Received: 15 January 2023 | Revised: 6 June 2023 | Accepted: 8 June 2023

DOI: 10.1002/hsr2.1365

ORIGINAL RESEARCH

Health Science Reports Open Access WILEY

Adherence to infection prevention and control measures and risk of exposure among health-care workers: A cross-sectional study from the early period of COVID-19 pandemic in Addis Ababa, Ethiopia

Abel Weldetinsae[1] | Zinabu A. Alemu[1] | Kirubel Tefaye[1] | Melaku Gizaw[1] | Ermias Alemahyehu[1] | Adamu Tayachew[1] | Sisay Derso[1] | Moa Abate[1] | Mesaye Getachew[1] | Daniel Abera[1] | Arone Mebrhatu[1] | Higu Kefale[2] | Shambel Habebe[1] | Tsigereda Assefa[1] | Aderajew Mekonnen[1] | Getachew Tollera[1] | Masresha Tessema[1]

[1]Ethiopian Public Health Institute, Addis Ababa, Ethiopia

[2]Ethiopia Ministry of Health, Addis Ababa, Ethiopia

Correspondence
Abel Weldetinsae, Ethiopian Public Health Institute, P.O.Box: 1242, Addis Ababa, Ethiopia.
Email: abelweldetinsae@gmail.com

Abstract

Background and Aim: Healthcare workers (HCWs) are considered a high-risk group for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) exposure, ascribed to the amount of time they spend in health-care facilities (HCFs). This study aimed to assess HCWs' compliance with Infection Prevention and Control (IPC) procedures and the risk of exposure during the early period of the pandemic in Addis Ababa, Ethiopia.

Methods: A descriptive cross-sectional survey was conducted from June to September 2020. With a response rate of 79.2%, a standardized questionnaire was administered among 247 HCWs, working in eight HCFs. Descriptive and multivariate regression analysis was carried out in STATA version 16.

Results: About 22.5% (55) of the HCWs had proper adherence to IPC procedures. Of the total participants, 28.2% (69) had proper use of Personal Protective Equipment (PPE), 40% (98) had proper hand hygiene practices, and 33.1% (81) had frequently cleaned their working environment. HCWs who received training on IPC protocols were four times more likely to follow IPC standards than those with no training (adjusted odds ratio [AOR] = 3.93; 95% confidence interval [CI]: 1.46, 10.58). Besides, HCWs working in treatment centers were four times more likely to follow IPC standards than those working in conventional hospitals (AOR = 3.61; 95% CI:1.63, 8.02). Nurses were four times more likely to have adherence to IPC measures than cleaners and runners (AOR = 4.37; 95% CI: 1.38–13.88).

Abbreviations: AGPs, Aerosol Generating Procedures; AOR, Adjusted Odds Ratios; CI, Confidence Interval; COR, Crude Odds Ratios; HCWs, Health Care Workers; ICU, Intensive Care Unit; IPC, Infection and Prevention Control; LMICs, Low and Middle-Income Countries; PPE, Personal Protective Equipment; WaSH, Water Sanitation and Hygiene; WHO, World Health Organization.

Conclusion: The nature and magnitude of the pandemic did not introduce the required degree of adherence to IPC procedures, *per se* does not match the level of diligence needed to halt SARS-CoV-2 transmission. Our finding suggested that providing periodic training of HCWs with particular emphasis on nonclinical staff is commendable. Furthermore, it is necessary to maintain resilent IPC in HCF through continous follow up and safety drills, to assess the readiness of HFCs' adherance to IPC measures under normal circumstances, which could improve prepardeness for an effective response during epidemics.

KEYWORDS
fomite, hygiene, infection-prevention, SARS-CoV-2

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic, which was speculated to be originated in Wuhan, China has ravaged every part of the world. The first case was reported in 2019 and on March 11, 2020, the World Health Organization (WHO) declared the incident a pandemic. Since the onset of the pandemic, health systems, countries' economies, and personal lives were disturbed by the virus.[1–3] In Ethiopia, as of December 22, 2022, there have been 495,348 confirmed cases of COVID-19, with 7572 deaths, reported to the WHO. The WHO acknowledged two distinct routes of transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus: respiratory and contact modes. Any subject who is in close contact with someone who sneezes and coughs is regarded as at risk of exposure to infective respiratory droplets. Contact-based transmission is also characterized by actions of handling or touching fomites that are deemed to be touched or used by COVID-19 patients.[4,5]

Healthcare workers (HCWs) are regarded as a high-risk group, for the reason that they spend a considerable amount of time in health-care facilities (HCFs), while having contact with patients and their surroundings. Any mishap of reluctantly adhering to infection prevention protocols could increase their risk of exposure. Implementing infection prevention and control (IPC) measures in healthcare settings is crucial to minimize the spread of infectious illnesses.[6,7]

One notable study conducted in China has identified that HCWs have a significantly higher contact infection rate than non-HCWs.[8] Especially during the early period of the pandemic, HCWs were exceedingly infected with SARS-CoV-2. The proportion has ranged from 15% to 18% and in some settings, up to 20% of the infected population were HCWs. We could not identify this figure in Ethiopia, though it is reported in cross-sectional studies that in 1997 sera samples of HCWs analyzed, the overall seroprevalence was closely 40.0%.[9] Another study reported confirmed SARS-CoV-2 infection among 19% of the HCWs.[10]

Before the pandemic, the proper infection prevention practices in some selected hospitals of Addis Ababa were in the range of 55.0%–66.0%. Factors associated with adherence to IPC procedures were inaccessibility of training and IPC guidelines, lack of the appropriate supply, educational background, and healthcare setting among others.[11] Also, some studies conducted at the later stage of the pandemic have indicated similar patterns of HCWs' compliance with infection prevention measures.[12–15] One might anticipate that HCWs' adherence to IPC measures during the COVID-19 epidemic would improve more than in previous encounters. In addition, HCWs' observance during the first wave of the pandemic was expected to be more vigilant to follow all the IPC protocols while interacting with their patients and their surroundings. Consequently, this article was destined to put this assumption into the evaluation and decipher the state of adherence to IPC protocols among HCWs, working in conventional hospitals and makeshift HCFs of Addis Ababa. It was aimed further, to identify factors associated with adherence to IPC procedures.

2 | METHODS

2.1 | Study design

A descriptive cross-sectional survey was conducted from mid of June to the end of September 2020.

2.2 | Setting

The study was conducted in Addis Ababa city administration, the capital city of Ethiopia and geographically located at the latitude of 9° 1′ North and longitude of 38° 44′ East.[16] Addis Ababa is a political and economic center for Ethiopia and Africa.[17] The city is organized into 10 sub–cities with a projected total population of 3.65 million.[18]

The health facilities selected for this survey were, St. Paul's Hospital Millennium Medical College-SPHMMC, Yekatit 12 Hospital, Millennium COVID-19 Care Center, Ekka Kotebe COVID-19 Treatment Center, Addis Ababa Science and Technology University COVID-19 Isolation and Quarantine Center, Hallelujah General

Hospital, Silk Road General Hospital. The first four health facilities are government-owned hospitals. The last two are privately owned hospitals. Before the outbreak of the pandemic, the hospitals were providing advanced and routine health services for the general public. Whereas, Addis Ababa Science and Technology University, Millennium Care Center, and Ekka Kotebe Treatment Center were converted into COVID-19 makeshift hospitals intended to handle the surge of COVID-19 cases.

During the study period, a total of 5160 confirmed COVID-19 cases were recorded in the country and 48 deaths were reported. The early period can be characterized by an intense panic of the general public and busy treatment centers.

2.3 | Study population

Medical doctors, health officers, nurses, porters, and cleaners were the study participants. Those, who were providing and have direct involvement in patient care were eligible for inclusion in the study. HCWs who were not providing services for consecutive 2 weeks before the interview and those who were critically ill during the study period were excluded from the study.

2.4 | Outcome variables and operational definitions

As shown in Table 1, the outcome variables are composite variables specified as IPC domains.

2.5 | Source of bias and control

Since HCWs' adherence to IPC standards are self-reported variables, the Hawthorne effect was identified as a source of bias. During the interview process, the effect was controlled keeping participants' response completely anonymous or confidential, so as participants could less likely alter their response as a result of taking part in the study.

2.6 | Data sources

A standardized questionnaire was adapted from WHO's interim guidance document.[3] It was applied to evaluate the adherence of HCWs to the IPC codes of conduct. The questionnaire was composed of six subsections. The first three sections were focused on general information about the

TABLE 1 Operational definition and/or action of compliance for outcome variables of standard precautionary measures and risk of exposure.

IPC domain	Action of compliance	Required level of compliance
Proper use of PPE	Use and frequency of PPE (Glove, surgical/N-95 mask, googles[a], gown[a]) during health-care interaction with COVID-19 patient	Always as recommended[b]
	Remove and replace PPE according to the protocol (e.g., when the medical mask is wet and when changing gloves)	Always as recommended[b]
Proper hand hygiene	Perform hand hygiene before and after touching COVID-19 patients, materials, surrounding	Always as recommended[b]
	Perform hand hygiene before and after any clean or aseptic procedure was performed (e.g., inserting: peripheric vascular catheter, urinary catheter, intubation, etc.).	Always as recommended[b]
	Perform hand hygiene after exposure to body fluid	Always as recommended[b]
	Perform hand hygiene after touching the COVID-19 patient's surroundings (bed, door handle, etc). Note: This is irrespective of wearing gloves	Always as recommended[b]
Proper environmental cleaning	During the period of health-care interaction with the COVID-19 case, HCW decontaminated high-touch surfaces frequently.	at least three times daily
Risk level	The risk level is defined based on the response matrix of the above IPC domains. Any response other than Always as recommended, such as most of the time[c], occasionally[d], and rarely[e] sets the HCW at higher risk of exposure to SARS-CoV-2.	
Conventional hospitals	Are health facilities that used to give routine medical treatment to the general public before and after the emergence of the pandemic.	
COVID-19 treatment centers	Are either makeshift facilities or hospitals exclusively assigned only to treat COVID-19 patients.	

Abbreviations: COVID-19, coronavirus disease 2019; HCW, health-care workers; IPC, Infection Prevention and Control; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[a]Depending on the risk level. Where

[b]Means more than 95% of the time

[c]Means 50% or more but not 100%

[d]Means 20% to under 50% and

[e]Means less than 20%.

HCW and the work he/she did on COVID-19 patients; the rest were focused on the adherence of the HCW toward standard and transmission-based precautionary measures while treating/managing the patient. Nurses and medical doctors/officers were provided with the questionnaire and allowed to self-administer the questionnaire. On the contrary for nonclinical personnel, such as hospital cleaners and runners, the questions were read out to them by a qualified interviewer. Operational definition and/or action of compliance for outcome variables used in the questionnaire are summarized in Table 1.

2.7 | Sample size

Before sample size estimation, the population size of the healthcare workforce providing direct or indirect care to COVID-19 patients in eight COVID-19 treatment and hospitals located in Addis Ababa was collected; the total population was found to be 976. Applying Yamane,[19] sample size estimation formula (Equation 1) and taking a 95% confidence interval ($e = 0.05$), the sample size was calculated to be closely 284. With the consideration of a 10% nonresponse rate, the overall sample size was 312. During the interview, the response rate was 79.2% and only 247 of the HCWs were interested to take part in the interview process of this two of the questionnaires were void because they were not complete.

$$n = \frac{N}{1} + N(e2)... \quad (1)$$

2.8 | Statistical methods

The data were cleaned and analyzed by STATA (version 16) software. Descriptive statistics of the distribution of adherence to IPC measures and risk level of HCWs exposure to SARS-CoV-2 across sociodemographic and environmental disparities was generated. To examine the association between the exploratory variable and adherence to standard precautionary measures and risk of exposure to SARS-CoV-2, a multivariate logistic regression was employed. The study used Cronbach's α[20] to measure the reliability of items for both outcome variables. The results showed that the items used to predict the adherence to IPC standards ($\alpha = 0.851$) and SARS-CoV-2 exposure risk level ($\alpha = 0.851$) were reliable. Bivariate and multivariate logistic regressions were used to identify associated factors, and variables with a p value of >0.2 were excluded in the multivariate analysis. The study used odds ratios and 95% confidence intervals to measure the association between the exploratory and outcome variables and determined that the models fit well based on Pearson goodness-of-fit tests.[21] Both models for adherence to IPC standards and SARS-CoV-2 exposure risk level of HCWs were found to be fitted with the observed data, with p values greater than 0.05 (0.261 and 0.148, respectively).

2.9 | Ethical review

Ethical approval was obtained from Ethiopian Public Health Institute, Institutional Review Board, a reference number, EPHI-IRB-263-2020. Written and verbal permission from managers or heads of each health facility was obtained. Besides, written consent was obtained from each respondent. The interviewee's confidentiality was maintained throughout the investigation, in which each participant was assigned a study identification number.

3 | RESULTS

3.1 | Demographic characteristics of HCWs

In this investigation, a total of 245 HCWs participated. Of the total respondents, 51% were male. Nearly, one-third (30.6%) of the participants were hospital cleaners and porters. In addition, 45.7% and 23.8% of the respondents were nurses and medical doctors/officers, respectively. The mean age of the respondents was 28 years. Almost three-fourths (72.2%) of the respondents were working in conventional hospitals and 27.8% of participants were engaged in makeshift treatment facilities and hospitals designated to treat COVID-19 patients. In addition, 25.7% of the respondents had not received standardized training on COVID-19 patient management and IPC measures (Table 2).

3.2 | HCWS' adherence to standard precautionary measures

HCWs' adherence to standard precautionary measures was measured as an aggregate of practices of proper hand hygiene, and personal protective equipment uses. Table 3 shows the distribution of standard precautionary measures across covariates of sociodemographic and environmental conditions. Of the number of HCWs, who have been providing direct care to patients ($N = 245$), only 22.5% (55) of them had proper adherence to IPC procedures. Similarly, as shown in Figures 1 and 2, 28.2% (69) had proper PPE use, 40% (98) had proper hand hygiene practices, and 33.1% (81) had frequently cleaned their working environment.

3.3 | Adherence to hand hygiene practices

To document the hand hygiene practice, workers were asked if they use water, soap, and/or alcohol rub before and after touching a patient, performing the aseptic procedure, and when exposed to body fluid and the patient's surroundings. Of the total participants ($N = 245$), only 69% of the participants kept their hand hygiene at all times. Comparatively, workers had better practices during and after performing aseptic procedures (78.0%) and body fluid exposure (79.8%) than when contacting patients (70.2%) and their surroundings (66.1%) (Table 3).

3.4 | Adherence to PPE use

In this article, proper PPE use is defined as the use of all the necessary PPEs, such as surgical gloves, N-95 masks, gowns, and

TABLE 2 Demographic characteristics of health-care workers (*N* = 245).

Study variables	Frequency	Percentage
Sex		
Female	120	49
Male	125	51
Age		
Age ≤ 28	159	64.9
Age >28	86	35.1
Training		
No	63	25.7
Yes	182	74.3
HCF cadres		
Porter/runner	75	30.6
Nurse	112	45.7
Medical doctors	58	23.7
Facility type		
Conventional Hospital	177	72.2
COVID-19 treatment center	68	27.8
Contact frequency with patients		
No contacts	69	28.16
<10 times	57	23.27
10–50 times	46	18.78
>50 times	73	29.8

Abbreviations: COVID-19, coronavirus disease 2019; HCF, health-care facilities.

google, when interacting with patients and their surroundings. It also encompasses the proper removal of these items after using them. In this regard, of the respondents (N = 245), very few proportions of HCWs had proper use of PPE (28.2%) and 48% of them followed the protocol for proper removal of PPE (Table 3). Furthermore, as shown in Table 3, more workers in treatment facilities, 54.4%, had proper removal than those in conventional hospitals. Only 12% of cleaners and porters followed the appropriate utilization of PPE.

3.5 | Adherence to environmental cleaning

The national COVID-19 guidance document recommends that HCWs clean their working environment at least three times per day. As per our observation almost all facilities except Silkroad general Hospital and Halelujia general hospital clean the health-care facilities on two shifts, often early in the morning and during the afternoon period. To supplement this observation workers were asked if they disinfect and clean their working environment as recommended. As shown in Figure 3, only 33.1% (81) of HCWs (*N* = 245) cleaned their environment after tending to their patients.

3.6 | Multivariate analysis of factors associated with IPC measures

After adjusting for other confounders, in the multivariate analysis except for the age of the HCWs, sex, exposure to IPC training, HCWs' profession, and type of facility became significant predictors of HCWs' adherence to standard precautionary measures.

As shown in Table 4, more females 70.9% (39) tend to adhere to standard precautionary measures than males 29.1% (16). Males were 0.28 times less likely to adhere to standard precautionary measures compared with females (adjusted odds ratio [AOR] = 0.28; 95% confidence interval [CI]: 0.14, 0.59). On the other hand, training significantly determined workers' adherence to proper hand hygiene and PPE use, thereof workers who have received training on infection prevention and control (IPC) were four times more likely to follow standard precautionary measures than workers who did not receive the training (AOR = 3.93; 95% CI: 1.46, 10.58). Similarly, facility type was found to be a significant predictor of adherence of workers to standard precautionary measures. Wherein, those providing patient care in treatment centers were approximately four times more likely to follow all standard precautionary measures than those working in conventional hospitals (AOR = 3.61; 95% CI: 1.63, 8.02). Furthermore, adjusting for sex, access to IPC training, the purpose of health facility, HCWs' presences during aerosol generating procedure (AGP), and contact with fomites, the multivariate logistic regression model has identified that the profession of the health-care workers found to be a significant predictor of adherence to standard precautionary measures. To be specific, nurses were four times more likely to have adherence to standard precautionary measures than cleaners and runners (AOR = 4.37; 95% CI: 1.38–13.88), while medical doctors and health officers tend to be approximately 10 times more likely to adhere to standard IPC practices during interactions with patients (AOR = 9.74; 95% CI: 2.88–32.97).

3.7 | Risk of exposure among HCWs

Risk of exposure is an index generated out of workers' responses to a question if they had encountered an occupational accident and failed to adhere to one and more standard precautionary measures, while providing care to the COVID-19 patient, touching patient materials and surroundings, and functioning inside the HCF and/or aerosol-generating procedures (AGPS). With this regard, of the total respondents (*N* = 245), the majority of HCWs 81.6% (200), were at high risk of exposure.

As shown in Table 5, the Sex of the HCW, training, profession, and purpose of the center was identified as predictors that significantly explain HCW's risk of exposure. Even though cleaners

TABLE 3 The proportion of adherence to IPC measures by Health care cadre and facility type among HCWs working in treatment facilities and non-COVID-19 hospitals ($N = 245$), in Addis Ababa, Ethiopia.

IPC procedure		HCF cadres			Type of facility		Total
		Medical doctors	Nurse	Porter/ runner	Conventional hospital	COVID-19 treatment center	
Hand washing							
Before and after touching the patient	Always	38 (65.5)	71 (63.4)	9 (12.0)	82 (46.3)	36 (52.9)	118 (48.2)
	Most time	14 (24.1)	30 (26.8)	13 (17.3)	43 (24.3)	14 (20.6)	57 (23.3)
	Occasionally	3 (5.2)	4 (3.6)	33 (44.0)	33 (18.6)	7 (10.3)	40 (16.3)
	Rarely	3 (5.2)	7 (6.3)	20 (26.7)	19 (10.7)	11 (16.2)	30 (12.2)
Before and after any aseptic procedure	Always	40 (69.0)	82 (73.2)	9 (12.0)	92 (52.0)	39 (57.4)	131 (53.5)
	Most time	12 (20.7)	21 (18.8)	5 (6.7)	30 (16.9)	8 (11.8)	38 (15.5)
	Occasionally	1 (1.7)	2 (1.8)	13 (17.3)	12 (6.8)	4 (5.9)	16 (6.5)
	Rarely	5 (8.6)	7 (6.3)	48 (64.0)	43 (24.3)	17 (25.0)	60 (24.5)
After exposure to body fluid	Always	42 (72.4)	83 (74.1)	9 (12.0)	94 (53.1)	40 (58.8)	134 (54.7)
	Most time	11 (19.0)	19 (17.0)	17 (22.7)	34 (19.2)	13 (19.1)	47 (19.2)
	Occasionally	2 (3.4)	3 (2.7)	32 (42.7)	28 (15.8)	9 (13.2)	37 (15.1)
	Rarely	3 (5.2)	7 (6.3)	17 (22.7)	21 (11.9)	6 (8.8)	27 (11.0)
After touching the patient's surroundings	Always	38 (65.5)	66 (58.9)	7 (9.3)	76 (42.9)	35 (51.5)	111 (45.3)
	Most time	8 (13.8)	30 (26.8)	14 (18.7)	41 (23.2)	11 (16.2)	52 (21.2)
	Occasionally	6 (10.3)	11 (9.8)	35 (46.7)	35 (19.8)	17 (25.0)	52 (21.2)
	Rarely	6 (10.3)	5 (4.5)	19 (25.3)	25 (14.1)	5 (7.4)	30 (12.2)
Type of PPE and its removal							
Glove	Always	43 (74.1)	69 (61.6)	9 (12.0)	89 (50.3)	32 (47.1)	121 (49.4)
	Most time	12 (20.7)	25 (22.3)	5 (6.7)	27 (15.3)	15 (22.1)	42 (17.1)
	Occasionally	1 (1.7)	2 (1.8)	41 (54.7)	28 (15.8)	16 (23.5)	44 (18.0)
	Rarely	2 (3.4)	16 (14.3)	20 (26.7)	33 (18.6)	5 (7.4)	38 (15.5)
Mask	Always	49 (84.5)	92 (82.1)	8 (10.7)	110 (62.1)	39 (57.4)	149 (60.8)
	Most time	4 (6.9)	17 (15.2)	6 (8.0)	17 (9.6)	10 (14.7)	27 (11.0)
	Occasionally	2 (3.4)	0 (0.0)	41 (54.7)	26 (14.7)	17 (25.0)	43 (17.6)
	Rarely	3 (5.2)	3 (2.7)	20 (26.7)	24 (13.6)	2 (2.9)	26 (10.6)
Google	Always	39 (67.2)	84 (75.0)	7 (9.3)	89 (50.3)	41 (60.3)	130 (53.1)
	Most time	12 (20.7)	18 (16.1)	7 (9.3)	30 (16.9)	7 (10.3)	37 (15.1)
	Occasionally	5 (8.6)	4 (3.6)	13 (17.3)	20 (11.3)	2 (2.9)	22 (9.0)
	Rarely	2 (3.4)	6 (5.4)	48 (64.0)	38 (21.5)	18 (26.5)	56 (22.9)
Gown	Always	43 (74.1)	72 (64.3)	8 (10.7)	89 (50.3)	34 (50.0)	123 (50.2)
	Most time	11 (19.0)	22 (19.6)	7 (9.3)	33 (18.6)	7 (10.3)	40 (16.3)
	Occasionally	1 (1.7)	8 (7.1)	44 (58.7)	33 (18.6)	20 (29.4)	53 (21.6)
	Rarely	3 (5.2)	10 (8.9)	16 (21.3)	22 (12.4)	7 (10.3)	29 (11.8)
Proper PPE removal	Always	35 (60.3)	74 (66.1)	9 (12.0)	81 (45.8)	37 (54.4)	118 (48.2)
	Most time	16 (27.6)	18 (16.1)	2 (2.7)	29 (16.4)	7 (10.3)	36 (14.7)
	Occasionally	0 (0.0)	10 (8.9)	35 (46.7)	35 (19.8)	10 (14.7)	45 (18.4)
	Rarely	7 (12.1)	10 (8.9)	29 (38.7)	32 (18.1)	14 (20.6)	46 (18.8)

TABLE 3 (Continued)

IPC procedure		HCF cadres: Medical doctors	Nurse	Porter/runner	Type of facility: Conventional hospital	COVID-19 treatment center	Total
Environmental cleaning							
Surfaces decontaminate	Always	27 (46.6)	50 (44.6)	4 (5.3)	52 (29.4)	29 (42.6)	81 (33.1)
	Most time	10 (17.2)	43 (38.4)	4 (5.3)	46 (26.0)	11 (16.2)	57 (23.3)
	Occasionally	11 (19.0)	13 (11.6)	48 (64.0)	50 (28.2)	22 (32.4)	72 (29.4)
	Rarely	10 (17.2)	6 (5.4)	19 (25.3)	29 (16.4)	6 (8.8)	35 (14.3)

Abbreviations: HCW, Healthcare worker; IPC, Infection Prevention and Control; PPE, personal protective equipment.

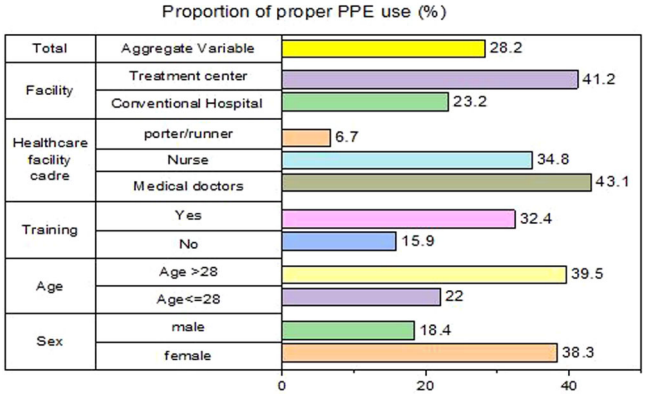

FIGURE 1 The proportion of adherence to proper personal protective equipment (PPE) use among health-care workers (HCWs) working in treatment facilities and non-coronavirus disease 2019 (COVID-19) hospitals, in Addis Ababa, Ethiopia.

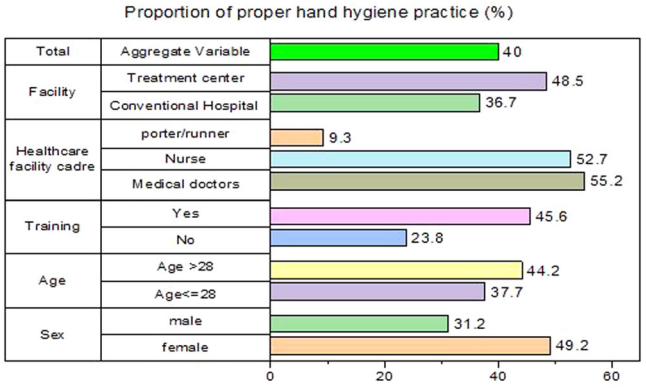

FIGURE 2 The proportion of adherence to hand hygiene practice among health-care workers (HCWs) working in treatment facilities and non-coronavirus disease 2019 (COVID-19) hospitals, in Addis Ababa, Ethiopia.

and runners had poor adherence to standard precautionary measures, medical doctors tend to have a much higher risk of exposure to SARS-CoV-2 than cleaners/porters. The multivariate logistic regression model result indicated that nurses were two times (AOR = 2.35; 95% CI: 0.99, 5.58) and Medical doctors seven times more likely (AOR = 7.35; 95% CI: 2.11, 255.58) to be at higher risk of exposure to SARS-CoV-2 than cleaners and runners. HCWs working in COVID-19 treatment centers were 0.31 less likely to be at high risk of exposure when compared with non-COVID-19 health facilities (AOR = 0.31; 95% CI: 0.13, 0.72). Male workers were 6.16 times more likely to be at higher risk of exposure than female HCWs (AOR = 6.16; 95% CI: 2.63, 14.42).

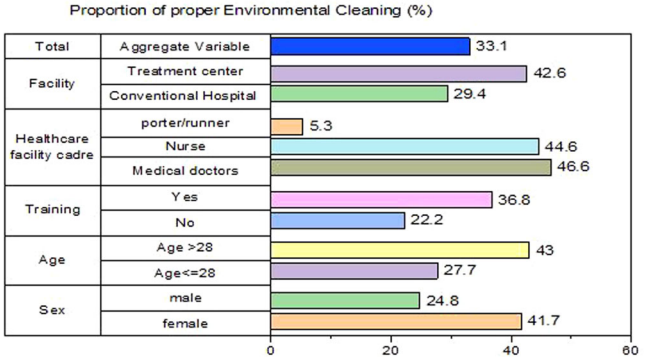

FIGURE 3 The proportion of adherence to Environmental Cleaning among health-care workers (HCWs) working in treatment facilities and non-coronavirus disease 2019 (COVID-19) hospitals, in Addis Ababa, Ethiopia.

4 | DISCUSSION

This research aimed to assess the level of HCWs' compliance with standard IPC procedures and the risk level of exposure to SARS-CoV-2. According to the WHO guidance for COVID-19 risk assessment, HCWs are considered to have proper adherence to IPC procedures, if they strictly adhere (at least 95% of the time) to hand hygiene practices, proper use of PPE, and decontamination of high-touch areas. Any poor adherence to the IPC code of conduct is considered a risk factor for exposure to SARS-CoV-2 or will set HCWs in the high-risk group.[3] In this regard, our survey identified that 81.6% (200) of the HCWs were categorized as a high-risk group. The proportion of HCWs falling within

TABLE 4 Adherence to standard precautionary measures using binary and multivariate analysis.

Characteristics ($N = 245$)	Standard precaution measures, *n* (%) Yes	No	*p* value	COR [95% CI]	*p* value	AOR [95% CI]
Sex						
Female	39 (70.9)	81 (42.6)		1		1
Male	16 (29.1)	109 (57.4)	0	0.3 [0.16, 0.58]	<0.001	0.28 [0.14, 0.59]
Age						
<=28 age	28 (50.9)	131 (68.9)	.	1	.	1
>28 age	27 (49.1)	59 (31.1)	0.01	2.14 [1.16, 3.95]	0.09	1.85 [0.91, 3.78]
Training						
No	7 (12.7)	56 (29.5)	.	1	.	1
Yes	48 (87.3)	134 (70.5)	0.02	2.87 [1.22, 6.72]	0.01	3.93 [1.46, 10.58]
HCF cadres						
Porter/runner	4 (7.3)	71 (37.4)	.	1	.	1
Nurse	28 (50.9)	84 (44.2)	0	5.92 [1.98, 17.67]	0.01	4.37 [1.38, 13.88]
Medical doctors	23 (41.8)	35 (18.4)	0	11.66 [3.74, 36.34]	<0.001	9.74 [2.88, 32.97]
Centers						
Conventional Hospital	33 (60.0)	144 (75.8)	.	1	.	1
Treatment center	22 (40.0)	46 (24.2)	0.02	2.09 [1.11, 3.93]	<0.001	3.61 [1.63, 8.02]
Contact frequency						
No contacts	10 (18.2)	59 (31.1)	.	1	.	1
<10 times	13 (23.6)	44 (23.2)	0.23	1.74 [0.7, 4.34]	0.21	1.96 [0.69, 5.6]
10–50 times	16 (29.1)	30 (15.8)	0.01	3.15 [1.27, 7.77]	0.02	3.53 [1.2, 10.35]
>50 times	16 (29.1)	57 (30.0)	0.26	1.66 [0.69, 3.95]	0.53	1.37 [0.51, 3.72]
Total	55 (22.5)	190 (77.5)				

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratios; HCF, health-care facility.

the high-risk group was higher compared with other similar studies conducted in Ethiopia.[10,20] The majority of the HCWs fall within the high-risk group because they had poor adherence to IPC procedures (poor hand hygiene practice during and after contact with patients, their material, and surroundings; improper use of PPE and poor practice of decontaminating high-touch areas).

In line with this, our finding also provided evidence that workers working during the early period of the COVID-19 pandemic in COVID-19 treatment and hospitals of Addis Ababa had very poor adherence to proper hand hygiene and personal protective equipment use. Accordingly, only less than a quarter of the HCWs (22.5% (55)) were following IPC procedures. When disaggregated only 40.0% (98) and 28.2% (69) of the respondents had proper hand hygiene and PPE use, respectively. A consistent result was reported in different studies.[14,21,22] None of the research conducted in the HCFs of Addis Ababa matched our findings.[23–25] Observed heterogeneity across studies might be a factor of variability in terms of facility type, study period, workers' acquaintance with IPC training, and provision of materials and infrastructure reliability can be the reasons and causes for the difference. In recognition of this, a state of poor adherence to IPC among HCWs identified in this research might be better explained with the facility type that the HCWs were working in and the study period, that is, early period of COVID-pandemic in Ethiopia. Since some of the health facilities were makeshift health facilities, they lacked the appropriate infrastructure and resources to implement COVID-19-related IPC measures. Moreover, the early period of the pandemic challenged countries like Ethiopia in acquiring the required resources to break the transmission. One notable global challenge faced at the outset of the COVID-pandemic was that countries had limited access to consumables and physical structures relevant to breaking the transmission of SARS-CoV-2 in a health-care setting.[26] A critical note by Patel et al.,[27] might further suffice the argument, that in developing countries access to clean water and hand rub alcohol are self-limiting to HCWs to practice hand hygiene and other IPC practices. By far, most papers reviewed,[20,28,29] strengthen this claim, however, the readiness of facilities in terms of access to water and disinfectant was not measured. In this study, therefore a conclusive remark cannot be drawn, though this does not exclude the importance of ensuring facility readiness during pandemics. Future assessments are commendable to map the

TABLE 5 Risk of exposure among health-care workers using binary and multivariate analysis.

Characteristics (*N* = 245)	Risk level, *n* (%)		*p* value	COR (95% CI)	*p* value	AOR (95% CI)
	High risk	Low risk				
Sex						
Female	84 (42.0)	36 (80.0)		1		1
Male	116 (58.0)	9 (20.0)	0	5.52 [2.53, 12.08]	<0.001	6.16 [2.63, 14.42]
Age						
≤28 age	136 (68.0)	23 (51.1)	.	1	.	1
>28 age	64 (32.0)	22 (48.9)	0.03	0.49 [0.26, 0.95]	0.14	0.56 [0.26, 1.22]
Training						
No	56 (28.0)	7 (15.6)	.	1	.	1
Yes	144 (72.0)	38 (84.4)	0.09	0.47 [0.2, 1.12]	0.06	0.38 [0.14, 1.03]
Healthcare facility cadre						
Porter/runner	39 (19.5)	19 (42.2)	.	1	.	1
Nurse	90 (45.0)	22 (48.9)	0.06	1.99 [0.97, 4.09]	0.05	2.35 [0.99, 5.58]
Medical doctors	71 (35.5)	4 (8.9)	0	8.65 [2.75, 27.22]	<0.001	7.35 [2.11, 25.58]
Centers						
Conventional Hospital	150 (75.0)	27 (60.0)	.	1	.	1
Treatment center	50 (25.0)	18 (40.0)	0.04	0.5 [0.25, 0.98]	0.01	0.31 [0.13, 0.72]
Contact frequency						
No contacts	60 (30.0)	9 (20.0)	.	1	.	1
<10 times	46 (23.0)	11 (24.4)	0.34	0.63 [0.24, 1.64]	0.3	0.56 [0.19, 1.67]
10–50 times	32 (16.0)	14 (31.1)	0.03	0.34 [0.13, 0.88]	0.05	0.32 [0.1, 0.99]
>50 times	62 (31.0)	11 (24.4)	0.73	0.85 [0.33, 2.19]	0.81	1.14 [0.39, 3.36]
Total	200 (81.6)	45 (18.4)				

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratios.

readiness of facilities in terms of facility engineering, availability of critical mass of consumables, access to WaSH services, IPC guideline, trained manpower, and so on, to address COVID-19 and other pandemics/epidemics.

Our study has further taken a step in the direction of defining the predictors of HCWs' adherence to safety precautionary measures in hospitals and makeshift COVID-19 treatment facilities found in Addis Ababa. To this effect, independent factors such as sex, exposure to IPC training, profession of the HCWs, and facility type have shown significant association with HCWs' adherence to IPC. Studies conducted in Ethiopia, before the COVID-19 pandemic has demonstrated sex as a significant factor in defining HCWs' adherence to IPC, though with an inconsistent variation in defining which gender has more adherence to IPC measures.[30–32] In the evaluation of this, we initially assumed that during the COVID-19 pandemic response, if workers are given the proper training and supervision, adherence to infection prevention protocols would be indifferent among men and women HCWs. However, the current finding explains that men were 80% times less likely to adhere to standard precautionary measures compared with females. Our finding was consistent with those studies conducted in different parts of Ethiopia [28,33] and reports from other LMICs.[34–36] Opposed to this, Tsegaye et al.[37] have identified better adherence among men than women HCWs. Whereas, a study by Jiee et al.,[38] from high-income countries has reported that sex has no effect on IPC adherence; rather workers' stress (burnout), workload, and exposure to IPC training were detrimental to maintaining proper IPC measures. Most of the reports lack to suggest why such variation among sex of the HCWs prevails, though the variation stated in this study can be an add-on of a plausible explanation made by Kemal Jemal et al.[28] According to them, Women tend to have better adherence to safety measures, because of their better experience of childcare and their sole responsibility in taking care of household activities, which might have imparted to them a more cautious attitude and higher responsibility than men. Further, this could be an extension of a generalized affirmation indicated by Wong et al.,[39] that women have better attitudes toward IPC, are willing to follow IPC guidelines and safety measures, and desire to deliver good patient care. However, these assertions need to be augmented with a thorough evaluation, as this article lacks to consider parameters of knowledge and attitude, as well as

socioeconomic variables which might also have an inherent impact on their performance.

Another important finding of the multivariate logistic regression was that profession of the HCWs was found to be a significant predictor of adherence to standard safety precautionary measures among HCWs. With a wider margin, both Medical doctors and nurses had a better likelihood of complying with proper IPC measures compared with the nonclinical staff, porters, or runners. This finding is consistent with earlier findings, suggesting that the professional backgrounds of HCWs are associated with adherence to IPC protocols.[37,40] On the contrary, being a medical doctor rather than a nurse was associated with lower compliance with standard precautionary measures such as hand hygiene, PPE use, and IPC practices.[41,42] Such discordant findings as was previously speculated might be due to variations in study settings, socioeconomic status of the study area, workload, and accessibility of the necessary consumables.[28,43]

Variations among cadres of the health facility, as observed in this study might be best explained with assertions of Tsegaye et al.,[37] of the conception that physicians tend to search for updated information due to their role in improving treatment outcomes for COVID-19 patients their inclination toward a continuous update of their knowledge might have given them an advantage in practicing IPC protocols effectively. Even though cleaners' and runners' educational level is not identified in this research, working in Ethiopian HCFs, seldom they are at the early stage of their educational attainment. Hence, this might have stalled them from accessing updated scientific information about the virus and the necessary IPC required while interacting with their surroundings.

Notwithstanding, one might also question if the appropriate training is provided to nonclinical workers, which might have contributed to wider variation in compliance with IPC protocols. Even though not addressed here, it is also worth evaluating the importance of workload and burnout which could affect HCWs' adherence to IPC.[28,38] Furthermore, nurses had lower IPC compliance than medical doctors. This could be due to the higher workload that nurses experience in Ethiopian HCFs than medical doctors. This can be further backed by data indicated in this research, that nurses had more frequent contact with patients than other health-care cadres, while interacting with patients and their surroundings.

Several studies have reported a strong link between strict adherence of HCWs to infection prevention measures and exposure to infection prevention training.[29,33,44] Some reports go even beyond this and identify knowledge and attitude as drivers of HCWs' adherence to IPC.[28,44–47] It appears also in this research that workers' acquaintance with standardized IPC training can positively influence infection prevention in the health-care environment. It is expressed elsewhere that pandemics such as COVID-19 have multifaceted nature, demanding periodic refreshing training on how to improve the prevention of nosocomial transmission of the virus as the science and care of the diseases advance and workers acquaintance with the development of new knowledge and practices can greatly benefit the improvement of workers knowledge, attitude, and practice.[48,49] Notably, when designing and conducting IPC training, considering the audience can enhance the effectiveness of the training. According to Patel et al.,[27] during the onset of the pandemic, training provided to developing countries, under the WHO guidance for infection prevention and emergency response was primarily directed, for instance in Ethiopia to only accommodate 4293 clinical practitioners, which has excluded the nonclinical workforce. It seems related to these shortcomings, that there is a wider gap in effective compliance with IPC practices among porters, runners, and hospital cleaners of health facilities in Addis Ababa. Another independent factor that was found significantly associated with HCWs' compliance with IPC practices was the health facility type that the workers render their services. Wherein, those providing patient care in COVID-19 treatment facilities were three times more likely to follow all standard precautionary measures than those working in isolation centers.

A pooled regression of Ethiopian studies on HCWs' compliance with IPC has shown that variation in IPC compliance across different types of HCFs can be evident. For instance, good compliance with COVID-19 preventive measures was 49.3% in studies conducted exclusively in hospitals and 52.4% among studies that included health centers and hospitals. The dichotomy was explained with variation in the location of the health facility; health facility level (Hospital Vs health centers) and unit within the HCF (ICU vs. emergency).[50] Variation in HCWs' compliance as indicated in our study, might be partly explained by the dichotomy of the nature of health facilities that hospitals versus makeshift COVID-19 facilities could have. On the other hand, the variation might be due to the condition that since HCWs working in COVID-19 treatment facilities were providing care to confirmed cases, they may have given extra care to comply with IPC protocols than those treating suspected or non-COVID-19 patients. Moreover, the conventional facilities might be overburdened with treating both confirmed and nonconfirmed cases, and the overcrowding at the health facilities might have created inconvenient working conditions to strictly implement the IPC measures. Such scenarios have been reported by many studies.[8,48,51,52] One might need to further decipher the performance psychology of workers working in different health-care settings, as this might provide us with directions on contents and modalities of training, supervision, and overall IPC improvement.

Although, the assessment was a success in defining the adherence level of HCWs to IPC procedures, the study has some limitations. The study lacks to identify HCWs' knowledge and attitude toward IPC standards. Albeit, variables of facility readiness in terms of access to water supply and availability of PPE materials in the HCFs are important to define workers' adherence to IPC practices, these variables were not included in the assessment. In addition, corroborating the self-reported response with real-time observation of practice could augment the self-reported response, while minimizing biases associated with the Hawthorne effect. Yet, the effect was tried to be controlled applying the interview process anonymously, protecting the confidentiality of the respondents.

5 | CONCLUSION

It was assumed that during the early period of the pandemic HCWs will act in full compliance with proper infection prevention and control measures, as their prudence toward actions of breaking the SARS-COV-2 transmission increases. The finding however goes against the assumption, only less than a quarter of the HCWs were compliant with the protocol of standard safety precautionary measures. The state and magnitude of the pandemic did not bring any changes of adherence to IPC procedures, the adherence level does not match the level of diligence needed to halt the transmission of the virus within the health-care environment. The majority of the HCWs were characterized by the poor practice of hand washing during and after contact with patients and their surroundings, poor or improper use of PPE, and poor or inadequate cleaning of frequently touched surfaces. In addition, adherence to infection prevention protocols was significantly associated with HCWs' sex, profession, access to training, and facility type. Our finding has also indicated the need for periodic and tailor-made training of HCWs about the IPC protocols that HCWs needed to be accustomed to the emerging science and practice of COVID-19 pandemic-related IPC. Special emphasis should be given to nonclinical staffs, such as porters/runners and janitors; a tailor-made training programs are ought to be designed to match their level of understanding and job specifications. Furthermore, continuous follow-up and conducting safety drills to evaluate and make sure the readiness of health facilities in terms of infrastructure and observance of IPC in normal circumstances are in the ordinance, so could further enhance health facilities' preparedness to effective response during epidemics.

AUTHOR CONTRIBUTIONS

Abel Weldetinsae: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; supervision; validation; writing—original draft; writing—review & editing. **Zinabu Assefa Alemu**: Data curation; investigation; methodology; validation; writing—original draft; writing—review & editing. **Kirubel Tefaye**: Investigation; methodology; writing—review & editing. **Melaku Gizaw**: Investigation; methodology. **Ermias Alemahyehu**: Data curation; validation; writing—original draft. **Adamu Tayachew**: Methodology; validation. **Sisay Derso**: Investigation; methodology; supervision. **Moa Abate**: Validation; writing—original draft; writing—review & editing. **Mesaye Getachew**: Writing—review & editing. **Daniel Abera**: Methodology; supervision. **Arone Mebrhatu**: Supervision; validation. **Higu Kefale**: Data curation; investigation; methodology; supervision; writing—review & editing. **Shambel Habebe**: Supervision; writing—review & editing. **Tsigereda Assefa**: Validation. **Aderajew Mekonnen**: Writing—review & editing. **Getachew Tollera**: Project administration. **Masresha Tessema**: Conceptualization; project administration.

ACKNOWLEDGMENTS

The authors would like to extend their gratitude to the finance and logistics departments of the Ethiopian Public Health Institute.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

TRANSPARENCY STATEMENT

The lead author Abel Weldetinsae affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Abel Weldetinsae http://orcid.org/0000-0003-2946-6077
Ermias Alemahyehu http://orcid.org/0000-0002-0640-946X
Aderajew Mekonnen http://orcid.org/0000-0002-7911-4152

REFERENCES

1. George MD. A novel corona virus (covid-19) pandemic, pathogenesis, clinical features and management options, public health measures. *Int J Trop Dis Health*. 2020;31:11-21.
2. Berber E, Sumbria D, Çanakoğlu N. Meta-analysis and comprehensive study of coronavirus outbreaks: SARS, MERS and COVID-19. *J Infect Public Health*. 2021;14(8):1051-64.
3. WHO. *Health Workers Exposure Risk Assessment and Management in the Context of COVID-19 Virus: Interim Guidance*. World Health Organization; 2020.
4. Shanmugaraj B, Siriwattananon K, Wangkanont K, Phoolcharoen W. Perspectives on monoclonal antibody therapy as potential therapeutic intervention for coronavirus disease-19 (COVID-19). *Asian Pac J Allergy Immunol*. 2020;38(1):10-18.
5. El Zowalaty ME, Järhult JD. From SARS to COVID-19: a previously unknown SARS related coronavirus (SARS-CoV-2) of pandemic potential infecting humans call for a one health approach. *One Health*. 2020;9:100124.
6. Ng K, Poon B, Kiat Puar T, Shan Quah J, Loh W, Wong YJ, Tan TY, Raghuram J. COVID-19 and the risk to health care workers: a case report. *Ann Intern Med*. 2020;172(11):766-767.
7. Ali S, Noreen S, Farooq I, Bugshan A, Vohra F. Risk assessment of healthcare workers at the frontline against COVID-19. *Pak J Med Sci*. 2020;36(COVID19-S4):S99.
8. Zheng L, Wang X, Zhou C, et al. Analysis of the infection status of healthcare workers in Wuhan during the COVID-19 outbreak: a cross-sectional study. *Clin Infect Dis*. 2020;71(16):2109-13.
9. Gelanew T, Seyoum B, Mulu A, et al. High seroprevalence of anti-SARS-CoV-2 antibodies among Ethiopian healthcare workers. *BMC Infect Dis*. 2022;22(1):261.
10. Atnafie SA, Anteneh DA, Yimenu DK, Kifle ZD. Assessment of exposure risks to COVID-19 among frontline health care workers in Amhara region, Ethiopia: A cross-sectional survey. *PLoS One*. 2021;16(4):e0251000.
11. Sahiledengle B, Tekalegn Y, Woldeyohannes D. The critical role of infection prevention overlooked in Ethiopia, only one-half of healthcare workers had safe practice: A systematic review and meta-analysis. *PLoS One*. 2021;16(1):e0245469.
12. Hailu D, Benayew M, Liknaw T, et al. Occupational health safety of health professionals and associated factors during COVID-19

pandemics at North Showa Zone, Oromia regional state, Ethiopia. *Risk Manag Healthc Policy*. 2021;14:1299-1310.
13. Shibabaw T, Teferi B. Knowledge and practice toward prevention of SARS-COV-2 among healthcare workers at delghi primary hospital during a massive test campaign in northwest Gondar, Ethiopia: institution-based descriptive cross-sectional survey. *Infect Drug Resist*. 2021;14:381-390390.
14. Tesfaye ZT, Yismaw MB, Negash Z, Ayele AG. COVID-19-related knowledge, attitude and practice among hospital and community pharmacists in Addis Ababa, Ethiopia. *Integr Pharm Res Pract*. 2020;9:105-112.
15. Mersha A, Shibiru S, Girma M, et al. Health professionals practice and associated factors towards precautionary measures for COVID-19 pandemic in public health facilities of Gamo zone, Southern Ethiopia: a cross-sectional study. *PLoS One*. 2021;16(3):e0248272.
16. Alemu ZA, Dioha MO. Climate change and trend analysis of temperature: the case of Addis Ababa, Ethiopia. *Environ Syst Res*. 2020;9(1):27.
17. Girmay AM, Gari SR, Mengistie Alemu B, Evans MR, Gebremariam AG. Determinants of sanitation and hygiene status among food establishments in Addis Ababa, Ethiopia. *Environ Health Insights*. 2020;14:117863022091568.
18. Alemu ZA, Dioha MO. Modelling scenarios for sustainable water supply and demand in Addis Ababa city, Ethiopia. *Environ Syst Res*. 2020;9(1):7.
19. Yamane T. *Statistics: An Introductory Analysis*. 2nd ed. Harper and Row; 1967.
20. Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ*. 2018;48:1273-1296.
21. Pearson K. X.On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *Lond Edinb Dublin Philos Mag J Sci*. 1900;50(302):157-175.
22. Hussen H, Aderaw Alemu Z. Risk of COVID-19 infection and associated factors among healthcare workers: a cross-sectional study at Eka Kotebe Treatment Center in Ethiopia. *Int J Gen Med*. 2021;14:1763-1772.
23. Zenbaba D, Sahiledengle B, Takele A, et al. Compliance towards infection prevention measures among health professionals in public hospitals, southeast Ethiopia: a cross-sectional study with implications of COVID-19 prevention. *Trop Med Health*. 2021;49(1):30.
24. Etafa W, Gadisa G, Jabessa S, Takele T. Healthcare workers' compliance and its potential determinants to prevent COVID-19 in public hospitals in Western Ethiopia. *BMC Infect Dis*. 2021;21(1):1-8.
25. Tadesse DB, Gebrewahd GT, Demoz GT. Knowledge, attitude, practice and psychological response toward COVID-19 among nurses during the COVID-19 outbreak in Northern Ethiopia, 2020. *New Microbes New Infect*. 2020;38:100787.
26. Baye AM, Ababu A, Bayisa R, et al. Alcohol-Based handrub utilization practice for COVID-19 prevention among pharmacy professionals in Ethiopian public hospitals: A cross-sectional study. *Drug Healthc Patient Saf*. 2021;13:37-46.
27. Mindaye ET, Assaminew B, Tesfay GK. Knowledge, perception of risk of disease, and infection prevention and control practices among healthcare workers and support staff toward COVID-19 in an Ethiopian referral hospital: a cross-sectional survey. *Int J Infect Control*. 2021;17:17.
28. Angrup A, Kanaujia R, Ray P, Biswal M. Healthcare facilities in low- and middle-income countries affected by COVID-19: time to upgrade basic infection control and prevention practices. *Indian J Med Microbiol*. 2020;38(2):139-143.
29. Patel LN, Kozikott S, Ilboudo R, et al. Safer primary healthcare facilities are needed to protect healthcare workers and maintain essential services: lessons learned from a multicountry COVID-19 emergency response initiative. *BMJ Glob Health*. 2021;6(6):e005833.
30. Jemal K, Gashaw K, Kinati T, Bedada W, Getahun B. Clean and safe healthcare environment: knowledge, attitude, and practice of infection prevention and control among health workforce at north showa zone Oromiya region. *J Environ Public Health*. 2020;2020:6021870.
31. Kebede AA, Taye BT, Wondie KY, Tiguh AE, Eriku GA, Mihret MS. COVID-19 preventive practices during intrapartum care-adherence and barriers in Ethiopia; a multicenter cross-sectional study. *PLoS One*. 2021;16(11):e0260270.
32. Gebresilassie A, Kumei A, Yemane D. Standard precautions practice among health care workers in public health facilities of mekelle special zone, Northern Ethiopia. *J Community Med Health Educ*. 2014;4(3):286.
33. Yohannes T, Kassa G, Laelago T, Guracha E. Health-care workers' compliance with infection prevention guidelines and associated factors in Hadiya zone, Southern Ethiopia: hospital based cross sectional study. *Epidemiol Int J*. 2019;3(1):1-13.
34. Hussein S, Estifanos W, Melese E, Moga F. Knowledge, attitude and practice of infection prevention measures among health care workers in wolaitta sodo Otona teaching and referral hospital. *J Nurs Care*. 2017;6(416):2167-1168.
35. Eyayu M, Motbainor A, Gizachew B. Practices and associated factors of infection prevention of nurses working in public and private hospitals toward COVID-19 in Bahir Dar city, northwest Ethiopia: institution-based cross-sectional study. *SAGE Open Med*. 2022;10:205031212210982.
36. Albaqawi HM, Alquwez N, Balay-Odao E, et al. Nursing students' perceptions, knowledge, and preventive behaviors toward COVID-19: a multi-university study. *Front Public Health*. 2020;8:573390.
37. Alshdefat A, Jansirani Natarajan MAJ, Baker RA, Qutishat MG. Knowledge, attitude and practice of nursing students towards COVID-19 pandemic in Oman. *Int J Nurs Educ*. 2021;13(1):23-30.
38. Okello G, Izudi J, Teguzirigwa S, Kakinda A, Van Hal G. Findings of a cross-sectional survey on knowledge, attitudes, and practices about COVID-19 in Uganda: implications for public health prevention and control measures. *BioMed Res Int*. 2020;2020:5917378.
39. Tsegaye D, Shuremu M, Oljira D, Dubale S, Befekadu G, Bidira K. COVID–19 related knowledge and preventive practices early in the outbreak among health care workers in selected public health facilities of Illu aba Bor and Buno Bedelle zones, southwest Ethiopia. *BMC Infect Dis*. 2021;21(1):490.
40. Jiee SF, Jantim A, Mohamed AF, Emiral ME. COVID-19 pandemic: determinants of workplace preventive practice among primary health-care workers in Sabah, Malaysia. *J Prev Med Hyg*. 2021;62(3):605.
41. Wong EL, Wong SY, Lee N, Cheung A, Griffiths S. Healthcare workers' duty concerns of working in the isolation ward during the novel H1N1 pandemic. *J Clin Nurs*. 2012;21(9-10):1466-1475.
42. Powell-Jackson T, King JJC, Makungu C, et al. Infection prevention and control compliance in Tanzanian outpatient facilities: a cross-sectional study with implications for the control of COVID-19. *Lancet Glob Health*. 2020;8(6):e780-e789.
43. Russell D, Dowding DW, McDonald MV, et al. Factors for compliance with infection control practices in home healthcare: findings from a survey of nurses' knowledge and attitudes toward infection control. *Am J Infect Control*. 2018;46(11):1211-1217.
44. Ganczak M, Szych Z. Surgical nurses and compliance with personal protective equipment. *J Hosp Infect*. 2007;66(4):346-351.
45. Lien LTQ, Chuc NTK, Hoa NQ, et al. Knowledge and self-reported practices of infection control among various occupational groups in a rural and an urban hospital in Vietnam. *Sci Rep*. 2018;8(1):5119.
46. Assefa J, Diress G, Adane S. Infection prevention knowledge, practice, and its associated factors among healthcare providers in primary healthcare unit of Wogdie district, northeast Ethiopia, 2019: a cross-sectional study. *Antimicrob Resist Infect Control*. 2020;9(1):136.

47. Sahiledengle B, Gebresilassie A, Getahun T, Hiko D. Infection prevention practices and associated factors among healthcare workers in governmental healthcare facilities in Addis Ababa. *Ethiop J Health Sci*. 2018;28(2):177-186.
48. Jemal B, Aweke Z, Mola S, et al. Knowledge, attitude, and practice of healthcare workers toward COVID-19 and its prevention in Ethiopia: a multicenter study. *SAGE Open Med*. 2021;9:205031212110343.
49. Girma S, Alenko A, Agenagnew L. Knowledge and precautionary behavioral practice toward COVID-19 among health professionals working in public university hospitals in Ethiopia: a web-based survey. *Risk Manag Healthc Policy*. 2020;13:1327-1334.
50. Alhumaid S, Al Mutair A, Al Alawi Z, et al. Anaphylactic and nonanaphylactic reactions to SARS-CoV-2 vaccines: a systematic review and meta-analysis. *Allergy Asthma Clin Immunol*. 2021;17(1):1-24.
51. Houghton C, Meskell P, Delaney H, et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. *Cochrane Database Syst Rev*. 2020;4(4):CD013582. doi:10.1002/14651858.CD013582
52. Zenbaba D, Sahiledengle B, Beressa G, et al. Healthcare workers' compliance with COVID-19 preventive measures, and associated factors, in Ethiopia: a systematic review and meta-analysis. *BMJ Open*. 2022;12(8):e060681.

How to cite this article: Weldetinsae A, Alemu ZA, Tefaye K, et al. Adherence to infection prevention and control measures and risk of exposure among health-care workers: a cross-sectional study from the early period of COVID-19 pandemic in Addis Ababa, Ethiopia. *Health Sci Rep*. 2023;6:e1365. doi:10.1002/hsr2.1365