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Knowledge, Attitude, and Practice Regarding Adverse Transfusion Reactions Among Nurses, Physicians, and Transfusion Specialists in China: A Multicenter Cross-Sectional Survey

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Introduction: Adverse transfusion reactions (ATRs) can threaten patient safety. Healthcare professionals (HPs) play crucial roles in the prevention and management of ATRs. Although ATRs occur in 0.2–0.6% of transfusions in China, no study has examined the knowledge, attitude, and practice (KAP) toward them. Therefore, the aim of this study was to investigate the KAP of HPs toward ATRs.

Methods: This multicenter cross-sectional study was conducted between October and December 2023 and included HPs from 146 medical institutions enrolled through WeChat professional groups using convenience sampling. An investigator-developed web-based questionnaire (Cronbach's α=0.82) was used to collect participants' demographic characteristics and their KAP towards ATRs. Bloom's cutoffs were used to categorize KAP dimension scores. Multivariable logistic regression analysis was performed, including the factors statistically significant in the univariable analyses.

Results: The study included 327 (40.93%) nurses, 253 (31.66%) physicians, and 219 (27.41%) transfusion specialists. Among the participants, 598 (74.84%) were females, 238 (29.79%) held a master's degree or higher, 389 (48.69%) possessed over 10 years of work experience. The knowledge and attitude scores were 11.78±1.78 (possible range: 0–14) and 50.43±4.74 (possible range: 11–55). The practice scores (possible range: 0–50) were evaluated for nurses, physicians, and transfusion specialists respectively, and the mean scores were 49.22±2.79, 47.60±5.09, and 44.35±14.13. Multivariate analysis showed that having a master's degree or above (OR=1.480, 95% CI: 1.079–2.027, P=0.015) was independently associated with knowledge. The knowledge (OR=1.280, 95% CI: 1.159–1.423, P=0.001), department (OR=1.731–1.763, 95% CI: 1.120–2.696, P<0.050), and the understanding of ATRs (OR=1.122, 95% CI: 1.035–1.218, P=0.006) were independently associated with attitude.

Conclusion: The surveyed Chinese healthcare professionals HPs displayed good KAP regarding ATRs. However, specific knowledge gaps were identified, particularly concerning bacterial contamination risks and delayed reactions. While attitudes and self-reported practices were largely positive, targeted educational interventions are recommended to address these identified knowledge deficits and reinforce best practices.

Keywords: knowledge, attitude, practice, healthcare professionals, China, transfusion reaction, cross-sectional study

Introduction

Blood transfusions are relatively common in hospitals worldwide and in China and can be performed to correct blood loss, manage non-hemorrhagic anemia (eg, in patients under chemotherapy), or correct specific medical conditions.[1] It is a crucial medical intervention in modern medicine that plays an irreplaceable role.[2–4] Although modern transfusions conducted under the strict guidance of blood banks are considered safe, adverse reactions during a transfusion can

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occur.[1,5,6] Most reactions can pose immediate or short-term health threats to the patients and can even be fatal, while others can increase the risk of infection or immune reactions in the long term and can also be fatal.[7–11] China has rapidly expanded and formalized its hemovigilance system in recent years, with the Chinese Hemovigilance Network established to systematically monitor transfusion safety and support a national policy on appropriate blood use and adverse reaction reporting.[12,13] In China, the overall adverse transfusion reaction (ATR) incidence is 0.2%-0.6%.[12–14] Therefore, ensuring transfusion safety and preventing and promptly addressing ATRs are pivotal aspects of enhancing patient treatment outcomes and quality of life.[6,15] Given these risks, the competence of healthcare professionals directly influences transfusion outcomes.

Healthcare professionals are the ones who perform transfusions and, therefore, play crucial roles in the prevention and management of ATRs. Their application of specialized knowledge and skills is required in the pre-transfusion assessment, monitoring during transfusion, and post-transfusion observation to identify and manage potential adverse reactions.[16] Timely intervention and accurate handling by healthcare professionals are key to avoiding or mitigating adverse reactions. In addition, healthcare professionals are responsible for educating patients and their families about transfusion-related knowledge and enhancing their awareness of transfusion risks, which is an integral component of improving transfusion safety.[17]

Given the role of healthcare professionals in the management of blood transfusion reactions, it is imperative to understand their awareness and competency in managing ATRs. Knowledge, attitude, and practice (KAP) studies provide quantitative and qualitative data about the gaps, misconceptions, and misunderstandings about a specific subject in a specific population.[18,19] KAP studies evaluate what is known (knowledge), what is believed (attitudes), and what is done (practice). KAP studies are often used to design educational activities about a specific subject. Studies in India showed good knowledge and attitudes of physicians toward ATRs but poor practice regarding their reporting,[20,21] while another study showed that practice was further complicated by COVID-19.[22] A study showed poor KAP toward blood transfusion in nurses in tertiary hospitals in India.[23] Although a meta-analysis reported a relatively elevated rate of unnecessary transfusions in China,[24] suggesting that improvements are needed in the KAP toward the indications for blood transfusion, no KAP data on ATRs are available.

Recognizing the pivotal role of healthcare professionals in transfusion safety, the aim of this study was to investigate Chinese healthcare professionals' KAP toward ATRs.

Materials and Methods

Study Design and Participants

This nationwide cross-sectional study was conducted among healthcare professionals from 146 medical institutions across 27 provinces in China between October and December 2023. The inclusion criteria were 1) age between 18 and 80 years and 2) physicians, nurses, and transfusion specialists engaged in clinical work or medical and nursing interns. The exclusion criteria were 1) duplicate questionnaires or 2) incomplete questionnaires. The study was approved by the Medical Ethics Committee of Liaoning Cancer Hospital (KY20231023). Written informed consent was obtained from the study participants before they completed the survey.

Questionnaire

The questionnaire was designed by the investigators based on the relevant literature and guidelines.[5,15,24,25] The Chinese guidelines are similar to international ones.[24] After designing the questionnaire, feedback from two experts (one specialist in transfusion therapy and one in surgery) was sought and incorporated. The expert review was mainly for the content validity. The modifications were mainly made to reduce the questions on similar topics and to check the questions and answers to make sure they were related to the topic and accurate. A small-scale pilot study was conducted with 67 participants, resulting in a Cronbach's α of 0.82, indicating acceptable internal consistency.

The final questionnaire was in Chinese and encompassed information collection across four dimensions: 14 questions on basic information, 14 on knowledge, 11 on attitude, and 30 on practice (ie, 10 for nurses, 10 for physicians, and 10 for transfusion specialists). In the knowledge dimension, a correct answer received 1 point, while an unclear or incorrect

answer received 0 points. In the attitude and practice dimensions, options were scored from high (5 points) to low (1 point) on a positive-to-negative scale. Supplementary Table S1 presents the classical roles of the healthcare professionals in the transfusion process in China. In summary, physicians evaluate transfusion indications, obtain informed consent, order and assess blood products, oversee the process clinically, and manage or report any transfusion reactions. Nurses execute the transfusion procedure safely, monitor and record the patient's condition throughout, promptly manage and report adverse reactions, and ensure post-transfusion follow-up and documentation. Transfusion service physicians perform and verify compatibility testing, authorize blood product release, investigate transfusion reactions, and monitor compliance with transfusion standards and documentation. The total score range was 0–14 for knowledge, 11–55 for attitude, and 10–50 for practice. The scores were evaluated based on Bloom's cutoffs: scores <60% were considered poor, 60–79% were considered moderate, and ≥80% were considered good.[26]

Questionnaire Distribution and Quality Control

The participants were enrolled through convenience sampling. Distribution of the questionnaires was carried out via official WeChat professional groups or DingTalk professional work groups of the Liaoning Province Society of Blood Transfusion, Society of Clinical Transfusion, Chinese Medical Association, and Blood Alert Network, Chinese Academy of Medical Sciences. The online questionnaire distribution was facilitated through the use of Sojump (https://www.wjx.cn). Participants had the option to either scan the provided QR code using WeChat or follow a provided link to access and complete the questionnaire. The first page was the informed consent form; its signature was mandatory for accessing the questionnaire. All items were mandatory. The research team, composed of three physicians trained as research assistants responsible for questionnaire promotion and distribution, conducted thorough reviews of all submissions. Incomplete questionnaires, those answers using all the same option (eg, all first options), those answered within 45 seconds, and those answered in more than 480 seconds were considered invalid. A given IP address could be used to submit only one questionnaire.

Sample Size Calculation

The sample size was calculated using the formula for cross-sectional studies: $\alpha=0.05$, $n=\left(Z_{1-\alpha/2}/\delta\right)^2\times P\times(1-P)$ where $Z_{1-\alpha/2}=1.96$ when $\alpha=0.05$, the assumed degree of variability of $P=0.5$ maximizes the required sample size, and δ is an admissible error (which was 5% here). The theoretical sample size was 480, which included an extra 20% to allow for subjects to be lost during the study.

Statistical Analysis

All analyses were performed using R4.3.0. Continuous variables conforming to a normal distribution (according to the Kolmogorov–Smirnov test) were presented as means ± standard deviations (SD) and maximum and minimum values and analyzed using Student's *t*-test (two categories) or ANOVA (more than two categories). Continuous variables not conforming to a normal distribution were presented as medians (interquartile ranges) and maximum and minimum values, and analyzed using the Mann–Whitney *U*-test (two categories) or the Kruskal–Wallis H-test (more than two categories). Categorical data were expressed as n (%) and analyzed using the chi-squared test. The correlations between KAP dimensions were determined using Spearman correlation analysis. Multivariate logistic regression analysis was used to determine the factors independently associated with knowledge and attitude. Univariate variables with $P<0.05$ were enrolled in the multivariate analysis. The professional titles and years of experience were considered in the analyses in a stratified manner. In the regression analyses, knowledge and attitude were dichotomized based on a cutoff of 70% of the score distribution. Multicollinearity was tested using the variance inflation factor (VIF). VIF=1: There is no correlation between the predictor variable and any of the other independent variables in the model. VIF 1–5: There is moderate correlation among the predictors. This is generally considered acceptable in most contexts. VIF >5: There is a high degree of correlation that may be problematic, leading to unreliable and unstable coefficient estimates. VIF ≥10: This indicates severe multicollinearity, which almost always requires corrective action. Two-sided P-values <0.05 were considered statistically significant.

Results

Characteristics of the Overall Participants

A total of 799 healthcare professionals participated in the study, consisting of 598 (74.84%) females and 201 (25.16%) males, with a mean age of 35.58 ± 8.27 years. The participants included 327 (40.93%) nurses, 253 (31.66%) physicians, and 219 (27.41%) transfusion specialists. Among all participants, 29.79% held a master's degree or higher, 44.56% had an intermediate professional title, and 48.69% possessed over 10 years of work experience. Most participants (87.48%) performed blood transfusions in their clinical work, and 72.34% had previously encountered ATRs. The knowledge and attitude scores were 11.78 ± 1.78 (possible range: 0–14) and 50.43±4.74 (possible range: 11–55), respectively (Table 1). The practice scores (possible range: 0–50) were evaluated for nurses, physicians, and transfusion specialists respectively. The primary sources of knowledge regarding ATRs were books (91.49%), followed by lectures (73.47%), classroom training (68.71%), and online resources (65.21%) (Supplementary Table S2).

Table 1 Characteristics and Knowledge, Attitude of the Participants

	n (%)	Knowledge		Attitude	
		Score	P	Score	P
Total	799 (100)	11.78±1.78		50.43±4.74	
Gender			0.282		0.021
Male	201 (25.16)	11.51±2.19		49.57±5.38	
Female	598 (74.84)	11.87±1.61		50.72±4.47	
Age	35.58±8.27				
Education			0.005		0.010
Bachelor's degree and below	561 (70.21)	11.69±1.80		50.66±4.60	
Master's degree and above	238 (29.79)	12.01±1.72		49.87±5.00	
Monthly average family income (RMB)			0.598		0.868
<5000	185 (23.15)	11.56±2.12		50.27±5.08	
5000–10,000	413 (51.69)	11.88±1.50		50.49±4.74	
10,000–20,000	173 (21.65)	11.83±1.95		50.49±4.37	
≥20,000	28 (3.50)	11.54±2.05		50.21±4.65	
Marital status			0.999		0.737
Other	232 (29.04)	11.61±2.23		49.85±5.80	
Married	567 (70.96)	11.85±1.56		50.66±4.21	
Department			0.370		0.016
Transfusion Department	219 (27.41)	11.75±1.79		50.07±4.47	
Internal Medicine	200 (25.03)	11.97±1.63		50.83±4.59	
Surgery	179 (22.40)	11.84±1.49		50.49±4.85	
Other Departments	201 (25.16)	11.58±2.12		50.36±5.05	
Professional title			0.005		<0.001
Medical student	67 (8.39)	10.64±2.85		47.40±6.68	
Junior	180 (22.53)	11.69±1.91		50.50±4.98	
Intermediate	356 (44.56)	11.96±1.49		51.12±4.19	
Senior	196 (24.53)	11.93±1.53		50.13±4.23	
Years of work			0.630		0.806
1–3 years	161 (20.15)	11.67±2.12		49.49±6.23	
4–6 years	108 (13.52)	11.60±2.39		50.38±4.47	
7–10 years	141 (17.65)	11.89±1.79		50.69±4.33	
>10 years	389 (48.69)	11.84±1.39		50.73±4.17	
Hospital level			0.207		<0.001
Provincial and ministerial level	497 (62.20)	11.92±1.56		50.72±4.78	
Municipal level	161 (20.15)	11.53±2.21		49.64±4.86	
County-level and below	141 (17.65)	11.60±1.93		50.28±4.35	

(*Continued*)

Table 1 (Continued).

	n (%)	Knowledge		Attitude	
		Score	P	Score	P
Blood transfusion operations at work			0.022		0.299
Yes	699 (87.48)	11.89±1.56		50.55±4.56	
No	100 (12.52)	11.05±2.80		49.60±5.79	
Adverse transfusion reactions encountered in work			0.016		0.444
Yes	578 (72.34)	11.94±1.48		50.50±4.34	
No	221 (27.66)	11.37±2.35		50.24±5.65	
Understanding of adverse transfusion reactions	7.49±2.04				
Position			0.991		<0.001
Nurse	327 (40.93)	11.89±1.41		51.39±4.21	
Transfusion specialist physicians	219 (27.41)	11.75±1.79		50.07±4.47	
Non-transfusion specialist physicians	253 (31.66)	11.67±2.17		49.49±5.35	

Notes: The possible ranges for knowledge and attitude scores were 0–14, and 11–55, respectively. Continuous variables are expressed as means ± standard deviations. Categorical variables are expressed as n (%).

Several knowledge items had notably low correct response rates, aligning with the knowledge gaps identified in the discussion section. The question with the lowest correct rate was K3: "Due to stringent storage and testing regulations for clinical blood use, patients are unlikely to experience ATRs due to bacterial contamination," with only 33.42% answering correctly. Other items with low to moderate correct rates included K10, concerning delayed hemolytic reactions, with a 34.42% correct rate; K12, regarding the classification of transfusion-transmitted diseases as ATRs, with a 39.30% correct rate; and K13, on the management of mild allergic reactions, with a 71.96% correct rate (Table 2). The attitude

Table 2 Knowledge Dimension

	Correct	Uncertain	Incorrect
K1. The primary purposes of blood transfusion therapy currently include replenishing blood volume, correcting anemia, and supplementing coagulation factors and platelets.	749 (93.74)	5 (0.63)	45 (5.63)
K2. Strict adherence to the "three checks and eight matches" verification standards during blood collection and before transfusion can prevent adverse transfusion reactions.	648 (81.10)	4 (0.50)	147 (18.40)
K3. Due to stringent storage and testing regulations for clinical blood use, patients are unlikely to experience adverse transfusion reactions due to bacterial contamination.	267 (33.42)	12 (1.50)	520 (65.08)
K4. Blood transfusion should follow the principle of starting slow and increasing speed later; different types of blood products should be infused at the specified rate and within the required time.	753 (94.24)	10 (1.25)	36 (4.51)
K5. Medications can be added to blood products during transfusion.	30 (3.75)	16 (2.00)	753 (94.24)
K6. After the completion of the transfusion, there is still a need to monitor the patient for adverse transfusion reactions.	28 (3.50)	3 (0.38)	768 (96.12)
K7. The most common adverse transfusion reaction is the non-hemolytic febrile reaction (FNHTR).	715 (89.49)	18 (2.25)	66 (8.26)
K8. Non-hemolytic febrile reaction (FNHTR) is primarily associated with the production of anti-leukocyte or platelet antibodies and the release of cytokines in the body.	719 (89.99)	45 (5.63)	35 (4.38)
K9. Hemolytic transfusion reaction is a severe adverse reaction to the transfusion.	759 (94.99)	13 (1.63)	27 (3.38)
K10. Delayed hemolytic reaction (DHTR) often occurs 24 hours to 28 days after transfusion and does not lead to renal failure or disseminated intravascular coagulation (DIC).	275 (34.42)	65 (8.14)	459 (57.45)
K11. Adverse reactions to large, rapid blood transfusions mainly include circulatory overload, citrate toxicity, hyperkalemia, and coagulation abnormalities.	763 (95.49)	13 (1.63)	23 (2.88)
K12. The transmission of diseases such as AIDS, syphilis, hepatitis, and malaria through blood transfusion does not fall under adverse transfusion reactions.	314 (39.30)	28 (3.50)	457 (57.20)
K13. When mild allergic reactions occur during the infusion of blood products, slowing down the transfusion rate and administering antiallergic medications for observation is an appropriate measure.	575 (71.96)	16 (2.00)	208 (26.03)

(*Continued*)

Table 2 (Continued).

	Correct	Uncertain	Incorrect
K14. In the event of a severe transfusion reaction in a patient, transfusion should be immediately halted, necessary treatment measures should be taken, and the transfusion department should be contacted to complete and submit an adverse transfusion reaction report.	778 (97.37)	9 (1.13)	12 (1.50)

item with the lowest score was A2, with only 48.44% of participants agreeing or strongly agreeing with the statement: "I believe that I can prevent patients from experiencing ATRs" (Table 3).

Knowledge, Attitude, and Practice (KAP) in Nurses

Of the 327 nurses, the vast majority were female (95.41%), with a mean age of 33.54 ± 7.12 years. Most held a bachelor's degree or below (96.64%), possessed an intermediate professional title (58.10%), and 48.62% had over 10 years of work experience. The nurses mean knowledge score was 11.89 ± 1.41, the mean attitude score was 51.39 ± 4.21, and the mean practice score was 49.22 ± 2.79 (Supplementary Table S3). The practice item with the lowest score among nurses was Pn3: "Before transfusion, I will provide education to patients or their families on transfusion speed, precautions for transfusion reaction symptoms, etc," although it still received a high positive response rate of 99.08% (Supplementary Table S4).

Table 3 Attitude Dimension

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A1. I believe that adverse transfusion reactions have a significant impact on the safety and health of patients.	623 (77.97)	115 (14.39)	46 (5.76)	9 (1.13)	6 (0.75)
A2. I believe that I can prevent patients from experiencing adverse transfusion reactions.	227 (28.41)	160 (20.03)	229 (28.66)	68 (8.51)	115 (14.39)
A3. I believe that pre-transfusion screening and testing can effectively reduce the occurrence of adverse transfusion reactions.	633 (79.22)	116 (14.52)	42 (5.26)	5 (0.63)	3 (0.38)
A4. I believe that healthcare professionals should receive training and education on the knowledge and management of adverse transfusion reactions.	662 (82.85)	96 (12.02)	37 (4.63)	4 (0.50)	0
A5. I believe that adverse transfusion reactions are important symptoms that doctors should also pay attention to.	688 (86.11)	81 (10.14)	25 (3.13)	3 (0.38)	2 (0.25)
A6. I believe that continuous learning and professional development are crucial for improving the prevention and management capabilities of adverse transfusion reactions.	690 (86.36)	80 (10.01)	27 (3.38)	1 (0.13)	1 (0.13)
A7. I believe that monitoring and reporting adverse transfusion reactions are not very important.	112 (14.02)	28 (3.50)	35 (4.38)	71 (8.89)	553 (69.21)
A8. I believe that healthcare professionals should promptly explain the reasons and management methods of adverse transfusion reactions to patients and their families.	634 (79.35)	116 (14.52)	40 (5.01)	5 (0.63)	4 (0.50)
A9. I believe that hospitals should strengthen communication and collaboration toward adverse transfusion reactions.	662 (82.85)	109 (13.64)	25 (3.13)	2 (0.25)	1 (0.13)
A10. I am willing to participate in the improvement and optimization of monitoring adverse transfusion reactions in the hospital.	658 (82.35)	108 (13.52)	30 (3.75)	1 (0.13)	2 (0.25)
A11. I am willing to participate in professional training related to transfusion therapy and procedures.	664 (83.10)	106 (13.27)	26 (3.25)	2 (0.25)	1 (0.13)

Correlation analysis revealed that nurses' knowledge scores were positively correlated with their attitude (r=0.192, P=0.001) and practice (r=0.120, P=0.030) scores. Furthermore, a strong positive correlation was observed between their attitude and practice scores (r=0.427, P<0.001) (Table 4).

Knowledge, Attitude, and Practice (KAP) in Physicians

Th 253 non-transfusion specialist physicians included a slight majority of females (52.96%) and had a mean age of 35.45 ± 8.63 years. Two-thirds of the physicians held a master's degree or higher (66.80%), 38.34% had a senior professional title, and 40.32% had worked for more than 10 years. For the 253 physicians, the knowledge score was 11.67 ± 2.17, the attitude score was 49.49 ± 5.35, and the practice score was 47.60 ± 5.09 (Supplementary Table S5). The practice item with the lowest score in this group was Pnts2: "I provide clear information to patients or their families before transfusion, explaining the purpose, method, risks, and alternative treatment options," with a 93.67% proactive response rate (Supplementary Table S6).

Correlation analysis showed that physicians' knowledge scores were positively correlated with both attitude (r=0.269, P<0.001) and practice (r=0.258, P<0.001). A very strong positive correlation was found between their attitude and practice scores (r=0.594, P<0.001) (Table 4).

Knowledge, Attitude, and Practice (KAP) in Transfusion Specialists

The cohort of 219 transfusion specialists was predominantly female (69.41%), with a mean age of 38.78 ± 8.47 years. The majority held a bachelor's degree or below (73.52%). The most common professional titles were intermediate (43.84%) and senior (35.16%), and over half of the participants (58.45%) had more than 10 years of work experience. For the transfusion specialists, the mean knowledge score was 11.75 ± 1.79, the mean attitude score was 50.07 ± 4.47, and the mean practice score was 44.35 ± 14.13 (Supplementary Table S7). The practice item with the lowest score was Pts7: "I will conduct post-transfusion efficacy assessments for patients, analyzing vital sign changes and other post-transfusion observations," with a 92.00% proactive response rate (Supplementary Table S8).

Correlation analysis indicated a positive correlation between knowledge and attitude scores (r=0.214, P=0.002) and between attitude and practice scores (r=0.300, P<0.001). However, no significant correlation was found between knowledge and practice scores (P=0.266) in this group (Table 4).

Multivariable Regression Analysis

Multivariate logistic regression analysis was performed to identify factors independently associated with knowledge and attitude scores across all participants. All VIFs were <2, suggesting minimal collinearity not impeding the analyses.

Table 4 Correlation Analysis

Non-transfusion Department Physicians	**Knowledge**	**Attitude**	**Practice**
Knowledge	1.000		
Attitude	0.269 (P <0.001)	1.000	
Practice	0.258 (P <0.001)	0.594 (P <0.001)	1.000
Nurses	**Knowledge**	**Attitude**	**Practice**
Knowledge	1.000		
Attitude	0.192 (P =0.001)	1.000	
Practice	0.120 (P =0.030)	0.427 (P <0.001)	1.000
Transfusion department physicians	**Knowledge**	**Attitude**	**Practice**
Knowledge	1.000		
Attitude	0.214 (P =0.002)	1.000	
Practice	0.075 (P = 0.266)	0.300 (P <0.001)	1.000

Note: Analysis using Spearman correlation coefficient.

A goodness-of-fit analysis was performed for the regression analysis. For knowledge, the model chi-squared value was 24.054 (P=0.031), while the Hosmer-Lemeshow chi-squared value was 8.788 (P=0.361). For attitude, the model chi-squared was 34.810 (P=0.004), while the Hosmer-Lemeshow chi-squared value was 14.053 (P=0.080). The analysis revealed that holding a master's degree or higher (OR=1.480, 95% CI: 1.079–2.027, P=0.015) was independently associated with a higher knowledge score (Table 5). Factors independently associated with a more positive attitude score included higher knowledge scores (OR=1.280, 95% CI: 1.159–1.423, P<0.001), working in the surgery department (OR=1.731, 95% CI: 1.120–2.685, P=0.014) or other departments (OR=1.763, 95% CI: 1.157–2.696, P=0.009) compared to the transfusion department, and a greater self-perceived understanding of ATRs (OR=1.122, 95% CI: 1.035–1.218, P=0.006) (Table 6).

Table 5 Multivariable Analysis of Knowledge

	Univariable			Multivariable		
	OR	**95% CI**	**P**	**OR**	**95% CI**	**P**
Gender						
Male	Ref.					
Female	1.181	0.846–1.660	0.334			
Age	0.990	0.972–1.007	0.244			
Education						
Bachelor's degree and below	Ref.			Ref.		
Master's degree and above	1.538	1.126–2.099	0.007	1.480	1.079–2.027	0.015
Average family income						
<5000	Ref.					
5000–10,000	1.188	0.825–1.722	0.358			
10,000–20,000	1.317	0.854–2.036	0.214			
≥20,000	1.562	0.683–3.497	0.280			
Marital status						
Other	Ref.					
Married	0.922	0.673–1.268	0.617			
Department						
Transfusion Department	Ref.					
Internal Medicine	0.958	0.643–1.427	0.834			
Surgery	0.925	0.612–1.395	0.712			
Other Departments	0.972	0.652–1.446	0.887			
Professional title						
Medical student	Ref.					
Junior	1.430	0.778–2.714	0.259			
Intermediate	1.643	0.934–3.005	0.094			
Senior						
Years of work						
1–3 years	Ref.					
4–6 years	0.835	0.503–1.378	0.482			
7–10 years	0.863	0.541–1.373	0.534			
>10 years	0.767	0.526–1.122	0.170			
Hospital level						
Provincial and ministerial level	Ref.			Ref.		
Municipal level	0.910	0.627–1.312	0.616	0.945	0.649–1.366	0.764
County-level and below	0.662	0.438–0.988	0.047	0.713	0.469–1.069	0.106
Blood transfusion operations at work						
Yes	Ref.					
No	0.809	0.512–1.256	0.354			

(*Continued*)

Table 5 (Continued).

	Univariable			Multivariable		
	OR	**95% CI**	**P**	**OR**	**95% CI**	**P**
Adverse transfusion reactions encountered in work						
Yes	Ref.					
No	0.827	0.594–1.143	0.254			
Understanding of adverse transfusion reactions	1.006	0.937–1.081	0.866			
Position						
Nurse	Ref.					
Transfusion specialist physicians	1.097	0.767–1.565	0.612			
Non-transfusion specialist physicians	1.105	0.784–1.554	0.568			

Table 6 Multivariate Analysis of Attitude

	Univariate			Multivariate		
	OR	**95% CI**	**P**	**OR**	**95% CI**	**P**
Knowledge	1.277	1.162–1.412	<0.001	1.280	1.159–1.423	<0.001
Gender						
Male	Ref.					
Female	1.378	0.993–1.924	0.057			
Age	0.987	0.970–1.004	0.148			
Education						
Bachelor's degree and below	Ref.					
Master's degree and above	0.782	0.571–1.065	0.121			
Average family income						
<5000	Ref.					
5000–10,000	1.047	0.737–1.492	0.800			
10,000–20,000	1.149	0.755–1.750	0.516			
≥20,000	0.695	0.286–1.580	0.399			
Marital status						
Other	Ref.					
Married	0.849	0.623–1.156	0.297			
Department						
Transfusion Department	Ref.			Ref.		
Internal Medicine	1.783	1.196–2.667	0.005	1.398	0.908–2.155	0.128
Surgery	2.051	1.363–3.102	0.001	1.731	1.120–2.685	0.014
Other Departments	1.915	1.287–2.863	0.001	1.763	1.157–2.696	0.009
Professional title						
Medical student	Ref.			Ref.		
Junior	2.211	1.221–4.129	0.010	1.693	0.899–3.266	0.108
Intermediate	2.182	1.252–3.942	0.007	1.513	0.820–2.863	0.192
Senior	1.225	0.674–2.292	0.514	0.897	0.465–1.766	0.749
Years of work						
1–3 years	Ref.					
4–6 years	0.850	0.517–1.391	0.518			
7–10 years	0.970	0.615–1.529	0.896			
>10 years	0.810	0.559–1.176	0.266			

(*Continued*)

Table 6 (Continued).

	Univariate			Multivariate		
	OR	**95% CI**	**P**	**OR**	**95% CI**	**P**
Hospital level						
Provincial and ministerial level	Ref.					
Municipal level	0.556	0.381–0.804	0.002			
County-level and below	0.549	0.368–0.809	0.003			
Blood transfusion operations at work						
Yes	Ref.					
No	0.974	0.633–1.487	0.905			
Adverse transfusion reactions encountered in work						
Yes	Ref.					
No	1.113	0.813–1.522	0.503			
Understanding of adverse transfusion reactions	1.162	1.082–1.252	<0.001	1.122	1.035–1.218	0.006

Discussion

The results suggest that Chinese nurses, physicians, and transfusion specialists have sufficient knowledge, active attitudes, and practice toward ATRs. Some specific areas of knowledge remain to be improved through educational activities. The results may help identify gaps in KAP and design educational activities to correct them. Improving the KAP of healthcare professionals should translate into improved patient safety when receiving blood transfusions. This study identified key knowledge and attitude items that would warrant education and training to improve the practice of blood transfusion. The training curricula in medical faculties in the study area could be adjusted based on the results of the present study.

No previous study has specifically examined the KAP toward ATRs in China or elsewhere. However, several studies from India exploring hemovigilance and ATRs reporting found that, although the attitude toward ATRs reporting was good, knowledge was variable and practice was moderate at best.[20–22,27] Chowdhary et al[20] reported that in Kathua (India), healthcare professionals had good knowledge and a positive attitude toward reporting ATRs, but their practice scores were poor. Shivgunde et al[27] reported that although healthcare providers in Nashik (India) had a positive attitude toward reporting ATRs, their knowledge was poor, and they almost never reported such reactions. In Nagpur, only 39% of the participants were aware of hemovigilance, 30% were aware of the existence of ATR reporting centers, and 22% were actually reporting events.[21] Previous studies in India also reported that only 9–20% of their participants had attended continuous medical education about ATRs.[20,27] On the other hand, in the present study, the rate of consulting educational material or attending educational activities about ATRs was high, and almost all participants used more than one method. A study of 247 residents and interns in India reported poor KAP toward safe transfusion practice;[28] similar results were reported in Brazil.[29] An international study reported poor knowledge of transfusion medicine among residents.[30] Previous studies also reported poor knowledge of transfusion medicine, including ATRs, among practicing physicians.[31–33] Haspel et al[34] proposed a framework for the proper training of physicians in transfusion medicine. In the present study, Chinese nurses, physicians, and transfusion specialists all showed high KAP scores toward ATRs. Discrepancies among studies and the different parts of the world could be related to the work experience of the participants, national guidelines and policies toward transfusion medicine, training curriculum, and the availability and content of continuous medical education.

A study by Mitchell et al in 1989 in Iowa[35] reported among faculty members, transfusion medicine medical directors, and transfusion chief technologists, the most common knowledge deficits were related to the selection and use of blood components, transfusion reactions, coagulation, blood products to treat hemostatic problems, and apheresis. In the present study, moderate knowledge scores were observed regarding the possibility of bacterial contamination of blood products, delayed hemolytic reaction, the definition of ATR pertaining to the transmission of blood-borne diseases, and the management of allergic reactions to blood products. Those points should be emphasized in future educational materials and activities.

In the present study, only higher education was independently associated with higher knowledge scores. The finding that working in surgery or other clinical departments was associated with a more positive attitude compared to professionals in the Transfusion Department is noteworthy. This highlights a potential "exposure effect" that may be linked to the nature of professional roles. Although transfusion specialists have the most in-depth technical expertise, healthcare professionals in high-transfusion clinical settings, like surgery, are on the front line, directly witnessing the immediate impact of transfusions and their complications on patients. This routine exposure may foster a greater appreciation for the importance of vigilance and proper management of ATRs, thereby shaping a more proactive attitude compared to those in departments with less transfusion activity. This suggests that familiarity and practical experience are key determinants of professional attitude in this context. The KAP dimensions were generally correlated with each other, as supported by the KAP theory, which states that knowledge is the basis for practice, while attitude is the force driving practice.[18,19] In transfusion specialists, knowledge did not correlate to practice, but knowledge correlated to attitude, which correlated to practice. Nevertheless, considering that the KAP scores were all skewed toward the higher ranges, correlation analyses should be taken with caution.

This study has limitations. Although it was open to nurses, physicians, and transfusion specialists across all of China, some provinces were underrepresented. In addition, the relatively short study period probably led to the small sample size (relative to the number of healthcare providers in China). Since the QR code for participation was distributed through social media, it is impossible to determine how many people saw the QR code but did not complete the questionnaire, preventing the calculation of metrics like the response rate. From a statistical perspective, while the total sample size of 799 is robust for overall analysis, the subgroup sizes for nurses (n=327), physicians (n=253), and transfusion specialists (n=219) may limit the power to draw definitive conclusions that are generalizable to each of these distinct professions across the entirety of China. A larger, nationally stratified sample would be necessary to fully represent the heterogeneity within each group of Chinese healthcare workers and strengthen the external validity of the subgroup-specific findings. Because of the different nature of their work, different practice questions had to be designed for nurses, physicians, and transfusion specialists, therefore the practice scores could not be compared among the three professions. The present study was cross-sectional, and the changes in KAP were not evaluated. Nevertheless, the results could eventually be used as a historical baseline to evaluate the effectiveness of an educational intervention. Due to the design of the knowledge items, there is a possibility of overestimating the knowledge scores. Finally, all KAP studies are at risk of social desirability bias. With such bias participants can be tempted to answer what they believe they should think or do instead of what they are really thinking or doing.[36,37] Considering that the knowledge scores were high and that the attitude and practice scores were also high, bias is a real possibility. Because participants were recruited from transfusion societies, there may have been an overestimation of the KAP level. Finally, the two experts consulted for questionnaire content validity included one specialist in transfusion therapy and one in surgery. The expert in surgery was consulted because transfusion is a common event in the perioperative period. Nevertheless, the lack of experts from other specialties is a limitation.

Conclusion

The cross-sectional survey results indicate that participating Chinese nurses, physicians, and transfusion specialists self-reported high levels of knowledge, positive attitudes, and appropriate practices regarding ATRs. Despite the high overall scores, specific, critical knowledge gaps related to bacterial contamination, delayed hemolytic reactions, and the classification of transfusion-transmitted diseases were identified. Future training initiatives should address these deficiencies to ensure that positive attitudes reported by healthcare professionals translate into consistently safe and effective transfusion practices. These results could provide valuable evidence to guide the refinement of national transfusion education programs and clinical protocols, supporting the continuous improvement of transfusion safety across healthcare settings in China.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article and its Supplementary Information Files.

Ethics Approval and Consent to Participate

This work has been carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. The study was approved by the Medical Ethics Committee of Liaoning Cancer Hospital (KY20231023). Written informed consent was obtained from the study participants before they completed the survey.

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Disclosure

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