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

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ABSTRACT

Objectives To assess the knowledge, attitude and practice (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 (HCWs) of one general hospital and one children's hospital in Wuhan city between 1 June and 30 September 2019.

Primary and secondary outcome measures The outcomes were KAPs concerning HAIs.

Results Data from 455 HCWs 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).

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

Strengths and limitations of this study

- A large sample was used to investigate knowledge, attitude and practice (KAP) concerning healthcare-associated infections and to 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 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 among the most significant public global health issues.[7] The risk of acquiring an HAI in low-income countries is 2–20 times higher than that in high-income 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 use of personal protective equipment (PPE), masks and gloves.[16]

Effective prevention and control measures should always be observed, specifically by HCWs, to minimise the risk of HAIs.[17] According to Kelman's theory of knowledge, attitude 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 described only the current KAP status, but the factors influencing KAP remain poorly understood. Second, the majority of published KAP reports have focused only 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 to 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, sociodemographic 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 1 June 2019 to 30 September 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 2 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's potential participants were randomly selected from the list of job numbers of HCWs and were 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 non-clinical 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 12 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 1 to 15 May 2019 to test the trial version of the quick response code for this study. The pilot participant responses were then analysed 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 and 4=very relevant) and to 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's 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 SD 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 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 V.14.0. Statistical tests were two-sided, and statistical significance was set at a p value of <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 contractual employees, and 70.1% worked in the general hospital. Among the 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 online supplemental tables A1–A4.

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 ($p<0.001$) (online supplemental table A1).

Online supplemental table A2 presents the factors associated with the mean attitude score. The participants who were contractual 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, contractual 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

Table 1 General characteristics of the participants

Variables	n (%)
Age (years), mean±SD	31.35±7.12
Gender	
Male	41 (9)
Female	414 (91)
Clinical work experience (years), mean±SD	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 higher	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)
Type of hospital	
Children's hospital	136 (29.9)
General hospital	319 (70.1)
Received HAI 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

HAI, healthcare-associated infection; KAP, knowledge, attitude and practice.

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) (online supplemental 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, contractual 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) (online supplemental table A4).

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). Being 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).

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 to 15.36)	1.10		11.99	<0.001
Gender					
Female (vs male)	2.36 (1.24 to 3.47)	0.57	0.19	4.15	<0.001
Age group (years)					
40–59 (vs 18–39)	3.04 (1.84 to 4.24)	0.61	0.27	4.98	<0.001
Type of employment					
Permanent staff (vs contractual)	−1.27 (−1.82 to −0.56)	0.32	−0.18	−3.93	<0.001
Clinical work experience (years)					
6–10 (vs 1–5)	−0.17 (−0.93 to 0.59)	0.39	−0.02	−0.44	0.660
11–15 (vs 1–5)	0.65 (−0.47 to 1.77)	0.57	0.05	1.14	0.253
16–20 (vs 1–5)	1.54 (0.40 to 2.68)	0.58	0.13	2.66	0.008
≥21 (vs 1–5)	0.87 (−0.34 to 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, having received healthcare-associated infection education within the previous year, occupational exposure within 6 months, having received invasive operation authority, having received antibacterial drug training, having department and clinical work experience, and having attended consultation of nosocomial infection disease.
Adjusted R^2=0.214 (p value of <0.001).

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,

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 to 27.51)	1.18		21.44	<0.001
Received HAI education within the previous year					
No (vs yes)	−0.97 (−1.64 to −0.29)	0.34	−0.17	−2.82	0.005
Occupational exposure within 6 months					
Yes (vs no)	0.90 (0.15 to 1.66)	0.38	0.16	2.36	0.019
Received invasive operation authority					
No (vs yes)	−1.04 (−2.05 to −0.65)	0.33	−0.17	−3.12	0.002
Attended consultation of nosocomial infection disease					
No (vs yes)	−0.73 (−1.27 to −0.19)	0.28	−0.13	−2.65	0.008
Department					
Surgery (vs internal medicine)	0.20 (−1.21 to 1.62)	0.72	0.03	0.28	0.778
Obstetrics (vs internal medicine)	−0.87 (−2.57 to 0.84)	0.87	−0.06	−1.00	0.319
Intensive care unit (vs internal medicine)	0.47 (−0.96 to 1.91)	0.73	0.07	0.65	0.517
Emergency (vs internal medicine)	−0.99 (−2.67 to 0.68)	0.85	−0.08	−1.16	0.245
Outpatient (vs internal medicine)	−2.11 (−4.13 to −0.09)	1.03	−0.12	−2.05	0.041
Operating room (vs Iiternal medicine)	0.38 (−1.02 to 1.78)	0.71	0.06	0.54	0.591
Infectious diseases (vs internal medicine)	0.46 (−1.02 to 1.94)	0.75	0.06	0.61	0.543
Other (vs internal medicine)	−0.94 (−2.64 to 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, having received healthcare-associated infection education within the previous year, occupational exposure within 6 months, having received invasive operation authority, having attended consultation of nosocomial infection disease and work department. Adjusted R^2=0.1434 (p value of <0.001).
HAI, healthcare-associated infection.

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 to 44.10)	1.73		23.58	<0.001
Gender					
Female (vs male)	1.55 (0.19 to 2.90)	0.69	0.09	2.24	0.025
Occupational exposure within 6 months					
No (vs yes)	−1.49 (−2.60 to −0.38)	0.56	−0.14	−2.64	0.009
Received invasive operation authority					
No (vs yes)	−1.70 (−2.67 to −0.74)	0.49	−0.15	−3.47	0.001
Received antibacterial drug training					
No (vs yes)	−3.01 (−3.85 to −2.17)	0.43	−0.29	−7.06	<0.001
Educational level					
Bachelor's degree (vs college degree)	3.40 (2.02 to 4.78)	0.70	0.31	4.85	<0.001
Master's degree or above (vs college degree)	3.74 (2.15 to 5.33)	0.81	0.31	4.62	<0.001
Attended consultation of nosocomial infection disease					
No (vs yes)	−2.60 (−3.40 to −1.80)	0.41	−0.25	−6.40	<0.001
Department					
Surgery (vs internal medicine)	2.78 (0.70 to 4.86)	1.06	0.21	2.62	0.009
Obstetrics (vs internal medicine)	−1.06 (−3.59 to 1.47)	1.29	−0.04	−0.82	0.412
Intensive care unit (vs internal medicine)	1.70 (−0.41 to 3.82)	1.08	0.13	1.58	0.114
Emergency (vs internal medicine)	0.91 (−1.56 to 3.38)	1.26	0.04	0.73	0.468
Outpatient (vs internal medicine)	2.18 (−0.78 to 5.14)	1.51	0.07	1.45	0.148
Operating room (vs internal medicine)	2.76 (0.71 to 4.81)	1.04	0.24	2.65	0.008
Infectious diseases (vs internal medicine)	2.70 (0.52 to 4.87)	1.11	0.19	2.43	0.015
Other (vs internal medicine)	0.08 (−2.44 to 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, having received healthcare-associated infection education within the previous year, occupational exposure within 6 months, having received invasive operation authority, having received antibacterial drug training, educational level, having attended consultation of nosocomial infection disease, department, clinical work experience and professional title.
Adjusted R^2=0.4705 (p value of <0.001).

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). Being 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).

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 programmes to promote the KAP of HCWs and to establish the basis for conducting future studies.

Table 5 Multiple linear regression analysis of the influencing factors for knowledge, attitude and practice total scores

Independent variables	B (95% CI)	SD	β	T	P value
Intercept	87.06 (85.12 to 88.99)	0.99		88.31	<0.001
Gender					
Female (vs male)	2.36 (1.11 to 4.40)	0.84	0.09	3.29	0.008
Age group (years)					
40–59 (vs 18–39)	6.65 (5.07 to 7.74)	0.68	0.30	9.44	<0.001
Position					
Head (vs Staff)	7.02 (3.88 to 8.45)	1.16	0.18	5.30	<0.001
Type of employment					
Permanent staff (vs contractual)	−1.08 (−2.08 to −0.07)	0.51	−0.07	−2.11	0.035
Received HAI education within the previous year					
No (vs yes)	−2.98 (−4.23 to −1.72)	0.64	−0.20	−4.65	<0.001
Received invasive operation authority					
No (vs yes)	−4.22 (−5.46 to −2.99)	0.63	−0.26	−6.71	<0.001
Received antibacterial drug training					
No (vs yes)	−4.38 (−5.45 to −3.31)	0.55	−0.29	−8.03	<0.001
Attended consultation of nosocomial infection disease					
No (vs yes)	−4.35 (−5.38 to −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, having received HAI education within the previous year, occupational exposure within 6 months, having received invasive operation authority, having received antibacterial drug training and having attended consultation of nosocomial infection disease.
Adjusted R^2=0.61 (p value of <0.001).
HAI, healthcare-associated infection.

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 (eg, age and gender), continuous education on HAIs remains essential to improve knowledge of HAIs. Previous studies similarly demonstrated that participants who underwent 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 underwent 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 outpatient 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 multicentre 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 with 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 programmes 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 100 000 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' 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 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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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	