American Journal of Infection Control 000 (2022) 1–8

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Risk factors for COVID-19 virus infection among health workers: A case-control study in the Bono East Region of Ghana

Michael Mireku Opoku BPharm, MPH [a,*], Kwaku Poku Asante MBChB, MPH, FWACP, PhD [b], Stephaney Gyaase BSc, MSc [b], Emmanuel A.A. Teviu MBChB, MPH, MGCPS [c], Kingsley Amponsah MBBS [d], Anthony Twum MBChB [e], Kwabena Fosuhene Kusi MBChB, MPH [f], Alfred Kwadwo Ampofo MBBS [g], Fred Adomako-Boateng MBChB, MPH, FWACP [h]

[a] Department of Epidemiology and Disease Control, School of Public Health, University of Ghana, Accra, Ghana
[b] Kintampo Health Research Centre, Research and Development Division, Ghana Health Service Kintampo North Muicipality, Bono East Region, Ghana
[c] District Health Directorate, Nkoranza South, Ghana Health Service, Ghana
[d] Atebubu Government Hospital, Ghana Health Service, Ghana
[e] Sene West District Hospital, Ghana Health Service, Ghana
[f] Municipal Health Directorate, Techiman South, Ghana Health Service, Ghana
[g] District Health Directorate, Techiman North, Ghana Health Service, Ghana
[h] Regional Health Directorate, Bono East, Ghana Health Service, Ghana

Key Words:
Infection control
Healthcare workers
Coronavirus disease
Africa

Background: Disproportionately high rates of COVID-19 infection among health workers prompts the need to identify the risk factors to help guide the design and implementation of interventions. The aim of this study was to characterize the risk factors for COVID-19 infection among health workers.

Methods: A case-control study was designed to recruit 154 health workers who tested positive for the COVID-19 virus and 308 who tested negative from 8 hospitals and 11 health directorates in the Bono East Region of Ghana. Crude and adjusted logistic regression analysis was used to determine risk factors.

Results: Hand hygiene compliance for the recommended moments ranged from 55.3% to 77.4%. Personal protective equipments (PPE) use was 59.5% when patients' COVID-19 status was unknown and at least 90.7% when patient was positive. We identified years of practice experience (adjusted odds ratio (AOR) = 1.81; 95% CI: 1.07, 3.07; P = .028), adherence to infection prevention and control (IPC) when in contact with patients whose COVID-19 status is unspecified (AOR = 1.71; 95% CI: 1.09, 2.70; P = .020) and type of facility (AOR = 1.69, 95% CI: 1.09, 2.62; P = .019) as risk factors.

Conclusion: The findings underscore the need for health workers to improve in COVID-19 risk perception.

From the beginning of the COVID-19 virus outbreak in December, 2019 to 27th October, 2021 (6:40 PM CEST) more than 244 million cases and 4.9 million deaths have been recorded globally.[1] The impact on health systems has been felt globally. Understandably, in a pandemic such as COVID-19, such may be expected since health facilities are known to facilitate epidemics and epidemics in turn overwhelm the health system's ability to deliver services.[2] This underscores the need to protect health workers in the control efforts.

Notably, infection prevention and control (IPC) practices including hand washing before and after contact with patients and/or their materials and surroundings, and the use of appropriate personal protective equipments (PPEs) have been recommended as precautionary measures in this vein. That notwithstanding, the impact of COVID-19 on health workers has been tremendous. Estimates suggest that every tenth case is a health worker.[3] COVID-19 deaths among health workers has been estimated at 0.05 per 100,000 population.[4] As of July 2020, the WHO estimated about 10,000 health workers to have been infected across sub-Saharan Africa.[5]

Abbreviations: CHAG, Christian Health Association of Ghana; COVID-19, Coronavirus disease 2019; GHS, Ghana Health Service; IPC, Infection prevention and Control; RT-PCR, Real time reverse transcriptase polymerase chain reaction; WHO, World Health Organization

* Address correspondence to Michael Mireku Opoku, BPharm, MPH, Department of Epidemiology and Disease Control, School of Public Health, University of Ghana, Accra, Ghana.
E-mail address: mmirekuopoku@gmail.com (M.M. Opoku).

Conflicts of interest: All the authors declare that they have no competing interests.
Funding: Funding for the study was provided by Regional Health Directorate, Bono East, Ghana Health Service.

https://doi.org/10.1016/j.ajic.2022.08.008

In this regard, the disproportionately high infection rates among health workers prompt the need to identify the risk factors to help guide the design and implementation of interventions. Available studies have identified COVID 19 infection risk factors as exposure to infected patients, lack of PPEs, high work burden, poor infection control practices, underlying medical conditions, race, rate of infection in area of residence, and poor risk perception.[6-8] In Ghana, a study to assess health workers' compliance with IPC at COVID-19 treatment centers found that there was seemingly higher compliance when performing aerosol-generating procedures than during other interactions with patients, with nonclinical staff being less likely to comply.[9] A noticeable gap in the literature relates to the scarcity of evidence from Africa on the risk factors for infection with the COVID-19 virus. Like the study in Ashinyo et al, most of the studies available from Africa at the time the present study was conducted were cross-sectional or modelling based studies. As such, assessing causal relationships between the factors and COVID-19 infection was limited.[10] This threatens the sustainability and effectiveness of interventions aimed at local control of the pandemic in these settings, as they may not be context specific or adequately focused. In this study, we aimed at characterizing the risk factors for COVID-19 infection among health workers.

METHODS

Study location

The study was conducted in the Bono East Region of Ghana. Bono East is one of the 16 administrative regions in the country, and it has 11 subregional administrative units (districts/municipalities). The region has a total number of seventeen (17) hospitals. Staff of eight (8) hospitals and the eleven (11) Municipal/District health directorates were recruited into the study. Four (4) of the hospitals are owned and managed by mission groups belonging to the Christian Health Association of Ghana (CHAG) and the other four (4) by the government through the Ghana Health Service (GHS).

COVID-19 testing and treatment

During the period of data collection, a centralized testing approach was in use. Nasopharyngeal or oropharyngeal swaps were taken from cases meeting the suspected and probable case definitions given by the WHO and sent immediately or kept in cold chain (2-8°C) for 1-2 days before sending in a pool to accredited laboratories. The average turnover at the laboratories was 4-5 days.[11] Suspected and probable cases were kept in isolation and treated as positive cases until laboratory results indicated otherwise. The primary health care structures in Ghana, well founded in community engagement, were leveraged to conduct contact tracing for those who tested positive. As regards treatment, confirmed cases categorized as mild or moderate were required to self-quarantine and managed at home while severe or critical ones were managed at a treatment centre. Typically, cases were de-isolated 3 consecutive days after showing no symptoms following a 14-day period of isolation from the day of symptoms onset or sample taking (for those who were asymptomatic).[12] Study design A case-control design was used. Health workers who were confirmed to have been infected with the COVID-19 virus using real time reverse transcriptase polymerase chain reaction (RT-PCR) were targeted for inclusion as cases in the study. Other health workers at the same facility exposed to the COVID-19 patient(s) but with negative RT-PCR test results were recruited as controls. A Health worker was defined as a health care professional, an administrative or support staff involved with the provision of care in the health system. We sought to recruit 2 controls for each case. The WHO tool on assessment of risk factors for COVID-19 among health workers was adapted and used.[13] Controls were not matched to cases on any variables.

Sample size determination

According to study by Akagbo et al (2017), 44% of health workers are reluctant to comply with the IPC standard precautions.[14] Assuming an allocation ratio of 2 controls to 1 case, a 0.80 power and a two-sided 5% test of significant, a total sample of 300 health workers will be required to detect an odds ratio of 2.0. Thus, a total sample of 100 health workers who had tested positive for COVID-19 against 200 health workers who tested negative for COVID-19. Adjusting for a 10% nonresponse rate, a total sample of 154 and 308 health workers will be required for the cases and control group respectively to answer the objectives of the study.

Recruitment

All health workers who tested for the COVID-19 virus from 19th May, 2020 to 28th February, 2021 using the RT-PCR were listed from all municipalities/districts. A sampling frame was generated separately for cases and controls in each facility. The number of cases selected from each facility was determined proportional to the size of the cases recorded per facility. The cases were selected from the list for each facility using a random number generator in Microsoft Excel 2016. For each case selected, 2 controls were randomly selected from the facility's sampling frame for controls using a random number generator in Microsoft Excel 2016. A control was excluded if at any point within the specified period of data collection she or he tested positive for the COVID-19 virus.

Variables

All practices assessed were for the 14 days prior to sample taking for the RT-PCR testing. Community exposure was defined as having been in close contact (within 1metre) with a person confirmed to have been infected with the COVID-19 virus outside the clinical setting or the line of duty. Occupational exposure was defined as having been in close contact (within 1 m) with a COVID-19 patient for a cumulative period of at least 15 min within the health facility or in the line of duty. In respect of the frequency of face mask use, social distancing, wearing of PPEs or hand hygiene, the frequent category was defined as the choice of always, as recommended or most of the time and infrequent was defined as the choice of occasionally, rarely, or never. Adherence to IPC was defined as frequent observance of hand hygiene at all 5 recommended hand hygiene moments and frequent use of PPEs when indicated, during contact with any patient regardless of patient's COVID-19 status. High risk of exposure was defined as infrequent observance of hand hygiene and infrequent use of appropriate PPE when a health worker in close contact (within 1 m radius) with COVID-19 patients touch them or their body fluids either directly or indirectly through their materials or surfaces around them or during the performance of aerosolizing procedures. PPEs assessed as part of the study were medical/surgical masks, face shield or goggles/glasses, gloves, gown and coverall, head cover, respirator (eg, N95, FFP2 or equivalent) and shoe covers.

Data collection

A data collection tool on assessment of risk factors for COVID-19 among health workers adapted from WHO was pretested and used to collect data on the socio-demographic variables, medical history, availability and frequency of use of PPEs, frequency of hand hygiene observance, contact with and exposure to COVID-19 patients following their admission to the health facility.[13] The period of data

collection was from 17th May to 1st June, 2021. The data was collected using KoBoCollect.[15] Five nonhealth workers with at least a bachelor's degree, were trained to do the data collection. Unique serial numbers were assigned to enable investigators identify cases and controls.

Ethical considerations

Informed consent was obtained from all participants. The data from the study was anonymized and have been secured on a password-protected computer with access limited to the investigators. Ethical clearance for the study was sought from the Kintampo Health Research Centre Institutional Ethics Committee.

Statistical analysis

Summary statistics were used to present background characteristics, preventive practices outside the health facilities, adherence to IPC measures when in contact with patients with unspecified COVID-19 status and when in contact with COVID-19 patients. Chi square test (or fisher's exact test, where appropriate) was used to determine the factors associated with being infected with COVID-19. Variables found to be used significant in the univariate model and those found to be important from literature were considered in the multivariable logistic regression model.

RESULTS

About ninety seven percent (96.8% [149 out of 154]) of cases and 76.6% (236 out of 308) of controls were recruited. 42.9% and 40.7% females were recruited as cases and controls, respectively. The high refusal to participate in the study was probably due to pandemic fatigue. Some were of opinion that the study might contribute to more stringent enforcement of preventive protocols at a time when most felt overburdened by it.

Demographic characteristics of health workers

Table 1 presents a summary of background characteristics by cases and controls. Males were 58.4% of participants. On average, respondents were 32 years ranging from 21 years to 59 years. Majority of workers were nurses including midwives and their auxiliaries (55.3%). The median years of active service was 5 (IQR: 3–10). Of those who had worked for 11 years or more the proportion of cases was 30.2% (45/149) and that of controls was 19.5% (46/236), $P = .046$). For CHAG-owned facilities, the proportion of cases was 59.7% while that of the controls was 49.6%. Those who were sure of having been

Table 1
Background characteristics of study participants

Characteristics	Cases (n = 149)	Controls (n = 236)	Total (N = 385)	*P*-value
Sex				.659
Male	85 (57.1)	140 (59.3)	225 (58.4)	
Female	64 (42.9)	96 (40.7)	160 (41.6)	
Age				.912
< 32 years	83 (56.1)	131 (55.5)	214 (55.7)	
≥ 32 years	65 (43.9)	105 (44.5)	170 (44.3)	
Professional cadre				.293
Medical Officers	3 (2.0)	5 (2.1)	8 (2.1)	
Physician Assistants	6 (4.0)	15 (6.4)	21 (5.5)	
Nurse/Midwife/Auxiliaries	83 (55.7)	130 (55.1)	213 (55.3)	
Laboratory/Radiography	9 (6.0)	13 (5.5)	22 (5.7)	
Pharmacy	0 (0.0)	6 (2.5)	6 (1.6)	
Nutrition/DC/ HP/HI	20 (13.4)	37 (15.7)	57 (14.8)	
Administrative/Support	28 (18.8)	30 (12.7)	58 (15.1)	
Years of Practice				.046*
1 - 5	72 (48.3)	125 (53.0)	197 (51.2)	
6 – 10	37 (21.5)	65 (27.5)	97 (25.2)	
11 or more	45 (30.2)	46 (19.5)	91 (23.6)	
Facility type				.052
Government-owned facilities	60 (40.3)	119 (50.4)	179 (46.5)	
CHAG-owned facilities	89 (59.7)	117 (49.6)	206 (53.5)	
Unspecified preventive measures				.026*
Yes	5 (3.4)	22 (9.3)	27 (7.0)	
No	144 (96.6)	214 (90.7)	358 (93.0)	
Has an underlying disease				.652
Yes	20 (13.4)	28 (11.9)	48 (12.5)	
No	129 (86.6)	208 (88.1)	337 (87.5)	
Community Exposure				0.483
Exposed	26 (17.5)	48 (20.3)	74 (19.2)	
Not Exposed	123 (82.5)	188 (79.7)	311 (80.8)	
Occupational Exposure				0.412
Exposed	79 (53.0)	115 (48.7)	194 (50.4)	
Not Exposed	70 (47.0)	121 (51.3)	191 (49.6)	
Adherence to IPC				0.016*
Adherent	89 (59.7)	169 (71.6)	258 (67.0)	
Non-adherent	60 (40.3)	67 (28.4)	127 (33.0)	
Risk of Exposure				.849
Low	131 (87.9)	209 (88.6)	340 (88.3)	
High	18 (12.1)	27 (11.4)	45 (11.7)	

*$P<0.05$.
CHAG, Christian Health Association of Ghana; DC, disease control; HP, health promotion; HI, health information.

exposed to the COVID-19 virus through a confirmed case outside their line of duty formed 19.2% (74/385) of study participants. The occurrence of cases did not differ by community exposure status (P = .483). Those who were occupationally exposed did not differ by cases and controls (53.0% vs 48.7%, P = .412). Regarding adherence to IPC practices (hand hygiene or use of PPEs), the proportion of cases which were nonadherent was higher than that of controls (40.3% vs 28.4%, P = .016). The risk of exposure was not significantly associated with the COVID-19 virus infection (12.1% cases vs 11.4% controls, P = .849). Other variables which were not significantly associated with being infected with COVID-19 were professional cadre (P = .293), having a known underlying medical condition (P = .652), frequency of face mask use in the community (P = .574), frequency of social distancing in the community (P = .424), community exposure (P = .483), occupational exposure (P = .412) and having been trained for COVID-19 care (P = .817).

Regarding practices in the community, 54.7% of controls and 52.4% of cases used public transport. The proportion of controls who had social interactions (ie, went to the market, attended a religious or social event) within 14 days before testing for COVID-19 was higher than the proportion of cases who had social interactions (83.1 vs 74.5%, P = .042). Of the participants, 7.0% reported observing other practices aimed at preventing infection with COVID-19; 3.4% (5/149) of cases and 9.3% (22/236) of controls. These practices included taking ginger, nonspecified herbal preparations, vitamin C tablets, and inhaling steam. Regarding the use of face masks, 93.5% admitted to frequently adhering. In total, those who reported frequently observing social distancing 14 days prior to testing were 80.5% (310/385). Those who reported observing social distancing infrequently were 20.8% (49/236) of controls and 17.4% (26/149) of cases.

IPC practices within the study area

Some practices related to IPC within the health facility when in contact with patients whose COVID-19 status was unknown are further summarized in Table 2. While 92.7% of health workers had been trained on IPC, only 16.4% correctly knew the five recommended hand hygiene moments. Of all the five recommended hand hygiene moments, hand hygiene after risk of body fluid exposure (77.4%), hand hygiene after touching a patient (70.9%) and hand hygiene before performing aseptic procedures (68.6%) were the top three moments observed by most health workers. The least observed moment was hand hygiene after touching patient surroundings (63.1%). Alcohol hand rub was reported by 93.8% of health workers to be available. About PPE use, 59.5% (229/385) reported wearing them always as recommended, 29.4% (113/385) reported wearing them most of the time and 11.2% (43/385) reported using them occasionally, rarely or never. When in contact with patients with unspecified COVID-19 status, an equal proportion of cases and controls performed hand hygiene infrequently after touching patient surroundings (16.1% vs 16.1%). With all other hand hygiene moments, a higher proportion of cases than controls infrequently performed hand hygiene. Furthermore, infrequent wearing of PPEs was observed in a higher proportion of cases (14.1%) than controls (9.3%).

Hand hygiene practices and PPE use by health workers when in close contact with COVID-19 patients are summarized in Table 3. Compared to the other moments assessed, health workers least

Table 2
IPC practice characteristics of cases and controls when in contact with patients with unspecified COVID-19 status in the Bono East region

Characteristics	Cases N = 149 n (%)	Controls N = 236 n (%)	Total N = 385 n (%)
Training on IPC			
Trained	139 (93.3)	218 (92.4)	357 (92.7)
Not trained	10 (6.7)	18 (7.6)	28 (7.3)
Knowledge of hand hygiene moments			
All 5 correctly identified	23 (15.4)	40 (17.0)	63 (16.4)
More or less than 5 identified	126 (84.6)	196 (83.0)	322 (83.6)
Hand hygiene before touching patient			
Always, as recommended	95 (63.8)	159 (67.4)	254 (66.0)
Most of the time	28 (18.8)	54 (22.9)	82 (21.3)
Occasionally, rarely or never	26 (17.4)	23 (9.7)	49 (12.7)
Hand hygiene before performing aseptic procedures			
Always, as recommended	99 (66.4)	165 (69.9)	264 (68.6)
Most of the time	23 (15.4)	51 (21.6)	74 (19.2)
Occasionally, rarely or never	27 (18.1)	20 (8.5)	47 (12.2)
Hand hygiene after risk of body fluid exposure			
Always, as recommended	118 (79.2)	180 (76.3)	298 (77.4)
Most of the time	13 (8.7)	31 (13.1)	44 (11.4)
Occasionally, rarely or never	18 (12.1)	25 (10.6)	43 (11.2)
Hand hygiene after touching patient			
Always, as recommended	102 (68.5)	171 (72.5)	273 (70.9)
Most of the time	29 (19.5)	42 (17.8)	71 (18.4)
Occasionally, rarely or never	18 (12.1)	23 (9.7)	41 (10.7)
Hand hygiene after touching patient surroundings			
Always, as recommended	96 (64.4)	147 (62.3)	243 (63.1)
Most of the time	29 (19.5)	51 (21.6)	80 (20.8)
Occasionally, rarely or never	24 (16.1)	38 (16.1)	62 (16.1)
Hand rub available			
Yes	140 (94.0)	221 (93.6)	361 (93.8)
No	6 (4.0)	6 (2.5)	12 (3.1)
Occasionally	3 (2.0)	7 (3.0)	10 (2.6)
Not sure	0 (0.0)	2 (0.9)	2 (0.5)
Wear PPE when indicated (n = 385)			
Always, as recommended	90 (60.4)	139 (58.9)	229 (59.5)
Most of the time	38 (25.5)	75 (31.8)	113 (29.4)
Occasionally, rarely, or never	21 (14.1)	22 (9.3)	43 (11.2)

frequently observed hand hygiene always, as recommended before having contact with patient's materials (55.3%, 57/103) and most frequently after close contact with patients (72.9%, 164/225) and after contact with patient's material (72.5%, 66/91). Those who observed hand hygiene always, as recommended before close contact with a COVID-19 patient were 64.0%. This frequency was comparable with those who practiced hand hygiene always, as recommended after contact with patient's surfaces (66.4%). It is worth noting that 4.9% and 7.7% of health workers performed hand hygiene with alcohol hand rub despite having had contact with body fluids via patient's material or surfaces around patient, respectively. In all the instances of PPE use assessed, at least 9 out of 10 health workers used PPEs, the least instance of use being for the performance of aerosolizing procedures (90.7%, 39/43) such as chest compression, intubation, nebulization among others. Whereas a higher proportion of cases than controls was infrequent with performing hand hygiene before contact with patient's material (26.3% vs 16.9%), the reverse was observed with performing hand hygiene before (11.2% vs 13.2%) and after (4.5% vs 9.5%) close contact with patients, after contact with patient's material (3.0% vs 15.5%) and after contact with patient's surroundings (7.7% vs 12.0%).

Some exposure characteristics

Those who had close contact (within 1 m) with COVID-19 patients 14 days before testing were 225 out of the 385 (58.4%). Of those who had close contact, 19.1% performed aerosolizing procedures with 9.3% (4/43) admitting to not wearing appropriate PPE. Of the close contacts, 19.6% (44/225) had direct contact with body fluid. The fluids they had direct contact with were blood or blood products (31.8%, 14/44), saliva (43.2%, 19/44), sweat (54.5%, 24/44), urine (22.7%, 10/44), and others including fecal matter and sputum (15.9%, 7/44). The proportion of those who had contact with patients' materials were 41.3% (93/225). Of these, 15 (16.1%) had contact with patient's body fluid through the materials. The materials included clothes (60.2%, 56/93), personal items (57.0%, 53/93), bedding material (34.4%, 32/93), medical devices used on patients (43.0%, 40/93), medical equipments connected to patients (32.3%, 30/93) and contact with other materials such as folders, phones, and computers (7.5%, 7/93). Those who had contact with surfaces around the patient were 56.8% (126/222) and a quarter (25.8%, 32/124) of this group had direct contact with body fluids through the surfaces. The surfaces included bed (40.5%, 51/126), bathroom (7.9%, 10/126), ward corridor (22.2%, 28/126), patient table (41.3%, 52/126), bedside table (47.6%, 60/126), ward dining table (8.7%, 11/126), medical gas panel (11.1%, 14/126) and other surfaces such as door handles and chairs (23.8%, 30/126) (Table 4).

Factors associated with COVID-19 infection

Crude and adjusted odds ratios of the association between COVID-19 infection and factors of interest are presented in Table 5. Cases had 1.7 times higher odds of being nonadherent to hand hygiene or use of PPEs compared to controls after accounting for all factors of interest (AOR = 1.71; 95% CI: 1.09, 2.70; P = .020). Cases were more likely to have 11 years of practice experience or more than controls (AOR = 1.81; 95% CI: 1.07, 3.07; P = .028). After accounting for all the variables of interest, health workers who were infected with the COVID-19 virus had 1.7 times higher odds of being staff of CHAG-owned facilities than those who were not infected (AOR = 1.69, 95% CI: 1.09, 2.62; P = .019).

Table 3
Hand hygiene practices and use of personal protective equipment by health workers who had close contact to COVID-19 patients

Characteristic	Cases	Controls	Total
Hand hygiene before 1m contact with patient (n = 225)			
Always, as recommended	57 (64.0)	87 (64.0)	144 (64.0)
Most of the time	22 (24.7)	31 (22.8)	53 (23.6)
Ocassionally, rarely or never	10 (11.2)	18 (13.2)	17 (7.5)
Hand hygiene after 1 m contact with patient (n = 225)			
Always, as recommended	66 (74.2)	98 (72.1)	164 (72.9)
Most of the time	19 (21.3)	25 (18.4)	44 (19.6)
Ocassionally, rarely or never	4 (4.5)	13 (9.5)	17 (7.5)
Hand hygiene before contact with patient's material (n = 103)			
Always, as recommended	21 (55.3)	36 (55.4)	57 (55.3)
Most of the time	7 (18.4)	18 (27.7)	25 (24.3)
Ocassionally, rarely or never	10 (26.3)	11 (16.9)	21 (20.4)
Hand hygiene after contact with patient's material (n= 91)			
Always, as recommended	28 (84.9)	38 (65.5)	66 (72.5)
Most of the time	4 (12.1)	11 (19.0)	15 (16.5)
Ocassionally, rarely or never	1 (3.0)	9 (15.5)	10 (11.0)
Hand hygiene after contact with patient's surface (n = 127)			
Always, as recommended	32 (61.5)	49 (65.3)	81 (63.8)
Most of the time	16 (30.8)	17 (22.7)	33 (26.0)
Ocassionally, rarely or never	4 (7.7)	9 (12.0)	13 (10.2)
Wore PPE for aerosolizing procedure (n = 43)			
Yes	15 (88.2)	24 (92.3)	39 (90.7)
No	2 (11.8)	2 (7.7)	4 (9.3)
Wore PPE during direct contact with body fluid (n = 44)			
Yes	15 (93.8)	26 (92.9)	41 (93.2)
No	1 (6.3)	2 (7.1)	3 (6.8)
Wore PPE during contact with body fluid via patient's material (n= 17)			
Yes	4 (100.0)	13 (100.0)	17 (100.0)
No	0 (0.0)	0 (0.0)	0 (0.0)
Wore PPE during contact with body fluid via patient's surface (n = 35)			
Yes	18 (94.7)	16 (100.0)	34 (97.1)
No	1 (5.3)	0 (0.0)	1 (2.9)

Table 4
Exposure characteristics of cases and controls who had close contact to COVID-19 patients

Characteristic	Cases	Control	Totals
Had contact within 1metre of COVID-19 patient (n= 385)			
Yes	89 (59.7)	136 (57.6)	225 (58.4)
No	42 (28.2)	83 (35.2)	125 (32.5
Unknown	18 (12.1)	17 (7.2)	35 (9.1)
Had contact within 1metre of COVID-19 patient (n = 225)			
Had direct contact with body fluid	16 (18.0)	28 (20.6)	44 (19.6)
Did not have direct contact with body fluid	67 (75.3)	94 (69.1)	161 (71.6)
Unknown	6 (6.7)	14 (10.3)	20 (8.9)
Had direct contact with patient's material (n = 225)			
Yes	33 (37.1)	60 (44.1)	93 (41.3)
No	53 (59.5)	70 (51.5)	123 (54.7)
Unknown	3 (3.4)	6 (4.4)	9 (4.0)
Had direct contact with patient's material (n = 93)			
Had contact with patient's body fluid	3 (9.1)	12 (20.0)	15 (16.1)
Did not have contact with patient's body fluid	22 (66.7)	31 (51.7)	53 (57.0)
Unknown	8 (24.2)	17 (28.3)	25 (26.9)
Had contact with surfaces around patient (n = 222)			
Yes	51 (58.0)	75 (56.0)	126 (56.8)
No	31 (35.2)	53 (39.5)	84 (37.8)
Unknown	6 (6.8)	6 (4.5)	12 (5.4)
Had contact with surfaces around patient (n = 124)			
Had contact with patient's body fluid	17 (34.0)	15 (20.3)	32 (25.8)
Did not have contact with patient's body fluid	23 (46.0)	39 (52.7)	62 (50.0)
Unknown	10 (20.0)	20 (27.0)	30 (24.2)
Performed Aerosolizing procedure (n = 225)			
Yes	17 (19.1)	26 (19.1)	43 (19.1)
No	72 (80.9)	110 (80.9)	182 (80.9)

DISCUSSION

We set out to determine the risk factors associated with COVID-19 infection among health workers. Training on IPC was almost universal, yet hand hygiene was not always observed as recommended. It was generally lower before contact with patients or their materials than after, except for contact with patient surroundings in which case compliance was as low as before contact with patients or their materials. Whereas PPE use was not utmost, it was likely to be lower when the patient's COVID-19 status was unspecified than otherwise. Years of practice experience, adherence to IPC when in contact with patients with unspecified COVID-19 status and type of facility one works in were risk factors for infection with the COVID-19 virus.

That majority of respondents had been trained on IPC but fewer adhered to hand hygiene and PPE use as recommended is indicative that the knowledge acquired during the training may not have translated into behavioral change. The observance of hand hygiene despite low knowledge of the clearly defined 5 moments is suggestive that health workers practice hand hygiene at moments which seem most protective to themselves and/or the patients though they may not identify these moments as having been specified by policy. That reinforces the idea that knowledge of IPC may not necessarily be translated into behavioral change.[16]

The generally high noncompliance is consistent with a study which showed that in spite of the COVID-19 pandemic hand washing compliance among health workers was on the descendency.[17] The higher compliance with hand hygiene recommendations after contact with patients compared to before contact has been explained to mean that health workers are likely to be more concerned with self-protection than patient-protection.[18] While our study findings can be explained by this finding, it is interesting to note that the frequency of adherence to hand hygiene after contact with patient surfaces in particular is comparable with rates observed before patient contact.

Table 5
Crude and Adjusted logistic regression models of variables of interest on the risk of COVID-19 infection among health workers in the Bono east region of Ghana

Variable	COR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
Years of Practice (Ref: 1-5)				
6-10	0.85 (0.52, 1.43)	.549	0.83 (0.49, 1.42)	.503
11 or more	1.70 (1.03, 2.81)	.039*	1.81 (1.07, 3.07)	.028*
Unspecified preventive measures (Ref: No)				
Yes	0.34 (0.3, 0.91)	.032*	0.24 (0.08, 0.69)	.008*
Adherence to IPC (Ref: Adherent)				
Nonadherent	1.70 (1.10, 2.62)	.016*	1.71 (1.09, 2.70)	.020*
Facility (Ref: Government-owned Facilities)				
CHAG-owned Facilities	1.51 (1.00, 2.28)	.052	1.69 (1.09, 2.62)	.019*
Underlying medical condition (Ref: Yes)				
No	1.15 (0.62, 2.13)	.652	0.90 (0.47, 1.73)	.75
Close occupational contact (Ref: Yes)				
No	0.77 (0.49, 1.22)	.27	0.69 (0.43, 1.12)	.132
Unknown	1.62 (0.79, 3.31)	.187	1.78 (0.84, 3.75)	.132

*$P < .05$.
AOR, Adjusted Odds Ratio; CHAG, Christian Health Association of Ghana; CI, confidence interval; COR, Crude Odds Ratio; IPC, Infection prevention and Control; Ref, Reference.

This may be indicative of a mistaken perception by health workers that patient surroundings pose minimal threats to their own safety.

The low adherence to PPE use could be the result of a perception among health workers that the PPEs are of low quality or that their importance was lost on those supposed to use them.[19,20] However, it seems more compelling that health workers used PPEs less when they perceived a lower risk considering that PPE use was almost universal when they had contact with COVID-19 patients and much less when the patients' COVID-19 status was unknown.

A study in Nigeria found that health workers with fewer years of practice experience were more knowledgeable about PPEs than their older colleagues.[20] This could explain our finding that those with more years of experience were more likely to be infected. Alternatively, the more experienced health workers may be complacent considering their familiarity with processes and how nonadherence to protocol may not necessarily have resulted in negative results always in the past.

In our study, the variables adherence to IPC and risk of exposure measured the same thing at different contact periods. The former measured frequency of hand washing and use of PPEs when health workers were in contact with patients whose COVID-19 infection status was not known, and the latter measured same when health workers were in contact with known COVID-19 patients. That adherence to IPC was significant but not risk of exposure implies that there was a higher risk of COVID-19 infection among health workers when they did not know the infection status of patients. This finding is consistent with other studies.[8] During the period we collected data for, all the health facilities had instituted a system of pretriaging at the outpatient departments aimed at identifying suspected cases early.[21] This system, while certainly not full proof, may have subconsciously misled health workers to let down their guard on the assumption that those who were not picked up at pretriaging were uninfected. On the risk of exposure, while other studies found that being exposed to infected patients was a risk factor the rather small proportion of people with high risk of exposure in our study suggests a larger sample size may be required for such a difference to be detectable.[7] Considering that majority of COVID-19 cases were asymptomatic the need for the observance of universal precaution cannot be emphasized enough.

On the role of facility ownership, a key difference of interest is that majority of the COVID-19 cases recorded in the Bono East region were managed in districts with CHAG-owned facilities. The higher case density at the CHAG-owned facilities is also accentuated by our finding that health workers are at higher risk of infection when patients' COVID-19 infection status was unknown. In that, attendance at the outpatient departments, where patients' COVID-19 status is assessed, was generally higher at CHAG-owned hospitals compared to government-owned hospitals.

One limitation of our study was the likelihood for recall bias. Also, respondents were likely to provide socially desirable responses which may not necessarily be truthful as the questionnaire was interviewer-administered. This effect was likely to be more pronounced if respondents thought that data collectors knew what the appropriate responses were. To help reduce the likelihood of this occurrence nonhealth workers did the data collection and this was disclosed to the respondents. Furthermore, data collectors were blinded to the case or control status of the participants. Finally, we did not include the effect of proper donning and doffing of PPEs. Since improper donning and doffing may undo the benefits of the use of appropriate PPEs, including it in our study may have helped to better characterize the role of PPEs use in infection transmission among health workers.

CONCLUSION

There was generally low compliance with recommended hand hygiene protocols and PPE use. This fact, despite the majority having been trained in IPC, suggests that knowledge may not necessarily be translating into behavior change. Also, health workers may be under the mistaken perception that patient surroundings pose minimal threats to their own safety. There is the need for health workers to adopt protective behavior consistent with the level of risk they are exposed to. Given the level of compliance with precautionary measures we did not find enough evidence that being in close contact to COVID-19 cases was a risk. However, there was evidence that infrequent compliance with hand hygiene recommendation and PPE use when in contact with patients whose COVID-19 status is unspecified was a risk. These findings underscore the need for health workers to improve in COVID-19 risk perception.

AUTHORS' CONTRIBUTIONS

The study was conceptualized FAB and designed by MMO, KPA, and FAB. MMO, EAT, and ST contributed to data acquisition, data management, analyses and interpretation. MMO, EAT, ST, KFK, AKA, AT, and KA contributed to drafting of the manuscript. All authors critically reviewed and approved the final manuscript for submission. FAB and KPA supervised the project.

Acknowledgments

We would like to acknowledge Raji Muftawu, Abigail Agyemang, Williams Cobbinah, Vida Addo and Ben Tampaa Chipie who did the data collection. We wish to thank all District Directors of Health Service and management teams of hospitals in the Bono East region of Ghana for the support they provided during the data collection.

References

1. WHO. WHO Coronavirus (COVID-19) Dashboard. Published 2021. Accessed October 28, 2021. covid19.who.int.
2. Chirico F, Nucera G, Magnavita N. COVID-19: protecting healthcare workers is a priority. *Infect Control Hosp Epidemiol*. 2020. Published online1-1.
3. Sahu AK, Amrithanand VT, Mathew R, Aggarwal P, Nayer J, Bhoi S. COVID-19 in health care workers – a systematic review and meta-analysis. *Am J Emerg Med*. 2020;38:1727–1731.
4. Erdem H, Lucey DR. Healthcare worker infections and deaths due to COVID-19: a survey from 37 nations and a call for WHO to post national data on their website. *Int J Infect Dis*. 2021;102:239–241.
5. WHO. Over 10 000 health workers in Africa infected with COVID-19. WHO | Regional Office for Africa. Published July 2020. Accessed September 6, 2020. afro.who.int/news/over-10-000-health-workers-africa-infected-covid-19.
6. Lan FY, Filler R, Mathew S, et al. Sociodemographic risk factors for coronavirus disease 2019 (COVID-19) infection among Massachusetts healthcare workers: a retrospective cohort study. *Infect Control Hosp Epidemiol*. 2021:1–6. Published online.
7. Mhango M, Dzobo M, Chitungo I, Dzinamarira T. COVID-19 risk factors among health workers: a rapid review. *Saf Health Work*. 2020;11:262–265.
8. Nienhaus A, Hod R. COVID-19 among Health Workers in Germany and Malaysia. *Int J Environ Res Public Health*. 2020;17:4881.
9. Ashinyo ME, Dubik SD, Duti V, et al. Infection prevention and control compliance among exposed healthcare workers in COVID-19 treatment centers in Ghana: a descriptive cross-sectional study. *PLOS One*. 2021;16:e0248282.
10. Gesesew HA, Koye DN, Fetene DM, et al. Risk factors for COVID-19 infection, disease severity and related deaths in Africa: a systematic review. *BMJ Open*. 2021;11:e044618.
11. PHCPI. Utilizing Primary Health Care for COVID-19 Testing and Contact Tracing in Ghana: COVID-19 Promising Practices [Interview]. Published online 2020. Accessed September 16, 2022. https://improvingphc.org/sites/default/files/Ghana_Testing%20and%20contact%20tracing.pdf.
12. Ministry of Health, Ghana. Provisional Standard Treatment Guidelines for Novel Coronavirus Infection COVID - 19 Guidelines for Ghana. *Standard Treatment Guidelines*.. 7th ed. Ghana National Drugs Programme, MOH; 2020:7–28.
13. WHO. Assessment of risk factors for coronavirus disease 2019 (COVID-19) in health workers: protocol for a case-control study. Published online 2020. Accessed September 16, 2022. All of the WHO. https:who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/early-investigations.
14. Akagbo SE, Nortey P, Ackumey MM. Knowledge of standard precautions and barriers to compliance among healthcare workers in the Lower Manya Krobo District, Ghana. *BMC Res Notes*. 2017;10.

15. ODK Inc. KoBoCollect; 2020. Accessed September 16, 2022. https://docs.opendatakit.org/.
16. Arlinghaus KR, Johnston CA. Advocating for behavior change with education. *Am J Lifestyle Med*. 2017;12:113–116.
17. Stangerup M, Hansen MB, Hansen R, et al. Hand hygiene compliance of healthcare workers before and during the COVID-19 pandemic: a long-term follow-up study. *Am J Infect Control*. 2021;49:1118–1122.
18. Huang F, Armando M, Dufau S, Florea O, Brouqui P, Boudjema S. COVID-19 outbreak and healthcare worker behavioural change toward hand hygiene practices. *J Hosp Infect*. 2021;111:27–34.
19. Archana A, Jennifer G, Stanly AM, Paul C. A study on personal protective equipment use among health care providers, Tamil Nadu. *Int J Commun Med Public Health*. 2018. Published online March 27.
20. Alao MA, Durodola AO, Ibrahim OR, Asinobi OA. Assessment of health workers' knowledge, beliefs, attitudes, and use of personal protective equipment for prevention of COVID-19 infection in low-resource settings. *Adv Public Health*. 2020;2020:e4619214.
21. Ayisi-Boateng NK, Singh A, Abu-Sakyi J, Tawiah P, Darkwa I, Wusu-Ansah OK. Fighting the COVID-19 pandemic in Ghana: a report from the Kwame Nkrumah University of Science and Technology, Kumasi. *Pan Afr Med J*. 2020;37(suppl 1):43.