BMJ Open

Occupation and SARS-CoV-2 seroprevalence studies: a systematic review

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ABSTRACT

Objective To describe and synthesise studies of SARS-CoV-2 seroprevalence by occupation prior to the widespread vaccine roll-out.

Methods We identified studies of occupational seroprevalence from a living systematic review (PROSPERO CRD42020183634). Electronic databases, grey literature and news media were searched for studies published during January–December 2020. Seroprevalence estimates and a free-text description of the occupation were extracted and classified according to the Standard Occupational Classification (SOC) 2010 system using a machine-learning algorithm. Due to heterogeneity, results were synthesised narratively.

Results We identified 196 studies including 591 940 participants from 38 countries. Most studies (n=162; 83%) were conducted locally versus regionally or nationally. Sample sizes were generally small (median=220 participants per occupation) and 135 studies (69%) were at a high risk of bias. One or more estimates were available for 21/23 major SOC occupation groups, but over half of the estimates identified (n=359/600) were for healthcare-related occupations. ‘Personal Care and Service Occupations’ (median 22% (IQR 9–28%); n=14) had the highest median seroprevalence.

Conclusions Many seroprevalence studies covering a broad range of occupations were published in the first year of the pandemic. Results suggest considerable differences in seroprevalence between occupations, although few large, high-quality studies were done. Well-designed studies are required to improve our understanding of the occupational risk of SARS-CoV-2 and should be considered as an element of pandemic preparedness for future respiratory pathogens.

INTRODUCTION

Occupation is a social determinant of health and an important risk factor for SARS-CoV-2 infection. Essential workers in health and social care occupations have an increased risk of COVID-19 compared with non-essential workers, but the risks for other occupations are not well defined.1–3 Studies using confirmed COVID-19 cases to examine occupational COVID-19 risk are affected by variable testing rates. For example, testing rates may be higher in workplaces offering testing or paid sick leave, and are impacted by geographic (eg, urban vs rural) and socioeconomic factors (eg, deprivation), potentially biasing results.4–6 Few high-quality, prospective studies using frequent, serial molecular or antigen testing covering a broad range of occupations have been conducted, in part due to the costs and administrative burden of such studies.7,8

Serological testing for SARS-CoV-2 antibodies provides evidence of previous infection and/or vaccination depending on vaccination status and the specific antigens targeted and can be used to obtain more accurate estimates of the cumulative incidence of infection.9 Accurate data on the occupational risks of COVID-19 and other respiratory infections are essential for informing the development of occupational safety guidelines and regulations, transmission control measures and resource allocation (testing, personal protective equipment (PPE), etc). The objectives of this review were to describe and synthesise studies of SARS-CoV-2 seroprevalence across a broad range of occupations globally prior to the widespread roll-out of vaccines.
METHODS

We identified seroprevalence studies with sample frames or subgrouping variables related to occupation or employment status from a database compiled via a living systematic review (PROSPERO CRD4202183634). The database has been described previously and includes...
We restricted the current review to studies published during January–December 2020 before vaccines were rolled-out, because differential vaccination rates by occupation may obscure results. We excluded studies that only reported seroprevalence for mixed occupation groups or workplaces (eg, ‘hospital staff’) rather than specific occupations, included children <18 years and that could not be machine-translated using Google Translate if unavailable in English or French (online supplemental file 1).

We extracted study information, sample characteristics, seroprevalence estimates and study-level risk of bias from the living review database. Risk of bias was assessed with a modified Joanna Briggs Institute Checklist for Prevalence Studies by one reviewer and verified independently as described previously. Overall risk of bias was assessed qualitatively based on whether seroprevalence estimates were very likely (corresponding to a low risk of bias), likely (moderate risk) or unlikely (low risk) to be correct for the author’s stated target population (online supplemental file 1). If multiple estimates were reported, the most recent estimate using laboratory-based methods (eg, ELISA) and anti-spike and/or IgG antibodies were prioritised, because non-IgG and anti-nucleocapsid antibodies may decline more rapidly. Free-text descriptions of occupations were extracted from the original studies by one researcher and reviewed by a second.

For each seroprevalence estimate, we identified the relevant Standard Occupational Classification (SOC) 2010 codes by applying the National Institute for Occupational Safety and National Institute for Health Industry and Occupation Computerised Coding System (NIOCCS) to occupation descriptions.

We anticipated substantial heterogeneity and an insufficient number of estimates relative to...
covariates for meta-regression, we planned to summarise
data using the median/IQR.

**Patient and public involvement**

It was not possible or appropriate to involve patients or
the public in this study.

**RESULTS**

We identified 196 studies of occupational seroprevalence
conducted in 2020 during the first and second waves of
the pandemic (figure 1). There were 591,940 participants
from 38 countries, including the USA (n=44 studies), UK
(n=16) and Italy (n=15). Most studies (n=162; 83%) were
conducted locally (eg, city, county) as opposed to regionally
(eg, state; n=20; 10%) or nationally (n=14; 7%).

Most were restricted to one occupational group (n=103),
limiting direct comparisons (ie, using the same reference
group). Sample sizes were often small (median=220, IQR
64–568 participants). Overall, 135 studies (69%) were at a
high risk of bias, 47 moderate (24%), 2 low (1%) and 12
unclear (6%). Common reasons for bias were inadequate
statistical analysis (ie, no adjustment for test or sample
characteristics; 92%), non-probability sampling (74%) and
small sample size (46%).

At least one estimate was available for all 23 major
SOC occupation groups, except for ‘legal’ and ‘military-
specific’ occupations (figure 2; all studies). Over half of the
600 estimates identified (n=359) were for healthcare-
related occupations. For SOC groups with three or
more estimates, the highest median seroprevalence was
reported for ‘personal care and service occupations’
(median 22% (IQR 9%–28%); n=14, eg, ‘personal care
aids’). The next highest was reported for ‘building and
grounds cleaning and maintenance’ occupations (11%
(3%–22%); n=17, for example, ‘maids and housekeeping
cleaners’) and ‘healthcare support’ (11% (2%–20%);
n=39, eg, ‘nursing assistants’) occupations. The lowest
median seroprevalence was 1% (0%–11%; n=6, eg,
‘athletes’) for ‘arts, design, entertainment, sports and
media occupations.’ Individual estimates are listed in
online supplemental file 2.

**DISCUSSION**

This review is the first comprehensive synthesis of occu-
pational COVID-19 seroprevalence studies worldwide. We
identified 196 studies representing 21 out of 23 major
SOC groups conducted during the first and second waves of
the SARS-CoV-2 pandemic in 2020, prior to the wide-
spread roll-out of vaccines, and described occupational
groups with high seroprevalence.

Seroprevalence studies may estimate the cumulative
incidence of infection more accurately than diagnostic
testing studies when access to testing and test perfor-
mance are poor, and also can identify asymptomatic
infections. The data identified suggest considerable
differences in seroprevalence by occupation, though we
did not statistically test for differences due to consider-
able variation in geography, study dates and workplace
determinants of infection (eg, PPE, ventilation). ‘Caring
and personal service’ occupations had the highest median
seroprevalence (22%), which was four times higher than
the unemployed (5%) and median seroprevalence across
all occupational groups (5%). The UK Office for National
Statistics reported a slightly lower cumulative incidence
for positive diagnostic or rapid tests for COVID-19
across 25 occupational groups of 4% (mean), but the
discrepancy between the true cumulative incidence and
confirmed infections is likely greater in regions with less
access to testing: some national, population-based sero-
surveys have estimated there are 10–20 serologically iden-
tifiable cases per 1 confirmed case.12

In future pandemics, large, well-reported, high-quality
seroprevalence studies across a broad range of occupa-
tions are needed at an early stage to inform appropriate
workplace policy. It has been suggested that 20% of the
US workforce was exposed to disease or infection at work
at least once a month prior to the pandemic.16 Accurate
data on the occupational risks of respiratory infections,
including SARS-CoV-2, are needed to inform under-
standing of transmission, occupational health and safety
agency guidelines and allocation of resources (eg, PPE
and vaccines) during outbreaks and pandemics. For
governments, there are also issues of occupational disease
recognition and compensation to be considered.

As such, future population-based studies on respira-
tory infections should collect data on occupation. In
the case of epidemic infection, collaboration between
academic centres with the capacity to conduct large-
scale studies and government agencies with expertise in
disease surveillance and access to workplace data (eg,
public health, occupational health and safety) may be
beneficial.12 Other authors have suggested the utility of
occupational surveillance systems.17 However, the routine
completion of the occupation field in electronic health
records would also serve this purpose as well as informing
patient reported outcome measures.

**Strengths and limitations**

Despite the large number of studies of occupational
seroprevalence conducted, many studies had method-
ological limitations. Only two studies were at a low risk of
bias and most occupational subgroups had small sample
sizes (median 220 participants). Many were limited to
one major SOC group (n=103 studies), which precluded
comparisons. Detailed descriptions of occupations were
often lacking, potentially contributing to coding errors
and misclassification, and workplace determinants of
infection (eg, use of PPE) were poorly reported.

In conclusion, our review shows that a large number
of seroprevalence studies covering a broad range of
occupations were published in the first year of the
pandemic. Results suggest considerable differences in
seroprevalence between occupations, although few large,
well-reported, high-quality studies were done. Carefully
designed, adequately powered seroprevalence studies with coverage of a broad range of occupations could improve our understanding of the occupational risk of SARS-CoV-2 and other respiratory infections and should be considered an element of pandemic preparedness and response.

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Contributors This secondary analysis of the SeroTracker database was conceived by NB, EB, DK and AA. Senior authors on this paper were NB, DK, RA and AA. The protocol was developed by EB, NB and DK. Data cleaning was performed by CC, OD, NatAD, SD’M and EB and verification by EB, SD, NathD and GB. Analysis was performed by EB and RA. The first draft of the manuscript was written by EB and revised by EB, RA, NB, NathD, GB, S’M, CC, AA, DK. The SeroTracker Consortium maintained the living systematic review database used in the study. All authors reviewed and agreed to the findings, and also provided critical revisions to the paper. EB accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Funding SeroTracker receives funding for SARS-CoV-2 seroprevalence study evidence synthesis from the Public Health Agency of Canada through Canada’s COVID-19 Immunity Task Force (Grant Number 2021-HQ-000056), the WHO Health Emergencies Programme, the Robert Koch Institute and the Canadian Medical Association Joule Innovation Fund.

Disclaimer No funding source had any role in the design of this study, its execution, analyses, interpretation of the data, or decision to submit results. This manuscript does not necessarily reflect the views of the WHO or any other funder.

Competing interests RA was previously a Technical Consultant for the Bill and Melinda Gates Foundation Strategic Investment Fund, is a minority shareholder of Alethea Medical and was a former Senior Policy Advisor at Health Canada. Each of these relationships is unrelated to the present work. JP reports grants to his institution from MedImmune, Sanofi Pasteur, Merck and AbbVie, and personal fees for lectures from AbbVie and Astra-Zeneca, all outside of the submitted work. MFC reports grants from McGill Interdisciplinary Initiative in Infection and Immunity, grants from Canadian Institutes of Health Research, during the conduct of the study; personal fees from GenEL LifeSciences, personal fees from nplex biosciences, personal fees from Kanvas biosciences, personal fees from AstraZeneca, non-financial support from Cidara therapeutics, non-financial support from Scynexis, non-financial support from Amplex Pharmaceuticals, outside the submitted work. In addition, MFC has a patent for methods detecting tissue damage, graft versus host disease, and infections using cell-free DNA profiling pending, a patent for methods assessing the severity and progression of SARS-CoV-2 infections using cell-free DNA pending, a patent for rapid identification of antimicrobial resistance and other microbial phenotypes using highly multiplexed fluorescence in situ hybridisation pending, and a patent highly multiplexed detection of gene expression with hybridisation chain reaction pending, all outside the submitted work.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement SeroTracker data are available in a public, open access repository. All data relevant to the study are included in the article or uploaded as online supplemental information. Seroprevalence data can be downloaded (or requested) from https://serotracker.com.

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