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## Knowledge, attitudes and practice towards healthcare-associated infections among healthcare workers in Wuhan, China: a cross-sectional study

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## Title page

**Title:** Knowledge, attitudes and practice towards healthcare-associated infections among healthcare workers in Wuhan, China: a cross-sectional study

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## ABSTRACT

**Objective:** To assess the knowledge, attitudes, and practice (KAP) concerning healthcare associated infections (HAI) among healthcare givers and to identify the factors influencing KAP.

**Design:** The study was a hospital-based, cross-sectional study.

**Setting:** Two public hospital in Wuhan, central China.

**Participants:** Participants for the study were recruited from the healthcare workers of a general hospital and children's hospital in Wuhan city from June 1 to September 30, 2019.

**Primary and secondary outcome measures:** The primary outcome was the level of knowledge, attitude, and practice using an self-designed questionnaire. The secondary outcome was independent factors influencing knowledge scores, attitude scores, practice scores and KAP scores. Descriptive analysis, univariate analysis and multiple linear regression analysis were used to analyse the data using Stata version 14.0.

**Results:** Gender, age, employment, and clinical work experience were identified as independent predictors of knowledge on HAI, while receiving HAI education within the last year, occupational exposure, receiving invasive operation authority, and attending clinical consultation were the independent predictors of attitude towards HAI. Gender, educational level, occupational exposure, undergoing invasive operation authority, undergoing antibacterial drug training, attended clinical

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4 consultation, and department were found to predict the practice towards HAI.  
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6 Regression analysis revealed that age, antibacterial drug training, and clinical  
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8 consultation were the predictors of the total KAP on HAI.  
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12 **Conclusions:** The controllable factors identified in this study can be used by hospital  
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14 managers to implement measures that improves KAP among healthcare workers.  
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16 Moreover, these measures should be customized to suit the specific medical staff  
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18 characteristics based on uncontrollable factors to improve KAP. We recommend  
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20 training programs for medical workers to increase awareness about HAI and foster  
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22 positive attitudes and practice.  
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## Article Summary

### Strengths and limitations of this study

The research hypothesis of our study was pointed based on Kelman's theory of knowledge, attitudes, and practice.

This is the first study to investigate the KAPs in relation to HAI and their influencing factors among health care workers in central China.

There may be bias in self-reported surveys, which may affect the accuracy of the data.

This study was cross-sectional, so causal relationship could not be found.



## INTRODUCTION

Healthcare-associated infections (HAI) or nosocomial infections are infections in hospital inpatients that were neither present nor incubating at the time of the patient's admission to hospital.[1] It is a major problem encountered in health care delivery services can result in prolonged hospital stays, microbial resistance, exacerbations of existing conditions, worsen patients' economic burdens, over stretching of the available health care resources and even deaths.[2-4] According to the World Health Organization (WHO), at any given moment, 1.4 million patients around the world bear the consequences of HAI.[5] It has been estimated that almost 10% of inpatients would develop HAI during their stay in hospital.[6] Healthcare challenges emerging from HAI are currently among the most important public health issues faced worldwide.[7] In developing countries, the risk of acquiring an HAI is about 2-20 times higher than in developed countries.[8, 9] A recent study by Wang and colleagues reported that the weighted prevalence of HAI varies between 1.73% and 5.45% across Chinese municipalities and provinces.[10] The direct economic burden of hospital infections in China is \$1.5 billion to \$2.3 billion annually.[11] Therefore, the prevention and management of HAI in China, in the presence of competing interests, remains an important clinical and public health topic. [12,13]

Most HAI are caused by the transmission of a pathogen from one patient to another, especially by healthcare workers who do not properly comply hospital hygiene practices when treating or caring for patients.[14] For example, healthcare workers touch other patients without washing their hands after evaluating or caring for one patient. A previous study reported adherence to hand hygiene recommendations among healthcare workers remains suboptimal, with compliance rates of about 30%.[15] To minimize the risk of HAI, effective prevention and control

measures should always be taken specifically for healthcare workers.[16] According to Kelman's theory of KAP, knowledge is the basis of practice change and attitude is the driving force of practice change.[17] Therefore, understanding KAP of healthcare workers in relation to HAI is essential in establishing these measures. In addition, it is also important to identify the factors that significantly affect KAP, as it can provide a basis for intervention by HAI managers. There have few studies to investigate the KAP in relation to HAI among healthcare workers.[18-20] However, these studies have some limitations. Firstly, they only described the current KAP status but the factors influencing KAP remain poorly understood. Secondly, majority of published KAP reports only focused hand hygiene. Additionally, to the best of our knowledge, no studies have been conducted to assess KAP and identify its influencing factors among Chinese healthcare workers towards HAI at various healthcare settings.

Hence, this study aimed to assessed KAP with regards to HAI and to identify the factors that significantly influence KAP among healthcare workers at two university-affiliated hospitals in China. Based on Kelman's theory of KAP [17], we hypothesized that the factors significantly affecting the knowledge and attitude of healthcare workers would be partially coincident with the factors influencing their practice towards HAI. Specifically, we hypothesized that socio-demographic and job-related factors would significantly influence the knowledge and practice of healthcare workers towards HAI, whereas the factors significantly influencing the attitude of healthcare workers towards HAI would be mainly job-related.

## **METHODS**

### **Study design and participants**

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3 We carried out a cross-sectional questionnaire survey study in Wuhan from June  
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5 1st, 2019 to September 30th, 2019. The study employed the following multi-stage,  
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7 stratified sampling approach: 1) 2 regions out of the 13 administrative regions of  
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9 Wuhan were randomly selected for the study, 2) for each of the 2 selected regions, 1  
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11 hospital out of all Grade-III level-A hospitals in the region was randomly selected for  
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13 the study, 3) the human resources departments of the two hospitals randomly sent  
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15 online questionnaires to medical workers at the respective hospitals, and 4) healthcare  
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17 workers who received questionnaires voluntarily completed and returned them online.  
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19 Because some of the information requested through the questionnaires could only be  
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21 provided by registered doctors and nurses, in this study the term ‘healthcare workers’  
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23 refers to doctors and nurses only and excludes interns, escorts, and medical students.  
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25 To be included in the study, healthcare workers had to meet the following criteria: 1)  
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27 they had to be formal doctors and nurses registered at two hospitals, 2) they must have  
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29 possessed professional qualification certificates, and 3) they voluntarily agreed to  
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31 participate in the study. Healthcare workers who had been on leave at the time of the  
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33 survey, as well as non-clinical staff, were excluded from this study.  
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40 The sample size for the study was calculated by statistical power analysis.  
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42 According to Cohen’s guidelines,[21] when using multiple linear regression analyses  
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44 with an estimate of 10 independent variables based on the literature,[22] a minimum  
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46 of 120 subjects would be needed to achieve a median effect size (0.15) at 80%  
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48 statistical power and a significance level of 0.05.[23][24] A total of 468 healthcare  
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50 workers completed the online questionnaire and after excluding incomplete  
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52 questionnaires, the remaining 455 were used for downstream analyses. The larger  
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54 samples increased the statistical power of our study.  
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## 60 **Measures**

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3 Due to a lack of previous research on the KAP of HAI among health care  
4 workers, our questionnaire was based on standard precaution knowledge questions  
5 and the core content of HAI prevention and control system in China.[25-28] The  
6 questionnaire consisted of sections, the 1st covering general information and the 2nd  
7 covering KAP toward HAI. The general information section comprised of 16  
8 subsections with questions about age, gender, clinical work experience, marital status,  
9 educational level, occupation, department, position, professional title, employment,  
10 type of hospital, HAI education within the last year, occupational exposure within the  
11 last six months, invasive operation authority, antibacterial drug training, and attended  
12 clinical consultation. The HAI knowledge section included 6 subsections with  
13 questions about knowledge on hand hygiene, HAI, multi-drug resistance, standard  
14 precaution, and surgery site infection. The HAI attitude domain was comprised of  
15 sections with questions about personal and social motivation and covering aspects of  
16 responsibility, attention, necessity, and initiative for HAI. The HAI practice section  
17 had 12 subsections that mostly focused on the aseptic operation, standard precaution,  
18 and antibiotic use. All responses to KAP questions were scored on a 1-to-5-point scale  
19 that spanned responses of “consistent with my cognition” to “very inconsistent with  
20 my cognition”  
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### 45 **Pilot study and reliability**

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48 To test the trial version of the quick response code for this study, we recruited 30  
49 participants to take part in pilot run of the study from May 1st, 2019 to May 15th,  
50 2019. The responses from the participants of the pilot study were then analyzed for  
51 clarity, understandability, and applicability of the questionnaire. The time to complete  
52 the questionnaire and any technical difficulties while scanning the quick response  
53 code were recorded.  
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3 The Cronbach's alpha values were 0.662 (domain A, knowledge), 0.784 (domain  
4 B, attitudes), and 0.806 (domain C, practice) in this study.  
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### 8 9 **Data collection procedure**

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11 Following the assessment of the reliability and validity of the questionnaire, a  
12 web links to the questionnaire and informed consents forms were emailed to the  
13 qualifying potential participants. The estimated time needed to complete the survey  
14 was 15 minutes. After completing the questionnaire, participants submitted their  
15 responses online and returned their electronic informed consents via email. The  
16 questionnaires were then carefully reviews and incomplete or incorrectly completed  
17 questionnaires excluded from downstream analyses.  
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### 28 29 **Data analysis**

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31 For continuous variables, the means and standard deviations were calculated  
32 whereas frequencies and percentages were calculated for categorical variables. The  
33 score of KAP for general characteristics were analyzed by t-test or analysis of  
34 variance for continuous data. To determine the effects of general characteristics on  
35 KAP, a stepwise multiple linear regression analysis was conducted in which variables  
36 with statistical significance in univariate analysis were included in the regression  
37 model. All statistical analyses were performed using the statistical software Stata  
38 version 14.0 (Stata Corporation, College Station, TX). The statistical tests were  
39 two-sided, and statistical significance was set at  $p < 0.05$ .  
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### 53 54 **Patient and public involvement**

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56 No patients and the public were involved in the design or planning of the study.  
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## 59 **RESULTS**

## Descriptive statistics of participant characteristics

In total, 500 healthcare workers were invited to participate in the study and finally 455 health care workers (395 nurses and 60 doctors) participated. The response rate is 91%. The age of the study participants ranged between 22 and 59 years and had a mean age of 31.35 years. Of the 455 study participants, 44.6% had 1-5 years of experience in clinical work. Approximately 68.1% of the participants held bachelor's degrees. 60.2% of the respondents reported having received HAI education within the previous year. The demographics and general characteristics of the participating group are shown in Table 1.

## Univariate Analysis

The results of univariate analysis of the factors that influence KAP are shown in Table A1 -Table A4 (Supplementary Data). The mean scores of knowledge, attitude, practice and total KAP were significantly higher among the following groups of respondents: those with 40-59 years of age, contract employees, those who had received HAI education within the previous year, those invasive operation authority, those with special training on antibacterial drug classification management system and those who had participated in clinical consultations with infectious disease doctors.

Results from this univariate analysis indicated that skin or mucous membrane exposure to patient bodily fluids within the previous six months, having worked in operating rooms and infectious disease departments and having greater than 10 years' work experience were the significant predictors for knowledge score. Being married, possessing higher education levels, holding a senior technical job position, having worked in an operating room, surgery department or the department of infectious

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3 diseases and possessing more than ten years' work experience, were significant  
4 predictors for attitude score. Being female, being a department head, having worked  
5 in general hospitals, possessing higher educational levels, having previous skin or  
6 mucous membrane exposure to patient bodily fluids in the previous six months and  
7 having worked in an operating room, a surgery department or department of  
8 infectious diseases were the significant predictors for practice score. Additionally,  
9 results from the univariate analysis suggest that being female, a nurse, a department  
10 head who worked in general hospitals and having had skin or mucous membranes  
11 exposure to patient bodily fluids within the previous six months were important  
12 factors influencing scores.  
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**Table 1.** General characteristics of participants

Variables	n (%)
Age (mean $\pm$ SD, year)	31.35 $\pm$ 7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (mean $\pm$ SD, year)	9.45 $\pm$ 8.35
Marital status	
Unmarried	99 (21.8)
Married	344 (75.6)
Widowed/divorced	12 (2.6)
Educational level	
Junior college	37 (8.2)
Bachelor's degree	310 (68.1)
Master's degree or above	108 (23.7)
Occupation	
Doctor	60 (13.2)
Nurse	395 (86.8)
Department	
Internal medicine	16 (3.5)
Surgery	83 (18.2)
Obstetrics	20 (4.4)
Intensive care unit	87 (19.1)
Emergency	21 (4.6)
Outpatient	11 (2.4)



	Operating room	128 (28.1)
	Infectious diseases	68 (14.9)
	Other	21 (4.6)
Position		
	Staff	437 (96)
	Head	18 (4)
Professional title		
	Senior	23 (5.1)
	Middle	130 (28.6)
	Primary	302 (66.4)
Type of employment		
	Contract	238 (52.3)
	Permanent	217 (47.7)

**Table 1** (continued)

	Variables	n (%)
Type of hospital		
	The children's hospital	136 (29.9)
	General hospital	319 (70.1)
Received HAI education within last year		
	Yes	274 (60.2)
	No	181 (39.8)
Occupational exposures (impaired skin or mucosa to blood, body fluid, secretion and excretion of patients within 6 months)		

	Yes	282 (62)
	No	173 (38)
Received invasive operation authority		
	Yes	326 (71.6)
	No	129 (28.4)
Received antibacterial drug training		
	Yes	257 (56.5)
	No	198 (43.5)
Attending consultation (nosocomial infection disease)		
	Yes	238 (52.3)
	No	217 (47.7)

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SD: standard deviations

### Multiple linear regression analysis

Multiple linear regression analysis showed that gender, age group, type of employment and clinical work experience explained the knowledge scores variance in 21.4% (adjusted  $R^2 = 0.214$ ). Female, older age and 16-20 years of clinical work experience were positively associated with knowledge scores excluding employment type of permanent staff (Table 2).

Multiple linear regression analysis built a significant model ( $p < 0.001$ ), explaining 14.3% of the variance in attitude scores (adjusted  $R^2 = 0.143$ ). Received HAI education within the last year, occupational exposure within the last six months, received invasive operation authority, attended clinical consultation and outpatient department were negatively correlated with attitude scores (Table 3).

From the results of the multiple linear regression analyses shown in Table 4, we found that gender, education, surgery department, operating room and infectious

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3 disease department had a significant positive influence on practice score. While  
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5 occupational exposure within 6 months, received invasive operation authority,  
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7 received antibacterial drug training and attending clinical consultation had a  
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9 significant negative influence. It is clear that independent variables explain 47.05%  
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11 (adjusted  $R^2 = 0.4705$ ) of the differences found between health workers.  
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15 Multiple linear regression analysis also built a significant model ( $p < 0.001$ ),  
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17 explaining 61% of the variance in KAP total scores (adjusted  $R^2 = 0.61$ ). Female,  
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19 older age, head of department and employment type of permanent staff had a  
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21 significant positive influence on KAP total scores. While received HAI education  
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23 within last year, received invasive operation authority, received antibacterial drug  
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25 training and attending clinical consultation were negatively correlated with KAP total  
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27 scores (Table 5).  
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**Table 2.** Multiple linear regression analysis of the influencing factors for knowledge scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	13.20 (11.03,15.36)	1.10		11.99	< 0.001
Gender					
Female (vs. Male)	2.36 (1.24, 3.47)	0.57	0.19	4.15	< 0.001
Age group (years)					
40-59 (vs.18-39)	3.04 (1.84, 4.24)	0.61	0.27	4.98	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.27 (-1.82, -0.56)	0.32	-0.18	-3.93	< 0.001
Clinical work experience (year)					
6-10 (vs.1-5)	-0.17 (-0.93, 0.59)	0.39	-0.02	-0.44	0.660
11-15 (vs.1-5)	0.65 (-0.47, 1.77)	0.57	0.05	1.14	0.253
16-20 (vs.1-5)	1.54 (0.40, 2.68)	0.58	0.13	2.66	0.008
$\geq 21$ (vs.1-5)	0.87 (-0.34, 2.08)	0.61	0.08	1.41	0.158

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4 Independent variables included in the regression model were: gender, age group, occupation, type of employment, received HAI education within  
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6 last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, department, clinical  
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8 work experience.  
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10 Adjusted R<sup>2</sup> (p-value): 0.214 (p < 0.001).  
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13 CI: confidence interval; SD: standard deviations.  
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**Table 3.** Multiple linear regression analysis of the influencing factors for attitude scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	25.20 (22.89, 27.51)	1.18		21.44	< 0.001
Received HAI education within last year					
No (vs. Yes)	-0.97 (-1.64, -0.29)	0.34	-0.17	-2.82	0.005
Occupational exposure within 6 months					
No (vs. Yes)	-0.90 (0.15, 1.66)	0.38	0.16	2.36	0.019
Received invasive operation authority					
No (vs. Yes)	-1.04 (-2.05, -0.65)	0.33	-0.17	-3.12	0.002
Attending consultation					
No (vs. Yes)	-0.73 (-1.27, -0.19)	0.28	-0.13	-2.65	0.008
Department					
Surgery (vs. Internal medicine)	0.20 (-1.21, 1.62)	0.72	0.03	0.28	0.778
Obstetrics (vs. Internal medicine)	-0.87 (-2.57, 0.84)	0.87	-0.06	-1.00	0.319
Intensive care unit (vs. Internal medicine)	0.47 (-0.96, 1.91)	0.73	0.07	0.65	0.517

Emergency (vs. Internal medicine)	-0.99 (-2.67, 0.68)	0.85	-0.08	-1.16	0.245
Outpatient (vs. Internal medicine)	-2.11 (-4.13, -0.09)	1.03	-0.12	-2.05	0.041
Operating room (vs. Internal medicine)	0.38 (-1.02, 1.78)	0.71	0.06	0.54	0.591
Infectious diseases (vs. Internal medicine)	0.46 (-1.02, 1.94)	0.75	0.06	0.61	0.543
Other (vs. Internal medicine)	-0.94 (-2.64, 0.76)	0.87	-0.07	-1.08	0.280

Independent variables included in the regression model were: received HAI education within last year, occupational exposure within 6 months, received invasive operation authority, full time doctors of department of infectious disease, attending consultation, department; Adjusted R<sup>2</sup> (p-value): 0.1434(p < 0.001); CI: confidence interval; SD: standard deviations.

**Table 4.** Multiple linear regression analysis of the influencing factors for practice scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	40.71 (37.31, 44.10)	1.73		23.58	< 0.001
Gender					
Female (vs. Male)	1.55 (0.19, 2.90)	0.69	0.09	2.24	0.025
Occupational exposure within 6 months					
No (vs. Yes)	-1.49 (-2.60, -0.38)	0.56	-0.14	-2.64	0.009

## Received invasive operation authority

No (vs. Yes)	-1.70 (-2.67, -0.74)	0.49	-0.15	-3.47	0.001
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## Received antibacterial drug training

No (vs. Yes)	-3.01 (-3.85, -2.17)	0.43	-0.29	-7.06	< 0.001
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## Educational level

Bachelor's degree	3.40 (2.02, 4.78)	0.70	0.31	4.85	< 0.001
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Master's degree or above	3.74 (2.15, 5.33)	0.81	0.31	4.62	< 0.001
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## Attending consultation of nosocomial infection disease

No (vs. Yes)	-2.60 (-3.40, -1.80)	0.41	-0.25	-6.40	< 0.001
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## Department

Surgery (vs. Internal medicine)	2.78 (0.70, 4.86)	1.06	0.21	2.62	0.009
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Obstetrics (vs. Internal medicine)	-1.06 (-3.59, 1.47)	1.29	-0.04	-0.82	0.412
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Intensive care unit (vs. Internal medicine)	1.70 (-0.41, 3.82)	1.08	0.13	1.58	0.114
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Emergency (vs. Internal medicine)	0.91 (-1.56, 3.38)	1.26	0.04	0.73	0.468
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Outpatient (vs. Internal medicine)	2.18 (-0.78, 5.14)	1.51	0.07	1.45	0.148
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Operating room (vs. Internal medicine)	2.76 (0.71, 4.81)	1.04	0.24	2.65	0.008
Infectious diseases (vs. Internal medicine)	2.70 (0.52, 4.87)	1.11	0.19	2.43	0.015
Other (vs. Internal medicine)	0.08 (-2.44, 2.60)	1.28	0	0.06	0.951

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Independent variables included in the regression model included: gender, age group, type of hospital, position, type of employment, received HAI education within last year, occupational exposure of within 6 months, received invasive operation authority, received antibacterial drug training, educational level, attending participating, department, clinical work experience, professional title.

Adjusted R<sup>2</sup> (p-value): 0.4705 (p < 0.001).

CI: confidence interval; SD: standard deviations.

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**Table 5.** Multiple linear regression analysis of the influencing factors for KAP total scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	87.06 (85.12, 88.99)	0.99		88.31	< 0.001
Gender					
Female (vs. Male)	2.36 (1.11, 4.40)	0.84	0.09	3.29	0.008
Age group (years)					
40-59 (vs.18-39)	6.65 (5.07, 7.74)	0.68	0.30	9.44	< 0.001
Position					
Head (vs. Staff)	7.02 (3.88, 8.45)	1.16	0.18	5.30	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.08 (-2.08, -0.07)	0.51	-0.07	-2.11	0.035
Received HAI education within last year					
No (vs. Yes)	-2.98 (-4.23, -1.72)	0.64	-0.20	-4.65	< 0.001
Received invasive operation authority					
No (vs. Yes)	-4.22 (-5.46, -2.99)	0.63	-0.26	-6.71	< 0.001

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Received antibacterial drug training

No (vs. Yes) -4.38 (-5.45, -3.31) 0.55 -0.29 -8.03 < 0.001

Attending consultation

No (vs. Yes) -4.35 (-5.38, -3.32) 0.52 -0.29 -8.31 < 0.001

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Independent variables included in the regression model were: gender, age group, type of hospital, occupation, position, type of employment, received HAI education within last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, attending consultation

Adjusted R<sup>2</sup>(p-value): 0.61 (p < 0.001); CI: confidence interval; SD: standard deviation.

## DISCUSSION

To the best of our knowledge, this is the first study describing the KAPs in relation to HAI and their influencing factors among health care workers in central China. Although recent years have seen increased awareness and stricter regulations on the control of hospital infections, our survey found that clear shortcomings still exist in health care workers' knowledge and practices with regards to HAI. These findings might inform the design and implementation of targeted intervention programs to promote the KAP of health care workers and as well as lay the groundwork for future studies.

According to our findings, participants with the highest knowledge scores have the following characteristics: 1) are senior health care workers or nurses, 2) have received training on HAI, 3) have surgical work experience and, 4) are occupationally exposed to HAI. Multiple linear regression analysis can be used for the examination of correlations between gender, age group, type of employment, and clinical work experience. This analysis revealed that age group and gender exhibits the highest and 2nd highest relationship levels, respectively. While type of employment displays the lowest relationship level. Similar observations have previously been reported,[29] demonstrating that participants who have received training within the previous five years obtain higher knowledge scores. A previous study of the KAP associated with central vascular catheters is highly consistent with our study and reported that knowledge scores are significantly higher in respondents who have received active formal training.[30] Compared to health care workers in the UK, our study revealed significant differences in knowledge levels across medical specializations. Among UK health care workers, career seniority and gender did not significantly correlate

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3 with differences in knowledge level. However, in our study, gender and age are the  
4 main factors that positively impact knowledge.[31] Interestingly, permanent staff  
5 exhibited lower knowledge than contract employees. We hypothesize that the better  
6 knowledge exhibited by contract employees is acquired because they face a higher  
7 risk of dismissal, which causes them to strengthen their knowledge of HAI in a bid to  
8 minimize this risk.  
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18 Senior health care workers with greater experience had higher scores on attitude.  
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20 Additionally, possessing HAI education, authority to perform invasive operations,  
21 participating in clinical consultations, working in the surgery department, or the  
22 department of infectious diseases promote positive HAI attitudes. Our regression  
23 model analysis indicated that the maximum correlation coefficient of factors  
24 associated with positive attitude toward HAI are outpatient medicine (vs. internal  
25 medicine), followed by having invasive operation authority, receiving HAI education  
26 within the previous year, occupational exposure, and attending clinical consultations.  
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28 It has been previously reported that respondents' attitudes toward prevention-related  
29 HAI are significantly high among ICU (intensive care unit) health care workers, who  
30 have appropriate knowledge and training.[30] Consistent with our study, a 2014  
31 multi-center study conducted in Shanghai, China revealed independent associations  
32 between older age or higher education and categorical knowledge among  
33 physicians.[25] The 2014 study also reported that higher work experience is inversely  
34 and independently associated with knowledge and attitude of health care workers.[25]  
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53 In the practice domain, it has been shown that the level of education has the  
54 highest influence on the ability of health care workers to implement infection  
55 prevention and control of HAI. Other positive factors include gender, occupational  
56 exposure within the previous six months, authority to perform invasive operations,  
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3 antibacterial drug training and attendance of clinical consultations. Prior studies have  
4 largely focused on hand hygiene practices and most have reported poor compliance to  
5 hand hygiene recommendation.[15, 32] Multiple studies have shown that factors  
6 including perceived severity, subjective norm, and job demands also significantly  
7 influence practice.[33] However, to some extent, influencing factors in our study,  
8 such as occupational exposure and training, also belong to self-perception.  
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17 Biases in self-reported surveys may exist, especially with respect to participant  
18 behavior and practices, which may lead to participants overstating their good  
19 practices. With this study being cross-sectional, inferences drawn from self-reported  
20 practices may vary from direct observation evidence. Moreover, no causal  
21 relationship can be found.  
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## 30 CONCLUSION

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33 In this study, we show that uncontrollable factors (such as gender, age, job  
34 position, employment type, educational level and clinical work experience), as well as  
35 controllable ones (such as HAI education within the previous year, occupational  
36 exposure within the previous six months, antibacterial drug training and participation  
37 in clinical consultations) are closely associated with KAP. The controllable factors  
38 emerging from the study suggest that hospital managers can take appropriate  
39 measures for all health care workers to promote the improved KAP. Furthermore,  
40 uncontrollable factors indicate that when taking measures to improve KAP, hospital  
41 managers should take into consideration the backgrounds of the individual health care  
42 workers. In addition, we found that some socio-demographic and job-related factors  
43 significantly influenced the knowledge and practice toward HAI in Chinese healthcare  
44 worker, whereas the factors significantly influenced the attitude of healthcare workers  
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3 towards HAI were mainly job-related. This result actually supports our study  
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5 hypotheses. However, more studies would be needed to establish the benchmark of  
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7 KPA toward HAI among healthcare workers.  
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11 **Author Contributions:** WWW conceived the study. WWW, WWR, YYF, LLK,  
12  
13 TYB, YJR and WY contributed in the survey design, data collection. DL contributed  
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15 in data analysis. All authors contributed to the interpretation of data and intellectual  
16  
17 revised multiple drafts. WWW and WWR drafted the manuscript. All authors have  
18  
19 approved the final version of the manuscript.  
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33 hospitals which allowed us to perform survey with their staff.  
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37 **Competing interests:** None declared.  
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40 **Ethics approval:** Ethical approval was received from the institutional ethics board of  
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42 Wuhan University Zhongnan Hospital (No:2019191).  
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46 **Data availability statement:** Data are available upon reasonable request.  
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## 50 REFERENCES

- 51 1. Breathnach, Aodhán S. Nosocomial infections and?infection control. *Medicine* 2013, 41,  
52 649-53.  
53
- 54 2. Daxboeck F, Budic T, Assadian O, et al. Economic burden associated with  
55 multi-resistant Gram-negative organisms compared with that for methicillin-resistant  
56 Staphylococcus aureus in a university teaching hospital. *J Hosp Infect* 2006, 62, 214-18.  
57  
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2  
3 3. Rattanaumpawan P, Thamlikitkul V. Epidemiology and economic impact of health  
4 care-associated infections and cost-effectiveness of infection control measures at a Thai  
5 university hospital. *Am J Infect Control* 2017, 45, 145-50.  
6  
7
- 8  
9 4. Hollmeyer HG, Hayden F, Poland G, et al. Influenza vaccination of health care workers  
10 in hospitals—A review of studies on attitudes and predictors. *Vaccine* 2009, 27, 3935-44.  
11  
12
- 13 5. Global patient safety challenge: 2005-2006/World Alliance for Patient Safety. Available  
14 online: <https://apps.who.int/iris/handle/10665/43358> (accessed on 16 June 2006).  
15  
16
- 17 6. Humphreys H, Newcombe RG, Enstone J, et al. Four Country Healthcare Associated  
18 Infection Prevalence Survey 2006: risk factor analysis. *journal of hospital infection*  
19 2008, 69, 249-57.  
20  
21
- 22 7. Rosenthal VD. Health-care-associated infections in developing countries. *Lancet* 2011,  
23 377, 186-8.  
24  
25
- 26 8. Xie DS, Fu XY, Wang HF, et al. Annual point-prevalence of healthcare-associated  
27 infection surveys in a university hospital in China, 2007-2011. *J Infect Public Health*  
28 2013, 6, 416-22.  
29  
30
- 31 9. Liu JY, Wu YH, Cai M, et al. Point-prevalence survey of healthcare-associated  
32 infections in Beijing, China: a survey and analysis in 2014. *J Hosp Infect* 2016, 93,  
33 271-9.  
34  
35
- 36 10. Wang J, Liu F, Tartari E, et al. The Prevalence of Healthcare-Associated Infections in  
37 Mainland China: A Systematic Review and Meta-analysis. *Infect Control Hosp*  
38 *Epidemiol* 2018, 39, 701-9.  
39  
40
- 41 11. Sun BW. Nosocomial infection in China: Management status and solutions. *American*  
42 *Journal of Infection Control* 2016, 44, 851-2.  
43  
44
- 45 12. Byarugaba, DK. A view on antimicrobial resistance in developing countries and  
46 responsible risk factors [J]. *International journal of antimicrobial agents* 2004, 24,  
47 105-10.  
48  
49
- 50 13. Mir F, Zaidi AKM. Hospital infections by antimicrobial-resistant organisms in  
51 developing countries. In *Antimicrobial resistance in developing countries*, 1nd ed.; AdJ  
52 Sosa, Byarugaba DK, Eds; Springer: New York, USA, 2010; 317, 199-232.  
53  
54  
55  
56  
57  
58  
59  
60



14. Adebimpe, WO, Asekun-Olarinmoye EO, Bamidele JO, et al. A comparative study of awareness and attitude to nosocomial infections among levels of health care workers in southwestern nigeria. *Continental Journal of Tropical Medicine* 2011, 5, 5.
15. Hien H, Drabo M, Ouédraogo L, et al. Knowledge and practices of health care workers in the area of healthcare-associated infection risks. A case study in a district hospital in Burkina Faso. *Sante Publique* 2013, 25, 219-26.
16. World Health Organization. Geneva. 2017. Guidelines for the prevention and control of carbapenem-resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in health care facilities.
17. Jiang H, Zhang S, Ding Y, et al. Development and validation of college students' tuberculosis knowledge, attitudes and practices questionnaire (CS-TBKAPQ). *Bmc Public Health* 2017, 17, 949.
18. Angelillo IF, Mazziotta A, Nicotera G. Nurses and hospital infection control: knowledge, attitudes and behaviour of Italian operating theatre staff. *Journal of Hospital Infection* 1999, 42, 105-12.
19. Balarabe SA, Joshua IA, Danjuma A, et al. Knowledge of Healthcare Workers on Nosocomial Infection in Selected Secondary Health Institutions in Zaria, Nigeria. *Journal of preventive medicine* 2015, 3, 1-6.
20. Adegboye MB, Zakari S, Ahmed BA, et al. Knowledge, awareness and practice of infection control by health care workers in the intensive care units of a tertiary hospital in Nigeria. *African Health Sciences* 2018, 18, 72-8.
21. Cohen J. A Power Primer. *Psychological bulletin* 1992, 112, 155-9.
22. Brown MT, Bussell JK. Medication Adherence: WHO Cares? *Mayo Clinic Proceedings* 2011, 86, 304-14.
23. Glader EL, Sjolander M, Eriksson M, et al. Persistent Use of Secondary Preventive Drugs Declines Rapidly During the First 2 Years After Stroke. *Stroke* 2010, 41, 397-401.
24. Maxwell SE. Sample size and multiple regression analysis.. *Psychological methods* 2000, 5, 434.
25. Zhou Y, Zhang D, Chen Y, et al. Healthcare-associated infections and Shanghai clinicians: a multicenter cross-sectional study. *PLoS One* 2014, 9, e105838-e105838.

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2  
3 26. Luo Y, He GP, Zhou JW, et al. Factors impacting compliance with standard precautions  
4 in nursing, China. *Int J Infect Dis* 2010, 14, e1106-e1114.  
5  
6  
7 27. Tavolacci MP, Ladner J, Bailly L, et al. Prevention of nosocomial infection and standard  
8 precautions: knowledge and source of information among healthcare students. *Infect*  
9 *Control Hosp Epidemiol* 2008, 29, 642-7.  
10  
11  
12 28. Circular of the general office of the National Health Commission on Further  
13 Strengthening the prevention and control of infection in medical institution. Available  
14 online: <http://www.cha.org.cn/plus/view.php?aid=15223> (accessed on 15 March 2017).  
15  
16  
17 29. Taffurelli C, Sollami A, Camera C, et al. Healthcare associated infection: good practices,  
18 knowledge and the locus of control in healthcare professionals. *Acta Biomed* 2017, 88,  
19 31-6.  
20  
21  
22 30. Bianco A, Coscarelli P, Nobile CGA, et al. The reduction of risk in central  
23 line-associated bloodstream infections: knowledge, attitudes, and evidence-based  
24 practices in health care workers. *Am J Infect Control* 2013, 41, 107-12.  
25  
26  
27 31. Brady RRW, McDermott C, Cameron F, et al. UK healthcare workers' knowledge of  
28 meticillin-resistant *Staphylococcus aureus* practice guidelines; a questionnaire study. *J*  
29 *Hosp Infect* 2009, 73, 264-70.  
30  
31  
32 32. Ellingson K, Haas JP, Aiello AE, et al. Strategies to prevent healthcare-associated  
33 infections through hand hygiene. *Infect Control Hosp Epidemiol* 2014, 35, S155-78.  
34  
35  
36 33. Brazzell BD. Improving High Hand-hygiene Compliance and Reducing  
37 Healthcare-associated Infection in Eight Nursing Units. *Am J Infect Control* 2014, 42,  
38 S25-6.  
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**Table A1.** Results of univariate analysis of knowledge

Variables	Mean ± SD	n	p-value
Gender			< 0.001
Male	13.88 ± 0.50	41	
Female	16.27 ± 0.17	414	
Age group (years)			< 0.001
18-39	15.60 ± 0.17	397	
40-59	19.19 ± 0.36	58	
Occupation			0.0031
Doctor	14.93 ± 0.38	60	
Nurse	16.22 ± 0.18	395	
Type of employment			< 0.001
Contract	16.69 ± 0.24	238	
Permanent	15.36 ± 0.23	217	

Received HAIs education within last year				0.0139
	Yes	16.40 ± 0.20	274	
	No	15.54 ± 0.29	181	
Occupational exposures within 6 months				0.0072
	Yes	16.41 ± 0.21	282	
	No	15.48 ± 0.27	173	
Received invasive operation authority				< 0.001
	Yes	16.38 ± 0.19	326	
	No	15.22 ± 0.31	129	
Prescription right of special class antibacterial drugs				0.0254
	Yes	16.38 ± 0.23	257	
	No	15.64 ± 0.24	198	

**Table A1.** (continued)

Variables	Mean ± SD	n	p-value
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5	Department			0.040
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7		Internal medicine	14.69 ± 4.51	16
8				
9		Surgery	15.77 ± 3.44	83
10				
11		Obstetrics	15.35 ± 2.23	20
12				
13		Intensive care unit	15.54 ± 3.00	87
14				
15		Emergency	14.43 ± 4.40	21
16				
17		Outpatient	13.45 ± 3.45	11
18				
19		Operating room	16.23 ± 3.27	128
20				
21		Infectious diseases	16.07 ± 3.30	68
22				
23		Other	14.67 ± 2.52	21
24				
25				
26				
27				
28	Clinical work experience (years)			0.025
29				
30		1-5	15.43 ± 3.40	203
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32		6-10	15.15 ± 3.38	110
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34		11-15	16.35 ± 2.98	40
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	16-20	16.48 ± 3.13	42	
	≥ 21	16.45 ± 3.17	60	
Attending consultation				< 0.001
	Yes	16.60 ± 0.22	238	
	No	15.47 ± 0.25	217	

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**Table A2.** Results of univariate analysis of attitude

Variables	Mean ± SD	n	p-value
Age group (years)			< 0.001
18-39	24.83 ± 0.14	397	
40-59	26.19 ± 0.36	58	
Type of employment			0.0168
Contract	25.29 ± 0.16	238	
Permanent	24.67 ± 0.20	217	
Received HAIs education within last year			< 0.001
Yes	25.41 ± 0.15	274	
No	24.38 ± 0.22	181	
Occupational exposure within 6 months			< 0.001
Yes	25.35 ± 0.15	282	
No	24.42 ± 0.22	173	

Received invasive operation authority				< 0.001
	Yes	25.37 ± 0.15	326	
	No	24.05 ± 0.25	129	
Received antibacterial drug training				0.0023
	Yes	25.34 ± 0.17	257	
	No	24.55 ± 0.20	198	
Educational level				0.012
	Junior college	24.30 ± 2.64	37	
	Bachelor's degree	24.86 ± 2.74	310	
	Master's degree or above	25.63 ± 2.73	108	

**Table A2.** (continued)

Variables	Mean ± SD	n	p-value
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5	Attending consultation			0.0089
6				
7	Yes	25.32 ± 0.18	238	
8				
9	No	24.65 ± 0.19	217	
10				
11				
12	Department			< 0.001
13				
14	Internal medicine	24.19 ± 2.93	16	
15				
16	Surgery	25.20 ± 3.02	83	
17				
18	Obstetrics	24.00 ± 2.97	20	
19				
20	Intensive care unit	25.54 ± 2.40	87	
21				
22	Emergency	23.19 ± 3.11	21	
23				
24	Outpatient	22.18 ± 3.37	11	
25				
26	Operating room	25.29 ± 2.46	128	
27				
28	Infectious diseases	25.54 ± 2.42	68	
29				
30	Other	23.24 ± 2.45	21	
31				
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35	Clinical work experience (years)			< 0.001
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	1-5	24.56 ± 2.76	203	
	6-10	24.77 ± 2.64	110	
	11-15	25.38 ± 2.39	40	
	16-20	26.31 ± 2.70	42	
	≥ 21	25.73 ± 2.79	60	
Marital status				0.002
	Unmarried	24.20 ± 2.82	99	
	Married	25.25 ± 2.72	344	
	Widowed/divorced	24.33 ± 1.56	12	

**Table A2.** (continued)

	Variables	Mean ± SD	n	p-value
Professional Title				< 0.001
	Senior	26.39 ± 2.13	23	

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Middle	25.53 ± 2.87	130
Primary	24.66 ± 2.68	302

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**Table A3.** Results of univariate analysis of practice

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Gender				0.0169
	Male	41.41 ± 0.86	41	
	Female	43.64 ± 0.25	414	
Age group (years)				< 0.001
	18-39	43.14 ± 0.26	397	
	40-59	45.50 ± 0.51	58	
Type of hospital				0.0207
	The children's hospital	42.61 ± 0.41	136	
	General hospital	43.79 ± 0.30	319	
Position				0.0207
	Staff	42.61 ± 0.41	136	
	Head	43.79 ± 0.29	319	

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Type of employment				< 0.001
	Contract	44.50 ± 0.33	238	
	Permanent	42.28 ± 0.34	217	
Educational level				< 0.001
	Junior college	38.24 ± 4.17	37	
	Bachelor's degree	43.85 ± 4.97	310	
	Master's degree or above	44.03 ± 5.04	108	
Received HAIs education within last year				< 0.001
	Yes	44.81 ± 0.29	274	
	No	41.36 ± 0.37	181	

**Table A3.** (continued)

Variables	Mean ± SD	n	p-value
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1				
2				
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4				
5	Occupational exposure within 6 months			< 0.001
6				
7	Yes	45.34 ± 0.26	284	
8				
9	No	40.28 ± 0.36	171	
10				
11				
12	Received invasive operation authority			< 0.001
13				
14	Yes	44.81 ± 0.26	326	
15				
16	No	39.98 ± 0.40	129	
17				
18				
19	Received antibacterial drug training			< 0.001
20				
21	Yes	45.35 ± 0.27	257	
22				
23	No	40.96 ± 0.36	198	
24				
25				
26	Department			< 0.001
27				
28	Internal medicine	38.13 ± 4.84	16	
29				
30	Surgery	44.51 ± 4.76	83	
31				
32				
33	Obstetrics	38.60 ± 4.27	20	
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35	Intensive care unit	43.95 ± 5.19	87	
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	Emergency	39.71 ± 3.66	21	
	Outpatient	39.36 ± 4.32	11	
	Operating room	44.98 ± 4.91	128	
	Infectious diseases	44.46 ± 3.80	68	
	Other	38.95 ± 4.40	21	
Attending consultation				< 0.001
	Yes	44.61 ± 0.30	238	
	No	42.16 ± 0.37	217	

**Table A3.** (continued)

	Variables	Mean ± SD	n	p-value
	Clinical work experience (years)			0.012
	1-5	42.89 ± 5.57	203	

1				
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4				
5		6-10	42.88 ± 5.33	110
6				
7		11-15	45.20 ± 3.34	40
8				
9		16-20	44.00 ± 4.54	42
10				
11		≥21	44.77 ± 4.24	60
12				
13				
14	Professional Title			0.022
15				
16		Senior	46.17 ± 4.03	23
17				
18		Middle	43.63 ± 4.78	130
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20		Primary	43.15 ± 5.33	302
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**Table A4.** Results of univariate analysis of KAP

Variables	Mean $\pm$ SD	n	p-value
Gender			0.0014
Male	80.41 $\pm$ 1.27	41	
Female	84.90 $\pm$ 0.36	414	
Age group (years)			< 0.001
18-39	83.56 $\pm$ 0.37	397	
40-59	90.88 $\pm$ 0.63	58	
Occupation			0.0244
Doctor	82.40 $\pm$ 0.98	60	
Nurse	84.81 $\pm$ 0.37	395	
Type of hospital			0.0169
The children's hospital	83.22 $\pm$ 0.63	136	
General hospital	85.03 $\pm$ 0.41	319	

Position				< 0.001
	Staff	84.06 ± 0.34	437	
	Head	95.06 ± 1.10	18	
Type of employment				< 0.001
	Contract	86.48 ± 0.46	238	
	Permanent	82.31 ± 0.48	217	
Received HAIs education within last year				< 0.001
	Yes	86.62 ± 0.39	274	
	No	81.28 ± 0.56	181	
Occupational exposure within 6 months				< 0.001
	Yes	87.12 ± 0.39	284	
	No	80.13 ± 0.52	171	

**Table A4.** (continued)

Variables	Mean ± SD	n	p-value
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1				
2				
3				
4				
5	Received invasive operation authority			< 0.001
6				
7		Yes	86.56 ± 0.38	326
8				
9		No	79.26 ± 0.54	129
10				
11				
12	Received antibacterial drug training			< 0.001
13				
14		Yes	87.07 ± 0.42	257
15				
16		No	81.15 ± 0.50	198
17				
18				
19	Attending consultation			< 0.001
20				
21		Yes	86.52 ± 0.42	238
22				
23		No	82.27 ± 0.52	217
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# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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		Reporting Item	Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	5
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	6
<b>Methods</b>			
Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	7
Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including periods of	7

1		recruitment, exposure, follow-up, and data collection	
2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of	7
3		participants.	
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5			
6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	8
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	8
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
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17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	8
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	7
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	8
22	variables	applicable, describe which groupings were chosen, and why	
23			
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25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	9
26	methods	confounding	
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29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	n/a
30	methods		
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33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	7
34	methods		
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37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	7
38	methods	strategy	
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41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	n/a
42	methods		
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44	<b>Results</b>		
45			
46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	7
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	7
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57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	n/a
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1	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	10
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	7
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	n/a
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14	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-14
15				
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19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	15-19
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21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	n/a
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29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	21
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34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	22
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	20-22
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	22
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47	<b>Other</b>			
48	<b>Information</b>			
49				
50				
51	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23
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# BMJ Open

## Knowledge, attitudes and practice towards healthcare-associated infections among healthcare workers in Wuhan, China: a cross-sectional study

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<b>Primary Subject Heading</b>:	Medical management
Secondary Subject Heading:	Medical management, Infectious diseases, Medical education and training
Keywords:	Infection control < INFECTIOUS DISEASES, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH

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**Title page**

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3 **Title:** Knowledge, attitudes and practice towards healthcare-associated infections  
4 among healthcare workers in Wuhan, China: a cross-sectional study

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23 **Word count:** 3319 words.

## ABSTRACT

**Objective:** To assess the knowledge, attitudes, and practice (KAP) concerning healthcare-associated infections (HAIs) among healthcare givers and to identify the factors influencing KAP.

**Design:** The study was a hospital-based, cross-sectional study.

**Setting:** Two public hospital in Wuhan, central China.

**Participants:** Participants for the study were recruited from the healthcare workers of a general hospital and children's hospital in Wuhan city from June 1 to September 30, 2019.

**Primary and secondary outcome measures:** The outcomes were knowledge, attitude, and practice towards HAIs.

**Results:** 455 healthcare workers were included in the final data analysis. The mean scores of KAP and total KAP were  $15.67 \pm 3.32$ ,  $25.00 \pm 2.75$ ,  $43.44 \pm 5.15$  and  $84.76 \pm 6.72$ , respectively. The following factors were significantly associated with the total KAP score towards HAIs, explaining 61% of the variance ( $p < 0.001$ ): gender ( $\beta = 2.36$ , 95% CI: 1.11 to 4.40), age ( $\beta = 6.65$ , 95% CI: 5.07 to 7.74), position ( $\beta = 7.02$ , 95% CI: 3.88 to 8.45), type of employment ( $\beta = -1.08$ , 95% CI:  $-2.08$  to  $-0.07$ ), with HAI education within last year ( $\beta = -2.98$ , 95% CI:  $-4.23$  to  $-1.72$ ), with invasive operation authority ( $\beta = -4.22$ , 95% CI:  $-5.46$  to  $-2.99$ ), antibacterial drug training ( $\beta = -4.38$ , 95% CI:  $-5.45$  to  $-3.31$ ) and with antibacterial drug training and clinical consultation ( $\beta = -4.35$ , 95% CI:  $-5.38$  to  $-3.32$ ).

**Conclusions:** The controllable factors identified in this study can be used by hospital managers to implement measures that improved KAP amongst healthcare workers. Moreover, these measures should be customised on the basis of uncontrollable factors to suit the specific characteristics of medical staff and improve KAP. Training programs should be designed for medical workers to increase their awareness about HAIs and foster positive attitudes and practice.

## Article Summary

### Strengths and limitations of this study

The research hypothesis of our study was developed on the basis of Kelman's theory of knowledge, attitudes and practice.

A large sample was used to investigate KAP towards HAIs and identify the significant influencing factors of KAP amongst healthcare workers in central China.

Conducting a self-reported survey might cause bias and affect the accuracy of findings.

This study was cross-sectional, so causal relationship could not be confirmed.

## 1 INTRODUCTION

2 Healthcare-associated infections (HAIs) refer to the infections acquired in  
3 hospitals but are neither present nor incubating at the time of a patient's admission to  
4 hospitals.<sup>1</sup> HAIs are major problem encountered in healthcare delivery services and can  
5 result in prolonged hospital stay, microbial resistance, exacerbations of existing  
6 conditions, worsening of patients' economic burdens, overstretching of available  
7 healthcare resources and even deaths.<sup>2-4</sup> According to the World Health Organization  
8 (WHO), at any given moment, 1.4 million patients around the world bear the  
9 consequences of HAIs.<sup>5</sup> It has been estimated that almost 10% of inpatients would  
10 suffer the consequences of HAIs.<sup>6</sup> Healthcare challenges emerging from HAIs are  
11 currently amongst the most important public health issues faced worldwide.<sup>7</sup> The risk  
12 of acquiring an HAI in developing countries is about 2–20 times higher than that in  
13 developed countries.<sup>8,9</sup> Wang and colleagues reported that the weighted prevalence of  
14 HAIs varies between 1.73% and 5.45% in Chinese municipalities and provinces.<sup>10</sup> The  
15 direct economic burden of hospital infections in China ranges from \$1.5 billion to \$2.3  
16 billion annually.<sup>11</sup> Therefore, the prevention and management of HAIs in China, in the  
17 presence of competing interests remain an important clinical and public health topic.  
18 <sup>12,13</sup>

19 One of the main causes of HAIs is the contact and transmission of contaminated  
20 hands and medical equipment by healthcare workers (HCWs) who do not properly  
21 comply with hospital hygiene practices.<sup>14</sup> For example, after evaluating or caring for  
22 one patient, HCWs touch another patient without washing their hands properly. A  
23 previous study reported that adherence to hand hygiene recommendations amongst  
24 HCWs remains suboptimal, and the compliance rate is about 30%.<sup>15</sup> In fact, nearly 42%  
25 of HCWs infected COVID-19 are related to the inappropriate utilisation of personal  
26 protective equipment (PPE), masks and gloves.<sup>16</sup>

27 Effective prevention and control measures should always be taken specifically by  
28 HCWs to minimise the risk of HAIs.<sup>17</sup> According to Kelman's theory of knowledge,  
29 attitudes and practice (KAP), knowledge is the basis for changing practice, and attitude  
30 is the driving force of such change.<sup>18</sup> Therefore, understanding KAP of HCWs in  
31 relation to HAIs is essential in establishing these measures. Identifying the factors that  
32 significantly affect KAP is also important, as it can provide a basis for implementing

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3 1 intervention measures by HAI managers. Few studies have investigated the KAP in  
4 2 relation to HAIs amongst HCWs. There have few studies to investigate the KAP in  
5 3 relation to HAIs among HCWs.<sup>19-21</sup> However, these studies have some limitations.  
6 4 Firstly, they only described the current KAP status, but the factors influencing KAP  
7 5 remain poorly understood. Secondly, a majority of published KAP reports have only  
8 6 focused on hand hygiene. To the best of our knowledge, no studies have assessed KAP  
9 7 and identified its influencing factors amongst Chinese HCWs towards HAIs in various  
10 8 healthcare settings.

11 9 Hence, this study aimed to assess KAP associated with HAIs and identify the  
12 10 factors that significantly influenced KAP amongst HCWs at two university-affiliated  
13 11 hospitals in China. Based on Kelman's theory of KAP,<sup>18</sup> our hypothesis was that the  
14 12 factors significantly affecting the knowledge and attitude of HCWs would be partially  
15 13 coincident with the factors influencing their practice towards HAIs. Specifically,  
16 14 sociodemographic and job-related factors would significantly influence the knowledge  
17 15 and practice of HCWs towards HAIs, whereas the factors significantly affecting the  
18 16 attitude of HCWs towards HAIs would be mainly job related.

## 19 17 **METHODS**

### 20 18 **Study design and participants**

21 19 A cross-sectional questionnaire survey was conducted in Wuhan from 1 June 2019  
22 20 to 30 September 2019. A total of 49 tertiary public hospitals are located in Wuhan, with  
23 21 8.41 hospital beds per 1000 people.<sup>22</sup> The following multistage stratified sampling  
24 22 approach was employed: 1) 2 regions out of the 13 administrative regions of Wuhan  
25 23 were randomly selected for the study; 2) for each of the two selected regions, one  
26 24 hospital out of all grade III level-A hospitals in the region was randomly chosen; 3)  
27 25 with the support of the department of human resources of the two study hospitals,  
28 26 potential participants were randomly selected from the list of job numbers of HCWs  
29 27 and given the online link of questionnaires; and 4) the HCWs who received  
30 28 questionnaires voluntarily completed and returned them online. The term 'HCWs'  
31 29 referred to doctors and nurses only and excluded interns, nurse assistants and medical  
32 30 students, because some of the information requested through the questionnaires could  
33 31 only be provided by registered doctors and nurses. To be included in the study, HCWs  
34 32 should meet the following criteria: 1) formal doctors and nurses registered at two

1 hospitals; 2) professional qualification certificates; and 3) voluntary participation in the  
2 study. HCWs who were on leave at the time of the survey and nonclinical staff were  
3 excluded from this study.

4 The sample size for the study was calculated through statistical power analysis.  
5 According to Cohen's guidelines,<sup>23</sup> in multiple linear regression analyses with an  
6 estimate of 10 independent variables,<sup>24</sup> a minimum of 120 subjects would be needed to  
7 achieve a median effect size (0.15) at 80% statistical power and a significance level of  
8 0.05.<sup>25 26</sup> A total of 468 HCWs completed the online questionnaire, and incomplete  
9 questionnaires were excluded. The 455 remaining questionnaires were used for  
10 downstream analyses. The larger samples increased the statistical power of our study.

## 11 **Measures**

12 Our questionnaire was based on standard precaution knowledge questions and the  
13 core content of HAI prevention and control system in China because of a lack of  
14 previous research on the KAP of HAIs amongst HCWs.<sup>27-30</sup> The questionnaire  
15 consisted of two sections: the first section covered general information, and the second  
16 one included KAP towards HAIs. The general information section comprised 16  
17 questions to collect the participants' sociodemographic data, including age, gender,  
18 clinical work experience, marital status, educational level, occupation, department,  
19 position, professional title, employment, type of hospital, HAI education within the last  
20 year, occupational exposure within the last 6 months, invasive operation authority,  
21 antibacterial drug training and attended clinical consultation.

22 The HAI knowledge domain consisted of six questions to assess the participants'  
23 knowledge on hand hygiene, HAIs, multidrug resistance, standard precaution and  
24 surgery site infection. The HAI attitude domain included eight questions to assess the  
25 participants' attitude about personal and social motivation, which covered the aspects  
26 of responsibility, attention, necessity and initiative amongst HAIs. The HAI practice  
27 domain had twelve questions to assess the participants' practice on aseptic operation,  
28 standard precaution and antibiotic use. The responses were scored on a 5-point Likert  
29 scale ranging from 1 = consistent with my cognition to 5 = very inconsistent with my  
30 cognition.

## 31 **Pilot study**

1 Thirty participants were recruited for the pilot run of the study from 1 May 2019  
2 to 15 May 2019 to test the trial version of the quick response code for this study. The  
3 responses from the participants of the pilot study were then analysed for clarity,  
4 understandability and applicability of the questionnaire. The time to complete the  
5 questionnaire and any technical difficulties whilst scanning the quick response code  
6 were recorded.

7 Cronbach's alpha values were 0.662 (domain A, knowledge), 0.784 (domain B,  
8 attitudes) and 0.806 (domain C, practice). In addition, six experts in the field of  
9 nosocomial infection were invited to review each item by using the 4-point rating scale  
10 (1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = very relevant) and test  
11 the content validity of the KAP. The overall content validity index was 0.95, which  
12 indicated that the content validity of the KAP questionnaire was good.

### 13 **Data collection procedure**

14 With the support of the hospital's human resources department, the potential  
15 participants were approached. After the assessment of the reliability and validity of the  
16 questionnaire, web links to the questionnaire and informed consent forms were emailed  
17 to the qualifying potential participants by the researchers. The estimated time needed  
18 to complete the survey was 15 min. After the questionnaires were completed by the  
19 participants, responses were submitted online, and their electronic informed consents  
20 were returned via email. The questionnaires were then carefully reviewed, and  
21 incomplete or incorrectly completed questionnaires were excluded for data analysis.

### 22 **Data analysis**

23 For continuous variables, the means and standard deviations were calculated  
24 whereas frequencies and percentages were calculated for categorical variables. The  
25 scores of KAP for general characteristics were analysed via t-test or analysis of variance  
26 for continuous data. Multiple linear regression analysis was performed to determine the  
27 significant factors influencing KAP and the KAP total scores. Variables with  $p < 0.05$   
28 determined from univariate analysis were included as independent variables in the  
29 regression model. Unstandardised coefficients and  $R^2$  were used to interpret the effects  
30 and variability of the significant dependent variables, respectively. Statistical analyses  
31 were performed using Stata version 14.0 (Stata Corporation, College Station, TX).  
32 Statistical tests were two sided, and statistical significance was at  $p < 0.05$ .

## 1 Patient and public involvement

2 No patients and the public were involved in the design or planning of the study.

## 3 RESULTS

### 4 Descriptive statistics of participant characteristics

5 A total of 500 HCWs were invited to participate in the study. A total of 468 HCWs  
6 completed the online questionnaire (response rate = 93.6%). After the incomplete  
7 questionnaires were excluded, the data from 455 HCWs (395 nurses and 60 doctors)  
8 were included in the final analysis. The age of the study participants ranged from 22  
9 years to 59 years (mean age = 31.35 years). The majority of the participants were female  
10 (91%), and the mean duration of working experience was 9.45 years. Most participants  
11 were married (75.6%) and attained a bachelor's degree (68.1%). More than a quarter of  
12 the participants were from the operating room (28.1%). The majority (96%) of the  
13 participants were general staff, and 66.4% had a junior professional title. More than  
14 half of the participants (52.3%) were contract employment, and 70.1% worked in the  
15 general hospital. Furthermore, 60.2% of the participants received HAI education within  
16 the previous year, 62% had occupational exposures, and most participants received  
17 invasive operation authority (71.6%). In addition, 56.5% received antibacterial drug  
18 training, and 52.3% attended clinical consultation. The participants' scores of KAP and  
19 total KAP were  $15.67 \pm 3.32$ ,  $25.00 \pm 2.75$ ,  $43.44 \pm 5.15$  and  $84.76 \pm 6.72$ , respectively.  
20 The demographics and general characteristics of the participating group are presented  
21 in Table 1.

### 22 Univariate Analysis

23 The univariate analyses were performed to identify the factors influencing KAP  
24 and the results are presented in Tables A1-A4 (Supplementary data).

25 The mean score of knowledge was significantly higher among the following  
26 groups of participants: received HAIs education within last year, received antibacterial  
27 drug training, worked in the operating room or infectious diseases department and had  
28 more than 10 years of work experience (all factors  $0.001 < p < 0.05$ ). There were also  
29 significant differences on knowledge score between the following groups: gender, age



1 group, type of employment, received invasive operation authority and participated in  
2 clinical consultations with infectious disease doctors ( $p < 0.001$ ) (Table A1).

3 Table A2 presents the factors associated with the mean score of attitude. The  
4 participants who were contract employees, were married, had higher education levels,  
5 had antibacterial drug training and had a higher education level reported a significantly  
6 higher score on attitude (all factors  $0.001 < p < 0.05$ ). In addition, the attitude score was  
7 significantly associated with age, HAI education within the previous year, skin or  
8 mucous membrane exposure to patient bodily fluids within the previous 6 months,  
9 invasive operation authority, work department, clinical work experience and job  
10 position (all factors  $p < 0.001$ ).

11 Univariate analysis also revealed that being female, having worked in general  
12 hospitals, being the department head, having more than 10 years of working experience  
13 and holding a senior technical job position were associated with higher mean scores of  
14 practice (all factors  $0.001 < p < 0.05$ ). In addition, the mean scores of practice were  
15 significantly higher amongst the following groups of participants: those aged 40–59  
16 years, contract employees, individuals with higher education levels, those who received  
17 HAI education within the previous year, those who had skin or mucous membrane  
18 exposure to patient bodily fluids within the previous 6 months, individuals with  
19 invasive operation authority, those who received antibacterial drug training, individuals  
20 working in an operating room, surgery department, intensive care unit or the department  
21 of infectious diseases and those who participated in clinical consultations with  
22 infectious disease doctors (all factors  $p < 0.001$ ) (Table A3).

23 Being female, working as a nurse and having worked in general hospitals were  
24 significantly associated with higher scores of the total KAP (all factors  $0.001 < p <$   
25  $0.05$ ). Furthermore, the participants with the following characteristics reported  
26 significantly higher scores of the total KAP: 40–59 years of age, department head,  
27 contract employees, received HAI education within the previous year, had skin or  
28 mucous membrane exposure to patient bodily fluids within the previous 6 months, had  
29 invasive operation authority, received antibacterial drug training and participated in  
30 clinical consultations with infectious disease doctors (all factors  $p < 0.001$ ) (Table A4).

31

1 **Table 1.** General characteristics of participants

Variables	n (%)
Age (Mean $\pm$ SD, years)	31.35 $\pm$ 7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (mean $\pm$ SD, years)	9.45 $\pm$ 8.35
Marital status	
Unmarried	99 (21.8)
Married	344 (75.6)
Widowed/divorced	12 (2.6)
Educational level	
Junior college	37 (8.2)
Bachelor's degree	310 (68.1)
Master's degree or above	108 (23.7)
Occupation	
Doctor	60 (13.2)
Nurse	395 (86.8)
Department	
Internal medicine	16 (3.5)
Surgery	83 (18.2)
Obstetrics	20 (4.4)
Intensive care unit	87 (19.1)
Emergency	21 (4.6)
Outpatient	11 (2.4)
Operating room	128 (28.1)
Infectious diseases	68 (14.9)
Other	21 (4.6)
Position	
Staff	437 (96)
Head	18 (4)
Professional title	
Senior	23 (5.1)
Middle	130 (28.6)
Junior	302 (66.4)
Type of employment	
Contract	238 (52.3)
Permanent	217 (47.7)

2

3

1 **Table 1** (continued)

Variables	n (%)
Type of hospital	
The children's hospital	136 (29.9)
General hospital	319 (70.1)
Received HAIs education within last year	
Yes	274 (60.2)
No	181 (39.8)
Occupational exposures (impaired skin or mucosa to blood, body fluid, secretion and excretion of patients within 6 months)	
Yes	282 (62)
No	173 (38)
Received invasive operation authority	
Yes	326 (71.6)
No	129 (28.4)
Received antibacterial drug training	
Yes	257 (56.5)
No	198 (43.5)
Attending consultation (nosocomial infection disease)	
Yes	238 (52.3)
No	217 (47.7)
Knowledge score (Mean $\pm$ SD)	15.67 $\pm$ 3.32
Attitude score (Mean $\pm$ SD)	25.00 $\pm$ 2.75
Practice score (Mean $\pm$ SD)	43.44 $\pm$ 5.15
KAP (Mean $\pm$ SD)	84.76 $\pm$ 6.72

2 SD: standard deviations

### 3 **Multiple linear regression analysis**

4 The results of the assessed regression models are reported in Tables 2–5. Gender,  
 5 age group, type of employment and clinical work experience were identified as the  
 6 significant predictors of knowledge in the multivariate regression analysis model  
 7 assuming knowledge as the outcome variable, and they accounted for 21.4% of variance  
 8 (adjusted  $R^2 = 0.214$ ,  $p < 0.001$ ). Female, older age and 16–20 years of clinical work  
 9 experience were significantly and positively associated with knowledge scores,  
 10 whereas permanent staff was significantly and negatively associated with knowledge  
 11 score (Table 2).

12 A significant model was built through multiple linear regression analysis ( $p < 0.001$ ),  
 13 explaining 14.3% of the variance in attitude score (adjusted  $R^2 = 0.143$ ). The following

1 aspects were positively associated with attitude scores (Table 3): received HAI  
2 education within the last year, had occupational exposure within 6 months, received  
3 invasive operation authority and attended clinical consultation.

4 The results of the multiple linear regression analysis on practice are shown in  
5 Table 4. Gender, education level, work department, occupational exposure within 6  
6 months, invasive operation authority, antibacterial drug training and attending clinical  
7 consultation were identified as significant predictors of practice, and these factors  
8 explained 47.05% (adjusted  $R^2 = 0.471$ ) of variance. Being female, having occupational  
9 exposure within 6 months, having invasive operation authority, having antibacterial  
10 drug training, achieving higher education level, attending clinical consultation and  
11 working in surgery, operating room or infectious disease department were significantly  
12 and positively associated with the practice of HCWs.

13 Another significant model was built through multiple linear regression analysis ( $p$   
14  $< 0.001$ ), explaining 61% of the variance of the total KAP scores (adjusted  $R^2 = 0.61$ ).  
15 Male, younger age, general staff and permanent staff had a significantly negative  
16 influence on KAP total scores. By contrast, the following aspects were positively  
17 associated with the total KAP scores: received HAI education within last year, received  
18 invasive operation authority, received antibacterial drug training and attended clinical  
19 consultation (Table 5).

**Table 2.** Multiple linear regression analysis of the influencing factors for knowledge scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	13.20 (11.03,15.36)	1.10		11.99	< 0.001
Gender					
Female (vs. Male)	2.36 (1.24, 3.47)	0.57	0.19	4.15	< 0.001
Age group (years)					
40-59 (vs.18-39)	3.04 (1.84, 4.24)	0.61	0.27	4.98	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.27 (-1.82, -0.56)	0.32	-0.18	-3.93	< 0.001
Clinical work experience (years)					
6-10 (vs.1-5)	-0.17 (-0.93, 0.59)	0.39	-0.02	-0.44	0.660
11-15 (vs.1-5)	0.65 (-0.47, 1.77)	0.57	0.05	1.14	0.253
16-20 (vs.1-5)	1.54 (0.40, 2.68)	0.58	0.13	2.66	0.008
$\geq$ 21 (vs.1-5)	0.87 (-0.34, 2.08)	0.61	0.08	1.41	0.158

Independent variables included in the regression model were: gender, age group, occupation, type of employment, received HAIs education within last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, department, clinical work experience and attending consultation.

Adjusted R<sup>2</sup> (p-value): 0.214 (p < 0.001).

CI: confidence interval; SD: standard deviations.

**Table 3.** Multiple linear regression analysis of the influencing factors for attitude scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	25.20 (22.89, 27.51)	1.18		21.44	< 0.001
Received HAIs education within last year					
No (vs. Yes)	-0.97 (-1.64, -0.29)	0.34	-0.17	-2.82	0.005
Occupational exposure within 6 months					
Yes (vs. No)	0.90 (0.15, 1.66)	0.38	0.16	2.36	0.019
Received invasive operation authority					
No (vs. Yes)	-1.04 (-2.05, -0.65)	0.33	-0.17	-3.12	0.002
Attending consultation					
No (vs. Yes)	-0.73 (-1.27, -0.19)	0.28	-0.13	-2.65	0.008
Department					
Surgery (vs. Internal medicine)	0.20 (-1.21, 1.62)	0.72	0.03	0.28	0.778
Obstetrics (vs. Internal medicine)	-0.87 (-2.57, 0.84)	0.87	-0.06	-1.00	0.319
Intensive care unit (vs. Internal medicine)	0.47 (-0.96, 1.91)	0.73	0.07	0.65	0.517
Emergency (vs. Internal medicine)	-0.99 (-2.67, 0.68)	0.85	-0.08	-1.16	0.245
Outpatient (vs. Internal medicine)	-2.11 (-4.13, -0.09)	1.03	-0.12	-2.05	0.041
Operating room (vs. Internal medicine)	0.38 (-1.02, 1.78)	0.71	0.06	0.54	0.591
Infectious diseases (vs. Internal medicine)	0.46 (-1.02, 1.94)	0.75	0.06	0.61	0.543
Other (vs. Internal medicine)	-0.94 (-2.64, 0.76)	0.87	-0.07	-1.08	0.280

Independent variables included in the regression model were: age group, type of employment, clinical work experience (years), educational level, marital status, professional title, received HAIs education within last year, occupational exposure within 6 months, received invasive operation authority, attending consultation and work department; Adjusted R<sup>2</sup> (p-value): 0.1434 (p < 0.001); CI: confidence interval; SD: standard deviations.

**Table 4.** Multiple linear regression analysis of the influencing factors for practice scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	40.71 (37.31, 44.10)	1.73		23.58	< 0.001
Gender					
Female (vs. Male)	1.55 (0.19, 2.90)	0.69	0.09	2.24	0.025
Occupational exposure within 6 months					
No (vs. Yes)	-1.49 (-2.60, -0.38)	0.56	-0.14	-2.64	0.009
Received invasive operation authority					
No (vs. Yes)	-1.70 (-2.67, -0.74)	0.49	-0.15	-3.47	0.001
Received antibacterial drug training					
No (vs. Yes)	-3.01 (-3.85, -2.17)	0.43	-0.29	-7.06	< 0.001
Educational level					
Bachelor's degree (vs. College degree)	3.40 (2.02, 4.78)	0.70	0.31	4.85	< 0.001
Master's degree or above (vs. College degree)	3.74 (2.15, 5.33)	0.81	0.31	4.62	< 0.001
Attending consultation of nosocomial infection disease					
No (vs. Yes)	-2.60 (-3.40, -1.80)	0.41	-0.25	-6.40	< 0.001
Department					
Surgery (vs. Internal medicine)	2.78 (0.70, 4.86)	1.06	0.21	2.62	0.009
Obstetrics (vs. Internal medicine)	-1.06 (-3.59, 1.47)	1.29	-0.04	-0.82	0.412
Intensive care unit (vs. Internal medicine)	1.70 (-0.41, 3.82)	1.08	0.13	1.58	0.114
Emergency (vs. Internal medicine)	0.91 (-1.56, 3.38)	1.26	0.04	0.73	0.468
Outpatient (vs. Internal medicine)	2.18 (-0.78, 5.14)	1.51	0.07	1.45	0.148
Operating room (vs. Internal medicine)	2.76 (0.71, 4.81)	1.04	0.24	2.65	0.008
Infectious diseases (vs. Internal medicine)	2.70 (0.52, 4.87)	1.11	0.19	2.43	0.015
Other (vs. Internal medicine)	0.08 (-2.44, 2.60)	1.28	0	0.06	0.951

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4 Independent variables included in the regression model included: gender, age group, type of hospital, position, type of employment, received HAIs  
5  
6 education within last year, occupational exposure of within 6 months, received invasive operation authority, received antibacterial drug training,  
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8 educational level, attending participating, department, clinical work experience, professional title.  
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10 Adjusted R<sup>2</sup> (p-value): 0.4705 (p < 0.001).  
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13 CI: confidence interval; SD: standard deviations.  
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**Table 5.** Multiple linear regression analysis of the influencing factors for KAP total scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	87.06 (85.12, 88.99)	0.99		88.31	< 0.001
Gender					
Female (vs. Male)	2.36 (1.11, 4.40)	0.84	0.09	3.29	0.008
Age group (years)					
40-59 (vs.18-39)	6.65 (5.07, 7.74)	0.68	0.30	9.44	< 0.001
Position					
Head (vs. Staff)	7.02 (3.88, 8.45)	1.16	0.18	5.30	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.08 (-2.08, -0.07)	0.51	-0.07	-2.11	0.035
Received HAIs education within last year					
No (vs. Yes)	-2.98 (-4.23, -1.72)	0.64	-0.20	-4.65	< 0.001
Received invasive operation authority					
No (vs. Yes)	-4.22 (-5.46, -2.99)	0.63	-0.26	-6.71	< 0.001
Received antibacterial drug training					
No (vs. Yes)	-4.38 (-5.45, -3.31)	0.55	-0.29	-8.03	< 0.001
Attending consultation					
No (vs. Yes)	-4.35 (-5.38, -3.32)	0.52	-0.29	-8.31	< 0.001

Independent variables included in the regression model were: gender, age group, type of hospital, occupation, position, type of employment, received HAIs education within last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, attending consultation

Adjusted R<sup>2</sup>(p-value): 0.61 (p < 0.001); CI: confidence interval; SD: standard deviation.

## 1 DISCUSSION

2 To the best of our knowledge, this study is the first to describe the KAPs in relation  
3 to HAIs and their influencing factors amongst HCWs in central China. Although  
4 increased awareness and stricter regulations on the control of hospital infections have  
5 been observed, our survey found that limitations still exist in HCWs' knowledge and  
6 practices in terms of HAIs. With the current COVID-19 pandemic, understanding  
7 HCWs' KAP towards HAIs and the significant factors influencing their KAP is  
8 essential. Our findings might provide a basis for designing and implementing targeted  
9 intervention programs to promote the KAP of HCWs and establish the groundwork for  
10 conducting future studies.

11 Our findings showed that the HCWs' sociodemographic factors, such as gender,  
12 age, employment and clinical work experience, significantly affected their knowledge  
13 on HAIs. Although some of these factors are unchangeable (e.g. age and gender),  
14 continuous education on HAIs is still essential to improve their knowledge on HAIs  
15 Previous studies also demonstrated that participants who received training within the  
16 previous 5 years obtain higher knowledge scores<sup>31</sup>. Another previous study on the KAP  
17 associated with central vascular catheters proved our point of view and reported that  
18 knowledge scores are significantly higher in respondents who received active formal  
19 training than those who did not.<sup>32</sup> However, career seniority and gender are not  
20 identified as significant factors influencing the knowledge level amongst UK HCWs,  
21 and this observation was partly inconsistent with our findings.<sup>33</sup>

22 Possessing HAI education, having occupational exposure within 6 months, having  
23 the authority to perform invasive operations and participating in clinical consultations  
24 promote positive HAIs attitudes; however, working in outpatient is not conducive to  
25 developing positive HAI attitude. Respondents' attitudes towards prevention-related  
26 HAIs are significantly high amongst HCWs who are assigned in intensive care units  
27 and have appropriate knowledge and training.<sup>32</sup> In a multicentre study conducted in  
28 Shanghai, China, independent associations between older age or higher education and  
29 categorical knowledge are observed amongst physicians.<sup>27</sup> A longer working  
30 experience is inversely and independently associated with the knowledge and attitude  
31 of HCWs.<sup>27</sup> However, age, education level and working experience were not identified  
32 as the significant influencing factors of attitude towards HAIs in our study. Whereas  
33 receiving HAIs education was the most significant influencing factor of attitude. The

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3 1 inconsistent findings between our study and the study conducted in Shanghai may be  
4 2 due to the difference in the selection of the study hospitals. The study conducted in  
5 3 Shanghai recruited HCWs from the community hospitals, where the HCWs normally  
6 4 have lower education level compared to those from the acute hospitals. In the COVID-  
7 5 19 pandemic, a high proportion of HCWs admitted that they are afraid of working.<sup>34</sup>  
8 6 As such, periodic educational interventions and training programs on infection control  
9 7 practices for COVID-19 must be implemented amongst all HCWs, especially those who  
10 8 face new emerging infectious diseases.<sup>35</sup>

11 9 In the practice domain, education level has the highest influence on the ability of  
12 10 HCWs to implement the prevention and control of HAIs. Other positive factors include  
13 11 gender, occupational exposure within the previous 6 months, authority to perform  
14 12 invasive operations, antibacterial drug training and attendance of clinical consultations.  
15 13 Previous studies largely focused on hand hygiene practices, and most of them reported  
16 14 poor compliance to hand hygiene recommendation.<sup>15 36</sup> Other studies have shown that  
17 15 factors such as perceived severity, subjective norm and job demands also significantly  
18 16 influence practice.<sup>37</sup> However, to some extent, influencing factors, such as occupational  
19 17 exposure and training, also belong to self-perception in our study.

20 18 In the COVID-19 pandemic, many medical professionals are infected because of  
21 19 the lack of PPE. Statistical data have shown that more than 100 thousand HCWs have  
22 20 been infected worldwide.<sup>38</sup> The adequate and correct use of PPE is the best measure to  
23 21 prevent HCWs from acquiring COVID-19 infection.<sup>39</sup> However, at the early stage of  
24 22 the outbreak, a global shortage of PPE occurred, and HCWs lacked practice on the  
25 23 proper donning and doffing of PPE.<sup>40</sup> Insufficient knowledge and skills related to the  
26 24 isolation of respiratory diseases have posed a high infection risk to HCWs. Although  
27 25 our study did not specifically focus on COVID-19, this pandemic calls for awareness  
28 26 and attention to prepare HCWs with adequate knowledge, positive attitude and practice  
29 27 in preventing and controlling transmitted infections and diseases.

30 28 Biases, especially those associated with participants' behaviour and practices, may  
31 29 exist in self-reported surveys. Consequently, participants may overstate their good  
32 30 practices. This study was cross-sectional, so inferences drawn from self-reported  
33 31 practices may vary from direct observation evidence. Moreover, no causal relationship  
34 32 can be found.

### 35 33 **CONCLUSION**

1 In this study, KAP is closely associated with uncontrollable factors (such as gender,  
2 age, job position, employment type, educational level and clinical work experience)  
3 and controllable ones (such as HAI education within the previous year, occupational  
4 exposure within the previous 6 months, antibacterial drug training and participation in  
5 clinical consultations). Controllable factors indicate that hospital managers can take  
6 appropriate measures for all HCWs to promote the improvement of KAP. Furthermore,  
7 uncontrollable factors imply that when taking measures to improve KAP, hospital  
8 managers should consider the backgrounds of individual HCWs. In addition, some  
9 sociodemographic and job-related factors significantly influence the knowledge and  
10 practice towards HAIs amongst Chinese HCWs, whereas job-related factors  
11 significantly affect the attitude of HCWs towards HAIs. This result supports our  
12 hypotheses. However, further studies should be performed to establish the benchmark  
13 of KPA towards HAIs amongst HCWs.

14 **Author Contributions:** WWW conceived the study. WWW, WWR, YYF, LLK, TYB,  
15 YJR and WY contributed in the survey design, data collection. DL contributed in data  
16 analysis. All authors contributed to the interpretation of data and intellectual revised  
17 multiple drafts. WWW and WWR drafted the manuscript. All authors have approved  
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25 **Ethics approval:** Ethical approval was received from the institutional ethics board of  
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27 **Data availability statement:** Some or all data, models, or code generated or used  
28 during the study are available from the corresponding author (Ying Wang) by request.  
29 Reuse of the data is permitted for non-commercial purposes. Contact details: Email:  
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## 31 REFERENCES

- 32 1. Breathnach, Aodhán S. Nosocomial infections and infection control. *Medicine* 2013;**41**:  
33 649-53. doi:10.1016/j.mpmed.2013.08.010  
34

- 1 2.  
2 Daxboeck F, Budic T, Assadian O, *et al.* Economic burden associated with multi-resistant  
3 Gram-negative organisms compared with that for methicillin-resistant *Staphylococcus*  
4 *aureus* in a university teaching hospital. *J Hosp Infect* 2006;**62**:214-18. doi:  
5 10.1016/j.jhin.2005.07.009 pmid: <https://pubmed.ncbi.nlm.nih.gov/16257092>
- 6 3.  
7 Rattanaumpawan P, Thamlikitkul V. Epidemiology and economic impact of health care-  
8 associated infections and cost-effectiveness of infection control measures at a Thai  
9 university hospital. *Am J Infect Control* 2017;**45**:145-50. doi:10.1016/j.ajic.2016.07.018  
10 pmid: <https://pubmed.ncbi.nlm.nih.gov/27665034>
- 11 4.  
12 Hollmeyer HG, Hayden F, Poland G, *et al.* Influenza vaccination of health care workers  
13 in hospitals—A review of studies on attitudes and predictors. *Vaccine* 2009;**27**:3935-44.  
14 doi: 10.1016/j.vaccine.2009.03.056 pmid: <https://pubmed.ncbi.nlm.nih.gov/19467744>
- 15 5.  
16 Global patient safety challenge: 2005-2006/World Alliance for Patient Safety. Available  
17 online: <https://apps.who.int/iris/handle/10665/43358> (accessed on 16 June 2006).
- 18 6.  
19 Humphreys H, Newcombe RG, Enstone J, *et al.* Four Country Healthcare Associated  
20 Infection Prevalence Survey 2006: risk factor analysis. *J Hosp Infect* 2008;**69**:249-57.  
21 doi:10.1016/j.jhin.2008.04.021 pmid: <https://pubmed.ncbi.nlm.nih.gov/18550214>
- 22 7.  
23 Rosenthal VD. Health-care-associated infections in developing countries. *Lancet*  
24 2011;**377**:186-8. doi:10.1016/S0140-6736(10)62005-3 pmid:  
25 <https://pubmed.ncbi.nlm.nih.gov/21146208>
- 26 8.  
27 Xie DS, Fu XY, Wang HF, *et al.* Annual point-prevalence of healthcare-associated  
28 infection surveys in a university hospital in China, 2007-2011. *J Infect Public Health*  
29 2013;**6**:416-22. doi:10.1016/j.jiph.2013.04.009 pmid:  
30 <https://pubmed.ncbi.nlm.nih.gov/23999334>
- 31 9.  
32 Liu JY, Wu YH, Cai M, *et al.* Point-prevalence survey of healthcare-associated infections  
33 in Beijing, China: a survey and analysis in 2014. *J Hosp Infect* 2016;**93**:271-9. doi:  
34 10.1016/j.jhin.2016.03.019 pmid: <https://pubmed.ncbi.nlm.nih.gov/27140419>
- 35 10.  
36 Wang J, Liu F, Tartari E, *et al.* The Prevalence of Healthcare-Associated Infections in  
Mainland China: A Systematic Review and Meta-analysis. *Infect Control Hosp*  
*Epidemiol* 2018;**39**:701-9. doi: 10.3389/fendo.2020.00336 pmid:  
<https://pubmed.ncbi.nlm.nih.gov/32582028>
11.  
Sun BW. Nosocomial infection in China: Management status and solutions. *Am J Infect*  
*Control* 2016;**44**:851-2. doi:10.1016/j.ajic.2016.01.039 pmid:  
<https://pubmed.ncbi.nlm.nih.gov/27067518>
12.  
Byarugaba, DK. A view on antimicrobial resistance in developing countries and  
responsible risk factors. *Int J Antimicrob Ag* 2004;**24**:105-10.  
doi:10.1016/j.ijantimicag.2004.02.015 pmid: <https://pubmed.ncbi.nlm.nih.gov/15288307>

13. Mir F, Zaidi AKM. Hospital infections by antimicrobial-resistant organisms in developing countries. *Springer* 2010;**317**:199-232.
14. Adebimpe, WO, Asekun-Olarinmoye EO, Bamidele JO, *et al.* A comparative study of awareness and attitude to nosocomial infections among levels of health care workers in southwestern nigeria. *Continent J Trop Med* 2011;**5**:5.
15. Hien H, Drabo M, Ouédraogo L, *et al.* Knowledge and practices of health care workers in the area of healthcare-associated infection risks. A case study in a district hospital in Burkina Faso. *Sante Publique* 2013;**25**:219-26. doi:10.1080/17441692.2013.770902
16. Jin YH, Huang Q, Wang YY, *et al.* Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers in a tertiary acute care hospital in Wuhan: a cross-sectional survey. *Mil Med Res.* 2020;**7**:24.
17. World Health Organization. Geneva. 2017. Guidelines for the prevention and control of carbapenem-resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in health care facilities.
18. Jiang H, Zhang S, Ding Y, *et al.* Development and validation of college students' tuberculosis knowledge, attitudes and practices questionnaire (CS-TBKAPQ). *BMC Public Health* 2017;**17**:949. doi:10.1186/s12889-017-4960-x pmid: <https://pubmed.ncbi.nlm.nih.gov/29233115>
19. Angelillo IF, Mazziotta A, Nicotera G. Nurses and hospital infection control: knowledge, attitudes and behaviour of Italian operating theatre staff. *J Hosp Infect* 1999;**42**:105-12. doi:10.1053/jhin.1998.0571 pmid:<https://pubmed.ncbi.nlm.nih.gov/10389059/>
20. Balarabe SA, Joshua IA, Danjuma A, *et al.* Knowledge of Healthcare Workers on Nosocomial Infection in Selected Secondary Health Institutions in Zaria, Nigeria. *J Prevent Med* 2015;**3**:1-6. doi: 10.12691/jpm-3-1-1.
21. Adegboye MB, Zakari S, Ahmed BA, *et al.* Knowledge, awareness and practice of infection control by health care workers in the intensive care units of a tertiary hospital in Nigeria. *Afri Health Sci* 2018;**18**:72-8. doi:10.4314/ahs.v18i1.11
22. Wuhan Statistical Bureau. Wuhan. 2019. Wuhan Health Statistical Yearbook. Available online: <http://tjj.wuhan.gov.cn/tjfw/tjnj/202004/P020200426461240969401.pdf> (accessed on 7 Sep 2020).
23. Cohen J. A Power Primer. *Psychological bulletin* 1992;**112**:155-9. doi:10.1037/0033-2909.112.1.155
24. Brown MT, Bussell JK. Medication Adherence: WHO Cares? *Mayo Clinic Proceedings* 2011;**86**:304-14. doi:10.4065/mcp.2010.0575

- 1  
2  
3 1 25. Glader EL, Sjolander M, Eriksson M, et al. Persistent Use of Secondary Preventive Drugs  
4 Declines Rapidly During the First 2 Years After Stroke. *Stroke* 2010;**41**:397-401.doi:  
5 2 10.1161/STROKEAHA.109.566950  
6 3  
7  
8 4 26. Maxwell SE. Sample size and multiple regression analysis. *Psychological methods*  
9 5 2000;**5**:434. doi: 10.1037/1082-989x.5.4.434 pmid:  
10 6 <https://pubmed.ncbi.nlm.nih.gov/11194207/>  
11 7  
12 27. Zhou Y, Zhang D, Chen Y, et al. Healthcare-associated infections and Shanghai clinicians:  
13 8 a multicenter cross-sectional study. *PLoS One* 2014;**9**:e105838-e105838. doi:  
14 9 10.1371/journal.pone.0105838 pmid: <https://pubmed.ncbi.nlm.nih.gov/25148526/>  
15 10  
16 28. Luo Y, He GP, Zhou JW, et al. Factors impacting compliance with standard precautions  
17 11 in nursing, China. *Int J Infect Dis* 2010;**14**:e1106-e1114. doi: 10.1016/j.ijid.2009.03.037  
18 12 pmid: <https://pubmed.ncbi.nlm.nih.gov/21071254>  
19 13  
20 29. Tavolacci MP, Ladner J, Bailly L, et al. Prevention of nosocomial infection and standard  
21 14 precautions: knowledge and source of information among healthcare students. *Infect*  
22 15 *Control Hosp Epidemiol* 2008;**29**:642-7. doi:10.1086/588683  
23 16  
24 30. Circular of the general office of the National Health Commission on Further Strengthening  
25 17 the prevention and control of infection in medical institution. Available online:  
26 18 <http://www.cha.org.cn/plus/view.php?aid=15223> (accessed on 15 March 2017).  
27 19  
28 31. Taffurelli C, Sollami A, Camera C, et al. Healthcare associated infection: good practices,  
29 20 knowledge and the locus of control in healthcare professionals. *Acta Biomed* 2017;**88**:31-  
30 21 6. doi: 10.23750/abm.v88i3-S.6611 pmid: <https://pubmed.ncbi.nlm.nih.gov/28752830/>  
31 22  
32 32. Bianco A, Coscarelli P, Nobile CGA, et al. The reduction of risk in central line-associated  
33 23 bloodstream infections: knowledge, attitudes, and evidence-based practices in health care  
34 24 workers. *Am J Infect Control* 2013;**41**:107-12. doi:10.1016/j.ajic.2012.02.038 pmid:  
35 25 <https://pubmed.ncbi.nlm.nih.gov/22980513/>  
36 26  
37 33. Brady RRW, McDermott C, Cameron F, et al. UK healthcare workers' knowledge of  
38 27 meticillin-resistant *Staphylococcus aureus* practice guidelines; a questionnaire study. *J*  
39 28 *Hosp Infect* 2009;**73**:264-70. doi: 10.1016/j.jhin.2009.07.020 pmid:  
40 29 <https://pubmed.ncbi.nlm.nih.gov/19783068/>  
41 30  
42 34. Rymarowicz J, Stefura T, Major P, et al. General surgeons' attitudes towards COVID-19:  
43 31 A national survey during the SARS-CoV-2 virus outbreak. *European Surgery*, 2020;**21**.  
44 32 doi: 10.1007/s10353-020-00649-w pmid: <https://pubmed.ncbi.nlm.nih.gov/32837516/>  
45 33  
46 35. Neupane HC, Shrestha N, Adhikari S, et al. Knowledge of Health Care Professionals and  
47 34 Medical Students Regarding Covid-19 in a Tertiary Care Hospital in Nepal. *JNMA J Nepal*  
48 35 *Med Assoc.* 2020;**58**:480-486. doi: 10.31729/jnma.4995 pmid:  
49 36 <https://pubmed.ncbi.nlm.nih.gov/32827009/>  
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3 1 36. Ellingson K, Haas JP, Aiello AE, *et al.* Strategies to prevent healthcare-associated  
4 infections through hand hygiene. *Infect Control Hosp Epidemiol* 2014;**35**:S155-78. doi:  
5 2  
6 3 10.1086/677145 pmid: <https://pubmed.ncbi.nlm.nih.gov/25026608>  
7  
8 4 37. Brazzell BD. Improving High Hand-hygiene Compliance and Reducing Healthcare-  
9 associated Infection in Eight Nursing Units. *Am J Infect Control* 2014;**42**:S25-6. doi:  
10 5  
11 6 10.1016/j.ajic.2014.03.076  
12  
13 7 38. Stubblefield WB, Talbot HK, Feldstein L, *et al.* Seroprevalence of SARS-CoV-2 Among  
14 8 Frontline Healthcare Personnel During the First Month of Caring for COVID-19 Patients  
15 - Nashville, Tennessee [published online ahead of print, 2020 Jul 6]. *Clin Infect Dis.* 2020;  
16 9 ciaa936. doi:10.1093/cid/ciaa936 pmid: <https://pubmed.ncbi.nlm.nih.gov/32628750>  
17 10  
18 11 39. Eyre DW, Lumley SF, O'Donnell D, *et al.* Differential occupational risks to healthcare  
19 workers from SARS-CoV-2 observed during a prospective observational study [published  
20 12 online ahead of print, 2020 Aug 21]. *Elife.* 2020;**9**: e60675. doi:10.7554/eLife.60675  
21 13  
22 14 pmid: <https://pubmed.ncbi.nlm.nih.gov/32820721>  
23  
24 15 40. Wang Y, Wu W, Cheng Z, *et al.* Super-factors associated with transmission of  
25 occupational COVID-19 infection among healthcare staff in Wuhan, China. *J Hosp Infect.*  
26 16 2020;**106**:25-34. doi: 10.1016/j.jhin.2020.06.023 pmid:  
27 17  
28 18 <https://pubmed.ncbi.nlm.nih.gov/32574702>  
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**Table A1.** Results of univariate analysis of knowledge

Variables	Mean ± SD	n	p-value
Gender			< 0.001
Male	13.88 ± 0.50	41	
Female	16.27 ± 0.17	414	
Age group (years)			< 0.001
18-39	15.60 ± 0.17	397	
40-59	19.19 ± 0.36	58	
Occupation			0.0031
Doctor	14.93 ± 0.38	60	
Nurse	16.22 ± 0.18	395	
Type of employment			< 0.001
Contract	16.69 ± 0.24	238	
Permanent	15.36 ± 0.23	217	
Received HAIs education within last year			0.0139
Yes	16.40 ± 0.20	274	
No	15.54 ± 0.29	181	
Occupational exposures within 6 months			0.0072
Yes	16.41 ± 0.21	282	
No	15.48 ± 0.27	173	
Received invasive operation authority			< 0.001
Yes	16.38 ± 0.19	326	
No	15.22 ± 0.31	129	
Received antibacterial drug training			0.0254
Yes	16.38 ± 0.23	257	
No	15.64 ± 0.24	198	

**Table A1.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Department				0.040
	Internal medicine	14.69 ± 4.51	16	
	Surgery	15.77 ± 3.44	83	
	Obstetrics	15.35 ± 2.23	20	
	Intensive care unit	15.54 ± 3.00	87	
	Emergency	14.43 ± 4.40	21	
	Outpatient	13.45 ± 3.45	11	
	Operating room	16.23 ± 3.27	128	
	Infectious diseases	16.07 ± 3.30	68	
	Other	14.67 ± 2.52	21	
Clinical work experience (years)				0.025
	1-5	15.43 ± 3.40	203	
	6-10	15.15 ± 3.38	110	
	11-15	16.35 ± 2.98	40	
	16-20	16.48 ± 3.13	42	
	≥21	16.45 ± 3.17	60	
Attending consultation				< 0.001
	Yes	16.60 ± 0.22	238	
	No	15.47 ± 0.25	217	

**Table A2.** Results of univariate analysis of attitude

Variables	Mean ± SD	n	p-value
Age group (years)			< 0.001
18-39	24.83 ± 0.14	397	
40-59	26.19 ± 0.36	58	
Type of employment			0.0168
Contract	25.29 ± 0.16	238	
Permanent	24.67 ± 0.20	217	
Received HAIs education within last year			< 0.001
Yes	25.41 ± 0.15	274	
No	24.38 ± 0.22	181	
Occupational exposure within 6 months			< 0.001
Yes	25.35 ± 0.15	282	
No	24.42 ± 0.22	173	
Received invasive operation authority			< 0.001
Yes	25.37 ± 0.15	326	
No	24.05 ± 0.25	129	
Received antibacterial drug training			0.0023
Yes	25.34 ± 0.17	257	
No	24.55 ± 0.20	198	
Educational level			0.012
Junior college	24.30 ± 2.64	37	
Bachelor's degree	24.86 ± 2.74	310	
Master's degree or above	25.63 ± 2.73	108	

**Table A2.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
	Attending consultation			0.0089
	Yes	25.32 ± 0.18	238	
	No	24.65 ± 0.19	217	
	Department			< 0.001
	Internal medicine	24.19 ± 2.93	16	
	Surgery	25.20 ± 3.02	83	
	Obstetrics	24.00 ± 2.97	20	
	Intensive care unit	25.54 ± 2.40	87	
	Emergency	23.19 ± 3.11	21	
	Outpatient	22.18 ± 3.37	11	
	Operating room	25.29 ± 2.46	128	
	Infectious diseases	25.54 ± 2.42	68	
	Other	23.24 ± 2.45	21	
	Clinical work experience (years)			< 0.001
	1-5	24.56 ± 2.76	203	
	6-10	24.77 ± 2.64	110	
	11-15	25.38 ± 2.39	40	
	16-20	26.31 ± 2.70	42	
	≥21	25.73 ± 2.79	60	
	Marital status			0.002
	Unmarried	24.20 ± 2.82	99	
	Married	25.25 ± 2.72	344	
	Widowed / divorced	24.33 ± 1.56	12	

**Table A2.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Professional title				< 0.001
	Senior	26.39 ± 2.13	23	
	Middle	25.53 ± 2.87	130	
	Primary	24.66 ± 2.68	302	

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**Table A3.** Results of univariate analysis of practice

Variables	Mean ± SD	n	p-value
Gender			0.0169
Male	41.41 ± 0.86	41	
Female	43.64 ± 0.25	414	
Age group (years)			< 0.001
18-39	43.14 ± 0.26	397	
40-59	45.50 ± 0.51	58	
Type of hospital			0.0207
The children's hospital	42.61 ± 0.41	136	
General hospital	43.79 ± 0.30	319	
Position			0.0207
Staff	42.61 ± 0.41	136	
Head	43.79 ± 0.29	319	
Type of employment			< 0.001
Contract	44.50 ± 0.33	238	
Permanent	42.28 ± 0.34	217	
Educational level			< 0.001
Junior college	38.24 ± 4.17	37	
Bachelor's degree	43.85 ± 4.97	310	
Master's degree or above	44.03 ± 5.04	108	
Received HAIs education within last year			< 0.001
Yes	44.81 ± 0.29	274	
No	41.36 ± 0.37	181	

**Table A3.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
	Occupational exposure within 6 months			< 0.001
	Yes	45.34 ± 0.26	284	
	No	40.28 ± 0.36	171	
	Received invasive operation authority			< 0.001
	Yes	44.81 ± 0.26	326	
	No	39.98 ± 0.40	129	
	Received antibacterial drug training			< 0.001
	Yes	45.35 ± 0.27	257	
	No	40.96 ± 0.36	198	
	Department			< 0.001
	Internal medicine	38.13 ± 4.84	16	
	Surgery	44.51 ± 4.76	83	
	Obstetrics	38.60 ± 4.27	20	
	Intensive care unit	43.95 ± 5.19	87	
	Emergency	39.71 ± 3.66	21	
	Outpatient	39.36 ± 4.32	11	
	Operating room	44.98 ± 4.91	128	
	Infectious diseases	44.46 ± 3.80	68	
	Other	38.95 ± 4.40	21	
	Attending consultation			< 0.001
	Yes	44.61 ± 0.30	238	
	No	42.16 ± 0.37	217	

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**Table A3.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Clinical work experience (years)	1-5	42.89 ± 5.57	203	0.012
	6-10	42.88 ± 5.33	110	
	11-15	45.20 ± 3.34	40	
	16-20	44.00 ± 4.54	42	
	≥21	44.77 ± 4.24	60	
Professional Title	Senior	46.17 ± 4.03	23	0.022
	Middle	43.63 ± 4.78	130	
	Primary	43.15 ± 5.33	302	

For peer review only



**Table A4.** Results of univariate analysis of KAP

Variables	Mean ± SD	n	p-value
Gender			0.0014
Male	80.41 ± 1.27	41	
Female	84.90 ± 0.36	414	
Age group (years)			< 0.001
18-39	83.56 ± 0.37	397	
40-59	90.88 ± 0.63	58	
Occupation			0.0244
Doctor	82.40 ± 0.98	60	
Nurse	84.81 ± 0.37	395	
Type of hospital			0.0169
The children's hospital	83.22 ± 0.63	136	
General hospital	85.03 ± 0.41	319	
Position			< 0.001
Staff	84.06 ± 0.34	437	
Head	95.06 ± 1.10	18	
Type of employment			< 0.001
Contract	86.48 ± 0.46	238	
Permanent	82.31 ± 0.48	217	
Received HAIs education within last year			< 0.001
Yes	86.62 ± 0.39	274	
No	81.28 ± 0.56	181	
Occupational exposure within 6 months			< 0.001
Yes	87.12 ± 0.39	284	
No	80.13 ± 0.52	171	

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**Table A4.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Received invasive operation authority	Yes	86.56 ± 0.38	326	< 0.001
	No	79.26 ± 0.54	129	
Received antibacterial drug training	Yes	87.07 ± 0.42	257	< 0.001
	No	81.15 ± 0.50	198	
Attending consultation	Yes	86.52 ± 0.42	238	< 0.001
	No	82.27 ± 0.52	217	

# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	4
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			

1	Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	5
2				
3	Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including	5
4			periods of recruitment, exposure, follow-up, and data collection	
5				
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7	Eligibility criteria	<a href="#">#6a</a>	Give the eligibility criteria, and the sources and methods of	5-6
8			selection of participants.	
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11		<a href="#">#7</a>	Clearly define all outcomes, exposures, predictors, potential	6
12			confounders, and effect modifiers. Give diagnostic criteria, if	
13			applicable	
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15				
16	Data sources /	<a href="#">#8</a>	For each variable of interest give sources of data and details of	6
17	measurement		methods of assessment (measurement). Describe	
18			comparability of assessment methods if there is more than one	
19			group. Give information separately for for exposed and	
20			unexposed groups if applicable.	
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24	Bias	<a href="#">#9</a>	Describe any efforts to address potential sources of bias	6-7
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27	Study size	<a href="#">#10</a>	Explain how the study size was arrived at	6
28				
29	Quantitative	<a href="#">#11</a>	Explain how quantitative variables were handled in the	7
30	variables		analyses. If applicable, describe which groupings were chosen,	
31			and why	
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34	Statistical	<a href="#">#12a</a>	Describe all statistical methods, including those used to control	7
35	methods		for confounding	
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38	Statistical	<a href="#">#12b</a>	Describe any methods used to examine subgroups and	n/a
39	methods		interactions	
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42	Statistical	<a href="#">#12c</a>	Explain how missing data were addressed	6
43	methods			
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46	Statistical	<a href="#">#12d</a>	If applicable, describe analytical methods taking account of	5
47	methods		sampling strategy	
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50	Statistical	<a href="#">#12e</a>	Describe any sensitivity analyses	n/a
51	methods			
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54	<b>Results</b>			
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56	Participants	<a href="#">#13a</a>	Report numbers of individuals at each stage of study—eg	8
57			numbers potentially eligible, examined for eligibility, confirmed	
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eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.

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5	Participants	<a href="#">#13b</a>	Give reasons for non-participation at each stage 8
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7	Participants	<a href="#">#13c</a>	Consider use of a flow diagram n/a
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10	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, 8
11			clinical, social) and information on exposures and potential
12			confounders. Give information separately for exposed and
13			unexposed groups if applicable.
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17	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each 8
18			variable of interest
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21	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. n/a
22			Give information separately for exposed and unexposed
23			groups if applicable.
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26	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder- 11-17
27			adjusted estimates and their precision (eg, 95% confidence
28			interval). Make clear which confounders were adjusted for and
29			why they were included
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33	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were 13,17
34			categorized
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37	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into n/a
38			absolute risk for a meaningful time period
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41	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and n/a
42			interactions, and sensitivity analyses
43			
44	<b>Discussion</b>		
45			
46	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives 18-19
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49	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of 19
50			potential bias or imprecision. Discuss both direction and
51			magnitude of any potential bias.
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54	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, 18-19
55			limitations, multiplicity of analyses, results from similar studies,
56			and other relevant evidence.
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1	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	19
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5	<b>Other</b>			
6	<b>Information</b>			
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9	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20
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# BMJ Open

## Knowledge, attitudes and practice concerning healthcare-associated infections among healthcare workers in Wuhan, China: a cross-sectional study

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**Title page**

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2  
3 **Title:** Knowledge, attitudes and practice concerning healthcare-associated infections  
4 among healthcare workers in Wuhan, China: a cross-sectional study

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23 **Word count:** 3268 words.

## ABSTRACT

**Objective:** To assess the knowledge, attitudes, and practices (KAP) concerning healthcare-associated infections (HAIs) among healthcare givers, and to identify the factors influencing KAP.

**Design:** This was a hospital-based, cross-sectional study.

**Setting:** Two public hospitals in Wuhan, central China.

**Participants:** Participants were recruited among healthcare workers of one general hospital and one children's hospital in Wuhan city between June 1 and September 30, 2019.

**Primary and secondary outcome measures:** The outcomes were knowledge, attitudes, and practices concerning HAIs.

**Results:** Data from 455 healthcare workers were included in the final data analysis. The mean scores of KAP and total KAP were  $15.67 \pm 3.32$ ,  $25.00 \pm 2.75$ ,  $43.44 \pm 5.15$ , and  $84.76 \pm 6.72$ , respectively. The following factors were significantly associated with the total KAP score concerning HAIs, explaining 61% of the variance ( $p < 0.001$ ): gender ( $\beta = 2.36$ , 95% CI: 1.11 to 4.40), age ( $\beta = 6.65$ , 95% CI: 5.07 to 7.74), position ( $\beta = 7.02$ , 95% CI: 3.88 to 8.45), type of employment ( $\beta = -1.08$ , 95% CI:  $-2.08$  to  $-0.07$ ), with HAI education within last year ( $\beta = -2.98$ , 95% CI:  $-4.23$  to  $-1.72$ ), with invasive operation authority ( $\beta = -4.22$ , 95% CI:  $-5.46$  to  $-2.99$ ), antibacterial drug training ( $\beta = -4.38$ , 95% CI:  $-5.45$  to  $-3.31$ ) and with antibacterial drug training and clinical consultation ( $\beta = -4.35$ , 95% CI:  $-5.38$  to  $-3.32$ ).

**Conclusions:** The controllable factors identified in this study can be used by hospital managers to implement measures that improve KAP among healthcare workers. Moreover, these measures should be customized, based on uncontrollable factors to suit the specific characteristics of medical staff and improve KAP. Training programs should be designed for medical workers to increase their awareness of HAIs and foster positive attitudes and practices.

## Article Summary

### Strengths and limitations of this study

A large sample was used to investigate KAP concerning HAIs and identify the significant influencing factors of KAP among healthcare workers in central China.

The use of self-reporting data can cause response bias, which potentially affected the accuracy of the findings.

This study was cross-sectional, so a causal relationship could not be confirmed.

## 1 INTRODUCTION

2 Healthcare-associated infections (HAIs) refer to the infections acquired in  
3 hospitals but are neither present nor incubating at the time of a patient's admission.<sup>1</sup>  
4 HAIs represent significant challenges to the effective delivery of healthcare services,  
5 and can result in prolonged hospital stays, microbial resistance, exacerbation of existing  
6 conditions, worsening of patients' economic burdens, stretching available healthcare  
7 resources, and even deaths.<sup>2-4</sup> According to the World Health Organization (WHO), at  
8 any moment, 1.4 million patients bear the consequences of HAIs globally.<sup>5</sup> It has been  
9 estimated that nearly 10% of inpatients suffer the consequences of HAIs.<sup>6</sup> Healthcare  
10 challenges emerging from HAIs are currently amongst the most significant public  
11 global health issues.<sup>7</sup> The risk of acquiring an HAI in developing countries is 2–20  
12 times higher than that in developed countries.<sup>8,9</sup> Wang and colleagues reported that the  
13 weighted prevalence of HAIs varies between 1.73% and 5.45% in Chinese  
14 municipalities and provinces.<sup>10</sup> The direct economic burden of hospital infections in  
15 China ranges from \$1.5 billion to \$2.3 billion annually.<sup>11</sup> Therefore, prevention and  
16 management of HAIs in China in the presence of competing interests remain an  
17 important clinical and public health topic.<sup>12,13</sup>

18 One of the primary causes of HAIs is the contact and transmission of contaminated  
19 hand and medical equipment by healthcare workers (HCWs), who do not properly  
20 comply with hospital hygiene practices.<sup>14</sup> For example, after evaluating or caring for  
21 one patient, HCWs occasionally touch another patient without properly washing their  
22 hands. A previous study reported that adherence to hand hygiene recommendations  
23 among HCWs remains suboptimal, yet the compliance rate is approximately 30%.<sup>15</sup> In  
24 fact, nearly 42% of COVID-19 infections in HCWs are related to the inappropriate  
25 utilization of personal protective equipment (PPE), masks, and gloves.<sup>16</sup>

26 Effective prevention and control measures should always be observed, specifically  
27 by HCWs, to minimize the risks of HAIs.<sup>17</sup> According to Kelman's theory of  
28 knowledge, attitudes and practice (KAP), knowledge is the basis for changing practice,  
29 and attitude is the driving force of change.<sup>18</sup> Therefore, understanding KAP of HCWs  
30 in relation to HAIs is essential in establishing these measures. Identifying the factors  
31 that significantly affect KAP is important, and can provide a basis for implementing  
32 intervention measures by HAI managers. Few studies have investigated the relationship

1 between KAP and HAIs among HCWs, or investigated the relationship between KAP  
2 and HAIs among HCWs.<sup>19-21</sup> However, these studies have some limitations. First, they  
3 only described the current KAP status, but the factors influencing KAP remain poorly  
4 understood. Second, the majority of published KAP reports have only focused on hand  
5 hygiene. To the best of our knowledge, no studies have assessed KAP and identified its  
6 influencing factors among Chinese HCWs concerning HAIs in various healthcare  
7 settings.

8 Hence, this study aimed to assess KAP associated with HAIs and identify the  
9 factors that significantly influence KAP among HCWs at two university-affiliated  
10 hospitals in China. Based on Kelman's theory of KAP,<sup>18</sup> the stated hypothesis was that  
11 the factors significantly affecting the knowledge and attitudes of HCWs would be  
12 partially coincident with the factors influencing their practices concerning HAIs.  
13 Specifically, socio-demographic and job-related factors would significantly influence  
14 the knowledge and practice of HCWs toward HAIs, whereas the factors significantly  
15 affecting the attitudes of HCWs concerning HAIs would be primarily job-related.

## 16 **METHODS**

### 17 **Study design and participants**

18 A cross-sectional questionnaire survey was conducted in Wuhan, from June 1,  
19 2019, to September 30, 2019. A total of 49 tertiary public hospitals were located in  
20 Wuhan, with 8.41 hospital beds per 1000 patients.<sup>22</sup> The following multistage stratified  
21 sampling approach was employed: 1) 2 out of the 13 administrative regions of Wuhan,  
22 were randomly selected for the study; 2) for each of the two selected regions, one  
23 hospital out of all the grade III level-A hospitals in the region was randomly chosen; 3)  
24 with the support of the department of human resources each study hospital, potential  
25 participants were randomly selected from the list of job numbers of HCWs and provided  
26 the online link for questionnaires; and 4) the HCWs who received questionnaires  
27 voluntarily completed and returned them online. The term 'HCWs' referred to doctors  
28 and nurses only, and excluded interns, nurse assistants and medical students, because  
29 some of the information requested could only be provided by them. To be included in  
30 the study, HCWs were required to meet the following criteria: 1) formal doctors and  
31 nurses registered at two hospitals; 2) professional qualification certificates; and 3)

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3 1 voluntary participation in the study. HCWs who were on leave at the time of the survey  
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5 2 and nonclinical staff were excluded from this study.  
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7 3 The sample size for the study was calculated using statistical power analysis.  
8  
9 4 According to Cohen's guidelines,<sup>23</sup> in multiple linear regression analyses with an  
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11 5 estimate of 10 independent variables,<sup>24</sup> a minimum of 120 subjects would be required  
12  
13 6 to achieve a median effect size (0.15) at 80% statistical power, and a significance level  
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15 7 of 0.05.<sup>25 26</sup> A total of 468 HCWs completed the online questionnaire, and incomplete  
16  
17 8 questionnaires were excluded. The 455 completed questionnaires were used for  
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19 9 downstream analyses. The larger samples increased the statistical power of the study.  
20

## 21 **Measures**

22  
23 11 The questionnaire was based on standard precaution knowledge questions and the  
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25 12 core content of HAI prevention and control systems in China, due to a lack of prior  
26  
27 13 research on the KAP of HAIs among HCWs.<sup>27-30</sup> The questionnaire consisted of two  
28  
29 14 sections: the first section covered general information, and the second one included  
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31 15 KAP concerning HAIs. The general information section comprised 16 questions to  
32  
33 16 collect the participants' sociodemographic data, including age, gender, clinical work  
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35 17 experience, marital status, educational level, occupation, department, position,  
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37 18 professional title, employment, hospital type, HAI education within the last year,  
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39 19 occupational exposure within the past 6 months, invasive operation authority,  
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41 20 antibacterial drug training, and attended clinical consultation.

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43 21 The HAI knowledge domain consisted of six questions to assess the participants'  
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45 22 knowledge of hand hygiene, HAIs, multidrug resistance, standard precautions, and  
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47 23 surgery site infection. The HAI attitude domain included eight questions to assess the  
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49 24 participants' attitudes about personal and social motivation, which addressed the  
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51 25 aspects of responsibility, attention, necessity, and initiative among HAIs. The HAI  
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53 26 practice domain consisted of twelve questions to assess the participants' practice of  
54  
55 27 aseptic operation, standard precautions, and antibiotic use. The responses were scored  
56  
57 28 on a 5-point Likert scale ranging from 1 (consistent with my cognition) to 5 (very  
58  
59 29 inconsistent with my cognition).  
60

## 30 **Pilot study**

1 Thirty participants were recruited for the pilot study from May 1, 2019, to May 15,  
2 2019 to test the trial version of the quick response code for this study. The pilot  
3 participant responses were then analyzed for clarity, understandability, and  
4 applicability of the questionnaire. The time to complete the questionnaire, and any  
5 technical difficulties while scanning the quick response code were recorded.

6 Cronbach's alpha values were 0.662 (domain A, knowledge), 0.784 (domain B,  
7 attitudes), and 0.806 (domain C, practice). In addition, six experts in the field of  
8 nosocomial infection were invited to review each item using a 4-point rating scale (1 =  
9 not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = very relevant), and test the  
10 content validity of the KAP. The overall content validity index was 0.95, which  
11 indicated that the content validity of the KAP questionnaire was reliable.

### 12 **Data collection procedure**

13 With the support of the hospital's human resources department, potential  
14 participants were contacted. After the questionnaire's reliability and validity assessment,  
15 web links to the questionnaire and informed consent forms were emailed to the  
16 qualifying potential participants by the researchers. The estimated time needed to  
17 complete the survey was 15 min. After the questionnaires were completed by the  
18 participants, responses were submitted online, and their electronic informed consent  
19 was returned via email. The questionnaires were then carefully reviewed for data  
20 analysis, and incomplete or incorrectly completed questionnaires were excluded.

### 21 **Data analysis**

22 For continuous variables, the means and standard deviations were calculated,  
23 whereas frequencies and percentages were calculated for categorical variables. The  
24 scores of KAP for general characteristics were analyzed via t-test or analysis of variance  
25 for continuous data. Multiple linear regression analysis was performed to determine the  
26 significant factors influencing KAP and KAP total scores. Variables with  $p < 0.05$   
27 determined from univariate analysis were included as independent variables in the  
28 regression model. Unstandardized coefficients and  $R^2$  were used to interpret the effects  
29 and variability of the significant dependent variables, respectively. Statistical analyses  
30 were performed using Stata version 14.0 (Stata Corporation, College Station, TX,  
31 USA). Statistical tests were two-sided, and statistical significance was set at  $p < 0.05$ .

## 1 Patient and public involvement

2 No patients or members of the public were involved in the design or planning of  
3 the study.

## 4 RESULTS

### 5 Descriptive statistics of participant characteristics

6 A total of 500 HCWs were invited to participate in the study. A total of 468 HCWs  
7 completed the online questionnaire (response rate = 93.6%). After the incomplete  
8 questionnaires were excluded, the data from 455 HCWs (395 nurses and 60 doctors)  
9 were included in the final analysis. The age of the study participants ranged from 22 to  
10 59 years (mean age = 31.35 years). Most of the participants were female (91%), and the  
11 mean duration of working experience was 9.45 years. Most participants were married  
12 (75.6%) and had attained a bachelor's degree (68.1%). More than a quarter of the  
13 participants worked in the operating room (28.1%). The majority (96%) of the  
14 participants were general staff, and 66.4% had a junior professional title. More than  
15 half of the participants (52.3%) were contract employees, and 70.1% worked in the  
16 general hospital. Among participants, 60.2% had received HAI education within the  
17 previous year, 62% experienced occupational exposures, and most participants received  
18 invasive operation authority (71.6%). In addition, 56.5% received antibacterial drug  
19 training, and 52.3% attended clinical consultation. The participants' scores of KAP and  
20 total KAP were  $15.67 \pm 3.32$ ,  $25.00 \pm 2.75$ ,  $43.44 \pm 5.15$ , and  $84.76 \pm 6.72$ , respectively.  
21 The demographics and general characteristics of the participating groups are presented  
22 in Table 1.

### 23 Univariate Analysis

24 Univariate analyses were performed to identify the factors influencing KAP, and  
25 the results are presented in Tables A1-A4 (Supplementary data).

26 The mean score of knowledge was significantly higher among the following  
27 groups of participants: received HAI education within the previous year, received  
28 antibacterial drug training, worked in the operating room or infectious diseases  
29 department, and had more than 10 years of work experience (all factors  $p < 0.05$ ). There  
30 were significant differences in knowledge scores between the following groups: gender,



1 age group, type of employment, received invasive operation authority, and participated  
2 in clinical consultations with infectious disease doctors ( $p < 0.001$ ) (Table A1).

3 Table A2 presents the factors associated with the mean attitude score. The  
4 participants who were contract employees, were married, had higher education levels,  
5 had antibacterial drug training, and had a higher education level reported a significantly  
6 higher score on attitude (all factors  $p < 0.05$ ). In addition, the attitude score was  
7 significantly associated with age, HAI education within the previous year, skin or  
8 mucous membrane exposure to patient bodily fluids within the previous 6 months,  
9 invasive operation authority, work department, clinical work experience, and job  
10 position (all factors  $p < 0.001$ ).

11 Univariate analysis also revealed that being female, having worked in general  
12 hospitals, being the department head, having more than 10 years of working experience  
13 and holding a senior technical job position, were associated with higher mean scores of  
14 practice (all factors  $p < 0.05$ ). In addition, the mean scores of practice were significantly  
15 higher among the following groups of participants: those aged 40–59 years, contract  
16 employees, individuals with higher education levels, those who received HAI education  
17 within the previous year, those who had skin or mucous membrane exposure to patient  
18 bodily fluids within the previous 6 months, individuals with invasive operation  
19 authority, those who received antibacterial drug training, individuals working in an  
20 operating room, surgery department, intensive care unit or the department of infectious  
21 diseases, and those who participated in clinical consultations with infectious disease  
22 doctors (all factors  $p < 0.001$ ) (Table A3).

23 Being female, working as a nurse, and having worked in general hospitals were  
24 significantly associated with higher total KAP scores (all factors  $p < 0.05$ ).  
25 Furthermore, the participants with the following characteristics reported significantly  
26 higher scores of the total KAP: 40–59 years of age, department head, contract  
27 employees, received HAI education within the previous year, had skin or mucous  
28 membrane exposure to patient bodily fluids within the previous 6 months, had invasive  
29 operation authority, received antibacterial drug training, and participated in clinical  
30 consultations with infectious disease doctors (all factors  $p < 0.001$ ) (Table A4).

31

1 **Table 1.** General characteristics of participants

Variables	n (%)
Age (Mean $\pm$ SD, years)	31.35 $\pm$ 7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (mean $\pm$ SD, years)	9.45 $\pm$ 8.35
Marital status	
Unmarried	99 (21.8)
Married	344 (75.6)
Widowed/divorced	12 (2.6)
Educational level	
Junior college	37 (8.2)
Bachelor's degree	310 (68.1)
Master's degree or above	108 (23.7)
Occupation	
Doctor	60 (13.2)
Nurse	395 (86.8)
Department	
Internal medicine	16 (3.5)
Surgery	83 (18.2)
Obstetrics	20 (4.4)
Intensive care unit	87 (19.1)
Emergency	21 (4.6)
Outpatient	11 (2.4)
Operating room	128 (28.1)
Infectious diseases	68 (14.9)
Other	21 (4.6)
Position	
Staff	437 (96)
Head	18 (4)
Professional title	
Senior	23 (5.1)
Middle	130 (28.6)
Junior	302 (66.4)
Type of employment	
Contract	238 (52.3)
Permanent	217 (47.7)

2

3

1 **Table 1** (continued)

Variables	n (%)
Type of hospital	
The children's hospital	136 (29.9)
General hospital	319 (70.1)
Received HAIs education within the previous year	
Yes	274 (60.2)
No	181 (39.8)
Occupational exposures (impaired skin or mucosa to blood, body fluid, secretion and excretion of patients within 6 months)	
Yes	282 (62)
No	173 (38)
Received invasive operation authority	
Yes	326 (71.6)
No	129 (28.4)
Received antibacterial drug training	
Yes	257 (56.5)
No	198 (43.5)
Attended consultation of nosocomial infection disease	
Yes	238 (52.3)
No	217 (47.7)
Knowledge score (Mean $\pm$ SD)	15.67 $\pm$ 3.32
Attitude score (Mean $\pm$ SD)	25.00 $\pm$ 2.75
Practice score (Mean $\pm$ SD)	43.44 $\pm$ 5.15
KAP (Mean $\pm$ SD)	84.76 $\pm$ 6.72

2 SD: standard deviations

### 3 **Multiple linear regression analysis**

4 The results of the assessed regression models are reported in Tables 2–5. Gender,  
 5 age group, type of employment, and clinical work experience, were identified as  
 6 significant predictors of knowledge in the multivariate regression analysis model,  
 7 assuming knowledge as the outcome variable, and accounted for 21.4% of variance  
 8 (adjusted  $R^2 = 0.214$ ,  $p < 0.001$ ). Female, older age, and 16–20 years of clinical work  
 9 experience were significantly and positively associated with knowledge scores,  
 10 whereas permanent staff was significantly and negatively associated with knowledge  
 11 scores (Table 2).

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3 1 A significant model was set up through multiple linear regression analysis ( $p < 0.001$ ),  
4 2 explaining 14.3% of the variance in attitude score (adjusted  $R^2 = 0.143$ ). The following  
5 3 aspects were positively associated with attitude scores (Table 3): received HAI  
6 4 education within the last year, experienced occupational exposure within 6 months,  
7 5 received invasive operation authority, and attended clinical consultation.  
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12 6 The results of the multiple linear regression analysis on practices are shown in  
13 7 Table 4. Gender, education level, work department, occupational exposure within 6  
14 8 months, invasive operation authority, antibacterial drug training, and attending clinical  
15 9 consultation, were identified as significant predictors of practice, and explained 47.05%  
16 10 (adjusted  $R^2 = 0.471$ ) of variance. Being female, experiencing occupational exposure  
17 11 within 6 months, having invasive operation authority, having antibacterial drug  
18 12 training, achieving higher education level, attending clinical consultation, and working  
19 13 in surgery, operating room, or infectious disease department were significantly and  
20 14 positively associated with the practice of HCWs.  
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28 15 Another significant model was established through multiple linear regression  
29 16 analysis ( $p < 0.001$ ), explaining 61% of the variance in the total KAP scores (adjusted  
30 17  $R^2 = 0.61$ ). Male, younger age, general staff, and permanent staff had a significantly  
31 18 negative influence on KAP total scores. In contrast, the following aspects were  
32 19 positively associated with the total KAP scores: received HAI education within the  
33 20 previous year, received invasive operation authority, received antibacterial drug  
34 21 training, and attended clinical consultation (Table 5).  
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**Table 2.** Multiple linear regression analysis of the influencing factors for knowledge scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	13.20 (11.03,15.36)	1.10		11.99	< 0.001
Gender					
Female (vs. Male)	2.36 (1.24, 3.47)	0.57	0.19	4.15	< 0.001
Age group (years)					
40-59 (vs.18-39)	3.04 (1.84, 4.24)	0.61	0.27	4.98	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.27 (-1.82, -0.56)	0.32	-0.18	-3.93	< 0.001
Clinical work experience (years)					
6-10 (vs.1-5)	-0.17 (-0.93, 0.59)	0.39	-0.02	-0.44	0.660
11-15 (vs.1-5)	0.65 (-0.47, 1.77)	0.57	0.05	1.14	0.253
16-20 (vs.1-5)	1.54 (0.40, 2.68)	0.58	0.13	2.66	0.008
$\geq$ 21 (vs.1-5)	0.87 (-0.34, 2.08)	0.61	0.08	1.41	0.158

The independent variables included in the regression model were gender, age group, occupation, type of employment, received HAI education within the previous year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, department, clinical work experience, and attended consultation of nosocomial infection disease.

Adjusted R<sup>2</sup> (p-value): 0.214 (p < 0.001).

CI: confidence interval; SD: standard deviations.

**Table 3.** Multiple linear regression analysis of the influencing factors for attitude scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	25.20 (22.89, 27.51)	1.18		21.44	< 0.001
Received HAIs education within the previous year					
No (vs. Yes)	-0.97 (-1.64, -0.29)	0.34	-0.17	-2.82	0.005
Occupational exposure within 6 months					
Yes (vs. No)	0.90 (0.15, 1.66)	0.38	0.16	2.36	0.019
Received invasive operation authority					
No (vs. Yes)	-1.04 (-2.05, -0.65)	0.33	-0.17	-3.12	0.002
Attended consultation of nosocomial infection disease					
No (vs. Yes)	-0.73 (-1.27, -0.19)	0.28	-0.13	-2.65	0.008
Department					
Surgery (vs. Internal medicine)	0.20 (-1.21, 1.62)	0.72	0.03	0.28	0.778
Obstetrics (vs. Internal medicine)	-0.87 (-2.57, 0.84)	0.87	-0.06	-1.00	0.319
Intensive care unit (vs. Internal medicine)	0.47 (-0.96, 1.91)	0.73	0.07	0.65	0.517
Emergency (vs. Internal medicine)	-0.99 (-2.67, 0.68)	0.85	-0.08	-1.16	0.245
Outpatient (vs. Internal medicine)	-2.11 (-4.13, -0.09)	1.03	-0.12	-2.05	0.041
Operating room (vs. Internal medicine)	0.38 (-1.02, 1.78)	0.71	0.06	0.54	0.591
Infectious diseases (vs. Internal medicine)	0.46 (-1.02, 1.94)	0.75	0.06	0.61	0.543
Other (vs. Internal medicine)	-0.94 (-2.64, 0.76)	0.87	-0.07	-1.08	0.280

The independent variables included in the regression model were age group, type of employment, clinical work experience (years), educational level, marital status, professional title, received HAI education within the previous year, occupational exposure within 6 months, received invasive operation authority, attended consultation of nosocomial infection disease and work department; Adjusted R<sup>2</sup> (p-value): 0.1434 (p < 0.001); CI: confidence interval; SD: standard deviations.

**Table 4.** Multiple linear regression analysis of the influencing factors for practice scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	40.71 (37.31, 44.10)	1.73		23.58	< 0.001
Gender					
Female (vs. Male)	1.55 (0.19, 2.90)	0.69	0.09	2.24	0.025
Occupational exposure within 6 months					
No (vs. Yes)	-1.49 (-2.60, -0.38)	0.56	-0.14	-2.64	0.009
Received invasive operation authority					
No (vs. Yes)	-1.70 (-2.67, -0.74)	0.49	-0.15	-3.47	0.001
Received antibacterial drug training					
No (vs. Yes)	-3.01 (-3.85, -2.17)	0.43	-0.29	-7.06	< 0.001
Educational level					
Bachelor's degree (vs. College degree)	3.40 (2.02, 4.78)	0.70	0.31	4.85	< 0.001
Master's degree or above (vs. College degree)	3.74 (2.15, 5.33)	0.81	0.31	4.62	< 0.001
Attended consultation of nosocomial infection disease					
No (vs. Yes)	-2.60 (-3.40, -1.80)	0.41	-0.25	-6.40	< 0.001
Department					
Surgery (vs. Internal medicine)	2.78 (0.70, 4.86)	1.06	0.21	2.62	0.009
Obstetrics (vs. Internal medicine)	-1.06 (-3.59, 1.47)	1.29	-0.04	-0.82	0.412
Intensive care unit (vs. Internal medicine)	1.70 (-0.41, 3.82)	1.08	0.13	1.58	0.114
Emergency (vs. Internal medicine)	0.91 (-1.56, 3.38)	1.26	0.04	0.73	0.468
Outpatient (vs. Internal medicine)	2.18 (-0.78, 5.14)	1.51	0.07	1.45	0.148
Operating room (vs. Internal medicine)	2.76 (0.71, 4.81)	1.04	0.24	2.65	0.008
Infectious diseases (vs. Internal medicine)	2.70 (0.52, 4.87)	1.11	0.19	2.43	0.015
Other (vs. Internal medicine)	0.08 (-2.44, 2.60)	1.28	0	0.06	0.951

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4 The independent variables included in the regression model included: gender, age group, type of hospital, position, type of employment, received HAI  
5 education within the previous year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training,  
6 educational level, attended consultation of nosocomial infection disease, department, clinical work experience, and professional title.  
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10 Adjusted R<sup>2</sup> (p-value): 0.4705 (p < 0.001).  
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12 CI: confidence interval; SD: standard deviations.  
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**Table 5.** Multiple linear regression analysis of the influencing factors for KAP total scores

Independent variables	B (95% CI)	SD	$\beta$	t	p-value
Intercept	87.06 (85.12, 88.99)	0.99		88.31	< 0.001
Gender					
Female (vs. Male)	2.36 (1.11, 4.40)	0.84	0.09	3.29	0.008
Age group (years)					
40-59 (vs.18-39)	6.65 (5.07, 7.74)	0.68	0.30	9.44	< 0.001
Position					
Head (vs. Staff)	7.02 (3.88, 8.45)	1.16	0.18	5.30	< 0.001
Type of employment					
Permanent staff (vs. Contract)	-1.08 (-2.08, -0.07)	0.51	-0.07	-2.11	0.035
Received HAIs education within the previous year					
No (vs. Yes)	-2.98 (-4.23, -1.72)	0.64	-0.20	-4.65	< 0.001
Received invasive operation authority					
No (vs. Yes)	-4.22 (-5.46, -2.99)	0.63	-0.26	-6.71	< 0.001
Received antibacterial drug training					
No (vs. Yes)	-4.38 (-5.45, -3.31)	0.55	-0.29	-8.03	< 0.001
Attended consultation of nosocomial infection disease					
No (vs. Yes)	-4.35 (-5.38, -3.32)	0.52	-0.29	-8.31	< 0.001

The independent variables included in the regression model were gender, age group, type of hospital, occupation, position, type of employment, received HAI education within the previous year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, and attended consultation of nosocomial infection disease.

Adjusted R<sup>2</sup>(p-value): 0.61 (p < 0.001); CI: confidence interval; SD: standard deviation.

## 1 DISCUSSION

2 This study appears to be the first to describe the KAPs in relation to HAIs and their  
3 influencing factors among HCWs in central China. Although increased awareness and  
4 stricter regulations on the control of hospital infections have been observed, the study  
5 survey found that limitations still exist in HCWs' knowledge and practices, in terms of  
6 HAIs. With the current COVID-19 pandemic, understanding HCWs' KAP concerning  
7 HAIs, and the significant factors influencing their KAP is essential. These findings may  
8 provide a basis for designing and implementing targeted intervention programs to  
9 promote the KAP of HCWs and establish the basis for conducting future studies.

10 Results indicated that the HCWs' sociodemographic factors, such as gender, age,  
11 employment, and clinical work experience, significantly affected their knowledge of  
12 HAIs. Although some of these factors are unchangeable (e.g., age and gender),  
13 continuous education on HAIs remains essential to improve knowledge of HAIs.  
14 Previous studies similarly demonstrated that participants who received training within  
15 the previous 5 years obtained higher knowledge scores.<sup>31</sup> Another previous study on  
16 the KAP, associated with central vascular catheters, proved this hypothesis, and  
17 reported that knowledge scores were significantly higher among respondents who  
18 received active formal training than those who did not.<sup>32</sup> However, career seniority and  
19 gender were not identified as significant factors influencing the knowledge level among  
20 UK HCWs, and this observation was partly inconsistent with the finding of this present  
21 study.<sup>33</sup>

22 Possessing HAI education, experiencing occupational exposure within 6 months,  
23 having the authority to perform invasive operations, and participating in clinical  
24 consultations promote positive HAI attitudes; however, working in outpatients clinics  
25 is not conducive to developing positive HAI attitudes. Respondents' attitudes toward  
26 prevention-related HAIs are significantly high among HCWs who are assigned in  
27 intensive care units and have appropriate knowledge and training.<sup>32</sup> In a multicenter  
28 study conducted in Shanghai, China, independent associations between older age or  
29 higher education and categorical knowledge are observed among physicians.<sup>27</sup> A longer  
30 working experience is inversely and independently associated with the knowledge and  
31 attitudes of HCWs.<sup>27</sup> However, age, education level, and working experience were not  
32 identified as significant influencing factors of attitudes concerning HAIs in this study.

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3 1 In contrast, receiving HAI education was the most significantly influential factor of  
4 2 attitudes. The inconsistent findings between this study and the study conducted in  
5 3 Shanghai may be due to the difference in the selection of the study hospitals. The study  
6 4 conducted in Shanghai recruited HCWs from community hospitals, where the HCWs  
7 5 typically possess a lower education level, compared to those from acute hospitals.  
8 6 During the COVID-19 pandemic, a high proportion of HCWs admitted fear of  
9 7 working.<sup>34</sup> As such, periodic educational interventions and training programs regarding  
10 8 infection control practices for COVID-19 must be implemented among all HCWs,  
11 9 especially those who encounter new emerging infectious diseases.<sup>35</sup>

12 10 In the practice domain, education level had the highest influence on the ability of  
13 11 HCWs to implement the prevention and control of HAIs. Other positive factors  
14 12 included gender, occupational exposure within the previous 6 months, authority to  
15 13 perform invasive operations, antibacterial drug training, and attendance of clinical  
16 14 consultations. Previous studies largely focused on hand hygiene practices, and most of  
17 15 them reported poor compliance with hand hygiene recommendations.<sup>15 36</sup> Other studies  
18 16 have shown that factors such as perceived severity, subjective norms, and job demands  
19 17 also influence practices significantly.<sup>37</sup> However, to some extent, influencing factors,  
20 18 such as occupational exposure and training, also relate to self-perception in this study.

21 19 Many medical professionals have become infected during the COVID-19  
22 20 pandemic, due to the lack of PPE. Statistical data have shown that more than 100  
23 21 thousand HCWs have been infected worldwide.<sup>38</sup> The adequate and correct use of PPE  
24 22 is the best measure to prevent HCWs from acquiring COVID-19 infection.<sup>39</sup> However,  
25 23 at the early stage of the outbreak, a global shortage of PPE occurred, and HCWs lacked  
26 24 practice on the proper donning and doffing of PPE.<sup>40</sup> Insufficient knowledge and skills  
27 25 related to the isolation of respiratory diseases pose a high risk of infection with HCWs.  
28 26 Although this study did not specifically focus on COVID-19, this pandemic demands  
29 27 awareness and attention to prepare HCWs with adequate knowledge, positive attitudes,  
30 28 and practice, in preventing and controlling transmitted infections and diseases.

31 29 Biases, especially those associated with participants' behavior and practices, may  
32 30 exist in self-reported surveys. Consequently, participants may overstate their good  
33 31 practices. This study was cross-sectional, so inferences drawn from self-reported  
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1 practices may vary from direct observation evidence. Moreover, no causal relationship  
2 was found.

### 3 **CONCLUSION**

4 In this study, KAP is closely associated with uncontrollable factors (such as gender,  
5 age, job position, employment type, educational level, and clinical work experience)  
6 and controllable ones (such as HAI education within the previous year, occupational  
7 exposure within the previous 6 months, antibacterial drug training, and participation in  
8 clinical consultations). Controllable factors indicate that hospital managers can respond  
9 appropriately for all HCWs to promote the improvement of KAP. Furthermore,  
10 uncontrollable factors imply that when taking measures to improve KAP, hospital  
11 managers should consider the backgrounds of individual HCWs. In addition, some  
12 sociodemographic and job-related factors significantly influence the knowledge and  
13 practices of HAIs among Chinese HCWs, whereas job-related factors significantly  
14 affect the attitudes of HCWs concerning HAIs. This result supports the hypotheses of  
15 this study. However, further studies should be performed to establish the benchmark of  
16 KPA for HAIs among HCWs.

17 **Author Contributions:** WWW conceived the study. WWW, WWR, YYF, LLK, TYB,  
18 YJR and WY contributed in the survey design, data collection. DL contributed in data  
19 analysis. All authors contributed to the interpretation of data and intellectual revised  
20 multiple drafts. WWW and WWR drafted the manuscript. All authors have approved  
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30 **Data availability statement:** Some or all data, models, or code generated or used  
31 during the study are available from the corresponding author (Ying Wang) by request.

1 Reuse of the data is permitted for non-commercial purposes. Contact details: Email:  
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#### 4 REFERENCES

- 5 1. Breathnach, Aodhán S. Nosocomial infections and infection control. *Medicine* 2013;**41**:  
6 649-53. doi:10.1016/j.mpmed.2013.08.010
- 7 2. Daxboeck F, Budic T, Assadian O, *et al.* Economic burden associated with multi-resistant  
8 Gram-negative organisms compared with that for methicillin-resistant *Staphylococcus*  
9 aureus in a university teaching hospital. *J Hosp Infect* 2006;**62**:214-18. doi:  
10 10.1016/j.jhin.2005.07.009 pmid: <https://pubmed.ncbi.nlm.nih.gov/16257092>
- 11 3. Rattanaumpawan P, Thamlikitkul V. Epidemiology and economic impact of health care-  
12 associated infections and cost-effectiveness of infection control measures at a Thai  
13 university hospital. *Am J Infect Control* 2017;**45**:145-50. doi:10.1016/j.ajic.2016.07.018  
14 pmid: <https://pubmed.ncbi.nlm.nih.gov/27665034>
- 15 4. Hollmeyer HG, Hayden F, Poland G, *et al.* Influenza vaccination of health care workers  
16 in hospitals—A review of studies on attitudes and predictors. *Vaccine* 2009;**27**:3935-44.  
17 doi: 10.1016/j.vaccine.2009.03.056 pmid: <https://pubmed.ncbi.nlm.nih.gov/19467744>
- 18 5. Global patient safety challenge: 2005-2006/World Alliance for Patient Safety. Available  
19 online: <https://apps.who.int/iris/handle/10665/43358> (accessed on 16 June 2006).
- 20 6. Humphreys H, Newcombe RG, Enstone J, *et al.* Four Country Healthcare Associated  
21 Infection Prevalence Survey 2006: risk factor analysis. *J Hosp Infect* 2008;**69**:249-57.  
22 doi:10.1016/j.jhin.2008.04.021 pmid: <https://pubmed.ncbi.nlm.nih.gov/18550214>
- 23 7. Rosenthal VD. Health-care-associated infections in developing countries. *Lancet*  
24 2011;**377**:186-8. doi:10.1016/S0140-6736(10)62005-3 pmid:  
25 <https://pubmed.ncbi.nlm.nih.gov/21146208>
- 26 8. Xie DS, Fu XY, Wang HF, *et al.* Annual point-prevalence of healthcare-associated  
27 infection surveys in a university hospital in China, 2007-2011. *J Infect Public Health*  
28 2013;**6**:416-22. doi:10.1016/j.jiph.2013.04.009 pmid:  
29 <https://pubmed.ncbi.nlm.nih.gov/23999334>
- 30 9. Liu JY, Wu YH, Cai M, *et al.* Point-prevalence survey of healthcare-associated infections  
31 in Beijing, China: a survey and analysis in 2014. *J Hosp Infect* 2016;**93**:271-9. doi:  
32 10.1016/j.jhin.2016.03.019 pmid: <https://pubmed.ncbi.nlm.nih.gov/27140419>
- 33 10. Wang J, Liu F, Tartari E, *et al.* The Prevalence of Healthcare-Associated Infections in  
34 Mainland China: A Systematic Review and Meta-analysis. *Infect Control Hosp*  
35 *Epidemiol* 2018;**39**:701-9. doi: 10.3389/fendo.2020.00336 pmid:  
36 <https://pubmed.ncbi.nlm.nih.gov/32582028>

11. Sun BW. Nosocomial infection in China: Management status and solutions. *Am J Infect Control* 2016;**44**:851-2. doi:10.1016/j.ajic.2016.01.039 pmid: <https://pubmed.ncbi.nlm.nih.gov/27067518>
12. Byarugaba, DK. A view on antimicrobial resistance in developing countries and responsible risk factors. *Int J Antimicrob Ag* 2004;**24**:105-10. doi:10.1016/j.ijantimicag.2004.02.015 pmid: <https://pubmed.ncbi.nlm.nih.gov/15288307>
13. Mir F, Zaidi AKM. Hospital infections by antimicrobial-resistant organisms in developing countries. *Springer* 2010;**317**:199-232.
14. Adebimpe, WO, Asekun-Olarinmoye EO, Bamidele JO, *et al.* A comparative study of awareness and attitude to nosocomial infections among levels of health care workers in southwestern nigeria. *Continent J Trop Med* 2011;**5**:5.
15. Hien H, Drabo M, Ouédraogo L, *et al.* Knowledge and practices of health care workers in the area of healthcare-associated infection risks. A case study in a district hospital in Burkina Faso. *Sante Publique* 2013;**25**:219-26. doi:10.1080/17441692.2013.770902
16. Jin YH, Huang Q, Wang YY, *et al.* Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers in a tertiary acute care hospital in Wuhan: a cross-sectional survey. *Mil Med Res.* 2020;**7**:24.
17. World Health Organization. Geneva. 2017. Guidelines for the prevention and control of carbapenem-resistant Enterobacteriaceae, *Acinetobacter baumannii* and *Pseudomonas aeruginosa* in health care facilities.
18. Jiang H, Zhang S, Ding Y, *et al.* Development and validation of college students' tuberculosis knowledge, attitudes and practices questionnaire (CS-TBKAPQ). *BMC Public Health* 2017;**17**:949. doi:10.1186/s12889-017-4960-x pmid: <https://pubmed.ncbi.nlm.nih.gov/29233115>
19. Angelillo IF, Mazziotta A, Nicotera G. Nurses and hospital infection control: knowledge, attitudes and behaviour of Italian operating theatre staff. *J Hosp Infect* 1999;**42**:105-12. doi:10.1053/jhin.1998.0571 pmid:<https://pubmed.ncbi.nlm.nih.gov/10389059/>
20. Balarabe SA, Joshua IA, Danjuma A, *et al.* Knowledge of Healthcare Workers on Nosocomial Infection in Selected Secondary Health Institutions in Zaria, Nigeria. *J Prevent Med* 2015;**3**:1-6. doi: 10.12691/jpm-3-1-1.
21. Adegboye MB, Zakari S, Ahmed BA, *et al.* Knowledge, awareness and practice of infection control by health care workers in the intensive care units of a tertiary hospital in Nigeria. *Afri Health Sci* 2018;**18**:72-8. doi:10.4314/ahs.v18i1.11

- 1  
2  
3 1 22. Wuhan Statistical Bureau. Wuhan. 2019. Wuhan Health Statistical Yearbook. Available  
4 online: <http://tjj.wuhan.gov.cn/tjfw/tjnj/202004/P020200426461240969401.pdf>  
5 (accessed on 7 Sep 2020).  
6  
7  
8 4 23. Cohen J. A Power Primer. *Psychological bulletin* 1992;**112**:155-9. doi:10.1037/0033-  
9 2909.112.1.155  
10  
11 6 24. Brown MT, Bussell JK. Medication Adherence: WHO Cares? *Mayo Clinic Proceedings*  
12 2011;**86**:304-14. doi:10.4065/mcp.2010.0575  
13  
14 8 25. Glader EL, Sjolander M, Eriksson M, et al. Persistent Use of Secondary Preventive Drugs  
15 Declines Rapidly During the First 2 Years After Stroke. *Stroke* 2010;**41**:397-401.doi:  
16 10.1161/STROKEAHA.109.566950  
17  
18 10 26. Maxwell SE. Sample size and multiple regression analysis. *Psychological methods*  
19 2000;**5**:434. doi: 10.1037/1082-989x.5.4.434 pmid:  
20 <https://pubmed.ncbi.nlm.nih.gov/11194207/>  
21  
22 13  
23 14 27. Zhou Y, Zhang D, Chen Y, et al. Healthcare-associated infections and Shanghai clinicians:  
24 a multicenter cross-sectional study. *PLoS One* 2014;**9**:e105838-e105838. doi:  
25 10.1371/journal.pone.0105838 pmid: <https://pubmed.ncbi.nlm.nih.gov/25148526/>  
26  
27 16 28. Luo Y, He GP, Zhou JW, et al. Factors impacting compliance with standard precautions  
28 in nursing, China. *Int J Infect Dis* 2010;**14**:e1106-e1114. doi: 10.1016/j.ijid.2009.03.037  
29 pmid: <https://pubmed.ncbi.nlm.nih.gov/21071254>  
30  
31 19 29. Tavolacci MP, Ladner J, Bailly L, et al. Prevention of nosocomial infection and standard  
32 precautions: knowledge and source of information among healthcare students. *Infect  
33 Control Hosp Epidemiol* 2008;**29**:642-7. doi:10.1086/588683  
34  
35 21 30. Circular of the general office of the National Health Commission on Further Strengthening  
36 the prevention and control of infection in medical institution. Available online:  
37 <http://www.cha.org.cn/plus/view.php?aid=15223> (accessed on 15 March 2017).  
38  
39 24 31. Taffurelli C, Sollami A, Camera C, et al. Healthcare associated infection: good practices,  
40 knowledge and the locus of control in healthcare professionals. *Acta Biomed* 2017;**88**:31-  
41 6. doi: 10.23750/abm.v88i3-S.6611 pmid: <https://pubmed.ncbi.nlm.nih.gov/28752830/>  
42  
43 26 32. Bianco A, Coscarelli P, Nobile CGA, et al. The reduction of risk in central line-associated  
44 bloodstream infections: knowledge, attitudes, and evidence-based practices in health care  
45 workers. *Am J Infect Control* 2013;**41**:107-12. doi:10.1016/j.ajic.2012.02.038 pmid:  
46 <https://pubmed.ncbi.nlm.nih.gov/22980513/>  
47  
48 29 33. Brady RRW, McDermott C, Cameron F, et al. UK healthcare workers' knowledge of  
49 meticillin-resistant *Staphylococcus aureus* practice guidelines; a questionnaire study. *J  
50 Hosp Infect* 2009;**73**:264-70. doi: 10.1016/j.jhin.2009.07.020 pmid:  
51 <https://pubmed.ncbi.nlm.nih.gov/19783068/>  
52  
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53  
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55  
56  
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58  
59  
60

- 1 34. Rymarowicz J, Stefura T, Major P, *et al.* General surgeons' attitudes towards COVID-19:  
2 A national survey during the SARS-CoV-2 virus outbreak. *European Surgery*, 2020;**21**.  
3 doi: 10.1007/s10353-020-00649-w pmid: <https://pubmed.ncbi.nlm.nih.gov/32837516/>
- 4 35. Neupane HC, Shrestha N, Adhikari S, *et al.* Knowledge of Health Care Professionals and  
5 Medical Students Regarding Covid-19 in a Tertiary Care Hospital in Nepal. *JNMA J Nepal*  
6 *Med Assoc.* 2020;**58**:480-486. doi: 10.31729/jnma.4995 pmid:  
7 <https://pubmed.ncbi.nlm.nih.gov/32827009/>
- 8 36. Ellingson K, Haas JP, Aiello AE, *et al.* Strategies to prevent healthcare-associated  
9 infections through hand hygiene. *Infect Control Hosp Epidemiol* 2014;**35**:S155-78. doi:  
10 10.1086/677145 pmid: <https://pubmed.ncbi.nlm.nih.gov/25026608>
- 11 37. Brazzell BD. Improving High Hand-hygiene Compliance and Reducing Healthcare-  
12 associated Infection in Eight Nursing Units. *Am J Infect Control* 2014;**42**:S25-6. doi:  
13 10.1016/j.ajic.2014.03.076
- 14 38. Stubblefield WB, Talbot HK, Feldstein L, *et al.* Seroprevalence of SARS-CoV-2 Among  
15 Frontline Healthcare Personnel During the First Month of Caring for COVID-19 Patients  
16 - Nashville, Tennessee [published online ahead of print, 2020 Jul 6]. *Clin Infect Dis.* 2020;  
17 ciaa936. doi:10.1093/cid/ciaa936 pmid: <https://pubmed.ncbi.nlm.nih.gov/32628750>
- 18 39. Eyre DW, Lumley SF, O'Donnell D, *et al.* Differential occupational risks to healthcare  
19 workers from SARS-CoV-2 observed during a prospective observational study [published  
20 online ahead of print, 2020 Aug 21]. *Elife.* 2020;**9**: e60675. doi:10.7554/eLife.60675  
21 pmid: <https://pubmed.ncbi.nlm.nih.gov/32820721>
- 22 40. Wang Y, Wu W, Cheng Z, *et al.* Super-factors associated with transmission of  
23 occupational COVID-19 infection among healthcare staff in Wuhan, China. *J Hosp Infect.*  
24 2020;**106**:25-34. doi: 10.1016/j.jhin.2020.06.023 pmid:  
25 <https://pubmed.ncbi.nlm.nih.gov/32574702>
- 26



**Table A1.** Results of univariate analysis of knowledge score

Variables	Mean ± SD	n	p-value
Gender			< 0.001
Male	13.88 ± 0.50	41	
Female	16.27 ± 0.17	414	
Age group (years)			< 0.001
18-39	15.60 ± 0.17	397	
40-59	19.19 ± 0.36	58	
Occupation			0.0031
Doctor	14.93 ± 0.38	60	
Nurse	16.22 ± 0.18	395	
Type of employment			< 0.001
Contract	16.69 ± 0.24	238	
Permanent	15.36 ± 0.23	217	
Received HAIs education within the previous year			0.0139
Yes	16.40 ± 0.20	274	
No	15.54 ± 0.29	181	
Occupational exposures within 6 months			0.0072
Yes	16.41 ± 0.21	282	
No	15.48 ± 0.27	173	
Received invasive operation authority			< 0.001
Yes	16.38 ± 0.19	326	
No	15.22 ± 0.31	129	
Received antibacterial drug training			0.0254
Yes	16.38 ± 0.23	257	
No	15.64 ± 0.24	198	

**Table A1.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Department				0.040
	Internal medicine	14.69 ± 4.51	16	
	Surgery	15.77 ± 3.44	83	
	Obstetrics	15.35 ± 2.23	20	
	Intensive care unit	15.54 ± 3.00	87	
	Emergency	14.43 ± 4.40	21	
	Outpatient	13.45 ± 3.45	11	
	Operating room	16.23 ± 3.27	128	
	Infectious diseases	16.07 ± 3.30	68	
	Other	14.67 ± 2.52	21	
Clinical work experience (years)				0.025
	1-5	15.43 ± 3.40	203	
	6-10	15.15 ± 3.38	110	
	11-15	16.35 ± 2.98	40	
	16-20	16.48 ± 3.13	42	
	≥21	16.45 ± 3.17	60	
Attended consultation of nosocomial infection disease				< 0.001
	Yes	16.60 ± 0.22	238	
	No	15.47 ± 0.25	217	

**Table A2.** Results of univariate analysis of attitude score

Variables	Mean ± SD	n	p-value
Age group (years)			< 0.001
18-39	24.83 ± 0.14	397	
40-59	26.19 ± 0.36	58	
Type of employment			0.0168
Contract	25.29 ± 0.16	238	
Permanent	24.67 ± 0.20	217	
Received HAIs education within the previous year			< 0.001
Yes	25.41 ± 0.15	274	
No	24.38 ± 0.22	181	
Occupational exposure within 6 months			< 0.001
Yes	25.35 ± 0.15	282	
No	24.42 ± 0.22	173	
Received invasive operation authority			< 0.001
Yes	25.37 ± 0.15	326	
No	24.05 ± 0.25	129	
Received antibacterial drug training			0.0023
Yes	25.34 ± 0.17	257	
No	24.55 ± 0.20	198	
Educational level			0.012
Junior college	24.30 ± 2.64	37	
Bachelor's degree	24.86 ± 2.74	310	
Master's degree or above	25.63 ± 2.73	108	

**Table A2.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
	Attended consultation of nosocomial infection disease			0.0089
	Yes	25.32 ± 0.18	238	
	No	24.65 ± 0.19	217	
Department				< 0.001
	Internal medicine	24.19 ± 2.93	16	
	Surgery	25.20 ± 3.02	83	
	Obstetrics	24.00 ± 2.97	20	
	Intensive care unit	25.54 ± 2.40	87	
	Emergency	23.19 ± 3.11	21	
	Outpatient	22.18 ± 3.37	11	
	Operating room	25.29 ± 2.46	128	
	Infectious diseases	25.54 ± 2.42	68	
	Other	23.24 ± 2.45	21	
Clinical work experience (years)				< 0.001
	1-5	24.56 ± 2.76	203	
	6-10	24.77 ± 2.64	110	
	11-15	25.38 ± 2.39	40	
	16-20	26.31 ± 2.70	42	
	≥21	25.73 ± 2.79	60	
Marital status				0.002
	Unmarried	24.20 ± 2.82	99	
	Married	25.25 ± 2.72	344	
	Widowed / divorced	24.33 ± 1.56	12	

**Table A2.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Professional title				< 0.001
	Senior	26.39 ± 2.13	23	
	Middle	25.53 ± 2.87	130	
	Primary	24.66 ± 2.68	302	

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**Table A3.** Results of univariate analysis of practice score

Variables	Mean ± SD	n	p-value
Gender			0.0169
Male	41.41 ± 0.86	41	
Female	43.64 ± 0.25	414	
Age group (years)			< 0.001
18-39	43.14 ± 0.26	397	
40-59	45.50 ± 0.51	58	
Type of hospital			0.0207
The children's hospital	42.61 ± 0.41	136	
General hospital	43.79 ± 0.30	319	
Position			0.0207
Staff	42.61 ± 0.41	136	
Head	43.79 ± 0.29	319	
Type of employment			< 0.001
Contract	44.50 ± 0.33	238	
Permanent	42.28 ± 0.34	217	
Educational level			< 0.001
Junior college	38.24 ± 4.17	37	
Bachelor's degree	43.85 ± 4.97	310	
Master's degree or above	44.03 ± 5.04	108	
Received HAIs education within the previous year			< 0.001
Yes	44.81 ± 0.29	274	
No	41.36 ± 0.37	181	

**Table A3.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
	Occupational exposure within 6 months			< 0.001
	Yes	45.34 ± 0.26	284	
	No	40.28 ± 0.36	171	
	Received invasive operation authority			< 0.001
	Yes	44.81 ± 0.26	326	
	No	39.98 ± 0.40	129	
	Received antibacterial drug training			< 0.001
	Yes	45.35 ± 0.27	257	
	No	40.96 ± 0.36	198	
	Department			< 0.001
	Internal medicine	38.13 ± 4.84	16	
	Surgery	44.51 ± 4.76	83	
	Obstetrics	38.60 ± 4.27	20	
	Intensive care unit	43.95 ± 5.19	87	
	Emergency	39.71 ± 3.66	21	
	Outpatient	39.36 ± 4.32	11	
	Operating room	44.98 ± 4.91	128	
	Infectious diseases	44.46 ± 3.80	68	
	Other	38.95 ± 4.40	21	
	Attended consultation of nosocomial infection disease			< 0.001
	Yes	44.61 ± 0.30	238	
	No	42.16 ± 0.37	217	

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**Table A3.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
Clinical work experience (years)	1-5	42.89 ± 5.57	203	0.012
	6-10	42.88 ± 5.33	110	
	11-15	45.20 ± 3.34	40	
	16-20	44.00 ± 4.54	42	
	≥21	44.77 ± 4.24	60	
Professional Title	Senior	46.17 ± 4.03	23	0.022
	Middle	43.63 ± 4.78	130	
	Primary	43.15 ± 5.33	302	

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**Table A4.** Results of univariate analysis of the total KAP score

Variables	Mean ± SD	n	p-value
Gender			0.0014
Male	80.41 ± 1.27	41	
Female	84.90 ± 0.36	414	
Age group (years)			< 0.001
18-39	83.56 ± 0.37	397	
40-59	90.88 ± 0.63	58	
Occupation			0.0244
Doctor	82.40 ± 0.98	60	
Nurse	84.81 ± 0.37	395	
Type of hospital			0.0169
The children's hospital	83.22 ± 0.63	136	
General hospital	85.03 ± 0.41	319	
Position			< 0.001
Staff	84.06 ± 0.34	437	
Head	95.06 ± 1.10	18	
Type of employment			< 0.001
Contract	86.48 ± 0.46	238	
Permanent	82.31 ± 0.48	217	
Received HAIs education within the previous year			< 0.001
Yes	86.62 ± 0.39	274	
No	81.28 ± 0.56	181	
Occupational exposure within 6 months			< 0.001
Yes	87.12 ± 0.39	284	
No	80.13 ± 0.52	171	

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**Table A4.** (continued)

	<b>Variables</b>	<b>Mean ± SD</b>	<b>n</b>	<b>p-value</b>
	Received invasive operation authority			< 0.001
	Yes	86.56 ± 0.38	326	
	No	79.26 ± 0.54	129	
	Received antibacterial drug training			< 0.001
	Yes	87.07 ± 0.42	257	
	No	81.15 ± 0.50	198	
	Attended consultation of nosocomial infection disease			< 0.001
	Yes	86.52 ± 0.42	238	
	No	82.27 ± 0.52	217	

# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	4
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			

1	Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	5
2				
3	Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including	5
4			periods of recruitment, exposure, follow-up, and data collection	
5				
6				
7	Eligibility criteria	<a href="#">#6a</a>	Give the eligibility criteria, and the sources and methods of	5-6
8			selection of participants.	
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11		<a href="#">#7</a>	Clearly define all outcomes, exposures, predictors, potential	6
12			confounders, and effect modifiers. Give diagnostic criteria, if	
13			applicable	
14				
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16	Data sources /	<a href="#">#8</a>	For each variable of interest give sources of data and details of	6
17	measurement		methods of assessment (measurement). Describe	
18			comparability of assessment methods if there is more than one	
19			group. Give information separately for for exposed and	
20			unexposed groups if applicable.	
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24	Bias	<a href="#">#9</a>	Describe any efforts to address potential sources of bias	6-7
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27	Study size	<a href="#">#10</a>	Explain how the study size was arrived at	6
28				
29	Quantitative	<a href="#">#11</a>	Explain how quantitative variables were handled in the	7
30	variables		analyses. If applicable, describe which groupings were chosen,	
31			and why	
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34	Statistical	<a href="#">#12a</a>	Describe all statistical methods, including those used to control	7
35	methods		for confounding	
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38	Statistical	<a href="#">#12b</a>	Describe any methods used to examine subgroups and	n/a
39	methods		interactions	
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42	Statistical	<a href="#">#12c</a>	Explain how missing data were addressed	7
43	methods			
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46	Statistical	<a href="#">#12d</a>	If applicable, describe analytical methods taking account of	6
47	methods		sampling strategy	
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50	Statistical	<a href="#">#12e</a>	Describe any sensitivity analyses	n/a
51	methods			
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54	<b>Results</b>			
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56	Participants	<a href="#">#13a</a>	Report numbers of individuals at each stage of study—eg	8
57			numbers potentially eligible, examined for eligibility, confirmed	
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eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.

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5	Participants	<a href="#">#13b</a>	Give reasons for non-participation at each stage 8
6			
7	Participants	<a href="#">#13c</a>	Consider use of a flow diagram n/a
8			
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10	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, 8
11			clinical, social) and information on exposures and potential
12			confounders. Give information separately for exposed and
13			unexposed groups if applicable.
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17	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each 8
18			variable of interest
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21	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. n/a
22			Give information separately for exposed and unexposed
23			groups if applicable.
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26	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder- 11-17
27			adjusted estimates and their precision (eg, 95% confidence
28			interval). Make clear which confounders were adjusted for and
29			why they were included
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33	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were 13,17
34			categorized
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37	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into n/a
38			absolute risk for a meaningful time period
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41	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and n/a
42			interactions, and sensitivity analyses
43			
44	<b>Discussion</b>		
45			
46	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives 18-19
47			
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49	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of 19-20
50			potential bias or imprecision. Discuss both direction and
51			magnitude of any potential bias.
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54	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, 18-19
55			limitations, multiplicity of analyses, results from similar studies,
56			and other relevant evidence.
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1	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study	19
2			results	
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5	<b>Other</b>			
6	<b>Information</b>			
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9	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the	20
10			present study and, if applicable, for the original study on which	
11			the present article is based	
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