

Original Article



# Facial Dermatoses Associated With Mask-Wearing in the COVID-19 Era: A Nationwide, Cross-Sectional, Multicenter, Questionnaire-based Study

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## ABSTRACT

**Background:** Daily usage of facial masks during coronavirus disease 2019 pandemic influenced on facial dermatoses.

**Objective:** This study investigated the impact of mask-wearing habits on facial dermatoses.

**Methods:** A nationwide, observational, questionnaire-based survey was conducted from July through August 2021, involving 20 hospitals in Korea.

**Results:** Among 1,958 facial dermatoses, 75.9% of patients experienced aggravation or

development of new-onset facial dermatoses after wearing masks. In aggravated or newly developed acne patients (543 out of 743), associated factors were healthcare provider, female gender, and a long duration of mask-wearing. Irritating symptoms, xerosis, and hyperpigmentation were more frequently observed in this group. Aggravated or newly developed rosacea patients (515 out of 660) were likely to be female, young, and have a long duration of mask-wearing per day. Seborrheic dermatitis patients who experienced aggravation or *de novo* development (132 out of 184) were younger, and they more frequently involved the chin and jaw in addition to the nasolabial folds and both cheeks. Contact dermatitis patients (132 out of 147) with aggravation or *de novo* development tended to be female, involve both cheeks, and complain of pruritus. Aggravated or newly developed atopic dermatitis patients (165 out of 224) were more likely to be female, and had a higher baseline investigator global assessment score before mask-wearing.

**Conclusion:** Clinical features and factors related to aggravation were different according to the types of facial dermatoses.

**Keywords:** Acne vulgaris; Atopic dermatitis; Contact dermatitis; Masks; Rosacea

## INTRODUCTION

The unprecedented coronavirus disease 2019 (COVID-19) pandemic has changed our daily routine significantly. A variety of non-pharmaceutical interventions (NPIs), including social distancing, lockdown measures, and mask-wearing have been adopted worldwide<sup>1-4</sup>. Despite ongoing debate of the cost-effectiveness of such public health measures, wearing personal protective equipment (PPE), such as facial masks, is considered important for containing the virus and is recommended in most countries<sup>1,5</sup>. In Korea, the use of facial hygienic masks has been mandatory in public places since February 2020<sup>6</sup>.

In dermatology practice, physicians have encountered patients who developed *de novo* facial dermatoses or experienced aggravation of pre-existing diseases after prolonged and frequent wearing of masks. A previous survey-based study conducted in Thailand revealed that adverse cutaneous reactions associated with facial mask use were observed in 54.5% of patients, with acne (39.9%) being the most common adverse skin reaction, followed by facial rashes (18.4%) and itching (15.6%)<sup>7</sup>. Moreover, previous studies have reported flare-ups or new-onset acne, rosacea, contact dermatitis, and seborrheic dermatitis<sup>8-10</sup>. A variety of factors, such as changes in the skin microbiome, mechanical irritation, increased skin temperature, along with sweat retention and chemical exposure, are suggested mechanisms underlying the aggravation or development of mask-associated facial dermatoses<sup>11,12</sup>.

Although previous case reports and case series have demonstrated a substantial influence of mask-wearing on each disease entity, there have been few integrated analyses of the impact of mask-wearing habits on facial dermatoses. Therefore, this study investigated the influence of protective facial mask-wearing on facial dermatosis development and aggravation, and compared aggravating factors, symptoms, and locations associated with each encountered type of eruption.

## MATERIALS AND METHODS

### Study design and patients

This multicenter, observational, questionnaire-based survey was conducted from July through August 2021, involving the dermatology departments of 20 tertiary or university hospitals in the Republic of Korea. Patients from the general public with facial dermatoses who visited these departments were included in the analysis. The specific inclusion criteria were the presence of facial dermatological disease, ability to understand and answer the survey questions, and having worn facial masks since the beginning of COVID-19 pandemic. There were no limitations in terms of sex, age, or disease entities.

### Questionnaire

Patient characteristics (e.g., age at the time of survey completion, sex, Fitzpatrick skin type) and clinical features (e.g., type of facial dermatosis, time to diagnosis, disease severity, and therapeutic history) were recorded by dermatologists. If several facial dermatoses were present in the same patient, they were documented separately. Regarding disease severity, the investigator global assessment (IGA) scale—from 0 (clear), 1 (almost clear), 2 (mild), 3 (moderate), to 4 (severe)—was adopted. Patients were asked about the frequency and duration of mask-wearing, type of masks, mask-changing frequency, and cleaning methods. Multiple choice questionnaire items included whether patients experienced aggravation or *de novo* development of facial dermatoses, occupation, history of allergic contact dermatitis, aggravated facial parts, and symptoms after wearing masks. Short-answer questions queried the mean time required for aggravation per day or the mean number of days required for aggravation per week. We defined “healthcare workers” as any persons serving in a healthcare setting who have the potential for direct or indirect exposure to patients, including doctors, nurses, assistant nurses, medical technologists, and administrative staff. Questionnaire is presented in **Supplementary Data 1**.

### Statistical analysis

Statistical analysis was conducted using SPSS Statistics for

Windows, version 21.0 (IBM Corp., Armonk, NY, USA). *p*-values <0.05 were considered statistically significant. Comparisons between groups of patients classified according to disease entity were performed using the  $\chi^2$  test and Fisher's exact test for categorical variables and *t*-tests and one-way analysis of variance for continuous variables. Univariable and multivariable logistic regression were used to analyze factors associated with aggravation of *de novo* development of each type of facial dermatosis.

### Ethics statement

This research protocol was approved by the Institutional Review Board (IRB) of Asan Medical Center and the IRBs of every hospital participated in this study (IRB approval No. 2021-0764). All patients voluntarily participated in this survey, and written informed consent was obtained from patients (or guardians of minors who were included in the study) after full explanation of the study.

## RESULTS

### Patient demographics

Patient demographics are summarized in **Table 1**. A total of 1,931 participants reported 1958 facial dermatoses, namely acne (*n*=743), rosacea and perioral dermatitis (*n*=660), seborrheic dermatitis (*n*=184), contact dermatitis (*n*=147), and atopic dermatitis (*n*=224). The mean patient age was 34.7 years (range, 3–86), and the male-to-female ratio was 1:2.03. The mean IGA score, as assessed by dermatologists at the time of the visits during which participants completed questionnaires, was 2.23. Healthcare workers accounted for 9.6% of the study sample. After wearing masks, 423 patients (21.6%) developed *de novo* facial dermatoses, and among 1,535 participants with pre-existing dermatoses, 1,064 (69.3%) reported aggravations. Overall, 1,487 patients (75.9%) experienced aggravation of pre-existing dermatoses or development of new-onset facial dermatoses after wearing masks. The new, first-time eruptions were 145 (19.5%), 162 (24.5%), 23 (12.5%), 71 (48.3%), and 22 (9.8%) cases of acne, rosacea, seborrheic dermatitis, contact dermatitis, and atopic dermatitis, respectively. Additionally, 398 (53.6%), 353 (53.5%), 109 (59.2%), 61 (41.5%), and 143 (63.8%) cases were aggravated, respectively. Compared with the other dermatoses, contact dermatitis was diagnosed among a significantly higher percentage of patients with aggravation or *de novo* development after mask-wearing (*p*<0.001) (**Table 1**).

### Patient characteristics and mask-wearing habits of aggravated or *de novo* facial dermatoses

**Table 2** summarizes the patient characteristics and the mask-wearing habits of each type of reported facial dermatosis. Aggravation

or *de novo* development was frequently observed among women (acne: 63.6% vs. 45.2%, *p*<0.001; rosacea: 83.5% vs. 68.3%, *p*<0.001; seborrheic dermatitis: 64.4% vs. 38.1%, *p*=0.042; contact dermatitis: 88.5% vs. 60.0%, *p*=0.009; atopic dermatitis: 55.8% vs. 32.2%, *p*=0.002). Younger age was associated with aggravation or *de novo* development of rosacea (40.7 vs. 45.2, *p*=0.002) and seborrheic dermatitis (39.9 vs. 46.1, *p*=0.021). Patients with aggravated or newly developed cases of all types of facial dermatoses reported higher patient-measured IGA scores after mask wearing (acne: 2.85 vs. 1.68, *p*<0.001; rosacea: 3.00 vs. 1.79, *p*<0.001; seborrheic dermatitis: 2.82 vs. 1.58, *p*<0.001; contact dermatitis: 2.73 vs. 1.79, *p*=0.024; atopic dermatitis: 2.87 vs. 1.59, *p*<0.001), while the baseline patient-measured IGA score before mask-wearing was higher only in patients with aggravated or newly developed atopic dermatitis (1.85 vs. 1.47, *p*=0.040). In acne patients, those who experienced aggravation or *de novo* development of acne after wearing facial masks tended to wear masks for a longer period per day (41.0% vs. 27.5% of patients wore masks more than or equal to 8 hours, *p*<0.001), wear masks more frequently per week (88.2% vs. 81.0% of patients wore masks more than 3 times per week, *p*=0.023), and more commonly worked at healthcare centers (16.4% vs. 4.6%, *p*<0.001). On the other hand, the duration of mask-wearing per day, frequency of mask-wearing per week, and occupation were not associated with aggravation or new development of rosacea, seborrheic dermatitis, contact dermatitis, or atopic dermatitis. In addition, the frequency of mask-changing and the mask type were not correlated with aggravation or the new development of all facial dermatoses, except for seborrheic dermatitis patients who wore a KF90/KF94/N95 less frequently (38.9% vs. 59.6%, *p*=0.011) in aggravated or newly developed cases.

### Comparison of aggravated location and symptoms associated with each facial dermatosis

**Table 3** and **Fig. 1** summarize the specific facial sites as well as the signs and symptoms associated with the aggravation or new development of each facial dermatosis. Both cheeks were associated with aggravation or the new development of all facial dermatosis. The nose bridge and lip were related to aggravated or newly developed cases of acne (20.6% vs. 12.7%, *p*=0.028) and atopic dermatitis (7.6% vs. 0.0%, *p*=0.039), respectively. Nasolabial folds and jaw involvement were more frequently observed in aggravated or newly developed acne (32.3% vs. 16.9%, *p*<0.001 and 38.4% vs. 15.1%, *p*<0.001, respectively), seborrheic dermatitis (50.0% vs. 17.6%, *p*<0.001 and 15.7% vs. 3.9, *p*=0.030, respectively), and atopic dermatitis (24.5% vs. 8.9%, *p*=0.013 and 35.0% vs. 3.6%, *p*<0.001). Chin involvement was associated with acne (58.4% vs. 28.4%, *p*<0.001), rosacea (42.1% vs. 18.8%, *p*<0.001), seborrheic dermatitis (42.2% vs. 19.6%, *p*=0.004), and atopic dermatitis (39.5% vs. 10.7%, *p*<0.001). Lastly, aggravation

**Facial Dermatoses Associated With Mask**

**Table 1.** Demographics of total facial dermatoses patients, aggravated or newly developed facial dermatoses cases, and patients who experienced neither aggravation of pre-existing dermatoses nor *de novo* development after mask-wearing

Clinical parameters	Total facial dermatoses (n=1,958)	Aggravated or newly developed cases (n=1,487)		Neither aggravation of pre-existing dermatoses nor <i>de novo</i> development after mask-wearing (n=471)	p-value
Sex					<b>&lt;0.001</b>
Men	643 (32.8)	416 (28.1)		227 (48.5)	
Women	1,306 (66.7)	1,065 (71.9)		241 (51.5)	
Age (yr)					<b>0.003</b>
Range	3–86	3–86		12–83	
Mean ± SD	34.7±14.7	34.2±14.1		36.5±16.3	
Fitzpatrick skin type					0.464
3	1,044 (53.3)	805 (55.0)		239 (51.7)	
4	869 (44.4)	649 (44.3)		220 (47.6)	
5	13 (0.7)	10 (0.7)		3 (0.6)	
Disease entity		Newly developed	Aggravated		
Acne	743	145 (19.5)	398 (53.6)	200 (26.9)	0.065
Rosacea	660	162 (24.5)	353 (53.5)	145 (22.0)	0.057
Seborrheic dermatitis	184	23 (12.5)	109 (59.2)	52 (28.3)	0.225
Contact dermatitis	147	71 (48.3)	61 (41.5)	15 (10.2)	<b>&lt;0.001</b>
Atopic dermatitis	224	22 (9.8)	143 (63.8)	59 (26.3)	0.519
IGA score assessed by dermatologists	2.23±0.9	2.23±0.9		2.21±0.9	0.350
IGA score assessed by patients before mask-wearing	1.66±1.1	1.68±1.0		1.62±1.2	0.178
IGA score assessed by patients after mask-wearing	2.61±1.1	2.89±0.9		1.69±1.2	<b>&lt;0.001</b>
Therapeutic history					
Oral medication	1,642 (83.9)	1,239 (83.3)		403 (85.7)	0.281
Topical treatment	1,332 (68.0)	985 (66.2)		347 (73.7)	<b>0.005</b>
Laser treatment	303 (15.5)	216 (14.5)		87 (18.8)	<b>0.048</b>
Others	267 (13.6)	197 (13.2)		70 (15.3)	0.392
Healthcare worker	188 (9.6)	167 (11.4)		21 (4.5)	<b>&lt;0.001</b>
Duration of mask-wearing per day					<b>&lt;0.001</b>
<4 hr	640 (32.7)	449 (30.3)		191 (40.6)	
4–8 hr	701 (35.8)	540 (36.4)		161 (34.2)	
≥8 hr	614 (31.4)	495 (33.4)		119 (25.3)	
Frequency of mask-wearing per week					0.188
0–3 days	324 (16.5)	235 (15.8)		89 (18.9)	
3–6 days	684 (34.9)	532 (35.8)		152 (32.3)	
7 days (everyday)	947 (48.4)	717 (48.3)		230 (48.8)	
Frequency of changing mask					<b>0.027</b>
Everyday	923 (47.1)	708 (47.8)		215 (45.6)	
2–3 days	978 (49.9)	742 (50.1)		236 (50.1)	
≥4 days	50 (2.6)	30 (2.0)		20 (4.2)	
Mask type (multiple choice)					
Surgical mask	678 (34.8)	517 (34.8)		161 (34.3)	0.795
Cotton mask	465 (23.8)	367 (24.8)		98 (20.9)	0.08
KF90/KF94/N95	825 (42.3)	609 (41.1)		216 (46.0)	0.064
Others	68 (3.5)	54 (3.6)		14 (3.0)	0.492
Cleansing after mask-wearing					<b>&lt;0.001</b>
With water	353 (18.0)	238 (16.0)		115 (24.6)	
With cleanser	1,484 (75.8)	1,179 (79.3)		305 (65.2)	
None	109 (5.6)	61 (4.1)		48 (10.3)	
Allergic contact dermatitis history	620 (31.7)	485 (32.6)		135 (29.3)	0.177
Aggravated season (multiple choice)					
Spring	114 (6.2)	91 (6.2)		23 (6.1)	0.984
Summer	1,174 (63.6)	997 (67.7)		177 (47.3)	<b>&lt;0.001</b>
Autumn	55 (3.0)	44 (3.0)		11 (2.9)	0.963
Winter	59 (3.2)	45 (3.1)		14 (3.7)	0.499
Not related	503 (27.2)	345 (23.4)		158 (42.2)	<b>&lt;0.001</b>

Values are presented as number (%) or mean ± SD. Multiple choice was allowed for mask type and aggravated season. Bold font of p-value column indicates statistical significance.

SD: standard deviation, IGA: investigator global assessment.

**Facial Dermatoses Associated With Mask**

**Table 2.** Comparison of clinical features and mask-wearing habits by facial dermatosis type among patients who experienced aggravation or *de novo* development

Clinical variables	Acne (n=743)		Rosacea (n=660)		Seborrheic dermatitis (n=184)		Contact dermatitis (n=147)		Atopic dermatitis (n=224)						
	Case	Con	Case	Con	Case	Con	Case	Con	Case	Con					
Sex															
Male	196 (36.4)	108 (54.8)	84 (16.4)	46 (31.7)	47 (35.6)	27 (51.9)	15 (11.5)	6 (40.0)	73 (44.2)	40 (67.8)					
Female	343 (63.6)	89 (45.2)	429 (83.5)	99 (68.3)	85 (64.4)	25 (38.1)	116 (88.5)	9 (60.0)	92 (55.8)	19 (32.2)					
Age (yr)	26.9 ±9.0	28.1 ±10.7	0.146	40.7 ±14.9	45.2 ±15.2	<b>0.002</b>	39.9 ±15.7	46.1 ±17.8	<b>0.021</b>	38.5 ±14.4	43.8 ±15.1	0.183	29.3 ±10.1	32.9 ±17.5	0.065
IGA score assessed by dermatologists	2.23 ±0.84	2.03 ±0.87	<b>0.005</b>	2.31 ±0.82	2.33 ±0.86	0.753	1.97 ±0.72	2.04 ±0.76	0.567	1.92 ±0.83	2.07 ±0.80	0.506	2.46 ±0.95	2.73 ±0.87	0.059
IGA score assessed by patients before mask-wearing	1.62 ±1.00	1.59 ±1.27	0.769	1.78 ±1.09	1.79 ±1.18	0.594	1.76 ±1.04	1.48 ±1.16	0.114	1.21 ±1.01	2.07 ±1.49	0.053	1.85 ±0.99	1.47 ±1.26	<b>0.040</b>
IGA score assessed by patients after mask-wearing	2.85 ±0.88	1.68 ±1.24	<b>&lt;0.001</b>	3.00 ±0.90	1.79 ±1.23	<b>&lt;0.001</b>	2.82 ±0.85	1.58 ±1.11	<b>&lt;0.001</b>	2.73 ±0.87	1.79 ±1.37	<b>0.024</b>	2.87 ±0.82	1.59 ±1.2	<b>&lt;0.001</b>
Healthcare worker	88 (16.4)	9 (4.6)	<b>&lt;0.001</b>	25 (5.0)	4 (2.8)	0.270	14 (10.7)	1 (2.0)	0.071	29 (22.1)	2 (13.3)	0.528	11 (6.7)	5 (8.5)	0.769
Duration of mask-wearing per day			<b>&lt;0.001</b>			0.061			0.833			0.574			0.774
<4 hr	124 (22.9)	76 (38.0)		209 (40.7)	75 (51.7)		47 (35.6)	19 (36.5)		30 (22.7)	5 (33.3)		39 (23.6)	16 (27.1)	
4–8 hr	196 (36.2)	69 (34.5)		179 (34.9)	42 (29.0)		49 (37.1)	21 (40.4)		41 (31.1)	5 (33.3)		75 (45.5)	24 (40.7)	
≥8 hr	222 (41.0)	55 (27.5)		125 (24.4)	28 (19.3)		36 (27.3)	12 (23.1)		61 (46.2)	5 (33.3)		51 (30.9)	19 (32.2)	
Frequency of mask-wearing per week			<b>0.023</b>			0.918			0.608			0.328			0.919
0–3 days	64 (11.8)	38 (19.0)		101 (19.7)	29 (20.0)		26 (19.7)	7 (13.5)		17 (12.9)	4 (26.7)		27 (16.4)	11 (18.6)	
4–6 days	198 (36.5)	59 (29.5)		172 (33.5)	46 (31.7)		48 (36.4)	20 (19.2)		49 (37.1)	4 (26.7)		65 (39.4)	23 (39.0)	
7 days	280 (51.7)	103 (51.5)		240 (46.8)	70 (48.3)		58 (43.9)	25 (48.1)		66 (50.0)	7 (46.7)		73 (44.2)	25 (42.4)	
Frequency of changing mask			0.344			0.170			0.585			0.339			0.313
Everyday	308 (56.9)	105 (52.5)		242 (47.4)	62 (42.8)		58 (44.3)	20 (38.5)		50 (37.9)	6 (40.0)		50 (30.3)	22 (37.3)	
2–3 days	224 (41.4)	89 (44.5)		258 (50.5)	76 (52.4)		71 (54.2)	30 (28.7)		80 (60.6)	8 (53.3)		109 (66.1)	33 (55.9)	
≥4 days	9 (1.7)	6 (3.0)		11 (2.2)	7 (4.8)		2 (1.5)	2 (3.8)		2 (1.5)	1 (6.7)		6 (3.6)	4 (6.8)	
Mask type															
Surgical mask	182 (33.6)	71 (68.3)	0.636	185 (36.1)	47 (32.6)	0.438	52 (39.7)	15 (28.8)	0.169	37 (28.0)	4 (26.7)	>0.999	62 (37.6)	25 (42.4)	0.516
Cotton mask	118 (22.3)	38 (42.4)	0.373	124 (24.2)	29 (20.0)	0.294	25 (19.1)	8 (9.4)	0.557	40 (30.3)	3 (20.0)	0.554	59 (35.8)	19 (32.2)	0.623
KF90/KF94/N95	241 (44.5)	90 (45.0)	0.912	210 (40.9)	68 (46.9)	0.199	51 (38.9)	31 (59.6)	<b>0.011</b>	58 (43.9)	8 (53.3)	0.488	46 (27.9)	18 (30.5)	0.701
Others	15 (2.8)	6 (3.0)	0.869	25 (4.9)	7 (4.8)	0.982	5 (3.8)	1 (1.9)	0.676	5 (3.8)	1 (6.7)	>0.999	5 (3.0)	1 (1.7)	>0.999
Time required for aggravation per day (hr)	5.9 ±3.0	-		4.6 ±2.9	-		5.3 ±2.6	-		5.4 ±2.8	-		5.2 ±2.4	-	
Days required for aggravation per week (days)	4.5 ±1.9	-		4.1 ±2.1	-		4.3 ±1.9	-		4.4 ±1.7	-		4.5 ±1.8	-	

Values are presented as number (%) or mean ± SD. Bold font of *p*-value columns indicates statistical significance.

Case: aggravated or newly developed facial dermatitis patients, Con: control, neither aggravation of pre-existing dermatoses nor newly developed after mask-wearing, SD: standard deviation, IGA: investigator global assessment.

\*Each *p*-value was analyzed comparing each facial dermatosis to the others using  $\chi^2$  test and t-test.

or *de novo* development of lesions in the postauricular area was noticed in cases of acne (14.0% vs. 7.7%, *p*=0.037) and atopic dermatitis (28.1% vs. 7.0%, *p*=0.001).

In terms of symptoms, erythema and an itching sensation were more frequently observed in aggravated or newly developed cases of all facial dermatoses. In addition, scales, xerosis, burning

**Table 3.** Comparison of aggravated facial location and symptoms by facial dermatosis type among patients who experienced aggravation or *de novo* development

Clinical variables	Acne (n=743)		p-value*	Rosacea (n=660)		p-value*	Seborrheic dermatitis (n=184)		p-value*	Contact dermatitis (n=147)		p-value*	Atopic dermatitis (n=224)		p-value*
	Case	Con		Case	Con		Case	Con		Case	Con		Case	Con	
<b>Location</b>															
Both cheeks	352 (68.0)	65 (39.2)	<b>&lt;0.001</b>	364 (73.1)	57 (47.5)	<b>&lt;0.001</b>	76 (58.9)	11 (22.0)	<b>&lt;0.001</b>	86 (65.6)	4 (28.6)	<b>0.007</b>	99 (61.9)	14 (24.1)	<b>&lt;0.001</b>
Nose bridge	101 (20.6)	20 (12.7)	<b>0.028</b>	133 (27.4)	23 (30.4)	0.083	32 (25.2)	7 (13.7)	0.094	21 (16.9)	2 (16.7)	>0.999	33 (20.8)	6 (10.7)	0.094
Nasolabial folds	159 (32.3)	27 (16.9)	<b>&lt;0.001</b>	162 (33.2)	29 (25.0)	0.093	65 (50.0)	9 (17.6)	<b>&lt;0.001</b>	40 (32.0)	2 (18.2)	0.502	39 (24.5)	5 (8.9)	<b>0.013</b>
Lip	36 (5.4)	4 (2.6)	0.154	45 (9.4)	7 (6.0)	0.234	9 (7.1)	2 (3.9)	0.515	14 (11.6)	0 (0.0)	0.371	12 (7.6)	0 (0.0)	<b>0.039</b>
Chin	299 (58.4)	46 (28.4)	<b>&lt;0.001</b>	205 (42.1)	22 (18.8)	<b>&lt;0.001</b>	54 (42.2)	10 (19.6)	<b>0.004</b>	52 (41.3)	1 (9.1)	0.050	64 (39.5)	6 (10.7)	<b>&lt;0.001</b>
Jaw	193 (38.4)	24 (15.1)	<b>&lt;0.001</b>	85 (17.8)	9 (18.3)	0.008	20 (15.7)	2 (3.9)	<b>0.030</b>	26 (21.1)	1 (9.1)	0.462	56 (35.0)	2 (3.6)	<b>&lt;0.001</b>
Postauricular area	68 (14.0)	12 (7.7)	<b>0.037</b>	36 (7.5)	8 (7.0)	0.824	15 (11.9)	6 (11.5)	0.945	13 (10.7)	2 (16.7)	0.626	45 (28.1)	4 (7.0)	<b>0.001</b>
<b>Symptoms</b>															
Erythema and flushing	267 (52.7)	58 (35.8)	<b>&lt;0.001</b>	426 (83.9)	77 (53.1)	<b>&lt;0.001</b>	89 (67.4)	20 (38.5)	<b>&lt;0.001</b>	92 (69.7)	3 (20.0)	<b>&lt;0.001</b>	99 (60.0)	8 (13.6)	<b>&lt;0.001</b>
Pustule	135 (27.4)	15 (9.6)	<b>&lt;0.001</b>	85 (17.9)	7 (6.0)	<b>0.001</b>	15 (11.5)	3 (5.9)	0.253	17 (13.9)	0 (0.0)	0.358	13 (8.2)	1 (1.8)	0.123
Scale	86 (17.7)	8 (5.2)	<b>&lt;0.001</b>	72 (15.0)	5 (4.3)	<b>0.002</b>	38 (29.7)	5 (9.8)	<b>0.005</b>	29 (23.8)	0 (0.0)	0.366	63 (39.1)	5 (8.9)	<b>&lt;0.001</b>
Xerosis	71 (14.6)	12 (7.8)	<b>0.030</b>	87 (18.1)	10 (8.5)	<b>0.011</b>	24 (18.8)	3 (5.9)	<b>0.030</b>	40 (32.0)	0 (0.0)	0.121	43 (27.0)	5 (8.9)	<b>0.005</b>
Oily skin	227 (44.5)	51 (31.7)	<b>0.004</b>	110 (22.8)	20 (16.9)	0.165	46 (35.9)	6 (11.8)	<b>0.001</b>	23 (18.9)	0 (0.0)	0.210	27 (17.0)	4 (7.1)	0.071
Edema	7 (1.5)	2 (1.3)	0.893	33 (6.9)	1 (0.9)	<b>0.011</b>	5 (3.9)	0 (0.0)	0.323	11 (8.9)	0 (0.0)	0.599	6 (3.8)	0 (0.0)	0.200
Itching sensation	282 (55.1)	55 (33.7)	<b>&lt;0.001</b>	281 (56.5)	34 (28.1)	<b>&lt;0.001</b>	82 (63.6)	19 (37.3)	<b>0.001</b>	86 (66.2)	4 (33.3)	<b>0.031</b>	123 (75.5)	7 (12.3)	<b>&lt;0.001</b>
Pain	30 (6.2)	4 (2.6)	0.083	39 (8.2)	1 (0.9)	<b>0.005</b>	7 (5.5)	2 (3.9)	0.733	7 (5.7)	0 (0.0)	0.643	4 (2.5)	1 (1.8)	>0.999
Burning sensation	107 (21.6)	17 (11.0)	<b>0.004</b>	221 (44.7)	26 (21.7)	<b>&lt;0.001</b>	35 (27.6)	6 (11.5)	<b>0.021</b>	35 (27.8)	0 (0.0)	0.065	38 (23.7)	1 (1.8)	<b>&lt;0.001</b>
Tingling sensation	120 (24.6)	15 (9.7)	<b>&lt;0.001</b>	163 (33.8)	17 (14.3)	<b>&lt;0.001</b>	31 (24.2)	5 (9.8)	<b>0.030</b>	44 (34.9)	1 (8.3)	0.103	47 (29.0)	1 (1.8)	<b>&lt;0.001</b>
Hyperpigmentation	53 (11.0)	6 (3.9)	<b>0.008</b>	34 (7.2)	4 (4)	0.139	7 (5.5)	1 (2.0)	0.442	15 (12.2)	0 (0.0)	0.365	11 (6.9)	0 (0.0)	0.070

Values are presented as number (%). Bold font of p-value columns indicates statistical significance.

Case: aggravated or newly developed facial dermatitis patients, Con: control, neither aggravation of pre-existing dermatoses nor newly developed after mask-wearing.

\*Each p-value was analyzed comparing each facial dermatosis to the others using  $\chi^2$  test and Fisher's exact test.

sensation, and tingling sensation were statistically significantly more frequently observed in aggravated or newly developed facial dermatoses, except for contact dermatitis. On the other hand, pustules were more frequently reported in acne (27.4% vs. 9.6%,  $p<0.001$ ) and rosacea (17.9% vs. 6.0%,  $p=0.001$ ), oily skin in acne (44.5% vs. 31.7%,  $p=0.004$ ) and seborrheic dermatitis (35.9% vs. 11.8%,  $p=0.001$ ), edema and pain in rosacea (6.9% and 0.9%,  $p=0.11$ ; 8.2% vs. 0.0%,  $p=0.005$ , respectively), and hyperpigmentation in acne (11.0% vs. 3.9%,  $p=0.008$ ).

**Factors associated with aggravation of pre-existing dermatoses or *de novo* dermatoses**

The multivariable analysis (Table 4) indicated that working in

healthcare (odds ratio [OR], 3.442; 95% confidence interval [CI], 1.575–7.519;  $p=0.002$ ), female sex (OR, 1.973; 95% CI, 1.402–2.776;  $p<0.001$ ), and duration of mask-wearing per day (4–8 hours OR, 1.680; 95% CI, 1.120–2.519;  $p=0.012$  and  $\geq 8$  hours OR, 1.744; 95% CI, 1.119–2.718;  $p=0.014$ ) were significantly associated with aggravation or *de novo* development of acne. Also, female sex (OR, 2.695; 95% CI, 1.734–4.187;  $p<0.001$ ), age (OR, 0.981; 95% CI, 0.969–0.993;  $p=0.003$ ), and duration of mask-wearing per day (4–8 hours OR, 1.684; 95% CI, 1.077–2.634;  $p=0.022$  and  $\geq 8$  hours OR, 1.759; 95% CI, 1.054–2.934;  $p=0.031$ ) were significantly associated with aggravation or new-onset development of rosacea. Age (OR, 0.976; 95% CI, 0.957–0.996;  $p=0.0019$ ) and sex (OR, 5.156; 95% CI, 1.609–16.522;  $p=0.006$ ) were significantly associated

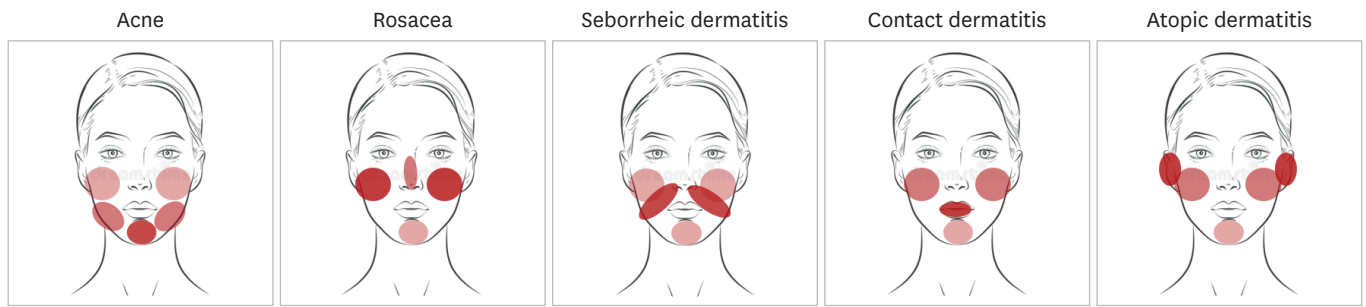


Fig. 1. Aggravated or newly developed sites according to each facial dermatosis.

Table 4. Multivariable analysis for factors associated with aggravation or *de novo* development of facial dermatosis compared to patients who did not experience aggravation or new development of facial dermatosis

Factors	OR	95% CI	p-value
<b>Acne</b>			
Healthcare worker	3.442	1.575–7.519	0.002
Sex (female)	1.973	1.402–2.776	<0.001
Duration of mask-wearing per day			
<4 hr	1	-	-
4–8 hr	1.680	1.120–2.519	0.012
≥8 hr	1.744	1.119–2.718	0.014
<b>Rosacea</b>			
Sex (female)	2.695	1.734–4.187	<0.001
Age	0.981	0.969–0.993	0.003
Duration of mask-wearing per day			
<4 hr	1	-	-
4–8 hr	1.684	1.077–2.634	0.022
≥8 hr	1.759	1.054–2.934	0.031
<b>Seborrheic dermatitis</b>			
Age	0.976	0.957–0.996	0.019
<b>Contact dermatitis</b>			
Sex (female)	5.156	1.609–16.522	0.006
<b>Atopic dermatitis</b>			
Sex (female)	2.835	1.456–5.521	0.002
IGA score assessed by patients before mask-wearing			
0–1 (clear to almost clear)	1	-	-
2–3 (mild to moderate)	2.925	1.524–5.614	0.001
4 (severe)	1.330	0.297–5.961	0.710

OR: odds ratio, CI: confidence interval, IGA: investigator global assessment.

with seborrheic dermatitis and contact dermatitis, respectively, in the multivariable analysis. Lastly, female sex (OR, 2.835; 95% CI, 1.456–5.521;  $p=0.002$ ) and the IGA score before mask-wearing (mild to moderate OR, 2.925; 95% CI, 1.524–5.614;  $p=0.001$ ) were significantly associated with aggravation or the new-onset development of atopic dermatitis.

## DISCUSSION

COVID-19 has changed the incidence and pattern of dermatological disease significantly, partly due to daily usage of masks. This study integrally analyzed a variety of facial dermatoses, compared

aggravated or newly developed symptoms and locations of each facial dermatosis, and evaluated related factors for aggravation in detail.

In this study, the duration of mask-wearing per day and the frequency of mask-wearing per week were only associated with aggravation or *de novo* development of acne. It has been previously reported that long duration and frequent usage of masks could cause higher temperatures, humidity, and carbon dioxide levels (from local expiration), leading to higher sebum concentration, pore occlusion, bacterial growth, and inflammation of follicles<sup>13-20</sup>. Moreover, in this study, post-inflammatory hyperpigmentation (PIH) was more frequently observed in aggravated or newly developed acne patients. Recent studies showed that physical trauma was strongly associated with the development of PIH after acne<sup>21-24</sup>. Therefore, unintended friction by prolonged periods of mask wearing could lead to a higher frequency of PIH in aggravated or newly developed acne patients.

In rosacea patients, female sex and younger age were significant factors related to aggravation or *de novo* development in multivariable analysis, which could be explained by the fact that aggravated or newly developed patients had a higher percentage of perioral dermatitis (8.7% vs. 2.8%). Longer periods of mask-usage per day were associated with aggravation or the new development of rosacea, but the time and days required for aggravation were shortest in association with rosacea among the facial dermatoses. Due to the decreased threshold for external irritation, even short periods of mask-wearing could lead to aggravation of pre-existing rosacea<sup>25,26</sup>. The anatomical locations associated with the aggravation or the new development of rosacea in this study were both cheeks and the chin, where friction-related damage could act significantly and Demodex densities are known to be higher than at other sites<sup>27</sup>. In addition, pain was only symptom associated with the aggravated or newly developed cases of rosacea among the facial dermatoses, suggesting that they suffered from various symptoms.

The aggravated or newly developed seborrheic dermatitis patients tended to be female and younger, and their lesions were found in common locations for seborrheic dermatitis, such as

both cheeks and the nasolabial folds. The aggravation of seborrheic dermatitis could be related to imbalances of microbiota, including *Malassezia*, *Cutibacterium*, and *Staphylococcus* species, due to increased temperatures beneath mask area<sup>10,28</sup>. Furthermore, irritating symptoms and signs of barrier defects in addition to oily skin and pruritus were also more frequently reported in aggravated or newly developed seborrheic dermatitis patients, implying that the irritating nature of masks could also lead to aggravation or *de novo* development of seborrheic dermatitis.

In this study, aggravated or newly developed contact dermatitis was associated with female sex, location on both cheeks, erythema, and pruritus. Exacerbations of skin conditions could be associated with exposure to preservatives (such as formaldehyde and polypropylene), rubber accelerators in elastic band, glue, and metal in face masks<sup>12,29,30</sup>. Nickel and cobalt in masks have been reported as suspected causes of allergic contact dermatitis, and humid environments combined with sweat and rubbing could lead to increased transfer of metal ions to the skin underneath masks<sup>31,32</sup>.

Previous researchers have revealed that, due to their barrier defects, patients with a history of atopy are more susceptible to external irritation<sup>12,23,33</sup>. In this study, atopic dermatitis patients frequently reported aggravation in all protruded areas as well as the postauricular area, implying that pressure and friction from the mask itself and string could be irritating for atopic dermatitis patients<sup>27</sup>. In addition, only aggravated atopic dermatitis patients had a higher IGA score before mask-wearing, suggesting that a high disease activity combined with poor barrier function in atopic dermatitis could be associated with flares after mask usage.

It was notable that face washing with cleansers was more frequently reported in association with aggravated or newly developed dermatoses overall (Table 1). Additional friction caused by washing or antibacterial soap with high pH could aggravate superficial maceration and damage the skin barrier. Additionally, we observed that patients experienced aggravation or *de novo* dermatosis development most frequently during the summer. High temperatures and moist environments in the summer could accelerate the negative effects of protective face masks. Furthermore, it was interesting that contact dermatitis was associated with the highest percentage of patients with aggravation or *de novo* development after mask-wearing. Lastly, controversy surrounds the identification of mask types that cause aggravation of facial dermatoses.<sup>7,34-39</sup> In our large-scale study, mask type was not found to be a factor related to aggravation or *de novo* development of facial dermatoses in the multivariable analysis.

An important limitation of this study was that it was conducted at tertiary and university hospitals. In addition, this study is relied on survey, and thus self-reporting bias could exist and it was impossible to prove causality. Moreover, we did not evaluate factors

other than face masks that could influence disease course, including patients' general lifestyle and compliance to treatment. Furthermore, we conducted the survey for limited period, from July through August, which could affect the severity and types of facial dermatoses, causing selection bias. Finally, the initial sex ratio of the participants in this study was imbalanced, which could have led to bias.

In conclusion, this study revealed that a variety of facial dermatoses were aggravated or newly developed in association with the wearing of protective facial, and the clinical features and aggravating factors varied according to disease entity. Integrated analysis of the influence of mask-wearing habits on facial dermatoses could lead to a better understanding of changes in dermatological disease patterns that have emerged during the COVID-19 pandemic.

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**CONFLICTS OF INTEREST**

The authors have nothing to disclose.

**DATA SHARING STATEMENT**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

**SUPPLEMENTARY MATERIAL****Supplementary Data 1**

Survey form

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