ASSESSING RISK FACTORS ASSOCIATED WITH COVID19 DISEASE AMONG HEALTH WORKERS AT KENYATTA NATIONAL HOSPITAL: A CASE CONTROL STUDY

BY

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF PUBLIC AND GLOBAL HEALTH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF PUBLIC HEALTH OF THE UNIVERSITY OF NAIROBI.

14th November 2022

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ACKNOWLEDGEMENT

We are sincerely grateful to Dr. John Kinuthia and his team at the department of Medical Research as well as the entire administration of Kenyatta National Hospital for the permission to collect data and the financial facilitation towards this study. We would also like to thank Dr. Jackson Atina, the Head of Department of the Respiratory Infectious Disease Unit of Kenyatta National Hospital, for highly recommending this study for funding considerations by the hospital.

We acknowledge Mr. Joshua Atunga from the Department of Medical statistics of University of Nairobi for the support he provided for the statistical data analysis techniques applied in this research.

Further support, guidance and mentorship provided by Dr. Marshall Mweu, Prof. Joyce Olenja and the administrators of the Department of Public and Global health of the University of Nairobi is highly appreciated.

Lastly, the data collectors and the participant health workers are greatly acknowledged for their participation in this study.

LIST OF ABBREVIATIONS

AGPS:	AEROSOL GENERATING PROCEDURES
AG-RDTS:	ANTIGEN-DETECTING RAPID DIAGNOSTIC TESTS
CD16:	CLUSTER OF DIFFERENTIATION 16 CELLS
CDC:	CENTER OF DISEASE CONTROL AND PREVENTION
CIR:	CASE INFECTION RATE
CFR:	CASE FATALITY RATE
DM:	DIABETES MELLITUS
ERC:	ETHICS AND RESEARCH COMMITTEE
HTN:	HYPERTENSION
HWS:	HEALTH WORKERS
HCWS:	HEALTH CARE WORKERS
HR:	HUMAN RESOURCE
HDU:	HIGH DEPENDENCY UNIT
HRP:	HIGH RISK PROCEDURES
HCP:	HEALTH CARE PROVIDERS
HRH:	HUMAN RESOURCE FOR HEALTH
IQR:	INTER QUARTILE RANGE
IPC:	INFECTION PREVENTION AND CONTROL
ILO:	INTERNATIONAL LABOR ORGANIZATIONS
IDU:	INFECTIOUS DISEASE UNIT
ICU:	INTENSIVE CARE UNIT

KNH:	KENYATTA NATIONAL HOSPITAL
MOH:	MINISTRY OF HEALTH
MERSCOV:	MIDDLE EAST RESPIRATORY SYNDROME CORONA VIRUS
NAAT:	NUCLEIC ACID AMPLIFICATION TESTS
NSW:	NIGHT SHIFT WORK
NCOV:	NOVEL CORONA VIRUS
OR:	ODDS RATIO
ORF:	OCCUPATIONAL RISK FACTORS
OSHA:	OCCUPATIONAL SAFETY AND HEALTH ACT
PPE:	PERSONAL PROTECTIVE EQUIPMENT
PRF:	PERSONAL RISK FACTORS
R0:	REPRODUCTION NUMBER
RT-PCR:	REVERSE TRANSCRIPTASE POLYMERASE CHAIN REACTION
SARSCOV:	SEVERE ACUTE RESPIRATORY SYNDROME CORONA VIRUS
US:	UNITED STATES
UON:	UNIVERSITY OF NAIROBI
WHO:	WORLD HEALTH ORGANIZATION

DEFINITION OF OPERATIONAL TERMS

Age: The self-reported chronological age counted in completed years since from birth till the last birthday(Agarwal et al., 2021).

Adherence to Staff to Staff Covid19 Protocol; this refers to failure of a health worker to observe Covid19 Infection prevention measures for slowing the spread of Covid19 disease among occupational colleagues(Suárez-García, Martínez de Aramayona López, Sáez Vicente, & Lobo Abascal, 2020). Assessed in this study by self-reported social distancing in tea room while dining and doffing as recommended before using tea room in the last 2 weeks before PCR Covid19 test in the study period. PPE use behavior while in the breakout room and interacting with colleagues.

Being on leave: a period of time usually between 2 or more days and not exceeding 30 days within the year when a HW is officially excused from work for non-medical reasons. Included as a variable of interest as a control for the differential duration of community and occupational exposure for health workers within the study period(Aylward & Liang, 2020).

Covid19 training status: This refers to **s**tated experience by the HW of either having gone through an informational or educational session on Covid19 disease and related infection, prevention and control measures within the last one year prior to their most recent Covid19 test result(Ali, Noreen, Farooq, Bugshan, & Vohra, 2020).

Comorbidity status: self-reported pre-existence of a chronic health condition or conditions by a health worker including diabetes, heart diseases, hypertension, cancer, chronic obstructive pulmonary disease(W. J. Guan et al., 2020).

Cadre: This is a job description characteristic of a health worker as dictated by the hospital policy, regulatory authorities and academic qualifications. This includes nurses, midwives, doctors, pharmacists, phlebotomists, physiotherapists, nutritionists, potters, cleaners and other support staffs, administrators and housekeeping staffs, security guards and caterers(MOH, 2014).

Community risk factors: these include factors beyond the hospital setup that could expose the health workers to Covid19 disease. Community exposure variables of interest include HW adherence to face masking while in social or private life, level of the usage of public transportation while commuting to work, HW household size, being on leave and self-reported community covid19 exposure(CDC, 2021d)

Double masking: The practice of using more than one face covering at the same type usually a variation either of wearing a respirator mask underneath a medical/surgical mask, or wearing a medical/surgical mask underneath a respirator mask or wearing two medical/surgical masks one atop the other(Brooks et al., 2021).

Department: this is a hospital characteristic that describes the nature of health care setting for the health workers including intensive care unit, renal unit, outpatients department, maternity unit, theatre, medical and surgical wards, and Covid19 Units and Infectious disease units(IDU)(Boffetta et al., 2020).

Exposure or Contact History: This describes the type and nature of the exposure from an infectious disease for the HW. Contact history could be household exposure to Covid19, health-worker to health worker exposure to Covd19, Patient to health worker exposure to Covid19, and suspect case exposure to Covid19 from family member, suspect fellow staff or suspect patient or lack of any known exposure(WHO, 2020h).

Face mask fit: A face mask fit refers to a self-reported appraisal by a HW on the proper face seal of the surgical or respirator face mask(Brooks et al., 2021).

Health Workers: Broadly defined as people working in the Kenyatta National Hospital within the two-month study period whose primary role was the provision of health care services either directly to the patients or indirectly by assisting the care providers(Rodriguez-Lopez et al., 2021). These include: nurses, midwives, pharmacists, medical doctors and specialists, supportive staffs such as cleaners, porters, security, and departmental administrative staffs such as nurse and medical managers highlighted as required staff for delivery of health as per Kenya HRH norms and standards report (MOH, 2014).

HW work experience: this refers to the self-reported completed number of years the health worker has been in the service delivery in their current cadre excluding the current year(Atnafie, Anteneh, Yimenu, & Kifle, 2021).

HW Sleep levels: Refers to self-reported average duration of sleep per day in the last one month before PCR Covid19 test conducted within the two month study period (November 2021 to December 2021).

Household size: Refers to number of people living within the same place or house in the last 1 month before their recent PCR Covid19 test within the study period(Federgruen & Naha, 2021).

Health systems: This entails components of the economy that support health delivery to the population including financing, governance and leadership, supply of equipment, drugs and vaccines, health information system, human resource for Health and service delivery processes(Folke et al., 2004).

Health systems' risk factors: These are administrative and organizational as well as policy decisions that influence the Health workers' predisposition to a disease or disease outcomes. This study investigates HRH Training on Covid19, perceived sufficiency of PPE supply, reasons for Covid19 testing among HWs and number of times participant HW tested for Covid19(Folke et al., 2004).

Number of times tested for Covid19 disease: this refers to the stated count of the reverse transcriptase polymerase chain reaction (RT-PCR) tests for Covid19 disease that the study participants took in the last 6 months in addition to the recent Covid19 test done within the study period(Antonio-Villa et al., 2021).

Occupational risk factors: For this study, Covid19 is considered an occupational disease because of its association with work place exposure factors including HW cadre, HW department, type of shift work, contact or exposure type, perceived PPE supply sufficiency, suboptimal PPE use, PPE reuse status, and HW to HW Covid19 protocol. International Labor Organization defines occupational diseases as biological agents at the place of work that have been established through natural and scientific means to arise from the conditions of work place and lead to disease outcomes among the workers (International Labour Organization, 2010).

Public Transport use: Whether HW uses public passenger vehicles where more than 5 people are usually enclosed in same unit at a fee while commuting between work and residential locations. This is as opposed to private means of transportation where a HWs drives or driven to work place from home, usually in company of 4 or less people whether at commercial fee or by personal vehicle(CDC, 2021d).

PPE reuse: a situation where a Health Worker uses the same PPE after donning and doffing it for more than once while in the same shift or in multiple shifts(Czubryt et al., 2020).

Reason for Covid19 testing: this refers to the justification provided by the HW for having done a Covid19 test. This could vary between initial Covid19 testing and subsequent tests hence this study examines the reason for the latest PCR Covid19 test conducted between November 2021 and December 2021 in line with different reasons for PCR Covid19 testing(CDC, 2021a).

Social demographic Factors: These are individual and personal characteristics of the Health workers which predispose them to a disease or disease outcomes(Schulte, Pandalai, Wulsin, & Chun, 2012). For this study, they include age, comorbidity status, gender, work experience, sleep levels, face masking off duty and in socio events and access to information as part of lifestyle factors, and means of transportation to work station or the within-hospital residence.

Suboptimal PPE / IPC adherence (Personal Protective Equipment): this is the primary risk factor for the spread of Covid19 disease and this has been defined as a breach in the PPE use or non-adherence to Infection prevention measures as per the WHO tool for assessing exposure to SARSCOV2 virus(causative agent for COVID-19 disease)(WHO, 2020b).

Shift work status (SW): this is an occupational characteristic of the health workers in terms of the time of the day spent in formal service delivery including day shift , mixed days and night shifts or night shifts only during the study period (Shan et al., 2018).

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ABSTRACT

The spread of Covid19 disease among health workers (HWs) has been associated with worsening acute shortage of HWs and overwhelmed health systems. Contextual evidence on the predominant source of Covid19 exposure among HWs remains scarce. Therefore, this study identifies the social-demographic, community, occupational, and health systems’ risk factors associated with Covid19 disease among HWs in a tertiary hospital in Kenya. Using a hospital-based, unmatched case-control study design and with an ethical approval obtained from KNH-UoN ethics committee and informed consent given by the participants, exposure differences between randomly sampled 39 Covid19 disease-positive HWs and conveniently sampled 108 Covid19 disease-negative and asymptomatic HWs were interviewed between November 2021 and December 2021. Adapting the WHO Covid19 risk assessment protocol, the socio-demographic, occupational, community and health systems characteristics were examined via phone interviews. At 95% Confidence Interval and applying multiple imputations for missing data at random, a multivariable logistic regression was applied to identify the statistically significant independent variables associated with the covid19 disease outcomes of a HW. Controlling for the sex and clinical status, sub-optimal adherence to face shield ($p<0.05$), suboptimal infection prevention control (IPC) adherence in tea rooms ($p<0.05$), working in medium risk departments ($p<0.05$), being on leave ($p<0.05$), history of exposure to a Covid19 suspect or case ($p<0.05$), and symptomatic PCR Covid19 testing ($p<0.05$) before PCR Covid19 testing were risk factors to Covid19 disease among HWs. In conclusion, the protection of HWs from further spread of Covid19 can be optimized by reinforcing optimal adherence to face protective gears as part of personal protective equipment and infection prevention protocol in places where HWs may lower their guard against Covid19 disease such as when dining with colleagues at work, in departments where perception of risk may be low and in extra-occupational setups such at the household or community. Prompt Covid19 testing for symptomatic HWs as vulnerable and priority groups should be sustained.

1. CHAPTER ONE: INTRODUCTION

1.1. Background

Since the declaration of the Covid19 pandemic, Health workers (HWs) have been at the frontline response to cases of Covid19 disease that is caused by a novel respiratory virus called SARSCoV2 virus (WHO, 2020a). The WHO Global reports indicate that growing number of Covid19 cases among the Health Workers has been associated with disrupted health service delivery and overwhelmed health systems(WHO, 2020g). Therefore, Health worker protection is a public health priority to sustain the capacity of the public health systems to contain and control the surge of Covid19 cases and other prevalent non-covid19 disease conditions.

Based on the definition by the World Health Organization (WHO), HWs are people whose intent is to deliver health whether working within health care institutions or in non-healthcare institutions of the health systems(WHO, 2020g). Health systems comprise "the sum of the organizations, institutions, and resources whose shared primary purpose is to improve health" (WHO, 2020g). Earlier definitions by the WHO (2006) state that HWs are people whose actions and intentions are geared towards the improvement and enhancing health. However, this definition is restricted to paid workers promoting health in any setting (WHO, 2006).

Centers for Disease Control and prevention (CDC)(2021) defines a health care personnel (HCP) to include all personnel working in the health setting either in direct or in indirect contact with the patients but could be exposed to infectious disease agents that are transmitted in the health setting. These include such as the emergency medical service personnel, nursing assistants, technicians, therapists, phlebotomists, pharmacists, students and trainees, physicians, nurses, contractual staff not employed by the healthcare facility, and persons not directly involved in patient care such as clerical officers, catering staffs, workers in the environmental services, laundry staff, security personnel, engineering and facilities management officers, administrative, billing, volunteer personnel (CDC, 2021b). The Ministry of Health (MOH) Kenya adopted the WHO's definition of health workers as listed in the Interim guidelines for human resources for health during the COVID-19 response (MOH, 2020c). Hence this study adopted a broader definition of a HW which is any worker whose primary role was the provision of health care services either directly to the patients or indirectly by assisting the care providers within the study period. The same definition was adopted in a recent case control study examining risk factors among HWs(Rodriguez-Lopez et al., 2021). These workers include: nurses, midwives, pharmacists, medical doctors and specialists, supportive staffs such as cleaners, porters, security, and departmental administrative staffs such as unit and hospital managers, health information officers and hospital clerks highlighted as required staff for delivery of health as per Kenya Human Resource for Health (HRH) norms and standards 2014 report (MOH, 2014). This contrasts the narrower definition of health professionals as workers trained in approved institutions and licensed to practice by cadre-specific and respective regulatory bodies to deliver health care following the Kenya Health Workforce Report(MOH, 2015).

1.1.1. The burden of Covid-19 Disease among Health workers

Health workers (HWs) at the frontline of health service delivery are at a relatively higher risk of contracting Covid19 disease than the rest of the population (WHO, 2020b). While HWs constitute less than 3% of the world population, the WHO global surveillance on Covid19 Report shows an over-presentation of Covid19 cases among health workers at an estimate of 14% of all reported Covid19 cases (WHO, 2020g). Compared to the general population, health workers face a disproportionate risk of contracting covid19 disease with the resultant effects of disruption of health service delivery (Nava, Tonelli, & Clini, 2020). For example, 19 % of the 49370 cases of covid19 disease who reported their identity on their occupation in the United States were health care workers (HCWs) who contracted the disease between 12th February and 9th April 2020(CDC, 2020). In Italy, health workers (HWs) with confirmed Covid19 infection contributed to 9% of all Italian Covid-19 cases with the resultant fatalities of more than 150 doctors and more than 40 nurses by 28th April 2020(Lapolla, Mingoli, & Lee, 2020). A retrospective hospital cohort study of 1911 HWs in Madrid Spain showed a Covid-19 prevalence among the health workers at 11% during the period of the study (Suárez-García et al., 2020).

As of 25th April 2021, a cumulative of 4860 covid19 cases among HWs constituting 3% of all Covid19 cases in Kenya had been reported with Nairobi County bearing the greatest burden of Covid19 caseload of 46% of all Covid19 cases reported in Kenya (MOH, 2021a). Relatively lower prevalence of Covid19 infection among HWs in Kenya compared to developed countries such as Italy and US has been attributed to the limited capacity for diagnostic SARSCoV2 testing among the HWs and in the general population for developing nations (Cheng et al., 2020; WHO, 2020d). However, a recent sero-prevalence study among 684 HCWs in Kenya established a 20.8% prevalence of the HCWs in Kenya who have been exposed to Covid19 disease with high variability between Nairobi County whose sero-prevalence was 43.8%, and peripheral counties including Kilifi whose sero-prevalence was established at 11.5% (Etyang et al., 2021). Another study to examine exposure among the general population of blood donors in Kenya established a sero-prevalence at 4.3%(Uyoga et al., 2021). These findings from local settings seem to support the observation that HWs have a relatively higher Covid19 exposure compared to the general population. Therefore, efforts should be directed at protecting HWs as a vulnerable group to Covid19 disease. Protection of HWs from further spread of Covid19 disease and related complications is hinged on integrated building blocks of health systems to support healthy working environments (Folke et al., 2004). For example, the sufficient supply of personal protective equipment for the safety of HWs has been supported in the literature as means of workplace safety (Y. Jin et al., 2020). Despite the current measures put in place to protect HWs from contracting Covid19 disease as instituted by the Government of Kenya such as sustained supply of PPE for frontline workers , reorganization of health workforce and HW prioritization in the Covid19 vaccination (MOH, 2020c, 2021d) evidence on the local predominant sources of exposure is still lacking (Wander, Orlov, Merel, & Enquobahrie, 2020).

1.1.2. Covid19 disease Initial Outbreak

Covid19 is a respiratory disease caused by the novel SARSCoV2 virus(Aylward & Liang, 2020). It was first discovered in January 2020 in Wuhan China as a novel virus in patients with pneumonia of previously unknown cause (Ralph et al., 2020). SARSCoV2 virus has been established to have a 79% genetic similarity to the 2002 severe acute respiratory syndrome coronavirus (SARSCoV) and a 50% similarity to the Middle East respiratory Syndrome (MERCoV) virus. Most of the initial cases of Covid-19 disease were linked to a zoonotic spread from the seafood wholesale market in Hubei China where aquatic animals were traded. However, an alarming number of Covid19 cases among the health workers and among people who had not visited Wuhan City confirmed the potentiality of the human-to-human spread of the disease (Ralph et al., 2020). Subsequently, the WHO declared Covid19 disease a pandemic after an epidemiologic assessment on 11th March 2020. The first Kenyan case of the disease was confirmed on 13th March 2020 and as of 20th August 2021, cumulative Covid19 cases stood at 225,663 and 4,404 cumulative number of Covid19 deaths (equivalent to a crude fatality rate of 2%) (MOH, 2021c).

The exact mode of Covid19 disease transmission is unknown however like other respiratory viruses, direct or indirect droplet transmission has been cited as the predominant mode of transmission (Chowdhury & Oommen, 2020). Direct droplet spread involves inhalation of respiratory droplets produced when one is talking, coughing, or sneezing(Bahl et al., 2020) while the indirect mode of transmission entails viral droplet surface contamination which spreads when contacted by a disease-free person with subsequent touching of their face or airway opening (Kampf, Todt, Pfaender, & Steinmann, 2020). There is limited evidence linking the spread of Covid19 disease through aerosols however researchers are calling on aerosol precautionary measures against Covid19, especially for HWs exposed to aerosol-generating procedures (AGPs) such as suctioning of the airway given the paucity of evidence on aerosol spread of the disease (Yu & Yang, 2020).

The risk of fecal-oral transmission remains unclear despite the detection of viral particles in stool samples in convalescing and symptomatic patients (Ding & Liang, 2020). There has been a concern about whether patients with negative results from the RT-PCR Covid19 tests based on pharyngeal swabs are disease-free given that such patients have had viral particles SARSCoV2 virus detected in the stool samples (Rubin & Crowe, 2020).

1.1.3. Covid19 Infectiousness, Virulence, and clinical manifestation

The epidemic spread of an infectious disease is characterized by its reproduction number (R0) which is the number of secondary cases arising from the primary case (Chowdhury & Oommen, 2020). A meta-analytic review estimated R0 for Covid19 at 2.79(Y. Liu, Gayle, Wilder-Smith, & Rocklöv, 2020) while other studies have given a range of R0 of 2 to 2.5(Aylward & Liang, 2020). However, this could be higher in health care settings and other areas with close human-to-human interactions such as social events where only a few cases are responsible for most of the cases of the disease, a phenomenon called super spreading events (SSE)(Althouse et al., 2020). For example, Althouse et al (2020) reported an R0 for Covid19 disease of 14 on the Diamond Cruise ship which means that every Covid19 case led to 14 other people contracting the disease. In addition, the WHO reports showing that despite previously known small R0 of less than 1 for MERSCoV disease, its R0 was estimated to be 2 to 5 in a hospital setting which was indicative of a higher risk of the spread of the disease among health workers compared to the community settings (Choi, Jung, Choi, Hur, & Ki, 2018). In addition, secondary attack rate, which shows the proportion of cases arising from an index case, is an important indicator of the impact of social interactions in the spread of the disease. The secondary attack rate for Covid19 disease has been estimated at 7.5 % in South Korea and 11 % in the U.S. (Chowdhury & Oommen, 2020).

The spread of Covid19 disease is known to occur both from the symptomatic and the asymptomatic patients. Upon acquiring the infection, the median incubation period is 5 to 6 days with 97% of the patients being found to develop symptoms within 11.5 days (Linton et al., 2020). There is uncertainty about the period of infectivity of the Covid19 patients with a growing number of studies citing that patients continually shed SARSCoV2 viral particles days to weeks after the symptoms resolve. For example, Raphe et al study report that viral shedding in stool persists 4 weeks after the nasopharyngeal tests are negative (Ralph *et al.*, 2020). Symptomatic cases manifest as mild, severe, or critical forms of pneumonia. Out of the 44415 Covid19 cases confirmed in China by February 11th, 2020, 81% developed a mild respiratory infection, 15% had severe symptoms and 5% developed critical health states including 1023 deaths (Zunyou Wu & McGoogan, 2020). The main presenting symptoms of Covid19 disease include fever, dry cough, anorexia, anosmia, loss of taste, myalgia (Chowdhury & Oommen, 2020) and gastrointestinal symptoms such as abdominal pain, nausea, diarrhea, and vomiting (Cheung et al., 2020). The Kenyan Covid19 cases have been predominantly asymptomatic at 91% of all reported Covid19 cases(MOH, 2021a).

1.1.4. Risk factors for covid19 disease and adverse outcomes

Covid19 disease has been shown to affect all age groups and gender with varying susceptibility to severity (Ralph *et al.*, 2020). Data from the US, Italy, and China showed a higher case fatality rate among the elderly population (Bialek et al., 2020; Onder, Rezza, & Brusaferro, 2020; Z Wu & McGoogan, 2020). A Kenyan study by Ombajo et al (2020) showed that male gender, older age above 60 years, and presence of comorbidities were predictors of Covid19 mortality (Ombajo et al., 2020). A systemic and meta-analytic review by Yang et al (2020) showed that comorbidities of hypertension, chronic respiratory diseases, and cardiovascular diseases significantly increased the risk of Covid19-related death at pooled OR of 2.36, 2.46, and 3.42 respectively(Yang, Zheng, Gou, Pu, & Chen, 2020). The risk of severe Covid19 disease such as in-hospital mortality and risk of intubation has been associated with a higher viral load of SARSCoV2 virus (Magleby et al., 2020). Studies have also postulated that HWs are likely to develop a severe form of the disease compared to the general population due to a higher viral load exposure acquired from multiple and frequent exposure procedures in the clinical settings (Nienhaus & Hod, 2020; Wander et al., 2020).

1.1.5. Source of the Covid19 spread to Health Workers

Currently, there is no conclusive evidence on the major source of the spread of the disease to health workers(Aylward & Liang, 2020). Joint WHO-China report cites that despite the relatively high exposure of HWs in the line of duty, occupational and work-related settings did not initially appear to be the predominant source of the disease for the infected HWs since 64% of the 1183 Covid19 clusters of health worker infections were attributed to having arisen from familial households' exposure (Aylward & Liang, 2020). The WHO Situation report number 82 cites that the community spread of Covid19 is a major source of Covid19 disease among HWs (WHO, 2020f). However, studies on previous outbreaks reported that hospital spread accounted for the major source of spread of the coronavirus disease among HWs. For example, HWs accounted for 50% of the nosocomial outbreak of MERSCoV disease (WHO, 2018). More recently, a report on the analysis of the HWs with Covid19 disease in Spain cites that 24% of all national Covid19 infections were health workers with 70% of the infected HWs attributing their exposure as either a confirmed or probable Covid19 case (Equipo profesional de Red Nacional de Vigilancia Epidemiologica (RENAVE), 2020).

Occupational exposure has been cited previously as a significant determiner of disease outcomes sch as Covid19 disease for the HWs, especially those at the frontline of health service delivery (M. G. Baker, Peckham, & Seixas, 2020; Schulte et al., 2012; Yassi et al., 2005). The breach in Infection Prevention and Control (IPC) measures such as improper use of face masks and improper disposal of PPE have been cited as a source of the spread of Covid-19 disease among HWs (Muñoz-Leyva & Niazi, 2020). Another study based on data review from hospitals in Qatar revealed that Covid19 disease among HWs were more prevalent in non-Covid19 facilities compared to HWs working in Covid19 facilities (Alajmi et al., 2020). The authors observed that being directly involved in the care of Covid19 patients does not necessarily translate into a higher risk of contracting the disease among the HWs.

1.1.6. Prevention and Treatment for Covid19 Disease

Based on the existing evidence on Covid19 disease as well as information from previous coronavirus outbreaks (MERSCoV and SARSCoV), the WHO has given out standard procedures for Covid19 infection prevention including wearing of face masks, hand hygiene measures, and social distancing to slow the spread of Covid19 disease in the general population(WHO, 2014, 2020d). Within the health systems, the WHO recommends droplet, fomite, and aerosol precautions for preventing the spread of Covid19 disease among HWs with special emphasis on the proper use of Personal Protective Equipment (PPE) (WHO, 2020d). In addition, the WHO recommends early recognition and triage for Covid19 cases in the health setups, observing five moments of hand hygiene, disinfection of surfaces, administrative controls such as training of HWs on IPC and PPE, facilitating adequate supply and optimal compliance with PPE and IPC measures as key measures for the protection of HWs from Covid19 disease (WHO, 2014, 2020c). There is growing evidence that the use of personal protective equipment including face masks, gloves, gowns, and goggles is protective against Covid19 disease (Ng et al., 2020). Disinfection of hospital surfaces has also been cited as a key infection control measure against surface droplets and spread through fomites (Kampf et al., 2020).

The WHO recommendations on Covid19 testing using Polymerase chain reaction (PCR) test for viral genetic markers for SARSCoV2 have been the gold standard for Covid19 disease testing(WHO, 2022) and useful tool that has been informing the Covid19 pandemic containment policy measures (Zitek, 2020). In light of insufficient PCR Covid19 testing in most countries, the missed Covid19 cases with asymptomatic presentation has been cited as a major bottleneck in the containment of the subclinical spread of the disease (Gandhi, Yokoe, & Havlir, 2020). The accuracy of the PCR Covid19 tests has also been a source of missed opportunities for case detection and containment given the false negative PCR results arising from the tests sensitivity estimates ranging from 63% to 78%(Zitek, 2020). Therefore, Zitek (2020) cites that a negative test result does not always translate to being free from exposure or the disease in a significant number of cases despite a positive test being highly sensitive to the disease at a sensitivity of 98.8%. Consequently, false negative test results have been implicated in the spread of Covid19 disease to HWs because of delayed identification and misclassification of the actual Covid19 cases in the healthcare settings(M. A. Baker et al., 2020; Zitek, 2020).

Similar to diseases caused by SARSCoV and MERSCoV viruses, the SARSCoV2 virus which causes Covid19 disease does not have a definitive treatment with the current medical management of Covid19 diseased patients being mainly supportive (W. Guan et al., 2020; Zunyou Wu & McGoogan, 2020). Despite the ongoing Covid19 vaccination efforts to induce population herd immunity, the acquired immunity from the vaccination or from natural acquisition of the disease has been cited to be short-lived (Edridge et al., 2020). This implies that non-pharmaceutical containment interventions such as social distancing, hand hygiene, and face masking continue to play a key role in slowing the spread of Covid19 disease to vulnerable groups such as HWs, preventing loss of lives and paving the way for research and development of effective therapeutics. For example, social distancing policies in China were estimated to have slowed the spread of the Covid19 disease by reducing the reproduction number was reduced from 3.8 at the beginning of the pandemic to 0.2 after the restrictive policy interventions (C. Wang et al., 2020). Herd immunity as a Covid19 prevention measure is induced when about 70% of the population either get vaccinated or naturally contracts the disease and recovers. However, herd immunity through Covid19 vaccination is preferred due to the risk of death from natural disease acquisition among vulnerable groups (Chowdhury & Oommen, 2020).

1.1.7. Covid19 Vaccination and the risk of Covid19 disease among HWs

Currently, a variety of Covid19 vaccines including Moderna, AstraZeneca, Pfizer, and Johnson and Johnson vaccines have been approved for emergency use and are currently being deployed to priority groups in the developing nations as a means to induce herd immunity and also avert Covid19-related deaths. For example, Covid19 vaccination has been cited to be highly effective in preventing deaths among vulnerable groups in the United States such as the elderly population above 65 years of age(Moline et al., 2021). In Kenya, health workers, the elderly, the essential service providers such teachers and people with preexisting medical conditions such as heart diseases have been prioritized in the Covid19 vaccination program by the Ministry of Health, whereby, 73% of the Health workers had been fully vaccinated with Covid19 vaccines as at 18th August 2021(MOH, 2021a). As a consequence, the reduction in the hospitalizations of severe cases of Covid19 disease has been hypothesized to have resulted from effectiveness of the covid19 vaccines in reducing the severity of Covid19 disease among HWs and other vulnerable groups(MOH, 2021c). This claim is consistent with findings from a cross-sectional study on 7523 HWs vaccinated against Covid19 disease in a Brazilian University Hospital, with a 62% reduction in new cases of Covid19 among HWs in the 7 weeks after the start of the Covid19 vaccination program (Toniasso et al., 2021). This implies that increasing Covid19 vaccination coverage among HWs is paramount in their protection from the disease. However, there is a challenge from the new variants of Concern of the SARSCoV2 virus and the report of breakthrough infections among vaccinated individuals (Bergwerk et al., 2021).

1.2. Statement of the Research problem

Covid19 disease among the HWs has been associated with a growing acute shortage of health workers which has also led to an overwhelming demand for health care both in developed and developing nations. This has arisen from the Covid19-related deaths among HWs and Covid19-related staff sick-leave days to facilitate isolation and quarantine of exposed HWs. The situation has been worse for developing nations of sub-Saharan Africa which have had critical shortages of health providers even before the emergence of the Covid19 pandemic (Naicker, Plange-Rhule, Tutt, & Eastwood, 2009).

The risk factors contributing to this problem have been documented based on previous coronavirus outbreaks such as SARSCoV and MERSCoV (WHO, 2018). In addition, based on the most recent studies on the association between Covid19 disease and the HWs, major risk factors contributing to Covid19 disease among HWs include limited access to PPE, the breach in the correct use of PPE and their disposal, noncompliance with Infection prevention measures for Covid19 among HWs and also delayed detection of the disease in the health care setting (M. A. Baker et al., 2020; Boffetta et al., 2020; Mhango, Dzobo, Chitungo, & Dzinamarira, 2020; Ng et al., 2020; Wander et al., 2020; Ye et al., 2020). There is a scarcity of local evidence on the role of PPE and adherence to IPC in the spread of Covid19 disease among HWs.

Globally, the evidence on the predominant source of exposure to HWs remains inconclusive with initial studies citing that familial and household Covid19 exposure sources were responsible for the high number of Covid19 infections among HWs (Aylward & Liang, 2020). Conversely, there exists a wealth of information showing how occupational exposure preferentially predisposes Health workers to respiratory diseases such as Covid19 and previously to other coronavirus outbreaks such as MERSCoV and SARSCoV (Y. Jin et al., 2020; Klompas, 2020). While the health setting occupational roles predisposes HWs to Covid19 disease because of the well-documented multiple and frequency of exposure, several studies have reported differential findings that health workers in non-covid19 facilities have high risks of contracting the disease compared to the HWs in Covid19 designated facilities given that less training and fewer precautions are observed in such settings compared to those who are directly involved in the direct care of Covid19 patients (Lau et al., 2004). The difference in the risk of Covid19 disease between Kenyan health workers working in designated Covid19 units and those in general non-covid19 units is not well established in the context of the Kenyan tertiary level hospitals.

The MOH Kenya has adopted International guidelines from WHO and CDC for Covid19 disease prevention measures particularly for enhancing HW safety at the frontline(MOH, 2020c). These guidelines have provided evidence-based instructions on the droplet, surface contamination as well as aerosol precautions to be observed in the clinical setting. Health workers have a personal responsibility as well as a professional obligation to comply with the set Covid19 protocols (WHO, 2020a). Unavailability of PPE is a well-established risk factor for hospital-acquired SARS infection among HWs (Chan-Yeung, 2004) while noncompliance with PPE as recommended also being implicated as a known risk factor for the disease (Alajmi *et al.*, 2020). Limited scientific evidence exists on the extent to which HWs in tertiary level health settings comply with the recommended Covid19 protocols. Despite the increased risk to Covid19 disease among HWs arising from community Covid19 exposure such as in public transportation, in bars and restaurants where more than 10 people congregate (Lentz et al., 2020), limited evidence exists with regard to the role of community Covid19 exposure sources for HWs in Kenya

1.3. Study Justification

The growing number of HWs with Covid19 disease heralded an acute shortage of health workers due to long periods of sick leave from quarantine and isolation of affected HWs. In addition, fatalities of HWs from Covid19 disease have incurred huge economic productivity losses the world over (Loeppke, 2008). This is a big issue, particularly in developing nations which have been previously cited to have been struggling with the severe shortage of HWs before the emergence of the Covid19 pandemic. For example, Kenya is one of the developing countries cited in the World Health Report 2006 to have a critical shortage of HWs which is below the 2.28 HWs per 1000 threshold (WHO, 2006). The Kenyan Health Workforce Report 2015 underscores this problem of shortage of health workers in addition to their misdistribution in the Kenyan devolved units with most of the HWs being centralized to work in Nairobi County (MOH, 2015).

Based on MOH updates on Covid19 among HWs in Kenya more than 3% of all reported Covid19 Infections and 1.5% of the reported Covid19 Deaths in Kenya were constituted by HWs(MOH, 2021a). These estimates are not truly reflective of the actual prevalence of Covid19 among HWs due to limitation in PCR tests for Covid19 disease. Nonetheless, taking a total of 208418 HWs in Kenya targeted for vaccination, 2.3% (4860)

of this number had Covid19 disease as at August 2021(MOH, 2021c). As a results, any HW infected with Covid19 disease in Kenya has been out of service delivery at some point due to related hospitalizations, sick-leave-related absenteeism, and some succumbed to Covid19 disease. As result, perpetual disruption of health service delivery in the Kenyan hospitals has been experienced. Therefore, efforts to sustain safe staffing ratios in the hospital have been a challenge in Kenya with the continuing spread of Covid19 disease among HWs. For example, the MOH Kenya guidelines require a ratio of 1 nurse to 6 patients in Covid19 general isolation wards and 1 nurse for every 1 patient in a Covid19 intensive care unit (ICU) (MOH, 2020c). For every sick HW with Covid19 disease who requires isolation, the remaining hospital staff is strained to cover the resultant workload.

The literature review on the factors contributing to Covid19 infections among the health workers established in literature include personal and community risk factors such as age, practice, extra-occupation and community exposure ,and occupational and organizational risk factors such as non-adherence to PPE and IPC protocol, provision of training, high risk cadres, aerosol-generating procedures (AGPs) and prolonged shift-hours(M. A. Baker et al., 2020; Schulte et al., 2012; Ye et al., 2020). A recent cost effectiveness modeling study in Kenya on the value of investing in PPE among the HWs in Kenya estimated that over 70% of the Covid19 cases among HWs in Kenya could have occurred due to scarcity of PPE (Kazungu et al., 2021). Another study in Kenya among the general population by Ombajo et al (2020) established risk factors to Covid19-related mortality in Kenya including male sex, gender and comorbidity status (Ombajo et al., 2020). However, there is little evidence investigating the sources of Covid19 exposure among health workers in Kenya. Therefore, this study adds to the body of local evidence on potential risk factors for Covid19 disease among HWs in a Kenyan hospital designated to care for Covid19 patients as well as other types of disease outcomes. Health systems, occupational, community and socio-demographic factors that could be associated with the spread of Covid19 among HWs will be examined and the findings from this study could inform policies aimed at protecting health workers from the spread of Covid19 disease in their line of duty.

1.4. Research questions

1. What socio-demographic risk factors are associated with Covid19 disease among health workers (HWs) at Kenyatta National Hospital?
2. What community risk factors are associated with Covid19 disease among health workers (HWs?) at Kenyatta National Hospital?
3. What occupational risk factors are associated with Covid19 disease among health workers (HWs?) at Kenyatta National Hospital?
4. What health systems risk factors are associated with Covid19 disease among health workers (HWs?) at Kenyatta National Hospital?

1.5. General Objective

To assess risk factors associated with Covid19 disease among health workers at Kenyatta National Hospital.

1.5.1. Specific Objectives

1. To identify socio-demographic factors associated with Covid19 disease among HWs at Kenyatta National Hospital;
2. To identify community risk factors associated with Covid19 disease among HWs at Kenyatta National Hospital;
3. To identify occupational risk factors associated with Covid19 disease among HWs at Kenyatta National Hospital;
4. To identify health systems risk factors associated with Covid19 disease among HWs at Kenyatta National Hospital.

1.6. Conceptual Framework

Based on the literature review, the study adapts Schulte et al (2012) Framework of the association between occupation risk factors(ORF), personal risk factors(PRF) and disease outcomes(Schulte et al., 2012). Specifically, the independent variables in the study were socio demographics, community variables, HW occupational and Health systems' characteristics.

From the 2nd and 3rd model proposed by Schulte et al(2012), ORF and PRF are independent risk factors to the work-related disease outcomes and could confound each other in their independent association with the disease outcomes in a work environment (Schulte et al., 2012). We will adapt the Schulte et al (2012) models to explore the relationship between the Covid19 disease outcome among HWs and the independent variables. The personal characteristics in the Schulte framework are expanded to cover both socio demographic and community interaction variables in this study. In addition to occupational category of the variables, we will add another category of variables called health systems' variables as illustrated in the conceptual framework in Fig 1 below.

Socio demographic risk factors include the sex, work experience, age, comorbidity status, and sleep levels. The community factors include the means of travel to hospital, use of face masking in social life, health worker household size, and history of exposure to Covid19 patients in the community. The occupational variables include the cadre, optimal PPE/ IPC adherence, PPE Re-use status, shift work type, perceived PPE sufficiency by HW, type of exposure or contact history, reported fit of face mask status, double masking status and non-adherence to HW to HW Covid19 Protocol in shared tea rooms, use of each PPE type and department of work. Health systems factors include the Covid19 training status of HW, reasons for HW Covid19 testing, number of individual HW Covid19 tests done, and timing of Covid19 vaccination**.**

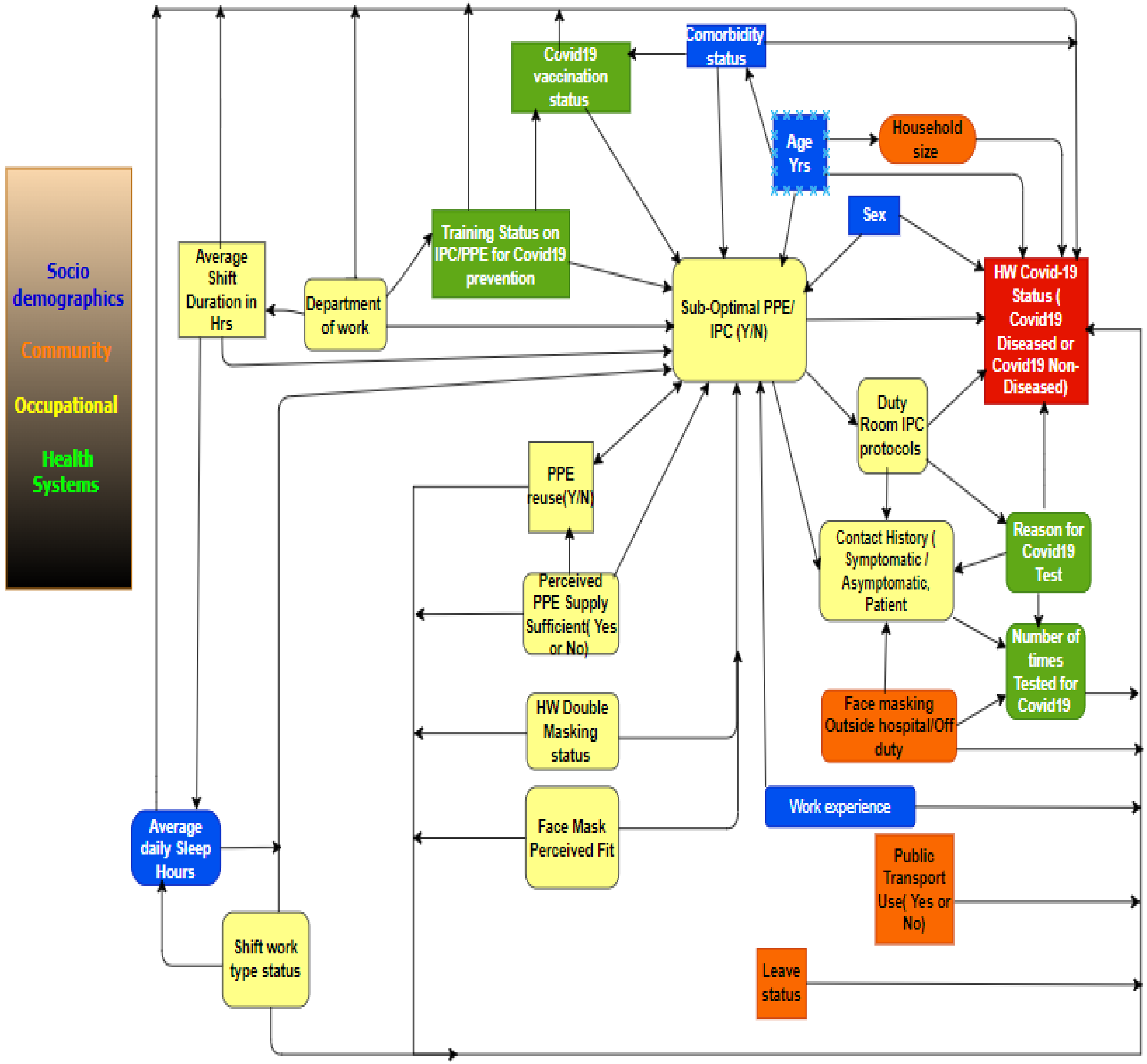

FIGURE 1 :CONCEPTUAL FRAMEWORK ON THE SOCIO-DEMOGRAPHIC, COMMUNITY , OCCUPATIONAL AND HEALTH SYSTEMS RISK FACTORS ASSOCIATED WITH COVID19 DISEASE AMONG THE PARTICIPANT HWS (Schulte et al., 2012)

2. CHAPTER TWO: LITERATURE REVIEW

2.1. Occupation and the risk of Covid19 disease among HWs

A health worker occupation is a known risk factor for contracting diseases related to respiratory pathogens such as SARS viruses (Yassi et al., 2005). Schulte et al (2012) posit four models showing ways in which occupational risk factors (ORF) such as work-related strain and personal risk factors such as age and intake of alcohol can lead to disease outcomes either independently or through interaction with factors such as personal characteristics. The first model shows that personal factors and occupational factors are independent risk factors for disease outcomes (Schulte et al., 2012).The second model shows that the magnitude of the effect of occupational risk factors on disease outcomes is dependent on the personal risk factors (PRFs). The third model shows that the magnitude of the effect of personal risk factors on disease outcomes is dependent on occupational risk factors. The second and third models show the interaction between the occupational and personal risk factors in their association with disease outcomes. The fourth model entails a situation where ORF and PRF cause different disease outcomes and disease states which interact with each other. Models 2, 3, and 4 demonstrate the role of interaction in the modification of the effect of personal and occupational risk factors. Description of interaction is important because it can reveal different causal pathways, shows how biological factors enhance or inhibit each other and can reveal subgroups that are in most need of an intervention (Schulte et al., 2012). Based on these models, Covid19 cases among HWs are likely to arise from an interplay of personal risk factors such as age and occupational risk factors such as the department of work and adherence to personal protective equipment (PPE).

Yassi et al (2005) highlights the role of the occupational environment in the control of SARS and other respiratory pathogens (Yassi et al., 2005). Health workers constitute a vulnerable group to Covid19 disease given their increased risk of multiple exposures from the health care setting. The findings of Ochoa et al (2020) systemic review on risk factors for covid19 infections among HWs support the claim that HWs are at a relatively higher risk of Covid19 infection than the rest of the population(Gómez-Ochoa et al., 2021). A relatively higher incident risk of Covid19 infections among HWs further illustrates that HWs are a vulnerable group in terms of contracting Covid19 disease. In Spain, 24% of all the reported Covid-19 cases were HWs (Equipo profesional de Red Nacional de Vigilancia Epidemiologica (RENAVE), 2020) with 70% of them reporting exposure from a probable or a confirmed covid19 patient. During the MERSCoV outbreak, health workers (HWs) constituted 50% of all nosocomial cases of the disease (WHO, 2018). Furthermore, recent studies are consistent with earlier observations on the association of a higher burden of disease among health care workers compared to the general population. A study based in China investigating the burden of Covid19 among health workers revealed that health workers have a higher case infection rate (CIR) than non-health workers (Zheng et al., 2020). Another single-center case study of 138 patients with Covid19 disease in Zhohum China, showed that 41% of the cases were associated with Hospital-acquired Covid19 infections, comprising 29% for the health workers and 12% of the hospitalized patients ((D. Wang et al., 2020). This illustrates that the health delivery environment poses a huge risk of Covid19 exposure both to the Health Workers and the patients they serve. In light of the increased risk of the spread of disease and relatively higher burden of the disease among Health workers, there is a need to identify modifiable factors for improved safety of health workers within the Covid19 pandemic.

2.2. HW Social demographics and Covid19 disease among HWs

Social demographics entail important personal characteristics and behaviors that influence health or disease outcomes. These include age, gender, marital status, occupation, residential areas, and the existence of comorbidity status. Schulte et al (2012) framework posit that personal characteristics can serve as independent risk factors for disease. Personal characteristics could modify the disease outcome or confound a relationship between an exposure and its disease outcome. In the context of Covid19 disease, there is growing evidence that the personal characteristics of HWs are associated with an increased risk of contracting covid19 disease. A cross-sectional study done across Health care workers of various occupational roles in India through online interviews established that the age of the HW as well their gender status and occupational classification were significantly associated with poor compliance to infection prevention practices such as PPE use and hand hygiene measures(Agarwal et al., 2021). Younger age of the HW below 31 years was associated with poor compliance of the PPE use compared to HW above 31 years while female HWs had better levels of compliance to PPE use than male counterparts. Compared to nurses and senior doctors, other paramedics in the hospital such as technicians and subordinate staff were reported to have poorer compliance levels of PPE use.

The scientific literature on the role of socio-demographic characteristics of the HW in the spread of Covid19 among HWs is growing despite a scarcity of evidence in the Kenyan context. One recent multicenter cohort Kenyan study, which was non-specific to risks among HWs, showed that risk factors for Covid19-related fatalities include male gender, comorbidities, and old age above 60 years among the general population (Ombajo et al., 2020).

Health workers are considered a vulnerable group to Covid19 disease not only due to their increased risk of contracting the disease but also from an established high risk of complications and mortality from the disease due to the prevalence of Covid19 fatality risk factors including obesity and hypertension as observed by

Kambhampati et al (2020). Out of the 6760 hospitalized cases of Covid19 between March 1st and May 1st, 2020, 5.9% were Health care providers (HCPs) and 89.8% of the hospitalized HCPs had at least one comorbid condition with obesity being the prevalent comorbidity among health workers(Kambhampati, O'Halloran, Whitaker, Magill, & Chea, 2020). Kambhampati et al (2020) employed a pragmatic definition of health workers defined as the "persons working in health care settings, home health care services, or health care occupations within other settings (e.g., school nurses) who have the potential for exposure to patients or infectious materials". A third of the hospitalized HCP cases worked in a nursing-related occupation. Obesity was present in 72.6% of the HCPS hospitalized, followed by HTN at 40% and DM at 30.9%. Among female HCP between 18 to 49 Years, 9.6% were pregnant. Upon admission, 96.6 % reported COVID-19 signs and symptoms including shortness of breath, cough, and fever/chills. The median length of hospitalization was 4 while that of ICU was 6 days. 27.6% of the HCP were admitted to ICU with 15% requiring mechanical ventilation and 4% HCP deaths (Kambhampati et al., 2020). There is growing evidence showing that having comorbid disease conditions such as obesity and increased age is associated with a higher viral load of the SARSCoV2 infection and thus higher pathogenesis and infectivity (Magleby et al., 2020). Obesity has been associated with increased severity of Covid19 disease and poor clinical outcomes (Gao et al., 2020). Prior studies have tried to establish the association between HW occupation and the prevalence of lifestyle diseases such as obesity and diabetes type two. For example, a 24-year follow-up study on female nurses working night shift roles aimed to establish the association between the risk of type 2 diabetes and the exposure factors including an unhealthy lifestyle marked by BMI levels above 25 and night shift work involving rotating night shift work for 5 to 10 years. The authors established that the occupational night shift roles of the nurses and the resultant unhealthy lifestyle interactively contributed to an increased risk of type two diabetes among the study participants (Shan et al., 2018). The findings of this study imply that increased vulnerability to Covid19 disease among HWs is related to an interplay between the personal health status of the HW including their comorbidity status, as well as occupational hazards such as unhealthy lifestyle among shift work health workers. In light of the increased risk for Covid19 and severe disease status among Health workers from scientific literature, addressing the burden of Covid19 disease among Kenyan HWs requires close regard to the risk profiles of the HWs including their comorbidity status, gender, and age distribution. A cross-sectional Kenyan study by Ondicho et al (2016) estimated the prevalence of obesity and overweight among HWs in Kisumu County to be 58.8% (Ondicho, Omondi, & Onyango, 2016). Therefore, seeking to generate local evidence on any association between the HW comorbid health status and their risk of Covid19 disease is imperative for targeted Covid19 protection measures among HW subgroups.

2.3. HW cadre, department of work and risk of Covid19 disease

Health workers have been termed as front responders, first-line workers, and frontline workers in the fight against the Covid19 pandemic given their primary mandate of delivering health within the health systems. A cross-sectional study by Rossi et al (2020) aimed at investigating the burden of mental health disease outcomes among HWs in Italy, proposes how frontline and second-line workers can be determined in a study. Rossi et al (2020) classified health care workers as either first line or second line based on a yes or no answer to the question, "are you currently working with Covid19 patients" (Rossi et al., 2020). This question was not specific enough to differentiate Health Workers working directly or indirectly in the delivery of health to Covid19 patients. However, it can be interpreted to mean that health workers working either directly or indirectly for Covid19 patients, probable cases, suspected cases, and even unidentified cases can be categorized as first-line or frontline responders within the health system given the risk of exposure inherent in their roles.

Boffeta et al (2020) sought to know whether being directly involved in Covid19 patients as a health worker posed a higher risk than being indirectly involved. The authors conducted a multicenter analysis of 10654 health workers who were tested for Covid19 infection from six Italian centers to determine if there were any significant differential exposure or risk factors to Covid19 among various cadres and departments within a hospital. They found a variation in the prevalence of Covid19 infections between the centers with a range of 3 % to 22%. Fitting a multivariate logistic regression model, the authors found no difference in the infection rates between job titles and working in high-risk versus low-risk areas. The use of face masks by the source of exposure was also protective while the use of masks by both the source of exposure and the health staff was found to have additive protective effects (Boffetta et al., 2020). Self-reported fever was strongly associated with Covid19 infection with cough, anosmia, dyspnea, and malaise being significantly associated with the infection. Contact with a patient as a potential source of spread was associated with a higher risk of infection compared to contact with a colleague. The authors concluded that the lack of significant differences in the proportion of cases and exposure risks between HWs providing direct care to Covid19 patients and those working in non-covid19 facilities indicated that all health workers working in Covid19 units do not have a different risk than those in non-covid19 units. Therefore, the distinction of first-line health workers should be based on the evidence-based risk stratification among the HWs(Boffetta et al., 2020). Boffetta et al (2020) concluded that the determiners of Covid19 cases among HWs do not significantly vary according to job titles or unit designation as either Covid19 or non-covid19 units. Hence, the protection of health workers within the health systems should be the same regardless of the unit of work or designation pending further studies to confirm or refute this claim (Boffetta et al., 2020).

A retrospective cohort study by Ran et al shows that unit designation was a significant contributor to Covid19 positivity among the HWs in addition to the long duration of duty hours and sub-optimal hand hygiene(Ran et al., 2020a). Another cross-sectional study based on secondary data from health care workers Covid19 infections in Wuhan China categorized health workers into occupation, sex, hospital type, infections status, and death status. 53% of all the HCWs infections were nurses, 33.62% were doctors and 14% were medical staff working in the hospitals except nurses and doctors (Zheng et al., 2020). The majority of the infections were from general hospital units at 89% while the rest of the infections were from specialized units at 5.7% and community hospitals at 5%. A possible explanation offered included the observation that health workers in specialized units tend to use more protective gear than their counterparts in general units. Hence they are less likely to contract the disease. The case infection rate (CIR) for doctors was statistically significantly lower than that of the nurses ($p<0.05$). The CIR for general hospitals was significantly higher than that of community and specialized hospitals at $p<0.05$. The study revealed that CIR was significantly higher for Health care workers (HCWS) than for non-HCWs however, the case fatality rate (CFR) for non-HCWs was significantly higher. The authors attributed the higher patient contact time for nurses compared to doctors as the reasoning behind the findings of a higher CIR among the nurses. From the study, more infections of HCWS occurred in the initial months of the pandemic where there were insufficient PPEs and the HCWS tended to work for longer hours(Zhang et al., 2020). The authors thus recommended the need for sufficient rest for health workers, adequate sleep, and a balanced diet for the improvement of immunity. None of the studies in this literature on the role of job designation and department of work in the spread of Covid19 disease among HWs is local. Therefore, local studies are needed studies on the role of department of work in the spread of Covid19 among HWs. For the purposes of this study, the clinical categorization of HWs based on either direct or indirect roles in the care of the patient in the hospital was adopted from the study by Seto et al (2011). Clinical staff were defined as HWs involved in the routine direct care of patients with opportunities for direct patient contact in their work and all others as non-clinical staff (W. H. Seto et al., 2011). This was similar to the categories made by Shah et al (2020) on patient-facing workers for those with direct involvement with patients and non-patient-facing for workers with indirect and supportive roles to the care of patients in the hospital (Shah et al., 2020). As per the norms and standards for Human Resources for Health in Kenya, clinical and non-clinical staff categories capture all the hospital staff that works to either deliver health to patient or assist the providers in the delivery of the care to the patients (MOH, 2014). Examples of clinical staff include doctors, clinical officers, nurses, laboratory officers, pharmacists and pharmacy technologists, nutritionists, counselors, physical therapists, phlebotomists. Non-clinical staff include administrative managers, security, messengers, data clerks, and catering staff.

2.4. Public transportation and hospital residence and the risk of HW Covid19 disease

Scanty evidence on the association between uses of public transportation by health workers and their risk of contracting Covid19. However, among the general population, the CDC has issued guidelines for enhanced protection from Covid19 while using the general public transport system which includes physical distancing, wearing of face mask, hand hygiene, and avoiding touching surfaces (CDC, 2021d).

The guidelines are based on existing literature that associates public transportation with the highest risk of covid19 spread among the general population. A study in china among bus riders showed that traveling in the same bus with an infected Covid19 patient increase the relative risk of being infected with Covid19 by 20% (Shen et al., 2020). Another prospective cohort study in Guoazou China investigating the risk of transmission in 3410 close contacts of Covid19 patients, revealed that the risk of the spread of Covid19 is rare in public transportation and health care settings compared to household settings. The authors found that 10% secondary attack rate in household settings, 0.1% in public transportation, 1% in health settings, and 1.3% in entertainment avenues (Luo et al., 2020). The findings were attributed to the observation that the use of protective face coverings had been mandated in health settings and public places like the transportation industry but not at the household levels. The findings also revealed that patients with severe symptoms had higher transmissibility of the disease than asymptomatic cases (Luo et al., 2020). These studies among the general population imply that health workers who use public transportation may be at an increased risk of contracting Covid19 disease if they happen to be in the same vehicle as a Covid19 patient especially if the infection prevention protocols of public mask wearing are not well observed outside the health care setting. In addition, Luo et al (2020) study further implicates household exposure as a potential source of the spread of Covid19 disease among family members. Health workers come from family units and therefore, they stand to be at risk of contracting the disease if exposed at the family or household level. This review of literature has not been able to trace any local literature examining the role of public transportation and household exposure to covid19 spread among the HWs.

2.5. Optimal PPE and risk for Covid19 disease among HWs

Proper use of PPE is an important component for the safety of HWs during an outbreak of highly infectious respiratory pathogens such as SARSCoV, MERSCoV, and Covid19 disease-causing SARSCoV2 virus

(WHO, 2020c). Optimal PPE use and compliance rank at the base of the Hierarchy of controls for infectious diseases in the health care setting(CDC, 2021b; Kapust, 2020) which means that optimal PPE use protects HWs when all other levels of controls fail to offer this protection from hospital-acquired infections such as SARS-COV2 virus.

Lau et al (2004) case-control study investigated the role of personal protective equipment in the prevention of SARS breakthrough infection among health workers at a Hong Kong hospital and employed a case-control design. The study included 72 case groups and 114 controls who were matched for analysis of their responses on PPE use, training status, perceived PPE supply, social contact, history of exposure to aerosol-generating procedures (AGPs), the fit of the facemasks, the clarity of the protective goggles, barriers to PPE use and the frequency of touching their protective masks. From the stepwise forward univariable and multivariable logistic regression analysis, the authors found that perceived PE supply. PPE use and IPC training were significant and independent predictors of SARS infection among Health workers (Lau et al., 2004). A recent rapid systemic review by Mhango et al (2020) on risk factors to Covid19 disease among health workers highlights five major groups of risk factors that contribute to the spread of Covid19 disease among HWs including lack of PPE, exposure to infected patients, work overload, poor infection control and pre-existing medical conditions (Mhango et al., 2020).

A global shortage of PPEs has been cited as a systemic contributor to the spread of Covid19 among health workers worldwide (X. Wang, Zhang, & He, 2020). For example, the Italian incidence of Covid19 infections among the HWs constituted 9% of all the reported Covid19 case by April 2020, a recent Italian self-reported review on availability of PPEs among health workers show that only 13% out of the 516 Physicians could have access to PPE whenever needed(Savoia et al., 2020). The role of insufficiency of PPE in the spread of the coronavirus respiratory pathogen among HWs was documented by Chan-Yeung et al (2005) during the SARSCoV outbreak in their publication on the reasons why health workers were infected with SARS infections(Chan-Yeung, 2004). The authors highlighted that different phases of the SARS epidemic contributed to the spread of the disease among hospital staff including the initial phase where workers had little understanding of the novel disease, followed by a period where there were insufficient PPEs, and followed by later phases of the epidemic where there was poor compliance on IPC measures and laxity of the institutional inflectional prevention measures such as lack of proper design of the physical distancing of the hospital beds and lack of hand hygiene and decontamination facilities.

Chan-Yeung et al (2004) also observe that atypical clinical presentation of SARSCoV infection was associated with the super spreading of the disease within the hospital setup and in extension affecting the HWs.

A cross-sectional data review study in a tertiary facility in Qatar to determine the prevalence of Covid19 among HWs revealed that working in a non-covid19 designated unit posed a higher risk of contracting Covid19 disease compared to working in a specialized Covid19 unit (Alajmi et al., 2020). In this study, the authors utilized a convenience sample of health care workers with Covid19 test status retrieved from electronic medical records both from Covid19 designated facilities and non-covid-19 facilities. Their results also established a prevalence of 10.6% for Covid19 disease positive health workers out of the 16,912 tests done. Among the infected, the hospitalization rate was 11.6%, 1.3% required oxygen, zero deaths, 0.6% needed ICU admission and 0.3% were intubated. Another observation was that 75% of the HWs reported having had Covid19 exposure from a patient or a colleague. Based on these findings, the authors concluded that less stringent use of PPES in non-covid19 facilities could have resulted in a higher burden of disease among HWs in non-covid19 units and hence the emphasis on the use of PPE by HWs regardless of whether Covid19 disease is confirmed in the clinical setting or not.

Another study by Seto et al (2003) using a case-control design on 13 HWs with SARS infection and 241 non-infected HWs in five Hong Kong hospitals, further underscored the utility of PPE in infection prevention among HWs. Univariable analysis using the Fishers test and stepwise logistic regression on the exposure variables and outcome variables revealed that the face masks had an overall significance in protecting the hospital staff from contracting the SARS infection (W. Seto et al., 2003). The authors concluded that droplet precautions were protective.

Everyday work for HWs involves high-risk procedures such as difficult endotracheal intubation, airway suctioning, bronchoscopy, and extensive bagging, therefore, their adherence to laid down protocols for disease prevention is paramount(Chan-Yeung, 2004). CDC (2020) recommendations on aerosol and droplet precautions require that health workers use N95 or equivalent masks and eye coverings when handling suspected or confirmed Covid19 cases and when performing aerosol-generating procedures(CDC, 2021c).

Ng et al (2020) case report study investigated the exposure of 41 health workers to a suspected case of Covid19 that later turned out to be a Covid19 patient. Their report showed that none of the 41 health workers was infected despite the exposure. The authors attributed this protection to the observation that all the health workers who attended to the patients performing AGPs had worn at least a medical mask or an N95 mask. While this is one report of exposure lacking generalizability due to limits in its methodology and sample, it illustrates that compliance with to correct use of personal protective equipment among HWs is paramount in preventing the spread of Covid19 in the clinical set-up (Ng et al., 2020).

Powell et al (2020) cross-sectional design study on 220 health facilities assessed compliance levels for infection prevention measures and the determiners of IPC compliance among health providers. Using secondary data from a 2018 randomized control trial for quality improvement in Tanzania, the authors focused on PPE use, re-use of disposable equipment, hand hygiene, gloves use and waste management. The results of the study revealed a low pre-covid19 baseline overall compliance on IPC measures at only 6.9% across the private hospitals in Tanzania. Hand hygiene compliance was also low when health providers used gloves suggesting that the use of gloves was viewed as an alternative to proper hand hygiene with soap and water. Low compliance on disinfection of reusable equipment such as stethoscopes at less than 1 % and thermometers at less than 13% was also observed among health providers. In addition, compliance with proper waste management was below 20%. Increased covid-19 waste materials and potential for improper disposal, high use of stethoscopes and thermometers, and poor compliance in disinfection are potential pathways for the spread of Covid19 disease within the hospital setting. The authors concluded that since private hospitals are relatively better equipped with hand hygiene supplies at above 80% compared to public facilities at only 58%, health care provider's compliance with hand hygiene could be worse off in public hospitals and thus the potential for a higher rate of the spread of the disease (Powell-Jackson, King, Makungu, Spieker, Woodd, Risha, & Goodman, 2020).

Besides IPC supplies and equipment, Balkhy et al (2016) note that compliance with IPC measures depends on HW personal factors. For example, a cross-sectional study assessing the level of fatigue, depression, and anxiety among the frontline HWs found that out of the 2614 HWs participants, 74% had reached a threshold of being fatigued, 50% had depression while 23% had anxiety(Teng et al., 2020). Worker fatigue and decline in mental capabilities have been cited to have a compounding effect on the incorrect use of PPE and risk factors for contracting Covid19 disease (Bai et al., 2020). Balkhy et al (2016) further notes that compliance with infection prevention is the Achilles’ heel in the fight against healthcare-associated transmission of infection based on the experience from MERSCoV outbreak. These authors propose a system-wide approach to addressing hospital-acquired infections including policies and procedures such as standard precautions for infection prevention, behavior, accountability, and leadership such as through example setting and training, facility equipment, and human resources such as through the provision of soap and water supplies for hang hygiene and other PPE (Balkhy, Perl, & Arabi, 2016). In the context of Covid19, examining the systemic factors that may act as barriers to compliance with infection prevention measures among HWs is warranted as a potential source of the Covid19 spread within the health care setting.

Consistently, improper PPE use and non-adherence to IPC standards are implicated in the spread of Covid19 disease among health workers as a retrospective cohort study on 72 HWs with Covid19-like symptoms by Ran et al (2020) shows that suboptimal use of PPE and noncompliance to hand hygiene measures is associative with a higher risk of contracting Covid19 disease among HWs. The authors concluded that long working hours, suboptimal hand hygiene, and high-risk departments were linked to the COVID-19 infection status. Contact with a diagnosed family member has also been associated with a higher risk of Covid19 disease among the health workers (OR, 2.76) while contact with diagnosed and suspected patients has been cited as protective (OR of 0.36 and 0.49 respectively). Non-adherence to hand hygiene before touching a patient and after attending to a patient and the improper use of the PPE was also significantly associated with the risk of Covid19 infection at OR of 3.4, 2.43, and 2.82 respectively(Ran et al., 2020b). Based on these findings, the authors recommend reduced work hours as a protective measure for health workers and their findings underscore the importance of adherence to guidelines on hand hygiene and other IPC measures as protective measures for health workers whether in the community or while working within the hospital settings.

2.6. Shift work and risk of Covid19 disease among HWs

There is growing evidence of the importance of timing of the work schedule to susceptibility to viral infections (Almeida & Malheiro, 2016; P. Y. Liu, Irwin, Krueger, Gaddameedhi, & Dongen, 2021). Previously, HWs engaged in night shift work schedules were found to have a higher prevalence of common cold, flu-like illnesses, and gastroenteritis compared to day shift workers (Mohren et al., 2002). Almeida and Malheiro (2016) highlight various mechanisms by which shift work weakens worker immunity states through a reduction in immune cells such as natural killer cells, CD16, and Inter-luekin 2 factors which are .responsible for fighting viral pathogens. In addition, night shift work is associated with abnormal cytokine levels (Lim, Wambier, & Goren, 2020). Besides night shift work is a direct modulator of the physiology of the immune systems and through circadian rhythm deregulation, it has an indirect effect on individual health status. For example, a systematic and meta-analytic review by Liu et al 2018 established that night shift work increases the workers' risk of being overweight and obese(Q. Liu et al., 2018). Both being overweight and obese have been strongly associated with Covid19 positivity and severe forms of Covid19 pneumonia (Gao et al., 2020; Simonnet et al., 2020). A within-subjects follow-up study on their sleep variation and the resultant concentration of immune cells in the blood revealed that shorter sleep duration was associated with a 30% reduction in the concentration of the natural killer cells (Fondell et al., 2011) which was consistent with findings from a cohort study by Nagai et al on fifty-seven female nurses engaged on night shift. Nagai et al observed that night shift work had deleterious effects on the natural killer cells' function and the effects depended on the level of fatigue (Nagai et al., 2011). These studies imply that shift work can alter the immune status of the workers and their ability to fight diseases. Almeida and Malheiro (2016) conclude from their review of literature on this subject that increased susceptibility to viral infections among shift workers is related to a compromised innate immunity (Almeida & Malheiro, 2016).

The association between the type of shift work and the risk of Covid19 disease among HWs has been established in several studies. For example, a recent retrospective single-center study by Bai et al (2020) examined risk factors for Covid19 disease among 118 health care workers out of which 12 HCWs acquired Covid19 disease. The authors conducted statistical tests of associations for the categorical variables while comparing the independent prevalence rates for the variables of interest between Covid19 infected HWs and non-Covid19 infected HWs. The results of the study showed that poor sleep quality reported pressure at the workplace and night shift work were significantly associated with Covid19 infections among health care workers (Bai et al., 2020). Findings from a UK-based biobank cohort study by Fatima et al (2021) investigating the association between night shift work and risk of Covid19 disease also revealed that workers in night-shift jobs were 1.85 times more likely to have Covid19 disease compared to those without night shift schedules (Fatima et al., 2021). Fatima et al (2021) observe that irrespective of the health settings, night shift work in any occupational group studied was associated with higher odds of Covid19 disease. These findings imply workers involved in the night shift work area are a vulnerable group to covid19 disease and NSW could compound the risk of Covid19 disease not only from the timing of the work but also due to inherent risk in the prolonged hours of work.

2.7. Re-use of PPE

Reuse of PPE such as face masks and also rationing of PPE are some of the means reportedly being employed to slow the spread of Covid19 disease in situations where the supply of PPE is not sufficient (Adeleye OO, Adeyemi AS, Oyem JC, 2020). However, reuse has been cited to offer inferior protection for SARSCoV viruses although it has been cited that reused masks are better than none at all (Garcia Godoy et al., 2020). Czubrt et al (2020) cite that PPE reuse is a feasible and safe strategy that can be used in helping to slow the spread of Covid19 disease but this has to be done under specific sterilization autoclaving conditions (Czubryt et al., 2020) Therefore, understanding how HWs are currently responding to difficult situations such as insufficient PPEs while required to provide health services is warranted. Rodríguez-Martinez et al (2020) review summarizes the existing evidence supporting the decontamination of face masks for reuse. The use of ultraviolet germicidal irradiation and vaporized hydrogen peroxide has been cited to be the most advantageous (Rodriguez-Martinez, Sossa-Briceño, & Cortés, 2020).

Given that developing countries such as Kenya are currently experiencing a shortage of PPEs such as face masks (Mwema & Nyika, 2020), HWs could be experiencing the need to reuse their PPE. Scientific Literature on the practice of PPE reuse in the local setting has not been traced and therefore, this study will seek to investigate it among the HWs of study interest.

2.8. Exposure type, HW to HW Exposure and the risk of Covid19 disease among HWs

Currently, the WHO and CDC recommend the observance of both droplet and aerosol precautions. Bahl et al (2020) systematic review of the existing evidence on Covid19 protocols to justify the existing current containment measures. Using the PRISM Approach for systemic and meta-analytic review of 118 studies, the authors observe that the current spatial distance of 2 meters for physical distancing is not supported by evidence. The authors highlight various articles that support protocols for aerosol precautions rather than droplet containment precautions are given the paucity of evidence on the difference between aerosolized and droplet spread. The authors note that droplets and aerosols cannot be separated given the physical dynamics associated with the transformation of droplets to aerosols and the weather and intensity of the particles in the air (Bahl et al., 2020).

A cross-sectional study examining the characteristics of health workers with covid19 infections in a tertiary public health hospital observed the role of HW to HW Covid19 spread within a hospital (Suárez-García et al., 2020). The authors purposively included all the 1911 Health workers who worked in the hospital between Feb 24th and April 30th, 2020. Personal characteristics of the health workers with Covid19 cases were obtained while stratifying health worker groups into those in high-risk occupational areas (those in frequent direct contact or caring for Covid19 patients for example in the Accident and Emergency, ICU, and pulmonology departments), moderate risk (those with occasional contact with Covid19 patients such as HWs in surgical and medical departments) and low-risk areas (such as administrative workers). HWs were also classified on the severity of the disease including mild cases, moderate cases, and radio graphical findings suggestive of viral pneumonia. From the descriptive analysis, 33% of the Health workers who had a confirmed molecular Covid19 result had met the symptomatic case definition for Covid19. This represented 11.1% of all HWs included in the study. There was a median 2 days delay in the staff presentation for care upon onset of symptoms. The level of occupational exposure was found to be an insignificant factor associated with Covid-19 infections however five departments were found to have a higher prevalence of Covid19 HW cases above 20% including neurology, dermatology, pulmonology, pediatrics, and oncology. Nurse supervisors and heads of departments were also found to have a high incidence of the disease at 37.5% and 23.1% respectively. The median sick leave for the 118 HWS with Covid19 was 20 days. 15.6% of all the health workers had received a form of Covid19 training. The findings on non-significance of occupational level, the peak of HW infections before the peak of the Covid19 admissions, and a few clusters of the infection among the HWs were suggestive of the predominance of HW to HW spread of the disease rather than the patient to HW spread (Suárez-García et al., 2020). The observation by Suarez-Garcia et al(2020) is similar to the findings by Bai et al (2020) who established that most HWs contracted Covid19 disease from a non-index case that further supports the predominance of the Covid19 transmission through staff-to-staff, and surface contamination methods (Bai et al., 2020).

The HW to HW spread of Covid19 may be propagated by tea and lunch breaks where health workers dine together. This review of literature could not find any local evidence implicating hospital tea rooms in the spread of Covid19 among HWs within Kenyan hospital settings.

There has been uncertainty about the major source of the Covid19 exposure among health workers (Aylward & Liang, 2020). In China, the nosocomial spread of the disease is cited not to have been a major source of the spread of the virus to the HWs. The majority of the HWs' covid19 infections were attributed to household covid19 cases and exposure. Out of the 1183 case clusters reported outside of Hubei Province in China, 64% of them were within familial household contacts, thus hospital spread was not considered the major source of the spread (Aylward & Liang, 2020). This was supported by findings by Lentz et al (2020) whose case-control study established that extra occupational exposure is associated with an increased risk of Covid19 infection among HWs including public transportation and gathering of more than 10 people (Lentz et al., 2020). Given the uncertainty between the major sources of exposure for health workers between the nosocomial and community sources, there is compelling public health need to understand Covid19 disease transmission among HWs both within the health setting and beyond the health care setting.

2.9. HW Training status and the risk for HW Covid19 disease

Insufficient HWs’ training on the use and disposal of PPE and IPC measures is another documented risk factor for Covid19 infection among HWs. Lack of accurate scientific information and understanding of the epidemiology of Covid19 disease and the optimal levels of personal protective measures has been associated with the spread of Covid19 among HWs (Ali et al., 2020). A tribute to Covid19 frontline HWs in China reports that while the novel Covid19 disease was increasingly being understood through ongoing scientific consultations about the virulence, evolving mutants' strains, and pathophysiology of the disease, the health workers were still contracting the disease at the frontline of Covid19 response (Xiang et al., 2020).

A matched case-control study of 72 health workers with SARS infections along with 114 controls from five hospitals in Hong Kong. They were presented with a questionnaire to assess explanatory variables to the health status of either SARS infection or non-SARS infection among the health workers. The author examined the PPE consistency of use and compliance, perceived sufficiency of PPEs including gloves, face mask, goggles, caps, and gown, exposure status whether in the direct care of SARS patients or otherwise, frequency of hand washing, mask fitness, goggles fogginess, and other issues associated with compliance with proper PPE use. The participants were also assessed on their history of contact with people who later turned out to be infected with the SARS virus. The status and length of training were also assessed between the controls and cases. The multivariate analysis using stepwise logistic regression showed that perceived inadequacy supply of PPE (adjusted OR,4.27, $p < 0.05$), <2 hours of training or no training on IPC (adjusted OR,13.6, $p<0.05$), and improper PPE use in more than one type when in direct contact with SARS patients (adjusted OR<5.06, $p<0.05$) were associated with a SARS infection among HWs (Lau et al., 2004). The findings further indicated that physical contact with a patient infected with SARS was not a risk factor. In addition, universal masking was not a predictor of the infection which suggested that droplet precautions are not sufficient in preventing the spread of SARS in the hospital setting. In light of the increased risk of contracting SARS among HWs of up to 13 times higher for HWs lacking SARS training compared to those who have been trained from studies in China (Lau et al., 2004). This review of literature could not trace any local evidence on the role of the training status on Covid19 disease on the spread of Covid19 among HWs.

2.10. Fit testing, fit checking, double masking, and the risk to HW Covid19 disease

Mask face-seal leakage is an established pathway for the spread of pathogens such as TB (Bates & Nardell, 1995). Bates and Nardell (1995) report that a suitable mask needs to have a high filtration material of more than 95 % and also a face-seal leakage of less than 10%. For the health workers who complied with the wearing of face masks for droplet or aerosol precautions but acquired SARS infection during the 2003 SARSCoV pandemic, Chan-Yeung (2004) posits that lack of fit testing or lack of training could have contributed to the health worker SARS infections but was not distinguishable. Chan-Yeung (2004) concluded that the acquisition of SARSCoV infection despite Face masking points to alternative potential routes of disease spread including face masks leak arising from lack of fit testing or fit checking measures (Chan-Yeung, 2004). Fit testing and fit checking are therefore important Infection Prevention measures for consideration for a study investigating factors contributing to Covid19 disease burden among HWs.

Regli (2020) highlights the current international recommendations on fit testing for droplet and aerosol personal protective equipment based on Australian Standard AS/NZS-1715:2009 and the Australian Guidelines on IPC measures within health care setting (Regli, 2020). The standards recommend annual fit testing for masks and respirators used by health workers. Despite inconclusive evidence on the effectiveness of fit-checking and fit-testing for face masks, non-fit-tested masks had been implicated in the nosocomial spread of SARS infections. The authors recommend that HWs in high-risk departments such as aerosol-generating procedures rooms and where there is no negative airway pressure should have fit-tested masks as fit checking is inferior in detecting the leaks (Regli, 2020).

Double masking has been cited as one strategy for improving the fit and protective effectiveness of face masks (Brooks et al., 2021). CDC (2021) conducted a recent simulation study using elastomeric source and head forms to determine whether modifications of face masks could improve the fit of the face masks and also improve the protection of the simulated wearer from experimentally generated aerosols and droplets akin to SARSCoV2 transmission (Brooks et al., 2021). The findings revealed that mask modifications could improve the fit and also combining two masks, a cloth mask over a medical mask, could reduce the exposure to aerosol levels in the wearer by more than 90%. These findings were consistent with Pan et al (2020) preprint study which cites that an infectious particle the size of 2 µm is likely to be lodged in the respiratory tract when one is wearing a mask. Pan et al (2020) also observe that multiple layers of masking provide a protective efficacy of more than 70% for the most penetrating particles and more than 90% for particles larger than 1 µm (Pan, Harb, Leng, & Marr, 2021). Sickbert-Bennett et al (2021) went further to study the effects of double masking on human volunteers using various combinations of face masks. The authors concluded that wearing a medical mask underneath cloth masks provided the best level of fitted filtration efficiency of the face mask owing to improved fit between the mask and the skin and also the filtration of infectious particles(Sickbert-Bennett et al., 2021). Despite the growing evidence on the importance of good fit of the face masks and also the need for double masking for improving the fit, this review of literature has not traced any local evidence on these practices within the local hospital setting especially among the Kenyan HWs.

2.11. Covid19 testing protocols and Risk of Covid19 among HWs

Covid19 testing has been cited as a key strategy in slowing the spread of Covid19 disease among the general population as well as among HWs (Zitek, 2020). CDC (2021) recommends prioritization of SARSCoV2 testing among HWs in four main categories, namely, testing for asymptomatic HWs with suspected exposure, testing for symptomatic HWs, testing asymptomatic HWs without known or suspected exposure as part of expanded Covid19 testing, and testing HWs with confirmed Covid19 disease to determine when they are no longer infectious (CDC, 2021a)

The gold standard for Covid19 testing adopted by the WHO and by the MOH Kenya is RT-PCR testing for SARSCoV2 virus, the causative agent for Covid19 disease (MOH, 2020b). Access to a covid19 test has been shown to enhance early mitigation and infection prevention measures including timely contact tracing, isolation, and quarantine to slow the further spread of Covid19 within the health care setting (Zitek, 2020). On the contrary, inadequate Covid19 testing among HWs has been cited as a contributor to the silent spread of the Covid19 disease among HWs (Ali et al., 2020). A prospective cohort study by Nguyen et al (2020) on health workers using the self-reported smart application for Covid19 symptoms from March 24th to April 23rd, 2020 investigated factors associated with a positive test for a health worker. Using a cox proportional modeling to determine multivariate-adjusted hazard ratios for a positive Covid19 test result among Health workers, the authors found that compared to the general population, HWs have an unadjusted hazard ratio of 12 times higher and a hazard ratio of 3 timers higher after adjusting for possible selection bias and also differences between the frequency of Covid19 testing between HWs and the general community (Nguyen et al., 2020). The study results also estimated that compared to the general population, HWs initially free from Covid19 symptoms had twice the hazard ratio of a Covid19 positive test outcome. HWs who reuse PPE and those reporting inadequate PPE had an increased hazard ratio for Covid19 positive test results (Nguyen et al., 2020). The risk for Covid19 positive test results among HWs was also increased for HWs taking care of suspected Covid19 patients (HR,2.39, 95% CI, 1.9-3.0) and for HWs caring for confirmed Covid19 patients(HR,4·83, 95% CI, 3·99–5·85) compared to those who did not care either suspected or confirmed Covid19 cases. HWs based in inpatient hospital settings have been estimated to have a higher risk of a Covid19 positive test result compared to outpatient settings (Nguyen et al., 2020). The authors conclude that the findings of higher risk of a covid19 positive results among HWs imply the need for increased Covid19 testing among HWs. The current guidelines for Covid19 testing in Kenya call for prioritization of Covid19 testing among HWs because of the increased vulnerability to covid19 disease in health care settings (MOH, 2020b).

The increased likelihood of Covid19 positive results among health workers underscores that HWs should have access to Covid19 testing for early detection of the disease to prevent HW to HW spread and even HW to patients or HW to family members Covid19 spread. The frequency of HW Covid19 testing could be an important indicator of access to Covid19 testing in the health care setting. In addition, the finding by Nguyen et al (2020)showing that asymptomatic HWs had an increased hazard of a positive Covid19 test result implies that preferential testing of symptomatic Covid19 testing could bias the true burden of Covid19 disease among HWs since the asymptomatic HWs could have limited testing opportunities(Ali et al., 2020). A case study by Baker et al (2020) underscores the importance of Covid19 testing in preventing the spread of Covid19 among HWs. The authors reported an exposure rate of 5% of the hospital HWs from an asymptomatic patient who turned positive after the first test for Covid19 13 days after hospitalization (M. A. Baker et al., 2020). This case study implies that the reasons or the protocol for Covid19 testing could be associated with the spread of Covid19 among HWs for instance from delayed testing of Covid19 among asymptomatic HWs and the patients. CDC recommends that Covid19 testing should have a turnaround around of not more than 24 hours for timely infection prevention interventions (CDC, 2021a). Despite the emphasis on optimal Covid19 testing among HWs, the association between the testing protocol and the frequency of HW Covid19 testing and the outcome of Covid19 positive results is not well established. Furthermore, this literature review has not traced any local evidence on the association between Covid19 testing protocol among HWs, and the risk of Covid19 disease among HWs.

2.12. Impact of Covid19 Disease on the HWs

The impact on Covid19 pandemic on Human resources for health has been manifested by the loss of workdays including 4 days and 6 days spent being hospitalized in the ward and longer periods in the Intensive care units. HWs stay at home or fatalities leads to the inability of the health system's capacity to handle the surge in demand for health care from Covid19 cases and other prevalent disease conditions. Therefore, we must prioritize health worker protection in the fight against Covid19 disease (Kambhampati et al., 2020). Loeppke et al (2008) estimate the lost health-related productivity from an occupational disease-related absenteeism or presenteeism for 8 days at $2598 per employee per Full-time equivalent employment (FTE) which translates to $153 million USD per year when total number of the FTE are accounted for in the workforce (Loeppke, 2008). In resource-constrained health settings such as in developing nations, preventing such a loss of health workforce productivity arising from covid19-related high fatality and disability in (Lapolla et al., 2020) becomes a pressing public health priority to enhance allocative efficiency for optimal response to Covid19 pandemic and other prevalent diseases using the available human resources for health(HRH).

In summary, this review of literature has highlighted existing evidence on the risk factors associated with Covid19 infection among HWs. These include PPE use, Covid19 and IPC training status, reuse of PPE and proper fit of the face mask, socio-demographic factors of the HWs such as male gender and comorbidity status, and health systems factors such as testing frequency and reasons for testing. A scarcity of local evidence on these risk factors has also been observed. Therefore, the overall objective of this study is justified to identify local evidence on social demographic factors, community, occupational factors, and health systems factors that are associated with Covid19 disease among HWs in Kenyan tertiary level hospital.

3. CHAPTER THREE: METHODOLOGY

3.1. Study Design

A hospital-based case-control study design was employed to assess the risk factors associated with Covid19 disease among tested Health Workers in Kenyatta National Hospital. The choice of the design of the study is considered suitable since it allows for the investigation of multiple exposures, and its appropriateness in investigating novel and rare diseases. The choice of the design has been considered suitable because Covid19 disease is an acute respiratory infectious disease that follows incident occurrences with short-lived duration of illness rather than prevalence patterns of occurrence where disease persists for a relatively longer period of time after initial acquisition. In addition, the design is considered relatively inexpensive in assessing multiple exposure variables and can establish useful research findings within a short period for health planning purposes.

3.2. Study Area and Setting

The study was conducted at Kenyatta National Hospital (KNH) which is Kenya's largest tertiary referral and teaching hospital under the management of the Ministry of Health Kenya. The hospital is located in the immediate west of Upper hill and West of the Central Business District of Nairobi City. The hospital has over 6000 hospital workers and has a bed capacity of 1800 (KNH, 2017, 2018). The hospital offers specialized health services through its various specialties including Accident and Emergency Unit, Specialized Outpatient clinics, Medical and surgical inpatient units, Infectious Disease Units located in KNH compounds and at Mbagathi Hospital grounds, maternity and family planning services units, laboratory and health information department.

Covid19 testing records at the Covid19 Testing Unit of KNH were reviewed to identify the confirmed cases of Covid19 disease among HWs. Since March 2021 when the first case of Covid19 disease was reported in Kenya, Covid19 testing Unit of KNH had conducted more than 37000 PCR SARSCoV2 virus tests with monthly tests among Health workers and their dependents raging between 400 to 500 Covid19 tests. This study was conducted just after the peak of the fourth wave of Covid19 outbreak experienced in Kenya based on the updates from the Ministry of Health Kenya(MOH, 2021c, 2022). All Covid19 tests at the KNH Covid19 testing unit were conducted during the weekdays and the SARSCoV2 testing was conducted free of charge for the employees of KNH hospital.

3.3. Study Population

The study population comprises health workers (HWs) employed and working at Kenyatta National Hospital between November 2021 and December 2021 (2 month study period) who were involved in the direct or indirect care of patients with Covid19 disease or Patients with unknown status of Covid19 disease. The 2-month study period was chosen for consistency since PPE and IPC recommendations and other covid19 protocols in the hospital and in the community were changing depending on the levels of outbreak in Kenya(MOH, 2021b). The HWs included clinical staff involved in the direct care of patients such as nurses and doctors, and non-clinical staff such as administrative and support staff involved in the indirect care of patients.

3.4. Sample size

The study sample size was determined by Kelsey (1996) formula for case control studies as shown below:

$$n = \frac{(Z\alpha + Z\beta)^2 \, p \, q \, (r + 1)}{r(p1 - p2)^2}$$

$$n2 = rn1$$

In All Studies

$$p1 = \frac{p2OR}{1 + p2\,(OR-1)}$$

$$p = \frac{p1 + rp2}{r+1} \quad \text{and } q = 1 - p$$

Where,

- n: is desired sample size for the cases,
- n2: is the desired sample size for the controls,
- $Z\alpha$: the value of $Z\alpha$ required for confidence= $1 - \alpha$: $Z\alpha/2 = 1.96$,
- $Z\beta$: The value of $Z\beta$ required for power= $1 - \beta$: $Z0.20 = -0.84$ Beta is always in the lower tail so it's negative and only one-tailed,
- *r:* Ratio of unexposed to exposed (or ratio of controls to cases in case-control studies). An r of 3 controls for every case was chosen,
- *p1:* Proportion of cases exposed in case-control studies,
- *p2:* Proportion of controls exposed in previous studies. A lower level of non-adherence to PPE/IPC of 23.7% was selected based on a recent study by El-Sokkary et al (2021).
  - Thus it was utilized as the exposure level among the controls in line with non-adherence levels to PPE/IPC among the general population of health workers during the covid19 pandemic period of less than 50% (Kishk et al., 2021) during the Covid19 pandemic as opposed to relatively higher levels of non-adherence to PPE /IPC in the pre-pandemic period

at 81.8% (Lakshmi, Jeniffer, Meriton, & Paul, 2018), 95.7% (Aguwa, Susan, & Ndu, 2016), and 84.8% (Hakim, Abouelezz, & Okda, 2016),

Kelsey's (1996) sample size formula was then applied as a code in the R Studio statistical software and key study parameters were fed into the function of the Kelsey (1996) sample size formula. The specific parameters included are the Confidence level of 0.95, power at 0.84, the ratio of controls to cases at 3, proportion of controls exposed at 24% as posited by a previous study (El-Sokkary et al., 2021), and an odds ratio (OR) required for statistical difference selected at 3 based on findings by El-Sokkary *et al.*, 2021 on the adherence to Infection Prevention Measures among health workers under study. The calculations were confirmed with the Open-Epi Online sample size calculator at https://www.openepi.com/SampleSize/SSCC.htm. A sample size of 160 including 40 cases and 120 controls was arrived at using the above R studio coded program for Kelsey's (1996) sample size determination

3.5. Sampling

A sample of health workers with a laboratory-confirmed Covid19 disease was selected as the cases for the study. A case of Covid19 is based on RT-PCR SARSCoV2 testing results as per the MOH Kenya case definition for Covid19 disease (Ministry of Health, 2020). Verification of the test results was made from the Covid19 testing results laboratory registers.

3.5.1. Inclusion and exclusion criteria for cases

Health workers (HWs) tested for Covid19 and working at Kenyatta National Hospital within the two-month study period and confirmed to have had a recent positive SARSCoV2 test result within the study period were defined as eligible cases for the study. Only those who voluntarily consented to participate in the study were included in the sample of the cases.

The exclusion criteria for cases included health workers with current severe symptoms of Covid19 disease, health workers unreachable through the human resource (HR) department or HWs confirmed to have succumbed to the disease as verified by the HR department, and health workers unwilling to consent to participate in the study were also be excluded from the study. HWs with suspected or probable Covid19 disease were not considered excluded as cases for the study. The definition of suspected case of Covid19 was considered as a person with fever and cough or acute onset of ANY THREE OR MORE of these symptoms: Fever, difficulty in breathing, general weakness/fatigue, headache, myalgia, sore throat, coryza, dyspnea, anorexia/nausea/vomiting, diarrhea, altered mental status, and without a positive test results confirming the presence of Covid19 disease (MOH, 2020a; WHO, 2020h). A probable case of Covid19 was defined as a person suspected of Covid19 disease based on the presence of Covid19 symptoms, with Chest

Imaging findings suggestive of Covid19 disease. For this study, imaging findings such as Computed tomography or x-ray findings were considered suitable for classifying a person as a probable case of Covid19 disease or not while pending further confirmation by an RT-PCR SARSCoV2 test (Long et al., 2020).

3.5.2. Inclusion and exclusion criteria for controls

Controls were selected from the same study population of the health workers (HWs) as the cases except that the HWs in the control group did not have the Covid19 disease outcome as the cases. Therefore, a control was regarded as a health worker exposed from the similar cadre of work as a case and PCR tested for Covid19 and is not classified as a suspected or probable, or confirmed Covid19 case within the last 2 weeks before the Covid19 test results in the study period between November 2021 and December 2021.

The inclusion criteria for controls entailed a HW with negative PCR test results, not having experienced 3 or more symptoms suggestive of Covid19 pneumonia in the last 2 weeks before Covid19 test results (either fever and cough of acute onset or any three of these symptoms: Fever, difficulty in breathing, general weakness/fatigue, headache, myalgia, sore throat, coryza, dyspnea, anorexia/nausea/vomiting, diarrhea, altered mental status), and the HW was not classified as either a suspected, probable, or confirmed Covid19 case in the last two weeks before receiving covid19 test results (tested for Covid19 in the study period with negative test results for SARSCoV2 virus, and did not have any chest X-ray or High-resolution CT scan imaging reports suggestive of Covid19 pneumonia or disease).

Based on the MOH criteria for confirmed, probable, and suspected cases of Covid19 disease, potential participants for the control group were screened to rule out their possibility of being suspected, probable, or confirmed cases of Covid19 within the study period. This was done by the use of a combination of the absence of 3 or more symptoms related to Covid19 for those who tested for covid19 with negative test results and also lack of any other imaging findings suggestive of having contracted Covid19 disease within the study period.

The exclusion criteria for controls included any HW not employed and not working at KNH within the study period, reporting having had either any positive PCR Covid19 test results within the study period, or had experienced 3 or more symptoms related to covid19 symptoms as per MOH case definition (fever, breathing difficulty, cough, headache, and chills) or had imaging findings suggestive of Covid19 pneumonia in the last 2 weeks before covid19 testing.

According to STROBE Guidelines for reporting observational studies, the control group should be representative of the source population that gave rise to the cases (Vandenbroucke et al., 2007). Therefore, the definition of the controls was restricted to Covid19 asymptomatic HWs to reduce the probable number of participants that could be misclassified as controls with false negative SARSCoV2 test results among study HWs. Given varying severity of Covid19 disease ranging from subclinical to severe clinical forms of the disease, a broader case definition comprising of symptoms and radiologic findings in addition to RT-PCR testing for Covid19 enhances better clinical suspicion of a Covid19 case and a better infection prevention effectiveness since a higher number of cases is detected in settings where there is a laboratory limitation of RT-PCR tests (Tsang et al., 2020). Therefore, we included symptomatic criteria for Covid19 pneumonia clinical suspicion as well as radiographic and imaging findings that could point to a health worker having had a subclinical Covid19 pneumonia or disease. These measures sought to ensure that the control group had a very minimal chance of misclassification for Covid19-diseased health workers being included in the control group.

3.6. Recruitment of study participants

3.6.1. Part A: Selection of Cases from the Covid19 testing and laboratory Records

HWs with Covid19 diagnosis were identified from the RT-PCR laboratory testing records between November and December 2021 with the permission of the KNH administration. 39 cases (against desired sample of 40) were obtained through simple random sampling from the list of Covid19 positive HWs in November 2021 and December 2021. Upon identification of a list of the potential cases for the study, the eligible health workers (HWs) in the case group were contacted for the invitation to the study.

3.6.2. Part B: Sampling and Recruitment of controls

Three controls were selected for every case included in the study. Controls were recruited parallel to the cases through convenient sampling from the PCR Covid19 testing registers and by case-referrals of 3 eligible health workers matching every case by the Covid19 testing dates and cadre. Cadre was self-reported while matching of the testing dates was done through weekly to monthly PCR Covid19 testing registers. After sampling potential study participants for the control group, the eligible health workers for the control group were contacted and invited to the study. Further screening of the HWs in the control group for eligibility was done by use of a screening tool (appendix 7.1) that examined whether a HW had 3 or more symptoms related to Covid19 and if they had any imaging findings or medical reports suggestive of Covid19 disease before their negative PCR Covid19 test results. This procedure under the recruitment section was repeated until a sufficient sample of controls of 108 was attained against a target of 120 as per the sample size formula.

3.6.3. Part C: Administration of the Informed Consent form and the questionnaire to the case group and the control group

Upon the invitation of the eligible study participants in the case and control groups, the Informed consent form was provided verbally and virtual consent was sought. For the participants who agreed to participate in the study, phone interview appointments were made for the case and control groups. The phone interviews were conducted using a structured questionnaire included in the appendix section of this research paper. Administration of the questionnaire was done with the assistance of two trained research assistants.

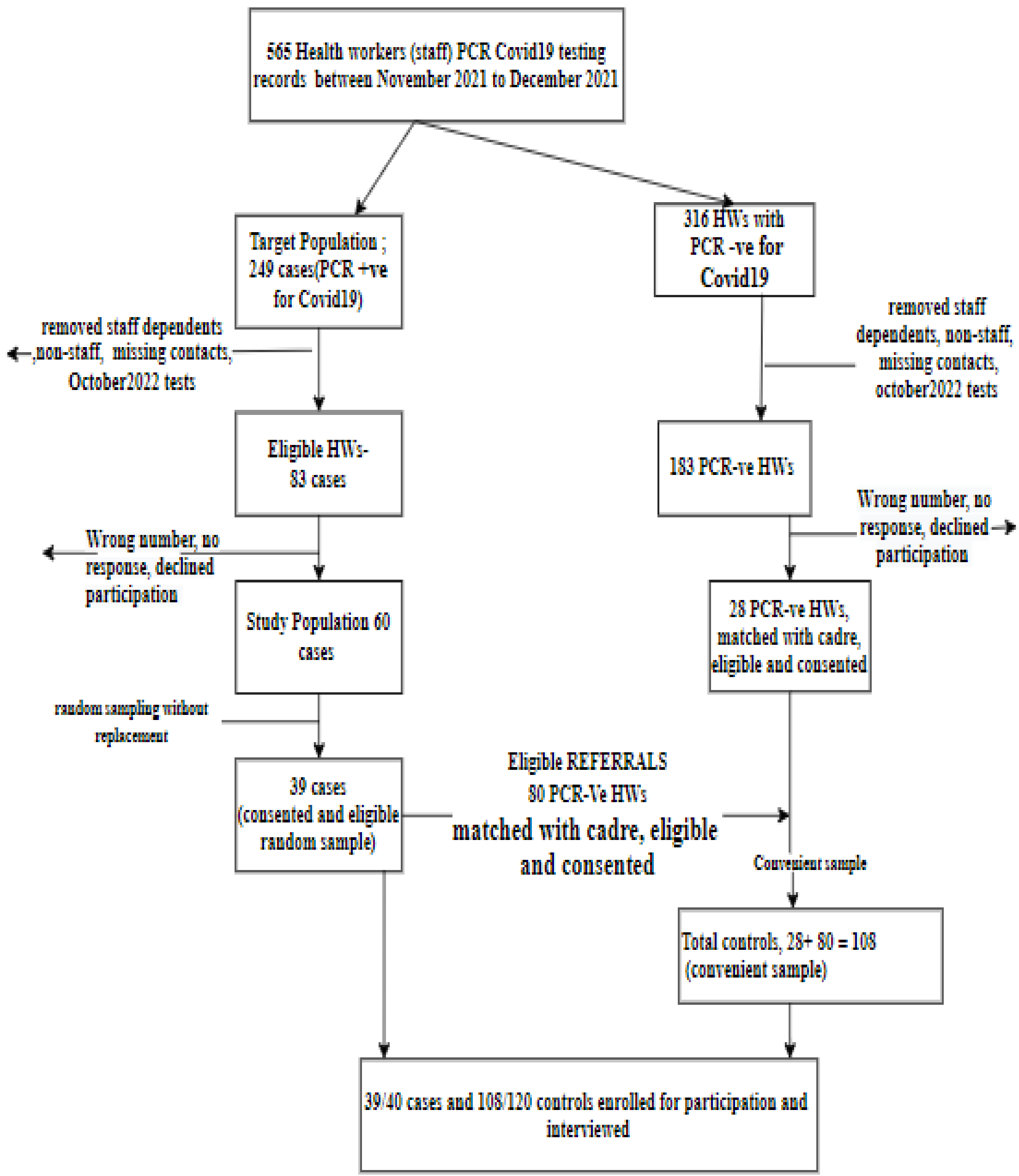

FIGURE 2: THE SAMPLING PROCEDURE AND THE PROCESS OF ENROLLING STUDY PARTICIPANTS

STUDY VARIABLES AND METHOD OF MEASUREMENT

As per the study objectives, the independent variables of interest for this study and their methods of measurement are highlighted in table 1. These includes socio-demographic, community, occupational and health systems' variables which were assessed within the 2 weeks to 1 month period before PCR Covid19 testing by the health worker and during the study period (November 2021to December 2021). The PCR Covid19 disease status of the HW has also been enlisted in the table as the dependent or the outcome variable of interest.

TABLE 1: STUDY VARIABLES AND METHODS OF MEASUREMENT

Variable (type)	Method of Measurement
Objective 1: HW Social demographics Variables –Explanatory	
Cadre(Nominal)	Nurse , Medical doctor, Administrative Staff, Support staff , Other Allied clinical health professionals
Comorbidity status(categorical)	None , One , Two , three or more)
Work experience In years(categorical)	Less than 5 years ,between 6 to 10years, more than 10 years
Age (Continuous)	To be reported by the Health Worker in completed years of life since date of birth
Lifestyle on Sleep Level(categorical)	8 hours or more per day , 6 to 7 hours per day ,4 to 5 years per day, Less than 4 years per day
Sex (nominal)	Male or Female
Objective 2: Community exposure variables	
Use of face masks in social events/ private life (categorical)	Yes(Always), No(Not always)
Household size (categorical)	1 individual, 2 to 3 Individuals, 4 to 5 individuals, More than 6 Individuals
Public transportation use (categorical)	O to 1 times per week , 2 to 3 times per week , 4 to 5 times per week, 6 to 7 times per week
Leave status	Yes(was on leave within 2 weeks prior to recent Covid19 PCR test) No (Was not on leave within 2 weeks prior to recent Covid19 PCR test)
Community exposure to Covid19 patient or person with Covid19 symptoms (categorical)	Yes or No
Objective 3: HW occupational variables –Explanatory	
Department (categorical)	Categorized as High risk, Medium risk, Low risk based on Attendance to Covid19 patients and presence of AGPs High risk , Medium risk and Low risk
Self-reported adherence on Use of gloves, face mask, Gown, Face shields , hand hygiene , surface decontamination	Categorized into Always, Most of the time , Occasionally and Rarely for each of the PPE

Suboptimal PPE use /IPC adherence (Nominal)	Assessed with an adapted Questionnaire from the WHO Questionnaire on assessing HW PPE use and Exposure status. Where PPE use and IPC measures specific to clinical status of the health worker were not adhered to, the HW was considered to be Covid19 exposed or having a status of suboptimal PPE and IPC adherence. Thus, the study participant HW was classified as having had **Suboptimal PPE/IPC use** (not adhered) or having **Optimal PPE/IPC use status** (adhered).
Exposure / contact Type (Categorical)	Confirmed **Covid19 patient** at hospital , Confirmed **Covid19 patient** community, confirmed **Covid19 household member**, Household **Suspect of Covid19**, **staff /colleague** with Covid19 , **No known exposure**
Exposure symptomatic status (categorical)	Symptomatic or asymptomatic exposure or uncertain exposure
Perceived PPE supply(categorical)	A subjective HW response on sufficiency of PPE supply in your workstation in the last two months of the survey during which the HW was attending suspected, confirmed or patients with unknown Covid19 status. Perceived PPE adequate during last encounter with suspected or confirmed case of Covid19, Rated as adequate or Not Adequate.
Work-time /Duty Hour (categorical)	Less than 8 hours per day, 8 to 12 hours per day, more than 12 hours per day
Shift work status (Categorical)	Defined by either working during all day shifts , mixed day and night shifts and only night shifts in the last two months of the study
PPE Reuse status (Categorical)	Assessed whether HW re-used PPE in the two week prior to getting Covid19 test results while attending to suspected, confirmed Covid19 patients or patients with unknown Covid19 status. PPE re-use status rated both in a • Single shift : -Yes or No • More than one shift -Yes or No
Double masking status (categorical)	Reported double masking status in the last two months of the study, either Yes or No
Reported Fit of face masks(categorical)	A health worker will report either having used a well-fitting face mask (yes) or non-well-fitting face mask (no) during the two week prior to getting Covid19 test results.
Adherence to HW to HW covid19 IPC protocol (categorical)	Derived through two variables in the study questionnaire, namely, self-reported regular social distancing and complete doffing before using tea rooms. A HW who reports always in both variables is considered to have adhered to IPC in tea rooms. A Health worker who self-reported using shared break and duty rooms before doffing and did not observe socio distancing with colleague while eating or talking to colleagues in breakout room is classified to have a "Non-adherent status" to HW to HW Covid19 IPC protocol". Another category of a health worker reporting not using tea room was derived as neither adherent nor non-adherent.
Objective 4: Health systems' Variables-Explanatory	

Training status (Categorical)	Trained on Proper PPE selection and use YES or NO Trained on Hand hygiene measures YES or NO
Reason for COVID19 Testing (Categorical)	Assessed as either Symptomatic reasons or Asymptomatic/routine Covid19 checkup
Covid19 vaccination status (categorical)	• Fully vaccinated, Partially vaccinated, Not vaccinated, non-disclosure about vaccination
Timing of vaccination prior to the two week of receiving Covid19 test results	• Within 1 month • Between 2 to 3 months • 4 to 5 months • 6 or more months
Outcome / Response Variable of Interest	
Health worker Covid19 status(categorical variable)	The status was either a case, for HWs with covid19 PCR positive results or a control who was a HW with negative Covid19 PCR test results without 3 or more covid19 symptoms or covid19 imaging findings within the 2 weeks prior to Covid19 test. The narrow definition of the controls for this study is in the light of likelihood of false negative results with RT-PCR Covid19 tests from its low sensitivity 63 to 75 % established in literature (Arevalo-Rodriguez et al., 2020).

3.7. Ethical Consideration

Approval to conduct this study was sought from the Kenyatta National Hospital-University of Nairobi (KNH-UON) Ethics and Research Committee through the study approval number P462/06/2021. Additional permission for data collection was sought from the KNH administration, including permission from the Health Information department in accessing the laboratory Covid19 testing records and permission from the Medical Research Department to allow for interviews involving the eligible and the participant health workers. Measures to prevent any harm to the study participants or the research personnel were observed including minimization of physical and social contacts as much as possible to prevent further spread of the Covid19 disease following Ministry of Health Covid19 prevention guidelines. Therefore, phone interviews were employed in data collection to prevent physical contact and interactions with HWs which could further the spread of Covid19 disease. Study participants were also encouraged to continue observing prevention measures including wearing face masks, observing hand hygiene measures, and social distancing of at least 2 meters for every interaction between the researcher and the research assistants during data entry and training discussions. Study participants were taken through the informed consent form to enhance their understanding of the purpose of the study, the procedures, risks and mitigation measures, and confidentiality and voluntariness in their participation in the study. Only participants who voluntarily agreed to participate after giving a verbal and virtual informed consent were subsequently enrolled in the study and booked for a phone interview at their time of choosing by the two research assistants using the study questionnaire (appendix sections 7.2 and 7.3).

The contact information of the eligible participants who either consented or did not consent for the study were anonymized and password-protected for confidentiality of their identifier information. Additionally, after each missed interview, successful interview and follow up calls on incomplete interviews, the contact information of the participants were not retained by the research assistants, was not shared with any other unauthorized personnel and the principal researcher maintained the confidentiality of the contact database as provided by the hospital without using it for any other purpose other than as intended for the study. Filled questionnaires were anonymized during data entry and the database was password-protected for access only to the principal researcher and the data analyst only for statistical analysis.

3.8. Data Collection

3.8.1. Data collection Tool

A structured questionnaire was developed and adapted from the *WHO Interim guidance (2020) on Risk assessment and management of exposure of health care workers in the context of Covid19*. Additional recent validated tools were used to develop the study questionnaire including the WHO's Protocol for assessment of potential risk factors for 2019-novel coronavirus (2019-nCoV) infection among health care workers in a healthcare setting (WHO, 2020b), Fatima et al (2021) study tool to assess Night shift status and its association with Covid19 Infection among HWs (Fatima et al., 2021) and in the case-control study tool by Celebi et al (2020) who assessed the spread of Covid19 among HWs in shared break out rooms(Çelebi et al., 2020) (APPENDIX 7.2). The questionnaire contains four major sections:

Section A entails questions on Socio-demographic characteristics of HWs including age in years, commodity status, sex, HW Work experience, HW cadre, and average sleep levels.

Section B contains the community exposure variables including the use of face masks in social and private life, use of public transportation, health worker household size, and HW's community exposure to Covid19 patients or probable cases.

Section C entails questions on occupational characteristics including optimal PPE use and IPC adherence, department of work, shift work status, perceived adequacy of PPE, type of Covid19 contact or exposure, PPE reuse status, and the adherence to PPE and IPC in HW breakout rooms. Through the series of questions on PPE and IPC adherence in section C, a HW was classified to have had either an optimal or suboptimal PPE or IPC adherence as the primary exposure of interest.

Section D entails questions on health systems including training status on IPC and PPE use, reasons for Covid19 testing, number of Covid19 tests done in the last six months before recent Covid19 test results, self-reported mask fit, double masking status, Covid19 vaccination status, and the timing of administration of Covid19 vaccination before this study. The study questionnaire can be accessed in the appendix section.

Two research assistants were recruited and trained on the data collection tool and the methods including the use of phone interviews, anonymization of the questionnaires, application of the inclusion criteria and the exclusion criteria for the case group and the controls group, and the ethical measures required while interviewing the study participants. The research assistants were not blinded to the cases and controls given the need to minimize misclassification of the cases and the controls. Minimization of errors was done through the administration of the study questionnaires to a random sample of 5 HWs to seek feedback on the clarity of the questions and for correction of grammatical and to train the research assistants in the application of the data collection tool. The 5 respondents for the pre-test of the data collection tool were not included in the desired sample size in section 3.7 and were not included in either case or control groups for data analysis.

Under the first objective, the questionnaire contained questions on the age, sex, and average daily sleep hours of health workers in the last 2 weeks before PCR Covid19 testing, cadre, professional work experience, comorbidity status, and the religion of the participant's health worker.

Under the second objective on the community risk factors, questions asked included HW’s household size in a month before PCR Covid19 testing, use of public transportation in the last 2 weeks before Covid19 PCR testing, whether HW attended a social gathering 2 weeks before PCR Covid19 testing, and self-reported face- masking in the social environment in last 2 weeks before PCR Covid19 testing. In addition, HW was asked whether they were on leave in the last 2 weeks before their recent PCR Covid19 testing.

Under the third objective on the occupational risk factors, questions asked included self-reported PPE use frequency of adherence to IPC, and usage of each PPE including gloves, N95 masks, surgical masks, gown, surface decontamination practice, face shield, moments of hand hygiene measures, and history of the accidental splash of body fluids 2 weeks before PCR testing and attributable type of exposure to Covid19 case or suspect case 2 weeks before Covid19 PCR testing, the performance of aerosol-generating procedures 2 weeks before PCR Covid19 testing, specific department of work within 1 month before PCR Covid19 testing and self-reported adherence to HW-to-HW IPC measures. In addition, average duty hours, night shiftwork status, and the frequency of PPE Reuse in the last weeks before PCR Covid19 testing were examined.

Under the fourth objective on the health systems’ risk factors, questions asked included self-reported practice of double masking, mask fitness, health worker’s Covid19 vaccination status in the last 2 weeks before PCR Covid19 testing and the current Covid19 vaccination status, timing of vaccination before PCR Covid19 testing and intention to vaccinate for the unvaccinated HWs, training on Covid19 PPE use and IPC measures for Covid19 within the last 1 year before recent PCR Covid19 testing, Covid19 designation working area status, reasons for the recent PCR Covid19 testing and the number of times tested for Covid19 in the last 6 months before recent PCR Covid19 testing.

With the help of two trained research assistants, 147 health workers gave informed consent for participation in the study and were subsequently interviewed by (39 Covid19 cases of HWs confirmed from laboratory testing hospital records and 108 HWs with Negative Covid19 test results and asymptomatic for Covid19 within the study period based on either the laboratory testing hospital records or case-cadre referrals) using the structured questionnaire data collection tool adapted from the WHO’s Protocol for assessment of potential risk factors for 2019-novel coronavirus (2019-nCoV) infection among health care workers in a health care setting (appendix section 7.2).

3.9. Data Analysis

Data was manually double entered with the help of two research assistants into an excel spreadsheet. After double checking for errors, completeness, and accuracy of the data, the excel sheet was exported into R studio version 4.1.2 (2021-11-01) for statistical analysis. Upon data visualization in the excel sheet as well in the R studio, some of the variables had missing values. Therefore multiple imputations were applied in R studio to enhance further completeness of the dataset and to minimize bias resulting from unavoidably missing values in the multivariate analysis (Jakobsen, Gluud, Wetterslev, & Winkel, 2017).

Descriptive analysis of the data was reported in form of counts, percentages, and proportions for categorical variables. Age was the only continuous variable, therefore, the normality test was applied using the Shapiro Wilk test which showed that age distribution within the case and the control group was not parametric, therefore, the median age in years for the case and control groups was reported in table 5. In addition, to compare percentage age distribution across the two groups, age categories in the case and control groups were developed and tabulated in form of percentages as shown in table 5. Additional categorical variables were derived from the primary data to form aggregate variables including suboptimal PPE/IPC use adherence, Health worker to Health Worker IPC protocol adherence, HWs' clinical status, and departmental risk type category shown in table 2, table 3, and table 4.

The health workers' Adherence to IPC protocols in the tea and shared restrooms was derived by use of two variables, namely, self-reported social distancing while using tea rooms and self-reported doffing of PPE before using tea rooms within the last 2 weeks before Covid19 testing. As a result, health workers who reported having regularly practiced social distancing in the tea rooms and having completely doffed before using tea rooms in the last 2 weeks before covid19 testing, were categorized to have adhered to IPC in tea rooms. Otherwise, they were categorized as not adhered to and also not using tea rooms for HWs who reported not to have used tea rooms.

Based on literature review(W. H. Seto et al., 2011; Shah et al., 2020), clinical and non-clinical staff categories were derived to cover HWs who were directly and indirectly involved in provision of care to the patients in the hospital within the study period as shown in table 2. These categories capture all the hospital workers as per the norms and standards for HRH in Kenya (MOH, 2014).

TABLE 2: CLINICAL AND NON-CLINICAL STAFF CATEGORIES (MOH, 2014; W. H. Seto et al., 2011; Shah et al., 2020)

Clinical (Direct patient care staff)	**Non clinical (Indirect patient care staff)**
Doctors	Clerks
Nurses	Administrative managers
Nutritionists	Catering staff
Theatre staff	Security
Cleaners	Marketing and communications officers
Porters	
Physiotherapists	
Nurse aids	
Radiographers	
Morgue attendants	

Based on the self-reported department work in the last 1 month before Covid19 PCR testing, three departmental risk categories were developed depending on the level of occupational exposure to SARSCoV2 virus. The categories including the high risk, medium risk, and low-risk department types were adapted from the U.S. Occupational Safety and Health Act (OSHA) Guidance on Preparing Workplaces for Covid19(OSHA, 2020) and the recent studies assessing Covid19 exposure risk factors among HWs (Suárez-García et al., 2020)(Ran *et al.*, 2020). OSHA recommends four levels of risk; very high risk (jobs involving performing aerosol degenerating procedures and handling specimens from Covid19 or suspected patients), high risk (jobs with opportunities for close-contact exposure to Covid19 patients or suspected patients), medium risk (jobs with close and frequent contact with people not known or not suspected with Covid19 disease) and low risk (jobs that require no contact with patients of unknown Covid19 status, suspected or confirmed with Covid19 and have minimal occupational contact with coworkers and members of public) were derived based on the type of routine procedures and severity of patients cared in each department(OSHA, 2020). For this study, the definition for high-risk departments were defined as hospital units that routinely perform high-risk procedures (HRP) that generate aerosols such as dental units, ICU and HDU, Accident and Emergency Units, and any Covid19 designated units such as infectious disease units (IDU), Covid19 isolation wards and Covid19 designated medical wards(Ran et al., 2020b). Medium risk departments were defined as hospital units where staff have frequent contact with patients without confirmed or suspected Covid19 disease and those with unknown and unspecified Covid19 status including outpatient medical and surgical clinics, general medical and surgical wards, radiology departments, and maternity. Low-risk departments were defined as units without any contact with patients regardless of Covid19 status and have minimal contact with patients' immediate environment such as the administrative and catering departments as shown in table 3. The distribution of department risk types was reported in percentages between the cases and controls in the results section.

TABLE 3 : DEPARTMENTAL RISK CATEGORIES (OSHA, 2020; Suárez-García et al., 2020)

High Risk	Medium risk	Low risk departments
ICU	Maternity	Administration
HDU	General Medical ward	Health information
Covid19 designated Unit	General surgical ward	Kitchen and catering
Infectious Disease Unit	Radiology	
Accident and Emergency	Outpatient clinics	
	Laboratory	
	Theatre	

Adherence to optimal PPE and IPC measures was derived and measured by the use of a 13 item-criteria adapted from the WHO interim guidance on '*Risk assessment and management of exposure of health care workers in the context of Covid19'* (WHO, 2020e). The guideline defines two categories of adherence, namely, high-risk exposure or non-adherence if the HW did not check 'Always as recommended' and if the HW reports 'Accidental exposure' to respiratory splashes within the adherence criteria and low-risk exposure for other responses in the criteria. We adopted this tool for data collection, however, we adapted the adherence criteria to fit different clinical categories of staff, namely, clinical and non-clinical staff study participants. PPE and IPC requirements should be specific to the risk category of the staff as per the MOH Kenya guidelines on PPE use among HWs(MOH, 2020c, 2021d). The guidelines indicate that clinical staff has stricter requirements for PPE and IPC adherence compared to the non-clinical staff. Therefore, a 13-item criteria for IPC and PPE was used (table 4) which tailored PPE and IPC adherence requirements for the clinical staff and the non-clinical staff in line with recommendations set out by the Ministry of Health Kenya(MOH, 2021d)). The assessment was subjectively conducted using four levels of self-reported adherence including always as recommended (>90% of the time), mostly (>50% of the time), occasionally

(20% to under 50% of the time), and rarely (<20% of the time). For example, a clinical staff such as a nurse who self-reported frequency of PPE use as always used gloves, mostly used N95, occasionally used a face shield, mostly adhered to use of gown, protocols on PPE, hand hygiene and surface decontamination and had zero accidental exposure to body fluids in last 2 weeks before PCR Covid19 testing was categorized as having optimal PPE and IPC adherence. The proportion of the HWs with optimal PPE and IPC adherence was calculated and tabulated in form of percentages for the case group and the control group.

TABLE 4 : ADAPTED CRITERIA FOR OPTIMAL PPE AND IPC ADHERENCE BY CLINICAL AND NON-CLINICAL STAFF (MOH, 2020c, 2021d)

Personal Protective equipment (PPE)	Clinical Staff	Non clinical staff
1. *Self-reported PPE use*	Yes	Yes
2. *Use of Gloves*	Always	Always or Mostly or Occasionally or Rarely
3. *Use of surgical masks*	Always	Always
4. *Use of N95 mask or equivalent respirator mask*	Always or Mostly	Always or Mostly or Occasionally
5. *Use of face shield*	Always or Mostly or Occasionally	Always or Mostly or Occasionally
6. *Use of Gown*	Always or Mostly	Always or Mostly or Occasionally
7. *Adherence to protocol of PPE*	Always or Mostly	Always or Mostly
8. *Hand Hygiene before and after touching a patient*	Always	Always
9. *Hand Hygiene after a procedure*	Always	Always
10. *Hand hygiene after exposure to body fluids*	Always	Always
11. *Hand hygiene after touching patients surroundings*	Always	Always
12. *Surface decontamination*	Always or Mostly	Always or Mostly
13. *Accidental exposure to body fluids(nasal, mouth ,open skin or eye splashes)*	No	No
Optimal PPE use and IPC adherence	The clinical Staff/ HW is considered Adhered to Optimal PPE/IPC use if meets the above criteria Yes…………No……….	The Non-Clinical Staff/ HW is considered Adhered to Optimal PPE/IPC use if meets the above criteria Yes………………No……….

In the bivariable analysis, odds ratio (OR) test was chosen as the measure of association owing to the design of the study. The OR were reported at 95% Confidence Intervals and an alpha of 0.05 (p-value) for statistical significance. Wald's Odds ratio test for the bivariate analysis in the cross-tabulation of the independent and dependent variables was applied to compute the p-value for variables whose observations had more than 20 % of the values with 5 or more values. Otherwise, Fisher's exact test was applied to determine the p values and the crude odds ratio of the association at a 95% confidence interval. Under the bivariable analysis, each explanatory study variable was cross-tabulated with the Covid19 disease status of the HW and the corresponding Odds Ratio (OR), 95% Confidence Interval and p values computed and tabulated.

In the multivariable analysis, a liberal p-value of less than 0.25 was chosen as the cut-off for selecting multiple variables to enter into the logistic regression model to control for confounding (Hosmer & Lemeshow, 2008). Additional independent variables hypothesized to be important confounders in the association between the suboptimal PPE use and the Covid19 status were added priory in the multivariable analysis even if they did not attain the 0.25 cut-off for liberal variable selection. These included the sex, overall adherence to optimal PPE use, department risk type, and the clinical status category of the health worker. The Akaike Information Criteria (AIC) was used to run the modeling simulations of the logistic regression to arrive at the most statistically significant combination of the independent variables that majorly accounted for the outcome in the dependent variable among the participant HWs. The statistical output of the AIC statistical modeling for the significant independent variables for the overall model was tabulated in table 9 shown in the results section.

Additional hierarchical models with additional independent variables and in different combinations were fit to the data and the respective Likelihood ratio tests applied to determine the model with the best fit of the data. The model with the least deviance from the model residuals and statistically significant p-value was selected. A p-value of less than 0.05 was taken to indicate that the fitted model was significantly different from the null model. The effect size was computed by the use of the pseudo R2 estimates by the Hosmer and Lemeshow, NegelKerke, and McFadden pseudo R2 estimation methods.

An interaction term was applied to assess the effect of gender on the association between department risk type and Covid19 disease status based on previous evidence of interaction between gender and the effect of department type and covid19 disease status (Ran et al., 2020b). The statistical significance of the interaction was assessed at a p-value of less than 0.05.Variance Inflation Factor (VIF) was employed to detect any multi-collinearity between the explanatory variables in the fitted model with a VIF of less than 4 indicating a lack of collinearity between the explanatory variables in the model (Kim, 2019).

4. CHAPTER FOUR: RESULTS

4.1. Socio demographic and clinical characteristics of the study participants (Table 5)

A total of 147 health workers (HWs) consented to participate in the study and were subsequently interviewed. These included 39 cases out of the desired sample of 40 cases and 108 controls out of the desired sample of 120 controls. Therefore, the respective response rates for the case group and the control group were 98% and 90%.

The median age for the participant health workers in the case and the control groups was 35 years and 37 years respectively (table 5). 87% (34/39) of the cases and 94% (102/108) of the controls had been either fully or partially vaccinated against Covid19 disease. Overall, 55% of all the participants were female health workers. Nurses (30%) and doctors (20%) cadres constituted 50% of the study participants while the rest of the participants were from other cadres including physiotherapists, managers, health information officers, and lab personnel.

The majority of the study participants 51% have had a professional work experience of more than 10 years. In terms of clinical categorization, 71% of the participant health workers were clinical staff with direct attendance to patients, handle patients' items, and work within the patients' surroundings unlike non-clinical staff. In terms of the co-morbidity status, 74% of the study participants did not have any preexisting medical condition, 8% of the participants reported hypertension as a comorbidity whereas 18% of the participants had other comorbid conditions including asthmatic, diabetes mellitus, heart disease, obesity, chronic kidney disease, and cancer.

TABLE 5 : SOCIAL DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE PARTICIPANT HEALTH WORKERS (HWS)

Demographics characteristics	**Controls N=108**	**Cases N= 39**	**Total observations 147 (100%)**
Age in years(median age)	37 (31.8,47.0)	35 (30.5,43.5)	36
Age categories : *20-30*	22	10	32 (21%)
31-35	27	12	39 (27%)
36-40	15	5	20 (14%)
41-45	12	3	15 (10%)
46-50	15	5	20 (14%)
50-60	17	4	21 (14%)
Sex : *Female*	64	17	81 (55%)
Male	44	22	66 (45%)
Cadre (matching variable)			
Others (Ref)	33	13	46 (31%)
Radiographer	1	1	2 (1%)
Doctors	22	8	30 (20%)
Laboratory Officers	4	10	6 (4%)
Managers	7	2	10 (7%)
Nurses	34	10	44 (30%)
Physiotherapists	7	2	9 (6%)
Occupation type			
Clinical	79	25	104 (71%)
Non clinical	29	14	43 (29%)
Work experience : *>=5 years*	26	12	38 (26%)
6 – 10 years	25	9	34 (23%)
>10 years	57	18	75 (51%)
Religion: *Catholic*	31	8	39 (27%)
Protestant	72	30	102 (69%)
Muslim	3	1	4 (3%)
Others	2	0	2 (1%)
Department of work: *Low Risk*	35	10	45 (31%)
Medium Risk	54	22	76 (52%)
High Risk	19	7	26 (18%)
Comorbidity Status: No (Ref)	81	27	108 (73%)
Yes	28	12	40 (27 %)
Comorbidity Type :*No comorbidity*	81	27	108 (73%)
Hypertension	8	4	12 (8%)
Any other comorbidities	20	8	28 (19%)
Covid19 Vaccination status : *Vaccinated*	102	34	136 (93%)
Not vaccinated	6	5	11 (7%)

4.2. Objective 1 and 2: The Association between the socio-demographic and community characteristics of the HWs and their Covid19 disease status

From the socio-demographic and community risk factors under the first and the second objective of the study, none of the variables had any statistically significant association with the covid19 status of the health worker as shown in table 6 below. However, there was an impact on the crude Odds Ratios (cOR) of the association between the sex, age category, comorbidity status and morbidity type, departmental risk type, work experience, and the cadre of the health worker, and the covid19 status of the health worker. The sex of the HW did not have any statistical association with the Covid19 disease status among participant HWs (cOR, 1.87; 95% Confidence Interval (CI) 0.88-3.92; p value>0.05). Similarly, having at least one comorbidity did not differ between the case and the control groups of the study participants (cOR 1.27; 95% CI 0.57-2.84; p >0.05) Further categories on the type of comorbidity status including HWs with preexisting hypertension disease(HTN) (cOR, 1.50; 95% CI 0.42-5.38; p >0.05), any other type of comorbidity disease excluding HTN (cOR, 1.26 ; 95% CI 0.50-3.21; p >0.05) did not show any significant statistical association with the status of covid19 among the participant HWs compared to the category without any preexisting medical condition. The crude OR of the association between the age categories and the risk of Covid19 were not statistically significant. In terms of the department risk type, the bivariable analysis showed that HWs working area did not have any effect on the risk of Covid19 disease both for the high-risk departments (cOR, 1.25; 95% CI 0.41-3.83; p >0.05) such as ICU and medium-risk departments (cOR, 1.39; 95% CI 0.59-3.28; p >0.05) such as general medical and surgical wards as compared to HWs in low risk departments such as management and administrative office units.

For community characteristics of the HWs, the bivariable analysis (Table 6) showed that self-reported use of facemasks while in social functions in the last 2 weeks before PCR Covid19 testing had a weak association with the covid19 status of the HW (cOR 0.48; 95% CI 0.22-1.01; p =0.05). In other words, use of face mask in a social event consisting of large gathering of people (30 or more) in the last 2 weeks before PCR Covid19 testing was protective but in a small way from bivariable analysis which did not persist in the multivariable analysis. Attendance of a social gathering in the last 2 weeks before PCR Covid19 test did not have any significant statistical association with the status of Covid19 disease (cOR, 1.45; 95% CI 0.69-3.02; p >0.05). While using public transportation at any time in the last two weeks before PCR Covid19 testing was not statistically associated with risk of Covid19 disease, the effect of public transportation shown to increase the risk of having Covid19 disease by 85% higher chances compared to non-users of public transportation among the HWs could be attributed to chance (cOR, 1.85; 95% CI 0.88-3.91; p>0.05). Being on leave for non-health related reasons increased the odds of Covid19 disease among a HW by 3 times (cOR, 3.14; 95%CI, 0.16-0.75; p<0.05) (Table 6).

Household size of more than 1 person did not have any effect on the risk of covid19 disease among HWs in the bivariable analysis (cOR, 0.63; 95%CI, 0.23-1.72; p>0.05). In terms of the vaccination status of the health worker, the odds of Covid19 disease among the Covid19 unvaccinated HWs compared to the Covid19 vaccinated HWs were not statistically different despite a 2.5 times higher odds of the disease among the vaccinated attributable to random chance(cOR,2.50; 95%CI,0.72-8.71;p>0.05). In addition, the temporal sequence interpretation on the effect of vaccination on risk of Covid19 would be spurious given that one group of the HWs got vaccinated after their PCR Covid19 test while another group got vaccinated before their PCR Covid19 test within the study period.

TABLE 6 : ASSOCIATION BETWEEN SOCIO DEMOGRAPHIC AND COMMUNITY CHARACTERISTICS, AND THE HWS COVID19 DISEASE STATUS

Characteristics	Controls(Covid19 Negative staffs)N=108	Cases(PCR Covid19+ staffs) N=39	Crude OR (95% CI)	P value
Age in years(median age)	37 (IQR 31.8,47.0)	35 (IQR 30.5,43.5)	0.98 (0.94, 1.02)	0.29
Age category: 20-30	22	10	ref	
31-35	27	12	0.98 (0.36, 2.69)	1.00
36-40	15	5	0.73(0.21,2.58)	0.75
41-45	12	3	0.55 (0.13, 2.39)	0.50
46-50	15	5	0.73(0.21 ,2.58)	0.75
50-60	17	4	0.520.14, 1.94)	0.36
Sex : Female (Ref)	62	17	ref	
Male	43	22	1.87 (0.88,3.92)	0.10
Cadre : Others (Ref)	33	13	ref	
Radiography Officers	1	1	2.54 (0.15, 43.67)	0.50
Doctors	22	8	0.92 (0.33, 2.59)	1.00
Laboratory Officers	4	2	1.27 (0.29, 7.79)	1.00
Administrative Managers	7	3	1.09 (0.24, 4.86)	1.00
Nurses	34	10	0.75 (0.29, 1.94)	0.63
Physiotherapists	7	2	0.73 (0.13, 3.96)	1.00
Occupation type: Clinical staff	68	23	ref	
Non clinical staff	40	16	1.18(0.56,2.50)	0.66
Work experience : >=5 years	26	12	ref	
6 – 10 years	25	9	0.78 (0.28, 2.17)	0.63
>10 years	57	18	0.68 (0.29, 1.63)	0.39
Comorbidity : No (Ref)	81	27	ref	
Yes	28	12	1.27(0.57, 2.84)	0.56
Morbidity Type : None	81	27	ref	
Others	20	8	1.26(0.50, 3.21)	0.62
HTN	8	4	1.50(0.42, 5.38)	0.53
Public transport status: Not used (ref)	62	16	ref	
Used	46	22	1.85(0.88,3.91)	0.10
Household size status: 1 Person	13	7	ref	
More than 1	94	32	0.63 (0.23, 1.72)	0.37
Social function In last 2 weeks before testing: No(ref)	57	17	ref	
Yes	51	22	1.45(0.69,3.02)	0.33
Vaccination-status: Vaccinated (ref)	102	34	ref	
Not vaccinated	6	5	2.50 (0.72, 8.71)	**0.14**
Social Face masking Prior to Test: No	**35**	**19**	**ref**	
Yes	**73**	**19**	**0.48(0.22,1.01)**	**0.05**
Leave : No (ref)	**96**	**28**	**ref**	
Yes	**12**	**11**	**3.14(1.25, 7.88)**	**0.01**

4.3. Objective 3 and 4: Crude Odds Ratio for the association between the occupational and health systems risk factors for Corona virus disease among Health

Under the third study objective on the occupational characteristics of the health workers, self-reported adherence to the protocol of changing PPE when necessary, and the use of gloves, gowns, and face shields were found to be strongly associated with the covid19 disease status of the HW from the bivariable analysis (Table 7A). The crude odds ratio of a health worker contracting Covid19 disease indicated by a positive PCR Covid19 test results was shown to be increased by 2.57 times (cOR,1.45; 95%CI, 1.11-5.67; $p<0.05$) in a rare use of gloves, 2.33 times (cOR,2.33; 95%CI,1.00-4.92; $p<0.05$) is not always following PPE protocol, 3.5 times (cOR,3.50; 95%CI,1.35-9.06; $p<0.05$)for not always using a gown and 3.39 times (cOR,3.50; 95%CI,1.37-8.36; $p<0.05$) for rare use of face shield while attending to patients and clients seeking health services in the hospital. Self-reported reuse of the PPE within-shift (cOR, 1.86; 95%CI, 0.89-3.90; $p>0.05$) and between shifts (cOR, 3.00; 95%CI, 0.70-12.50; $p>0.05$) did not have statistical significance in the association with the Covid19 status of the health worker. The WHO five moments of hand hygiene including hand hygiene before and after touching a patient(cOR,1.103,95%CI 0.48-3.65, $p>0.05$), hand hygiene before and after a procedure(cOR,0.88;95%CI 0.41-1.92; $p>0.05$), hand hygiene after exposure to body fluids(cOR,1.14;95%CI 0.45-2.84, $p>0.05$) and hand hygiene after touching patients' surroundings(cOR,0.70;95% CI 0.30-1.54; $p>0.05$) did not have any significance in the statistical association with the Covid19 status of the health worker and the crude odd ratio of the impact of each of the hand hygiene moments had minimal difference from the ratio of no effect (OR=1). In terms of the use of face masks, there was no significant statistical association between the use of surgical masks (cOR, 1.72; 95%CI 0.39-7.50; $p>0.05$) and N95 masks (cOR, 1.23; 95%CI 0.50-3.00; $p>0.05$) and the odds of Covid19 disease among the health workers. Self-reported practice of surface decontamination as recommended did not have any effect on the risk of Covid19 disease from the bivariable analysis (cOR, 1.87; 95%CI 0.90-4.22; $p>0.05$) (Table 7A).

Table 7 a: The Association between PPE/IPC adherence and HWs' Covid19 status

Characteristics	Controls(Covid19 Negative staffs)N=108	Cases(PCR Covid19 + staffs)N=39	Crude OR (95% CI)	P value
PPE use : No	8	5	ref	
Yes	100	34	1.84(0.56, 6.00)	0.31
Gloves use				
Yes	**85**	**23**	**ref**	
No(Rarely)	**23**	**16**	**2.57(1.11,5.67)**	**0.02**
Use of surgical/med-mask				
Always	103	36	ref	
Not always	5	3	1.72(0.39, 7.50)	0.43
Use of N95 :Always	26	8		
Not Always	82	31	1.23(0.50,3.00)	0.65
Use of Face shield				
Yes(Occasional, Mostly, Always)	**46**	**7**	**ref**	
No (Rarely)	**62**	**32**	**3.39(1.37,8.36)**	**0.01**
Use of Gown: Yes(Always)	**42**	**6**	**ref**	
No(Not Always)	**66**	**33**	**3.50(1.35,9.06)**	**0.01**
Surface decontamination status				
Yes(Occasionally,Mostly,Always)	74	21		
No(Rarely)	34	18	1.87(0.90,4.22)	0.10
PPE Protocol adherence				
Yes (Always) (ref)	**79**	**21**	**ref**	
No	**29**	**18**	**2.33 (1.00,4.92)**	**0.02**
Hand hygiene before/after touch PT				
Always (ref)	77	27	ref	
Not Always	31	12	1.103(0.48,3.65)	0.80
HH before/After Procedure				
Always (ref)	69	26	ref	
Not Always	39	13	0.88(0.41, 1.92)	0.75
HH before/After fluid exposure				
Always (ref)	88	31	ref	
Not Always	20	8	1.14 (0.45, 2.84)	0.78
HH after Touch of Surroundings				
Always (ref)	71	29	ref	
Not Always	37	10	0.70(0.30, 1.54)	0.32
Accidental Splash Exposure				
No	84	33	ref	
Yes	24	6	0.64 (0.58, 23.48)	0.36
PPE Reuse(within same shift)				
No	69	19	ref	
Yes	39	20	1.86(0.89,3.90)	0.10
PPE Reuse(more than one shift)				
No	104	35	Ref	
Yes	4	4	3.00(0.70, 12.50)	0.21

Further results from bivariable analysis (Table 7B), showed that HWs with exposure to suspect Covid19 patient in the last 2 weeks before PCR covid19 testing had 3.53 times (cOR,3.53; 95%CI,1.64-7.56; $p<0.05$) higher odds of Covid19 disease compared to those without exposure from a suspect Covid19 patient. HWs reporting lack of any known exposure had reduced odds of Covid19 disease by 0.09 times (cOR, 3.53; 95%CI, 0.01-0.71; $p<0.05$) compared to those with any known Covid19 exposure before PCR covid19 testing both of which were statistically significant (Table 7B). In addition, non-adherence to HW-HW IPC Protocol in tea break rooms had a significant crude statistical association with the status of Covid19 among HWs as it was found to increase the odds of Covid19 disease among the health workers by 5.97 times (cOR,5.97; 95%CI,1.32-26.90; $p<0.05$). Health workers reporting never using hospital tea rooms also had 5.57 times higher odds of Covid19 disease (cOR,5.57; 95%CI, 1.080-28.62; $p<0.05$) compared to those who used tea rooms while adhering to HW to HW IPC protocol. There was no significant statistical significance association for the covid19 unit designation, self-reported double masking practice and mask fitness, perceived adequacy of the PPE, and overall optimal PPE/IPC adherence in the last 2 weeks before PCR Covid19 testing. For example, the crude OR of 2.14 for the association between Covid19 designation ward and covid19 status of the HW is attributable to chance and hence a potentially spurious estimate (cOR, 2.14; 95%CI, 0.75-6.10; $p>0.05$). Overall suboptimal adherence to PPE/IPC increased the crude odds of Covid19 disease among health workers by 4.30 times however this effect was of no statistical significance and could have arisen from chance (cOR, 4.30; 95%CI, 0.54-34.50; $p>0.05$). In addition, double masking and self-reported inadequate PPE supply by the health worker in the last 2 weeks before PCR Covid19 testing lacked any significant statistical effect on the risk of Covid19 disease. Similarly, self-reported lack of mask fitness did not have any statistical association with the Covid19 disease status among HWs (cOR, 0.57; 95%CI, 0.23-1.43; $p>0.05$).

Under the fourth objective of the study, the bivariable analysis showed that the health system characteristics with a statistically significant effect on the status of Covid19 of the health workers included reasons for PCR Covid19 testing (Table 7B). The odds of Covid19 positive test results were multiplied by 6.55 times (cOR,6.55; 95%CI, 2.38-18.02; $p<0.05$) for health workers who went for PCR covid19 test for non-specific symptomatic reasons compared to those who tested for asymptomatic and routine health checkup reasons (Table 7B). No significant statistical association was found between the covid19 status of the health workers and their Covid19 vaccination status (cOR, 2.50; 95%CI, 0.72-8.71; $p>0.05$), as well as the number of times tested for Covid19 (cOR, 1.49; 95%CI 0.70-3.14; $p>0.05$) in the last 6 months before their PCR Covid19 test.

TABLE 7 B: THE ASSOCIATION BETWEEN THE OCCUPATIONAL AND HEALTH SYSTEMS' RISK FACTORS, AND THE STATUS OF COVID19 DISEASE OF THE HWS

Characteristics	Controls(Covid19 -Ve staffs) N=108	Cases(PCR Covid19 +Ve staffs) N=39	Crude OR (95% CI)	P value
PPE Supply : Adequate (Ref)	71	23	ref	
Not adequate	37	16	1.33 (0.63, 2.83)	0.44
Type of Department –Low risk	34	10	ref	
Medium Risk	54	22	1.39 (0.59, 3.28)	0.46
High risk	19	7	1.25 (0.41, 3.83)	0.69
PPE/IPC-Adherence(Primary Exposure) Optimal (Ref)	11	1	ref	
Suboptimal	97	38	4.30(0.54 34.5)	0.18(f)
Night shift Status: No	81	29		
Yes	27	10	1.03(0.45, 2.40)	1.0
Shift type: Day shifts(Ref)	81	29	ref	
Mixed	24	9	1.05(0.44, 2.51)	1.0
Night shifts	3	1	0.93(0.09, 9.31)	1.0
DUTY HOURS: <8 Hrs (ref)	18	7	ref	
8 to 12 Hrs	65	22	0.87(0.32, 2.36)	0.78
More than 12 Hrs	25	10	1.03(0.33, 3.22)	0.96
Symptomatic status: No (Ref)	44	13	ref	
Yes	64	26	1.38(0.64, 2.96)	0.42
Exposure History :				
Community expo: No	97	36	ref	
Yes	11	3	0.73 (0.19 2.78)	0.76
Family Member : No	90	27	ref	
Yes	18	12	2.22(0.95, 5.18)	0.06
Hospital covid19 case :No	73	30	ref	
Yes	35	8	0.56 (0.23,1.34)	0.19
Suspect Covid19 patient				
No	**79**	**17**	**ref**	
Yes	**29**	**22**	**3.53 (1.64,7.56)**	**0.01**
Staffs to staff exposure: No	63	22	ref	
Yes	45	17	1.08 (0.52,2.27)	0.83
Unknown (no known exposure)				
No	**84**	**38**	**ref**	
Yes	**24**	**1**	**0.09(0.01,0.71)**	**0.01**
AGP Performance :No (ref)	77	28	ref	
Yes	31	11	0.98(0.43,2.20)	0.95
HW-HW IPC Protocol in tea rooms				
Yes(ref)	**26**	**2**		
No	**61**	**28**	**5.97(1.32,26.90)**	**0.01**
Not using tea room	**21**	**9**	**5.57(1.08,28.62)**	**0.04**
Covid19 Designation:				
Non-Covid unit(Ref)	98	32	ref	

Covid unit	10	7	2.14(0.75, 6.10)	0.15
Mask Fitness : Yes (ref) No	78 30	32 7	ref 0.57(0.23, 1.43)	 0.23
IPC trained: Yes (ref) No	78 30	27 12	ref 1.16(0.51, 2.57)	 0.72
PPE Trained : Yes (ref) No	81 27	27 12	ref 1.33(0.59, 2.99)	 0.48
DOUBLE MASKING: Yes (ref) No (rarely)	66 32	19 18	**ref** 1.82 (0.87, 3.83)	 0.111
Vaccination Status before testing Vaccinated(full /partial-(ref) Not vaccinated	 84 24	 32 7	 ref 0.77(0.30, 1.95)	 0.57
Current Vaccination status Vaccinated (ref) Not vaccinated	 102 6	 34 5	 ref 2.50 (0.72, 8.71)	 0.14
Reason for Covid19 testing *Routine Asymptomatic reasons* *Symptomatic reasons*	 53 55	 5 34	 ref 6.55(2.38,18.02)	 **0.0001**
Timing of vaccination After test Before test(ref)	 23 85	 7 32	 ref 1.24(0.48, 3.16)	 0.66
Times tested: 1 PCR test >1 PCR test	52 56	15 24	ref 1.49(0.70, 3.14)	 0.30

4.4. Selection of variables for multivariable analysis from the bivariable analysis

The table (8) below contains a summary of the socio demographic, community, occupational and health systems' variables that were selected for the multivariable analysis using a cut-off liberal p value of less than 0.25. In addition, the **variables on the sex, department risk type and the clinical status of the HW were chosen for multivariable logistic regression analysis since they have been previously identified as predictors of covid19 disease among HWs, hence, potential confounders** in this study.

TABLE 8 : CRUDE OR OF THE FACTORS ASSOCIATED WITH COVID19 DISEASE AMONG HEALTH WORKERS (INDEPENDENT VARIABLES INCLUDED IN THE MULTIVARIABLE ANALYSIS)

Characteristics	Levels	Crude Odds Ratio(OR)	95% CI	P value
Use of Face shield	**Yes (ref) (Occasional, Mostly, Always)** **No (Rarely)**	**ref** **3.39**	**1.38, 8.36**	**0.022**
Sex :	Female (Ref) Male	ref 1.88	0.89, 3.95	0.092
Public transport (PT) status:	Not used PT (ref) Used PT	**ref** 1.94	0.92,4.07	**0.079**
PPE/IPC Adherence(Primary	**Optimal (Ref)** **Suboptimal**	**ref** **4.31**	**ref** **0.54, 34.53**	**0.183**
PPE reuse Single shift:	No (ref) Yes (Always)	**ref** 1.86	0.85,3.91	0.097
PPE reuse Between shifts:	No Yes	**ref** 2.97	0.71, 12.51	0.122
History of Suspect patient exposure	**No** **Yes**	**ref** **3.53**	**1.64,7.56**	**0.001**
History of any known exposure	**No** **Yes**	**ref** **10.85**	**1.42, 0.83.22**	**0.001**
HW-HW Protocol in tea rooms :	Yes(ref) No Not using tea room	**ref** 5.97 5.57	1.32,26.90 1.08,28.62	**0.001** **0.026**
Covid19 Designation:	Non-Covid unit(Ref) Covid unit	**ref** 2.14	0.75, 6.10	0.150
Double Masking:	Yes (ref) No	**ref** 1.82	0.87, 3.83	**0**.111
Mask Fitness :	Yes (ref) No	**ref** 0.57	0.23, 1.43	0.225
Leave(Excused from Work)	**No** **Yes (ref)**	**ref** **3.14**	**3.14(1.25, 7.88)**	**0.012**
Reason for COVID19 PCR testing	**Routine-Asymptomatic checkup** **Symptomatic Reasons for testing**	**ref** **6.55**	**2.38, 18.02**	**0.001**
Current Vaccination status	Vaccinated (ref) Not vaccinated	**ref** 2.50	0.72, 8.71	**0.140**
Covid19 status	Control case	**ref** **2.5**	0.72, 8.71	**0.160**
Use of Face shield	**Yes (Occasional, Mostly, Always)** **No (Rarely)**	**ref** **3.39**	**1.38, 8.36**	**0.006**
Social Face masking	**Yes(Always)(ref)** **No**	**ref** **2.09**	**0.98,4.42**	**0.040**
Protocol adherence	**Yes (Always) (ref)** **Not always**	**ref** **2.34**	**1.09, 4.99**	**0.027**
Surface decontamination status	Yes(Occasionally,Mostly,Always)(ref) No(Rarely)	ref 1.87	0.88, 3.95	0.100
Use of Gown:	Yes(Always) No(Not Always)	**ref** 3.50	1.35, 9.07	**0.007**
Clinical status	Nonclinical staff Clinical staff	ref 0.66	0.30, 1.43	0.290
Use of Gloves	**Yes** **No**	**ref** **2.57**	**1.17, 5.65**	**0.017**

Departmental Risk type	*Low risk* *Medium risk* *High risk*	ref 1.43 1.29	 0.60, 3.37 0.42, 3.94	 0.418 0.655

4.5. Objectives 1, 2, 3 and 4: Risk Factors associated with Covid19 disease among HWs from the Multivariable Logistic regression analysis.

In the multivariable analysis, the AIC model simulations did not select the hypothesized aggregate suboptimal PPE /IPC use (primary exposure of interest) as an important variable in the in predicting risk of Covid19 disease among the participant HWs. To eliminate collinearity effects the independent variable on suboptimal PPE /IPC use was not reintroduced in the model owing to its relatedness with specific PPE items included in the AIC simulation output including use of face shields and gloves. Under the first study objective, none of the socio-demographic characteristics had any statistically significant association with the Covid19 disease status of the HW. However, the effect of sex of the HW was important as a confounder whose statistical control improved the accuracy of the overall model (Table 9). Under the second objective, the community interaction exposure variable of being on leave within the last 2 weeks before the PCR Covid19 test (**aOR, 11.36; 95%CI, 2.75-64.93; p<0.05)** was associated with a positive test for Covid19 disease among HWs after controlling for the effect of the covariates in the model (Table 9).

Under the third objective, occupational factors identified to be associated with covid19 disease after controlling for the effect of covariates for each variable in the model include lack of optimal use of face shield **(aOR,4.01; 95%CI, 1.33-14.18; p<0.05**) and non-adherence to IPC protocol while using tea-breakout rooms **(aOR,8.00; 95%CI 1.61-68.47; p<0.05**), working in a medium risk department (**aOR,7.29; 95%CI,1.36-58.10; p<0.05**) and history of any history of exposure to a Covid19 case or suspect in the last 2 weeks before PCR Covid19 testing (**aOR, 11.14; 95%CI, 1.71-226.29; p<0.05)** (Table 9)**.**

Under the fourth objective, the symptomatic reasons for PCR Covid19 testing (**aOR, 16.29; 95%CI, 4.51-83.76; p<0.05)** as a health systems variable was significantly associated with the spread of coronavirus disease amongst the health workers after controlling for the study covariates. There was negligible collinearity (VIF <4) between the predictors in the final multivariable logistic model as shown by the variance inflation factor (VIF) test results in table 9. In addition, the final model had significant goodness of fit (p<0.05) and had an explicative value estimate of 37% (Hosmer-Lemeshow, pseudo R2), 36% (Cox and Snell pseudo-R2) 37% (McFadden pseudo R2**),** and 51% (NagelKerke pseudo R2) on the variation in the outcome (Table 9).

TABLE 9: ADJUSTED OR OF THE FACTORS ASSOCIATED WITH COVID19 DISEASE AMONG HWS AT KENYATTA NATIONAL HOSPITAL

Risk factors associated with COVID19 among HWs	B (SE)	95% Confidence Interval			P value	VIF
		Lower	Adjusted OR	Upper		
Being on Leave						1.49
No (reference)						
Yes	2.43(0.79)	2.75	11.36	64.93	0.01***	
Reason for PCR Testing						1.48
Asymptomatic checkup(reference)						
Symptomatic reasons	2.79(0.73)	4.51	16.29	83.76	0.01***	
Sex :						1.10
Female (reference)						
Male	0.72(0.50)	0.77	2.05	5.67	0.15	
Face shield Use						1.14
Yes as recommended (reference)						
No	1.40(0.60)	1.33	4.01	14.18	0.02*	
Usage of Gloves						2.14
Yes (reference)						
No	1.30(0.75)	0.86	3.67	17.06	0.08	
History of Covid19-Exposure						1.06
No (reference)						
Yes	2.41(1.14)	1.71	11.14	226.29	0.03*	
Adherence on IPC in tea room:						1.52
Yes (reference)						
No	2.08(0.92)	1.61	8.00	68.47	0.02*	
Not using Tea room in Hospital	1.57(1.08)	0.66	4.80	51.93	0.15	
Departmental Risk						3.65
Low risk (reference)						
Medium risk	1.99(0.94)	1.36	7.29	58.10	0.04*	
High risk	1.35(1.04)	0.55	3.86	34.81	0.19	
Clinical status						3.41
Non-clinical staff (reference)						
Clinical staff	-0.83(0.95)	0.06	0.44	2.66	0.38	

Key: The asterisk, *, represents the strength of the association with * representing some association and ** or *** representing moderate to strong statistical association. Model Pseudo R squared (R^2) for Logistic Regression: 0.37 (Hosmer and Lemeshow Pseudo R^2), 0.35 (Cox and Snell Pseudo R^2), 0.37 (McFadden Pseudo R^2), 0.51 (Nagelkerke Pseudo R^2). Model Goodness of fit by Likelihood Ratio Test (LRT): p value, <0.05. Variance Inflation factor <4 for all model independent variables.

5. CHAPTER FIVE: DISCUSSION

This study identified community characteristics and occupational and health systems factors associated with a Covid19 disease among health workers at the Kenyatta National Hospital. Particularly, occupational factors observed to increase the risk for a positive PCR Covid19 test results after controlling for other important independent variables included failure to use face shields as recommended when handling patients, working in medium risk department compared to a low-risk department, self-reported non-adherence to infection prevention protocols while using staff tea and dining rooms and self-reported prior history of exposure to Covid19 case or suspect patient within two weeks before their recent PCR Covid19 test of the study period. Being on leave was observed to increase the risk of a health worker testing positive for Covid19 disease as a community risk factor. In addition, the symptomatic reason for Covid19 PCR testing was strongly associated with a positive status for Covid19 disease for a health worker as a health systems risk factor. The following discussion under each study objective provides detailed comparisons and contrasts between our findings and the previous literature on risk factors for Covid19 disease among HWs.

5.1. Social demographic risk factors

Among the socio-demographic characteristics studied including the age, comorbidity status, and sex, and the work experience of the HW, none were found to have any significant association with the Covd19 disease status of the HW both in bivariable and multivariable analysis.

With regard to the sex of the HW, mixed findings on the association between sex of the HW and the risk of Covid19 disease have been reported. For example, Rodriguez-Lopez et al (2021) found a statistically significant 4 fold increase in the odds of Covid19 disease among male health workers compared to female HWs (Rodriguez-Lopez et al., 2021), and a 93% higher risk of Covid19 disease among the male workers as cited by Chatterjee et al (Chatterjee et al., 2020). In addition to the increased risk of contracting Covid19, the male gender among the general population has been cited as an independent risk factor for Covid19-related mortality compared to the female gender (Ombajo et al., 2020) (J. M. Jin et al., 2020). Contrasting findings on an 11 % higher risk Covid19 disease among female HWs than for male HWs were reported by a recent systemic review and meta-analytic review involving 10 studies (Dzinamarira *et al.*, 2022). Dzinamarira et al attributed their findings to a relatively higher proportion of female HW participants in the study compared to the male participants. The higher risk of Covid19 disease among male health workers has been posited by Ombajo et al (2020) to result from unexplored biological sex differences and a higher prevalence of risky health behaviors and non-compliance to hand hygiene(Powell-Jackson, King, Makungu, Spieker, Woodd, Risha, & Goodmann, 2020). Lack of significant association of the sex status and the risk of Covid19 disease in this study is attributed to the relatively low power of the study to detect sex differences in the risk of Covid19 owing to a relatively smaller random sample size for the study. The predominance of overall participant female HWs at 55% in our study could be a reflection of a higher proportion of female HWs at 70 % in the overall global health workforce reported by Boniel et al (2019) and at 58% in the population studied for health workforce demographic distribution in Kenya by Okoroafor et al (2022) (Boniol et al., 2019) (Okoroafor et al., 2022). A higher proportion of Female HWs the source population for the cases and the controls could have unauthenticated the true effect of sex on the risk of covid19 in this study. Contrastingly, a preponderance of male HWs in the PCR Covid19 diagnostic testing has been reported due to pronounced disease symptoms among males that lead then to be overly represented in the PCR Covid19 tested population(Ballering, Oertelt-Prigione, Olde Hartman, & Rosmalen, 2021). Therefore, controlling for these effects could result to better and unbiased estimates of the magnitude of the association between sex and the risk of Covid19 disease among HWs.

Preexisting medical conditions such as obesity and hypertension among HWs and among the general population have been previously associated with a higher risk of Covid19 disease(Magleby et al., 2020) and related death (Ombajo et al., 2020). While a 58.8% prevalence of obesity and overweight among HWs in random Kenyan health facilities in Kisumu county was reported (Ondicho et al., 2016), only 27% of all the study participants reported any form of comorbidity (with obesity and hypertension being included) in this study whose effect across the case and the control group of this study was not statistically significant. Methodological differences, in the essence that this study relied on subjective data from self-reported comorbidity status unlike objective anthropometric and medical report source of data by Ondicho et al (2016), in examining the comorbidity status and type could explain a lower prevalence of comorbidity in the study population hence the biased estimates of lack of association of the comorbidity status and the risk of Covid19 disease.

Despite previous findings on the confounding effect of age on PPE adherence (Agarwal et al., 2021) and its statistically significant effect on the risk of Covid19 disease among HWs (Ombajo et al., 2020)(Magleby et al., 2020), the age of the HW was not found to have an effect on the risk of Covid19 disease among HWs in this study population. This lack of association is attributed to a relatively smaller sample size of the study sample that could have rendered age non-normal and hence non-robust regression estimates. No effect of association was observed despite applying grouping remedial for non-normal distribution of age in this study which contrasts recent cross sectional study report of a statistically significant Covid19 risk-protective effect of older age groups (25-34 years and 35-44 years) compared to younger age group (18-24 years) (Atnafie et al., 2021). In addition, Atnafie et al (2021) found a statistically significant effect of the HWs' work experience and the risk of Covid19 disease contrary to the findings of this study. The difference in these observations are attributable to a larger sample size of the participant HWs and the complete randomization which was possible in sampling the participant HWs in the study by Atnafie et al (2021).

5.2. Community risk factors

In terms of community factors, being on leave in the last 2 weeks before PCR covid19 testing was observed to increase the odds of a health worker having a positive covid19 test result by 11 folds compared to a health worker who was not on leave controlling for use of tea room, sex, department risk type, use of gloves and face shields, and self-reported lack of any Covid19 exposure before Covd19 testing. By excluding staff sick-leave for any health condition, self-report on being on leave is routine as per terms of staff employment hence the confounding effect of ill-health as the reason for absence from work was eliminated. Being on leave as risk factor to Covid19 disease among HWs is consistent with findings by the Luo et al (2020) prospective cohort study which examined risks of SARSCoV2 transmission in 3410 close contacts. The authors established that household settings had a secondary attack rate of 10% compared to a 1% attack rate for hospital settings (Luo et al., 2020). The higher risk of covid19 disease at community settings specifically at the household settings has been attributed to the observation that health workers spend more time at the home during their leave days and are likely to be unprotected since the public health protocols such as wearing face masks may not be reinforced at home compared to other public places (Luo *et al.*, 2020). Future research should confirm or disprove our findings. However, these preliminary evidence on non-occupational risk of Covid19 among HWs calls for exploration of the predominant sources of extra-occupation disease exposure for HWs in similar settings.

The effects of self-reported wearing face masks in social events in the 2 weeks before PCR Covid19 testing was observed to have a weak albeit crude statistical association with the risk of Covid19 disease (cOR, 95%CI 0.98-4.42; $p<0.05$) . This association was rendered insignificant upon controlling for other covariates in the analysis and could have resulted from the confounding effects of other variables in the study. In addition, other community risk factors including public transportation, household size, and attending any social function in the last 2 weeks before PCR Covid19 testing did not have any association with the status of covid19 disease among HWs. Converse to our findings, use of public transportation was shown to have an 11-fold increase in the risk of Covid19 for a HW travelling in public bus having a case of Covid19 among passengers compared to a HW travelling in public bus without any covid19 diseased passenger (Shen *et al.*, 2020) In addition, contrary to our findings showing lack of the effect of household size on the risk of covid19 disease among HWs (cOR,0.63; 95%CI,0.23-1.72 ;p>0.05). Federgruen et al (2021) cite that household size is an independent predictor of Covid19 infection rates among the general population based on data from New York City where larger households positively impacted Covid19 incidence rates and larger household sizes were the overall drivers of 62% of the Covid19 infection rates in a population (Federgruen & Naha, 2021). These contrary findings could be attributed to the methodological limitation of the current study in examining effect of household size on the risk of Covid19 among HWs which was done through self-reporting whereas Federgruen and Naha (2021) examined zip code granularity across households to study covid19 incidence rates among the general population. Future studies employing similar methods as Federgruen and Naha (2021) for the study population of HWs in our setting could give us different results on the association between household size and the risk of Covid19 disease among HWs.

5.3. Occupational risk factors

In terms of the occupational factors, only non-adherence to face shield as recommended was observed to significantly increase the odds of a health worker having covid19 disease by 4 folds after controlling for confounders. This finding underscores the importance of protecting mucous membranes including the mouth and the eyes while caring for patients during in the period of Covid19 pandemic and during any other similar infectious disease outbreak for a HW irrespective of patient's disease status as corroborated by a recent retrospective cohort study on occupational Covid19 exposure among health care professionals(Ibiebele et al., 2021). The authors cite that omission of face protection while attending to patients not suspected of Covid19 disease was associated with covid19 disease positivity(Ibiebele et al., 2021). Further simulation experiments have established the efficacy and protectiveness of using face shields for face and eye protection from droplet and aerosol contamination (Lindsley, Noti, Blachere, Szalajda, & Beezhold, 2014). Our findings support earlier recommendations by the WHO recommendations on the use of face shields as an adjunct protective PPE (WHO, 2014). Other PPE and IPC measures cited to be protective against Covid19 disease among HWs include adherence to hand hygiene measures, gown, gloves, facemasks including surgical and N95 masks and surface decontamination. However, there was no difference in their usage between the HWs in the case group and in the control group. After controlling for clinical status of the HW, the failure to the use of gloves as recommended lost statistical significance as a risk factor to Covid19 disease among the HWs. This is attributed to the broad definition of HWs that included both clinical and non-clinical staff with the later not having a requirement to use gloves as a PPE. For clinical HWs, the use of gloves in addition to hand hygiene measures is highly recommended in preventing excess skin contamination with infectious viral droplets in case of SARS and novel acute respiratory infections (ARI) (WHO, 2014). The

WHO recommends that gloves should be discarded after use and followed by hand hygiene at all times. Therefore, the usage of gloves alone is not a substitute for hand hygiene but the use of gloves together with other hand hygiene measures are to prevent excessive contamination and protect the non-intact skin from infectious pathogens (WHO, 2014). Contrary to our findings on statistically significant increased odds of Covid19 disease for failure to use face shields as recommended(aOR,4.07 ;95%CI 1.33-14.18; $p<0.05$) and non-statistically significance of non-adherence to use of gloves as risk factors to Covid19 disease among HWs controlling for clinical status (aOR,3.66;95%CI 0.86-17.06 ; $p>0.05$), Rodriguez-Lopez at el (2021) observed increased odds of Covid19 disease among Health workers who always used face shields, surgical caps, and gloves. These findings were attributed to the possibility of self-contamination from the continuous use of the face shields and gloves without proper decontamination measures (Rodriguez-Lopez et al., 2021). The contrast in findings between Rodriguez-Lopez at el (2021) case control study and this study could be attributed to the differences in power where the former had control-case ratio of 1 and utilized simple random sampling for the controls, while this study has a control-case ratio of 3 and used convenient sampling for the controls. In addition, while both studies recruited controls with negative PCR test results for Covid19, this study further excluded controls with classic symptoms of Covid19 unlike Rodriquez-Lopez et al (2021) study. Future studies on the role of each PPE and IPC protocols in reducing risk of Covid19 or similar occupational infectious disease exposure could support or disapprove the findings of this study.

Overall, the 8% self-reported level of compliance with optimal PPE use and IPC adherence (PPE included gloves, masks, gown, and face shield while IPC measures include adhering to PPE protocol use and hand hygiene measures) in our study grossly differs from recent studies with higher self-reported compliance levels of 88% for hand hygiene and 90% for PPE use by Ashinyo et al (Ashinyo et al., 2021)and a 76% self-reported compliance level on PPE use among the controls for the study by El-Sokkary et al (El-Sokkary et al., 2021). However, our findings were similar to the report by Powell et al of inadequate IPC compliance at 6 % during the pre-pandemic period based on secondary data from Tanzania(Powell-Jackson *et al.*, 2020) and an 18.1% self-reported compliance level by the health workers reported by Lakshmi et al (Lakshmi *et al.*, 2018). Although lower compliance levels are reported in Tanzania are attributed to the stricter observation compliance assessment methods as compared to self-reported methods by Ashinyo et al, we attribute our low levels of adherence to PPE and IPC measures to the period of time of data collection (Ashinyo et al., 2021) such as when Covid19 infections rates had waned within the hospital settings as well as time period after the relaxation of overall Covid19 protocols in Kenya(MOH, 2021b). In addition ,we posit that a higher coverage of Covid19 vaccination among the participant health workers during the study period could have impacted their compliance to Covid19 IPC and PPE protocols rendering them less cautious and less afraid to contract the disease owing to assured forms of vaccination immunity compared to the acute phases of the pandemic when there weren't any vaccines available and compliance level to PPE were shown to be higher(Ashinyo et al., 2021; El-Sokkary et al., 2021).

The overall odds ratio of the association on the suboptimal PPE/IPC adherence was not statistically significant. However, overall suboptimal PPE/IPC increased the adjusted OR by 4 times ($p<0.05$) for Covid19 disease among HWs (Rodriguez-Lopez et al., 2021), and had a 29% (CI, 16% to 41%) reduced risk ratio for Covid19 disease among HWs recent studies (Dzinamarira et al., 2022). Although the findings of this study on the overall PPE/IPC adherence lacked any statistical significance as a risk factor to Covid19 among HWs in the crude and multivariable regression model, the direction of the crude association (cOR,4: $p>0.05$) underscores the importance of WHO recommendations on comprehensive and proper PPE use by health workers depending on their occupational risk profile (WHO, 2014) and the need for improved methods of future research to generate unbiased estimates on the overall effect of PPE and IPC adherence on the risk of Covid19 disease among HWs within the tertiary hospitals in a similar setting. Compared to earlier cited studies, our failure to detect a statistical association between overall adherence to optimal PPE and IPC and the status of Covid19 among HWs both in this analysis can be attributed to differences in the tools used to assess overall compliance to PPE and IPC adherence. Variation in the adaptation of the WHO tool for risk assessment for Covid19 exposure(WHO, 2020c, 2020d) to suit different contexts could have resulted in different tools for assessing overall PPE /IPC adherence which could results to differences in content validity of the compliance estimates (Dzinamarira et al., 2022; Rodriguez-Lopez et al., 2021)(table 4). However, tailor-making a criterion for assessing overall PPE and IPC adherence is supported by the observation that there is a lack of a standard definition of what constitutes a proper PPE for a given task, cadre and in a given organizational hospital setup (Dzinamarira et al., 2022; WHO, 2020d, 2020g). Therefore, this discussion supports the recommendation by Dzinamarira et al (2022) for the evidence-based and contextual design of risk assessment criteria for monitoring overall PPE/IPC adherence and effectiveness among the health workers. Clinical and economic value of investing in the adequate PPE/ IPC for health workers has been underscored in local literature(Kazungu et al., 2021), however, monitoring PPE/IPC adherence is at the core of their effectiveness and hence evidence-based tool for monitoring contextual and periodic adherence should be a consideration for policy and for future research.

Despite wide evidence-base supporting the need for optimal adherence to PPE as a safety measure for health workers during Covid19 pandemics and future outbreaks (M. A. Baker et al., 2020; WHO, 2020d), PPE use has been cited as only one of the safety measures against respiratory pathogens such as Covid19 disease causing SARSCoV2 virus and also the least effective measure in preventing exposure to occupational hazards based on the hierarchy of control for occupational exposures. Consistent with that observation, is the finding of this study showing that HWs with a history of any attributable exposure to Covid19 case or suspect were observed to have 11 times higher odds of Covid19 disease compared to HWs who did not report any Covid19 case exposure in any setting within 2 weeks before the PCR covid19 test. Therefore, the adherence to PPE should be emphasized together with other superior and effective disease control measures as per the hierarchy of infectious disease control measures such as the elimination of the pathogenic hazard within the working environment, the substitution of the hazard where possible, engineering controls such as isolating people from the hazard, and administrative controls to minimize exposure to the hazard such as the spacious working environment for physical and social distancing between staff and among the patients (WHO, 2014).

Besides the PPE and IPC adherence, other occupational risk factors observed to have a positive effect on the risk of Covid19 disease among health workers included the department risk type and HW adherence to IPC measures while using tea and break-out rooms. Health workers working in medium and high-risk departments had their odds of Covid19 disease being multiplied by 7 times (aOR, 7.29; 95%CI, 1.36-58.10; $p<0.05$) and 3 times (aOR, 3.86; 95%CI, 0.55-34.81; $p>0.05$) compared to HWs from low-risk departments. Our findings are consistent with a retrospective cohort study by Ran et al that found significantly increased risk for covid19 disease for health workers working in high-risk departments compared to low-risk departments albeit the presence of statistical interaction of effects by the male gender, the clinical status of the HW and hand hygiene adherence (Ran et al., 2020b). In line with OSHA's definition of occupational risks, low-risk departments were defined as distinct physical units of the hospital without direct patient involvement and with very minimal patient interaction including the administrative offices, kitchen, and catering and communication departments. Medium-risk departments were defined as hospital units handling a patient with less severe illnesses and unspecified respiratory illnesses including outpatient medical and surgical clinics, general medical and surgical wards, radiology departments, and maternity while high-risk departments were defined as unit handling severely sick patients, those with a confirmed diagnosis of Covid19 and departments with a higher frequency of aerosol-generating procedures including ICU, HDU, Covid19 designated wards and accident, and emergency(OSHA, 2020). Contrary to the increased odds of

Covid19 disease for medium and high-risk departments in our study, a multicenter study by Boffeta et al found no association between cadres and departmental categories for Covid19 and non-covid19 departments (Boffetta et al., 2020) while a recent case-control study showed that HWs in noncovid19 designated unit had higher infections rates than those in Covid19 designated units (57% vs. 43%)(Dev, Meena, Gupta, Gupta, & Sankar, 2021)In addition, Dev et al (2021) cite that the cadre of the health worker is an independent risk factor for Covid19 disease, however, the differences in the odds of Covid19 disease between the cadres for this study were not examined since the cadre category was utilized in matching the controls to the cases, thus any risk differential effect per cadre was eliminated at design or to be regarded as an outlier observation.

While controlling for covariates, HWs who self-reportedly failed to social distance and to completely doff their PPE before using tea rooms had 8 times (aOR,8.00; 95%CI 1.54-68.47; $p<0.05$) higher odds of Covid19 disease than those who completely doffed before using tea rooms within the last 2 weeks before having their covid19 test. However, a further category of HWs who never used hospital tea rooms before their PCR covid19 test observed to have non-significant association with risk of the disease (aOR, 4.82; 95%CI 0.66-51.93; $p>0.05$) after controlling for the effect of other covariates. Our findings are consistent with a prospective study by Contejean et al (2020) conducted in Paris, which reported that 19% of the health with positive covid19 diagnosis admitted to removing their face masks during tea breaks and lunch breaks with their colleagues despite the introduction of the universal masking protocol in the hospital (Contejean et al., 2020). In addition, our findings corroborated a recent retrospective cohort study by Suarez-Garcia et al which aimed to describe clinical characteristics of Covid19 disease among HWs in Madrid Spain. The results revealed that health worker to health worker covid19 transmission was dominant and was reflected in the pattern of Covid19 infections clustering within one profession and within a few departments, and the peak of Covid19 cases among HWs peaked before the peak in the cases presenting from outside the hospital (Suárez-García et al., 2020). Ibiebele et al (2021) study also cites the predominance of exposure of HWs from their coworkers during dining rather than from the patients(Ibiebele et al., 2021) These findings underscore the need for behavior change among HWs and the need for hospital employees to maintain physical distancing when dining and to adhere to other infection prevention protocols to minimize worker-to-worker or patient-to-worker nosocomial events when there is a resurgence of Covid19 or any other similar infectious disease outbreak within the hospital setting.

5.4. Health systems' risk factors

In terms of the health system factors such as protocols on HW Covid19 testing, HW training, and HW covid19 vaccination coverage, symptomatic testing was the only health systems risk factor strongly associated with Covid19 disease status of the HW after controlling for other risk factors of Covid19 disease. The odds of Covid19 disease were multiplied by 16 times (aOR, 16.29; 95%CI 4.51-83.76; $p<0.05$) for HWs who tested for any symptomatic reasons compared to those who tested either for traveling or for routine asymptomatic reasons. Our findings are consistent with a large cohort of HWs who were evaluated for early symptoms to predict a model for SARSCoV2 positivity (Tostmann et al., 2020). Tostmann et al (2020) found that non-respiratory symptoms such as anosmia, headache, muscle ache, general body malaise, ocular pain, and fever were highly predictive of covid19 positivity with a moderate discriminative value of a 91.5% specificity and 55.6% sensitivity. Hence, their conclusion that three or more symptoms of covid19 could be used for screening patients with higher chances of having a positive PCR covid19 diagnostic which could be extremely useful in low resource setting to allocate testing target groups among HWs (Tostmann et al., 2020). Our findings on the association between non-specific symptoms and covid19 positivity support the WHO recommendations on utility of symptomatic case definition for public health surveillance as well as its use in priority-setting for allocating limited screening and diagnostics tests such as antigen-detecting rapid diagnostic tests (Ag-RDTs) and Nucleic acid amplification tests (NAAT) respectively(WHO, 2022). Higher positivity among HWs presenting with non-specific symptoms as the their reason for Covid19 testing supports the current Covid19 testing strategy by the Ministry of Health Kenya which targets symptomatic individuals and the HWs as a priority groups for PCR covid19 testing in in addition to other vulnerable groups (MOH, 2020b). However, caution in the interpretation of the observed strong association of the symptomatic Covid19 testing and high risk of Covid19 test positivity is called for, first, due to the biasing effect of the exclusion of HW participants with at least any three classic Covid19 symptoms of the cough , shortness of breath , headache , fever and myalgia symptoms (as per the Covid19 case definition of the WHO and the Ministry of Health Kenya) from the control group in a bid to minimize false negative misclassification of suspect and probable cases as controls (MOH, 2020a; WHO, 2020h). Non-specific and any symptoms that prompted the study participants to go for Covid19 testing which appears more prevalent in the case group than in the controls group from this study supports the utilization of symptomatic-case definition as a tool for allocating limited Covid19 testing resources and also as a screening tool for preventing nosocomial Covid19 spread. However, higher prevalence of non-classic symptoms of Covid19 among the case group points to the need for regular and context-specific review and update of the case definition to reflect the true clinical realities. For example, Baruch et al (2022) reports that Covid19 case-definition vary as per the phase of the pandemic, the geographical location and the emerging Covid19 variants. Baruch et al further observed that the WHO case definition for Covid19 was met by only 56.7% of the laboratory confirmed 260000 Covid19 patients in the International Severe Acute Respiratory and Emerging Infectious Consortium (ISARIC) database (Baruch et al., 2022) . Therefore, utility of the Kenyan case definition in screening for Covid19 diseased HWs to prevent nosocomial spread is useful only if it is regularly updated to reflect the emerging variants(Tsang et al., 2020), the local context and the phase of the covid19 pandemic.

Beside the reasons Baruch *et al.*, 2022for Covid19 testing, the frequency of covid19 testing among HWs lacked any statistical association with the risk of Covid19 disease among HWs (cOR, 1.49; 95%CI 0.70-3.14; $p>0.05$). These findings indicate that the frequency of testing by a HW within the study period did not impact their chances of being diagnosed as a Covid19 case. Conversely, Antoine et al (2021) recommends a higher frequency of Covid19 testing among HWs compared to the general population owing to increased risk of Covid19 positivity for HWs to have a higher frequency of turning positive from the Covid19 test regardless of reasons for testing with a Hazard ratio (HR) of 3 times higher compared to the general population owing to their multiple exposures from hospital settings and hence the justification for the (Antonio-Villa et al., 2021).Therefore, to enhance early diagnosis and early containment measures for SARSCoV2 cases among HWs and similar pandemic-causing pathogens, frequent PCR covid19 testing among the HWs based on any history of suspected exposure and any symptom is justified (Antonio-Villa et al., 2021)). This is likely to enhance minimal family member and colleague exposure as well as staff to patient exposure and vice versa.

Vaccination against Covid19 disease has been proven to be efficacious in preventing laboratory confirmed Covid19 disease(Polack et al., 2020). Among HWs, breakthrough Covid19 infections have been reported among previously vaccinated HWs(Porru et al., 2022) although higher titers of vaccine-induced antibodies among HWs early in their vaccination has been cited to be effective in lowering the risk of Covid19 disease (Katz et al., 2020). Therefore, vaccination is effective in lowering the risk of Covid19 disease before the immunity acquired through the vaccines wanes. While 93% of all participant HWs were vaccinated against Covid19 disease, there was no statistically significant association between the vaccination status and the risk of Covid19 disease among the participant HWs. These findings could be spurious for two reasons, firstly, the HW’s vaccination status was not ascertained from the laboratory records and hence the information provided was prone to interviewee bias to want to report what was desirable to the interviewer.

Secondly, the timing of the vaccination could not be ascertained as would be required for robust assessment of timing of vaccination in preventing the risk of new disease. Therefore, with improved methods, future studies should consider examining the effect of the HWs vaccination status on the risk of Covid19 disease among HWs in a similar study setting.

5.5. Study limitations

This study has several strengths. First, due to the lack of a local and distinct standard tool for the assessment of the primary exposure of suboptimal PPE use in this study, an adaptation of WHO risk assessment for Covid19 exposure to estimate overall use of PPE as recommended and as appropriate for health worker clinical category was used. Second, the study design was appropriate in the essence that the dependent variable of the study, Covid19 disease status of the HW, was rare within the study period thus allowing examination of multiple independent exposure variables preceding the outcome and within a short period of time. In addition, the design allowed for increasing power of the study through the sampling of 3 controls for every case in the study. Third, recall period for independent variables was restricted to a 2 week period before PCR Covid19 testing by the participants while the differential recall between the cases and the control was minimized through matching of the cases and control in terms of cadre of work and testing dates by same month period. Fourth, misclassification of the cases and the controls was minimized by the pre-exclusion of study participants with classic covid19 symptoms from the control group while case were sampled from laboratory confirmed Covid19 positive staff. Fifth, bias resulting from the broad definition of health workers (HW) that included the clinical and non-clinical health workers was minimized at analysis stage by controlling for the confounding effect of the clinical staff and non-clinical staff categories.

The study has several limitations. First, study findings were based on the tertiary level hospital as the study setting from which we selected a study population. Therefore, if this study was done in different hospital settings such as a health center, the risk factors to Covid19 disease could differ. Therefore, the findings of this study are not generalizable to HWs in lower level hospital facilities. Second, in the choice of the study design a relatively small sample size was obtained that could not have been robust enough in detecting statistical association of key variables such as the effect of sex of the HW on risk of Covid19. Third, the study was prone to sampling bias on male HWs who are reportedly likely to go for testing due to pronounced symptoms and get diagnosed with Covid19 than female HWs (Ballering et al., 2021). However, over-representation of female HWs in our sample at 55% of all participants reflects that the predominance of female HWs in the general population of the hospital staff. The effects of the preponderance of male HWs

in PCR Covid19 testing and higher proportion of the female HWs could negatively impact on the true association between the sex of the HW and their risk of Covid19 from this study. Therefore, more controlled and randomized design would be recommended for a robust assessment of the effect of sex on the risk of Covid19 in the current study setting. Fourth, the recall bias was not fully minimized since HWs were required to report their exposure back in time a few days and weeks before PCR Covid19 test considered within the three-month study period. In addition, differential recall between cases and controls could not be fully eliminated despite matching the testing dates and examining exposure in reference to recent Covid19 PCR test conducted within the three-month study period. Lastly, the self-reporting of the exposure variables could have resulted to interviewee bias whereby the participants could have preferred to report positive answers such as false compliance with PPE and IPC measures. As a result, this could have resulted in invalid responses that could falsify the true Odds ratio of the association between the exposure and the outcome.
Measures made to minimize the limitations include matching the Covid19 testing dates by same week or same month restricting the assessment of the community, occupational, and health systems' exposure factors to the last two weeks before the participants' recent PCR Covid19 test in the study period, two-week recall period for occupational and community exposure variables was considered relatively short during which the health worker could remember their clinical practices and health behaviors. A simple random sampling of the cases was employed to minimize selection bias associated with non-random case samples. However, the selection bias was not fully eliminated because only the Covid19 cases that survived the disease and those who consented to voluntary participation were included in the study.

5.6. Conclusion

Health workers who were on leave for non-medical reasons, those with a history of known Covid19 exposure as well as those who went for PCR Covid19 test due to non-specific disease symptoms in the last 2 weeks before their PCR Covid19 test had increased risk of Covid19 disease. In terms of specific PPE use, health workers who sub-optimally adhered to face protective gears in their line duty had an increased risk of Covid19 disease. In addition, suboptimal adherence with PPE and IPC protocol among staff while using shared hospital tea and dining rooms increased their risk of Covid19 disease. Working in medium-risk departments such as outpatient clinics which are traditionally regarded as having a lower risk of disease compared to low risk administrative units and high-risk specialized units such as ICU, were shown to increase the risk of Covid19 disease among the HWs.

5.7. Recommendations

The hospital to reinforce adherence to optimal use of face shields and other face protective gears as recommended as part of PPE and IPC measures during the resurgence of Covid19 and other novel infectious disease pandemics as recommended by the Kenyan Ministry of Health and the World Health Organization.

The hospital to institute infection prevention protocols and explore other measures for enhancing IPC protocol adherence among HWs in areas where they are likely to lower their guard such as when taking tea or dining with hospital colleagues. Future research should examine and explore extra-occupational sources of exposure to Covid19 disease or similar pandemic-causing infectious diseases among HWs.

The hospital and the Ministry of Health to institute and sustain prompt PCR Covid19 testing among symptomatic HWs. Prompt PCR testing could enhance early definitive diagnosis of Covid19 or for a novel pandemic-causing pathogen and also for purposes of early isolation and initiation of treatment to prevent further spread and to enhance timely treatment for better clinical outcomes among HWs.

The Ministry of health to regularly update case-definition to reflect evolving Covid19 disease and to enhance the sensitivity of the symptomatic-case definition as a surveillance tool to inform allocation of scarce PCR tests among HWs.

The hospital and similar settings to adapt the departmental categories of low to medium to high risk based on risk profile among HWs to inform planning and allocation of personal protective equipment and other exposure minimization and elimination strategies.

The hospital to conduct research and clinical audits for departmental exposure sources among HWs to inform departmental risk profiles. For example, during a resurgent pandemic or an acute outbreak of a novel pathogen, a staff working in an outpatient medical clinic assumed a lesser risk of Covid19 disease compared to a staff working in the intensive care unit or in the infectious disease unit.

Future research should explore evidence-based and contextual tool for monitoring PPE/ IPC adherence and effectiveness among HWs in similar settings.

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7. APPENDIX

7.1. SCREENING TOOL FOR THE CONTROL GROUP

Table1: Questions on eligibility for study among Covid19 negative HWs	**Response**
1. I did not have any three of these symptoms in the last 2 weeks before testing for covid19 (**Fever, difficulty in breathing, cough, general weakness/fatigue, headache, myalgia, sore throat, coryza, dyspnea, anorexia/nausea/vomiting, diarrhea, altered mental status;** Covid19 symptoms as per MOH Kenya Interim Guidance on case management (Ministry of Health Kenya, 2020)) and the WHO case definitions (WHO, 2020h)	**Yes ☐No☐**
2. I did not have severe acute respiratory illness (characterized by fever > 38.0^0 and cough) that required hospitalization in the last 1 month before testing	**Yes☐ No☐**
3. I did not have severe acute respiratory illness (characterized by fever > 38.0^0 and cough) that required hospitalization in the 1 month after testing for covid19 disease	**Yes☐ No☐**
4. I did not have radiologic and imaging findings suggestive of Covid19 pneumonia in the last 2 weeks of Testing for Covid19 and 2 weeks after testing for Covid19 disease.	**Yes☐ No ☐**
5. I did not have a medical report suggestive of Covid19 pneumonia in the last 2 weeks of Testing for Covid19 and 2 weeks after testing for Covid19 disease.	**Yes☐ No☐**
If all questions are checked YES, then the participant is eligible for participation in the control study group.	
HW Participant Eligibility Yes☐ No ☐	

7.2. INFORMED CONSENT FORM

Section 1

TITLE OF STUDY: ***"Assessing risk factors associated with Corona virus disease (COVID19) among health workers (HWs) at Kenyatta National Hospital: A Case control study"***

PRINCIPALINVESTIGATOR

My name is John Kiragu. I am a researcher at Kenyatta National Hospital and University of Nairobi. My study is about identifying factors that are associated with the spread of Covid19 disease among health care providers at Kenyatta National Hospital. Given that Health workers are a very important resource that is helping the Kenyan government and the Kenyan communities to fight Covid19 disease and take care of those who have been infected, it is important that they are protected from contracting Covid19 disease.

STUDY PROCEDURES

Your role as a participant involves responding to the questions contained in this interview by use of a structured questionnaire. The Researcher and the assistants will arrange to conduct a phone interview with you at your most convenient time.

In case of any question or need for any clarification, the researcher or the research assistant will be available to assist you. The phone interview takes between 15 and 25 minutes of your time.

VOLUNTARY PARTICIPATION, CONFIDENTIALITY, RISKS

If you decide to take part in this study, you will be asked to voluntarily sign an online consent form. After you sign the consent form, you are still free to withdraw from the study at any time and without giving any reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed. As a participant, your responses to this questionnaire-based interview will be anonymous. Every effort will be made to preserve your confidentiality including assigning code names/numbers for participants on all research notes and keeping notes in a locked file cabinet in the personal possession of the researcher. To avoid any risk contracting Covid19 from close physical and social distance while we are engaging you towards filling this questionnaire, we will conduct phone interviews to minimize any physical contacts. We also encourage you to follow hand hygiene measures and keep physical distance of not less than 2 meters while in your line of work or in your private social life as recommended by the Ministry of Health Kenya.

BENEFITS

There will be no monetary benefits for participating in the study. However, your participation in the study is very much appreciated because the information you will provide will inform infection prevention policies and protocols which will be an indirect benefit to you and to your colleagues.

CONTACT INFORMATION OF THE RESEARCHER

If you have questions at any time about this study, or you experience any problem situation as a result of participating in this study, you may contact the researcher through the Mobile number: +254719311135 and Email addresses at kiragujm@students.uonbi.ac.ke/ kiragu.jonny@gmail.com. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Primary Investigator, please contact the KNH-UON Ethics and Research Committee. Thank you very much.

Participant's signature ______________________________

Date: ______________________________

7.3. STUDY QUESTIONNAIRE

Section 1: Informed Consent
I have read and signed the consent form (section 5.1) and I understand that I have the right to with draw at any time and that the information I will provide will be kept confidential and my identity will be kept anonymous. I understand that I will receive no direct monetary benefits but the information I provide may help to inform Infection prevention measures at the hospital.

Mark only one oval.

- Yes, I agree to participate
- No, I do not agree to participate

Section 2
Socio-Demographic information

PPE is an abbreviation used in this questionnaire which stands for personal protective equipment. This means materials designed to prevent the spread of Covid19 disease including :surgical or respirator face masks, gloves , apron, protective eye glasses or face shields for health workers directly or indirectly attending to patients in the hospital or while conducting aerosol generating procedures)

2. Gender *

Mark only one oval.

- Male
- Female

3. Age in Years *

4. Occupation in hospital * *Mark only one oval.*

- Radiology/x-ray technician
- Phlebotomist
- Physical therapist
- Nutritionist/dietician
- Laboratory personnel
- Admission/reception clerk
- Patient transporter
- Catering staff
- Cleaner
- Administration/ Managers
- Medical doctor
- Registered nurse (or equivalent)
- Assistant nurse, nurse technician (or equivalent)

Other: ______________________________

5. Work experience * *Mark only one oval.*

- Less than 5 years
- Between 6 to 10 years
- More than 10 years

6. Religion *

Mark only one oval.

- Catholic Christian
- Protestant Christian
- Muslim
- Other: ______________________________

7. On average, what best describes your daily sleep hours within the last two weeks before your most recent Covid19 test results? *

Mark only one oval.

- 8 hours or more hours per day
- 6 to 7 hours per day
- 4 to 5 hours per day
- Less than 4 hours per day

8. Do you have any preexisting medical condition *Mark only one oval.*

- Yes
- No
- Not sure

9. Tick all that applies to you in terms whether you have any of the preexisting medical conditions listed below

Check all that apply.

- Pregnancy within the last 6 months
- Cancer
- Diabetes mellitus
- HIV/other immune deficiency
- Heart disease
- Asthma (requiring medication)
- Chronic lung disease (non-asthma)
- Chronic liver disease
- Chronic hematological disorder
- Chronic kidney disease
- Chronic neurological impairment/disease
- Organ/bone marrow recipient
- Obesity (BMI >30)
- None
- Unknown

Other:

Section 3: Community characteristics

10. In the last 2 weeks before your covid19 test results, did you attend a social function e.g a church /mosque service, religious gathering, funeral , wedding , home or public party, bar or political gathering ? *

Mark only one oval.

- Yes
- No

11. In the last 2 weeks before your Covid19 test results, did you always use of face mask while with friends or in social functions such as parties, weddings, church or mosque or when visiting a bar? *

Mark only one oval.

- Yes (Always)
- No (Not always)

12. Outside of the hospital, have you been in close contact (less than 1.5 meter distance for more than 15 minutes) with a confirmed COVID-19 patient or a person with COVID-19 symptoms in the last 2 weeks prior to your Covid19 results? Examples of Covid19 symptoms include cough, breathing difficulty, fever, tiredness and body weakness.

Mark only one oval.

- Yes
- No

13. In the last 1 month before your covid19 test results, how many individuals lived in your household (including yourself)? (a household is defined as a group of people (two or more) living in the same residential house) *

Mark only one oval.

- 1 Individual
- 2 to 3 Individuals
- 4 to 5 Individuals
- More than 6 Individuals
- Other: ____________________

14. In the last 2 weeks before your Covid19 test results, how many times per week on average did you used public transportation besides a family car (public bus, shared van, train, subway /metro)? *

Mark only one oval.

- 0 times per week
- 1 to 2 days per week
- 3 to 5 days per week

6 to 7 days per week

Section 4: Occupation **Infection Prevention Measures**

15. Please choose your department of Work in the last 1 month before your Covid19 test results *
Check all that apply.

- IDU (Infectious Disease Unit)
- Covid19 designated Ward
- General Medical Ward
- General Surgical Ward
- ICU
- HDU
- NICU
- Maternity/Labor Ward
- Laboratory Unit
- Blood Transfusion Unit (BTU)
- Administration Offices including HR, Finance, Cashiers)
- Radiography Department
- Outpatient Medical and Surgical clinics
- Theatre
- CSSD/ Sterilization department
- Kitchen and Catering Department
- Accident and Emergency Department (Casualty)

Other: ____________________

16. What is the best description of your type of hospital shift work within the last 2 months before your Covid19 test results? *

Mark only one oval.

- All day shifts
- Mixed day/night shifts
- Mostly night shifts

17. What best describes your average duty-hours in the last two weeks before your Covid19 test results *
Mark only one oval.

Less than 8 hours per day
8 to 12 hours per day
More than 12 hours per day (Night shifts)

18. In the last 2 weeks before your Covid19 test results, were you on leave(officially being excused from hospital work or duty)

Mark only one oval.

Yes
No
Other: ______________________

19. Did you reuse gowns/PPE within the last two weeks before your Covid19 test results? Tick all that applied to your situation *

Mark only one oval per row.

	Yes / Always	Mostly	Commonly	Occasionally	No / Rarely
I re-used PPE in single shift (same PPE for more than one patient in one shift)					
I re-used PPE in more than Shift (same PPE in more than one shift)					

20. Within the last two weeks before your Covid19 test results, what type of exposure to Covid19 disease did you experience in your line of duty or in your private life ? Tick all that applies. *

Check all that apply.

I had exposure to a confirmed case of Covid19 in the Hospital
I had exposure to a confirmed case of Covid19 in the community/ within my household
I had exposure to a Patient with Unknown Covid19 status or Suspected Covid19 Patient
I had exposure to a Family member of unknown Covid19 status or suspected of Covid19
I had exposure to a Staff Colleague suspected / confirmed of covid19 disease
Unknown exposure

21. Within the last two weeks before your Covid19 test results, was the source of your exposure to Covid19 symptomatic? Examples of Covid19 symptoms include cough , breathing difficulty, fever, tiredness and body weakness *

Mark only one oval.

Yes
No

Unknown status

22. Within the last two weeks before your Covid19 test results, did you have adequate PPE in your line of duty while caring for Covid19 patients or other patients whose Status of Covid19 was unknown? *

Mark only one oval.

Yes (Adequate)

No (Not adequate)

Other:

23. Please indicate which situation best matches your practice within the last 2 weeks before your Covid19 test results *

Mark only one oval per row.

	Always	Mostly	Commonly	Occasionally	Rarely
Did you carry face Shields/gowns/PPE to your ward''s breakfast room before completely doffing?					
Did you maintain at least 1-m distance while eating food with your colleagues within the last two months?					
Did you maintain at least 1-m distance while talking to my Colleagues in the duty rooms in the last two months?					

24. In the last two weeks before your Covid19 test results, were you a health worker who was specifically dedicated / designated or deployed to care for confirmed COVID-19 patients? *

Mark only one oval.

Yes (Care of Confirmed covid19 patients

No, Care of patients of Unknown Covid19 status *Skip to question 32*

No, Care of patients suspected of covid19 *Skip to question 32*

Section 5: Infection Prevention

Care of Confirmed Covid19 patients

25. In the last 2 weeks before your Covid19 test results, did you wear personal protective equipment while attending to a covid19 patient (PPE) that you handled?

**Mark only one oval.*

- ⬭ Yes
- ⬭ No *Skip to question 32*

26. If yes in question above , indicate how often you used each item of PPE below: *

Mark only one oval per row.

	Always	Most of the time	Occasionally	Rarely /Did not use
Single-use gloves	⬭	⬭	⬭	⬭
Medical mask	⬭	⬭	⬭	⬭
N95 mask	⬭	⬭	⬭	⬭
Face shield or goggles or Protective glasses	⬭	⬭	⬭	⬭
Disposable gown	⬭	⬭	⬭	⬭

27. In the last two weeks before receiving your Covid19 test results, select what practice matches you at that time you were caring for patients with confirmed Covid19 disease *

Mark only one oval per row.

	Always	Most of the Time	Occasionally	Rarely/ did not use
Did you remove and replace your PPE according to protocol (e.g. when medical mask became wet, disposed the wet PPE in the waste bin,, performed hand hygiene,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene				

before and after touching the COVID-19 patient (whether or not you were wearing gloves)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after any clean or aseptic procedure was performed (e.g. while inserting a peripheral vascular catheter,, urinary catheter,, intubation,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after exposure to body fluid?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after touching the patient''s surroundings (bed,, door handle,, etc.),, regardless of whether you were wearing gloves?	⬭	⬭	⬭	⬭
Were high-touch surfaces decontaminated frequently (at least three times daily)?	⬭	⬭	⬭	⬭

28. In the last 2 weeks before receiving your Covid19 test results, did you wear personal protective equipment (PPE) during aerosol-generating procedures on the performed on a Covid19 patient that you handled? Examples of aerosol generating procedures include tracheal intubation, nebulizer treatment, open airway suctioning, collection of sputum, tracheotomy, bronchoscopy, cardiopulmonary resuscitation (CPR), etc.). *

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to question 38*

29. If yes in the question above ,indicate how often you used each PPE item below: (Frequency: Always =more than 90% times), Mostly =approx. 75% times, commonly =approx. 50% times, occasionally = approx. 25% times, rarely =less than 10% times)

**Mark only one oval per row.*

	Always	Most of the time	Occasionally	Rarely
Single-use gloves	◯	◯	◯	◯
Medical mask	◯	◯	◯	◯
N95 mask	◯	◯	◯	◯
Face shield or goggles or Protective glasses	◯	◯	◯	◯
Disposable gown	◯	◯	◯	◯
Waterproof apron	◯	◯	◯	◯

30. Select what matches you in the following situations when performing Aerosol generating Procedures (AGPs) in the last 2 weeks before your Covid19 test results. Examples of AGPs include tracheal intubation, nebulizer treatment, open airway suctioning, collection of sputum, tracheotomy, bronchoscopy, cardiopulmonary resuscitation (CPR), etc.). *

Mark only one oval per row.

	Always	Most of the time	Occasionally	Rarely/ Never
Did you remove and replace your PPE according to protocol (e.g. when medical mask became wet,, disposed the wet PPE in the waste bin,, performed hand hygiene,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after touching the COVID-19 patient,, regardless of whether you were wearing gloves?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after any clean or aseptic procedure was performed?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after touching the patient''s surroundings (bed,, door handle,, etc),, regardless of whether you were wearing gloves?	⬭	⬭	⬭	⬭

31. In the last 2 weeks before your covid19 test results, did you have any type of accident with body fluid/respiratory secretions while caring for a Covid19 patient? Select all that applied to you *

Mark only one oval.

⬭ Splash of biological fluid/respiratory secretions in the mucous membrane of eyes *Skip to question 38*

Splash of biological fluid/respiratory secretions in the mucous membrane of

mouth/nose *Skip to question 38*

Splash of biological fluid/respiratory secretions on non-intact skin

Skip to question 38

Puncture/sharp accident with any material contaminated with biological

fluid/respiratory secretions *Skip to question 38*

Did not have any type of accident with body fluids/ respiratory secretions.

Skip to question 32

Section 6: Infection prevention

Care of Patients with Unknown status of Covid19

32. In the last two weeks before your Covid19 test results, did you wear personal protective equipment (PPE) while attending to a patient whose status of Covid19 was not known,? *

Mark only one oval.

Yes

No *Skip to question 38*

33. If yes in the question above, indicate how often you used each item of PPE below *

Mark only one oval per row.

	Always	Most of the time	Occasionally	Rarely
Single-use gloves	⬭	⬭	⬭	⬭
Medical mask	⬭	⬭	⬭	⬭
N95 mask	⬭	⬭	⬭	⬭
Face shield or goggles or Protective glasses	⬭	⬭	⬭	⬭
Disposable gown	⬭	⬭	⬭	⬭

34. Select what matches you in the last two weeks prior to your Covid19 test results while caring for a patient with Unknown status of COVID-19 … *

Mark only one oval per row.

	Always	Most of the time	Occasionally	Rarely
Did you remove and replace your PPE according to protocol (e.g. when medical mask became wet,, disposed the wet PPE in the waste bin,, performed hand hygiene,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after touching the COVID-19 patient (whether or not you were wearing gloves)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after any clean or aseptic procedure was performed (e.g. while inserting a peripheral vascular catheter,, urinary catheter,, intubation,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after exposure to body fluid?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after touching the patient''s surroundings (bed,, door handle,, etc.),, regardless of whether you were wearing gloves?	⬭	⬭	⬭	⬭
Were high-touch surfaces				

	Always	Most of the time	Occasionally	Rarely
decontaminated frequently (at least three times daily)?	⬭	⬭	⬭	⬭

35. During aerosol-generating procedures (e.g tracheal intubation, nebulizer treatment, open airway suctioning, collection of sputum, tracheotomy, bronchoscopy, cardiopulmonary resuscitation (CPR), etc.) on the last patient you handled with Unknown status of Covid19 during the last two weeks prior to your Covid19 test results , did you wear personal protective equipment (PPE)? *

Mark only one oval.

⬭ Yes

⬭ No *Skip to question 38*

36. During aerosol generating procedures (AGPS) on a patient with Unknown status of COVID-19 that you last handled within the last two weeks prior to your Covid19 test results … *

Mark only one oval per row.

	Always	Most of the time	Occasionally	Rarely
Did you remove and replace your PPE according to protocol (e.g. when medical mask became wet,, disposed the wet PPE in the waste bin,, performed hand hygiene,, etc.)?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after touching the COVID-19 patient,, regardless of whether you were wearing gloves?	⬭	⬭	⬭	⬭
Did you perform hand hygiene before and after any clean or aseptic procedure was performed?	⬭	⬭	⬭	⬭
Did you perform hand hygiene after touching the patient''s surroundings (bed,, door handle,, etc),, regardless of	⬭	⬭	⬭	⬭

whether you were wearing gloves?

Were high-touch surfaces decontaminated frequently (at least three times daily)?

37. In the last two weeks prior to your Covid19 test results, did you have any type of accident with body fluid/respiratory secretions while attending to a patient with Unknown status of covid19? Select all that applies to you *

Check all that apply.

- [ ] Splash of biological fluid/respiratory secretions in the mucous membrane of eyes
- [ ] Splash of biological fluid/respiratory secretions in the mucous membrane of mouth/nose
- [ ] Splash of biological fluid/respiratory secretions on non-intact skin
- [ ] Puncture/sharp accident with any material contaminated with biological fluid/respiratory secretions
- [ ] Did not have any type of accident with body fluids/ respiratory secretions.

Section 7: Heath systems Health Systems factors

38. Within the last 1 year prior to your most recent Covid19 test results, did you get any specific training on covid19 disease and infection prevention measures for Covid19? *

Mark only one oval.

- Yes
- No

39. Within the last 1 year prior to your most recent Covid19 test results, did you get trained on proper PPE and selection and their use? *

Mark only one oval.

- Yes
- No
- don't know what is PPE

40. In the last two weeks prior to your covid19 test results, did you consider the face masks you were using to be well-fitting to completely cover your nose and your mouth while attending to patients?

Mark only one oval.

Yes (always fitting))

No (not always fitting)

41. Within the last two weeks before your Covid19 test results, did you double mask in your line duty?(Double masking means wearing two masks ,one facemask atop another) *

Mark only one oval.

Always

Most of the time

Occasionally

Rarely / Never

42. If you ever double masked in the two weeks prior to your Covid19 test results, please indicate the reason for having double masked. Use the space provided below to type your response *

43. Within last 6 months prior to your most recent Covid19 test results, how many times did you get tested for Covid19 disease using the nasal swab for Covid19 PCR TEST? *

Mark only one oval.

Tested Once

Tested twice

Tested three or more times

44. Prior to your most recent covid19 test results, what prompted your to go for Covid19 PCR testing *

Mark only one oval.

I had Symptoms of Covid19like disease

Asymptomatic and had exposure to Covid19 patient or Suspected case of Covid19

Asymptomatic and went for a random test

Asymptomatic and went to test as part of routine check up

Asymptomatic and the test was part of Health worker mass testing

Asymptomatic and tested for travel documents

Other:

45. In the 2 weeks prior to your most recent covid19 test results, what was your Covid19 vaccination status? (Fully vaccinated=means two doses of AstraZeneca vaccine or Two doses of Moderna Vaccine or One dose of Johnson and Johnson vaccine or Two doses of Pfizer vaccine as per the vaccination protocol by the Ministry of Health Kenya)Tick one that applies to you *

Mark only one oval.

- I was fully vaccinated against Covid19 disease
- I was partially vaccinated
- I was not vaccinated *Skip to question 47*
- I do not want to disclose my vaccination status at that time

46. Prior to my most recent covid19 test results, when did you receive your Covid19 vaccine? (Asks First dose of covid19 vaccine for partially vaccinated or the second dose of Covid19 vaccine if fully vaccinated)

Mark only one oval.

- Within the last 1 month prior to my most recent covid19 test results
- In 2 to 3 months prior to my most recent covid19 test results
- In 4 to 5 months prior to my most recent covid19 test results
- In 6 or more month prior to my most recent covid19 test results
- Other:

Section 8

Intention to Get Vaccinated

47. What is your current Covid19 vaccination status *Mark only one oval.*

- Vaccinated
- Not vaccinated

48. If not vaccinated, do you intend to go for Covid19 vaccination * *Mark only one oval.*

- Yes
- No
- Maybe

8. STUDY WORK PLAN

Research Activity	Dec 2020 to April 2021	May 2021 to August 2021	Sept 2021 to January 2022	Feb 2022 to June 2022	July 2022 to November 2022
Concept Development					
Research Proposal Development	■				
Submission to ERC and resubmission to ERC		■	■		
Data collection and Data analysis				■	
Report writing and discussion					■
Publication					■
Policy Brief and Thesis defense					■

9. BUDGET

Component	Unit of measure	Duration/ Number	Unit cost (Kshs)	**Total cost (Kshs)**
Personnel				
Research Assistant	1	37	1,500.00	**55,500.00**
Statistician	1		30,000.00	**30,000.00**
Printing				
Consent Form	1	2	10.00	**20.00**
Questionnaires	1	21	10.00	**210.00**
Final Report	1	150	10.00	**1,500.00**
Photocopying				
Consent Form	160	2	5.00	**1,600.00**
Questionnaires	160	21	5.00	**16,800.00**
Final Report	5	150	5.00	**3,750.00**
Final Report Binding	6	1	800.00	**4,800.00**
Other costs				
ERC Fees				**2,000.00**
Records Access Fee				**1,500.00**
Poster Printing	1	1	3,000.00	**3,000.00**
Calls	146	25	5.00	**18,250.00**
Box files	2	1	350.00	**700.00**
Note books	3	1	100.00	**300.00**
Pens	6	1	30.00	**180.00**
Total (kshs)				**140,110.00**

10. APPROVAL LETTERS

10.1. REQUEST FOR THE ERC APPROVAL FOR DATA COLLECTION

John Kiragu,

P.O Box 30197 GPO,

Department of Public and Global Health- University of Nairobi,

Nairobi Kenya.

Date: 19th September 2021

KNH-UON Ethics and Research committee,

P.O Box

Nairobi.

Dear Sir or Madam,

RE: APPLICATION FOR THE RESEARCH STUDY TITLED '*ASSESSING RISK FACTORS ASSOCIATED WITH CORONA VIRUS DISEASE (COVID19) AMONG HEALTH WORKERS (HWs) AT KENYATTA NATIONAL HOSPITAL: A CASE CONTROL STUDY'*

I am writing to seek permission and approval to conduct the research as titled above. The necessary ethical requirements have been met and relevant documents provided with this letter as per the KNH-UON Ethics and Research Guidelines including the plagiarism report.

The proposed data collection site will be from Health Workers sampled in KNH hospital at the selected hospital departments including ICU, HDU, Medical Outpatient Clinic, maternity and Covid19 designated units both IDU and Covid19 wards. The required sample size for the study population of health workers has been arrived at 160 health workers comprising of 40 cases and 120 controls. The consent form provided as well as the methodology section on ethical consideration gives an outline of how the study procedure and processes will adhere to Covid19 regulations so as to guarantee safety of the voluntary and informed participants. Permission to collect data from the Health workers will also be sought from the KNH administration.

In case of need for further clarification about the study, my mobile and email contact information are 0719311135 and kiragu.jonny@gmail.com respectively. I look forward to hear from you about the consideration for this study. Thank you.

Yours Sincerely,

John Kiragu (H57/35548/2019)

10.2. INITIAL ETHICAL APPROVAL LETTER

UNIVERSITY OF NAIROBI
FACULTY OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/408

3rd November 2021

03 NOV 2021

John Macharia Kiragu
Reg. No.H57/355548/2019
Dept. of Public and Global Health
Faculty of Health Sciences
University of Nairobi

Dear John

RESEARCH PROPOSAL: ASSESSING RISK FACTORS ASSOCIATED WITH CORONA VIRUS DISEASE(COVID19) AMONG HEALTH WORKERS(HWs) AT KENYATTA NATIONAL HOSPITAL: A CASE CONTROL STUDY (P462/06/2021)

This is to inform you that KNH-UoN ERC has reviewed and approved your above research proposal. Your application approval number is **P462/06/20201.** The approval period is 3rd November 2021 – 2nd November 2022.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KNH-UoN ERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KNH-UoN ERC 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH-UoN ERC within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to KNH-UoN ERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Protect to discover

Yours sincerely

PROF. M.L. CHINDIA
SECRETARY, KNH-UON ERC

c.c. The Dean-Faculty of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Head, Dept. of Public Health and Global Health, UoN
Supervisor: Dr. Richard Ayah, Dept of Public and Global Health, UoN

10.3. ETHICAL APPROVAL FOR MODIFICATIONS ON THE STUDY

UNIVERSITY OF NAIROBI
FACULTY OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref. No.KNH/ERC/Mod&SAE/12

28th January, 2022

John Macharia Kiragu
Reg. No. H57/35548/2019
Dept. of Public and Global Health
Faculty of Health Sciences
University of Nairobi

Dear John,

Re: Approval of Modifications – study titled "Assessing risk factors associated with Corona Virus Disease (COVID-19) among health workers (HWs) at Kenyatta National Hospital; A case control study" (P462/06/2021)

Your communication received at the KNH- UoN ERC office on 7th January 2022 refers.

Upon review, the KNH- UoN ERC has **approved** the following modifications to the study:

1. Change in definition of Study Population to include only health workers who were PCR tested for COVID-19 disease at least once in the study period.
2. Change in Sampling Procedure for controls- Convenient sampling of health workers (controls) and matched with the cases in terms of the testing dates where possible, and matched by the same or similar department of work as the cases.
3. Change in the Study Proforma for evaluating potential participants to the study control group.
4. Revised Study Flow Chart.
5. Change in the Study Questionnaire to examine COVID-19 exposure variables of the study groups in reference to the period before they receive their COVID-19 test results.

Consequently, the following documents have been approved:

a. Revised Research Proposal.
b. Revised Study Instruments.

The changes have been incorporated in the revised proposal and are acceptable.

The study instruments are hereby endorsed and stamped for use.

Yours sincerely,

DR. BEATRICE K.M. AMUGUNE
SECRETARY, KNH- UoN ERC

cc. The Dean, Faculty of Health Sciences, UoN
The Senior Director, Clinical Services, KNH
The Chair, KNH-UoN ERC
The Chair, Dept. of Public and Global Health, UoN
Supervisor: Dr. Richard Ayah, Dept. of Public and Global Health, UoN

10.4. FUNDING AWARD FROM KENYATTA NATIONAL HOSPITAL

KENYATTA NATIONAL HOSPITAL
P.O. Box 20723-00202 Nairobi

Tel.: 2726300/2726450/2726565
Research & Programs: Ext. 44705
Fax: 2725272
Email: knhresearch@gmail.com

KNH/R&P/23K/31/6 **Date: 11th February, 2022**

John Macharia Kiragu
Principal Investigator
KNH

Dear Mr. Kiragu,

RE: KNH RESEARCH GRANT NOTICE OF AWARD

It is our great pleasure to inform you that your study titled **"Assessing risk factors associated with corona virus disease (COVID19) among health workers (HWS) at Kenyatta National Hospital: A case control study"** is approved for funding. The funding period is 11th February 2022 - 10th February 2023.

TERMS AND CONDITIONS OF AWARD:

A. Scope:
1. The award will only cover payments for items or services included in the study budget approved by the Grants Office.
2. Prior written approval **must** be obtained before incurring any other costs not covered in the approved budget.

B. Performance period:
1. The study should be completed within the timeliness approved by the KNH-UoN ERC.
2. The Principal Investigator will be expected to submit quarterly progress report by 30th of September, December, March and June.
3. The Principal Investigator will be expected to provide a preliminary report within 6 weeks after completion of data collection.

C. Procurement of services and supplies:
1. The Hospital will assume responsibility of procuring all supplies and services.
2. The Hospital will procure all capital items.
3. Direct payments will be made to relevant departments for services as needed.
4. The Principal Investigator will be allowed to incur costs in line with the approved budget and submit receipts for reimbursement for the following:
   a. KNH-UoN ERC protocol processing fee.
   b. Printing of one copy of study instruments (consent, questionnaires and interview guides).
   c. Photocopying of study instruments (consent, questionnaires and interview guides).
   d. Printing of one final report.
   e. Photocopying of final report.
   f. Binding of the final report.
   g. Printing of one poster.

D. Disbursement of funds:

1. The Principal Investigator will pay for approved services and items and request for refund.
2. Research Assistants shall be paid directly by the Hospital upon request from the Principal Investigator. They will be clocking in and out at Research and Programs and provide their CV.
3. The statistician should have a minimum of BSC statistics and will be paid directly by the Hospital upon request by the Principal Investigator. The following documents will be required before payments to the statistician can be processed:
   a. Study report
   b. Policy brief
   c. Statistician CV
   d. Completed study dissemination form. The form will be signed by the KNH Head of department where the study was conducted.
4. The Principal Investigator will submit completed payment form (KNH/R&P/FORM/03) to initiate payments.
5. Copies of the following documents will be required from any individual whose payment is being processed:
   a. KRA PIN
   b. NSSF Card
   c. NHIF Card
   d. ID Card
   e. Bank account Card (Front page only)

E. Publications and or presentations:

Publications arising from study supported by this award must acknowledge Kenyatta National Hospital.

F. Non Completion of study:

1. The Principal Investigator will be required to refund all funds disbursed for the study.
2. The Hospital will reserve the right to initiate recovery measures for disbursed funds.

G. Acceptance of award:

To be able to access the research funds, the Principal Investigator will need to:

1. Complete the KNH Research Award Acceptance form
2. Provide a copy of:
   a. National ID
   b. Staff or student ID

We look forward to working with you in implementing this study. Please do not hesitate to contact the department if you have any questions or issues.

Congratulations.

Dr. John Kinuthia MBChB, MMed, MPH
Deputy Director, Medical Reserch