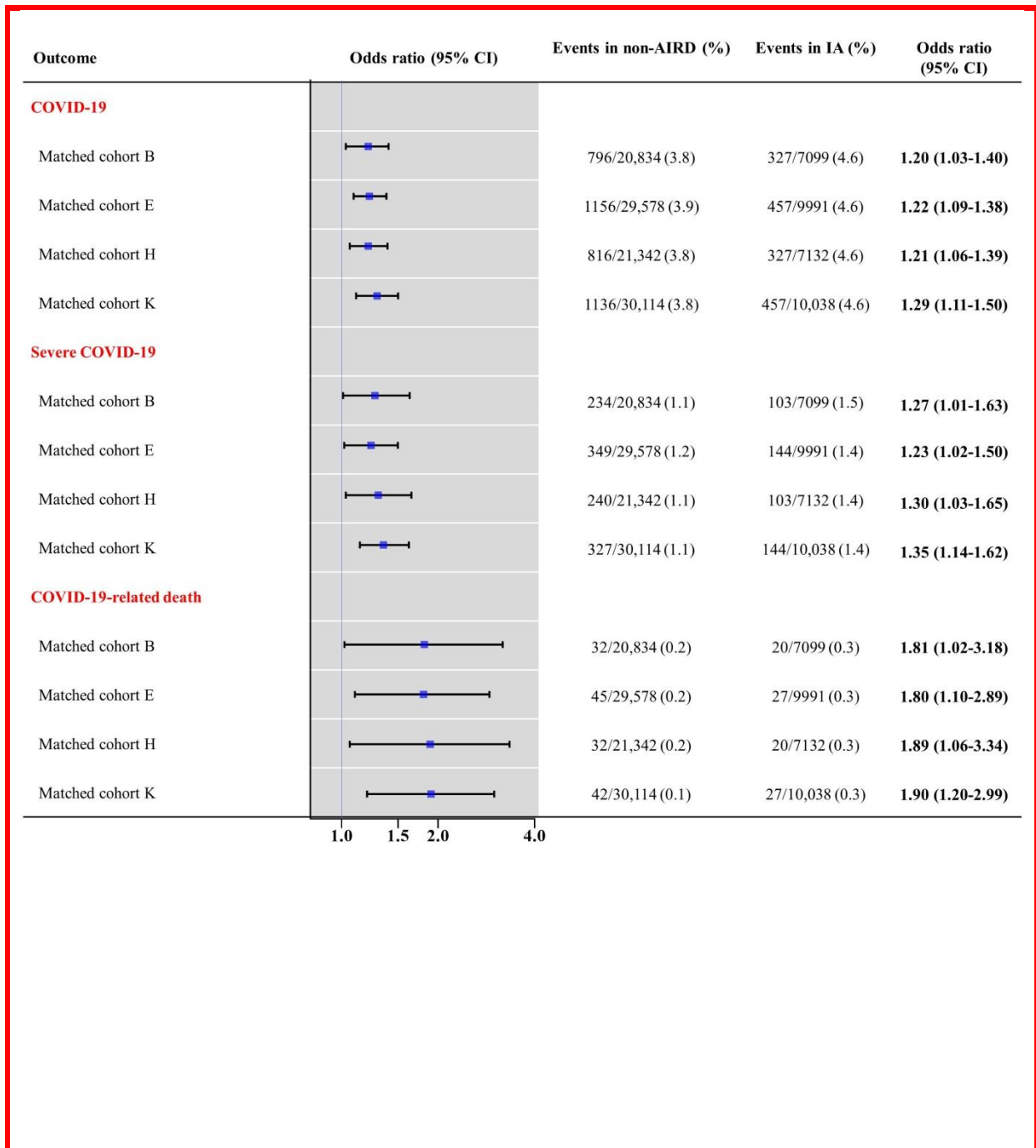
**Figure S17.** Propensity score-matched association of AIRD with SARS-CoV-2

AIRD, autoimmune inflammatory rheumatic disease; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



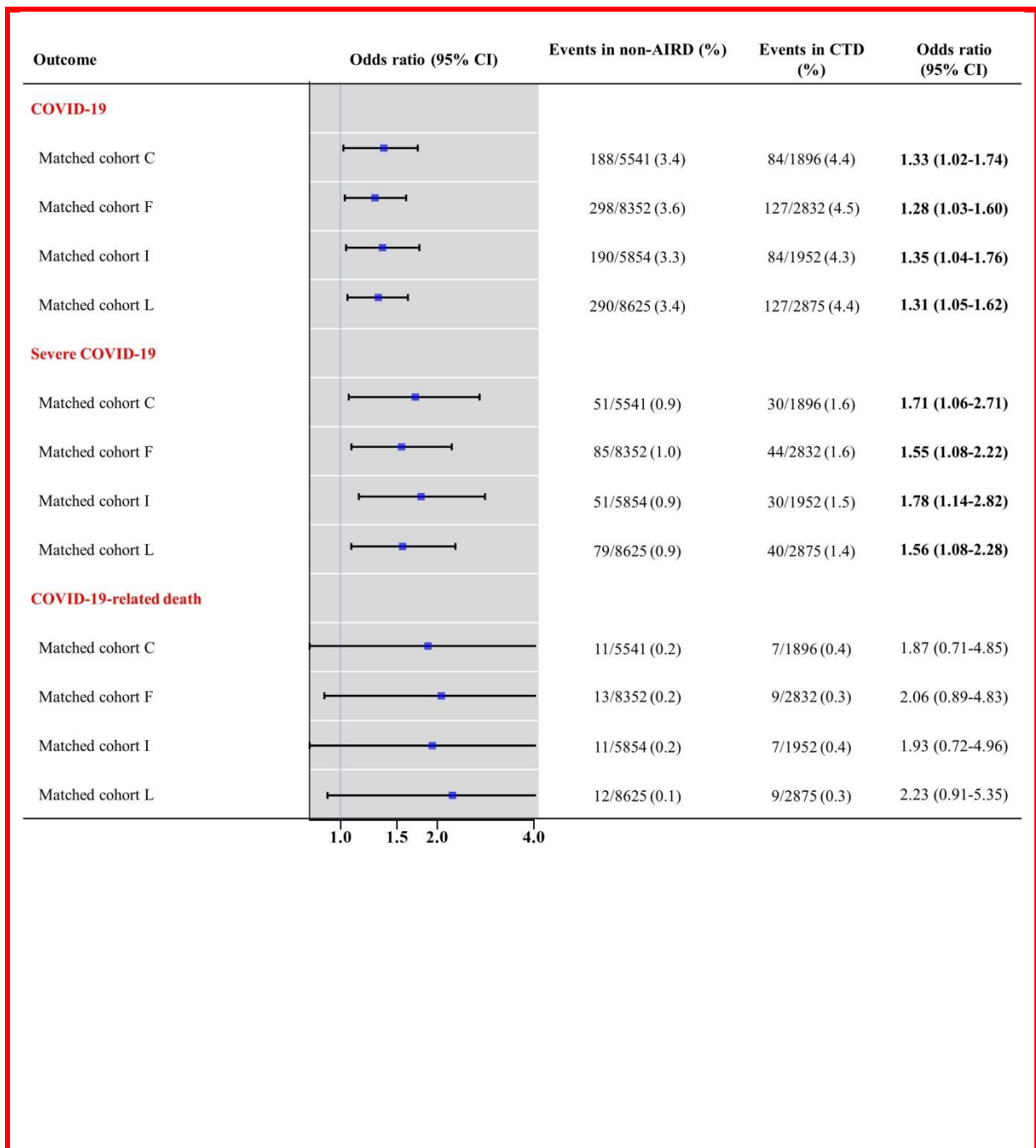
**Figure S18.** Propensity score-matched association of IA with SARS-CoV-2

AIRD, autoimmune inflammatory rheumatic disease; IA, inflammatory arthritis; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



**Figure S19.** Propensity score-matched association of CTD with SARS-CoV-2

AIRD, autoimmune inflammatory rheumatic disease; CTD, connective tissue disease; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



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**Supplement Method.** ICD-10 codes used to define etiology

<b>Etiology</b>		<b>ICD-10 codes</b>
Inflammatory arthritis	Rheumatoid arthritis	M05, M06, M08.0, M08.2-M08.9
	Psoriatic arthritis	L40.5, M07.0-07.3
	Spondyloarthritis	M45.9, M08.1
Connective tissue disease	Systemic lupus erythematosus	M32
	Sjogren's syndrome	M35.0
	Systemic sclerosis	M34.0, M34.1, M34.8, M34.9
	Polymyalgia rheumatica	M35.3
	Mixed connective tissue disease	M35.1
	Dermatomyositis/polymyositis	M33
	Polyarteritis nodosa	M30.0
	Vasculitis	I77.6, L95

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ICD-10, International Classification of Disease 10th revision.