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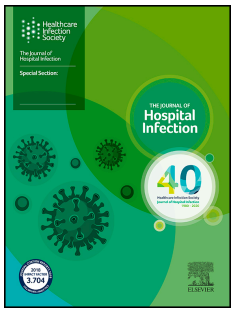

Global and national estimates of the number of healthcare workers at high risk of SARS-CoV-2 infection

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Global and national estimates of the number of healthcare workers at high risk of SARS-CoV-2 infection

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Running title: Defining healthcare workers at high risk

Text

In order to promote equitable and efficient allocation of coronavirus disease 2019 (COVID-19) vaccines, the World Health Organization (WHO) Strategic Advisory Group of Experts on Immunization (WHO-SAGE-I) has published a 'Roadmap for Prioritising Use of COVID-19 Vaccination in the Context of Limited Supply,' outlining which groups should be prioritised under various supply scenarios [1]. Healthcare workers at high or very high risk of acquiring and transmitting SARS-CoV-2 are included in Stage I, when supply remains very limited.

Wang et al. (2020) [2] estimated the target population sizes of priority groups for vaccination, including healthcare workers. However, their estimate was based on the number of doctors, nurses and midwives only, and they did not attempt to stratify by risk. In this study, we expanded the definition of a healthcare worker to match the WHO definition more closely. We also compared risk across key healthcare occupational groups to determine which occupations are associated with the highest risk. Our findings suggest that the majority of healthcare workers (about 70-90%) could be considered at high risk, and sparsity of country-level data means that effectively stratifying by risk would be challenging to implement at a programmatic level.

The WHO defines healthcare workers as "all people engaged in work actions whose primary intent is to improve health" [1]. This is intended to include not only health professionals, but health management and support personnel [3]. For this analysis, we included all those classified as health professionals (sub-major group 22) and health associate professionals (sub-major group 32) in the International Standard Classification of Occupations (ISCO-08). For the 111 countries which report values for these two categories in ILOSTAT [4], the healthcare workforce on average constitutes less than 1% (0.80%; IQR: 0.39-1.53) of the national population [5].

The definition of high risk in the WHO-SAGE-I Roadmap is based on exposure to suspected or confirmed cases of COVID-19 or risk of exposure to aerosols with SARS-CoV-2. Yet several studies have reported comparable or even higher infection rates in healthcare workers on general wards compared to COVID-19 wards [6], and others have reported higher risk of severe COVID-19 in medical support staff compared to health professionals [7]. These findings suggest that access to personal protective equipment (PPE) and testing capacity may have a more substantial impact on risk than exposure to confirmed COVID-19 cases, given the risk posed by patients with asymptomatic or undiagnosed infection.

We compared risk of SARS-CoV-2 infection across key groups of healthcare occupations listed in the Global Health Observatory (GHO) [8], using data from surveys of US employees reported in the O*NET database [9]. "Exposure to disease or infections" and "physical proximity" were used as proxy indicators for risk of SARS-CoV-2 infection. The ISCO-08 codes listed in the GHO were mapped to occupations in the O*NET database. The mean proportion at high risk was then generated for each GHO group, with a weighting determined by the number of individuals in the US employed in each occupation [10]. For both indicators, dentistry was the group in which the highest proportion of workers were found to be at high risk (Figure 1A). Using the "physical proximity" indicator, the proportion at high risk was around 80% or higher for all groups except "environmental and occupational health" and "medical and pathology laboratory

personnel". These results emphasise that a limited definition of healthcare worker may exclude occupations associated with the highest risk. Doctors, nurses and midwives only constitute 65.9% (95%CI: 60.0-72.8) of the total number of health professionals and health associate professionals.

Country-level estimates for the number of healthcare workers at high risk were generated by mapping occupations listed as health professionals or health associate professionals in ISCO-08 onto the O*NET occupations. Using the "exposure to disease or infections" indicator, 85.2% (95%CI 83.5-87.0%) of health professionals and 74.0% (71.8-76.1%) of health associate professionals were estimated to be at high or very high risk. The "physical proximity" indicator produced a similar estimate for health professionals of 86.7% (95%CI 85.0-88.3%); for health associate professionals, it was 83.7% (81.9-85.6%). When these proportions were applied to the country estimates for these groups from ILOSTAT, healthcare workers at high risk constituted 0.64% (IQR: 0.30-1.24) of the national population when using the "exposure to disease or infections" indicator, and 0.68% (IQR: 0.33-1.30) when using "physical proximity" (Figure 1B).

Using this approach to estimate the proportion of healthcare workers at high risk globally does require extrapolation of data on working conditions in the US to all countries in the world. It also relies on proxy indicators that do not specifically relate to SARS-CoV-2 risk. However, the issue of sparsity of country-specific data on risk of infection is not just only a limitation of this analysis – it indicates that effectively identifying and vaccinating healthcare workers at high risk could be extremely logistically challenging.

Therefore, rather that narrowing down the estimate provided by Wang et al., we suggest widening the net. There is evidence that basing estimates for the number of healthcare workers on doctors, nurses and midwives excludes some of the occupations at the highest risk. The results also suggest that the majority of healthcare workers could be considered at high risk (70-90%). Given that healthcare workers only constitute on average around 1% of the national population, we argue that the benefit of prioritising the vaccination of healthcare workers at high risk may not compensate for the additional logistical challenges of identifying these highest risk healthcare workers.

References

[1] World Health Organization, "WHO SAGE Roadmap for Prioritizing Uses of COVID-19 Vaccines in the Context of Limited Supply." 2020.

[2] W. Wang *et al.*, "Global, regional, and national estimates of target population sizes for covid-19 vaccination: Descriptive study," *The BMJ*, vol. **371**, 2020, doi: 10.1136/bmj.m4704.

[3] World Health Organization, "Classifying health workers : Mapping occupations to the international standard classification," *World Health Organization*, pp. 1–14, 2008, [Online]. Available: http://www.who.int/hrh/statistics/workforce_statistics/en/.

[4] ILOSTAT, “Employees by sex and occupation - ILO modelled estimates.” https://ilostat.ilo.org/data (accessed Jan. 22, 2021).

[5] World Bank Group, Population Estimates and Projections. https://datacatalog.worldbank.org/dataset/population-estimates-and-projections (accessed Jan. 15, 2021).

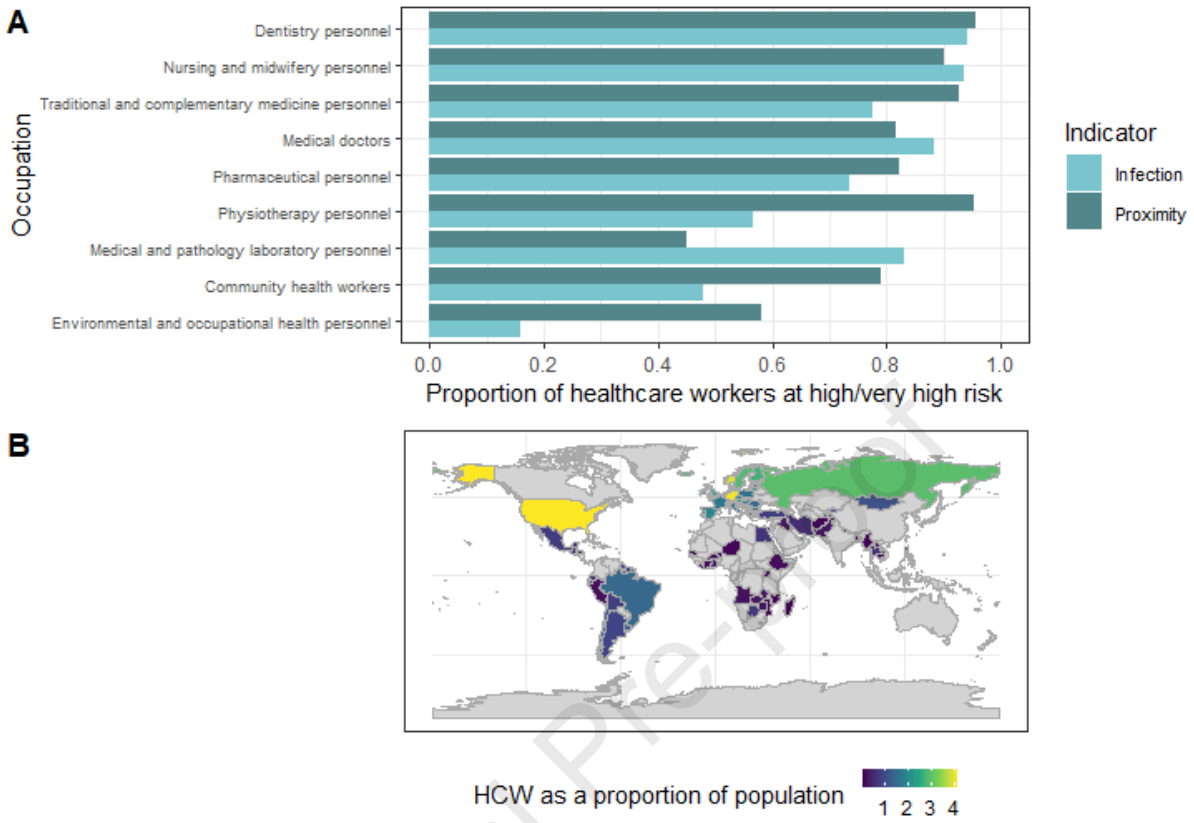
[6] X. Lai *et al.*, “Coronavirus Disease 2019 (COVID-2019) Infection Among Health Care Workers and Implications for Prevention Measures in a Tertiary Hospital in Wuhan, China,” *JAMA Network Open*, vol. **3**, no. 5, p. e209666, 2020, doi: 10.1001/jamanetworkopen.2020.9666.

[7] M. Mutambudzi *et al.,* “Occupation and risk of severe COVID-19: Prospective cohort study of 120 075 UK Biobank participants,” *Occup. Environ. Med.,* Published Online First: 09 December 2020. doi: 10.1136/oemed-2020-106731.

[8] World Health Organization, “The 2018 Update, Global Health Workforce Statistics.” http://www.who.int/hrh/statistics/hwfstats/ (accessed Jan. 01, 2021).

[9] “Work Context - O*NET 25.1 Data Dictionary at O*NET Resource Center.” [Online]. Available: https://www.onetcenter.org/dictionary/25.1/excel/work_context.html. (accessed: Jan. 03, 2021).

[10] U. S. Department of Labor. Bureau of Labor Statistics, “Occupational Employment Statistics.” www.bls.gov/oes/ (accessed Nov. 30, 2020).



Caption:

Figure 1. ***A.*** Proportion of healthcare workers at high risk by occupational group. ***B.*** National estimates for total size of the healthcare workforce as a proportion of national population.

Declaration of interest: none.

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