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# Prevalence, severity, and characteristics of medical device related pressure injuries in adult intensive care patients: A prospective observational study

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## Abstract

This study was intended to determine the characteristics of Medical Related Pressure Injury (MDRPI) in adult intensive care patients. MDRIs are recognized as significant and complex health problems among hospitalized patients. Underestimated true scale of the problem is evident because the systematic clinical evaluation of MDRPI occurrence is not part of routine skin assessment among intensive care patients. A prospective approach was used to obtain data of MDRPIs with two weeks follow up to monitor the prevention and treatment strategies. Participants were 329 adult patients from three large referral and teaching centres in Jordan. Data were collected using a screening form that included demographic and clinical characteristics, and a list of medical devices. The primary outcome for this study was MDRPI and defined as a pressure injury (PI) found on the skin or mucous membrane with a medical device in use at the location of the injury (EPUAP, 2019). The patients with MDRPI were followed up for 2 weeks for prevention and treatment strategies. Prevalence of MDRPI was 5.01% (15/299) with 41 injuries, 27/41 (65.8%) were skin injuries and 14/41(34.2%) were mucosal. Most mucous membrane MDRPIs were at mouth/lips and caused by ET tube and meatal orifice caused by foley catheter. Skin MDRPIs were at the nose and caused by NG tube and hands by peripheral intravenous line and arms caused by blood pressure cuff. Inadequate prevention was provided on daily care as only 177 prevention and treatment interventions were provided over 2 weeks for 15 patients. As a growing problem among Jordanian adults in intensive care, MDRPI required the need for effective prevention. About one-thirds of MDRPIs were mucosal, a finding not previously reported, indicating the need to include mucous membrane assessment with skin assessment when a medical device such as NG and ET tubes or foley catheters are in use. Prevention and treatment interventions provided to patients with MDRPIs were not systematic and based on routine care with no clear guidelines. A consensus has yet to be reached suggesting the

need to establish effective prevention strategies for medical device-related pressure injuries. Future research is recommended to follow up MDRPI prevention and treatment strategies among patients in ICU. We suggest to continue studying the prevalence of MDRPIs and monitoring the location, prevention and treatment of both skin and mucosal MDRPIs.

**KEYWORDS**

adult patients, characteristics, intensive care units, Jordan, MDRPI, prevalence, prevention and treatment, severity

**Key Messages**

- Using medical devices in intensive care units to sustain the lives of patients puts them at the risk of medical device-related pressure injuries (MDRPIs)
- Most MDRPIs developed in males with a mean age of 70 years old and who were admitted to medical ICU with a higher risk of PI development (mean Braden score was 10.9) and had about 2 weeks long ICU stay
- Hands and wrist, nose and lips or mouth in addition to the meatal orifice were the most common sites of MDRPIs suggesting the need to include mucous membrane assessment with skin assessment when a medical device such as an NG and ET tubes or foley catheters are in use.
- Although prevention of MDRPIs is the main goal, earlier detection could result in a better prognosis and lower the financial impact of this disease.

Employment of advanced technology is essential in caring for hospitalized patients, especially in intensive care units (ICUs) (Also known as critical care units). Using medical devices (MDs) in physically-compromised critically ill (also known as patients in ICU) adults, children, and trauma or orthopaedic patients is pervasive to sustaining life and promoting healing during patients' hospital stay.[1,2] With the MDs, the risk of MD-related pressure injuries (MDRPIs) is inevitable.[3] Patients in ICU who are on mechanical ventilation are 2.4 times more likely to develop hospital-acquired pressure injuries (HAPIs) compared to those patients without a device during their hospital stay.[1,4,5] Consistently, The National Pressure Ulcer Advisory Panel (NPUAP) (2016) and European Pressure Ulcer Advisory Panel (EPUAP) (2019) identified a medical device-related PI (MDRPI) as arising "from the use of devices designed and applied for diagnostic or therapeutic purposes. The resultant pressure injury generally conforms to the pattern or shape of the device".[6,7] MDRPIs can be staged using the PI staging system for skin injuries, although were caused by pressure (from a medical device). MDRPI occurring on mucous membranes cannot be staged. These are assigned the category of mucous membrane MDRPI. Mucous membrane injuries are shallow, open and visually difficult to distinguish apart from deeper injuries. In addition, the coagulum formed in mucous membranes resembles the slough seen in stage III PIs but is a soft blood clot.[6,7] However, similar descriptions used skin and mucous membrane tissue cannot be used.

MDRPIs are an important type of PI in critically ill adults. Of the 14 studies reported the prevalence of MDRPI, ten studies were conducted in adult critical and acute care settings, and four were in children.[8] The estimated pooled prevalence of MDRPI was 0·4%[9] to 44.7%.[10] With limited research, it appears that the prevalence of MDRPIs varies widely according to the population investigated, the location of the injury, and the MD used. For instance, concerning location and population, 35% of MDRPIs developed on the ears[1] in an adult population and nearly 50% of neonates and children developed MDRPIs most commonly on the nose and feet due to the application of pulse oxygen probes and bilevel and continuous positive airway pressure ventilator support systems.[3]

MDs causing injuries are also widely variable. Endotracheal tubes (ET tubes) and Foley catheters,[11] cervical collar or braces,[2] oxygen therapy tubes and masks[10] and feeding tubes such as nasogastric (NG) and jejunal tubes[12] were reported as the most common devices causing MDRPIs.

MDRIs have been recognized as significant and complex health problems in critical care settings in terms of human suffering, pain, disfigurement, extended hospitalization, and financial burden, where the use of MDs is essential to sustain a patient's life.[8] Yet, under-reporting of MDRPIs may occur because nearly 74% are not

clinically identified until they are stage III, IV, or unstageable, and there has been poor documentation of device removal, pressure relief, and/or skin inspections.[2] The true scale of the problem was not known because the systematic clinical evaluation of MDRPI occurrence is not part of routine skin assessment among critically ill patients.[13] However, more specific data are needed to document the significance of the problem and provide the basis for appropriate prevention. Prospective data may be useful to provide insights into the prevalence of MDRPIs, severity, aetiology, and consequences, which in turn improves our understanding of the nature and characteristics of MDRPIs in critically ill patients and helps clinicians to develop better prevention plans. Recently, an international consensus on MDRPI has been developed[14] and reviewed aetiology, assessment, prevention and management of MDRPI. This consensus recommended safe conditions for the implementation of medical device including biomechanical and thermodynamic tissue conditions at the skin-device interface. The consensus also suggested future research including laboratory investigations, clinical trials and computer modelling to prevent MDRPI occurrence. However, MDRPI prevention needs team work of biomedical engineers, tissue viability nurses and medical team to mitigate the risks of MDs are available in clinical use.

The overall aim of this study was to determine the characteristics of MDRIs in adult critically ill patients. The specific objectives were to determine: (a) the prevalence, severity, location and etiology of MDRPIs in adult critically ill patients; (b) demographic and clinical characteristics of patients screened for device-related pressure injuries; and (c) the frequency of MDRPIs treatment and prevention strategies among critically ill patients.

## 1 | METHODS

### 1.1 | Study design

A prospective observational study using convenience sample of patients admitted to the ICU was employed. Two weeks of follow-up for patients diagnosed with MDRPI was used to monitor the prevention and treatment strategies. The data were collected from all clinical settings April thru July 2021. STORBE guidelines were used to report this study.[15]

### 1.2 | Study settings and sample

The study was conducted on three Jordanian medical settings that are large referral and teaching centers, all of which are located in Amman, the capital of Jordan. The public setting comprised nine ICUs with 100 beds, the private included 10 ICUs with 130 beds and the university teaching included 9 ICUs with 100 beds (Please see Table 6). These settings admit patients with major neurological disorders, trauma, acute medical-surgical and oncology conditions. The occupancy rate of ICUs in Jordan is almost 100%.[16] All adults of ≥18 years in the ICUs who were admitted before midnight on the predetermined day of data collection and had MDs in situ were screened for MDRPI. Only critically ill patients who were diagnosed with MDRPI were followed up for prevention and treatment.

### 1.3 | Study measures

Data were collected using a screening form developed by researchers and based on,[13] included demographic and clinical characteristics, and a list of medical devices. Demographic characteristics were age and gender. Clinical characteristics were the admitting ward, hospital stay and number of ICU days at the time of screening, previous hospitalization, medical diagnosis and Charlson Comorbidity index scoring (CCI).[17] Pressure injury (PI) risk was measured using The Braden Scale (Braden scores). The Braden scale used six subscales, each of which is rated from 1 to -4 except for friction/shear, which is scored from 1 to 3. Mobility, activity, sensory perception, skin moist and nutritional status are all subscales that contribute to PI development.[18] The Braden scale score ranges from 6 to 23, with the lower the score, the greater the chance of development PI and vice versa. Patients with a score of less than 18 were considered at risk of developing PI.

The list of devices was modified by recording the devices that were present on patients in the selected ICUs to include respiratory devices (endotracheal tube, face mask including simple/non-rebreathing mask, non-invasive positive pressure ventilation, nasal oxygen cannula, and tracheostomy); vascular lines (central venous catheter, peripheral intravenous catheter, arterial line, and epidural catheter); gastrointestinal/genitourinary devices (nasogastric tube, percutaneous endoscopic gastrostomy or jejunostomy tube, urinary catheter, condom and faecal drains); monitoring equipment (oxygen saturation probe, non-invasive blood pressure cuff, electrocardiogram leads and pacemaker); and preventive devices (sequential compression device, thromboembolic deterrent stockings, cervical collar, and restraints-splints, casts, braces, traction).

The data collection form identified mucous membrane MDRPI, which were not staged but classified as mucosal injuries. The primary outcome for this study was MDRPI and defined according to NPUAP (2016) and EPUAP

(2019)[6,7] as a PI found on the skin or mucous membrane with a medical device in use at the location of the injury.[6,7] MDRPIs found on mucous membranes are defined as shallow open mucous membrane injuries related to a medical device. Those MDRPI found on the skin were classified according to the NPUAP/EPUAP classification system of four stages and two unstageable categories.[6,7] In addition, MDRPI location and device causing injury were also documented. Based on Talley and O'Connor's clinically accepted physical examination techniques of the skin,[19] MDRPI peri-wound and skin under and around each device were evaluated. MDRPI peri-wound was evaluated for redness, oedema and/or maceration and MDRPI wound bed was evaluated for necrosis, exudates and/or odour. Additional outcome to this study was MDRPI prevention and treatment. The patients with MDRPI were followed up for 2 weeks or until discharge, transfer to other clinical areas or dead for prevention and treatment strategies. MDRPI prevention and treatment included strategies such as device repositioning, device padding, cleansing, moisturizing and receiving nutritional supplements at least once through the observation period.[6,7]

### 1.4 | Ethical consideration

Ethical approval was sought and granted by the Research and Ethics Committee of the School of Nursing, The University of Jordan and the Ethics Committee of each participating clinical setting. Permission was granted at each setting to screen all patients for all devices in use and the prevalence of MDRPIs. Each patient or his/her first-degree relative (if the patient's level of consciousness was 8 or less according to the Glasgow coma scale assessment by the caring team) was asked to sign a written consent to participate in the study and to be followed up for 2 weeks. First-degree relatives included a person's parents, siblings, adult son or daughter. The right to withdraw from the study at any stage was assured.

### 1.5 | Procedure

Researchers met the directors of nursing at the study settings and the screening form was fully discussed. Heads of education departments, tissue viability nurses and heads of ICU departments at the selected settings reviewed the screening form and the data collection procedure. As a result of the group meeting, the screening form was modified and edited to suit Jordanian ICUs in terms of feasibility and convenience to clinical practice. The researchers asked the university of Jordan to recruit qualified research nurses to collect data for 4 months. Six research nurses were trained to use the screening form, perform a skin assessment, and identify pressure injuries and MDRPIs, which established interrater reliability in the use of the data collection tools. The ICU in charge and bedside nurses at the selected ICUs were oriented to the aims of the study and the data collection period.

Two research nurses were appointed at each clinical setting to collect data. On the predetermined day of data collection, research nurses identified and screened all patients in the selected ICUs at the medical settings who met the inclusion criteria in coordination with charge and bedside nurses. Then research nurses used screening forms among all eligible patients which included reviewed medical records, performed skin examination for pressure injuries found on the skin or mucous membranes with a medical device in use at the location of the injury and documented all MDs attached to the patient. Skin assessment was coordinated with routine nursing care to reduce the patient's physical and psychological burden.

All patients diagnosed with MDRPI and stayed at ICU were followed on daily basis (6–8 hours per day) for up to 2 weeks or until discharge, transfer to other clinical areas or dead to record prevention and treatment strategies. In addition, the tissue viability nurse at the selected setting was notified to ensure the continuity of care of patients with MDRPI.

## 2 | DATA ANALYSIS

Data entry was completed using Statistical Packages for Social Sciences (SPSS, version 24).[20] Preliminary data screening was conducted to identify missing data. All extreme values were evaluated by the researchers to ensure accurate data entry. Descriptive statistics were calculated for all variables (means and SDs for continuous variables; frequencies and percentages for categorical variables).

MDRPI prevalence was calculated by the total number of MDRPIs present on the day of screening divided by the total number of ICU patients screened at the same day of observation from all study settings. The demographic and clinical data of patients who had MDRPI were then described and the frequency of prevention and treatment strategies used were reported. All percentages were rounded to the nearest digit.

## 3 | RESULTS

Overall, 329 adult patients in critical care units were eligible for the inclusion criteria of the study. Thirteen

**TABLE 1** Description of the study settings and sample

| Medical sector | Total # of beds in each medical setting | # of selected ICUs | # of ICU beds | Total # of ICU patients eligible for screening | # of patients excluded | # of observed patients (screened sample) |
|---|---|---|---|---|---|---|
| Public | 816 | 9 | 162 | 100 | 12 | 88 |
| Private | 794 | 10 | 150 | 129 | 13 | 116 |
| University teaching | 1099 | 9 | 108 | 100 | 5 | 95 |
| Total | 3151 | 28 | 420 | 329 | 30 | 299 |

patients did not grant their consent and 17 were not available at the time of skin examination giving a final screened sample of 299 patients. The mean age of the screened sample was 60.5 (SD = 18.6) years and almost half were males. Clinical characteristics of the sample showed higher risk of PI development (mean Braden scores 12.7, SD = 4.7), admitted to surgical, medical and oncology ICUs, with a mean ICU stay of 9.6 days (SD = 15·1) and of 13.1 hospital stay days (SD = 18.4). Almost two-thirds of the sample (n = 218, 72.9%) had previous hospitalization and the mean CCI score was 3.6 (SD = 3.1) (Table 1). The mean number of devices used per person in screened patients was 8 (SD = 2.2). MDs employed in more than half of the screened patients were used for monitoring (peripheral oxygen probes, electrocardiogram leads, pacemakers, blood pressure cuffs), urinary foley catheters and peripheral intravenous lines (Table 2).

(i) The prevalence, severity, location and aetiology of MDRPIs in adult critically ill patients

**TABLE 2** Demographic and clinical characteristics of patients screened for device-related pressure injuries (N = 299)

| Patient characteristics | F (%), Mean (SD) |
|---|---|
| Age (Mean, SD) | 60.5 (18.6) |
| Gender (n = 291) | |
| Male | 148 (51.0%) |
| Female | 143 (49.0%) |
| ICU days[a] | 9.6 (15.1) |
| Hospital days[a] | 13.1 (18.4) |
| Admitting ICU | |
| Medical | 86 (28.8%) |
| Surgical | 109 (36.4%) |
| Oncology | 104 (34.8%) |
| Braden scale scores (Mean, SD) | 12.7 (4.7) |
| Previous hospitalization | |
| Yes | 218 (72.9%) |
| No | 81 (27.1%) |
| CCI score (Mean, SD) | 3.6 (3.1) |
| Mean device per patient (SD) | 8 (2.2) |

Abbreviation: CCI, Charlson comorbidity score. SD: Standard Deviation. F: Frequency

[a]At time of screening.

## 3.1 | Prevalence

The overall prevalence of MDRPI was 5.01% (15/299) including a MDRPI found on the skin or mucous membranes with a medical device in use at the location of the injury. Among the 15 critically ill patients found with MDRPIs, 41 injuries were recorded. The skin MDRPI was 27/41 (65.8%) and the mucous membrane MDRPI was 14/41(34.2%). The majority of the patients had 2 or more injuries.

## 3.2 | Severity

The MDRPI found on the skin were evaluated by the depth and classified according to the NPUAP/EPUAP classification system of four stages and two unstageable categories.[6,7] There were 10 injuries were stage I, 14 were stage II and 3 were stage III injuries. The mucous membrane was not evaluated by depth.[6,7] Abnormal peri-wound findings in terms of redness, oedema, maceration, and MDRPI wound bed in terms of necrosis, exudates, and odour descriptions were presented in details among individual injuries either skin MDRPI (particularly stages II and III) or mucous membrane MDRPI in Table 5.

## 3.3 | Location and aetiology

Ten MDRPIs were reported on the hands and wrist, seven on the nose, seven on the mouth/lips, and seven on the meatal orifice. Four MDRPIs were reported on

arms, three on the chest, one on the posterior thigh, one on the cheeks, and one on male genitalia. Seven of the MDRPIS were caused by the endotracheal tube, seven were due to damage by foley catheters, five were due to peripheral intravenous lines, five were due to nasogastric tubes, four were related to blood pressure cuff, three were caused by facemasks including non-rebreathing mask and non-invasive ventilation, three were due to using oxygen saturation probes, three were related to using leads of electrocardiogram, two were due to radial arterial lines, one was due to using sequential compression device, and one was due to using condom catheter (Table 5).

(ii) Demographic and clinical characteristics of patients with device-related pressure injuries

Of the 299 screened patients, 15 had MDRPI with a mean age of 71 years old (SD = 17.6), 60% were male and the majority were admitted to the medical ICU. The mean ICU length of stay was 13.6 days (SD = 12.1) and the mean hospital stay was 17.6 days (SD = 16.6) with a higher risk of PI development (mean Braden scores = 10.9, SD = 4.4). The mean comorbidity score was 3.4 (SD = 3.2), half of the patients previously admitted to hospital care, and the average number of MDs used was 8.6 per patient (SD = 2.3) (Table 3). Individual demographic and clinical characteristics were presented in Table 4.

(iii) The frequency of MDRPIs treatment and prevention strategies among critically ill patients

Of the 15 patients identified with MDRPIs, two died and two were transferred before completing the 14 days of follow-up observation. MDRPI prevention and treatment for the remaining 11 patients included strategies such as device repositioning, device padding, cleansing, moisturizing and receiving nutritional supplements at least once through the observation period[6,7]Results revealed that nutritional supplements were offered only once for two patients (Table 5). There were 177 prevention and treatment assessments documented by research nurses over the observation period. The most frequent treatment was cleansing (73/177), followed by repositioning (55/177), padding (36/177) and moisturizing (13/177) (Table 5). It was reported that some patients did not receive any treatment or prevention over the follow-up (observation) period. For instance, patient coded (O) did not receive adequate prevention or treatment strategy over five days follow up (observation) although tissue viability nurse was notified. Research nurses also reported the use of normal saline 0.9% or chlorohexidine sachets (0.02%) for cleansing MDRPIs, and paraffine, aqua cream and petroleum gel to moisturize the skin underneath the MDRPIs.

## 4 | DISCUSSION

The overall prevalence of MDRPI is relatively low in this sample of critically ill adult patients from three large Jordanian medical settings and is almost similar to that reported by Coyer et al[13] and Hobson et al.[21] Authors

**TABLE 3** Total number and percent of devices present in the screening sample of intensive care patients (N = 294)

| Device | (F, %)[a] |
|---|---|
| Respiratory | |
| ET Tube | 58 (19.7) |
| Face Mask[b] | 59 (20.0) |
| Nasal oxygen | 107 (36.4) |
| Tracheostomy | 14 (4.8) |
| Vascular lines | |
| Central venous catheter | 37 (12.6) |
| Arterial | 26 (8.8) |
| Epidural | 5 (1.7) |
| PIV line | 250 (85.0) |
| GI/GU | |
| Foley catheter | 216 (73.5) |
| Condom | 8 (2.7) |
| Fecal drain | 2 (0.7) |
| NGT | 61 (24.5) |
| PEG/PEJ | 11 (3.7) |
| Monitoring | |
| SpO2 probe | 257 (87.4) |
| Leads (ECG, EEG) | 186 (63.3) |
| Pacemaker | 142 (48.3) |
| BP cuff | 271 (92.2) |
| Preventive devices | |
| TEDS | 3 (1) |
| Cervical collars | 4 (1.4) |
| SCDs | 37 (12.6) |
| Restraints (splints, casts, Braces, traction) | 37 (12.6) |
| Mean device per patient (SD) | 8 (2.2) |

Abbreviations: %, Percentage; BP, blood pressure; ECG, electrocardiograph; EEG, electroencephalography; ET, endotracheal; F, Frequency; GI/GU, gastrointestinal/genitourinary; NGT, Nasogastric tube; PEG, percutaneous endoscopic gastrostomy; PEJ, percutaneous endoscopic jejunostomy; PIV line, Peripheral intravenous line; SCDs, sequential compression device; SpO2, peripheral oxygen saturation of haemoglobin; TEDS, thromboembolism deterrent stockings.

[a]Chest tubes, patient identification bands, wheelchair, diapers, bedpan, and drawsheets were reported as a device causing injury in literature and were not included in screening form in this study. These were observed accidentally in some patients, as a result, not systematically reported in this table.

[b]Includes non-rebreathing mask and non-invasive ventilation.

**TABLE 4** MDRPIs' description, days observed, MDRPI wound findings, prevention and treatment strategies

| ID | Type of Injury | Location | Device causing injury | # of days observed | Peri wound description | MDRPI wound findings | | | Frequency of prevention and treatment strategies | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | N | E | O | P | M | C | R | N |
| A | Skin-stage II | Hands-L wrist | RA line | 11 | Redness | NP | CP | NP | 0 | 0 | 0 | 0 | † |
| | Mucosal | Mouth/lips | ET tube | | Redness | NP | CP | NP | 3 | 0 | 5 | 0 | |
| B | Mucosal | Mouth/lips | ET tube | 13 | Redness | NP | NP | NP | 0 | 0 | 4 | 2 | X |
| | Skin-stage II | Hands-L wrist | RA line | | Redness & oedema | NA | CP | NP | 0 | 0 | 0 | 0 | |
| | Skin-stage I | Nose | NGT | | Redness | NP | NP | NP | 0 | 0 | 0 | 0 | |
| C | Skin-stage I | Hands-L | PIV line | 10, died | Redness | NP | NP | NP | 4 | 0 | 2 | 0 | † |
| | Skin-stage II | Nose | NGT | | Redness | NP | NP | NP | 0 | 0 | 0 | 2 | |
| | Mucosal | Meatal orifice | FC | | Maceration | NA | CP | CP | 0 | 0 | 0 | 1 | |
| D | Skin-stage III | Nose | Face Mask[a] | 14 | Maceration | CP | CP | CP | 0 | 0 | 0 | 0 | x |
| | Mucosal | Mouth/Lips | ET tube | | Maceration | NP | CP | CP | 0 | 0 | 0 | 0 | |
| | Skin-stage I | Hands-L | PIV line | | NA | NP | NP | NP | 2 | 0 | 3 | 0 | |
| E | Skin-stage III | Nose | Face Mask[a] | 14 | Maceration | NP | CP | CP | 0 | 0 | 0 | 0 | x |
| | Mucosal | Meatal orifice | FC | | Maceration | NP | CP | CP | 0 | 0 | 5 | 0 | |
| | Skin-stage I | Hands-L index | SpO2 probe | | NA | NP | NP | NP | 0 | 0 | 0 | 2 | |
| F | Skin-stage II | Arm-L | BP cuff | 14 | NA | NP | CP | CP | 6 | 1 | 4 | 6 | x |
| | Skin-stage II | Male genitalia | Condom | | Maceration | NP | CP | CP | 2 | 0 | 8 | 9 | |
| | Skin-stage I | Hands-L | PIV line | | NA | NP | NP | NP | 2 | 0 | 3 | 0 | |
| G | Skin-stage II | Arm-R | BP cuff | 11 | NA | NP | NP | NP | 2 | 2 | 5 | 2 | x |
| | Skin-stage I | Hands-L index | SpO2 probe | | Redness | NP | NP | NP | 1 | 2 | 3 | 5 | |
| | Mucosal | Meatal orifice | FC | | Maceration | NA | CP | CP | 1 | 4 | 7 | 1 | |
| H | Mucosal | Mouth/lips | ET tube | 7, transferred | Maceration | CP | CP | CP | 2 | 2 | 5 | 0 | x |
| | Skin-stage I | Chest | ECG leads | | Redness | NP | NP | NP | 0 | 0 | 0 | 1 | |
| | Skin-stage II | Arm-L | BP cuff | | NA | NP | NP | NP | 1 | 0 | 0 | 2 | |
| I | Mucosal | Mouth/lips | ET tube | 5, died | Redness | NP | NP | NP | 1 | 0 | 0 | 0 | x |
| | Mucosal | Meatal orifice | FC | | Redness | NP | NP | NP | 0 | 0 | 0 | 1 | |
| | Skin-stage II | Hands-L index | SpO2 probe | | Redness | NA | NP | NP | 0 | 0 | 0 | 1 | |
| J | Skin-stage III | Nose | NGT | 13 | Maceration | CP | CP | CP | 0 | 0 | 1 | 0 | x |
| | Skin-stage II | Chest | ECG leads | | Redness | NP | NP | NP | 0 | 0 | 2 | 3 | |
| | Mucosal | Meatal orifice | FC | | NA | NP | NP | NP | 0 | 0 | 2 | 0 | |
| K | Mucosal | Meatal orifice | FC | 12 | NA | NP | NP | NP | 0 | 0 | 3 | 0 | x |
| | Skin-stage II | Chest | ECG leads | | NA | NP | NP | NP | 0 | 0 | 0 | 2 | |
| | Skin-stage II | Arm-L | BP cuff | | NA | NA | NP | NP | 0 | 0 | 0 | 4 | |
| L | Skin-stage II | Cheeks | Face Mask[a] | 14 | Redness | NP | CP | CP | 0 | 0 | 0 | 0 | x |
| | Skin-stage II | Nose | NGT | | NA | NP | NP | NP | 0 | 0 | 0 | 0 | |

(Continues)

TABLE 4 (Continued)

| ID | Type of Injury | Location | Device causing injury | # of days observed | Peri wound description | MDRPI wound findings | | | Frequency of prevention and treatment strategies | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | N | E | O | P | M | C | R | N |
| | Mucosal | Mouth/Lips | ET tube | | NA | NA | NP | NP | 2 | 0 | 5 | 6 | |
| M | Mucosal | Meatal orifice | FC | 7, transferred | Redness | NP | NP | NP | 2 | 1 | 2 | 1 | x |
| | Skin-stage I | Posterior thigh | SCDs | | Redness | NP | NP | NP | 1 | 0 | 0 | 0 | |
| | Mucosal | Mouth/lips | ET tube | | Maceration | NA | NP | NP | 3 | 0 | 2 | 2 | |
| N | Skin-stage II | Nose | NGT | 12 | Redness | CP | NP | NP | 1 | 1 | 2 | 2 | x |
| | Skin-stage I | Hands-L | PIV line | | NA | NP | NP | NP | 0 | 0 | 0 | 0 | |
| O | Skin-stage I | Hands-L | PIV line | 5, transferred | Redness | NP | NP | NP | 0 | 0 | 0 | 0 | x |

Abbreviations: #, number; CP, Clinically present; D, Patient identifier; NA, not documented; NP, not clinically present. *Medical devices:* BP, blood pressure; ECG, electrocardiograph; ET, endotracheal; FC, foley catheter; L, Left; NGT, naso gastric tube; PIV, peripheral intravenous line; R, Right; RA, radial arterial line; SCDs, sequential compression device; SpO2, peripheral oxygen saturation of haemoglobin. *MDRPI wound findings*: E, exudates; N, necrosis; O, odour. *MDRPIs prevention and treatment:* C, cleaning skin under the device; M, moisturizing skin under the device; N, received supplemental nutrition (†, patient received supplemental nutrition at least once over the observation period, X, patient did not receive any supplemental nutrition over the observation period); P, padding the device; R, repositioning the device.

[a]Includes non-rebreathing mask and non-invasive ventilation.

found most MDRPIs developed in males with a mean age of 70 years old and who were admitted to medical ICU with a higher risk of PI development (mean Braden score was 10.9) and had about 2 weeks long ICU stay. Dissimilar to many studies, this study revealed that mucosal injuries were less than half of the reported injuries (14/41, 34.2%).[1,13,22] Considering the use of a large number of MDs for diagnosis, prevention, and treatment purposes, patients who developed MDRIs in this study had an average of 8 devices, suggesting the potential risk of device-related injuries was high, yet MDRI prevalence was almost 5%. Overall, inadequate prevention of MDRPIs and potential risk of having medical-related injuries was evident in this study and suggesting the need to establish effective prevention strategies for medical device-related pressure injuries.

Several studies reported MDRPIs in adult acute and intensive care patients.[1,9-11,13,21-24] The overall prevalence of MDRPIs from these studies was variable and ranged from 0.4% in Clark et al[9] to 44.7% in Arnold-Long et al.[10] Comparison of data from this study with that of other studies is challenging due to lack of reporting the prevalence of MDRPIs and specific devices that caused the injuries were not reported, and variability in the type of population investigated based on age and medical diagnoses. In addition, many studies did not report the number of ICU patients screened precluding calculation of ICU MDRI prevalence rate. The paucity of specific data among patients with MDRPIs limits the nurses' ability to devise and demonstrate early prevention interventions to patients at risk of MDRPI whose treatment requires the use of multiple devices to save their lives.

The findings from this study represent different location sites for device-related injuries than other published data by Black et al,[1] Van Gilder et al[22] and Kayser et al[24] where the ears were the most frequent location of MDRIs, and Watts et al[25] and Apold and Rydrych[2] where cervical collars were the most common sites. Findings of this study identified the hands and wrist, nose and lips or mouth in addition to meatal orifice as the most common sites were partially similar to findings reported by Coyer et al[13] and Amirah et al[11] in those injuries related to nose, lips or mouth specifically caused by NG and ET tubes, devices commonly used in ICUs, although specific MDs that caused injuries were not reported in many studies.[9,22,23]

An important finding from this study is reporting the number of mucous injuries (MDRPI-M) in contrast with only skin injuries in the other studies,[1,2,22,25] suggesting the need to include mucous membrane assessment with skin assessment when a medical device such as an NG and ET tubes or foley catheters are in use. This study reported MDRPI-M was 14/41(34.2%) and identified that

**TABLE 5** Demographic and clinical characteristics of patients with device-related pressure injuries (N = 15)

| Patient characteristics | Patients with MDRPI (N = 15) |
|---|---|
| Age (Mean, SD) | 70.9 (17.6) |
| Gender | |
| Male | 9 (60%) |
| Female | 6 (40%) |
| ICU days[a] | 13.6 (12.1) |
| Hospital days[a] | 17.6 (16.6) |
| Admitting ICU | |
| Medical | 12 (80%) |
| Surgical | 3 (20%) |
| Oncology | 0.0 |
| Braden scale scores (Mean, SD) | 10.9 (4.4) |
| Previous hospitalization | |
| Yes | 8 (53%) |
| No | 7 (47%) |
| CCI score (Mean, SD) | 3.4 (3.2) |
| Mean device per patient (SD) | 8.6 (2.3) |

Abbreviation: CCI, Charlson comorbidity score.
[a]At time of screening.

most MDRPI-M were at mouth/lips and caused by ET tube and the meatal orifice caused by foley catheter. The most MDRPI-S were at the nose and caused by the NG tube and hands by peripheral intravenous line and arms caused by blood pressure cuff. On the other extreme of understanding, these findings suggest that the key risk for developing an MDRI was the placement of the device itself, which is in line with Balck et al's study.[1] In addition, reporting the ICU data by exploring clinical characteristics of a single injury rather than by patient may improve our understanding of the type, location and the aetiology of MDRPIs and would be helpful to assess, identify, and initiate early prevention for potential MDRPIs. Moreover, future research is needed to explore the relationship between the type of device and the depth of tissue involved in the MDRPI.

Unlike other studies,[1,2,13,22] secondary analysis of the data showed a significant relationship between PI risk assessment and the development of MDRPI. A plausible explanation of this result is due to the number of patients who developed MDRPI and had classic PIs (n = 7/15, 46.7%) and the sample characteristics which included patients with a mean age of 70 years old patients were admitted to medical ICU with a higher risk of PI development (mean Braden score was 10.9). Among this case, the Braden scale was used routinely to assess the risk of PI among patients who have had classic PI or are at risk to develop PI, yet deemed unreliable to assess the risk of MDRPI.[1] Thus, further research is suggested to assess the ability of the Braden scale to assess the risk of MDRPI development or to devise a reliable tool as an alternative.

Considering the use of a large number of MDs in ICU for diagnosis and treatment purposes, the average devices used was 8.6 in 15 patients who have had MDRPIs, and the observation for 2 weeks, advocate inadequate prevention provided on daily care (177 prevention and treatment interventions provided over 2 weeks for 15 patients). Additional evidence supporting this figure is also the number of patients with serious MDRPI-S was 27/41 (65.8%) and the MDRPI-M was 14/41(34.2%), and the majority of those patients had 2 or more injuries.

Although prevention of MDRPIs is the main goal, earlier detection could result in a better prognosis and lower the financial impact of this disease. This can be done with a routine physical examination by the caring team and taking proper precautions. However, unfortunately, there are no clear guidelines in this regard and a consensus has yet to be reached suggesting the need to establish effective prevention strategies for medical device-related pressure injuries.

In addition to a lack of prevention guidelines and/or standardized practice, there is also evidence of inadequate training, low awareness, poor nursing knowledge on securing tubing (eg tracheostomies, ET tubes and oxygen support systems), poor positioning or fixation of MDs, inappropriate MD size and selection, skin being obscured from the site and lack of awareness of the impact of oedema.[26] Determining the sites where MDRPIs occur may enhance the development of a prevention policy and improve the clinical effectiveness of MDRPI care. It might also clarify which components of prevention are the most effective in promoting positive patient outcomes. An earlier study documented inadequate nurses' knowledge and skills to lead effective PI prevention and treatment[27] showed that, although nurses had adequate PI knowledge, their prevention measures were insufficient. Thus, there is a gap between theory and practice. While identifying PI does not provide action, assessment and diagnosis of PI is essential and primitive step yet to make change in clinical practice. A wider change plan of clinical practice could consider change management program, employing, for example, awareness programs of PI prevention and treatment interventions using a variety of approaches (education, use of risk assessment tools, grading scores and clinical guidelines). In such an area of interest and growing problem of MDRPIs in ICUs, protocols on prevention and treatment of MDRPIs across the countries and further research in the hope of reaching a consensus in prevention

**TABLE 6** Individual demographic and clinical characteristics of patients with MDRPI (N = 15)

| ID | Age | Gender | Diagnosis | ICU | Sector | Previous ICU admission | Total # of devices[a] | B.S[a] | CCI | Hosp. Days[a] | ICU days[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 66 | Male | Sepsis | Med. | Private | No | 13 | 9 | 7 | 24 | 22 |
| B | 82 | Female | CA Pancreas | Med. | Private | Yes | 11 | 9 | 12 | 41 | 13 |
| C | 84 | Male | Septic Shock | Med. | Public | No | 7 | 7 | 3 | 11 | 10 |
| D | 80 | Female | Cardiac Arrest | Med. | Public | Yes | 8 | 10 | 2 | 14 | 14 |
| E | 73 | Male | Sepsis | Med. | Public | No | 6 | 10 | 3 | 32 | 29 |
| F | 70 | Male | Myocardial Infarction | Med. | Public | Yes | 6 | 16 | 1 | 16 | 14 |
| G | 71 | Male | Pneumonia | Med. | Public | Yes | 7 | 14 | 1 | 13 | 11 |
| H | 64 | Male | Multiple trauma | Surg. | Public | No | 7 | 6 | 1 | 10 | 10 |
| I | 67 | Female | Sepsis | Med. | Public | No | 6 | 12 | 1 | 13 | 13 |
| J | 74 | Female | Subarachnoid hemorrhage | Surg. | Public | Yes | 7 | 11 | 3 | 13 | 13 |
| K | 37 | Male | Pneumonia | Med. | Public | Yes | 6 | 6 | 1 | 21 | 12 |
| L | 82 | Female | CA stomach | Med. | University | Yes | 10 | 11 | 7 | 29 | 16 |
| M | 62 | Female | Pneumonia | Med. | Private | No | 10 | 7 | 6 | 9 | 9 |
| N | 71 | Male | Multiple trauma | Surg. | University | Yes | 10 | 10 | 4 | 12 | 12 |
| O | 80 | Male | Sepsis | Med. | Public | No | 6 | 13 | 1 | 6 | 6 |

Abbreviations: B.S., braden score; CA Stomach, cancer stomach; CCI, Charlson comorbidity score; ICU, Intensive Care Unit; Med, Medical; PI, Pressure Injury; Surg., Surgical.
[a]At time of screening.

strategies, detection and treatment of this disease are highly recommended.

This study is subject to limitations of the cross-sectional design used to collect prevalence data. The exclusion of patients younger than 18 years and from other clinical settings may alter the true prevalence of MDRPIs in Jordan. Only adults were included in this analysis, and further research is necessary for the paediatric population. In addition, the absence of a specific risk assessment tool for developing MDRPIs made it difficult to assess properly the risk in our patients. The study focuses primarily on critical care settings, and therefore, these sample sizes from each set were quite small, making it infeasible to examine variances in characteristics of MDRPIs across care settings. Timing variations were present related to the day prevalence data was calculated which may have affected the number of devices identified as patients being discharged from the unit had many devices removed and those admitted directly may have had more devices present. It was also noticeable that no effort was made in this study to evaluate the mechanism by which devices caused injuries among intensive care patients as well as the time from device initiation to detection of an MDR injury was not calculated. Moreover, the current analysis was restricted to facilities that choose to participate in the study. Studies using larger samples from non-acute care settings are needed to know whether these results can be generalized beyond acute care.

## 5 | CONCLUSION

This study indicates the need to include mucous membrane assessment with skin assessment when MDs such as NG and ET tubes or foley catheters commonly used in ICU, a finding not previously reported in the most relevant literature. The foremost common anatomic mucous membrane MDRPIs were at mouth/lips and caused by ET tube and meatal orifice caused by foley catheter and skin MDRPIs were at the nose and caused by NG tube and hands by peripheral intravenous line and arms caused by blood pressure cuff. Future work is essential to assess the risk for MDRPI or alternative either as the Braden scale yet deemed unreliable. Prevention and treatment interventions provided to patients with MDRPIs were not systematic and based on routine care with no clear guidelines in Jordan. Additionally, future research is recommended to recruit and follow up MDRPI prevention and treatment strategies among critically ill patients. We suggest continuous follow-up studies on the prevalence of MDRPIs across clinical settings including critical care to evaluate and

monitor types, location, aetiologies, and prevention and treatment of both skin and mucosal MDRPIs, particularly when NG, ET tubes and foley catheters are in use.

## DATA AVAILABILITY STATEMENT

Data available on request from the authors

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