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Knowledge, attitudes, and practice of physicians and pharmacists regarding the prevention and treatment of cardiovascular toxicity associated with cancer treatment

Congxin Li[1,5]✉, Wei Yan[1,5], Meiling Gao[1], Zhihan Zhang[2], Ling Zhao[1], Jingtao Ma[3], Xuejing Li[1], Yuan Gao[1], Dongxia Zhang[4] & Shan Gao[1]

This study aimed to explore physicians' and pharmacists' knowledge, attitudes, and practice (KAP) regarding the prevention and treatment of cardiovascular toxicity associated with cancer treatment. A multicenter cross-sectional study included physicians and pharmacists between April 2023 and June 2023. The study included 918 participants (514 physicians and 404 pharmacists). The average scores of knowledge, attitudes, and practice were 11.6 ± 3.39, 24.7 ± 2.6, and 26.3 ± 6.8 points. Sufficient knowledge was significantly associated with age ≥ 41 years (odds ratio (OR) = 2.745, 95% confidence interval (CI) 1.086–6.941, P = 0.033), male (OR = 2.745, 95% CI 1.150–2.223, P = 0.005), bachelor's degree (OR = 0.084, 95% CI 0.013–0.533, P = 0.009), master's degree and above (OR = 0.096, 95% CI 0.015–0.609, P = 0.013), physician occupation (OR = 7.601, 95% CI 1.337–43.207, P = 0.022), pharmacy department (OR = 18.858, 95% CI 3.245–109.57, P = 0.001), oncology department (OR = 4.304, 95% CI 2.426–7.634, P < 0.001), cardiology department (OR = 3.001, 95% CI 1.387–6.492, P = 0.005), hospitals located in Eastern China (OR = 1.957, 95% CI 1.120–3.418, P = 0.018), and hospitals located in Western China (OR = 3.137, 95% CI 1.783–5.518, P < 0.001). Positive attitudes were significantly associated with a senior professional title (OR = 2.989, 95% CI 1.124–7.954, P = 0.028) and hospitals located in Eastern China (OR = 0.424, 95% CI 0.257–0.698, P = 0.001), Western China (OR = 0.231, 95% CI 0.136–0.394, P < 0.001), and Southern China (OR = 0.341, 95% CI 0.198–0.587, P < 0.001). Proactive practice was significantly associated with male (OR = 1.414, 95% CI 1.029–1.943, P = 0.033), senior professional title (OR = 3.838, 95% CI 1.176–12.524, P = 0.026), oncology department (OR = 3.827, 95% CI 2.336–6.272, P < 0.001), and cardiology department (OR = 2.428, 95% CI 1.263–4.669, P = 0.008). Both physicians and pharmacists had positive attitudes toward the prevention and treatment of cardiovascular toxicity associated with cancer treatment, while their knowledge and practice were not as proactive.

Keywords Cardiotoxicity, Health knowledge, Attitudes, Practice, Cross-sectional study, Healthcare providers, Cancer treatment

Emerging cancer therapies could assist cancer patients with more treatment modalities to improve their survival and decrease the recurrence rate. However, such new therapies are inevitably associated with a higher incidence of toxicity[1,2]. Cardiovascular toxicity is one of the most important adverse reactions associated with cancer treatment[3,4]. Cancer treatment may affect the cardiovascular system through multiple potential mechanisms,

[1]Department of Pharmacy, Hebei Medical University Third Hospital, Shijiazhuang 050051, China. [2]Department of Nutrition, The Fourth Hospital of Hebei Medical University, Shijiazhuang 050010, China. [3]Department of Cardiovascular, The Fourth Hospital of Hebei Medical University, Shijiazhuang 050010, China. [4]Department of Hepatology Infection, Bethune International Peace Hospital, Shijiazhuang 050051, China. [5]These authors contributed equally: Congxin Li and Wei Yan. ✉email: congxinli@hebmu.edu.cn; licongxin21@126.com

including directive cellular toxicity, influencing the coagulation system, arrhythmogenic effects, hypertensive effects, and myocardial inflammation, which may lead to subclinical myocardial dysfunction to irreversible heart failure, or even death[5,6]. A recent study demonstrated that in patients receiving anticancer therapy who are at moderate or high risk of cardiotoxicity, cardiotoxicity was identified in 37.5% of patients at follow-up[7]. Furthermore, cases with severe cardiotoxicity were found to be at a significantly increased risk of all-cause mortality[4]. The overall beneficial effects of cancer therapy may be negatively affected by the potential damage to the patient's cardiovascular health, and the development of cardiovascular diseases may be deleterious to the optional doses and timing of lifesaving cancer therapy[8]. It is important for healthcare providers to profoundly understand the mechanisms of cardiovascular toxicity related to cancer treatment and appropriately monitor, prevent, and treat cancer-related heart disease[9,10].

To date, few studies have concentrated on healthcare providers' perspectives on the prevention and treatment of cardiovascular toxicity associated with cancer treatment. A qualitative study on breast cancer patients' cardiac surveillance found that oncologists were unaware of the cardiotoxicity risk and the benefit of cardiac surveillance in cancer treatment[11]. Another interventional study also demonstrated that oncologists had unsatisfactory knowledge and cardiovascular screening practice at baseline[12]. Furthermore, one mixed-method study investigating the treatment of cancer patients found that oncologists have rarely discussed the potential for cardiotoxicity and risk modification strategies with patients, demonstrating the need to improve care management[13]. However, these studies are restricted by the small sample sizes and failure to include non-oncology physicians and pharmacists, playing an important role in the management of cancer treatment. A comprehensive study is therefore required to investigate physicians' and pharmacists' knowledge, attitudes, and practice (KAP) regarding the prevention and treatment of cardiovascular toxicity associated with cancer treatment. A KAP survey is a quantitative method that is widely used for health-related topics based on the principle that knowledge may affect behavior and practice of disease management[14]. The KAP of cardiovascular toxicity associated with cancer treatment among healthcare providers has not yet been studied.

Understanding physicians' and pharmacists' KAP on this topic may effectively promote the management of cancer treatment-related cardiovascular toxicity. Therefore, the present study aimed to assess the KAP toward the prevention and treatment of cardiovascular toxicity associated with cancer treatment among physicians and pharmacists and to identify factors influencing KAP.

Results

Demographic characteristics

A total of 1,196 questionnaires were distributed, and 918 questionnaires were included in the analysis (76.8%). More than half of the participants were 31–40 years old (60.2%), female (52.6%), and physicians (56.0%) (Table 1). The majority of them obtained a master's degree or above (71.9%). Most of the participants had intermediate titles (60.0%), followed by senior titles (20.4%) and primary titles (16.0%). Over one-third had 6–10 years of work experience, followed by those with ≤ 5 years (25.9%), 11–15 years (19.8%), and ≥ 16 years (19.3%). Around 42% of participants worked in the pharmacy department, followed by the oncology department (28.2%), the cardiology department (6.2%), and other departments (23.6%). Over 80% of participants worked in tertiary hospitals. Northern China had the largest number of hospitals (35.6%).

Scores of knowledge, attitudes, and practice dimensions

The average score of knowledge dimension was 11.6 ± 3.39 (range, 0–17) points (Table 1). Knowledge-based questions on the negative effects and the primary prevention of cardiovascular toxicity had higher correct rates (89.0–90.1%), while questions regarding drug properties (e.g., first-line antihypertensive drugs, cardiotoxicity of chemotherapy, and correct administration of targeted therapy with chemotherapeutic drugs) had lower correct rates (13.9–46.6%) (Table 2).

The average score of attitude dimension was 24.7 ± 2.6 (range, 6–30) points (Table 1). Supplementary Fig. S2 shows the distribution of the attitudes. The average score of practice dimension was 26.3 ± 6.8 (range, 8–40) points (Table 1). The distribution of the practice evaluation is presented in Supplementary Fig. S3.

A comparison of the correct rates of questions related to the knowledge dimension revealed that participants from the oncology department and those from hospitals in Western China tended to have higher correct rates (Supplementary Table 1). Physicians, those who worked in the oncology department, and those from hospitals in Northern China were more likely to rate Strongly Agree on questions related to the attitude dimension (Supplementary Table 2). Physicians, those who worked in oncology departments, and those from hospitals in Eastern China were more likely to participate in the development of treatment plans; physicians, those who worked in non-oncology clinical departments, and those from hospitals in Northern China tended to receive training on cardiovascular toxicity associated with cancer treatment (Supplementary Table 3).

Correlations between the knowledge, attitude, and practice scores

Pearson correlation analysis (Table 3) revealed that the knowledge score was significantly positively correlated with the attitude score ($r = 0.208$, $P < 0.001$) and practice score ($r = 0.277$, $P < 0.001$). There was also a positive correlation between the attitude and practice scores ($r = 0.268$, $P < 0.001$).

Factors associated with KAP

The results of multivariable logistic regression analysis revealed that sufficient knowledge was significantly associated with age ≥ 41 years (odds ratio (OR) = 2.745, 95% confidence interval (CI) 1.086–6.941, P = 0.033), male (OR = 2.745, 95% CI 1.150–2.223, P = 0.005), bachelor's degree (OR = 0.084, 95% CI 0.013–0.533, P = 0.009), master's degree and above (OR = 0.096, 95% CI 0.015–0.609, P = 0.013), physician occupation (OR = 7.601, 95% CI

	N (%)	Knowledge Score (total: 17)	Attitudes Score (total: 30)	Practice Score (total: 40)
Total	918	11.61 ± 3.39	24.69 ± 2.57	26.26 ± 6.82
Age (years old)				
≤ 30	156 (17.0%)	10.39 ± 3.44	24.53 ± 2.68	23.34 ± 7.66
31–40	553 (60.2%)	11.35 ± 3.43	24.75 ± 2.5	25.63 ± 6.60
≥ 41	209 (22.8%)	13.20 ± 2.60	24.61 ± 2.67	30.07 ± 4.86
Gender				
Male	435 (47.4%)	11.99 ± 3.45	24.72 ± 2.48	27.27 ± 6.73
Female	483 (52.6%)	11.27 ± 3.29	24.65 ± 2.65	25.35 ± 6.78
Educational level				
Junior college or below	9 (1.0%)	12.33 ± 4.15	24.89 ± 3.37	24.00 ± 9.22
Bachelor's degree	249 (27.1%)	11.41 ± 3.65	23.86 ± 2.85	24.38 ± 7.59
Master's degree or above	660 (71.9%)	11.68 ± 3.27	24.99 ± 2.38	27.00 ± 6.33
Occupation				
Physician	514 (56.0%)	11.85 ± 3.32	24.89 ± 2.58	27.82 ± 6.38
Pharmacist	404 (44.0%)	11.30 ± 3.44	24.43 ± 2.53	24.28 ± 6.85
Professional title				
None	33 (3.6%)	11.18 ± 3.13	25.12 ± 2.70	22.24 ± 7.47
Primary title	147 (16.0%)	10.41 ± 3.71	24.22 ± 2.59	23.78 ± 7.91
Intermediate title	551 (60.0%)	11.54 ± 3.31	24.52 ± 2.55	25.90 ± 6.27
Senior title	187 (20.4%)	12.80 ± 2.91	25.44 ± 2.46	29.98 ± 5.68
Work experience (years)				
≤ 5	238 (25.9%)	10.62 ± 3.39	24.76 ± 2.52	24.10 ± 7.49
6–10	321 (35.0%)	10.99 ± 3.56	24.86 ± 2.50	25.44 ± 6.66
11–15	182 (19.8%)	12.25 ± 3.04	24.24 ± 2.72	26.53 ± 6.07
≥ 16	177 (19.3%)	13.40 ± 2.46	24.72 ± 2.59	30.37 ± 4.83
Department				
Pharmacy department	385 (41.9%)	11.43 ± 3.41	24.41 ± 2.51	24.41 ± 6.80
Oncology department	259 (28.2%)	13.44 ± 2.05	24.69 ± 2.44	29.66 ± 5.63
Cardiology department	57 (6.2%)	11.54 ± 3.27	25.23 ± 2.51	27.16 ± 5.89
Others	217 (23.6%)	9.37 ± 3.44	25.02 ± 2.80	25.26 ± 6.87
Hospital level				
Tertiary hospital	791 (86.2%)	11.68 ± 3.38	24.68 ± 2.60	26.54 ± 6.70
Secondary hospital	119 (13.0%)	11.32 ± 3.37	24.72 ± 2.40	24.83 ± 7.15
Primary hospital	8 (0.9%)	9.13 ± 4.12	24.75 ± 2.86	20.13 ± 8.67
The region of hospital				
Eastern China	156 (17.0%)	12.53 ± 3.03	24.22 ± 2.66	27.53 ± 5.51
Western China	173 (18.8%)	13.34 ± 2.27	24.17 ± 1.95	24.56 ± 6.14
Southern China	120 (13.1%)	11.69 ± 3.31	24.39 ± 2.79	25.83 ± 6.77
Northern China	327 (35.6%)	10.43 ± 3.61	24.95 ± 2.64	25.36 ± 7.58
Central China	142 (15.5%)	11.13 ± 3.30	25.44 ± 2.57	25.71 ± 6.71

Table 1. Distribution of participants' baseline data and KAP results.

1.337–43.207, P = 0.022), pharmacy department (OR = 18.858, 95% CI 3.245–109.57, P = 0.001), oncology department (OR = 4.304, 95% CI 2.426–7.634, P < 0.001), cardiology department (OR = 3.001, 95% CI 1.387–6.492, P = 0.005), hospitals located in Eastern China (OR = 1.957, 95% CI 1.120–3.418, P = 0.018), and hospitals located in Western China (OR = 3.137, 95% CI 1.783–5.518, P < 0.001) (Table 4).

Positive attitudes were significantly associated with a senior professional title (OR = 2.989, 95% CI 1.124–7.954, P = 0.028) and hospitals located in Eastern China (OR = 0.424, 95% CI 0.257–0.698, P = 0.001), Western China (OR = 0.231, 95% CI 0.136–0.394, P < 0.001), and Southern China (OR = 0.341, 95% CI 0.198–0.587, P < 0.001) (Table 4).

Proactive practice was significantly associated with male (OR = 1.414, 95% CI 1.029–1.943, P = 0.033), senior professional title (OR = 3.838, 95% CI 1.176–12.524, P = 0.026), oncology department (OR = 3.827, 95% CI 2.336–6.272, P < 0.001), and cardiology department (OR = 2.428, 95% CI 1.263–4.669, P = 0.008) (Table 4).

Question	Correct rate (%)
K1. Correct statement of cardiotoxicity of antineoplastic drugs	418 (45.5%)
K2. The antineoplastic drugs that cause myocardial dysfunction and cardiovascular diseases	754 (82.1%)
K3. Mechanism of cardiotoxicity induced by antineoplastic drugs	577 (62.9%)
K4. Drug-related cardiovascular toxicity can affect the efficacy of antineoplastic drugs and reduce the overall prognosis and quality of life of patients (Correct)	827 (90.1%)
K5. There is genetic susceptibility to cardiac toxicity of tumor (Correct)	745 (81.2%)
K6. Cardiotoxic events shared by alkylating agents and antimicrotubular drugs	637 (69.4%)
K7. BCR-ABL drugs such as imatinib and nilotinib can accelerate atherosclerosis and endothelial dysfunction and cause thrombotic micro-vessels (Correct)	770 (83.9%)
K8. Examination methods for monitoring heart-related adverse reactions	661 (72.0%)
K9. Biochemical indicators for monitoring cardiovascular adverse events	745 (81.2%)
K10. Risk factors for cardiovascular toxicity associated with cancer treatment	762 (83.0%)
K11. High-risk factors for development of cardiovascular toxicity associated with cancer therapy	593 (64.6%)
K12. Primary prevention of cardiovascular toxicity of chemotherapy and targeted drugs	817 (89.0%)
K13. Anti-HER-2 targeted drugs can be combined with anthracyclines (Correct)	428 (46.6%)
K14. Differences between anti-HER-2 targeted drugs and anthracyclines	579 (63.1%)
K15. Postmenopausal breast cancer patients undergoing endocrine therapy must be closely monitored their blood lipids, which belongs to the primary prevention of dyslipidemia in endocrine therapy (Correct)	743 (80.9%)
K16. The first-line antihypertensive drugs for tumor-associated hypertension	128 (13.9%)
K17. The antineoplastic drugs that can cause ventricular tachycardia/ventricular fibrillation	473 (51.5%)

Table 2. Correct rates of questions related to the knowledge dimension.

	Knowledge	Attitudes	Practice
Knowledge	1		
Attitudes	0.208 (P < 0.001)	1	
Practice	0.277 (P < 0.001)	0.268 (P < 0.001)	1

Table 3. Correlation analysis of the three dimensions of the questionnaire.

Structural equation modeling

Figure 1 presents the SEM. Knowledge directly affected attitudes ($\beta = 0.406$, $P < 0.001$) and practice ($\beta = 0.353$, $P < 0.001$). Attitudes directly affected practice ($\beta = 0.316$, $P < 0.001$). Knowledge indirectly affected practice by influencing occupation ($\beta = 0.240$, $P = 0.004$), which, in turn, influenced practice ($\beta = 0.232$, $P < 0.001$).

Discussion

This KAP study concluded that both physicians and pharmacists had positive attitudes toward the prevention and treatment of cardiovascular toxicity associated with cancer treatment, while their knowledge and practice were not proactive. The regression analyses demonstrated that age > 41 years, male, bachelor's degree, master's degree and above, physician occupation, pharmacy department, oncology department, cardiology department, hospitals located in Eastern China, and hospitals located in Western China were associated with adequate knowledge; senior professional titles and working at hospitals from Central China were associated with positive attitudes; male gender, senior professional titles, and working at the oncology and cardiology departments were associated with proactive practice. The above-mentioned factors related to each dimension are valuable in identifying individuals who need further training and intervention.

The average score of the knowledge dimension was 11.6 out of 17 points (< 70%), which is consistent with findings of similar studies on oncologists and other healthcare providers[15–17]. In an international survey on the knowledge of cardiac complications related to cancer treatment, 66.9% of healthcare providers demonstrated that they were familiar with guidelines for managing cardiotoxicity[15]. While more participants were aware of the negative effects of cardiotoxicity associated with cancer treatment, fewer correctly answered questions related to the properties of cancer drugs. The knowledge gap was also recognized in other studies[15,16]. Additional efficient strategies are therefore required to fill in the knowledge gap regarding the prevention and treatment of cardiotoxicity associated with cancer treatment. The present study also revealed that participants who worked in oncology, cardiology, and pharmacy departments had better knowledge than others. Although physicians from other clinical departments can have to treat cancer patients in routine care, they might not have relevant knowledge about cardiotoxicity associated with cancer treatment. Among non-oncology physicians, cardiology specialists play a critical role in the management of cardiotoxicity in cancer patients because the risk of post-treatment recurrence is noteworthy[18]. Therefore, it is important to train non-oncology and non-cardiology physicians on the knowledge related to this topic. Furthermore, the survey revealed that a higher educational level was not necessarily an indicator of a greater level of knowledge, and healthcare providers with different educational levels should be assisted with relevant educational and training programs.

	Knowledge		Attitudes		Practice	
	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Age (years old)						
≤30	Ref		Ref		Ref	
31–40	1.627 (0.821, 3.222)	0.163	0.955 (0.565, 1.615)	0.864	0.943 (0.514, 1.730)	0.850
≥41	2.745 (1.086, 6.941)	0.033	0.726 (0.314, 1.676)	0.452	1.534 (0.644, 3.653)	0.334
Gender						
Male	1.599 (1.15, 2.223)	0.005	1.260 (0.942, 1.684)	0.119	1.414 (1.029, 1.943)	0.033
Female	Ref		Ref		Ref	
Educational level						
Junior college and below	Ref		Ref		Ref	
Bachelor's degree	0.084 (0.013, 0.533)	0.009	0.319 (0.072, 1.421)	0.134	0.175 (0.036, 0.859)	0.297
Master's degree and above	0.096 (0.015, 0.609)	0.013	0.532 (0.120, 2.358)	0.406	0.283 (0.058, 1.382)	0.728
Occupation						
Physician	7.601 (1.337, 43.207)	0.022	1.115 (0.458, 2.715)	0.811	1.336 (0.458, 3.896)	0.596
Pharmacist	Ref		Ref		Ref	
Professional title						
None	Ref		Ref		Ref	
Primary title	1.049 (0.331, 3.327)	0.935	0.629 (0.279, 1.420)	0.264	2.172 (0.771, 6.125)	0.142
Intermediate title	1.241 (0.370, 4.163)	0.727	1.015 (0.429, 2.402)	0.973	1.609 (0.539, 4.805)	0.394
Senior title	2.013 (0.549, 7.382)	0.291	2.989 (1.124, 7.954)	0.028	3.838 (1.176, 12.524)	0.026
Work experience (years)						
≤5	Ref		Ref		Ref	
6–10	0.850 (0.483, 1.495)	0.573	1.160 (0.743, 1.810)	0.514	1.222 (0.731, 2.042)	0.445
11–15	0.927 (0.473, 1.816)	0.825	0.644 (0.363, 1.141)	0.131	1.103 (0.581, 2.093)	0.764
≥16	1.103 (0.447, 2.720)	0.832	0.878 (0.374, 2.064)	0.766	1.936 (0.803, 4.668)	0.141
Department						
Pharmacy department	18.858 (3.245, 109.57)	0.001	1.054 (0.437, 2.539)	0.907	1.3 (0.447, 3.779)	0.630
Oncology department	4.304 (2.426, 7.634)	<0.001	1.184 (0.756, 1.855)	0.461	3.827 (2.336, 6.272)	<0.001
Cardiology department	3.001 (1.387, 6.492)	0.005	1.022 (0.551, 1.899)	0.944	2.428 (1.263, 4.669)	0.008
Others	Ref		Ref		Ref	
Hospital level						
Tertiary hospital	1.059 (0.086, 13.073)	0.965	0.711 (0.144, 3.503)	0.675	1.208 (0.181, 8.051)	0.845
Secondary hospital	0.817 (0.064, 10.479)	0.877	0.917 (0.179, 4.701)	0.917	1.009 (0.144, 7.066)	0.993
Primary hospital	Ref		Ref		Ref	
The region of hospital						
Eastern China	1.957 (1.12, 3.418)	0.018	0.424 (0.257, 0.698)	0.001	0.891 (0.509, 1.557)	0.685
Western China	3.137 (1.783, 5.518)	<0.001	0.231 (0.136, 0.394)	<0.001	0.873 (0.493, 1.546)	0.641
Southern China	1.05 (0.565, 1.949)	0.878	0.341 (0.198, 0.587)	<0.001	0.847 (0.460, 1.560)	0.595
Northern China	0.851 (0.496, 1.458)	0.556	0.687 (0.451, 1.046)	0.080	1.283 (0.786, 2.096)	0.319
Central China	Ref		Ref		Ref	

Table 4. Results of multivariate logistic regression analysis.

The present study demonstrated a satisfactory level of attitudes toward the prevention and treatment of cardiotoxicity in cancer treatment among physicians and pharmacists. The average score of attitude dimension was 24.7 out of 30 points (>70%). Similar studies have previously reported mixed results. On the one hand, a qualitative study conducted by Knowle et al. found that the majority of healthcare providers were aware of the risk of cardiotoxicity in cancer treatment and agreed that it is an important issue to address[17]. On the other hand, Kozhukhov et al. reported that most healthcare providers did not agree that increased cardiac monitoring can prevent cardiotoxicity in cancer patients or improve cancer patients' quality of life[19]. However, those with more positive attitudes demonstrated that their colleagues' lack of knowledge on the topic was a major barrier. Notably, a lack of knowledge on the topic could negatively affect healthcare providers' perceptions[17].

The average score of the practice dimension was 26.3 out of 40 points (<70%), representing a less-than-satisfactory level of practice among physicians and pharmacists. This finding is consistent with the literature. In an international survey, 12% of oncologists agreed that cardiotoxicity should be monitored in asymptomatic cancer patients, and only 2.1% felt comfortable treating cardiovascular complications associated with cancer therapy[15]. In Clark et al.'s study, cancer patients who developed cardiotoxicity raised the concern that oncologists did not discuss the potential for cardiotoxicity with them before treatment, and no risk modification strategy

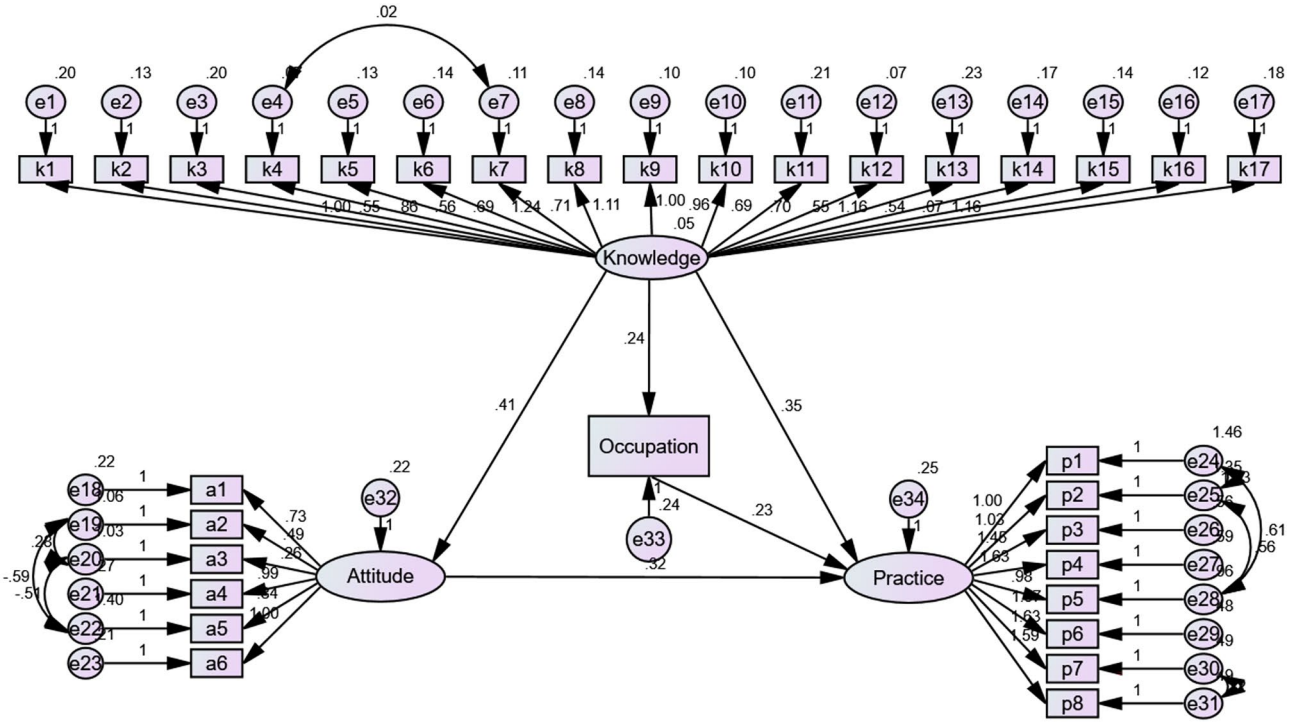

Fig. 1. Structural equation modeling.

was applied[13]. Additionally, the necessary diagnostic tools, such as biomarkers, have not been well utilized by healthcare providers[19,20]. This is an important concern that needs to be addressed to provide high-quality cancer treatment and improve patients' outcomes. The present study also indicated that pharmacists and physicians from non-oncology and non-cardiology departments had lower scores in the practice dimension, reflecting the necessity of additional training for such healthcare providers.

The present study had several limitations. Firstly, due to the self-reporting nature of the study, the results might deviate from the actual practice. The questionnaire was distributed through professional WeChat groups, and no general list of registered physicians/pharmacists was used was used, possibly leading to bias. Secondly, the majority of participants positively answered the questions related to the attitude dimension, and the results might be affected by the social desirability bias. Thirdly, there might be non-response bias from the use of online surveys. However, this study collected data from all regions in China, which enhanced the representativeness of the findings.

In conclusion, the present cross-sectional study demonstrated satisfactory attitudes toward the prevention and treatment of cardiovascular toxicity associated with cancer treatment among physicians and pharmacists, while the levels of knowledge and practice were less satisfactory. Effective educational and training programs are needed for this population, especially in the weaker areas, such as the properties of anticancer drugs. Various factors associated with the level of KAP were also identified. It is important to take these factors into account when designing training programs. For instance, physicians from non-oncology and non-cardiology departments may need additional education and training to enhance their knowledge and practice in this area. Educational tools, including electronic learning guidelines, case discussions, and multidisciplinary team consultations, are potentially advantageous in improving KAP toward the prevention and treatment of cardiovascular toxicity associated with cancer treatment. Future studies should explore effective interventions to enhance this population's KAP.

Methods

Study design and participants

The present cross-sectional study was conducted in China between April 2023 and June 2023, and the participants were Chinese physicians and pharmacists.

The inclusion criteria were as follows: (1) Physicians who were experts in cancer treatment and were certified as occupational physicians; (2) Physicians who had experience treating cancer patients in non-oncology departments and were certified as occupational physicians; and (3) Pharmacists who had experience of anti-tumor treatment and were certified as occupational pharmacists.

The present study was approved by the Ethics Committee of the Third Hospital of Hebei Medical University (2023-015-1), and informed consent was obtained from all participants.

Questionnaire design

The questionnaire was designed with reference to the Chinese Society of Clinical Oncology Guidelines for the Prevention and Treatment of Cardiovascular Toxicity Associated with Cancer Treatment (2021)[21], and it was then

modified based on 6 senior experts' comments. In total, 41 physicians and pharmacists (22 physicians and 19 pharmacists) were selected by random sampling to examine the reliability of the questionnaire, with a Cronbach's α coefficient of 0.8380, suggesting a satisfactory internal consistency.

The final questionnaire included four dimensions: demographic characteristic dimension (age, gender, occupation, professional title, work experience, department, level of hospital, and the region of the hospital (Supplementary Fig. S1), knowledge dimension, attitude dimension, and practice dimension. In China, junior, intermediate, and senior professional titles are used to reflect the technical level, ability, and academic achievement of healthcare professionals. Healthcare professionals gain professional designations when they meet the requirements for each title, including reaching the minimum years of work experience for the position, successfully completing the relevant examinations, and completing the various specialty- and location-specific requirements. Qualified physicians who have not yet been accredited in their specialty (e.g., trainee psychiatrists) have no professional title; they receive the junior title once they obtain their certification. The system is similar for other healthcare professionals (e.g., pharmacists and nurses)[22]. The knowledge dimension included 17 questions, including 1 point for correct answers and 0 points for wrong or unclear answers, and the score ranged from 0 to 17 points. The attitude dimension consisted of 6 questions, and a 5-point Likert scale was used, in which positive attitude questions rated from "Strongly Agree" (5 points) to "Strongly Disagree" (1 point) and the negative attitude question (Question 5) was rated reversely, ranging from 6 to 30 points. The practice dimension consisted of 9 questions, and a 5-point Likert scale was utilized, ranging from "Always" (5 points) to "Never" (1 point). Question 9 was not included in the total practice score, and therefore, the practice dimension ranged from 8 to 40 points.

A score greater than 70% of the total was defined as sufficient knowledge, positive attitudes, and proactive practice[23].

Data collection and quality control

The questionnaire content was reviewed and imported into the *Sojump* online platform (https://www.wjx.cn/app/survey.aspx), and a valid link was generated. In order to conduct the survey more objectively, we did not set a specific center, hospital, or clinic. The questionnaires were mainly distributed through relevant medical and pharmacy professional WeChat groups. A research staff introduced the purpose, content, and significance of the study to potential participants and screened them by convenient sampling for eligibility via WeChat. Eligible participants who agreed to participate in the survey were then invited to complete the online informed consent form, and a web link for the questionnaire was forwarded to each participant. Any inquiries raised by the participants could be answered promptly by the research staff. The questionnaire could not be submitted until all items had been completed by the participant to ensure that there were no missing items in the returned questionnaire. To prevent duplication of questionnaires, each participant could only submit the questionnaire once using an electronic device (e.g., a mobile phone or a computer). Reviewers could directly review the collected questionnaires by logging into the platform. Questionnaires with incomplete or contradictory answers determined by logical judgment were regarded as invalid questionnaires.

The sample size calculation was not carried out due to the large number of registered physicians and pharmacists in China.

Statistical analysis

SPSS 26.0 software (IBM Corp., Armonk, NY, USA) was used to perform statistical analysis. Continuous data were first tested for normality, in which normally distributed continuous data were expressed as mean ± standard deviation (SD) and abnormally distributed continuous data were expressed as median (range). The categorical data were presented as n (%) and analyzed using the chi-square test and Fisher's exact probability test. Pearson correlation analysis was used to evaluate the correlations between the knowledge, attitude, and practice scores. Multivariable logistic regression analysis (variable screening: Enter) was used to explore the influential factors of KAP measured binary as 'sufficient' or 'not sufficient'. The interactions among the KAP dimensions were evaluated using a structural equation model (SEM). It was hypothesized that knowledge directly affects attitudes and practice, while attitudes directly affect practice. $P < 0.05$ was considered statistically significant.

Data availability

All data generated or analysedanalyzed during this study are included in this published article [and its supplementary information files].

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Author contributions

CXL, WY, and MLG carried out the studies, participated in collecting data, and drafted the manuscript. CXL, JTM, ZHZ, XJL, LZ, YG, and DXZ performed the statistical analysis and participated in its design. CXL and SG participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The study was carried out after the protocol was approved by the Ethics Committee of the Third Hospital of Hebei Medical University (2023-015-1). I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments, and informed consent was obtained from all participants.

Additional information

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Correspondence and requests for materials should be addressed to C.L.