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Clinics in Dermatology (2021) **39**, 451–456

Clinics in Dermatology

# Availability of personal protective equipment among dermatologists in the COVID-19 pandemic: Assessment and risk factors in a web-based, global study

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**Abstract Background**: The availability of personal protective equipment (PPE) among dermatologists during the Coronavirus Disease 2019 (COVID-19) pandemic has not been studied. **Methods**: We have assessed PPE availability among dermatologists and relevant aspects of hospital service by surveying 733 dermatologists. **Results**: Considerable percentages of respondents had to purchase their own PPE (40.2%) and were not provided with it at the hospital (37.7%). Only 27% of respondents provided hospital service, and 18.4% were assigned to nondermatologic duty. A substantial percentage (64.4%) indicated the availability of hospital-issued management guidelines (HIMG) for COVID-19 patients. Nearly half of the survey participants (49.1%) responded that the health care system was not equipped for the pandemic. Purchasing one's own PPE was strongly associated with the private practice setting and continent, with the highest rates in Central and South America and in Europe ($P < .001$). PPE availability at a hospital was associated with 2 continents, with the highest rates in Europe and in North America ($P < .001$). In logistic regression, the most important factor reducing the odds ratio (OR) for purchasing their own PPE was HIMG for COVID-19 patients (OR, 0.55; 95% confidence interval [CI], 0.32-0.97). Respondents' assessment that the health care system was equipped for COVID-19 was the most powerful increaser of OR for PPE availability (OR, 9.43; 95% CI, 5.37-16.56) followed by >1,000 COVID-19 cases in a participant's country. **Conclusions:** Substantial percentages of respondents had to purchase their own PPE and were not provided with it at the hospital. Strategies to increase PPE availability should be implemented by hospitals, industry, and government authorities.


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https://doi.org/10.1016/j.clindermatol.2021.01.008
0738-081X/

## Introduction

The emergence of the Coronavirus Disease 2019 (COVID-19) pandemic has become a global health threat. Because there is no specific treatment for COVID-19 at this time and the introduction of vaccines has just begun, control measures remain the mainstay to contain disease transmission. The increasing number of people infected has jeopardized health care systems including dermatology clinics across the globe.[1-6] In several parts of the world, dermatologists have served on the front lines to combat COVID-19 and have played an important role in enhancing preventive measures.[7-12] The use of personal protective equipment (PPE), including facial masks, face shields and visors, goggles, gloves, gowns, and air-purifying respirators, is pivotal to reducing the risk to which health care workers (HCWs) are exposed during the outbreak of this highly transmissible disease.[13-15] HCWs are facing the shortage in PPE, which is becoming an increasing international concern owing to the single-use nature of PPE.[16-18] Because PPE is heat sensitive, conventional sterilization techniques employed in hospitals cannot effectively reprocess it.

PPE is so indispensable that it has caused a scramble to procure it amid HCWs' complaints of the shortage. This shortage can be attributed to a continual rise in COVID-19 cases, misinformation, panic buying, and stockpiling. Improper handling and unnecessary consumption of PPE by HCWs may have been contributing factors.[19] It is imperative to safeguard the supply chain of properly fitted PPE, which is required to sustain vital health care provision and reduce disease transmission to HCWs and their patients.

Our study assesses PPE availability among dermatologists and relevant aspects of hospital service. We performed a comparative analyses to identify clinically meaningful associations of PPE availability among dermatologists during the pandemic. Logistic regression models were built to identify predictors of purchasing their own PPE and of PPE availability at the hospital.

## Methods

### *Survey instrument and administration*

The questionnaire was formatted in Google forms and pilot tested. The survey instrument was distributed electronically from April 1, 2020-April 20, 2020 to the principal investigators' contacts (ie, board-certified dermatologists on social media sites). Participants were provided with a link to access the survey. Reminder e-mails were sent to increase participation. This was an anonymous survey and recording or dissemination did not generate identifiable information. An exemption for the study was obtained from the RD Gardi Institutional Review Board (Ujjain, India).

### *Statistical analysis*

We excluded13 respondents because they were not board-certified dermatologists, missed essential demographic questions, and/or responded to <80% of questions for which they were qualified. This left a sample of 733 respondents for analysis. Frequencies (percentages) of participants who responded to each question are provided. Assessments of associations between pairs of categoric variables were performed with $\chi^2$ test. We attempted to identify statistically significant associations among variables including hospital service specifics, purchasing their own PPE, PPE availability at the hospital, and demographic data. The threshold of significance (ie, respective $P$ value) was adjusted for multiple comparisons by using false discovery rate.[20]

Finally, we created logistic regression models for "purchase own PPE" and "PPE availability at hospital."[21] Independent factors included demographic factors (continent, population density of practice, practice setting, and years in practice) and hospital service specifics—such as providing hospital service, allocation of nondermatologic duty, hospital-issued management guidelines (HIMG) for COVID-19 patients, and number of COVID-19 cases in patient's country at the time of the survey. The estimated odds ratio (OR) for each predictor is the factor by which the base rate OR would be multiplied if that predictor equalled "yes" to obtain the OR of the dependent variable being endorsed "yes." Precision estimates (95% confidence intervals [CIs]), z values (OR: standard error), and $P$ values for estimated ORs are provided. Statistical analysis was performed using Stata 15.1, (StataCorp, LLC, College Station, Texas).

## Results

### *Demographic data*

The demographic data are presented in Table 1. A total of 733 valid responses were received from qualified dermatologists from all continents. The largest group came from Asia (47.6%). Close to half (45%) the respondents had been practicing dermatology ≤10 years, half (47.2%) were involved exclusively in private practice, and three-quarters (78.6%) practiced in an urban area.

### *Descriptive data*

Relevant responses are summarized in Table 2. More than one-fourth of respondents (27%) were providing hospital service, and 18.4% were assigned to nondermatologic duty during the pandemic. More than half of respondents volunteered to serve on the front line with available PPE. Less than two-thirds of respondents indicated that HIMG for COVID-19 patients were available. Nearly half (49.1%) of participants responded that the health care system was not

**Table 1** Practice demographics

| Characteristic | Survey distribution[a] |
|---|---|
| **Years in practice** (N = 733) | |
| ≤10 | 330 (45.0) |
| 11-20 | 205 (28.0) |
| >20 | 198 (27.0) |
| **Location** (continent) (N = 733) | |
| Asia | 349 (47.6) |
| North America[b] | 137 (18.7) |
| Central and South America | 131 (17.9) |
| Europe | 102 (13.9) |
| Other | 14 (1.9) |
| **Population density of practice** (N = 733) | |
| Urban | 576 (78.6) |
| Suburban | 137 (18.7) |
| Rural | 20 (2.7) |
| **Practice setting** (N = 733) | |
| Private | 346 (47.2) |
| Private and hospital | 249 (34.0) |
| Tertiary hospital | 91 (12.4) |
| General hospital | 47 (6.4) |

[a] Data are reported as number (percentage) of respondents. Percentages are rounded to the decimal place.
[b] Group includes predominantly United States participants.

**Table 2** Hospital and healthcare system specifics during pandemic

| Characteristic | Survey distribution[a] |
|---|---|
| **Do you provide hospital service?** (n = 660) | |
| Yes | 178 (27.0) |
| **Has the hospital allotted you a nondermatologic duty?** (n = 651) | |
| Yes | 120 (18.4) |
| **Has your hospital provided management guidelines for COVID-19 patients?** (n = 667) | |
| Yes | 430 (64.4) |
| No | 96 (14.4) |
| Do not know | 141 (21.1) |
| **Is PPE available at your hospital?** (n = 677) | |
| Yes | 261 (38.5) |
| No | 255 (37.7) |
| Do not know | 161 (23.8) |
| **Do you have to purchase your own PPE?** (n = 677) | |
| Yes | 272 (40.2) |
| **Are you willing to volunteer at frontline (eg, intensive care unit, field hospital) with available PPE?** (N = 733) | |
| Yes | 392 (53.5) |
| **Is your health care system equipped for the pandemic?** (N = 733) | |
| Yes | 169 (23.1) |
| No | 360 (49.1) |
| Unsure | 204 (27.8) |
| **How many COVID-19 cases are currently reported in your country?** (N = 733) | |
| ≤1,000 | 360 (49.1) |
| 1,001-10,000 | 197 (26.9) |
| 10,001-50,000 | 176 (24.0) |

[a] Data are reported as number (percentage) of respondents. Percentages are rounded to the decimal place.*COVID-19*, Coronavirus Disease 2019; *PPE*, personal protective equipment.

equipped well to fight COVID-19. A considerable percentage of respondents had to purchase their own PPE (40.2%) because the hospital had not provided it (37.7%). Significant percentages of respondents who had to purchase their own PPE worked in general or tertiary hospitals (23.5%), combined practices (39.4%), or private practice (48.5%).

#### *Comparative statistics*

The comparative statistics are summarized in Table 3. Assignment to nondermatologic duty was associated with a participant's willingness to volunteer services on the front line ($P < .001$). HIMG for COVID-19 patients was associated with practice setting (stronger in general hospital [$P < .001$]) and respondent's assessment that the health care system is equipped for the pandemic ($P = .004$). Purchasing one's own PPE was strongly associated with a private practice setting and continent (highest rates in Central and South America and in Europe [$P < .001$ for each]). Higher PPE availability at the hospital was noted in Europe and in North America. Other associations of "purchasing own PPE" and "PPE availability at hospital" are presented in Table 3.

#### *Logistic regression models*

The most important factor reducing the OR for having to purchase one's own PPE was HIMG for COVID-19 patients (OR, 0.55; 95% CI, 0.32-0.97) (Table 4, model 1). Others were hospital settings, North American practice location, and PPE availability at their hospital. Respondents' assessment that the health care system was equipped for COVID-19 was the most powerful predictor of PPE availability (OR, 9.43; 95% CI, 5.37-16.56), followed by >1,000 COVID-19 cases in the country of participant (Table 4, model 2).

## Discussion

COVID-19 has had a considerable impact on dermatology care provided in the hospital setting.[3,12] Dermatology specialty clinics have been reduced or postponed indefinitely,[22] and wards have been repurposed as COVID care and quarantine centers in developing countries.[6] This disruption is owing to social distancing measures and concerns that dermatology examinations may be a vector of COVID-19 transmission.[23,24] In this study, only 27% of dermatologists provided hospital service. We also observed that hospitals assigned nondermatologic duty to 18.4% of dermatologists (68% of those providing hospital service) during this

**Table 3** Statistically significant associations

| Hospital or health care system during pandemic | | *P* value[a] | Group analyses[b] |
|---|---|---|---|
| **Purchase own PPE** (n = 677) | Practice setting | < .001 | Y/GT[c]: PP (48.5); CP (39.4); GH (25.5); TH (22.5)<br>PP vs CP ($P = .035$); CP vs TH ($P = .004$) |
| | Continent | < .001 | Y/GT: CSA (53.8); E (47.1); A (37.4); NA (24.6)<br>E vs NA ($P < .001$); A vs NA ($P = .009$) |
| | HIMG for COVID-19 patients | < .001 | Y/GT: No (58.5%); Yes (33.4%) |
| | PPE availability in hospital | < .001 | Y/GT: No (57.3%); Yes (26.1%) |
| | Health care system equipped for pandemic | .001 | Y/GT: No (44.6%); Yes (29.4%) |
| **Willing to volunteer service on frontline with available PPE** (N = 733) | Allocation of nondermatologic duty | < .001 | |
| **HIMG for COVID-19 patients** (n = 677) | Practice setting | < .001 | Y/GT: GH (23.9); PP (15.8); CP (12.7); TH (8.6)<br>GH vs PP (<.001) |
| | Health care system equipped for pandemic | .004 | |
| **PPE availability at hospital** (n = 677) | Years in practice | .004 | <10 (42.9); 11-20 (33.5); >20 (23.6)<br><10 vs >20 ($P = .012$) |
| | Practice setting | < .001 | Y/GT: GH (55.3); TH (55.1); CP (36.2); PP (32.9)<br>TH vs CP ($P = .001$) |
| | Continent | < .001 | Y/GT: E (47.1); NA (47.0); CSA (34.6); A (32.7)<br>NA vs CSA ($P = .04$) |
| | Hospital service | < .001 | |
| | Allocation of nondermatologic duty | < .001 | |
| | HIMG for COVID-19-patients | < .001 | |
| | Health care system equipped for pandemic | < .001 | |

NOTE: The $\chi^2$ test was performed unless otherwise noted.

[a] Only statistically significant *P* values are presented.

[b] Refers to groups of variables in second column.

[c] Y/GT is given as percentage in a parenthesis (number rounded to decimal place), and percentages of groups are listed in descending order.

*A*, Asia; *COVID*-19, Coronavirus Disease 2019; *CP*, combined practice (private + hospital); CSA, Central and South America; *E*, Europe; *GH*, general hospital; *GT*, group's total; *HIMG*, hospital-issued management guidelines; *NA*, North America; *PP*, private practice; *PPE*, personal protective equipment; *TH*, tertiary hospital; *Y/GT*, yes group's total.

pandemic, and more than half were willing to provide service on the front line; these observations were associated ($P <$ .001). Nearly half of respondents to our survey estimated that the health care system was not well equipped for the pandemic. This may be in part attributable to the unavailability of PPE at some hospitals. In our study, 37.7% of participants responded that PPE was unavailable at the local hospital.

PPE shortages pose a tremendous challenge to health care systems during this pandemic.[16,25-27] In this study, 40.2% of respondents purchased their own PPE—notably, 23.5% of those working exclusively in general or tertiary hospitals. Factors that indicate the health care system's preparedness for the pandemic (ie, HIMG for COVID-19 patients and PPE availability at the hospital) were negatively associated with purchasing one's own PPE. In the logistic regression model 1, the most important factor reducing the OR for purchasing one's own PPE was HIMG for COVID-19 patients. This may indicate that hospitals that promptly issued management guidelines for COVID-19 patients may have a better overall organization for ensuring enhanced PPE availability.

Hospital service, assignment to nondermatologic duty, HIMG for COVID-19 patients, and participants' assessment that their health care system was well equipped were associated with higher PPE availability. These associations may be explained by hospital guidance to enhance PPE availability. Larger organizations, such as the United States Centers for Disease Control and Prevention and the World Health Organization, have issued guidelines to improve the

**Table 4** Logistic regression models

| Model | Dependent variable | Independent variables | LR $x^2$ | OR | SE | Z[a] | *P* value | 95% CI |
|---|---|---|---|---|---|---|---|---|
| **1** | **Purchase own PPE** | | 71.93 | | | | | |
| | | HIMG for COVID-19 patients | | 0.55 | 0.16 | –2.06 | .039 | 0.32-0.97 |
| | | Hospital (general/tertiary) setting | | 0.43 | 0.12 | –3.12 | .002 | 0.25-0.73 |
| | | North America | | 0.39 | 0.14 | –2.64 | .008 | 0.19-0.78 |
| | | PPE availability at hospital | | 0.30 | 0.07 | –5.23 | < .001 | 0.19-0.47 |
| | | _cons[b] | | 6.25 | 2.96 | 3.87 | < .001 | 2.47-15.81 |
| **2** | **PPE availability at hospital** | | 134.37 | | | | | |
| | | Healthcare system equipped for pandemic | | 9.43 | 2.70 | 7.82 | < .001 | 5.37-16.56 |
| | | >1,000 COVID-19 cases in country | | 2.08 | 0.52 | 2.95 | .003 | 1.28-3.40 |
| | | Purchase own PPE | | 0.26 | 0.07 | –5.21 | < .001 | 0.16-0.44 |
| | | _cons | | 0.58 | 0.13 | –2.39 | .017 | 0.37-0.91 |

NOTE: All LR $x^2$ $P < .0001$. Numbers are rounded to 2 decimal places in all but *P* value (3 decimal places) column.

[a] Defined as OR:SE.

[b] Estimates baseline odds.*CI*, confidence interval; *COVID*-19, Coronavirus Disease 2019; *HIMG*, hospital-issued management guidelines; *LR*, likelihood ratio; *OR*, odds ratio; *PPE*, personal protective equipment; *SE*, standard error.

assessment of PPE requirements and decrease the PPE burn rate.[28,29] The Joint Commission recommended that hospitals must conserve PPE, when these items are in short supply to protect staff that performs high-risk procedures.[30] In logistic regression model 2, the participants' assessment of the health care system being equipped for the pandemic was the most powerful reason for increasing OR for PPE availability, followed by >1,000 COVID-19 cases in the participants' country. The latter may suggest an enhanced availability of hospital resources for dermatologists in the geographic locations more affected by the pandemic, possibly attributable to a higher level of alert in the health care system.

Implications of PPE shortage include an increased infection risk for HCWs, increased patient-to-patient transmission, HCW burnout that can result in unsafe patient care, psychologic aggravation of the HCW, and a heightened epidemic curve associated with more sickness overall. This last implication, coupled with scarce resources, diminishes the quality of care and increases the probability of poor outcomes.[1,31] A recent meta-analysis indicated that HCWs who are COVID-19 positive constituted a significant proportion (10.1%) of all COVID-19 patients.[32] Also, studies have reported that COVID-19 infection in HCWs is due to ill-fitting PPE.[33] Rationing PPE is recommended by many authorities and can be the best available option in the midst of the current shortage.[34] Unfortunately, it does not comply with well-established infection prevention protocols and may increase infection risk. Finally, a shortage of PPE increases distress among HCWs, when they believe that their lives are at risk without PPE. The financial burden of purchasing their own PPE can aggravate the distress.[35-37] In some cases, hospital directors asked HCWs not to disclose the PPE shortage, which raised ethical concerns and increased distress in HCWs.[38]

Medical organizations, such as the American Medical Association and the World Health Organization, have called on governments and industry to increase PPE manufacturing by 40% to meet rising global demands.[29,39] Unfortunately, many companies were producing low-quality PPE, resulting in adverse effects that are usually observed with prolonged PPE use. As suggested by Patrice Harris, president of the American Medical Assocation,[40] creating a national tracking system of acquisition and distribution of critical PPE supplies is warranted. Until supply shortages can be resolved, the American Medical Association and other organizations have been issuing guidelines on health care resource allocation and are urging healthcare leaders to put procedures in place to help reduce the decision-making burden on physicians.[39]

## Conclusions

During the COVID-19 pandemic, dermatologists have endured a PPE shortage in the health care system. In this study, the most important factor for reducing the OR for purchasing one's own PPE was HIMG for COVID-19 patients. Participants' assessment that their health care system was equipped for the pandemic was the most powerful increaser of OR for PPE availability. The PPE shortage has severe implications, and rationing PPE may only help to a certain extent. Hospitals should assess PPE requirements and implement strategies to decrease PPE burn rate. Most important, industry and governments should take steps to increase PPE manufacturing.

## Declaration of Competing Interest

The authors declare no conflicts of interest.

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