COVID-19 AND HEALTH CARE WORKER EXPOSURE AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

Dr. Sara Chaya Glatt

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements of the degree of Master of Medicine in the branch of Dermatology

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DECLARATION

I, Sara Chaya Glatt, declare that this research report is my own work. It is being submitted for the degree of Master of Medicine (in the submissible format with my protocol and extended literature review) at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Dr. Sara Chaya Glatt

5th day of December 2021 in Johannesburg

DEDICATION

With dedication to:

My husband Steve and my daughter Emma.

The healthcare workers working tirelessly at the frontline, putting themselves at risk to save others.

ABSTRACT

Background: Health care workers (HCWs) are at an increased risk of acquiring coronavirus disease 2019 (COVID-19). Appropriate risk assessments and testing are essential to reduce transmission and avoid workforce depletion.

Objective: Investigate the risk of COVID-19 infection among HCWs at Chris Hani Baragwanath Academic Hospital who fulfil the Person Under Investigation (PUI) case definition or had exposure to a confirmed COVID-19 contact.

Methods: A retrospective review of HCW records was conducted over a two month period. Data collected included demographics, exposure type, risk level, and COVID-19 test result. Frequency distribution tables, bivariate analyses and univariate and multivariate analyses were conducted.

Results: Among the 1111 HCWs reviewed, 643 were tested with 35.6% positive results. PUI's accounted for 62.4% of positive cases. Symptomatic HCWs with no known contact were at a greater risk of infection than those with a patient exposure (p=0.000). Risk of testing positive was higher after a patient exposure (p=0.000) compared to a co-worker contact.

Conclusion: There is a higher positivity rate among HCWs than the general population. The presence of symptoms warrants testing. Nosocomial transmission was derived from patient more than co-worker contacts.

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NOMENCLATURE

ARDS	Acute respiratory distress syndrome
ARI	Acute respiratory illness
CDC	Centre for Disease Control
CHBAH	Chris Hani Baragwanath Academic Hospital
COVID-19	Coronavirus disease 2019
DOH	Department of Health
HCW	Health care worker
HIV	Human immunodeficiency virus
HOD	Head of Department
HRE	High risk exposure
IPC	Infection prevention control
LRE	Low risk exposure
MERS	Middle east respiratory syndrome
NICD	National Institute of Communicable Diseases
OHS	Occupational health and safety
PPE	Personal protective equipment
PUI	Person under investigation
RAQ	Risk assessment questionnaire
RNA	Ribonucleic acid
RT-PCR	Real-time polymerase chain reaction
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
TB	Tuberculosis
WHO	World Health Organization

CHAPTER 1: PROTOCOL WITH EXTENDED LITERATURE REVIEW

1.1 Health care worker exposure

The nature of many health care workers' (HCWs) occupation is that of close contact with ill patients. This makes HCWs vulnerable to occupationally acquired infectious diseases and often when outbreaks of infectious diseases occur, HCWs are the most affected. Blood borne infections such as hepatitis B, hepatitis C, and human immunodeficiency virus (HIV) have transmission rates from patient to HCW of up to 30%, 1.8%, and 0.3% respectively (1). HCWs are also at increased risk of infections transmitted via droplet spread such as viral haemorrhagic fevers (2) or airborne transmission such as tuberculosis (TB) (3) compared to the general population. These infectious diseases can carry high morbidity and mortality. For example, the Ebola outbreak in Sierra Leone in 2014 resulted in 250 infected HCWs and 125 HCW deaths (2).

1.2 Occupational health

Occupational health services (OHS) in hospitals should protect HCWs against potential hazards at work, provide management for any illness or injury arising out of work, ensure HCWs are suited to and adapted to their jobs, and promote wellness (4). There is substantial variability between hospitals and provinces in South Africa concerning the range of OHS provided. One study found that only 32% of hospitals had an OHS clinic, and many of them were not staffed with qualified OHS professionals (5). In South Africa, OHS deals with the prevention and management of a variety of infectious diseases. The Coronavirus disease 2019 (COVID-19) pandemic has introduced a new hazard into the workplace. A meta-analysis looking at studies worldwide showed an increased prevalence of COVID-19 among HCWs as compared to the general population (6). In the UK and USA, HCWs had an up to 12 times increased risk of COVID-19 infection compared to the general population (7) and in Scotland, patient-facing HCWs were at threefold increased risk of hospital admission from COVID-19 (8). The National Institute of Communicable Diseases (NICD) hospital surveillance report released in May 2021, reported that 3.5% of all COVID-19 hospital admissions were HCWs and 11.2% of them died (9). There is now an added role of OHS in hospitals to implement precautions and procedures in the work place in order to protect the health and safety of HCWs during this pandemic.

1.3 Coronavirus disease 2019

1.3.1 Epidemiology

COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The WHO declared the COVID-19 outbreak as a global public health emergency on the 30 January 2020 (10). South Africa's first case was reported on 5 March 2020 and as of 13th September 2021 there were 2 860 835 positive cases and 85 002 deaths reported in South Africa (11). Transmission occurs via aerosols or droplets that contain the virus and are inhaled or come into direct contact with mucous membranes (12, 13). The incubation period of COVID-19 is between 1-14 days (14) with a mean incubation period of 5,2 days (15). SARS-CoV-2 is highly contagious. An epidemiological study of the COVID-19 outbreak in China found that in about 30 days the virus had spread rapidly from one city to the entire country (16). The SARS-CoV-2 reproductive number (R0 – the number of secondary cases directly caused by one case in a susceptible population) is estimated to be between 2.4 and 3.1 (17). In comparison to the other coronaviruses, severe acute respiratory syndrome (SARS) has an R0 between 2-5 and middle east respiratory syndrome (MERS) R0 less than 1 (14). Emerging variants of SARS-CoV-2 have been discovered with increasing transmissibility and virulence (18). The delta variant, responsible for 53% of new infections in June 2021 in South Africa has shown to be 97% more transmissible than the original lineage (19).

1.3.2 Flattening the curve

Governments of many countries have instituted mitigation or suppression strategies aimed at reducing the spread of disease. In China, for example, suppression strategies were aimed at reducing the R0 to less than one. This involved drastic quarantine measures and other restrictions (20). Other countries such as Spain and South Africa have been proactive and have launched mitigation strategies. These strategies aim to flatten the epidemic curve by slowing the spread of the pandemic. The intention of flattening the curve is to give time for the health care system and other facilities to prepare and ease the effects of the pandemic. Mitigation strategies include infection prevention and control (IPC) measures such as social distancing, the mandatory wearing of facemasks, and vigilant hand hygiene. Physical distancing measures taken by the government in South Africa included the closure of schools, stadiums, cinemas, and travel restrictions (11). A study done in Spain evaluating the mitigating strategies implemented by the Spanish government found that they were successful in flattening the curve (21). A systematic review and meta-analysis by Chu et al, found that across 16 countries the

implementation of physical distancing and wearing of personal protective equipment (PPE) (such as facemasks and eye coverings) in public and adequate IPC measures in health care settings, resulted in a large reduction in risk of infection (22).

1.3.3 Clinical presentation

The clinical presentation is that of respiratory symptoms ranging in severity from asymptomatic to severe pneumonia leading to acute respiratory distress syndrome (ARDS). The NICD defines a person under investigation (PUI) as a person with acute respiratory illness with sudden onset (less than or equal to 14 days) of at least one of the following: a cough, sore throat, shortness of breath, or anosmia/ dysgeusia with or without other symptoms (23). The majority of cases have been reported as mild, with 14% severe and 5% critical (24). A proportion of the severely and critically ill group required intensive care admission and mechanical ventilation. A 3-stage classification system has been proposed by Siddiqi et al. Stage I - early infection (mild) occurs at the time of infection as the virus triggers the non-specific symptoms. Stage II (established pulmonary disease) is characterized by viral multiplication and localized pulmonary inflammation triggered by the host. Stage III - hyperinflammation phase (severe) manifests as an extra-pulmonary systemic hyperinflammation syndrome (25).

1.3.4 Nosocomial transmission

Nosocomial transmission of COVID-19 to patients and HCWs is a major concern as an amplifier of local transmission. Countries worldwide including China (26), United Kingdom (27, 28) and the United States (29) have shown rapid spread of COVID-19 through health care facilities.

A nosocomial outbreak of COVID-19 that occurred at St. Augustine's Hospital in Durban, South Africa highlighted these concerns. A thorough investigation was conducted to determine how the spread of infection occurred through the hospital. The investigation concluded that a single patient admitted to the Emergency Department most likely caused the hospital outbreak. Subsequent to this, there were 119 confirmed COVID-19 cases at St. Augustine's Hospital. Of these cases, 80 were staff members and 39 were patients. The predominant modes of transmission in this outbreak were hypothesized to be via indirect contact through HCWs or fomite transmission (30). The St. Augustine's outbreak highlights the rapid spread of COVID-19 and that HCWs are implicated in amplifying nosocomial transmission. The

recommendations of this investigation emphasized the importance of staff training, adherence to IPC protocols, and regular staff testing.

1.4 Covid-19 and health care workers at Chris Hani Baragwanath Academic Hospital

1.4.1 Staffing crisis

SARS-CoV-2 has caused a global health emergency and has placed unprecedented stress on health care systems worldwide. Chris Hani Baragwanath Academic Hospital (CHBAH) is the third-largest hospital in the world with approximately 3200 beds (31) and an average nurse to patient ratio of 3:31 (32). Prior to COVID-19, staff shortages were already a challenge (32) and during the COVID-19 pandemic, with quarantine periods and HCWs absent due to illness, ensuring adequate staffing has been a major obstacle. Registrars, consultants, and medical officers from departments such as Surgery, Urology, and Orthopaedics were required to work in the Internal Medicine COVID wards. Dermatology staff were involved in infection control and occupational health. All departments at CHBAH were required to work together and contribute towards managing the COVID-19 pandemic in order maintain a balance between keeping HCWs and patients safe as well as endeavouring to offer the best possible health care to our patients.

1.4.2 Personal protective equipment

Personal protective equipment (PPE) has been proven to reduce transmission of COVID-19 and is the cornerstone to limiting hospital-acquired infections when used correctly (22). Global and local shortages of PPE have occurred and therefore appropriate use needs to be advocated to curb transmission and prevent waste (33).

1.4.3 Risk assessment

While underuse of appropriate risk assessments and testing will result in rapid spread amongst HCWs and patients, overzealous quarantine or under-testing of exposed HCWs may result in unnecessary and unaffordable depletion of an already strained workforce (34). For example, in the United Kingdom, when 125 000 HCWs were self-isolating, less than 2% had been tested (35) although only one in seven self-isolating HCWs who were tested for COVID-19 had a positive result (36) and therefore many HCWs were unnecessarily absent from work. In addition, there are multiple limitations to interpreting a negative test result including sample technique, transportation process, limited gene detection of currently used real-time polymerase chain reaction (RT-PCR) test kits, and incubation period (37). While one study

recommends mass testing of all HCWs, both symptomatic and asymptomatic (38), the test limitations described above, in addition to resource constraints in the public sector in South Africa, preclude this approach. To optimise health care services and protect HCWs during this pandemic, clear guidelines are required to determine if / when an exposed HCW should be tested and / or self-isolate or continue to work.

As such, internationally, the Centre for Disease Control (CDC) (39) and World Health Organisation (WHO) (40) have published guidelines for the risk assessment and management of exposed and symptomatic HCWs. Based on these guidelines, the South African Department of Health (DOH) has issued guidelines relevant to the South African setting (41). The CHBAH OHS department used these guidelines to develop risk assessment tools and algorithms for exposed and symptomatic HCWs. These guidelines have since been amended by reducing isolation and quarantine periods from 14 to 10 days.

The CHBAH questionnaire entitled "risk assessment questionnaire" (RAQ) tool was aimed at collecting the relevant information and using it to categorise HCWs into high-risk exposure (HRE), low-risk exposure (LRE), or PUI groups. It contained four sections. The first section stipulated the demographics of the HCW. The second section established whether the COVID positive contact was a patient, colleague, family member, or community contact. The third section, regarding variables such as duration of contact and proximity of contact, was used to establish if the contact was a HRE or a LRE. A HRE was defined as exposure within one meter to a confirmed COVID-19 case that lasts for more than 15 minutes without appropriate PPE or failure of PPE and/or direct contact with respiratory secretions (41). A LRE was defined as an exposure more than one meter away from a COVID-19 confirmed case for less than 15 minutes OR within one meter but wearing appropriate PPE (41). The last section established if symptoms included in the PUI definition were present.

Based on the information from the RAQ, two screening algorithms were used to guide the management of HCWs. The first algorithm applied to an asymptomatic HCW that comes into contact with a COVID-19 positive case. After the HCW reported the exposure to the line manager and OHS, a risk assessment was done to establish whether the exposure was a HRE or a LRE. The algorithm then outlined management depending on the risk category whether the HCW needed to self-isolate or was able to continue work. The second algorithm outlined the management for a symptomatic HCW that fulfilled the PUI definition. This algorithm included the requirement for testing of a PUI and further management based on this result.

South Africa is currently in a third wave, with a possible fourth wave predicted to occur later this year. This is likely to put even more strain on the health care system. There is emerging data internationally evaluating risk assessment and testing procedures for HCWs (42), however, local data is lacking.

As such it is a research priority to assess the effectiveness of these risk assessment and testing processes in their ability to protect HCWs and patients, reduce the spread of COVID-19 in the hospital and mitigate workforce depletion for evidence-based decisions to be made.

1.5 Aim

This study aims to assess the risk of COVID-19 among HCWs who fulfil the COVID-19 PUI case definition or exposure to a confirmed COVID-19 contact.

1.6 Objectives

1. To describe the demographics of HCWs that were included in this study.
2. To compare the HRE, LRE, and PUI groups to the COVID-19 test results.
3. To determine the socio-demographic factors associated with a positive COVID-19 test result.

1.7 Methods

1.7.1 Study setting and design

This is a retrospective review of the RAQs of HCWs that were exposed to and/or tested for COVID-19 by the CHBAH OHS department over two months, from 1st May 2020 to 1st July 2020. HCWs were managed as per the NICD and South African DOH guidelines. COVID-19 PCR tests were done on all PUI's, all the HRE on day 8 post exposure and HCWs in the LRE group that became symptomatic. This period was during the first wave of infections of the COVID-19 pandemic in South Africa and therefore appropriate risk assessment and management was crucial to reduce transmission.

1.7.2 Study population

The study population will include:

1. Asymptomatic HCWs exposed to a confirmed positive case.
2. Symptomatic HCWs who meet the criteria of the PUI definition.

1.7.3 Inclusion criteria

For comprehensive and effective management, all staff working at CHBAH regardless of designation (including allied staff, security, and cleaning personnel) will be included as HCWs. Allied staff included physiotherapy, occupational therapy, speech and hearing therapy, and dietetics.

1.7.4 Exclusion criteria

Staff not directly employed by CHBAH, such as medical students and non-governmental organisation (NGO) staff. Records with missing data will be excluded.

1.8 Data collection

The RAQ will be used as the source document for clinical data. All patient identifiers will be removed from the final data analysis. Each patient will receive a study number, which will be different from the identifiable hospital number. The study number will be kept separately from the patient identification data set. Data will be entered into an excel spreadsheet.

The following data will be included (see Appendix 1: Data Information Sheet): Demographics (age, gender), designation, department, exposure type, risk level, COVID-19 test result (if tested). Only doctors and nurses will be analysed with regard to "department" as other HCWs work in multiple areas.

1.9 Sample size

Convenience sampling will be used as this time frame was during the peak of the first wave. It is anticipated that approximately 1000 HCWs will fulfil the criteria for inclusion in this study.

1.10 Data analysis

Frequency distribution tables showing percentages and numbers will be used to describe the categorical variables such as designation. Frequency distribution tables will also be used to describe categorical variables with the outcome (COVID positive and COVID negative result). For the description of continuous variables we will use means and standard deviations (for parametric data) or medians and interquartile ranges (for non-parametric data) for each group. These will be done to describe the three objectives. bivariate analyses will be conducted for paired combinations of either categorical variables, continuous variables, or both. For two

independent categorical variables, the Pearson's chi-square test will be utilised. The univariate and multivariable logistic regression procedure will be used for the third objective to determine the factors associated with positivity in HCWs. A systematic stepwise regression procedure will be used, that is allowing variables showing marginal significance from the univariate to be included in the multivariable analyses and also adaptation of the automated forward and backward elimination logistic regression to come up with the final multivariable analysis. A p-value < 0.05 will be considered significant.

1.11 Ethics

An application has been submitted to the Human Research and Ethics Committee of the University of Witwatersrand. Approval from the CHBAH management has been granted subject to approval from HREC.

1.12 Timeline

Activity	May 2020	June 2020	July/ Aug 2020	Sept/ Oct 2020	Nov/Dec 2020	Jan/Feb/ Mar/Apr 2021	May/June/ July 2021	Aug/ Sept 2021
Preparing Protocol								
Ethics application								
Protocol Assessment								
Collect data and analyse								
Publish research outputs								

1.13 Funding

Stationary, printing, and photocopying costs of approximately R1000 will be self-funded.

1.14 Limitations

Some RAQs were incomplete. Testing was done only on HCWs who fulfilled criteria based on the South African DOH guidelines, therefore the true prevalence of asymptomatic infection in LREs will not be able to be determined. The HCW screening algorithm relied on self-reporting and HCWs might have had a recall bias.

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CHAPTER 2: SUBMISSIBLE ARTICLE

Title: COVID-19 and health care worker exposure at Chris Hani Baragwanath Academic Hospital

Authors:

Sara Chaya Glatt[1]

Lai ling Winchow[2]

Merika Tsitsi[2]

Eustasius Musenge[3]

Colin Nigel Menezes[2]

Affiliations: [1] Division of Dermatology, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. [2]Department of Internal Medicine, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. [3]School of Public Health, University of the Witwatersrand, Johannesburg, South Africa.

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Corresponding author: Dr. Sara Chaya Glatt

Division of Dermatology, Department of Internal Medicine

Chris Hani Baragwanath Academic hospital

Email: drsaraglatt@gmail.com

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Abstract

Background: Health care workers (HCWs) are at an increased risk of acquiring coronavirus disease 2019 (COVID-19). Appropriate risk assessments and testing are essential to reduce transmission and avoid workforce depletion.

Objective: Investigate the risk of COVID-19 infection among HCWs at Chris Hani Baragwanath Academic Hospital who fulfil the Person Under Investigation (PUI) case definition or had exposure to a confirmed COVID-19 contact.

Methods: A retrospective review of HCW records was conducted over a two month period. Data collected included demographics, exposure type, risk level, and COVID-19 test result. Frequency distribution tables, bivariate analyses and univariate and multivariate analyses were conducted.

Results: Among the 1111 HCWs reviewed, 643 were tested with 35.6% positive results. PUI's accounted for 62.4% of positive cases. Symptomatic HCWs with no known contact were at a greater risk of infection than those with a patient exposure (p=0.000). Risk of testing positive was higher after a patient exposure (p=0.000) compared to a co-worker contact. HCWs in Paediatrics had the highest risk of infection (p=0.002).

Conclusion: There is a higher positivity rate among HCWs than the general population. The presence of symptoms warrants testing. Nosocomial transmission was derived from patient more than co-worker contacts.

Introduction

Coronavirus disease 2019 (COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The World Health Organisation (WHO) declared the COVID-19 outbreak as a global public health emergency on 30 January 2020 (1). South Africa's first case was reported on 5 March 2020 and as of 13th September 2021 there were 2 860 835 positive cases and 85 002 deaths reported in South Africa (2).

Healthcare workers (HCW) are at an increased risk of acquiring SARS-CoV-2 infection than the general population. International data has shown that the estimated prevalence of SARS-CoV-2 in HCWs to be 11% (3). In the UK and the USA, HCWs had an up to 12 times increased risk of COVID-19 infection compared to the general population (4) and in Scotland, patient-facing HCWs were at a threefold increased risk of hospital admission from COVID-19 (5). The National Institute of Communicable Diseases (NICD) hospital surveillance survey from January 2021, reported that 3.5% of hospital admissions in South Africa were HCWs and 11.2% of them died (6). It is critical to implement precautions and procedures in the workplace to protect the health and safety of HCWs during this pandemic.

Furthermore, nosocomial transmission of COVID-19 is a major concern as an amplifier of local transmission. Reports from different countries worldwide, including China (7), United Kingdom (8, 9), and the USA (10), have shown a rapid spread of COVID-19 through health care facilities. A nosocomial outbreak of COVID-19 in Durban, South Africa highlighted these concerns where a single COVID-19 positive patient resulted in 119 confirmed COVID-19 cases and of these cases, 80 were staff members (11). Transmission occurs via aerosols that are inhaled or droplets that contain the virus and come into direct contact with mucous membranes (12, 13).

SARS-CoV-2 has placed unprecedented stress on health care systems worldwide. Chris Hani Baragwanath Academic Hospital (CHBAH) is the third-largest hospital in the world with approximately three thousand two hundred beds (14) and an average nurse to patient ratio of 3:31 (15). Before COVID-19 staff shortages were already a challenge (15), and with quarantine periods and HCWs absent due to illness, ensuring adequate staffing has been a major obstacle. The staffing crisis necessitated doctors and nurses from all departments such as Dermatology, Surgery, and Orthopaedics to suspend their usual duties and dedicate their time to caring for SARS-CoV-2 infected patients and staff.

While underuse of appropriate risk assessments and testing will result in rapid spread amongst HCWs and patients, overzealous quarantine or under-testing of exposed HCWs may result in unnecessary and unaffordable depletion of an already strained workforce (16). In order to optimise health care services and protect HCWs during this pandemic, clear guidelines are required to determine if/when an exposed or symptomatic HCWs should be tested and/or self-isolate or continue to work. The Centre for Disease Control (CDC) (17) and WHO (18) have published guidelines for the risk assessment and management of exposed and symptomatic HCWs. Based on these guidelines, the South African Department of Health has issued guidelines relevant to the South African setting (19). A questionnaire entitled "risk assessment questionnaire" (RAQ) was used by the CHBAH OHS department to collect relevant information in order to categorise HCWs into high-risk exposure (HRE), low-risk exposure (LRE), or person under investigation (PUI) groups and thereby direct management according to the aforementioned guidelines.

There is emerging data internationally evaluating risk assessment and testing procedures for HCWs (20), however, local data is lacking. We, therefore, undertook to assess the risk of COVID-19 among HCWs at CHBAH who fulfil the COVID-19 PUI case definition or had exposure to a confirmed COVID-19 contact.

Methods

Study sampling and study population

This is a retrospective review of the RAQs of HCWs that were exposed to and/or tested for COVID-19 by the CHBAH OHS department. Convenience sampling was used. RAQs over two months, from 1st May 2020 to 1st July 2020 were reviewed. This period was during the first wave of the COVID-19 pandemic.

The study population included asymptomatic HCWs exposed to a confirmed positive case and symptomatic HCWs who met the criteria of the PUI definition.

Risk assessment of HCWs

A HRE was defined as exposure within one meter to a confirmed COVID-19 case that lasts for more than fifteen minutes without appropriate PPE or failure of PPE and/or direct contact with

respiratory secretions (19). A LRE was defined as an exposure more than one meter away from a COVID-19 confirmed case for less than fifteen minutes OR within one meter but wearing appropriate PPE (19). A PUI was defined as a person with acute respiratory illness with sudden onset (less than or equal to fourteen days) of at least one of the following: a cough, sore throat, shortness of breath, or anosmia/ dysgeusia with or without other symptoms (21). HCWs were managed as per the NICD and South African DOH guidelines. COVID-19 PCR tests were done on all PUIs, all HRE on day eight post-exposure to assess early return to work, and HCWs in the LRE group that became symptomatic. HCWs in the PUI and HRE groups were required to self-isolate while HCWs in the LRE group were able to return to work and monitor for symptoms for fourteen days post exposure.

Inclusion criteria

All staff working at CHBAH regardless of designation were included as HCWs. Staff not directly employed by CHBAH, such as medical students and non-governmental organisation (NGO) staff were excluded. RAQs lacking risk category assessment were excluded.

Statistical analysis

Each patient received a study number, which was different from the identifiable hospital number. The study number was kept separately from the patient identification data set. Data was entered into an excel spreadsheet.

The following data was included: age, gender, designation, department, exposure type, risk level, and HCW COVID-19 test result (if tested). Only doctors and nurses were analysed with regard to “department” as other HCWs work in multiple areas.

Frequency distribution tables showing percentages and numbers were used to describe the categorical variables of age, gender, designation, department, and exposure type. Frequency distribution tables were also used to describe categorical variables with the test result (COVID positive and COVID negative result). Bivariate analyses were conducted using Pearson’s Chi-square tests. The univariate and multivariable logistic regression procedure was used to determine the factors associated with positivity. Stata Inc software version 16 was used and a p-value of less than 0.05 was considered significant.

Ethics

This study was approved by the Human Research Ethics Committee (Medical), University of the Witwatersrand (approval no. M200660) (Appendix 5).

Results

Demographic data

The sociodemographic characteristics of the 1111 HCWs are presented in Table 1. There was a female predominance (81.4%) and most of the HCWs were in the 30-39 age category (38.6%). The HCWs comprised mostly of nurses (48.5%) and doctors (27.0%). Most HCWs were from Internal Medicine (33.4%) and Obstetrics & Gynaecology (25.4%), followed by Surgery (18.9%) and Paediatrics (12.7%). Occupational exposure accounted for 88.8% of exposures, with 49.2% due to co-worker exposure and 39.6% due to patient exposure. Only 1.4% of HCW exposure was due to community exposure (family & travel) and 9.8% of HCWs had no known exposure. A third of the HCWs (57.9%) met the criteria for testing for SARS-CoV-2.

Risk level and COVID-19 test results

Only 19.0% met the criteria for HRE, whilst 51.1% for LRE and 29.9% fulfilled the definition of a PUI. The positivity rate in the PUI and HRE groups was 43.1% and 25.6% respectively. In the LRE group, 83.1% of HCWs were not tested as they did not fulfil criteria for testing. However, 17.0% of LRE HCWs became symptomatic within 14 days post-exposure and were tested. Of the HCWs in the LRE group that were tested, 32.0% were positive (Table 2). A significant association between test result and risk level was noted (p=0.001) (Table 2).

Factors associated with increased risk of COVID-19 infection

A total of 643 participants were tested with 35.6% positive results (Table 2). More than half the HCWs were nurses (53.7%) followed by doctors (24.9%). Internal Medicine (38.3%) and Obstetrics & Gynaecology (17.2%) accounted for most of the positive cases followed by Paediatrics (14.4%) and Surgery (13.9%). Around 42.4% reported a patient contact followed by co-worker contact (28.4%), no known contact (25.3%), and a family contact (3.9%). The PUI group accounted for 62.4% of the positive cases followed by 23.6% in the HRE group and

14.0% were from the LRE group that became symptomatic and were therefore tested. A significant association was noted between age (p=0.0201), department (p=0.0001), designation (p=0.0001), exposure type (p<0.0001), risk level (p=0.0001) and a positive test result. There was no significant association between gender (p=0.9621) and test result (Table 3).

In a univariate analysis (Table 4) the age groups from 30-60 years were at a higher risk of COVID-19 infection than the age group <30 years, with the highest risk in the 50-60 year age group (p=0.004). Security personnel were more likely to test positive than nurses (p=0.001) while support and logistics staff were less likely to test positive than nurses (p=0.025). The wide confidence interval seen in the security group can be explained by the small sample size. There was no significant difference between nurses' and doctors' positivity rates (p=0.850). HCWs in Obstetrics and Gynaecology were less likely to test positive than HCWs in Paediatrics (p=0.004). Symptomatic HCWs who reported no known exposure to COVID-19 were more likely to have a positive COVID-19 test result than those who reported an occupational exposure to a COVID-19 positive patient contact (p=0.000). In terms of occupational exposure, the risk of testing positive for COVID-19 was less after exposure to a co-worker contact as compared to a patient contact (p=0.000). PUIs were more likely to test COVID-19 positive than LREs that became symptomatic (p=0.049) (Table 4).

In light of other factors the adjusted multivariate analysis (Table 5) showed a marginally higher odds of COVID-19 infection in the PUI group than in LRE that became symptomatic but it was not statistically significant (AOR=1.58; 95%CI:0.93 - 2.70; p=0.089). The odds of COVID-19 infection was higher in age groups 30-39 years (AOR=2.61; 95%CI:1.52 - 4.47; p=0.000), 40-49 years (AOR=2.59; 95%CI:1.47 - 4.57; p=0.001) and 50-60 years (AOR=2.46; 95%CI:1.31 - 4.62; p=0.005) as compared to < 30 years. Symptomatic HCWs with no known exposure were at a greater odds of infection than those with an occupational patient exposure (AOR=2.29; 95%CI:1.32 - 3.97; p=0.003) and a marginally increased risk of infection was seen with a family exposure as compared to an occupational exposure (AOR=2.96; 95%CI:0.85 - 10.30; p=0.87). Staff working in security were more likely to test COVID-19 positive than nurses (AOR=50.81; 95%CI:10.55 - 244.57; p=0.000).

Discussion

The WHO declared the COVID-19 outbreak as a global public health emergency on 30 January 2020 (1). HCWs are the frontline response to the COVID-19 pandemic and their occupational health and safety is central to the fight against the outbreak and maintenance of health workforce. There is increasing evidence showing that HCWs are at a greater risk of SARS-CoV-2 infection than the general population (3). Our findings show a higher positivity rate of SARS-CoV-2 infection in HCWs (35.6%) compared with the NICD data from the general population in South Africa reported at this time showing a positivity rate of up to 7.5% (22).

The majority of HCWs were female (82.7%) however there was no significant association between gender and COVID-19 result (p=0.9621). This concurs with a seroprevalence study in healthy South African blood donors which showed no gender predilection (23) and in the UK and USA where risk estimates of COVID-19 were similar between male and female HCWs (4). Our results likely reflect the demographics of HCWs employed at CHBAH as well as the superior health care-seeking behaviour seen in females (24).

We found that HCWs between 30-60 years were more likely to test COVID-19 positive than those less than 30 years. As age is a risk factor for severe disease (25), HCWs in older age groups should be particularly vigilant with IPC protocols and correct PPE. Our findings are in contrast to HCWs in Switzerland where being older than 50 years was associated with a lower seroprevalence. This difference may be explained by age-related declines in humoral immunity affecting the seropositivity versus RT-PCR tests in our study which will not be affected by this (20).

HCW designation is a significant predictor of COVID-19 positivity in our study as well as other studies in Denmark (26), Switzerland (20), Scotland (5), Ghana (27), and Cape Town, South Africa (28). These studies all show that patient-facing designations such as nurses, have a higher risk of SARS-CoV-2 infection than non-patient facing, non-clinical designations such as support & logistics. Furthermore, HCW COVID-19 infections were more likely as a result of a patient contact than a co-worker contact. These findings suggest nosocomial transmission to be the source of COVID-19 infections in HCWs.

Of particular significance in our study, however, is that security personnel were 50 times more likely to test COVID-19 positive than any other designation. Security personnel wear standard PPE (masks only), are required to check bags and vehicles of all people entering and exiting the hospital, and are in close proximity to those on their shift, HCWs, and patients. Moreover, security personnel may be less aware of the risks of severe COVID-19 infection and this may influence their stringency to follow personal protective measures. These factors likely contributed to this high positivity rate and highlights the necessity of adequate PPE, IPC protocols and training for all HCWs regardless of designation in order to reduce transmission.

HCWs in Internal Medicine showed the highest rates of COVID-19 positive results, however, a multivariate analysis showed that HCWs in Paediatrics had the highest risk of COVID-19 infection. Initial studies have shown that children are less likely to be infected by and transmit SARS-CoV-2 (29) and this may have led to complacency in protective measures in paediatric staff. The nature of the close patient and parent contact in this department and the paucity of symptoms often shown in paediatric populations may further contribute to increase transmission risk. There is growing data to suggest that Paediatric HCWs are at a greater risk of COVID-19 infection than initially presumed (30, 31).

One of the strongest predictors of SARS-CoV-2 infection in HCWs is “symptoms”. The risk of COVID-19 was higher in HCWs who were symptomatic but had no known exposure than HCWs exposed to a patient contact. Almost two-thirds of the COVID-19 positive HCWs in our study were in the PUI risk level. Symptoms are a stronger predictor of SARS-CoV-2 infection than a positive HRE history and the current amended CDC guidelines state that fully vaccinated HRE HCWs do not need to self-isolate but can rather continue to work and monitor for symptoms (32). HCWs in the PUI risk level were more likely to have SARS-CoV-2 infection than LRE that became symptomatic, this may be because these HCWs were likely on high alert for symptom onset and more readily reported symptoms and were tested. These findings are supported by a meta-analysis showing that symptoms were significantly associated with SARS-CoV-2 infection in HCWs (3). All staff should be required to monitor symptoms and if present, should be tested.

With the rollout of vaccination of HCWs in South Africa, HCWs may feel influenced to be less stringent with PPE and more complacent with isolation periods post-exposure. However, COVID-19 infection is still possible post-vaccination. In Israel, 22 of 4081 (0.54%) HCWs

developed COVID-19 within 10 days post-vaccination (33). Our study highlights the importance of strict isolation periods particularly in those who are symptomatic.

There are some limitations to this study. This study was a retrospective review and testing was done only on HCWs who fulfilled criteria based on the South African DOH guidelines. Therefore the true prevalence of asymptomatic infection in LREs was not able to be determined. This testing strategy may have been influenced by resource constraints at the time and limited access to testing. The HCW screening algorithm relied on self-reporting and HCWs might have had a recall bias. A small sample size was noted in certain designations such as security personnel, therefore we recommend future studies to look further into these subgroups.

Conclusion

Our results suggest a higher positivity rate of HCWs than that of the general population. The presence of symptoms should be a good screening tool to signify that a HCW should immediately go for testing and isolate. Nosocomial transmission appeared to be derived from patients more than co-workers and therefore strict PPE and IPC protocols should be adhered to in patient-facing settings. Evidence-based HCW screening protocols are required to ensure HCW safety and at the same time adequate staffing. These findings should be considered when designing HCW screening protocols.

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Tables

Table 1. Sociodemographic characteristics of HCWs

Variables	Frequency (n) n=1111	Percent (%)
Age (in years)		
<30	220	19.8
30-39	429	38.6
40-49	271	24.4
50-60	165	14.8
>60	26	2.3
Gender		
Female	904	81.4
Male	207	18.6
Designation		
Allied	101	9.1
Cleaner	36	3.2
Doctor	300	27.0
Nurse	539	48.5
Pharmacist	1	0.09
Radiographer	12	1.1
Support & Logistics	102	9.2
Security	20	1.8
Department	n=839*	
Anaesthesiology	10	1.2
Emergency	35	4.2
Internal Medicine	280	33.4
Obstetrics & Gynaecology	213	25.4
Paediatrics	107	12.7
Psychiatry	25	3.0
Radiology	10	1.2
Surgery	159	18.9
Exposure type		
Co-worker	547	49.2
Family	14	1.3
No known contact	109	9.8
Patient	440	39.6
Travel	1	0.1
Tested for SARS-CoV-2		
Yes	643	57.9
No	468	42.1

*Only Doctors and Nurses included in Department
All data expressed as frequencies and percentages

Table 2. SARS-CoV-2 result and risk level

Variables	PUI n=332 n (%)	HRE n=211 n (%)	LRE n=100 † n (%)	Total n=643 n (%)	p-value
SARS-CoV-2 result					
Positive	143 (43.1)	54 (25.6)	32 (32.0)	229 (35.6)	0.0001
Negative	189 (56.9)	157 (74.4)	68 (68.0)	414 (64.4)	

**PUI= person under investigation HRE= high risk exposure LRE= low risk exposure
† Became symptomatic and therefore tested

Table 3. Distribution of HCW demographics and COVID-19 test result

	COVID-19 Positive	**COVID-19 Negative**	
	n=229	**n=414**	
Variables	**n (%)**	**n (%)**	**p-value**
Age (in years)			
<30	26 (11.4)	91 (22.0)	0.0201
30-39	91 (39.7)	152 (36.7)	
40-49	65 (28.4)	99 (23.9)	
50-60	40 (17.5)	59 (14.3)	
>60	7 (3.1)	13 (2.0)	
Gender			
Female	184 (80.3)	332 (80.2)	0.9621
Male	45 (19.7)	82 (19.8)	
Designation			
Allied	16 (7.0)	40 (9.7)	0.0001
Cleaner	6 (2.6)	18 (4.3)	
Doctor	57 (24.9)	95 (22.9)	
Nurse	123 (53.7)	213 (51.4)	
Pharmacist	0 (0)	1 (0.2)	
Radiographer	1 (0.4)	0 (0)	
Support & Logistics	12 (5.2)	45 (10.9)	
Security	14 (6.1)	2 (0.5)	
Department			
Anaesthesiology	10 (5.6)	0 (0)	0.0001
Emergency	6 (3.3)	14 (4.5)	
Internal Medicine	69 (38.3)	122 (39.6)	
Obstetrics & Gynaecology	31 (17.2)	89 (28.9)	
Paediatrics	26 (14.4)	28 (9.1)	
Psychiatry	12 (6.7)	10 (3.2)	
Radiology	1 (0.6)	0 (0)	
Surgery	25 (13.9)	45 (14.6)	
Exposure type			
Co-worker	65 (28.4)	226 (54.6)	<0.0001
Family	9 (3.9)	5 (1.2)	
No known contact	58 (25.3)	32 (7.7)	
Patient	97 (42.4)	151 (36.5)	
Travel	0 (0)	0 (0)	
Risk level			
PUI	143 (62.4)	189 (45.7)	0.0001
HRE	54 (23.6)	157 (37.9)	
LRE	32 (14.0)	68 (16.4)	

*Only Doctors and Nurses included in Department
**PUI= person under investigation HRE= high risk exposure LRE= low risk exposure

Table 4: Univariate analysis of sociodemographic characteristics and COVID-19 test result

	COVID-19 Positive		
Variable	**AOR**	**95%CI**	**p-value**
Age (years)			
<30	1		
30-39	2.09	1.26-3.48	0.004
40-49	2.29	1.35-3.92	0.002
50-60	2.37	1.31-4.29	0.004
>60	1.88	0.68-5.21	0.222
Designation			
Nurse	1		
Doctor	1.03	0.69-1.54	0.850
Allied	0.69	0.37-1.28	0.246
Support & Logistics	0.46	0.23-0.90	0.025
Cleaner	0.57	0.22-1.49	0.257
Security	12.12	2.7-54.2	0.001
Department			
Paediatrics	1		
Internal Medicine	0.61	0.33-1.12	0.111
Surgery	0.59	0.29-1.23	0.164
Obstetrics & Gynaecology	0.37	0.19-0.73	0.004
Emergency	0.46	0.15-1.37	0.166
Psychiatry	1.29	0.47-3.49	0.613
Exposure type			
Patient	1		
Co-worker	0.44	0.30-0.65	0.000
No known exposure	2.82	1.70-4.65	0.000
Family	2.80	0.91-8.61	0.072
Risk level			
LRE	1		
HRE	0.73	0.43-1.23	0.239
PUI	1.61	1.00-2.58	0.049

*Only Doctors and Nurses included in Department
**PUI= person under investigation HRE= high risk exposure LRE= low risk exposure

Table 5: Multivariate analysis of sociodemographic characteristics and COVID-19 test result

	COVID-19 Positive		
Variable	**AOR**	**95%CI**	**p-value**
Risk level			
HRE	0.62	0.34-1.12	0.115
PUI	1.58	0.93-2.70	0.089
Age			
30-39	2.61	1.52-4.47	0.000
40-49	2.59	1.47-4.57	0.001
50-60	2.46	1.31-4.62	0.005
Exposure type			
Co-worker	0.31	0.20-0.48	0.000
No known contact	2.29	1.32-3.97	0.003
Family	2.96	0.85-10.39	0.087
Department			
Paediatrics	2.71	1.43-5.13	0.002
Designation			
Security	50.81	10.55-244.57	0.000

*Only Doctors and Nurses included in Department
**PUI= person under investigation HRE= high risk exposure LRE= low risk exposure

Appendix 1: Data information sheet

STUDY NUMBER	
AGE	
GENDER	☐ **MALE** ☐ **FEMALE**
DESIGNATION	☐ **DOCTOR** ☐ **NURSE** ☐ **ALLIED** ☐ **SECURITY** ☐ **CLEANER** ☐ **PHARMACY** ☐ **RADIOGRAPHER** ☐ **S&L**
DEPARTMENT	☐ **MEDICINE** ☐ **SURGERY** ☐ **PAEDS** ☐ **ANAESTHETICS** ☐ **RADIOLOGY** ☐ **EMERGENCY** ☐ **O&G** ☐ **PSYCH**
EXPOSURE TYPE	☐ **PATIENT** ☐ **CO-WORKER** ☐ **FAMILY** ☐ **NOT KOWN** ☐ **TRAVEL**
RISK LEVEL	☐ **HRE** ☐ **LRE** ☐ **PUI**
TEST RESULT	☐ **POSITIVE** ☐ **NEGATIVE** ☐ **NOT TESTED**

Appendix 2: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Sara Glatt

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200660 MED20-06-084

NAME: (Principal Investigator)	Dr Sara Glatt
DEPARTMENT:	Internal Medicine Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	COVID-19 and Health Care Worker exposure at Chris Hani Baragwanath Academic Hospital
DATE CONSIDERED:	26/06/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Colin Menezes, Dr Merika Tsitsi and Dr Lai-ling Winchow
APPROVED BY:	Dr C Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	14/09/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed June and will therefore be due in the month of June each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 3: Plagiarism report

COVID-19 and HCW exposure at CHBAH .docx

ORIGINALITY REPORT

13%	10%	7%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	academicjournals.org Internet Source	3%
2	Daniel J Cooper, Sara Lear, Laura Watson, Ashley Shaw et al. "A prospective study of risk factors associated with seroprevalence of SARS-CoV-2 antibodies in healthcare workers at a large UK teaching hospital", Cold Spring Harbor Laboratory, 2020 Publication	2%
3	Emilie Mosnier, Olivia Nevissas, Sandrine Loubière, Marine Mosnier et al. "SARS-CoV-2 rapid serological tests for field-based healthcare workers in homeless communities: A mixed-methods exploratory analysis", Public Health in Practice, 2021 Publication	1%
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9	Submitted to University of Witwatersrand Student Paper	1%
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13	Kerrigan M. McCarthy, Stefano Tempia, Tendesayi Kufa, Jackie Kleynhans et al. "The importation and establishment of community transmission of SARS-CoV-2 during the first eight weeks of the South African COVID-19 epidemic", EClinicalMedicine, 2021 Publication	<1%
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18	Farhaan Vahidy, H Dirk Sostman, David Bernard, Marc L Boom et al. "Prevalence of SARS-CoV-2 infection among asymptomatic healthcare workers in greater Houston: a cross-sectional analysis of surveillance data from a large healthcare system", Cold Spring Harbor Laboratory, 2020 Publication	<1%
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