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Knowledge of Safe Handling of Chemotherapy among the nurses in Queen Elizabeth Hospital, Kota Kinabalu, Sabah

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ABSTRACT

There are various types of cytotoxic agents used in the treatment of chemotherapy, and each agent can cause undesirable side effects in both patients and nurses, who are also skilled in dealing with these antineoplastic agents. Twenty true or false, closed-ended questionnaires were utilised to assess and evaluate the knowledge of nurses regarding the safety of chemotherapy. A total of 107 nurses participated in the assessment and evaluation, with only 59.22% receiving correct answers overall. The majority of respondents, 73.8% (79 out of 107) demonstrated moderate knowledge with 10 to 16 correct responses out of 20 questions. The majority of their knowledge regarding the safe handling of chemotherapy came from Continuous Nursing/Medical Education (CNE/CME) and the internet respectively. In general, the results demonstrated that nurses have insufficient knowledge of cytotoxic agents, as evidenced by the fact that the average percentage of correct responses was below 60%. Therefore, nurses must receive extensive additional education about anticancer agents in nursing school and through in-hospital continuing education. It is essential for nurses to participate in a structured educational programme, such as a Post Basic or Advanced Diploma in Oncology Care, in order to obtain proper updates and certification. In addition, the study suggested that updating the knowledge of safe handling among nurses with supported guidelines and policies will aid in enforcing safety implementation within clinical settings.

1. Introduction

Chemotherapy is an essential cancer treatment modality that destroys cancer cells with the intention of promoting cure, disease control, or palliative manifestation. According to [18], it was first discovered in 1940, during World War II, by two Yale School of Medicine pharmacologists who discovered that

individuals exposed to nitrogen mustard developed leukopenia, a condition characterised by a low white blood cell count, which was subsequently discovered in the treatment of lymphoma. Cytotoxic drugs exhibit carcinogenicity, genotoxicity, teratogenicity, fertility impairment, serious organ damage, or any other toxic exposure at low doses in both animal and human experiments [1], [16], [49]. In the meantime, doctors, pharmacists, and nurses are at risk of exposure during the chemotherapy treatment process, including preparation, transportation, administration, and disposal. [9], [53], [8] found that cytotoxic exposure among healthcare workers occurs during the manufacturing, transport, distribution, use in healthcare settings, and waste disposal cycles. The National Institute for Occupational Safety and Health [33] lists 324 anti-neoplastic drugs, the majority of which are used as chemotherapy, also known as anti-neoplastic drugs, anticancer drugs, cytostatic drugs, cytotoxic drugs, or hazardous drugs.

These medications are available in numerous dosage forms, including tablets, capsules, solutions, and injections. According to the [48], more than 11 million patients worldwide are diagnosed with cancer each year. This number is projected to increase to 21.6 million by 2030. Cancer, also known as neoplasm or malignant tumour, is the second leading cause of death worldwide in 2018, accounting for one out of every six deaths. The leading cause of cancer-related mortality is advanced disease, or metastasis, a process in which abnormal cells grow and proliferate uncontrollably by invading adjacent organs. However, the treatment processes can also cause adverse signs and symptoms in healthcare personnel when they are exposed to dangerous agents. Alopecia, headache, dizziness, malaise, nausea, dermatitis, rash, skin and mucous membrane irritation or ulceration, and eye or throat irritation are some of the short-term symptoms of acute exposure [46], [42]. Over time, the adverse effects of constant exposure will become increasingly significant and hazardous. Oncology is a branch of medicine concerned with the diagnosis, prevention, treatment, and palliation of cancer in both solid tumours and haematological leukaemia, as well as the dissemination of the most recent information and specialisations regarding antineoplastic agents among healthcare professionals.

Oncology is a specialised branch of medicine that focuses on the care, diagnosis, and treatment of cancer [30]. It includes medical oncology, radiation oncology, and surgical oncology. The care of cancer patients with conditions like breast cancer, lung cancer, melanoma, leukaemia, and more is provided by oncology nurses [10]. The initiation of the field in the early 1970s necessitated advanced and ongoing training, in addition to education beyond basic nursing certification, to ensure the quality of care. In addition, with a greater understanding of oncology care, healthcare professionals can eliminate hazards in the clinical environment and administer chemotherapy to patients in a safe manner. revealed that knowledge can impact the quality of care and the safety of healthcare professionals [45]. Therefore, to remain a dynamic and proactive oncology nursing professional, it is essential to remain dynamic and proactive with the latest guidelines and updates in cancer treatment and cytotoxic agent handling. Along with the development of new anti-neoplastic agents and the rise in the number of cancer patients, the treatment protocol for each type of cancer has evolved. Undoubtedly, nurses are the majority of personnel involved in the administration and handling of chemotherapy in the clinical setting. [44] reported that Iranian nurses exposed to cytotoxic drugs are at risk for anaemia, iron deficiency, and thyroid diseases, as well as changes in genotoxicological and immunotoxicological functions. These drugs are dangerous due to their carcinogenicity, genotoxicity, and teratogenicity, which may cause infertility, damage to vital organs, or other toxic manifestations. According to [5], [8], the pharmacological property of antineoplastic agents is to destroy cancerous cells by interfering with their ability to divide. Nevertheless, their pharmacology is not only specific to cancerous cells, but also damages noncancerous cells immediately after administration. Consequently, these cytotoxic agents can cause significant side effects in the treatment chain for both patients and medical staff. [41] in the United Kingdom found that the greater the frequency of cytotoxic

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drug administration, the greater the risk of cytotoxic exposure among healthcare professionals. In addition, the study revealed that 33% of nurses developed alopecia, 38% of nurses experienced skin irritation, and 26% experienced nausea while working in the oncology and haematology departments.

According to [13], nurses are the primary healthcare workers in the United States who administer chemotherapy to patients. Due to suboptimal use of personal protective equipment (PPE) when handling hazardous drugs, the study revealed that nurses face an increased risk of cytotoxic exposure. In addition, the study revealed an alarming lack of tested interventions to enhance practise. Thus, two interventions were implemented in the clinical setting: the provision of an educational module and the collection of feedback from nurses to improve nurses' knowledge and reduce barriers to PPE utilisation. After performing these interventions, nurses can learn and recognise the significance of PPE in the oncology ward, particularly when handling chemotherapy.

Multiple studies have demonstrated that nurses who have handled cytotoxic drugs on the job are susceptible to alopecia, dermatitis, and nausea. Researchers [41], [42] discovered cytotoxic contamination in the urine samples of nurses who had administered chemotherapy. In addition, [23] reported that children of nurses with chronic exposure to cytotoxic agents have an elevated risk of miscarriage, preterm labour, and learning disabilities. Every person who administers cytotoxic drugs is exposed to contaminated clothing, working environment, medical equipment, and patient excreta [4]. During the administration process, the cytotoxic agents are administered through direct contact, inhalation, and ingestion. Sadly, limited research has been conducted on the effects of cytotoxic exposures in Malaysia. Oncology wards and other general medical wards comprised the study population. Consequently, this study was conducted to assess the knowledge of nurses in the study population regarding the safe handling of cytotoxic agents. In addition, this study can help raise awareness among nurses regarding the significance of following standard operating procedures (SOP) in order to reduce work hazards associated with cytotoxic drug exposure.

Literature Review

Occupational health and safety are essential concerns for the protection of workers' health, safety, and welfare. This is due to the fact that employees are an organization's most valuable asset, particularly in health care settings, which require a free of hazards, illnesses, and injuries working environment. According to the [26], healthcare workers are frequently exposed to chemical hazards, particularly in wards, oncology settings, laboratories, radiology units, and pharmacies. The hazards can enter the body via inhalation, dermal and mucous membrane absorption, ingestion, and trans-placental, where the foetus is exposed through the blood circulation of the pregnant mother. Thus, healthcare facilities across the globe are conducting research on the practise and safe handling of cytotoxic agents in order to investigate the complications and preventative measures necessary to ensure the safety of healthcare workers. [50] conducted a study in Osaka, Japan, and discovered that almost all occupational exposure to cytotoxic agents in 155 hospitals among healthcare providers was due to noncompliance with PPE use. Only 82.7% of healthcare providers wore gloves, 69% wore a mask, 62.1% wore gowns, and 36.8% wore goggles, according to the findings. Moreover, 10.1% of personnel handling the cytotoxic drug did not utilise any PPE. In addition, the study revealed that less than 80% of cytotoxic waste was properly managed and disposed of, and that less than 10% of patients' excrement was collected. The conclusion of the study was that safety precautions should be promoted.

Research done by [15] showed that in their study done in London with 507 participants, a total of 286 (56%) questionnaires were returned. 78% of nurses worked in inpatient and outpatient settings, and 61% administered chemotherapy daily. The median time spent administering chemotherapy was eight years,

while the median time spent working in oncology was ten. The most worrisome aspects of handling were dealing with allergic or anaphylactic reactions, extravagance, treatment side effects, and colleagues' lack of knowledge. There was no significant difference in anxiety based on the nurse's level of education, but those with oncology credentials had less knowledge about anxiety. Significant correlations existed between the number of years qualified, working in oncology, and administering chemotherapy and the anxiety domains. The investigation revealed that when nurses are initially anticipating the administration of chemotherapy, they are anxious and concerned about making a medication error.

The main factor contributing to hazardous exposure among healthcare professionals, according to [28], was the lack of policy and procedure books in the workplace. In addition, 86.2% of nurses reported having a heavy workload, 83.1% reported a lack of safe boxes for drug transportation, and 78.5% reported being unaware of the safety measures involved in the handling of anticancer agents. Through observation, [8] determined that, in General Hospital Malaysia, there were improper chemotherapy handling practises among nurses in the wards, despite the fact that antineoplastic agents had been primarily handled by nurses for approximately thirty years, with daily cytotoxic drug reconstitution (CDR) activities among nurses in the wards including transportation of undiluted cytotoxic agents from the pharmacy, preparation, administration, storage, and sprinkling. The average knowledge score of registered nurses on the initial evaluation was 45.50. In order to provide pharmacy CDR services, the pharmacist diluted and prepared cytotoxic agents using a closed system into readily usable forms with labels and instructions for handling. In the interim, the hospital also provided continuing nursing education (CNE) and cytotoxic agent handling. The second evaluation yielded a score of 73.4, which reflected an improvement.

[51] evaluated nurses' knowledge of chemotherapy with a questionnaire that included 20 true-false items. The empirical findings suggest that nurses have inadequate knowledge of chemotherapy administration. [20] study in Cyprus reported that the majority of nurses were aware of the potential risks associated with chemotherapy handling. The participants' knowledge resulted in a score of 79.43% out of a possible 100. During the preparation of anti-neoplastic agents, the majority of participants reported high levels of compliance with the use of gloves and protective gowns (95.4% and 84.5%, respectively). The vast majority of nurses (98.1%) reported using a safety cabinet during preparation. However, only 53.4% reported annual medical examinations, and only 33.3% reported receiving specialised training. They concluded that while nurses' knowledge of safe handling and use of personal protective equipment are high, employee training and medical surveillance appear to be lacking. [24] conducted their study in New York using a descriptive-correlational, self-reported survey in accordance with the current Occupational Safety and Health Administration (OSHA) guidelines for the handling of chemotherapy. They were all members of the Oncology Nursing Society who specified that they worked in a clinic, office, or outpatient private practise. More than 94% of participants reported routinely wearing gloves when handling chemotherapy; 55% reported using laboratory coats as protective garments. In 99 percent of workplaces, laminar air flow hoods were reported to be used for the preparation of chemotherapy. Only 46% of sites were reported to provide medical monitoring. Less than six percent of workers typically wore face and respiratory protection. In the meantime, the use and availability of personal protective equipment has increased when handling cytotoxics, but medical monitoring of exposure among employees is neither widely practised nor consistent with OSHA guidelines.

[21] found that 96 nurses working in healthcare settings in Klang, Malaysia that dealt with chemotherapy had above-average knowledge and attitude regarding the handling of cytotoxic agents. More than 85 percent of nurses learned how to handle cytotoxic drugs from their colleagues, especially senior staff, and less than 10 percent of nurses received formal oncology care education on chemotherapy. In addition, the study

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revealed that there was no correlation between nurses' working experience and cytotoxic agent handling experience and their level of knowledge. In Egypt, a study by [28] reported that none of them had received sufficient information in the training course of cytotoxic handling management, despite the fact that more than 70% of them had worked in oncology settings for more than 5 years. The top five complaints among registered nurses are alopecia (54 nurses), headache (50 nurses), eye injury (41 nurses), sore throat (40 nurses), dizziness, cough, and bronchitis (19 nurses). According to a study conducted in Iran by [16], 270 nurses experienced adverse effects, including headache and vertigo for 15%, alopecia for 13.3%, and skin rashes, itching, and burning sensation in the eyes for 12%. All exposure reactions were primarily caused by the cytotoxic preparation procedure. Thus, they suggested that providing educational courses and adhering to national standard guidelines for the handling of cytotoxic drugs is essential for healthcare personnel.

The use of personal protective equipment (PPE) and safe handling by nurses also play a crucial role in preventing cytotoxic drug-related hazards. Consequently, the objective of this quantitative study is to assess the nurses' knowledge and awareness of occupational hazards and adverse effects of chemotherapy. The findings will aid in the implementation of guidelines and policies pertaining to the safe handling of chemotherapy, which will be introduced into the healthcare system, particularly in settings where cytotoxic drugs are administered.

2. Methods

2.1 Samples

This was a correlational, cross-sectional study using a questionnaire adapted from [51]. All nurses who were permanently employed at Queen Elizabeth Hospital in Kota Kinabalu, Sabah, and were involved in the administration of chemotherapy. The hospital consisted of all the Covid-19 Isolation Wards, the Hematology Unit, and the General Medical Wards that handled cytotoxic agents. These locations were chosen because nurses were available to administer, prepare, store, and dispose of anti-neoplastic agents. According to a study by [51], 63.5% of the subjects had inadequate knowledge of cytotoxic handling practises. As a result, the expected prevalence is 63.5%, with a P = 0.635. Thus, the margin of error will be 5 percent and the level of confidence will be 95 percent. The sample size was calculated using a sample size calculator adapted from [29]. According to precision, the recommended sample size was 357 subjects. Because of the current COVID-19 pandemic and the short study period, the researcher only used 30% of the calculated sample. Following the discussion with the clinical research centre officer, QEH, there were 107 subjects. The nurses who are currently employed at the hospital were reached through a mail survey. In addition, meetings with respondents and voicemails were used to explain the questionnaire's specifics in response to inquiries about the study.

There were 107 nurses of various ages who responded to the survey. The youngest registered nurse was 25 years old, and the eldest was 57. The age group of 30–34 years old had the highest proportion of respondents, with 58 (54.2%). The second-highest proportion of respondents are between the ages of 25 and 29 (25.2%) Then, there were 13 respondents (12.1%) between the ages of 35 and 39. The percentage of respondents in the 40–44-year-old age bracket was the same, at 3.7% (4 respondents). There is 1 respondent in the 55-59 age bracket (0.9%). The majority of nurses, according to data obtained, are women in fertile years. The majority of respondents are female, with 94 (87.9%) females and 13 (12.1%) males. The majority of respondents had married (81 (75.7%), 25 (23.4%) were single, and 1 (0.9%) was divorced or separated. In terms of education level, there are 8 respondents with a Bachelor's degree (7.5%), 24 respondents with a Post-Basic education (22.4%), and 75 respondents with a Diploma or STPM (70.1%). A total of 32 (29.9%) out of 107 respondents hold post-and bachelor's bachelor's degrees, indicating that a

minority of nurses have acquired specialised nursing care qualifications. Next, 7 (6.5%) of whom are nurses with Post Basic in Oncology Care, while the remaining 100 (93.5%) do not have Post Basic in Oncology Care. More than half of the nurse population had been working for 5 to 10 years, with 56 respondents (52,3%), followed by 30 respondents (28%) who had been working for more than 10 years and 21 respondents (19.6%) who had been in the service for less than 5 years. In terms of department, the majority of respondents, 44 (41.1%), come from the Hematology Department, whose primary clinical setting is the administration of cytotoxic drugs. Followed by the COVID ward with 13 (12.1%) responses, General Medical with 9 (8.4%) responses, AIM with 8 (7.5%) responses, and the ICU with 6 (5.6%) responses. Then, for departments with less than 5% cumulative respondents, such as Respiratory with 5 (4.7%) respondents and Geriatric with 4 (3.7%), ENT, ETD, Nephrology, and PAW each had 3 (2.8%) respondents. The Eye ward, the ID ward, and the Neuromedical ward each had two (1.9%) respondents. Among the 107 respondents, 66 (61.7%) have worked in haematology or oncology-related healthcare settings. Aside from that, 41 (38.3%) nurses reported having no experience or exposure to haematology or oncology healthcare management.

2.2 Instruments

A 20-item true/false open-ended questionnaire was adapted from a previous study by [51]. A request for permission to adapt was sent via email. In addition, expert opinion was considered (content validity) through consultation with the hospital's pharmacist, physician, and consultant. Four areas of knowledge and experience in the handling of cytotoxic agents served as the basis for the questionnaire: Knowledge of the characteristics of cytotoxic agents (Domain 1); Knowledge of exposure to cytotoxic agents and health hazards (Domain 2); Knowledge of safe handling of cytotoxic agents (Domain 3); Knowledge of protecting oneself and the surroundings (Domain 4).

2.3 Ethical consideration

Ethical approval was obtained from the National Medical Research Register (Approval code: 21-01953-KMI). Respondents were also acknowledged by providing them with a consent form to fill out prior to answering the questionnaire. The researcher ensured the anonymity and confidentiality of respondent information. In addition, nurses were informed that they could leave the study at any time without penalty.

2.4 Data Analysis

In order to conduct a descriptive analysis of the data, Statistical Package for the Social Sciences (SPSS) version 25 was utilised. As a means of describing the findings, we provided information in the form of frequencies, percentages, and standard deviations. To determine the level of nurses' knowledge and practise in the safe handling of chemotherapeutic agents at the Queen Elizabeth Hospital in Kota Kinabalu, Sabah. The level of knowledge is categorised as poor (0-9); moderate (10-16); and good (17-20).

3. Results

Table 1 and Figure 1 display the summaries of each question's scores. The total scores on the questionnaire were computed and listed in Table 2. It revealed that 79 (73.8%) of 107 nurses have moderate knowledge with a total score of 10 to 16 points. In addition, there are seven (6.5%) nurses with a total score between 17 and 20 points who have good knowledge. Without exception, one-fifth of the respondents (19.6%), or 21 nurses, have inadequate knowledge with a total score between 0 and 9 points.

Table 1. Knowledge of the nurses in the safe handling of chemotherapy

Question	True (%)	False (%)	Correct answer

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1. Cancer drugs affect not only cancer cells but also normal cells	92 (86.0%)	15 (14%)	TRUE
2. Bone marrow, hair, gastric and reproductive cells are all easily affected by cancer drugs	97 (90.7%)	10 (9.3%)	TRUE
3. It is an established fact that Methotrexate or 5-fluorouracil is a highly cancer-inducing drug	59 (55.1%)	48 (44.9%)	FALSE
4. Cisplatin, cyclophosphamide, and dacarbazine are classified as having a low likelihood of causing nausea and vomiting	64 (56.8%)	43 (40.2%)	FALSE
5. Extravasation of vesicant cancer drugs usually causes mild irritation for a short time	55 (51.4%)	52 (48.6%)	FALSE
6. Each cancer drug has its own guidelines for the lowest safe dosage of exposure	98 (91.6%)	9 (8.4%)	FALSE
7. Healthcare providers working with cancer drugs are at increased risk for cancer	67 (62.6%)	40 (37.4%)	TRUE
8. Healthcare providers working with cancer drugs are at increased risk for adverse reproductive outcomes	72 (67.3%)	35 (32.7%)	TRUE
9. Only during the first trimester, but not the second or third, can a fetus be affected by cancer drugs	50 (46.7%)	57 (53.3%)	FALSE
10. Skin is rarely contaminated by cancer drugs	27 (25.2%)	80 (74.8%)	FALSE
11. When the white blood cell count is 3,000/mm^3 or the absolute neutrophil count is 1,500/mm^3, treatment with cancer drugs is not appropriate	67 (62.6%)	40 (37.3%)	FALSE
12. Using a Luer Lock connector with a closed infusion system can prevent the leakage of cancer drugs	92 (86%)	15 (14%)	TRUE
13. Use glucose or Normal Saline solution before and after the infusion of cancer drugs	94 (87.9%)	13 (12.1%)	TRUE
14. For extravasation, cold compression with non-DNA-binding cancer drugs (e.g., vincristine) and hot compression with DNA-binding cancer drugs (e.g., doxorubicin) should be used	79 (73.8%)	28 (26.2%)	FALSE
15. When preparing cancer drugs, it is necessary to spread double sterile water-absorbing dressing pads on the table	90 (84.1%)	17 (15.9%)	FALSE
16. Ten days after injection of a cancer drug, the patient's urine is still considered contaminated with the cancer drug	68 (63.6%)	39 (36.4)	FALSE
17. During the ongoing process of administering cancer drugs, gloves, gown, and mask should not be changed even if broken	13 (12.1%)	94 (87.9%)	FALSE
18. To prevent contamination by cancer drugs, it is advisable to wear PPE for the whole shift (7 to 12 hours) without changing it	15 (14%)	92 (86%)	FALSE
19. Depending on the different types of cancer drugs, it is not necessary to treat all the waste (e.g., gloves, gown, mask) as toxic waste	23 (21.5%)	84 (78,5%)	FALSE
20. Body fluids are not affected by cancer drugs, so gloves and dressings should be treated as non-toxic waste	37 (34.6%)	70 (65.4%)	FALSE

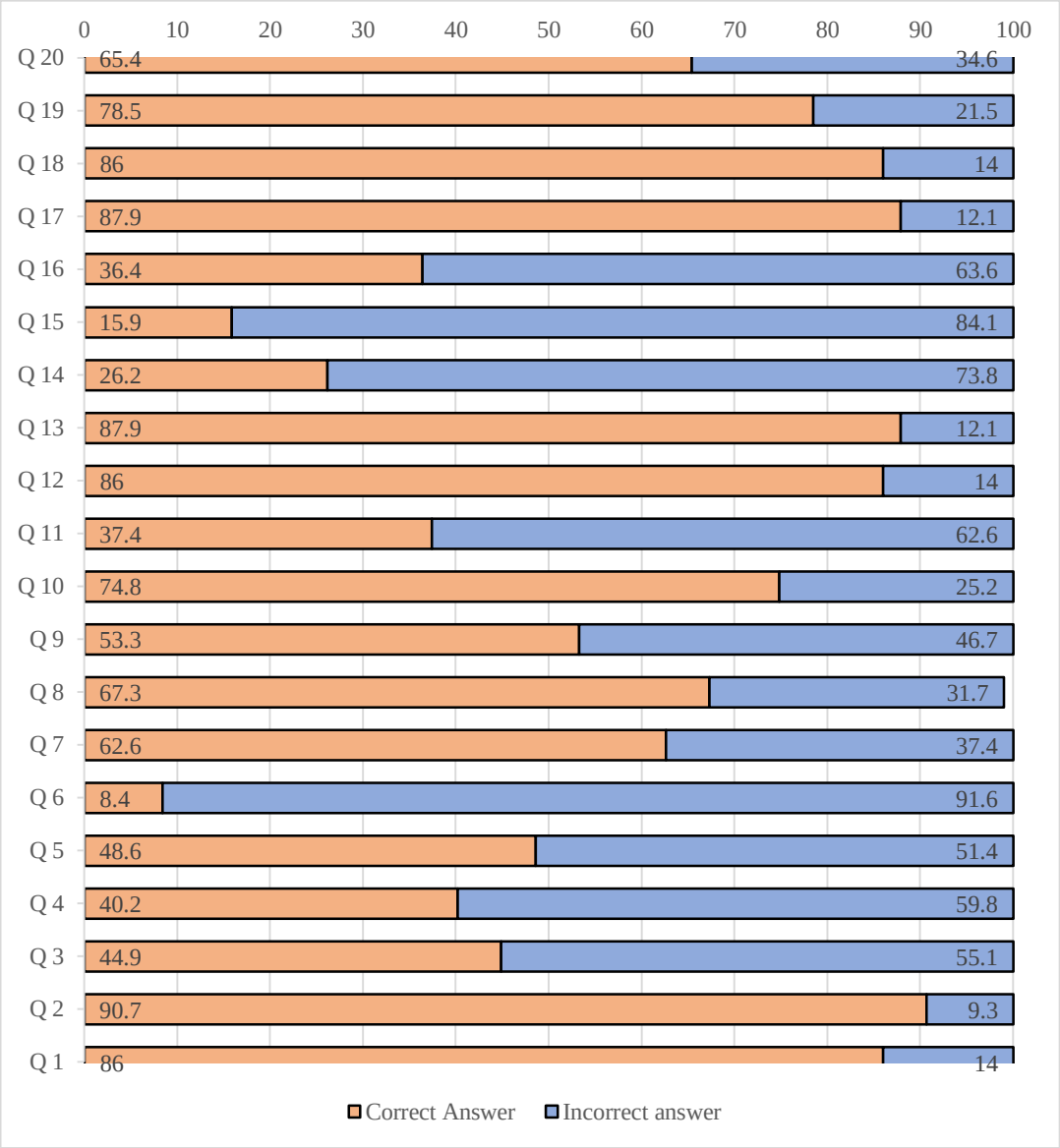

Figure 1. Score summary of the questionnaire in percentage

Table 2. Total score of the respondents

Scores	Frequency	Percent (%)
Poor (0-9 marks)	21	19.6
Moderate (10-16 marks)	79	73.8
Good (17-20 marks)	7	6.5
Total	107	100.0

4. Discussion

The current study's goal is to assess nurses' knowledge level in chemotherapy safe handling. According to a study conducted by [14], antineoplastic agents can disrupt the growth of both normal and cancerous cells, which can result in dangerous adverse effects for both patients receiving these agents and healthcare workers involved in the procedures of handling them, such as preparation, administration, transport, spill cleaning, and waste handling. Nurses are the healthcare providers most at risk of being exposed to cytotoxic effects. As a result, they must acquire specialised knowledge and skills in order to protect themselves from health risks while also ensuring the safety of their patients. With a rate of 95.4% of nurses aged 25 to 44

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years old, the results showed that the nurses are young, possibly under their family planning, and may have an increased risk of foetal hazard exposure while working in hazardous clinical settings. When evaluating nurses' knowledge of chemotherapy types and safe handling, the overall rate of correct answers was 59.22%, which is considered inadequate.

When compared to a previous study conducted in Taiwan using the same questionnaire by [51], the overall rate of correct answers was 60.9%. Domain 4: Knowledge of Protecting Oneself and Surroundings had the highest correct answer rate of any of the four domains, with an average correct answer of 70.84%. Following that, Domain 1: Knowledge of the characteristics of cytotoxic agents received the second highest correct answer (62.08%). Domain 2: Knowledge of cytotoxic agent exposure and health hazards, with a score of 53.28% on average, and Domain 3: Knowledge of cytotoxic agent safe handling, with a score of 50.68% on average. These findings revealed that nurses had insufficient knowledge of the treatment processes involving antineoplastic agents, particularly in terms of exposure and health hazards, as well as the safe handling of cytotoxic agents.

The findings provide some insight into the safe administration of chemotherapy. Nurses would recognise the importance of knowledge in the safe handling of chemotherapy and prioritise their own safety before caring for patients receiving chemotherapy. [28] report that there is a positive improvement in the knowledge, attitude, and practise of chemotherapy safe handling among nurses following the implementation of safe-handling guidelines, as evidenced by significant differences in enhancement between pre and post-test scores. As a result, organising cytotoxic safe handling courses is critical to raising awareness and knowledge of the existence of guidelines and measures to reduce hazardous workplace exposure. The data provided would inform the nurse manager and matron on how to handle chemotherapy safely. Superiors would recognise the link between safe handling knowledge and educational level. Thus, managing nurses based on their work experience leads to additional studies such as post-basic and bachelor of nursing degrees to promote safety in health care settings among health care providers and patients. Furthermore, the implementation of the most recent guidelines and SOP in the safe handling of chemotherapy will be updated in accordance with Occupational Safety and Health recommendations (OSH). The findings demonstrated nurses' professionalism in the safe administration of chemotherapy. The information provided aids in the education of nursing professionals as well as the advancement of the profession by developing new policies and guidelines for chemotherapy procedures. As a result, safe chemotherapy handling in clinical settings will become standard practise as nurses gain confidence and competence in providing quality and safe patient care, particularly in the preparation, administration, and disposal of cytotoxic waste. Antineoplastic agent administration in the healthcare setting has become one of the occupational hazards, because nurses are at risk of potentially being exposed to health hazards while providing patient care during and after chemotherapy administration. Furthermore, improper handling of these hazards can lead to cytotoxic residues infiltrating the healthcare environment on the surface and in the air. As a result, proper training with the most recent guidelines and protocols is required to raise awareness among nurses about chemotherapy safety. According to [3], a lack of adequate training among nurses can have a direct impact on their knowledge and practise of safe antineoplastic agent handling. As a result, in addition to training, it is critical to develop standard practise guidelines and provide adequate personal protective equipment in healthcare settings.

5. Limitations of the study

The study's findings and results must be viewed in light of some limitations. The study was carried out within the hospital. However, because respondents were chosen at random from all in-patient wards, the sample may not be representative of all nurses who handle chemotherapy. Despite the use of this method,

61.7% of the nurses stated that they have worked in haematology and oncology settings. Only 7 respondents, on the other hand, were certified in Oncology Care Nursing, which distinguished them from other nurses who did not have Post Basic. The instrument for the study questionnaire was adapted from a previous study, which was the second limitation. There were no questions about nurses' attitudes toward chemotherapy safety, as the study's goal was to highlight the need for nurses to gain sufficient knowledge in accordance with the most recent guidelines. The third limitation was related to questionnaire distribution, which was hampered by the COVID-19 pandemic situation, which caused the process of questionnaire distribution to be prolonged. At the same time, due to the Standard of Precautions (SOP), the face-to-face meeting with respondents was cancelled and replaced with a video call.

6. Directions for Future Research

The study's findings suggest several avenues for future research. First, this study should be replicated with a larger, more representative sample of oncology nurses or nurses who work primarily in oncology settings, as it was insignificant to study the knowledge and practise of safe chemotherapy administration if non-oncology nurses were included. Second, a study of nurses' attitudes toward the safe handling of cytotoxic agents should be included to investigate additional factors that can lead to insufficient knowledge and unsafe practise in the management of antineoplastic agents. On the other hand, some assessment of both the occurrence of exposure and its biological effects on nurses handling antineoplastic agents is required. This is because Malaysia has no registry of data on nurses' exposure history and health outcomes. A longitudinal and epidemiological study of oncology nurses, comparing both antineoplastic agents exposed to nurses and unstressed nurses, is critical for investigating and quantifying the occurrence of adverse effects from cytotoxic exposure in healthcare settings. The study must include objective measures of cytotoxic exposure, such as collecting and analysing urine samples or evaluating the biological consequences of health hazards, which can help determine the extent of exposure among healthcare workers.

7. Conclusion

The findings of this study revealed that nurses have insufficient knowledge of chemotherapy safety, with an average score of 59.22%. The highest correct answer achieved in all four domains of the questionnaire was Domain 4 (Knowledge of Protecting Oneself and Surroundings); whereas Domain 3 (Knowledge in the Safe Handling of Cytotoxic Agents) had the lowest correct answer rate. This finding demonstrated that nurses were aware of the importance of using personal protective equipment when handling cytotoxic agents. However, the nurses' lack of knowledge about the proper handling of cytotoxic agents may pose a health risk. Despite the provision of CNE/CME, the availability of internet services, consultation with colleagues, and daily practise in clinical settings, particularly in haematology and oncology, there were still gaps in nurses' knowledge of chemotherapy safety. To achieve proper updates and knowledge input with certification, nurses must attend a structured educational programme such as a Post Basic or Advanced Diploma in Oncology Care. According to a recent study conducted by [38], nurses' knowledge and practises in the safe handling of cytotoxic agents have been refined. Simultaneously, the study suggested that continuously and consistently updating nurses' knowledge of safe handling with supported guidelines and policies will aid in enforcing safety implementation in clinical settings. As a result, it is critical to provide opportunities for nurses to further their studies in post-basic to have more structured and consistent oncology education. Furthermore, organising chemotherapy-related courses or symposiums and CNE/CME in the hospital can provide nurses with insight and knowledge of chemotherapy handling among healthcare workers.

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