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Knowledge, Attitude, and Practice Towards Safe Antineoplastic Drug Handling: A Cross Sectional Pilot Study Among Nurses in a Teaching Hospital

Muhammad Idham Jasmiad[1], Aslina Mohamed Yasin[1*], Nur Izzati Mansor[1], Amira Raudhah Abdullah[2], Noor Wahidah Mohd Nasri[3]

[1]Department of Nursing, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, [2]Discipline of Anatomy, Department of Medical Sciences 1, Faculty of Medicine and Health Science, Universiti Sains Islam Malaysia, Nilai, Negeri Sembilan, [3]Department of Physiology, Faculty of Medicine Manipal University College Malaysia, Melaka, Malaysia

ABSTRACT

Objectives: Antineoplastic drugs (ANPDs) play a vital role in cancer treatment. However, their hazardous properties, such as mutagenicity, teratogenicity, and carcinogenicity, pose significant occupational health risks to healthcare workers, particularly nurses. Prolonged exposure to these agents can lead to severe health consequences. Despite the establishment of guidelines and growing awareness about the importance of ANPDs and safe handling practices, studies reveal gaps in compliance among nurses that are attributed to insufficient training, workload pressures, and resource limitations. This study aims to evaluate the knowledge, attitude, and practice (KAP) of nurses in Klang Valley, Malaysia, on the safe handling of ANPDs.

Material and Methods: A cross-sectional pilot study was conducted on 30 oncology, haematology, and medical nurses at Hospital Canselor Tuanku Muhriz (HCTM). The participants were randomly selected, and data were collected using a validated, 33-item questionnaire previously tested with Cronbach's alpha reliability score of 0.7.

Results: The study found that nurses with post-basic certification and formal training in ANPD handling had significantly better knowledge (M = 55.11, SD = 7.66) compared to those without training (M = 43.83, SD = 10.62). Additionally, 66.7% of the nurses scored above the average mean in knowledge (56.50±6.19), while 70% scored above the mean in both attitude (32.95±2.22) and practice (51.29±4.94), suggesting a positive correlation between experience, training, and safe handling practices.

Conclusion: The findings highlight that nurses have a strong understanding of the safe handling of ANPDs; however, there is a need to implement more training programs to improve safety further and ensure consistent adherence to recommended guidelines.

Keywords: Antineoplastic drug (ANPDs), Attitude, Haematology, Knowledge, Nurses

INTRODUCTION

Antineoplastic drugs (ANPDs) are crucial in treating cancer and are classified as human carcinogens.[1,2] In 2020, the global statistics reported 19.3 million new cancer cases and 9.96 million cancer-related deaths.[3] The incidence of cancer has been reported to increase worldwide. The widespread use of ANPDs underscores their essential role in cancer management. Given the estimated increase in the number of cancer cases worldwide, nurses who handle and administer ANPDs may face an increased risk of exposure.[4,5] Kyprianou (2010) reported that over 50% of the nurses in the studied population experience symptoms of exposure.[6] Exposure to ANPDs has been linked to chronic health hazards, including genotoxicity, mutagenicity, and carcinogenicity,[7] and may cause symptoms such as skin rashes, sore throats, coughs, dizziness, headaches, eye irritation, hair loss, and allergic reactions.[8,9] The impact of occupational exposure highlights the importance of effectively managing and implementing safe practices in the handling of ANPDs.

As mentioned, nurses play a critical role in the administration and handling of ANPDs as part of cancer treatment,[10] similar to the practice in Malaysian Hospital settings. Their responsibilities include preparing and administering ANPDs, monitoring patients for side effects, ensuring proper safety

***Corresponding author:** Dr. Aslina Mohamed Yasin, Department of Nursing, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia. aslina@hctm.ukm.edu.my

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protocols are being followed as well as continuous patient education.[11,12] Numerous guidelines and protocols have been implemented to enhance the safe handling of ANPDs and protect nurses from potential exposure risks.[11] These guidelines typically include the use of personal protective equipment (PPE), drug preparation and administration protocol, spill management, and disposal of ANPDs.[6,8] However, studies have shown that varying levels of exposure persist and lack of adherence to the existing safety guidelines.[13,14] Previous studies have also reported incidences of drug spills and the presence of biological evidence of occupational exposure among nurses.[15] Findings highlighted that these challenges are largely due to issues related to the inconvenience of PPE use, time constraints while on duty, and limited resource availability.[16,17] Hence, the nurses' awareness of the safe handling of ANPDs remains a concern.

KAP evaluation and its relationship with their attitude is crucial to identifying the level of a nurse's knowledge and their implementation of safe ANPD practices. To date, there is a significant lack of research on this topic within the context of Malaysian hospital settings. Previous studies addressing this topic have taken place in other countries, making their direct applicability within the Malaysian hospital setting uncertain.[18,19] Increased knowledge among nurses improves adherence to safety measures and, in turn, enhances their well-being.[20] Therefore, this study aims to evaluate the knowledge, attitude, and practice (KAP) of oncology, haematology, and medical nurses at Hospital Canselor Tuanku Muhriz (HCTM) concerning the safe handling of ANPDs. Furthermore, the study seeks to provide an understanding of the relationship between KAP and the impact of socio-demographic variables on knowledge levels among nurses. The findings allow for improvements and planned intervention to mitigate any occurrence of accidental hazards and exposure, which will lead to a safer handling practice of ANPDs among nurses in Malaysia.

MATERIAL AND METHODS

Study design

A cross-sectional pilot study evaluating the safe handling of ANPDs was conducted among nurses working in the oncology, haematology, and medical-based wards at HCTM between June 2023 and September 2023. These settings were chosen because they are tertiary healthcare facilities providing specialised clinical services for a large population within Klang Valley, Malaysia. The study was designed as a pilot to test the feasibility of the questionnaire and assess all components of the research before proceeding with the full-scale study. A random sampling method was used to enrol 30 nurses into this study. Data were collected at a single point in time. The inclusion criteria for participants was a minimum of six months of working experience in oncology, haematology, and medical-based wards at HCTM who are informed about the safe handling of ANPDs. Nurses without prior working experience and those on long leave and maternity leave were excluded from this study.

Research instrument

The KAP instrument was adopted from a study conducted by Alehashem and Baniasadi (2018).[21] The study instrument includes a self-administered questionnaire consisting of 33 questions presented in two languages, both English and Malay. The instrument has been validated by the previous study with a reported Cronbach alpha of 0.7. The study instruments have four sections assessing the level of knowledge, risk, and training provided on the safe handling of ANPDs. The first section contains demographic information. The following section comprises 13 questions that evaluate the participants' knowledge of the protocols and standards for the preparation, administration, waste disposal, and storage of ANPDs. The third section, on the other hand, analyses the participants' attitudes toward working as a haematology, oncology, and medical nurse and their concerns about the safe handling of ANPDs. The last section consists of 12 questions that focus on the participant's practice based on the training and standard guidelines provided when dealing with ANPDs. All the items require an ordinal response through a five-point Likert scale. KAP scoring was calculated based on the mean, with a higher mean score indicating greater agreement with the statement and scores above the mean are evaluated as sufficient. The maximum scores for knowledge, attitude, and practice are 65, 40, and 60, respectively.

Ethical aspect

The study was approved by the Universiti Kebangsaan Malaysia (UKM) Research Ethics Committee (Number UKM PPPI/111/8/JEP-2-23-461). Informed consent was obtained from the nurses before they completed the questionnaires. The data were collected anonymously and used exclusively for this study.

Statistical analysis

The data obtained in this study were analysed using IBM SPSS (statistical package for social sciences) version 25.0 for Windows. The Shapiro-Wilk test was conducted to test for normality. Descriptive analyses were performed to outline the participants' socio-demographic data. Mean and standard deviation (SD) were used to describe continuous data. Meanwhile, bivariate analyses were performed to determine the relationship between knowledge, attitude, and

practice and associated socio-demographic factors, using the Spearman correlation test, independent t-test, and one-way ANOVA (analysis of variance) test. A significant level (α) of $p < 0.05$ was set for all tests.

RESULTS

Sociodemographic characteristics of participants

A total of 30 nurses with experience in handling ANPDs participated in this study, and 30 valid questionnaires were collected. The distribution of participants demographics has been described in Table 1, including age, gender, marital status, working experience (years), education, post-basic certification, and formal training in ANPDs. Most participants were in the 31-40 (66.67%) years age range, with a mean of 51.80 ± 10.03 and a mean of 33.60 ± 5.24 for the total age. Most participants were females (90.0%), married (66.67%), and had more than five years of working experience (73.33%). All nurses possessed a nursing diploma (100.0%). Additionally, most of the participants did not hold post-basic certification (66.67%), while most nurses had undergone formal training in ANPDs (60.0%).

Table 1: Sociodemographic characteristics of nurses in Hospital Canselor Tuanku Muhriz (HCTM)

Characteristic	Number (n) %	Knowledge		Attitude		Practice	
		Mean (± SD)	*p* value	Mean (± SD)	*p* value	Mean (± SD)	*p* value
Total	30 (100.0)	50.60 (±10.43)		30.23 (± 8.38)		43.00 (± 8.38)	
Age (years)	33.60 (± 5.24)		0.031		0.370		0.707
21-30	7 (23.33)	43.00 (± 8.38)		28.43 (± 5.76)		45.00 (± 7.02)	
31-40	20 (66.67)	51.80 (± 10.03)		30.40 (± 5.03)		46.30 (± 10.90)	
41-50	3 (10.0)	60.33 (± 9.50)		33.33 (± 1.15)		50.67 (± 6.42)	
Gender			0.093		0.98		0.377
Male	3 (10.0)	41.00 (± 2.00)		25.67 (± 1.52)		41.67 (± 5.132)	
Female	27 (90.0)	51.67 (± 10.45)		30.74 (± 5.04)		46.96 (± 9.95)	
Marital Status			0.521		0.712		0.987
Single	8 (26.67)	52.75 (± 14.05)		29.63 (± 6.41)		46.50 (± 12.91)	
Married	20 (66.67)	49.15 (± 8.82)		30.20 (± 4.74)		46.30 (± 8.974)	
Others	2 (6.67)	56.50 (± 12.02)		33.00 (± 1.41)		47.50 (± 2.12)	
Working experience (years)	9.83 (±5.77)		0.065		0.537		0.813
1-5	8 (26.67)	43.63 (± 11.79)		28.50 (± 7.63)		45.38 (±11.21)	
6-10	10 (33.33)	51.50 (± 9.59)		30.10 (± 4.30)		47.50 (± 9.25)	
11-15	7 (23.33)	51.29 (± 7.61)		30.57 (± 3.86)		44.14 (± 11.95)	
16-35	5 (16.67)	59.00 (± 7.96)		32.80 (± 1.78)		49.20 (±5.07)	
Education Level							
Diploma	30 (100.0)	50.60 (± 10.43)		30.23 (± 5.03)		46.43 (± 9.65)	
Post-Basic Certification			0.273		0.726		0.338
Yes	10 (33.33)	53.60 (± 9.24)		30.70 (± 3.59)		44.00 (± 10.04)	
No	20 (66.67)	49.10 (± 10.89)		30.00 (± 5.69)		47.65 (± 9.48)	
Specialty Post-Basic			0.226		0.484		0.120
No Post Basic	20 (66.67)	49.10 (± 10.89)		30.00 (± 5.69)		47.65 (± 9.48)	
Oncology/Haematology Post Basic	4 (13.33)	59.00 (± 8.04)		33.00 (± 1.15)		50.75 (±5.12)	
Other Post Basic	6 (20.0)	50.00 (± 8.71)		29.17 (± 3.92)		39.50 (± 10.25)	
Formal Training in Handling of ANPDs			0.002		0.010		0.002
Yes	18 (60.0)	55.11 (± 7.66)		32.11 (± 3.00)		50.67 (± 5.32)	
No	12 (40.0)	43.83 (± 10.62)		27.42 (± 6.20)		40.08 (± 11.34)	

SD: Standard deviation, ANPDs: Antineoplastic drugs.

Nurses' knowledge, attitudes, and practice regarding the safe handling of ANPDs

KAP scores were computed for each participating nurse based on their responses. The mean of participant responses was set as the cut-off point for each analysed item. The mean scores of responses were 50.60±10.43 for knowledge, 30.23±5.03 for attitude, and 46.43±9.65 for practice, as shown in Table 2. Of all participants, 66.7% had a knowledge score above the mean score of 56.50±6.19, and 70% scored above the mean for attitude (32.95±2.22) and practice (51.29±4.94). The results indicate that the nurses who took part in this study demonstrated good knowledge, attitude, and practice.

Table 2: Mean KAP scoring of the nurses towards safe handling of ANPDs

Score	Number (n) %		
		Mean	Std. deviation (SD)
Total	30 (100.0)		
Knowledge		50.60	+10.43
Good (48-65)	20 (66.7)	56.50	+6.19
Moderate (31-47)	8 (26.7)	41.50	+2.39
Poor (13-30)	2 (6.7)	28.00	+2.82
Attitude		30.23	+5.03
Good (30-40)	21 (70)	32.95	+2.22
Moderate (19-29)	8 (26.7)	24.88	+2.64
Poor (8-18)	1 (3.3)	16.00	-
Practice		46.43	+9.65
Good (40-60)	21 (70)	51.29	+4.94
Moderate (29-44)	7 (23.3)	38.71	+5.09
Poor (12-28)	2 (6.7)	22.50	+2.12

KAP: Knowledge, attitude and practice, ANPDs: Antineoplastic drugs.

Knowledge items

The nurses were assessed with 13 items for their level of knowledge towards the safe handling of ANPDs, as shown in Table 3, and the summary has been presented in Figure 1. The highest proportion of "strongly agree" responses was recorded for three items: awareness of the cytotoxic nature of ANPDs (46.7%), understanding of routes of exposure to ANPDs (33.3%), and the necessity of using a biological safety cabinet (BSC) for preparation (33.3%). Meanwhile, most items received an "agree" response, including knowledge of the adverse health effects of ANPDs (40%), safe administration practices (40%), and correct usage of personal protective equipment (PPE) (43.3%). This indicates an overall adequate awareness of standard safety protocols. These responses highlight the understanding of critical safety aspects among the nurses in HCTM. However, a significant number of nurses

Table 3: Nurses knowledge towards safe handling of antineoplastic drugs (ANPDs)

Variables	Number of participants (n) %					Mean	Std. deviation (SD)
Knowledge statements[b]	**Strongly agree[a]**	**Agree[a]**	**Neutral[a]**	**Disagree**	**Strongly disagree**		
Antineoplastic drugs (ANPDs) are cytotoxic	**14 (46.7)**	11 (36.7)	3 (10)	2 (6.7)	0	4.23	±0.89
I am aware of all routes of exposure to ANPDs	**10 (33.3)**	8 (26.7)	**10 (33.3)**	2 (6.7)	0	3.87	±0.97
I am aware of adverse health effects of ANPDs	10 (33.3)	**12 (40)**	5 (16.7)	3 (10.0)	0	3.97	±0.96
I know management of adverse health effects of ANPDs	8 (26.7)	**10 (33.3)**	**10 (33.3)**	2 (6.7)	0	3.60	±0.93
I know guidelines and standards for safe preparation of ANPDs	7 (23.3)	9 (30.0)	**11 (36.7)**	3 (10.0)	0	3.67	±0.95
I know safe administration of ANPDs	11 (36.7)	**12 (40.0)**	6 (20.0)	1 (3.3)	0	3.83	±0.95
I know safe transport and storage of ANPDs	7 (23.3)	**14 (46.7)**	6 (20)	3 (10.0)	0	3.83	±0.91
I have to use biological safety cabinet (BSC) for all preparations	**10 (33.3)**	**10 (33.3)**	8 (26.7)	2 (6.7)	0	3.93	±0.94
I know correct use of BSC	7 (23.3)	9 (30.0)	**10 (33.3)**	4 (13.3)	0	3.63	±0.99
I know management of accidents in handling of ANPDs	8 (26.7)	**10 (33.3)**	**10 (33.3)**	2 (6.7)	0	3.80	±0.92
I know all required personal protective equipment (PPE)	10 (33.3)	**13 (43.3)**	6 (20.0)	1 (3.3)	0	4.07	±0.82
I know how to use PPE correctly	10 (33.3)	**13 (43.3)**	6 (20.0)	1 (3.3)	0	4.07	±0.82
I know safe waste disposal of ANPDs	11 (36.7)	**12 (40.0)**	6 (20.0)	1 (3.3)	0	4.10	±0.84

[a]The highest respond answers are highlighted in bold
[b]These questions were adapted from previous studies by Alehashem and Baniasadi (2018).

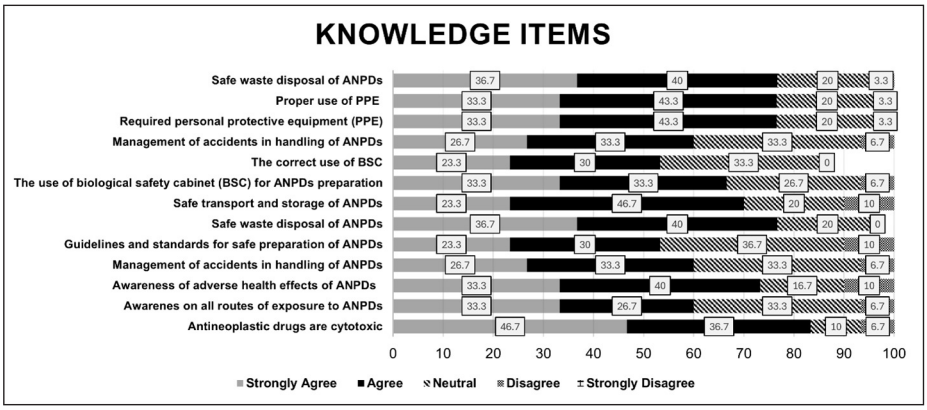

Figure 1: Responses from participants on individual knowledge items. ANPDs: Antineoplastic drugs.

express neutral responses to questions about the guidelines and standards for the safe preparation of ANPDs (36.7%), management of adverse health effects (33.3%), and proper use of BSCs (33.3%). These findings suggest a lack of confidence or insufficient familiarity with these specific aspects of safety protocols.

Attitude items

A total of 8 items were asked among the nurses regarding their attitude towards safe handling of ANPDs, as described in Table 4 and presented in Figure 2. Overall, the results demonstrated a strong awareness of the importance of safe handling practices among the participants. A majority (86.6%) agreed or strongly agreed that adhering to safe handling protocols ensures they are not at risk. Similarly, the use of PPE in handling ANPDs was considered essential by 86.7% of the participants. When asked about handling ANPDs during workload pressure, 63.3% of nurses either agreed or strongly agreed that unsafe handling in such conditions is unacceptable. However, 33.3% of respondents responded with a neutral response. Additionally, concerns about the adverse health effects of exposure to ANPDs were prevalent, with 73.4% of nurses expressing their worry.

The behavioural aspects of handling ANPDs were also explored. Most nurses (76.7%) stated that they handle these drugs without hurrying, and 83.4% agreed that they pay close attention to precautionary measures, demonstrating a good approach to safety. However, when assessing job satisfaction and willingness to work in oncology, only 33.3% of nurses reported being willing to start their work in oncology, and 36.6% expressed a continued willingness to remain in this field. These findings may indicate challenges in job motivation and satisfaction in a high-risk and high-stress environment.

Table 4: Nurses attitude towards safe handling of antineoplastic drugs (ANPDs)

Variables	Strongly agree[a]	Number of participants (n) %				Mean	Std. deviation (SD)
Attitude statements[b]		Agree[a]	Neutral[a]	Disagree	Strongly disagree		
Safe handling of ANPDs make me ensure that I am not at risk	10 (33.3)	**16 (53.3)**	3 (10.0)	1 (3.3)	0	4.17	±0.74
Use of PPE in handling of ANPDs is essential	12 (40.0)	**14 (46.7)**	3 (10.0)	1 (3.3)	0	4.23	±0.77
Unsafe handling in work overload condition is unacceptable	6 (20.0)	**13 (43.3)**	10 (33.3)	1 (3.3)	0	3.80	±0.80
Adverse health effects of ANPDs exposure are worrying	8 (26.7)	**14 (46.7)**	7 (23.3)	1 (3.3)	0	3.97	±0.80
I handle ANPDs without hurrying	6 (20.0)	**17 (56.7)**	4 (13.3)	3 (10.0)	0	3.86	±0.87
I pay attention to precautions measurement's	8 (26.7)	**17 (56.7)**	4 (13.3)	1 (3.3)	0	4.07	±0.74
I started my work in oncology with my willing	1 (3.3)	9 (30.0)	**14 (46.7)**	2 (6.7)	4 (13.3)	3.03	±1.03
I continue my work in oncology with my willing	1 (3.3)	10 (33.3)	**13 (43.3)**	3 (10.0)	3 (10.0)	3.10	±0.99

[a]The highest respond answers are highlighted in bold
[b]These questions were adapted from previous studies by Alehashem and Baniasadi (2018).
ANPDs: Antineoplastic drugs, PPE: Personal protective equipment.

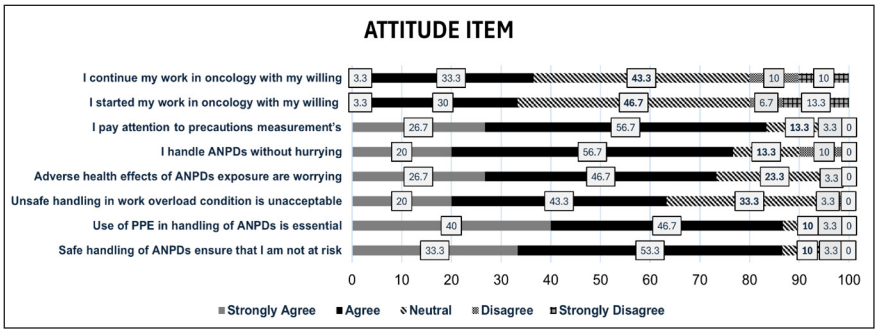

Figure 2: Participants feedback on each attitude items. ANPDs: Antineoplastic drugs, PPE: Personal protective equipment.

Table 5: Nurses practice towards safe handling of antineoplastic agent.

Variables	Number of participants (n) %					Mean	Std. deviation (SD)
Practice statements[b]	**Strongly Agree[a]**	**Agree[a]**	**Neutral[a]**	**Disagree**	**Strongly disagree**		
I always prepare ANPDs in preparation room	9 (30.0)	**10 (33.3)**	8 (26.7)	3 (10.0)	0	3.83	±0.98
I always prepare ANPDs in BSC	3 (10.0)	10 (33.3)	**12 (40.0)**	5 (16.7)	0	3.37	±0.89
I never do risky behaviour (eat, drink, smoke) in preparation room/	**14 (46.7)**	8 (26.7)	5 (16.7)	2 (6.7)	1 (3.3)	4.07	±1.11
I don't store ANPDs in preparation room	6 (20.0)	8 (26.7)	**10 (33.3)**	5 (16.7)	1 (3.3)	3.43	±1.10
I use standard guidelines for handling of ANPDs	**10 (33.3)**	**10 (33.3)**	7 (23.3)	2 (6.7)	1 (3.3)	3.87	±1.07
I use PPE for preparation of ANPDs	**13 (43.3)**	11 (36.7)	5 (16.7)	1 (3.3)	0	4.20	±0.84
I use PPE for administration of ANPDs	**13 (43.3)**	12 (40.0)	4 (13.3)	1 (3.3)	0	4.23	±0.81
I use PPE for transport and storage of ANPDs	7 (23.3)	**16 (53.3)**	5 (16.7)	2 (6.7)	0	3.93	±0.82
I manage accidents in handling based of standard protocols	8 (26.7)	**13 (43.3)**	7 (23.3)	7 (23.3)	0	3.90	±0.88
I record and report all accidents in handling of ANPDs	8 (26.7)	**14 (46.7)**	6 (20.0)	1 (3.3)	1 (3.3)	3.90	±0.96
I consult with clinical pharmacist about safe handling	9 (30.0)	**15 (50.0)**	4 (13.3)	1 (3.3)	1 (3.3)	4.00	±0.94
I consult with occupational medicine specialist about related health problems	6 (20.0)	**12 (40.0)**	10 (33.3)	1 (3.3)	1 (3.3)	3.70	±0.95

[a]The highest respond answers are highlighted in bold.
[b]These questions were adapted from previous studies by Alehashem and Baniasadi (2018).
ANPD: Antineoplastic drugs, BSC: Biological safety cabinet PPE: Personal protective equipment.

Practice items

A set of twelve questions was presented to the nurses, addressing their practices related to the safe handling of ANPDs, as outlined in Table 5 and exhibited in Figure 3. Some of the nurses (33.3%) agreed that they always prepare ANPDs in the preparation room, while only a small percentage (10.0%) strongly agreed to prepare ANPDs in the BSC. Nearly half of the respondents (46.7%) strongly agreed that they never engage in activities such as eating, drinking, or smoking in the preparation room. With respect to storage practices, 33.3% of the nurses showed a neutral response, and 26.7% agreed that they avoid storing ANPDs in the preparation room. Adherence to standard guidelines for handling ANPDs was affirmed by a majority of the nurses, with 33.3% strongly agreeing and 33.3% agreeing. There is strong compliance with the use of PPE during preparation and administration; 43.3% strongly agreed, and 53.3% agreed to use PPE during transport and storage. In terms of accident management, 43.3% agreed to handle accidents based on standard protocols, but fewer respondents (26.7%) strongly agreed. When asked about the reporting practices, 46.7% agreed to recording and reporting accidents, while 50.0% agreed to consulting clinical pharmacists for guidance on safe handling.

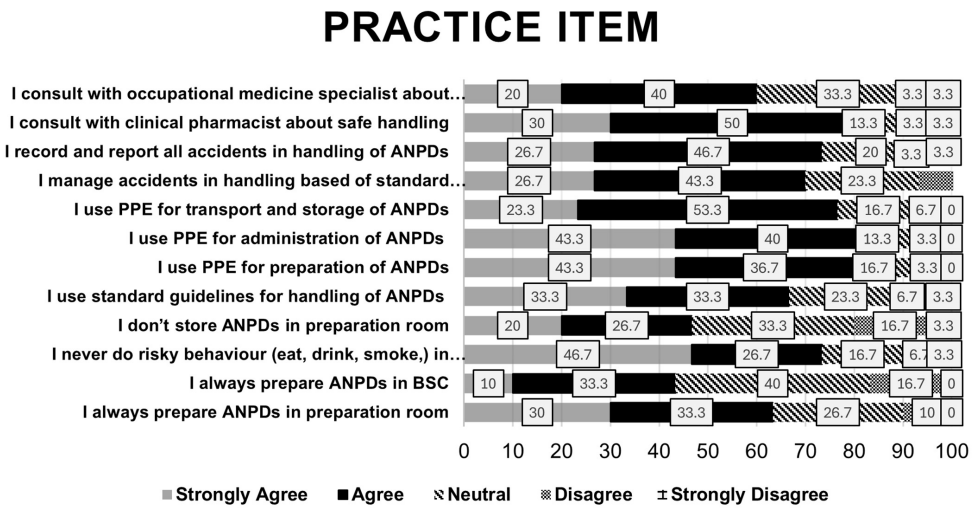

Figure 3: Participants' responses on each item of the practice items.

Relationship between knowledge, attitude, and practice with demographic characteristics of the nurses

Bivariate analysis was done to understand the relationship between nurses' knowledge and their sociodemographic characteristics. Spearman correlation test revealed significant correlations between knowledge and attitude (ρ=0.779; $p<0.001$) as well as knowledge and practice ($\rho = 0.679$; $p < 0.001$). Age was also significantly correlated with knowledge ($\rho = 0.367$; $p = 0.046$). This shows that as age increases, the knowledge about the safe handling of ANPDs improves. Additionally, results show that working experience was positively correlated with knowledge (ρ=0.486, p=0.006). However, the One-way ANOVA test indicated that nurses with post-basic certification did not show a statistically significant difference in knowledge levels (F=1.573, p=0.226). Interestingly, formal training in handling ANPDs demonstrated a statistically significant influence on knowledge (t=3.382, p=0.002), analysed using the independent sample t-test.

DISCUSSION

To the best of our knowledge, this is the first study to explore the KAP of nurses in Malaysia regarding the safe handling of ANPDs. Our study examined both the level of nurses' knowledge, attitude and their reported safe handling practices. The cross-sectional pilot study conducted received a 100% response rate. According to the sociodemographic description of the participants, the participants were mostly 31-40 years old (66.7%), and more than half of them had more than five years of working experience (73.3%). Hence, most of the participating nurses in this study possess considerable professional experience in their respective fields. Previous findings have mentioned that experienced nurses are an important resource for decision-making.[22] Experienced nurses reflect on their practice, which influences their judgment and aids decision-making in clinical settings.[23]

Most importantly, the study reveals that the nurses possess good level of knowledge (66.7%); scoring surpassing the mean. A strong foundation of knowledge concerning ANPDs is crucial to fostering the nurse's commitment to safety guidelines. These results are higher than those of studies conducted in Turkey[24] and Iran.[13,21] Nonetheless, the knowledge score among these nurses is lower compared to the study conducted in Cyprus[6] and Egypt.[18] Meanwhile, 70% of the nurses scored above the mean for attitude (32.95±2.22) and practice (51.29±4.94). Results from this study suggested better attitude and practice as compared to the nurses reported in Pakistan,[25] Jordan[26] and Ethiopia.[12] Khanali *et al* (2021) reported that most nurses in Pakistan only have a moderate level of attitude towards safe ANPD handling when compared to our study.[27] Item analysis response for attitude reveals that most nurses agreed on the need for safety protocols and PPE use. While many rejected unsafe practices during workload pressure, some gave neutral responses, suggesting room for improvement in safety attitudes. The concerns about health risks from exposure were fair, highlighting the need for better support and education. Although most nurses reported being cautious in handling ANPDs, this study reported low job satisfaction and willingness to work in the oncology department, which suggests challenges in retaining the staff in the oncology field.

The Spearman's ρ correlation results in Table 6 showed a strong, significant positive correlation between the nurses' knowledge and attitude. Meanwhile, there is also a strong, significant positive correlation between knowledge and practice regarding the safe handling of ANPDs. Alehashem *et*

al (2018) found a similar correlation among the nurses in Iran regarding the safe handling of ANPDs.[21] A reported study from India also indicated a positive relationship between knowledge and practice together with knowledge and attitude.[28] Item analysis on the practice items revealed that the majority of the nurses adhered to safety protocols. However, the ANPD storage practices showed inconsistency, with some nurses remaining neutral in their responses, indicating a need for clearer guidelines. Strong compliance was noted in PPE use during transport and storage. Nevertheless, fewer nurses strictly followed the accident management protocols. These results emphasise the need for targeted training and stricter enforcement to ensure consistent safety practices.

Our findings also revealed that there was a significant correlation between age and work experience in nursing with the knowledge scores. Reported studies have shown that the number of years of working experience in the field of nursing helps to facilitate the nurses' clinical judgment.[22] Additionally, the study showed that post-basic certification in oncology nursing was significantly associated with knowledge. Out of all the participants that took part in this study, only 30% possess post-basic certification specialising in either oncology or haematology. Advance certification is a process that validates nurses' knowledge and expertise in a defined clinical area of nursing.[29] Thus, earning a certification in oncology signifies that a nurse possesses the knowledge and skills necessary to provide effective care for cancer patients.[30-32] Research has supported that certified oncology nurses exhibited superior knowledge in the assessment and management of oncology-specific tasks as compared to their noncertified colleagues.[33] Hence, the advantages of post-basic certification for nurses should not be disregarded.

Lastly, there was a significant difference between the level of nurses' knowledge and the training in handling ANPDs. As highlighted, continuing nursing education is vital for staying updated with the latest practices and knowledge related to the safe handling of ANPDs. In a web-based survey conducted by the National Institute for Safety and Health (NIOSH), Boiano *et al* (2014) revealed a high number of failures of nurses to fully follow proper ANPD administration guidelines.[34] There are also studies reporting that most nurses deployed to the oncology department did not receive formal training prior to their placement.[35,36] Workplace training plays a crucial role in improving staff knowledge of ANPDs while simultaneously increasing their awareness of the standard practice. Therefore, findings from this study underscore the importance of attitude and practice as critical factors in shaping knowledge, while age, working experience, and formal training also play significant roles in improving nurses' understanding of safe ANPD handling practices. Although the study offers valuable preliminary data on nurses' KAP in the safe handling of ANPDs within a Malaysian healthcare setting, the small sample size limits the generalizability of the findings. As a pilot study, its primary purpose is to assess the feasibility of the research design rather than provide definitive conclusions for broader populations.

CONCLUSION

In conclusion, this study provides valuable insights into the KAP of nurses in Malaysia regarding the safe handling of ANPDs. The findings indicate a strong foundation of knowledge and positive attitudes towards safety protocols. However, some areas, such as storage practices and accident management, showed inconsistencies that highlight the need for clearer guidelines and improved training. The study also identified key factors, including age, work experience, and post-basic oncology certification, that significantly contributed to better knowledge and adherence to safe handling practices. Furthermore, the importance of continuing nursing education and formal training in enhancing nurses' competence in handling ANPDs was emphasised. While the study offers valuable preliminary data, the small sample size limits the generalisability of the findings, suggesting the need for further research with a larger sample to confirm and expand upon these results.

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Author contribution

A.M.Y. conceived and designed the study. N.I.M. and N.W.M.N. were involved in planning and supervising the work. M.I.J. conducted the experimental studies, acquired the data, performed the data analysis, and wrote the manuscript. A.M.Y., N.I.M., N.W.M.N., and A.R.A. reviewed and edited the manuscript. A.M.Y. assumes responsibility as the guarantor for the integrity of the work as a whole, from preparation to publication. All authors have read, approved, and agreed to the final version of the manuscript.

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Availability of data and materials

All materials analysed for this study are included in this article.

Ethics approval and consent to participate

Prior to participating in this study, the participants were given adequate information on the aim, procedure, nature and confidentiality of the study, and their oral consent to participate was obtained.

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