Assiut Scientific Nursing Journal
http://asnj.journals.ekb.eg http://www.arabimpactfactor.com
DOI: 10.21608/asnj.2024.279442.1804 http://olddrji.lbp.world/indexedJournals.aspx
https://vlibrary.emro.who.int/journals/assiut-scientific-nursing-journal

Effect of Mind Mapping with Artificial Intelligence for High Alert Medications on Novice Nurses′ Performance at Neonatal Intensive Care Unit

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Abstract
Background: Mind mapping is a smart and attractive method that used for learning advancement and makes recalling information more clear and easy. **Aim:** Identify the effect of mind mapping with artificial intelligence for high alert medications on novice nurses performance at intensive care unit of neonate. **Design:** The study design used was quasi-experimental. **Setting:** This study was conducted at neonates' intensive care units at Tanta University Main Hospital and International Teaching Hospitals. **Sample:** A purposive sample of all novice nurses (30) who were working in the previously declared places. **Tools:** Two tools were involved .**Tool (I):** High alert medications knowledge questionnaire. **Tool (II):** High alert medications observational checklist. **Results:** All nurses (100%) showed high level of knowledge immediately after implementing mind mapping contrary to one month of implementing it as this percentage declined to 86.7%. In addition, all studied nurses (100%) demonstrated unsatisfactory level of practices before implementation of mind mapping while majority of them (96.7%) demonstrated satisfactory level of practices immediately following using mind mapping then this percentage reached to76.7% after one month. **Conclusion:** Mind mapping with artificial intelligence had a positive effect on neonatal intensive care unit novice nurses' performance regarding high alert medications. **Recommendation:** Conduct periodic in-service educational training utilizing innovative teaching techniques such as mind mapping and artificial intelligence to improve novice nurses' performance about high alert drugs.

Keywords: Artificial Intelligence, High Alert Medications, Intensive Care Unit, Mind Mapping, Neonatal &Novice Nurses' Performance.

Introduction
Medication safety is considered a pillar stone in achieving a high-quality care and maintaining patient's safety as announced by worldwide health organizations. Medication safety alerts advice on taking actions to avoid upcoming undesirable events or to decline the risk of medication errors. Errors of medication is the most frequent cause of morbidity and mortality in medical profession. **(Graham, et al., 2020)**.

Medication errors can be used as patient safety indicators in hospitals due to their repeated occurrence and prospective risks to patients. Medication errors prevention has obtained a high priority worldwide since they are costly to healthcare systems, patients, and their families. This process depends on various disciplines working collaboratively for confirming safe delivery from the time of placing order to its administration especially high-alert medications **(John, & Meray.2019)**.

High-alert medications (HAM) are drugs that have higher risk of causing significant patient harm when used in error. Medication administration is uniquely risky process in neonatal intensive care unit owing to neonates' vulnerable nature and the complexity of medications used. Some stresses can lead to medication errors as workload, unpredictable workflow, rapidly changing patient acuity, poor lighting, loud noise, and frequent distractions and interruptions. **(Manjula et al., 2018)**.

High-alert medications can be classified into many categories. The top high-alert medications are potassium, calcium, dopamine, heparin and insulin. In addition to amiodarone, digoxin, epinephrine, norepinephrine, fentanyl, morphine, phenytoin, propofol and tacrolimus. Additionally, mild sedatives such as chloral hydrate and narcotics/opioids (oral, transdermal, and IV), including liquid concentrates, formulations with both rapid and prolonged release, neuromuscular blockers such as succinylcholine, preparations for parenteral nutrition, radio contrast agents, and injection of sodium chloride (hypertonic, >0.9%) **(Saaed, et al., 2019)**.

A major concern of health care professionals is improving medication safety, particularly high-alert medications, owing to medication errors incidence and its consequences in the neonatal intensive care units, evidenced based safety procedures and guidelines for drugs administration are pivotal. So

HAM standardization and documentation should be integrated into the electronic medication administration record system **(Resident et al., 2022)**.
Nurses have a professional obligation to know about high alert medications, which are considered a basic part of nurses' duties in their daily practice. Knowledge and practices about high alert medications in intensive units of neonates were lacking especially novice nurses. Training programs help nurses acquire new skills and develop their practice. **(Wilson & Chris. 2019).**
Teaching strategies of educational programs are expanded all over the world for increasing nursing students and novice nurses' active interaction and enhancing attitude for learning to ensure lifelong continuing education. Mind map is considered a recent instructional tool in both nursing curriculum and training **(Tariq et al., 2021)**.
Mind mapping is an effective tool for novice nurses to enhance their memory recall and create a new environment for processing knowledge. The mind map (MM) is a colorful graphic technique can be used as a teaching strategy which facilitates the understanding of difficult concepts. **(Fusco, et al., 2021)**.
The mind map as a learning tool could help nurses to think critically and provide high standard neonatal care, especially in administration and dealing with high alert medications. **(Yang & Chen. 2021)**. The application of the mind map approach as a learning aid and the development of a dependable scoring system for the efficient assessment of students' use of it presented challenges for researchers in the past. The mind mapping tool helps in brainstorming, and projects management.
Artificial intelligence (AI) applications enable the quick creation of simple attractive electronic mind maps and more such as mind maps created through Whimsical website. Nowadays Artificial Intelligence enables generating mind maps instantly to visualize ideas and connections. This guide to easily create customized mind maps for clarifying thoughts, planning projects, studying, and more. **(Bahrami & Purfarzad. 2019).**

Significance of the study:

High alert medication is one of life saving concept for improving neonatal safety. About 80% of all deaths from medication errors are caused by high alert medications. **(Efstratios 2022).** So, nurses especially novice one must have knowledge and skills for improving medications administration to spot probable medication errors before its occurrence, this in turn will save and improve child's life. In addition to cost reducing, decreasing length of hospitalization, and reducing adverse outcome.

The study aimed to:
Identify the effect of mind mapping with artificial intelligence for high alert medications on novice nurses' performance at neonatal intensive care unit**.**
Research hypothesis
Novice nurses' performance regarding HAM is expected to be improved after using mind mapping with artificial intelligence.

Subjects and Method

Research design: This study design was a quasi-experimental.
Setting
Intensive care units of neonates at Tanta University Main Hospital and International Teaching Hospital which are affiliated to The Ministry of Higher Education and Scientific Research.
Subjects:
Purposive samples of novice nursing staff (30) who were working in the prior mentioned settings were included.
Criteria of selected nurses:
- Newly graduated nurses
- Had less than one year of experience
- Directly handled with high alert medications

The study tools: This study involved two tools:-
Tool (I): High alert medications knowledge questionnaire: it was established by the researchers after reviewing related recent guidelines and literatures review to collect the needed data **(Mahrous et al. 2022)**. It encompassed the following parts:
Part (I): Socio-demographic characteristics of novice nurses: as age, gender, residence, qualifications**,** number of work hours per day and attending seminars related to high alert medication**.**
Part (II): Nurses' knowledge about high alert medication as definition, categories, common risk factors, storage, guidelines on safe use of high alert medication, preparation, monitoring, documentation and patient education.
The nurses' knowledge was scored as following:
Score (1) for true answers
Score (0) for wrong answers.
Score of total nurses' knowledge was as follows:
Below 60% pointed to low knowledge level.
From 60% to less than 80% pointed to moderate knowledge level.
From 80% to 100% pointed to high knowledge level.
Tool (II): High alert medications observational checklist. It was established by the investigators following a review of literature. **(Bader 2021).** It was used to assess novice nurses' general practices toward HAMs in neonatal intensive care units and it covered 4 basic dimensions as HAMs preparation, administration, storage and documentation.

Nurses' practices scoring system was as following:
- Score (1) for done correct and complete.
- Scored (0) for not done

Nurses' practices total scoring was calculated as following:
- Unsatisfactory practices if less than 80 %
- Satisfactory practices from 80 % to 100%

Method

Obtaining approval:

The researcher obtained an official permission to conduct the study from the responsible authorities, Dean of Faculty of Nursing, Tanta University and Neonatal intensive care units at Tanta university main hospital to obtain their approval and cooperation for conducting the present study after clarifying the purpose of it and setting the time for beginning the study.

Ethical considerations:-

The Ethics Committee of Tanta University's Faculty of Nursing granted the researcher permission to carry out the study; code **(288-8-2023)**
- The aim, nature and advantage of the present study were illustrated to every novice nurse at the beginning of the interview and they were informed that they can leave the study at any time. Novice nurses gave their informed consent.
- The study's nature did not result in any harm or pain to any of the studied novice nurses.
- Privacy and confidentiality regarding the gathered data were taken into account.

Developing the study tools:

Tool (I): it was established by the investigators following updating literature review **(Mahrous et al . 2022)** and tool II was adapted by the investigators based on recent guidelines for practice. **(Bader 2021).** A panel of five pediatric nursing specialists evaluated the study tools for face and content validity. The content validity index was **98.6%** according to opinions of experts.

Conducting the pilot study:

A pilot research involving 10% of the sample size was conducted (3 novice nurses) who were working at the prior stated settings to test the applicability of the constructed tools and the clarity of the included questions related to high alert medications. Required modification was done accordingly. There were some new questions added, while others were removed. The study sample didn't include those nurses.

The reliability of the study tools was calculated through using Cronbach's Alpha test. The value of Cronbach's alpha coefficient **was = 0.890.**

Phases of the study:

Assessment phase: It was applied for all novice nurses by researchers to collect baseline data of their knowledge about high alert medications (Tool I) and to assess their practices about high alert medications (Tool II).

Phase of Planning:

Setting objectives of the educational program.

Researchers preparation: The researchers reviewed recent researches in order to be knowledgeable about high alert medications in intensive care units of neonates. The researchers began to search on how to use the artificial intelligence application to prepare the content of sessions through use of **Whimsical software which retrieved at https://whimsical.com/mind-maps.**

Content preparation: The researchers began to create an account on the Whimsical website at https://whimsical.com/mind-maps. It is a free mind map maker by artificial intelligence technology that helped the researcher visualized, clarified, and organized ideas and information about HAMS faster and effectively. The researcher started to insert the outlines about HAMS one by one and clicked on mapping. The Whimsical map maker began to organize free electronic mind mapping with attractive manner and the researcher began to use these mapping to prepare power point presentation for sessions of the study. The researcher a assigned these presentation and applied them to nurses during sessions.

Novice nurses' preparation: the researchers met the novice nurses of each cluster group according their clinical rotation.

The study aim was clarified to novice nurses and their informed consent was obtained by the researchers.

Data collection took about 3 months.

Phase of Implementation:

The researchers arranged the sample (30) nurses to 6 groups; each group consisted of 5 nurses. Each group took 2 sessions / week for 3 consecutive weeks. The researchers attended to the NICU in the morning shift at 10 am and started 5 teaching sessions for novice nurses. Each session for 45-60 minutes as the following:

The first session:

It covered objectives of sessions about HAMS, introduction about Institute of Safe Medication Practices (ISMP) HAMS, definition of HAMS and WHO third global safety challenge which called (medication without harm).

The second session:

It focused on categories of HAMS which included wide range of classes and groups of drugs. The researchers collected these groups of drugs in a simple and smart mnemonics called (NEAT CLIN). Each letter of these mnemonics referred to one class of HAMS as following: N for Narcotics as morphine, E for concentrated Electrolyte as potassium chloride and magnesium sulphate. Letter A referred to 4

classes of HAMS as Adrenergic agonist, Adrenergic antagonist, Antiarrhythmic and Anticoagulant group. T for Thrombolytic class of HAMS which is the last class in NEAT mnemonics.

The third session:

The researchers continued the categories of HAMS focused on CLIN mnemonics. C for chemotherapy class as vincristine, L for LOOK ALIKE SOUND ALIKE class as (digoxin &thyroxin), I letter acromion for two classes of HAMS Inotropic drugs as dopamine doputamine and Insulin. Finally the last class of HAMS was N for Neuromuscular blocking agent as mediasetic.

The fourth session:

It included the most common errors of nursing staff with HAMS as lack of double checking during preparation and before administration and principle and component of preventive strategy to safe handling of HAMS without harm for neonate in NICU which started from procurement of HAMS until documentation process of medication after administration.

The fifth session:

It concentrated on demonstration of steps for preparation and storage of HAMS effectively by the researchers and re-demonstration by novice nurses.

The six sessions:

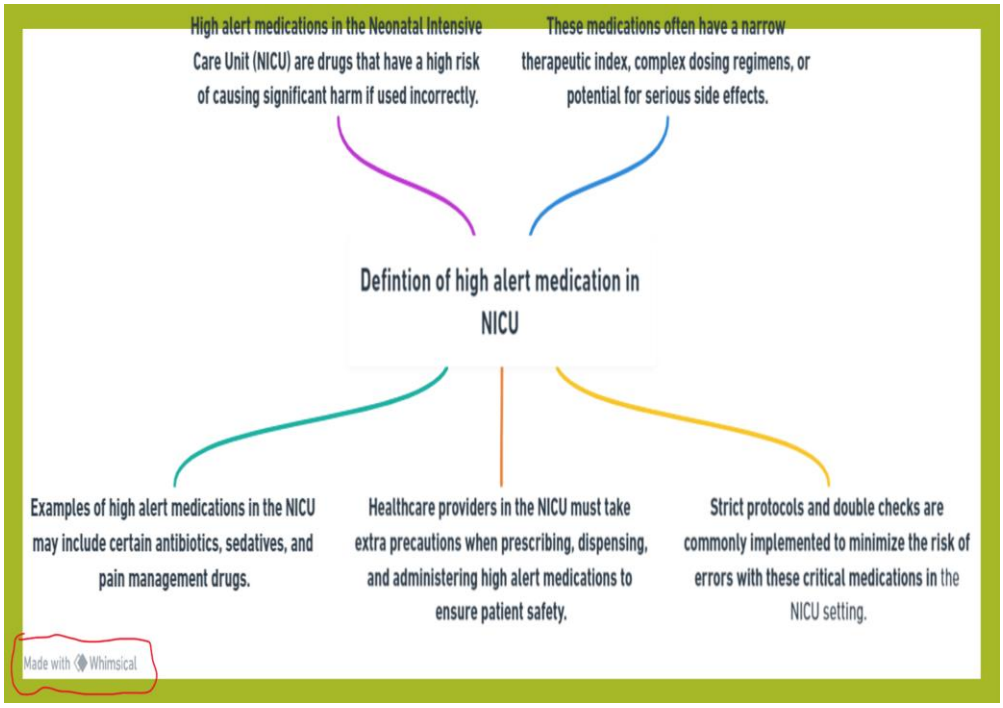
It covered demonstration of correct steps for administration and documentation by the researchers and re-demonstration by novice nurses.

Evaluation phase:

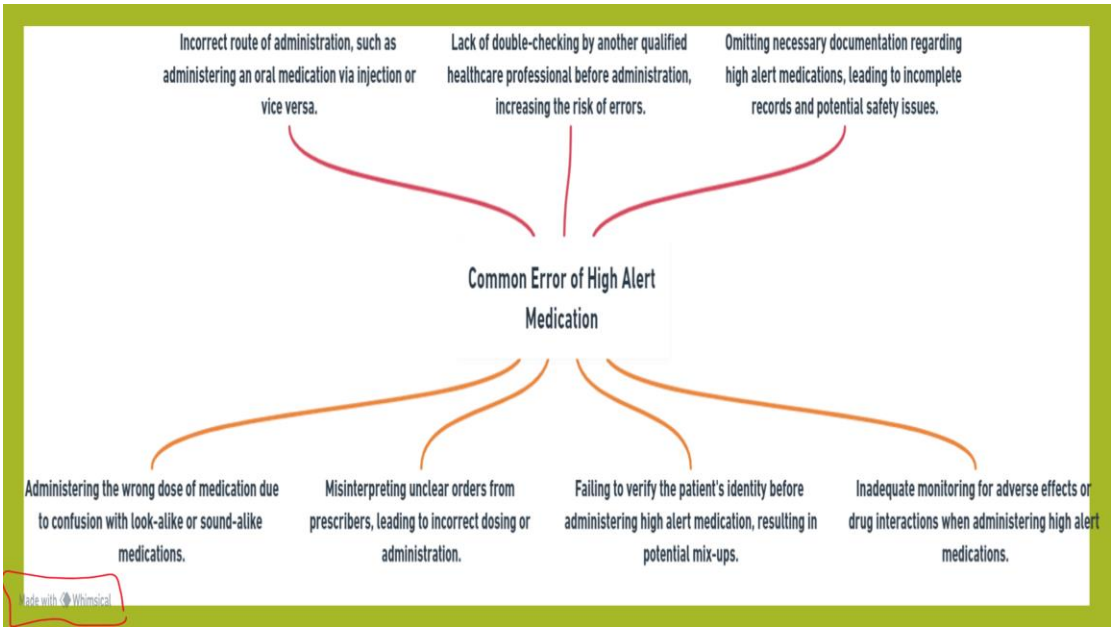
During this phase, the impact of educational program was assessed through immediate evaluation included immediate post program implementation for all novice nurses using the same tools that were used before the program. Following a month of program implementation, novice nurses were given the opportunity to use all of the research items to assess their level of performance regarding high alert drugs. The period of time for gathering data was three months, starting in September 2023 and ending in November 2023.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.



Definition of high alert medication designed with artificial intelligence (whimsical website)



Common errors of high alert medication designed with artificial intelligence (whimsical website)

Results

Table (1*):* Percentage distribution of novice nurses socio–demographic characteristics (n = 30)

Socio- demographic characteristics	The novice nurses (n=30)	
	No.	%
Age (years)		
Less than 25	30	100.0
Mean ± SD.	**23.03 ± 0.81**	
Sex		
Male	9	30.0
Female	21	70.0
Residence		
Urban	7	23.3
Rural	23	76.7
Qualifications		
Diploma	0	0.0
Technical institute	8	26.7
Bachelors	22	73.3
Previous training about high alert medication		
No	24	80.0
Yes	6	20.0
Number of work hours		
6 – 8	10	33.3
8 – 12	20	66.7

Table (2): Levels of total knowledge scores of novice nurses toward high alert medication (n = 30)

Knowledge levels	The novice nurses (n=30)							
	Pre		Immediate		After 1 month		Test of Sig.	p
	No.	%	No.	%	No.	%		
Low (<60%)	18	60.0	0	0.0	0	0.0	Fr= 53.416*	<0.001*
Moderate (60 – <80%)	11	36.7	0	0.0	4	13.3		
High (≥ 80%)	1	3.3	30	100.0	26	86.7		
Total score (0 – 38)								
Min. – Max.	0.0 – 31.0		31.0 – 38.0		25.0 – 37.0		F= 99.617*	<0.001*
Mean ± SD.	21.80 ± 6.58		35.77 ± 2.13		33.37 ± 2.97			
Average Score (0 – 1) (Mean ± SD.)	0.57 ± 0.17		0.94 ± 0.06		0.88 ± 0.08			

Table (3): Levels and mean of total scores of practices of novice nurses toward high alert medication (n=30).

Practices levels	The novice nurses (n=30)							
	Pre		Immediate		After 1 Months		Test of Sig.	p
	No.	%	No.	%	No.	%		
Unsatisfied (<80%)	30	100.0	1	3.3	7	23.3	Q= 48.483*	<0.001*
Satisfied (≥ 80%)	0	0.0	29	96.7	23	76.7		
Total score (0 – 24)								
Min. – Max.	0.0 – 16.0		18.0 – 24.0		6.0 – 24.0		F= 134.565*	<0.001*
Mean ± SD.	7.10 ± 5.09		23.20 ± 1.52		20.43 ± 4.46			
Average Score (0 – 1) (Mean ± SD.)	0.30 ± 0.21		0.97 ± 0.06		0.85 ± 0.19			

Table (4): Correlation between total scores of novice nurses knowledge and practices toward high alert medications pre, immediately and after one month of mind mapping application.

Variables		The novice nurses (n=30)		
		Pre	Immediate	After 1 Month
Total Knowledge Score	**r**	0.227	0.517*	0.514*
Total Practices Score	**p**	0.228	0.003*	0.004*

Table (5): Correlation between novice nurse's knowledge, practicesand their scio demographic characteristics toward high alert medication pre, immediately and after one month of mind mapping application.

Scio demographic data		Knowledge			Practices		
		Pre	Immediate	After 1 Months	Pre	Immediate	After 1 Months
Age (years)	r_s	–	–	–	–	–	–
	p	–	–	–	–	–	–
Qualifications	r_s	0.168	0.255	0.256	0.305	0.161	0.147
	p	0.376	0.174	0.172	0.102	0.394	0.438
Years of experience	r_s	-0.022	0.220	0.218	0.272	-0.186	-0.121
	p	0.909	0.242	0.248	0.146	0.326	0.525
Number of work hours	r_s	0.066	0.423	0.373*	0.083	0.500*	0.422*
	p	0.728	0.020	0.042*	0.663	0.005*	0.020*

Table (1): Presented percentage distribution of socio–demographic characteristics of novice nurses. All nurses (100 %) were obviously less than twenty five years old and three quarters of them (70.0%, 76.7) were females and were living in rural areas respectively. As regards their qualifications, three quarters of them (73.3%) had bachelors of nursing. Regards previous training about high alert medication, it was found that 80% of them did not receive any training about high alert medication. As

regards, number of work hours, it was clear that more than two thirds of them (66.7%) worked for about 8 – 12 hours.

Table (2): Illustrated levels of total knowledge scores of novice nurses about high alert medication. It was noted that 30.0% of them had low level of knowledge, prior to the implementation of mind mapping program, only 3.3% of them demonstrated a high level of knowledge, whereas 66,7% exhibited a moderate level of knowledge. In comparison to immediately after implementing it, where all nurses (100%) showed high level of knowledge contrary to one month of conducting as this percentage declined to 86.7%. At the same time, there was statistically significant difference between levels of total knowledge scores of the studied nurses pre, immediately after and one month after using mind mapping whereas p= <0.001*.

Table (3): Explained levels and mean of total scores of practices of the novice nurses regarding high alert medication. All studied nurses (100%) demonstrated unsatisfactory level of practices before implementation of program while majority of them (96.7%) demonstrated satisfactory level of practices immediately following using mind mapping then this percentage reached to76.7% after one month with statistically significant difference between levels of total practices scores of the novice nurses pre, immediately after and one month after mind mapping using whereas p= <0.001*

Table (4): Described correlation between total nurses' knowledge score and their total practices score. A positive significant correlation was determined between the overall knowledge and practices score of novice nurses both immediately following and one month following the use of mind mapping where r= 0.517* and p= 0.003 , r= 0.514* and p= 0.004* respectively.

Table (5): Shows the relationship between the knowledge, practice, and sociodemographic traits of novice nurses. After one month of employing mind mapping, there was an important positive correlation found between the amount of work hours worked by novice nurses and their level of knowledge whereas r=0.373* and p= 0.042*.Contrary to their practices as there was positive significant correlation between their number of work hours and their practices both immediately after and one month of mind mapping using where r= 0.500* p=0.422* r=0.005* p=0.020* respectively.

Discussion

Education is an important part in life and everyone must obtain the highest level of knowledge in a very short possible period. Novice nurses must read more and more in their field that reasons retention issues. Numerous advanced technologies have been developed recently for overcoming this. Hence, mind mapping is involved as a study tool to construct a pure link and relationship between topics that might help those nurses in giving more real instruction (**Eshwar et al., 2019).** Therefore**,** this study aimed to evaluate the effect of mind mapping with artificial intelligence for high alert medications on novice nurses performance in intensive care unit of neonates.

Regarding levels of total knowledge scores of novice nurses for high alert medications, there was a noticeable improvement with a statistically significant difference among total levels of knowledge of the studied nurses pre, immediately after and one month after mind mapping using.

In researchers' opinion, this may be because those novice nurses didn't receive any prior training program about high alert medications, as they were working as bedside nurse and are overworked due to staff nursing shortage. Consequently; they had inadequate time to enrich their critical care knowledge. But such improvement in their knowledge reflected the influence of mind mapping with artificial intelligence as a teaching method in knowledge integration and retention. **Beside, et al., (2020)** found that after mind mapping training, there was marked improvement in studied groups' knowledge contrary to prior its application. **Ibeid et al (2021)** also, supported using mind mapping in teaching as they said that the nurses' knowledge was statistically different before and after using mind mapping.

Similary & Abdel Hamid, (2017) reported that mind maps assisted students for better information recalling. In addition, the use of mind maps to enhance nurses' performance in terms of infection control was noted by **Mahrous et al., (2022)** in their study who found that there was improvement of majority of nurses' knowledge after mind map using than before using it.

Regarding novice nurses' practices, all of them had an unsatisfactory practices level before mind mapping , but majority of them demonstrated satisfactory level immediately after and one month of using mind mapping with statistically significant difference among total levels of practices pre, immediately after and one month following using application of mind mapping .

This can be explained that unsatisfactory level pre mind mapping could be due to low knowledge level as mentioned previously which in turn affected the practices level contrary to post mind mapping using where the total level of knowledge was enhanced which led to satisfactory level of practices as a positive influence of using mind mapping. This meant that mind map can be used to organize patient quickly

and staff education at the same time, evaluating the learner's comprehension of critical information **(Kalyanasundaram & Abraham 2020).**

Bayumi et al (2022) reached to same finding as they published that there was a highly statistically significant improvement regarding nurses' practices of infection control measures following applying mind mapping than pre application of it. **Ashour etal., (2023)** as well announced that studied nurses demonstrated competent performance after using mind-mapping than before using it.

This preceding finding was reinforced by **Spoorthi et al., (2019)** who reported that mind mapping can help linking the gap between knowledge and clinical practice. Also, **Wenjun et al., (2020)** was congruent with this result and discovered that mind mapping enhanced medical students' knowledge of nosocomial infection prevention and control, as well as their operational skills in this area. It also increased the students' satisfaction and compliance with hand hygiene practices. The prior results were reinforced by **Bawaneh (2019)** who reported that majority of the study sample suggested adding mind mapping during their training and be a part in the clinical work. Such result was contraindicated with **Phillips et al., (2019)** who stated that; it was unnecessary to expand nurses' performance.

The existing study showed that there was a positive significant correlation between total nurses' knowledge and their total practices immediately after and one month following using mind mapping. This might be due to the improvement of knowledge as a result of using mind mapping which caused retention of information and it in turn caused practices improvement. This relation explains that increasing information must result in an increased performance.

This result was in same direction with **Mahrous et al., (2022)** who found that there was a statistical significant correlation between nurses' performance and mind mapping using. These results agreed with **Davies (2020)** who reported that there was highly statistical significance of the study sample performance who had theoretical knowledge about the mind mapping. It could be enlightened that perfect understanding of mind mapping strategy gives a chance for nurses to be actively involved in their process of training.

Beside, **Eshwar et al., (2019)** mentioned that active learning methods enhance nursing students cognitive, affective, and psychomotor skills. **Zyoud et al., (2019)** found a strong association between high alert medication knowledge and practice, which enhanced these findings. Following a month of mind mapping, the results of a recent study demonstrated a positive and important correlation between the number of work hours by novice nurses and their level of knowledge.

Contrary to their practices as there was positive significant correlation between their number of work hours and their practices both immediately after and one month of mind mapping using. In the researcher opinion, when nurses work more and more they acquire great experience which in turn will enhance their practice. This was matched with **Mohamed et al., (2022)** who declared that there were significantly higher frequencies of the effect of working hours, and level of practices as forecasters to level of knowledge.

The study also explored that there was no relation among nurses' age, qualifications, years of experience and their knowledge and practice. **Labib et al. (2018)** provided support for this by reporting a non-significant correlation between knowledge scores and the age and years of experience of nurses. In addition, **Abdel Hamid (2017)** referred that infection control performance weren't affected either by age or years of experience. In contrast, **Zyoud et al. (2019)** found a strong relationship between gender and knowledge scores.

Conclusion

It can be concluded that performance of novice nurses about high alert drugs in intensive care units was found to be improved by the use of artificial intelligence and mind mapping Additionally, immediately after and one month after utilizing mind mapping, there was a positive significant association found between the total nurses' knowledge and their practices score.

Recommendations

- Conducting periodic in-service educational training involving new teaching methods as mind mapping and artificial intelligence for neonatal and novice nurses to increase their knowledge and practices concerning high alert medications.
- Integration of mind mapping and artificial intelligence in the different nursing curriculums.
- Creating relevant workplace policies and procedures based on international safety standards and guidelines for the safe handling of HAMs.
- Creating job orientation for recently graduated nurses regarding HAMs.

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