

Nurses' knowledge, perceptions, and behaviors regarding antineoplastic drugs: the mediating role of protective knowledge[†]



Original Article

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Abstract: **Objective:** To explore the relationships between Chinese nurses' knowledge, perceptions, and attitudes and their behavior and actual implementation of safety measures when handling antineoplastic drugs (ADs) in their daily work.
Methods: This was a multisite study conducted in 8 public hospitals in China. A self-administered questionnaire was sent to participants querying the degree of contact with ADs. The hypothesized relations were explored using structural equation modelling via the bootstrap method. Mediation analysis was applied to explore the mediating role of protective knowledge regarding AD exposure on the associations among protective training, using warning labels, and using protective masks.
Results: A total of 305 nurses were enrolled. The average age of all participants was 30.2 (standard deviation [SD]: 6.2) years. Nurses who had received protective training for AD exposure were more likely to use labels for ADs after age, body mass index (BMI), length of service, marital status, education, and department were controlled as covariates. The bias-corrected bootstrap of 95% confidence interval (CI) indicated that protective knowledge significantly mediated (23.4%) the association between protective training and using labels (indirect effect = 0.202, 95% CI: 0.009, 0.495); the proportion of mediation was 23.4%. Protective knowledge significantly mediated the association between protective training and using protective masks (indirect effect = 0.157, 95% CI: 0.048, 0.325); the proportion of mediation was 27.2%.
Conclusions: The findings of this study have provided baseline information on the current state of Chinese nurses' perceptions, knowledge, and preventive behaviors toward ADs as the crisis is happening. Training is also recommended to improve nurses' perceptions of the risks associated with ADs.

Keywords: antineoplastic drugs • Chinese nurses • developed city • mediation • occupational exposure

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1. Introduction

To our knowledge, this is the first study to evaluate the knowledge, attitudes, and perceptions of nurses regarding the handling of antineoplastics drugs (ADs) in well-developed areas in China. This study gives a vivid picture of the situation in southern China, which is an economically developed area, and it gives us insights into the relationships between nurses' knowledge, perceptions, and attitudes and their behavior and actual usage of safety measures when handling ADs, providing us a route for developing solutions to their issues.

Hence, the current study sought to highlight the weak points in our system with respect to managing the concerns of nurses regarding their handling of ADs in their daily work and to determine whether protective knowledge mediates the relationship between protective training and warning label use.

ADs are widely used agents for the treatment of cancer. Recent studies have shown an increase in the potential risks due to occupational exposure to ADs.^{1,2} Nurses are the main group exposed to these drugs in hospitals. They are typically exposed while administering ADs.³ ADs may cause adverse effects in nurse.^{4,5} Given this, there is a risk to nurses who handle and administer ADs.^{4,6,7}

Although nurses are knowledgeable regarding the risk of exposure to ADs, they often do not adhere to safe work practices.^{2,8} However, the knowledge, perceptions, and behavior in other healthcare job categories at risk of exposure have yet to be determined.^{9,10} Nieweg et al.¹¹ found that although 80% of respondents indicated they were aware that patient excreta may contain drug residual, only 21% of the nurses wore a gown, 18% wore a mask, and 3% used goggles. However, most of the research has been carried out in low-income countries, and research on this topic from high-income areas in the mainland of China is limited. There are no baseline occupational health data available and no occupational disease surveillance systems in place. As such, research on occupational exposure to ADs among Chinese nurses in developed cities is scarce.

Few studies have focused on the association between protective knowledge and occupational exposure to ADs. Thus, there is limited evidence on the association between protective knowledge and nurses' behaviors regarding ADs. To date, there have been no published investigations on this issue. The current study therefore aimed to survey a range of nurses from the Shenzhen Special Economic Zone, China, about their knowledge, perceptions, and behaviors regarding ADs as well as the mediating role of protective knowledge.

A self-administered questionnaire was sent to nurses to assess their degree of contact with ADs, knowledge of the risks associated with ADs, perceptions of personal risk, previous training with respect to ADs, and safe work practices. Participants were recruited from 8 public hospitals in Shenzhen. The results of this research will identify gaps in knowledge and point to where improvements can be made to promote safe handling of ADs and minimize occupational exposure to ADs in nurses. In addition, we also aimed to explore the association between protective training regarding AD exposure, protective knowledge, the use of warning labels, and the use of protective masks. Given these aims, the hypotheses of this study are as follows:

- (1) Protective training regarding AD exposure will be associated with protective knowledge when handling ADs.
- (2) Protective knowledge regarding AD exposure will be associated with using warning labels and protective masks when handling ADs.
- (3) There will be a significant mediation effect of protective knowledge on the association of protective training regarding AD exposure with using warning labels and using protective masks.

These jobs were selected based on evidence from observations and exposure measurement studies that identified them as being at risk of exposure. The results of this study will identify gaps in knowledge and point to where improvements can be made to promote safe handling of ADs and minimize occupational exposure.

2. Methods

2.1. Aims

The survey was conducted between July 2018 and April 2019 and explored the associations among protective knowledge regarding AD exposure, protective training, label use, and protective mask use. Moreover, the study examined whether protective knowledge regarding ADs exposure mediated the associations among protective training, using warning labels, and using protective masks. A multisite study was conducted among nurses from 8 public hospitals in a southern city of China. Data on protective knowledge regarding AD exposure, protective training, warning label use, and protective mask use were collected. Mediation analysis was applied to explore the mediating role of protective knowledge regarding AD exposure on the associations among protective training, warning label use, and protective mask use.

2.2. Design

A cross-sectional design was used to collect the data. To improve the quality of the research, we carried out the study in line with the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist.

2.2.1. Subjects

The Shenzhen Special Economic Zone is a developed area in China that neighbors Hong Kong and Macao, and 2/3 of the Fortune 500 companies have a presence here. It is the world's most successful special economic zone. The region is representative of nurses with respect to working conditions and geographical distribution. Therefore, a survey of nurses from this region can accurately represent the status of nurses in developed cities in China. Nurses who participated met the following inclusion criteria: (a) had worked for at least 1 year in the current hospital and (b) were willing to participate in this study. Wu¹² proposed that a sample size ≥ 200 is needed to construct a stable model. Therefore, we aimed to collect at least 300 valid questionnaires.

2.2.2. Instrument design and pre-testing

The questionnaire was developed using the Delphi expert consultation method. The finalized questionnaire was divided into multiple sections as follows:

- (1) Researcher-developed demographic questionnaire collecting information on sociodemographic factors, including age, sex, marital status, fertility, work department, education, height, weight, number of years as a registered nurse (RN), and number of years as an oncology nurse;
- (2) Lifestyle, smoking, and other habits;
- (3) Personal and family medical, occupational, and exposure history;
- (4) Degree of contact with ADs;
- (5) Knowledge of the proper implementation of protective measures during the preparation and administration of ADs and knowledge of the potential risks of ADs;
- (6) Perceptions of personal risk;
- (7) Protective training with respect to ADs;
- (8) Use of a protective mask; and
- (9) Hand hygiene practices and use of warning labels.

A draft version of the questionnaire was pre-tested on a small group of nurses who were representative of the population of interest but worked at facilities that did

not participate in the research project. Where necessary, draft questions were modified based on the feedback of the pre-test group and a second version of the survey was re-tested on a smaller subset of the pre-test group. A final version of the questionnaire was vetted by the relevant research ethics boards prior to distribution to nurses.

Returned questionnaires were reviewed for completeness. When questions were unanswered, the nurse was contacted by a trained research assistant who subsequently requested that the subject respond to any unanswered questions via WeChat (a Chinese social communication app) or telephone.

2.3. Data collection

Convenience sampling was carried out between July 2018 and April 2019. A self-administered questionnaire was sent to participants querying the degree of contact with ADs. Knowledge of risks associated with ADs, perceptions of personal risk, previous training with respect to ADs, and safe work practices. Nurses were recruited from 8 public hospitals in Shenzhen, China, using convenience sampling. After filtering, 305 questionnaires were considered valid.

2.4. Quality control

Participants were contacted first by email and then by follow-up telephone calls to explain the study. During the face-to-face field survey, trained research assistants explained how to fill in the questionnaires and helped nurses complete them. The procedure lasted 18 min on average. Questionnaires that were <80% complete were rejected. The database was established by Epi Data 3.02 (Epi Data Association, Odense, Denmark), and double input was conducted to ensure accuracy.

2.5. Statistical analysis

We conducted descriptive analyses of the sociodemographic characteristics of the participants. Continuous variables are expressed as the mean $\pm$ standard deviation (SD), and categorical variables are described as proportions. T-tests or ANOVA was used to compare the differences in the continuous variables between different groups, and χ^2 tests were performed to compare categorical variables across groups. Correlation analyses were used to estimate the associations among protective training courses regarding AD exposure, protective knowledge regarding AD exposure, the use of warning labels for ADs, and the use of protective masks when handling ADs.

Furthermore, to determine whether protective knowledge regarding AD exposure served as a mediator of the association of protective training with using warning labels for ADs and using protective masks when handling ADs, we performed the mediation analysis proposed by MacKinnon et al.¹³ with a series of multiple linear regression and logistic regression models after controlling for potential confounders. First, an association (coefficient: *c*) exists between the independent variable (protective training regarding AD exposure, *X*) and the dependent variable (using warning labels for ADs/using protective masks when handling ADs, *Y*). Second, an association (coefficient: *a*) exists between the independent variable and the hypothesized mediating variable (protective knowledge regarding AD exposure, *M*). Third, the mediator is related (coefficient: *b*) to the dependent variable when the independent variable is controlled in the model. Then, the indirect effect of the independent variable on the dependent variable through a mediator is evaluated as $\exp(a \times b)$ (namely, OR^{IE} ; dichotomous outcome), and the direct effect of *X* on *Y* is estimated as $\exp(c')$ (namely, OR^{DE}). A bootstrapping procedure using MPLUS was conducted using 5000 resamples to test the mediation effect. In this approach, effects are assessed with bias-corrected bootstrap confidence intervals (CIs) that are considered significant if the upper and lower bounds of the bias-corrected 95% CIs do not contain zero.

The proportion of mediation is interpreted as the proportion of the effect of the independent variable on the dependent variable that is mediated by the mediator. The proportion of mediation is calculated as follows^{13,14}:

$$\frac{OR^{DE} \times (OR^{IE} - 1)}{OR^{DE} \times OR^{IE} - 1}$$

All the analyses were performed using R 3.6.1 (R Development Core Team 2019, <https://www.r-project.org>), and the R packages with the terms “car”, “psych”, “multcomp”, “Hmisc”, “corrplot”, and “vcd” were the main ones used. All the tests were two-sided, and $P < 0.05$ was considered to be statistically significant.

3. Results

3.1. General characteristics of the study population

A total of 305 participants were ultimately included in the present analyses. The general characteristics of the participants are described in Table 1. The average age of all participants was 30.2 (SD: 6.2) years: 37 (12.1%) were overweight, 104 (34.1%) worked as nurses for

more than 10 years, 150 (49.2%) were married, 225 (73.8%) had more than 16 years of education, and 143 (20.0%) worked in oncology.

3.2. Association among protective training regarding AD exposure, regarding protective knowledge, using warning labels, and using protective masks

Figure 1 shows that protective training regarding AD exposure was positively associated with protective knowledge regarding AD exposure ($r = 0.19$, $P < 0.01$), using warning labels for ADs ($r = 0.22$, $P < 0.001$) and using protective masks when handling ADs ($r = 0.18$, $P = 0.003$). Protective knowledge regarding AD exposure was positively associated with using warning labels for ADs ($r = 0.13$, $P = 0.013$) and using protective masks when handling ADs ($r = 0.19$, $P = 0.002$).

3.3. Mediation effect of protective knowledge on the association of protective training regarding AD exposure with using warning labels and using protective masks

The following variables were controlled as covariates: age, body mass index (BMI), length of service, marital status, education, and department. The results showed that nurses receiving protective training regarding AD exposure were more likely to use labels for ADs ($OR = 4.270$, 95% CI: 1.424, 12.806; Table 2, Model 2). After protective knowledge regarding AD exposure was added to the model, the association between protective training and label use was attenuated ($OR = 3.762$, 95% CI: 1.242, 11.396; Table 2, Model 3), and the associations between protective knowledge and label use were positive and significant ($OR = 1.751$, 95% CI: 1.019, 3.010; Table 2, Model 3). The bias-corrected bootstrap 95% CI indicated that protective knowledge significantly mediated the association between protective training and label use (indirect effect = 0.202, 95% CI: 0.009, 0.495), and the proportion of mediation was 23.4% (Figure 2).

The results also showed that nurses receiving protective training regarding AD exposure were more likely to use protective masks when handling ADs ($OR = 2.087$, 95% CI: 1.314, 3.317; Table 3, Model 2). After protective knowledge regarding AD exposure was added to the model, the association between protective training regarding AD exposure and protective mask use was attenuated ($OR = 1.836$, 95% CI: 1.145, 2.944; Table 3, Model 3), and the association between protective knowledge and protective mask use was positive and significant ($OR = 1.545$, 95% CI: 1.165, 2.047; Table 3, Model 3). The bias-corrected bootstrap 95%

Characteristics	Number of participants, n (%)	Using warning labels			Using protective masks				
		Yes, n (%)	No, n (%)	χ^2/t	P	Single-layer surgical mask, n (%)	Double-layer surgical mask, n (%)	N95, n (%)	3M, n (%)
Age (years, Mean (SD))	30.19 (6.24)	32.35 (7.27)	29.87 (6.02)	2.36 ^a	0.019	30.19 (5.79)	30.63 (6.43)	29.92 (6.62)	28.92 (6.63)
BMI (kg/m ²)				0.01 ^c	0.996				
<18.5	62 (20.3)	8 (20.0)	54 (20.4)			23 (20.2)	19 (20.1)	15 (16.9)	5 (41.7)
18.5-23.9	206 (67.5)	27 (67.5)	179 (67.5)			82 (71.9)	58 (64.4)	60 (67.4)	6 (50.0)
≥24	37 (12.1)	5 (12.5)	32 (12.1)			9 (7.9)	13 (14.4)	14 (15.7)	1 (8.3)
Length of service (years)				4.73 ^c	0.094				
<3.81	100 (32.8)	8 (20.0)	92 (34.7)			36 (31.6)	24 (26.7)	34 (38.2)	6 (0.5)
3.81-10.27	101 (33.1)	13 (32.5)	88 (33.2)			38 (33.3)	36 (40.0)	24 (27.0)	3 (0.25)
>10.27	104 (34.1)	19 (47.5)	85 (32.1)			40 (35.1)	30 (33.3)	31 (34.8)	3 (0.25)
Married				3.91 ^c	0.048				
No	155 (50.8)	14 (35.0)	141 (53.2)			56 (49.1)	42 (46.7)	50 (56.2)	7 (58.3)
Yes	150 (49.2)	26 (65.0)	124 (46.8)			58 (50.9)	48 (53.3)	39 (43.8)	5 (41.7)
Education (years)				2.37 ^c	0.124				
<16	80 (26.2)	6 (15.0)	74 (27.9)			22 (19.3)	26 (28.9)	29 (32.6)	3 (25.0)
≥16	225 (73.8)	34 (85.0)	191 (72.1)			92 (80.7)	64 (71.1)	60 (67.4)	9 (75.0)
Department				18.91 ^c	<0.001				
Gynaecology	61 (33.1)	17 (42.5)	84 (31.7)			32 (28.1)	34 (37.8)	34 (38.2)	1 (8.3)
Oncology	143 (20.0)	16 (40.0)	45 (17.0)			20 (17.5)	21 (23.3)	18 (20.2)	2 (16.7)
Other	101 (46.9)	7 (17.5)	136 (51.3)			62 (54.4)	35 (38.9)	37 (41.6)	9 (75.0)

Note: BMI, body mass index; ^aStatistics were estimated by t-test; ^bStatistics were estimated by ANOVA; ^cStatistics were estimated by the χ^2 test; ^dStatistics were estimated by the Mantel-Haenszel χ^2 test.

Table 1. General characteristics of the participants.

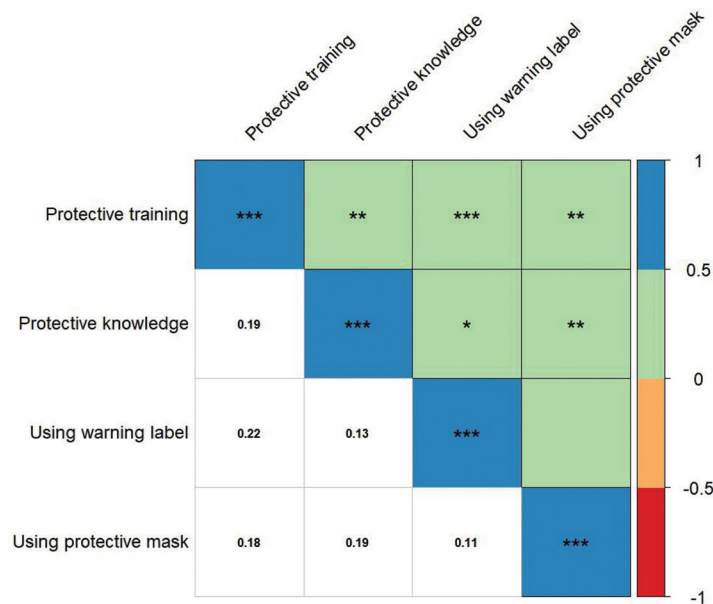


Figure 1. Association matrix of protective training for AD exposure, protective knowledge, using warning labels and using protective masks.

Items	Protective knowledge (M, β , 95% CI)		Warning label use (Y, OR, 95% CI)	
	Model 1 X→M	Model 2 X→Y	Model 3 X+M→Y	
<i>Protective training (X)</i>				
No	Reference	Reference	Reference	
Yes	0.361 (0.173, 0.550)***	4.270 (1.424, 12.806)**	3.762 (1.242, 11.396)*	
<i>Protective knowledge (M)</i>				
			1.751 (1.019, 3.010)*	

Note: All effect sizes were adjusted for age, BMI, length of service, marital status, education, and department; *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$.

Table 2. Association between protective training regarding AD exposure, protective knowledge, and use of warning labels.

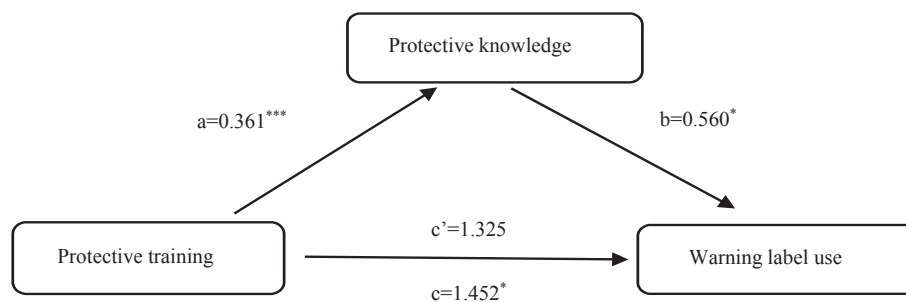


Figure 2. Mediation effect of protective knowledge on the association of protective training regarding AD exposure with warning label use.

Note: The proportion of mediation = 23.4%.

CI indicated that protective knowledge significantly mediated the association between protective training and protective mask use (indirect effect = 0.157, 95% CI: 0.048, 0.325), and the proportion of mediation was 27.2% (Figure 3).

4. Discussion

In our study, we attempted to explore the influence of Chinese nurses' knowledge, perceptions, and attitudes on their behavior and their actual usage of safety measures

Items	Protective knowledge (M, β , 95% CI)	Protective mask use (Y, OR, 95% CI)	
	Model 1 $X \rightarrow M$	Model 2 $X \rightarrow Y$	Model 3 $X + M \rightarrow Y$
<i>Protective training (X)</i>			
No	Reference	Reference	Reference
Yes	0.361 (0.173, 0.550)***	2.087 (1.314, 3.317)**	1.836 (1.145, 2.944)*
<i>Protective knowledge (M)</i>			
			1.545 (1.165, 2.047)*

Note: All effect sizes were adjusted for age, BMI, length of service, marital status, education, and department; *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$.

Table 3. Association between protective training regarding AD exposure, protective knowledge, and using protective masks.

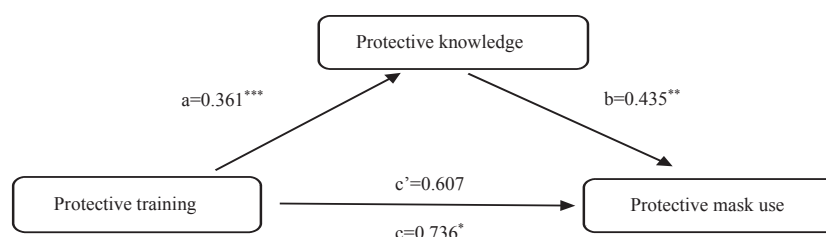


Figure 3. Mediation effect of protective knowledge on the association of protective training regarding AD exposure with protective mask use.

Note: The proportion of mediation = 27.2%.

when handling ADs in their daily work. These issues have been investigated in a broad range of nurses, and researchers have thoroughly assessed occupational exposure to ADs and the practices involved in the manipulation of these agents.

The results showed that, notwithstanding the rules and regulations pertaining to ADs, participants in this study did not comply with them fully and reported that regular ongoing supervision was not sufficient. In accordance with earlier studies, the interaction between knowledge and preventive behavior was weak.¹⁵ The following variables were controlled as covariates: age, BMI, length of service, marital status, education, and department. The results showed that nurses receiving protective training for AD exposure were more likely to use labels for Ads. After protective knowledge for AD exposure was added to the model, the association between protective training for AD exposure and label use was attenuated. Moreover, the bias-corrected bootstrap 95% CI indicated that protective knowledge significantly mediated the association between protective training and protective mask use, and the proportion of mediation was 27.2%. Due to the cross-sectional nature of this study, a temporal association between AD-related knowledge and training and overall precautionary behavior could not be established. Hence, in the future, we will conduct a longitudinal study to identify the true impact of AD training on improving the knowledge of nurses.

Our findings regarding AD exposure protective training were positively associated with protective knowledge regarding the handling of ADs in nurses, which was consistent with our first hypothesis and with the results of several previous studies. For example, Hon et al.¹⁶ suggested that knowledge regarding the risks associated with ADs can be improved. There is also a gap between knowledge and compliance with glove usage and hand hygiene. Protective training is also recommended to improve health care nurses' perceptions of the risks associated with ADs. Papadopolis et al.¹ reported that a higher perception of risk is related to a greater likelihood of behaving safely; therefore, investigation of perceptions of risk is very useful for predicting behavior.

Our findings that nurses' protective knowledge regarding AD exposure was associated with using warning labels and using protective masks when handling Ads were consistent with our second hypothesis as well as with previous studies. Although our study focused on occupational exposure to ADs in nurses, it is conceivable that friends and family members are also at risk of exposure, as suggested by Sorsa et al.¹⁷

To our knowledge, this is the first study to evaluate the knowledge, attitudes, and perceptions of nurses regarding the handling of ADs in well-developed areas in China. This study gives a vivid picture of the situation in southern China, which is an economically developed area, and it gives us insights into the relationships between nurses' knowledge, perceptions, and attitudes

and their behavior and actual usage of safety measures when handling ADs, providing us a route for developing solutions to their issues. Hence, the current study sought to highlight the weak points in our system with respect to managing the concerns of nurses regarding their handling of ADs in their daily work and to determine whether protective knowledge mediates the relationship between protective training and warning label use.

The current study had a few limitations as well. One limitation of this study is that the questionnaire data are self-reported and we were unable to confirm the accuracy of responses regarding behaviors, i.e., hand hygiene practices and glove usage. Another limitation was that the survey was conducted in a developed area of China where upper socioeconomic classes predominate. Therefore, we could not differentiate the perceptions of nurses according to socioeconomic strata.

5. Conclusions

In conclusion, this is the first study to find evidence for the effect of the combination of protective knowledge, protective training, warning label use, and protective mask use among Chinese nurses in developed cities. Exposure to ADs is a known risk in hospitals in China and globally; in addition, the study provides information that can be used to formulate policies and to implement control measures to protect nurses. The findings of this study have provided baseline information on the current state of Chinese nurses' perceptions, knowledge, and preventive behavior toward ADs as the crisis is happening. Training is also recommended to improve nurses' perceptions of the risks associated with ADs.

Relevance to clinical practice

The safety protection of nurses is the key point in the field of medical and health care. It is helpful to know their knowledge, belief, and practice about the occupational environment of tumors and provide reference and basis for the management department to formulate nurse training plan and occupational protection countermeasures.

The findings of this study have provided baseline information on the current state of Chinese nurses' perceptions, knowledge, and preventive behaviors toward AD as the crisis is happening. The findings revealed some areas that should be focused on by nursing education, as well as health agencies, to ensure that the nurses have adequate knowledge and correct preventive behaviors. Such research will help identify further targets for intervention in the knowledge, perceptions, and behaviors of nurses with respect to ADs.

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Author contributions

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Ethical approval

To keep the paper blinded, the research proposal was submitted to and approved by the Ethical Review Committee in the target region. Oral informed consent was obtained from each participant. Participants were assured of their right to refuse to participate or to withdraw from the study at any time. The anonymity and confidentiality of the participants and their data were assured.

Conflicts of interest

All contributing authors declare no conflicts of interest.

References

1. Papadopoli R, Nobile CGA, Trovato A, Pileggi C, Pavia M. Chemical risk and safety awareness, perception, and practices among research laboratories workers in Italy. *J Occup Med Toxicol*. 2020;15:17.
2. Videnros C, Selander J, Wiebert P, et al. Postmenopausal breast cancer and occupational exposure to chemicals. *Scand J Work Environ Health*. 2019;45:642–650.
3. Rai R, El-Zaemey S, Dorji N, Fritschi L. Occupational exposures to hazardous chemicals and agents among healthcare workers in Bhutan. *Am J Ind Med*. 2020;63:1109–1115.
4. Gustavsson P, Andersson T, Gustavsson A, Reuterwall C. Cancer incidence in female laboratory employees: extended follow-up of a Swedish cohort study. *Occup Environ Med*. 2017;74:823–826.

5. Laouali N, Pilorget C, Cyr D, et al. Occupational exposure to organic solvents and risk of male breast cancer: a European multicenter case-control study. *Scand J Work Environ Health*. 2018;44:312–322.
6. Kullberg C, Selander J, Albin M, Borgquist S, Manjer J, Gustavsson P. Female white-collar workers remain at higher risk of breast cancer after adjustments for individual risk factors related to reproduction and lifestyle. *Occup Environ Med*. 2017;74:652–658.
7. Shih YW, O'Brien AP, Hung CS, Chen KH, Hou WH, Tsai HT. Exposure to radiofrequency radiation increases the risk of breast cancer: a systematic review and meta-analysis. *Exp Ther Med*. 2021;21:11.
8. Li YL, Ma L. Exposure to solar ultraviolet radiation and breast cancer risk: a dose-response meta-analysis. *Medicine*. 2020;99:e23105.
9. Fernandez-Martinez NF, Ching-Lopez A, Lima AOD, et al. Relationship between exposure to mixtures of persistent, bioaccumulative, and toxic chemicals and cancer risk: a systematic review. *Environ Res*. 2020;188:109787.
10. Rodgers KM, Udesky JO, Rudel RA, Brody JG. Environmental chemicals and breast cancer: an updated review of epidemiological literature informed by biological mechanisms. *Environ Res*. 2018;160:152–182.
11. Nieweg RM, de Boer M, Dubbleman RC, et al. Safe handling of antineoplastic drugs. Results of a survey. *Cancer Nurs*. 1994;17:501–511.
12. Wu ML. *Structural equation model: operation and application of AMOS*. Chongqing: Chongqing University Press; 2009 (in Chinese).
13. Hayes AF. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York, NY: Guilford Press; 2013.
14. MacKinnon DP, Fairchild AJ, Fritz MS. Mediation analysis. *Annu Rev Psychol*. 2007;58:593–614.
15. Ben-Ami S, Shaham J, Rabin S, Melzer A, Ribak J. The influence of nurses' knowledge, attitudes, and health beliefs on their safe behavior with cytotoxic drugs in Israel. *Cancer Nurs*. 2001;24:192–200.
16. Hon CY, Teschke K, Shen H. Health care workers' knowledge, perceptions, and behaviors regarding antineoplastic drugs: survey from British Columbia, Canada. *J Occup Environ Hygiene*. 2015;12:669–677.
17. Sorsa M, Hämeilä M, Järviuoma E. Handling anticancer drugs. *Ann NY Acad Sci*. 2006;1076:628–634.