

Association of COVID-19 with skin diseases and relevant biologics: a cross-sectional study using nationwide claim data in South Korea*

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Summary

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Background As the coronavirus disease 2019 (COVID-19) pandemic has spread, information about COVID-19 and skin disease or related biologics is still lacking. **Objectives** To identify the association between COVID-19 and skin diseases or biologics.

Methods A nationwide claim dataset relevant to COVID-19 in South Korea was analysed. This dataset included insurance claim data before and during COVID-19 treatment and clinical outcomes. Claim data related to skin diseases and relevant biologics were analysed to determine the association of COVID-19 with skin diseases and relevant biologics.

Results The dataset contained a total of 234 427 individuals (111 947 male and 122 480 female) who underwent COVID-19 testing. Of them, 7590 (3.2%) were confirmed as having COVID-19, and 227 (3.0%) confirmed patients died. Among various skin diseases and biologics, no significant increase in the presence of specific skin diseases or exposure to biologics was observed in the COVID-19-positive group, even after adjusting for or matching covariates. The presence of skin diseases and exposure to biologics also did not seem to affect clinical outcomes including mortality.

Conclusions Underlying skin diseases did not appear to increase susceptibility to COVID-19 or mortality from COVID-19. Considering the risks and benefits, biologics for dermatological conditions might be continuously used during the COVID-19 pandemic.

What is already known about this topic?

- There is concern about the association between coronavirus disease 2019 (COVID-19) and skin diseases or relevant biologics.
- Clinical information about COVID-19 and skin disease or related biologics is lacking.

What does this study add?

- Underlying skin diseases or exposure to relevant biologics did not appear to increase susceptibility to COVID-19 or mortality from COVID-19.
- Biologics for dermatological conditions might be continuously used during the COVID-19 pandemic.

Coronavirus disease 2019 (COVID-19) was first found in Wuhan, Hubei Province, China in December 2019 and has now become a global pandemic.¹ COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2),

which is an enveloped, nonsegmented, positive-sense, single-stranded RNA virus.² SARS-CoV-2 infection causes immune responses including a T-cell response.² Previous studies reported that COVID-19 can cause immune dysregulation in

the form of cytokine storms, including an elevation of inflammatory cytokines such as tumour necrosis factor (TNF)- α , interleukin (IL)-1 β , IL-4, IL-12p70 or IL-17A.^{3,4}

Many skin diseases, such as alopecia areata, atopic dermatitis, psoriasis, rosacea and vitiligo, are known to be caused by abnormal immunological pathways.^{5–9} Classic immunosuppressants are broadly used for various dermatological conditions, and recently, biologics targeting specific cytokines have been widely used in dermatology.¹⁰ Studies of patients with severe COVID-19 reported elevated serum levels of TNF- α and IL-17, which are major targets of biologics in dermatology.¹¹ In addition, recent articles have reported cases of COVID-19 in dermatological patients under biologic treatments,^{12–18} and thus there is a concern regarding maintenance of biologics for skin diseases during the COVID-19 pandemic.^{10,19}

South Korea borders China and experienced an early outbreak of COVID-19 in February 2020.²⁰ Recently, the Ministry of Health and Welfare and the Health Insurance Review & Assessment Service (HIRA) in South Korea opened a dataset of emerging confirmed cases of COVID-19 from the Korea Centers for Disease Control and Prevention (KCDC) and insurance claims relevant to cases of COVID-19 (OpenData4Covid19). In this study, we aimed to identify the association of COVID-19 with the presence of skin diseases and the use of biologics.

Patients and methods

Study design, data source and study population

This study was a cross-sectional study using nationwide claim data in South Korea. The OpenData4Covid19 project is provided by HIRA via their website (<https://hira-covid19.net>). According to the guidelines in South Korea, KCDC confirmed cases of COVID-19 based on laboratory tests, SARS-CoV-2 real-time reverse-transcriptase polymerase chain reaction, or virus isolation.^{20,21} HIRA released a dataset of relevant insurance claims up to 15 May 2020 of those who were tested for COVID-19, along with the individual's claim records for the past 3 years, which were merged with data of SARS-CoV-2 confirmation and mortality from KCDC (Figure 1).

The government of South Korea has actively traced people suspected of SARS-CoV-2 infection or those who had close contact with patients with COVID-19, based on advanced information technology,^{22,23} to find almost all potential patients with COVID-19 in South Korea.^{23,24} In this regard, the OpenData4Covid19 dataset built by HIRA and KCDC contains almost all confirmed and suspicious but negative cases of COVID-19 in South Korea and is highly reliable.

This study was approved by the institutional review board of Seoul National University Hospital (no. E-2004-036-1116).

Definition of skin diseases and related biologics

The dataset contains all claim records of patients up to 3 years before COVID-19 tests. All Korean residents are required to join the National Health Insurance System, and insurance

claims regarding their visits to any health institution are stored in this system.²⁵ Thus, the dataset contained all medical insurance claim data of the patient, including dates of visits, the locations of medical institutes, diagnostic codes, procedures, treatments and the prescription of drugs.²⁶

Patients with specific skin diseases were defined as those who had more than three claim records between 2017 and COVID-19 testing, with International Classification of Diseases 10th Revision codes as follows: alopecia areata (L63.x), atopic dermatitis (L20.x), psoriasis (L40.x), rosacea (L71.x) and vitiligo (L80). In adjusting for other comorbidities, patients with diabetes (E10.x–E14.x), hypertension (I10.x), heart failure (I50.x) and chronic pulmonary disease (CPD; I27.8, I27.9, J40–J47, J60–J67.x, J68.4, J70.1, J70.3) were defined by the same method.

Patients exposed to biologics were defined as those with a history of any biologic prescription between October 2019 and COVID-19 testing, considering the early outbreak in South Korea. Biologics approved for dermatological use (including psoriatic arthritis) in South Korea are as follows: TNF- α inhibitors (etanercept, adalimumab, infliximab, golimumab), IL-12/23 inhibitor (ustekinumab), IL-23 inhibitor (guselkumab), IL-17 inhibitors (secukinumab, ixekizumab) and IL-4/13 inhibitor (dupilumab).

Clinical outcomes

The main outcome in this study was SARS-CoV-2 infection among patients with specific skin diseases and those being treated with biologics. The secondary outcome was a severe clinical course in patients with SARS-CoV-2 infection, defined by hospitalization, admission to an intensive care unit (ICU), ventilator use or mortality. Hospitalization was confirmed by the claim dataset relevant to admission. ICU admission and ventilator use were defined by the claim record during hospitalization for COVID-19 treatment. Mortality was based on the transferred data from KCDC mentioned above.

Statistical analysis

To reduce potential bias, we matched controls to cases according to propensity scores computed with a nonparsimonious logistic regression model. The covariates included for propensity scores were age, sex, residency, and comorbidities including diabetes, hypertension, heart failure and CPD. An explosive outbreak related to a religious group in Daegu and Gyeongsangbuk-do (Dae-Gyeong area) occurred,²⁰ and thus residency was further subdivided as to whether a patient was in the Dae-Gyeong area or not. These locations had more confirmed cases of COVID-19 per population than other cities or provinces in South Korea. For example, the number of confirmed cases in the Dae-Gyeong area was 72.4 per 100 000 persons, which was more than 66 times greater than the 1.1 per 100 000 persons in other cities and provinces in South Korea, as of 2 March 2020.²⁰

Pearson's χ^2 -test or Fisher's exact test was used for categorical variables, and Student's t-test was used for continuous

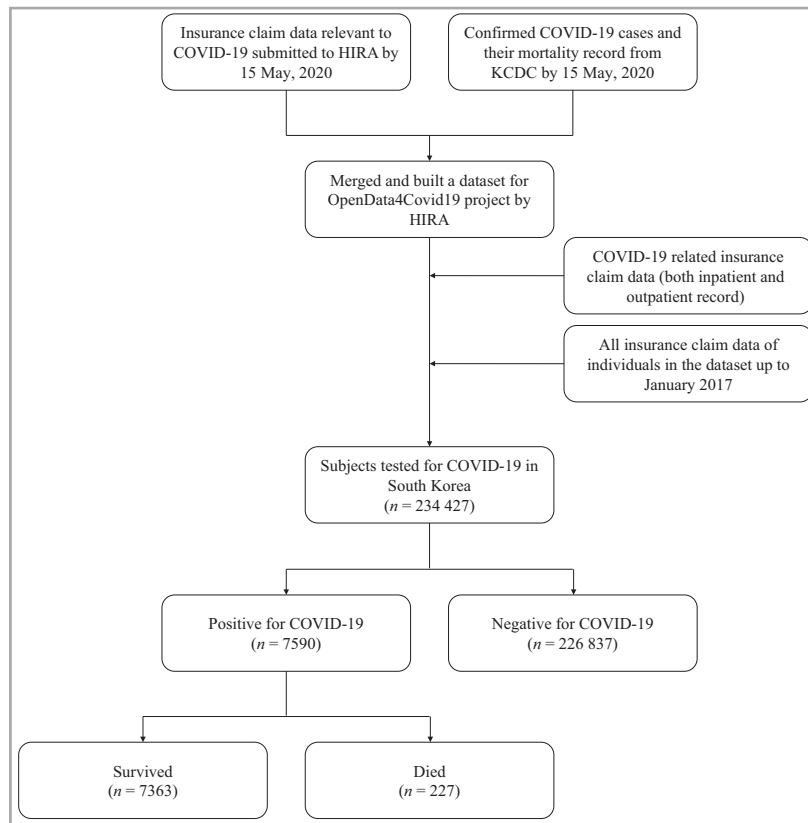


Figure 1 Summary of the OpenData4Covid19 dataset. HIRA, Health Insurance Review & Assessment Service; KCDC, Korea Centers for Disease Control and Prevention.

variables. Outcomes from logistic regression are presented as odds ratios with 95% confidence intervals. All statistical tests were performed with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Demographics of the population

The dataset contained 234 427 patients (111 947 male and 122 480 female) who had been tested for COVID-19. Of them, 7590 (3.2%; 3095 male and 4495 female) were positive for COVID-19. The COVID-19-positive group had more female patients and was younger overall compared with the COVID-19-negative group (Table 1). Most COVID-19 testing was conducted in provinces other than the Dae-Gyeong area ($n = 197\,252$, 84.1%), but there were more confirmed COVID-19 cases in the Dae-Gyeong area ($n = 4234$, 55.8%). Thus, the rate of positive COVID-19 tests was significantly higher in the Dae-Gyeong area (11.4% vs. 1.7%, $P < 0.001$).

Association between COVID-19-positive test results and skin diseases or use of biologics

No significant increase was seen in the presence of specific skin diseases in the COVID-19-positive group (Table 2). After

adjusting for age, sex, residence and comorbidities, no skin disease was found to increase the risk of COVID-19 (Table 3). Subgroup analyses in the Dae-Gyeong area and other provinces were also consistent with this result (Tables 2 and 3). Similarly, the use of neither single biologics nor classes of biologics showed an increase in susceptibility to COVID-19.

Additional analysis in the propensity-score-matched population showed consistent results. We selected two controls matched to a case by propensity score, considering age, sex, residency and comorbidities. After matching, the demographics became comparable between the groups positive and negative for COVID-19, and no increases in the presence of skin diseases or the use of biologics were found (Tables S1 and S2; see Supporting Information). Furthermore, we built propensity-score-matched populations for each class of biologics with a 1 : 10 ratio, and found a consistent result regarding susceptibility to COVID-19 in patients treated with biologics (Table S3; see Supporting Information).

Association between the clinical outcomes of the COVID-19-positive group and skin diseases or use of biologics

Of the patients with COVID-19, 227 (3.0%) died, and most of them died while hospitalized (218, 96.0%). They were significantly older (mean \pm SD 77.1 ± 10.8 years) than those who survived (44.9 ± 19.2 years), and all comorbidities

Table 1 Demographics of the population according to the results of COVID-19 testing

	Total			Areas					
	COVID-19 negative n = 226 837	COVID-19 positive n = 7590	P-value	Dae-Gyeong area ^a			Other cities and provinces		
				COVID-19 negative n = 32 941	COVID-19 positive n = 4234	P-value	COVID-19 negative n = 193 896	COVID-19 positive n = 3356	P-value
Sex			< 0.001			< 0.001			< 0.001
Male	108 852 (48.0)	3095 (40.8)		15 743 (47.8)	1707 (40.3)		93 109 (48.0)	1388 (41.4)	
Female	117 985 (52.0)	4495 (59.2)		17 198 (52.2)	2527 (59.7)		100 787 (52.0)	1968 (58.6)	
Age (years), mean ± SD)	46.8 ± 21.9	45.9 ± 19.8	< 0.001	48.4 ± 21.0	50.3 ± 20.0	< 0.001	46.6 ± 20.0	40.3 ± 18.0	< 0.001
Age (years)			< 0.001			< 0.001			< 0.001
0–9	9211 (4.1)	82 (1.1)		968 (2.9)	37 (0.9)		8243 (4.3)	45 (1.3)	
10–19	8367 (3.7)	346 (4.6)		925 (3.0)	132 (3.1)		7442 (3.8)	214 (6.4)	
20–29	39 827 (17.6)	1855 (24.4)		5355 (16.3)	809 (19.1)		34 472 (17.8)	1046 (31.2)	
30–39	38 517 (17.0)	776 (10.2)		5202 (15.8)	367 (8.7)		33 315 (17.2)	409 (12.2)	
40–49	32 010 (14.1)	1003 (13.2)		4960 (15.1)	512 (12.1)		27 050 (14.0)	491 (14.6)	
50–59	30 303 (13.4)	1503 (19.8)		5218 (15.8)	886 (20.9)		25 085 (12.9)	617 (18.4)	
60–69	25 859 (11.4)	1061 (14.0)		4129 (12.5)	737 (17.4)		21 730 (11.2)	324 (9.6)	
70–79	22 544 (9.9)	590 (7.8)		3252 (9.9)	444 (10.5)		19 292 (9.9)	146 (4.4)	
≥ 80	20 199 (8.9)	374 (4.9)		2932 (8.9)	310 (7.3)		17 267 (8.9)	64 (1.9)	
Province			< 0.001						
Dae-Gyeong area ^a	32 941 (14.5)	4234 (55.8)							
Others	193 896 (85.5)	3356 (44.2)							
Comorbidity									
Diabetes mellitus	37 067 (16.3)	965 (12.7)	< 0.001	5283 (16.0)	712 (16.8)	0.35	31 784 (16.4)	253 (7.5)	< 0.001
Hypertension	61 350 (27.0)	1573 (20.7)	< 0.001	9040 (27.4)	1133 (26.8)	0.20	52 310 (27.0)	440 (13.1)	< 0.001
Heart failure	9503 (4.2)	171 (2.3)	< 0.001	1547 (4.7)	141 (3.3)	< 0.001	7956 (4.1)	30 (0.9)	< 0.001
CPD	70 426 (31.0)	1500 (19.8)	< 0.001	9268 (28.1)	932 (22.0)	< 0.001	61 158 (31.5)	568 (16.9)	< 0.001

The data are presented as n (%) unless stated otherwise. CPD, chronic pulmonary disease. ^aIncluding Daegu and Gyeongsangbuk-do.

(including diabetes, hypertension, heart failure and CPD) were more common in those who died ($P < 0.001$ in each) (Table S4; see Supporting Information). Most deaths occurred in the Dae-Gyeong area ($n = 201$, 88.5%). In total 7157 patients (94.3%) were admitted to hospital for COVID-19. Of the inpatients, 216 (3.0%) were admitted to the ICU, and 127 (1.8%) used a ventilator.

No significant association between cases with mortality and the presence of skin disease was observed (Table 4). The hospitalization rate did not increase significantly in patients with skin diseases or in patients exposed to any biologics. In addition, in the COVID-19-positive hospitalization group, there was no significant association between skin diseases and ICU admission or ventilator use. In addition, no COVID-19-positive patient exposed to biologics had a record of ICU admission, ventilator use or mortality.

There was a significant difference in hospitalization according to region, with a hospitalization rate of 91.8% in the Dae-Gyeong area and 97.4% in other areas ($P < 0.001$). However, the associations between death and sex, age, underlying disease, skin disease and relevant biologics were similar in the two regional groups (Tables S4 and S5; see Supporting Information).

Discussion

The present study is a nationwide analysis of the association between COVID-19 and dermatological diseases or biologics. The dataset is highly reliable as it captured COVID-19-related claim data of the Korean population from both confirmed cases and negative cases, provided by Korean government institutions.

It has been reported that inflammatory cytokines such as TNF- α and IL-17 are increased in patients with COVID-19, which sometimes results in fatal cytokine storms.^{3,4,11} It is well known that immunological mechanisms are important in the pathogenesis of various skin diseases. For example, acne, alopecia areata, atopic dermatitis, hidradenitis suppurativa, psoriasis and vitiligo show elevated levels of IL-17,²⁷ which can play an important role in acute respiratory distress syndrome in COVID-19.²⁸ Thus, it is not unreasonable to suspect that skin diseases with immunological pathogenesis might affect the clinical course of COVID-19.

However, in this study, patients with any dermatological disease did not show an increased susceptibility to SARS-CoV-2 infection. Among patients with COVID-19, the presence of

Table 2 The rate of the presence of various skin diseases and exposure to biologics according to the results of COVID-19 testing

	Total			Areas					
			P-value	Dae-Gyeong area ^a			Other cities and provinces		
	COVID-19 negative n = 226 837	COVID-19 positive n = 7590		COVID-19 negative n = 32 941	COVID-19 positive n = 4234	P-value	COVID-19 negative n = 193 896	COVID-19 positive n = 3356	P-value
Skin disease									
Alopecia areata	1383 (0.6)	42 (0.6)	0.54	241 (0.7)	21 (0.5)	0.085	1142 (0.6)	21 (0.6)	0.78
Atopic dermatitis	8640 (3.8)	180 (2.4)	< 0.001	950 (2.9)	93 (2.2)	0.011	7690 (4.0)	87 (2.6)	< 0.001
Psoriasis	1717 (0.8)	55 (0.7)	0.75	260 (0.8)	35 (0.8)	0.78	1457 (0.8)	20 (0.6)	0.30
Rosacea	473 (0.2)	11 (0.1)	0.23	52 (0.2)	5 (0.1)	0.68	421 (0.2)	6 (0.2)	0.64
Vitiligo	383 (0.2)	12 (0.2)	0.82	63 (0.2)	8 (0.2)	0.97	320 (0.2)	4 (0.1)	0.52
Biologics									
TNF- α inhibitors	339 (0.15)	3 (0.04)	0.009	50 (0.15)	1 (0.02)	0.026	289 (0.15)	2 (0.06)	0.25
Etanercept	47 (0.02)	1 (0.01)	1.00	8 (0.02)	0	0.61	39 (0.02)	1 (0.03)	0.50
Infliximab	151 (0.07)	1 (0.01)	0.10	14 (0.04)	0	0.39	137 (0.07)	1 (0.03)	0.74
Adalimumab	132 (0.06)	1 (0.01)	0.14	27 (0.08)	1 (0.02)	0.36	105 (0.05)	0	0.43
Golimumab	14 (0.01)	0	1.00	2 (0.01)	0	1.00	12 (0.01)	0	1.00
IL-12/23 or IL-23 inhibitors	34 (0.01)	0	0.63	4 (0.01)	0	1.00	30 (0.02)	0	1.00
Ustekinumab	24 (0.01)	0	1.00	2 (0.01)	0	1.00	22 (0.01)	0	1.00
Guselkumab	11 (< 0.01)	0	1.00	2 (0.01)	0	1.00	9 (< 0.01)	0	1.00
IL-17 inhibitors	17 (0.01)	2 (0.03)	0.13	2 (0.01)	1 (0.02)	0.30	15 (0.01)	1 (0.03)	0.24
Secukinumab	11 (< 0.01)	2 (0.03)	0.065	0	1 (0.02)	0.11	11 (0.01)	1 (0.03)	0.19
Ixekizumab	6 (< 0.01)	0	1.00	2 (0.01)	0	1.00	4 (< 0.01)	0	1.00
IL-4/13 inhibitors	9 (< 0.01)	0	1.00	1 (< 0.01)	0	1.00	8 (< 0.01)	0	1.00

IL, interleukin; TNF, tumour necrosis factor. ^aIncluding Daegu and Gyeongsangbuk-do.

any dermatological disease also did not affect the clinical outcome, including ICU admission, ventilator use or mortality. As various comorbidities like diabetes, hypertension and CPD are associated with poor prognosis after COVID-19,^{29,30} we adjusted for these comorbidities, as well as age and sex, and found the same result. This trend was consistent even in the analyses of the propensity-score-matched population and subgroups according to the region with an explosive outbreak.

Continuing biologics during the COVID-19 pandemic is an important issue. Discontinuation of biologics usually results in relapse of skin disease, including psoriasis,^{31,32} and some patients are unable to achieve the previous response to biologics.³³ The guideline from the American Academy of Dermatology did not recommend discontinuation of biologics without evidence of COVID-19 infection or reasonable risk.³⁴ Another statement from the European Task Force on Atopic Dermatitis also recommended biologics such as dupilumab for atopic dermatitis during the COVID-19 pandemic, because they are not considered to increase the risk of viral infection.³⁵ However, clinical evidence for continuing biologics for dermatological diseases is insufficient, and there are concerns derived from clinical trials of biologics reporting an increasing risk of various infectious diseases, such as those caused by bacteria and fungi or tuberculosis.^{19,36,37}

Recently, a study from a single hospital cohort in Lombardy, Italy reported that the rates of COVID-19 were higher in patients treated with biologics than in residents in the same province.³⁸ On the other hand, there was no ICU admission

or deaths among patients with psoriasis treated with biologics in the same study.³⁸ However, this study from Lombardy is limited because the method of capturing data was different between cases and controls. Furthermore, the differences in demographic characteristics and comorbidities between groups were not considered. Other observational studies from Italy showed no increase in hospitalization due to COVID-19 and no cases of death from COVID-19 in patients treated with biological therapy compared with the general population.^{12,14,39} In several cases, dermatological patients receiving biologics were reported to recover from COVID-19 infection without complications.^{15–18} The results of the present study, like the other studies mentioned, showed that the use of biologics in dermatological patients may not increase the susceptibility to COVID-19 and may not lead to injurious clinical outcomes after COVID-19.

This study had some limitations. Firstly, the data from insurance benefit claims did not include detailed clinical information such as disease severity or lab results. The definition of skin diseases was based on the diagnostic codes, which might cause misclassification of some individuals. Secondly, medications other than biologics were not included in the analysis. Thirdly, there could be racial or ethnic disparities in reference to COVID-19 infection.⁴⁰ Fourthly, the number of patients exposed to biologics other than TNF- α inhibitors was relatively small. Thus, additional research is needed to overcome racial or ethnic disparities and small sporadic reports from across the world. Dermatologists around the world can work

Table 3 Odds ratios of various skin diseases and exposure to biologics in the COVID-19-positive group compared with the COVID-19-negative group

	Model 1		Model 2		Model 3	
	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value
Skin disease						
Alopecia areata	0.91 (0.67–1.23)	0.53	0.82 (0.60–1.12)	0.21	0.69 (0.44–1.08)	0.10
Atopic dermatitis	0.61 (0.52–0.71)	< 0.001	0.76 (0.65–0.88)	< 0.001	0.82 (0.66–1.02)	0.073
Psoriasis	1.00 (0.77–1.31)	0.98	1.03 (0.78–1.36)	0.81	1.07 (0.75–1.53)	0.70
Rosacea	0.68 (0.38–1.24)	0.21	0.80 (0.44–1.48)	0.48	0.75 (0.30–1.87)	0.53
Vitiligo	0.92 (0.52–1.64)	0.78	0.86 (0.48–1.54)	0.60	0.95 (0.45–1.98)	0.89
Biologics						
TNF- α inhibitors	0.27 (0.088–0.84)	0.024	0.27 (0.087–0.85)	0.026	0.18 (0.024–1.27)	0.085
Etanercept	0.64 (0.089–4.63)	0.66	0.66 (0.089–4.91)	0.68	NA	0.93
Infliximab	0.20 (0.028–1.43)	0.11	0.23 (0.032–1.67)	0.15	NA	0.93
Adalimumab	0.24 (0.034–1.67)	0.15	0.20 (0.027–1.42)	0.11	0.32 (0.044–2.38)	0.27
Golimumab	NA	0.92	NA	0.91	NA	0.95
IL-12/23 or IL-23 inhibitors	NA	0.92	NA	0.89	NA	0.95
Ustekinumab	NA	0.90	NA	0.91	NA	0.95
Guselkumab	NA	0.90	NA	0.90	NA	0.94
IL-17 inhibitors	3.53 (0.82–15.3)	0.092	3.56 (0.77–16.6)	0.11	4.21 (0.37–47.8)	0.25
Secukinumab	5.44 (1.20–24.6)	0.028	6.87 (1.40–33.8)	0.018	NA	0.93
Ixekizumab	NA	0.93	NA	0.93	NA	0.95
IL-4/13 inhibitors	NA	0.91	NA	0.92	NA	0.94

CI, confidence interval; IL, interleukin; NA, not applicable; TNF, tumour necrosis factor. Model 1: result of logistic regression after adjustment for age and sex. Model 2: result of logistic regression after adjustment for age, sex, residence, diabetes, hypertension, congestive heart failure and chronic pulmonary disease. Model 3: result of logistic regression in Daegu and Gyeongsangbuk-do after adjustment for age, sex, diabetes, hypertension, heart failure and chronic pulmonary disease.

Table 4 Association of clinical outcomes in patients with COVID-19 with various skin diseases and exposure to biologics

	Mortality (n = 7590)			Admission (n = 7590)			In-hospital patient with COVID-19 (n = 7157)					
	Survived (n = 7363)		P-value	Without (n = 433)		P-value	Intensive care unit event			Ventilator event		
	Died (n = 227)	Without (n = 433)		With (n = 7157)	Without (n = 6941)		With (n = 216)	P-value	Without (n = 7030)	With (n = 127)	P-value	
Skin disease												
Alopecia areata	42 (0.6)	0	0.64	6 (1.4)	36 (0.5)	0.016	36 (0.5)	0	0.63	36 (0.5)	0	1.00
Atopic dermatitis	172 (2.3)	8 (3.5)	0.25	10 (2.3)	170 (2.4)	0.93	166 (2.4)	4 (1.9)	0.82	166 (2.4)	4 (3.1)	0.55
Psoriasis	51 (0.7)	4 (1.8)	0.081	3 (0.7)	52 (0.7)	1.00	49 (0.7)	3 (1.4)	0.21	50 (0.7)	2 (1.6)	0.24
Rosacea	11 (0.1)	0	1.00	0	11 (0.2)	1.00	11 (0.2)	0	1.00	11 (0.2)	0	1.00
Vitiligo	11 (0.1)	1 (0.4)	0.31	0	12 (0.2)	1.00	12 (0.2)	0	1.00	12 (0.2)	0	1.00
Biologics												
TNF- α inhibitors	3 (0.04)	0	1.00	0	3 (0.04)	1.00	3 (0.04)	0	1.00	3 (0.04)	0	1.00
Etanercept	1 (0.01)	0	1.00	0	1 (0.01)	1.00	1 (0.01)	0	1.00	1 (0.01)	0	1.00
Infliximab	1 (0.01)	0	1.00	0	1 (0.01)	1.00	1 (0.01)	0	1.00	1 (0.01)	0	1.00
Adalimumab	1 (0.01)	0	1.00	0	1 (0.01)	1.00	1 (0.01)	0	1.00	1 (0.01)	0	1.00
Golimumab	0	0	NA	0	0	NA	0	0	NA	0	0	NA
IL-12/23 or IL-23 inhibitors	0	0	NA	0	0	NA	0	0	NA	0	0	NA
Ustekinumab	0	0	NA	0	0	NA	0	0	NA	0	0	NA
Guselkumab	0	0	NA	0	0	NA	0	0	NA	0	0	NA
IL-17 inhibitors	2 (0.03)	0	1.00	0	2 (0.03)	1.00	2 (0.03)	0	1.00	2 (0.03)	0	1.00
Secukinumab	2 (0.03)	0	1.00	0	2 (0.03)	1.00	2 (0.03)	0	1.00	2 (0.03)	0	1.00
Ixekizumab	0	0	NA	0	0	NA	0	0	NA	0	0	NA
IL-4/13 inhibitors	0	0	NA	0	0	NA	0	0	NA	0	0	NA

IL, interleukin; NA, not applicable; TNF, tumour necrosis factor.

together to build case registries to overcome the small sample sizes of dermatological patients with COVID-19 to inform evidence-based management practices during the COVID-19 pandemic.^{41–43} In addition, even if the skin disease itself does not increase the susceptibility to SARS-CoV-2 infection, in order to reduce potential exposure of dermatological patients to patients with COVID-19, it is necessary to reduce nonurgent outpatient visits and consider telemedicine during the COVID-19 pandemic.^{42,44}

This study showed that patients with various dermatological diseases or exposure to biologics were not particularly susceptible to COVID-19 and did not have worse outcomes of COVID-19 compared with others. Further research needs to be conducted to determine whether these associations are also observed in other population groups. Dermatologists may continue treatment during the COVID-19 pandemic, taking the patient's risks and benefits into consideration and following the latest guidelines from dermatology groups.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1 Demographics of the population according to the results of COVID-19 tests, after propensity score matching.

Table S2 The rate of the presence of various skin diseases and exposure to biologics according to COVID-19 test results after propensity score matching.

Table S3 Comparison of the rates of positive COVID-19 tests between patients exposed to biologics and propensity-score-matched controls.

Table S4 Demographics of the population according to the mortality from COVID-19.

Table S5 The rate of the presence of various skin diseases and exposure to biologics according to the mortality from COVID-19.

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