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Infection prevention and control status at public hospitals and factors associated with COVID-19 infection among healthcare workers in Myanmar: A cross-sectional study

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Abstract

Background Hospitals should prepare for emerging diseases and protect healthcare workers (HCWs) from work-related infection. This study aims to assess public hospital preparedness for the coronavirus disease 2019 (COVID-19) a year after the Myanmar government began implementing COVID-19 prevention measures, and to identify factors associated with work-related COVID-19 infection among HCWs in Myanmar.

Methods In January 2021, data were collected from 101 hospitals and 706 HCWs who had COVID-19 in Myanmar in 2020. Data from the hospitals included basic information, the status of infection prevention and control (IPC), the preparedness for COVID-19 (guidelines, checklists, fever screening, patient pathway, and training), handwashing facilities, and availability of personal protective equipment (PPE). Data of COVID-19 infected HCWs included age, occupation, workplace, severity and source of COVID-19 infection, knowledge and practice of handwashing, and working environment. Chi-square test was performed to compare the preparedness for COVID-19 among three hospital levels (primary, secondary and tertiary levels). Logistic regression analysis was performed to identify the associated factors of work-related infection of HCWs.

Results The total number of beds, HCWs, and COVID-19 patients in 2020 at the 101 hospitals was 12,888, 14,421, and 19,835, respectively. The availability of PPE was high in hospitals at all levels. Approximately 80% of hospitals had functional status of IPC, set up fever screening and patient pathway, and provided training on IPC and COVID-19. However, only 39.6% of hospitals had developed COVID-19 guidelines and 55.4% had developed checklists. The percentage of hospitals that prepared each measurement was lowest at the primary level. The factors associated with work-related COVID-19 among HCWs were being 30–39 years old, working as a doctor, working at isolation wards, having disinfection technique training, and having enough PPE at the workplace.

Conclusion The preparedness for COVID-19 at public hospitals in Myanmar in January 2021 was insufficient, especially in the availability of the guidelines and checklists and at primary hospitals. A support system for hospital

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pandemic preparedness and monitoring of IPC implementation is needed. The government should prepare for emerging diseases and provide appropriate and adequate PPE and additional training to all HCWs, especially HCWs who work for isolation wards.

Keywords COVID-19, Healthcare workers, Infection prevention and control, Myanmar, Work-related infection

Background

The World Health Organization (WHO) declared a pandemic of the coronavirus disease 2019 (COVID-19) on March 11, 2020. On May 5 2023, the WHO announced that COVID-19 would no longer constitute a public health emergency of international concern [1]. However, based on WHO data [2], the cumulative number of confirmed cases and deaths due to COVID-19 in the world was estimated to be more than 773 million and more than 7 million, respectively, at the end of 2023 [3]. Approximately 3,000 deaths occurred every week in January 2024 [4]; therefore, COVID-19 is still an ongoing public health issue in most countries, especially in developing countries. Transmission of COVID-19 is primarily through infectious respiratory particles, therefore physical distancing, wearing masks, face covering, and hand hygiene are recommended for preventing transmission of COVID-19 [5]. At the beginning of the COVID-19 pandemic, healthcare workers (HCWs) were infected largely because of insufficient personal protective equipment (PPE), unavoidable contact with COVID-19 cases, prolonged working time, and a heavy workload [6, 7]. A systematic review of COVID-19 infections among HCWs reported that a total of 152,888 HCWs had been infected with COVID-19 by May 8, 2020 in the world, which accounted for 3.9% of the total number of COVID-19 cases [8]. Infection prevention and control (IPC) behaviors were associated with COVID-19 infection among HCWs [5, 8–10]. Identifying suspected cases by screening at the initial healthcare facilities is one of the IPC priorities that is recommended by WHO and the Centers for Disease Control and Prevention, in the United States [5, 11].

In Myanmar, the Ministry of Health (MoH) began implementing measures to prevent and control COVID-19 infections in December 2019, such as providing training and educational sessions to healthcare professionals. The MoH developed guidelines and checklists for monitoring and evaluating hospital preparedness including IPC measures for hospitals [12, 13]. The first COVID-19 wave was from March to August 2020, which was not large enough to affect the country or HCWs compared to other countries. The second COVID-19 wave was from August 2020 to May 2021 starting with the cases in Rakhine State. By the end of 2020, a total of 123,740 cases were admitted to hospitals, which accounted for 0.2% of the total population, and 2,507 patients died [14, 15]. In 2020, alcohol-based hand rub was provided to hospitals by the MoH but hospitals also bought their own using their budget.

Rapid assessment conducted during the early phase of the second wave, which was conducted for response activities and not published, showed that HCWs had COVID-19 infections mostly at their workplaces by closely working with co-workers or by unexpected contact with patients who had asymptomatic COVID-19 infections. To protect HCWs from infections, hospitals should have good indoor ventilation, adequate PPE, handwashing facilities, and alcohol-based hand rub, provide training and education about infection control practice to HCWs, and have a response plan for an outbreak [6, 16, 17]. Good ventilation reduces the risk of spreading severe acute respiratory syndrome coronavirus 2 (SARS-CoV2). Effective hand hygiene using water-based handwashing and alcohol-based hand rubs reduces healthcare-associated infections [18]. A multidisciplinary IPC team with good leadership and preparedness before having infected patients are the key factors for effective control at hospitals. It is important to understand the factors associated with work-related COVID-19 infection among HCWs to improve hospital management, to prevent infections among HCWs, and to improve patient safety. Many studies have shown that the nursing profession was more vulnerable to get COVID-19 infection compared to other professions, because they have a longer contact with patients [7, 10, 19, 20]. An analysis of the data from 152,888 COVID-19 infected HCWs in 195 countries during the early period of the COVID-19 pandemic showed that midwives had the lowest risk of infection and that nurses had the highest risk followed by doctors and allied health professionals [8]. This study was conducted to assess the preparedness for COVID-19 patients at public hospitals a year after the Myanmar government started to take action to prevent COVID-19 infections and to identify factors associated with work-related COVID-19 infection among HCWs in Myanmar.

Methods

Study design

This is a cross-sectional study and secondary analysis was performed using the survey data collected by the Department of Medical Service, the MoH, Myanmar. The survey was conducted from January 1 to 31 in 2021 and the data were collected from hospitals in the public sector and HCWs of public health facilities who were diagnosed as COVID-19 infection in 2020. COVID-19 infection was

defined as testing positive for the SARS-CoV-2 antigen by the Standard Q COVID-19 Rapid Diagnostic Test (SD Biosensor, Inc., Cheongju-si, Republic of Korea) or testing positive for COVID-19 polymerase chain reaction test. The survey data was provided by the Myanmar Department of Medical Services to the authors of this study.

Questionnaire forms

Two questionnaire forms were developed to collect data for the survey. The first questionnaire form was for collecting basic information of hospitals in the public sectors and understanding the situation of IPC for COVID-19 infection. The first form included questions about the name of hospitals, the number of beds (total beds, isolation beds, intensive care unit [ICU] beds), the number of HCWs and COVID-19 infected HCWs in 2020, the total number of COVID-19 patients in 2020, the number of handwashing facilities, the availability of running water, masks, PPE (gowns, gloves, goggles, face shields, and boots/closed shoes), and waste bins, the status of the IPC activities, and the preparedness for COVID-19 patients including the availability of COVID-19 clinical guidelines, preparedness checklists, fever screening at emergency departments, separate pathways for infected or suspected patients, and COVID-19 training (Additional file 1). This questionnaire was developed according to the preparedness guidelines for hospitals in Myanmar. Questions concerning ventilation systems and alcohol-based hand rub were not included in the questionnaire, because most hospitals in Myanmar had similar ventilation systems that were difficult to change in a short period of time and it was difficult to measure the availability of alcohol-based hand rub.

The second questionnaire form was designed to understand the characteristics of HCWs who worked for public health facilities and who had COVID-19 infection in 2020. This form included questions on (1) socio-demographic factors (age, occupation, and workplace), (2) information on COVID-19 infection (date of admission, the severity, treatment, and possible source of infection) of HCWs, and (3) experiences of education, knowledge and practice of handwashing, and the work environment of the HCWs (Additional file 2). In this study, HCWs included doctors, interns, dentists, nurses, medical technicians, and non-medical professionals (general workers, receptionists, and other supporting staff). Workers of health facilities who did not have direct contact with patients, such as office staff and teaching staff, were not included in this study.

At the beginning of January 2021, the first questionnaire form was sent to all public hospitals ($n=1,177$) and 101 hospitals returned the responses by January 31. The second questionnaire form was sent to all public hospitals and regional health offices ($n=17$). Regional health offices distributed the forms to all health centers in their areas. Each facility distributed the questionnaire form to HCWs who worked for the facility and who had COVID-19 infection in 2020 and collected the responses. The total number of COVID-19 infected HCWs in 2020 was reported to be 2,194. By January 31 2021, responses were returned from 101 hospitals, two regional health offices, and 930 HCWs. The response rate of public hospitals, regional health offices, and COVID-19 infected HCWs was 8.5%, 11.8%, and 42.4%, respectively. Finally, 706 HCWs were included in this study because 224 HCWs who answered "don't know" or did not answer about a possible source of COVID-19 infection were excluded.

Variables for characteristics of hospitals and IPC for COVID-19 infection

Hospitals were divided into the tertiary level (national hospitals), the secondary level (state hospitals, regional hospitals, and district hospitals), or the primary level (township hospitals and station hospitals) according to the MoH categorization based on different levels of care. Each level has a different bed capacity and specialties: the primary level has 16–50 beds, the secondary level has 100–500 beds, and the tertiary level has 150–2000 beds. The number of total inpatient beds, isolation beds, and ICU beds was collected. Isolation beds were beds in isolation rooms or beds for patients with highly infectious diseases. The number of COVID-19 patients who were hospitalized in 2020, those who had treatment at ICU, and those who died was collected. The questionnaires asked about the total number of facilities for handwashing at a hospital, the availability of running water, masks, PPE, and waste bins, and the provision of training related to COVID-19 to HCWs. Questions regarding IPC activities asked if hospitals had an action plan of IPC activities, if they established an IPC committee, if the IPC committee was functional, if there was an IPC team under the IPC committee, and if the IPC team was functional. The availability of COVID-19 guidelines and checklists for hospital preparedness was asked. Checklists were for checking if the administrative procedures, outpatient department, emergency department, isolation and quarantine wards, communication and information management, and drugs and medical equipment were prepared for receiving COVID-19 patients. Hospitals were asked if they provided fever screening at an emergency department and if the pathway from the emergency department to an isolation ward or ICU was decided for infected or for patients suspected of being infected. Regarding providing training related to COVID-19, content of training included IPC, PPE, disinfection, waste management, and others.

Characteristics of HCWs who had COVID-19 infection in 2020

The age of HCWs was categorized into younger than 29 years, 30–39 years, 40–49 years, or 50 years and older. Occupation was categorized into doctors, nurses, other medical professionals (medical technicians, interns, and dentists), or non-medical professional. Non-medical professionals included general workers, receptionists, and other support staff. Health facilities of the HCWs were categorized into hospitals or others (health centers and health offices). The level of health facilities was categorized into the primary level (health centers, township hospitals, station hospitals), the secondary level (district health offices, district hospitals, state hospitals, and regional hospitals), or the tertiary level (national hospitals). The HCWs were asked if they had worked for an emergency department, an isolation ward, or ICU before COVID-19 infection and responses were categorized into yes or no/no answer. The severity of COVID-19 infection was categorized into no symptoms, mild/moderate, or severe according to the clinical management guidelines. Regarding the treatment of COVID-19 infection, the HCWs selected one or more from no treatment, injection of antibiotics, remdesivir (a nucleotide analogue prodrug that inhibits viral RNA polymerases), and intensive care (admission to ICU). Possible sources of COVID-19 infection included patients, co-workers at the workplace, family members, friends, during travel, others, or unknown. In this study, work-related infection was defined as an infection from patients or co-workers. HCWs who selected patients or co-workers at the workplace were categorized into "work-related infection" and those who selected family members, friends, during travel, or others were categorized into "non-work-related infection".

Education, knowledge, and the work environment of HCWs who had COVID-19 infection

The questionnaire administered to the HCWs included questions asking if they had education about COVID-19, IPC training, PPE training, training of disinfection techniques, and training of waste management. The HCWs were asked about the number of steps and the appropriate time for proper handwashing and the answers were categorized into correct (7 steps and 40–60 s) or wrong/no answer. They were asked how often they performed proper handwashing, and the responses were categorized into always, often, or sometimes/never/no answer. The HCWs were asked if their health facility had enough basins, soap, running water, PPE, and masks. The responses were categorized into enough or not enough/no answer.

Data analysis

Chi-squared test or Fisher's exact test was performed to compare the characteristics of hospitals among the three levels and to compare the characteristics of HCWs between HCWs who had work-related infection (the work-related infection group) and others (the non-work-related infection group). Logistic regression analyses were performed to identify the factors associated with work-related infection among HCWs who had COVID-19 infection. Odds ratios (ORs) were estimated to assess the strength of the associations using 95% confidence intervals (CIs) for significance testing. P values were two-sided and a $p<0.05$ was regarded as statistically significant in all analyses. IBM SPSS software (version 22.0) was used for data analyses.

Ethical considerations

Informed consent was obtained from each participant before answering the questionnaire. This study was approved by the Institutional Review Board of the MoH in Myanmar (approval number IRB/2023-11). Written informed consent was waived because participants answered the questionnaire anonymously and it was approved by the Institutional Review Board of the MoH in Myanmar.

Results

The capacity and COVID-19 patients at hospitals

Of the 1,177 hospitals, 101 hospitals answered the questionnaire about the preparation for COVID-19 patients (response rate, 8.5%). Most hospitals ($n=66$) were hospitals of the primary level (Table 1). The total number of inpatient beds of the 101 hospitals was 12,888 and isolation beds and ICU beds accounted for 21.3% and 1.1% of the total beds, respectively. The percentage of isolation beds was highest at hospitals in the primary level (29.6%) and lowest in the tertiary level (18.5%). The percentage of ICU beds was 1.1% in total and it was highest at the tertiary level (1.4%) followed by the secondary level (0.9%). The overall COVID-19 positive rate of HCWs was 7.6% while the positive rate at tertiary level hospitals (10.8%) was higher than that of hospitals in the secondary (4.4%) and primary levels (1.1%). Of the 19,835 COVID-19 patients in 2020, most patients ($n=12,610$) were admitted to tertiary hospitals. The percentage of ICU admissions and deaths among the COVID-19 patients was 3.3% and 6.3%, respectively, and the percentages were higher at the tertiary level (4.5% and 8.2%) than the secondary level (1.2% and 3.6%).

IPC and preparation for COVID-19 patients at hospitals

Handwashing facilities per bed and per HCW was 0.39 and 0.35, respectively, at all hospitals, but the primary level had only 0.06 handwashing facilities per HCW.

Table 1 Characteristics and preparation for COVID-19 of 101 public hospitals

Variables		Total	Level of hospitals			*P* value
			Tertiary	Secondary	Primary	
Number of hospitals		101	15	20	66	-
Inpatient beds						
	Total	12,888	6,500	4,850	1,538	-
	Isolation beds (%)	2,741 (21.3)	1,205 (18.5)	1,081 (22.3)	455 (29.6)	0.425
	ICU beds (%)	139 (1.1)	92 (1.4)	47 (0.9)	0 (0.0)	< 0.001
HCW						
	Total	14,421	7,632	5,687	1,102	-
	COVID-19 positive	1,092	828	252	12	-
	Positive rate	7.6%	10.8%	4.4%	1.1%	< 0.001
COVID-19 patients						
	Total	19,835	12,610	5,325	1,900	
	ICU (%)	635 (3.3)	573 (4.5)	62 (1.2)	0 (0.0)	< 0.001
	Death (%)[a]	1,220 (6.3)	1,030 (8.2)	190 (3.6)	0 (0.0)	< 0.001
Handwashing facilities						
	Total	5,082	2,725	1,754	603	-
	Facilities per bed	0.39	0.42	0.36	0.39	0.778
	Facilities per HCW	0.35	0.36	0.31	0.06	0.457
Availability						
	Running water	95 (94.1)	15 (100.0)	19 (95.0)	61 (92.4)	0.760
	Mask	100 (99.0)	15 (100.0)	20 (100.0)	65 (98.5)	0.765
	PPE	95 (94.1)	14 (93.3)	20 (100.0)	61 (92.4)	0.451
	Waste bin	91 (90.1)	13 (86.7)	19 (95.0)	59 (89.4)	0.679
IPC						
	IPC action plan	77 (76.2)	14 (93.3)	19 (95.0)	44 (66.7)	0.008
	IPC committee	83 (82.2)	15 (100.0)	19 (95.0)	49 (74.2)	0.015
	IPC committee function	74 (73.3)	15 (100.0)	17 (85.0)	42 (63.6)	0.007
	IPC team	84 (83.2)	15 (100.0)	20 (100.0)	49 (74.2)	0.004
	IPC team function	73 (72.3)	15 (100.0)	16 (80.0)	42 (63.6)	0.012
COVID-19 guidelines		40 (39.6)	11 (73.3)	11 (55.0)	18 (27.3)	0.001
Preparedness checklist		56 (55.4)	13 (86.7)	14 (70.0)	29 (43.9)	0.004
Fever screening at emergency department		90 (89.1)	15 (100.0)	20 (100.0)	55 (83.3)	0.038
Patient pathway		86 (85.1)	15 (100.0)	18 (90.0)	53 (80.3)	0.122
COVID-19 training						
	IPC	71 (70.3)	14 (93.3)	19 (95.0)	38 (57.6)	0.001
	PPE	71 (70.3)	15 (100.0)	19 (95.0)	37 (56.1)	0.115
	Disinfection	64 (63.4)	11 (73.3)	18 (90.0)	35 (53.0)	0.230
	Waste management	67 (66.3)	10 (66.7)	18 (90.0)	39 (59.1)	0.016
	Other	13 (12.9)	4 (26.7)	3 (15.0)	6 (9.1)	0.542

COVID-19, the coronavirus disease 2019; ICU, intensive care unit; HCW, healthcare worker; IPC, infection prevention and control; PPE, personal protective equipment

[a]Death includes deaths due to COVID-19 and deaths due to other diseases with COVID-19 infection

Running water, masks, PPE, and waste bins were available at most hospitals of all levels. Regarding the IPC program, 77 hospitals (76.2%) had already developed an IPC action plan before the beginning of January 2021 (Table 1). Of the 101 hospitals, 83 hospitals (82.2%) had an IPC committee and 84 hospitals (83.2%) had an IPC team however, the committees and teams were functioning at 74 hospitals (73.3%) and 73 hospitals (72.3%), respectively. COVID-19 guidelines and hospital preparedness checklists were available at 40 hospitals (39.6%) and 56 hospitals (55.4%), respectively. The screening of COVID-19 suspected patients by checking fever was performed at all hospitals of the tertiary and secondary levels but only 83.3% ($n=55$) of hospitals at the primary level. A separate pathway for COVID-19 confirmed and suspected patients was established at 86 hospitals (85.1%). Of the 101 hospitals, 71 hospitals (70.3%) provided IPC and PPE training, 64 hospitals (63.4%) provided disinfection

Table 2 Characteristics of healthcare workers who had COVID-19 infection in 2020 (*N* = 706)

Characteristics	Total	Work-related infection	Non-work-related infection	*P* value
	N (%)	*n* (%)	*n* (%)	
	706 (100)	554 (78.5)	152 (21.5)	
Age (years old)				0.052
≤ 29	368 (52.1)	281 (76.4)	87 (23.6)	
30–39	182 (25.8)	156 (85.7)	26 (14.3)	
40–49	100 (13.0)	75 (75.0)	25 (25.0)	
50≤	74 (8.0)	42 (78.5)	14 (21.5)	
Occupation				0.022
Doctor	137 (19.4)	119 (86.9)	18 (13.1)	
Nurse	346 (49.0)	272 (78.6)	74 (21.4)	
Other medical profession[a]	49 (6.9)	35 (71.4)	14 (28.6)	
Non-medical profession[b]	174 (24.6)	128 (78.5)	46 (21.5)	
Health facility				0.043
Hospital	696 (98.6)	549 (78.9)	147 (21.1)	
Other	10 (1.4)	5 (50.0)	5 (50.0)	
Level of facility				0.243
Primary	14 (2.0)	8 (57.1)	6 (42.9)	
Secondary	146 (20.7)	114 (78.1)	32 (21.9)	
Tertiary	545 (77.2)	431 (79.1)	114 (20.9)	
Worked at emergency department				0.039
No/no answer	461 (65.3)	351 (76.1)	110 (23.9)	
Yes	245 (34.7)	203 (82.9)	42 (17.1)	
Worked at isolation ward				< 0.001
No/no answer	383 (54.2)	279 (72.8)	104 (27.2)	
Yes	323 (45.8)	275 (85.1)	48 (14.9)	
Worked at ICU				0.166
No/no answer	597 (84.6)	463 (77.6)	134 (22.4)	
Yes	109 (15.4)	91 (83.5)	18 (16.5)	
Severity of COVID-19 (*n* = 697)[c]				0.569
No symptom	107 (15.3)	80 (74.8)	27 (25.2)	
Mild to moderate	568 (81.5)	449 (79.0)	119 (21.0)	
Severe	22 (3.2)	18 (81.8)	4 (18.2)	
Treatment for COVID-19[d]				
No special treatment	595 (86.6)	465 (78.2)	130 (21.8)	0.463
Antibiotics	81 (11.8)	67 (82.7)	14 (17.3)	0.336
Remdesivir	34 (4.9)	25 (73.5)	9 (26.5)	0.459
Intensive care	8 (1.2)	5 (62.5)	3 (37.5)	0.378

COVID-19, the coronavirus disease 2019; ICU, intensive care unit

[a]Other medical profession includes medical technicians, residents, and dentists

[b]Non-medical profession includes general workers, receptionists and other supporting staff

[c]Nine healthcare workers did not answer

[d]Multiple responses when healthcare workers had treatment

training, and 67 hospitals (66.3%) provided waste management training. The percentage of hospitals that provided training was lowest at primary level hospitals (53.0-59.1%) compared to the tertiary and secondary levels, especially IPC training.

Characteristics of HCWs who had COVID-19 infection

A total of 930 HCWs who were confirmed COVID-19 positive in 2020 answered the questionnaire (response rate, 42.4%) and 706 HCWs were included in this study. Most HCWs (52.1%) were 29 years old or younger and in the nursing profession (49.0%) (Table 2). Almost all the participants (98.6%) worked at hospitals while nine and one workers worked at health centers and at health offices, respectively. The majority (77.2%) worked for tertiary level hospitals, followed by HCWs who worked for the secondary (20.7%) and primary levels (2.0%). Regarding the working places, 34.7% of the HCWs had worked at the emergency department, 45.8% had worked at an isolation ward, and 15.4% had worked at an ICU. Most participants (81.5%) had mild to moderate symptoms and 86.6% answered that they did not receive any special treatment for COVID-19 infection.

According to the source of infection, 554 HCWs (78.5%) were categorized into the work-related infection group and the other HCWs were the non-work-related infection group (21.5%). The work-related infection group had more doctors and nurses compared to other professionals, HCWs who worked for hospitals, and HCWs who had worked at the emergency department and isolation department before COVID-19 infection (Table 2). There was no significant difference of severity and treatment for COVID-19 among the two groups.

Education, knowledge, and the work environment of HCWs who had COVID-19 infection

Of the 706 HCWs, 98.4% received education on COVID-19, but the percentage of HCWs who had IPC training, PPE training, disinfection training, and waste management training was 41.1%, 65.4%, 42.1%, and 40.8%, respectively (Table 3). In the assessment of the knowledge of handwashing, 57.8% of the HCWs correctly answered about handwashing steps, but only 15.7% correctly answered about the duration of handwashing. There were 351 HCWs (49.7%) who always did handwashing properly. Regarding the availability of PPE and handwashing facilities, more than 90% of the HCWs reported that their workplace had enough PPE and handwashing facilities. When experience of education and training, knowledge and practice of handwashing, and the work environment of the HCWs were compared between the work-related infection group and the non-work-related infection group, the work-related infection group had more HCWs who had disinfection technique

Table 3 Education, knowledge, and the working environment of healthcare workers who had COVID-19 infection in 2020 (*N* = 706)

Variables		Total (*N* = 706)	Work-related (*N* = 554)	Non-work related (*N* = 152)	*P* value
		N (%)	*n* (%)	*n* (%)	
Health education					0.711
	Yes	695 (98.4)	546 (78.6)	149 (21.4)	
	Never/no answer	11 (1.6)	8 (72.7)	3 (27.3)	
IPC training					0.099
	Yes	292 (41.4)	238 (81.5)	54 (18.5)	
	No	414 (58.6)	316 (76.3)	98 (23.7)	
PPE training					0.103
	Yes	462 (65.4)	371 (80.3)	91 (19.7)	
	No	244 (34.6)	183 (75.0)	61 (25.0)	
Disinfection technique training					0.027
	Yes	297 (42.1)	245 (82.5)	52 (17.5)	
	No	409 (57.9)	309 (75.6)	100 (24.4)	
Waste management training					0.040
	Yes	288 (40.8)	237 (82.3)	288 (40.8)	
	No	418 (59.2)	317 (75.8)	418 (59.2)	
Knowledge of handwashing step					0.476
	Correct	408 (57.8)	324 (79.4)	84 (20.6)	
	Wrong/no answer	298 (42.2)	230 (77.2)	68 (22.8)	
Knowledge of handwashing time					0.327
	Correct	111 (15.7)	91 (82.0)	20 (18.0)	
	Wrong/no answer	595 (84.3)	463 (77.8)	132 (22.2)	
Practice of handwashing					0.270
	Always	351 (49.7)	270 (76.9)	81 (23.1)	
	Often	271 (38.4)	221 (81.5)	50 (18.5)	
	Sometimes/never/no answer	84 (11.9)	63 (75.0)	21 (25.0)	
Basin at workplace					0.134
	Enough	665 (94.2)	518 (77.9)	147 (22.1)	
	Not enough/no answer	41 (5.8)	36 (87.8)	5 (12.2)	
Soap at workplace					0.376
	Enough	668 (94.6)	522 (78.1)	146 (21.9)	
	Not enough/no answer	38 (5.4)	32 (84.2)	6 (15.8)	
Running water at workplace					0.636
	Enough	652 (92.4)	513 (78.7)	139 (21.3)	
	Not enough/no answer	54 (7.6)	41 (75.9)	13 (24.1)	
PPE at workplace					0.031
	Enough	644 (91.2)	512 (79.5)	132 (20.5)	
	Not enough/no answer	62 (8.8)	42 (67.7)	20 (32.3)	
Masks at workplace					0.555
	Enough	682 (96.6)	534 (78.3)	148 (21.7)	
	Not enough/no answer	24 (3.4)	20 (83.3)	4 (16.7)	

COVID-19, the coronavirus disease 2019; IPC, infection prevention and control; PPE, personal protective equipment

training and waste management training and whose workplaces had enough PPE compared to the non-work-related infection group.

Factors associated with work-related COVID-19 infection among HCWs

Multiple logistic regression analysis was performed to identify the factors associated with work-related COVID-19 infection among HCWs who had COVID-19 in 2020. The age group of 30–39 years old compared to the group of <30 years old (adjusted OR [AOR] = 2.00, 95% CI 1.14-3.53, P = 0.016), doctors compared to non-medical professions (AOR = 0.41, 95% CI 0.20–0.83, P = 0.013), having worked at an isolation ward (AOR = 1.70, 95% CI 1.06–2.73, P = 0.027), having disinfection technique training (AOR = 0.50, 95% CI 0.27–0.94, P = 0.031), and working for health facilities that had enough PPE (AOR = 0.47,

95% CI 0.23–0.94, $P=0.034$) were associated with work-related COVID-19 infection (Table 4).

Discussion

This study showed that the preparedness of hospitals for the COVID-19 pandemic was insufficient a year after the Myanmar government started preparation. The action plan for IPC was not available and IPC committees and teams were not functioning well at all hospitals, especially secondary and primary hospitals. The MoH of Myanmar developed the guidelines and standard operating procedures for the management of COVID-19 patients including laboratory testing, treatment, transportation of patients, isolation wards, and the hospital preparedness checklist by modifying the international guidelines according to the situation of Myanmar [12, 21, 22]. WHO recommends that a well-established IPC program is one of the core components for IPC [23]. A study conducted in the United States during the early phase of the COVID-19 pandemic also suggests that strengthening IPC and implementing the federal guidelines are needed to better prepare for pandemic potential [24]. The results of this study suggest that the IPC program was not effectively implemented especially at primary hospitals in Myanmar. This may be because the communication between the MoH and the hospitals in the public sector was weak, especially with primary hospitals. Most primary hospitals are in rural areas where Internet access is unavailable or unstable. These conditions might have resulted in weak preparedness for COVID-19 pandemic at hospitals in Myanmar. Therefore, the system to send important information to all hospitals through the responsible health department should be improved.

COVID-19 training was not provided to HCWs at approximately 40% of primary hospitals during the first year after the COVID-19 pandemic started. Of COVID-19 infected HCWs, 40–60% answered they had no training related to IPC, PPE, and disinfection. The MoH in Myanmar provided IPC training at referral hospitals that had 200 beds or more in 2020, but not district hospitals or primary hospitals. A systematic review including 40 papers on training in the first year of the COVID-19 pandemic proposed that key principles of successful training were delivering training promptly in accordance with infection control guidelines, providing training with approaches blended with theory and practice, and providing repeatedly short training sessions rather than only one session including all information [25]. Therefore, the MoH should provide additional training programs to all levels of hospitals when an emerging infectious disease occurs.

In this study, hospitals in the higher level had a higher positive rate of COVID-19 infections among HCWs and more COVID-19 patients who were admitted to ICUs or died. Hospitals in the higher level must have received more COVID-19 patients, especially during the first and second waves of the COVID-19 pandemic, because they were referral hospitals with a larger capacity in terms of beds and staff. However, when the data were collected in January 2021, the number of available ICU beds was less than the target level (2% of hospital beds) at tertiary and secondary hospitals, because of a shortage of healthcare professionals who were trained in ICU management. After the second COVID-19 wave finished, the MoH could upgrade the quality and the capacity of ICUs in tertiary and secondary hospitals. The number of ICU beds increased from 393 in 2020 to 736 in 2022. These results suggest that ICU professionals should be trained enough at referral hospitals to prepare for a pandemic of infectious diseases.

Factors associated with work-related infection among HCWs were being 30–39 years old compared to 29 years old or younger, being a doctor compared to non-medical professions, having worked at an isolation ward, having disinfection technique training, and having enough PPE at workplaces. It is understandable that doctors were significantly more likely to have work-related infection because doctors have more direct contact with infected patients during their work compared to other HCWs [26]. HCWs who are 30–39 years may be the most active among all age groups; therefore, they must work for patients closely. Previous studies conducted in other countries also reported that HCWs of 35 years old or younger had more COVID-19 infections compared to younger age groups [7, 10, 19, 20, 27, 28]. It may be because HCWs who have enough work experience and are relatively young engage more in the care of COVID-19 patients compared to HCWs who are very young. Training sessions for frontline HCWs should be developed and delivered differently from those for other HCWs [25].

There was a positive association between work-related infection and having enough PPE at the workplace, although a shortage of PPE can be one of the reasons of increasing work-related infections among HCWs. It may be because hospitals, departments, or inpatient wards that accepted more COVID-19 patients or severe COVID-19 cases were provided PPE preferentially and their HCWs had a high risk of transmission from patients. Inappropriate use of PPE by HCWs and low quality of PPE are also considered as reasons to cause work-related infections at workplaces with enough PPE [26]. Another reason may be that the HCWs answered about the availability of PPE at their hospitals in January 2021, but it might be different from when they had an infection in 2020. There was an association between work-related infection and having disinfection technique training, too. However, having correct knowledge

Table 4 Factors associated with work-related infection among COVID-19 infected healthcare workers

Variables		Work-related COVID-19 infection		*P* value
		OR (95%CI)	AOR (95%CI)	
Age (years old)				
	≤ 29	1 (Reference)	1 (Reference)	
	30–39	1.08 (0.56–2.06)	2.00 (1.14–3.53)	0.016
	40–49	2.00 (0.96–4.16)	1.09 (0.59–2.01)	0.792
	50≤	1.00 (0.47–2.13)	1.03 (0.46–2.30)	0.933
Occupation				
	Doctor	1 (Reference)	1 (Reference)	
	Nurse	0.56 (0.32–0.97)	0.66 (0.34–1.28)	0.222
	Other medical profession[a]	0.38 (0.17–0.84)*	0.49 (0.19–1.26)	0.140
	Non-medical profession[b]	0.42 (0.23–0.77)*	0.41 (0.20–0.83)	0.013
Health facility				
	Hospital	0.27 (0.08–0.94)*	7.70 (0.53-112.25)	0.135
	Other	1 (Reference)	1 (Reference)	
Level of facility				
	Primary	1 (Reference)	1 (Reference)	
	Secondary	0.39 (0.14–1.14)	1.69 (0.50–5.72)	0.394
	Tertiary	0.94 (0.60–1.47)	2.08 (0.65–6.64)	0.215
Worked at emergency department				
	No/no answer	1 (Reference)	1 (Reference)	
	Yes	1.51 (1.02–2.25)*	1.32 (0.81–2.15)	0.259
Worked at isolation ward				
	No/no answer	1 (Reference)	1 (Reference)	
	Yes	2.14 (1.46–3.12)***	1.70 (1.06–2.73)	0.027
Worked at ICU				
	No/no answer	1 (Reference)	1 (Reference)	
	Yes	1.46 (0.85–2.51)	0.91 (0.47–1.38)	0.766
Had health education				
	Yes	1 (Reference)	1 (Reference)	
	No/no answer	0.73 (0.19–2.78)	0.89 (0.21–3.77)	0.883
Had IPC training				
	Yes	1 (Reference)	1 (Reference)	
	No/no answer	1.37 (0.94–1.98)	0.81 (0.47–1.73)	0.439
Had PPE training				
	Yes	1 (Reference)	1 (Reference)	
	No/no answer	0.74 (0.51–1.06)	0.98 (0.61–1.58)	0.930
Had disinfection technique training				
	Yes	1 (Reference)	1 (Reference)	
	No/no answer	0.66 (0.45–0.95)*	0.50 (0.27–0.94)	0.031
Had waste management training				
	Yes	1 (Reference)	1 (Reference)	
	No/no answer	0.67 (0.46–0.98)*	1.23 (0.64–2.35)	0.535
Knowledge of handwashing step				
	Correct	1 (Reference)	1 (Reference)	
	Wrong/no answer	0.87 (0.61–1.26)	0.97 (0.63–1.51)	0.905
Knowledge of handwashing time				
	Correct	1 (Reference)	1 (Reference)	
	Wrong/no answer	0.77 (0.46–1.29)	0.64 (0.35–1.18)	0.151
Practice of proper handwashing				
	Always	1 (Reference)	1 (Reference)	
	Often	1.32 (0.89–1.97)	1.38 (0.90–2.11)	0.140
	Sometimes/never/no answer	0.90 (0.52–1.56)	0.94 (0.49–1.79)	0.847
Basin at workplace				

Table 4 (continued)

Variables		Work-related COVID-19 infection		*P* value
		OR (95%CI)	AOR (95%CI)	
	Enough	1 (Reference)	1 (Reference)	
	Not enough/no answer	2.04 (0.79–5.30)	3.24 (0.84–12.44)	0.087
Soap at workplace				
	Enough	1 (Reference)	1 (Reference)	
	Not enough/no answer	1.49 (0.61–3.64)	0.82 (0.26–2.56)	0.735
Running water at workplace				
	Enough	1 (Reference)	1 (Reference)	
	Not enough/no answer	0.85 (0.44–1.64)	0.76 (0.29–1.94)	0.572
PPE at workplace				
	Enough	1 (Reference)	1 (Reference)	
	Not enough/no answer	0.54 (0.31–0.95)*	0.47 (0.23–0.94)	0.034
Masks at workplace				
	Enough	1 (Reference)	1 (Reference)	
	Not enough/no answer	1.39 (0.47–4.12)	1.43 (0.42–4.89)	0.566

COVID-19, the coronavirus disease 2019; OR, odds ratio; CI, confidence interval; AOR, adjusted odds ratio; ICU, intensive care unit; IPC, infection prevention and control; PPE, personal protective equipment

[a]Other medical profession includes medical technicians, interns, and dentists

[b]Non-medical profession includes general workers, receptionists and other supporting staff

*$P<0.05$, **$P<0.01$, ***$P<0.001$

of handwashing steps and time were not associated with work-related infection. These results suggest that only having training or correct knowledge may not be enough to prevent work-related infection and that practicing is more important.

This study has some limitations. First, the results of this study cannot represent the preparedness of all hospitals in Myanmar because only 101 hospitals in the public sector were included in this study. Furthermore, hospitals in the private sector or of non-governmental organizations were not included. Second, the data was collected from HCWs who had infections in 2020 about their characteristics and the information of their working place, but the data collection period was in January 2021. Therefore, the information of working places of the HCWs might be different from when the HCWs had infection. Third, this study used data that was reported by hospital managers or HCWs but not observed by survey teams. Therefore, information may not be accurate and there might be recall bias or reporting bias. Work-related COVID-19 infections are difficult to ascertain as HCWs cannot 100% predict where they contracted the virus, and it is difficult to compare the incidence of work-related infection of this study with those in other studies. Fourth, gender was not included in the characteristics of HCWs in this study because the original survey did not include a gender question. Finally, this study did not include HCWs who had no infection. If the non-work-related infection group included HCWs who had no infection, factors associated with work-related infection may be different and the results may be meaningful for improving the working environment of HCWs. Despite these limitations, the study used the data of a nationwide survey of hospitals and the results showed the gaps of preparedness for the outbreak among the hospital levels. The study also showed the extent to which the hospitals tried to adhere to the MoH's policies. These results are helpful for the MoH and hospitals to strengthen IPC and improve their preparedness for the future outbreak.

In conclusion, the preparedness for COVID-19 at public hospitals in Myanmar a year after the COVID-19 pandemic began was insufficient, especially in the availability of the guidelines and checklists and at primary hospitals. Factors associated with work-related infection among HCWs who had COVID-19 infection were being 30–39 years old compared to 29 years or younger, being as a doctor compared to non-medical professions, having worked at an isolation ward, having disinfection technique training, and having enough PPE at the workplace. In Myanmar, a support system for hospital pandemic preparedness and monitoring of IPC implementation is needed and basic educational training should be provided to HCWs at all hospitals, especially primary hospitals. The Myanmar government also should prepare for emerging diseases and provide appropriate and adequate PPE and additional training to all HCWs, especially HCWs who work for isolation wards.

Abbreviations

AOR	Adjusted odds ratio
CI	Confidence interval
COVID-19	The coronavirus disease 2019
HCW	Healthcare worker
ICU	Intensive care unit
IPC	Infection prevention and control
MoH	Ministry of Health

OR	Odds ratio
PPE	Personal protective equipment
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1

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Author contributions
TMT, MK, YMS, and EY designed the study and developed the analysis plan. TMT, TA, EMW, and NH analyzed the data. TMT, YMS and YT drafted the manuscript. TMT, NH, SI, KN, and EY revised the manuscript. The final manuscript was reviewed and approved by all authors.

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Data availability
The datasets used in this study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was taken from Institutional Review Board of MoH, Myanmar (approval number IRB/2023-11) and approval for usage of the data were obtained from the Department of Medical Services and the Department of Public Health, Myanmar. Informed consent was obtained from each HCW before answering the questionnaire. Written informed consent was waived because participants answered the questionnaire anonymously and it was approved by the Institutional Review Board of the MoH. All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication
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Competing interests
The authors declare no competing interests.

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