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REVIEW

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Facial dermatoses induced by face masks: A systematic review and meta-analysis of observational studies

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Abstract

The use of masks for infection control was common in the COVID-19 pandemic. As numerous cross-sectional studies have suggested a link between the use of such masks and various facial dermatoses, a systematic review and meta-analysis of published studies was conducted to evaluate this association, as well as potential risk factors for the development of such facial dermatoses. Observational studies were searched for in MEDLINE, EMBASE and the Cochrane Central Register. Thirty-seven observational studies with a total of 29 557 study participants were identified. This study was performed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 checklist and quality was assessed via the Newcastle-Ottawa Quality Assessment Scale., Overall prevalence of facial dermatoses was 55%. Individually, acne, facial dermatitis, itch and pressure injuries were consistently reported as facial dermatoses, with a pooled prevalence of 31%, 24%, 30% and 31%, respectively. Duration of mask-wear was the most significant risk factor for the development of facial dermatoses (95% CI: 1.31–1.54, $p < 0.001$). Overall, facial dermatoses associated with mask wear are common, and consist of distinct entities. They are related to duration of use. Appropriate and tailored treatment is important to improve the outcomes for these affected patients.

KEYWORDS

acne, face mask, facial eczema, itch, meta-analysis, systemic review

1 | BACKGROUND

The COVID-19 global pandemic has plagued us for over 2 years now,[1] and has dramatically altered many of our ways of life.[2] Among other things, due to the high infectivity and virulence of this respiratory pathogen,[3] the use of facial masks as an effective way to limit its spread[4] has become commonplace, not only in high-risk healthcare settings among healthcare workers (HCWs) who must wear personal protective equipment (PPE) to protect themselves and their patients from the virus, but even in the community setting, due to fears of contracting this disease, social responsibility and sometimes government mandate. With the increased adoption of face masks worldwide, there have been numerous complaints of various facial dermatoses attributed to the prolonged use of facial masks; terms such as 'maskne' have even been coined to describe acne mechanica from prolonged mask-wear. Over these past 2 years, many small cross-sectional studies on this phenomenon have been performed, However, their findings are distinct, and do not always correlate. While we hypothesize that facial dermatoses induced by face masks are extremely prevalent, and that possible risk factors could include duration of mask wear, type of mask worn, the climate in which the study is performed and the occupation of the target group, among others, currently, updated epidemiological data to statistically quantify this phenomenon and elucidate the actual effect of these hypothesized risk factors is lacking. Hence, to better understand the various adverse skin pathologies induced by face masks, to quantify the extent and the severity of this

Abbreviations: HCW, healthcare worker; PPE, personal protective equipment.

problem and to determine the risks factors for facial dermatoses induced by masks, we performed a large-scale systematic review and meta-analysis to quantitatively evaluate the problem of skin issues arising from protective mask wearing.

2 | METHODS

The Preferred Reporting Items for Systematic reviews and Meta-Analyses 2020 27-item checklist[5] was followed in conducting this study. A systematic and quantitative synthesis of all studies that evaluated the relationship between the use of facial masks and the prevalence or incidence of various dermatological conditions and symptoms affecting the face was planned a priori.

2.1 | Search strategy

A comprehensive database search was performed using Medline, EMBASE and the Cochrane Central Register. Our search strategy is detailed in Table S1. A protocol was not registered for this meta-analysis but the methodology was determined a priori.

The search was limited to English language studies published from inception to March 20, 2022. All abstracts were evaluated based on the inclusion criteria to determine eligibility for meta-analysis. Additional studies were identified from manual searches of references in retrieved articles. Unpublished data was not included in this meta-analysis.

2.2 | Selection of articles

The following inclusion criteria were used to select original studies for the analysis: cross-sectional, case–control or cohort study design; analysis of the prevalence of signs and symptoms of facial dermatoses after the use of facial masks. Studies would need to provide sufficient information, such as the sample size, the pooled prevalence of facial dermatoses and/or the prevalence of individual facial dermatoses including acne, facial dermatitis, itch and/or pressure injury in the study population, so that the corresponding standard errors could be calculated. Studies which did not specify the location of dermatitis or itch were excluded as some of these studies merged the statistics for facial dermatitis and hand dermatitis induced by hand-washing or alcohol scrubs. Studies which included only patients with existing facial dermatoses or only patients who visited specialized clinics that exclusively evaluated occupational dermatoses were excluded, as these populations were considered to be non-representative.

Two reviewers (L.Y.S.J., Y.Y.W.) independently reviewed the titles and abstracts of these articles. Based on the inclusion criteria and information from abstracts, eligible articles were identified for full-text review. Full-length articles were then reviewed independently to determine their eligibility for inclusion in the meta-analysis. Any disagreements were resolved by consensus.

2.3 | Data extraction

Reviewers independently extracted the data from selected studies using a standardized data extraction form. Relevant information extracted, if available, included the year of publication, country of study, study design, sample size, characteristics of the study population, age of participants, the pooled prevalence of facial dermatoses, the prevalence of acne, dermatitis, itch or pressure injury in the study population, the method used to evaluate these facial dermatoses, the duration for which masks were worn and the type of mask worn. Exposure in terms of use of facial masks was based on self-reported use of any type of mask (cloth, surgical, N95, etc.) on a regular basis.

The quality of the studies was assessed via the Newcastle-Ottawa Quality Assessment Scale,[6] adapted for cross-sectional studies. Three main categories are included in this scale: selection of sample, comparability of samples and assessment of outcome. Within the 'selection of sample' category, values of 0 or 1 were assigned to the four following sub-categories: representativeness of the sample, sample size, non-respondents and ascertainment of the exposure, for a maximum score of 4 points. Within the 'comparability of samples' category, values of 0, 1 or 2 were assigned based on whether the study controlled for duration of mask wear, which was deemed to be the most important factor, and on whether the study controlled for any other important factor, such as occupation or type of mask, for a maximum score of 2 points. Within the 'assessment of outcomes' category, values of 1 or 2 were assigned based on whether the outcome was ascertained via self-report or via professional assessment respectively, and an additional value of 0 or 1 was assigned based on whether statistical analysis was adequately performed, for a maximum score of 3 points. Studies with a total quality score of 0–6 were considered lower quality, while those with a score of 7–9 were considered higher quality. Any differences in scores were adjudicated by consensus.

Subsequently, the GRADE system[7] was used to assess the confidence in risk estimates as high, moderate, low or very low, based on explicit criteria, including study design, risk of bias, imprecision, inconsistency, indirectness and magnitude of effect. Two reviewers (L.Y.S.J., Y.Y.W.) independently reviewed the risk of bias in these articles. Any disagreements were resolved by consensus.

2.4 | Meta-analysis

Few studies provided 95% confidence intervals (CIs) for prevalence. Standard error was calculated for each study by assuming prevalence as a Bernoulli random variable (p), with variance being equal to $p(1-p)$. Random-effects models of DerSimonian and Laird were used to estimate pooled prevalences of facial dermatoses related to the use of face masks, owing to heterogeneity between studies ($I^2 > 25\%$). Prevalences and 95% CIs were presented in forest plots. Random-effects meta-regression and stratified meta-analysis were further performed to determine the relative risk of facial dermatoses related to mask wear based on the duration of mask wear and the type of mask worn.

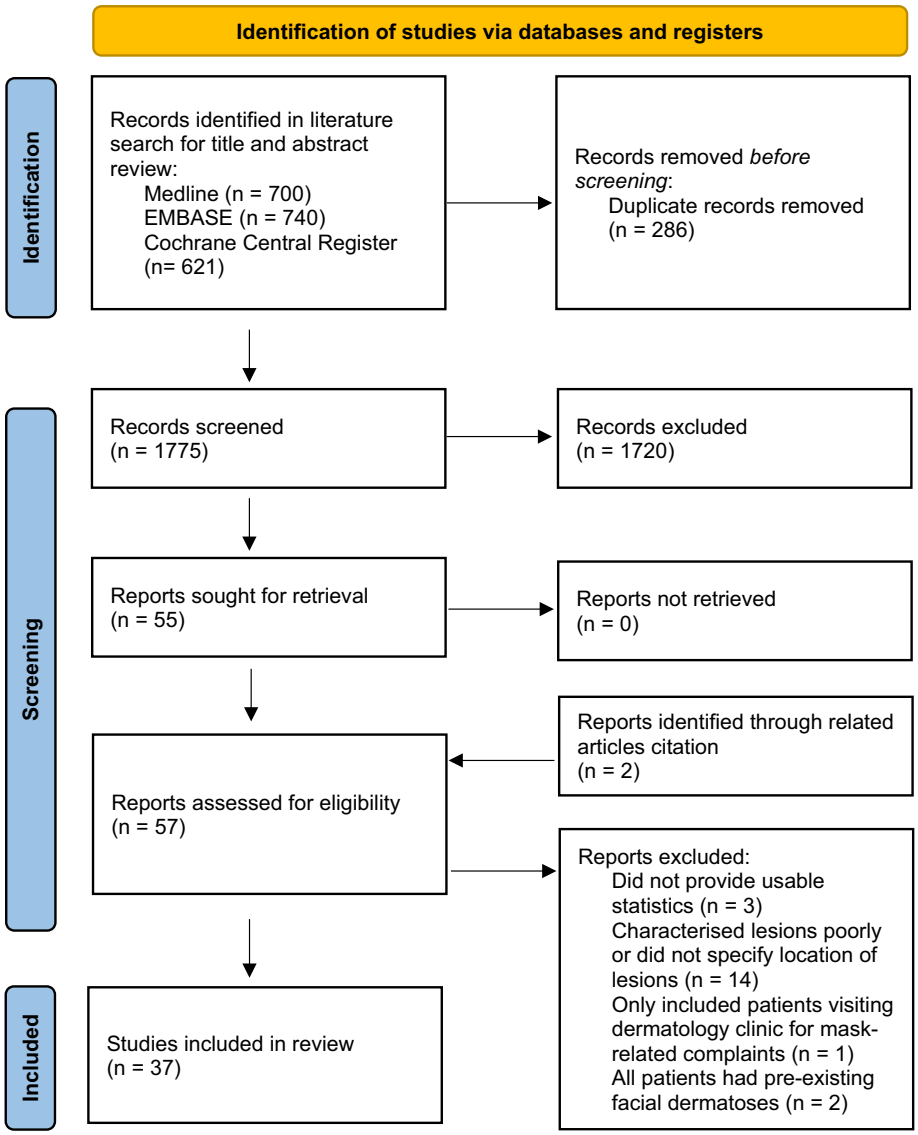

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram

The prevalences of facial dermatoses related to mask wear were also calculated, and stratified based on occupation and region, to assess the burden of skin problems due to mask-wearing during the pandemic. These additional sub-analyses were also planned a priori, and performed if there were three or more studies from which data could be extracted. A two-sided p value less than 0.05 was considered statistically significant. Statistical analyses were performed using STATA software (version13.0, StataCorp).

3 | RESULTS

3.1 | Search results

A search using Medline, EMBASE and the Cochrane Central Register yielded a total of 2061 articles, as shown in Figure 1. Of the 1775 articles (after removing duplicate studies) initially identified, 55 studies were selected, after reviewing both the titles and abstracts, based on the prescribed inclusion criteria. Two more articles were identified via relevant citations from some of the full-text articles. After assessing full-length articles, 20 studies were excluded for the following reasons: did not provide usable statistics[8–10] ($n = 3$), characterized the dermatoses poorly or did not specify the location of dermatoses[11–24] ($n = 14$), only included patients presenting to dermatological clinic already with mask-related dermatoses[25] ($n = 1$), all patients had pre-existing facial dermatoses[26,27] ($n = 2$). After these exclusions, 37 published studies were included in the meta-analysis.[28–64]

3.2 | Study characteristics

The 37 observational studies were published from 2004 to 2022, with the majority being published in 2020 after the onset of the global pandemic, and one being published in 2004 during the SARS pandemic[39] during which HCWs had similar PPE requirements. Of these 37 studies, all were cross-sectional studies.

TABLE 1 Characteristics of the study populations

Study	Year	Country	Study design	Study participants (*n*)	Mean age (years)	Main facial dermatoses reported	Assessment of mask usage	Assessment of facial dermatoses	Occupation	Other comparisons made	Quality score	Quality assessment
Aloweni et al.	2022	Singapore	Cross-Sectional	592	35.4	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs	Type of mask	7	High quality
Altun and Topaloglu	2021	Turkey	Cross-Sectional	101	30	Acne	Self-reported questionnaire	Dermatological consultation	HCWs	Type of mask	8	High quality
Battista et al.	2020	Italy	Cross-Sectional	381	35	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	Overall Population	Duration of mask wear (6 h), type of mask	6	Low quality
Caglar et al.	2020	Turkey	Cross-Sectional	315	31.6	Dermatitis	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Chaiyabutr et al.	2020	Thailand	Cross-Sectional	1231	Not given	Acne, dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population	Duration of mask wear (4 h), type of mask	6	Low quality
Choi et al.	2021	Korea	Cross-Sectional	330	35.5	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Dermatological consultation	Overall Population	Duration of mask wear (4 h), type of mask	7	High quality
Christopher et al.	2020	Indonesia	Cross-Sectional	200	27	Acne, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		6	Low quality
Cribier et al.	2021	Europe (France, Italy, Spain, Germany)	Cross-Sectional	8077	32	Itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population		5	Low quality
Daye et al.	2020	Turkey	Cross-Sectional	440	33.5	Acne	Self-reported questionnaire	Self-reported questionnaire	HCWs		6	Low quality
Deshpande et al.	2020	India	Cross-Sectional	230	Not given	Itch	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Devi et al.	2021	India	Cross-Sectional	220	34.6	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs	Type of mask	7	High quality
Foo et al.	2004	Singapore	Cross-Sectional	307	32.4	Acne, dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Gao et al.	2021	UK	Cross-Sectional	805	35.3	Acne, dermatitis, pressure injury	Self-reported questionnaire	Dermatological consultation	HCWs		5	Low quality
Gurlek et al.	2022	Turkey	Cross-Sectional	297	Not given	Acne, dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Hamnerius et al.	2021	Sweden	Cross-Sectional	751	46	Acne, dermatitis, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		6	Low quality
Hu et al.	2020	China	Cross-Sectional	61	33.2	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Inan Doğan and Kaya	2020	Turkey	Cross-Sectional	150	28.6	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Dermatological consultation	Overall Population	Duration of mask wear (4 h), type of mask	5	Low quality
Jiang et al.	2020	China	Cross-Sectional	4306	32.5	Pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		8	High quality
Jose et al.	2021	India	Cross-Sectional	137	30.4	Dermatitis, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		8	High quality
Krajewski et al.	2020	Poland	Cross-Sectional	1156	40.5	Itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population	Duration of mask wear (4 h), type of mask	7	High quality
Kumar and Singh	2020	India	Cross-Sectional	423	29	Acne	Self-reported questionnaire	Self-reported questionnaire	HCWs		5	Low quality
Lan et al.	2020	China	Cross-Sectional	542	Not given	Dermatoses in general	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (6 h)	8	High quality
Marraha et al.	2021	Morocco	Cross-Sectional	273	34	Dermatitis, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Metin et al.	2020	Turkey	Cross-Sectional	526	34	Acne, dermatitis	Self-reported questionnaire	Self-reported questionnaire	HCWs		5	Low quality

TABLE 1 (Continued)

Study	Year	Country	Study design	Study participants (*n*)	Mean age (years)	Main facial dermatoses reported	Assessment of mask usage	Assessment of facial dermatoses	Occupation	Other comparisons made	Quality score	Quality assessment
Niesert et al.	2021	Germany	Cross-Sectional	550	46	Dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population		5	Low quality
Park et al.	2021	Korea	Cross-Sectional	303	Not given	Acne, dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	HCWs	Type of mask	7	High quality
Purushot et al.	2020	India	Cross-Sectional	250	25.8	Acne, dermatitis	Self-reported questionnaire	Self-reported questionnaire	HCWs		7	High quality
Resuello and Puyat	2022	Philippines	Cross-Sectional	313	35.9	Acne, dermatitis, itch	Self-reported questionnaire	Dermatological consultation	Overall Population		7	High quality
Santoro et al.	2022	Italy	Cross-Sectional	1184	43.4	Dermatoses in general	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (6 h), type of mask	8	High quality
Singh et al.	2020	India	Cross-Sectional	43	32.8	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Dermatological consultation	HCWs		6	Low quality
Skiveren et al.	2022	Denmark	Cross-Sectional	751	44.8	Acne, dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (6 h), type of mask	7	High quality
Szepietowski et al.	2020	Poland	Cross-Sectional	2307	20.2	Itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population	Duration of mask wear (4 h), type of mask	7	High quality
Techasatian et al.	2020	Thailand	Cross-Sectional	833	32	Acne, dermatitis, itch	Self-reported questionnaire	Self-reported questionnaire	Overall Population	Duration of mask wear (4 h), type of mask	5	Low quality
Yaqoob et al.	2021	India	Cross-Sectional	193	27.5	Acne	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (8 h), type of mask	8	High quality
Yuan et al.	2021	China	Cross-Sectional	275	30.7	Dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (6 h), type of mask	7	High quality
Zaib et al.	2020	Pakistan	Cross-Sectional	300	Not given	Acne, dermatitis, itch	Self-reported questionnaire	Dermatological consultation	HCWs	Type of mask	8	High quality
Zuo et al.	2020	China	Cross-Sectional	404	Not given	Dermatitis, itch, pressure injury	Self-reported questionnaire	Self-reported questionnaire	HCWs	Duration of mask wear (4 h), type of mask	6	Low quality

Abbreviation: HCW, healthcare worker.

The 37 studies were conducted across 17 countries, including 16 in Europe (43.2%), eight in India/Pakistan (21.6%), six in South East Asia (16.2%), five in China (13.5%) and two in Korea (5.4%). All 37 studies were conducted in the adult population. Within these 37 studies, 19 (51.4%) included the pooled prevalence of any facial dermatosis, while 24 (64.9%) surveyed respondents on the presence of acne specifically, 25 (67.6%) surveyed respondents on the presence of facial dermatitis specifically, 22 (59.4%) surveyed respondents on the presence of itch or pruritus specifically and 18 (48.6%) surveyed respondents on the presence of pressure injury. Other skin changes that were infrequently reported included dry, greasy or peeling skin, hyperhidrosis, dyspigmentation, wheals and aphthous stomatitis, as well as the subjective sensations of burning and pain; statistical analysis was not performed for these complaints due to the small number of studies.

The usage of masks, type of mask worn and duration of mask-wear was self-reported in all studies. Of these, 14 studies (37.8%) further provided separated statistics for one or more facial dermatoses based on participants' duration of mask wear and compared the prevalence of facial dermatoses between sub-populations, while 17 studies (45.9%) did the same based on the type of masks (surgical masks or respirators, e.g., N95, FFP2, FFP2, FFP3, etc.) worn by the respondents. The presence of these facial dermatoses was self-reported in 30 studies (81.1%), and diagnosed by trained dermatologists in seven studies (18.9%).

Among these studies, 27 (73.0%) focused solely on healthcare workers (HCWs), while 10 (27.0%) focused on the overall population, and included participants from the general public. However, it was noted that a few of these studies still included responses from healthcare professionals, perhaps due to convenient sampling.

The quality of the studies was also assessed via the Newcastle-Ottawa Quality Assessment Scale.[6] Among the studies, 14 (37.8%) were rated as low quality (score of 0–6) and 23 (62.2%) were rated as high quality (score of 7–9).

Table 1 summarizes the study population characteristics and the characteristics of the studies performed.

3.3 | Pooled prevalence of facial dermatoses associated with mask wear

Pooled meta-analysis of the prevalence of facial dermatoses associated with mask wear was determined by using random-effects weighting owing to heterogeneity (I^2 = 96.7%–99.1%). Among the 19 studies that reported the overall prevalence of any facial dermatoses, the pooled prevalence of facial dermatoses as a whole was 55% (95% CI, 46%–63%).

Subsequently, the overall prevalence of individual facial dermatoses was calculated. The facial dermatoses focused on in this meta-analysis were acne, dermatitis, pruritis and pressure injury since they were the most consistently reported facial dermatoses among the studies that met the inclusion criteria.

In the 24 studies that included acne, the pooled prevalence of acne was 31% (95% CI: 26%–37%). In the 25 studies that included facial dermatitis, the pooled prevalence of facial dermatitis was 24% (95% CI: 20%–29%). In the 22 studies that included itch, the pooled prevalence of itch was 30% (95% CI: 26%–34%). Finally, in the 18 studies that included pressure injuries, the pooled prevalence of pressure injuries was 31% (95% CI: 26%–37%). Figure 2 summarizes the above results.

3.4 | Risk factors for developing facial dermatoses

Subsequently, the relative risk of developing various facial dermatoses due to duration of mask wear and type of mask worn was calculated, as these were commonly reported risk factors for facial dermatoses in the studies which were found to be eligible for this meta-analysis. Studies were also stratified according to the different characteristics of their study populations, to ascertain the stratifying factors affecting the prevalence of facial dermatoses in different sub-groups. These sub-groups were divided based on occupation and the region in which the study was conducted.

3.4.1 | Duration of mask wear

The pooled prevalence of facial dermatoses and the prevalence of acne, dermatitis and itch was compared between different sub-groups of respondents with different durations of mask exposure. For this comparison, only studies that provided data on the prevalence of these dermatoses for both the sub-group that wore masks for less than 4–6 h and the sub-group that wore masks for more than 4–6 h were included, such that the relative risk could be calculated within the study. There was insufficient data for analysis of the prevalence of pressure injury between different duration of mask wearing.

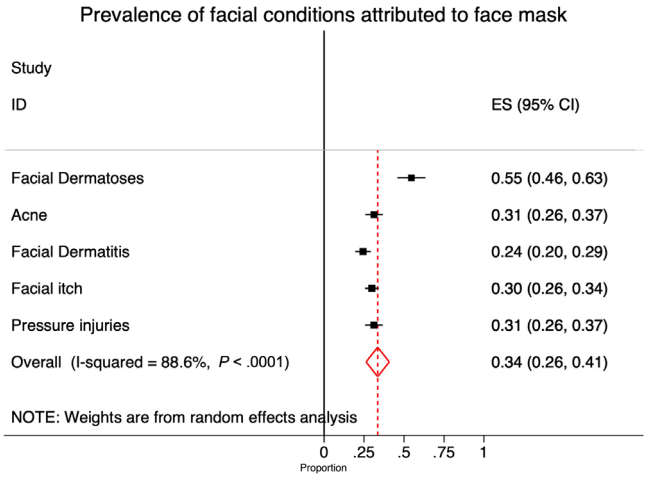

FIGURE 2 Prevalence of facial dermatoses in general, and individual facial dermatoses that are attributed to the use of face masks

Pooled analysis of eight studies[30,53,56,58,60,63–65] showed that the overall relative risk of developing any facial dermatosis in the population which used face masks for above 4–6 h was significantly higher at 1.42 (95% CI: 1.31–1.54, $p < 0.001$), compared to the population which used face masks for less than four to six hours.

Subsequently, the relative risk of developing individual facial dermatoses in the population which used face masks for above four to six hours was calculated. Pooled analysis of four studies[30,38,44,61] revealed that the relative risk of developing acne in the population which used face masks for above four to six hours was 1.27 (95% CI: 0.79–2.04, $p = 0.329$). Pooled analysis of three studies[30,33,44] showed that the relative risk of developing dermatitis in the population which used face masks for above four to six hours was 1.47 (95% CI: 1.05–1.69, $p = 0.254$). Finally, pooled analysis of four studies revealed that the relative risk of developing facial itch[30,44,47,59] in the population which used face masks for above four to six hours was 1.38 (95% CI: 1.01–1.89, $p = 0.041$). Figure 3 summarizes the above results.

3.4.2 | Type of mask worn

Subsequently, the pooled prevalence of facial dermatoses and the prevalence of acne, dermatitis and itch was compared between different populations which used different types of mask. Surgical masks and respirators were the focus of this comparison, as they were the more commonly used types of mask within the papers analysed. For this comparison, only studies that provided data on the prevalence of these dermatoses for both the sub-group that wore respirators and the sub-group that wore surgical masks were included, such that the relative risk could be calculated within the study. There was insufficient data for analysis of the prevalence of pressure injury between different duration of mask wearing.

Seventeen studies provided sufficient data for pooled analysis of the relative risks of developing any facial dermatoses, and acne, facial dermatitis or itch individually from wearing respirators compared to surgical masks (Figure 4). Statistical analysis showed no significant differences ($p > 0.05$) in the relative risks of developing any facial dermatoses in patients who used surgical masks compared to respirators.

3.4.3 | Occupation

Subsequently, the prevalences of facial dermatoses as a whole, or acne, dermatitis or itch in studies that only included healthcare workers were

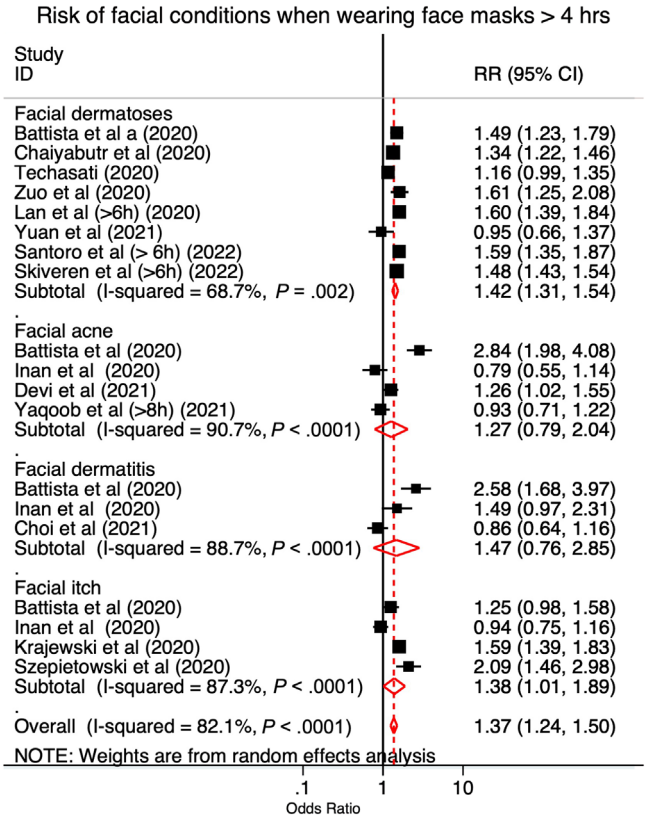

FIGURE 3 Relative risks of developing facial dermatoses when wearing masks for >4–6 h compared to <4–6 h

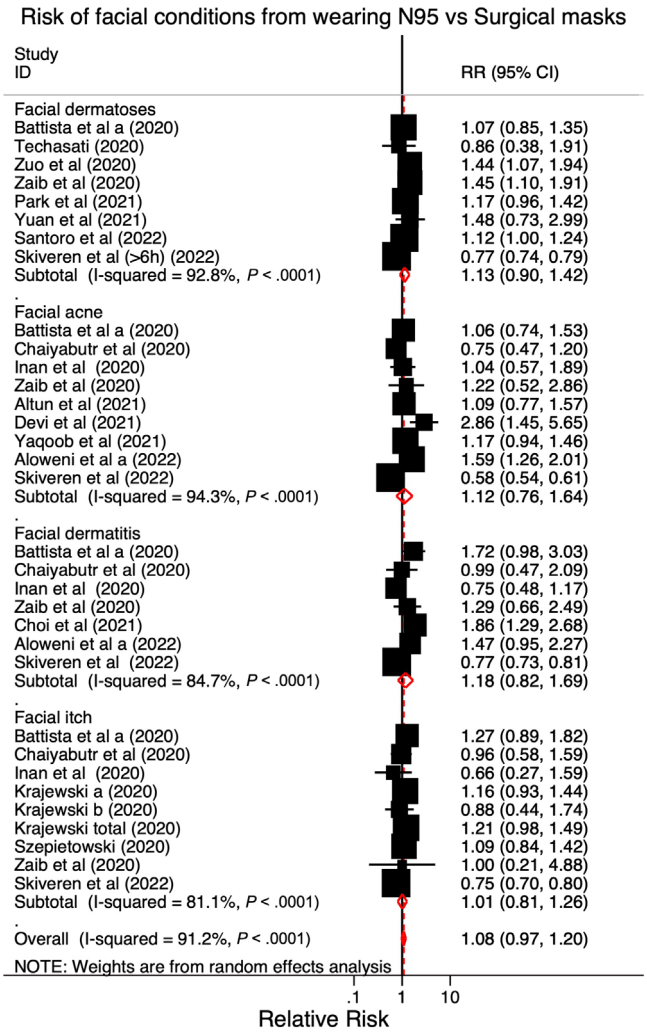

FIGURE 4 Relative risks of developing facial dermatoses when using respirators in comparison to surgical masks

TABLE 2 Grading of studies

Outcome	Quality assessments						Number of patients with respective dermatoses		Effect	
	Number of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	>4–6 h	<4–6 h	Relative risk (95% CI)	Quality
Pooled facial dermatoses	8	Observational	Serious	Serious	Not serious	Not serious	6433/9567 (67.2%)	2537/5402 (46.7%)	1.42 (1.31–1.54)	Low
Acne	4	Observational	Serious	Serious	Not serious	Serious	255/474 (53.8%)	161/431 (37.4%)	1.27 (0.79–2.04)	Very low
Dermatitis	3	Observational	Serious	Serious	Not serious	Serious	161/419 (38.4%)	101/403 (25.1%)	1.47 (1.05–1.69)	Very low
Itch	4	Observational	Serious	Serious	Not serious	Not serious	483/1265 (38.2%)	622/2901 (21.4%)	1.38 (1.01–1.89)	Low

Outcome	Quality assessments						Number of patients with respective dermatoses		Effect	
	Number of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Respirator	Surgical Mask	Relative risk (95% CI)	Quality
Pooled facial dermatoses	8	Observational	Serious	Serious	Not serious	Not serious	2785/5898 (47.2%)	6916/11955 (57.9%)	1.13 (0.90–1.42)	Very low
Acne	9	Observational	Serious	Serious	Not serious	Serious	1391/5669 (24.5%)	4248/11415 (37.2%)	1.12 (0.76–1.64)	Very low
Dermatitis	7	Observational	Serious	Serious	Not serious	Serious	1494/5571 (26.8%)	3771/11247 (33.5%)	1.18 (0.82–1.69)	Very low
Itch	7	Observational	Serious	Serious	Not serious	Not serious	1249/5538 (22.6%)	3684/12924 (28.5%)	1.01 (0.81–1.26)	Very low

compared to those reported in studies that included the overall population as a whole. Surprisingly, the prevalence of facial dermatoses as a whole, and acne, dermatitis, facial itch and pressure injuries individually, did not differ between both categories (Figure S1).

3.4.4 | Geographical region

Additionally, the prevalences of facial dermatoses as a whole, or acne, dermatitis or itch in studies conducted in non-Asian countries were compared to those reported in studies conducted in Asian countries. There were no significant differences in the stratified prevalence of facial dermatoses as a whole, and acne, dermatitis, facial itch and pressure injuries individually, between studies conducted in different regions (Figure S2).

3.4.5 | Quality

The proportion of the various facial dermatoses was also compared between the studies we rated as low quality and the studies we rated as high quality. Overall, the prevalence of facial dermatoses as a whole, and acne, dermatitis, facial itch and pressure injuries individually, were similar between both categories (Figure S3).

3.4.6 | Grade assessment

The confidence in the estimates for the risk of facial dermatoses due to prolonged mask-wear and the type of mask were assessed in accordance with the criteria outlined in the GRADE system. All studies were cross-sectional studies, which start as low confidence. The risk of bias was assessed to be serious as due to the potential for responder bias in any survey which participants could voluntarily participate in, which is how most studies included in this meta-analysis were conducted. There was also inconsistency in the findings, in that there was perceptible heterogeneity on visual inspection. The risk of imprecision was also rated as serious in studies involving acne or dermatitis, as the facial dermatoses were not professionally diagnosed in most studies, and were deemed to be morphologically similar and hence easily confused by the layperson. The overall grade assessment of duration of mask wear and the type of masks as risk factors for facial dermatoses is hence 'Low' for the relationship between the duration of mask wear and the development of facial dermatoses in general or itch, and 'Very Low' for the other relationships. These assessments are summarized in Table 2.

4 | DISCUSSION

This meta-analysis quantitatively evaluate the prevalence of the various distinct adverse skin reactions associated with the usage of face masks. Our study, after analysing data from these 37 reports with a total of 29 557 subjects, has found that the prevalence of facial dermatoses that could be attributed to mask-wear was common, affecting over half of this large study population. Moreover, the individual facial dermatoses, including acne, facial dermatitis, itch and pressure injury are all relatively prevalent in people who use face masks, each affecting almost a third of their respective study population. The prevalence of face-mask-induced facial dermatoses in our meta-analysis suggests that this problem is likely to be under-reported,[66] and that there is great value in undertaking further research in this area.

This meta-analysis revealed that a prolonged duration of mask wear was the main statistically significant risk factor for the development of all facial dermatoses, including acne, dermatitis and itch. This finding is not surprising, since prolonged exposure to any irritant would likely cause an increase in the prevalence of symptoms. However, our meta-analysis shows that even exposure to face masks for as short as 4 h a day can lead to facial dermatoses; this level of exposure would be far below the average duration that people wear masks in countries where mask-wearing is mandated. This finding also suggests that in professions that require prolonged mask-wear, especially healthcare, there is a role in instituting regular breaks to temporarily remove PPE, to reduce the time spent using facial PPE in a single stretch[67] and hence reducing their risk of developing facial dermatoses.

On the other hand, there was insufficient evidence to show that respirators, such as N95 masks, cause a statistically significant increased risk for developing any facial dermatoses, as compared to surgical masks. This suggests that although using N95 masks is, anecdotally, significantly less comfortable than using surgical masks, the extent of facial dermatoses caused by surgical masks cannot be belittled. It has been shown the materials in surgical masks can cause contact dermatitis.[26] Surgical masks can also cause the accumulation of moisture,[68] which predisposes wearers to skin breakdown and the penetration of irritants and allergens, and is also comedogenic. Moreover, surgical masks can also cause contact dermatitis. However, it is also worth noting that there was only a single study by Skiveren et al.,[58] but with an extremely large sample size of 10 287 respondents, which suggested that surgical masks cause a higher prevalence of facial dermatoses than respirators; this may have skewed the results.

Inter-study comparisons also did not show any differences in the prevalence of any facial dermatoses that can be attributed to occupation or region. This suggests that even outside of high risk settings such as healthcare, individuals in the general population are still using face masks for prolonged periods, which are sufficient to cause a significant amount of dermatological morbidity. Moreover, it appears that face masks inducing facial dermatoses is a global problem, and is not isolated to a single region with a unique climate.

This meta-analysis has some limitations. First, most studies rely on self-reporting of both the symptoms of facial dermatoses and the duration of mask wear. Hence, the results may be confounded by the inability of respondents to accurately diagnose their dermatological conditions, and are also subject to recall bias. Second, the results of this meta-analysis may have been influenced by publication bias

(Figure S4). For instance, studies with small sample size and low prevalence if facial dermatoses from mask-wearing may not have been published. Hence, the actual burden of facial dermatoses could potentially be misrepresented. Moreover, this analysis was limited to only studies published in the English language, and did not include unpublished studies. Third, few studies in the meta-analysis had a control group for comparison. This is understandable since many countries, as mentioned earlier, strongly encourage the use of masks, and it would be unethical to expose a control group to a higher risk of contracting COVID-19; nevertheless, this decreases the statistical power of aggregated intra-study comparisons. Finally, although type of mask, occupation and region were not shown to influence the prevalence of facial dermatoses, there could still be further confounding variables that could account for the gross heterogeneity between the studies in this meta-analysis. Hence, there is definitely a role for additional interventional studies to determine, for example, if the types of masks worn or any adjunctive measures are useful in mitigating the risk of facial dermatoses.

Additionally, while conducting this meta-analysis, it was noted that some studies did not further characterize mask-related facial dermatoses into specific dermatological diagnoses. Instead, these studies employed umbrella terms such as 'mask-related skin conditions', especially while elucidating risk factors for these facial dermatoses. However, acne, facial dermatitis, itch and pressure injuries are all distinct identities that are all commonly reported in the literature included in this meta-analysis, and there are yet other less-reported facial dermatoses related to the usage of masks. These multitudinous facial dermatoses have distinct pathophysiological mechanisms, and are hence also likely to have unique risk factors. Hence, these discrete dermatological diagnoses should be better distinguished, and more information should be elucidated in further studies to ascertain the risk factors for each of these unique dermatological conditions.

Moreover, formal dermatological review of reported facial dermatoses secondary to mask use was uncommon among studies conducted. Clinical information on the exact facial dermatoses induced by face masks may hence be inaccurate, since these pathologies may all appear similar to the layperson. As discussed previously, the specific dermatological pathologies that can result from the use of face masks are varied and distinct. Thus, targeted recommendations for reducing the prevalence of specific face-mask-related facial dermatoses are needed, especially since there might be interactions between management of co-existing facial dermatoses. During this COVID-19 pandemic, telemedicine might be an especially valuable tool to provide accurate diagnoses while minimizing the need for interpersonal interaction and the resultant spread of this virus; in dermatology, it has already been shown to be a reliable consultation tool.[69]

In summary, while the pandemic seems to be improving and there has been gradual easing of mask wearing requirements across the globe, face masks will likely continue to be part of our daily lives for some time to come as part of personal protection. Our meta-analysis has shown that several distinct facial dermatoses can be induced by the use of masks, some of which are prevalent, and could potentially be underreported. Moreover, these dermatoses likely affect not only healthcare workers, but also the general public. Hence, there could be value in conducting further research to better understand these distinct clinical entities that comprise 'mask-induced facial dermatoses', and provide recommendations for some of these clinical entities. This way, we can continue to be protected by face masks as part of infection control, while mitigating their deleterious effects on the skin underneath.

AUTHOR CONTRIBUTIONS

Lim Yi Shen Justin: Conceptualization; methodology; data curation; software; formal analysis; investigation; validation; writing – original draft; writing – review and editing. **Yik Weng Yew:** Conceptualization; investigation; methodology; validation; software; formal analysis; data curation; supervision; writing – review and editing; writing – original draft.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in PubMed at https://pubmed.ncbi.nlm.nih.gov/.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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