

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<u>http://bmjopen.bmj.com</u>).

If you have any questions on BMJ Open's open peer review process please email <u>info.bmjopen@bmj.com</u>

BMJ Open

BMJ Open

High risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

Journal:	BMJ Open
Manuscript ID	bmjopen-2021-058369
Article Type:	Original research
Date Submitted by the Author:	14-Oct-2021
Complete List of Authors:	Albuquerque, Maria de Fátima; Centro de Pesquisas Aggeu Magalhaes Souza, Wayner; Centro de Pesquisas Aggeu Magalhaes Montarroyos, Ulisses; University of Pernambuco Pereira, Cresio ; Ministry of Health of Brazil Braga, Cynthia ; Centro de Pesquisas Aggeu Magalhaes Velho Barreto de Araùjo, Thalia ; Universidade Federal de Pernambuco, Departamento de Medicina Social Arraes de Alencar Ximenes, Ricardo; Federal University of Pernambuco, Department of Tropical Medicine Miranda-Filho, Demócrito de Barros; University of Pernambuco Szwarcwald, Célia; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ Souza-Junior , Paulo Roberto ; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ-RJ Xavier, Morgana ; Centro de Pesquisas Aggeu Magalhaes Morais, Clarice ; Centro de Pesquisas Aggeu Magalhaes Albuquerque, Gabriela ; Centro de Pesquisas Aggeu Magalhaes Bresani-Salvi, Cristiane; Centro de Pesquisas Aggeu Magalhaes Araújo Mariz, Carolline ; Centro de Pesquisas Aggeu Magalhaes Teixeira de Siqueira-Filha, Noemia; University of York, Department of Health Sciences Galindo, Jadson ; Centro de Pesquisas Aggeu Magalhaes França-Neto, Cláudio Luiz; University of Pernambuco Barbosa, Jessyka Mary Vasconcelos; Centro de Pesquisas Aggeu Magalhaes Veras, Maria Amelia ; Faculty of Medical Sciences of Santa Casa de São Paulo Lima, Luana ; Universidade do Estado do Para Cruz, Luciane; Institute of Health Technology Assessment (IATS) Kendall, Carl; Universidade Federal do Ceara; Tulane University School of Public Health and Tropical Medicine Kerr, L; Universidade Federal do Ceara Turchi Martelli, Celina Maria; Centro de Pesquisas Aggeu Magalhaes
Keywords:	COVID-19, Epidemiology < TROPICAL MEDICINE, PUBLIC HEALTH

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

SCHOLARONE"
Manuscripts
Manuscripts
For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our <u>licence</u>.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which <u>Creative Commons</u> licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

review only

High risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

Maria de Fátima Pessoa Militão de Albuquerque¹, PhD, MD, Wayner Vieira de Souza¹, PhD, Ulisses Ramos Montarroyos², PhD, Cresio Romeu Pereira³, PhD, MD, Cynthia Braga¹, PhD, MD, Thália Velho Barreto de Araújo⁴, PhD, MD, Ricardo Arraes de Alencar Ximenes^{2,5}, PhD, MD, Demócrito de Barros Miranda-Filho², PhD, MD, Célia Landmann Szwarcwald⁶, PhD, Paulo Roberto Borges de Souza Junior⁶, PhD, Morgana do Nascimento Xavier^{1,7}, PhD, Clarice Neuenschwander Lins de Morais¹, PhD, Gabriela Diniz Militao de Albuquerque², Spc, Cristiane C. Bresani Salvi¹, PhD, MD, Carolline de Araújo Mariz^{1,8}, PhD, Noêmia Teixeira de Siqueira Filha⁹, PhD, Jadson Mendonça Galindo¹, MSc, Cláudio Luiz de França Neto², BSc, Jessyka Mary Vasconcelos Barbosa¹, PhD, Maria Amelia de Sousa Mascena Veras¹¹, PhD, MD, Luana Nepomuceno Gondim Costa Lima¹², PhD, Luciane Nascimento Cruz¹⁰, PhD, MD, Carl Kendall^{11,14}, PhD, Ligia Regina Franco Sansigolo Kerr¹⁴, PhD, MD, Celina Maria Turchi Martelli^{1,1}, PhD, MD

Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz), Recife, Brazil

²University of Pernambuco, Recife, Brazil

³Ministry of Health of Brazil, São Paulo, Brazil

⁴Department of Social Medicine

³Department of Tropical Medicine, Federal University of Pernambuco, Recife, Brazil

Institute of Scientific and Technological Communication and Information (ICIT), Oswaldo
 Cruz Foundation (Fiocruz), Rio de Janeiro, Brazil

Department of Biology, Federal University of Pernambuco, Vitória de Santo Antão, Brazil

^sOlinda Medical School, Olinda, Brazil

⁹Department of Health Sciences, University of York, UK

¹⁰Institute for Health Technology Assessment (IATS), Porto Alegre, Brazil and Hospital, Porto Alegre, Brazil

"Faculty of Medical Sciences of Santa Casa de São Paulo, São Paulo, Brazil

¹²State University of Pará, Belém, Brazil

¹³Department of Social, Behavioral and Population Sciences and Tulane University School of

Public Health and Tropical Medicine, New Orleans, USA

¹⁴Federal University of Ceará, Fortaleza, Brazil

Corresponding Author: Celina Maria Turchi Martelli, PhD
Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz)
Address: Av. Prof. Moraes Rego, S/N – Cidade Universitária – 50670-420 Recife, Brazil
Telephone: +55 11 98685-5734
E-mail: turchicm@gmail.com

tor occite teries only

Abstract

Introduction: The disparities in the risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection among frontline health care workers (HCWs) and the unique work circumstances are poorly documented for low-and middle-income countries.

Methods: We assessed the frequency of SARS-CoV-2 infection, personal protective equipment (PPE) shortages, PPE use, and accidents involving biological material among HCWs in the Recife metropolitan area, Northeast Brazil. Using respondent driven sampling (RDS), we included HCWs attending suspected or confirmed COVID-19 patients from May 2020 to February 2021.

Results: We analyzed 1,525 HCWs (527 physicians, 471 registered nurses, 263 nursing assistants/technicians, and 264 physical therapists). Women predominated in all categories (81.1%). Nurses were older and had more comorbidities (hypertension and overweight/obesity) than the other HCWs. The overall prevalence of SARS-CoV-2 infection was 61.8% after adjustment for the cluster random effect, weighted by network, and reference population size. The independent risk factors for a positive RT-PCR test were being a nursing assistant (OR adjusted: 2.56), not always using all recommended PPE in routine practice (ORadj: 2.15), and reporting a splash of biological fluid/respiratory secretion in the eyes (ORadj: 3.37).

Conclusions: The high risk of infection among HCWs reflects PPE shortages and younger, possibly less experienced, frontline HCWs. There were disparities in the risk of SARS-CoV-2 infection among HCWs, with nursing assistants being the most vulnerable, possibly due to their longer and frequent contact with COVID-19 patients.

Strengths and limitations of this study

- One of the strengths of this study is that the design enables the health care system and community in general to get a comprehensive picture of the physicians, nurses, nursing assistants, and physical therapists at the frontline during the COVID-19 pandemic in Northeast Brazil.
- Using respondent driven sampling (RDS) methodology allowed the inclusion of frontliners from different healthcare settings, in the private and public health sector. The results captured the full extent of characteristics of the workforce and the risk factors for infection during the pandemic in our setting. There was also an advantage of applying an online questionnaire which avoided face-to-face interviews. This fieldwork approach was appropriated during the lockdown and/or social distancing restrictions. It also aimed at reducing errors in data transcription, and in obtaining timely results.
- This study had some limitations inherent of RDS methodology regarding the representativeness of the participants recruited. We also acknowledge that there was also an imbalance in recruitment among the HCW categories. In our study physicians and nurses were more rapidly enrolled by RDS methodology than nursing assistants and physical therapists at the frontline.

Introduction

The unprecedented rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and its potentially severe outcomes have highly impacted the healthcare system, the global economy, and security.^{1,2} According to the World Health Organization (WHO), the global cumulative number of confirmed coronavirus disease 2019 (COVID-19) cases had reached approximately 190.5 million with four million deaths by July 19, 2021.³ In Brazil, approximately 19 million COVID-19 cases and 514,000 related deaths were reported within the same period. These figures represent almost 10% and 13% of the global COVID-19 cases and registered deaths, respectively, yet the Brazilian population represents approximately 2.5% of the global population. Since the beginning of the pandemic, the federal government has opposed the recommendations for social distancing and individual protection measures while endorsing ineffective pharmaceutical interventions, hampering the epidemic control efforts of the public health authorities at the state and municipal levels.⁴

Healthcare workers (HCWs) are considered a high-risk group due to the nature of their work. An Anglo-American prospective cohort that included approximately 100,000 HCWs showed a 3.4-fold higher risk of COVID-19 among frontline workers compared with the general community.⁵ This comprehensive study used an online survey with the advantage of potentially avoiding personal contact during the pandemic, as well as allowing timely responses and dissemination of results.⁵ A systematic review and meta-analysis, covering the period from the inception of the pandemic to July 2020, included 46 studies: approximately 70% were conducted in Europe (n=31), nine in the USA, six in Asia, and none in Latin America. Among symptomatic HCWs, the pooled overall prevalence of SARS-CoV-2 infection was 19% using reverse transcription-polymerase chain reaction (RT-PCR).⁶

In the Americas, 569,304 COVID-19 cases, including 2,506 deaths, had been reported among HCWs by August 2020.⁷ According to public health surveillance, approximately 32% of Mexico City HCWs (n=11,226) had been infected with SARS-CoV-2 by July 2020.⁸ Additionally, cross-sectional studies conducted in Brazil, Colombia, and Ecuador revealed lack of personal protective equipment (PPE) among 70% of frontline workers in the early pandemic response.⁹ In Brazil, studies conducted using RT-PCR in teaching hospitals showed a varying prevalence of SARS-CoV-2 infection (42.4%–15%).^{10,11,12} However, information on the prevalence of SARS-CoV-2 infection among frontline HCWs and risk factors for most regions of Brazil is limited.

This study assessed the prevalence of SARS-CoV-2 infection and evaluated PPE shortages, use of individual protective measures, and biological accidents among HCWs in Recife metropolitan area of Northeast Brazil.

Methods

Study design

This prospective study assessed the frequency of infected HCWs and their risk factors, using the respondent-driven sampling (RDS) methodology, and collecting data with a smartphone-based application. RDS was chosen as a sampling approach for two main reasons: restrictions in conducting face-to-face interviews due to lockdown and the lack of a frame list of frontline HCWs attending emergency rooms, hospitals, and new field hospitals. RDS approach is based upon direct participant involvement.

The baseline findings are described following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for RDS.¹³

Setting

The study was conducted in the Recife metropolitan region, Pernambuco State, Northeast Brazil, where the first COVID-19 case was reported on March 12, 2020 The peak of the pandemic was during the 21st epidemiologic week in 2020.^{14,15} This densely populated region comprises 15 municipalities with approximately four million inhabitants, corresponding to 42% of the state population.¹⁶ The Brazilian unified health system (Sistema Unico de Saude—SUS) has provided universal coverage since 1990, with heterogeneity among the regions.¹⁷

Formative research

Formative research (FR) was conducted with the four HCW categories included in the study (physicians, nurses, nurse assistants, and physical therapists). The FR applied in-depth interviews to explore workplace changes, use and access to PPE, routine attendance, and possible acceptability of the study.

Participants and Public Involvement

Participants and/or the public were not involved in the design. However, the formative research was valuable to adequate the research questions considering participants' priorities, experience, and preferences. Also the chosen methodology RDS requires direct involvement of the study

BMJ Open

participants in the recruitment and in indicating other members of the network. Therefore, the participants had an active role in the enrollment of other participants and in the development of the field work. This project was planned in collaboration with the official health care department and professional associations. The coordinators issued periodic reports with preliminary results to the institutions, local newspapers and social media. The final results will be disseminated by institutional platforms.

Participants

We recruited HCWs attending suspected or confirmed COVID-19 patients from May 21, 2020 to February 10, 2021. Recruitment started with five "seeds" for each category, non-randomly selected from the target population. We asked each participant to identify five other members of the same professional network category, providing their names and mobile phone numbers to the fieldworkers. The process continued until a suitable sample size was reached. This study did not offer any incentive.

We calculated a sample size of 1,100 HCWs, considering a 95% confidence level (CI) to estimate a 40% prevalence of infections with a 5% error and a design effect of three.

The network size of each HCW was measured by the final answer to the following questions: 1) "How many colleagues do you know, who also know you by name, work in the Recife metropolitan region and are assisting COVID-19 patients?", 2) "How many of those colleagues have been in professional contact with you in the last two weeks?," and 3) "How many of them are close to you and you would invite to participate in this study?."

Variables

The variables collected were adapted from the WHO interim guidance (March 2020) on health workers' exposure risk assessment and management in the context of the COVID-19 pandemic. The variables were:

(1) Age, sex, and professional category;

(2) Self-reported comorbidities (diabetes mellitus, hypertension, overweight or obesity, cardiopathy, nephropathy, and others);

(3) Healthcare attending—public or private sector, outpatient, emergency rooms and intensive care units (ICU); number of healthcare facilities.

(4) Adherence to infection prevention and control (IPC). We checked for gloves, medical masks, face shields, goggles or protective glasses, and waterproof aprons.

BMJ Open

(5) Adherence to IPC when performing aerosol-generating procedures (AGPs) using the abovementioned grading criteria. In this section, we added the N95 respirator. The variables related to adherence to IPC (items 4 and 5) were grouped as always versus not always.

(6) Accidents with biological material—I) during the period of healthcare interaction and II) if there was an accident with biological fluid or respiratory secretions, which type it was (splash in the mucous membrane of eyes, mouth, or nose; non-intact skin; and puncture-sharp accident).¹⁸ The outcome was a self-reported positive RT-PCR test for SARS-CoV-2.

Data collection

Data were collected using a web-based software platform by FITec (Recife, Pernambuco, Brazil). The HCWs answered the questionnaire by accessing a link that could be opened on a smartphone or a computer browser.

Providing electronic informed consent was mandatory to participate and access the questionnaire. The project was approved by the National Ethics Committee (CONEP; CAAE: 30629220.8.0000.0008).

Data analysis

Participants were weighted by the size of each category, provided by each professional board, and by the inverse of the size of their professional network, based on the following question: "How many of these colleagues are close to you and would you invite to participate in this study?" To avoid the influence of extreme network sizes on the weight of each professional, we limited the network size to 3 to 150 for outlier correction.¹⁹ For missing data—representing around 8% of the total—we used available information from the other two questions related to network size, and when necessary, we applied the overall mean of the stratum. The seeds (primary) were used to define the cluster of the study.

Categorical variables are presented as percentages and 95% CIs by HCW category and overall frequencies adjusted for the design. The chi-squared test was used for comparison between groups. We calculated the means, medians, and 95% CIs for continuous variables. Bivariate analysis was performed to assess the association between potential risk factors and RT-PCR positivity. Variables associated with the outcome at p<0.20 were included in the multivariate model. In the final model, we considered variables at the p<0.10 level statistically significant. All statistical analyses were performed using Stata, version 15.0 (StataCorp LLC, College Station, TX, USA).

Role of the funding source

The funding source had no involvement in any stage of the project.

Results

Participants

We recruited 2,474 health care workers and 1,525 of them were included in the analysis, in the following categories: 527 physicians, 471 registered nurses, 263 nursing assistants, and 264 physical therapists. The exclusions were: 638 HCWs who did not sign the informed consent; 238 that refused to participate and 28 did not complete the questionnaires. Figure 1 illustrates the recruitment chain for each category.

Descriptive data

Overall, women represented 81.1% of the sample after adjustment to the reference population and for the study design (Table 1). Women also predominated in all professional categories, with the lowest percentage among physicians (63.4%) and the highest among nurses (86.7%) and nursing assistants (85.5%). The age distribution was as follows: 32.7% and 35.6% were <30 and 30–39 years old, respectively. Only 0.1% of the participants were aged \geq 60 years. Physicians and physical therapists were the youngest groups, comprising 56.6% and 45.0%, respectively, of those 20–29 years old. Comorbidities affected 30.0% of the studied population. Overweight/obesity (12.6%) and hypertension (11.9%) were the most prevalent comorbidities among nursing assistants and nurses than among the other categories. In total, 71.4% of HCWs attended COVID-19 cases exclusively in the public sector, including hospitals, emergency units, ambulance services, and primary care units. Most HCWs (73.5%) worked either in emergency rooms or ICU. Notably, 55.8% of the physicians and 37.8% of the physical therapists indicated working in three or more institutions during the pandemic (Table 1).

Overall, 78.0% of the participants received training on the use of PPE. Physical therapists (87.0%) and nursing assistants (81.1%) received a higher and similar frequency of training compared to the other categories. Almost half of the HCWs (47.7%) reported a shortage of PPE items during the COVID-19 pandemic. Regarding wearing PPE in routine activities, the overall frequencies varied widely for each item: 90.1% for single-use gloves to 29.9% for face shields. Most HCWs (82.2%) reported performing AGPs on COVID-19 patients. Almost all participants reported having always used single-use gloves (98.4%) and N95 respirators (86.4%) during AGPs. The N95/PPF2 respirator was reused for more than seven days by approximately 28.3% of the participants, with highest and lowest frequencies reported by

physicians (49.3%) and nursing assistants (20.6%), respectively. Overall, 63.7% of the HCWs reported always wearing all PPE items as recommended by the WHO. The self-perception of SARS-CoV-2 risk of infection in the previous 15 days varied: 33.4% for "performing a procedure on a patient with COVID-19;" 17.7% for "sharing the break room with their colleagues;" 16% for the "reuse of N95 respirators;" 10.6% for the "use of poor quality PPE;" 10.2% during "doffing;" 9.6% for "working with colleagues with COVID-19 symptoms;" 1.9% for "lack of PPE in the service;" and 0.5% for "donning PPE." HCWs reported 186 episodes of exposure to biological fluids/respiratory secretions during healthcare interaction with COVID-19 patients. Accidents were more frequent among physicians (13.9%) and less frequent among physical therapists (7.6%) (Table 2).

The frequency of COVID-19 testing varied from 41.2% for physical therapists to 51.1% for physicians. Individuals with any comorbidity were more likely to get tested (56.8%) than those without comorbidities (p<0.001). HCWs who worked in three or more health services were also more likely to get tested (54.9%) than those who worked in only one health service (42.1%) (p<0.001). There was no statistical difference in the likelihood of testing, according to sex, age group (<30 versus ≥30 years old), work setting (outpatients, inpatients, and emergency rooms and ICU), self-perception of risk (no risk to high risk of exposure), reported accidents with biological fluid/respiratory secretion, and when performing AGPs (Supplementary Table 1).

For the tested HCWs, mostly symptomatic, the overall self-reported SARS-CoV-2 infection was 61.8% after adjustment for random cluster effects, weighted by network and population size. The highest infection positivity was among nursing assistants (70.0%), followed by physicians (55.0%), physical therapists (54.7%), and nurses (48.1%), adjusted for random cluster effects (Figure 2). RT-PCR screening was performed mainly among symptomatic cases in all categories, ranging from 81.8% to 91.8% for physicians and nursing assistants, respectively.

Almost half of the HCWs (47.8%) reported taking sick leave due to COVID-19, with a similar trend among the other categories (p=0.159). The median length of health leave was 14 days for all professional categories, reflecting a standard procedure. Of 399 symptomatic SARS-CoV-2 infected HCWs, 10% (n=41) were hospitalized.

In a bivariate analysis, the nursing assistant category was positively associated with infection (odds ratio [OR]=2.77, p<0.001) compared to nurses. Reporting any accident involving body fluid/respiratory secretion was associated with infection (OR=2.67, p<0.014). When considering each accident, splashes in the eyes were a stronger predictor of infection (OR=4.07, p<0.031). During routine assistance of COVID-19 patients, not always wearing the complete

BMJ Open

set of recommended PPE items was associated with infection (OR=2.14; p=0.013) when compared to always using PPE. Not always using the complete recommended PPE items during AGPs was also associated with infection (OR=1.69; p=0.063) when compared with always using PPE (Supplementary Table 2).

In the final multivariate logistic regression model, the following were risk factors for infection: being a nursing assistant (OR adjusted=2.56, p=0.002), not always having used PPE during care of patients with COVID-19 (OR adjusted=2.15, p=0.044), and having suffered a splash to the eyes (OR adjusted=3.37, p=0.034) (Table 3).

Discussion

The current study showed substantial heterogeneity in demographic and self-referred comorbidities between HCW categories during the COVID-19 pandemic. Of note, physicians and physical therapists at the frontline were younger and mainly worked in the Intensive Care Units and emergency rooms when compared with nurses. This reflects the expansion of the healthcare workforce with the inclusion of younger physicians and physical therapists, possibly inexperienced professionals, forcibly driven to work as front liners in a high-risk environment. Nurses and nursing assistants were older and reported more comorbidities, particularly hypertension and overweight/obesity. According to the accumulated evidence, the public health strategy was to prevent exposure among older age groups and/or individuals with comorbidities, as older age and comorbidities are strong prognostic factors for hospitalization and death.²⁰

To our knowledge, our study depicted one of the highest frequencies of SARS-CoV-2 infections among HCWs. One likely explanation is that most of the participants tested were symptomatic, reflecting the policy of making RT-PCR tests for COVID-19 diagnosis available to frontline HCWs. Thus far, there has been no mass RT-PCR testing strategy for the Brazilian population despite WHO recommendations.²¹ Worldwide, the prevalence closest to that of our study was 55%, by RT-PCR among 177 symptomatic medical residents in New York City at the beginning of the COVID-19 pandemic.²² In Southeast Brazil, a high prevalence of SARS-CoV-2 infection (42%) tested by RT-PCR was found among symptomatic HCWs at a teaching hospital in Sao Paulo, from March to May 2020.¹⁰ Another study found a prevalence of 14% (701 out of 4,987) using RT-PCR in a group composed of mainly symptomatic HCWs, at a hospital in the south of Brazil from April to June 2020.¹² This variation might be attributable to the dynamics of the pandemic in different regions of the country, the availability/quality of PPE, and training in different healthcare settings.

 Our study found a 7% prevalence of infection (by RT-PCR) among the 105 asymptomatic HCWs, which is similar to the overall 5% prevalence of infection found by a large screening study for SARS-CoV-2 infection in the metropolitan area of Mexico City.²³ As expected, these results reflect the positive predictive value of clinical manifestations. Although seroprevalence studies cannot be directly compared to our findings, the frequencies of SARS-CoV-2 infection among HCWs in São Paulo city ranged from 5.5% (IgG ELISA) in a private hospital to 14% (IgG/IgM antibody, WONDFOTM) in a large public hospital in 2020.^{11,24} Both hospital settings stated that they adopted high-quality hospital infection control and provided complete PPE in the early stages of the COVID-19 pandemic. This may reflect especially high-quality healthcare facilities in more developed regions of the country and the rates reported were similar to those reported in another meta-analysis of seroprevalence studies.²⁵

Critical aspects for the high risk of SARS-CoV-2 infection included shortage of PPE items reported by approximately half the HCWs. Moreover, 22% of HCWs reported not been trained on PPE use. The lack of preparedness of the health workforce to respond to the COVID-19 pandemic was not only encountered by low- and medium-income countries like Brazil but also in high-income countries at the beginning of the pandemic.²⁶ At the individual level, one-fourth of the HCWs reported that PPE was not always used according to the WHO recommendations.²¹ When performing AGPs, the nursing staff had the highest frequency (over 35%) of not fully adhering to complete PPE.²⁷ Furthermore, not using the recommended PPE during routine attendance of COVID-19 cases caused a 2.2-fold increased risk of a SARS-CoV-2 positive RT-PCR test result. Accidents with biological fluids occurred in all categories, however, they were most frequently reported among physicians, the youngest, and perhaps the group with the least experience working in critical conditions. Reporting an accident with biological fluids, such as a splash in the eye, was positively associated with infection in the final multivariable model. Although it is uncertain whether viruses occasionally present in biofluids are infectious, these fluids should be considered potentially infectious.²⁸ Moreover, the eye has been considered a possible route of SARS-CoV-2 entry through drainage via the nasolacrimal duct to the upper respiratory tract.²⁹ These accidents with biological fluids should be further investigated in other studies, as recommended by the WHO guidelines.¹⁸ The prevalence among HCWs in the current study was at least 20-fold higher when compared to the 3.2% seroprevalence in a population-based survey using SARS-CoV-2 antibody rapid tests conducted during the first wave of the pandemic in the same region.³⁰ Therefore, there is strong evidence that HCWs are at a high risk of SARS-CoV-2 infection in low- and medium-income settings, such as Northeast Brazil.

BMJ Open

To the best of our knowledge, this is the largest Latin American study of HCWs during the COVID-19 pandemic, with the inclusion of the four main healthcare professionals in the public and private sectors and multiple levels of health services. Previous investigations conducted in Brazil were mainly restricted to one hospital setting and did not apply the WHO questionnaire.¹⁸ One advantage of using the RDS methodology was that it allowed the inclusion of frontline HCWs from different healthcare settings, including the private and public health services, providing a more comprehensive picture of frontline HCWs during the pandemic. Furthermore, as HCWs worked in more than one health service and/or in newly implemented "field hospitals/units," this strategy allowed us to capture the full extent of characteristics of the workforce and the risk factors for infection. Another advantage of applying an online questionnaire was to avoid face-to-face interviews during the lockdown and/or social distancing restrictions, reduce errors in data transcription, and obtain timely results.

This study had some limitations. First, there was an imbalance in recruitment among the HCW categories; physicians and nurses were more rapidly enrolled by RDS than nursing assistants. One possible explanation is that physicians and nurses seem to understand research methodology better and/or to have either better smartphones or data plans required to answer the approximately 15-minute online questionnaire. Physicians and nurses were also a more vocal category early in the pandemic, publicizing the constraints/pressure of the workplace. Conversely, nursing assistants, as routine healthcare assistants, spend more time providing direct patient care and have low wages. They could also be less confident/willing to participate due to work overload or unfavorable socio-economic conditions when compared to the other categories that require university degrees. Additionally, disclosure of the work environment concerning PPE and infection control prevention may be problematic for nursing assistants whose jobs are less stable and more prone to replacement in our setting. The current study did not discriminate the source of SARS-CoV-2 infection among HCWs. Accidents involving biological fluids should be further investigated in other studies to validate this finding.

Finally, our findings provide a comprehensive picture of the factors associated with SARS-CoV-2 infection among HCWs. This study highlighted the high prevalence of SARS-CoV-2 infection among all HCW categories, with nursing assistants being the most affected.

Data availability statement

Proposals for the dataset (de-identified participant data, data dictionary) should be directed to the corresponding author: turchicm@gmail.com. To gain access, data requestors will need to present their plan of analysis and sign a data access agreement.

Ethics statements

Providing electronic informed consent was mandatory to participate and access the questionnaire. The project was approved by the National Ethics Committee (CONEP; CAAE: 30629220.8.0000.0008).

Acknowledgments

We thank HCWs for their participation. We acknowledge the Institute of Health Technology Assessment and MCTIC/CNPq/FNDCT/MS/SCTIE/Decit N° 07/2020 for support. The following researchers received scholarship (CNPq-Pq): 308974/2018-2 to CMTM, 309722/2017-9 to RAAX, 301905/2017-7 to MFPMA, no. 30735/2018-1 to CB and 303661/2017-8 to WVS. CRP received scholarship from CNPq, EV-1 no. 315877/2020-0. We thank all participants for their important contribution in this project.

Author contributions

MFPMA, WVS, CMTM, RAAX, DBMF, TB, CK, and LRFSK contributed to the study concept and design. CB, MNX, CNLM, GDMA, CBS, CAM, NTSF, JMG, CLFN, and JMVB contributed to the acquisition of data. MFPMA, URM, WVS, CLS, PRBSJ, and CRP contributed to the data analysis and creation of tables and figures. MFPMA, WVS, CMTM, RAAX, DMF, TVBA, MASMV, LNGCL, CB, and LNC contributed to data interpretation. MFPMA, WVS, URM have verified the underlying data. CMTM, MFPMA, WVS, and CRP drafted the initial manuscript and all other coauthors contributed scientific inputs equally towards the interpretation of the findings and the final draft of the manuscript. All authors confirm that they had full access to all the data in the study and accept responsibility to submit for publication.

Funding

This investigation was funded by Health Technology Assessment Institute (IATS) and by MCTIC/CNPq/FNDCT/MS/SCTIE/Decit N° 07/2020. The funding agency had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Declaration of interests

We declare no competing interests.

1 ว		
2 3	Ref	erences
4 5	1	Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. N Engl J
6 7		<i>Med</i> 2020; 382 : 1268–9. doi:10.1056/NEJMe2002387.
8	2	Morens DM, Daszak P, Taubenberger JK. Escaping Pandora's box—another novel
9 10		coronavirus. N Engl. J Med 2020: 382 : 1293–5. doi:10.1056/NEJMp2002106.
11 12	3	World Health Organization URL: www.COVID19 who int_accessed July 19 2021
13	4	The Lancet COVID-19 in Brazil: "So what?" Lancet 2020: 395 : 1461
14 15		doi:10.1016/S0140-6736(20)31095-3
16 17	5	Nguyen I H Drew DA Graham MS et al. Risk of COVID 19 among front line health
18	5	are workers and the general community a prospective schort study. I great Public
19 20		<i>L L</i> 2020 5 475 22 1 : 10 1101/2020 04 20 20084111
21 22	<i>.</i>	Health 2020; 5: 4/5–83. doi:10.1101/2020.04.29.20084111.
22	6	Gómez-Ochoa AS, Franco OH, Rojas LZ, et al. COVID-19 in health-care workers: a
24 25		living systematic review and meta-Analysis of prevalence, risk factors, clinical
26		characteristics, and outcomes. <i>Am J Epidemiology</i> 2021; 190 : 161–17.
27 28		doi:10.1093/aje/kwaa191.
29 30	7	Pan American Health Organization/World Health Organization. Epidemiological alert:
31		COVID-19 among health workers. August 31, 2020
32 33		https://www.paho.org/en/documents/epidemiological-alert-covid-19-among-health-
34		workers-31-august-2020 [Accessed May 8, 2021].
35 36	8	Antonio-Villa NE, Bello-Chavolla OY, Vargas-Vázquez A, et al. Assessing the burden
37 38		of coronavirus disease 2019 (COVID-19) among healthcare workers in Mexico City: a
39		data-driven call to action. <i>Clin Infect Dis 2021</i> : 73 : e191–8. doi:10.1093/cid/ciaa1487.
40 41	9	Martin-Delgado I Viteri E Mula A et al Availability of personal protective
42 43	,	equipment and diagnostic and treatment facilities for healthcare workers involved in
44		COVID 10 array a group solutional study in Provil Colombia and Foundar, <i>PLoS</i>
45 46		Over 2020: 15: e0242185 dei:10.1271/jeumel.nene.0242185
47	10	One 2020, 15: e0242185. doi:10.1371/journal.pone.0242185.
48 49	10	Buonafine CP, Paiatto BNM, Leal FB, et al. High prevalence of SARS-CoV-2 infection
50 51		among symptomatic healthcare workers in a large university tertiary hospital in São
52		Paulo, Brazil. <i>BMC Infect Dis</i> 2020; 20 : 917. doi:10.1186/s12879-020-05662-8.
53 54	11	Costa SF, Giavina-Bianchi P, Buss L, et al. SARS-CoV-2 seroprevalence and risk
55 56		factors among oligo/asymptomatic healthcare workers (HCW): estimating the impact of
57		community transmission. Clin Infect Dis 2020.doi:10.1093/cid/ciaa1845.
58 59	12	Schmidt Fernandes F, de Castro Cardoso Toniasso S, Castelo Branco Leitune J, et al.
60		COVID-19 among healthcare workers in a Southern Brazilian hospital and evaluation

of a diagnostic strategy based on the RT-PCR test and retest for Sars-CoV-2. *Eur Rev Med Pharmacol Sci* 2021; **25**: 3365–74. doi:10.26355/eurrev_202104_25748.

- 13 White RG, Hakim AJ, Salganik MJ, et al. Strengthening the reporting of observational studies in epidemiology for respondent-driven sampling studies: "STROBE-RDS" statement. J *Clin Epidemiol* 2015; **68**: 1463–71. doi:10.1016/j.jclinepi.2015.04.002.
- Souza WV, Martelli CMT, Silva APSC, et al. The first hundred days of COVID-19 in Pernambuco State, Brazil: epidemiology in historical context. *Cad Saude Publica* 2020; 36: e00228220. doi:10.1590/0102-311X00228220.
- Ximenes RAA, Albuquerque MFPM, Martelli CMT, et al. Covid-19 in the Northeast of Brazil: from lockdown to the relaxation of social distancing measures. *Cien Saude Colet* 2021; 26: 1441–56. doi:10.1590/1413-81232021264.39422020.
- IBGE. Instituto Brasileiro de Geografia e Estatistica. Censo demográfico Brasileiro.
 2010. https://www.ibge.gov.br/cidades-e-estados/pe/recife.html [Accessed July 10, 2021].
- Castro MC, Massuda A, Almeida G, et al. Brazil's unified health system: the first 30 years and prospects for the future. *Lancet* 2019; **394**: 345–56. doi:10.1016/S0140-6736(19)31243-7.
- 18 World Health Organization. Health workers exposure risk assessment and management in the context of COVID-19 virus: interim guidance. March 4, 2020. https://apps.who.int/iris/handle/10665/331340 [accessed April 15, 2020].
- Gonçalves B, Perra N, Vespignani A. Modeling users' activity on twitter networks: validation of Dunbar's number. *PLoS One* 2011; 6: e22656.
 doi:10.1371/journal.pone.0022656.
- 20 Knight SR, Ho A, Pius R, et al. Risk stratification of patients admitted to hospital with covid-19 using the ISARIC WHO clinical characterisation protocol: development and validation of the 4C mortality score. *BMJ* 2020; **370**: m3339. doi:10.1136/bmj.m3339.
- 21 World Health Organization. Responding to community spread of COVID-19). Interim guidance 7 March 2020.
- Breazzano MP, Shen J, Abdelhakim AH, et al. New York City COVID-19 resident physician exposure during exponential phase of pandemic. *J Clin Invest* 2020; 130: 4726–33. doi:10.1172/JCI139587.
- 23 Rajme-López S, González-Lara MF, Ortiz-Brizuela E, et al. Large-scale screening for severe acute respiratory coronavirus virus 2 (SARS-CoV-2) among healthcare workers: prevalence and risk factors for asymptomatic and pauci-symptomatic carriers, with

Page 19 of 33

1		17
2		
3		emphasis on the use of personal protective equipment (PPE). Infect Control Hosp
5		<i>Epidemiol</i> 2021. doi:10.1017/ice.2021.68.
6 7	24	Oliveira MS, Lobo RD, Detta FP, et al. SARS-Cov-2 seroprevalence and risk factors
8		among health care workers: Estimating the risk of COVID-19 dedicated units. Am J
9 10		Infect Control 2021; 49 : 1197–9. doi:10.1016/j.ajic.2021.03.010.
11 12	25	Hossain A. Nasrullah SM. Tasnim Z. Hasan MK. Hasan MM. Seroprevalence of
13		SARS-CoV-2 IgG antibodies among health care workers prior to vaccine
14		administration in Europe, the USA and East Asia: a systematic review and meta-
16 17		analysis <i>E Clinical Medicine</i> 2021: 33 : 100770 doi:10.1016/j.eclinm.2021.100770
18 19	26	Paffenholz P Peine A Hellmich M et al Percention of the 2020 SARS-CoV-2
20	20	nandemic among medical professionals in Germany: results from a nationwide online
21 22		survey Emerg Microbes Infact 2020: 9: 1590-9 doi:10.1080/22221751.2020.1785951
23 24	27	Anvisa Nota Técnica Cyima/Catas/Anvisa Nº 04/2020, Orientaçãos para Sarviços da
25	21	Anvisa Nota Techica Ovinis/Ogles/Anvisa N 04/2020. Offentações para Serviços de
26 27		Saude: Medidas de prevenção e controle que devem ser adotadas durante a assistencia
28 29		aos casos suspeitos ou confirmados de infecção pelo novo Coronavirus (SARS-Co V -2)
30		(updated 08/05/2020).
31 32	28	Schindler SE, Jicha GA, Nelson PT, et al. Maximizing safety in the conduct of
33		Alzheimer's Disease fluid biomarker research in the era of COVID-19. J Alzheimer's
34 35		<i>Dis</i> 2020; 76 : 27–31. doi:10.3233/JAD-20068.
36 37	29	Abobaker A, Alzwi A. The eye: a possible new route of infection in COVID-
38		19. Disaster Med Public Health Prep 2020; 14: e25-6. doi:10.1017/dmp.2020.270.
39 40	30	Hallal PC, Hartwig FP, Horta BL, et al. SARS-CoV-2 antibody prevalence in Brazil:
41 42		results from two successive nationwide serological household surveys. Lancet Glob
43		Health 2020; 8: e1390-8. doi:10.1016/S2214-109X(20)30387-9.
44 45		
46 47		
48		
49 50		
51 52		
53		
54 55		
56 57		
58		
59 60		

BMJ Open

18	
----	--

Table 1. Demographic, clinical, and working baseline characteristics of health care workers in th	ne metropolitan region of Recife, Northeast Brazil, 2020 to 2021
---	--

	Physicians $(n = 527)$		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$,	Total
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Sex										
Female	63.4	58.6-67.9	86.7	82.7-89.9	85.5	79.8-89.7	70.3	63.6-76.3	81.1	77.8-84.1
Male	36.6	32.1-41.4	13.2	10.1-17.3	14.5	10.2-20.2	29.7	23.7-36.4	18.9	15.9-22.2
Age, years										
< 30	56.6	51.7-61.4	25.8	21.6-30.6	26.9	20.8-33.9	45.1	38.3-52.1	32.7	28.8-36.9
30-39	34.1	29.6-38.9	37.3	32.5-42.4	34.5	28.0-41.6	45.3	38.5-52.4	35.6	31.5-40.0
\geq 40	9.3	6.8-12.6	36.9	32.1-41.9	38.6	32.0-45.7	9.6	6.2-14.4	31.7	27.6-36.0
Any comorbidity										
Any	23.3	19.5–27.6	33.9	29.2–38.8	32.0	25.8-38.9	19.0	14.1-25.1	30.1	26.1-34.3
None	76.7	72.4-80.5	66.1	61.2–70.8	68.0	61-74.2	81.0	74.9-85.9	69.9	65.7-73.8
Diabetes	1.0	0.4-2.6	2.1	1.1-4.1	2.0	0.8-5.1	0.4	0.1-3.1	1.8	0.9-3.4
Hypertension	4.0	2.5-6.4	13.2	10.0–17.1	14.4	10.1-19.9	4.8	2.5-8.9	11.9	9.2-15.1
Overweight/Obesity	7.3	5.3-10.0	11.1	8.2–14.6	14.9	10.6-20.4	8.9	5.6-13.7	12.6	9.9–15.9
Heart disease	0.4	0.1-1.3	1.2	0.5-3.0	0.9	0.2-3.5	0.0		0.1	0.3-2.1
Kidney disease	0.0		0.2	0.03-1.5	0.1	0.02-1.1	0.8	0.2-3.1	0.2	0.1-0.6
Others comorbidities	13.1	10.1-16.7	14.8	11.6-18.8	9.4	5.9–14.7	6.9	4.2-11.4	10.8	8.4-13.8
Number of workplaces										
< 3	44.2	39.4-49.0	91.8	88.4–94.2	95.2	92.0–97.2	62.2	55.2-68.7	84.2	82.1-86.1
\geq 3	55.8	51.0-60.6	8.2	5.8-11.6	4.8	2.8-8.0	37.8	31.3-44.8	15.8	13.9–17.9
Missing	2		0		1		0		3	
Institution provider										
Private	5.2	3.5-7.8	7.2	4.8-10.5	7.0	4.1-11.5	14.8	10.4-20.5	7.2	5.3-9.8
Public	44.5	39.7-49.3	81.2	76.8-85.0	79.8	73.5-85.0	35.2	28.9-42.2	71.4	67.6–74.9
Both	50.3	45.5-55.2	11.6	8.7-15.4	13.2	9.1-18.9	50.0	43-56.9	21.4	18.4-24.7
Work setting										
Outpatient/Inpatient clinics	12.0	9.1–15.6	41.6	36.6-46.8	27.7	21.6-34.7	11.5	7.6-17.0	26.5	22.7-30.8
ICU/Emergency	88.0	84.4–90.9	58.4	53.2-63.4	72.3	65.3-78.4	88.5	83.0-92.4	73.5	69.2–77.3

Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network and population size. CI, confidence interval; ICU, intensive care unit

BMJ Open

	Physicians (n = 527)		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$		Total	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% (
Training on PPE use										
Yes	68.9	64.2-73.2	72.3	67.4–76.7	81.1	74.8-86.1	87.0	81.6-91.0	78.0	74.2-81
No	31.1	26.8-35.8	27.7	23.3-32.6	18.9	13.9–25.2	13.0	9.0-18.4	22.0	18.7–25
Missing	3		0		0		0		3	
While providing routine assistance to patients with COVID-19, have you used these PPE:										
Single Gloves										
Always	74.1	69.6-78.1	84.4	80.3-87.8	95.4	90.9–97.7	96.1	92.1-98.1	90.1	87.7–92
Not always	25.9	21.9-30.4	15.6	12.2–19.7	4.6	2.3-9.1	3.9	1.9-7.9	9.9	8.0-12
Missing	2		2		0		1		5	
Surgical mask										
Always	45.3	40.6-50.2	58.6	53.5-63.6	51.0	43.8-58.1	36.9	30.3-44.0	50.5	46.0-54
Not always	54.7	49.8–59.4	41.4	36.4-46.5	49.0	41.9–56.1	63.1	56.0-69.6	49.5	45.1-53
Missing	2		2		0		1		5	
N95 respirator										
Always	64.4	59.6-68.9	57.4	52.3-62.4	66.3	59.1-72.9	87.3	81.6–91.4	65.9	61.4-70
Not always	35.6	31.1-40.3	42.6	37.6-47.7	33.7	27.1–40.9	12.7	8.6-18.4	34.1	30.0-38
Missing	2		2		0		1		5	
Face shield										
Always	19.6	16.0-23.9	28.8	24.4-33.7	31.6	25.3-38.6	42.4	35.7-49.3	29.9	25.9-34
Not always	80.4	76.1-84.0	71.2	66.3-75.6	68.4	61.4–74.7	57.6	50.7-64.3	70.1	65.8-74
Missing	2		2		0		1		5	
Goggles/protective glasses										
Always	18.7	15.3-22.7	24.6	20.4-29.3	38.3	31.6-45.4	45.6	38.7 - 52.6	33.2	29.1-37
Not always	81.3	77.2-84.7	75.4	70.7–79.5	61.7	54.6-68.4	54.4	47.4-61.3	66.8	62.3-70
Missing	2		2		0		1		5	
Disposable gown										

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open

-	-
	$^{\circ}$
_	v

Always	48.0	43.3-52.9	50.8	45.6–55.9	63.8	56.6-70.4	67.2	60.3-73.3	59.2	54.8-63.5
Not always	52.0	47.1–56.7	49.2	44.1–54.4	36.2	29.5-43.4	32.8	26.7-39.7	40.8	36.5-45.2
Missing	2		2		0		1		5	
Waterproof apron										
Always	30.5	26.2-35.2	38.6	33.7-43.7	48.9	41.6-56.3	62.6	55.3-69.4	44.9	40.5-49.5
Not always	69.5	64.8-73.8	61.4	56.3-66.3	51.1	43.7-58.4	37.4	30.6-44.7	55.1	50.5-59.5
Missing	14		11		11		18		54	
During provision of routine assistance to COVID-19 patients, did you wear all PPE items as recommended by the WHO?										
Always	89.6	86.2–92.3	79.2	74.7-83.1	70.0	63.1-76.1	69.0	62.2-75.1	74.7	70.5-78.5
Not always	10.4	7.7–13.8	20.8	16.9–25.3	30.0	23.9-36.9	31.0	24.9-37.8	25.3	21.5-29.5
Missing	2		2		0		1		5	
Participated in AGP*										
Yes	79.6	75.3-83.2	75.6	70.8–79.8	83.4	77-88.3	95.8	91.7–97.8	82.2	78.4-85.5
No	20.4	16.8-24.7	24.4	20.2–29.2	16.6	11.7 - 23	4.2	2.1-8.3	17.8	14.5-21.0
Missing	1		1		1		2		5	
While participating in AGPs, have you used:										
Single Gloves										
Always	97.8	95.5–98.9	97.7	95.1–99	98.5	94.2–99.6	99.7	98.1–99.9	98.4	96.4–99.3
Not always	2.2	1.1-4.5	2.3	1–4.9	1.5	0.4–5.8	0.3	0.04-1.9	1.6	0.7-3.6
Missing	0		0		0		1		1	
Surgical mask										
Always	61.5	56.2-66.6	49.9	44.1-55.7	46.5	38.9-54.3	60.2	52.9-67.1	50.5	45.6-55.3
Not always	38.5	33.4-43.8	50.1	44.3-55.9	53.5	45.7-61.1	39.8	32.9-47.1	49.5	44.7-54.4
Missing	0		0		0		1		1	
N95 respirator										
Always	92.4	89–94.9	85.0	80.3-88.8	84.2	77.8-89.1	93.3	88.2–96.3	86.4	82.5-89.5
Not always	7.6	3.1-11	15.0	11.2–19.7	15.7	10.9-22.2	6.7	3.7-11.8	13.6	10.5-17.5
Missing	0		0		0		1		1	
Face shield										

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Page 2	3 of 33
--------	---------

 BMJ Open

										_
Always	51.6	46.2–56.9	48.3	42.6–54.1	48.0	40.3-55.7	41.4	34.5-48.6	48.1	43.2–53.0
Not always	48.4	43.1-53.8	51.7	45.8-57.4	52.0	44.2-59.7	58.6	51.4-65.5	51.9	47.0-56.8
Missing	0		0		0		1		1	
Soggles/Protective glasses										
Always	62.5	57.1-67.6	59.3	53.5-64.9	51.4	43.6-59.1	47.1	40-54.3	54.0	49.1–58.9
Not always	37.5	32.4-42.8	40.7	35.1-46.5	48.6	40.9-56.4	52.9	45.7 - 60	46.0	41.1-50.9
Missing	0		0		0		1		1	
Disposable gown										
Always	60.3	55.0-65.4	60.1	54.3 - 65.7	64.0	60.3-74.9	68.3	61.3-74.4	65.6	60.8-70.1
Not always	39.7	34.6-45.0	39.9	34.3-45.7	32.0	25.1-39.7	31.7	25.6-38.7	34.4	29.9–39.2
Missing	0		0		0		1		1	
Waterproof apron										
Always	55.2	49.7–60.6	60.7	54.8-66.3	62.5	54.4-69.9	74.6	67.4-80.7	61.9	57.0-66.7
Not always	44.8	39.4-50.3	39.3	33.7-45.2	37.5	30.1-45.6	25.4	19.3-32.6	38.1	33.3-43.0
Missing	9		7		9		17		42	
When performing an AGP in COVID-19 patients, did you wear all recommended PPE tems as in WHO guidance?										
Always	66.0	60.0-71.4	58.0	51.4-64.3	63.8	54.1-72.6	74.7	64.2-82.8	63.7	57.8-69.2
Not always	34.0	28.6-40.0	42.0	35.7-48.6	36.2	27.4-45.9	25.3	17.2-35.8	36.3	30.8-42.2
Missing	0		0		0		1		1	
Duration of N95 respirator use										
< 8 days	50.7	45.8-55.6	71.4	66.6-75.8	79.4	73.0-84.6	54.6	47.6-61.5	71.7	67.9–75.3
≥ 8 days	49.3	44.4-54.2	28.6	24.2-33.4	20.6	15.4-27.0	45.4	38.5-52.4	28.3	24.7-32.1
Missing	9		5		8		4		26	
Any accident involving body fluid/respiratory secretion										
Yes	13.9	11-17.4	10.8	7.9–14.5	11.7	7.9–17.1	7.6	4.9-11.7	11.6	9.1-14.8
No	86.1	82.6-89	89.2	85.5-92.1	88.3	82.9-92.1	92.4	88.3-95.1	88.4	85.2–90.9
Organ involved										
Splash in the Mouth	1.9	1.02-3.8	1.9	0.85-4.3	0.2	0.04-1.5	0.7	0.2-3.1	0.8	0.5-1.4
Splash on the Skin	2.4	1.4-3.9	3.4	1.9-6.0	1.3	0.5-3.2	3.9	1.9–7.7	2.0	1.3-3.0
Splash on the Eyes	2.3	1.4-3.9	3.5	1.9-6.1	2.1	0.8-5.8	2.5	1.2-5.0	2.4	1.4-4.2

2	2
7	7

Puncture/sharps	8.2	5.9–11.3	3.0	1.7-5.3	8.2	4.9–13.4	0.0	-	6.7	4.6–9.7
Self-perception of risk										
None/Low	21.6	17.9-25.9	24.9	20.7-29.6	21.9	16.3-28.7	17.2	12.5-23.3	22.0	18.5-26.1
Medium/High	78.4	74.1-82.1	75.1	70.3-79.3	78.1	71.3-83.7	82.8	76.7-87.5	78.0	73.8-81.5
Missing	9		2		6		4		21	

 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network and population size.

AGPs, aerosol-generating procedures; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment; WHO, World Health Organization

Table 3. Final multivariate model for factors associated with reported positive PCR COVID-19 results

	Odds Ratio	95% CI	P-value
Occupation			
Nurse	1.0		
Physical therapist	1.47	0.80-2.72	0.214
Physician	1.20	0.76-1.90	0.426
Nursing assistant	2.56	1.42-4.61	0.002
Splash on the eyes			
No accident	1.0		
Yes	3.37	1.10-10.34	0.034
Any accident	1.59	0.51-4.90	0.421
Used all PPE items while assisting patients with COVID-19			
Yes	1.0		
No	2.15	1.02-4.53	0.044

Adjusted for cluster random effect and weighted by network and population size COVID-19, coronavirus disease 2019; CI, confidence interval; PPE, personal protective equipment

ore review only

Figure Legends

Figure 1. Respondent-driven sampling recruitment chains.

Figure 2. Frequencies of self-reported SARS-CoV-2 infection by healthcare categories.

tor peer terier only



Figure 1. Respondent-driven sampling recruitment chains

338x190mm (170 x 170 DPI)



Occupation

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open

– Lower Limit – Upper Limit Prevalence(%)

				-
		RT-PCR testing		P-value
		Yes (%)	No (%)	
Occupation category				0.02
	Physician	269 (51.1)	257 (48.9)	
	Registered nurse	224(47.6)	247(52.4)	
	Nursing assistant	110 (42.0)	152 (58.0)	
	Physical therapist	108(41.2)	154(58.8)	
Sex	•			0.4
	Female	530 (46.2)	618 (53.8)	
	Male	181 (48.5)	192 (51.5)	
Age group, years				$0 \cdot 1$
	< 30	523 (45.7)	622 (54.3)	
	\geq 30	188 (50.0)	188 (50.0)	
Any comorbidity			. ,	< 0.00
	Yes	246 (56.8)	187 (43.2)	
	No	465 (42.7)	623 (57.3)	
Number of workplaces (hospitals/clinics)		~ /		< 0.0
r in r	<3	247 (54.0)	210 (46.0)	
	>3	462 (43.5)	599 (56.5)	
Work setting	_	~ /		0.3
	Emerg/ICU	565 (47.3)	629 (52.7)	
	Outpat/Inpatients	146 (44.7)	181 (55.3)	
Institution provider	1 1			< 0.00
	Private	48(42.1)	66 (57.9)	
	Public	393 (43.0)	522 (57.0)	
	Both	270 (54.9)	222 (45.1)	
Performed aerossol				0.3
generating procedure				
	Yes	600 (47.3)	669 (52.7)	
	No	110 (44.5)	137 (55.5)	
	Missing	1 (20.0)	4 (80.0)	
Same N95 respirator, use duration, days		· · · ·		0.02
• <i>i i i</i>	≤ 7	458 (49.00	476 (51.0)	
	> 7	243 (43.0)	322 (57.0)	
Self-perceived risk				0.8
-	None/Low	36 (45.1)	43 (54.9)	
	Medium/High	665 (46.7)	760 (53.3)	
Accident involving biological	-			0.64
fluid/respiratory secretion				
	Yes	84 (45.2)	102 (54.8)	
	No	627 (47.0)	708 (53.0)	
Sick leave due to				< 0.00
COVID-19 symptoms				
•	Yes	576 (79.7)	147 (20.3)	
	No	130 (16.5)	659 (83.5)	
Had COVID-19-like symptoms/signs			× /	< 0.00
	Yes	601 (68.2)	280 (31.8)	
	No	110 (17.0)	530 (82.8)	
OVID 10 coronavirus disease 2010. RT PCE	reverse transcription	n nolymerase	phain reaction	

Supplementary Table 1. Characteristics of the study population according to RT-PCR testing

Supplementary Table 2. Potential risk factors for reporting a positive PCR COVID-19 result among front line healthcare professionals

	Odds Ratio	95% CI	<i>P</i> -value
Sex			
Female	1.0		••
Male	1.35	0.78-2.34	0.288
Age, years	1.03	0.65-1.64	0.889
Occupation			
Nurse	1.0		
Physical therapist	1.42	0.88 - 2.27	0.148
Physician	1.32	0.91-1.91	0.142
Nursing Assistant	2.77	1.64-4.67	< 0.001
Any comorbidity	1.19	0.75 - 1.90	0.454
Number of workplaces			
< 3	1.0		
<u>≥</u> 3	0.83	0.53-1.30	0.428
Institution provider			
Private	1.0		
Public	0.92	0.42-2.02	0.844
Both	0.93	0.41-2.10	0.863
Work setting			
Outpatient /Inpatient clinics	1.0		
ICU/Emergency	1.54	0.92-2.60	0.102
Training on PPE use	1.06	0.62-1.80	0.829
Any accident involving body fluid/respiratory secretion	2.67	1.22–5.82	0.014
Splash in the mouth			
No accident	1.0		
Yes	3.84	0.64–22.95	0.140
Other accident	2.30	0.85-6.23	0.102
Splash on the skin			
No accident	1.0		
Yes	1.86	0.54-6.44	0.328
Other accident	2.50	0.80-7.85	0.116
Splash in the eyes			
No accident	1.0		
Yes	4.07	1.14-14.55	0.031
Other accident	2.07	0.71-6.08	0.184
Puncture/sharp accident			
No accident	1.0		
Yes	2.25	0.51-9.89	0.282
Other accident	2.51	1.10-5.72	0.028
Duration N95 respirator use			
< 8 days			
$\geq 8 \text{ days}$	0.96	0.59–1.55	0.869
Used All PPE items during AGP#			
Did not Always use	1.68	0.97-2.92	0.063

	-	
-	-	

1.0		
2.14	1.18-3.88	0.013
0.997	0.994-1.000	0.042
	1.0 2.14 0.997	$\begin{array}{cccccccccccccccccccccccccccccccccccc$

Adjusted for cluster random effect and weighted by network and population size.

AGP, aerosol-generating procedure; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment

tor peer terier only

Tabela 1. STROBE-RDS Statement Checklist for the manuscript title "High risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach"

Item	#	STROBE-RDS checklist	Main
			Document
Title and abstract	1	(a) Indicate 'respondent-driven sampling' in the title or abstract	Done, RDS in the Title and abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg. 1, lines 5- 17. Abstract included methods,
			results and conclusions.
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction, paragraph 1-3 Done
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction, paragraph 4
Methods			
Study design	4	(a) Present key elements of study design early in the article	Done, Methods, paragraph 1
		(b) State why RDS was chosen as the sampling method	Methods, paragraph 1 "RDS was chosen as a sampling approach for two main reasons: restrictions in conducting face-to-face interviews"
Setting	5	 (a) Describe the setting, locations, and relevant dates, including periods of recruitment and data collection (b) Describe formative research findings used to inform RDS. 	Done. Methods, paragraph 3 and 5
		study	Methods, paragraph 4
Participants	6	(a) Give the eligibility criteria and the sources and methods of selection of participants. Describe how participants were trained/instructed to recruit others, number of coupons issued per person, any time limits for referral	Done Methods, paragraph 5
		(b) Describe methods of seed selection and state number at start of study and number added later	Methods, paragraph 6 and 7
		(c) State if there was any variation in study procedures during data collection (e.g., changing numbers of coupons per recruiter, interruptions in sampling, or (stopping recruitment chains)	Done
		(d) Report wording of personal network size question(s)	Done. Methods, paragraph 7
		(e) Describe incentives for participation and recruitment	No incentives were offered.

1	
2	
۲ ۲	
1	
4	
с С	
6	
7	
8	
9	
10	
11	
12	
13	
11	
15	
10	
10	
1/	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
22	
20	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
<u>4</u> 2	
-72 //2	
45 74	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
50	
20	
29	
00	

			pg8 line 6.
			"This study
			did not offer
			any
			incentive."
Variables	7	(a) If applicable, clearly define all outcomes, correlates,	Done.
		predictors, potential confounders, effect modifiers, and	Methods, pg
		diagnostic criteria	8; "The
			variables
			collected
			were adapted
			from the
			WHO interim
		(h) State reconsiturent velationship was the sheed	Eigung 1
		(b) State recruitment relationship was tracked	Figure I "Deenendent
			driver
			anven
		6	sampling
			chains"
Data sources/	Q	(a) For each variable of interest, give sources of data and datails	Done
measurement	0	of methods of measurement. Describe comparability of	Methods ng
measurement		measurement methods if there is more than one group	8. the
		incustionent methods it there is more than one group	variables of
			interest were
			specified.
		(b) Describe methods to assess eligibility and reduce repeat	Methods, pg
		enrollment (e.g., coupon manager software, biometrics)	9. Data
			collection.
			"Data were
			collected
			using a web-
			based
			software
			platform by
			Filec
			(Recife,
			Pernambuco,
			Brazil). The
			nuws answarad the
			answered the
			hy accessing a
			link that could
			he opened on
			a smartphone
			or a computer
			browser."
Bias	9	Describe any efforts to address potential sources of bias	Not done
Study size	10	Explain how the study size was arrived at	Methods, "We
			calculated a
			sample size of
			1,100 HCWs,
			considering a
			95%
			confidence
			level (CI) to
			estimate a
			40%
			prevalence of

			infections with a 5% error and a design effect of three."
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Methods, section "variable" and "Data analysis".
Statistical methods	12	(a) Describe all statistical methods, including those to account for sampling strategy (e.g., the estimator used) and, if applicable, those used to control for confounding	Methods, section "Data analysis"
		specific analysis settings used	section "Data analysis"
		(c) Describe any methods used to examine subgroups and interactions	Not applicable
		(d) Explain now missing data were addressed	section "Data analysis"
		 (e) Describe any sensitivity analyses (f) Report any criteria used to support statements on whether estimator conditions or assumptions were appropriate 	Not done Not done
		(g) Explain how seeds were handled in analysis	Done, pg 9 "Data
		2.	seeds were used to define the cluster of
Deculto			the study.
Participants	13	(a) Report the numbers of individuals at each stage of the	Done
		study, for example, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, and analyzed	Results, Text, first paragraph
		(b) Give reasons for nonparticipation at each stage (e.g., not eligible, does not consent, decline to recruit others)	Done
		(c) Consider use of a flow diagram	as Flowchart due to limited number of Figures of the Journal
		(d) Report number of coupons issued and returned	Not applicable
		(e) Report number of recruits by seed and number of RDS recruitment waves for each seed. Consider showing graph of entire recruitment network	Done Figure 1. Presents RDS recruitment chains.
		(f) Report recruitment challenges (e.g., commercial exchange of coupons, imposters, duplicate recruits) and how addressed	Not Done
		(g) Consider reporting estimated design effect for outcomes of interest	Done Figure 2 shows prevalence adjusted "for
1			

2			
2			
2			
4			
5			
6			
7			
8			
9			
10			
11			
10			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
ו∡ רב			
22			
23			
24			
25			
26			
27			
28			
29			
20			
30 21			
51			
32			
33			
34			
35			
36			
37			
38			
20			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
40			
77 50			
50			
51			
52			
53			
54			
55			
56			
57			
58			
50			
リブ			

			random cluster effects" Pq 11
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and, if applicable, information on correlates and potential confounders. Report unweighted sample size and percentages, estimated population proportions or means with estimated precision (e.g., 95% confidence interval)	Done Table 1 and table 2
		(b) Indicate the number of participants with missing data for each variable of interest	Done. Missing Data presented for each variable (Tables 1 and 2)
Outcome data	15	If applicable, report number of outcome events or summary measures	Done. Presented in Figure 2.
Main results	16	(a) Give unadjusted and study design adjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence intervals). Make clear which confounders were adjusted for and why they were included	Done. Results section and Tables 3
		(b) Report category boundaries when continuous variables	Not
		(c) If adjustment of primary outcome leads to marked changes, report information on factors influencing the adjustments (e.g., personal network sizes, recruitment patterns by group, key confounders)	The adjustment only modified slightly not
		4.	general results
Other analyses	17	Report other analyses done for example, analyses of subgroups and interactions, sensitivity analyses, different RDS estimators and definitions of personal network size	All analyses were reported
Discussion			1
Key results	18	Summarize key results with reference to study objectives	Done. Discussion, paragraph 1
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Done. Discussion, paragraph 7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion, paragraph 2-5
Generalizability	21	Discuss the generalizability (external validity) of the study results	Discussion, paragraph 6 and 8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	page 16, funding section

BMJ Open

Risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

Journal:	BMJ Open
Manuscript ID	bmjopen-2021-058369.R1
Article Type:	Original research
Date Submitted by the Author:	15-Feb-2022
Complete List of Authors:	Albuquerque, Maria de Fátima; Centro de Pesquisas Aggeu Magalhaes Souza, Wayner; Centro de Pesquisas Aggeu Magalhaes Montarroyos, Ulisses; University of Pernambuco Pereira, Cresio ; Ministry of Health of Brazil Braga, Cynthia ; Centro de Pesquisas Aggeu Magalhaes Velho Barreto de Araùjo, Thalia ; Universidade Federal de Pernambuco, Departamento de Medicina Social Arraes de Alencar Ximenes, Ricardo; Federal University of Pernambuco, Department of Tropical Medicine Miranda-Filho, Demócrito de Barros; University of Pernambuco Szwarcwald, Célia; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ Souza-Junior , Paulo Roberto ; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ-RJ Xavier, Morgana ; Centro de Pesquisas Aggeu Magalhaes Morais, Clarice ; Centro de Pesquisas Aggeu Magalhaes Albuquerque, Gabriela ; Centro de Pesquisas Aggeu Magalhaes Bresani-Salvi, Cristiane; Centro de Pesquisas Aggeu Magalhaes Araújo Mariz, Carolline ; Centro de Pesquisas Aggeu Magalhaes Teixeira de Siqueira-Filha, Noemia; University of York, Department of Health Sciences Galindo, Jadson ; Centro de Pesquisas Aggeu Magalhaes França-Neto, Cláudio Luiz; University of Pernambuco Barbosa, Jessyka Mary Vasconcelos; Centro de Pesquisas Aggeu Magalhaes Veras, Maria Amelia ; Faculty of Medical Sciences of Santa Casa de São Paulo Lima, Luana ; Universidade do Estado do Para Cruz, Luciane; Institute of Health Technology Assessment (IATS) Kendall, Carl; Universidade Federal do Ceara; Tulane University School of Public Health and Tropical Medicine Kerr, L; Universidade Federal do Ceara Turchi Martelli, Celina Maria; Centro de Pesquisas Aggeu Magalhaes
Primary Subject Heading :	Epidemiology
Secondary Subject Heading:	Infectious diseases
Keywords:	COVID-19, Epidemiology < TROPICAL MEDICINE, PUBLIC HEALTH

1	
2	
4	
5	
6 7	SCHOLARONE™
8	Manuscripts
9	Manascripts
10	
12	
13	
14	
16	
17	
18	
19 20	
21	
22	
23	
25	
26	
27	
28 29	
30	
31	
32 33	
34	
35	
36 37	
38	
39	
40	
41	
43	
44	
45 46	
47	
48	
49 50	
50	
52	
53	
54 55	
56	
57	
58 59	
60	For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our <u>licence</u>.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which <u>Creative Commons</u> licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

review only

BMJ Open

Risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

- Maria de Fátima Pessoa Militão de Albuquerque, PhD, MD, Wayner Vieira de Souza, PhD, Ulisses Ramos Montarroyos², PhD, Cresio Romeu Pereira³, PhD, MD, Cynthia Braga¹, PhD, MD, Thália Velho Barreto de Araújo⁴, PhD, MD, Ricardo Arraes de Alencar Ximenes^{2,5}, PhD, MD, Demócrito de Barros Miranda-Filho², PhD, MD, Célia Landmann Szwarcwald⁶, PhD, Paulo Roberto Borges de Souza Junior, PhD, Morgana do Nascimento Xavier, PhD, Clarice Neuenschwander Lins de Morais¹, PhD, Gabriela Diniz Militao de Albuquerque², Spc, Cristiane C. Bresani Salvi¹, PhD, MD, Carolline de Araújo Mariz^{1,8}, PhD, Noêmia Teixeira de Sigueira Filha⁹, PhD, Jadson Mendonça Galindo¹, MSc, Cláudio Luiz de França Neto², BSc, Jessyka Mary Vasconcelos Barbosa¹, PhD, Maria Amelia de Sousa Mascena Veras¹¹, PhD, MD, Luana Nepomuceno Gondim Costa Lima¹², PhD, Luciane Nascimento Cruz¹⁰, PhD, MD, Carl Kendall^{13,14}, PhD, Ligia Regina Franco Sansigolo Kerr¹⁴, PhD, MD, Celina Maria Turchi Martelli^{1,*}, PhD, MD

Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz), Recife, Brazil

²University of Pernambuco, Recife, Brazil

³Ministry of Health of Brazil, São Paulo, Brazil

⁴Department of Social Medicine

- Department of Tropical Medicine, Federal University of Pernambuco, Recife, Brazil
- Institute of Scientific and Technological Communication and Information (ICIT), Oswaldo
- Cruz Foundation (Fiocruz), Rio de Janeiro, Brazil
- Department of Biology, Federal University of Pernambuco, Vitória de Santo Antão, Brazil
- ⁸Olinda Medical School, Olinda, Brazil
- ⁹Department of Health Sciences, University of York, UK
- ¹⁰Institute for Health Technology Assessment (IATS), Porto Alegre, Brazil and Hospital, Porto

Alegre, Brazil

- "Faculty of Medical Sciences of Santa Casa de São Paulo, São Paulo, Brazil
- ¹²State University of Pará, Belém, Brazil
- ¹³Department of Social, Behavioral and Population Sciences and Tulane University School of
- Public Health and Tropical Medicine, New Orleans, USA
- ¹⁴Federal University of Ceará, Fortaleza, Brazil

1 ว		
2	1	Corresponding Author: Celina Maria Turchi Martelli, PhD
4 5	2	Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz)
6 7	3	Address: Av. Prof. Moraes Rego, S/N – Cidade Universitária – 50670-420 Recife, Brazil
8 9	4	Telephone: +55 11 98685-5734
10	5	E-mail: turchicm@gmail.com
12	6	
13 14	7	Keywords: COVID-19; Health care Workers; Brazil.
15 16	8	
17	9	Word count: 4.063
19	10	
20 21	11	
22 23	12	
24	13	
25 26	14	
27 28	15	
29 30	16	
31	17	
32 33	18	
34 35	19	
36 37	20	
38	21	
39 40	22	
41 42	23	
43 44	24	
45	25	
46 47	26	
48 49	27	
50 51	28	
52	29	
53 54	30	
55 56	31	
57	32	
58 59	33	
60	34	

BMJ Open

2		
3 4	1	Abstract
5	2	Objectives: We assessed the prevalence of severe acute respiratory syndrome coronavirus
6 7	3	(SARS-CoV-2) infection, personal protective equipment (PPE) shortages and occurrence of
8 9	4	biological accidents among frontline health care workers (HCW).
10	5	Design, setting and participants: Using respondent driven sampling (RDS), the study
12	6	recruited distinct categories of HCW attending suspected or confirmed COVID-19 patients
13 14	7	from May 2020 to February 2021, in the Recife metropolitan area, Northeast Brazil.
15 16	8	Outcome measures: The criterion to assess SARS-CoV-2 infection among HCW was a
17	9	positive self-reported PCR test.
18 19	10	Results: We analyzed 1,525 HCW: 527 physicians, 471 registered nurses, 263 nursing
20 21	11	assistants, and 264 physical therapists. Women predominated in all categories (81.1%; 95%
22	12	CI: 77.8% - 84.1%). Nurses were older with more comorbidities (hypertension and
23 24	13	overweight/obesity) than the other staff. The overall prevalence of SARS-CoV-2 infection was
25 26	14	61.8% (95% CI: 55.7%-67.5%) after adjustment for the cluster random effect, weighted by
27	15	network, and the reference population size. Risk factors for a positive RT-PCR test were being
28 29	16	a nursing assistant (ORadjusted: 2.56; 95% CI: 1.42 - 4.61), not always using all recommended
30 31	17	PPE while assisting patients with COVID-19 (ORadj: 2.15; 95% CI: 1.02 - 4.53) and reporting
32 33	18	a splash of biological fluid/respiratory secretion in the eyes (ORadj: 3.37; 95% CI: 1.10 -
34	19	10.34).
35 36	20	Conclusions: This study shows the high frequency of SARS-CoV2 infection among HCW
37 38	21	presumably due to workplace exposures. In our setting nursing assistant comprised the most
39 40	22	vulnerable category. Our findings highlight the need for improving health care facility
41	23	environments, specific training and supervision to cope with public health emergencies.
42 43	24	
44 45	25	
46	26	
47 48	27	
49 50	28	
51 52	29	
53	30	
54 55	31	
56 57	32	
58	33	
60	34	

Page 6 of 33

Strengths	and	limitations	of	this	study
Strengths	unu	mmuutoms	•••	UIIIG	study

- Respondent-driven sampling (RDS) technique applied in this study allowed the enrolment of the healthcare workers (HCW) attending COVID-19 patients. HCW were considered a hard-to-reach population regarding their work conditions during the pandemic.
- The study has a large sample size including the major categories of health care professionals who attended Covid-19 patients in the public, private or newly implemented campaign hospitals.
- Data were collected using a web-based platform, allowing the use of online questionnaire, also facilitating timely data analysis and lesser transcript data errors.
- The Respondent-driven sampling chains could potentially induce the recruitment of participants with similar characteristics, prone to selection bias. However, the study achieved a large and heterogeneous sample.

• The source of SARS-CoV-2 infection among HCW could not be ascertained and this is another limitation of the study.

review only

The unprecedented rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and its potentially severe outcomes have highly impacted the healthcare system, the global economy, and security.^{1,2} According to the World Health Organization (WHO), the global cumulative number of confirmed coronavirus disease 2019 (COVID-19) cases had reached approximately 364.2 million and 5.6 million deaths by January 28, 2022.³ In Brazil, approximately 24.5 million COVID-19 cases and 624,413 related deaths were reported within the same period. These figures represent almost 7% and 11% of the global COVID-19 cases and registered deaths, respectively, yet the Brazilian population represents approximately 2.5% of the global population. In Brazil Covid-19 epidemiological data showed a high burden on hospital system with 678 235 patients' admission with a positive RT-PCR for SARS-CoV-2 between February 2020 and April 2021. Hospital mortality increased from 34.8% in the first wave (February 25, 2020 to November 5, 2020) to 39.3% in the second wave (November 6, 2020, to April 30, 2021). The northeast and north states of the country concentrate the worst in-hospital mortality rates, which are the regions with lower Human Development Indexes.⁴ Since the beginning of the pandemic, the federal government has opposed the recommendations for social distancing and individual protection measures while endorsing ineffective pharmaceutical interventions, hampering the epidemic control efforts of the public health authorities at the state and municipal levels.⁵

Healthcare workers (HCW) are considered a high-risk group due to the nature of their work. An Anglo-American prospective cohort that included approximately 100,000 HCW showed a 3.4-fold higher risk of COVID-19 among frontline workers compared with the general community.⁶ A systematic review and meta-analysis, covering the period from the inception of the pandemic to August 2021, showed a significant burden of COVID-19 among HCW in several countries, with a pooled prevalence of 11% (95% CI: 7 to 16%) in studies using PCR test.⁷ Another systematic review and metanalysis suggested that exposure in settings with familiar contact increases SARS-CoV-2 transmission. However, to explore the transmission pattern in health facilities, workplace and social settings is still challenging due to limited data so far.⁸ These previous reviews did not include studies from Brazil.

In the Americas, 569,304 COVID-19 cases, including 2,506 deaths, had been reported among
HCW by August 2020.⁹ According to public health surveillance, approximately 32% of Mexico
City HCW (n=11,226) had been infected with SARS-CoV-2 by July 2020.¹⁰ Additionally,
cross-sectional studies conducted in Brazil, Colombia, and Ecuador revealed lack of personal
protective equipment (PPE) among 70% of frontline workers in the early pandemic response.¹¹

In line with the previous studies a survey among HCW reported PPE shortage in the first COVID-19 wave in Brazil 2020¹², and the inadequate working conditions were also reported by the media¹³. In Brazil, prevalence of SARS-CoV-2 infection using RT-PCR in teaching hospitals varied from 15% to 42.4% among symptomatic HCW in the south region and southeast regions, respectively.^{14,15,16} However, information on the prevalence of SARS-CoV-2 infection among frontline HCW and risk factors for most regions of Brazil is limited.

This study assessed the prevalence of SARS-CoV-2 infection and evaluated PPE shortages, use of individual protective measures, and biological accidents among HCW in Recife metropolitan area of Northeast Brazil.

Methods

Study design

This prospective study assessed the frequency of infected HCW and their risk factors, using the respondent-driven sampling (RDS) methodology¹⁷, and collecting data with a smartphone-based application. RDS was chosen as a sampling approach for two main reasons: restrictions in conducting face-to-face interviews due to lockdown and the lack of a frame list of frontline HCW attending emergency rooms, hospitals, and new field hospitals. RDS approach is based upon direct participant involvement.

The baseline findings are described following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for RDS.¹⁸

Setting

The study was conducted in the Recife metropolitan region, Pernambuco State, Northeast Brazil, where the first COVID-19 case was reported on March 12, 2020. The peak of the pandemic was during the 21st epidemiologic week in 2020.^{19,20} This densely populated region comprises 15 municipalities with approximately four million inhabitants, corresponding to 42% of the state population.²¹ The Brazilian unified health system (Sistema Unico de Saude— SUS) has provided universal coverage since 1990, with heterogeneity among the regions.²²

Formative research

Formative research (FR) was conducted with the four HCW categories included in the study (physicians, nurses, nurse assistants, and physical therapists). The FR applied in-depth interviews to explore workplace changes, use and access to PPE, routine attendance, and possible acceptability of the study.

Participants and Public Involvement

Participants and/or the public were not involved in the design. However, the formative research was valuable to adequate the research questions considering participants' priorities, experience, and preferences. Also the chosen methodology RDS requires direct involvement of the study participants in the recruitment and in indicating other members of the network. Therefore, the participants had an active role in the enrolment of other participants and in the development of the field work. This project was planned in collaboration with the official health care department and professional associations. The coordinators issued periodic reports with preliminary results to the institutions, local newspapers and social media. The final results will be disseminated by institutional platforms.

Participants

We recruited HCW attending suspected or confirmed COVID-19 patients from May 21, 2020 to February 10, 2021. Recruitment started with five "seeds" for each category, non-randomly selected from the target population. We asked each participant to identify five other members of the same professional network category, providing their names and mobile phone numbers to the fieldworkers. The process continued until a suitable sample size was reached. This study did not offer any incentive.

We calculated a sample size of 1,100 HCW, considering a 95% confidence level (CI) to estimate a 40% prevalence of infections with a 5% error and a design effect of three.

The network size of each HCW was measured by the final answer to the following questions: 1) "How many colleagues do you know, who also know you by name, work in the Recife metropolitan region and are assisting COVID-19 patients?", 2) "How many of those colleagues have been in professional contact with you in the last two weeks?," and 3) "How many of them are close to you and you would invite to participate in this study?."

Variables

We applied the WHO questionnaire developed as an operational tool to determine the risk of COVID-19 virus infection among HCW exposed to a COVID-19 patient in a health care facility. This questionnaire was developed as an interim guidance for risk assessment by the WHO personnel/ experts in response to COVID-19 pandemic in the early months (March 2020).²³ The variables were:

1 2 Page 10 of 33

3 4	1	(1) Age, sex, and professional category;
5	2	(2) Self-reported comorbidities (diabetes mellitus, hypertension, overweight or obesity,
6 7	3	cardiopathy, nephropathy, and others);
8 9	4	(3) Healthcare attending—public or private sector, outpatient, emergency rooms and intensive
10	5	care units (ICU); number of healthcare facilities.
12	6	(4) Adherence to infection prevention and control (IPC). We checked for gloves, medical
13 14	7	masks, face shields, goggles or protective glasses, and waterproof aprons. These variables were
15 16	8	grouped as: i) always as recommended (more than 95% of the time); ii) most of the time
17	9	(ranging from 50% to 95%); iii) occasionally (1-49%); iv) never; v) unavailable.
18 19	10	(5) Adherence to IPC when performing aerosol-generating procedures (AGPs) using the
20 21	11	abovementioned grading criteria. In this section, we added the N95 respirator. The variables
22	12	related to adherence to IPC (items 4 and 5) were grouped as always versus not always.
23 24	13	(6) Accidents with biological material—I) during the period of healthcare interaction and II) if
25 26	14	there was an accident with biological fluid or respiratory secretions, which type it was (splash
27 28	15	in the mucous membrane of eyes, mouth, or nose; non-intact skin; and puncture-sharp
29	16	accident).
30 31	17	
32 33	18	Outcome measure
34 35	19	The criterion to assess SARS-CoV-2 infection among HCW was a positive self-reported PCR
36	20	test. Serologic tests were not considered as diagnostic criteria.
37 38	21	
39 40	22	Data collection
41	23	Data were collected using a web-based software platform by FITec (Recife, Pernambuco,
42 43	24	Brazil). The HCW answered the questionnaire by accessing a link that could be opened on a
44 45	25	smartphone or a computer browser.
46 47	26	Providing electronic informed consent was mandatory to participate and access the
48	27	questionnaire. The project was approved by the National Ethics Committee (CONEP; CAAE:
49 50	28	30629220.8.0000.0008).
51 52	29	
53	30	Data analysis
55	31	Participants were weighted by the size of each category, provided by each professional board,
56 57	32	and by the inverse of the size of their professional network, based on the following question:
58 59	33	"How many of these colleagues are close to you and would you invite to participate in this
60	34	study?" To avoid the influence of extreme network sizes on the weight of each professional,

BMJ Open

we limited the network size to 3 to 150 for outlier correction.²⁴ For missing data—representing

around 8% of the total—we used available information from the other two questions related to

network size, and when necessary, we applied the overall mean of the stratum. The seeds (primary) were used to define the cluster of the study. Categorical variables are presented as percentages and 95% CIs by HCW category and overall frequencies adjusted for the design. The chi-squared test was used for comparison between groups. We calculated the means, medians, and 95% CIs for continuous variables. Bivariate analysis was performed to assess the association between potential risk factors and RT-PCR positivity. Variables associated with the outcome at p < 0.20 were included in the multivariate model. In the final model, we considered variables at the p < 0.10 level statistically significant. All statistical analyses were performed using Stata, version 15.0 (StataCorp LLC, College Station, TX, USA). *Role of the funding source* The funding source had no involvement in any stage of the project. **Results** *Participants* We recruited 2,474 health care workers and 1,525 of them were included in the analysis, in the following categories: 527 physicians, 471 registered nurses, 263 nursing assistants, and 264 physical therapists. The exclusions were: 638 HCW who did not sign the informed consent; 238 that refused to participate and 28 did not complete the questionnaires. Figure 1 illustrates the recruitment chain for each category. Descriptive data Overall, women represented 81.1% (95% CI: 77.8% – 84.1%) of the sample after adjustment to the reference population and for the study design (Table 1). Women also predominated in all professional categories, with the lowest percentage among physicians (63.4%; 95% CI: 58.6% – 67.9%) and the highest among nurses (86.7%; 95% CI: 82.7% – 89.9%) and nursing assistants (85.5%; 95% CI: 79.8% – 89.7%). The age distribution was as follows: 32.7% (95% CI: 28.8% – 36.9%) and 35.6% (95% CI: 31.5% – 40.0%) were <30 and 30–39 years old, respectively. Only 0.1% of the participants were aged ≥ 60 years. Physicians and physical therapists were the youngest groups, comprising 56.6% (95% CI: 51.7% - 61.4%) and 45.1%(95% CI: 38.3% - 52.1%), respectively, of those 20-29 years old. Comorbidities affected

30.1% (95% IC: 26.1% – 34.3%) of the studied population. Overweight/obesity (12.6%; 95% CI: 9.9% – 15.9%) and hypertension (11.9%; 95% CI: 9.2% – 15.1%) were the most prevalent comorbidities among nursing assistants and nurses than among the other categories. In total, 71.4% (95% CI: 67.6% – 74.9%) of HCW attended COVID-19 cases exclusively in the public sector, including hospitals, emergency units, ambulance services, and primary care units. Most HCW (73.5%; 95% CI: 69.2% – 77.3%) worked either in emergency rooms or ICU. Notably, 55.8% (95% CI: 51.0% – 60.6%) of the physicians and 37.8% (95% CI: 31.3% – 44.8%) of the physical therapists indicated working in three or more institutions during the pandemic (Table 1).

Overall, 78.0% (95% CI: 74.2% – 81.3%) of the participants received training on the use of PPE. Physical therapists (87.0%; 95% CI: 81.6% – 91.0%) and nursing assistants (81.1%; 95% CI: 74.8% - 86.1%) received a higher and similar frequency of training compared to the other categories. Almost half of the HCW (47.7%) reported a shortage of PPE items during the COVID-19 pandemic. Regarding wearing PPE in routine activities, the overall frequencies varied widely for each item: 90.1% (95% CI: 87.7% - 92.0%) for single-use gloves to 29.9% (95% CI: 25.9% - 34.2%) for face shields. Most HCW (82.2%; 95% CI: 78.4% - 85.5%) reported performing AGPs on COVID-19 patients. Almost all participants reported having always used single-use gloves (98.4%; 95% CI: 96.4% – 99.3%) and N95 respirators (86.4%; 95% CI: 82.5% – 89.5%) during AGPs. The N95/PPF2 respirator was reused for more than seven days by approximately 28.3% (95% CI: 24.7% - 32.1%) of the participants, with highest and lowest frequencies reported by physicians (49.3%; 95% CI: 44.4% - 54.2%) and nursing assistants (20.6%; 95% CI: 15.4% – 27.0%), respectively. Overall, 63.7% (95% CI: 57.8% – 69.2%) of the HCW reported always wearing all PPE items as recommended by the WHO. The self-perception of SARS-CoV-2 risk of infection in the previous 15 days varied: 33.4% for "performing a procedure on a patient with COVID-19;" 17.7% for "sharing the break room" with their colleagues;" 16% for the "reuse of N95 respirators;" 10.6% for the "use of poor quality PPE;" 10.2% during "doffing;" 9.6% for "working with colleagues with COVID-19 symptoms;" 1.9% for "lack of PPE in the service;" and 0.5% for "donning PPE." HCW reported 186 episodes of exposure to biological fluids/respiratory secretions during healthcare interaction with COVID-19 patients. Accidents were more frequent among physicians (13.9%; 95% CI: 11.0% - 17.4%) and less frequent among physical therapists (7.6%; 95% CI: 4.9% -11.7%) (Table 2).

The frequency of COVID-19 testing varied from 41.2% for physical therapists to 51.1% for
 physicians. Individuals with any comorbidity were more likely to get tested (56.8%) than those

BMJ Open

without comorbidities (p < 0.001). HCW who worked in three or more health services were also

more likely to get tested (54.9%) than those who worked in only one health service (42.1%)

(p < 0.001). There was no statistical difference in the likelihood of testing, according to sex, age

group (<30 versus ≥ 30 years old), work setting (outpatients, inpatients, and emergency rooms

and ICU), self-perception of risk (no risk to high risk of exposure), reported accidents with

For the tested HCW, mostly symptomatic, the overall self-reported SARS-CoV-2 infection was

61.8% (95% CI: 55.7%-67.5%) compared with 14.9% (CI: 4.9%-37.5%) among asymptomatic,

after adjustment for random cluster effects, weighted by network and population size. The

highest infection positivity was among nursing assistants (70.0%; 95%CI: 59.0%-79.1%),

followed by physicians (55.0%; 95%CI: 47.5%-62.3%), physical therapists (54.7%; 95%CI:

43.1%-65.7%), and nurses (48.1%; 95%CI: 40.3%-56.0%), adjusted for random cluster effects

(Figure 2). RT-PCR screening was performed mainly among symptomatic cases in all

Almost half of the HCW (47.8%) reported taking sick leave due to COVID-19, with a similar

trend among the other categories (p=0.159). The median length of health leave was 14 days for

all professional categories, reflecting a standard procedure. Of 399 symptomatic SARS-CoV-

In a bivariate analysis, the nursing assistant category was positively associated with infection

(odds ratio [OR]=2.77; 95% CI: 1.64–4.67, p<0.001) compared to nurses. Reporting any

accident involving body fluid/respiratory secretion was associated with infection (OR=2.67;

95% CI: 1.22–5.82, p < 0.014). When considering each accident, splashes in the eyes were a

stronger predictor of infection (OR=4.07; 95% CI: 1.14–14.55, p<0.031). During routine

assistance of COVID-19 patients, not always wearing the complete set of recommended PPE

items was associated with infection (OR=2.14; 95% CI: 1.18–3.88, p=0.013) when compared

to always using PPE. Not always using the complete recommended PPE items during AGPs

was also associated with infection (OR=1.68; 95% CI: 0.97-2.92, p=0.063) when compared

In the final multivariate logistic regression model, the following were risk factors for infection:

being a nursing assistant (OR adjusted=2.56; 95% CI: 1.42–4.61, p=0.002), not always having

used PPE during care of patients with COVID-19 (OR adjusted=2.15; 95% CI: 1.02-4.53,

p=0.044), and having suffered a splash to the eyes (OR adjusted=3.37; 95% CI: 1.10–10.34,

2 infected HCW, 10% (n=41) were hospitalized.

with always using PPE (Supplementary Table 2).

p=0.034) (Table 3).

categories, ranging from 81.8% to 91.8% for physicians and nursing assistants, respectively.

biological fluid/respiratory secretion, and when performing AGPs (Supplementary Table 1).

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

1 Discussion

The current study showed substantial heterogeneity in demographic and self-referred comorbidities between HCW categories during the COVID-19 pandemic. Of note, physicians and physical therapists at the frontline were younger and mainly worked in the Intensive Care Units and emergency rooms when compared with nurses. This reflects the expansion of the healthcare workforce with the inclusion of younger physicians and physical therapists, possibly inexperienced professionals, forcibly driven to work as frontliners in a high-risk environment. Nurses and nursing assistants were older and reported more comorbidities, particularly hypertension and overweight/obesity. According to the accumulated evidence, the public health strategy was to prevent exposure among older age groups and/or individuals with comorbidities, as older age and comorbidities are strong prognostic factors for hospitalization and death.²⁵

To our knowledge, our study depicted one of the highest frequencies of SARS-CoV-2 infections among HCW, being nursing assistant the most vulnerable category. In consonant with this finding, nursing assistant also had the highest prevalence of infection comparing with the other staff in a university hospital in the southeast of Brazil.¹⁶ One likely explanation is that most of the participants tested were symptomatic, reflecting the policy of making RT-PCR tests for COVID-19 diagnosis available to frontline HCW. Thus far, there has been no mass RT-PCR testing strategy for the Brazilian population despite WHO recommendations.²⁶ Worldwide, the prevalence closest to that of our study was 55%, by RT-PCR among 177 symptomatic medical residents in New York City at the beginning of the COVID-19 pandemic.²⁷ In Southeast Brazil, a high prevalence of SARS-CoV-2 infection (42%) tested by RT-PCR was found among symptomatic HCW at a teaching hospital in Sao Paulo, from March to May 2020.¹⁵ Another study found a prevalence of 14% (701 out of 4,987) using RT-PCR in a group composed of mainly symptomatic HCW, at a hospital in the south of Brazil from April to June 2020.¹⁴ This variation might be attributable to the dynamics of the pandemic in different regions of the country, the availability/quality of PPE, and training in different healthcare settings.

Seroprevalence studies cannot be directly compared to our findings, the frequencies of SARS-CoV-2 infection among HCW in São Paulo city ranged from 5.5% (IgG ELISA) in a private hospital to 14% (IgG/IgM antibody, WONDFOTM) in a large public hospital in 2020.^{28,29} Both hospital settings stated that they adopted high-quality hospital infection control and provided complete PPE in the early stages of the COVID-19 pandemic. This may reflect especially high-

Page 15 of 33

BMJ Open

quality healthcare facilities in more developed regions of the country and the rates reported were similar to those reported in another meta-analysis of seroprevalence studies.³⁰

In our setting, critical aspects for the high risk of SARS-CoV-2 infection included shortage of PPE items reported by approximately half the HCW. Moreover, 22% of HCW reported not been trained on PPE use. The lack of preparedness of the health workforce to respond to the COVID-19 pandemic was not only encountered by low- and medium-income countries like Brazil but also in high-income countries at the beginning of the pandemic.³¹ At the individual level, one-fourth of the HCW reported that PPE was not always used according to the WHO recommendations.²⁶ When performing AGPs, the nursing staff had the highest frequency (over 35%) of not fully adhering to complete PPE.³² However, not always used the recommended PPE during performance of AGPs was not associated with PCR positive report in our analysis. This finding is in line with a recent study questioning the concept of aerosol-generating procedures for risk-stratifying patients since most procedures considered as AGPs do not meaningfully increase respiratory aerosols.³³ In the current study, not using the recommended PPE during routine attendance of COVID-19 cases caused a 2.2-fold increased risk of a SARS-CoV-2 positive RT-PCR test result. Accidents with biological fluids occurred in all categories, however, they were most frequently reported among physicians, the youngest, and perhaps the group with the least experience working in critical conditions. Reporting an accident with biological fluids, such as a splash in the eye, was positively associated with infection in the final multivariable model. Although it is uncertain whether viruses occasionally present in biofluids are infectious, these fluids should be considered potentially infectious.³⁴ Moreover, the eye has been considered a possible route of SARS-CoV-2 entry through drainage via the nasolacrimal duct to the upper respiratory tract.³⁵ These accidents with biological fluids should be further investigated in other studies, as recommended by the WHO guidelines.²³ The prevalence among HCW in the current study was at least 20-fold higher when compared to the 3.2% seroprevalence in a population-based survey using SARS-CoV-2 antibody rapid tests conducted during the first wave of the pandemic in the same region.³⁶ Therefore, there is strong evidence that HCW are at a high risk of SARS-CoV-2 infection in low- and medium-income settings, such as Northeast Brazil.

To the best of our knowledge, this is the largest South American study of HCW during the COVID-19 pandemic, with the inclusion of the four main healthcare professionals in the public and private sectors and multiple levels of health services. Previous investigations conducted in Brazil were mainly restricted to one hospital setting and did not apply the WHO questionnaire.23

The advantage of using respondent-driven sampling technique was that it allowed the inclusion of HCW from different healthcare settings, including the private and public health services, providing a more comprehensive picture of frontline HCW during the pandemic. Furthermore, as HCW worked in more than one health service and/or in newly implemented "field hospitals/units," this strategy allowed us to capture the full extent of characteristics of the workforce and the risk factors for infection. Another advantage of applying an online questionnaire was to avoid face-to-face interviews during the lockdown and/or social distancing restrictions, reduce errors in data transcription, and obtain timely results.

This study has some limitations. Respondent-driven sampling study are traditionally designed for "hard-to-reach population" in a lack of a sampling frame.¹⁷ In the study setting, the population of health professionals at frontline although not a hard-to-reach population was made more difficult to access due a lack of sampling frame and the enormous time burden on the staff. Therefore, we did not access this population in a probabilistic sampling, but via the chain referral samples (social network), which potentially induce selection bias. Despite of this limitation, inherent of RDS technique, the study had several waves of recruitment chains, achieving a large and heterogeneous sample. In addition, we estimated the weighted prevalence of SARS-CoV-2 infection considering the social network size to minimize the potential selection bias introduced by the study design. Another limitation is that the study was not designed as genomic surveillance or contact tracing to distinguish the setting of the transmission. However, the participants were frontliners attending suspected or confirmed Covid-19 patients. In fact, only 15.2% of them referred to have had contact with COVID-19 cases simultaneously in health-care facilities and at the household (data not shown). In our analysis the risk factors associated with infection were higher among nursing assistant; HCW not using all PPE items as recommended to professionals reporting an accident during their activities. It is likely that the high frequency of infection among frontline HCW was presumably healthcare associated infections in line with our findings, with the scenario of shortage of PPE and the high health care pressure during the first pandemic wave. Nevertheless, the source of SARS-CoV-2 infection could not be ascertained in this study.

There was an imbalance in recruitment among the HCW categories; physicians and nurses were more rapidly enrolled by RDS than nursing assistants. One possible explanation is that physicians and nurses seem to understand research methodology better and/or to have either better smartphones or data plans required to answer the approximately 15-minute online questionnaire. Physicians and nurses were also a more vocal category early in the pandemic, publicizing the constraints/pressure of the workplace. Conversely, nursing assistants, as routine

BMJ Open

healthcare assistants, spend more time providing direct patient care and have low wages. They could also be less confident/willing to participate due to work overload or unfavourable socio-economic conditions when compared to the other categories that require university degrees. Additionally, disclosure of the work environment concerning PPE and infection control prevention may be problematic for nursing assistants whose jobs are less stable and more prone to replacement in our setting. Accidents involving biological fluids should be further investigated in other studies to validate this finding. The study shows the high frequency of SARS-CoV2 infection among HCW presumably due to workplace exposures. In our setting nursing assistants comprised the most vulnerable category. Our findings highlight the need for improving health care facility environments, specific training and supervision to cope with public health emergencies.

13 Data availability statement

Proposals for the dataset (de-identified participant data, data dictionary) should be directed to
the corresponding author: turchicm@gmail.com. To gain access, data requestors will need to
present their plan of analysis and sign a data access agreement.

Ethics statements

All participants provided electronic informed consent in the web-based platform. HCW could
only access the questionnaire after giving the on-line Informed Consent Form (ICF). In our
study we applied the ICF in agreement with both: the requirements of the National Ethics
Committee (CONEP, 30629220.8.0000.0008); and with the current protocols for electronic
survey.

43 24

25 Acknowledgments

We thank HCW for their participation. We acknowledge the Institute of Health Technology Assessment and MCTIC/CNPq/FNDCT/MS/SCTIE/Decit Nº 07/2020 for support. The following researchers received scholarship (CNPq-Pq): 308974/2018-2 to CMTM, 309722/2017-9 to RAAX, 301905/2017-7 to MFPMA, no. 30735/2018-1 to CB and 303661/2017-8 to WVS. CRP received scholarship from CNPq, EV-1 no. 315877/2020-0. We thank all participants for their important contribution in this project.

- 5833Author contributions
 - For peer review only http://bmjopen.bmj.com/site/about/guidelines.xhtml

MFPMA, WVS, CMTM, RAAX, DBMF, TB, CK, and LRFSK contributed to the study concept and design. CB, MNX, CNLM, GDMA, CBS, CAM, NTSF, JMG, CLFN, and JMVB contributed to the acquisition of data. MFPMA, URM, WVS, CLS, PRBSJ, and CRP contributed to the data analysis and creation of tables and figures. MFPMA, WVS, CMTM, RAAX, DMF, TVBA, MASMV, LNGCL, CB, and LNC contributed to data interpretation. MFPMA, WVS, URM have verified the underlying data. CMTM, MFPMA, WVS, and CRP drafted the initial manuscript and all other coauthors contributed scientific inputs equally towards the interpretation of the findings and the final draft of the manuscript. All authors confirm that they had full access to all the data in the study and accept responsibility to submit for publication. Funding This investigation was funded by Health Technology Assessment Institute (IATS) and by MCTIC/CNPq/FNDCT/MS/SCTIE/Decit N° 07/2020. The funding agency had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the

report; and in the decision to submit the paper for publication.

- **Declaration of interests**
 - We declare no competing interests.

References

- elien Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. N Engl J Med 2020; 382: 1268-9. doi:10.1056/NEJMe2002387.
- Morens DM, Daszak P, Taubenberger JK. Escaping Pandora's box—another novel coronavirus. N Engl J Med 2020; 382: 1293-5. doi:10.1056/NEJMp2002106.
- World Health Organization. https://www.who.int/emergencies/diseases/novel-coronavirus-2019 [Accessed January 28, 2021].
- Zeiser FA, Donida B, Costa CA et al. First and second COVID-19 waves in Brazil: A crosssectional study of patients' characteristics related to hospitalization and in-hospital mortality. The Lancet Regional Health - Americas 2022; 6: 100107. doi:
- 10.1016/j.lana.2021.100107
- The Lancet. COVID-19 in Brazil: "So what?". Lancet 2020; 395: 1461.
- doi:10.1016/S0140-6736(20)31095-3

Page 19 of 33

BMJ Open

1			17
2 3	1	6	Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-
4 5	2		care workers and the general community: a prospective cohort study. Lancet Public
6 7	3		Health 2020; 5: 475-83. doi:10.1101/2020.04.29.20084111.
8 9	4	7	Dzinamarira T, Murewanhema G, Mhango M et al. COVID-19 Prevalence among
10	5		Healthcare Workers. A Systematic Review and Meta-Analysis. Int. J. Environ. Res.
11 12 13 14	6		Public Health 2022; 19: 146. doi: 10.3390/ ijerph19010146.
	7	8	Thompson HA Mousa A, Digheet A al, Severe Acute Respiratory Coronavirus 2
15 16	8		(SARS-CoV-2) Setting Specific Transmission rates : A systematic Review and Meta-
17	9		Analysis. Clin Infect Dis 2021; 743: e754-64. doi: 10.1093/cid/ciab100.
18 19	10	9	Pan American Health Organization/World Health Organization. Epidemiological alert:
20 21	11		COVID-19 among health workers. August 31, 2020
22 23	12		https://www.paho.org/en/documents/epidemiological-alert-covid-19-among-health-
24	13		workers-31-august-2020 [Accessed May 8, 2021].
25 26	14	10	Antonio-Villa NE, Bello-Chavolla OY, Vargas-Vázquez A, et al. Assessing the burden
27 28 29 30 31 32 33 34 35 36	15		of coronavirus disease 2019 (COVID-19) among healthcare workers in Mexico City: a
	16		data-driven call to action. Clin Infect Dis 2021; 73: e191-8. doi:10.1093/cid/ciaa1487.
	17	11	Martin-Delgado J, Viteri E, Mula A, et al. Availability of personal protective
	18		equipment and diagnostic and treatment facilities for healthcare workers involved in
	19		COVID-19 care: a cross-sectional study in Brazil, Colombia, and Ecuador. PLoS
	20		One 2020; 15: e0242185. doi:10.1371/journal.pone.0242185.
38	21	12	Cotrin P, Moura W, Gambardela-Tkacz CM, et al. Healthcare Workers in Brazil during
39 40	22		the COVID-19 Pandemic: A Cross Sectional online survey. <i>Inquiry</i> 2020; 57:
41 42	23		46958020963711. doi: 10.1177/0046958020963711
43 44	24	13	Vedovato TG, Andrade CB, Santos DL, et al Health workers and COVID-19: flailing
44 45	25		working conditions? Revista Brasileira de Saúde Ocupacional 2021, 46: e1. doi:
46 47	26		10.1590/2317-6369000028520.
48 49	27	14	Schmidt Fernandes F, de Castro Cardoso Toniasso S, Castelo Branco Leitune J, et al.
50 51	28		COVID-19 among healthcare workers in a Southern Brazilian hospital and evaluation
52	29		of a diagnostic strategy based on the RT-PCR test and retest for Sars-CoV-2. Eur Rev
53 54	30		<i>Med Pharmacol Sci</i> 2021; 25 : 3365–74. doi:10.26355/eurrev_202104_25748.
55 56	31	15	Buonafine CP, Paiatto BNM, Leal FB, et al. High prevalence of SARS-CoV-2
57 58	32		infection among symptomatic healthcare workers in a large university tertiary hospital
59 60	33		in São Paulo, Brazil. <i>BMC Infect Dis</i> 2020; 20 : 917. doi:10.1186/s12879-020-05662-8.

2			
3 4	1	16	Faíco-Filho KS, Carvalho JMA, Conte DD et al. COVID-19 in health care workers in a
5	2		university hospital during the quarantine in São Paulo city. The Brazilian Journal of
6 7	3		Infectious Diseases 2020; 24: 462-465. doi:10.1016/j.bjid.2020.08.003
8 9	4	17	Heckathorn DD. Respondent-Driven Sampling: A New Approach to the Study of
10 11	5		Hidden Populations. Social Problems 1997; 44: 174-199. doi: 10.2307/3096941
12	6	18	White RG, Hakim AJ, Salganik MJ, et al. Strengthening the reporting of observational
13 14	7		studies in epidemiology for respondent-driven sampling studies: "STROBE-RDS"
15 16	8		statement. J Clin Epidemiol 2015; 68: 1463-71. doi:10.1016/j.jclinepi.2015.04.002.
17	9	19	Souza WV, Martelli CMT, Silva APSC, et al. The first hundred days of COVID-19 in
18 19	10		Pernambuco State, Brazil: epidemiology in historical context. Cad Saude Publica 2020;
20 21	11		36: e00228220. doi:10.1590/0102-311X00228220.
22 23	12	20	Ximenes RAA, Albuquerque MFPM, Martelli CMT, et al. Covid-19 in the Northeast of
24	13		Brazil: from lockdown to the relaxation of social distancing measures. Cien Saude
25 26	14		Colet 2021; 26: 1441–56. doi:10.1590/1413-81232021264.39422020.
27 28	15	21	IBGE. Instituto Brasileiro de Geografia e Estatistica. Censo demográfico Brasileiro.
29	16		2010. https://www.ibge.gov.br/cidades-e-estados/pe/recife.html [Accessed July 10,
30 31 32 33 34 35 36 37 38	17		2021].
	18	22	Castro MC, Massuda A, Almeida G, et al. Brazil's unified health system: the first 30
	19		years and prospects for the future. Lancet 2019; 394 : 345–56. doi:10.1016/S0140-
	20		6736(19)31243-7.
	21	23	World Health Organization. Health workers exposure risk assessment and management
39 40	22		in the context of COVID-19 virus: interim guidance. March 4, 2020.
41 42	23		https://apps.who.int/iris/handle/10665/331340 [accessed April 15, 2020].
43	24	24	Gonçalves B, Perra N, Vespignani A. Modeling users' activity on twitter networks:
44 45	25		validation of Dunbar's number. PLoS One 2011; 6: e22656.
46 47	26		doi:10.1371/journal.pone.0022656.
48	27	25	Knight SR, Ho A, Pius R, et al. Risk stratification of patients admitted to hospital with
49 50	28		covid-19 using the ISARIC WHO clinical characterisation protocol: development and
51 52	29		validation of the 4C mortality score. BMJ 2020; 370 : m3339. doi:10.1136/bmj.m3339.
53 54	30	26	World Health Organization. Responding to community spread of COVID-19: Interim
55	31		guidance 7 March 2020. https://www.who.int/publications/i/item/responding-to-
56 57	32		community-spread-of-covid-19 [accessed February 7, 2022].
58 59			
60			

Page 21 of 33

BMJ Open

1			
2	1	27	Breazzano MP, Shen J, Abdelhakim AH, et al. New York City COVID-19 resident
4 5	2		physician exposure during exponential phase of pandemic. J Clin Invest 2020; 130:
6 7	3		4726–33. doi:10.1172/JCI139587.
8 9	4	28	Costa SF, Giavina-Bianchi P, Buss L, et al. SARS-CoV-2 seroprevalence and risk
10	5		factors among oligo/asymptomatic healthcare workers (HCW): estimating the impact of
12	6		community transmission. Clin Infect Dis 2020.doi:10.1093/cid/ciaa1845.
13 14	7	29	Oliveira MS, Lobo RD, Detta FP, et al. SARS-Cov-2 seroprevalence and risk factors
15 16	8		among health care workers: Estimating the risk of COVID-19 dedicated units. $Am J$
17	9		Infect Control 2021; 49: 1197-9. doi:10.1016/j.ajic.2021.03.010.
19	10	30	Hossain A, Nasrullah SM, Tasnim Z, Hasan MK, Hasan MM. Seroprevalence of
20 21	11		SARS-CoV-2 IgG antibodies among health care workers prior to vaccine
22 23	12		administration in Europe, the USA and East Asia: a systematic review and meta-
24	13		analysis. E Clinical Medicine 2021; 33 : 100770. doi:10.1016/j.eclinm.2021.100770.
25 26	14	31	Paffenholz P, Peine A, Hellmich M, et al. Perception of the 2020 SARS-CoV-2
27 28	15		pandemic among medical professionals in Germany: results from a nationwide online
29 30	16		survey. Emerg Microbes Infect 2020; 9: 1590–9. doi:10.1080/22221751.2020.1785951.
31 22	17	32	Anvisa Nota Técnica Gvims/Ggtes/Anvisa Nº 04/2020. Orientações para Serviços de
32 33	18		Saúde: Medidas de prevenção e controle que devem ser adotadas durante a assistência
34 35 36 37	19		aos casos suspeitos ou confirmados de infecção pelo novo Coronavírus (SARS-CoV-2)
	20		(updated 08/05/2020).
38	21	33	Klompas M, Milton DK, Rhee C, et al. Current Insights Into Respiratory Virus
39 40	22		Transmission and Potential Implications for Infection Control Programs. Annals of
41 42	23		Internal Medicine 2021; 174: 1710-1718. doi:10.7326/M21-2780.
43 44	24	34	Schindler SE, Jicha GA, Nelson PT, et al. Maximizing safety in the conduct of
45	25		Alzheimer's Disease fluid biomarker research in the era of COVID-19. J Alzheimer's
46 47	26		Dis 2020; 76: 27–31. doi:10.3233/JAD-20068.
48 49	27	35	Abobaker A, Alzwi A. The eye: a possible new route of infection in COVID-
50	28		19. Disaster Med Public Health Prep 2020; 14: e25-6. doi:10.1017/dmp.2020.270.
52	29	36	Hallal PC, Hartwig FP, Horta BL, et al. SARS-CoV-2 antibody prevalence in Brazil:
53 54	30		results from two successive nationwide serological household surveys. Lancet Glob
55 56	31		Health 2020; 8: e1390-8. doi:10.1016/S2214-109X(20)30387-9.
57			
58 59			
60			

Table 1. Demographic, clinical, and working baseline characteristics of health care workers in the metropolitan region of Recife, Northeast Brazil, 2020 to 2021

	Physicians $(n = 527)$		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$			Total
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Sex										
Female	63.4	58.6-67.9	86.7	82.7-89.9	85.5	79.8-89.7	70.3	63.6-76.3	81.1	77.8-84.1
Male	36.6	32.1-41.4	13.2	10.1-17.3	14.5	10.2-20.2	29.7	23.7-36.4	18.9	15.9–22.2
Age, years										
< 30	56.6	51.7-61.4	25.8	21.6-30.6	26.9	20.8-33.9	45.1	38.3-52.1	32.7	28.8-36.9
30–39	34.1	29.6-38.9	37.3	32.5-42.4	34.5	28.0-41.6	45.3	38.5-52.4	35.6	31.5-40.0
\geq 40	9.3	6.8-12.6	36.9	32.1-41.9	38.6	32.0-45.7	9.6	6.2-14.4	31.7	27.6-36.0
Any comorbidity										
Any	23.3	19.5–27.6	33.9	29.2–38.8	32.0	25.8-38.9	19.0	14.1-25.1	30.1	26.1-34.3
None	76.7	72.4-80.5	66.1	61.2–70.8	68.0	61-74.2	81.0	74.9-85.9	69.9	65.7-73.8
Diabetes	1.0	0.4-2.6	2.1	1.1-4.1	2.0	0.8-5.1	0.4	0.1-3.1	1.8	0.9-3.4
Hypertension	4.0	2.5-6.4	13.2	10.0–17.1	14.4	10.1-19.9	4.8	2.5-8.9	11.9	9.2-15.1
Overweight/Obesity	7.3	5.3-10.0	11.1	8.2–14.6	14.9	10.6-20.4	8.9	5.6-13.7	12.6	9.9–15.9
Heart disease	0.4	0.1-1.3	1.2	0.5-3.0	0.9	0.2-3.5	0.0		0.1	0.3-2.1
Kidney disease	0.0		0.2	0.03-1.5	0.1	0.02–1.1	0.8	0.2-3.1	0.2	0.1-0.6
Others comorbidities	13.1	10.1-16.7	14.8	11.6–18.8	9.4	5.9–14.7	6.9	4.2-11.4	10.8	8.4-13.8
Number of workplaces										
< 3	44.2	39.4-49.0	91.8	88.4-94.2	95.2	92.0–97.2	62.2	55.2-68.7	84.2	82.1-86.1
\geq 3	55.8	51.0-60.6	8.2	5.8-11.6	4.8	2.8-8.0	37.8	31.3-44.8	15.8	13.9–17.9
Missing	2		0		1		0		3	
Institution provider										
Private	5.2	3.5-7.8	7.2	4.8-10.5	7.0	4.1-11.5	14.8	10.4-20.5	7.2	5.3-9.8
Public	44.5	39.7-49.3	81.2	76.8-85.0	79.8	73.5-85.0	35.2	28.9-42.2	71.4	67.6–74.9
Both	50.3	45.5-55.2	11.6	8.7-15.4	13.2	9.1-18.9	50.0	43-56.9	21.4	18.4–24.7
Work setting										
Outpatient/Inpatient clinics	12.0	9.1-15.6	41.6	36.6-46.8	27.7	21.6-34.7	11.5	7.6-17.0	26.5	22.7-30.8
ICU/Emergency	88.0	84.4–90.9	58.4	53.2-63.4	72.3	65.3-78.4	88.5	83.0-92.4	73.5	69.2-77.3

Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network and population size. CI, confidence interval; ICU, intensive care unit

BMJ Open

	Physicians $(n = 527)$		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$		Total	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% (
Training on PPE use										
Yes	68.9	64.2-73.2	72.3	67.4–76.7	81.1	74.8-86.1	87.0	81.6-91.0	78.0	74.2-81
No	31.1	26.8-35.8	27.7	23.3-32.6	18.9	13.9-25.2	13.0	9.0-18.4	22.0	18.7–25
Missing	3		0		0		0		3	
While providing routine assistance to patients with COVID-19, have you used these PPE:										
Single Gloves										
Always	74.1	69.6-78.1	84.4	80.3-87.8	95.4	90.9–97.7	96.1	92.1-98.1	90.1	87.7–92
Not always	25.9	21.9-30.4	15.6	12.2–19.7	4.6	2.3-9.1	3.9	1.9-7.9	9.9	8.0-12
Missing	2		2		0		1		5	
Surgical mask										
Always	45.3	40.6-50.2	58.6	53.5-63.6	51.0	43.8-58.1	36.9	30.3-44.0	50.5	46.0-54
Not always	54.7	49.8–59.4	41.4	36.4-46.5	49.0	41.9–56.1	63.1	56.0-69.6	49.5	45.1–53
Missing	2		2		0		1		5	
N95 respirator										
Always	64.4	59.6-68.9	57.4	52.3-62.4	66.3	59.1-72.9	87.3	81.6–91.4	65.9	61.4-70
Not always	35.6	31.1-40.3	42.6	37.6-47.7	33.7	27.1–40.9	12.7	8.6-18.4	34.1	30.0-38
Missing	2		2		0		1		5	
Face shield										
Always	19.6	16.0-23.9	28.8	24.4-33.7	31.6	25.3-38.6	42.4	35.7–49.3	29.9	25.9-34
Not always	80.4	76.1-84.0	71.2	66.3-75.6	68.4	61.4–74.7	57.6	50.7-64.3	70.1	65.8–74
Missing	2		2		0		1		5	
Goggles/protective glasses										
Always	18.7	15.3-22.7	24.6	20.4-29.3	38.3	31.6-45.4	45.6	38.7 - 52.6	33.2	29.1-37
Not always	81.3	77.2-84.7	75.4	70.7–79.5	61.7	54.6-68.4	54.4	47.4–61.3	66.8	62.3-70
Missing	2		2		0		1		5	
Disposable gown										

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

2	2
	2

Always	48.0	43.3-52.9	50.8	45.6–55.9	63.8	56.6-70.4	67.2	60.3-73.3	59.2	54.8-63.
Not always	52.0	47.1-56.7	49.2	44.1-54.4	36.2	29.5-43.4	32.8	26.7-39.7	40.8	36.5-45.
Missing	2		2		0		1		5	
Waterproof apron										
Always	30.5	26.2-35.2	38.6	33.7-43.7	48.9	41.6-56.3	62.6	55.3-69.4	44.9	40.5-49.
Not always	69.5	64.8-73.8	61.4	56.3-66.3	51.1	43.7-58.4	37.4	30.6-44.7	55.1	50.5-59.
Missing	14		11		11		18		54	
During provision of routine assistance to COVID-19 patients, did you wear all PPE items as recommended by the WHO?										
Always	89.6	86.2–92.3	79.2	74.7-83.1	70.0	63.1-76.1	69.0	62.2-75.1	74.7	70.5-78.
Not always	10.4	7.7–13.8	20.8	16.9–25.3	30.0	23.9-36.9	31.0	24.9-37.8	25.3	21.5-29.
Missing	2		2		0		1		5	
Participated in AGP*										
Yes	79.6	75.3-83.2	75.6	70.8–79.8	83.4	77-88.3	95.8	91.7–97.8	82.2	78.4-85.
No	20.4	16.8-24.7	24.4	20.2–29.2	16.6	11.7 - 23	4.2	2.1-8.3	17.8	14.5-21.
Missing	1		1		1		2		5	
While participating in AGPs, have you used:										
Single Gloves										
Always	97.8	95.5–98.9	97.7	95.1–99	98.5	94.2–99.6	99.7	98.1–99.9	98.4	96.4–99.
Not always	2.2	1.1-4.5	2.3	1-4.9	1.5	0.4–5.8	0.3	0.04-1.9	1.6	0.7–3.
Missing	0		0		0		1		1	
Surgical mask										
Always	61.5	56.2-66.6	49.9	44.1-55.7	46.5	38.9-54.3	60.2	52.9-67.1	50.5	45.6–55.
Not always	38.5	33.4-43.8	50.1	44.3-55.9	53.5	45.7-61.1	39.8	32.9-47.1	49.5	44.7-54.
Missing	0		0		0		1		1	
N95 respirator										
Always	92.4	89–94.9	85.0	80.3-88.8	84.2	77.8-89.1	93.3	88.2–96.3	86.4	82.5-89.
Not always	7.6	3.1-11	15.0	11.2–19.7	15.7	10.9-22.2	6.7	3.7-11.8	13.6	10.5-17.
Missing Face shield	0		0		0		1		1	

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Page 2	25 of	33
--------	-------	----

 BMJ Open

										2
Always	51.6	46 2-56 9	48 3	42 6-54 1	48.0	40 3-55 7	41 4	34 5-48 6	48 1	43 2-53 (
Not always	48.4	43 1-53 8	51.7	45 8-57 4	52.0	44 2-59 7	58.6	51.4-65.5	51.9	47 0-56 8
Missing	0		0		0		1	0111 0010	1	.,
Goggles/Protective glasses	-		Ţ		÷		_		-	
Always	62.5	57.1-67.6	59.3	53.5-64.9	51.4	43.6-59.1	47.1	40-54.3	54.0	49.1-58.9
Not always	37.5	32.4-42.8	40.7	35.1-46.5	48.6	40.9-56.4	52.9	45.7 - 60	46.0	41.1-50.
Missing	0		0		0		1		1	
Disposable gown										
Always	60.3	55.0-65.4	60.1	54.3 - 65.7	64.0	60.3-74.9	68.3	61.3-74.4	65.6	60.8-70.
Not always	39.7	34.6-45.0	39.9	34.3-45.7	32.0	25.1-39.7	31.7	25.6-38.7	34.4	29.9–39.2
Missing	0		0		0		1		1	
Waterproof apron										
Always	55.2	49.7–60.6	60.7	54.8-66.3	62.5	54.4-69.9	74.6	67.4-80.7	61.9	57.0–66.2
Not always	44.8	39.4-50.3	39.3	33.7-45.2	37.5	30.1-45.6	25.4	19.3-32.6	38.1	33.3-43.0
Missing	9		7		9		17		42	
When performing an AGP in COVID-19 patients, did you wear all recommended PPE items as in WHO guidance?										
Always	66.0	60.0-71.4	58.0	51.4-64.3	63.8	54.1-72.6	74.7	64.2-82.8	63.7	57.8–69.2
Not always	34.0	28.6-40.0	42.0	35.7-48.6	36.2	27.4–45.9	25.3	17.2-35.8	36.3	30.8-42.2
Missing	0		0		0		1		1	
Duration of N95 respirator use										
< 8 days	50.7	45.8-55.6	71.4	66.6-75.8	79.4	73.0-84.6	54.6	47.6-61.5	71.7	67.9–75.3
\geq 8 days	49.3	44.4-54.2	28.6	24.2-33.4	20.6	15.4-27.0	45.4	38.5-52.4	28.3	24.7-32.
Missing	9		5		8		4		26	
Any accident involving body fluid/respiratory secretion										
Yes	13.9	11-17.4	10.8	7.9–14.5	11.7	7.9–17.1	7.6	4.9–11.7	11.6	9.1–14.
No	86.1	82.6-89	89.2	85.5-92.1	88.3	82.9-92.1	92.4	88.3-95.1	88.4	85.2-90.9
Organ involved										
Splash in the Mouth	1.9	1.02-3.8	1.9	0.85-4.3	0.2	0.04-1.5	0.7	0.2-3.1	0.8	0.5-1.4
Splash on the Skin	2.4	1.4–3.9	3.4	1.9-6.0	1.3	0.5-3.2	3.9	1.9–7.7	2.0	1.3-3.0
Splash on the Eyes	2.3	1.4-3.9	3.5	1.9-6.1	2.1	0.8-5.8	2.5	1.2-5.0	2.4	1.4-4.2

2	Λ
_	+

Puncture/sharps	8.2	5.9–11.3	3.0	1.7–5.3	8.2	4.9–13.4	0.0	-	6.7	4.6-9.7
Self-perception of risk										
None/Low	21.6	17.9-25.9	24.9	20.7-29.6	21.9	16.3-28.7	17.2	12.5-23.3	22.0	18.5-26.1
Medium/High	78.4	74.1-82.1	75.1	70.3-79.3	78.1	71.3-83.7	82.8	76.7-87.5	78.0	73.8-81.5
Missing	9		2		6		4		21	

 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network and population size.

AGPs, aerosol-generating procedures; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment; WHO, World Health Organization

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Table 3. Final multivariate model for factors associated with reported positive PCR COVID-19 results

	Odds Ratio	95% CI	P-value
Occupation			
Nurse	1.0		
Physical therapist	1.47	0.80-2.72	0.214
Physician	1.20	0.76-1.90	0.426
Nursing assistant	2.56	1.42-4.61	0.002
Splash on the eyes			
No accident	1.0		
Yes	3.37	1.10-10.34	0.034
Any accident	1.59	0.51-4.90	0.421
Used all PPE items while assisting patients with COVID-19			
Yes	1.0		
No	2.15	1.02-4.53	0.044

Adjusted for cluster random effect and weighted by network and population size COVID-19, coronavirus disease 2019; CI, confidence interval; PPE, personal protective equipment

Pertexiew only

Figure Legends

Figure 1. Respondent-driven sampling recruitment chains.

Figure 2. Frequencies of self-reported SARS-CoV-2 infection by healthcare categories.

tor oper terien only



Figure 1. Respondent-driven sampling recruitment chains

338x190mm (170 x 170 DPI)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml



Occupation

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open

– Lower Limit – Upper Limit Prevalence(%)

		RT-PCR	testing	P-v
		Yes (%)	No (%)	
Occupation category				0
	Physician	269 (51.1)	257 (48.9)	
	Registered nurse	224(47.6)	247(52.4)	
	Nursing assistant	110(42.0)	152 (58.0)	
	Physical therapist	108(41.2)	154(58.8)	
Sex	J		- (/	
	Female	530(46.2)	618 (53.8)	
	Male	181(48.5)	192(51.5)	
Age group vears	Wate	101 (40 5)	1)2 (51 5)	
Age group, years	< 30	523 (45.7)	622 (54.3)	
	≤ 30	123(43.7)	122(54.3)	
A a a	≥ 30	188 (30.0)	188 (30.0)	,
Any comorbialty	V	$\mathbf{O}\mathbf{A}\mathbf{C}$ (5.6.9)	107 (42.0)	<
	Yes	246 (56.8)	187 (43.2)	
	No	465 (42.7)	623 (57.3)	
Number of workplaces (hospitals/clinics)	-		91 0 (1 = 5)	<
	<3	247 (54.0)	210 (46.0)	
	≥ 3	462 (43.5)	599 (56.5)	
Work setting				
	Emerg/ICU	565 (47.3)	629 (52.7)	
	Outpat/Inpatients	146 (44.7)	181 (55.3)	
Institution provider				<
	Private	48 (42.1)	66 (57.9)	
	< Public	393 (43.0)	522 (57.0)	
	Both	270 (54.9)	222 (45.1)	
Performed aerossol			· · · ·	
generating procedure				
Server and Le connert	Yes	600(47.3)	669 (52.7)	
	No	110(44.5)	137(55.5)	
	Missing	1(20.0)	4 (80.0)	
Same N95 respirator use duration days	witsbillg	1 (20 0)	1 (00 0)	
sume ive respirator, use unration, days	< 7	458 (49.00	476 (51.0)	
		243 (43.0)	322 (57.0)	
Self-nerceived rick		273 (43.0)	522 (57.0)	
Sen-perceiveu lisk	None/Low	36 (45.1)	13 (54.0)	
	Modium/Lich	50(43.1)	45 (54·9) 760 (52-2)	
A said out involving hisls size	Medium/High	003 (40.7)	/00 (55.3)	
Accuent involving biological				
iluid/respiratory secretion	V	04 (45 0)	102 (54.0)	
	Yes	84 (45.2)	102 (54.8)	
	No	627 (47.0)	708 (53.0)	
Sick leave due to				<
COVID-19 symptoms				
	Yes	576 (79.7)	147 (20.3)	
	No	130 (16.5)	659 (83.5)	
Had COVID 10 like armitemalaiana				<
nau COVID-19-like symptoms/sighs				
Had COVID-19-like symptoms/signs	Yes	601 (68.2)	280 (31.8)	

Supplementary Table 1. Characteristics of the study population according to RT-PCR testing

Supplementary Table 2. Potential risk factors for reporting a positive PCR COVID-19 result among front line healthcare professionals

Sex Female 1.0 Male 1.35 0.78-2.34 0.28 Age, yars 1.03 0.65-1.64 0.88 Occupation Nurse 1.0 Physical therapist 1.42 0.88-2.27 0.14 Physician 1.32 0.91-1.91 0.14 Nursing Assistant 2.77 1.64-4.67 <0.00 Any comorbidity 1.19 0.75-1.90 0.45 Number of workplaces < 3 1.0 ≥ 3 0.83 0.53-1.30 0.42 Institution provider Private 1.0 Public 0.92 0.42-2.02 0.84 Both 0.93 0.41-2.10 0.88 Work setting Outpatient /Inpatient clinics 1.0 CU/Emergency 1.54 0.92-2.60 0.10 Training on PPE use 1.06 0.62-1.80 0.82 Any accident involving body 2.67 1.22-5.82 0.00 fuidrespiratory scretion Splash in the mouth No accident 1.0 Yes 3.84 0.64-22.95 0.14 Other accident 1.0 Yes 1.86 0.54-6.44 0.32 Other accident 1.0 Yes 1.86 0.54-6.44 0.32 Other accident 1.0 Yes 1.86 0.54-6.44 0.32 Other accident 1.0 Yes 2.50 0.80-7.85 0.11 Splash in the eyes No accident 1.0 Yes 2.25 0.51-9.89 0.25 Other accident 1.0 Yes 2.25 0.51-9.80 0.25 Other accident 1.0 Yes 2.25 0.51-9.80 0.25 Other accident 1.0 Y		Odds Ratio	95% CI	<i>P</i> -value
Female 1.0 Male 1.35 $0.78-2.34$ 0.24 Age, years 1.03 $0.65-1.64$ 0.83 Occupation Physical therapist 1.42 $0.88-2.27$ 0.14 Physician 1.32 $0.91-1.91$ 0.14 Nurse 1.0 $0.75-1.90$ 0.45 Number of workplaces <3 0.83 $0.53-1.30$ 0.42 Number of workplaces <3 0.83 $0.53-1.30$ 0.42 Institution provider <3 0.83 $0.53-1.30$ 0.42 Institution provider <2 0.42 0.84 Both 0.92 $0.42-2.02$ 0.84 0.64 0.80 Work setting 0 $CU/Emergency$ 1.54 $0.92-2.60$ 0.10 Training on PPE us 1.00 $$ C C C C Apy accident involving body 2.67 $1.22-5.82$ 0.010 </th <th>Sex</th> <th></th> <th></th> <th></th>	Sex			
Male 1.35 $0.78-2.34$ 0.28 Age, years 1.03 $0.65-1.64$ 0.86 Occupation Physical therapist 1.42 $0.88-2.27$ 0.14 Physical therapist 1.42 $0.88-2.27$ 0.14 Nursing Assistant 2.77 $1.64-4.67$ <0.00 Any comobidity 1.19 $0.75-1.90$ 0.43 Number of workplaces < 3 0.83 $0.53-1.30$ 0.42 Institution provider > 2 $0.42-2.02$ 0.84 Both 0.92 $0.42-2.02$ 0.84 0.64 0.36 Work setting 0.02 $0.42-2.02$ 0.84 0.86 Work setting 0.92 $0.42-2.02$ 0.86 Outpatient /Inpatient clinics 1.0 1.0 1.7 $1.4-4.67$ 0.05 Training on PFE use 1.06 $0.62-1.80$ 0.85 0.16 $0.62-1.80$ 0.85 Splash in the mouth No accident 1.0 $$	Female	1.0		
Age, years 1.03 0.65-1.64 0.88 Occupation Physical therapist 1.42 0.88-2.27 0.14 Physician 1.32 0.91-1.91 0.14 Nursing Assistant 2.77 1.64-4.67 <0.00	Male	1.35	0.78-2.34	0.288
Occupation Nurse 1.0 Physical therapist 1.42 $0.88-2.27$ 0.14 Physician 1.32 $0.91-1.91$ 0.17 Nursing Assistant 2.77 $1.64-4.67$ <0.00 Any comorbidity 1.19 $0.75-1.90$ 0.42 Number of workplaces ≥ 3 0.83 $0.53-1.30$ 0.42 Institution provider ≥ 3 0.83 $0.53-1.30$ 0.42 Institution provider ~ 2 $0.42-2.02$ 0.84 Both 0.92 $0.42-2.02$ 0.84 0.64 0.33 $0.14-2.10$ 0.86 Work setting $CUVEmergency$ 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.82 Any accident 1.0 Yes 0.16 Splash in the mouth Yes 0.142 No accident<	Age, years	1.03	0.65-1.64	0.889
Nurse 1.0 Physicial therapist 1.42 $0.89-2.27$ 0.14 Physicial therapist 1.32 $0.91-1.91$ 0.14 Nursing Assistant 2.77 $1.64-4.67$ <0.00 Any comorbidity 1.19 $0.75-1.90$ 0.43 Number of workplaces $≥ 3$ 0.83 $0.53-1.30$ 0.44 Institution provider $≥ 3$ 0.83 $0.53-1.30$ 0.44 Both 0.92 $0.42-2.02$ 0.84 0.94 0.94 0.94 0.94 Mork setting 0.01 0.92 $0.42-2.02$ 0.84 Both 0.93 $0.41-2.10$ 0.86 0.97 0.16 $0.62-1.80$ 0.86 Work setting 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100	Occupation			
Physical therapist 1.42 $0.88-2.27$ 0.14 Physician 1.32 $0.91-1.91$ 0.17 Nursing Assistant 2.77 $1.64-4.67$ <0.00 Any comorbidity 1.19 $0.75-1.90$ 0.42 Number of workplaces $<$ $<$ $<$ $<$ < 3 0.83 $0.53-1.30$ 0.42 Institution provider $<$ $<$ $<$ Private 1.0 $$ $<$ Public 0.92 $0.42-2.02$ 0.88 Both 0.93 $0.41-2.10$ 0.86 Work setting 0 $$ $<$ Outpatient /Inpatient clinics 1.0 $$ $<$ ICU/Emergency 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.82 Any accident involving body 2.67 $1.22-5.82$ 0.01 No accident 1.0 $$ $$ $$ Yes 3.84 $0.64-22.95$ 0.14 Other accident<	Nurse	1.0		
Physician 1.32 0.91-1.91 0.14 Nursing Assistant 2.77 1.64-4.67 <0.00	Physical therapist	1.42	0.88 - 2.27	0.148
Nursing Assistant 2.77 1.64-4.67 <0.00	Physician	1.32	0.91-1.91	0.142
Any comorbidity 1.19 $0.75-1.90$ 0.43 Number of workplaces 3 1.0 ≥ 3 0.83 $0.53-1.30$ 0.42 Institution provider $Private$ 1.0 Public 0.92 $0.42-2.02$ 0.88 Both 0.92 $0.42-2.02$ 0.88 Work setting Outpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.88 Any accident involving body 2.67 $1.22-5.82$ 0.01 Training on PPE use 1.06 $0.62-1.80$ 0.88 Any accident involving body 2.67 $1.22-5.82$ 0.01 No accident 1.0 Yes 0.16 Splash in the mouth Yes 0.16 Splash on the skin 1.0 Yes 0.16 No accident 1.0 Yes 0.05 No accident	Nursing Assistant	2.77	1.64-4.67	< 0.001
Number of workplaces < 3	Any comorbidity	1.19	0.75 - 1.90	0.454
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Number of workplaces			
≥ 3 0.83 0.53-1.30 0.44 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.93 0.41-2.10 0.86 0.94 0.93 0.41-2.10 0.86 0.94 0.93 0.41-2.10 0.86 0.92 0.42-2.02 0.84 0.93 0.41-2.10 0.86 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.84 0.92 0.42-2.02 0.14 0.85 0.85 0.85 0.85 0.85 0.85 0.14 0.85 0.85 0.14 0.85 0.85 0.10 0 0.94 accident 1.0 0.10 0.10 0.10 0.10 0.10 0.10	< 3	1.0		. .
Institution provider Private 1.0 Public 0.92 $0.42-2.02$ 0.88 Both 0.93 $0.41-2.10$ 0.86 Work setting Outpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.83 Any accident involving body 2.67 $1.22-5.82$ 0.01 fluid/respiratory secretion Splash in the mouth No accident 1.0 Yes 3.84 $0.64-22.95$ 0.14 Other accident 2.30 $0.85-6.23$ 0.10 Splash on the skin No accident 1.0 Yes 1.86 $0.54-6.44$ 0.32 Other accident 2.50 $0.80-7.85$ 0.11 Splash in the eyes No accident 1.0 Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use < 8 days $\geq 8 days$ 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# Did not Always use 1.68 $0.97-2.92$ 0.00	≥3	0.83	0.53-1.30	0.428
Private 1.0 Public 0.92 0.42–2.02 0.84 Both 0.93 0.41–2.10 0.86 Work setting 0 0.10 Outpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 0.92–2.60 0.10 Training on PPE use 1.06 0.62–1.80 0.88 Any accident involving body 2.67 1.22–5.82 0.01 fluid/respiratory secretion Splash in the mouth No accident 1.0 Yes 0.84 0.64–22.95 0.14 Other accident 2.30 0.85–6.23 0.10 Yes 0.16 Splash on the skin Splash on the skin 1.0 Splash in the eyes 0.80 No accident 1.0	Institution provider			
Public 0.92 0.42–2.02 0.84 Both 0.93 0.41–2.10 0.86 Work setting 1.0 102 0.10 Outpatient /Inpatient clinics 1.0 0.10 0.10 Training on PPE use 1.06 0.62–1.80 0.82 Any accident involving body 2.67 1.22–5.82 0.01 fluid/respiratory secretion Splash in the mouth No accident 1.0 Yes 3.84 0.64–22.95 0.14 0.10 Yes 3.84 0.64–22.95 0.14 0.10 0.10 Splash in the mouth 1.0 <td>Private</td> <td>1.0</td> <td></td> <td></td>	Private	1.0		
Both 0.93 $0.41-2.10$ 0.86 Work setting Outpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.86 Any accident involving body 2.67 $1.22-5.82$ 0.01 fluid/respiratory secretion Yes $0.64-22.95$ 0.14 No accident 1.0 Yes $0.44-22.95$ 0.14 Other accident 2.30 $0.85-6.23$ 0.16 0.16 Splash in the mouth Yes 0.86 $0.54-6.44$ 0.32 Splash on the skin	Public	0.92	0.42-2.02	0.844
Work setting 0.utpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 0.92–2.60 0.10 Training on PPE use 1.06 0.62–1.80 0.82 Any accident involving body 2.67 1.22–5.82 0.01 fluid/respiratory secretion 5 0.01 0.82 Splash in the mouth 1.0 7 No accident 1.0 0.42 0.45 0.14 Other accident 2.30 0.85–6.23 0.14 0.15 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.	Both	0.93	0.41-2.10	0.863
Outpatient /Inpatient clinics 1.0 ICU/Emergency 1.54 0.92–2.60 0.16 Training on PPE use 1.06 0.62–1.80 0.82 Any accident involving body 2.67 1.22–5.82 0.01 fluid/respiratory secretion Splash in the mouth Yes 0.46–22.95 0.14 No accident 1.0 Yes 0.85–6.23 0.10 Splash on the skin No Yes 1.86 0.54–6.44 0.32 Other accident 1.0 Yes 0.10 Yes 1.86 0.54–6.44 0.32 0.11 Splash in the eyes 0.11 No accident 1.0 Yes 0.11 Splash in the eyes 1.0 Yes 0.13 No accident 1.0 Yes 0.26 Other accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 1.0 Yes 0.25 Other	Work setting			
ICU/Emergency 1.54 $0.92-2.60$ 0.10 Training on PPE use 1.06 $0.62-1.80$ 0.82 Any accident involving body 2.67 $1.22-5.82$ 0.01 fluid/respiratory secretion 1.0 0.82 Splash in the mouth 1.0 $0.64-22.95$ 0.14 No accident 2.30 $0.85-6.23$ 0.10 Splash on the skin Yes $0.85-6.23$ 0.10 Splash on the skin Yes $0.80-7.85$ 0.11 Splash in the eyes 1.86 $0.54-6.44$ 0.32 0.62 0.16 Splash in the eyes 1.86 $0.54-6.44$ 0.32 0.11 Splash in the eyes 1.0 Yes 0.11 Splash in the eyes 0.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 Yes 0.28 Other accident 1.0 Yes 0.28 0.028 Other accident 1.0	Outpatient /Inpatient clinics	1.0		
Training on PPE use 1.06 $0.62-1.80$ 0.82 Any accident involving body 2.67 $1.22-5.82$ 0.01 fluid/respiratory secretion 1.0 $0.12-5.82$ 0.01 Splash in the mouth 1.0 $0.12-5.82$ 0.01 No accident 1.0 0.14 0.16 0.14 Other accident 2.30 $0.85-6.23$ 0.10 0.14 Splash on the skin 1.0 $0.85-6.23$ 0.10 Yes 1.86 $0.54-6.44$ 0.32 0.11 Splash in the skin 1.0 0.11 0.11 Splash in the eyes 1.0 0.12 0.02 No accident 1.0 0.12 0.11 Splash in the eyes 0.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 0.28 0.028 Other accident 1.0 0.28 0.026 0.029 Duration N95 respirator use < 8 days <t< td=""><td>ICU/Emergency</td><td>1.54</td><td>0.92-2.60</td><td>0.102</td></t<>	ICU/Emergency	1.54	0.92-2.60	0.102
Any accident involving body 2.67 $1.22-5.82$ 0.01 fluid/respiratory secretion 1.0 3.84 $0.64-22.95$ 0.14 No accident 2.30 $0.85-6.23$ 0.10 Other accident 2.30 $0.85-6.23$ 0.10 Splash on the skin 1.0 $0.85-6.23$ 0.10 No accident 1.0 $0.85-6.23$ 0.10 Splash on the skin 0.0 $0.85-6.23$ 0.10 No accident 1.0 $0.85-6.23$ 0.11 Splash on the skin $0.85-6.23$ 0.11 0.32 0.11 Splash in the skin 1.0 $0.80-7.85$ 0.11 Splash in the eyes $0.80-7.85$ 0.11 0.16 Splash in the eyes 0.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 0.28 Puncture/sharp accident 1.0 0.16 0.26 Other accident 2.51 $1.10-5.72$ 0.026 Other accident	Training on PPE use	1.06	0.62-1.80	0.829
Splash in the mouth 1.0 Yes 3.84 $0.64-22.95$ 0.14 Other accident 2.30 $0.85-6.23$ 0.16 Splash on the skin 1.0 Yes $0.85-6.23$ 0.16 Splash on the skin 1.0 Yes $0.85-6.23$ 0.16 No accident 1.0 Yes $0.85-6.23$ 0.16 Other accident 1.0 Yes 0.32 0.32 Other accident 2.50 $0.80-7.85$ 0.11 Splash in the eyes No accident 1.0 0.32 No accident 1.0 0.92 0.06 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 Yes 0.28 Other accident 1.0 Yes 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 days$ $$ $$ $\geq 8 days$ 0.96	Any accident involving body fluid/respiratory secretion	2.67	1.22–5.82	0.014
No accident 1.0 Yes 3.84 $0.64-22.95$ 0.14 Other accident 2.30 $0.85-6.23$ 0.10 Splash on the skin No accident 1.0 Yes 1.86 $0.54-6.44$ 0.32 Other accident 2.50 $0.80-7.85$ 0.11 Splash in the eyes No accident 1.0 Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 days$ 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# Did not Always use <td>Splash in the mouth</td> <td></td> <td></td> <td></td>	Splash in the mouth			
Yes 3.84 $0.64-22.95$ 0.14 Other accident 2.30 $0.85-6.23$ 0.10 Splash on the skin 1.0 $$ $$ No accident 1.0 $$ $$ Yes 1.86 $0.54-6.44$ 0.32 Other accident 2.50 $0.80-7.85$ 0.11 Splash in the eyes $$ $$ $$ No accident 1.0 $$ $$ Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 $$ $$ No accident 1.0 $$ $$ Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.025 Duration N95 respirator use $$ $$ $$ $< 8 days$ 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# $$ $$ $$ $$ Did not Always use 1.68	No accident	1.0		
Other accident 2.30 $0.85-6.23$ 0.10 Splash on the skin 1.0 No accident 1.0 Yes 1.86 $0.54-6.44$ 0.32 Other accident 2.50 $0.80-7.85$ 0.116 Splash in the eyes Yes $0.407-8.5$ 0.116 Splash in the eyes Yes $0.607-8.5$ 0.116 Splash in the eyes Yes $0.067-8.5$ 0.116 Splash in the eyes <td< td=""><td>Yes</td><td>3.84</td><td>0.64–22.95</td><td>0.140</td></td<>	Yes	3.84	0.64–22.95	0.140
Splash on the skin 1.0 Yes 1.86 0.54-6.44 0.32 Other accident 2.50 0.80-7.85 0.11 Splash in the eyes 0.00 0.00 0.00 Splash in the eyes 1.0 Yes 0.03 No accident 1.0 Yes 0.03 Other accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 1.0 Yes 0.25 Other accident 1.0 Yes 0.25 Other accident 2.51 1.10-5.72 0.02 Duration N95 respirator use $< 8 $ days 0.96 0.59-1.55 0.86 Used All PPE items during AGP# Did not Always use 1.68 0.97-2.92 0.06	Other accident	2.30	0.85-6.23	0.102
No accident 1.0 Yes 1.86 0.54-6.44 0.32 Other accident 2.50 0.80-7.85 0.11 Splash in the eyes 0.00 0.00 0.00 No accident 1.0 1.0 0.00 Yes 4.07 1.14-14.55 0.03 Other accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 1.0 1.8 No accident 1.0 1.8 No accident 1.0 1.8 No accident 1.0 1.8 No accident 1.0 Yes 2.25 0.51-9.89 0.28 Other accident 2.51 1.10-5.72 0.02 Duration N95 respirator use < 8 days	Splash on the skin			
Yes1.860.54-6.440.32Other accident2.50 $0.80-7.85$ 0.11 Splash in the eyes 1.0 No accident 1.0 Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use < 8 days < 8 days ≥ 8 days 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	No accident	1.0		
Other accident 2.50 $0.80-7.85$ 0.11 Splash in the eyes 1.0 No accident 1.0 Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 2.07 $0.71-6.08$ 0.18 No accident 1.0 1.8 No accident 1.0 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use < 8 days $$ $$ ≥ 8 days 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	Yes	1.86	0.54-6.44	0.328
Splash in the eyes 1.0 Yes 4.07 1.14–14.55 0.03 Other accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 1.0 1.0 No accident 1.0 1.0 Yes 2.25 0.51–9.89 0.28 Other accident 2.51 1.10–5.72 0.02 Duration N95 respirator use < 8 days	Other accident	2.50	0.80-7.85	0.116
No accident 1.0 Yes 4.07 1.14–14.55 0.03 Other accident 2.07 0.71-6.08 0.18 Puncture/sharp accident 1.0 10 No accident 1.0 10 10 Yes 2.25 0.51–9.89 0.28 Other accident 2.51 1.10–5.72 0.02 Duration N95 respirator use < 8 days	Splash in the eyes			
Yes 4.07 $1.14-14.55$ 0.03 Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 $ days ≥ 8 days 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	No accident	1.0		
Other accident 2.07 $0.71-6.08$ 0.18 Puncture/sharp accident 1.0 No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use < 8 days $$ $$ ≥ 8 days 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	Yes	4.07	1.14-14.55	0.031
Puncture/sharp accident1.0No accident1.0Yes2.25 $0.51-9.89$ 0.28 Other accident2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 $ days $\geq 8 $ days0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP#1.68 $0.97-2.92$ 0.06	Other accident	2.07	0.71-6.08	0.184
No accident 1.0 Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 \text{ days}$ $$ $$ $< 8 \text{ days}$ 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	Puncture/sharp accident			
Yes 2.25 $0.51-9.89$ 0.28 Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 \text{ days}$ $\geq 8 \text{ days}$ 0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP# 1.68 $0.97-2.92$ 0.06	No accident	1.0		
Other accident 2.51 $1.10-5.72$ 0.02 Duration N95 respirator use $< 8 $ days ≥ 8 days0.96 $0.59-1.55$ 0.86 Used All PPE items during AGP#Did not Always use 1.68 $0.97-2.92$ 0.06	Yes	2.25	0.51–9.89	0.282
Duration N95 respirator use $< 8 \text{ days}$ $\geq 8 \text{ days}$ 0.960.59–1.550.86Used All PPE items during AGP#1.680.97–2.920.06	Other accident	2.51	1.10-5.72	0.028
$< 8 \text{ days}$ $\geq 8 \text{ days}$ 0.960.59–1.550.86Used All PPE items during AGP#1.680.97–2.920.06	Duration N95 respirator use			
≥ 8 days 0.96 0.59–1.55 0.86 Used All PPE items during AGP# Did not Always use 1.68 0.97–2.92 0.06	< 8 days			
Used All PPE items during AGP# Did not Always use 1.68 0.97–2.92 0.06	> 8 days	0.96	0.59–1.55	0.869
Did not Always use 1.68 0.97–2.92 0.06	Used All PPE items during AGP#			
-	Did not Always use	1.68	0.97-2.92	0.063

-		
	,	
-	۰.	
-	,	

Used all PPE items while assisting			
COVID-19 patients			
Yes	1.0		
No	2.14	1.18-3.88	0.013
Time on the front-line, days	0.997	0.994-1.000	0.042

Adjusted for cluster random effect and weighted by network and population size.

AGP, aerosol-generating procedure; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment

tor peer terier only

Tabela 1. STROBE-RDS Statement Checklist for the manuscript title "High risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach"

Item	#	STROBE-RDS checklist	Main Document		
Title and abstract	1	(a) Indicate "respondent-driven sampling" in the title or abstract	Page:1/ Line: 1-2		
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page:3/ Line:2-23		
Introduction					
Background/	2	Explain the scientific background and rationale for the	Page:5/ Line: 2-34;		
rationale		investigation being reported	Page:6/ Line: 1-6		
Objectives	3	State specific objectives, including any prespecified hypotheses	Page:6/ Line: 7-9		
Methods					
Study design	4	(a) Present key elements of study design early in the article	Page:6/ Line: 13-18		
~ .		(b) State why RDS was chosen as the sampling method	Page:6/ Line: 15-17		
Setting	5	(a) Describe the setting, locations, and relevant dates, including	Page:6/ Line: 23-28		
		(b) Describe formation measure for diagonal to inform DDS	Page: // Line: 13-14		
		(b) Describe formative research findings used to inform RDS	Page:6/ Line: 31-34		
Participants	6	(a) Give the eligibility criteria and the sources and methods of	Dage: 7/ Line: 12.18		
Farticipants	0	(a) Give the englority citteria and the sources and methods of selection of participants. Describe how participants were	rage. // Line. 13-18		
		trained/instructed to recruit others, number of coupons issued per			
		person, any time limits for referral			
		(b) Describe methods of seed selection and state number at start	Page: 7/ Line: 19-25		
		of study and number added later			
		(c) State if there was any variation in study procedures during	Page:7/ Line: 17		
		data collection (e.g., changing numbers of coupons per recruiter,			
		interruptions in sampling, or (stopping recruitment chains)			
		(d) Report wording of personal network size question(s)	Page:7/ Line: 21-25		
	ļ	(e) Describe incentives for participation and recruitment	Page:7/ Line: 17-18		
Variables	7	(a) If applicable, clearly define all outcomes, correlates,	Page:7/ Line: 28-32		
		predictors, potential confounders, effect modifiers, and diagnostic	Page:8/ Line: 1-20		
		criteria (b) State mean item and malation along the load	$D_{2} = 0/L = 22.22$		
Data sources/	•	(b) State recruitment relationship was tracked	Page:9/ Line: 22-23		
Data sources/	0	(a) For each variable of interest, give sources of data and details	Page: 0/ Line: 51-54 Page: 0/ Line: 1-10		
measurement		measurement methods if there is more than one group	1 age. 9/ Line. 1-10		
		(b) Describe methods to assess eligibility and reduce repeat	Page:8/ Line: 23-25		
		enrollment (e.g., coupon manager software, biometrics)			
Bias	9	Describe any efforts to address potential sources of bias	Not done		
Study size	10	Explain how the study size was arrived at	Page:7/ Line: 19-20		
Quantitative	11	Explain how quantitative variables were handled in the analyses.	Page:7/ Line: 28-32		
variables		If applicable, describe which groupings were chosen and why	Page:8/ Line: 1-16		
			Page:8/ Line: 31-34		
			Page:9/ Line: 1-10		
Statistical methods	12	(a) Describe all statistical methods, including those to account for	Page:8/ Line: 31-34		
		sampling strategy (e.g., the estimator used) and, if applicable,	Page:9/ Line: 1-10		
		(b) State data analysis software, version number, and	Dego:0/Line: 11.12		
		(b) State data analysis software, version number, and	Page.9/ Line. 11-12		
		(c) Describe any methods used to examine subgroups and	Not applicable		
		interactions			
		(d) Explain how missing data were addressed	Page: 9/ Line: 1-3		
	1	(e) Describe any sensitivity analyses	Not done		
	1	(f) Report any criteria used to support statements on whether	Not done		
		estimator conditions or assumptions were appropriate			
		(g) Explain how seeds were handled in analysis	Page:9/ Line: 3-4		
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the	Page:9/ Line: 19-23		
		study, for example, numbers potentially eligible,			
		examined for eligibility, confirmed eligible, included in the study, and analyzed			
-------------------	----	---	--		
		(b) Give reasons for nonparticipation at each stage (e.g., not eligible does not consent decline to recruit others)	Page:9/ Line: 21-22		
		(c) Consider use of a flow diagram	Not included as Flowchart due to limited number of Figures of the Journal		
		(d) Report number of coupons issued and returned	Not applicable		
		(e) Report number of recruits by seed and number of RDS recruitment waves for each seed. Consider showing graph of entire recruitment network	Page:9/ Line: 22-23 Figure 1		
		(f) Report recruitment challenges (e.g., commercial exchange of coupons, imposters, duplicate recruits) and how addressed	Not Done		
		(g) Consider reporting estimated design effect for outcomes of interest	Page:11/ Line:7-13		
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and, if applicable, information on correlates and potential confounders. Report unweighted sample size and percentages, estimated population proportions or means with estimated precision (e.g., 95% confidence interval)	Page:9/ Line: 26-34 Page:10/ Line: 1-32		
		(b) Indicate the number of participants with missing data for each variable of interest	Page: 20-24		
Outcome data	15	If applicable, report number of outcome events or summary measures	Page:11/ Line: 7-13		
Main results	16	(a) Give unadjusted and study design adjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence intervals). Make clear which confounders were adjusted for and why they were included	Page:11/ Line: 19-33		
		(b) Report category boundaries when continuous variables were categorized	Not applicable		
		(c) If adjustment of primary outcome leads to marked changes, report information on factors influencing the adjustments (e.g., personal network sizes, recruitment patterns by group, key confounders)	The adjustment only modified slightly not affecting the general results		
Other analyses	17	Report other analyses done for example, analyses of subgroups and interactions, sensitivity analyses, different RDS estimators and definitions of personal network size	All analyses were reported		
Discussion					
Key results	18	Summarize key results with reference to study objectives	Page:12/ Line: 2-14		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page:14/ Line: 9-34 Page:15/ Line: 1-7		
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page:12/ Line: 14-33 Page:13/ Line: 1-34		
Generalizability	21	Discuss the generalizability (external validity) of the study results	Page:13/ Line:30-34 Page:14/ Line: 1-8		
Other information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original	Page:16/ Line: 13-16		
		study on which the present article is based			

BMJ Open

Risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

Journal:	BMJ Open
Manuscript ID	bmjopen-2021-058369.R2
Article Type:	Original research
Date Submitted by the Author:	16-Mar-2022
Complete List of Authors:	Albuquerque, Maria de Fátima; Centro de Pesquisas Aggeu Magalhaes Souza, Wayner; Centro de Pesquisas Aggeu Magalhaes Montarroyos, Ulisses; University of Pernambuco Pereira, Cresio ; Ministry of Health of Brazil Braga, Cynthia ; Centro de Pesquisas Aggeu Magalhaes Velho Barreto de Araùjo, Thalia ; Universidade Federal de Pernambuco, Departamento de Medicina Social Arraes de Alencar Ximenes, Ricardo; Federal University of Pernambuco, Department of Tropical Medicine Miranda-Filho, Demócrito de Barros; University of Pernambuco Szwarcwald, Célia; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ Souza-Junior , Paulo Roberto ; Institute of Scientific Communication and Information and Technological (ICIT), FIOCRUZ-RJ Xavier, Morgana ; Centro de Pesquisas Aggeu Magalhaes Morais, Clarice ; Centro de Pesquisas Aggeu Magalhaes Albuquerque, Gabriela ; Centro de Pesquisas Aggeu Magalhaes Bresani-Salvi, Cristiane; Centro de Pesquisas Aggeu Magalhaes Araújo Mariz, Carolline ; Centro de Pesquisas Aggeu Magalhaes Teixeira de Siqueira-Filha, Noemia; University of York, Department of Health Sciences Galindo, Jadson ; Centro de Pesquisas Aggeu Magalhaes França-Neto, Cláudio Luiz; University of Pernambuco Barbosa, Jessyka Mary Vasconcelos; Centro de Pesquisas Aggeu Magalhaes Veras, Maria Amelia ; Faculty of Medical Sciences of Santa Casa de São Paulo Lima, Luana ; Universidade do Estado do Para Cruz, Luciane; Institute of Health Technology Assessment (IATS) Kendall, Carl; Universidade Federal do Ceara; Tulane University School of Public Health and Tropical Medicine Kerr, L; Universidade Federal do Ceara Turchi Martelli, Celina Maria; Centro de Pesquisas Aggeu Magalhaes
Primary Subject Heading :	Epidemiology
Secondary Subject Heading:	Infectious diseases
Keywords:	COVID-19, Epidemiology < TROPICAL MEDICINE, PUBLIC HEALTH

SCHOLARONE" Manuscripts
For noar roviow only http://bmionan.hmi.com/site/about/guidalines.yhtml
For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xntml



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our <u>licence</u>.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which <u>Creative Commons</u> licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

review only

BMJ Open

Risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach

Maria de Fátima Pessoa Militão de Albuquerque, PhD, MD, Wayner Vieira de Souza, PhD, Ulisses Ramos Montarroyos², PhD, Cresio Romeu Pereira³, PhD, MD, Cynthia Braga¹, PhD, MD, Thália Velho Barreto de Araújo⁴, PhD, MD, Ricardo Arraes de Alencar Ximenes^{2,5}, PhD, MD, Demócrito de Barros Miranda-Filho², PhD, MD, Célia Landmann Szwarcwald⁶, PhD, Paulo Roberto Borges de Souza Junior, PhD, Morgana do Nascimento Xavier, PhD, Clarice Neuenschwander Lins de Morais¹, PhD, Gabriela Diniz Militao de Albuquerque², Spc, Cristiane C. Bresani Salvi¹, PhD, MD, Carolline de Araújo Mariz^{1,8}, PhD, Noêmia Teixeira de Sigueira Filha⁹, PhD, Jadson Mendonça Galindo¹, MSc, Cláudio Luiz de França Neto², BSc, Jessyka Mary Vasconcelos Barbosa¹, PhD, Maria Amelia de Sousa Mascena Veras¹¹, PhD, MD, Luana Nepomuceno Gondim Costa Lima¹², PhD, Luciane Nascimento Cruz¹⁰, PhD, MD, Carl Kendall^{13,14}, PhD, Ligia Regina Franco Sansigolo Kerr¹⁴, PhD, MD, Celina Maria Turchi Martelli^{1,*}, PhD, MD Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz), Recife, Brazil ²University of Pernambuco, Recife, Brazil ³Ministry of Health of Brazil, São Paulo, Brazil ⁴Department of Social Medicine Department of Tropical Medicine, Federal University of Pernambuco, Recife, Brazil Institute of Scientific and Technological Communication and Information (ICIT), Oswaldo Cruz Foundation (Fiocruz), Rio de Janeiro, Brazil Department of Biology, Federal University of Pernambuco, Vitória de Santo Antão, Brazil

- ⁴⁴⁴⁵ 25 ^sOlinda Medical School, Olinda, Brazil
- ⁴⁶ 26 ³Department of Health Sciences, University of York, UK
- ⁴⁸ 27 ¹⁰Institute for Health Technology Assessment (IATS), Porto Alegre, Brazil and Hospital, Porto

50 28 Alegre, Brazil

- ⁵¹₅₂ 29 "Faculty of Medical Sciences of Santa Casa de São Paulo, São Paulo, Brazil
- ⁵³ 30 ¹²State University of Pará, Belém, Brazil
- ⁵⁵ 31 ¹³Department of Social, Behavioral and Population Sciences and Tulane University School of
- 5657 32 Public Health and Tropical Medicine, New Orleans, USA
- ⁵⁸⁵⁹ 33 ¹⁴Federal University of Ceará, Fortaleza, Brazil

2		
3 4	1	Corresponding Author: Celina Maria Turchi Martelli, PhD
5	2	Aggeu Magalhaes Institute (IAM), Oswaldo Cruz Foundation (Fiocruz)
6 7	3	Address: Av. Prof. Moraes Rego, S/N – Cidade Universitária – 50670-420 Recife, Brazil
8 9	4	Telephone: +55 11 98685-5734
10	5	E-mail: turchicm@gmail.com
11 12	6	
13 14	7	Keywords: COVID-19; Health care Workers; Brazil.
15	8	
16 17	9	Word count: 4.226
18 19	10	
20	11	
21 22	12	
23 24	13	
25	14	
26 27	15	
28 29	16	
30 21	17	
32	17	
33 34	10	
35 36	19	
30 37	20	
38 39	21	
40 41	22	
42	23	
43 44	24	
45 46	25	
40 47	26	
48 49	27	
50 51	28	
52	29	
53 54	30	
55 56	31	
57	32	
58 59	33	
60	34	

BMJ Open

2								
3 4	1	Abstract						
5	2	Objectives: We assessed the prevalence of severe acute respiratory syndrome coronavirus						
6 7	3	(SARS-CoV-2) infection, personal protective equipment (PPE) shortages and occurrent biological accidents among frontline health care workers (HCW).						
8 9	4							
10	5	Design, setting and participants: Using respondent driven sampling (RDS), the study						
12	6	recruited distinct categories of HCW attending suspected or confirmed COVID-19 patients						
13 14	7	from May 2020 to February 2021, in the Recife metropolitan area, Northeast Brazil.						
15 16	8	Outcome measures: The criterion to assess SARS-CoV-2 infection among HCW was a						
17	9	positive self-reported PCR test.						
18 19	10	Results: We analyzed 1,525 HCW: 527 physicians, 471 registered nurses, 263 nursing						
20 21	11	assistants, and 264 physical therapists. Women predominated in all categories (81.1%; 95%						
22	12	CI: 77.8% - 84.1%). Nurses were older with more comorbidities (hypertension and						
23 24	13	overweight/obesity) than the other staff. The overall prevalence of SARS-CoV-2 infection was						
25 26	14	61.8% (95% CI: 55.7%-67.5%) after adjustment for the cluster random effect, weighted by						
27 28	15	network, and the reference population size. Risk factors for a positive RT-PCR test were being						
29	16	a nursing assistant (ORadjusted: 2.56; 95% CI: 1.42 - 4.61), not always using all recommended						
30 31	17	PPE while assisting patients with COVID-19 (ORadj: 2.15; 95% CI: 1.02 - 4.53) and reporting						
32 33	18	a splash of biological fluid/respiratory secretion in the eyes (ORadj: 3.37; 95% CI: 1.10 -						
34 25	19	10.34).						
36	20	Conclusions: This study shows the high frequency of SARS-CoV2 infection among HCW						
37 38	21	presumably due to workplace exposures. In our setting nursing assistant comprised the most						
39 40	22	vulnerable category. Our findings highlight the need for improving health care facility						
41	23	environments, specific training and supervision to cope with public health emergencies.						
42 43	24							
44 45	25							
46 47	26							
48	27							
49 50	28							
51 52	29							
53	30							
54 55	31							
56 57	32							
58 59	33							
60	34							

1		
2 3	1	Strengths and limitations of this study
4 5	2	Ser engens una minimularis et ems sea ay
6 7	3	• Respondent-driven sampling (RDS) technique applied in this study allowed the enrolment
8	4	of the healthcare workers (HCW), a hard-to-reach population regarding their work
9 10	5	conditions, during the pandemic.
11 12	6	• The study has a large sample size including the major categories of health care professionals
13 14	7	who attended Covid-19 patients in the public, private or newly implemented campaign
15 16	8	hospitals.
17	9	• Data were collected using a web-based platform, allowing the use of an online questionnaire,
18 19	10	also facilitating timely data analysis and less transcript data errors.
20 21	11	• The respondent-driven sampling chains could potentially induce the recruitment of
22 23	12	participants with similar characteristics, which was prone to selection bias.
24 25	13	• The source of SARS-CoV-2 infection among HCW could not be ascertained and this is
26 27	14	another limitation of the study.
28	15	
29 30	16	
31 32	17	
33 34	1/	
35 36	18	
37	19	
39	20	
40 41	20	
42 43	21	
44 45	22	
46 47	23	
48	25	
49 50	24	
51 52	25	
53 54	26	
55 56		
57 58	27	
59 60	28	
00		

1 Introduction

The unprecedented rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and its potentially severe outcomes have greatly impacted the healthcare system, the global economy, and security.^{1,2} According to the World Health Organization (WHO), the global cumulative number of confirmed coronavirus disease 2019 (COVID-19) cases had reached approximately 364.2 million infections and 5.6 million deaths by January 28, 2022.³ In Brazil, approximately 24.5 million COVID-19 cases and 624,413 related deaths were reported within the same period. These figures represent almost 7% and 11% of the global COVID-19 cases and registered deaths, respectively, yet the Brazilian population represents approximately 2.5% of the global population. In Brazil Covid-19 epidemiological data showed a high burden on the hospital system with 678,235 patients admitted with a positive RT-PCR for SARS-CoV-2 between February 2020 and April 2021. Hospital mortality increased from 34.8% in the first wave (February 25, 2020 to November 5, 2020) to 39.3% in the second wave (November 6, 2020, to April 30, 2021). The highest in-hospital mortality rates are concentrated in the northeast and north states of the country, which are also the regions with lower Human Development Indexes.⁴ Since the beginning of the pandemic, the federal government has opposed the recommendations for social distancing and individual protection measures while endorsing ineffective pharmaceutical interventions, hampering the epidemic control efforts of the public health authorities at the state and municipal levels.⁵

Healthcare workers (HCW) are considered a high-risk group due to the nature of their work. An Anglo-American prospective cohort that included approximately 100,000 HCW showed a 3.4-fold higher risk of self-reporting a positive test for COVID-19 among frontline workers compared with the general community using a smartphone application.⁶ A systematic review and meta-analysis covering the period from the inception of the pandemic to August 2021, showed a significant burden of COVID-19 among HCW in several countries, with a pooled prevalence of 11% (95% CI: 7 to 16%) in studies using PCR testing.⁷ Another systematic review and metanalysis suggested that exposure in settings with familiar contact increases SARS-CoV-2 transmission. However, exploring the transmission pattern in health facilities, workplace and social settings has been challenging due to limited data thus far.⁸ These previous reviews did not include studies from Brazil.

In the Americas, 569,304 COVID-19 cases, including 2,506 deaths, had been reported among
HCW by August 2020.⁹ According to public health surveillance, approximately 32% of Mexico
City HCW (n=11,226) had been infected with SARS-CoV-2 by July 2020.¹⁰ Additionally,

⁶⁰ 34 cross-sectional studies conducted in Brazil, Colombia, and Ecuador revealed lack of personal

protective equipment (PPE) among 70% of frontline workers in the early pandemic response.¹¹

In line with the previous studies a survey among HCW reported PPE shortages during the first

COVID-19 wave in Brazil 2020¹², and the inadequate working conditions were also reported

 by the media¹³. In Brazil, the prevalence of SARS-CoV-2 infection using RT-PCR in teaching hospitals varied from 15% to 42.4% among symptomatic HCW in the south region and southeast regions, respectively.^{14,15,16} However, information on the prevalence of SARS-CoV-2 infection among frontline HCW and risk factors for most regions of Brazil is limited. This study assessed the prevalence of SARS-CoV-2 infection and evaluated PPE shortages, the use of individual protective measures, and biological accidents among HCW in Recife metropolitan area of Northeast Brazil. Methods Study design This prospective study assessed the frequency of infected HCW and their risk factors, using the respondent-driven sampling (RDS) methodology¹⁷, and collecting data with a smartphone-based application. RDS was chosen as a sampling approach for two main reasons: restrictions in conducting face-to-face interviews due to lockdown and the lack of a frame list of frontline HCW attending emergency rooms, hospitals, and new field hospitals. RDS approach is based upon direct participant involvement. The baseline findings are described following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for RDS.¹⁸ Setting The study was conducted in the Recife metropolitan region, Pernambuco State, Northeast Brazil, where the first COVID-19 case was reported on March 12, 2020. The peak of the first pandemic wave was during the 21st epidemiologic week in 2020.^{19,20} This densely populated region comprises 15 municipalities with approximately four million inhabitants, corresponding to 42% of the state population.²¹ The Brazilian unified health system (Sistema Unico de Saude—SUS) has provided universal coverage since 1990, with heterogeneity among the regions.²² Formative research Formative research (FR) was conducted with the four HCW categories included in the study (physicians, nurses, nurse assistants, and physical therapists). The FR applied in-depth For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

 interviews to explore workplace changes, use and access to PPE, routine attendance, and
 possible acceptability of the study.
 Participants and Public Involvement

Participants and/or the public were not involved in the design. However, the formative research was valuable to adequate the research questions considering participants' priorities, experience, and preferences. Also the chosen methodology RDS requires direct involvement of the study participants in the recruitment and in indicating other members of the network. Therefore, the participants had an active role in the enrolment of other participants and in the development of the field work. This project was planned in collaboration with the official health care department and professional associations. The coordinators issued periodic reports with preliminary results to the institutions, local newspapers and social media. The final results will be disseminated by institutional platforms.

14 Participants

We recruited HCW attending suspected or confirmed COVID-19 patients from May 21, 2020 to February 10, 2021. Recruitment started with five "seeds" for each category, non-randomly selected from the target population. We asked each participant to identify five other members of the same professional network category, providing their names and mobile phone numbers to the fieldworkers. The process continued until a suitable sample size was reached. This study did not offer any incentive.

We calculated a sample size of 1,100 HCW, considering a 95% confidence level (CI) to
estimate a 40% prevalence of infections with a 5% error and a design effect of three.

The network size of each HCW was measured by the final answer to the following questions: 1) "How many colleagues do you know, who also know you by name, work in the Recife metropolitan region and are assisting COVID-19 patients?", 2) "How many of those colleagues have been in professional contact with you in the last two weeks?," and 3) "How many of them are close to you and you would invite to participate in this study?."

29 Variables

We applied the WHO questionnaire developed as an operational tool to determine the risk of
COVID-19 virus infection among HCW exposed to a COVID-19 patient in a health care
facility. This questionnaire was developed as an interim guidance for risk assessment by the

WHO personnel/ experts in response to COVID-19 pandemic in the early months (March

(2) Self-reported comorbidities (diabetes mellitus, hypertension, overweight or obesity,

(3) Healthcare attending—public or private sector, outpatient, emergency rooms and intensive

(4) Adherence to infection prevention and control (IPC). We checked for gloves, medical

masks, face shields, goggles or protective glasses, and waterproof aprons. These variables were

grouped as: i) always as recommended (more than 95% of the time); ii) most of the time

(5) Adherence to IPC when performing aerosol-generating procedures (AGPs) using the

abovementioned grading criteria. In this section, we added the N95 respirator. The variables

(ranging from 50% to 95%); iii) occasionally (1-49%); iv) never; v) unavailable.

2020).²³ The variables were:

(1) Age, sex, and professional category;

cardiopathy, nephropathy, and others);

care units (ICU); number of healthcare facilities.

related to adherence to IPC (items 4 and 5) were grouped as always versus not always. (6) Accidents with biological material—I) during the period of healthcare interaction and II) if there was an accident with biological fluid or respiratory secretions, which type it was (splash in the mucous membrane of eyes, mouth, or nose; non-intact skin; and puncture-sharp accident). *Outcome measure* The primary outcome was the frequency of positive self-reported PCR tests. In the study, HCW were considered as a priority population for COVID-19 tests as part of the COVID-19 public health response at state level. Laboratory confirmation was performed at the Pernambuco LACEN, which is the public health reference laboratory for the diagnosis of SARS-CoV-2 regionally. Also, PCR-based swab was the most available test for HCW, and the technique used has been previously published.²⁴ Data collection Data were collected using a web-based software platform by FITec (Recife, Pernambuco, Brazil). The HCW answered the questionnaire by accessing a link that could be opened on a smartphone or a computer browser.

32 Providing electronic informed consent was mandatory to participate and access the
33 questionnaire. The project was approved by the National Ethics Committee (CONEP; CAAE:
34 30629220.8.0000.0008).

3	
4	
5	
6	
7	
, 8	
9	
10	
11	
12	
12	
1/	
14	
15	
10	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
57	
52	
55	
54	
55 57	
50 57	
5/ 50	
58	
59	
60	

1 Data analysis

2 Participants were weighted by the size of each category, provided by each professional board, 3 and by the inverse of the size of their professional network, based on the following question: 4 "How many of these colleagues are close to you and would you invite to participate in this 5 study?" To avoid the influence of extreme network sizes on the weight of each professional, we limited the network size to 3 to 150 for outlier correction.²⁵ For missing data—representing 6 7 around 8% of the total—we used available information from the other two questions related to 8 network size, and when necessary, we applied the overall mean of the stratum. The seeds 9 (primary) were used to define the cluster of the study.

10 Categorical variables are presented as percentages and 95% CIs by HCW category and overall 11 frequencies adjusted for the design. The chi-squared test was used for comparison between 12 groups. We calculated the means, medians, and 95% CIs for continuous variables. Bivariate 13 analysis was performed to assess the association between potential risk factors and RT-PCR 14 positivity. Variables associated with the outcome at p < 0.20 were included in the multivariate 15 model. In the final model, we considered variables at the p < 0.10 level statistically significant. 16 All statistical analyses were performed using Stata, version 15.0 (StataCorp LLC, College 17 Station, TX, USA).

19 Role of the funding source

20 The funding source had no involvement in any stage of the project.

22 **Results**

21

18

23 Participants

We recruited 2,474 health care workers and 1,525 of them were included in the analysis, in the
following categories: 527 physicians, 471 registered nurses, 263 nursing assistants, and 264
physical therapists. The exclusions were: 638 HCW who did not sign the informed consent;
238 that refused to participate and 28 did not complete the questionnaires. Figure 1 illustrates
the recruitment chain for each category.

29

30 Descriptive data

Overall, women represented 81.1% (95% CI: 77.8% – 84.1%) of the sample after adjustment
to the reference population and for the study design (Table 1). Women also predominated in
all professional categories, with the lowest percentage among physicians (63.4%; 95% CI:
58.6% – 67.9%) and the highest among nurses (86.7%; 95% CI: 82.7% – 89.9%) and nursing

assistants (85.5%; 95% CI: 79.8% – 89.7%). The age distribution was as follows: 32.7% (95% CI: 28.8% – 36.9%) and 35.6% (95% CI: 31.5% – 40.0%) were <30 and 30–39 years old, respectively. Only 0.1% of the participants were aged ≥ 60 years. Physicians and physical therapists were the youngest groups, comprising 56.6% (95% CI: 51.7% - 61.4%) and 45.1%(95% CI: 38.3% - 52.1%), respectively, of those 20-29 years old. Comorbidities affected 30.1% (95% IC: 26.1% – 34.3%) of the studied population. Overweight/obesity (12.6%; 95% CI: 9.9% – 15.9%) and hypertension (11.9%; 95% CI: 9.2% – 15.1%) were the most prevalent comorbidities among nursing assistants and nurses than among the other categories. In total, 71.4% (95% CI: 67.6% – 74.9%) of HCW attended COVID-19 cases exclusively in the public sector, including hospitals, emergency units, ambulance services, and primary care units. Most HCW (73.5%; 95% CI: 69.2% - 77.3%) worked either in emergency rooms or ICU. Notably, 55.8% (95% CI: 51.0% – 60.6%) of the physicians and 37.8% (95% CI: 31.3% – 44.8%) of the physical therapists indicated working in three or more institutions during the pandemic (Table 1).

Overall, 78.0% (95% CI: 74.2% – 81.3%) of the participants received training on the use of PPE. Physical therapists (87.0%; 95% CI: 81.6% – 91.0%) and nursing assistants (81.1%; 95% CI: 74.8% - 86.1%) received a higher and similar frequency of training compared to the other categories. Almost half of the HCW (47.7%) reported a shortage of PPE items during the COVID-19 pandemic. Regarding wearing PPE in routine activities, the overall frequencies varied widely for each item: 90.1% (95% CI: 87.7% - 92.0%) for single-use gloves to 29.9% (95% CI: 25.9% – 34.2%) for face shields. Most HCW (82.2%; 95% CI: 78.4% – 85.5%) reported performing AGPs on COVID-19 patients. Almost all participants reported having always used single-use gloves (98.4%; 95% CI: 96.4% – 99.3%) and N95 respirators (86.4%; 95% CI: 82.5% – 89.5%) during AGPs. The N95/PPF2 respirator was reused for more than seven days by approximately 28.3% (95% CI: 24.7% – 32.1%) of the participants, with highest and lowest frequencies reported by physicians (49.3%; 95% CI: 44.4% - 54.2%) and nursing assistants (20.6%; 95% CI: 15.4% - 27.0%), respectively. Overall, 63.7% (95% CI: 57.8% -69.2%) of the HCW reported always wearing all PPE items as recommended by the WHO. The self-perception of SARS-CoV-2 risk of infection in the previous 15 days varied: 33.4% for "performing a procedure on a patient with COVID-19;" 17.7% for "sharing the break room with their colleagues;" 16% for the "reuse of N95 respirators;" 10.6% for the "use of poor quality PPE;" 10.2% during "doffing;" 9.6% for "working with colleagues with COVID-19 symptoms;" 1.9% for "lack of PPE in the service;" and 0.5% for "donning PPE." HCW reported 186 episodes of exposure to biological fluids/respiratory secretions during healthcare

BMJ Open

- 11.7%) (Table 2).
 - interaction with COVID-19 patients. Accidents were more frequent among physicians (13.9%; 95% CI: 11.0% 17.4%) and less frequent among physical therapists (7.6%; 95% CI: 4.9% –
 - The frequency of COVID-19 testing varied from 41.2% for physical therapists to 51.1% for physicians. Individuals with any comorbidity were more likely to get tested (56.8%) than those without comorbidities (p<0.001). HCW who worked in three or more health services were also more likely to get tested (54.9%) than those who worked in only one health service (42.1%) (p<0.001). There was no statistical difference in the likelihood of testing, according to sex, age group (<30 versus ≥30 years old), work setting (outpatients, inpatients, and emergency rooms and ICU), self-perception of risk (no risk to high risk of exposure), reported accidents with biological fluid/respiratory secretion, and when performing AGPs (Supplementary Table 1).
 - For the tested HCW, mostly symptomatic, the overall self-reported SARS-CoV-2 infection was 61.8% (95% CI: 55.7%-67.5%) compared with 14.9% (CI: 4.9%-37.5%) among asymptomatic, after adjustment for random cluster effects, weighted by network and population size. The highest infection positivity was among nursing assistants (70.0%; 95%CI: 59.0%-79.1%), followed by physicians (55.0%; 95%CI: 47.5%-62.3%), physical therapists (54.7%; 95%CI: 43.1%-65.7%), and nurses (48.1%; 95%CI: 40.3%-56.0%), adjusted for random cluster effects (Figure 2). RT-PCR screening was performed mainly among symptomatic cases in all categories, ranging from 81.8% to 91.8% for physicians and nursing assistants, respectively.
 - Almost half of the HCW (47.8%) reported taking sick leave due to COVID-19, with a similar trend among the other categories (p=0.159). The median length of health leave was 14 days for all professional categories, reflecting a standard procedure. Of 399 symptomatic SARS-CoV-2 infected HCW, 10% (n=41) were hospitalized.
 - In a bivariate analysis, the nursing assistant category was positively associated with infection (odds ratio [OR]=2.77; 95% CI: 1.64–4.67, p<0.001) compared to nurses. Reporting any accident involving body fluid/respiratory secretion was associated with infection (OR=2.67; 95% CI: 1.22–5.82, p<0.014). When considering each accident, splashes in the eyes were a stronger predictor of infection (OR=4.07; 95% CI: 1.14–14.55, p<0.031). During routine assistance of COVID-19 patients, not always wearing the complete set of recommended PPE items was associated with infection (OR=2.14; 95% CI: 1.18–3.88, p=0.013) when compared to always using PPE. Not always using the complete recommended PPE items during AGPs was also associated with infection (OR=1.68; 95% CI: 0.97–2.92, p=0.063) when compared with always using PPE (Supplementary Table 2).

In the final multivariate logistic regression model, the following were risk factors for infection:
 being a nursing assistant (OR adjusted=2.56; 95% CI: 1.42–4.61, *p*=0.002), not always having
 used PPE during care of patients with COVID-19 (OR adjusted=2.15; 95% CI: 1.02–4.53,
 p=0.044), and having suffered a splash to the eyes (OR adjusted=3.37; 95% CI: 1.10–10.34,
 p=0.034) (Table 3).

7 Discussion

The current study showed substantial heterogeneity in demographic and self-referred comorbidities between HCW categories during the COVID-19 pandemic. Of note, physicians and physical therapists at the frontline were younger and mainly worked in the Intensive Care Units and emergency rooms when compared with nurses. This reflects the expansion of the healthcare workforce with the inclusion of younger physicians and physical therapists, possibly inexperienced professionals, forcibly driven to work as frontliners in a high-risk environment. Nurses and nursing assistants were older and reported more comorbidities, particularly hypertension and overweight/obesity. According to the accumulated evidence, the public health strategy was to prevent exposure among older age groups and/or individuals with comorbidities, as older age and comorbidities are strong prognostic factors for hospitalization and death.²⁶

To the best of our knowledge, our study depicted one of the highest frequencies of SARS-CoV-2 infections among HCW, with nursing assistants being the most vulnerable category. In consonance with this finding, nursing assistants also had the highest prevalence of infection comparing with the other staff in a university hospital in the southeast of Brazil.¹⁶ One likely explanation is that most of the participants tested were symptomatic, reflecting the policy of making RT-PCR tests for COVID-19 diagnosis available to frontline HCW. Thus far, there has been no mass RT-PCR testing strategy for the Brazilian population despite WHO recommendations.²⁷ Worldwide, the prevalence closest to that of our study was 55%, by RT-PCR among 177 symptomatic medical residents in New York City at the beginning of the COVID-19 pandemic.²⁸ In Southeast Brazil, a high prevalence of SARS-CoV-2 infection (42%) tested by RT-PCR was found among symptomatic HCW at a teaching hospital in Sao Paulo, from March to May 2020.¹⁵ Another study found a prevalence of 14% (701 out of 4,987) using RT-PCR in a group composed of mainly symptomatic HCW, at a hospital in the south of Brazil from April to June 2020.¹⁴ This variation might be attributable to the dynamics of the pandemic in different regions of the country, the availability/quality of PPE, and training in different healthcare settings.

BMJ Open

Finding of seroprevalence studies cannot be directly compared to our results. The frequencies of SARS-CoV-2 infection among HCW in São Paulo city ranged from 5.5% (IgG ELISA) in a private hospital to 14% (IgG/IgM antibody, WONDFOTM) in a large public hospital in 2020.^{29,30} Both hospital settings stated that they adopted high-quality hospital infection control and provided complete PPE in the early stages of the COVID-19 pandemic. This may reflect especially high-quality healthcare facilities in more developed regions of the country and the rates reported were similar to those reported in another meta-analysis of seroprevalence studies.³¹

In our setting, critical aspects for the high risk of SARS-CoV-2 infection included a shortage of PPE items reported by approximately half the HCW. Moreover, 22% of HCW reported not been trained on PPE use. The lack of preparedness of the health workforce to respond to the COVID-19 pandemic was not only encountered by low- and medium-income countries like Brazil but also in high-income countries at the beginning of the pandemic.³² At the individual level, one-fourth of the HCW reported that PPE was not always used according to the WHO recommendations.²⁷ When performing aerosol-generating procedures (AGPs), the nursing staff had the highest frequency (over 35%) of not fully adhering to complete PPE.³³ However, not always using the recommended PPE during performance of AGPs was not associated with PCR positive reports in our analysis. This finding is in line with a recent study questioning the concept of AGPs for risk-stratifying patients since most procedures considered as AGPs do not meaningfully increase respiratory aerosols.³⁴ In the current study, not using the recommended PPE during routine attendance of COVID-19 cases caused a 2.2-fold increased risk of a SARS-CoV-2 positive RT-PCR test result. Accidents with biological fluids occurred in all categories, however, they were most frequently reported among physicians, the youngest, and perhaps the group with the least experience working in critical conditions. Reporting an accident with biological fluids, such as a splash in the eye, was positively associated with infection in the final multivariable model. Although it is uncertain whether viruses occasionally present in biofluids are infectious, these fluids should be considered potentially infectious.³⁵ Moreover, the eye has been considered a possible route of SARS-CoV-2 entry through drainage via the nasolacrimal duct to the upper respiratory tract.³⁶ These accidents with biological fluids should be further investigated in other studies, as recommended by the WHO guidelines.²³ The prevalence among HCW in the current study was at least 20-fold higher when compared to the 3.2% seroprevalence in a population-based survey using SARS-CoV-2 antibody rapid tests conducted during the first wave of the pandemic in the same region.³⁷ Therefore, there is strong

evidence that HCW are at a high risk of SARS-CoV-2 infection in low- and medium-income settings, such as Northeast Brazil.

 To the best of our knowledge, this is the largest South American study of HCW during the COVID-19 pandemic, with the inclusion of the four main healthcare professionals in the public and private sectors and multiple levels of health services. Previous investigations conducted in Brazil were mainly restricted to one hospital setting and did not apply the WHO questionnaire.23

The advantage of using the respondent-driven sampling technique was that it allowed the inclusion of HCW from different healthcare settings, including the private and public health services, providing a more comprehensive picture of frontline HCW during the pandemic. Furthermore, as HCW worked in more than one health service and/or in newly implemented "field hospitals/units," this strategy allowed us to capture the full extent of characteristics of the workforce and the risk factors for infection. Another advantage of applying an online questionnaire was to avoid face-to-face interviews during the lockdown and/or social distancing restrictions, reduce errors in data transcription, and obtain timely results.

We acknowledge as a potential limitation that our result was based on self-report COVID-19 results. In fact, this outcome is in consonance with previously large-scale online surveys published during COVID-19 pandemic.^{6,38,39} HCW have the ability by their professional training for reporting a positive PCR test for COVID-19. It is important to mention that during this study period, the most available test was the PCR-based nasal swab, mainly performed by the reference laboratory in charge of the COVID-19 public health response regionally. Nevertheless, some misclassification of the outcome cannot be excluded.

Respondent-driven sampling study are traditionally designed for "hard-to-reach population" in a lack of a sampling frame.¹⁷ In the study setting, the population of health professionals at frontline although not a hard-to-reach population was made more difficult to access due a lack of sampling frame and the enormous time burden on the staff. Therefore, we did not access this population in a probabilistic sampling, but via the chain referral samples (social network), which potentially induce selection bias. Despite of this limitation, inherent of RDS technique, the study had several waves of recruitment chains, achieving a large and heterogeneous sample. In addition, we estimated the weighted prevalence of SARS-CoV-2 infection considering the social network size to minimize the potential selection bias introduced by the study design. Another limitation is that the study was not designed as genomic surveillance or contact tracing to distinguish the setting of the transmission. However, the participants were frontliners attending suspected or confirmed Covid-19 patients. In fact, only 15.2% of them referred to

BMJ Open

have had contact with COVID-19 cases simultaneously in health-care facilities and at the household (data not shown). In our analysis the risk factors associated with infection were higher among nursing assistants; HCW not using all PPE items as recommended, and to professionals reporting an accident during their activities. It is likely that the high frequency of infections among frontline HCW was presumably healthcare associated infections in line with our findings, with the scenario of shortage of PPE and the high health care pressure during the first pandemic wave. Nevertheless, the source of SARS-CoV-2 infection could not be ascertained in this study.

There was an imbalance in recruitment among the HCW categories; physicians and nurses were more rapidly enrolled by RDS than nursing assistants. One possible explanation is that physicians and nurses seem to understand research methodology better and/or to have either better smartphones or data plans required to answer the approximately 15-minute online questionnaire. Physicians and nurses were also a more vocal category early in the pandemic, publicizing the constraints/pressure of the workplace. Conversely, nursing assistants, as routine healthcare assistants, spend more time providing direct patient care and have low wages. They could also be less confident/willing to participate due to work overload or unfavourable socio-economic conditions when compared to the other categories that require university degrees. Additionally, disclosure of the work environment concerning PPE and infection control prevention may be problematic for nursing assistants whose jobs are less stable and more prone to replacement in our setting. Accidents involving biological fluids should be further investigated in other studies to validate this finding.

The study shows the high frequency of SARS-CoV2 infection among HCW presumably due to workplace exposures. In our setting nursing assistants comprised the most vulnerable category. Our findings highlight the need for improving health care facility environments, specific training and supervision to cope with public health emergencies.

27 Data availability statement

Proposals for the dataset (de-identified participant data, data dictionary) should be directed to
 the corresponding author: turchicm@gmail.com. To gain access, data requestors will need to
 present their plan of analysis and sign a data access agreement.

32 Ethics statements

All participants provided electronic informed consent in the web-based platform. HCW could
 only access the questionnaire after giving the on-line Informed Consent Form (ICF). In our

study we applied the ICF in agreement with both: the requirements of the National Ethics
 Committee (CONEP, 30629220.8.0000.0008); and with the current protocols for electronic
 survey.

Acknowledgments

6 We thank HCW for their participation. We acknowledge the Institute of Health Technology 7 Assessment and MCTIC/CNPq/FNDCT/MS/SCTIE/Decit N° 07/2020 for support. The 8 following researchers received scholarship (CNPq-Pq): 308974/2018-2 to CMTM, 9 309722/2017-9 to RAAX, 301905/2017-7 to MFPMA, no. 30735/2018-1 to CB and 10 303661/2017-8 to WVS. CRP received scholarship from CNPq, EV-1 no. 315877/2020-0. We 11 thank all participants for their important contribution in this project. We would like to thank 12 Editage (www.editage.com) for English language editing.

14 Author contributions

MFPMA, WVS, CMTM, RAAX, DBMF, TB, CK, and LRFSK contributed to the study concept and design. CB, MNX, CNLM, GDMA, CBS, CAM, NTSF, JMG, CLFN, and JMVB contributed to the acquisition of data. MFPMA, URM, WVS, CLS, PRBSJ, and CRP contributed to the data analysis and creation of tables and figures. MFPMA, WVS, CMTM, RAAX, DMF, TVBA, MASMV, LNGCL, CB, and LNC contributed to data interpretation. MFPMA, WVS, URM have verified the underlying data. CMTM, MFPMA, WVS, and CRP drafted the initial manuscript and all other coauthors contributed scientific inputs equally towards the interpretation of the findings and the final draft of the manuscript. All authors confirm that they had full access to all the data in the study and accept responsibility to submit for publication.

26 Funding

This investigation was funded by Health Technology Assessment Institute (IATS) and by MCTIC/CNPq/FNDCT/MS/SCTIE/Decit N° 07/2020. The funding agency had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

- **Declaration of interests**
- 33 We declare no competing interests.
- 60 34

2			
3 4	1	Refe	erences
5	2	1	Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. N Engl J
7	3		Med 2020; 382: 1268–9. doi:10.1056/NEJMe2002387.
8 9	4	2	Morens DM, Daszak P, Taubenberger JK. Escaping Pandora's box-another novel
10 11	5		coronavirus. N Engl J Med 2020; 382 : 1293–5. doi:10.1056/NEJMp2002106.
12	6	3	World Health Organization. https://www.who.int/emergencies/diseases/novel-
13 14	7		coronavirus-2019 [Accessed January 28, 2021].
15 16	8	4	Zeiser FA, Donida B, Costa CA et al. First and second COVID-19 waves in Brazil: A
17	9		crosssectional study of patients' characteristics related to hospitalization and in-hospital
18	10		mortality. The Lancet Regional Health - Americas 2022; 6: 100107. doi:
20 21	11		10.1016/j.lana.2021.100107
22 23	12	5	The Lancet. COVID-19 in Brazil: "So what?". Lancet 2020; 395: 1461.
24	13		doi:10.1016/S0140-6736(20)31095-3
25 26	14	6	Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-
27 28	15		care workers and the general community: a prospective cohort study. Lancet Public
29 30	16		Health 2020; 5: 475-83. doi:10.1101/2020.04.29.20084111.
31	17	7	Dzinamarira T, Murewanhema G, Mhango M et al. COVID-19 Prevalence among
32 33	18		Healthcare Workers. A Systematic Review and Meta-Analysis. Int. J. Environ. Res.
34 35	19		Public Health 2022; 19: 146. doi: 10.3390/ ijerph19010146.
36	20	8	Thompson HA Mousa A, Digheet A al, Severe Acute Respiratory Coronavirus 2
37 38	21		(SARS-CoV-2) Setting Specific Transmission rates : A systematic Review and Meta-
39 40	22		Analysis. Clin Infect Dis 2021; 743: e754-64. doi: 10.1093/cid/ciab100.
41 42	23	9	Pan American Health Organization/World Health Organization. Epidemiological alert:
43	24		COVID-19 among health workers. August 31, 2020
44 45	25		https://www.paho.org/en/documents/epidemiological-alert-covid-19-among-health-
46 47	26		workers-31-august-2020 [Accessed May 8, 2021].
48 40	27	10	Antonio-Villa NE, Bello-Chavolla OY, Vargas-Vázquez A, et al. Assessing the burden
49 50	28		of coronavirus disease 2019 (COVID-19) among healthcare workers in Mexico City: a
51 52	29		data-driven call to action. Clin Infect Dis 2021; 73: e191-8. doi:10.1093/cid/ciaa1487.
53 54	30	11	Martin-Delgado J, Viteri E, Mula A, et al. Availability of personal protective
55	31		equipment and diagnostic and treatment facilities for healthcare workers involved in
50 57	32		COVID-19 care: a cross-sectional study in Brazil, Colombia, and Ecuador. PLoS
58 59	33		One 2020; 15: e0242185. doi:10.1371/journal.pone.0242185.
60			

1 ว			10
2	1	12	Cotrin P, Moura W, Gambardela-Tkacz CM, et al. Healthcare Workers in Brazil during
4 5	2		the COVID-19 Pandemic: A Cross Sectional online survey. Inquiry 2020; 57:
6 7	3		46958020963711. doi: 10.1177/0046958020963711
8 9	4	13	Vedovato TG, Andrade CB, Santos DL, et al Health workers and COVID-19: flailing
10	5		working conditions? Revista Brasileira de Saúde Ocupacional 2021, 46: e1. doi:
12	6		10.1590/2317-6369000028520.
13 14	7	14	Schmidt Fernandes F, de Castro Cardoso Toniasso S, Castelo Branco Leitune J, et al.
15 16	8		COVID-19 among healthcare workers in a Southern Brazilian hospital and evaluation
17	9		of a diagnostic strategy based on the RT-PCR test and retest for Sars-CoV-2. Eur Rev
18 19	10		Med Pharmacol Sci 2021; 25: 3365–74. doi:10.26355/eurrev_202104_25748.
20 21	11	15	Buonafine CP, Paiatto BNM, Leal FB, et al. High prevalence of SARS-CoV-2
22 23	12		infection among symptomatic healthcare workers in a large university tertiary hospital
24	13		in São Paulo, Brazil. BMC Infect Dis 2020; 20: 917. doi:10.1186/s12879-020-05662-8.
25 26	14	16	Faíco-Filho KS, Carvalho JMA, Conte DD et al. COVID-19 in health care workers in a
27 28	15		university hospital during the quarantine in São Paulo city. The Brazilian Journal of
29 30	16		Infectious Diseases 2020; 24: 462-465. doi:10.1016/j.bjid.2020.08.003
31	17	17	Heckathorn DD. Respondent-Driven Sampling: A New Approach to the Study of
32 33	18		Hidden Populations. Social Problems 1997; 44: 174–199. doi: 10.2307/3096941
34 35	19	18	White RG, Hakim AJ, Salganik MJ, et al. Strengthening the reporting of observational
36 37	20		studies in epidemiology for respondent-driven sampling studies: "STROBE-RDS"
38	21		statement. J Clin Epidemiol 2015; 68: 1463-71. doi:10.1016/j.jclinepi.2015.04.002.
39 40	22	19	Souza WV, Martelli CMT, Silva APSC, et al. The first hundred days of COVID-19 in
41 42	23		Pernambuco State, Brazil: epidemiology in historical context. Cad Saude Publica 2020;
43 44	24		36: e00228220. doi:10.1590/0102-311X00228220.
45	25	20	Ximenes RAA, Albuquerque MFPM, Martelli CMT, et al. Covid-19 in the Northeast of
46 47	26		Brazil: from lockdown to the relaxation of social distancing measures. Cien Saude
48 49	27		<i>Colet</i> 2021; 26 : 1441–56. doi:10.1590/1413-81232021264.39422020.
50 51	28	21	IBGE. Instituto Brasileiro de Geografia e Estatistica. Censo demográfico Brasileiro.
52	29		2010. https://www.ibge.gov.br/cidades-e-estados/pe/recife.html [Accessed July 10,
53 54	30		2021].
55 56	31	22	Castro MC, Massuda A, Almeida G, et al. Brazil's unified health system: the first 30
57 58	32		years and prospects for the future. Lancet 2019; 394: 345-56. doi:10.1016/S0140-
59 60	33		6736(19)31243-7.

Page 21 of 34

1 ว			17
2	1	23	World Health Organization. Health workers exposure risk assessment and management
4 5	2		in the context of COVID-19 virus: interim guidance. March 4, 2020.
6 7	3		https://apps.who.int/iris/handle/10665/331340 [accessed April 15, 2020].
8 9	4	24	Magalhães JJF, Mendes RPG, Silva CTA et al. Epidemiological and clinical
10	5		characteristics of the first 557 successive patients with COVID-19 in Pernambuco state,
12	6		Northeast Brazil. Travel Medicine and Infectious Disease 2020; 38:101884. doi:
13 14	7		10.1016/j.tmaid.2020.101884.
15 16	8	25	Gonçalves B, Perra N, Vespignani A. Modeling users' activity on twitter networks:
17	9		validation of Dunbar's number. PLoS One 2011; 6: e22656.
18 19	10		doi:10.1371/journal.pone.0022656.
20 21	11	26	Knight SR, Ho A, Pius R, et al. Risk stratification of patients admitted to hospital with
22 23	12		covid-19 using the ISARIC WHO clinical characterisation protocol: development and
24	13		validation of the 4C mortality score. BMJ 2020; 370 : m3339. doi:10.1136/bmj.m3339.
25 26	14	27	World Health Organization. Responding to community spread of COVID-19: Interim
27 28	15		guidance 7 March 2020. https://www.who.int/publications/i/item/responding-to-
29 30	16		community-spread-of-covid-19 [accessed February 7, 2022].
31 22	17	28	Breazzano MP, Shen J, Abdelhakim AH, et al. New York City COVID-19 resident
32 33	18		physician exposure during exponential phase of pandemic. J Clin Invest 2020; 130:
34 35	19		4726–33. doi:10.1172/JCI139587.
36 37	20	29	Costa SF, Giavina-Bianchi P, Buss L, et al. SARS-CoV-2 seroprevalence and risk
38	21		factors among oligo/asymptomatic healthcare workers (HCW): estimating the impact of
39 40	22		community transmission. Clin Infect Dis 2020.doi:10.1093/cid/ciaa1845.
41 42	23	30	Oliveira MS, Lobo RD, Detta FP, et al. SARS-Cov-2 seroprevalence and risk factors
43 44	24		among health care workers: Estimating the risk of COVID-19 dedicated units. Am J
45	25		Infect Control 2021; 49: 1197–9. doi:10.1016/j.ajic.2021.03.010.
46 47	26	31	Hossain A, Nasrullah SM, Tasnim Z, Hasan MK, Hasan MM. Seroprevalence of
48 49	27		SARS-CoV-2 IgG antibodies among health care workers prior to vaccine
50 51	28		administration in Europe, the USA and East Asia: a systematic review and meta-
52	29		analysis. E Clinical Medicine 2021; 33 : 100770. doi:10.1016/j.eclinm.2021.100770.
53 54	30	32	Paffenholz P, Peine A, Hellmich M, et al. Perception of the 2020 SARS-CoV-2
55 56	31		pandemic among medical professionals in Germany: results from a nationwide online
57	32		survey. Emerg Microbes Infect 2020; 9: 1590–9. doi:10.1080/22221751.2020.1785951.
58 59	33	33	Anvisa Nota Técnica Gvims/Ggtes/Anvisa Nº 04/2020. Orientações para Serviços de
60	34		Saúde: Medidas de prevenção e controle que devem ser adotadas durante a assistência

1			20
2 3	1		aos casos suspeitos ou confirmados de infecção pelo novo Coronavírus (SARS-CoV-2)
4 5	2		(undated $08/05/2020$)
6 7	3	34	Klompas M, Milton DK, Rhee C, et al. Current Insights Into Respiratory Virus
8	4		Transmission and Potential Implications for Infection Control Programs. <i>Annals of</i>
9 10	5		Internal Medicine 2021; 174 : 1710-1718. doi:10.7326/M21-2780.
11 12	6	35	Schindler SE, Jicha GA, Nelson PT, et al. Maximizing safety in the conduct of
13 14	7		Alzheimer's Disease fluid biomarker research in the era of COVID-19. J Alzheimer's
15 16	8		Dis 2020; 76: 27-31. doi:10.3233/JAD-20068.
17	9	36	Abobaker A, Alzwi A. The eye: a possible new route of infection in COVID-
18 19	10		19. Disaster Med Public Health Prep 2020; 14: e25-6. doi:10.1017/dmp.2020.270.
20 21	11	37	Hallal PC, Hartwig FP, Horta BL, et al. SARS-CoV-2 antibody prevalence in Brazil:
22 23	12		results from two successive nationwide serological household surveys. Lancet Glob
24	13		Health 2020; 8: e1390-8. doi:10.1016/S2214-109X(20)30387-9.
25 26	14	38	Firew T, Sano ED, Lee JW et al. Protecting the front line: a cross-sectional survey
27 28	15		analysis of the occupational factors contributing to healthcare workers' infection and
29 30	16		psychological distress during the COVID-19 pandemic in the USA. BMJ Open 2020
31 32	17		Oct 21; 10: e042752. doi: 10.1136/bmjopen-2020-042752.
33	18	39	Varsavsky T, Graham MS, Canas LS et al. Detecting COVID-19 infection hotspots in
34 35	19		England using large-scale self-reported data from a mobile application: a prospective,
36 37	20		observational study. Lancet Public Health 2021; 6: e21-e29. doi: 10.1016/S2468-
38 39	21		2667(20)30269-3.
40 41			
41 42			
43 44			
45 46			
47			
48 49			
50 51			
52			
53 54			
55 56			
50 57			
58 59			
60			

Page 23 of 34

BMJ Open

2	1
7	I

	Physicians $(n = 527)$		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$		Total	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% C
Sex										
Female	63.4	58.6-67.9	86.7	82.7-89.9	85.5	79.8-89.7	70.3	63.6-76.3	81.1	77.8-84.
Male	36.6	32.1-41.4	13.2	10.1-17.3	14.5	10.2-20.2	29.7	23.7-36.4	18.9	15.9-22.2
Age, years										
< 30	56.6	51.7-61.4	25.8	21.6-30.6	26.9	20.8-33.9	45.1	38.3-52.1	32.7	28.8-36.9
30-39	34.1	29.6-38.9	37.3	32.5-42.4	34.5	28.0-41.6	45.3	38.5-52.4	35.6	31.5-40.0
\geq 40	9.3	6.8-12.6	36.9	32.1-41.9	38.6	32.0-45.7	9.6	6.2-14.4	31.7	27.6-36.0
Any comorbidity										
Any	23.3	19.5–27.6	33.9	29.2–38.8	32.0	25.8-38.9	19.0	14.1-25.1	30.1	26.1-34.3
None	76.7	72.4-80.5	66.1	61.2–70.8	68.0	61-74.2	81.0	74.9-85.9	69.9	65.7–73.8
Diabetes	1.0	0.4-2.6	2.1	1.1-4.1	2.0	0.8-5.1	0.4	0.1-3.1	1.8	0.9-3.4
Hypertension	4.0	2.5-6.4	13.2	10.0–17.1	14.4	10.1-19.9	4.8	2.5-8.9	11.9	9.2-15.1
Overweight/Obesity	7.3	5.3-10.0	11.1	8.2–14.6	14.9	10.6-20.4	8.9	5.6-13.7	12.6	9.9–15.9
Heart disease	0.4	0.1-1.3	1.2	0.5-3.0	0.9	0.2-3.5	0.0		0.1	0.3-2.1
Kidney disease	0.0		0.2	0.03-1.5	0.1	0.02-1.1	0.8	0.2-3.1	0.2	0.1–0.6
Others comorbidities	13.1	10.1-16.7	14.8	11.6-18.8	9.4	5.9–14.7	6.9	4.2-11.4	10.8	8.4-13.8
Number of workplaces										
< 3	44.2	39.4-49.0	91.8	88.4–94.2	95.2	92.0–97.2	62.2	55.2-68.7	84.2	82.1-86.1
\geq 3	55.8	51.0-60.6	8.2	5.8-11.6	4.8	2.8-8.0	37.8	31.3-44.8	15.8	13.9–17.9
Missing	2		0		1		0		3	
Institution provider										
Private	5.2	3.5-7.8	7.2	4.8-10.5	7.0	4.1-11.5	14.8	10.4-20.5	7.2	5.3-9.8
Public	44.5	39.7-49.3	81.2	76.8-85.0	79.8	73.5-85.0	35.2	28.9-42.2	71.4	67.6–74.9
Both	50.3	45.5-55.2	11.6	8.7-15.4	13.2	9.1-18.9	50.0	43-56.9	21.4	18.4-24.7
Work setting										
Outpatient/Inpatient clinics	12.0	9.1-15.6	41.6	36.6-46.8	27.7	21.6-34.7	11.5	7.6-17.0	26.5	22.7-30.8
ICU/Emergency	88.0	84.4-90.9	58.4	53.2-63.4	72.3	65.3-78.4	88.5	83.0-92.4	73.5	69.2-77.3

Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network and population size. CI, confidence interval; ICU, intensive care unit

	Physicians $(n = 527)$		Nurses $(n = 471)$		Nursing assistants $(n = 263)$		Physical therapists $(n = 264)$]	Total
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% C
Training on PPE use										
Yes	68.9	64.2-73.2	72.3	67.4–76.7	81.1	74.8-86.1	87.0	81.6-91.0	78.0	74.2-81.3
No	31.1	26.8-35.8	27.7	23.3-32.6	18.9	13.9–25.2	13.0	9.0-18.4	22.0	18.7-25.8
Missing	3		0		0		0		3	
While providing routine assistance to patients with COVID-19, have you used these PPE: Single Cloves										
Always	74-1	69 6-78 1	84.4	80 3-87 8	95.4	90 9_97 7	96.1	92 1_98 1	90.1	87 7_92 (
Not always	25.9	21 9-30 4	15.6	12 2-19 7	2.4 4.6	2 3_9 1	3.9	1 9_7 9	9.0	8 0–12 [·]
Missing	23.5	21.9 50.4	2	12.2 19.7	ч.0 0	2.5 7.1	1	1.9 7.9	5	0.0 12.
Surgical mask	-		-		Ŭ		1		U U	
Always	45.3	40.6-50.2	58.6	53.5-63.6	51.0	43.8-58.1	36.9	30.3-44.0	50.5	46.0-54.9
Not always	54.7	49.8-59.4	41.4	36.4-46.5	49.0	41.9-56.1	63.1	56.0-69.6	49.5	45.1-53.9
Missing	2		2		0		1		5	
N95 respirator										
Always	64.4	59.6-68.9	57.4	52.3-62.4	66.3	59.1-72.9	87.3	81.6-91.4	65.9	61.4-70.
Not always	35.6	31.1-40.3	42.6	37.6-47.7	33.7	27.1-40.9	12.7	8.6-18.4	34.1	30.0-38.0
Missing	2		2		0		1		5	
Face shield										
Always	19.6	16.0-23.9	28.8	24.4-33.7	31.6	25.3-38.6	42.4	35.7-49.3	29.9	25.9-34.
Not always	80.4	76.1-84.0	71.2	66.3-75.6	68.4	61.4-74.7	57.6	50.7-64.3	70.1	65.8–74.
Missing	2		2		0		1		5	
Goggles/protective glasses										
Always	18.7	15.3-22.7	24.6	20.4–29.3	38.3	31.6-45.4	45.6	38.7 - 52.6	33.2	29.1-37.
Not always	81.3	77.2-84.7	75.4	70.7–79.5	61.7	54.6-68.4	54.4	47.4–61.3	66.8	62.3-70.9
Missing	2		2		0		1		5	
Disposable gown										

Table 2. Adherence to infection prevention and control during healthcare interactions with COVID-19 patients and accidents with biological materials

 For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

 BMJ Open

1											23
2											
3	Always	48.0	43.3-52.9	50.8	45.6-55.9	63.8	56.6-70.4	67.2	60.3-73.3	59.2	54.8-63.5
4	Not always	52.0	47.1–56.7	49.2	44.1-54.4	36.2	29.5-43.4	32.8	26.7-39.7	40.8	36.5-45.2
5	Missing	2		2		0		1		5	
0 7	Waterproof apron										
, 8	Always	30.5	26.2-35.2	38.6	33.7-43.7	48.9	41.6-56.3	62.6	55.3-69.4	44.9	40.5-49.5
9	Not always	69.5	64.8-73.8	61.4	56.3-66.3	51.1	43.7-58.4	37.4	30.6-44.7	55.1	50.5-59.5
10	Missing	14		11		11		18		54	
11	During provision of routine										
12	assistance to COVID-19										
13	patients, did you wear all PPE										
14 15	items as recommended by the										
15		89.6	86 2 92 3	70.2	74 7 83 1	70.0	63 1_76 1	60.0	62 2 75 1	74 7	70 5-78 5
17	Not always	10 /	7 7-13 8	20.8	16 9 25 3	30.0	23 0_36 0	31.0	02.2-73.1 24.9-37.8	25.3	70.5-78.5
18	Missing	10. 4 2	7.7-13.8	20.8	10.9-23.5	0	23.9-30.9	1	24.9-37.8	25.5	21.3-29.5
19	Participated in ACP*	2		2		0		1		5	
20	Vos	70.6	75 2 82 2	75.6	70 9 70 9	82.4	77 88 2	05.8	017078	01 1	70 / 05 5
21	I es	79.0	16.8 24.7	75.0	70.8-79.8	03.4 16.6	117 22	95.8	91.7 - 97.0	02.2	14 5 21 6
22	Missing	20.4	10.6-24.7	24.4	20.2-29.2	10.0	11.7 - 23	4.2	2.1-0.5	17.0	14.3-21.0
23	While participating in ACDs	1		1				2		5	
24 25	while participating in AOPS,										
26	Single Gloves										
27	Always	97.8	95 5_98 9	97 7	95 1_99	98.5	94 2-99 6	99 7	98 1_99 9	98.4	96 4-99 3
28	Not always	22	1 1-4 5	23	1-4.9	1.5	0.4-5.8	0.3	0.04–1.9	1.6	0.7-3.6
29	Missing	0	1.1 1.5	0	1 1.9	0	0.1 5.0	1	0.01 1.9	1.0	0.7 5.0
30	Surgical mask	Ū		Ū		0				1	
31	Always	61.5	56 2-66 6	<u>49 9</u>	44 1-55 7	46.5	38 9-54 3	60.2	52 9-67 1	50.5	45 6-55 3
32	Not always	38.5	33 4-43 8	50.1	44 3-55 9	40.5 53 5	45 7-61 1	39.8	32.9 07.1	20.5 49 5	45.0 55.5
33 34	Missing	0	JJ.+ +J.0	0	1.5 55.7	0	43.7 01.1	1	52.9 47.1	1	
35	N95 respirator	0		0		0		1		1	
36	Always	92 4	89_94 9	85.0	80 3-88 8	84 2	77 8_80 1	93 3	88 2_96 3	86.4	82 5-89 5
37	Not always	7.5 7.6	3 1_11	15.0	11 2_19 7	15 7	10 9_22 2	67	3 7_11 8	13.6	10 5-17 5
38	Missing	7.0 0	5.1-11	13.0	11.2-17.7	13.7	10.9-22.2	1	5.7-11.0	15.0	10.5-17.5
39	Face shield	U		U		U		1		1	
40	race sinciu										

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

2	Λ
_	-

Always	51.6	46.2–56.9	48.3	42.6-54.1	48.0	40.3-55.7	41.4	34.5-48.6	48.1	43.2–53.0
Not always	48.4	43.1-53.8	51.7	45.8–57.4	52.0	44.2–59.7	58.6	51.4-65.5	51.9	47.0–56.8
Missing	0		0		0		1		1	
Goggles/Protective glasses										
Always	62.5	57.1-67.6	59.3	53.5-64.9	51.4	43.6-59.1	47.1	40-54.3	54.0	49.1–58.9
Not always	37.5	32.4-42.8	40.7	35.1-46.5	48.6	40.9-56.4	52.9	45.7 - 60	46.0	41.1-50.9
Missing	0		0		0		1		1	
Disposable gown										
Always	60.3	55.0-65.4	60.1	54.3 - 65.7	64.0	60.3-74.9	68.3	61.3–74.4	65.6	60.8-70.1
Not always	39.7	34.6-45.0	39.9	34.3-45.7	32.0	25.1-39.7	31.7	25.6-38.7	34.4	29.9-39.2
Missing	0		0		0		1		1	
Waterproof apron										
Always	55.2	49.7–60.6	60.7	54.8-66.3	62.5	54.4-69.9	74.6	67.4-80.7	61.9	57.0-66.7
Not always	44.8	39.4-50.3	39.3	33.7-45.2	37.5	30.1-45.6	25.4	19.3-32.6	38.1	33.3-43.0
Missing	9		7		9		17		42	
COVID-19 patients, did you wear all recommended PPE items as in WHO guidance?										
Always	66.0	60.0-71.4	58.0	51.4-64.3	63.8	54.1-72.6	74.7	64.2-82.8	63.7	57.8-69.2
Not always	34.0	28.6-40.0	42.0	35.7-48.6	36.2	27.4-45.9	25.3	17.2-35.8	36.3	30.8-42.2
Missing	0		0		0		1		1	
Duration of N95 respirator use										
< 8 days	50.7	45.8-55.6	71.4	66.6-75.8	79.4	73.0-84.6	54.6	47.6-61.5	71.7	67.9–75.3
\geq 8 days	49.3	44.4-54.2	28.6	24.2-33.4	20.6	15.4-27.0	45.4	38.5-52.4	28.3	24.7-32.1
Missing	9		5		8		4		26	
Any accident involving body fluid/respiratory secretion										
Yes	13.9	11-17.4	10.8	7.9–14.5	11.7	7.9–17.1	7.6	4.9–11.7	11.6	9.1-14.8
No	86.1	82.6-89	89.2	85.5-92.1	88.3	82.9-92.1	92.4	88.3-95.1	88.4	85.2-90.9
Organ involved										
Splash in the Mouth	1.9	1.02-3.8	1.9	0.85-4.3	0.2	0.04-1.5	0.7	0.2-3.1	0.8	0.5-1.4
Splash on the Skin	2.4	1.4-3.9	3.4	1.9-6.0	1.3	0.5-3.2	3.9	1.9–7.7	2.0	1.3-3.0
Splash on the Eyes	2.3	1.4-3.9	3.5	1.9-6.1	2.1	0.8-5.8	2.5	1.2-5.0	2.4	1.4-4.2

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Page	27	of	34
------	----	----	----

2 3 Puncture/sharps 8.2 5.9–11.3 3.0 1.7–5.3 8.2 4.9–13.4 0.0 - 6.7 4 Self-perception of risk 5 None/Low 21.6 17.9–25.9 24.9 20.7–29.6 21.9 16.3–28.7 17.2 12.5–23.3 22.0 7 Medium/High 78.4 74.1–82.1 75.1 70.3–79.3 78.1 71.3–83.7 82.8 76.7–87.5 78.0 8 Missing 9 2 6 4 21 9 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and	4.6–9.7 8.5–26.1 3.8–81.5
4 Self-perception of risk 5 None/Low 21.6 17.9–25.9 24.9 20.7–29.6 21.9 16.3–28.7 17.2 12.5–23.3 22.0 6 Medium/High 78.4 74.1–82.1 75.1 70.3–79.3 78.1 71.3–83.7 82.8 76.7–87.5 78.0 8 Missing 9 2 6 4 21 9 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and	8.5–26.1 3.8–81.5
S None/Low 21.6 17.9–25.9 24.9 20.7–29.6 21.9 16.3–28.7 17.2 12.5–23.3 22.0 7 Medium/High 78.4 74.1–82.1 75.1 70.3–79.3 78.1 71.3–83.7 82.8 76.7–87.5 78.0 8 Missing 9 2 6 4 21 9 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and	8.5–26.1 3.8–81.5
Medium/High78.474.1-82.175.170.3-79.378.171.3-83.782.876.7-87.578.0Missing9264219Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and	'3.8-81.5
 Missing 9 2 6 4 21 9 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and 	unighted
9 Frequency for each professional category: adjusted for cluster random effect and weighted by network size. Total frequency: adjusted for cluster random effect and	waightad
	vergnied
10 by network and population size.	
AGPs, aerosol-generating procedures; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment	WHO,
12 World Health Organization	
13	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
20	
30	
31	
32	
33	
34	
35	
36	
37	
38	

Table 3. Final multivariate model for factors associated with reported positive PCR COVID-19 results

	Odds Ratio	95% CI	P-value
Occupation			
Nurse	1.0		
Physical therapist	1.47	0.80-2.72	0.214
Physician	1.20	0.76-1.90	0.426
Nursing assistant	2.56	1.42-4.61	0.002
Splash on the eyes			
No accident	1.0		
Yes	3.37	1.10-10.34	0.034
Any accident	1.59	0.51-4.90	0.421
Used all PPE items while assisting patients with COVID-19			
Yes	1.0		
No	2.15	1.02-4.53	0.044

Adjusted for cluster random effect and weighted by network and population size COVID-19, coronavirus disease 2019; CI, confidence interval; PPE, personal protective equipment

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Figure Legends

Figure 1. Respondent-driven sampling recruitment chains.

Figure 2. Frequencies of self-reported SARS-CoV-2 infection by healthcare categories.

tor peer terier only



Figure 1. Respondent-driven sampling recruitment chains

338x190mm (170 x 170 DPI)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml





Nursing Assistant Physical therapist Overall Occupation

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open

– Lower Limit – Upper Limit Prevalence(%)

Occupation category Description 0.02 0.02 Physician Registered nurse Nursing assistant Physical therapist 269 (51-1) 227 (52.4) 0.02 Sex 0.43 224(47.6) 247 (52.4) 0.04 Age group, years 0.43 110 (42.0) 152 (58.0) 0.43 Age group, years 0.43 110 (42.0) 152 (58.0) 0.43 Age group, years 0.43 110 (42.0) 152 (58.0) 0.43 Any comorbidity Yes 230 188 (50.0) 188 (50.0) 0.43 Number of workplaces (hospitals/clinics) <3 247 (54.0) 210 (46.0) 0.01 Soft Add Stating Emerg/ICU 565 (47.3) 629 (52.7) 0.39 Muttion provider Private 48 (42.1) 66 (57.9) 0.39 Same N95 respirator, use duration, days ≤7 458 (49.00) 476 (51.0) 230 Self-perceived risk 0 0.43 0.42.7) 0.22 (45.7) 0.22 Self-perceived risk 0 57 243 (43.0) 322 (57			RT-PCR Yes (%)	testing No (%)	<i>P</i> -value
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Occupation category		200 (70)	110 (70)	0.02
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Physician	269 (51.1)	257 (48.9)	
Nursing assistant Physical therapist110 (42-0) 152 (58-0) 158(48-2)152 (58-0) 154(58-8)Sex -0.43 Female Male530 (46-2) 181 (48-5)618 (53-8) 192 (51-5)Age group, years -0.15 < 30 ≥ 30 523 (45-7) 188 (50-0)622 (54-3) ≥ 30 Any comorbidity < 30 ≥ 30 188 (50-0)Number of workplaces (hospitals/clinics) $< 3247 (54-0)$ ≥ 32 210 (46-0) ≥ 32 $< 3247 (54-0)$ $\geq 210 (46-0)$ $> 3247 (54-0)$ $\geq 210 (46-0)$ < 0.01 		Registered nurse	224(47.6)	247(52.4)	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Nursing assistant	110(42.0)	152 (58.0)	
Sex Female Male 530 (46·2) (181 (48·5) 618 (53·8) (192 (51·5) Age group, years 0.15 < 30		Physical therapist	108(41.2)	154(58.8)	
Female Male530 (46-2) (181 (48-5))618 (53-8) (192 (51-5))0.15 (0.15)Age group, years < 30 ≥ 30 188 (50-0) 188 (50-0) < 0.001 (0.001)Any comorbidityYes Yes ≥ 30 246 (56-8) (242 (43-5))187 (43-2) (23 (57-3)) < 0.01 (0.001)Number of workplaces (hospitals/clinics) < 3 	Sex	<i>J</i>			0.43
Age group, yearsMale181 (48-5)192 (51-5)0-15 $\langle 30$ 523 (45-7)622 (54-3) ≥ 30 188 (50-0)(88 (50-0))Any comorbidityYes246 (56-8)187 (43-2) < 0.01 $\langle 32$ 247 (54-0)210 (46-0) ≥ 3 462 (43-5)599 (56-5)Work settingEmerg/ICU565 (47-3)629 (52-7)0.39 $\langle 0.011$ 210 (46-0) ≥ 3 462 (43-5)599 (56-5) < 0.01 Work settingEmerg/ICU565 (47-3)629 (52-7)0.39 $\langle 0.011$ 210 (46-0) ≥ 33 (43-0)522 (57-0) < 0.001 Private48 (42-1)66 (57-9) > 9 > 90 blic393 (43-0)522 (57-0) $\langle 0.023$ 222 (45-1) < 0.023 $< 322 (45-0)$ < 0.023 Performed aerossolYes $600 (47-3)$ $669 (52-7)$ < 0.023 $\langle 57$ 243 (43-0)322 (57-0) < 0.023 $< 57 (54-7)$ < 0.023 Self-perceived riskNone/Low $36 (45-1)$ $43 (54-9)$ < 0.85 Medium/High $665 (46-7)$ $760 (53-3)$ < 0.001 Sick leave due toYes $84 (45-2)$ $102 (54-8)$ < 0.001 COVID-19 symptomsYes $84 (45-2)$ $102 (54-8)$ < 0.001 Ves $80 (168-2)$ $280 (31-8)$ < 0.001 Ves $80 (16-5)$ $659 (83-5)$ < 0.001 Ves $80 (168-2)$ $280 (31-8)$ < 0.001		Female	530 (46.2)	618 (53.8)	
Age group, years 0.15 0.15 0.15 Any comorbidity ≥ 30 188 (50.0) 188 (50.0) Number of workplaces (hospitals/clinics) Yes 246 (56.8) 187 (43.2) Number of workplaces (hospitals/clinics) < 3		Male	181(48.5)	192(51.5)	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Age group, years	illuit	101 (10 5)	1)2 (01 0)	0.15
$\begin{array}{c ccccc} & 230 & 188 (50 \cdot 0) & 188 (50 \cdot 0) \\ \geq 30 & 188 (50 \cdot 0) & 188 (50 \cdot 0) & 188 (50 \cdot 0) \\ & & & & & & & & & & & & \\ & & & & & $	inge group, years	< 30	523 (45.7)	622(54.3)	0 10
Any comorbidity <0.001		> 30	188(50.0)	188(50.0)	
$\begin{array}{c cccc} \mbox{Yes} & 246 (56.8) & 187 (43.2) \\ \mbox{No} & 465 (42.7) & 623 (57.3) \\ \mbox{No} & 465 (42.7) & 623 (57.3) \\ \mbox{Setting} & & & & & & & & & & & & & & & & & & &$	Any comorbidity	2.50	100 (50 0)	100 (50 0)	< 0.001
$\begin{array}{c cccc} & 1.05 & 240 (30) & 163 & 23 \\ & No & 465 (42.7) & 623 (57.3) \\ & & & & & & & & & & & & & & & & & & $	They contorblatey	Ves	246 (56.8)	187 (43.2)	< 0 001
Number of workplaces (hospitals/clinics) < (0.01 <3		No	240(300)	623 (57.3)	
$\begin{array}{c ccccc} < & < < < < < < < < < < < < < < < < < $	Number of workplaces (bospitals/clinics)	110	405 (4217)	025 (57-5)	< 0.01
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Number of workplaces (nospitals/chines)	~3	247(54.0)	210 (46.0)	< 0.01
Work setting 23 402 (43.3) 339 (30.3) 0.39 Institution providerEmerg/ICU Outpat/Inpatients 565 (47.3) 146 (44.7) 629 (52.7) 181 (55.3) <0.001 Institution providerPrivate Both 48 (42.1) 270 (54.9) 66 (57.9) 222 (45.1) <0.001 Performed aerossol generating procedureYes $800h$ 600 (47.3) 270 (54.9) 669 (52.7) $222 (45.1)0.36Performed aerossolgenerating procedureYes800h600 (47.3)110 (44.5)669 (52.7)137 (55.5)Missing0.023Self-perceived risk0.023\leq 7243 (43.0)480.0)0.023Self-perceived risk0.655 (46.7)700 (53.3)0.644fluid/respiratory secretionYesYes84 (45.2)102 (54.8)100 (17.0)0.644fluid/respiratory secretionYesYes84 (45.2)102 (54.8)100 (17.0)530 (82.8)Had COVID-19-like symptoms/signsYesYes800576 (79.7)147 (20.3)N0410 (17.0)530 (82.8)$		\sim	247(34.0)	210(40.0)	
Work setting Emerg/ICU Outpat/Inpatients 565 (47.3) 146 (44.7) 629 (52.7) 181 (55.3) Institution provider Private 9 Public 48 (42.1) 393 (43.0) 666 (57.9) 522 (57.0) Both 270 (54.9) 222 (45.1) Performed aerossol generating procedure Ves 600 (47.3) 669 (52.7) No 110 (44.5) 137 (55.5) 0.36 Same N95 respirator, use duration, days ≤ 7 458 (49.00 476 (51.0) > 7 243 (43.0) 322 (57.0) 0.023 Self-perceived risk 0.435 0.435 Accident involving biological fluid/respiratory secretion 0.651 (45.1) 43 (54.9) Yes 84 (45.2) 102 (54.8) 0.644 Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) <0.001	Work setting	≥ 3	402 (43.3)	399 (30.3)	0.30
Enling TCO 503 (47-3) 029 (32-7) Outpat/Inpatients 146 (44-7) 181 (55-3) Institution provider <0.001	work setting	Emorg/ICU	565 (17 2)	620 (52 7)	0.39
Institution provider Outpat/inpatients 148 (44.7) 181 (35.3) Private 48 (42.1) 66 (57.9)		Outpot/Impotionto	303(47.3)	129(32.7)	
Institution provider		Outpat/Inpatients	146 (44.7)	181 (55.5)	.0.001
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Institution provider	Dalasta	40 (42 1)	((57.0))	< 0.001
Public $393 (43.0)$ $522 (57.0)$ Both $270 (54.9)$ $222 (45.1)$ Performed aerossol0.36generating procedureYes $600 (47.3)$ $669 (52.7)$ No $110 (44.5)$ $137 (55.5)$ Missing $1 (20.0)$ $4 (80.0)$ Same N95 respirator, use duration, days ≤ 7 $458 (49.00$ $476 (51.0)$ Self-perceived risk 0.023 Self-perceived risk 0.85 None/Low $36 (45.1)$ $43 (54.9)$ Medium/High $665 (46.7)$ $760 (53.3)$ Accident involving biological 0.644 fluid/respiratory secretionYes $84 (45.2)$ $102 (54.8)$ No $627 (47.0)$ $708 (53.0)$ 0.644 Fluid/respiratory secretionYes $576 (79.7)$ $147 (20.3)$ No $130 (16.5)$ $659 (83.5)$ < 0.001 Yes $601 (68.2)$ $280 (31.8)$ < 0.001 Yes $601 (68.2)$ $280 (31.8)$ < 0.001		Private	48(42.1)	66 (57.9)	
Performed aerossol generating procedureBoth $2/0 (54.9)$ $222 (43.1)$ Performed aerossol generating procedure0.36Yes $600 (47.3)$ $669 (52.7)$ No $110 (44.5)$ $137 (55.5)$ Missing 0.023 Same N95 respirator, use duration, days ≤ 7 $458 (49.00$ $476 (51.0)$ > 7 $243 (43.0)$ $322 (57.0)$ Self-perceived risk 0.023 ≤ 7 $458 (49.0)$ $476 (51.0)$ > 7 0.023 Accident involving biological fluid/respiratory secretion 0.644 0.644 Yes $84 (45.2)$ $102 (54.8)$ No $0.627 (47.0)$ $708 (53.0)$ Sick leave due to COVID-19 symptomsYes $576 (79.7)$ $147 (20.3)$ No $130 (16.5)$ $659 (83.5)$ Had COVID-19-like symptoms/signsYes $601 (68.2)$ $280 (31.8)$ < 0.001		Public	393 (43.0)	522(57.0)	
Performed aerossol 0.36 generating procedure Yes $600 (47.3)$ $669 (52.7)$ No 110 (44.5) 137 (55.5) Missing 1 (20.0) 4 (80.0) Same N95 respirator, use duration, days ≤ 7 $458 (49.00$ $476 (51.0)$ Self-perceived risk 0.023 Accident involving biological 0.655 (46.7) 760 (53.3) Accident involving biological 0.644 fluid/respiratory secretion Yes $84 (45.2)$ $102 (54.8)$ No 627 (47.0) 708 (53.0) <0.001		Both	270 (54.9)	222 (45.1)	0.04
generating procedure Yes 600 (47.3) 669 (52.7) No 110 (44.5) 137 (55.5) Missing 1 (20.0) 4 (80.0) Same N95 respirator, use duration, days 0.023 ≤ 7 458 (49.00) 476 (51.0) > 7 243 (43.0) 322 (57.0) Self-perceived risk 0.85 None/Low 36 (45.1) 43 (54.9) Medium/High 665 (46.7) 760 (53.3) Accident involving biological 0.644 fluid/respiratory secretion Yes 84 (45.2) 102 (54.8) No 627 (47.0) 708 (53.0) Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)	Performed aerossol				0.36
Yes $600 (47.3)$ $669 (52.7)$ $110 (44.5)$ $137 (55.5)$ $137 (55.5)$ Same N95 respirator, use duration, days < 7 $458 (49.00)$ $476 (51.0)$ > 7 $243 (43.0)$ $322 (57.0)$ Self-perceived risk 0.023 ≤ 7 $458 (49.00)$ $476 (51.0)$ > 7 $243 (43.0)$ $322 (57.0)$ Self-perceived risk $0.65 (46.7)$ $760 (53.3)$ Accident involving biological fluid/respiratory secretion 0.644 Yes $84 (45.2)$ $102 (54.8)$ No $0.627 (47.0)$ Sick leave due to COVID-19 symptomsYes $576 (79.7)$ $147 (20.3)$ NoYes $576 (79.7)$ $147 (20.3)$ No $130 (16.5)$ $659 (83.5)$ Had COVID-19-like symptoms/signsYes $601 (68.2)$ $280 (31.8)$ Yes $601 (68.2)$ $280 (31.8)$ 0.001	generating procedure				
No $110 (44.5)$ $137 (55.5)$ Missing $1 (20.0)$ $4 (80.0)$ Same N95 respirator, use duration, days 0.023 Self-perceived risk 0.023 Self-perceived risk 0.023 Accident involving biological fluid/respiratory secretion 0.023 Yes $84 (45.2)$ $0.322 (57.0)$ Sick leave due to COVID-19 symptoms $0.627 (47.0)$ $760 (53.3)$ Had COVID-19-like symptoms/signsYes $576 (79.7)$ $147 (20.3)$ No $130 (16.5)$ Had COVID-19-like symptoms/signsYes $601 (68.2)$ $280 (31.8)$ No $110 (17.0)$ $530 (82.8)$ 0.021		Yes	600 (47.3)	669 (52.7)	
Same N95 respirator, use duration, daysMissing $1 (20 \cdot 0)$ $4 (80 \cdot 0)$ Self-perceived risk $0 \cdot 023$ Self-perceived risk $0 \cdot 023$ Accident involving biological fluid/respiratory secretion $0 \cdot 023$ Yes $84 (45 \cdot 2)$ $102 (54 \cdot 8)$ $0 \cdot 053 \cdot 0)$ Sick leave due to COVID-19 symptoms $0 \cdot 023$ Yes $576 (79 \cdot 7)$ $147 (20 \cdot 3)$ $130 (16 \cdot 5)$ Yes $601 (68 \cdot 2)$ $280 (31 \cdot 8)$ $110 (17 \cdot 0)$ Yes $601 (68 \cdot 2)$ $280 (31 \cdot 8)$		No	110 (44.5)	137 (55.5)	
Same N95 respirator, use duration, days 0.023 ≤ 7 $458 (49.00)$ $476 (51.0)$ >7 $243 (43.0)$ $322 (57.0)$ Self-perceived risk 0.85 None/Low $36 (45.1)$ $43 (54.9)$ Accident involving biological 0.623 fluid/respiratory secretion $0.65 (46.7)$ $760 (53.3)$ Yes $84 (45.2)$ $102 (54.8)$ No $627 (47.0)$ $708 (53.0)$ Sick leave due to < 0.001 COVID-19 symptoms Yes $576 (79.7)$ $147 (20.3)$ No $130 (16.5)$ $659 (83.5)$ < 0.001 Yes $601 (68.2)$ $280 (31.8)$ < 0.001		Missing	1(20.0)	4 (80.0)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Same N95 respirator, use duration, days				0.023
>7 243 (43.0) 322 (57.0) Self-perceived risk 0.85 Accident involving biological fluid/respiratory secretion 065 (46.7) 760 (53.3) Yes 84 (45.2) 102 (54.8) No 627 (47.0) 708 (53.0) Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		≤7	458 (49.00	476 (51.0)	
Self-perceived risk 0.85 None/Low 36 (45.1) 43 (54.9) Accident involving biological 0.655 (46.7) 760 (53.3) fluid/respiratory secretion Yes 84 (45.2) 102 (54.8) No 627 (47.0) 708 (53.0) Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		>7	243 (43.0)	322 (57.0)	
None/Low 36 (45·1) 43 (54·9) Accident involving biological Medium/High 665 (46·7) 760 (53·3) fluid/respiratory secretion Yes 84 (45·2) 102 (54·8) No 627 (47·0) 708 (53·0) Sick leave due to COVID-19 symptoms Yes 576 (79·7) 147 (20·3) No 130 (16·5) 659 (83·5) Had COVID-19-like symptoms/signs Yes 601 (68·2) 280 (31·8) No 110 (17·0) 530 (82·8)	Self-perceived risk				0.85
Accident involving biological fluid/respiratory secretion Medium/High 665 (46.7) 760 (53.3) Yes 84 (45.2) 102 (54.8) No 627 (47.0) 708 (53.0) Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		None/Low	36 (45.1)	43 (54.9)	
Accident involving biological 0.644 fluid/respiratory secretion Yes 84 (45.2) 102 (54.8) No 627 (47.0) 708 (53.0) Sick leave due to COVID-19 symptoms Yes 576 (79.7) 147 (20.3) No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		Medium/High	665 (46.7)	760 (53.3)	
fluid/respiratory secretion Yes 84 (45·2) 102 (54·8) No 627 (47·0) 708 (53·0) Sick leave due to < 0·001	Accident involving biological				0.644
Yes 84 (45·2) 102 (54·8) No 627 (47·0) 708 (53·0) Sick leave due to COVID-19 symptoms Yes 576 (79·7) 147 (20·3) No 130 (16·5) 659 (83·5) Had COVID-19-like symptoms/signs Yes 601 (68·2) 280 (31·8) No 110 (17·0) 530 (82·8)	fluid/respiratory secretion				
No 627 (47.0) 708 (53.0) Sick leave due to < 0.001		Yes	84 (45.2)	102 (54.8)	
Sick leave due to COVID-19 symptoms < 0.001 Had COVID-19-like symptoms/signs Yes No 576 (79.7) 147 (20.3) (16.5) Yes 601 (68.2) 280 (31.8) No < 0.001		No	627 (47.0)	708 (53.0)	
COVID-19 symptoms Yes 576 (79·7) 147 (20·3) No 130 (16·5) 659 (83·5) Had COVID-19-like symptoms/signs < 0·001	Sick leave due to				< 0.001
Yes $576(79\cdot7)$ $147(20\cdot3)$ $130(16\cdot5)$ Had COVID-19-like symptoms/signs < 0.001 Yes $601(68\cdot2)$ $280(31\cdot8)$ $110(17\cdot0)$ So $110(17\cdot0)$ $530(82\cdot8)$	COVID-19 symptoms				
No 130 (16.5) 659 (83.5) Had COVID-19-like symptoms/signs < 0.001 Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		Yes	576 (79.7)	147 (20.3)	
Had COVID-19-like symptoms/signs < 0.001 Yes 601 (68.2) 280 (31.8) No 110 (17.0) 530 (82.8)		No	130 (16.5)	659 (83.5)	
Yes $601 (68.2) 280 (31.8)$ No $110 (17.0) 530 (82.8)$	Had COVID-19-like symptoms/signs				< 0.001
No $110(17.0)$ $530(82.8)$	v x - 0	Yes	601 (68.2)	280 (31.8)	
		No	110 (17.0)	530 (82.8)	
COVID-19, coronavirus disease 2019; RT-PCR, reverse transcription polymerase chain reaction	COVID-19, coronavirus disease 2019; RT-PCH	R, reverse transcriptio	on polymerase c	chain reaction	

Supplementary Table 1. Characteristics of the study population according to RT-PCR testing

Supplementary Table 2. Potential risk factors for reporting a positive PCR COVID-19 result among front line healthcare professionals

	Odds Ratio	95% CI	P-value
Sex			
Female	1.0		
Male	1.35	0.78-2.34	0.288
Age, years	1.03	0.65 - 1.64	0.889
Occupation			
Nurse	1.0		
Physical therapist	1.42	0.88 - 2.27	0.14
Physician	1.32	0.91–1.91	0.142
Nursing Assistant	2.77	1.64-4.67	< 0.00
Any comorbidity	1.19	0.75 - 1.90	0.454
Number of workplaces			
< 3	1.0		
<u>≥</u> 3	0.83	0.53-1.30	0.428
Institution provider			
Private	1.0		
Public	0.92	0.42 - 2.02	0.844
Both	0.93	0.41 - 2.10	0.86
Work setting			
Outpatient /Inpatient clinics	1.0		
ICU/Emergency	1.54	0.92-2.60	0.102
Training on PPE use	1.06	0.62 - 1.80	0.829
Any accident involving body fluid/respiratory secretion	2.67	1.22–5.82	0.014
Splash in the mouth			
No accident	1.0		
Yes	3.84	0.64–22.95	0.140
Other accident	2.30	0.85-6.23	0.102
Splash on the skin			
No accident	1.0		
Yes	1.86	0.54-6.44	0.328
Other accident	2.50	0.80-7.85	0.110
Splash in the eyes			
No accident	1.0		
Yes	4.07	1.14-14.55	0.03
Other accident	2.07	0.71-6.08	0.184
Puncture/sharp accident			
No accident	1.0		
Yes	2.25	0.51-9.89	0.282
Other accident	2.51	1.10-5.72	0.02
Duration N95 respirator use			
< 8 days			
$\geq 8 \text{ days}$	0.96	0.59–1.55	0.869
Used All PPE items during AGP#			
Did not Always use	1.68	0.97-2.92	0.06

Used all PPE items while assisting			
COVID-19 patients			
Yes	1.0		
No	2.14	1.18-3.88	0.013
Time on the front-line, days	0.997	0.994-1.000	0.042
A 1'	-l	1-+i	

Adjusted for cluster random effect and weighted by network and population size.

AGP, aerosol-generating procedure; COVID-19, coronavirus disease 2019; CI, confidence interval; ICU, intensive care unit; PPE, personal protective equipment

For peer review only
Tabela 1. STROBE-RDS Statement Checklist for the manuscript title "High risk of SARS-CoV-2 infection among frontline healthcare workers in Northeast Brazil: a respondent-driven sampling approach"

Item	#	STROBE-RDS checklist	Main Document
Title and abstract	1	(a) Indicate "respondent-driven sampling" in the title or abstract	Page:1/ Line: 1-2
		(b) Provide in the abstract an informative and balanced summary	Page:3/ Line:2-23
		of what was done and what was found	
Introduction			
Background/	2	Explain the scientific background and rationale for the	Page:5/ Line: 2-34;
rationale	-	Investigation being reported	Page:6/ Line: 1-6
<u>Objectives</u>	3	State specific objectives, including any prespecified hypotheses	Page:6/ Line: 7-9
Study design	1	(a) Present key elements of study design early in the article	Page: 6/ Line: 13-18
Study design		(a) Firesent key elements of study design early in the article (b) State why RDS was chosen as the sampling method	Page:6/ Line: 15-17
Setting	5	(a) Describe the setting locations and relevant dates including	Page:6/ Line: 23-28
		periods of recruitment and data collection	Page:7/ Line: 13-14
		(b) Describe formative research findings used to inform RDS	Page:6/ Line: 31-34
		study	
Participants	6	(a) Give the eligibility criteria and the sources and methods of	Page:7/ Line: 13-18
		selection of participants. Describe how participants were	
		trained/instructed to recruit others, number of coupons issued per	
		person, any time limits for referral	D 7/1: 10.05
		(b) Describe methods of seed selection and state number at start	Page: 7/ Line: 19-25
		(c) State if there was any variation in study procedures during	Page:7/Line:17
		data collection (e.g., changing numbers of coupons per recruiter	1 age. // Line. 17
		interruptions in sampling, or (stopping recruitment chains)	
		(d) Report wording of personal network size question(s)	Page: 7/ Line: 21-25
		(e) Describe incentives for participation and recruitment	Page:7/ Line: 17-18
Variables	7	(a) If applicable, clearly define all outcomes, correlates,	Page:7/ Line: 28-32
		predictors, potential confounders, effect modifiers, and diagnostic	Page:8/ Line: 1-20
		criteria	
		(b) State recruitment relationship was tracked	Page:9/ Line: 22-23
Data sources/	8	(a) For each variable of interest, give sources of data and details	Page:8/ Line: 31-34
measurement		of methods of measurement. Describe comparability of	Page:9/ Line: 1-10
		(b) Describe methods to assess eligibility and reduce repeat	Page: 8/ Line: 23-25
		enrollment (e.g. coupon manager software biometrics)	1 age. 0/ Line. 25-25
Bias	9	Describe any efforts to address potential sources of bias	Not done
Study size	10	Explain how the study size was arrived at	Page: 7/ Line: 19-20
Quantitative	11	Explain how quantitative variables were handled in the analyses.	Page:7/ Line: 28-32
variables		If applicable, describe which groupings were chosen and why	Page:8/ Line: 1-16
			Page:8/ Line: 31-34
			Page:9/ Line: 1-10
Statistical methods	12	(a) Describe all statistical methods, including those to account for	Page:8/ Line: 31-34
		sampling strategy (e.g., the estimator used) and, if applicable,	Page:9/ Line: 1-10
	-	those used to control for confounding	Daga: 0/Lina: 11.12
		(b) State data analysis software, version number, and	Page.9/ Line. 11-12
		(c) Describe any methods used to examine subgroups and	Not applicable
		interactions	
		(d) Explain how missing data were addressed	Page: 9/ Line: 1-3
		(e) Describe any sensitivity analyses	Not done
		(f) Report any criteria used to support statements on whether	Not done
		estimator conditions or assumptions were appropriate	
		(g) Explain how seeds were handled in analysis	Page:9/ Line: 3-4
Results			
Participants	13	(a) Report the numbers of individuals at each stage of the	Page:9/ Line: 19-23
		study, for example, numbers potentially eligible,	

		examined for eligibility confirmed eligible included in	
		the study, and analyzed	
		(b) Give reasons for nonparticipation at each stage (e.g., not eligible, does not consent, decline to recruit others)	Page:9/ Line: 21-22
		(c) Consider use of a flow diagram	Not included as Flowchart due to limited number of Figures of the Journal
		(d) Report number of coupons issued and returned	Not applicable
		(e) Report number of recruits by seed and number of RDS recruitment waves for each seed. Consider showing graph of entire recruitment network	Page:9/ Line: 22-23 Figure 1
		(f) Report recruitment challenges (e.g., commercial exchange of coupons, imposters, duplicate recruits) and how addressed	Not Done
		(g) Consider reporting estimated design effect for outcomes of interest	Page:11/ Line:7-13
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and, if applicable, information on correlates and potential confounders. Report unweighted sample size and percentages, estimated population proportions or means with estimated precision (e.g., 95% confidence interval)	Page:9/ Line: 26-34 Page:10/ Line: 1-32
		(b) Indicate the number of participants with missing data for each variable of interest	Page: 20-24
Outcome data	15	If applicable, report number of outcome events or summary measures	Page:11/ Line: 7-13
Main results	16	(a) Give unadjusted and study design adjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence intervals). Make clear which confounders were adjusted for and why they were included	Page:11/ Line: 19-33
		(b) Report category boundaries when continuous variables were categorized	Not applicable
		(c) If adjustment of primary outcome leads to marked changes, report information on factors influencing the adjustments (e.g., personal network sizes, recruitment patterns by group, key confounders)	The adjustment only modified slightly not affecting the general results
Other analyses	17	Report other analyses done for example, analyses of subgroups and interactions, sensitivity analyses, different RDS estimators and definitions of personal network size	All analyses were reported
Discussion			
Key results	18	Summarize key results with reference to study objectives	Page:12/ Line: 2-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page:14/ Line: 9-34 Page:15/ Line: 1-7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page:12/ Line: 14-33 Page:13/ Line: 1-34
Generalizability	21	Discuss the generalizability (external validity) of the study results	Page:13/ Line:30-34 Page:14/ Line: 1-8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original	Page:16/ Line: 13-16
		study on which the present article is based	