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ASSESSMENT OF RISK FACTORS FOR CORONAVIRUS DISEASE 2019 AMONG HOSPITAL HEALTHCARE WORKERS, SIERRA LEONE

BY

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THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN APPLIED EPIDEMIOLOGY AND DISEASE CONTROL

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DECLARATION

I James Sylvester Squire, declare that this dissertation is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where I have used other people's work or my own, this has been properly referenced and in accordance with the University of Ghana's requirement. I understand what Plagiarism is and I am aware of the University's policy in this regard. I understand that any false claim in respect of this work will result in disciplinary action, in accordance with the University Plagiarism Policy.

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APPROVAL BY SUPERVISORS

This dissertation has been submitted for review with my approval as University supervisor

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DEDICATION

I dedicate this work to my lovely wife, Aminata, our children Luba, Mukeh and N'dileh and to the memory of my late father, James Sylvester Squire.

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LIST OF ABBREVIATIONS

ABHR	Alcohol-based hand rub
AGP	Aerosol generating procedure
BGH	Bo Government Hospital
CHO	Community Health Officer
CI	Confidence Interval
COVID-19	Coronavirus disease 2019
HCW	Healthcare worker
IPC	Infection Prevention and Control
KGH	Kenema Government Hospital
MOHS	Ministry of Health and Sanitation
PLGH	Port Loko Government Hospital
PPE	Personal Protective Equipment
rRT-PCR	real-time reverse-transcriptase polymerase chain reaction
RR	Relative risk
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SECHN	State Enrolled Community Health Nurse
SIR	Secondary infection rate
SL	Sierra Leone
SRN	State Registered Nurse
WHO	World health organization

ABSTRACT

Background: Healthcare workers (HCWs) are at increased risk of COVID-19 infection due to their role in caring for patients. Despite reports of HCW infections in Sierra Leone, little information exists on the extent and risk factors for infection in healthcare settings. This study aims at investigating the extent and risk factors for COVID-19 infection among healthcare workers exposed to COVID-19 patients at three regional hospitals in Sierra Leone.

Methods: A case-ascertained prospective study was conducted in Bo, Kenema, and Port Loko Regional Hospitals from May to July 2020. HCWs exposed to confirmed COVID-19 patients were recruited and followed. A semi-structured questionnaire was used to collect data on demographics, infection prevention and control (IPC) practice, clinical presentation, exposures and contact information. Infection status was determined by laboratory detection of SARS-CoV-2 RNA by real-time reverse transcriptase-polymerase chain reaction (rRT-PCR) on nasopharyngeal swab samples. Risk factors were assessed by comparing COVID-19 infected and non-infected participants using binary logistic regression model.

Results: Out of 152 participants, 58.6% (89/152) were from Bo Government Hospital, 20.4% (31/152) from Port Loko Government Hospital, and 21.0% (32/152) from Kenema Government Hospital. The median age was 34.0 years (range: 20 – 63 years). About 74.3% (113/152) were females. Overall, the secondary infection rate (SIR) was 28.9% (44/152). SIR was highest among cleaners (55.6% [10/18]). About 68.2% (30/44) of infected HCWs were asymptomatic. Among symptomatic cases, the most common symptoms were headache 27.3% (12/44), fever 18.2% (8/44), and cough 15.9% (7/44). Contact with surfaces around patient (RR 3.3; 95% CI: 1.14 – 9.30; p=0.028), exposure at the triage/isolation or outpatient unit (RR 8.3; 95% CI: 2.49 – 28.27; p=0.001) and cleaning of patient room (RR 4.1; 95% CI: 1.12 – 14.96; p=0.034) were associated

with increased risk of COVID-19 infection. Good hand hygiene practice (RR 0.04; 95% CI: 0.01 – 0.23) was associated with a decreased risk of infection.

Conclusion: The infection rate for COVID-19 among HCWs was high. Contact with patient's environment, cleaning of patient room, and exposure at the triage or outpatient units were risk factors for infection. This study emphasized the need for strict adherence to infection control measures by HCWs.

Keywords: Risk factors, COVID-19, SARS-CoV-2, Healthcare workers, Hospital, Sierra Leone

DEFINITION OF TERMS

Healthcare worker: This refers to all staff (clinical and non-clinical) in the health care facility involved in the provision of care for a COVID-19 infected patient, including those who have been present in the same area as the patient, as well as those who may not have provided direct care to the patient, but who have had contact with the patient's body fluids, potentially contaminated items or environmental surfaces. This includes health care professionals, allied health workers, auxiliary health workers (e.g. cleaning and laundry personnel, x-ray physicians and technicians, clerks, nutritionists, social workers, physical therapists, lab personnel, cleaners, admission/reception clerks, patient transporters, catering staff etc.).

Exposure to COVID-19 patient: This refers to close contacts (within 1 meter) with a COVID-19 patient; or direct physical contacts with COVID-19 infected patient whether in PPE or not; or indirect contact with patient body fluids, fomites (example, utensils, linen, clothes, furniture etc.), materials, medical devices or equipment linked to the patient, and contaminated surfaces.

Healthcare worker contact: This was defined as a staff who stayed or worked in the same area or ward as the index patient.

Secondary infection rate: This refers to a measure of the frequency of new cases of COVID-19 infection among the HCW contacts of a confirmed case within the same health care facility in a defined period of time, as determined by a confirmed COVID-19 positive laboratory result. It is defined in simple terms as the proportion of HCW contacts of a primary case who subsequently become infected with COVID-19.

Confirmed COVID-19: This refers to persons in whom SARS-CoV-2 infection is detected by rRT-PCR regardless of the presence or absence of respiratory symptoms.

Monitoring: This -refers to daily communication through phone calls with exposed HCWs in quarantine to assess for the presence of symptoms consistent with COVID-19 for 14 days after the date of last exposure.

Appropriate PPE use: This refers to the use of surgical or N95 mask, face shield or googles, gown and gloves when in close contact within one meter of a suspected or confirmed COVID-19 patient.

Hand hygiene compliance: This refers to the use of AHBR or soap and water before and after exposure to index patient

Patient materials: This refers to personal belongings, linen and medical equipment that the patient may have had contact with

Index case or unsuspected COVID-19 patients: This refers to the patients that were initially hospitalised for non-COVID-19 related condition at the study sites who were later diagnosed with COVID-19 and to which the HCWs were exposed

CHAPTER ONE

INTRODUCTION

1.1 Background

The Coronavirus Disease 2019 (COVID-19) pandemic is a respiratory illness caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). First isolated in China in late December 2019, SARS-CoV-2 belong to the beta-coronavirus family; an enveloped single stranded RNA viruses, the same species as the SARS-like bat CoVs and human SARS (Chan et al., 2020; Lu et al., 2020; Zhu et al., 2020). Earlier studies that looked at the patterns of spread showed that SARS-CoV-2 is primarily transmitted from person-to-person through respiratory droplets and contact route, with more transmissibility than SARS-CoV (Chan et al., 2020; Chen et al., 2020; Liu et al., 2020; Li et al., 2020). Virus binding and cell entry is mediated by spike proteins and initial characterization of SARS-CoV-2 spike proteins indicates that it binds on angiotensin-converting enzyme 2, the same receptor as SARS-CoV (Wan, Shang, Graham, Baric, & Li, 2020). This receptor is expressed in both the upper and lower human respiratory tracts. COVID-19 is characterised by fever, cough, fatigue, headache, muscle pains, shortness of breath, pneumonia and other respiratory tract symptoms (Chen et al., 2020; Wang et al., 2020; Yang et al., 2020). In many cases the disease can progress to death and individuals with comorbid conditions such as diabetes, cardiovascular disease and renal conditions are at higher risk of severe disease (Williamson et al., 2020).

Since SARS-CoV-2 was first detected in Wuhan, China in December 2019 (Li et al., 2020), the COVID-19 epidemic has spread to more than 210 countries and territories including Sierra Leone. As of May 4, 2020, there have been 3,435,894 cases of COVID-19 and 239,604 deaths reported worldwide, with the WHO African region accounting for 0.9% (30,536 cases) and 0.5% (1,085

deaths) of the global cases and deaths (World Health Organization, 2020a). Sierra Leone reported its first case of COVID-19 on 30th March, 2020; diagnosed in a Sierra Leonean citizen who travelled from France, and the first local case with no travel history or travel-related contact history was reported on 3rd April, 2020. By May 4, 2020, the country had recorded 178 confirmed COVID-19 cases and nine deaths (Ministry of Health and Sanitation, 2020a; World Health Organization, 2020a). Since the first case of COVID-19 was confirmed on 30th March, 2020, the magnitude of the outbreak has increased and the outbreak has spread to eight out of sixteen districts with seventy-nine cases reported in the last 7 days (Ministry of Health and Sanitation, 2020a).

Just like any other infectious disease outbreak, healthcare workers have been at the frontline in the fight against COVID-19 and at the same time providing non-COVID-19 essential services. As SARS-CoV-2 transmission is associated with droplet secretions and close contacts to COVID-19 patients, HCWs are at increased risk of becoming infected. This is particularly true in the case of novel disease outbreaks when transmission dynamics are yet to be fully characterised. A report from the Chinese Center for Disease Control and Prevention noted that by February 11th, 2020 a total of 1,716 HCWs had been diagnosed with COVID-19 (China CDC, 2020). Reports on HCW infection has also been documented in other parts of the world. In the United States, around 9,282 healthcare personnel were infected with COVID-19 by 9 April, 2020 (CDC COVID-19 Response Team, 2020). Healthcare workers in the WHO African Region have been greatly affected by the COVID-19 outbreak, and as of 4 May, 2020 a total of 945 have being infected in 28 countries since the beginning of the outbreak, with 29 cases reported among HCWs in Sierra Leone (World Health Organization, 2020c).

There are several factors related to HCWs exposure risk. Recent evidence suggests that most HCWs are infected with COVID-19 while performing clinical care at the workplaces and

communities. The infections are associated with longer duty hours, lack of knowledge of respiratory pathogens, non-compliance with standard precaution measures such as hand hygiene, lack of personal protective equipment (PPE) and its improper use (Houghton et al., 2020). While it is believed that person-to-person spread of SARS-CoV-2 occurs predominantly through droplet and contact transmission, data on specific risk factors for COVID-19 among HCWs in a health care setting in Sierra Leone is lacking.

1.2 Problem statement

Healthcare workers play a critical role at the frontline of the health service delivery, providing care for patients during the COVID-19 pandemic. As SARS-CoV-2 transmission is associated with droplet inhalation and closed contacts to COVID-19 patients, HCWs are at increased risk of becoming infected. Given the current COVID-19 pandemic, infection among HCWs is a common occurrence globally. Globally an estimated 22, 073 confirmed cases of COVID-19 has been reported among HCWs as of 8 April, 2020 (WHO, 2020a). However, at present no systematic or standardized reporting of COVID-19 infected HCWs exist. Therefore, this number most likely under-represents the true global numbers of infected HCWs. In China, a total of 1, 716 HCWs had been diagnosed of COVID-19 by February 11th, 2020 (China CDC, 2020). In the WHO African Region, HCWs have been greatly affected by the COVID-19 outbreak, and as of 4 May, 2020 a total of 945 have been infected in 28 countries, with 29 cases reported among HCWs in Sierra Leone (Information & Assessment, 2020).

Recent studies conducted in China and elsewhere have highlighted HCW related factors as important risk factors associated with transmission of SARS-CoV-2 to HCWs in a healthcare setting (Alqahtani et al., 2020; Ran et al., 2020; Ng et al., 2020; Wang, Pan, & Cheng, 2020; Liu et al., 2020). These factors include age, HCW job category, pre-existing medical conditions,

tobacco use, work unit, lack of training in IPC, improper use of PPE, non-compliance to hand hygiene measures and improper mask use. Other studies have highlighted frequent and prolonged unprotected contact with confirmed COVID-19 patient and exposure to certain aerosol generating procedures as important exposure related factors influencing transmission of SARS-CoV-2 to HCWs (Heinzerling et al., 2020).

HCWs are a major risk group for nosocomial transmission and amplification events within healthcare facilities should they become ill. It is therefore important to understand COVID-19 infections among HCWs in a healthcare setting. This will help in characterizing risk factors for COVID-19 infection, informing and updating infection control measures at health facility, preventing future infections in HCWs and reducing secondary transmission of SARS-CoV-2 within healthcare settings. This study aims at investigating the extent of infection and risk factors for COVID-19 infection among HCWs who were exposed to a COVID-19 infected patients at the three Government Hospitals in BO, Kenema and Port Loko districts before the diagnosis were made. Follow-up and testing of respiratory specimens of HCWs within a facility in which a confirmed case of COVID-19 patient has received care can provide useful information on transmissibility and routes of transmission, and are important for limiting amplification events in health care facilities.

1.3 Justification

This study will contribute to available evidence on factors influencing transmission of SARS-CoV-2 among HCW in a healthcare setting in Africa where human and financial inadequacies pose challenges to the implementation of IPC, thus would inform policy and practice. At the end of the study, the extent of infection and risk factors for COVID-19 among HCWs will be determined. The information generated from this study will guide policy makers in developing specific measures and guidelines to prevent healthcare associated infections, recognize infection in HCWs as soon as possible, and provide care for HCWs infected with COVID-19.

The health and well-being of HCWs are critical for COVID-19 response and for supporting non-COVID 19-related health services. Therefore, identifying and managing HCWs who have been exposed to a patient with COVID-19 is of great importance in preventing healthcare transmission and protecting staff and vulnerable patients in healthcare settings.

As community transmission of COVID-19 increases, it becomes more difficult to determine where HCW infections are acquired. This study will provide a unique opportunity to investigate exposures associated with SARS-Cov-2 transmission in a healthcare setting without documented community exposures. Describing exposures among HCWs who will or will not develop COVID-19 can inform guidance on how to best protect them.

1.4 Conceptual framework

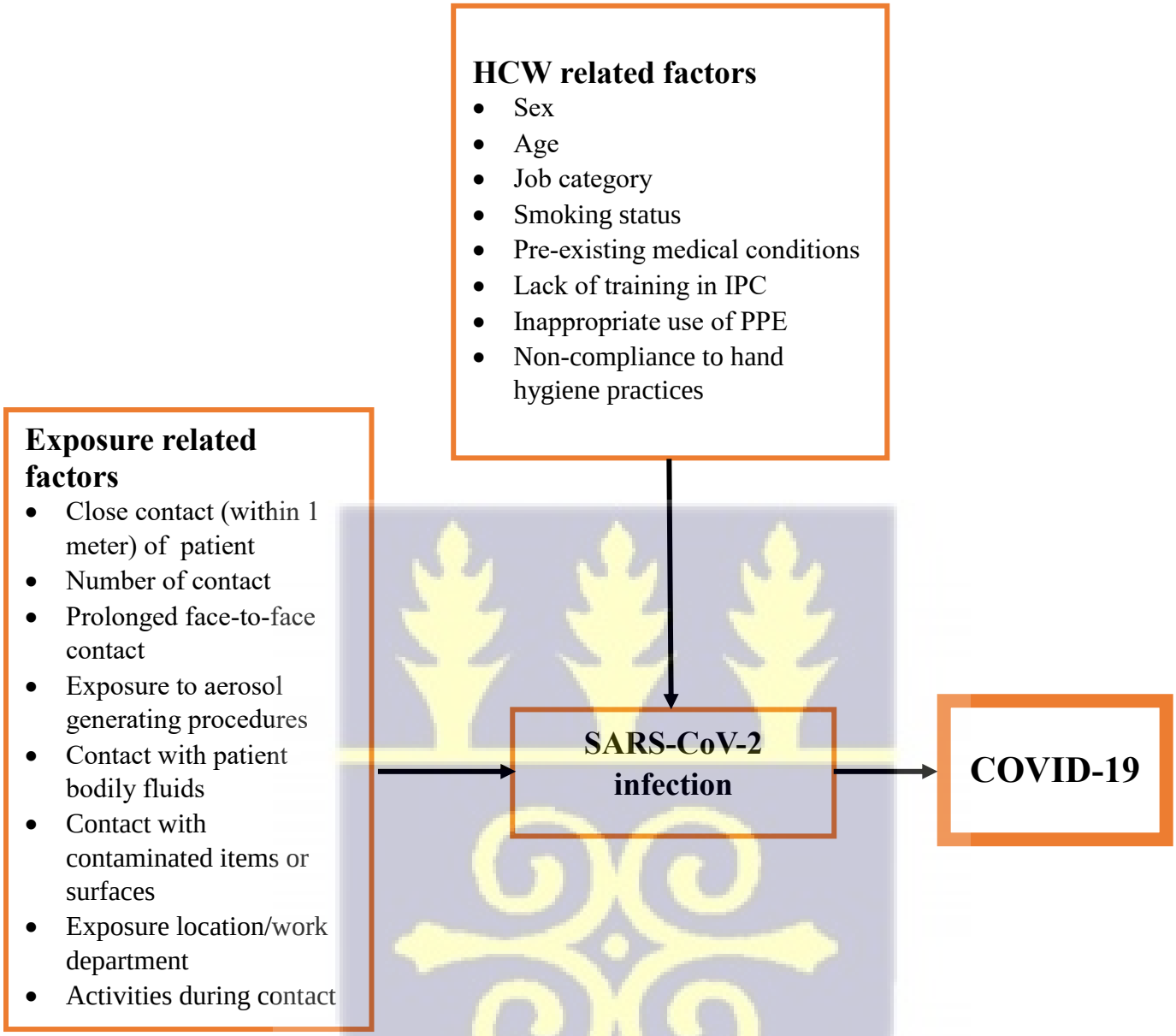

Figure 1: Conceptual framework for assessment of risk factors for COVID-19 among hospital HCWs

The conceptual framework in Figure 1 describes the factors related to the transmission of SARS-CoV-2. As shown in the figure, SARS-CoV-2 is the direct cause of COVID-19. The virus is transmitted by direct contact with infected persons, or by contact with contaminated surfaces and objects (Chan et al., 2020; Chen et al., 2020; Liu et al., 2020; Li et al., 2020).

The broad spectrum of variables that influences the transmission of SARS-CoV-2 causing COVID-19 are grouped under two categories: (1) HCW related factors, and (2) exposure related factors. The HCW related factors can also be grouped into sociodemographic (age, sex, job category, underlying medical conditions & smoking status), knowledge and practice of infection prevention and control measures. HCWs aged 50 years and above are prone to SARS-CoV-2 infection and are more likely to suffer severe form of the diseases with worst outcomes including death. This is as a result of deterioration in the immune functions with age and underlying chronic diseases. Sex has also been shown to be a predisposing factor to COVID-19, with men more prone to being infected with SARS-CoV-2. HCW job category could also influence the transmission of SARS-CoV-2, with nurses being at increased risk of infection. By providing nursing care and attending to other needs of the patients, nurses spend more time with patients, thus exposing them. Similarly so, HCWs with underlying chronic diseases and conditions such as diabetes, hypertension, chronic lung diseases and cancers are at increased risk of SARS-CoV-2 infections, disease severity and death. Tobacco smoking is a known risk factor for many respiratory infections and increases the severity of respiratory diseases. The impact of tobacco smoking on vulnerability to COVID-19 and poor outcomes has also been explored (Alqahtani et al., 2020). Smoking most likely raises the transmission rate and severity of COVID-19 infection. The underlying mechanism behind this is that smoking has been related to higher expression of ACE2 (the receptor for SARS-CoV-2) (Cai, 2020). In addition, smoking impairs lung functions and since COVID-19 primarily attacks the lungs, this makes it harder for the body to fight off the disease.

HCW knowledge and practice in IPC measures are important factors in protecting against infectious diseases including respiratory diseases. HCWs who lack the requisite training in IPC including transmission-based precautions are at increased risk of infection. In addition, HCWs who have the training but lacks the right attitude in ensuring compliance increases their risk of infection. Improper use of PPE, non-compliance to hand hygiene and medical mask use are all important risk factors for SARS-CoV-2 transmission to HCWs.

Droplet transmission requires close proximity between an infected individual and a susceptible person. Therefore prolonged face-to-face contact within 1meter of a confirmed COVID-19 case without wearing appropriate PPE for more than 15 minute has been shown to increase risk of SARS-CoV-2 transmission. Similarly, exposure to contaminated patients body fluids including respiratory secretions, items, surfaces or surroundings have been associated with increased risk for infection in HCWs. This is more likely when hand hygiene practices are not adhered to by HCWs.

HCWs exposed to high concentrations of aerosols from an infected patients during procedures such as endotracheal intubation, manual (bag) ventilation, airway suctioning, nebulizer treatment, and high flow oxygen therapy are potentially at risk of infection.

Certain work department in a healthcare setting increases risk of exposure of HCWs and subsequent transmission of SARS-CoV-2. HCWs who worked in high risk department, accident and emergency units are at particularly increased risk of infection than those working in general wards. This is more likely when IPC measures are not adhered to.

1.5 Research Questions

1. What is the extent of COVID-19 infection among HCWs exposed to an unsuspected COVID-19 patients receiving care in a health care setting, Sierra Leone?
2. What are the risk factors for COVID-19 infection among HCWs exposed to an unsuspected COVID-19 patients receiving care in a health care setting, Sierra Leone?

1.6 Objectives

1.6.1 General Objective

To assess the extent of infection and risk factors for COVID-19 infection among HCWs exposed to unsuspected COVID-19 patients at the Bo, Kenema and Port Loko Government Hospitals, Sierra Leone.

1.6.2 Specific objectives:

1. To describe infection prevention and control practices among healthcare workers
2. To assess the secondary infection rate (SIR) for HCWs exposed to COVID-19 patient
3. To describe clinical presentations of COVID-19 infection among HCWs
4. To determine the risk factors for COVID-19 infection among HCWs

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of COVID-19 Pandemic

On 31 December 2019, the World Health Organization (WHO) was notified of a cluster of pneumonia cases of unknown aetiology detected in Wuhan city, China (World Health Organization, 2020e). SARS-CoV-2 was identified as the cause (Lu et al., 2020; Zhu et al., 2020) and the disease was named as COVID-19 on 12 February 2020 (World Health Organization, 2020f). Transmission of SARS-CoV-2 from person-to-person is mainly through respiratory droplet infection and direct contact with infected patients or contaminated items and surfaces. Health care workers are particularly at risk for SARS-CoV-2 infection (Koh, 2020), and since early in the outbreak reports have described the disease in HCWs (Wang et al., 2020). Preventing SARS-CoV-2 infection in HCWs is important for reducing secondary transmission, amplification events in healthcare settings, maintaining the health system capacity, and reducing morbidity and potential mortality (Adams & Walls, 2020; Perlis, 2018).

2.2 COVID-19 infection rate among HCWs

As HCWs continue to be infected, the burden of SARS-CoV-2 infection in healthcare workers has been of great concern in the current COVID-19 pandemic. The available evidence on rates of COVID-19 infection among HCWs varies widely across settings, countries, local prevalence, HCW roles and testing methods. This review report infection rates in HCWs from rRT-PCR based studies. Reports on the burden of SARS-CoV-2 infection among HCWs have been documented in several studies, including cohort, cross-sectional and case series (Barrett et al., 2020; Kluytmans-Van den Bergh et al., 2020; Jie Liu et al., 2020; McMichael et al., 2020; Ran et al., 2020a; Reusken et al., 2020; N. C. P. E. R. E. Team, 2020). Two studies in the Netherlands that evaluated 1, 097

and 1,353 HCWs with mild respiratory symptoms for SARS-CoV-2 found infection rate of 4.1% (45/1,097) and 6.4% (86/1,353) respectively (Kluytmans- Van den Bergh et al., 2020; Reusken et al., 2020).

A retrospective cohort study conducted in Wuhan, China reported incidence of 38.9% among 72 clinicians exposed to a confirmed COVID-19 patient (Ran et al., 2020a). An epidemiological analysis of 44,672 confirmed cases of COVID-19 (PCR confirmed) in China from 31 December, 2019 through to 11 February 2020, reported infection rate of 3.8% (1,716/44,672) among HCWs (N. C. P. E. R. E. Team, 2020). Of the 1,716 cases reported in HCWs, five died and 247 were classified as severe. Another non-peered-reviewed study in Wuhan, china evaluated 25,961 PCR-confirmed COVID-19 cases from 31 December 2019 to 18 February 2020 (C. Wang et al., 2020). The study reported that HCWs accounted for 5.1% (1,316/25,961) of the total cases. The overall attack rate was higher in HCWs than the general population (144.7 [95% CI: 137.0 – 152.8] versus 41.7 [95% CI: 41.2 – 42.2] per 10^6 people). A study among 171 HCWs exposed to an unsuspected COVID-19 hospitalized patient in the neurosurgery department of Tongji medical college hospital, Wuhan China reported an infection rate of 8.2% (14/171) (Bai et al., 2020a).

In a prospective cohort study conducted in a university hospital and university setting in New Jersey, among 829 participants (546 HCWs and 283 non-HCWs) without previous diagnosis of COVID-19 the authors reported infection rate of 7.3% among HCWs and 0.4% in non-HCWs. Nurses had the highest infection rate (11.1%) compared to attending physicians (1.8%) (Barrett et al., 2020). The study also noted a lower infection rate among intensive care unit workers (2.1%) compared to staff in other units (4.9 – 9.7%) (Barrett et al., 2020). Heinzerling and colleagues (2020) reported an infection rate of 7.9% among cohort of exposed healthcare personnel in a hospital setting in California (Heinzerling et al., 2020). Report of a universal screening of HCWs

in a maternity hospital in London from 7th March through 16th April, 2020 showed an infection rate of 18.0% (47/266), with 34.0% (16/47) reported no symptoms at the time of testing (Khalil, Hill, Ladhani, Pattisson, & Brien, 2020). A seroprevalence study conducted among 500 asymptomatic HCWs in Malawi indicated an overall infection rate of 12.3% (Chibwana et al., 2020).

2.4 Infection prevention and control among HCWs

Nosocomial spread of infections including respiratory pathogens can be avoided by implementing multimodal infection prevention and control strategies such as hand hygiene, environmental cleaning and standard precautions (Grayson et al., 2011; Ho, Seto, Wong, & Wong, 2012). Despite the availability of low-cost interventions, compliance with IPC among HCWs remains low, particularly in low and middle-income countries. In India, health care workers (HCWs) were more likely to be compliant if they had more IPC experience, were more knowledgeable about transmission of pathogens and were committed to workplace safety (Kermode et al., 2005). In Botswana, emergency nurses identified resource constraints such as the lack of the necessary hygiene facilities, inadequate equipment and materials, inadequate staffing and the lack of sustainable in-service education (Chelenyane & Endacott, 2006).

Achieving high IPC compliance is of critical importance in Sierra Leone. During 2014 and 2015, the country was one of the West African countries that experienced the worst Ebola virus disease (EVD) outbreak in history. All 16 health districts in the country were affected with over 13,000 cases and 6,000 deaths (World Health Organization, 2016). Health care workers were disproportionately affected, with 300 infected and 221 Ebola-related deaths (World Health Organization, 2016). Recognizing the importance of IPC, the Ministry of Health and Sanitation (MOHS) of Sierra Leone established, for the first time (in 2015), a national IPC policy (and

guidelines) for implementing IPC activities in public health facilities. The five focus areas include hand hygiene, adequate protective wear, sharps safety management, sterilization and, waste management (MOHS, 2015a, 2015b). Despite efforts in improving IPC practices in Sierra Leone, implementation of effective IPC measures in public health facilities across the country still remains a challenge. Findings from a national service availability and readiness assessment (SARA) survey conducted in 2017 showed that only 26 % of health facilities had all infection control items, (MOHS, 2017). A narrative review on compliance to hand hygiene by HCWs in sub-Saharan Africa estimated an overall compliance of 21.1% among HCWs (Atalyero, Dyson, & Graham, 2019). The study identified lack of hand sanitizer or water and soap, poorly positioned facilities and heavy workload as important barriers to hand hygiene practices (Atalyero et al., 2019).

2.5 Clinical characteristics of COVID-19

The incubation period for SARS-CoV-2 ranges from 2 to 14 days with a median of 5.6 days (Backer, Klinkenberg, & Wallinga, 2020; Lauer et al., 2020; Li et al., 2020). Most people with COVID-19 will present with mild to moderate symptoms and recover without hospitalization. The most common symptom of COVID-19 is fever followed by dry cough and fatigue (Grant et al., 2020). Loss of appetite, shortness of breath, cough with sputum production and muscle and joint pains are other common symptoms that have been documented from patients with COVID-19 (Chen et al., 2020; Grant et al., 2020), while symptoms such as nausea, vomiting, and diarrhoea have been observed in varying percentages (Huang et al., 2020; C. Lai, Shih, Ko, Tang, & Hsueh, 2020; Wei et al., 2019). Less common symptoms that have been observed include runny nose, sneezing, sore throat, skin rash, loss of smell and loss of taste (WHO, 2020; Xydakis et al., 2020).

In a minority of cases patients with COVID-19 may not develop any noticeable symptoms (Gao et al., 2020). The role of these asymptomatic cases in transmission is not fully known and in most

cases are not tested (Lai et al., 2020). Preliminary evidence however suggest they may play a role in the spread of the disease (Furukawa, Brooks, & Sobel, 2020).

The clinical characteristics of COVID-19 infection among HCWs have been described in previous studies (Bergh et al., 2020; Jie Liu et al., 2020; M. Liu et al., 2020; X. Wang, Liu, et al., 2020; Yasmin et al., 2020).

2.6 Risk factors for transmission of SARS-CoV-2 infection to HCWs

Implementing specific infection control measures to protect HCWs from infection require understanding COVID-19 infection in HCWS. To date evidence on risk factors for COVID-19 infection among HCWs is limited and preliminary findings suggest HCW infection occur at the workplace as well as in the community. Factors associated with HCW infection in the healthcare setting include longer duty hours, lack of knowledge of respiratory pathogens, non-compliance with standard precautions such as hand hygiene, lack of or inadequate personal protective equipment (PPE), and improper use of PPE (Houghton et al., 2020; Bai et al., 2020b; Grimm, 2020; Ing, Xu, Salimi, & Torun, 2020; Schwartz, King, & Yen, 2020; J. Wang, Zhou, & Liu, 2020).

A retrospective cohort study conducted in a hospital in Wuhan, China evaluated risk factors for COVID-19 in 72 exposed HCWs with acute symptoms (Ran et al., 2020a). Risk factors identified included working in high risk department (relative risk [RR], 2.13 [95% CI: 1.11-3.95]), inappropriate use of PPE (RR, 2.82 [95% CI: 1.11 – 7.18]), longer duty hours (log-rank p=0.020, and suboptimal hand hygiene before and after contact with patient (RR, 3.10 [95% CI: 1.43 – 6.73] and 2.82 [95% CI: 1.11 – 7.18]) respectively. This study however, found no statistically significant association between aerosol-generating procedures such as sputum suction, bronchoscopy, cardiopulmonary resuscitation and endotracheal intubation to risk of SARS-CoV-2 infection.

Other studies have equally evaluated risk factors for COVID-19 in exposed HCWs (Ng et al., 2020; X. Wang, Pan, & Cheng, 2020). These studies found mask use, especially N95 to be associate with decreased risk of COVID-19 infection. A review on physician deaths from COVID-19 identified male gender, older age (57 years or older) and pre-existing medical conditions (hypertension, chronic lung disease, cardiovascular disease, immunosuppression and diabetes) as important risk factors for COVID-19 (Ing et al., 2020).

CHAPTER THREE

METHODS

3.1 Study Design

A case-ascertained prospective study was conducted to collect both qualitative and quantitative data on HCWs working at the Bo, Kenema and Port Loko Government Hospitals where a laboratory confirmed COVID-19 infected patient received care. Nasopharyngeal swab samples were collected from all HCW contacts for SARS-CoV-2 testing by rRT-PCR. The study included all HCWs identified as contacts during epidemiological investigation and was conducted from May to July, 2020

3.2 Study site

The study was conducted at the three regional hospitals (Bo, Kenema and Port Loko Government Hospitals) located in Bo, Kenema and Port Loko districts, Sierra Leone.

These three hospitals were chosen for the study because at the time of developing the proposal they have not recorded any case of COVID-19 and as such was ideal for the type of study design in investigating the risk factors for COVID-19 among HCWs.

3.2.1 Profile, demography and health services of Bo, Kenema and Port Loko districts

Bo district, located in the Southern Province of Sierra Leone, has an estimated 2020 population of 647,931 projected from the 2015 census, a total area of 5,219 km^2 and is subdivided into sixteen chiefdoms (Sierra Leone Statistics, 2016). The district share borders with Kenema district to the east, Moyamba district to the west, Tonkolili district to the north, Pujehun district to the south and Bonthe district to the southwest (Figure 2). The district has 146 health facilities including one Government and five Mission/private hospitals, 41 Community Health Centers (CHC), 24 Community Health Posts, and 75 Maternal and Child Health Posts (MCHP).

Kenema district, located in the Eastern Province of Sierra Leone, has an estimated 2020 population of 686,676 projected from the 2015 census, a total area of 6,053 km^2 and is subdivided into sixteen chiefdoms (Sierra Leone Statistics, 2016). The district share borders with Kailahun district to the east, Bo district to the west, Tonkolili and Kono districts to the north, Pujehun district to the southwest and Liberia to the southeast (Figure 2). The district has 126 health facilities including one Government and two Mission hospitals, and 123 primary health care facilities.

Port Loko district, located in the North-western Province of Sierra Leone, has an estimated 2020 population of 692,852 projected from the 2015 census, a total area of 5,719 km^2 and is subdivided into thirteen chiefdoms (Sierra Leone Statistics, 2016). The district share borders with Bombali and Karene districts to the east, Western area to the west, Kambia district to the north and Tonkolili district to the south (Figure 2). The district has 105 health facilities including two Government and five Mission hospitals, and 98 primary health care facilities.

3.2.2 Profile of Bo, Kenema and Port Loko Government Hospitals

The Bo Government Hospital is one of the four regional referral hospitals in Sierra Leone. The hospital is situated in the district headquarter town; Bo town, the second largest city in Sierra Leone and the district capital. The Bo Government Hospital is a 300-bed hospital providing medical, paediatric, obstetric, surgical, reproductive health and other essential services with an average of 1,000 inpatient admissions per month. The clinical staff includes 9 doctors, 28 community health officers and 586 nurses of different cadres. The hospital has a triage station for screening of all patients and a 14-bed isolation facility which was built after the 2014/2015 Ebola outbreak to isolate suspected cases of haemorrhagic fevers. The isolation facility is currently being used for isolation of suspected COVID-19 patients.

The Kenema Government Hospital is a regional referral hospital for Kenema district and is located in the district headquarter town. It is a 300-bed hospital providing medical, paediatric, obstetric, surgical, reproductive health and other essential services with an average of 900 inpatient admissions per month. The clinical staff includes 5 doctors, 10 community health officers and 315 nurses of different cadres. The hospital has a triage station for screening of all patients and a 10-bed isolation facility which was built after the 2014/2015 Ebola outbreak to isolate suspected cases of haemorrhagic fevers. The isolation facility is currently being used for isolation of suspected COVID-19 patients. The hospital also has an established viral haemorrhagic fever unit for research and managing patients with Lassa fever.

The Port Loko Government Hospital is the main referral hospital in the district with 150-bed capacity. The hospital is situated in the district headquarter town of Port Loko and provides medical, paediatric, obstetric, surgical, reproductive health and other essential services with an average of 300 inpatient admissions per month. The clinical staff includes 4 doctors, 9 community health officers and 100 nurses of different cadres. The hospital has a triage station for screening of all patients and a 10-bed isolation facility which was built after the 2014/2015 Ebola outbreak to isolate suspected cases of haemorrhagic fevers. The isolation facility is currently being used for isolation of suspected COVID-19 infected patients.

All three hospitals were not serving as treatment facilities for COVID-19 patients during the study period.

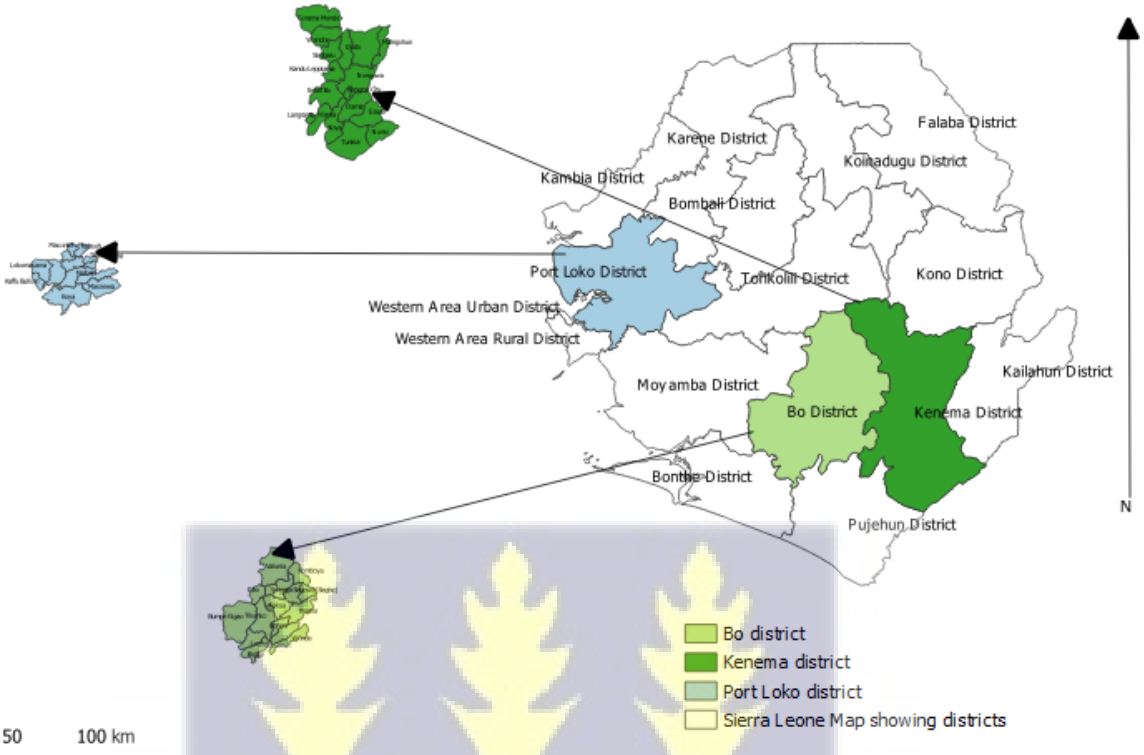

Figure 2: Map of Sierra Leone highlighting locations of Bo, Kenema and Port Loko districts
Source: Author design

3.3 Sampling

3.3.1 Study Population

The study population included healthcare workers at the three Government Hospitals in Bo, Kenema and Port Loko districts where laboratory confirmed COVID-19 patients had received care before the diagnosis were made.

3.3.2 Inclusion criteria

All healthcare workers working at the Bo, Kenema or Port Loko Government Hospitals, who were exposed at the respective hospitals to unsuspected COVID-19 patients were included in the study.

3.3.3 Exclusion criteria

All health care workers with a confirmed COVID-19 case among his or her households or close contacts were excluded from the study.

3.4 Study Variables

The outcome variable was confirmed COVID-19 infection. This was defined as a HCW contacts with a positive laboratory result for SARS-CoV-2 by real-time RT-PCR test on nasopharyngeal swab specimen collected at baseline and or during follow-up irrespective of symptoms. The independent variables of interest are categorized into HCW and exposure related factors (Table 1):

Table 1: HCW characteristics and exposure variables

Health care worker characteristics	Exposure factors
• Sex • Age • Job category/professional role • Smoking status • Pre-existing medical conditions • IPC training	• Close contact (within 1minute) of index case • Number of contacts with index case • Prolonged face-to-face exposure • Use of appropriate PPE • Use of medical mask (surgical or N95 mask) • Use of surgical gloves • Use of face shields or googles • Use of gown • Patient care activities during contact • Hand hygiene with ABHR or soap and water after each contact with patient • Exposure to aerosol-generating procedure • Contact with patient body fluids • Contact with patient materials • Contact with surfaces around patient • Exposure location /Work department

Data was also collected on general and respiratory symptoms.

3.5 Sample size

The sample size was calculated with Epi Info StatCalc software using the following parameters:

Confidence level = 95%, and margin of error of 5%

Ratio (Unexposed: Exposed) = 1

% outcome in unexposed group: 15.3%

Risk ratio: 2.28

These parameters were derived from one retrospective cohort study in Wuhan, China that evaluated risk factors for COVID-19 in 72 healthcare workers exposed to a confirmed COVID-19 patient in a designated hospital (Ran et al., 2020a). The study assessed among other risk factors, hand washing and use of PPE. The study showed that the relative risk (RR) for suboptimal handwashing before and after patient contact was 3.10 and 2.28 respectively, and 2.82 for improper use of PPE.

The minimum sample size to detect RR of 2.28 with 80% statistical power, 95% confidence level and 5% margin of error assuming two equal groups using Epi Info StatCalc (Figure 4) was 152

The sample size included 152 HCWs identified by the investigation team after exposure risk assessment conducted for all HCWs at the three regional hospitals in Bo, Kenema and Port Loko districts.

Unmatched Cohort and Cross-Sectional Studies (Exposed and Nonexposed)

Two-sided confidence level:	95%
Power:	80 %
Ratio (Unexposed : Exposed):	1
% outcome in unexposed group:	15.3 %
Risk ratio:	2.28
Odds ratio:	2.96781
% outcome in exposed group:	34.9 %

	Kelsey	Fleiss	Fleiss w/ CC
Exposed	77	76	86
Unexposed	77	76	86
Total	154	152	172

Figure 3: Sample size estimate from Epi Info StatCalc

3.6 Epidemiological investigation (see appendix 4 for detailed investigation report)

3.6.1 Bo Government Hospital

On 3rd May, 2020, an epidemiological investigation was commenced when a patient; a senior clinician at the hospital was diagnosed with COVID-19. The patient had stayed and received care at the annex and inpatient therapeutic feeding (IPF) wards of the hospital for two days before being transferred to Connaught Hospital in Freetown where the diagnosis was made.

3.6.2 Port Loko Government Hospital

On 9th May, 2020, the Port Loko surveillance team was notified of a patient who had visited the hospital three times with recurrent and worsening respiratory symptoms. An epidemiological investigation was carried out when the patient test result was confirmed for COVID-19.

3.6.3 Kenema Government Hospital

On 16th May, 2020 the Kenema surveillance team commenced an epidemiological investigation when a patient who had been admitted for six days at the annex ward of the hospital was later tested positive for COVID-19.

A second epidemiological investigation was carried out from 26th May, 2020 when another patient; a HCW from a different unit in the hospital who had no contact with the previous case was diagnosed with COVID-19.

3.7 Recruitment of study participants

All HCWs at the three regional hospitals in Bo, Kenema, and Port Loko Districts identified by the investigation team after conducting exposure risk assessment were recruited into the study (Figure 4). The investigators reviewed the medical files of the patients in each of the respective hospitals and recorded all the areas of the hospitals the patients visited. They held meetings with the individual units and all healthcare workers present during the patients stay in the hospitals were recruited. Duty rosters of identified areas in the hospitals the patients visited were reviewed and HCWs on duty were enrolled. Health care workers who were present in every area of the hospitals the case-patients visited irrespective of whether they had direct contact or not with the patient were identified and recruited. In addition, HCWs that visited the case-patients whilst hospitalized were recruited into the study. Identification and recruitment of HCWs was done in consultation with the hospital administration. All HCW contacts identified were quarantined and monitored for 14 days after the date of last exposure as per the Government protocol (Ministry of Health and Sanitation, 2020c).

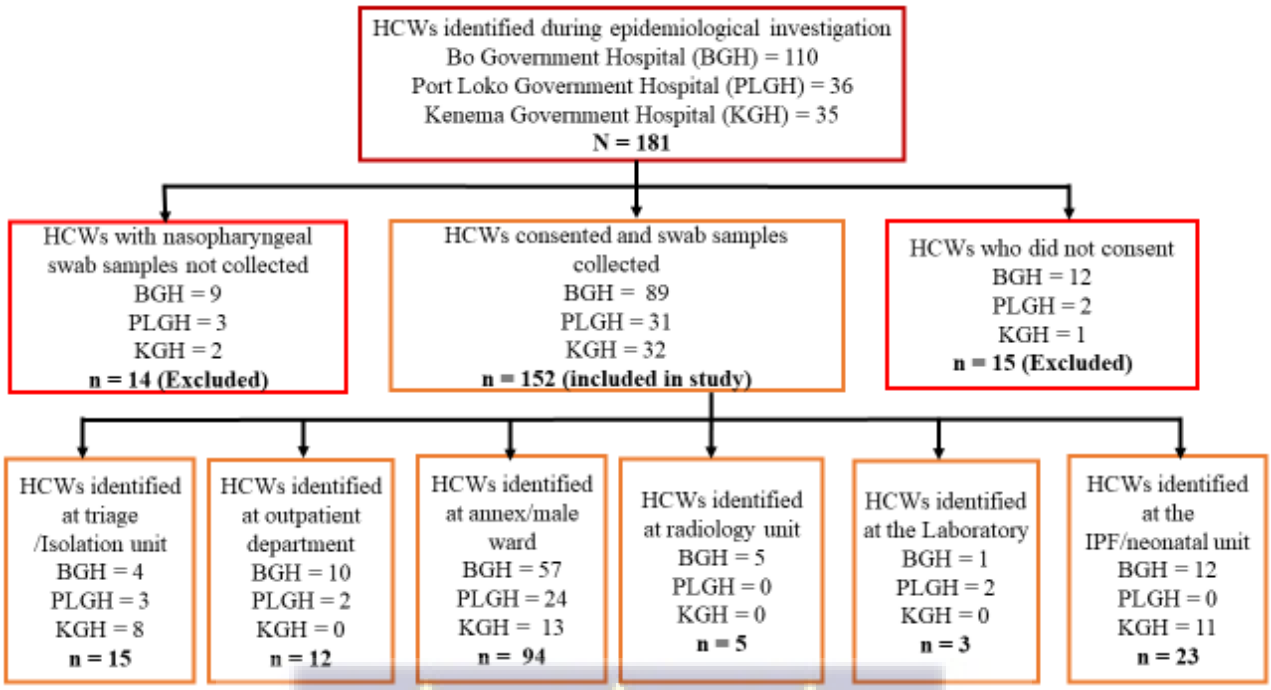

Figure 4: Process of identifying and recruiting HCWs into the study

3.8 Follow-up and data collection

Enrolled HCWs were followed daily for COVID-19 symptoms for the first 14 days of their last exposure to the case-patients. Those that became positive were admitted and followed up at treatment centre up to final outcome to document the range of clinical presentations. Participants were enrolled at different times during the study depending on when the index cases were identified and the date the HCWs started quarantine. Thus the follow-up times varied depending on the enrolment date. In Bo district, HCWs were enrolled and followed up from 6th May through 4th July, 2020, while in Port Loko and Kenema districts from 11th May to 22nd June, 2020 and from 17th May to 24th June, 2020 respectively. Baseline information at enrolment was collected for each HCW after an initial oral consent was obtained. Written consents were obtained from all participants on completion of 14 days quarantine and/or discharge from treatment centre. A semi-structured interviewer-administered questionnaire adapted from the WHO protocol for "assessment of potential risk factors for COVID-19 infection among health care workers in a

health care setting" (World Health Organization, 2020g) was used to collect information. The questionnaire covers demographic information, adherence to standard infection prevention and control (IPC) measures, contact with and exposure to COVID-19 patient since admission to the hospital, respiratory and other symptoms and pre-existing medical conditions. Information collected on exposed HCWs included sociodemographic data (age, sex, nationality, work location, job category and smoking status), pre-existing medical condition, exposure location, patient care activities while in contact with patient, and compliance with recommendations for personal protection, i.e. wearing of mask (surgical/N95), gloves, face shields or googles, gown and consistent hand hygiene practice after patient contacts. Detailed exposure information were also collected to include close contact with index patient, patient materials, surfaces around patient, exposure to aerosol generating procedures (AGP) or body fluids.

Each HCW contacts was given a symptom diary and asked to record daily the presence or absence of signs and symptoms for the period in quarantine or in treatment centre. Follow-up through phone calls were made at 5:00pm daily by the research team to ensure compliance and to document on a separate follow-up sheet the record on the symptom diary.

The hospital administrators involved in the study completed a health facility form that assesses IPC implementation in the hospitals. All questionnaires were administered in English.

3.8.1 Respiratory sample collection, transportation and Laboratory testing

Trained laboratory personnel collected two nasopharyngeal swab samples from each HCW contacts irrespective of symptoms as per the MOHS guideline. For HCW that reported symptoms on follow-up visit an immediate nasopharyngeal swabs was collected. Samples collected were stored in a viral transport media at 2-8^{o}C and transported the same day in triple packaging to the testing facilities for COVID-19. Samples from Bo and Kenema were sent to the Viral

Haemorrhagic Fever Reference Laboratory in Kenema district and samples from Port Loko were sent to the Jui P3 laboratory run by China CDC in Western area. Laboratory testing for SARS-CoV-2 were performed by trained laboratory scientist and virologists. Laboratory confirmation of COVID-19 was based on detection of unique sequences of virus RNA by rRT-PCR method as described in the MOHS laboratory guideline for COVID-19 (MOHS, 2020). Briefly, the real time PCR test involves the amplification of base pair sequences of the E-gene and RdRP-gene with specific primers detected by a FAM label hydrolysis probe. The assay detects SARS-CoV-2 virus as well as other bat-associated SARS-related viruses (Sarbecovirus); no cross reactivity with common human respiratory CoV NL63, 229E, HKU, OC43 or MERS. A 76 bp long fragment from the E-gene and 100bp long fragment for the RdRP-gene is detected with FAM labelled hydrolysis probes.

Laboratory test results were recorded on a laboratory form for each HCW. HCWs with positive test results were transferred to a designated COVID-19 treatment facility for management of symptoms and outcome documented.

3.8.2 Recruitment and training of investigation team

A total of 11 personnel (5 in Bo, 3 each in Port Loko and Kenema) who were part of the districts COVID-19 surveillance and laboratory response pillars were recruited to serve as research assistants. The categories of staff included epidemiologist, disease surveillance officers and laboratory scientists.

Data collection was carried out by epidemiologist and disease surveillance officers experienced in epidemiological investigation. Training on the purpose of the study, nasopharyngeal swab sample collection, IPC, interview techniques and how to fill the questionnaire was conducted for the investigation team by the principal investigator.

3.8.3 Quality control

3.8.3.1 Laboratory quality control

Adequate control of all equipment, materials and procedures was ensured and all aspect of quality assurance incorporated in the standard operating procedures of laboratory including pre-analytic, analytic and post-analytic phases were followed strictly. For the COVID-19 outbreak, the testing laboratories participate in routine internal quality control using kit control, in-house control and inter-laboratory comparison. The testing laboratories also participate in regional quality assurance by sending all positives and ten percent negatives to Noguchi laboratory in Ghana, Pasteur in Senegal, CDC US Respiratory virus laboratory and Public Health England laboratory.

3.8.3.2 Data collection quality assurance

Training was conducted for all personnel on the study objectives, laboratory procedures and data collection instruments. The data collection tools were pre-tested at the Ola During Children's hospital where nosocomial spread of SARS-CoV-2 among HCWs was first reported in early April, 2020. Responses were documented with corrections and modifications made to the questionnaires. A unique identification number was assigned to each questionnaire which had run through the identification of laboratory samples. Supervision and audit at predetermined intervals was carried out by the principal investigator to ensure quality was maintained at all times. All data collected was kept under lock and key and accessed only by the principal investigator. Data was backed-up daily in a password protected computer.

3.8.3.3 Quarantine of HCW contacts

Identified HCW contacts were quarantined as per the protocol, each placed in a separate self-contained room to prevent mingling and were monitored. To minimise the risk of infection or spread among HCW contacts, adherence to strict IPC measures were enforced.

3.9 Data processing and analysis

3.9.1 Data management

Data collected was checked for completeness, and transcription errors. Data was entered into SPSS and all variables collected were coded. Data cleaning was done in SPSS which included crosschecking for outliers, duplicates and missing data. Continuous variables like age were categorised for further analysis. Data was analysed using Stata IC version 15.1 (StataCorp., Texas, USA) software.

3.9.2 Data analysis

Descriptive statistics: Median and range were used to describe continuous variables. Categorical variables obtained from the HCWs were expressed as frequencies and proportions. The proportion of all exposed HCW to the case-patients who subsequently became infected with COVID-19 was computed with 95% confidence interval. The clinical manifestations, HCW pre-existing medical conditions and self-reported IPC practices among HCWs were described and reported as frequencies and proportions. The data was presented in tables and text.

Inferential statistics: Differences in proportions observed between COVID-19 positive and negative HCWs for categorical variables were compared using Pearson Chi-squared or Fisher's exact tests of association. Two sample test of proportion was used to compare SIR for COVID-19 among age group, sex, pre-existing conditions, smoking status and reported close contact with index patients. To determine risk factors for COVID-19 infection among HCWs, a bivariate logistic regression analysis was carried out. This was followed by a multivariable logistic regression using a purposeful selection approach (Hosmer, Lemeshow, & Sturdivant, 2013). Relative risk (RR) and 95% confidence interval (CI) was computed to assess the strength of association and levels of statistical significance was set at p-value <0.05.

3.10 Ethical considerations

Ethical approval

Ethical approval was sought from the Sierra Leone Ethics and Scientific Committee. Permission to conduct the study was sought from the management of the Bo, Kenema and Port Loko Government Hospitals.

Potential risks and benefits

It was anticipated that participants may feel some discomfort during collection of nasopharyngeal samples. The procedure of nasopharyngeal swab collection were carried out by trained and experienced personnel.

The participants directly benefited from the investigation, in that those confirmed with COVID-19 infection were identified early and were appropriately managed in a COVID-19 designated treatment facility. The indirect benefit is that data collected would help improve and guide efforts to understanding transmission of SARS-CoV-2 and prevent further spread of COVID-19 in health care settings.

Confidentiality

Confidentiality and anonymity of participants was ensured throughout the investigation. A unique identifier for the labelling of questionnaire and clinical specimens was assigned by the investigation team to each subject that consented to participate in the study. The link of this identification number to individuals was maintained by the investigation team and unauthorized persons were not allowed access to the information collected. Data shared included only the study identification number and not any personably identifiable information. Information collected from study participants was kept in a secure storage facility and under lock and key.

Informed consent

Information with regards to the rationale and objectives of the study was provided to all identified HCW contacts of a confirmed COVID-19 infected patient. All study participants gave written consent. Each participant was informed that participation was voluntary and that they are free to opt out of the study at any time without any consequences and without affecting professional responsibilities.

Prevention of COVID-19 infection in investigation team members

All personnel involved in the study were trained on standard IPC procedures specific to COVID-19 and based on national guidelines (Ministry of Health and Sanitation, 2020b). The training - included proper hand hygiene procedure, and the correct use of PPEs. Interviews were conducted at a distance of at least 1 meter from the study participants. Research assistants were supplied with basic PPEs (N95 respirator mask, face shields, gowns, gloves and alcohol-based hand rub). Laboratory personnel were dressed in full PPE and donning and doffing was supervised and supported by a second personnel. To prevent frequent contacts with exposed HCW, subsequent follow-ups by research team were conducted through phone calls.

Conflict of interest

None.

CHAPTER FOUR

RESULTS

4.1 Demographic and exposure characteristics of study participants

Of 152 HCW contacts of the COVID-19 case, 58.6% (89/152) were from the Bo Government Hospital, 20.4% (31/152) from the Port Loko Government Hospital and 21.0% (32/152) from the Kenema Government Hospital. Table 2 summarizes the characteristics of the study participants. The median (range) age of study participants was 34.0 (20 - 63) years, with majority 95.4% (145/152) less than 50 years old. Median (range) age of COVID-19 positive HCWs was 34.0 (21 -54) years and that for COVID-19 negative HCWs was 33.5 (20 – 63) years. The majority of participants were females 74.3% (113/152); of Sierra Leonean nationality 98.7% (150/152); and did not smoke 96.1% (146/152). Most of the HCWs 45.4% (69/152)) were State Enrolled Community Health Nurses (SECHN). Only 7.2% (11/152) had pre-existing medical condition with hypertension 3.3% (5/152) and asthma 2.0% (3/152) being the most frequent. The distributions of demographic (age, sex, job category), lifestyle (cigarette smoking), place of work, pre-existing condition and HCW IPC training status were comparable between HCWs diagnosed with COVID-19 and those without COVID-19. Compared to HCWs with negative test result, CoVID-19 positive HCWs were less likely to wear N95 mask (29.6% vs. 67.6%), gloves (72.7% vs. 88.9%), face shields (27.3% vs. 55.6%) and gown (38.6% vs. 67.6%) when in contact with index patient. Infected HCWs were less likely to perform hand hygiene with alcohol-based hand rub (ABHR) or soap and water after each contact with the patient than uninfected HCWs (70.5% versus 97.2% (Table 2).

Table 3 summarizes HCW exposure information. Most of the HCWs 58.6% (89/152) had close contact (within 1 meter) with index patients, 40.1% (61/152) had prolonged (more than 15

minutes) face-to-face contact with patient. About 77.0% (117/152) of respondents were exposed at the inpatient ward, 17.8% (27/152) at the triage/isolation or outpatient units and 5.2% (8/152) at the x-ray or laboratory unit. Only 12.5 % (19/152), 30.3% (46/152) and 32.9% (50/152) had direct contact with patient body fluids, patient materials and surfaces around patient. Compared to HCWs who tested negative for COVID-19, HCWs with positive test results were more likely to had close contact (within 1 meter) with the index patients (79.5% [35/44] vs. 50.0% [54/108]), contact patient body fluids (22.7% [10/44] vs. 8.3% [9/108], contact patient materials (52.3% [23/44] vs. 21.3% [21/108]) and contact surfaces around patient (59.1% [26/44] vs. 22.2% [24/108]). Higher proportion of infected HCWs reported to have being exposed at the triage and or outpatient department than HCWs without COVID-19 (36.4% [16/44] vs 10.2% [11/108]) (Table3).

About 57.2% (87/152) of respondents carried out at least one activity during exposure to index patient, while 42.8% (65/152) reported no direct patient care activity only stayed in the same room with index patient. HCWs with COVID-19 were more likely to report lifting or position of patient 31.8% (14/44), changing patient bed linens 20.5% (9/44) and cleaning patient room 22.7% (10/44) than HCWs without COVID-19 10.2% (11/108), 6.5% (7/108) and 5.6% (6/108) respectively (Table 4). None of the HCWs reported exposure to any aerosol generating procedure.

Table 2: Characteristics of study participants according to COVID-19 outcome status, Sierra Leone, 2020

Characteristics	All HCWs (N=152) No. (%)	HCWs COVID-19 testing outcome	
		Positive (n= 44) No. (%)	Negative (n= 108) No. (%)
Age group (in years)			
< 50	145 (95.4)	43 (97.7)	102 (94.4)
≥ 50	7 (4.6)	1 (2.3)	6 (5.6)
Sex			
Male	39 (25.7)	13 (29.6)	26 (24.1)
Female	113 (74.3)	31 (70.4)	82 (75.9)
Job Category/Cadre			
Medical doctor	4 (2.6)	1 (2.3)	3 (2.8)
SRN	11 (7.2)	1 (2.3)	10 (9.3)
SECHN	69 (45.4)	18 (40.9)	51 (47.2)
Nursing Aid	15 (9.9)	4 (9.1)	11 (10.2)
Cleaner	18 (11.8)	10 (22.7)	8 (7.4)
Others¥	35 (23.1)	10 (22.7)	25 (23.1)
Smokes			
No	146 (96.1)	41 (93.2)	105 (97.2)
Yes	6 (3.9)	3 (6.8)	3 (2.8)
Pre-existing Condition			
No	141 (92.8)	41 (93.2)	100 (92.6)
Yes	11 (7.2)	3 (6.8)	8 (7.4)
Trained in IPC			
No	26 (17.1)	8 (18.2)	18 (16.7)
Yes	126 (82.9)	36 (81.8)	90 (83.3)
Reported used$ specified PPE when in contact with index patient			
Surgical mask	120 (79.0)	34 (77.3)	86 (79.6)
N95 mask	86 (56.6)	13 (29.6)	73 (67.6)
Gloves	128 (84.2)	32 (72.7)	96 (88.9)
Face shields or googles	72 (47.4)	12 (27.3)	60 (55.6)
Gown	90 (59.2)	17 (38.6)	73 (67.6)
Hand hygiene after each contact with index patient			
No	16 (10.5)	13 (29.5)	3 (2.8)
Yes	136 (89.5)	31 (70.5)	105 (97.2)
Inappropriate use of PPE			
No	93 (61.2)	17 (38.6)	76 (70.4)
Yes	59 (38.8)	27 (61.4)	32 (29.6)

HCWs=Healthcare workers; COVID-19 = Coronavirus disease 2019; IPC= Infection prevention and control; SRN=State registered nurse; SECHN =State enrolled community health nurse; PPE=Personal protective equipment

¥include driver, security, cook, nutritionist, Community health officer, x-ray technician, laboratory technician, electrician, reception/admission clerk, porter and pharmacist

$Versus no use

Table 3: Exposure characteristics of study participants according to COVID-19 testing outcome, Sierra Leone, 2020

Exposure type	All HCWs (N=152) No.	(%)	HCWs COVID-19 testing outcome Positives (n= 44) No.	(%)	Negative (n= 108) No.	(%)
Close contact (within 1 meter) with index case						
No	63	(41.4)	9	(20.5)	54	(50.0)
Yes	89	(58.6)	35	(79.5)	54	(50.0)
Estimated individual number of contacts						
No contact	63	(41.5)	9	(20.5)	54	(50.0)
1 - 2 contacts	67	(44.1)	24	(54.5)	43	(39.8)
≥ 3 contacts	22	(14.4)	11	(25.0)	11	(10.2)
Pro-longed (>15minute) face-to-face contact						
No	91	(59.9)	22	(50.0)	69	(63.9)
Yes	61	(40.1)	22	(50.0)	39	(36.1)
Exposure location						
X-ray/Laboratory unit	8	(5.2)	2	(4.6)	6	(5.6)
Triage/Isolation/Outpatient unit	27	(17.8)	16	(36.4)	11	(10.2)
Inpatient ward [Φ]	117	(77.0)	26	(59.0)	91	(84.2)
Contact with patient body fluids						
No	133	(87.5)	34	(77.3)	99	(91.7)
Yes	19	(12.5)	10	(22.7)	9	(8.3)
Respiratory secretions	2	(1.3)	2	(4.6)	0	(0.0)
Urine	3	(2.0)	2	(4.6)	1	(0.9)
Saliva	3	(2.0)	2	(4.6)	1	(0.9)
Sweat	8	(5.3)	6	(13.6)	2	(1.9)
Blood	9	(5.9)	4	(9.1)	5	(4.6)
Contact with patient materials						
No	106	(69.7)	21	(47.7)	85	(78.7)
Yes	46	(30.3)	23	(52.3)	23	(21.3)
Clothes	30	(19.7)	15	(34.1)	15	(13.9)
Bed linens	27	(17.8)	15	(34.1)	12	(11.1)
Medical devices used on patient	11	(7.2)	3	(6.8)	8	(7.4)
Medical equipment connected to patient	11	(7.2)	6	(13.6)	5	(4.6)
Contact with surfaces around patient						
No	102	(67.1)	18	(40.9)	84	(77.8)
Yes	50	(32.9)	26	(59.1)	24	(22.2)
Bed	44	(29.0)	23	(52.3)	21	(19.4)
Bathroom	6	(4.0)	3	(6.8)	3	(2.8)
Ward corridor	5	(3.3)	3	(6.8)	2	(1.9)
Bedside table	15	(9.9)	7	(15.9)	8	(7.4)
Medical gas panel	2	(1.3)	2	(4.6)	0	(0.0)
Medicine cabinet	19	(12.5)	8	(18.2)	11	(10.2)

HCWs = Healthcare workers; COVID-19 = Coronavirus disease 2019

[Φ] Include Annex, male, Inpatient Feeding and neonatal wards

Table 4: Reported patient care activities carried out by HCWs according to COVID-19 testing outcome, Sierra Leone, 2020

Activities	HCWs COVID-19 testing outcome				p-value*
	Positive (n= 44)		Negative (n= 108)		
	No.	(%)	No.	(%)	
Activities during exposure to index patient (yes)[φ]					
Medical history taking	3	(6.8)	7	(6.5)	0.999
Physical examination	1	(2.3)	4	(3.7)	0.999
Taking vital signs	13	(29.6)	24	(22.2)	0.340
Giving medication	15	(34.1)	26	(24.1)	0.207
Bath or clean patient	4	(9.1)	3	(2.8)	0.108
Lifting/positioning patient	14	(31.8)	11	(10.2)	0.001
Carrying patient on wheelchair	6	(13.6)	5	(4.6)	0.080
Emptying bedpan	4	(9.1)	2	(1.9)	0.059
Changing bed linens	9	(20.5)	7	(6.5)	0.018
Cleaning patient room	10	(22.7)	6	(5.6)	0.003
IV line insertion	5	(11.4)	11	(10.2)	0.779
Drawing blood	3	(6.8)	3	(2.8)	0.357
Manipulating patient oxygen mask/tubing	1	(2.3)	6	(5.6)	0.674
Perform X-ray on patient	0	(0.0)	3	(2.8)	0.557
No direct patient care, stayed in same room	7	(15.9)	58	(53.7)	< 0.001

HCW= Healthcare worker; COVID-19= Coronavirus disease 2019

[φ]More than one responses possible

*p-value from the results of a X^2 or Fishers' exact test

4.2 Self-reported infection prevention and control practices among healthcare workers

Out of 152 HCWs interviewed, 82.9% (126/152) reported to have being trained in infection prevention and control (Table 5). Of these, 66.7% (84/126) had their last IPC training more than a year. About 63.8% (97/152) reported they always follow recommended hand hygiene practices, with 61.2% (93/152) mentioned always use ABHR or soap and water before touching patient, 67.8% (103/152) before cleaning or aseptic procedure, 80.9% (123/152) after risk of body fluid exposure, 76.3% (116/152) after touching a patient and 73.7% (112/152) after touching a patient surrounding. While 66.5% (101/152) mentioned they always follow standard IPC precautions when in contact with any patient, 15.8% (24/152) said they don't know what standard precautions are (Table 5). The majority of HCWs 66.4% (101/152) mentioned PPE were not available in sufficient quantity in the hospitals.

Table 5: Self-reported infection prevention and control practices among HCWs, Sierra Leone, 2020

	N = 152	
Reported IPC practices	**Frequency**	**Proportion (%)**
Ever trained in IPC		
No	26	17.1
Yes	126	82.9
Follow recommended hand hygiene practices		
Always as recommended	97	63.8
Most of the time	38	25.0
Occasionally	12	7.9
Rarely	5	3.3
Use ABHR or soap and water before touching patient		
Always, as recommended	93	61.2
Most of the time	36	23.7
Occasionally	9	5.9
Rarely	14	9.2
Use ABHR or soap and water before cleaning/aseptic procedure		
Always, as recommended	103	67.8
Most of the time	31	20.4
Occasionally	7	4.6
Rarely	11	7.2
Use ABHR or soap and water after risk of body fluid exposure		
Always, as recommended	123	80.9
Most of the time	20	13.1
Occasionally	8	5.3
Rarely	1	0.7
Use ABHR or soap and water after touching a patient		
Always, as recommended	116	76.3
Most of the time	21	13.8
Occasionally	12	7.9
Rarely	3	2
Use ABHR or soap and water after touching patient surroundings		
Always, as recommended	112	73.7
Most of the time	19	12.5
Occasionally	16	10.5
Rarely	5	3.3
Follow standard IPC precautions when in contact with any patient		
Always, as recommended	101	66.5
Most of the time	23	15.1
Occasionally	3	2.0
Rarely	1	0.6
HCW don't know what standard precautions are	24	15.8
Wear PPE when indicated		
Always, as recommended	92	60.5
Most of the time	36	23.7
Occasionally	14	9.2
Rarely	10	6.6
PPE available in sufficient quantity in the hospital		
Yes	51	33.6
No	101	66.4

IPC=Infection prevention and control; HCWs= Healthcare workers; PPE= Personal Protective equipment

4.3 Secondary infection rate (SIR) for COVID-19 among exposed hospital HCWs

Overall 44 out of 152 exposed HCWs tested positive for COVID-19 during the study, yielding a secondary infection rate of 28.9% (95% CI: 21.9% – 36.8%). All HCWs diagnosed with COVID-19 survived with none requiring ventilation. The SIR varied slightly by hospital with BGH, 27.0% (24/89), PLGH, 25.8% (8/31) and KGH, 37.5% (12/32) (Table 6). SIR also varied by job category with cleaners having the highest SIR (55.6% [10/18]), followed by other health staff (28.6% [10/35]), Nursing Aid (26.7% [4/15]) and SECHN (26.1% [18/69]). SIR was also highest among staff working at the triage or outpatient unit of the hospitals (59.3% [16/27]). There was significant difference in the SIR for COVID-19 among HCW who had close contact with the index patients than among those who did not ($z = -3.353$; p-value < 0.001). Secondary infection rates did not differ by age, sex, pre-existing condition and smoking status (Table 6).

4.4 Clinical characteristics of COVID-19 infection among HCWs

Majority of the study participant were asymptomatic 90.1% (137/152), with symptoms reported in 31.8% (14/44) of the HCWs diagnosed with COVID-19 and 0.9% (1/108) of those tested negative for COVID-19. Table 7 summarises clinical characteristics of COVID-19 among HCWs with positive test result. About 68.2% (30/44) of infected HCWs reported no symptoms. Among symptomatic cases, headache 27.3% (12/44), fever 18.2% (8/44) and cough 15.9% (7/44) were the common symptoms reported. Among COVID-19 positive HCWs, 93.1% (41/44) had no pre-existing medical conditions. Hypertension 4.5% (2/44) and asthma 2.3% (1/44) were the conditions reported (Table 7).

Table 6: Secondary infection rates of COVID-19 among exposed HCWs by demographic and exposure characteristics, SL, 2020

Characteristics	All HCWs	COVID-19 positive HCWs	SIR	p-value*
Age group (in years)				0.381
< 50	145	43	29.7	
≥ 50	7	1	14.3	
Sex				0.484
Male	39	13	33.3	
Female	113	31	27.4	
Job Category/Cadre				NA
Medical doctor	4	1	25.0	
SRN	11	1	9.1	
SECHN	69	18	26.1	
Nursing Aid	15	4	26.7	
Cleaner	18	10	55.6	
Others[¥]	35	10	28.6	
Pre-existing Condition				0.899
Yes	11	3	27.3	
No	141	41	29.1	
Smokes cigarette				0.246
Yes	6	3	50.0	
No	41	41	28.1	
Hospital				NA
BGH	89	24	27.0	
PLGH	31	8	25.8	
KGH	`32	12	37.5	
Exposure location				NA
X-ray/Laboratory unit	8	2	25.0	
Triage/Isolation/Outpatient unit	27	16	59.3	
Inpatient ward[ϕ]	117	26	22.2	
Close contact with index case				< 0.001
No	63	9	14.3	
Yes	89	35	39.3	

COVID-19 = Coronavirus disease 2019; HCWs = Healthcare workers; SL=Sierra Leone; SIR= Secondary infection rate, SRN= State registered nurse; SECHN= State enrolled community health nurse; BGH= Bo Government Hospital; PLGH= Port Loko Government Hospital; KGH= Kenema Government Hospital; NA= Not applicable
[¥]Positive HCWs include cook=1, driver=2, laboratory technician=2, porter=1, security=3, X-ray technician=1
[ϕ]Included Annex, male, Inpatient Feeding and neonatal wards
*p-value indicates differences in proportions, from the results of a Two-sample test of proportions

Table 7: Clinical characteristics of COVID-19 among infected HCWs, Sierra Leone, 2020

	COVID-19 positive HCWs (N=44)	
Clinical characteristics	**n**	**Proportion (%)**
Symptom classification		
Asymptomatic	30	68.2
Symptomatic	14	31.8
Symptoms[φ]		
Headache	12	27.3
Fever	8	18.2
Cough	7	15.9
Loss of appetite	6	13.6
Joint aches	6	13.6
Fatigue	6	13.6
General malaise	6	13.6
Loss of taste	5	11.4
Chills	3	6.8
Nausea	2	4.6
Muscle aches	2	4.6
Shortness of breath	1	2.3
Sore throat	1	2.3
Vomiting	1	2.3
Abdominal pain	1	2.3
Pre-existing Condition		
No	41	93.2
Yes	3	6.8
Hypertension	2	4.5
Asthma	1	2.3

COVID-19= Coronavirus disease 2019; HCWs= Healthcare workers

[φ]More than one responses possible

4.5 Risk factors for COVID-19 infection among HCWs

In a bivariate analysis of HCW-related factors, inappropriate use of PPE was significantly associated with risk of COVID-19 infection. HCWs who reported inappropriate use of PPE had almost 4 folds increased risk of infection than those who did not (RR=3.77; 95% CI: 1.81 – 7.86; p<0.001) (Table 8). Conversely, wearing of N95 mask, gloves, face shields or gown during contact with index patient significantly decreases the risk of COVDI-19 infection. HCWs who wore N95 mask during contact with index case had 76% decreased risk of COVID-19 infection than HCWs who did not wear N95 mask (RR=0.24; 95% CI: 0.07 – 0.77; p = 0.017). HCWs who reported wearing gloves (RR=0.33; 95% CI: 0.14 – 0.82; p=0.016), or face shields (RR=0.30; 95% CI: 0.14 – 0.64; p=0.002) or gown (RR=0.30; 95% CI: 0.15 – 0.63; p=0.001) during contact with index patient had significantly decreased risk of COVID-19 infection than those who did not. Similarly, HCWs who performed hand hygiene after each contact with the index patients had 93% lower risk of COVID-19 infection than those who did not (RR = 0.07; 95% CI: 0.02 – 0.25; p<0.001). Other HCW related factors such as age, sex, job category, pre-existing medical conditions and smoking showed no significant association with testing positive for COVID-19 in the bivariate analysis (Table 8).

Important exposure related factors that significantly increased the risk of COVID-19 infection at the bivariate level includes close contact (within 1 meter) with index patient (RR 3.89; 95% CI: 1.71 – 8.86; p=0.001), greater than two estimated individual contacts (RR 6.00; 95% CI: 2.01 – 17.91; p=0.001), lifting or position patient (RR 4.12; 95% CI 1.69 – 10.02; p=0.002), changing patient bed linens (RR 3.71; 95% CI: 1.29 – 10.71; p=0.015), cleaning patient room (RR 5.00; 95% CI: 1.69 – 14.78; p=0.004)), exposure in triage or outpatient unit (RR 5.09; 95% CI: 2.11 – 12.31; p<0.001), contact with patient body fluids (RR 3.24; 95% CI: 1.21 – 8.63; p=0.019), contact

with patients materials (RR 4.05; 95% CI: 1.91 – 8.57; p<0.001) and contact with surfaces around patient (RR 5.06; 95% CI: 2.38 – 10.73; p<0.001) (Table 9).

Table 8: Bivariate logistic analysis of HCW-related factors associated with COVID-19 infection, Sierra Leone, 2020

HCW Characteristics	No. of HCWs tested positive for COVID-19 (n=44)	No. of HCWs tested negative for COVID-19 (n=108)	CRR	(95% CI)	p-value
Age group2 (in years)					
< 50	43	102		1	
≥ 50	1	6	0.40	(0.05 - 3.38)	0.397
Sex					
Female	31	82		Ref	
Male	13	26	1.32	(0.60 - 2.90)	0.484
Job Category/Cadre					
Medical doctor	1	3		1	
SRN	1	10	0.30	(0.01 - 6.38)	0.440
SECHN	18	51	1.06	(0.10 - 10.84)	0.962
Nursing Aid	4	11	1.09	(0.09 - 13.78)	0.946
Cleaner	10	8	3.75	(0.32 - 43.31)	0.290
Others¥	10	25	1.20	(0.11 - 12.95)	0.881
Pre-existing Condition					
No	41	100		1	
Yes	3	8	0.91	(0.23 - 3.62)	0.899
Smokes cigarette					
No	41	105		1	
Yes	3	3	2.56	(0.50 - 13.21)	0.261
Ever trained in IPC					
No	8	18		1	
Yes	36	90	0.90	(0.36 - 2.25)	0.822
Inappropriate use of PPE					
No	17	76		1	
Yes	27	32	3.77	(1.81 - 7.86)	< 0.001
Reported used appropriate PPE when in contact with patient (yes)					
Surgical mask	34	86	0.87	(0.37 - 2.03)	0.747
N95 mask	13	73	0.20	(0.09 - 0.43)	< 0.001
Gloves	32	96	0.33	(0.14 - 0.82)	0.016
Face shields	12	60	0.30	(0.14 - 0.64)	0.002
Gown	17	73	0.30	(0.15 - 0.63)	0.001
Hand hygiene after each contact with index patient					
No	13	3		1	
Yes	31	105	0.07	(0.02 - 0.25)	< 0.001

COVID-19= Coronavirus disease 2019; HCWs= Healthcare workers; CRR= Crude relative risk
CI= Confidence interval; SRN= State registered nurse; SECHN= State enrolled community health nurse; IPC= Infection prevention and control; PPE= Personal protective equipment

Table 9: Bivariate logistic analysis of exposure related factors associated with COVID-19 infection in HCWs, Sierra Leone, 2020

Exposure variables	No. of HCWS tested positive for COVID-19 (n=44)	No. of HCWs tested negative for COVID-19 (n=108)	CRR	(95% CI)	p-value
Close contact (within 1 meter) with index case					
No	9	54		1	
Yes	35	54	3.89	(1.71 - 8.86)	0.001
Estimated individual number of contacts					
No contact	9	54		1	
1 - 2 contacts	24	43	3.35	(1.41 - 7.95)	0.006
≥ 3 contacts	11	11	6.00	(2.01 - 17.91)	0.001
Pro-longed (>15 minute) face-to-face contact					
No	22	69		1	
Yes	22	39	1.77	(0.87 - 3.60)	0.115
Activities during exposure to index patient (yes)					
Lifting/positioning patient	14	11	4.12	(1.69 - 10.02)	0.002
Changing bed linens	9	7	3.71	(1.29 - 10.71)	0.015
Cleaning patient room	10	6	5.00	(1.69 - 14.78)	0.004
No direct patient care, stayed in same room with patient	7	58	0.16	(0.07 - 0.40)	< 0.001
Exposure location					
X-ray or Laboratory unit	2	6	1.17	(0.22 - 6.13)	0.855
Triage/Isolation or Outpatient unit	16	11	5.09	(2.11 - 12.31)	< 0.001
Inpatient ward	26	91		1	
Contact with patient body fluids					
No	34	99		1	
Yes	10	9	3.24	(1.21 - 8.63)	0.019
Contact with patient materials					
No	21	85		1	
Yes	23	23	4.05	(1.91 - 8.57)	<0.001
Contact with surfaces around patient					
No	18	84		1	
Yes	26	24	5.06	(2.38 - 10.73)	< 0.001

COVID-19= Coronavirus disease 2019; HCWs= Healthcare workers; CRR= Crude relative risk
CI= Confidence interval

In the multivariable logistic regression analysis, contact with surfaces around patient, exposure at the triage/isolation or outpatient unit and cleaning of patient room were significant independent risk factors for COVID-19 infection among hospital HCWs (Table 10). The risk of COVID-19 infection among HCWs who had contact with the surfaces around the patient is three times higher than those who did not (RR 3.25; 95% CI: 1.14 – 9.30; p=0.028). The risk of infection increased eight folds among HCWs who got exposed at the triage/isolation or outpatient unit of the hospitals compared to HCWs who got exposed at the inpatient ward of the hospital (RR 8.3; 95% CI: 2.49 – 28.27; p=0.001). HCWs who cleaned patient room had four fold increased risk of infection than those that did not clean the patient room (RR 4.08; 95% CI: 1.12 – 14.96; p=0.034).

There were significantly decreased risk of COVID-19 infection among HCWs that performed hand hygiene with ABHR or soap and water (RR 0.04; 95% CI: 0.01 – 0.23); p <0.001) compared to those that did not. Similarly, the risk of COVID-19 infection decreased by 75% among HCWs who did not carry out any patient care activity but only stayed in the same room as patient (RR 0.25; 95% CI: 0.08 – 0.80; p=0.020) compared to those that did (Table 10).

Table 10: Multivariable logistic analysis of factors associated with COVID-19 infection among exposed HCWs, Sierra Leone, 2020

Variables	No. of HCWS tested positive for COVID-19 (n=44)	No. of HCWs tested negative for COVID-19 (n=108)	ARR (95% CI)	p-value
Contact with surfaces around patient				
No	18	84	1	
Yes	26	24	3.25 (1.14 - 9.30)	0.028
Exposure location				
X-ray/Laboratory unit	2	6	0.94 (0.14 - 6.56)	0.951
Triage/Isolation/Outpatient unit	16	11	8.39(2.49 - 28.27)	0.001
Inpatient ward	26	91	1	
Activities during exposure to index patient (yes)				
Cleaning patient room	10	6	4.08(1.12 - 14.96)	0.034
No direct contact, stayed in same room with patient	7	58	0.25 (0.08 - 0.80)	0.020
Hand hygiene after each contact with index patient				
No	13	3	1	
Yes	31	105	0.04 (0.01 - 0.23)	< 0.001

COVID-19= Coronavirus disease 2019; HCWs= Healthcare workers; ARR= Adjusted relative risk; CI= Confidence interval;

CHAPTER FIVE

DISCUSSION

5.0 Self-reported Infection prevention and control practices among exposed HCWs

Healthcare worker practice in IPC, driven by their knowledge can play a pivotal role in infection control in hospitals. This study shows that 82.9% of the exposed HCWs reported to had received training in IPC. Among those who had ever received IPC training, about 66.7% reported last IPC training was conducted more than a year. The reported proportion of IPC trained HCWs obtained in this study is relatively higher than the proportions of 66.0% and 72.1% reported in two studies conducted in Sierra Leone during the Ebola outbreak in 2014/2016 (Olu et al., 2015; Qin et al., 2018). The reported high proportion of IPC trained HCWs obtained in the present study could be attributed to the series of IPC improvement programs instituted by the MOHS and partners following the 2014/2016 Ebola epidemic.

Proper hand hygiene with ABHR or soap and water is one of the most simple and cost-effective intervention in reducing healthcare-associated infections. In this study, 63.8% of HCWs reported they always follow the recommended hand hygiene practices. This is lower than what was reported in a study conducted four years ago in Sierra Leone, which reported 82.6% (Qin et al., 2018). A narrative review on compliance to hand hygiene by HCWs in sub-Saharan Africa estimated an overall compliance of 21.1% among HCWs (Atalyero et al., 2019). The study identified lack of hand sanitizer or water and soap, poorly positioned facilities and heavy workload as important barriers to hand hygiene practices(Atalyero et al., 2019). Most of the HCWs in the current study reported to have last received IPC training more than a year ago. The long duration since last IPC training coupled with irregular hand hygiene audits may have contributed to lower proportions of HCWs who reported adherence to recommended hand hygiene practices. Because training was

received a long time ago, the knowledge and skills of HCWs in IPC may have been rudimentary. In this study, 66.4% of respondent reported PPE not available in sufficient quantities. Insufficient PPE has been cited as an imported risk factor for COVID-19 infection among HCWs (Bai et al., 2020b; Grimm, 2020; Schwartz et al., 2020).

5.1 Secondary infection rate (SIR) among HCWs exposed to COVID-19 patient

This study found an overall secondary infection rate of 28.9% for COVID-19 in the study population. This was substantially higher than the infection rates reported in previous studies from the Netherlands (6.0% & 11.0%) and the United Kingdom (18.0%) (Keeley et al., 2020; Kluytmans- Van den Bergh et al., 2020; Tostmann et al., 2020). These studies, conducted only one molecular rRT-PCR testing on symptomatic HCWs with fever or mild respiratory symptoms. The overall infection rate in this study was lower than what was reported in a study conducted in China that reported an infection rate of 38.9% (Ran et al., 2020a). While the current study excluded HCWs with close family members with COVID-19 infection, the authors in the China study included HCWs that got exposed to family members with COVID-19. This could account for the much higher much higher infection rate obtained in the study. A universal screening conducted among HCWs in a maternity hospital in London from 7th March through 16th April, 2020 reported an infection rate of 18.0% (Khalil et al., 2020). A report from a seroprevalence study conducted among 500 asymptomatic HCWs (331 clinical and 169 non-clinical staff) from Blantyre City, Malawi indicated an overall infection rate of 12.3% after adjusting for test sensitivity and specificity (Chibwana et al., 2020). The present study observed SIR to be highest among cleaners (55.6%), followed by nursing aids (26.7%) and SECHNs (26.1%). This was contrary to findings from other studies that reported high infection rate among clinical staff than non-clinical staff (Lapolla, Mingoli, & Lee, 2020; Barrett et al., 2020; Zheng et al., 2020). This study hypothesized

that cleaners most likely were exposed to contaminated surfaces or patient materials during cleaning of index patient rooms and or changing patient bed linens.

The study also observed high infection rate among HCWs exposed at triage/isolation or outpatient units of the hospitals. COVID-19 infection rate have been shown to vary between clinical departments (Gong et al., 2020; Iversen et al., 2020; Ran et al., 2020b; Zheng et al., 2020; Zheng et al., 2020). The high infection rates reported among HCWs in this study is alarming, thus testifying the lack of knowledge of the virus and the need for improvement in infection control practices.

5.2 Clinical Characteristics of COVID-19 infection among HCWs

In this study, a large proportion (68.2%) of HCWs with COVID-19 reported no symptoms. For symptomatic HCWs, headache, fever and cough were the most frequent symptoms reported. These findings were consistent with other studies (Bergh et al., 2020; Jie Liu et al., 2020; Liu et al., 2020; Wang, Liu, et al., 2020; Yasmin et al., 2020). The high proportion of infected asymptomatic HCWs observed in this study has important implications for infection prevention and control precautions in healthcare facilities. Although the role of asymptomatic transmission of SARS-CoV-2 has not been fully established (Lai et al., 2020), preliminary evidence suggest people with asymptomatic infection can spread the virus (Chaw et al., 2020; Cheng et al., 2020; Lai et al., 2020; Luo et al., 2020; Park et al., 2020). Furthermore, similar viral load pattern was detected in asymptomatic and symptomatic patients, indicating the transmission potential of COVID-19 asymptomatic patients (Zou et al., 2020). HCWs with unrecognized COVID-19 infection may serve as major risk group for nosocomial transmission and amplification events within healthcare facilities. Thus, control of SARS-CoV-2 transmission in a healthcare setting could depend on maintaining a low threshold for suspicion of COVID-19 infection among exposed HCWs.

5.3 Risk factors for COVID-19 infection among HCWs

Nosocomial transmission of respiratory diseases including COVID-19 are common occurrences. In this study, contact with surfaces around patient, cleaning patient room and exposure at the triage or outpatient units were found to be associated with increased risk for COVID-19 infection in HCWs. The multivariable logistic regression in this study reveals that, HCWs who had contact with surfaces around the patient had 3.25 folds increased risk of infection. To date, no strong evidence exist for transmission of COVID-19 through contaminated surfaces (fomites) (WHO, 2020b). However, SARS-CoV-2 viral RNA has been detected on surfaces in the immediate environments of infected patients, suggesting the environment as potential route of SARS-CoV-2 transmission (Guo et al., 2020; Jiang et al., 2020; Ong et al., 2020; Wu et al., 2020). In the current study, cleaning patient room was significantly associated with increased risk of COVID-19 infection among HCWs. In addition all the index cases were symptomatic on admission with possible viral shedding and contamination of their immediate surroundings. These two findings support the fact that fomite transmission might be the main route of infection in the current study. These findings were also supported by the high infection rates noted among cleaners and low cadre nurses (Nursing Aid and SECHNs). These staff are mostly responsible for cleaning patient rooms and changing of bed linens.

This study found that exposure at triage or outpatient units significantly increase the risk of infection. The transmission of COVID-19 among HCWs has been reported to occur in a variety of work departments within hospitals (Gong et al., 2020; Iversen et al., 2020; Ran et al., 2020b; Zheng et al., 2020; Zheng et al., 2020; Sua´rez-Garcı´a, Lo´pez, Vicente, & Abascal, 2020). This finding has important implications for infection control at the triage or outpatient department as these units are the entry point to the hospital by all patients. HCWs at these units are therefore expected to apply at all times standard precautions including transmission-based precautions. Infection in

HCWs could have occurred as a result of non-adherence to standard infection control practices including hand hygiene and use of appropriate PPE.

Hand hygiene is considered the most cost-effective intervention in preventing healthcare-associated infections including COVID-19. This study found that hand hygiene with ABHR or soap and water after each contact with the index patient was associated with a 96% reduced risk of infection. Most often transmission of SARS-CoV-2 from patients to HCWs occurs following contamination of HCW's hands after either direct contact with the patients or contaminated surfaces. A retrospective cohort study conducted in a hospital in Wuhan, China found suboptimal hand hygiene before and after contact with patient to increase HCW risk by three folds (Ran et al., 2020a).Therefore to prevent infection in a healthcare setting, WHO recommends the use of contact and droplet precautions by HCWs caring for patients with COVID-19 (WHO, 2020c). The result in this study highlights the importance of hand hygiene in preventing healthcare-associated infections.

Despite consistent evidence supporting droplet infection and close contact with infected individuals as the primary route of COVID-19 transmission (Burke et al., 2020; Chan, Yuan, et al., 2020; Pung et al., 2020; Tong et al., 2020; Yu, Zhu, Zhang, & Han, 2020), this study found no association between close contact within 1 meter with index case and COVID-19 infection at the multivariable level. However, this association was significant at the bivariate level with a fourfold increased risk of infection in HCWs who had close contact (within 1 meter) with index case. As all the index patients were symptomatic on admission, the possibility of droplet and close contact transmission cannot be ruled out in this study.

This study did not find any association with smoking or pre-existing medical conditions, most likely because the prevalence of smoking (3.9%) and pre-existing medical conditions (7.2%) was

low in the study population. The study also found no association between COVID-19 infection age and sex.

None of the HCWs reported exposure to any aerosol-generating procedures. Therefore the role of AGPs in the transmission of COVID-19 in a healthcare setting were not examined in this study.

5.4 Strengths and limitation

This study has several strengths. First, the study was conducted immediately when the hospitals reported confirmed cases, thus minimizing the risk of HCW exposure in the community. Second, to determine risk factors for COVID-19 infection during patient care activities this study compared COVID-19 positive and negative HCWs. Third, exposed HCWs were immediately quarantined and tested twice by molecular method irrespective of symptoms during the 14 days follow up to determine infection status. This enabled an unbiased case ascertainment. Fourth, this was a prospective study and the questionnaires were administered immediately within a week after exposure. Thus the potential for recall bias was minimized.

This study also has limitations. First, this study did not use serological method to determine infection status among HCWs, thus the full extent of infection cannot be ascertained. However, the high infection rate noted among HCWs could represent the true extent of infection. Second, the possibility of cross-infection among HCWs especially those that were asymptomatic in quarantine facilities cannot be ruled out. Third, whole-genome sequencing in specimen from HCWs and index patients was not carried out to determine the actual source of infection. Thus the study was unable able to determine whether the overall infection rate was due to nosocomial or community transmission. Lastly hospital related component of IPC such as hospital design, availability of PPEs or hand hygiene materials were not investigated as risk factors in this study.

Despite these limitations, our findings have important implications for infection control practices in healthcare settings in Sierra Leone.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study highlight detailed assessment of the extent of and risk factors for COVID-19 infection associated with HCW involvement in patient care activities and their infection prevention and control practices. The findings have important implications for infection control practices. Most of the HCWs in this study do not always follow standard IPC precautions including recommended hand hygiene practices. The secondary infection rate for COVID-19 among HCWs in this study was high, especially among cleaners and those exposed at the triage or outpatient units of the hospitals. Infected HCWs were mostly asymptomatic. This study identified contact with surfaces around index patient, cleaning of patient room and working in triage or outpatient unit to be significant risk factors for COVID-19 infection among HCWs in the study settings. This study further provide confirmation that hand hygiene with ABHR or soap and water after each contact with a patient is effective in preventing nosocomial spread of COVID-19. The following recommendations are being made for consideration based on the findings of this study.

6.2 Recommendations

Healthcare workers

- HCWs should ensure they always apply standard precautions for all patients. This include hand hygiene practices, use of appropriate PPE and environmental cleaning and disinfection.
- Cleaning staff should ensure they wear appropriate PPE during cleaning patient rooms and other clinical areas within the hospital

Hospital administrations of the study sites

- Hospital management should intensify and improve infection control practices
- Hospital management to provide training for healthcare staff on IPC specifically transmission-based precautions
- Hospital management should institute regular screening of HCWs to timely identify asymptomatic infections
- Hospital management should ensure environmental cleaning and disinfection are carried out consistently and correctly.

REFERENCES

Adams, J. G., & Walls, R. M. (2020). Supporting the Health Care Workforce during the COVID-19 Global Epidemic. *JAMA - Journal of the American Medical Association*, *323*(15), 1439–1440. https://doi.org/10.1001/jama.2020.3972

Alqahtani, J. S., Oyelade, T., Aldhahir, A. M., Alghamdi, S. M., Almehmadi, M., Alqahtani, A. S., Quaderi, S., Mandal, S., & Hurst, J. R. (2020). Prevalence, Severity and Mortality associated with COPD and Smoking in patients with COVID-19 : A Rapid Systematic Review and Meta-Analysis. *PLoS ONE*, *15*(5), 1–13. https://doi.org/http://dx.doi.org/10.1371/journal.pone.0233147

Atalyero, Y., Dyson, J., & Graham, M. (2019). Barriers to hand hygiene practices among healthcare workers in Sub- Saharan African countries: a narrative review. *American Journal of Infection Control*, *47*(5), 565–573. https://doi.org/https://doi.org/10.1016/j.ajic.2018.09.014

Backer, J. A., Klinkenberg, D., & Wallinga, J. (2020). Incubation period of 2019 novel coronavirus (2019- nCoV) infections among travellers from Wuhan, China, 20 28 January 2020. *Eurosurveillance*, *25*(5), 1–6. https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000062

Bai, Y., Wang, X., Huang, Q., Wang, H., Gurarie, D., Ndeffo-Mbah, M., Fan, F., Fu, P., Horn, M. A., Xu, S., Mondal, A., Jiang, X., & Zhao, H. (2020a). SARS-CoV-2 infection in health care workers: a retrospective analysis and a model study. *MedRxiv*. https://doi.org/10.1101/2020.03.29.20047159

Bai, Y., Wang, X., Huang, Q., Wang, H., Gurarie, D., Ndeffo-Mbah, M., Fan, F., Fu, P., Horn, M. A., Xu, S., Mondal, A., Jiang, X., & Zhao, H. (2020b). SARS-CoV-2 infection in health care workers: a retrospective analysis and a model study. *MedRxiv*, 2020.03.29.20047159. https://doi.org/10.1101/2020.03.29.20047159

Barrett, E. S., Horton, D. B., Roy, J., Gennaro, M. L., Brooks, A., Tischfield, J., Greenberg, P., Andrews, T., Jagpal, S., Reilly, N., Blaser, M. J., Carson, J. L., & Panettieri, R. A. (2020). Prevalence of SARS-CoV-2 infection in previously undiagnosed health care workers at the onset of the U.S. COVID-19 epidemic. *MedRxiv*. https://doi.org/10.1101/2020.04.20.20072470

Bergh, M. F. Q. K. den, Buiting, A. G. M., Pas, S. D., Bentvelsen, R. G., Bijllaardt, W. van den, Oudheusden, A. J. G. van, Rijen van, M. M. L., Verweij, J. J., Koopmans, M. P. G., & Kluytmans, J. A. J. W. (2020). SARS-CoV-2 infection in 86 healthcare workers in two Dutch hospitals in March 2020. *MedRxiv*, 1–16. https://doi.org/https://doi.org/10.1101/2020.03.23.20041913

Burke, R. M., Midgley, C. M., Dratch, A., Fenstersheib, M., Haupt, T., Holshue, M., Ghinai, I., Jarashow, M. C., Lo, J., McPherson, T. D., Rudman, S., Scott, S., Aron J. Hall, A. J., Fry, A. M., & Rolfes, M. A. (2020). Active Monitoring of Persons Exposed to Patients with Confirmed COVID-19 — United States, January–February 2020. *Morbidity and Mortality Weekly Report*, *69*(9), 245–246. https://doi.org/10.15585/mmwr.mm6909e1

Cai, H. (2020). Sex difference and smoking predisposition in patients with COVID-19. *The Lancet Respiratory Medicine*, *8*(4), e20. https://doi.org/10.1016/S2213-2600(20)30117-X

Chan, J. F. W., Kok, K. H., Zhu, Z., Chu, H., To, K. K. W., Yuan, S., & Yuen, K. Y. (2020). Genomic characterization of the 2019 novel human-pathogenic coronavirus isolated from a patient with atypical pneumonia after visiting Wuhan. *Emerging Microbes and Infections*, *9*(1), 221–236. https://doi.org/10.1080/22221751.2020.1719902

Chan, J. F. W., Yuan, S., Kok, K. H., To, K. K. W., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C. C. Y., Poon, R. W. S., Tsoi, H. W., Lo, S. K. F., Chan, K. H., Poon, V. K. M., Chan, W. M., Ip, J. D., Cai, J. P., Cheng, V. C. C. C., Chen, H., Hui, C. K. M., & Yuen, K. Y. (2020). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *The Lancet*, *395*(10223), 514–523. https://doi.org/10.1016/S0140-6736(20)30154-9

Chaw, L., Koh, W. C., Jamaludin, S. A., Naing, L., Alikhan, M. F., & Wong, J. (2020). SARS-CoV-2 transmission in different settings: Analysis of cases and close contacts from the Tablighi cluster in Brunei Darussalam. *MedRxiv*. https://doi.org/10.1101/2020.05.04.20090043

Chelenyane, M., & Endacott, R. (2006). Self-reported infection control practices and perceptions of HIV/AIDS risk amongst emergency department nurses in Botswana. *Accident and Emergency Nursing*, *14*(3), 148–154. https://doi.org/10.1016/j.aaen.2006.03.002

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., Xia, J., Yu, T., Zhang, X., & Zhang, L. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet*, *395*(10223), 507–513. https://doi.org/10.1016/S0140-6736(20)30211-7

Cheng, H. Y., Jian, S. W., Liu, D. P., Ng, T. C., Huang, W. T., & Lin, H. H. (2020). Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods before and after Symptom Onset. *JAMA Internal Medicine*, *180*(9), 1156–1163. https://doi.org/10.1001/jamainternmed.2020.2020

Chibwana, M. G., Jere, K. C., Kamn'gona, R., Mandolo, J., Katunga-Phiri, V., Tembo, D., Mitole, N., Musasa, S., Sichone, S., Lakudzala, A., Sibale, L., Matambo, P., Kadwala, I., Byrne, R. L., Mbewe, A., Henrion, M. Y. R., Morton, B., Phiri, C., Mallewa, J., Mwandumba, H. C., Adams, E. R., Gordon, S. B., & Jambo, K. C. (2020). High SARS-CoV-2 seroprevalence in health care workers but relatively low numbers of deaths in urban Malawi 3. *MedRxiv*. https://doi.org/https://doi.org/10.1101/2020.07.30.20164970 .

Feng, Z., Li, Q., Zhang, Y., Wu, Z., Dong, X., Ma, H., Yin, D., Lyu, K., Wang, D., Zhou, L., Ren, R., Li, C., Wang, Y., Ni, D., Zhao, J., Li, B., Wang, R., Niu, Y., Wang, X., Zhang, L., Sun, J., Liu, B., Deng, Z., Ma, Z., Yang, Y., Liu, H., Shao, G., Li, H., Liu, Y., Zhang, H., Qu, S., Lou, W., Shan, D., Hu, Y., Hou, L., Zhao, Z., Liu, J., Wang, H., Pang, Y., Han, Y., Ma, Q., Ma, Y., Chen, S., Li, W., Yang, R., Li, Z., Guo, Y., Liu, X., Jiangtulu, B., Yin, Z., Xu, J., Wang, S., Xiao, L., Xu, T., Wang, L., Qi, X., Shi, G., Tu, W., Shi, X., Su, X., Li, Z., Luo, H., Ma, J., & McGoogan, J. M. (2020). The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) - China, 2020. *China CDC Weekly*, *2*(8), 113–122. https://doi.org/10.46234/ccdcw2020.032

Furukawa, N. W., Brooks, J. T., & Sobel, J. (2020). Evidence Supporting Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 While Presymptomatic or Asymptomatic. *Emerging Infectious Diseases*, *26*(7), 13–17. https://doi.org/10.3201/eid2607.201595

Gao, Z., Xu, Y., Sun, C., Wang, X., Guo, Y., Qiu, S., & Ma, K. (2020). A systematic review of asymptomatic infections with COVID-19. *Journal of Microbiology, Immunology and Infection*, 1–5. https://doi.org/10.1016/j.jmii.2020.05.001

Gong, H., Feng, H., Yu, L., Tu, N., Wang, T., Yao, Y., Wei, Y., Wang, Y., Hu, W., Li, X., Fu, Z., Song, X., Song, Q., & Bu, L. (2020). Coronavirus Disease 2019 Infection Among Medical Staff in Wuhan: A Retrospective Study From a Single Center. *Chest*. https://doi.org/https://doi.org/10.1016/j.chest.2020.05.529

Grant, M. C., Geoghegan, L., Arbyn, M., Mohammed, Z., McGuinness, L., Clarke, E. L., & Wade, R. (2020). The Prevalence of Symptoms in 24,410 Adults Infected by the Novel Coronavirus (SARS-CoV-2; COVID-19): A Systematic Review and Meta-Analysis of 148 Studies from 9 Countries. *PLoS ONE*. https://doi.org/10.2139/ssrn.3582819

Grayson, M. L., Russo, P. L., Cruickshank, M., Bear, J. L., Gee, C. A., Hughes, C. F., Johnson, P. D. R., Mccann, R., McMillan, A. J., Mitchell, B. G., Selvey, C. E., Smith, R. E.,& Wilkinson, I. J. (2011). Outcomes from the first 2 years of the Australian National Hand Hygiene Initiative. *Medical Journal of Australia*, *195*(10), 615–619. https://doi.org/10.5694/mja11.10747

Grimm, C. A. (2020). *Hospital Experiences Responding to the COVID-19 Pandemic: Results of a National Pulse Survey March 23–27, 2020*. Retrieved from https://oig.hhs.gov/oei/reports/oei-06-20-00300.pdf

Guo, Z.-D., Wang, Z.-Y., Zhang, S.-F., Li, X., Li, L., Li, C., Cui, Y., Fu, R. B., Dong, Y. Z., Chi, X. Y., Zhang, M. Y., Liu, K., Cao, C., Liu, B., Zhang, K., Gao, Y. W., Lu, B., & Chen, W. (2020). Aerosol and Surface distribution of severe acute respiratory syndrome coronavirus 2 in Hospital wards, Wuhan, China, 2020. *Emerging Infectious Diseases*, *26*(7), 1586–1591. https://doi.org/10.1177/1420326X20942938

Heinzerling, A., Stuckey, M. J., Scheuer, T., Xu, K., Perkins, K. M., Resseger, H., Magill, S., Verani, J. R., Jain, S., Acosta, M., & Epson, E. (2020). Transmission of COVID-19 to health care personnel during exposures to a hospitalized patient - Solano County, California, February 2020. *Morbidity and Mortality Weekly Report*, *69*(15), 472–476. https://doi.org/10.15585/MMWR.MM6915E5

Ho, M., Seto, W., Wong, L., & Wong, T. (2012). Effectiveness of Multifaceted Hand Hygiene Interventions in Long-Term Care Facilities in Hong Kong: A Cluster-Randomized Controlled Trial. *Infection Control & Hospital Epidemiology*, *33*(8), 761–767. https://doi.org/10.1086/666740

Hosmer, D. W. J., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied Logistic Regression Analysis. Model-Building Strategies and methods for Logistic Regress* (3rd ed.). Hoboken, New Jersey: John Wiley & sons, Inc. https://doi.org/10.4135/9781412983433, ISBN: 9780470582473

Houghton, C., Meskell, P., Delaney, H., Smalle, M., Glenton, C., Booth, A., Xhs, C., Devane, D., & Lm, B. (2020). Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases : a rapid qualitative evidence synthesis (Review). *Cochrane Database of Systematic Reviews 2020, Issue 4. Art. No.: CD013582.* https://doi.org/10.1002/14651858.CD013582.Copyright

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., Xiao, Y., Gao, H., Guo, L., Xie, J., Wang, G., Jiang, R., Gao, Z., Jin, Q., Wang, J., & Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*, *395*, 497–506. https://doi.org/https://doi.org/10.1016/ S0140-6736(20)30183-5

Ing, E., Xu, A. Q., Salimi, A., & Torun, N. (2020). Physician deaths from corona virus (COVID-19) disease. *Occupational Medicine*. https://doi.org/10.1093/occmed/kqaa088

Iversen, K., Bundgaard, H., Hasselbalch, R. B., Kristensen, J. H., Nielsen, P. B., Pries-Heje, M., Knudsen, A. D., Christensen, C. E., Fogh, K., Norsk, J. B., Andersen, O., Fischer, T. K., Jensen, C. A. J., Larsen, M., Torp-Pedersen, C., Rungby, J., Ditlev, S. B., Hageman, I., Møgelvang, R., Hother, C. E., Gybel-Brask, M., Sørensen, E., Harritshøj, L., Folke, F., Sten, C., Benfield, T., Nielsen, S. D., & Ullum, H. (2020). Risk of COVID-19 in health-care workers in Denmark: an observational cohort study. *The Lancet Infectious Diseases*, *2*(20), 3–10. https://doi.org/10.1016/S1473-3099(20)30589-2

Jiang, F.-C., Jiang, X. L., Wang, Z.-G., Meng, Z.-H., Shao, S.-F., Anderson, B. D., & Ma, M.-J. (2020). Detection of Severe Acute Respiratory Syndrome Coronavirus 2 RNA on Surfaces in Quarantine Rooms. *Emerging Infectious Diseases*, *26*(9), 1–3. https://doi.org/10.3201/eid2609.201435

Keeley, A. J., Evans, C., Colton, H., Ankcorn, M., Cope, A., State, A., Bennett, T., Giri, P., de Silva, T. I., & Raza, M. (2020). Roll-out of SARS-CoV-2 testing for healthcare workers at a large NHS Foundation Trust in the United Kingdom, March 2020. *Eurosurveillance*, *25*(14), 1–4. https://doi.org/10.2807/1560-7917.ES.2020.25.14.2000433

Kermode, M., Jolley, D., Langkham, B., Thomas, M. S., Holmes, W., & Gifford, S. M. (2005). Compliance with Universal/Standard Precautions among health care workers in rural north India. *American Journal of Infection Control*, *33*(1), 27–33. https://doi.org/10.1016/j.ajic.2004.07.014

Khalil, A., Hill, R., Ladhani, S., Pattisson, K., & Brien, P. O. (2020). COVID-19 screening of health-care workers in a London maternity hospital. *The Lancet Infectious Diseases*, (May 18). https://doi.org/10.1016/S1473-3099(20)30403-5

Kluytmans- Van den Bergh, M. F. Q., Buiting, A. G., Pas, S. D., Bentvelsen, R. G., Bijllaardt, W. van den, van Oudheusden, A. J., van Rijen, M. M. L., Verweij, J. J., Koopmans, M. P. G., & Kluytmans, J. A. (2020). SARS-CoV-2 infection in 86 healthcare workers in two Dutch hospitals in March 2020. *MedRxiv*, 1–16. https://doi.org/https://doi.org/10.1101/2020.03.23.20041913

Koh, D. (2020). Occupational risks for COVID-19 infection. *Occupational Medicine*, *70*(1), 3–5. https://doi.org/10.1093/occmed/kqaa036

Lai, C.-C., Liu, Y. H., Wang, C.-Y., Wang, Y.-H., Hsueh, S.-C., Yen, M.-Y., Ko, W.-C., &

Hsueh, P.-R. (2020). Asymptomatic carrier state, acute respiratory disease, and pneumonia due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2): Facts and myths. *Journal of Microbiology, Immunology and Infection*, *53*, 404–412. https://doi.org/10.1007/s00134-020-05991-x.Bizzarro

Lai, C., Shih, T., Ko, W., Tang, H., & Hsueh, P. (2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *International Journal of Antimicrobial Agents*, *55*. https://doi.org/https://doi.org/10.1016/j.ijantimicag.2020.105924

Lapolla, P., Mingoli, A., & Lee, R. (2020). Deaths from COVID-19 in healthcare workers in Italy - What can we learn? *Infection Control and Hospital Epidemiology*, 1–2. https://doi.org/10.1017/ice.2020.241

Lauer, S. A., Grantz, K. H., Bi, Q., Jones, F. K., Zheng, Q., Meredith, H., Azman, A. S., Reich, N. G., & Lessler, J. (2020). The incubation period of 2019-nCoV from publicly reported confirmed cases: estimation and application. *MedRxiv*. https://doi.org/https://doi.org/10.1101/2020.02.02.20020016

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., Ren, R., Leung, K. S. M., Lau, E. H. Y., Wong, J. Y., Xing, X., Xiang, N., Wu, Y., Li, C., Chen, Q., Li, D., Liu, T., Zhao, J., Liu, M., Tu, W., Chen, C., Jin, L., Yang, R., Wang, Q., Zhou, S., Wang, R., Liu, H., Luo, Y., Liu, Y., Shao, G., Li, H., Tao, Z., Yang, Y., Deng, Z., Liu, B., Ma, Z., Zhang, Y., Shi, G., Lam, T. T. Y., Wu, J. T., Gao, G. F., Cowling, B. J., Yang, B., Leung, G. M., & Feng, Z. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *New England Journal of Medicine*, *382*(13), 1199–1207. https://doi.org/10.1056/NEJMoa2001316

Liu, Jiaye, Liao, X., Qian, S., Yuan, J., Wang, F., Liu, Y., Wang, Z., Wang, F., Liu, L., & Zhang, Z. (2020). Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China, 2020. *Emerging Infectious Diseases*, *26*(6), 1320–1323. https://doi.org/https://doi.org/10.3201/eid2606.200239

Liu, Jie, Ouyang, L., Fu, P., Cao, Y., Yang, D., Han, X., Alwalid, O., Wu, H., Tao, J., Peng, S., Shi, H., Yang, F., & Zheng, C. (2020). Epidemiological, Clinical Characteristics and Outcome of Medical Staff infected with COVID-19 in Wuhan, China: A Retrospective Case Series Analysis. *MedRxiv*. https://doi.org/https://doi.org/10.1101/2020.03.09.20033118

Liu, M., He, P., Liu, H. G., Wang, X. J., Li, F. J., Chen, S., Lin, J., Chen, P., Liu, J. H., & Li, C. H. (2020). Clinical characteristics of 30 medical workers infected with new coronavirus pneumonia. *Chinese Journal of Tuberculosis and Respiratory Diseases*, *43*(0), E016. https://doi.org/DOI: 10.3760/cma.j.issn.1001-0939.2020.0016.

Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., Wang, W., Song, H., Huang, B., Zhu, N., Bi, Y., Ma, X., Zhan, F., Wang, L., Hu, T., Zhou, H., Hu, Z., Zhou, W., Zhao, L., Chen, J., Meng, Y., Wang, J., Lin, Y., Yuan, J., Xie, Z., Ma, J., Liu, W. J., Wang, D., Xu, W., Holmes, E. C., Gao, G. F., Wu, G., Chen, W., Shi, W., & Tan, W. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *The Lancet*, *395*(10224), 565–574. https://doi.org/10.1016/S0140-6736(20)30251-8

Luo, L., Liu, D., Liao, X., Wu, X., Jing, Q., Zheng, J., Liu, F., Yang, S., Li, Z., Liu, J., & Song, W. (2020). Modes of contact and risk of transmission in COVID-19 among close contacts. *MedRxiv*. https://doi.org/10.7551/mitpress/10890.003.0026

McMichael, T. M., Currie, D. W., Clark, S., Pogosjans, S., Kay, M., Schwartz, N. G., Lewis, J., Baer, A., Kawakami, V., Lukoff, M. D., Ferro, J., Brostrom-Smith, C., Rea, T. D., Sayre, M. R., Riedo, F. X., Russell, D., Hiatt, B., Montgomery, P., Rao, A. K., Chow, E. J., Tobolowsky, F., Hughes, M. J., Bardossy, A. C., Oakley, L. P., Jacobs, J. R., Stone, N. D., Reddy, S. C., Jernigan, J. A., Honein, M. A., Clark, T. A. & Duchin, J. S. (2020). Epidemiology of covid-19 in a long-term care facility in King County, Washington. *New England Journal of Medicine*, *382*(21), 2008–2011. https://doi.org/10.1056/NEJMoa2005412

Ministry of Health and Sanitation. (2020a). *Corona Virus Disease (COVID-19) Situational Report - 035*. Sierra Leone Ministry of Health and Sanitation. Retrieved from https://ddc.moph.go.th/viralpneumonia/eng/index.php, Date retrieved: 4th July, 2020

Ministry of Health and Sanitation. (2020b). *Infection Prevention and Control Standard Operating Procedures On COVID – 19*. Retrieved: 3rd July, 2020

Ministry of Health and Sanitation. (2020c). *Protocol for COVID-19 Quarantine in Sierra Leone – April 2020*. Date retrieved: 27th June, 2020

MOHS. (2015a). Infection Prevention and Control Guidelines. *Ministry of Health and Sanitation*, (March), 48. Retrieved from http://www.cdsbc.org/~ASSETS/DOCUMENT/CDSBC_Infection_Prevention_and_Control_Guidelines_July_2012.pdf [19 June 2015]. Date retrieved: 4th July, 2020

MOHS. (2015b). National Infection Prevention and Control Policy. *Ministry of Health and Sanitation*, 1–182. Retrieved from https://www.idealclinic.org.za/docs/National-Priority-Health-Conditions/Nationl IPC Guideline 2015.pdf. Date retrieved: 4th July, 2020

MOHS. (2017). *Summary Report of the 2017 SARA Plus Report in Sierra Leone*. Retrieved from https://mohs2017.files.wordpress.com/2018/05/mohs-sierra-leone_sara-report_final.pdf. Date retrieved: 4th July, 2020.

MOHS. (2020). *Tib-Molbiol's 2019-nCoV RT-PCR Assay*. *Sierra Leone Ministry of Health and Sanitation*. Date retrieved: 3rd September, 2020

Ng, K., Poon, B. H., Kiat Puar, T. H., Shan Quah, J. L., Loh, W. J., Wong, Y. J., Tan, T. Y., & Raghuram, J. (2020). COVID-19 and the Risk to Health Care Workers: A Case Report. *Annals of Internal Medicine*, *172*(11), 766–767. https://doi.org/10.7326/L20-0175

Olu, O., Kargbo, B., Kamara, S., Wurie, A. H., Amone, J., Ganda, L., Ntsama, B., Poy, A., Kuti-George, F., Engedashet, E., Worku, N., Cormican, M., Okot, C., Yoti, Z., Kamara, K. B., Chitala, K., Chimbaru, A., & Kasolo, F. (2015). Epidemiology of Ebola virus disease transmission among health care workers in Sierra Leone, May to December 2014: A retrospective descriptive study. *BMC Infectious Diseases*, *15*(1), 1–9. https://doi.org/10.1186/s12879-015-1166-7

Ong, S. W. X., Tan, Y. K., Chia, P. Y., Lee, T. H., Ng, O. T., Wong, M. S. Y., & Marimuthu, K. (2020). Air, Surface Environmental, and Personal Protective Equipment Contamination by

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) from a Symptomatic Patient. *JAMA - Journal of the American Medical Association*, *323*(16), 1610–1612. https://doi.org/10.1001/jama.2020.3227

Park, S. Y., Kim, Y. M., Yi, S., Lee, S., Na, B. J., Kim, C. B., Kim, J., Kim, H. S., Kim, Y. B., Park, Y., Huh, I. S., Kim, H. K., Yoon, H. J., Jang, H., Kim, K., Chang, Y., Kim, I., Lee, H., Gwack, J., Kim, S S., Kim, M., Kweon, S., Choe, Y. J., Park, O., Park, Y. J., & Jeong, E. K. (2020). Coronavirus disease outbreak in call center, South Korea. *Emerging Infectious Diseases*, *26*(8), 1666–1670. https://doi.org/10.3201/eid2608.201274

Perlis, R. H. (2018). Exercising Heart and Head in Managing Coronavirus Disease 2019 in Wuhan. *JAMA - Journal of the American Medical Association*, *319*(15), 1541–1542. https://doi.org/10.1001/jama.2018.1331

Pung, R., Chiew, C. J., Young, B. E., Chin, S., Chen, M. I. C., Clapham, H. E., Cook, A. R., Maurer-Stroh, S., Toh, M. P. H. S., Poh, C., Low, M., Lum, J., Koh, V. T. J., Mak, T. M., Cui, L., Lin, R. V. T. P., Heng, D., Leo, Y. S., Lye, D. C., Lee, V. J. M., Kam, K., Kalimuddin, S., Tan, S. Y., Loh, J., Thoon, K. C., Vasoo, S., Khong, W. X., Suhaimi, N. A., Chan, S. J. H., Zhang, E., Oh, O., Ty, A., Tow, C., Chua, Y. X., Chaw, W. L., Ng, Y., Abdul-Rahman, F., Sahib, S., Zhao, Z., Tang, C., Low, C., Goh, E. H., Lim, G., Hou, Y., Roshan, I., Tan, J., Foo, K., Nandar, K., Kurupatham, L., Chan, P. P., Raj, P., Lin, Y., Said, Z., Lee, A., See, C., Markose, J., Tan, J., Chan, G., See, W., Peh, X., Cai, V., Chen, W. K., Li, Z., Soo, R., Chow, A. L. P., Wei, W., Farwin, A., & Ang, L. W. (2020). Investigation of three clusters of COVID-19 in Singapore: implications for surveillance and response measures. *The Lancet*, *395*(10229), 1039–1046. https://doi.org/10.1016/S0140-6736(20)30528-6

Qin, B. Y., Bangura, H. S., Li, B., Zhou, Y., Yuan, Y., Sun, Y., Li, J., Zhao, Z., Jiao, J., Sevalie, S., Song, Y., Jiang, J., Sahr, F., & Jiang, T.-J. (2018). Self-Reported Knowledge and Practices of Healthcare Workers on Occupational Exposure and Protection from Infectious Disease at the Military Hospital in Sierra Leone. *Global Journal of Medical Research (K)*, *18*(5).

Ran, L., Chen, X., Wang, Y., Wu, W., Zhang, L., & Tan, X. (2020a). Risk Factors of Healthcare Workers with Corona Virus Disease 2019 : A Retrospective Cohort Study in a Designated Hospital of Wuhan in China. *Clinical Infectious Diseases*. https://doi.org/10.1093/cid/ciaa287

Ran, L., Chen, X., Wang, Y., Wu, W., Zhang, L., & Tan, X. (2020b). Risk Factors of Healthcare Workers with Corona Virus Disease 2019: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China. *Clinical Infectious Diseases*, 1–4. https://doi.org/10.1093/cid/ciaa287

Reusken, C. B., Buiting, A., Bleeker-Rovers, C., Diederen, B., Hooiveld, M., Friesema, I., Koopmans, M., Kortbeek, T., Lutgens, S. P. M., Meijer, A., Murk, J. L., Overdevest, I., Trienekens, T., Timen, A., Van Den Bijllaardt, W. Van Dissel, J., Van Gageldonk-Lafeber, A., Van Der Vegt, D., Wever, P. C., Van Der Hoek, W., & Kluytmans, J. (2020). Rapid assessment of regional SARS-CoV-2 community transmission through a convenience sample of healthcare workers, the Netherlands, March 2020. *Eurosurveillance*, *25*(12), 6–9. https://doi.org/10.2807/1560-7917.ES.2020.25.12.2000334

Schwartz, J., King, C. C., & Yen, M. Y. (2020). Protecting Healthcare Workers During the Coronavirus Disease 2019 (COVID-19) Outbreak: Lessons From Taiwan's Severe Acute Respiratory Syndrome Response. *Clinical Infectious Diseases*, *71*(15), 858–860. https://doi.org/10.1093/cid/ciaa255

Sierra Leone Statistics. (2016). 2015 Population and Housing Census Summary of Final Results, (May 2012), 1–14. Retrieved from https://www.statistics.sl/images/StatisticsSL/Documents/final-results_-2015_population_and_housing_census.pdf%0Ahttps://www.statistics.sl/wp-content/uploads/2017/01/final-results_-2015_population_and_housing_census.pdf%0Ahttp://www.statsghana.gov.gh/docfi

Sua´rez-Garcı´a, I., Lo´pez, M. J. M. de A., Vicente, A. S., & Abascal, P. L. (2020). SARS-CoV-2 infection among healthcare workers in a hospital in Madrid , Spain. *Journal of Hospital Infection*, *106*(2020), 357–363. https://doi.org/10.1016/j.jhin.2020.07.020

Team, C. C.-19 R. (2020). Characteristics of Health Care Personnel with COVID-19 —United States, February 12-April 9, 2020. *CDC Morbidity and Mortality Weekly Report*, *69*(15), 477–481.

Team, N. C. P. E. R. E. (2020). The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020. *Chinese Journal of Epidemiology*, *41*(2), 145–151. https://doi.org/10.3760/cma.j.issn.0254-6450.2020.02.003

Tong, Z. D., Tang, A., Li, K. F., Li, P., Wang, H. L., Yi, J. P., Zhang, Y. L., & Yan, J. B. (2020). Potential presymptomatic transmission of SARS-CoV-2, Zhejiang Province, China, 2020. *Emerging Infectious Diseases*, *26*(5), 1052–1054. https://doi.org/10.3201/eid2605.200198

Tostmann, A., Bradley, J., Bousema, T., Yiek, W. K., Holwerda, M., Bleeker-Rovers, C., ten Oever, J., Meijer, C., Rahamat-Langendoen, J., Hopman, J., van der Geest-Blankert, N., & Wertheim, H. (2020). Strong associations and moderate predictive value of early symptoms for SARS-CoV-2 test positivity among healthcare workers, the Netherlands, March 2020. *Eurosurveillance*, *25*(16). https://doi.org/10.2807/1560-7917.ES.2020.25.16.2000508

Wan, Y., Shang, J., Graham, R., Baric, R. S., & Li, F. (2020). Receptor Recognition by the Novel Coronavirus from Wuhan: an Analysis Based on Decade-Long Structural Studies of SARS Coronavirus. *Journal of Virology*, *94*(7), 1–9. https://doi.org/10.1128/jvi.00127-20

Wang, C., Liu, L., Hao, X., Guo, H., Wang, Q., Huang, J., He, N., Yu, H., Lin, X., Pan, A., Wei, S., & Wu, T. (2020). Evolving Epidemiology and Impact of Non-pharmaceutical Interventions on the Outbreak of Coronavirus Disease 2019 in Wuhan, China. *MedRxiv*. https://doi.org/https://doi.org/10.1101/2020.03.03.20030593

Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., Wang, B., Xiang, H., Cheng, Z., Xiong, Y., Zhao, Y., Li, Y., Wang, X., & Peng, Z. (2020). Clinical Characteristics of 138 Hospitalized Patients with 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *JAMA - Journal of the American Medical Association*, *323*(11), 1061–1069. https://doi.org/10.1001/jama.2020.1585

Wang, J., Zhou, M., & Liu, F. (2020). Reasons for healthcare workers becoming infected with novel coronavirus disease 2019. *Journal of Hospital Infection*, *105*(1), 100–101. https://doi.org/10.1016/j.jhin.2020.03.002

Wang, X., Liu, W., Zhao, J., Lu, Y., Yu, C., Hu, S., Shen, N., Sun, Z., & Li, W. (2020). Clinical characteristics of 80 hospitalized frontline medical workers infected with COVID-19 in Wuhan, China. *Journal of Hospital Infection*, *105*(3), 399–403. https://doi.org/10.1016/j.jhin.2020.04.019

Wang, X., Pan, Z., & Cheng, Z. (2020). Association between 2019-nCoV transmission and N95 respirator use. *Journal of Hospital Infection*, *105*(1), 104–105. https://doi.org/10.1016/j.jhin.2020.02.021

Wei, X., Wang, X., Peng, W., Wang, Z., Ma, W., & Wang, X. (2019). Clinical characteristics of SARS-CoV-2 infected pneumonia with diarrhea. *The Lancet Global Health*, *4*.

WHO. (2020). Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). *World Health Organization*, *2019*(February), 16–24. Retrieved from https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf. Date retrieved: 4th July, 2020

Williamson, E., Walker, A. J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C. E., Curtis, H. J., Mehrkar, A., Evans, D., Inglesby, P., Cockburn, J., Mcdonald, H. I., Mackenna, B., Douglas, I. J., Rentsch, C. T., Mathur, R., Wong, A., Harrison, D., Forbes, H., Schultze, A., Croker, R., Parry, J., Harper, S., Perera, R., Evans, S., Smeeth, L., & Goldacre, B. (2020). Factors associated with COVID-19-related hospital death in the linked electronic health records of 17 million adult NHS patients. *MedRxiv*, 1–21. https://doi.org/https://doi.org/10.1101/2020.05.06.20092999

World Health Organization. (2016). *Ebola Situation Report January 20th 2016*.

World Health Organization. (2020a). *Coronavirus Disease (COVID-19) Situation Report - 105*. Retrieved from https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200504-covid-19-sitrep-105.pdf?sfvrsn=4cdda8af_2. Date retrieved: 4th July, 2020

World Health Organization. (2020b). *Coronavirus disease 2019 (COVID-19) Situation Report - 82*. Retrieved from https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200411-sitrep-82-covid-19.pdf?sfvrsn=74a5d15_2: Date retrieved: 19th September, 2020

World Health Organization. (2020c). *COVID-19 Situation update for the WHO African Region*. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/331989/SITREP_COVID-19_WHOAFRO_20200506-eng.pdf. Date retrieved: 21st June, 2020

World Health Organization. (2020d). *Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed*. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus- 2019/technical-guidance-publications. Date retrieved: 20th September, 2020

World Health Organization. (2020e). Novel Coronavirus – China 2020. Retrieved June 30, 2020, from https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/

World Health Organization. (2020f). *Novel Coronavirus (2019-nCoV) Situation Report – 22*. Retrieved from https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200211-sitrep-22-ncov.pdf?sfvrsn=fb6d49b1_2.

World Health Organization. (2020g). *Protocol for assessment of potential risk factors for 2019-novel coronavirus (2019-nCoV) infection among health care workers in a health care setting*. Retrieved from https://www.who.int/publications/i/item/protocol-for-assessment-of-potential-risk-factors-for-2019-novel-coronavirus-(2019-ncov)-infection-among-health-care-workers-in-a-health-care-setting

World Health Organization. (2020h). *Transmission of SARS-CoV-2: implications for infection prevention precautions*. Retrieved from https://www.who.int/publications/i/item/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations

Wu, S., Wang, Y., Jin, X., Tian, J., Liu, J., & Mao, Y. (2020). Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. *American Journal of Infection Control*, *48*(8), 910–914. https://doi.org/10.1016/j.ajic.2020.05.003

Xydakis, M. S., Dehgani-Mobaraki, P., Holbrook, E. H., Geisthoff, U. W., Bauer, C., Hautefort, C., Herman, P., Manley, G. T., Lyon, D. M., & Hopkins, C. (2020). Smell and taste dysfunction in patients with COVID-19. *The Lancet Infectious Diseases*, *3099*(20), 30293. https://doi.org/10.1016/S1473-3099(20)30293-0

Yang, Y., Lu, Q., Liu, M., Wang, Y., Zhang, A., Jalali, N., Dean, N., Longini, I., Halloran, M. E., Xu, B., Zhang, X., Wang, L., Liu, W., & Fang, L. (2020). Epidemiological and clinical features of the 2019 novel coronavirus outbreak in China. *MedRxiv*. https://doi.org/10.1101/2020.02.10.20021675

Yasmin, R., Parveen, R., Azad, N. Al, Deb, S. R., Paul, N., Haque, M. M., Haque, M. A., & Azad, S. (2020). Corona Virus Infection among Healthcare Workers in a COVID Dedicated Tertiary Care Hospital in Dhaka, Bangladesh. *Journal of Bangladesh College of Physicians and Surgeons*, *38*, 43–49. https://doi.org/10.3329/jbcps.v38i0.47442

Yu, P., Zhu, J., Zhang, Z., & Han, Y. (2020). A familial cluster of infection associated with the 2019 novel coronavirus indicating possible person-to-person transmission during the incubation period. *Journal of Infectious Diseases*, *221*(11), 1757–1761. https://doi.org/10.1093/infdis/jiaa077

Zheng, C., Hafezi-Bakhtiari, N., Cooper, V., Davidson, H., Habibi, M., Riley, P., & Breathnach, A. (2020). Characteristics and transmission dynamics of COVID-19 in healthcare workers at a London teaching hospital. *Journal of Hospital Infection*, *106*(2020), 325–329. https://doi.org/https://doi.org/10.1016/j.jhin.2020.07.025

Zheng, L., Wang, X., Zhou, C., Liu, Q., Li, S., Sun, Q., Wang, M., Zhou, Q., & Wang, W. (2020). Analysis of the Infection Status of Healthcare Workers in Wuhan During the COVID-19 Outbreak: A Cross-sectional Study. *Clinical Infectious Diseases*, (January), 1–5. https://doi.org/10.1093/cid/ciaa588

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P., Zhan, F., Ma, X., Wang, D., Xu, W., Wu, G., Gao, G. F., & Tan, W. (2020). A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*, *382*(8), 727–733. https://doi.org/10.1056/NEJMoa2001017

Zou, L., Ruan, F., Huang, M., Liang, L., Huang, H., Hong, Z., Yu, J., Kang, M., & Song, Y. (2020). SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. *New England Journal of Medicine*, *382*(12), 1175–1177. https://doi.org/10.1056/NEJMc2000231

BUDGET

Category of Item/activity	Item/activity	Description	Qty	Unit cost (Le)	Total (Le)
Ethics approval	Ethical committee approval	Ethics approval fees @ Le 950,000	1	950,000	950,000
	Sub-total				**950,000**
Stationery	Pack A4 papers	4 packets A4 papers @ Le40,000 per pk	4	40,000	160,000
	Pens	1 packet pen @ Le30,000 per pk	1	30,000	30,000
	Notebook	2 large notebooks @ Le5,000 per book	2	5,000	10,000
	Plastic folder	13 plastic folders at Le 2,000 per folder	13	2,000	26,000
	Print and bound 5 report copies	3 drafts & 5 final (lumpsome)		2,000,000	2,000,000
	Sub-total				**2,226,000**
	Tea & Lunch	Full launch for 12 people (11 participants and 1 facilitator @ Le100,000 per person x 2 days	24	100,000	2,400,000
	Transport refund	Transport refund to 12 people @ Le 20,000 per day x 2 days	24	20,000	480,000
	Printing & photocopies of training materials	lump sum	1	500,000	500,000
	Markers	1 packet indelible @ Le50,000 per pk	1	50,000	50,000
	Sub-total				**3,430,000**
Data Collection	Allowance for data collectors	allowance for 5 data collectors @ Le300,000 per person per month x 3 months	15	300,000	4,500,000
	Allowance for laboratory personnel	allowance for 6 laboratory personnel @ Le300,000 per person per month x 3 months	18	300,000	5,400,000
	Sub-total				**9,900,000**

Communication & internet	Air-time for data collectors	Top-up for 5 data collectors @ Le50,00 per month x 3 months	15	50,000	750,000
	Air-time for laboratory personnel	Top-up for 6 Laboratory personnel @ Le50,00 per month x 3 months	18	50,000	900,000
	Air-time for data entry clerk	Top-up for 1 data entry clerk @ Le50,00 per month x 3 months	3	50,000	150,000
	Air-time for Principal investigator (PI)	Top-up for 1 PI @ Le100,00 per month x 6 months	6	100,000	600,000
	Internet subscription for Principal investigator (PI)	Le 550,000 per month x 12 months	12	550,000	6,600,000
	Sub-total				**9,000,000**
Grand Total					**25,506,000**
					$2,685

APPENDICES

Appendix 1: Questionnaire

Assessment of risk factors for COVID-19 among hospital health care workers, Sierra Leone

Form 1: Baseline Questionnaire

Participant unique ID							

Data collectors code [1] [2] [3] [4] [5] [6] [7]

COVID-19 index patient outbreak ID ……

Date of interview (dd/mm/yyyy) ……

Date form completed (dd/mm/yyy)……

Name of Hospital……

District……..

Section A: Personal details of healthcare worker

1.1 Sociodemographic information

1.2 Current status of healthcare worker

[1] Alive

[2] Dead

1.3 What is your phone number? ……

1.4 What is your sex

[1] Male

[2] Female

1.5 What is your date of birth? (dd/mm/yyyy) ……

1.6 How old are you? (Age in completed years)……

1.7 What is your nationality……

1.8 Do you smoke cigarette?

[1] Yes

[2] No

1.9 What is your job category/cadre? .....

Section B: Information on healthcare worker IPC practices

2.0 Healthcare worker adherence to infection prevention and control measures

2.1 Have you ever been trained in IPC since you have been working in this health facility?

[1] Yes

[2] No ⟶ Skip to Q 2.4

2.2 If yes when was your last IPC training?

[1] ≤ 1 year

[2] > 1 year

2.3 If yes, how much cumulative IPC training have you had at this health care facility?

[1] < 2 hours

[2] > 2 hours

2.4 Do you follow recommended hand hygiene practices?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.5 Do you use alcohol-based hand rub or soap and water before touching a patient?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.6 Do you use alcohol-based hand rub or soap and water before cleaning/aseptic procedures?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.7 Do you use alcohol-based hand rub or soap and water after (risk of) body fluid exposure?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.8 Do you use alcohol-based hand rub or soap and water after touching a patient?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.9 Do you use alcohol-based hand rub or soap and water after touching a patient's surroundings?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.10 Do you follow IPC standard precautions when in contact with any patient?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

[5] I don't know what IPC standard precautions are

2.11 Do you wear PPE when indicated?

[1] Always, as recommended

[2] Most of the time

[3] Occasionally

[4] Rarely

2.12 Is PPE available in sufficient quantity in the hospital?

[1] Yes

[2] No

Section C: Exposure information

3.0 Healthcare worker exposure to COVID-19 infected patient

3.1 Date COVID-19 patient visited the hospital (DD/MM/YYYY)……

3.2 Date COVID-19 patient admitted to hospital (DD/MM/YYYY)……..

3.3 Where in the hospital did you get exposed to the patient? …….

3.4 Which date was your last exposure to the COVID-19 patient? (DD/MM/YYYY)…….

3.5 Have you had close contact (within 1 meter) with the patient since his/her admission?

[1] Yes

[2] No ⟶ Skip to Q 3.17

3.6 If yes to Q 3.5, how many times (total)? …….

3.7 If yes to Q 3.5, for how long each time?

[1] < 5 minutes

[2] 5 – 15 minutes

[3] > 15 minutes

[4] Not applicable

3.8 If yes to Q 3.5, did you have prolonged face-to-face exposure (>15 minutes)?

[1] Yes

[2] No

[3] Not applicable

3.9 If yes to Q 3.5 did you perform hand hygiene before contact with the patient?

[1] Yes

[2] No

[3] Not applicable

3.10 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.11 If yes to Q 3.5 did you perform hand hygiene after contact with the patient?

[1] Yes

[2] No

[3] Not applicable

3.12 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.13 If yes to Q 3.5, did you wear PPE when in close contact with the patient?

[1] Yes

[2] No

[3] Not applicable

3.14 If yes, what type PPE where you wearing? (**Tick all that apply**)

[1] Surgical mask
[2] Face shield
[3] Gloves
[4] Goggles/glasses
[5] Gown
[6] Coverall
[7] Head cover
[8] N95 respirator mask
[9] Shoe covers
[10] Not applicable

3.15 If you were wearing a N95 mask, was it test fitted?

[1] Yes
[2] No
[3] Not applicable

3.16 If you were wearing gloves, did you remove gloves after contact with the patient?

[1] Yes
[2] No
[3] Not applicable

3.17 Which activities did you perform during contact with the patient? (**Tick all that apply**)

[1] Taking medical history
[2] Performing physical exam
[3] Taking vital signs
[4] Giving medications
[5] Bathing or cleaning patient
[6] Lifting or positioning patient
[7] Carry patient on wheelchair
[8] Emptying bedpan
[9] Changing linens
[10] Cleaning patient room
[11] IV line insertion
[12] Drawing blood
[13] Manipulation of oxygen mask or tubing
[14] Performing X-ray on patient
[15] No direct contact, stayed in same room

3.18 Were you present for any aerosol generating procedures performed on the patient?

[1] Yes
[2] No → Skip to Q 3.22

3.19 If yes to Q 3.18, describe the procedure? (**Tick all that apply**)

[1] Airway suctioning
[2] Manual (bag) ventilation
[3] Nebulizer treatment
[4] Endotracheal intubation
[5] Cardiopulmonary resuscitation
[6] High-flow oxygen therapy
[7] Not applicable

3.20 If yes to Q 3.18, were you wearing PPE?

[1] Yes

[2] No

[3] Not applicable

3.21 If yes, what type PPE where you wearing? (**Tick all that apply**)

[1] Surgical mask
[2] Face shield
[3] Gloves
[4] Goggles/glasses
[5] Gown
[6] Coverall
[7] Head cover
[8] N95 respirator mask
[9] Shoe covers
[10] Not applicable

3.22 Did you come into contact with the patient's body fluids?

[1] Yes

[2] No → Skip to Q 3.31

3.23 If yes to Q3.22, which body fluids? (**Tick all that apply**)

[1] Respiratory secretions
[2] Urine
[3] Saliva
[4] Sweat
[5] Blood
[6] Not applicable

3.24 If yes to Q 3.22 did you perform hand hygiene before contact with the patient's body fluids?

[1] Yes

[2] No

[3] Not applicable

3.25 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.26 If yes to Q 3.22 did you perform hand hygiene after contact with the patient's body fluids?

[1] Yes

[2] No

[3] Not applicable

3.27 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.28 If yes to Q 3.22, did you wear PPE when in contact with the patient's body fluids?

[1] Yes

[2] No

[3] Not applicable

3.29 If yes, what type PPE where you wearing? (**Tick all that apply**)

[1] Surgical mask

[2] Face shield

[3] Gloves

[4] Goggles/glasses

[5] Gown

[6] Coverall

[7] Head cover

[8] N95 respirator mask

[9] Shoe covers

[10] Not applicable

3.30 If you were wearing gloves, did you remove gloves after contact with the patient's body fluids?

[1] Yes

[2] No

[3] Not applicable

3.31 Did you come into direct contact with the patient's materials since his/her admission?

[1] Yes

[2] No → Skip to Q 3.43

3.32 If yes to Q3.31, which materials? (**Tick all that apply**)

[1] Clothes

[2] Bed linens

[3] Medical devices used on patients

[4] Medical equipment connected to the patients (e.g. IV infusion)

[5] Not applicable

3.33 If yes to Q3.31, how many times you had contact with the patient's materials? …….....

3.34 If yes to Q3.31, did you come in contact with the patient's body fluids via the patient's materials?

[1] Yes

[2] No

[3] Not applicable

3.35 If yes, which body fluids? (**Tick all that apply**)

[1] Respiratory secretions [4] Sweat

[2] Urine [5] Blood

[3] Saliva [6] Not applicable

3.36 If yes to Q 3.31 did you perform hand hygiene before contact with the patient's materials?

[1] Yes

[2] No

[3] Not applicable

3.37 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.38 If yes to Q 3.31 did you perform hand hygiene after contact with the patient's materials?

[1] Yes

[2] No

[3] Not applicable

3.39 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.40 If yes to Q 3.31, did you wear PPE when in contact with the patient's materials?

[1] Yes

[2] No

[3] Not applicable

3.41 If yes, what type PPE where you wearing? (**Tick all that apply**)

[1] Surgical mask
[2] Face shield
[3] Gloves
[4] Goggles/glasses
[5] Gown
[6] Coverall
[7] Head cover
[8] N95 respirator mask
[9] Shoe covers
[10] Not applicable

3.42 If you were wearing gloves, did you remove gloves after contact with the patient's materials?

[1] Yes
[2] No
[3] Not applicable

3.43 Have you had direct contact with the surfaces around the patient?

[1] Yes
[2] No → Skip to Q 4.0.

3.44 If yes to Q3.43, which surfaces? (**Tick all that apply**)

[1] Bed
[2] Bathroom
[3] Ward corridor
[4] Bedside table
[5] Medical gas panel
[6] Medicine cabinet
[7] Not applicable

3.45 If yes to Q3.43, how many times you had contact with the surfaces? …….....

3.46 If yes to Q3.43, did you come into contact with the patient's body fluids via the surfaces?

[1] Yes
[2] No
[3] Not applicable

3.47 If yes, which body fluids? (**Tick all that apply**)

[1] Respiratory secretions
[2] Urine
[3] Saliva
[4] Sweat
[5] Blood
[6] Not applicable

3.48 If yes to Q 3.43 did you perform hand hygiene after contact with these surfaces?

[1] Yes
[2] No
[3] Not applicable

3.49 If yes, what did you use?

[1] Alcohol-based hand rub

[2] Soap and Water

[3] Water only

[4] Not applicable

3.50 If yes to Q 3.43, did you wear PPE when in contact with the surfaces around the patient?

[1] Yes

[2] No

[3] Not applicable

3.51 If yes, what type PPE where you wearing? (**Tick all that apply**)

[1] Surgical mask
[2] Face shield
[3] Gloves
[4] Goggles/glasses
[5] Gown
[6] Coverall
[7] Head cover
[8] N95 respirator mask
[9] Shoe covers
[10] Not applicable

Section C: Symptoms

4.0 Health care worker symptoms

4.1 Have you experienced any respiratory symptoms since after your exposure to the patient?

[1] Yes

[2] No → Skip to Q 4.5

4.2 Date of first symptom onset (DD/MM/YYY)? ……..

4.3 Fever (≥38°C) or history of fever?

[1] Yes

[2] No

4.4 Respiratory symptoms	
Sore throat	[1]Yes [2] No
Cough	[1] Yes [2] No
Runny nose	[1]Yes [2] No
Stuffy nose	[1]Yes [2] No
Shortness of breath	[1]Yes [2] No

4.5 Other symptoms	
Chills	[1]Yes [2] No
Vomiting	[1]Yes [2] No
Nausea	[1]Yes [2] No
Diarrhoea	[1]Yes [2] No
Headache	[1]Yes [2] No
Rash	[1]Yes [2] No
Conjunctivitis	[1]Yes [2] No
Muscle aches	[1]Yes [2] No
Joint ache	[1]Yes [2] No
Loss of appetite	[1]Yes [2] No
Loss of taste	[1]Yes [2] No
Loss of Smell	[1]Yes [2] No
Abdominal pains	[1]Yes [2] No
Fatigue	[1]Yes [2] No
General malaise	[1]Yes [2] No

4.6 Clinical classification

[1] Asymptomatic

[2] Symptomatic

Section D: Pre-existing medical conditions

5.0 Health care worker pre-existing condition(s)	
Cancer	[1]Yes [2] No
Diabetes	[1]Yes [2] No
Hypertension	[1]Yes [2] No
Stroke	[1]Yes [2] No
HIV/other immune deficiency	[1]Yes [2] No
Heart disease	[1]Yes [2] No
Asthma (requiring medication)	[1]Yes [2] No
Chronic lung disease (non-asthma)	[1]Yes [2] No
Chronic liver disease	[1]Yes [2] No
Sickle cell disease	[1]Yes [2] No
Pregnancy	[1]Yes [2] No [3] Not applicable

Chronic Kidney disease	[1]Yes [2] No

6.0 Date you started quarantine? (DD/MM//YYY) ……

Assessment of risk factors for COVID-19 among hospital health care workers, Sierra Leone

Form 2: Follow-up monitoring forms

7a. Health care worker symptoms	
Have you experienced any respiratory symptoms (sore throat, cough, running nose, shortness of breath) in the period since the baseline visit and specimen collection?	□ Yes □ No If no, please skip to next section 7c
Date of first symptom onset (DD/MM/YYYY)	(DD/MM/YYYY) __/___/___
Fever (≥38 °C) or history of fever	□ Yes □ No □ Unknown If yes, specify maximum temperature:
7b. Respiratory symptoms	
Sore throat	□ Yes □ No □ Unknown
Cough	□ Yes □ No □ Unknown
Runny nose	□ Yes □ No □ Unknown
Stuffy nose	□ Yes □ No □ Unknown
Shortness of breath	□ Yes □ No □ Unknown
7c. Other symptoms	
Chills	□ Yes □ No □ Unknown
Vomiting	□ Yes □ No □ Unknown
Nausea	□ Yes □ No □ Unknown
Diarrhoea	□ Yes □ No □ Unknown
Headache	□ Yes □ No □ Unknown
Rash	□ Yes □ No □ Unknown
Conjunctivitis	□ Yes □ No □ Unknown
Muscle aches	□ Yes □ No □ Unknown
Joint ache	□ Yes □ No □ Unknown
Loss of appetite	□ Yes □ No □ Unknown
Loss of taste	□ Yes □ No □ Unknown
Loss of smell	□ Yes □ No □ Unknown
Abdominal pain	□ Yes □ No □ Unknown
Fatigue	□ Yes □ No □ Unknown
General malaise	□ Yes □ No □ Unknown
Other symptoms	□ Yes □ No □ Unknown If yes, specify:

Assessment of risk factors for COVID-19 among hospital health care workers, Sierra Leone

Form 3: Laboratory results

To be completed by coordinator:

8a. Baseline swab testing methods and results:	
Lab identification number	
Date baseline sample collected (DD/MM/YYYY)	(DD/MM/YYYY)___/___/___
Date baseline sample received (DD/MM/YYYY)	(DD/MM/YYYY)___/___/___
Type of sample	□ Nasal swab □ Throat swab □ Nasopharyngeal swab □ Others, specify:
Result (COVID-19 PCR CT value)	
Date of result (DD/MM/YYYY)	___/___/___
Specimen shipped to other laboratory for confirmation - Date (DD/MM/YYYY)	□ Yes □ No (DD/MM/YYYY)___/___/___

8b. Follow-up swab testing methods and results:	
Lab identification number	
Date follow up sample collected (DD/MM/YYYY)	(DD/MM/YYYY)___/___/___
Date follow up sample received (DD/MM/YYYY)	(DD/MM/YYYY)___/___/___
Type of sample	□ Nasal swab □ Throat swab □ Nasopharyngeal swab □ Others, specify:
Result (COVID-19 PCR CT value)	
Date of result (DD/MM/YYYY)	___/___/___
Specimen shipped to other laboratory for confirmation - Date (DD/MM/YYYY)	□ Yes □ No (DD/MM/YYYY)___/___/___

Assessment of risk factors for COVID-19 among hospital health care workers, Sierra Leone

Form 4: Symptom diary

Day	Symptoms						
	No symptoms (check if none experienced)	**Fever ≥38°C or history of fever**	**Sore throat**	**Cough**	**Runny nose**	**Shortness of breath**	**Other symptoms: specify**
0	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
1	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
2	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
3	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
4	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
6	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
7	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
8	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
9	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
10	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
11	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
12	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
13	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	
14	□ None	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	□ Yes □ No	

Appendix 2: Operational definition and measurement scale of study variables

Operational definition and measurement scale for HCW characteristics and exposure variables

Variables	Operational definition	Measurement scale	Method of Data collection/Data source
Age	Age of HCW in completed years	Categorical (ordinal) • ≤19 • 20 – 29 • 30 – 39 • 40 - 49 • ≥ 50	Interview of HCW
Sex	Sex of HCW	Categorical • Male • Female	Interview
Job category	Cadre of HCW	Categorical • Medical doctor • SRN • SECHN • CHO • X-ray technician • Laboratory technician • Cleaner • Others	Interview
Smoke	HCW smokes tobacco	Categorical • Yes • No	Interview
Exposure location	Unit in hospital where HCW got exposed	Categorical • Screening/triage station • Outpatient department • Inpatient ward • Radiology department	Interview
Close contact	Physical or close contact within 1 meter with patient	Categorical • Yes • No	Interview
Number of contact	Estimated individual number of contact with patient	Categorical (ordinal) • 1 - 2 • 3 - 5 • 6 - 10 • > 10	Interview
Duration of contact	Estimated cumulative duration of each contact in minutes	Categorical • < 5 • 5 – 15 • > 15	Interview

Prolonged Face-to-face exposure	Face-to-face exposure with COVID-19 patient for more than 15 minutes	Categorical • Yes • No • Unknown	Interview
Use of PPE	HCW used Personal Protective Equipment during prolonged face-face contact or aerosolizing procedure or contact with patient body fluids or patient materials or contacts with surfaces around patient	Categorical • Yes • No • Unknown	Interview
Type of PPE	Type of PPE HCW wear during contact with patients	Categorical • Medical mask • Face shield • Gloves • Goggles/glasses • Gown • Coverall • Head cover • Respirator • Shoe covers	Interview
Use of medical mask	HCW wearing medical mask when in close contact with the patient	Categorical • Yes • No	Interview
Medical mask type	Type of medical mask used	Categorical • Surgical mask • N95 respirator	Interview
Use of gloves	HCW wore gloves during contact with patient	Categorical • Yes • No	Interview
Remove gloves	HWC removed gloves after contact with patient or patient body fluids/materials/surroundings	Categorical • Yes • No	Interview
Hand hygiene	HCW performed hand hygiene before and after contact with patient	Categorical • Yes • No •	Interview
Hand hygiene type	Type of hand hygiene procedure	Categorical • Alcohol-based hand rub • Soap and water	Interview

		• Water	
Exposure to aerosolizing procedure	HCW present for any aerosol generating procedure (AGP)	Categorical • Yes • No • Unknown	Interview
Type of AGP	Type of aerosol generating procedure	Categorical • Airway suctioning • Endotracheal intubation • Manual ventilation • Oxygen concentrator • Cardiopulmonary resuscitation • Nebulizer treatment	Interview
Contact with patient body fluids	HCW came in contact with patient body fluids	Categorical • Yes • No • Unknown	Interview
Contact with patient materials	HCW came in contact with patient materials	Categorical • Yes • No • Unknown	Interview
Type of patient materials	Type of patient material HCW came in contact with	Categorical • Clothes • Personal items • Bed linens • Medical devices used on patient • Medical equipment connected to patient (e.g. IV infusion) • Others (specify)	Interview
Contact surfaces	HCW came in direct contact with surfaces around patient	Categorical • Yes • No • Unknown	Interview
Type of surfaces	Surfaces around patient HCW came in contact with since patient was admitted	Categorical • Bed • Bathroom • Ward corridor • Bedside table • Dining table • Others (specify)	Interview

Operational definition and measurement scale for respiratory and other symptoms

Variables	Operational definition	Measurement scale	Method of Data collection/Data source
Fever	Measured fever (≥ 37.5°C) or history of fever	Categorical • Yes • No	Interview
Sore throat	HCW reported having sore throat	Categorical • Yes • No	Interview
Cough	HCW reported having cough	Categorical • Yes • No	Interview
Runny nose	HCW reported having running nose	Categorical • Yes • No	Interview
Stuffy nose	HCW reported having stuffy or blocked nose	Categorical • Yes • No	Interview
Shortness of breath	HCW reported having breathing difficulties	Categorical • Yes • No	Interview
Headache	HCW reported having headache	Categorical • Yes • No	Interview
Muscle aches	HCW reported having pains in the muscles	Categorical • Yes • No	Interview
Joint aches	HCW reported having joint pains	Categorical • Yes • No	Interview
Fatigue	HCW reported feel week and tired	Categorical • Yes • No	Interview
General malaise	HCW reported feeling sick	Categorical • Yes • No	Interview
Rash	HCW reported having rash	Categorical • Yes • No	Interview
Conjunctivitis	HCW reported having red painful eyes	Categorical • Yes • No	Interview
Chills	HCW reported feeling cold	Categorical • Yes • No	Interview

Loss of appetite	HCW reported loss of appetite	Categorical • Yes • No	Interview
Loss of taste	HCW reported loss of taste	Categorical • Yes • No	Interview
Loss of smell	HCW reported loss of smell	Categorical • Yes • No	Interview
Nausea	HCW reported nausea	Categorical • Yes • No	Interview
Vomiting	HCW reported vomiting	Categorical • Yes • No	Interview
Abdominal pains	HCW reported abdominal pains	Categorical • Yes • No	Interview
Diarrhoea	HCW reported having watery stools	Categorical • Yes • No	Interview

Operational definition and scale of measurement for HCW pre-existing medical conditions

Variables	**Operational definition**	**Measurement Scale**	**Method of Data collection**
Hypertension	Health care worker admit being hypertensive and on medication	Categorical • Yes • No	Interview
Diabetes	Health care worker admit being diabetic and on medication	Categorical • Yes • No	Interview
Asthma	Health care worker admit having asthma and on medication	Categorical • Yes • No	Interview
Stroke	Health care worker admit having stroke and on medication	Categorical • Yes • No	Interview/observation
Chronic lung disease (non-asthma)	Health care worker admit having chronic lung disease and on medication	Categorical • Yes • No	Interview

Heart disease	Health care worker admit having heart problem and on medication	Categorical • Yes • No	Interview
Chronic liver disease	Health care worker admit having liver problem and on medication	Categorical • Yes • No	Interview
Sickle cell disease	Health care worker admit having sickle cell disease and on medication	Categorical • Yes • No	Interview
Chronic Kidney disease	Health care worker admit having kidney disease and on medication	Categorical • Yes • No	Interview
Cancer	Health care worker admit having Cancer of any type and on medication	Categorical • Yes • No	Interview
Pregnancy	Health care worker pregnant	Categorical • Yes • No	Interview

Operational definition and measurement scale of outcome variables

Variables	**Operational definition**	**Measurement Scale**	**Method of Data collection**
Confirmed COVID-19	A positive laboratory result for SARS-CoV-2 by real-time RT-PCR test on nasopharyngeal specimen	Categorical • Positive • Negative	Results from laboratory

Operational definition and scale of measurement for adherence to IPC measures by HCWs

Variables	**Operational definition**	**Measurement Scale**	**Method of Data collection**
IPC training	HCW ever trained in IPC	Categorical • Yes • No	Interview
IPC training date	Duration since last IPC training	Categorical • ≤ 1 year • > 1 year	
Cumulative IPC training	Time spent for each IPC training	Categorical • < 2 hours • ≥ 2 hours	Interview
Hand hygiene practice	HCW follow recommended hand hygiene practice	Categorical • Always, • Most of the time • Occasionally • Rarely	Interview
Standard IPC precaution	HCW follow standard IPC precaution when in contact with patient	Categorical • Always, • Most of the time • Occasionally • Rarely • I don't know what standard IPC precautions are	Interview
PPE use	HCW use PPE when indicated	Categorical • Always, • Most of the time • Occasionally • Rarely	Interview

Appendix 3: Participants consent form

Study title: Assessment of risk factors for COVID-19 among hospital health care workers, Sierra Leone

Objective of the study: To assess the extent of infection and potential risk factors for COVID-19 infection among HCWs who were exposed to unsuspected COVID-19 patient at the Bo, Kenema and Port Loko Government Hospitals, Sierra Leone.

Principal investigator: James Sylvester Squire

Qualification: Master of Philosophy, Applied Epidemiology and Disease Control

Institution: Department of Epidemiology, School of Public Health, University of Ghana, Legon

Supervisor: Dr. Samuel O. Sackey: Ghana Field Epidemiology and Laboratory Training Program, Department of Epidemiology, School of Public Health, University of Ghana, Legon

Section A: Information sheet

Introduction

My name is James Sylvester Squire, a graduate student of the University of Ghana. I am carrying out a study on "Assessment of risk factors for Severe Acute Respiratory Syndrome Coronavirus-2 infection among health care workers in three regional hospitals, Sierra Leone" as partial fulfilment of the requirements of the University. I will give you information on what the study is about and invite you to be part in this study. Your participation is voluntary and before you decide to participate, you are free to talk to anyone you feel comfortable concerning the study. As we go through the information sheet, please feel comfortable to stop me if you do not understand any word. I will take my time to explain to your understanding. Do not hesitate to ask me if you have any questions later.

Purpose of the study

Health care workers are at the frontline in providing essential care to both COVID-19 and non-COVID-19 patients. Given the current COVID-19 pandemic, infection among HCWs is a common occurrence globally. Despite reports of HCW infection in Sierra Leone, no documented evidence exist on the extent and associated risk factors for SARS-CoV-2 infection among HCW in a health care setting where COVID-19 confirmed patient has received care. This study will provide useful information on the extent of infection and possible risk factors for infection among HCWs who were exposed to an unsuspected COVID-19 patient while receiving care at the health facility. The health and well-being of HCWs are critical for COVID-19 response and for supporting non-COVID 19-related health services. Therefore, identifying and managing HCWs who have been exposed to a patient with COVID-19 is of great importance in preventing healthcare transmission and protecting other staff members and vulnerable patients. The information generated from this study will guide policy makers in developing specific measures and guidelines to prevent healthcare associated infections, recognize infection in HCWs as soon as possible, and provide care for HCWs infected with COVID-19.

Selection of participants

I will invite all health care workers with potential exposure to an unsuspected COVID-19 patient at the hospital.

Participation

Your decision to take part in this study is entirely voluntary. This will not affect any help the hospital will offer to you.

Procedure to be followed

With your permission, I will ask some questions about yourself, your work and circumstances surrounding your exposure the COVID-19 confirmed patient. A trained health personnel will

collect swab from your nose immediately we complete the questionnaire and on day 14. If you show any symptoms before day 14, we will immediately collect another swab for testing. The swab will be stored in a viral transport medium and taken to the laboratory for testing. The result of the test will be communicated to you within 24 -72 hours. If any of your test results come back positive you will be taken to a treatment facility, where we will monitor you until you discharged. However, if your day 14 test result is negative will discharge you from quarantine and end your follow-up.

Risks and benefits

It is anticipated that you may feel some discomfort during collection of nasopharyngeal samples. The procedure of nasopharyngeal swab collection will be carried out by a trained and expressed personnel.

You will directly benefit from the investigation, in that COVID-19 infection detected would allow for appropriate monitoring and treatment. The indirect benefit is that data collected will help improve and guide efforts to understanding transmission of SARS-CoV-2 and prevent further spread of COVID-19 in health care settings.

Cost/Reimbursement

You will not be charged any amount for the laboratory test that will be done. Also you will not be paid or given any monetary benefits for participating in the study.

Maintaining confidentiality

Confidentiality and anonymity of participants will be ensured throughout the investigation. A unique identifier for the labelling of questionnaire and clinical specimens will be assigned to you by the investigation team. The link of this identification number to individuals will be maintained by the investigation team and unauthorized persons will not be allowed access to the information collected. If data is to be shared, this will include only the study identification number and not any

personably identifiable information. Information collected will be kept under lock and key and no unauthorized person (s) will not have access to it.

Contacts

In case you have questions relating to the study please contact the following:

Principal investigator: James Sylvester Squire

Tel No. +232-79838465

Supervisor: Dr. Samuel O. Sackey

Tel No. +233-24-221-6542

Sierra Leone Ethics, Scientific and Review Committee

Tel No. +232-76629251/+232-78366493

Section B: Participant consent

I have read and understood the information provided above and the nature of the study have been explained to me. I have had the opportunity to ask questions, and all questions asked were satisfactorily answered. I voluntarily consent to participate in this study and to respond to all questions that will be asked. I also give my consent for a swab sample to be collected from me.

Name of Health care worker……..

Signature …….

Date……..

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed. I certify that the consent given by the participant was voluntary and no participant has been coerced into given consent.

Researcher/Research assistant

Name…….

Signature…….. Date……

Appendix 4: Epidemiological investigation report of index cases at Bo, Port Loko and Kenema Government Hospitals

Bo Government Hospital

The first confirmed case of COVID-19 in Bo district was reported on the 3rd of May, 2020. The index case (case 156), a 59 year old male, was a HCW and a senior clinical staff of the Bo Government Hospital presented on 29th April, 2020 at the outpatient department of the hospital after being screened at the triage with history of cough and difficult breathing with onset on the 26th April, 2020. The case-patient a known hypertensive was admitted the same day at the annex ward with diagnosis of congestive heart failure. Routine laboratory tests and chest x-ray were carried out on the day of admission. At the time of admission, COVID-19 was not suspected as the index patient denied travel or contacts with symptomatic persons. On the night of admission case-patient was transferred to the pediatric inpatient feeding center (IPF) within the hospital for oxygen therapy, where he stayed overnight. On the 30th April, 2020 at 9:00 am, case-patient was reviewed by attending physician and due to worsening symptoms was referred to Connaught Hospital in Freetown at 5:30 pm. During a 2-day hospitalization, the patient was managed with little or no standard precautions observed by attending HCWs as neither the patient nor the HCWs or family members were aware of any SARS-CoV-2 exposure. Three days after the patients was transferred to the Connaught Teaching Hospital Complex in Freetown, a real-time reverse-transcriptase polymerase chain reaction (rRT-PCR) test for SARS-CoV-2 on nasopharyngeal swab returned positive, which triggered epidemiological investigation in Bo Government hospital. A total of 110 HCWs were identified as contacts after risk assessment.

Port Loko Government Hospital

The index case in PLGH, a 44 year old Police officer attached as security guard to one of the quarantine facilities in the district, attended the outpatient department of the hospital at 7:00 am on 1st May, 2020 with fever, headache, loss of appetite and abdominal pains with onset on the 28th April, 2020. The patient received treat for malaria at the outpatient department and was sent home later the same day. He made a second visit to the hospital on May 4, 2020 due to worsening symptoms, for which he was admitted at the male ward and treated for malaria and typhoid. The patient was discharged on May 6th, 2020 at around 2:0 pm after completing a course of IV medications. During the period of admission, COVID-19 was not suspected as he denied contact with suspected or symptomatic persons. The patient made a third visit at the hospital on May 7th, 2020 with symptoms of fever, headache, chills, nausea, vomiting, chest pains and difficult breathing. At the time of his third visit, health workers have been oriented on COVID-19 case definitions. He was immediately isolated, investigated by the surveillance team and nasopharyngeal swab samples collected for rRT-PCR for COVID-19. Laboratory result came back positive for COVID-19 on May 9th, 2020. Thirty-six healthcare workers were identified through surveillance and immediately quarantined and followed as per protocol

Kenema Government Hospital

Index case 1

A 20 year old male, resident of Kenema visited the outpatient department of the KGH on May 10th, 2020 with symptoms of fever, headache of three days duration. The case patient had chronic neurological condition. The patient was screened at the triage with temperature of 37.5°C and was admitted at the annex ward of the hospital with diagnosis of hypertension. At the time of admission, COVID-19 was not suspected as he has no history of travel or contact with suspected or confirmed

case of COVID-19. On the 16th May, 2020, the case-patient was reviewed by the attending physician, who due to symptoms suggestive of COVID-19, made a suspected diagnosis of COVID-19 and alerted the district surveillance team. Case patient was investigated by the surveillance team and sample collected for COVID-19 testing. On 17th May, 2020, laboratory result proved positive for COIVD-19. This triggered further epidemiological investigation at the hospital. A total of 15 HCWs were identified as contact by the surveillance team.

Index case 2

Case patient is a 39-year old female a nurse attached to the neonatal unit of the KGH. On 24th May, 2020 the case-patient complain of headache and muscle pains to the neonatal ward in-charge while she was on duty. Few hours later she collapsed in the ward. She was subsequently given first aid at the nurses' room in the neonatal unit by her colleagues and later was taken on wheel chair assisted by other staff to the triage. On arrival, the attending physician diagnosed 4 weeks pregnancy. Her temperature was 36.8ºC. She was later admitted the same day at the isolation unit where she was cared for by her colleagues and other nurses working at the isolation unit. During this period, COVID-19 was not suspected as she has no travel history or contact with suspected or confirmed COVID-19 patient. On the 25th May, 2020 the attending physician notified the surveillance team and investigation was effected immediately. Nasopharyngeal swab sample was collected and sent to the laboratory for COVID-19 testing. Laboratory result came out positive for COVID-19 on May 26th, 220. The surveillance team conducted further investigation and line-listed 20 HCWs as contacts to the case.