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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 consultation, and department were found to predict the practice towards HAI. Regression analysis revealed that age, antibacterial drug training, and clinical consultation were the predictors of the total KAP on HAI.

Conclusions: The controllable factors identified in this study can be used by hospital managers to implement measures that improves KAP among healthcare workers. Moreover, these measures should be customized to suit the specific medical staff characteristics based on uncontrollable factors to improve KAP. We recommend training programs for medical workers to increase awareness about HAI and foster positive attitudes and practice.

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 heath 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

We carried out a cross-sectional questionnaire survey study in Wuhan from June 1st, 2019 to September 30th, 2019. The study employed the following multi-stage, stratified sampling approach: 1) 2 regions out of the 13 administrative regions of Wuhan were randomly selected for the study, 2) for each of the 2 selected regions, 1 hospital out of all Grade-III level-A hospitals in the region was randomly selected for the study, 3) the human resources departments of the two hospitals randomly sent online questionnaires to medical workers at the respective hospitals, and 4) healthcare workers who received questionnaires voluntarily completed and returned them online. Because some of the information requested through the questionnaires could only be provided by registered doctors and nurses, in this study the term 'healthcare workers' refers to doctors and nurses only and excludes interns, escorts, and medical students. To be included in the study, healthcare workers had to meet the following criteria: 1) they had to be formal doctors and nurses registered at two hospitals, 2) they must have possessed professional qualification certificates, and 3) they voluntarily agreed to participate in the study. Healthcare workers who had been on leave at the time of the survey, as well as non-clinical staff, were excluded from this study.

The sample size for the study was calculated by statistical power analysis. According to Cohen's guidelines,[21] when using multiple linear regression analyses with an estimate of 10 independent variables based on the literature,[22] a minimum of 120 subjects would be needed to achieve a median effect size (0.15) at 80% statistical power and a significance level of 0.05.[23][24] A total of 468 healthcare workers completed the online questionnaire and after excluding incomplete questionnaires, the remaining 455 were used for downstream analyses. The larger samples increased the statistical power of our study.

Measures

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

Pilot study and reliability

To test the trial version of the quick response code for this study, we recruited 30 participants to take part in pilot run of the study from May 1st, 2019 to May 15th, 2019. The responses from the participants of the pilot study were then analyzed for clarity, understandability, and applicability of the questionnaire. The time to complete the questionnaire and any technical difficulties while scanning the quick response code were recorded.

The Cronbach's alpha values were 0.662 (domain A, knowledge), 0.784 (domain B, attitudes), and 0.806 (domain C, practice) in this study.

Data collection procedure

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

Data analysis

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

Patient and public involvement

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

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

Table 1. General characteristics of participants

Variables	n (%)
Age (mean ± SD, year)	31.35 ± 7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (mean ± SD, year)	9.45 ± 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)

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 disease department had a significant positive influence on practice score. While occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training and attending clinical consultation had a significant negative influence. It is clear that independent variables explain 47.05% (adjusted $R^2 = 0.4705$) of the differences found between health workers.

Multiple linear regression analysis also built a significant model ($p < 0.001$), explaining 61% of the variance in KAP total scores (adjusted $R^2 = 0.61$). Female, older age, head of department and employment type of permanent staff had a significant positive influence on KAP total scores. While received HAI education within last year, received invasive operation authority, received antibacterial drug training and attending clinical consultation were negatively correlated with KAP total scores (Table 5).

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

Independent variables	B (95% CI)	SD	β	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
≧ 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 HAI education within last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, department, clinical work experience.

Adjusted R^2 (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	β	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^2 (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	β	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	3.40 (2.02, 4.78)	0.70	0.31	4.85	< 0.001
Master's degree or above	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

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^2 (p-value): 0.4705 ($p < 0.001$).

CI: confidence interval; SD: standard deviations.

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

Independent variables	B (95% CI)	SD	β	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

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 HAI education within last year, occupational exposure within 6 months, received invasive operation authority, received antibacterial drug training, attending consultation

Adjusted R^2(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 with differences in knowledge level. However, in our study, gender and age are the main factors that positively impact knowledge.[31] Interestingly, permanent staff exhibited lower knowledge than contract employees. We hypothesize that the better knowledge exhibited by contract employees is acquired because they face a higher risk of dismissal, which causes them to strengthen their knowledge of HAI in a bid to minimize this risk.

Senior health care workers with greater experience had higher scores on attitude. Additionally, possessing HAI education, authority to perform invasive operations, participating in clinical consultations, working in the surgery department, or the department of infectious diseases promote positive HAI attitudes. Our regression model analysis indicated that the maximum correlation coefficient of factors associated with positive attitude toward HAI are outpatient medicine (vs. internal medicine), followed by having invasive operation authority, receiving HAI education within the previous year, occupational exposure, and attending clinical consultations. It has been previously reported that respondents' attitudes toward prevention-related HAI are significantly high among ICU (intensive care unit) health care workers, who have appropriate knowledge and training.[30] Consistent with our study, a 2014 multi-center study conducted in Shanghai, China revealed independent associations between older age or higher education and categorical knowledge among physicians.[25] The 2014 study also reported that higher work experience is inversely and independently associated with knowledge and attitude of health care workers.[25]

In the practice domain, it has been shown that the level of education has the highest influence on the ability of health care workers to implement infection prevention and control of HAI. Other positive factors include gender, occupational exposure within the previous six months, authority to perform invasive operations, antibacterial drug training and attendance of clinical consultations. Prior studies have largely focused on hand hygiene practices and most have reported poor compliance to hand hygiene recommendation.[15, 32] Multiple studies have shown that factors including perceived severity, subjective norm, and job demands also significantly influence practice.[33] However, to some extent, influencing factors in our study, such as occupational exposure and training, also belong to self-perception.

Biases in self-reported surveys may exist, especially with respect to participant behavior and practices, which may lead to participants overstating their good practices. With this study being cross-sectional, inferences drawn from self-reported practices may vary from direct observation evidence. Moreover, no causal relationship can be found.

CONCLUSION

In this study, we show that uncontrollable factors (such as gender, age, job position, employment type, educational level and clinical work experience), as well as controllable ones (such as HAI education within the previous year, occupational exposure within the previous six months, antibacterial drug training and participation in clinical consultations) are closely associated with KAP. The controllable factors emerging from the study suggest that hospital managers can take appropriate measures for all health care workers to promote the improved KAP. Furthermore, uncontrollable factors indicate that when taking measures to improve KAP, hospital managers should take into consideration the backgrounds of the individual health care workers. In addition, we found that some socio-demographic and job-related factors significantly influenced the knowledge and practice toward HAI in Chinese healthcare worker, whereas the factors significantly influenced the attitude of healthcare workers towards HAI were mainly job-related. This result actually supports our study hypotheses. However, more studies would be needed to establish the benchmark of KPA toward HAI among healthcare workers.

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Data availability statement: Data are available upon reasonable request.

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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**

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)

Variables	**Mean ± SD**	**n**	**p-value**

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)

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

Middle	25.53 ± 2.87	130
Primary	24.66 ± 2.68	302

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)

Variables	Mean ± SD	n	p-value

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	

Table A3. (continued)

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

	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				0.022
	Senior	46.17 ± 4.03	23	
	Middle	43.63 ± 4.78	130	
	Primary	43.15 ± 5.33	302	

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	

Table A4. (continued)

Variables	**Mean ± SD**	**n**	**p-value**

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	
Attending consultation				< 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.

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

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

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8
Bias	#9	Describe any efforts to address potential sources of bias	8
Study size	#10	Explain how the study size was arrived at	7
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	n/a
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	7
Statistical methods	#12e	Describe any sensitivity analyses	n/a
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	7
Participants	#13b	Give reasons for non-participation at each stage	7
Participants	#13c	Consider use of a flow diagram	n/a

Descriptive data	#14a	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
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	n/a
Main results	#16a	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
Main results	#16b	Report category boundaries when continuous variables were categorized	15-19
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	#18	Summarise key results with reference to study objectives	21
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	22
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	20-22
Generalisability	#21	Discuss the generalisability (external validity) of the study results	22
Other Information			
Funding	#22	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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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 (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 ± 3.32, 25.00 ± 2.75, 43.44 ± 5.15 and 84.76 ± 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.

INTRODUCTION

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

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

Effective prevention and control measures should always be taken specifically by HCWs to minimise the risk of HAIs.[17] According to Kelman's theory of knowledge, attitudes and practice (KAP), knowledge is the basis for changing practice, and attitude is the driving force of such change.[18] Therefore, understanding KAP of HCWs in relation to HAIs is essential in establishing these measures. Identifying the factors that significantly affect KAP is also important, as it can provide a basis for implementing intervention measures by HAI managers. Few studies have investigated the KAP in relation to HAIs amongst HCWs. There have few studies to investigate the KAP in relation to HAIs among HCWs.[19-21] However, these studies have some limitations. Firstly, they only described the current KAP status, but the factors influencing KAP remain poorly understood. Secondly, a majority of published KAP reports have only focused on hand hygiene. To the best of our knowledge, no studies have assessed KAP and identified its influencing factors amongst Chinese HCWs towards HAIs in various healthcare settings.

Hence, this study aimed to assess KAP associated with HAIs and identify the factors that significantly influenced KAP amongst HCWs at two university-affiliated hospitals in China. Based on Kelman's theory of KAP,[18] our hypothesis was that the factors significantly affecting the knowledge and attitude of HCWs would be partially coincident with the factors influencing their practice towards HAIs. Specifically, sociodemographic and job-related factors would significantly influence the knowledge and practice of HCWs towards HAIs, whereas the factors significantly affecting the attitude of HCWs towards HAIs would be mainly job related.

METHODS

Study design and participants

A cross-sectional questionnaire survey was conducted in Wuhan from 1 June 2019 to 30 September 2019. A total of 49 tertiary public hospitals are located in Wuhan, with 8.41 hospital beds per 1000 people.[22] The following multistage stratified sampling approach was employed: 1) 2 regions out of the 13 administrative regions of Wuhan were randomly selected for the study; 2) for each of the two selected regions, one hospital out of all grade III level-A hospitals in the region was randomly chosen; 3) with the support of the department of human resources of the two study hospitals, potential participants were randomly selected from the list of job numbers of HCWs and given the online link of questionnaires; and 4) the HCWs who received questionnaires voluntarily completed and returned them online. The term ‘HCWs’ referred to doctors and nurses only and excluded interns, nurse assistants and medical students, because some of the information requested through the questionnaires could only be provided by registered doctors and nurses. To be included in the study, HCWs should meet the following criteria: 1) formal doctors and nurses registered at two hospitals; 2) professional qualification certificates; and 3) voluntary participation in the study. HCWs who were on leave at the time of the survey and nonclinical staff were excluded from this study.

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

Measures

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

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

Pilot study

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

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

Data collection procedure

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

Data analysis

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

Patient and public involvement

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

RESULTS

Descriptive statistics of participant characteristics

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

Univariate Analysis

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

The mean score of knowledge was significantly higher among the following groups of participants: received HAIs education within last year, received antibacterial drug training, worked in the operating room or infectious diseases department and had more than 10 years of work experience (all factors $0.001 < p < 0.05$). There were also significant differences on knowledge score between the following groups: gender, age group, type of employment, received invasive operation authority and participated in clinical consultations with infectious disease doctors ($p < 0.001$) (Table A1).

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

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

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

Table 1. General characteristics of participants

Variables	**n (%)**
Age (Mean ± SD, years)	31.35 ± 7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (mean ± SD, years)	9.45 ± 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)

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 ± SD)	15.67±3.32
Attitude score (Mean ± SD)	25.00±2.75
Practice score (Mean ± SD)	43.44±5.15
KAP (Mean ± SD)	84.76±6.72

SD: standard deviations

Multiple linear regression analysis

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

A significant model was built through multiple linear regression analysis ($p < 0.001$), explaining 14.3% of the variance in attitude score (adjusted $R^2 = 0.143$). The following aspects were positively associated with attitude scores (Table 3): received HAI education within the last year, had occupational exposure within 6 months, received invasive operation authority and attended clinical consultation.

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

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

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

Independent variables	B (95% CI)	SD	β	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
≧ 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^2 (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	β	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^2 (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	β	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

Independent variables included in the regression model included: gender, age group, type of hospital, position, type of employment, received HAIs 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^2 (p-value): 0.4705 ($p < 0.001$).

CI: confidence interval; SD: standard deviations.

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

Independent variables	B (95% CI)	SD	β	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^2(p-value): 0.61 ($p < 0.001$); CI: confidence interval; SD: standard deviation.

DISCUSSION

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

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

Possessing HAI education, having occupational exposure within 6 months, having the authority to perform invasive operations and participating in clinical consultations promote positive HAIs attitudes; however, working in outpatient is not conducive to developing positive HAI attitude. Respondents' attitudes towards prevention-related HAIs are significantly high amongst HCWs who are assigned in intensive care units and have appropriate knowledge and training.[32] In a multicentre study conducted in Shanghai, China, independent associations between older age or higher education and categorical knowledge are observed amongst physicians.[27] A longer working experience is inversely and independently associated with the knowledge and attitude of HCWs.[27] However, age, education level and working experience were not identified as the significant influencing factors of attitude towards HAIs in our study. Whereas receiving HAIs education was the most significant influencing factor of attitude. The inconsistent findings between our study and the study conducted in Shanghai may be due to the difference in the selection of the study hospitals. The study conducted in Shanghai recruited HCWs from the community hospitals, where the HCWs normally have lower education level compared to those from the acute hospitals. In the COVID-19 pandemic, a high proportion of HCWs admitted that they are afraid of working.[34] As such, periodic educational interventions and training programs on infection control practices for COVID-19 must be implemented amongst all HCWs, especially those who face new emerging infectious diseases.[35]

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

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

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

CONCLUSION

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

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Data availability statement: Some or all data, models, or code generated or used during the study are available from the corresponding author (Ying Wang) by request. Reuse of the data is permitted for non-commercial purposes. Contact details: Email: wangying19900621@126.com.

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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)

Variables		Mean ± SD	n	p-value
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)

Variables		Mean ± SD	n	p-value
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)

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

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)

Variables		Mean ± SD	n	p-value
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	

Table A3. (continued)

Variables	Mean ± SD	n	p-value
Clinical work experience (years)			0.012
1-5	42.89 ± 5.57	203	
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			0.022
Senior	46.17 ± 4.03	23	
Middle	43.63 ± 4.78	130	
Primary	43.15 ± 5.33	302	

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	

Table A4. (continued)

Variables	Mean ± SD	n	p-value
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	
Attending consultation			< 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.

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

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

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

		eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	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.	8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	8
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	n/a
Main results	#16a	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	11-17
Main results	#16b	Report category boundaries when continuous variables were categorized	13,17
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	#18	Summarise key results with reference to study objectives	18-19
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	19
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	18-19

Generalisability	#21	Discuss the generalisability (external validity) of the study results	19
Other Information			
Funding	#22	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

Title: Knowledge, attitudes and practice concerning 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 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 ± 3.32, 25.00 ± 2.75, 43.44 ± 5.15, and 84.76 ± 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 (β = 2.36, 95% CI: 1.11 to 4.40), age (β = 6.65, 95% CI: 5.07 to 7.74), position (β = 7.02, 95% CI: 3.88 to 8.45), type of employment (β = −1.08, 95% CI: −2.08 to −0.07), with HAI education within last year (β = −2.98, 95% CI: −4.23 to −1.72), with invasive operation authority (β = −4.22, 95% CI: −5.46 to −2.99), antibacterial drug training (β = −4.38, 95% CI: −5.45 to −3.31) and with antibacterial drug training and clinical consultation (β = −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.

INTRODUCTION

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

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

Effective prevention and control measures should always be observed, specifically by HCWs, to minimize the risks of HAIs.[17] According to Kelman's theory of knowledge, attitudes and practice (KAP), knowledge is the basis for changing practice, and attitude is the driving force of change.[18] Therefore, understanding KAP of HCWs in relation to HAIs is essential in establishing these measures. Identifying the factors that significantly affect KAP is important, and can provide a basis for implementing intervention measures by HAI managers. Few studies have investigated the relationship between KAP and HAIs among HCWs, or investigated the relationship between KAP and HAIs among HCWs.[19-21] However, these studies have some limitations. First, they only described the current KAP status, but the factors influencing KAP remain poorly understood. Second, the majority of published KAP reports have only focused on hand hygiene. To the best of our knowledge, no studies have assessed KAP and identified its influencing factors among Chinese HCWs concerning HAIs in various healthcare settings.

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

METHODS

Study design and participants

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

The sample size for the study was calculated using statistical power analysis. According to Cohen's guidelines,[23] in multiple linear regression analyses with an estimate of 10 independent variables,[24] a minimum of 120 subjects would be required to achieve a median effect size (0.15) at 80% statistical power, and a significance level of 0.05.[25 26] A total of 468 HCWs completed the online questionnaire, and incomplete questionnaires were excluded. The 455 completed questionnaires were used for downstream analyses. The larger samples increased the statistical power of the study.

Measures

The questionnaire was based on standard precaution knowledge questions and the core content of HAI prevention and control systems in China, due to a lack of prior research on the KAP of HAIs among HCWs.[27-30] The questionnaire consisted of two sections: the first section covered general information, and the second one included KAP concerning HAIs. The general information section comprised 16 questions to collect the participants' sociodemographic data, including age, gender, clinical work experience, marital status, educational level, occupation, department, position, professional title, employment, hospital type, HAI education within the last year, occupational exposure within the past 6 months, invasive operation authority, antibacterial drug training, and attended clinical consultation.

The HAI knowledge domain consisted of six questions to assess the participants' knowledge of hand hygiene, HAIs, multidrug resistance, standard precautions, and surgery site infection. The HAI attitude domain included eight questions to assess the participants' attitudes about personal and social motivation, which addressed the aspects of responsibility, attention, necessity, and initiative among HAIs. The HAI practice domain consisted of twelve questions to assess the participants' practice of aseptic operation, standard precautions, and antibiotic use. The responses were scored on a 5-point Likert scale ranging from 1 (consistent with my cognition) to 5 (very inconsistent with my cognition).

Pilot study

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

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

Data collection procedure

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

Data analysis

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

Patient and public involvement

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

RESULTS

Descriptive statistics of participant characteristics

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

Univariate Analysis

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

The mean score of knowledge was significantly higher among the following groups of participants: received HAI education within the previous year, received antibacterial drug training, worked in the operating room or infectious diseases department, and had more than 10 years of work experience (all factors $p < 0.05$). There were significant differences in knowledge scores between the following groups: gender, age group, type of employment, received invasive operation authority, and participated in clinical consultations with infectious disease doctors ($p < 0.001$) (Table A1).

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

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

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

Table 1. General characteristics of participants

Variables		n (%)
Age (Mean ± SD, years)		31.35 ± 7.12
Gender		
	Male	41 (9)
	Female	414 (91)
Clinical work experience (mean ± SD, years)		9.45 ± 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)

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 ± SD)	15.67±3.32
Attitude score (Mean ± SD)	25.00±2.75
Practice score (Mean ± SD)	43.44±5.15
KAP (Mean ± SD)	84.76±6.72

SD: standard deviations

Multiple linear regression analysis

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

A significant model was set up through multiple linear regression analysis ($p < 0.001$), explaining 14.3% of the variance in attitude score (adjusted $R^2 = 0.143$). The following aspects were positively associated with attitude scores (Table 3): received HAI education within the last year, experienced occupational exposure within 6 months, received invasive operation authority, and attended clinical consultation.

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

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

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

Independent variables	B (95% CI)	SD	β	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
≧ 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^2 (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	β	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^2 (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	β	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

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

Adjusted R^2 (p-value): 0.4705 ($p < 0.001$).

CI: confidence interval; SD: standard deviations.

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

Independent variables	B (95% CI)	SD	β	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^2(p-value): 0.61 ($p < 0.001$); CI: confidence interval; SD: standard deviation.

DISCUSSION

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

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

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

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

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

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

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

CONCLUSION

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

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Data availability statement: Some or all data, models, or code generated or used during the study are available from the corresponding author (Ying Wang) by request.

Reuse of the data is permitted for non-commercial purposes. Contact details: Email: wangying19900621@126.com.

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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)

Variables	Mean ± SD	n	p-value
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)

Variables	Mean ± SD	n	p-value
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)

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

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)

Variables	Mean ± SD	n	p-value
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	

Table A3. (continued)

Variables	Mean ± SD	n	p-value
Clinical work experience (years)			0.012
1-5	42.89 ± 5.57	203	
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			0.022
Senior	46.17 ± 4.03	23	
Middle	43.63 ± 4.78	130	
Primary	43.15 ± 5.33	302	

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	

Table A4. (continued)

Variables	Mean ± SD	n	p-value
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 sectionalreporting guidelines, and cite them as:

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

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

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

		eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	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.	8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	8
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	n/a
Main results	#16a	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	11-17
Main results	#16b	Report category boundaries when continuous variables were categorized	13,17
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	#18	Summarise key results with reference to study objectives	18-19
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	19-20
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	18-19

Generalisability	#21	Discuss the generalisability (external validity) of the study results	19
Other Information			
Funding	#22	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

 This checklist was completed on 23. September 2020 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai