



# Initial evidence that skin health deteriorates for younger age groups and with increased daily use of face masks for healthcare professionals at a dental hospital in the United Kingdom

Aaron Kua, Stephen Richmond, Damian JJ Farnell\*

School of Dentistry, Cardiff University, Cardiff CF14 4XY, Wales, United Kingdom

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## ABSTRACT

**Objective:** To determine the incidence and site of any adverse effects of wearing face masks via an online questionnaire.

**Methods:** Healthcare workers in a dental hospital who wear Respiratory Protective Equipment (RPE) were invited to participate. An online questionnaire was used to identify adverse effects as a result of wearing face masks and possible remedies.

**Results:** Red marks (72.1 %) and indentations (66.7 %) were the most frequently reported issues with increased use of the RPE. The bridge of the nose and cheeks were the most frequently reported sites of facial skin problems, such as blanching (54.1 % and 42.2 %, respectively) and pressure damage (42.3 % and 24.3 %, respectively). Overall perceived facial skin health deteriorated strongly and significantly ( $P < 0.001$ ) following the use of RPE, where the mean skin health score (0 = best possible skin health and 10 = worst possible skin health) increased from 2.68 to 4.76. Broadly, there was increased discomfort with increased hours of use of RPE per day ( $P = 0.049$ ). 71 % of participants said that they generally felt safe or very safe using RPE.

**Conclusion:** The facial skin health of respondents deteriorated strongly after the use of RPE. Guidelines for using RPE should be made clearer. A greater range of face mask sizes or bespoke masks should be made available to improve the fit and wearability, as well as to reduce the frequency and incidence of surface skin problems.

**Clinical significance:** This study has identified the factors influencing adverse skin reactions from face mask use, which can be used to inform face mask designers and manufacturers to improve the fit and wearability of face masks.

## 1. Introduction

Aerosols are often generated during routine dental and medical procedures. Therefore, it is necessary to provide safe, comfortable, flexible, lightweight and fluid resistant Respiratory Protective Equipment (RPE) that filters out potential harmful viruses, droplets or particles in the air. Basic Personal Protective Equipment (PPE) such as gloves, Fluid Resistant Surgical Masks (FRSM) and eye protection are worn by dental professionals for routine dental procedures due to the risk of contamination from blood and saliva during treatment. The most commonly and easily available RPE is the medical face mask. There has been a high incidence of soft tissue injuries reported related to long-term use of RPE. These injuries result from pressure, moisture retention are often associated with dermatitis and skin tears which occur frequently at

the bridge of the nose, cheeks, and forehead [1]. In addition, poor fit and skin irritation may lead to clinicians touching their faces to alleviate discomfort, therefore increasing the risk of cross infection.

COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV 2). Efforts were made during the COVID-19 pandemic to control the widespread infection of COVID-19 via social distancing, maintaining a good standard of self-hygiene, and wearing face masks in crowded, public places [2]. Wearing of face masks was found to be effective and relatively inexpensive way of reducing the spread of COVID-19 [3]. The World Health Organizations (WHO) released guidance alongside Public Health England and the Royal College of Surgeons of England recommending the use of a “fit tested and checked Filtering Face Pieces (FFP3) masks” alongside full PPE for high-risk procedures known to create aerosols or droplets [4]. This has

\* Corresponding author.

E-mail address: [farnelld@cardiff.ac.uk](mailto:farnelld@cardiff.ac.uk) (D.J. Farnell).

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been further reinforced by studies which found that surgical masks alone were insufficient and ineffective in preventing the spread of COVID-19 virus [5–9]. The use of a respirator mask is capable of providing an excellent facial seal over the mouth and nose, whilst simultaneously providing a fluid resistant barrier [10].

The aim of this study is to identify the site of any adverse effects with increased use of face masks or respirators during this period of COVID-19 pandemic in an effort to prevent or reduce facial skin problems of all healthcare workers in future.

## 2. Materials and methods

### 2.1. Study design

This cross-sectional study invited staff and students working in a Dental Hospital in United Kingdom to complete an online questionnaire related to face mask wear. All clinical staff and students at the dental hospital (dentists, therapists, dental nurses, dental technicians, hygienists, undergraduate and postgraduate dental students) were invited to participate. A questionnaire was designed and based on a questionnaire in a related study [11]. This survey included details of each participant's age, sex, ethnicity, social history, and their professional occupation, as well as the different types of reusable or disposable face masks that they used. In addition, it gathered evidence relating to the frequency and duration of use of RPE. Participants were also asked about the comfort and pain levels while wearing the RPE, including the nature and location of any adverse skin reactions, as well as any preventive measures that were used by them. A copy of the entire questionnaire is provided in an Appendix as online supplementary resources to this paper. The questionnaire was distributed online using the Online Surveys platform [12]. All clinical staff and students working in the dental hospital were invited to participate. There were no specific exclusion criteria. Participation was purely voluntary, and each subject was provided with a subject information sheet that stated (amongst other things) that consent was implied by completion of the questionnaire. This project was approved by the Cardiff University Dental Research Ethics Committee with reference number of 2101a.

### 2.2. Data collection

The online questionnaire was distributed through Online Surveys platform to 652 staff and students. Data collection was conducted for a three-month period, namely, from April 2021 to June 2021. Participants were asked to complete all items in the questionnaire, although they were also given the option to leave questions unanswered.

### 2.3. Statistical analysis

Data analysis was carried out by using the IBM SPSS statistical package V27. Descriptive statistics and frequencies were used to explore the data. Chi-squared tests were used to determine if statistically significant associations occurred between categories variables (with respect to a 5 % level of significance). The Wilcoxon signed-rank test was used to test if an increase occurred in perceived skin problems (measured on an ordinal scale) with respect to two questions in the questionnaire relating to changes before and after using RPE.

## 3. Results

111 subjects participated in this study. However, we estimate that only 510 clinical members of staff (250 subjects) or students (260 subjects) of the 652 approached were active clinically during the timeframe of the study (April 2021 to June 2021) and so were regular users of RPE. The response rate with respect to this group of clinically active subjects during this timeframe was roughly 22 %. The mean number of days of use of RPE per week was 4.35 (median = 5 days; SD = 1.1). Skin effects

from specific types of mask were impossible to disaggregate. For example, 53 out of 111 subjects (47.7 %) used more than one type of disposable face mask; and, 95 % of those who reported that they used reusable facemasks reported that they used disposable face masks also. 89.2 % of subjects used a three-ply disposable face mask, followed by the 3 M Face Mask 1863+ (38.7 %). All other types of disposable face mask (e.g., armor face mask or 3 M Face Mask 8833) was used by less than 10 % of subjects. 60 subjects reported that they used reusable face masks. Of these 60 subjects, 58.3 % said that they used the 3 M 7501 mask, 10.0 % used the 3 M 7502 mask, 8.3 % the 3 M 7503 mask, 10 % used the JSP Force 8 mask respirator, and 13.3 % used other types of reusable masks. Of the 60 subjects who wore re-usable facemasks, 95 % reported that they also regularly used conventional face masks. Small-sized reusable masks were used by 48.2 % of subjects, medium sized by 34.6 %, large sized by 2.7 % and "other" by 14.5 %. 55 out of 92 subjects who responded to the question (59.1 %) wore a face mask less than four hours per day, 17.2 % wore them four to six hours a day, 9.7 % six to eight hours per day, and 14.0 % more than eight hours per day. 82.9 % of subjects were female and the mean age of subjects was 31.6 years old (median = 28.0). The most common occupation was undergraduate dental students (31.6 %), followed by dentists (25.2 %), and then postgraduate dental student (19.8 %). All other professionals were less than 10 %. Finally, 75.7 % of the 111 subjects who responded to the question were white, 13.5 % were Asian or Asian British, 1.8 % were black, 2.7 % were mixed, and 6.3 % were "other."

80 out of 111 (72.1 %) reported having red marks after wearing RPE and 74 (66.7 %) noticed indentations on their faces. 19 (17.1 %) individuals reported skin problems after using their RPE for a long time. Facial signs included redness blanching, itchiness, rashes, pressure damage (i.e., areas of damage to the skin and the underlying tissue caused by constant pressure or friction), spots, or dry skin. Different sites of the face were divided into areas A, B, C, D, and E. Fig. 1 summarizes the incidence of various facial skin problems on different sites of the face, including percentages. Redness blanching and pressure damage were most commonly seen on the bridge of the nose (Site B), followed by the cheeks (Site C). Spots were the most commonly reported on the chin and cheeks (Sites D & C), followed by the bridge of the nose (Site B). Dry Skin was distributed quite evenly on the cheeks, chin, and bridge of the nose (Site C, D, and B). As for the itchiness and rashes, they were generally distributed fairly evenly on all sites of the face.

Using a scale of 0 to 10 (0 = best possible skin health and 10 = worst possible skin health), the mean for overall facial skin health before using the RPE was 2.68 (median = 2.00 and standard deviation = 2.185). Perceived overall skin health of the participants deteriorated after increased daily frequency of use of RPE, where the mean was 4.76 (median = 5.00 and standard deviation = 2.509). There was a statistically significant increase in adverse skin reactions after using RPE (Wilcoxon-signed rank test:  $P < 0.001$ ).

In order to find out which factors had an influence on comfort, breathability, safety, pain, and facial skin health of all the participants, Cramer's  $V$  (a measure of strength of association) and  $P$ -values from chi-squared analyses were calculated (Table A1 in the Appendix). We now focus on those factors with the largest values of  $V$  (i.e., that showed the strongest associations) and that were significant ( $P < 0.05$ ).

As shown in Table 1, older respondents were less likely to suffer pressure damage ( $P = 0.007$ ), redness / blanching ( $P = 0.013$ ), and spots ( $P = 0.034$ ). 59 female participants (64.1 % of 92 female subjects in total) reported spots, which was significantly ( $P = 0.004$ ) higher than for males (5 subjects or 26.3 % of 19 male subjects in total). However, males tended to be older than females. The relationship between the age of the participants and the feeling of safety when wearing the RPE was also found to be significant ( $P = 0.01$ ), where older subjects generally felt safer (Table 2). Most participants reported feeling either safe (56 subjects out of 107 who responded to this question or 52.3 %) or very safe (20 subjects out of 107 or 18.7 %) using RPE regardless of their age group.

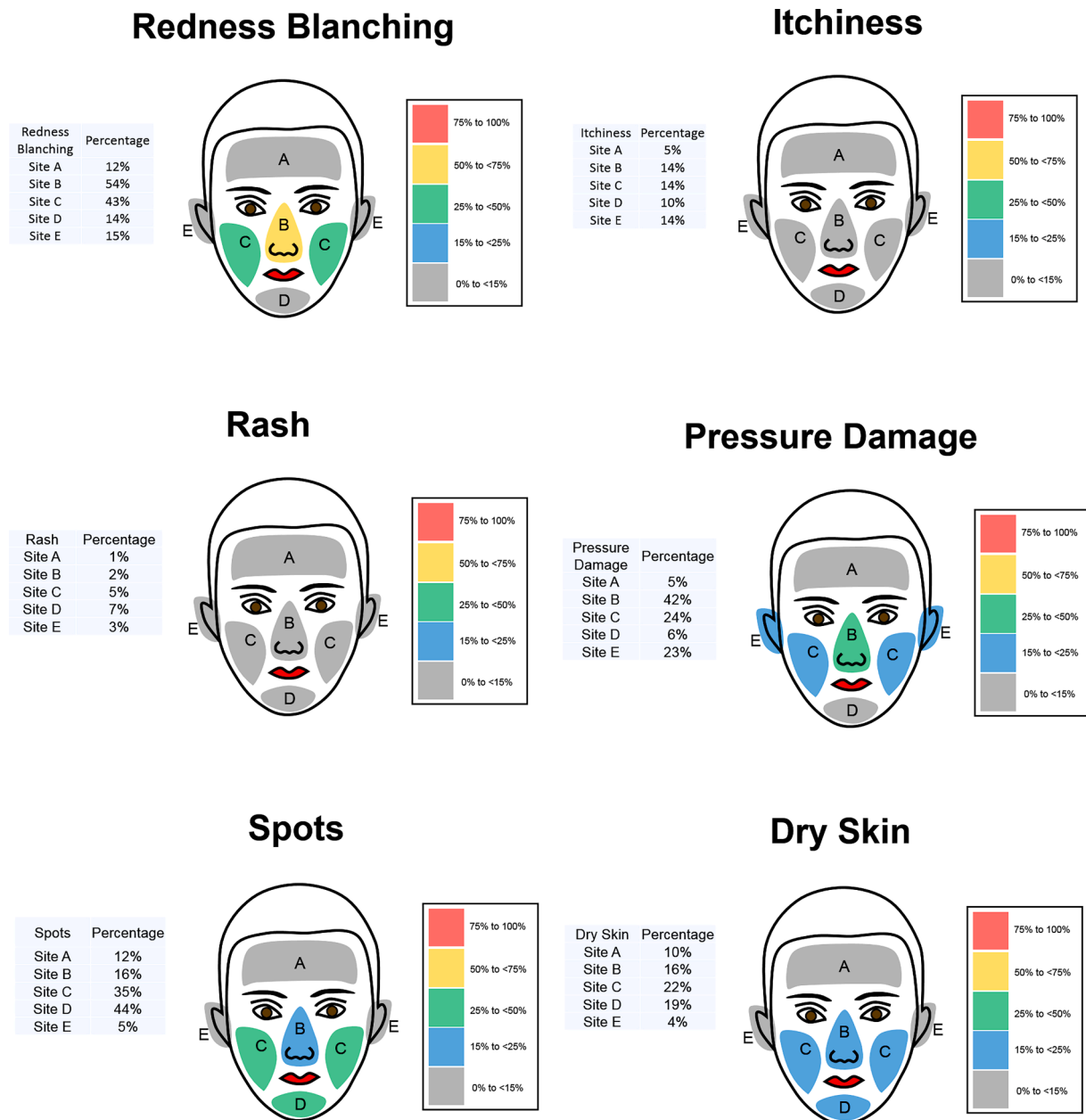


Fig. 1. Incidence of different facial skin problems on different sites of the face.

As shown in Table 3, there was a significant ( $P = 0.022$ ) relationship between occupation and perceived comfort, although 71 out of 103 participants (who responded to this question, i.e., 68.9 %) from all disciplines reported to generally feeling either uncomfortable or very uncomfortable wearing RPE. Similarly, there is a strong and significant ( $P = 0.009$ ) association between redness / blanching and occupation. Undergraduate students were more likely to experience redness blanching on their facial skin after prolonged use of RPE (85.2 %). Age was related to occupation with students generally being younger than the other categories.

As shown in Table 4, four to six hours of wearing RPE had the highest incidence of responses of uncomfortable or very uncomfortable and (separately) presence of acne. Broadly, we interpret this pattern of results in Table 4 as suggesting that discomfort increased significantly ( $P = 0.049$ ) and that the risk of acne also increased significantly ( $P = 0.049$ ) with increased hours of wear of RPE per day.

See Tables A2 to A5 in the Appendix (provided as online supplementary resources to this paper) for details of other associations that

were significant ( $P < 0.05$ ). For example, there was a significant ( $P < 0.05$ ) relationship between both sex (Table A2 in the Appendix) and ethnicity (Table A3 in the Appendix) and the incidence of spots on the face. The highest incidence of spots were reported in Asian / Asian British group (11 out of 15 subjects or 73.3 %), followed by mixed ethnicity (2 out of 3 subjects or 66.7 %), and Whites (50 out of 84 subjects or 59.5 %). Asian / Asian British respondents tended to be younger than those subjects who identified as white. 26 (42.6 %) out of 61 respondents who used cosmetic products found themselves able either to breathe easily or very easily with the RPE compared to only 18 out of 50 subjects (36.0 %) who did not ( $P = 0.037$ ; Table A4 in the Appendix). Furthermore, 41 out of 61 respondents (67.2 %) of those subjects who used cosmetic products reported spots whereas only 23 out of 50 subjects (36.0 %) who did not ( $P = 0.034$ ) (Table A5 in the Appendix). However, those respondents who tended to use cosmetics also were older and female.

**Table 1**  
Pressure damage ( $P = 0.007$ ), redness or blanching ( $P = 0.013$ ), and prevalence of spots ( $P = 0.034$ ) reported as a function of age.

Age group	Pressure damage		Redness / Blanching		Spots	
	No	Yes	No	Yes	No	Yes
19 to 24	12 (32.4 %)	25 (67.6 %)	10 (27.0 %)	27 (73.0 %)	15 (40.5 %)	22 (59.5 %)
25 to 29	10 (40.0 %)	15 (60.0 %)	6 (24.0 %)	19 (76.0 %)	8 (32.0 %)	17 (68.0 %)
30 to 34	8 (61.5 %)	5 (38.5 %)	5 (38.5 %)	8 (61.5 %)	6 (46.2 %)	7 (53.8 %)
35 to 39	2 (22.2 %)	7 (77.8 %)	1 (11.1 %)	8 (88.9 %)	1 (11.1 %)	8 (88.9 %)
40 to 44	4 (57.1 %)	3 (42.9 %)	4 (57.1 %)	3 (42.9 %)	6 (85.7 %)	1 (14.3 %)
45 to 49	2 (100.0 %)	0 (0.0 %)	2 (100.0 %)	0 (0.0 %)	2 (100.0 %)	0 (0.0 %)
50 to 54	5 (83.3 %)	1 (16.7 %)	5 (83.3 %)	1 (16.7 %)	4 (66.7 %)	2 (33.3 %)
55 to 59	7 (87.5 %)	1 (12.5 %)	4 (50.0 %)	4 (50.0 %)	4 (50.0 %)	4 (50.0 %)
All Ages	50 (46.7 %)	57 (53.3 %)	37 (37.1 %)	60 (62.9 %)	46 (43.0 %)	61 (57.0 %)

**Table 2**  
Relationship between age group and feelings of safety ( $P = 0.01$ ).

Age group	Feelings of safety				
	Very safe	Safe	Neither safe nor unsafe	Unsafe	Very unsafe
19 to 24	9 (24.3 %)	23 (62.2 %)	3 (8.1 %)	2 (5.4 %)	0 (0.0 %)
25 to 29	2 (8.0 %)	14 (56.0 %)	6 (24.0 %)	3 (12.0 %)	0 (0.0 %)
30 to 34	2 (15.4 %)	7 (53.8 %)	3 (23.1 %)	1 (7.7 %)	0 (0.0 %)
35 to 39	2 (22.2 %)	2 (22.2 %)	2 (22.2 %)	1 (11.1 %)	2 (22.2 %)
40 to 44	2 (28.6 %)	1 (14.3 %)	4 (57.1 %)	0 (0.0 %)	0 (0.0 %)
45 to 49	0 (0.0 %)	1 (50.0 %)	0 (0.0 %)	0 (0.0 %)	1 (50.0 %)
50 to 54	2 (33.3 %)	2 (33.3 %)	2 (33.3 %)	0 (0.0 %)	0 (0.0 %)
55 to 59	1 (12.5 %)	6 (75.0 %)	1 (12.5 %)	0 (0.0 %)	0 (0.0 %)

#### 4. Discussion

The overall aim of this study was to determine the incidence of any adverse effects of wearing face masks or respirators as well as the relative contributions of various factors related to increased daily frequency of use of these RPE. The respondents comprised different age groups, ethnicities, backgrounds, and occupations. However, the majority of respondents were White Caucasian female students. Facial skin health deteriorated with RPE wear for both males and females. All age groups

**Table 3**  
Relationship between occupation and comfort ( $P = 0.022$ ) and separately occupation and redness / blanching ( $P = 0.009$ ).

Occupation	Comfort					Redness / Blanching	
	Very comfortable	Comfortable	Neither comfortable nor uncomfortable	Uncomfortable	Very uncomfortable	No	Yes
Undergraduate Student	1 (3.7 %)	6 (22.2 %)	6 (22.2 %)	12 (44.4 %)	2 (7.4 %)	4 (14.8 %)	23 (85.2 %)
Postgraduate Student	1 (4.8 %)	4 (19.0 %)	3 (14.3 %)	11 (52.4 %)	2 (9.5 %)	11 (52.4 %)	10 (47.6 %)
Hygienist	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	1 (100.0 %)	0 (0.0 %)	1 (100.0 %)
Technician	0 (0.0 %)	1 (25.0 %)	0 (0.0 %)	3 (75.0 %)	0 (0.0 %)	3 (75.0 %)	1 (25.0 %)
Dental Nurse	0 (0.0 %)	1 (16.7 %)	2 (33.3 %)	2 (33.3 %)	1 (16.7 %)	4 (66.7 %)	2 (33.3 %)
Therapist	0 (0.0 %)	0 (0.0 %)	1 (10.0 %)	2 (20.0 %)	7 (70.0 %)	2 (20.0 %)	8 (80.0 %)
Dentist	0 (0.0 %)	2 (5.9 %)	4 (11.8 %)	27 (79.4 %)	1 (2.9 %)	9 (26.5 %)	25 (73.5 %)
All Occupations	2 (2.0 %)	14 (13.6 %)	16 (15.5 %)	57 (55.3 %)	14 (13.6 %)	33 (32.0 %)	70 (68.0 %)

and both sexes experienced a reduction in their overall facial skin health after increased daily frequency of use of RPE. In this study, most participants felt safe and in control with no difficulty in breathing through the RPE, as well as relatively low level of pain.

Broadly, respondents experienced deterioration of facial skin health after increased daily frequency of use RPE. The bridge of the nose and the cheeks remained the most commonly affected locations (Fig. 1), which agrees with findings of a previous study [13]. This might be the result of cumulative effects of irritation to the skin, particularly due to temperature, pressure, and humidity, all of which could decrease the tolerance of skin to RPE application [14]. Skin at all facial sites were vulnerable to facial skin problems in the form of redness blanching and pressure damage. Most RPE have been designed with respect to white male face shapes [15], the one-size-fits-all principle may be a significant factor affecting these adverse skin reactions [16].

Age had a significant effect on pressure damage, redness blanching, spots, and feeling safe. Older were less likely to experience pressure damage, redness blanching, and spots on their facial skin than younger subjects. This might be due to the younger skin having a greater sub-surface reflectivity and more even surface reflectivity [17], thus easier for them to identify these adverse skin reactions after prolonged usage of the RPE, and / or increased skin sensitivity in younger subjects. All respondents felt safe using RPE regardless of age groups. Age was a strong confounding factor, and this should be taken in account when considering the results presented here.

Females were also found to have a higher chance of developing spots on their facial skin as compared to males. This is contrary to a previous study which showed that males have a higher prevalence of this symptom [1]. With reference to ethnicity, Asians were more prone to developing spots on their facial skin. It was known that pigmentation disorders were more commonly found in Japanese and Indian women [18]. Professional discipline / occupation had a significant effect on the level of comfort and redness blanching. Most participants regardless of their role felt uncomfortable with prolonged wear of the RPE. Undergraduates were more likely to develop redness and blanching.

Participants who used cosmetic products on a regular basis were found to be able to breathe through the RPE much easier compared to those who do not. However, they were more likely to develop facial spots. The adverse reactions of the cosmetic products could have contributed to our findings [19]. Again, age (and sex) might have been a confounder here though. Our study has identified the nature of the adverse skin reactions as well as the level of comfort and their associations with the amount of time spent using the RPE. There was clear evidence that respondents who wore the RPE longer felt more uncomfortable and were more prone to develop facial spots [20].

##### 4.1. Implications and recommendations for clinical practice

The use of face masks were crucial to control and prevent the spread of this virus during the COVID-19 pandemic. However, face masks that are currently available are commonly designed to fit an average male Caucasian face and so might not necessarily be a good fit to male and female facial shapes and / or across different ethnicities [21,22].

**Table 4**Relationship between the amount of time (hours per day) wearing RPE and comfort ( $P = 0.049$ ) and separately with the presence of acne ( $P = 0.049$ ).

Hours per day wearing RPE	Comfort					Acne	
	Very comfortable	Comfortable	Neither Comfortable nor uncomfortable	Uncomfortable	Very uncomfortable	No	Yes
Less than 4 hours	2 (3.6 %)	9 (16.4 %)	9 (16.4 %)	31 (56.4 %)	4 (7.3 %)	24 (43.6 %)	31 (56.4 %)
4 to 6 hours	0 (0.0 %)	0 (0.0 %)	1 (6.3 %)	9 (56.3 %)	6 (37.5 %)	3 (18.8 %)	13 (81.3 %)
6 to 8 hours	0 (0.0 %)	3 (33.3 %)	0 (0.0 %)	4 (44.4 %)	2 (22.2 %)	3 (33.3 %)	6 (66.7 %)
More than 8 hours	1 (7.7 %)	1 (7.7 %)	3 (23.1 %)	8 (61.5 %)	0 (0.0 %)	9 (69.2 %)	4 (30.8 %)

This study has identified various adverse effects of face masks wear during this COVID-19 pandemic. Overall facial skin health deteriorated strongly and significantly ( $P < 0.05$ ) as the result of extensive use of face masks. This study has identified the factors influencing adverse skin reactions from face mask use. The findings from this study can inform face mask designers and manufacturers to improve the fit and wearability of face masks. The one-size-fit-all concept for the face masks studied is no longer a viable concept to maintain the facial health of the wearers [23]; personalized custom-made fitted face masks may be a viable alternative.

Healthcare workers who need to use RPE for a prolonged period of time should take precautionary measures such as applying appropriate facial skin products such as moisturisers daily, which may help in improving their facial skin health. A short break in wearing the RPE may also help reduce any adverse facial conditions developing.

#### 4.2. Study limitations

We estimate that the survey response rate was approximately 22 % of the clinically active staff or students (April 2021 and June 2021), which is somewhat low. Non-response bias might have played a factor in the results presented here, perhaps (albeit speculatively) leading to an overestimate of prevalence of skin problems. However, it is equally likely that the relatively low response rate was due to people simply “missing” emails of invitation to participate during this difficult time of the pandemic. Subjects were mainly female white Caucasians, and they born in the same area of the UK (South Wales). This limits the external validity / generalizability of these findings to some extent.

It was known that smoking and alcohol consumption significantly impacts facial skin health [24]. Although this study measured both smoking and alcohol consumption status of participants in the study, a statistical analysis could not be carried out with respect to these factors due to small sample sizes for these smoking and / or drinking groups. A larger overall sample size across multiple sites in the UK in future might allow analysis for these factors. More sophisticated statistical modeling approaches than the relatively simple chi-squared analysis presented here also require larger sample sizes. The socioeconomic status and dietary habits of these participants were not recorded. Environmental influences could have a potential effect on the overall general facial skin health. Again, future studies examining face mask design will address all of these issues.

#### 5. Conclusion

From the study undertaken to assess the adverse events in facial mask wear in the Dental Hospital, it is possible to conclude that:

1. Red marks and indentations were the most frequently reported skin problems after increased daily frequency of use of the RPE.
2. The bridge of the nose and cheeks were the most frequently reported site of facial skin problems, with blanching and pressure damage as the most common form of facial skin injury in these sites.

3. The overall facial skin health of participants had deteriorated after increased daily frequency of use of the RPE.
4. Younger participants tend to have higher chances of experiencing pressure damage, redness blanching, and spots on their facial skin. Age was a strong confounding variable.
5. All participants regardless of age groups felt safe wearing these RPE.
6. Asian / Asian British group reported the highest frequency with facial spots.
7. All participants, regardless of professional discipline / occupation felt uncomfortable wearing RPE, however undergraduate students were the highest to have experienced redness or blanching on their facial skin.
8. Participants using cosmetic products on a regular basis could breathe easier through the RPE, but they were more prone to develop spots on their skin.
9. Discomfort increased as the number of times RPE was worn per day increased.

#### CRediT authorship contribution statement

**Aaron Kua:** Data curation, Formal analysis, Writing – original draft. **Stephen Richmond:** Conceptualization, Supervision, Writing – original draft. **Damian JJ Farnell:** Conceptualization, Supervision, Formal analysis, Writing – original draft.

#### Declaration of Competing Interest

There are no competing / conflicting interests.

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#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jdent.2023.104799](https://doi.org/10.1016/j.jdent.2023.104799).

#### References

- [1] Q. Jiang, S. Song, J. Zhou, Y. Liu, A. Chen, Y. Bai, J. Wang, Z. Jiang, Y. Zhang, H. Liu, J. Hua, The prevalence, characteristics, and prevention status of skin injury caused by personal protective equipment among medical staff in fighting COVID-19: a multicenter, cross-sectional study, *Adv. Wound Care (New Rochelle)* 9 (7) (2020) 357–364.
- [2] X. Yu, R. Yang, COVID-19 transmission through asymptomatic carriers is a challenge to containment, *Influenza Other Respir. Viruses* 14 (4) (2020) 474–475.
- [3] C. Raina MacIntyre, S. Jay Hasanain, Community universal face mask use during the COVID 19 pandemic—from households to travellers and public spaces, *J. Travel Med.* 27 (3) (2020).
- [4] World Health Organization, 2020. Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19). [https://www.who.int/publications/i/item/rational-use-of-personal-protective-equipment-for-coronavirus-disease-\(covid-19\)-and-considerations-during-severe-shortages](https://www.who.int/publications/i/item/rational-use-of-personal-protective-equipment-for-coronavirus-disease-(covid-19)-and-considerations-during-severe-shortages) [Accessed: 23rd September 2023].

- [5] M. Bergman, Z. Zhuang, E. Brochu, A. Palmiero, Fit assessment of N95 filtering-facepiece respirators in the US centers for disease control and prevention strategic national stockpile, *J. Int. Soc. Respir. Prot.* 32 (2015) 50.
- [6] A.A. Chughtai, H. Seale, W.D. Rawlinson, M. Kunasekaran, C.R. Macintyre, Selection and use of respiratory protection by healthcare workers to protect from infectious diseases in hospital settings, *Ann. Work Exposures Health* 64 (2020) 1–10.
- [7] Y.J. Huh, H.M. Jeong, J. Lim, et al., Fit characteristics of N95 filtering facepiece respirators and the accuracy of the user seal check among Koreans, *Infect. Control Hosp. Epidemiol.* 39 (2018) 104–107.
- [8] Y. Long, T. Hu, L. Liu, et al., Effectiveness of N95 respirators versus surgical masks against influenza: a systematic review and meta-analysis, *J. Evid. Based Med.* 13 (2020).
- [9] Z. Wen, L. Yu, W. Yang, et al., Assessment the protection performance of different level personal respiratory protection masks against viral aerosol, *Aerobiologia (Bologna)* 29 (2013) 365–372.
- [10] Z. Wen, L. Yu, W. Yang, L. Hu, N. Li, J. Wang, K. Zhang, Assessment the protection performance of different level personal respiratory protection masks against viral aerosol, *Aerobiologia (Bologna)* 29 (2013) 365–372.
- [11] N.Y. Zhou, L. Yang, L.Y. Dong, Y. Li, X.J. An, J. Yang, L. Yang, C.Z. Huang, J. Tao, Prevention and treatment of skin damage caused by personal protective equipment: experience of the first-line clinicians treating SARS-CoV-2 infection, *Int. J. Dermatol. Venereol.* 3 (02) (2020) 70–75.
- [12] <https://www.onlinesurveys.ac.uk/> [Accessed: 23rd September 2023].
- [13] D.M. Elston, Occupational skin disease among health care workers during the coronavirus (COVID-19) epidemic, *J. Am. Acad. Dermatol.* 82 (5) (2020) 1085–1086.
- [14] S.R. Coleman, R. Grover, The anatomy of the aging face: volume loss and changes in 3-dimensional topography, *Aesthetic Surg. J.* 26 (1 Supplement) (2006) S4–S9.
- [15] A. Merson, Unions say coronavirus crisis has brought 'into sharp focus' the problem of women being expected to wear PPE designed for men, *Press J* 16 (2020). <https://www.pressandjournal.co.uk/fp/politics/uk-politics/2142580/union-s-say-coronavirus-crisis-has-brought-into-sharp-focus-the-problem-of-women-being-expected-to-wear-ppe-designed-for-men/> [Accessed: 24 September 2023].
- [16] J.W.R. Verberne, P.R. Worsley, D.L. Bader, A 3D registration methodology to evaluate the goodness of fit at the individual-respiratory mask interface, *Comput. Methods Biomech. Biomed. Eng.* 24 (7) (2021) 728–739.
- [17] A. Matsubara, Differences in the surface and subsurface reflection characteristics of facial skin by age group, *Skin Res. Technol.* 18 (1) (2012) 29–35.
- [18] F. Flament, A. Abric, A.S. Adam, Evaluating the respective weights of some facial signs on perceived ages in differently aged women of five ethnic origins, *J. Cosmetic Dermatol.* 20 (3) (2021) 842–853.
- [19] M. Tammela, M. Lindberg, M. Isaksson, A. Inerot, J. Rudel, B. Berne, Patch testing with own cosmetics—a prospective study of testing and reporting of adverse effects to the Swedish Medical Products Agency, *Contact Derm.* 67 (1) (2012) 42–46.
- [20] N. Abiakam, P. Worsley, H. Jayabal, K. Mitchell, M. Jones, J. Fletcher, F. Spratt, D Bader, Personal protective equipment related skin reactions in healthcare professionals during COVID-19, *Int. Wound J.* 18 (3) (2021) 312–322.
- [21] L. Ball, S. Alberti, C. Belfortini, C. Almondo, C. Robba, D. Battaglini, C. Cravero, P. Pelosi, V. Caratto, M. Ferretti, Effects of distancing and pattern of breathing on the filtering capability of commercial and custom-made facial masks: an in-vitro study, *PLoS One* 16 (4) (2021), e0250432.
- [22] TUC. 2017. **Personal Protective Equipment and Women.** <https://www.tuc.org.uk/research-analysis/reports/personal-protective-equipment-and-women> [Accessed: 24 September 2023].
- [23] T. Solano, R. Mittal, K. Shoele, One size fits all?: A simulation framework for face-mask fit on population-based faces, *PLoS One* 16 (6) (2021), e0252143.
- [24] G.D. Goodman, J. Kaufman, D. Day, R. Weiss, A.K. Kawata, J.K. Garcia, S. Santangelo, C.J. Gallagher, Impact of smoking and alcohol use on facial aging in women: results of a large multinational, multiracial, cross-sectional survey, *J. Clin. Aesthet. Dermatol.* 12 (8) (2019) 28.