

Original Research

Cite this article: Ahmad J, Anwar S, Latif A, Haq NU, Sharif M, Nauman AA (2022) Association of PPE availability, training, and practices with COVID-19 sero-prevalence in nurses and paramedics in tertiary care hospitals of Peshawar, Pakistan. *Disaster Med Public Health Prep* 16: 975–979. doi: <https://doi.org/10.1017/dmp.2020.438>.

First published online: 5 November 2020


Keywords:

COVID-19; PPE; training; practices; sero-prevalence; Pakistan

Corresponding author:

Junaid Ahmad,
Email: jahmad@piph.prime.edu.pk.

Association of PPE Availability, Training, and Practices with COVID-19 Sero-Prevalence in Nurses and Paramedics in Tertiary Care Hospitals of Peshawar, Pakistan

Junaid Ahmad PhD¹ , Saeed Anwar MBBS, MPH¹, Abdul Latif MSc¹, Najib U. Haq MBBS, MRCP², Muhammad Sharif MBBS¹ and Ahmed A. Nauman MBA¹

¹Prime Institute of Public Health, Peshawar Medical College, Peshawar, K.P.K., Pakistan and ²Peshawar Medical College, Peshawar, K.P.K., Pakistan

Abstract

Objective: Nurses and paramedics by being the frontline workers of the health-care profession need to be equipped with the relevant knowledge, skills, and protective gears against different forms of infection, including coronavirus disease 2019 (COVID-19). Although the governments and concerned stakeholders have provided personal protective equipment (PPE), training and information to protect the health-care professionals; however, until now the scientific literature has virtually not reported the impact of PPE availability, training, and practices on the COVID-19 sero-prevalence among the nurses and paramedics. This study aimed to assess the impact of PPE availability, training, and practices on COVID-19 sero-prevalence among nurses and paramedics in teaching hospitals of Peshawar, Pakistan.

Methods: A cross-sectional survey was conducted with a total of 133 nurses and paramedics as subjects of the study.

Results: A univariate analysis was done for 4 variables. The findings indicate that the health-care professionals (nurses and paramedics) who have received PPE on time at the start of COVID-19 emergence have fewer chances of contracting the COVID-19 infection (odds ratio = 0.96); while the odds for PPE supplies was 0.73, and the odds of hand hygiene training was 0.95.

Conclusions: The study concluded that the availability of the PPE, COVID-19-related training, and compliance with World Health Organization recommended practices against COVID-19 were instrumental in protection against the infection and its spread.

Pandemics and epidemics are not something new to humanity. Several devastating epidemics, pandemics happened and were recorded in the past.¹ Just in the past couple of decades, since the beginning of 21st century, more than 6 major epidemics and pandemics have struck humanity in different parts of the world including the Ebola virus epidemic, Zika virus epidemic, Dengue virus epidemic, H1N1 virus epidemics, Middle East respiratory syndrome (MERS) epidemics, and the current pandemic of coronavirus disease 2019 (COVID-19).² Mostly, the major pandemics in the past were caused by influenza viruses. Among all the recorded pandemics, the most iconic pandemic is the “Spanish flu” that hit the world in 1918 and resulted in an estimated 17–100 million deaths.^{3–5} The current COVID-19 pandemic is the worst in recent history, which until now has impacted more than 186 countries across the globe and shut down almost every business both in the developed and developing country.⁶

COVID-19 has emerged not only as a public health issue, but also a geopolitical one.⁷ Governments, oppositions, and organizations are using the COVID-19 associated aspects, especially mortality and morbidity rates to safeguard their public and political images.⁸ One such issue is the availability of personal protective equipment (PPE) for health-care professionals.⁹ The issue has been highlighted a lot all over the electronic and social media that governments failed to provide the frontline health-care professionals with enough PPE, resulting in health-care professionals being more vulnerable and at higher risk of contracting COVID-19 compared with the general public.^{7–9} This is reported both in developing and developed countries. Although much is being discussed both at official and nonofficial platforms about the lack of PPE provision, however, the evidence-based figure has rarely been reported about the COVID-19 prevalence in health-care professionals.

Just as all over the world, the pandemic of COVID-19 also severely affected Pakistan. Pakistan, a South-Asian country, is a neighboring country to the 2 of the worst affected countries by the COVID-19, that is, The Peoples Republic of China (the epicenter of COVID-19) and the Islamic Republic of Iran (one of the worst-hit COVID-19 countries). Although the COVID-19 originated and initially spread from the Peoples Republic of China, Pakistan recorded its first confirmed COVID-19 case as an imported case from the Islamic Republic of Iran on February

© Society for Disaster Medicine and Public Health, Inc. 2020. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted re-use, distribution, and reproduction in any medium, provided the original work is properly cited.

26, 2020.⁸ By August 30, Pakistan recorded a total of 295,896 confirmed COVID-19-positive cases and 6294 COVID-19-induced deaths throughout the country. The health-care professionals in Pakistan are the hard-hit segments of society by the COVID-19, as, by June 30, a total of 5367 health-care professionals contracted the coronavirus infection. Among all the health-care professionals who became infected with COVID-19, doctors make the significant chunk, as 61% (3275 out of 5367) of the total were doctors, followed by the paramedical staff at 27% (1453 of 5367), and nurses at 27% (639 of 5367).¹⁰ The province of Khyber Pakhtunkhwa (K.P.K.) in general as well as in terms of health-care professionals is the worst affected province of the country in terms of COVID-19 infections. The province makes up only 11% of the total country population, but 33.66% (1807 of 5367) of health-care professionals infected with COVID-19 were from K.P.K.¹¹

Since the newly emerged pandemic of the COVID-19, much has been discussed about its place of origin, etiology, clinical features, mortality and morbidity rates, etc.^{12,13} Also, much has been emphasized that health-care professionals are the frontline warriors and are at high risk of contracting the COVID-19.¹⁴ However, studies that reported the prevalence of COVID-19 in health-care professionals rarely exist, and even the limited number of available studies are restricted to retrospective and symptomatic cases only.¹⁵⁻¹⁷ It is worth mentioning that, until today, not a single study has reported the impact of PPE availability, training, and practices on COVID-19 sero-prevalence in health-care workers, including nurses and paramedics.

Methods

This study is a part of a larger study ($N = 1012$)¹⁸ by the investigators that aim at studying seroprevalence for COVID-19 among the various health-care providers working in a set of 3 selected public and private sector teaching hospitals of Peshawar, Pakistan. The larger study (not published yet) has found a comparatively very high prevalence among nurses and paramedics. This study using both descriptive and analytical techniques aimed to determine if the availability of PPE, COVID-19 infection prevention and control training, and compliance with the World Health Organization (WHO) recommended practices was in any way related with seroprevalence among the nurses and paramedics. A cross-sectional study was conducted with 38% participation rate (aggregate of the nurses and paramedics; $N = 350$). The study subjects were telephonically interviewed by means of a pretested structured questionnaire, designed explicitly for the purpose, after informed verbal consent.

Data entry and analysis were done with the help of IBM SPSS Statistics V22.0. The socio-demographic variables included the profession with a breakdown by age and gender. Significance testing (chi-squared test) was done, or odds ratios were calculated for categorical variables and other variables of interest to identify the protective and risk factors among the subjects.

Study Area

The study was conducted in the metropolitan city Peshawar, a capital city of the Khyber Pukhtunkwah (K.P.K.). This is one of the most marginalized and underprivileged provinces in the country, which has been very hard hit by conflicts, wars, and natural disaster for the past 40 y. The city is hosting public (governments), private (for-profit), and charity (not-for-profit) hospitals. The total population of the city is approximately 1.97 million,

Table 1. Descriptive statistics of the demographic profile

| | Health-Care Worker | Sero +Ve n (%) | Sero -Ve n (%) | Total |
|------------|-------------------------|-------------------|-------------------|-------|
| Profession | Nurses | 23 (48%) | 25 (52%) | 48 |
| | Degree holder (n = 12) | 6 (50%) | 6 (50%) | 12 |
| | Diploma holder (n = 36) | 17 (47%) | 19 (53%) | 36 |
| | Paramedics (n = 85) | 35 (41%) | 50 (58.8%) | 85 |
| | Degree holder (n = 13) | 5 (38%) | 8 (62%) | 13 |
| | Diploma holder (n = 72) | 30 (42%) | 42 (58%) | 72 |
| Gender | Male | 48 (41%) | 70 (59.3%) | 118 |
| | Female | 5 (33%) | 10 (67%) | 15 |
| Age | 15-24 | 15 (24%) | 21 (33%) | 63 |
| | 25-50 | 35 (52%) | 41 (61%) | 67 |
| | 65-Above | 0 | 4 (100%) | 4 |

and the total documented beds in the hospitals are approximately 8000.

Inclusion Criteria

Nurses and paramedics who were full-time and fully-paid employees of the participating hospitals and consented voluntarily to participate in the study were included in the study.

Institutional Review Board Approval

The Institutional Ethical Review Board of Peshawar Medical College gives exemption from full review for this study based on no intervention involved in the study.

Results

Demographic information

A sub-sample of 350 nurses and paramedics was drawn from the earlier phase study sample ($N_1 = 1012$) for telephonic interview. All nurses and paramedics who were tested for COVID-19 antibodies were contacted through telephonic calls. A structured text message indicating the purpose of the study and voluntary participation, along with ensuring participants confidentiality and anonymity, was delivered to all the participants a day before the interview. All the eligible participants ($N_2 = 350$) were contacted through phone calls; however, with a 38% response rate, only 133 participants responded to the questionnaire. Of them, 36% ($n = 48$) participants were nurses and 64% ($n = 85$) paramedics. Among the nurses, diploma holders were 75% ($n = 36$), and only 25% ($n = 12$) were graduates in nursing

Paramedics were also predominantly diploma holders 85% ($n = 72$), while only 15% ($n = 13$) were degree holders. The majority of our study participants were male, 89% ($n = 118$). Compared with 33% of the females, 41% of males have reactive antibodies against COVID-19. A significant difference in seropositivity was observed among the age group 15-24 y (24%, $n = 63$) and 25-55 y (52%, $n = 67$). Sero-positivity in nurses and paramedics were 48% ($n = 23$) and 41% ($n = 35$), respectively (Table 1).

Practices of the Participants

Descriptive statistics were calculated for practices of the study participants regarding COVID-19 infection prevention comprising 9 areas of possible risk factors. For each, multiple variable responses

(always, most of the time, never, sometimes, and occasionally) were recorded to achieve a real situation of the practices by the respondents.

The data analysis revealed that 55% ($n = 73$) of the study participants went to crowded places during an active pandemic, and 45% ($n = 59$) used public transportation during this time. Always wear a mask when leaving home was reported by 78% ($n = 102$), while careful removal of the protective gear was reported by 61% ($n = 81$) of the participants.

Furthermore, 79% ($n = 105$) of the participants stated that, during coughing and sneezing, they cover their mouth and faces. Washing hands with soap and water were reported by 77% ($n = 102$) while washing hands after returning home with soap and water were recorded by 87% ($n = 116$) of the participants. Only 52% of the study participants always complied with the most critical preventive practice against COVID-19; social distancing. Surprisingly, although 51% ($n = 57$) of the participants have reactive antibodies against COVID-19, only 9.8% ($n = 13$) of the participants self-isolated at home during the pandemic (Table 2).

Relationship of Early Availability of PPE and COVID-19-Related Training with Sero-prevalence in Health-Care Workers

Univariate analyses were done for 4 variables as potential risk factors for contracting COVID-19 infection. The absence of adequate and timely supplies of PPE and lack of infection control training, including COVID-19-related training, were considered to be risk factors along with unsafe practices in acquiring COVID-19 infection in health-care workers. Odds ratios (ORs; q_x) were calculated to determine any association among the mentioned variables, and whether sero-prevalence exists. Findings suggest that 3 variable (PPE timely and adequate availability, COVID-19-related training, and hand hygiene training) had a positive association with seronegativity. Health-care workers who have received PPE on time at the start of COVID-19 emergence had less chance of acquiring COVID-19 infection (OR = 0.96). There is a mild protective association among timely PPE availability and seronegativity; however, other confounding factors, such as environmental factors, cannot be ruled out. Similarly, health-care workers who had not faced any interruption of PPE supply had comparatively lesser reactive COVID-19 antibodies (OR = 0.733). Adequate and timely availability of PPE has mild protective effects on COVID-19 infection. COVID-19-related training, including PPE use (donning, doffing), social distancing, isolation, quarantine, lockdown, had a protective association with COVID-19 infection (OR = 0.98). There was no difference in the odds for the training and sero-prevalence between the diploma holders and graduate health professionals. Furthermore, health-care workers who had received training on hand hygiene had less chances of getting COVID-19 infection (OR = 0.95) (Table 3).

Discussion

This study is unique, because it assessed the impact of PPE availability, training, and practices on COVID-19 sero-prevalence in nurses and paramedics in teaching hospitals of Peshawar-Pakistan. However, a lot of research has been conducted and much can be found in the published literature about the efficacy of mask use in

Table 2. Descriptive statistics of practices as reported by the study participants

| | | |
|---|--|---------------------|
| Have you gone to any crowded place during the COVID-19 pandemic? | Always | 1.5% ($n = 2$) |
| | Most of the time | 3% ($n = 4$) |
| | Never | 45.1% ($n = 60$) |
| | Occasionally | 42.1% ($n = 56$) |
| | Sometimes | 8.3% ($n = 11$) |
| | Total | 100% ($n = 133$) |
| Do you wear a mask when leaving home? | Always | 76.7% ($n = 102$) |
| | Most of the time | 5.3% ($n = 7$) |
| | Never | 0.8% ($n = 1$) |
| | Occasionally | 9.8% ($n = 13$) |
| | Sometimes | 6.8% ($n = 9$) |
| | Total | 100% ($n = 133$) |
| Did you remove protective equipment carefully as a routine? | Always | 60.9% ($n = 81$) |
| | Most of the time | 4.5% ($n = 6$) |
| | Never | 0.8% ($n = 1$) |
| | Occasionally | 24.1% ($n = 32$) |
| | Sometimes | 9.8% ($n = 13$) |
| | Total | 100% ($n = 133$) |
| Do you cover mouth when coughing and sneezing during this pandemic? | Always | 78.9% ($n = 105$) |
| | Most of the time | 8.3% ($n = 11$) |
| | Never | 2.3% ($n = 3$) |
| | Occasionally | 7.5% ($n = 10$) |
| | Sometimes | 3% ($n = 4$) |
| | Total | 100% ($n = 133$) |
| Have you used public transport during the COVID-19 pandemic? | Always | 13.5% ($n = 18$) |
| | Most of the time | 3% ($n = 4$) |
| | Never | 55.6% ($n = 74$) |
| | Occasionally | 18.8% ($n = 25$) |
| | Sometimes | 9% ($n = 12$) |
| | Total | 100% ($n = 133$) |
| Do you wash hands with soap and water? | Always | 76.7% ($n = 102$) |
| | Most of the time | 8.3% ($n = 11$) |
| | Never | 0.8% ($n = 1$) |
| | Occasionally | 11.3% ($n = 15$) |
| | Sometimes | 3% ($n = 4$) |
| | Total | 100% ($n = 133$) |
| Do you wash hands after returning home? | Always | 87.2% ($n = 116$) |
| | Most of the time | 4.5% ($n = 6$) |
| | Occasionally | 5.3% ($n = 7$) |
| | Sometimes | 3% ($n = 4$) |
| | Total | 100% ($n = 133$) |
| | Do you comply with the recommended social distancing for COVID-19? | Always |
| Most of the time | | 7.5% ($n = 10$) |
| Never | | 4.5% ($n = 6$) |
| Occasionally | | 19.5% ($n = 26$) |
| Sometimes | | 15% ($n = 20$) |
| Total | | 100% ($n = 133$) |
| Did you take care of self-isolation or quarantine at home also during the pandemic? | Always | 9.8% ($n = 13$) |
| | Most of the time | 7.5% ($n = 10$) |
| | Never | 58.6% ($n = 78$) |
| | Occasionally | 19.5% ($n = 26$) |
| | Sometimes | 4.5% ($n = 6$) |
| | Total | 100% ($n = 133$) |

Table 3. Association of early availability of PPEs and COVID-19-related training with sero-prevalence in health-care workers

| | | Antibody Test Result | | | Risk Estimates/OR | 95% Confidence Interval |
|--|-----|----------------------|-----|-------|-------------------|-------------------------|
| | | -Ve | +Ve | Total | | |
| Did you get the PPEs early during the pandemic? | No | 24 | 19 | 43 | 0.966 | (0.464-2.009) |
| | Yes | 51 | 39 | 90 | | |
| | | 75 | 58 | 133 | | |
| Were PPEs provided in adequate amount? | No | 10 | 10 | 20 | 0.733 | (0.104-2.04) |
| | Yes | 65 | 48 | 113 | | |
| | | 75 | 58 | 133 | | |
| Did you obtain COVID-19 related training, such as PPE use (donning, doffing), social distancing, isolation, quarantine, lock-down, etc.? | No | 32 | 25 | 57 | 0.982 | (0.492-1.96) |
| | Yes | 43 | 33 | 76 | | |
| | | 75 | 58 | 133 | | |
| Did you obtain hygienic hand washing during the past 3 years? | No | 29 | 23 | 52 | 0.959 | (0.475-1.93) |
| | Yes | 46 | 35 | 81 | | |
| | | 75 | 58 | 133 | | |

the prevention of COVID-19, the usefulness of handwashing in avoiding the transmission of COVID-19, and efficacy of information dissemination in minimizing the spread of COVID-19. However, limited information is available when it comes to establishing as to what is their impact on the sero-prevalence among health-care workers, including nurses and paramedics.

The inadequate supply of PPE is/was an issue not only in developing countries but also developed countries also faced such hurdles. Like, the study reported that the high prevalence rate of COVID-19 in health-care professionals is partly attributed to the lack of adequate supply of PPE to health-care workers.¹⁸ The findings of our study are also fully aligned with the finding reported by Ranney *et al.*¹⁹ Whereas, COVID-19 is surrounded by many uncertainties in terms of its place of origin, etiology, clinical features, mortality rates, morbidity rates, risk prevention strategies, etc., this study is of paramount importance, as it will initiate a debate among the policy-makers and concerned stakeholders to take into account the protection of nurses and paramedics with the existing recommended preventive measures as well as the launch of additional interventions to make sure that a package comprising the adequate supply of PPE, tailored infection prevention and control training, and access to updated personal protection protocols by the WHO is made available to them.

Conclusions

Based on the findings of this study, it can be concluded that COVID-19 sero-prevalence in nurses and paramedics is directly determined by PPE availability, training, and practices in tertiary care hospitals. The health-care workers in general, and specifically nurses and paramedics, will always be at high risk for contracting the COVID-19 if they are not provided with an adequate supply of PPE, up to date infection control training, and proper infection prevention practices. There is no doubt that, in the current age of unprecedented pandemic of COVID-19, governments and concerned stakeholders are under pressure to provide adequate supply of PPE to protect health-care worker against COVID-19; however, there is no short-term and shortcut solution to tackle the spread of COVID-19, other than to make sure PPE availability, regularly conduct infection control training, and enforce WHO recommended practices.

Author Contributions. Conceptualization and Supervision: Dr Najib Ul Haq and Dr Saeed Anwar. Methodology: Software and Data Curation, Dr Junaid Ahmad, and Dr Abdul Latif Validation; and Formal Analysis: Dr Muhammad Sharif, Dr Abdul Latif, and Dr Junaid Ahmad. Resources and Project Administration: Ahmed Ali Nauman. Writing – Original Draft Preparation: Dr Saeed Anwar, Dr Abdul Latif, and Dr Junaid Ahmad.

Funding. The study did not receive any funding from any organization.

Conflict of Interest. The authors declare no conflict of interest.

References

1. Yang Y, Peng F, Wang R, *et al.* The deadly coronaviruses: the 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China. *J Autoimmun.* 2020;109:102434. doi: [10.1016/j.jaut.2020.102434](https://doi.org/10.1016/j.jaut.2020.102434)
2. Dhama K, Patel SK, Sharun K, *et al.* SARS-CoV-2 jumping the species barrier: zoonotic lessons from SARS, MERS and recent advances to combat this pandemic virus. *Travel Med Infect Dis.* 2020;37:101830. doi: [10.1016/j.tmaid.2020.101830](https://doi.org/10.1016/j.tmaid.2020.101830)
3. Patterson KD, Pyle GF. The geography and mortality of the 1918 influenza pandemic. *Bull Hist Med.* 1991;65(1):4–21.
4. Spreuwenberg P, Kroneman M, Paget J. Reassessing the global mortality burden of the 1918 influenza pandemic. *Am J Epidemiol.* 2018;187(12):2561–2567. doi: [10.1093/aje/kwy191](https://doi.org/10.1093/aje/kwy191)
5. Jilani TN, Jamil RT, Siddiqui AH. H1N1 influenza. [Updated November 19, 2020]. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK513241/>. 2020. Accessed December 20, 2020.
6. Wijdicks EFM. Historical lessons from twentieth-century pandemics due to respiratory viruses. *Neurocrit Care.* 2020;33(2):591–596. doi: [10.1007/s12028-020-00983-7](https://doi.org/10.1007/s12028-020-00983-7)
7. Lurie N, Saville M, Hatchett R, *et al.* Developing Covid-19 vaccines at pandemic speed. *N Engl J Med.* 2020;382(21):1969–1973. doi: [10.1056/NEJMp2005630](https://doi.org/10.1056/NEJMp2005630)
8. Dzieciatkowski T, Szarpak L, Filipiak KJ, *et al.* COVID-19 challenge for modern medicine. *Cardiol J.* 2020;27(2):175–183. doi: [10.5603/CJ.a2020.0055](https://doi.org/10.5603/CJ.a2020.0055)
9. Ilyas A. Covid-19 pandemic: emergence of a new geopolitical perspective. <https://think-asia.org/bitstream/handle/11540/11906/Covid-19-Pandemic-Emergence-of-a-new-Geopolitical-Perspective.pdf.pdf?sequence=1>. 2020. Accessed December 15, 2020.
10. McCloskey B, Zumla A, Ippolito G, *et al.* Mass gathering events and reducing further global spread of COVID-19: a political and public health dilemma. *Lancet.* 2020;395(10230):1096–1099. doi: [10.1016/S0140-6736\(20\)30681-4](https://doi.org/10.1016/S0140-6736(20)30681-4)

11. **Government of Pakistan.** COVID-19 dash board. <http://covid.gov.pk/stats/pakistan>. 2020. Accessed December 15, 2020.
12. **Guo Y-R, Cao Q-D, Hong Z-S, et al.** The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – an update on the status. *Mil Med Res.* 2020;7(1):1–10. doi: [10.1186/s40779-020-00240-0](https://doi.org/10.1186/s40779-020-00240-0)
13. **Cascella M, Rajnik M, Cuomo A, et al.** Features, evaluation, and treatment of coronavirus (COVID-19). 2020. <https://www.ncbi.nlm.nih.gov/books/NBK554776/>. Accessed December 15, 2020.
14. **Jary A, Flandre P, Chabouis A, et al.** Clinical presentation of Covid-19 in health care workers from a French University Hospital. *J Infect.* 2020;81(3): e61–e63. doi: [10.1016/j.jinf.2020.06.048](https://doi.org/10.1016/j.jinf.2020.06.048)
15. **Amendola A, Tanzi E, Folgori L, et al.** Low seroprevalence of SARS-CoV-2 infection among healthcare workers of the largest children hospital in Milan during the pandemic wave. *Infect Control Hosp Epidemiol.* 2020;41(12):1468–1469. doi: [10.1017/ice.2020.401](https://doi.org/10.1017/ice.2020.401)
16. **Korth J, Wilde B, Dolff S, et al.** SARS-CoV-2-specific antibody detection in healthcare workers in Germany with direct contact to COVID-19 patients. *J Clin Virol.* 2020;128:104437. doi: [10.1016/j.jcv.2020.104437](https://doi.org/10.1016/j.jcv.2020.104437)
17. **Xiang B, Li P, Yang X, et al.** The impact of novel coronavirus SARS-CoV-2 among healthcare workers in hospitals: an aerial overview. *Am J Infect Control.* 2020;48(8):915–917. doi: [10.1016/j.ajic.2020.05.020](https://doi.org/10.1016/j.ajic.2020.05.020)
18. **Haq M, Rehman A, Muhammad N, et al.** Seroprevalence and risk factors of SARS CoV-2 in health care workers of tertiary-care hospitals in the province of Khyber Pakhtunkhwa, Pakistan. *medRxiv.* 2020. doi: [10.1101/2020.09.29.20203125](https://doi.org/10.1101/2020.09.29.20203125)
19. **Ranney ML, Griffeth V, Jha AK.** Critical supply shortages - the need for ventilators and personal protective equipment during the Covid-19 pandemic. *N Engl J Med.* 2020;382(18):e41. doi: [10.1056/NEJMp2006141](https://doi.org/10.1056/NEJMp2006141)