Factors Affecting Medical Device-Related Pressure Injuries in Intensive Care Units

Fatma Z. Ali[1], Sahar Y. Mohammed[2], Dalia A. Ameen[3]

[1]Adult Health Nursing Department, Faculty of Nursing, Badr University in Cairo, Cairo, Egypt.
e-mail: Fatma_Zidan@buc.edu.om OCRCHID: 0009-0003-9623-971X
[2]Critical Care Nursing Department, Faculty of Nursing, Ain Shams University, Cairo, Egypt.
e-mail: dr.sahar.yassien@nursing.asu.edu.eg
[3]Critical Care Nursing Department, Faculty of Nursing, Ain Shams University, Cairo, Egypt.
e-mail: dr.dalia.ameen@nursing.asu.edu.eg

Received June 14, 20232, accepted July 31, 2023, Published October 9, 2023.

ABSTRACT

Context: Medical device-related pressure injuries (MDRPI) are a common complication that can occur in critically ill patients and require medical devices in the intensive care unit. MDRPI can occur when pressure from a medical device, such as a ventilator, catheter, or feeding tube, is exerted on the patient's skin for prolonged periods, causing tissue damage and leading to pressure injuries. MDRPI can result in pain, discomfort, prolonged hospital stays, and increased healthcare costs. Therefore, preventing and managing MDRPI in ICU patients is crucial to improving patient outcomes.

Aim: The study aimed to assess factors affecting medical devices related to pressure injury in intensive care units.

Methods: A descriptive and exploratory research design was employed to fulfill the objectives of this study. The study included two distinct samples: a purposive sample of 157 adult patients admitted to the intensive care unit and connected to various medical devices such as NGT, EET, CVC, UC, and CPAP masks, as well as a convenience sample of 50 nurses working in the intensive care unit who provided care to the same group of patients. Data were collected through a self-administered questionnaire, nurses' practice observational checklists, patient assessment records, and medical device assessment records.

Results: The findings from this study reveal that 40% of the nurses under investigation demonstrated a moderate level of knowledge concerning Medical Device-Related Pressure Injuries (MDRPI). In comparison, 68.8% exhibited unsatisfactory practice in this area. Moreover, 56% of the nurses displayed a negative attitude towards factors associated with pressure injuries caused by medical devices in intensive care units. Concurrently, 58% of the patients in the study were found to have pressure injuries linked to medical devices, with 48% of these cases being attributed to CPAP masks. Furthermore, a highly significant statistical correlation was identified between the total knowledge scores of the nurses and their overall practice.

Conclusion: The current study's conclusions indicate that the highest percentage of the participating nurses possessed an average level of knowledge, displayed inadequate practice, and harbored negative attitudes regarding factors contributing to medical device-related pressure injuries in intensive care units. Consequently, it is recommended that an educational training program be implemented to enhance nurses' competence in preventing medical device-related pressure injuries in intensive care units.

Keywords: Medical devices related to pressure injury, factors, intensive care units

Citation: *Ali, F. Z., Mohammad, S. Y., & Ameen, D. A. (2023).* Factors Affecting Medical Device Related Pressure Injuries in Intensive Care Units. *Evidence-Based Nursing Research*, 5*(4)*, 24-37. http://doi.org/ 10.47104/ebnrojs3.v5i4.309 .

1. Introduction

The intensive care unit (ICU) is a centralized care unit for critically ill patients, which uses various monitoring and instrumentation tools for effective treatment and care *(Abd El Wareth, 2019).* Using a medical device (MD) is essential for maintaining life and promoting healing in critically ill adults who are physically compromised. However, medical device-related pressure injuries (MDRPIs) occur when a medical device causes prolonged pressure or shear in any body part, including mucous membranes, especially in critically ill patients during hospital stays *(Brophy et al., 2021).*

Medical device-related pressure injuries (MDRPIs) are skin and subcutaneous tissue damages caused by devices used for diagnostic or therapeutic purposes. MDRPI includes PIs in the mucous membranes *(Choi et al., 2020).*

In a systematic review, the included studies reported that the incidence of MDRPIs in adults within the acute care setting was 28.1% *(Brophy et al., 2021*). Hospital-acquired pressure injuries hurt approximately 2.5 million patients yearly, leading to 60,000 deaths and costing an estimated $27 billion. Research shows that when medical devices are used on patients, they are 2.4 times more likely to develop HAPIs than those without devices *(Colo, 2023).*

Medical device-related pressure injuries (MDRPIs), unlike immobilization-related pressure injuries, occur around or under medical devices and generally take the shape of these devices. It reduces the quality of life in patients and causes loss of workforce for health care personnel, so it deserves the

[1]*Correspondence author: Fatma Zidan Ali*

attention of the professionals in the health care system *(Nan et al., 2023).*

Medical device-related pressure injuries (MDRPIs) develop due to several reasons. Firstly, devices are usually made of rigid material, which may cause rubbing or pressure on the underlying soft tissue. Adhesive tapes to secure these devices may also irritate the susceptible skin, especially in edema. Secondly, these medical devices must be secured tightly to seal properly. This fixation may create excessive pressure on the underlying skin, worsening further if the patient becomes edematous. Humidity and heat between the device and the skin further deteriorate matter. Other contributing factors are poor device selection (in size and location), prolonged use, poor use, poor tissue oxygenation, reduced sensory perception, malnutrition, and limited communication ability. Preventing MDRPIs is more complex and difficult than postural PIs because, most of the time, these medical devices are essential for survival *(Mehta et al., 2019).*

Nurses can play a critical role in preventing medical device-related injuries. Hospital-acquired pressure injuries (HAPIs) are preventable, particularly if nurses and other medical professionals know the risk factors and take precautions. If a patient is over age 65, common risk factors include impaired sensory perception, skin moisture/incontinence, limited mobility, poor nutrition, existing medical issues like diabetes or high blood pressure, and the use of medical devices during surgery *(Colo, 2023).*

2. Significance of the study

Medical device-related Pressure injuries are significant health issues and are one of the biggest challenges organizations face daily. In addition to the high cost of treatment, pressure injuries also profoundly impact patients' health and healthcare providers' ability to provide appropriate care. A previous study conducted by *Abd El Wareth (2019)* aimed to determine what factors increase the risk of medical devices-related pressure injuries in critically ill patients in a university hospital in Alexandria governorate. One hundred sixty-eight medical device-related pressure injuries (MDRPIs) resulted from 17 medical devices. The highest percent of skin medical devices related pressure injuries MDRPIs resulted from pulse oximeter (23.2%), followed by endotracheal tube ETT fixation (14.3%), fully urinary catheter FUC (11.9%), endotracheal tube ETT (10.7%), and nasogastric tube NGT (10.1%). 83.3% of the injuries were stage 1 injuries, and 4.2% and 12.5 % of the developed injuries were stage 2 and deep tissue pressure injuries, respectively. Cheeks, fingers, and thighs are the most affected sites by skin medical device-related pressure injuries (MDRPIs). There is a lack of domestic clinical practice guidelines for MDRPI prevention, and most preventive measures taken by clinical nurses are based on routines and experience *(Tan et al., 2020).*

The significance of this study lies in its potential to enhance patient care and safety in Intensive Care Units (ICUs). By identifying the factors contributing to Medical Device-Related Pressure Injuries (MDRPI), healthcare providers and institutions can develop targeted strategies for prevention and intervention. These strategies can lead to reduced patient suffering, improved patient outcomes, and cost savings for healthcare facilities. Additionally, the study's findings may contribute to the body of knowledge on MDRPI and inform future research and healthcare practices in ICUs.

3. Aim of the study

This study aims to assess factors affecting the occurrence of medical device-related pressure injury in intensive care units through the following:

- Assess nurses' factors affecting the occurrence of medical devices-related pressure injuries.
- Assess patient factors affecting the occurrence of medical device-related pressure injuries.
- Assess medical device factors affecting the occurrence of medical device-related pressure Injuries.

4. Subjects & Methods

4.1. Research Design

A descriptive exploratory design was followed to achieve the aim of this study. A descriptive exploratory research design is a research methodology used in scientific investigations. It combines descriptive and exploratory research approaches to gather information, describe phenomena, and explore potential relationships or factors of interest *(Boru, 2018).*

4.2. Study setting

This study was conducted at El-Demerdash Hospital in two intensive care units. The first one is the Medical Intensive Care Unit located on the medical hospital building on the first floor and consists of three rooms: A large room with 15 beds, two isolation rooms with four beds, a supplies store, two bathrooms, laboratory room. The second unit is the Cardiac Intensive Care Unit, located on the second floor and consists of two large rooms. Each room consists of eight beds with 16 beds and one bathroom, which is affiliated to Ain Shams University, Cairo, Egypt.

4.3. Subjects

This study consists of two distinct samples:

The first sample: This study included a convenient sample of all available nurses with 50 nurses. Thirty nurses worked in the medical ICU, and 20 worked in the cardiac intensive care unit where the study was conducted.

The second sample is a purposive sample of 157 adult patients from both genders, regardless of their educational level, who received routine care from the selected nurses in the previously mentioned setting. The patients were selected according to the following inclusion criteria. On admission, they should have intact skin and be connected to any medical device. Also, the patient had no skin disease or was previously exposed to any medical device-related pressure injuries. The exact patient sample size is 157 as calculated by (G Power analysis) (multivariate, two tail, Effect size = 0.3, $\alpha = 0.05$, Power $(1-\beta) = 0.97$) with numerical predictors.

4.4. Tools of data collection

4.4.1. Self-Administrated Questionnaire

The investigator developed it in simple Arabic to assess nurses' knowledge of the medical devices related to pressure injuries. It consists of two parts:

The first part included demographic characteristics of nurses under study, such as age, gender, marital status, education, years of experience, and attendance of previous training related to MDRPIs.

The second part was adapted from *Sönmez and Bahar (2022), Kaçmaz et al. (2023), and Nan et al. (2023)* and modified by the investigator. The modification was done by adding 20 questions about nurse's knowledge regarding the care of medical devices such as CPAP masks, EET, NGT, CVC, and Urinary catheters. The questionnaire was composed of 56 closed-ended questions. This part is divided into two sections.

The first section consists of 36 closed-ended (True and False) questions. It is concerned with the assessment of nurses' knowledge about medical device-related pressure injuries, such as the definition and description of MDRPIs (9 questions), causes and risk factors (8 questions), stages (3 questions), prevention, treatment, and complications (16 questions).

Scoring system

Each correct answer was graded as one, and zero for incorrect answers. The total score equals 36 marks.

The second section is composed of 20 closed-ended questions concerning nurses' knowledge about the care of the selected medical devices, including central venous catheter (7 questions), care of nasogastric tube (3 questions), care of endotracheal tube (4 questions), care of urinary catheter (4 questions), care of continues positive airway pressure mask (2 questions).

Scoring system

Each correct answer was graded as one, and zero for incorrect answers. The total score equals 20 marks. The total grades of nurses' knowledge regarding medical devices related to pressure injuries in critical care units is 56 points, categorized as follows:

- Poor: 0-28 points (0-50%).
- Average: 29-42 points (51-75%).
- Good: 43-56 points (76-100%).

4.4.2. Nurses' Practice Observational Checklist

It is a dichotomous scale developed by the investigator after reviewing the recent articles by *Pinto et al. (2020)* **and** *Pittman and Gillespie (2020)* to assess nurses' level of practice regarding preventing medical device-related pressure injuries in vulnerable patients. It developed in the English language and consisted of two parts with 158 steps distributed under two main parts:

Part I concerns the nurses' general practice (prevention strategies to avoid the MDRPIs). This checklist consists of 24 steps, such as appropriate selection, fitting, and securing the device, choosing a device that meets the patient's needs, and removing the device as soon as medically possible.

Scoring system

The nurses' practice was evaluated against a dichotomous scale of done and not done. One grade was given for each done step and zero for each not done, with a total score of 24 marks.

Part two consists of preventive care of the selected five medical devices (134 steps), such as nasogastric tube care (20 steps), central venous catheter care (21 steps); urinary catheter care (30 steps), endotracheal tube care (32 steps); and continuous positive airway pressure mask care (31steps).

Scoring system

The nurses' practice was evaluated against a dichotomous scale of done and not done. One grade was given for each done step and zero for each not done, with a total score of 134 marks.

- Incompetent: Score < 80% (< 107 degree).
- Competent: Score ≥ 80% (≥107 degree).

4.4.3. Patient Assessment Record

The investigator developed it after reviewing recent articles by *Dang et al. (2022), Nan et al. (2023), and Koo et al. (2019)* to record patient assessment data and the occurrence of medical device-related pressure injuries. It aimed to record patient-associated factors for medical device-related pressure injuries. It consisted of two parts.

Part I concerns patients' demographic characteristics such as age, gender, educational level, occupation, marital status, area of residence, hospital length of stay, and body mass index (BMI).

Part II is concerned with the patient's medical history. This part includes 17 questions completed by the investigator after the patient's physical assessment, such as admission route, primary diagnosis, and surgical history.

4.4.4. Medical Device-Related Pressure Injuries Record

The investigator developed it after reviewing the related and recent literature by *Coyer et al. (2022) and Dang et al. (2022)* to record medical device-related factors such as size, type, material, location, stages, and number of medical devices.

4.5. Procedures

The tools' face and content validity were revised by a jury of five experts from different academic categories (one professor, two assistant professors, and two lecturers) from the Critical Care and Emergency Nursing Department, Faculty of Nursing, Ain Shams University. The experts reviewed the tools and their content for clarity, relevance, comprehensiveness, accuracy, logical sequence, applicability, and simplicity. Modifications were done according to their recommendations.

Reliability testing of the proposed tools was done statistically by the Cronbach Alpha test. Nurses' knowledge assessment questionnaire 0.813 (good reliability), nurses' practice observational checklist 0.903 (excellent reliability),

Ethical consideration: The research approval was obtained from the Scientific Research and Ethical Committee of the Faculty of Nursing, Ain Shams University,

before starting the study. The investigator clarified the objective and aim of the study to the nurses and patients and relatives of patients included in the study before starting the study. The investigator maintained anonymity and confidentiality of the subjects' data included in the study. Nurses and patient relatives were informed that they were allowed to choose to participate or not, and they had the right to withdraw from the study at any time without any reason. Verbal consent was obtained from nurses and patients relative to participate in the study.

A pilot study was carried out in the medical ICU and cardiac intensive care unit department on 10% of the study subjects (5 nurses and 16 patients) to test the applicability, clarity, and efficiency of the tools and the feasibility of the research process. the pilot study serves to determine the time needed to fill in the study tools. Nurses and patients included in the pilot study were included in the study sample because no modifications were made after conducting the pilot study.

Data collection took about five months, from the beginning of December 2022 to the end of April 2023. The self-administered questionnaire took 15 to 20 min to be filled by the studied subjects. The investigator filled the observational checklists in up to 30 min by observing each nurse during work hours while caring for patients connected with any of the mentioned medical devices.

The first sample was all the available subjects (50 nurses out of 60 nurses because the other ten nurses refused to participate in the study for personal reasons, to ensure maximum participation from all available staff members in the selected intensive care units, the researchers conducted interviews during different shifts, including day, morning, night shifts and weekend. This schedule was necessary as some staff members had fixed schedules during the night shift. After completing the questionnaire, the researcher evaluated the practical performance of the same participant involved in the study by conducting an observation during patient care. This observation involved using a practical observational checklist that took approximately 20 minutes for the investigator to complete. The observation was based on the care provided to the same patient by the same nurse.

The second study sample (157 adult patients) was selected based on specific criteria such as the newly admitted patient who connected with one of the following medical devices: CPAP mask, EET, Urinary catheter, NGT, CVC. The investigator introduced herself if the patient was conscious, explained the aim of the study to the patient, and took the verbal agreement to proceed to the physical assessment; throughout the data collection phase, a total of 34 patients withdrew from the study due to various factors, including mortality, loss of connection to the monitoring device, and discharge from the hospital.

4.6. Limitations of study

Some limitations were faced during the data collection, such as the patients being discharged, the disconnection of medical devices, and the busy work area for nurses related to the staff shortage.

4.7. Data analysis

Data were collected, revised, coded, and entered into the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations, and ranges when their distribution was parametric. Also, qualitative variables were presented as numbers and percentages. Cronbach Alpha test was used to assess the internal consistency of the study instruments. The confidence interval was 95%, and the accepted error margin was 5%. So, the p-value was considered significant $P \leq 0.05$.

5. Results

Table 1 shows the frequency and percentage distribution of studied nurses' demographic characteristics, 46% aged 25 to less than 30 years old with a mean age of 28.6±3.89 years. Also, 68.0% were males, 50% were single, and 58% had technical education. Moreover, 36% have 1 to less than three years of experience, with a mean of 3.36±1.14 years. Besides, 88% have not attended any training course relevant to MDRPIs.

Table 2 illustrates the nurses' knowledge of MDRPIs. 50% of studied nurses had average knowledge about the description and definition of medical devices-related pressure injuries and the prevention and treatment of medical devices-related pressure injuries. In comparison, 46% of studied nurses had poor knowledge about risk factors for MDRPIs, and 48% had poor knowledge about degrees and stages of MDRPIs.

Besides, 48% of studied nurses had average knowledge about Nasogastric tube care, urinary catheter care, and CPAP mask care, and 46% had average knowledge about central venous catheter care and endotracheal tube care. While 34% had poor knowledge of central venous catheter care, 32% had poor knowledge of endotracheal tube care.

Figure 1 illustrates the percentage distribution of the total knowledge score of the studied nurses; 40.0% have an average total knowledge score. Also, 36.0% have a poor level, while 24.0% have a good level.

Table 3 clarifies the frequency and percentage distribution of the studied nurses' practice regarding preventing MDRPIs in vulnerable patients. The 74% of studied nurses were incompetent regarding their general practice for preventing MDRPIs and CPAP mask care. Also, 72% of studied nurses were incompetent regarding endotracheal tube care, 70% were incompetent regarding central venous catheter care, and 68% were incompetent regarding urinary catheter care.

Figure 2 represents the percentage distribution of the nurses' total practice score; 68.0% of the studied nurses were incompetent regarding the total preventive practice of MDRPIs.

Table 4 demonstrates the frequency and percentage distribution of the studied patients' demographic characteristics: 57.3% were aged between 35 to 50 years old, with a mean of 46.9±9.84 years, and 57.9% were females. Additionally, 38.2% and 38.8% had secondary school diplomas and Bachelor's education, respectively. As well, most of them (85.9%) were married. Moreover, 60.5% live in urban areas. Besides, 73.2% were unemployed, 49%

stayed in the hospital 15 or more days ago, and 63% were obese (30 kg/m2).

Table 5 reveals the frequency and percentage distribution of studied patients' medical history and physical assessment; 84.1% were admitted from emergency. The Primary diagnosis among 38.2% of them was respiratory failure. In addition, 31.8% had surgical history. Also, 36.3% were smokers. As well, 63.1% were bedridden. Additionally, 45.8% of them were confused according to their Glasgow Coma score. Moreover, 22.9% had a fever. Besides, 53.5% and 54.8% use anticoagulant and vasopressor medication, respectively.

Also, table 5 shows that 59.2% of the studied patients had hypoalbuminemia, 49.7% stayed in the hospital before ICU admission, and 68.8% were affected by edema.

Table 6 demonstrates the frequency and percentage distribution of medical device-related injuries; 48.3% of studied patients had injuries related to CPAP masks, and 34.7% had endotracheal tube-related pressure injuries. Moreover, 24.5% had urinary catheter-related pressure injuries, 15.7% of studied patients had injuries related to nasogastric tube, and 18.1% had central venous catheter-related pressure injuries.

Figure 4 clarifies that 58% of the studied patients develop medical devices related to pressure injur**ies (**MDRPIs).

Table 7 reflects a statistically significant negative correlation between the studied nurses' total knowledge and total practice with pressure injury p< 0.01.

Table 8 reveals patient-related risk factors significantly related to the development of MDRPIs. The table reveals that patients with edema had a 7.85 more risk of developing MDRPIs, and length of stay had a 6.77 more risk of developing MDRPIs. Also, BMI had 4.66 more risks for developing MDRPIs, hemodynamic shock during current hospitalization had 4.50 more risk of developing MDRPIs, and bedridden patients had 4.01 more risk for developing MDRPIs. Moreover, previous hospital stays before ICU admission had 3.24 more risk of medical device-related pressure injury. In comparison, age had 3.04 more risk for developing MDRPIs; DM had 2.02 more risk of developing MDRPIs. Also, fever (1.87), smoking (1.76), Vasopressors medication (1.50), HTN (1.64), and abnormal serum albumin (1.53) have a statistically significant effect on the development of medical device-related pressure injury at p< 0. 05.

Table 9 reveals the CPAP device-related factors. The table demonstrates that inappropriate fixation of CPAP mask (odd ratio of 8.39), inappropriate size (odd ratio of 8.15), and unavailability of equipment (odd ratio of 7.66) are related to the occurrence of medical device-related pressure injury on the studied patients at p< 0.05. The table also shows that inappropriate site of the central venous catheter (odd ratio of 4.45), inappropriate fixation (odd ratio of 3.99), inappropriate size 3.89, and unavailability of equipment 2.87, with catheter uncovered (odd ratio of 2.74) are related to the occurrence of medical device-related pressure injury on the studied patients at p< 0. 05.

Moreover, this table shows that inappropriate fixation of the urinary catheter (odd ratio of 5.32) and, inappropriate size (odd ratio of 2.13), unavailability of equipment (odd ratio of 1.99) are related to the occurrence of medical device-related pressure injury on the studied patients at p< 0. 05 with the urinary catheter material was insignificantly affecting the occurrence of medical device-related injury. Regarding the endotracheal tube, this table demonstrates that inappropriate fixation (odd ratio of 5.68), inappropriate size (odd ratio of 4.63), and unavailability of equipment (odd ratio of 2.18) are related to the occurrence of medical device-related pressure injury on the studied patients at p< 0. 05. Nasogastric tube risk factors show that inappropriate fixation (odd ratio of 3.67) and availability of equipment (odd ratio of 2.45) are related to occurrence of medical device-related pressure injury on the studied patients at p< 0. 05, While Inappropriate size and insertion site of nasogastric tube had no significant effect on occurring pressure injury at p> 0.01.

Table (1): Frequency and percentage distribution of the studied nurses' demographic characteristics (n=50).

Demographic characteristics	No.	%
Age		
20 - <25	8	16
25 - <30	23	46
30 -<35	16	32
35- 40	3	6
Mean±S.D	28.6±3.89	
Range	20–40	
Gender		
Male	34	68
Female	16	32
Marital status		
Single	25	50
Married	20	40
Widow	5	10
Divorced	0	0
Educational Qualification		
Secondary school diploma	3	6
Technical Health Institute diploma	29	58
Bachelor's Degree in Nursing	16	32
Postgraduate	2	4
Years of experience		
<1	7	14
1-<3	18	36
3-<5	16	32
5–<7	6	12
7+	3	6
Mean±S.D	3.36±1.14	
Range	1–10	
Attended training courses related to MDRPIs		
Yes	6	12
No	44	88
If yes, the number of training courses		
1	4	66.6
2	2	33.3

Table (2): Frequency and percentage distribution of the studied nurses' knowledge level (n=50).

Domains of knowledge	Good		Average		Poor	
	No.	%	No.	%	No.	%
Nurses' knowledge of medical devices related to pressure injuries (MDRPIs)						
Description and definition of MDRPIs	8	16	25	50	17	34
Risk factors for the occurrence of MDRPIs	8	16	19	38	23	46
Degrees and stages of MDRPIs	7	14	19	38	24	48
Prevention, treatment, and complications of MDRPIs	9	18	25	50	16	32
Nurses' knowledge regarding the care of patients connected with each device						
Central venous catheter care	10	20	23	46	17	34
Nasogastric tube care	12	24	24	48	14	28
Endotracheal Tube care	11	22	23	46	16	32
Urinary catheter care	13	26	24	48	13	26
CPAP mask care	14	28	24	48	12	24

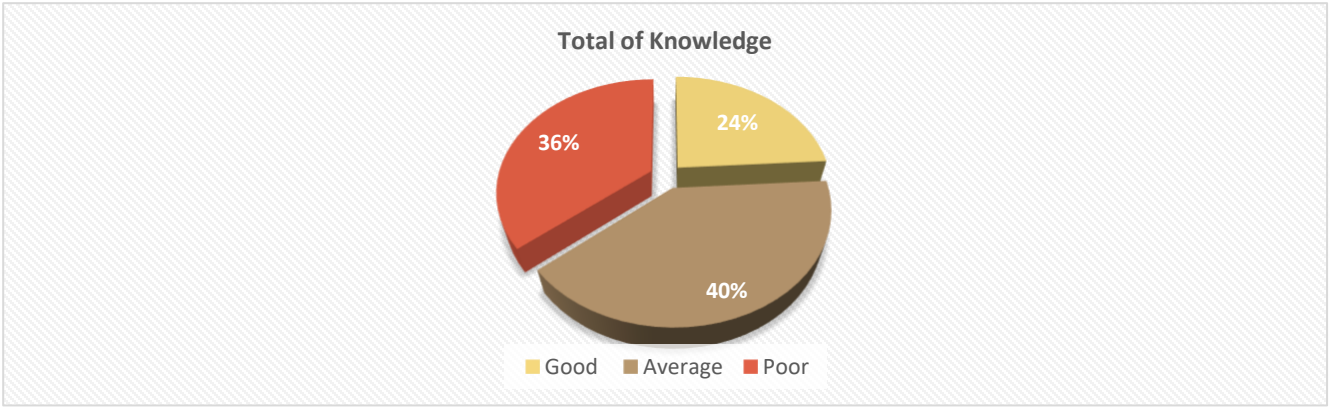

Figure (1): Percentage distribution of studied nurses' total knowledge score (n= 50).

Table (3): Frequency and percentage distribution of the studied nurses according to their domains of practice (n=50).

Practice	Competent		Incompetent	
	No.	%	No.	%
General practice for prevention of MDRPIs	13	26	37	74
Practical care for each device				
Nasogastric Tube Care	20	40	30	60
Central venous catheter care	15	30	35	70
Urinary catheter care	16	32	34	68
Endotracheal tube care	14	28	36	72
CPAP mask care	13	26	37	74

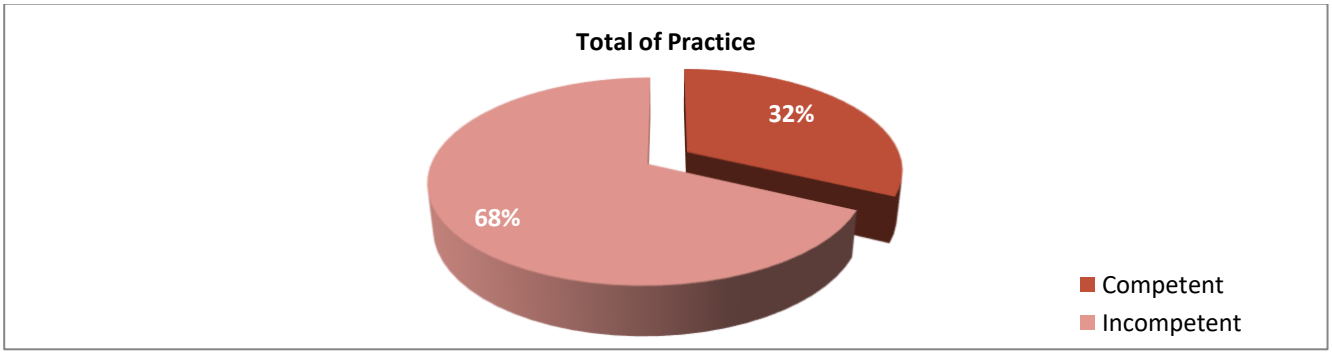

Figure (2): Percentage distribution of studied nurses' total practice score (n= 50).

Table (4): Frequency and percentage distribution of the studied patients' demographic characteristics (n=157).

Personal information	No.	%
Age		
20 - <35	13	8.3
35 - <50	90	57.3
50 – 65	54	34.4
Mean±S.D	46.9±9.84	
Range	21–64	
Gender		
Male	66	42.1
Female	91	57.9
Educational degree		
Cannot read and write	7	4.5
Primary	26	16.6
Secondary	60	38.2
Bachelor	61	38.8
Postgraduate	3	1.9
Marital status		
Married	135	85.9
Unmarried	22	14.1
Residence		
Rural	62	39.5
Urban	95	60.5
Occupation		
Employed	42	26.8
Unemployed	115	73.2
Length of stay		
5-<10	24	15.3
10-<15	56	35.7
15+	77	49
BMI		
Underweight	3	1.9
Normal (18.5-25kg/m^2)	10	6.4
Overweight (25-29.9 kg/m^2)	45	28.7
Obesity (30 kg/m^2)	99	63

6. Discussion

Nurses play a significant role and are responsible for preventing pressure injuries in critically ill patients. This prevention is considered an essential part of nursing care. Workload and a lack of knowledge may affect pressure injury prevention. Most nurses were able to identify medical devices that may cause pressure injuries and suggest ways to prevent them. However, some nurses lack awareness about the implications of placing medical devices in close contact with the skin *(Tan et al., 2020).* This study aims to assess factors affecting the occurrence of medical device-related pressure injuries in the intensive care unit.

Demographic characteristics of the studied nurses reveal that around half were 25 to less than 30 years old, more than two-thirds were males, half were singles, and more than half had technical nursing education. More than one-third had experienced between one and three years. Most of them did not attend any training regarding MDRPIs. These data reflect the younger age with middle nursing education and few experiences of the studied nurses.

This finding agrees with *Zhang et al. (2021),* who conducted a study to assess the effect of critical care nurses' knowledge, attitude, and practice on preventing MDRPIs in western China" and found that half of the studied subjects were in the age group between 25 years old to less than 30 years old. Similarly, *Tirgari et al. (2018)* stated that the study subject was between 20 and 30 years old in an Iranian study about pressure injury prevention knowledge and practice among nurses. This result disagreed with *Hu et al. (2021),* who conducted a study assessing the knowledge, attitude, and practice of intensive care unit nurses regarding pressure injury prevention in China:" and found that most of the sample in the study had aged more than 30 years old.

Gender is an important factor to consider in the nursing profession. The current study finding agrees with *Luo et al. (2023),* who conducted a study about ambulance referral of more than 2 hours could result in a higher prevalence of medical-devices-related pressure injuries (MDRPIs) " and found that more than two-thirds of study nurses were males. The current study findings disagree with *Yan et al. (2022),* who studied the influence of training programs on nurses' ability to care for subjects with pressure injuries and found that most study participants were females. This finding disagrees with *Erbay Dalli and Kelebek Girgin (2022),* who conducted a study about nurses' knowledge, perception, and preventive practice in intensive care units regarding medical device-related pressure injuries and reported that most were females.

Table (5): Frequency and percentage distribution of the studied patients' medical characteristics (n=157).

Variables	No.	%
Admission route		
Emergency	132	84.1
Ward	13	8.3
Operation room	12	7.6
Primary diagnosis		
Respiratory failure	60	38.2
Renal failure	40	25.4
Cardiovascular disease	57	36.2
Surgical History		
Yes	50	31.8
No	137	87.2
Current multiple comorbidities		
Smoking	57	36.3
Ischemic heart disease	14	8.9
Vascular disease (peripheral vascular disease cerebral)	25	15.9
Hemodynamic shock during current hospitalization	26	16.6
Hypertension	34	21.7
Diabetes mellitus	22	14
Patient mobility		
Normal	9	5.7
Ambulatory (including aided)	12	7.6
Wheelchair	37	23.6
Bedridden	99	63.1
Glasgow Coma Scale		
Conscious	37	23.6
Confused	72	45.8
Coma	48	30.6
Fever		
Yes	36	22.9
No	121	77.1
Medication use		
Anticoagulant	84	53.5
Corticosteroids	69	43.9
Sedative	75	47.8
Vasopressors	86	54.8
Chemotherapy	3	1.9
Serum albumin		
Normal	64	40.8
Hypoalbuminemia	93	59.2
Hyperalbuminemia	0	0
Hospital stays before ICU admission		
Yes	78	49.7
No	79	50.3
Presence of edema		
Yes	108	68.8
No	49	31.2

Education level can have a significant impact on a nurse's career. The current study findings are in the same line with *Mohamed and Weheida (2015),* who conducted a study about the effects of education about pressure ulcer control on nurses' knowledge and safety of immobilized patients and found that most nurses working in ICU had a secondary education and technical institute of nursing. On the other hand, these findings disagreed with *Zhang et al. (2021)* and *Hu et al. (2021)*; they concluded that most of the sample in their studies had a Bachelor's level of education.

Years of experience and previous training programs can also impact a nurse's performance. The current study finding was in the same line with *Yan et al. (2022),* who conducted a study about the effect of training on nurses' capability to care for patients with pressure injuries and found that most of the study participants had less than five years of experience and did not participate in any training programs.

On the other hand, this result disagreed with *Lotfi et al. (2019),* who conducted a study about the effect of knowledge behavior and attitudes of Iranian on the prevention and management of pressure injury. They reported that almost two-thirds of the studied nurses had more than fourteen years of experience. *Erbay Dalli and Kelebek Girgin (2022)* conducted a similar study and found that most studied nurses had previous MDRPI training courses.

Table (6): Frequency and percentage distribution of injuries related to different medical devices (n=91).

Devices	No.	%
Injuries related to the nasogastric tube (n=83)		
Yes	13	15.7
No	70	84.3
Injuries related endotracheal tube (n=75)		
Yes	26	34.7
No	49	65.3
Injuries related to a urinary catheter (n=94)		
Yes	23	24.5
No	71	75.5
Injuries related to central venous catheter (n=83)		
Yes	15	18.1
No	68	81.9
Injuries related to CPAP mask (n=29)		
Yes	14	48.3
No	15	51.7

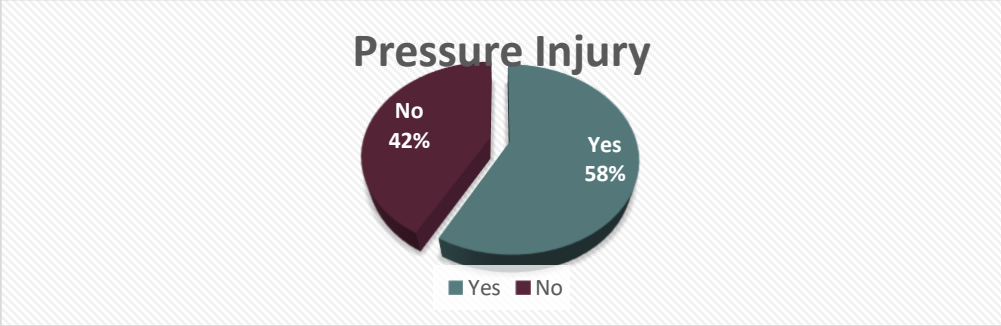

Figure (4): Percentage distribution of medical devices related to pressure injury MDRPIs among the studies patients (n= 157).

Table (7): Correlation between nurse's total knowledge, practice, and occurrence of pressure injury

Variables		Knowledge	Practice
Total practice	R	0.718	
	P	0.000	
Pressure injury	R	-0.563	-0.499
	P	0.001	0.001

Table (8): Logistic regression model of patients' related predisposing factors for medical device-related pressure injury.

Patients related factors	Odds Ratio	(95% Confidence interval)		P-value
		Lower	Upper	
Presence of edema	7.85	4.2	9.12	0.000
Age	3.04	2.15	5.66	0.006
Length of stay	6.77	3.8	8.65	0.000
BMI	4.66	2.90	6.81	0.001
Bedridden patient	4.01	3.26	5.97	0.002
Fever	1.87	1.03	3.46	0.012
Smoking	1.76	1.01	3.12	0.014
DM	2.02	1.46	3.98	0.011
Vasopressors medication	1.50	1.10	3.24	0.016
Hemodynamic shock during current hospitalization	4.50	3.14	6.26	0.001
HTN	1.64	1.11	3.70	0.013
Abnormal serum albumin	1.53	1.04	3.65	0.015
Hospital stays before ICU admission	3.24	2.69	5.17	0.006

Table (9): Logistic regression model of device-related predisposing factors for medical device-related pressure injury.

Device related factors	Odds Ratio	(95% Confidence Interval)		P. value
		lower	upper	
CPAP				
Size "Inappropriate"	8.15	4.9	11.08	0.000
Availability of equipment for Care "Unavailable."	7.66	3.64	10.52	0.000
Fixation "Inappropriate"	8.39	5.12	12.66	0.000
Central venous catheter				
Size "Inappropriate"	3.89	2.63	6.68	0.001
Site "Inappropriate"	4.45	3.15	7.63	0.000
Availability of equipment for Care "Unavailable."	2.87	2.16	5.44	0.011
Fixation "Inappropriate"	3.99	3.14	6.18	0.003
Catheter cover "Not covered"	2.74	2.01	4.65	0.012
Urinary catheter				
Size "Inappropriate"	2.13	1.54	3.89	0.014
Material "Silicon"	0.543	0.165	0.846	0.063
Availability of equipment for Care "Unavailable."	1.99	1.02	4.05	0.012
Fixation "Inappropriate"	5.32	3.78	8.09	0.002
Endotracheal tube				
Size "Inappropriate"	4.63	3.30	6.55	0.006
Insertion site "Naso"	0.213	0.064	0.470	0.083
Availability of equipment for Care "Unavailable."	2.18	1.65	4.09	0.012
Fixation "Inappropriate"	5.68	4.23	8.76	0.001
Nasogastric tube				
Size "Inappropriate"	1.08	0.64	1.75	0.056
Insertion site "nasogastric tube"	0.43	0.12	0.98	0.82
Availability of equipment for Care "Unavailable."	2.45	1.81	4.00	0.011
Fixation "Inappropriate"	3.67	1.84	5.78	0.004

Nurse's knowledge is essential to their ability to provide safe and effective patient care. The present study finding reveals that over one-third of the studied nurses had poor knowledge, and two-fifths exhibited average knowledge. This finding may be attributed to the younger nurses' age, fewer years of experience, and lack of training concerning the MDRPIs that were evident in this study.

The previous findings match with *Sayed et al. (2022),* who conducted a study about the impact of nurses' education on their application of preventive measures regarding medical devices related to pressure injuries and patients' clinical outcomes. They found that most nurses had a low level of knowledge regarding MDRPIs. Also, the findings match *Nasreen et al. (2017),* who conducted a study in a general hospital in Lahore regarding nurses' knowledge and practices toward pressure injury prevention. They reported a poor level of total nurses' knowledge. *Sönmez and Bahar (2022)* reported insufficient knowledge regarding the prevention and treatment of MDRPIs when studying the nurses' knowledge of MDRPIs and the factors affecting them. *Kaçmaz et al. (2023)* reported similar findings in a study to assess nurses' knowledge and practice in preventing pressure injuries in intensive care units. They reported poor nurses' knowledge and practice in preventing pressure injury. Similarly, *Li et al. (2023),* who conducted a study about Critical care nurses' knowledge, attitudes, and practices of pressure injury prevention in China, found that the knowledge level of PI prevention in ICU nurses was low.

Regarding nurses' total practice, this study found that more than two-thirds of the studied nurses are incompetent in the general practice of prevention of MDRPIs and the specific care for each studied device. This finding may be related to the poor nurses' knowledge regarding the prevention of MDRPIs and the specific care for each studied device. This finding contradicts *Dang et al. (2022),* who studied the risk factors for developing medical device-related pressure injuries in intensive care units. They found that prevention practices were satisfactory. Also, *Jiang et al. (2020)* conducted a study to assess nurses' knowledge, practice, attitudes, and behaviors related to pressure injury prevention. They found that Chinese general nurses' practices of PI prevention were also at a high level.

Medical device-related pressure injuries (MDRPIs) can occur due to a combination of patient-related and device-related factors. Regarding characteristics of studied patients, the results of the present study reveal that more than half of the studied patients were in the age group between 35 to 50 years old and females. Almost three-quarters of them are unemployed, and most of them are married. Nearly half of the studied patients stayed in the hospital for more than fifteen days, and nearly two-thirds were obese. This result follows the result of *Ali et al. (2022),* who conducted a study Comparing the effectiveness of twill and adhesive tape techniques in securing the endotracheal tube and maintaining the integrity of oral mucous membrane among critically ill patients. They stated that elderly males were predominant in the study; three-quarters are married, and almost three-quarters are unemployed. *Ali et al. (2022)* added that prolonged hospital stays correlate with prolonged use of

devices and can cause pressure injuries, extending the length of hospital stay.

This result was supported by the results of *Dang et al. (2022),* who conducted a study about " Risk factors of medical device-related pressure injury in intensive care units" and found that patients with longer ICU stays (particularly ≥10 days) were more likely to have MDRPI. However, these results were congruent with the result of *Mehta et al. (2019),* who conducted a study about "MDRPU-an uncommonly recognized common problem in ICU" and found that a higher length of ICU stays was associated with MDRPI.

Similarly, *Hanonu and Karadag (2016)* conducted a descriptive study to determine the rate, characteristics, and risk factors for developing medical device-related pressure ulcers in intensive care units. They found that the incidence of MDRPI increased with the length of hospital stay**.** *Saleh and Ibrahim (2023),* who conducted a study about "Prevalence, severity, and characteristics of medical device-related pressure injuries in adult intensive care patients," found that the higher the Braden score, the lower the risk of MDRPI, Patients with skin edema had a three to four times higher risk of developing MDRPI than those without skin edema.

Medical device-related pressure injuries can occur in patients with a variety of primary diagnoses. However, some conditions may increase the risk of developing these injuries; regarding primary diagnosis, this study found that The Primary diagnosis among more than one-third of them was respiratory failure. This study contraindicated with *Ali et al. (2022),* who stated that most subjects were diagnosed with neurological disorders.

Regarding medication use, this study showed that more than half of them use vasopressors and anticoagulants, respectively, more than three-quarters of them use sedatives, and nearly half of them use Corticosteroids. These are common medications used in the intensive care unit. This finding aligns with *Koo et al. (2019),* who conducted a study about "Risk factors of medical device-related pressure ulcer in intensive care units." They found that the use of steroids, vasopressor, and sedatives can increase the risk of MDRPI. *Dang et al. (2022)* added that patients who use vasopressors have a higher prevalence of MDRPI.

Also, this finding is supported by *Hanon and Karadag (2016),* who conducted a study to determine the rate and characteristics of and risk factors for developing medical device-related pressure ulcers in intensive care units. They reported that steroids prevent the formation of collagen fibers. Also, the use of sedatives can affect patients' sensory ability, which can prevent patients from adequately expressing any discomfort caused by using medical devices. Besides, the ability of nursing staff to mitigate MDRPI risk for ICU patients receiving these medications may be limited because these agents are life-saving modalities that cannot be terminated to prevent MDRPI development. So, patients who use this kind of medicine should be paid more attention to ensure their safety. It will be the case in a disturbed conscious patient who cannot communicate his/her pain due to device pressure. There were more than three-quarters in this study. This finding aligns with *Koo et al. (2019),* who found that most patients with MDRPI are in a coma or confused.

Edema can contribute to developing medical device-related pressure injuries (MDRPIs). This study found that almost two-thirds of them have edema. This finding may be because nearly two-thirds of the patients had hypoalbuminemia. This finding aligns with *Koo et al. (2019),* who found that patients with skin edema had a three times higher risk of developing MDRPI than those without skin edema and were obese. This result is in the same line with *Coyer et al. (2020),* who reported that more than half of them were overweight.

Medical devices that can cause MDRPI include endotracheal tubes, nasogastric tubes, oxygen masks and nasal cannulas, feeding tubes, urinary catheters, intravenous catheters, dressings, and bandages. Besides, backboards, cervical collars, continuous positive airway pressure (CPAP) masks, wheelchairs, and beds. Regarding medical devices that cause MDRPI**,** the current study shows that almost half of the studied patients have injuries related to CPAP masks, while less than one-fifth have injuries related to NGT. Nearly one-third of them have injuries related to EET. These findings may be related to the method of applying the CPAP mask that should be firmly fitted on the patient's face for a long period of time. Also, this was the case for an irreplaceable endotracheal tube in the case of life-saving mechanical ventilation. Also, it needs frequent cuff deflation from nursing staff to avoid pressure injuries. This result, supported by *Mehta et al. (2019),* found that MDRPIs were most associated with using non-invasive ventilation CPAP and BIPAP masks as common respiratory support methods for respiratory distress syndrome widely used in ICU patients. Similarly, *Shapira-Galitz et al. (2018)* conducted a study about "Evaluation and predictors for nasogastric tube associated pressure ulcers in critically Ill patients in Israel and found that nasogastric tube-related pressure injuries lead to the higher incidence of nasal mucosal pressure injuries in ICU patients and this incidence of nasal mucosal pressure injuries in ICU patients about eighty-eight percent.

This finding is in the same line with *Erabi Dallı et al. (2022),* who conducted a study about "Incidence, characteristics and risk factors of medical device-related pressure injuries" and found that about one-third of patients have MDRPI related to CPAP and *Koo et al. (2019),* who conducted a study about "Risk factors of medical device-related pressure ulcer in intensive care units" and found that the EET cause of the majority of MDRPI inpatient in this study. *Mehta et al. (2019)* found that MDRPUs were most associated with using NIV Mask, NGT, and ETT. PUs of both types resulted in longer length of ICU stay.

Medical device-related pressure injuries MDRPIs are a common problem in healthcare settings. This study showed that more than half of the patients had medical device-related pressure injuries. This finding may be referred to lack of awareness among nursing staff to this important and common problem in ICU patients. This finding was supported by *Barakat-Johnson et al. (2017),* who conducted a study titled “Medical device-related pressure injuries: An

exploratory, descriptive study in an acute tertiary hospital in Australia," and reported that almost two-thirds of the sample developed MDRPI.

Regarding the nurses-related factors affecting the development of MDRPIs, the current study shows a statistically significant negative correlation between pressure injury and nurses' knowledge and practice. This finding may explain the importance of enhancing nurses' knowledge and practice regarding this critical issue in the ICU. This result is in the same line with *Grešš et al. (2021),* who conducted a study about "Nurses' knowledge and attitudes towards prevention of pressure ulcers" and found that having a bachelor's degree in nursing or a higher qualification was associated with a 2.61 times higher positive attitude towards preventing PIs.

This result aligns with *Malinga and Dlungwane (2020),* who conducted a study about "Nurses' knowledge, attitudes and practices regarding Pressure Ulcer Prevention in the Umgungundlovu District." This study showed that nurses' knowledge of pressure injury prevention was low, and their level of practice was low.

Linear regression model of patient-related predisposing factors to the development of MDRPIs reveals that the presence of edema, length of stay, BMI, hemodynamic shock during hospitalization, immobility (bedridden), hospital stay before ICU admission, and age had the highest odd ratio as risk factors in developing the MDRPIs (of odd ratio between 3.04 and 7.85). The linear regression also indicates other significant factors that could help develop the MDRPIs. They are DM, fever, smoking, hypertension, abnormal serum albumin, and vasopressin medication of an odd ratio between 2.02 and 1.50). These findings may be related to the negative effect of these factors on the tissue health of increasing edema, decreasing tissue immunity, exposure to infection, poor tissue perfusion, and frailty with aging. All are participating in the development of MDRPIs.

Similar findings were reported by *Rashvand et al. (2020),* who studied the incidence and risk factors for medical device-related pressure ulcers and reported that age, hospital stay, hypoalbuminemia, gender, having usual pressure ulcers were significant risk factors in developing MDRPIs in their sample. Also, *Semerci et al. (2023)* reported similar factors of albumin level, hemoglobin e level, MBI, and length of hospital stay among factors that influence the development of PU. Similarly, *Togluk Yiğitoğlu and Aydoğan (2023)* reported age, enteral feeding, prone positioning, and Braden score <12 among medical device-related pressure injury risk factors. *Kim et al. (2019)* reported similar findings in a study about medical device-related pressure ulcers (MDRPU) in acute care hospitals and their perceived importance and prevention performance by clinical nurses. They reported sensory impairment, dampness beneath the medical device, problematic perfusion and tissue durability, malnutrition, and edema.

In this study, medical device inappropriate size, unavailability of equipment, and inappropriate fixation were significant device-related risk factors in developing medical device-related pressure injuries. At the same time, the material was revealed as an insignificant factor. The site of the device was an insignificant factor in a nasotracheal and nasogastric tube, while it was significant in the central venous catheter. These findings may be due to the unavailability of the common sizes and the improper fixation done by the staff to maintain the device in place at the expense of tissue pressure. Similar findings were reported by *Kim et al. (2019),* who reported the improper fixation of the device among the risk factors of device-related factors in MDRPIs in ICU patients.

7. Conclusion

In summary, the results of this study revealed that more than one-third of the studied nurses had poor knowledge regarding MDRPIs, and two-fifths of them had average knowledge. Additionally, more than two-thirds of the studied nurses had incompetent practice toward prevention and care of patients with MDRPIs, with nurses' knowledge and practice significantly and negatively related to MDRPIs.

The study also reveals that more than half of the patients developed MDRPIs. The presence of edema, length of stay, BMI, hemodynamic shock during current hospitalization, immobility, hospital stay before ICU admission, age, DM, fever, smoking, hypertension, abnormal serum albumin, and vasopressin medications are significant risk factors in developing MDRPIs.

Besides, inappropriate medical device size, unavailability of equipment, and inappropriate fixation were significant device-related risk factors in developing medical device-related pressure injuries in this study.

8. Recommendations

The study recommended focusing on nursing staff knowledge, skills, and attitude. Nurses must have access to updated information, learning resources, and continuous educational opportunities. The nurses must constantly seek better ways to improve their care to patients connected with medical devices by acquiring knowledge and implementing the established standards of care, which must be updated periodically. Also, implementing an educational training program to improve nurses' performance regarding preventing medical devices-related pressure injuries in intensive care units.

MDRPIS must be taken seriously by all members of the healthcare team, especially nurses, and protocols should be established for improvements. The findings of this study should be taken into consideration in order to understand which of the underlying factors are preventable. The study recommended implementing an educational training program to improve nurses' performance in preventing medical device-related pressure injuries in intensive care units.

9. References

Abd El Wareth, M. S. (2019). Medical device-related pressure injuries in critically ill patients. *International Journal of Novel Research in Healthcare and Nursing,* 6(2), 1509-1518.

Ali, R. F., Fathallah, M., & Kandeel, N. A. (2022). Comparing Between the effectiveness of twill and adhesive tape techniques in securing the endotracheal tube and maintaining the integrity of oral mucous membrane among critically ill patients. *Mansoura Nursing Journal, 9*(1), 9-21. https://doi.org/10.21608/mnj.2022.258996.

Barakat-Johnson, M., Barnett, C., Wand, T., & White, K. (2017). Medical device-related pressure injuries: An exploratory descriptive study in an acute tertiary hospital in Australia. *Journal of Tissue Viability, 26*(4), 246–253. https://doi.org/10.1016/j.jtv.2017.09.008

Boru, T. (2018). Chapter five: Research design and methodology. Available at: https://www.researchgate.net/publication/329715052_CHAPTER_FIVE_RESEARCH_DESIGN_AND_METHODOLOGY_51_Introduction_Citation_Lelissa_TB_2018_Research_Methodology_University_of_South_Africa_PHD_Thesis#fullTextFileContent

Brophy, S., Moore, Z., Patton, D., O'Connor, T., & Avsar, P. (2021). What is the incidence of medical device-related pressure injuries in adults within the acute hospital setting? A systematic review. *Journal of Tissue Viability, 30*(4), 489-498. https://doi.org/10.1016/j.jtv.2021.03.002.

Choi, B. K., Kim, M. S., & Kim, S. H. (2020). Risk prediction models for the development of oral-mucosal pressure injuries in intubated patients in intensive care units: a prospective observational study. *Journal of Tissue Viability, 29*(4), 252-257. https://doi.org/10.1016/j.jtv.2020.06.002.

Colo, A. (2023). Nurses can play a critical role in preventing medical device-related injuries. College of Nursing, University of Colorado Anschutz Medical Campus. Available at: https://news.cuanschutz.edu/nursing/nurses-role-preventing-medical-device-injuries#:~:text=Up%20to%2045%25%20of%20all,related%20pressure%20injuries%20(MDRPIs).

Coyer, F., Cook, J. L., Brown, W., Vann, A., & Doubrovsky, A. (2020). Securement to prevent device-related pressure injuries in the intensive care unit: A randomized controlled feasibility study. *International Wound Journal, 17*(6), 1566-1577. https://doi.org/10.1111/iwj.13432

Coyer, F., Cook, J. L., Doubrovsky, A., Vann, A., & McNamara, G. (2022). Exploring medical device-related pressure injuries in a single intensive care setting: A longitudinal point prevalence study. *Intensive and Critical Care Nursing,* 68, 103155. https://doi.org/10.1016/j.iccn.2021.103155.

Dang, W., Liu, Y., Zhou, Q., Duan, Y., Gan, H., Wang, L., Zhu, Q., Xie, C., & Hu, A. (2022). Risk factors of medical device-related pressure injury in intensive care units. *Journal of Clinical Nursing, 31*(9-10): 1174-1183. https://doi.org/10.1111/jocn.15974.

Erbay Dalli, Ö., & Kelebek Girgin, N. (2022). Knowledge, perception, and prevention performance of intensive care unit nurses about medical device-related pressure injuries. *Journal of Clinical Nursing, 31*(11-12), 1612-1619. https://doi.org/10.1111/jocn.16014.

Erbay Dallı, Ö., Ceylan, İ., & Kelebek Girgin, N. (2022). Incidence, characteristics and risk factors of medical device-related pressure injuries: An observational cohort study. *Intensive & critical care nursing, 69,* 103180. https://doi.org/10.1016/j.iccn.2021.103180.

Grešš Halász, B., Bérešová, A., Tkáčová, Ľ., Magurová, D., & Lizáková, Ľ. (2021). Nurses' knowledge and attitudes towards prevention of pressure ulcers. *International journal of environmental research and public health, 18*(4), 1705. https://doi.org/10.3390/ijerph18041705.

Hanonu, S., & Karadag, A. (2016). A prospective, descriptive study to determine the rate and characteristics of and risk factors for the development of medical device-related pressure ulcers in intensive care units. *Ostomy Wound Manage, 62*(2), 12–22.

Hu, L., Sae-Sia, W., & Kitrungrote, L. (2021). Intensive care nurses' knowledge, attitude, and practice of pressure injury prevention in China: A cross-sectional study. *Risk Management and Healthcare Policy, 14,* 4257-4267. https://doi.org/10.2147/RMHP.S323839.

Jiang, L., Li, L., & Lommel, L. (2020). Nurses' knowledge, attitudes, and behaviors related to pressure injury prevention: A large-scale cross-sectional survey in mainland China. *Journal of Clinical Nursing, 29*(17-18), 3311-3324. https://doi.org/10.1111/jocn.15358

Kaçmaz, H. Y., Ceyhan, Ö., Güler, H. B., & Balcılar, F. (2023). Nurses' knowledge and practice in preventing pressure injuries in intensive care units. *Journal of Wound Care, 32*(Sup4), S22-S28. https://doi.org/10.12968/jowc.2023.32.Sup4.S22.

Kim, J. Y., Lee, Y. J., & Korean Association of Wound Ostomy Continence Nurses (2019). Medical device-related pressure ulcer (MDRPU) in acute care hospitals and its perceived importance and prevention performance by clinical nurses. *International wound journal, 16* (Suppl 1), 51–61. https://doi.org/10.1111/iwj.13023.

Koo, M., Sim, Y., & Kang, I. (2019). Risk factors of medical device-related pressure ulcer in intensive care units. *Journal of Korean Academy of Nursing, 49*(1), 36-45. https://doi.org/10.4040/jkan.2019.49.1.36.

Li, J., Zhu, C., Liu, Y., Li, Z., Sun, X., Bai, Y., Song, B., Jin, J., Liu, Y., Wen, X., Cheng, S., & Wu, X. (2023). Critical care nurses' knowledge, attitudes, and practices of pressure injury prevention in China: A multicentric cross-sectional survey. *International wound journal, 20*(2), 381–390. https://doi.org/10.1111/iwj.13886.

Lotfi, M., Aghazadeh, A. M., Asgarpour, H., & Nobakht, A. (2019). Iranian nurses' knowledge, attitude, and behavior on skin care, prevention and management of pressure injury: A descriptive cross-sectional study. *Nursing open, 6*(4), 1600-1605. https://doi.org/10.1002/nop2.365.

Luo, Z., Liu, S., Yang, L., Zhong, S., & Bai, L. (2023). Ambulance referral of more than 2 hours could result in a higher prevalence of medical-devices-related pressure

injuries (MDRPIs) with characteristics different compared to the inpatient setting: A descriptive observational study. *BMC Emergency Medicine 23*(44). https://doi.org/10.1186/s12873-023-00815-9**.**

Malinga, S., & Dlungwane, T. (2020). Nurses' knowledge, attitudes and practices regarding pressure ulcer prevention in the Umgungundlovu District, South Africa. *Africa Journal of Nursing & Midwifery*, *22*(2). 1-17. https://doi.org/0.25159/2520-5293/7691.

Mehta, C., Ali, M., Mehta, Y., George, J. V., & Singh, M. K. (2019). MDRPU-an uncommonly recognized common problem in ICU: A point prevalence study. *Journal of Tissue Viability*, *28*(1), 35–39. https://doi.org/10.1016/j.jtv.2018.12.002.

Mohamed, S. A., & Weheida, S. M. (2015). Effects of implementing an educational program about pressure ulcer control on nurses' knowledge and safety of immobilized patients. *Journal of Nursing Education and Practice*, *5*(3), 12. https://doi.org/10.5430/jnep.v5n3p12.

Nan, R., Su, Y., Pei, J., Chen, H., He, L., Dou, X., & Nan, S. (2023). Characteristics and risk factors of nasal mucosal pressure injury in intensive care units. *Journal of Clinical Nursing*, *32*(1-2), 346-356. https://doi.org/10.1111/jocn.16193.

Nasreen, S., Afzal, M., Sarwar, H., & Waqas, A. (2017). Nurses knowledge and practices toward pressure ulcer prevention in general hospital Lahore. *Saudi Journal of Medical and Pharmaceutical Sciences*, 3(6), 520-527. https://doi.org/10.21276/sjmps.

Pinto, H. J., D'silva, F., & Sanil, T. S. (2020). Knowledge and practices of endotracheal suctioning amongst nursing professionals: A systematic review. *Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine*, *24*(1), 23-32. https://doi.org/10.5005/jp-journals-10071-23326.

Pittman, J., & Gillespie, C. (2020). Medical device–related pressure injuries. *Critical Care Nursing Clinics*, *32*(4), 533-542. https://doi.org/10.1016/j.cnc.2020.08.004.

Rashvand, F., Shamekhi, L., Rafiei, H., & Nosrataghaei, M. (2020). Incidence and risk factors for medical device-related pressure ulcers: The first report in this regard in Iran. *International Wound Journal*, *17*(2), 436-442. https://doi.org/10.1111/iwj.13290.

Saleh, M. Y. N., & Ibrahim, E. I. M. (2023). Prevalence, severity, and characteristics of medical device-related pressure injuries in adult intensive care patients: A prospective observational study. *International Wound Journal*, *20*(1), 109-119. https://doi.org/10.1111/iwj.13845.

Sayed, S. E., Ali, H. A., & El Maraghi, S. K. (2022). Effect of educational program about preventive nursing measures of medical devices related pressure injuries on nurses' performance and patients' clinical outcome. *Tanta Scientific Nursing Journal*, *27*(4), 119-139. https://doi.org/10.21608/TSNJ.2022.274239.

Semerci, R., Umaç, E. H., Yılmaz, D., & Karadağ, A. (2023). Analysis of the prevalence and risk factors of pressure injuries in the hospitalized pediatric population: A retrospective study. *Journal of Tissue Viability*, *32*(3), 333-338. https://doi.org/10.1016/j.jtv.2023.04.004.

Shapira-Galitz, Y., Karp, G., Cohen, O., Halperin, D., Lahav, Y., & Adi, N. (2018). Evaluation and predictors for nasogastric tube associated pressure ulcers in critically Ill patients. *Israel Medical Association Journal*, *20*(12), 731–736.

Sönmez, M., & Bahar, A. (2022). Medical device-related pressure injuries: Knowledge levels of nurses and factors affecting these. *Journal of Tissue Viability*, *31*(2), 231-238. https://doi.org/10.1016/j.jtv.2022.01.006.

Tan, J. J. M., Cheng, M. T. M., Hassan, N. B., He, H., & Wang, W. (2020). Nurses' perception and experiences towards medical device-related pressure injuries: A qualitative study. *Journal of Clinical Nursing*, *29*(13-14), 2455-2465. https://doi.org/10.1111/jocn.15262.

Tirgari, B., Mirshekari, L., & Forouzi, M. A. (2018). Pressure injury prevention: Knowledge and attitudes of Iranian intensive care nurses. *Advances in Skin & Wound Care*, *31*(4), 1-8. https://doi.org/10.1097/01.ASW.0000530848.50085.ef.

Togluk Yiğitoğlu, E., & Aydoğan, S. (2023). Determination of medical device-related pressure injury in COVID-19 patients: A prospective descriptive study. *Journal of Tissue Viability*, *32*(1), 74-78. https://doi.org/10.1016/j.jtv.2022.10.004.

Yan, B., Dandan, H., & Xiangli, M. (2022). Effect of training programs on nurses' ability to care for subjects with pressure injuries: A meta-analysis. *International Wound Journal*, *19*(2), 262-271. https://doi.org/10.1111/iwj.13627.

Zhang, Y. B., He, L., Gou, L., Pei, J. H., Nan, R. L., Chen, H. X., Wang, X. L., Du, Y. H., Yan, H., & Dou, X. M. (2021). Knowledge, attitude, and practice of nurses in intensive care unit on preventing medical device-related pressure injury: A cross-sectional study in western China. *International wound journal*, *18*(6), 777–786. https://doi.org/10.1111/iwj.13581.