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What is the incidence of medical device-related pressure injuries in adults within the acute hospital setting? A systematic review

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ABSTRACT

Medical devices provide effective therapeutic care for patients. However, medical device-related pressure injuries (MDRPI) are caused by prolonged pressure or shear from a medical device on any location on the body, including mucosal cavities. The primary outcome of this quantitative systematic review was to identify the incidence of MDRPIs in adults within the acute hospital setting. Secondary outcomes include grading, anatomical location and devices that caused such injuries. Electronic databases (CINAHL Plus with Full Text, MEDLINE, EBSCO Host, Health Business Elite Web of Science, PsychINFO, Google Scholar, and Research Gate) were searched for all potential primary studies between November 2019–January 2020. Studies were refined to the English language only, had no time limit from publication, and had to include participants over the age of 18 years with an MDRPI in the acute hospital setting and 720 potential primary studies were identified. Fourteen articles were identified that matched the predefined criteria and were included in the review. All included studies were critically appraised using the evidence-based librarianship critical appraisal tool and data analysis and narrative synthesis were completed. The incidence of MDRPIs in adults within the acute care setting was 28.1% (SD: 29.1%, min: 1.14%, max: 100%). 71.3% of studies documented anatomical locations of MDRPIs, 36.2% included grading of MDRIs, and 71.4% studies documented the offending medical devices. The mean quality appraisal percentage of all included studies was 76.67% (SD: 4.61%; min: 66.6%, max: 83.3%). Despite the heterogeneity of the studies, the review has identified that MDRPIs are prevalent among individuals cared for within the acute hospital setting. Thus, given the morbidity associated with these wounds, it is important to develop strategies to reduce the scope of this problem.

1. Introduction

Pressure injuries (PIs), otherwise known as pressure sores, bedsores or decubitus ulcers, are a recurrent healthcare phenomenon among patients within the acute hospital setting, resulting in extended lengths in hospital stays, an increase in patients' pain, reduced motor function, and cost in the region of $26.8 billion in wound treatment [1]. Furthermore, up to 30% of PIs are directly caused by medical devices and patients who require medical devices are 2.4 times more likely to develop an MDRPI [2]. In 2016, NPUAP introduced a clear definition of medical device-related pressure injuries (MDRPIs), namely: MDRPIs "*result from the use of devices designed and applied for diagnostic or*

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therapeutic purposes. The resultant pressure injury generally conforms to the pattern or shape of the device". Risk factors include being critically unwell, reduced mobility, sensory and perfusion functioning, malnutrition, comorbidity conditions, microclimate, the patient's skin condition and relying on medical devices in order to sustain life [3].

Unlike PIs, MDRPIs can cause pressure damage to the skin in any location on the body that a medical device has been in contact [4]. Thus, MDRPIs commonly damage areas other than protruding bone regions, including soft tissue areas and mucosal membranes within cavities, such as nasal and tracheal cavities [4]. The pathological development of PIs and MDRPIs, however, are similar. Due to prolonged pressure, shear, or friction in combination with shear to a localised area, blood flow becomes disrupted to the compressed area [5]. This response causes inflammatory oedema to the localised area, an increase in interstitial pressure and obstructs lymphatic and vascular flow and tissue ischaemia [6]. The decay caused by ischaemia amplifies tissue injury by absorbing oxygen and preventing full reoxygenation to the localised area [7]. Furthermore, prolonged pressure to an area obstructs circulation and when reperfusion occurs, the dispense of oxygen-free radicals in combination with the inflammatory response creates further tissue damage and causes a reperfusion injury [7]. In contrast to generic PIs, which are primarily developed by friction, pressure or shear as a result of body weight and immobility, the cause of pressure in MDRPIs is due to the use of a medical device [6]. Friction in combination with shear from consistent rubbing or movement from a poorly positioned medical device can create a contact force parallel to the skin [7].

Medical devices are predominantly composed of synthetic products, such as plastic, which generates heat, moisture and humidity to the localised area and in turn creates a change in microclimate to the area [8]. This change in environment, along with pressure exertion over an area with a reduced amount of adipose tissue and using a medical device that requires fixation greatly contribute towards the production of MDRPIs [9,10]. Furthermore, in areas where oedema is evident and is in contact with a medical device, the amount of pressure to an area increases and further escalates the risk of MDRPI development [8]. Moisture caused by secretions from mucosal cavities where medical devices are situated can macerate and expose surrounding skin to acidic substances, which ultimately impairs skin integrity [8].

As the older demographic continues to age, live longer, and develop more co-morbidity conditions, the risk of developing MDRPIs will be an ever prevailing and increasing healthcare issue [12]. While previous research has investigated the incidence of MDRPIs among all age groups within all healthcare settings [13,14], it is important to differentiate the incidence of MDRPIs between children and adults. It has been identified that the primary cause of PI development among neonates and children has been related to the use of medical devices, however, it remains unclear the incidence of MDRPIs in adults [17]. Therefore, it is still of particular interest to raise awareness and examine MDRPIs specifically in adults within the acute hospital setting. Thus, in order to address this recurring healthcare concern, the objective of this systematic review was to explore the incidence of MDRPIs in adults within the acute hospital setting and identify further areas where research should be conducted.

2. Method

2.1. Design

This integrative review follows a systematic design to identify the incidence of MDRPIs in adults within the acute hospital setting. This included a comprehensive review of all available research literature applicable to the research question and adhered to the recommendations and guidelines provided by the Cochrane Handbook for the Systematic Reviews of Interventions [19] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [20].

2.2. Outcomes

The primary outcome for this review was the incidence of MDRPIs in adults within the acute hospital setting. The secondary outcomes of interest were the grading of MDRPIs, the anatomical location of MDRPIs, and the types of devices that caused MDRPIs.

2.3. Inclusion criteria

The inclusion criteria was: adult patients aged over 18 years, studies, adults who developed an MDRPI in an acute hospital setting, primary studies including the intervention of incidence and/or prevalence of MDRPIs concerning the population sample and setting, and quantitative methodologies examining the incidence, epidemiology and/or prevalence of MDRPIs such as cross-sectional studies, observational studies, cohort studies, retrospective analyses, and prospective analyses written in the English language only.

2.4. Exclusion criteria

The exclusion criteria were: patients under the age of 18 years, paediatric, natal or neonatal patients, MDRPIs developed outside of the acute hospital setting, studies that do not include incidence rates of MDRPIs, studies not written in the English language, and methodologies including experimental or qualitative designs, such as randomised controlled trials, non-randomised trials, before and after studies, interview-based research, peer reviews, policy reports, systematic reviews, case reports, management standard articles, guideline recommendation reports, quality improvement projects, and expert opinions. Grey literature such as national body publications, theses, dissertations, and reports were also excluded.

2.5. Search strategy

A preliminary search was performed using the Cumulative Index to Nursing and Allied Health Literature (CINAHL) Plus with Full Text Database with the guidance of the PEO tool [21]. The search incorporated all published literature relevant to the research question [19]. The main search strategy commenced November 2019 and was completed in January 2020 and searched the following databases: MEDLINE, EBSCO host, CINAHL Plus with Full Text, Health Business Elite, Web of Science, and PsycINFO [23]. Citation indexes from relevant articles, studies, and guidelines were incorporated into the search strategy to identify further potential primary research. Article titles were assessed by two authors independently, and their abstracts (when available) of the studies identified by the search strategy were screened for their eligibility, according to the inclusion and exclusion criteria. The full-text version of potentially relevant studies was obtained and two authors independently screened this against the inclusion criteria. Every result from each data source was recorded by the author on a word document and duplicates were removed through the screening of each data search. The search strategy and the rationale behind the study selection process are presented using the PRISMA Flow Diagram (see Fig. 1.) [24] to allow full disclosure for assessment of the search strategy and its replication [11].

2.6. Quality appraisal

Each included study was quality appraised to assess the methodology and the presentation of findings and results for each article [26]. The evidence-based librarianship (EBL) critical appraisal tool [27] was the most suitable quality appraisal tool to critically appraise the primary studies in this review due to its diversity to evaluate an array of studies that vary in their methodologies [26].

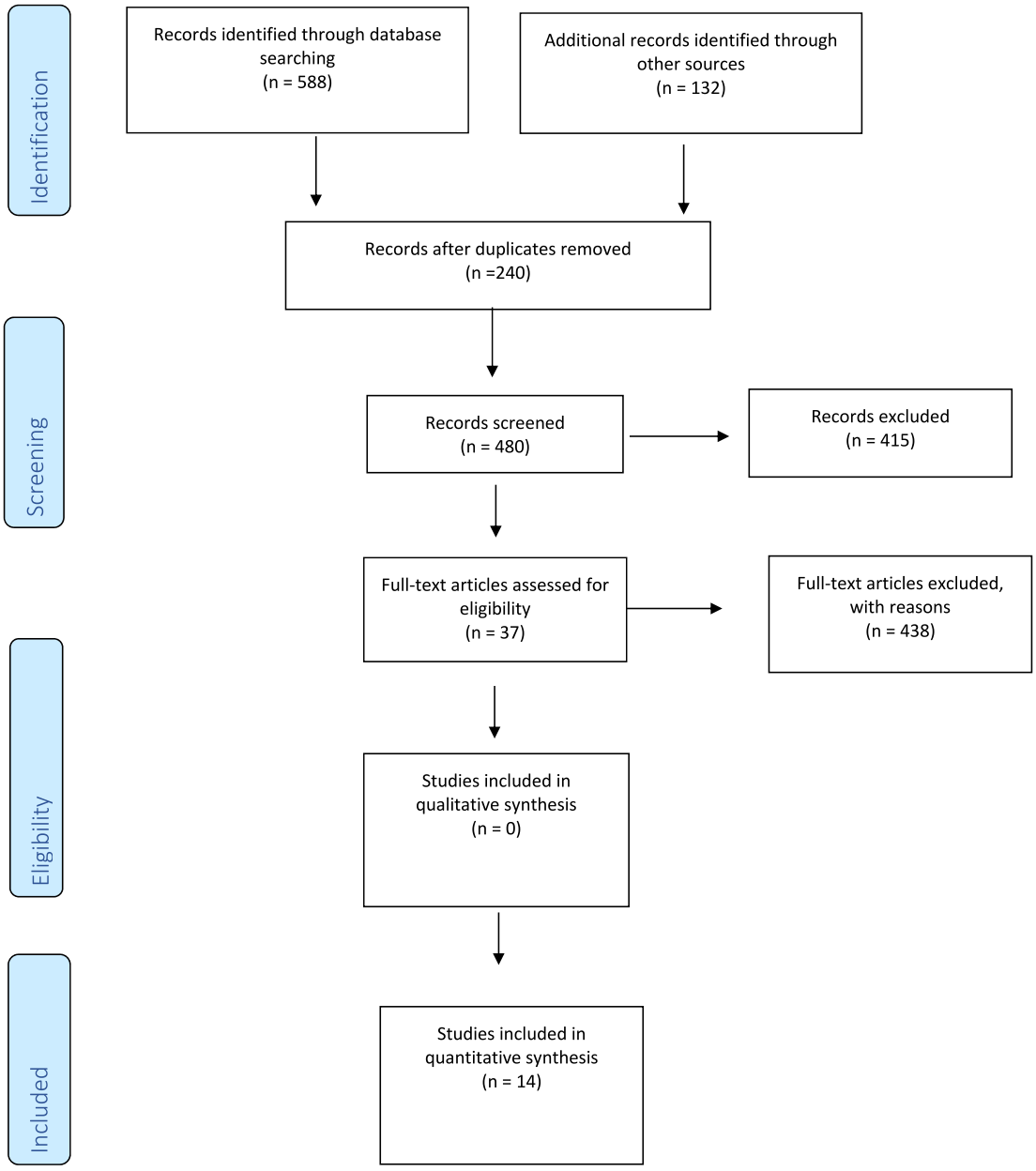

Fig. 1. PRISMA flow diagram for study selection.

2.7. Data extraction and synthesis

All studies that met the pre-eligibility criteria for the review underwent the data extraction process and all relevant data were populated onto a data extraction table (see Table 2). Data extracted from each study included the author, year of publication, study title, country, study design, care setting, data collection tool, duration of study, population size, primary outcome, secondary outcomes, measures, results and EBL critical appraisal percentage score. One review author extracted and summarised the eligible data. The data entry was then checked by a second review author.

Due to the heterogeneity of the included studies in this review and the exclusion of randomised controlled trials, a meta-analysis could not be achieved in this systematic review [19]. However, a basic descriptive statistical analysis was achieved using raw data extracted from each study and Microsoft Excel to calculate the mean and standard deviation of the raw data. The synthesised data allowed the author to compile a synopsis of findings from the studies. To summarise the secondary outcomes of the review, sub-groups were formed to allow extracted of data specific to anatomical location, MDRPI grading and devices that caused MDRIs. Table 2 outlines the data from the included studies including their EBL scores.

3. Results

The literature search identified 720 potential studies, duplicates, and articles from reviewing the title or abstract were identified as unrelated to the research question or did not meet the inclusion criteria, were removed. 37 articles were screened for eligibility. Having reviewed the full text of these articles, 23 of these studies were excluded from the review [2,28–32]; [15,16,33],; [12,18,35,38,40–47], and [48]. These studies were excluded for the following reasons: inclusion of participants under the age of 18 years, unrelated primary and/or secondary outcomes, research methodologies including before and after studies, clinical reports, cross-sectional studies, clinical guideline recommendations, quality improvement projects, prospective, descriptive studies,

the inclusion of non-acute hospital settings such as long-term care, rehabilitation, and hospice facilities (see Table 1).

Finally, 14 articles were identified that matched the predefined criteria and were included in the review [49,50]; [63,64]; [8–10,34, 51–54,56], and [3].

Table 1
Excluded studies.

Author/Year	Reason for Exclusion
[28]	Participants under 18 years included. 74.6% were male (SD: 16.7 years, range: 15–82 years). 25.4% were female (SD: 20.4 years, range: 15–88 years).
[29]	Participants under 18 years included. Age ranged between 16 and 91 years. Number of participants aged under 18 years was not disclosed.
[30]	Study examined the biomechanical effects of the presence and positioning of an endotracheal tubing model and providing a framework for safe positioning.
[31]	Participants under 18 years included. 6% (n = 3) of the sample population were neonates.
[2]	Participants under 18 years included. A subset analysis was created to include participants over the age of 17 years. No further characteristics and age of the participants were disclosed.
[32]	Clinical report: adaptation of a risk management standard to establish risk management modes to improve the MDRPI risk management process and analyse risks associated with MDRPIs.
Coyer et al. (2014)	Participants under 18 years included. Participants included in the study were aged over 16 years. Mean 56.0 years. Number of 16–17 year old participants was not disclosed in the study.
[15]	Participants under 18 years included. Participants over the age of 16 years were included in the study. The number of 16–17 year old participants was not disclosed in the article.
Coyer et al. (2016)	Before and after study design: to test an interventional patient skin integrity bundle to reduce pressure injuries in an adult intensive care unit.
[35]	Participants under 18 years included. Participants over the age of 16 years were included in the study. The number of 16–17 year old participants was not disclosed in the article.
[36]	Cross-sectional study. To detect the prevalence of pressure injuries in intensive care units. No documentation of MDRPIs provided.
[12]	Clinical guideline recommendations following the updated definition of MDRPIs. Research design excluded from pre-specified inclusion criteria.
[38]	Participants under 18 years included. The participants' aged between 2 and 90 years of age. There was no disclosure of the number of participants aged between 2 and 17 years of age.
[40]	Case report. Device related atypical pressure ulcerate on after cardiac surgery in 1 participant.
[41]	Prospective, descriptive study. Assessment of nursing staff perceptions and interventions to prevent MDRPIs. Examined the nurses' experiences with medical device use and the interventive and preventive measures for MDRPIs.
[42]	Retrospective analyses. Included non-acute hospital settings such as long-term care, rehabilitation and hospice facilities.
[43]	Quality improvement project. Development of an evidence-based guideline for the acute care setting for the prevention of MDRPIs and introduce a new nasogastric tube securement device to prevent MDRPIs.
[44]	Quality improvement project. Application of a stockinette to patients' arms prior to blood pressure cuff use to minimise the risk of MDRPIs associated with continuous blood pressure monitoring in the perioperative setting.
[45]	Quality improvement project. Prevention of MDRPIs associated with respiratory equipment use in the intensive care setting. Involved training respiratory nurse specialists to examine for MDRPI development on a daily basis and interdisciplinary teams to inspect for MDRPI development on biweekly patient rounds among patients with respiratory devices or as indicated.
[46]	Descriptive study. Included non-acute care settings, such as outpatients clinics and vascular outpatient departments.
[47]	Descriptive study. Surveillance of medical device-related hazards and adverse events in hospitalised patients involving mechanical and infection complications. No documentation of MDRPIs.
[48]	Cross-sectional cohort study. Pressure ulcer prevalence survey examining acute and non-acute facilities, such as long-term care and rehabilitation facilities.

3.1. Characteristics of included studies

3.1.1. Year of study

The included studies were published between 1998 and 2019, with 73.3% (n = 11) published between 2015 and 2019 (n = 11) [3,8–10,34, 51–54,56].

3.1.2. Geographical location

The studies were conducted in the U.K. [50], Saudi Arabia [51], the Netherlands [52], Turkey [9], Portugal [53], Australia [56], Egypt [8], Korea [10] and India [3]. The most prevalent geographical location was the U.S.A. (35.7%; n = 5) [49]; [63,64]; [34,54].

3.1.3. Care setting

The studies were all performed were in acute hospital settings, 64.2% (n = 9) in intensive care units, while the remainder of the studies were performed in a trauma centre hospital 14.2% (n = 2) or an acute hospital 21.4% (n = 3) without denoting which specific directorate.

3.1.4. Study design

The study designs included retrospective studies (28.5%; n = 4), descriptive studies (21.4%; n = 3), cross-sectional studies (14.2%, n = 2), cohort studies (14.2%; n = 2), before and after studies (7.1%; n = 1), epidemiological studies (7.1%; n = 1) and quasi-experimental studies (7.1%; n = 1).

3.1.5. Data collection methods

The data collection methods included data collection forms, such as forms created by study authors and established skin assessment forms (28.5%; n = 4), chart reviews (21.4%; n = 3), electronic database reviews (21.4%; n = 3), systematic observational methods (14.2%; n = 2) and data collection tools that were designed by study authors (14.2%; n = 2). The duration of the studies extended from 30 days [51] to 5 years [50]. One of the studies did not disclose the duration of their study period [3].

3.1.6. Study participants

Patient characteristics included a mixture of men and women who were all aged 18 years or older. The total sample population was 6033 participants (mean: 431; SD: 639. The smallest sample size was 34 [49], while the largest was 2008 [56], accounting for 33.28% of the total sample population.

3.1.7. Primary outcome

All 14 studies reported the primary outcome incidence of MDRPI. One of the studies [53] examined both the prevalence and incidence of all PIs but included a subset analysis of the incidence of MDRPIs thereby meeting the pre-set eligibility criteria.

The mean incidence of MDRPIs was 28.1% (SD: 29.1%; min: 1.14% [[52]], max: 100% [[10]]). The highest reported incidence originated from Korea 100% (n = 227 participants [[10]]) and the lowest incidence was reported from the U.S.A. 1.14% (n = 88 participants [[52]]). The incidence rates of the individual studies can be viewed in Fig. 2.

3.1.8. Secondary outcomes

3.1.8.1. Anatomical location. A total of 71.3% (n = 10) of the studies reported the anatomical location of the MDRPIs. Overall, 754 MDRPI locations were reported which were categorised into 13 groups (see Fig. 3).

3.1.8.2. Grading of MDRPIs. A total of 64.2% of the studies (n = 9) reported the grade of MDRPI in 886 wounds. Out of the studies that graded MDRPIs, only one study [10] included grades 1–4. The most common grades were grade 1 (38.26%) and grade 2 (37.92%) (see

Table 2
Included studies and EBL score.

Author	Country	Study Design	Population	Primary Outcome	Secondary Outcome	EBL Score
[49].	U.S.A.	Retrospective chart review.	34 acute adult patients.	Incidence of cervical collar-related pressure injuries.	Devices.	75%.
[50].	U.K.	Cross-sectional study.	90 acute adult patients.	Incidence of PUs with cervical spinal injuries.	MDRPI incidence. Anatomical location. Device.	79%.
[63].	U.S.A.	Retrospective chart review.	88 acute adult patients.	Cervical collar-related pressure injuries.	Anatomical location. Grade. Device.	75%.
[64].	U.S.A.	Before and after study.	100 acute adult patients.	Face mask-related pressure injuries.	Anatomical location. Grade. Device.	75%.
[51].	Saudi Arabia.	Prospective cohort study.	84 acute adult patients.	PU incidence in ICU.	MDRPI incidence. Anatomical location.	66.6%
[52].	Netherlands.	Prospective observational cohort study.	290 acute adult patients.	MDRPI incidence.	Anatomical location. Grade. Device.	83.3%.
[9].	Turkey.	Prospective descriptive study.	175 acute adult patients.	MDRPI incidence.	Anatomical location. Grade. Device.	87.5%.
[53].	Portugal.	Epidemiological study.	600 acute adult patients.		MDRPI incidence.	79%.
[54].	U.S.A.	Retrospective descriptive study.	304 acute adult patients.	MDRPI incidence.	Anatomical location. Grade. Device.	75%.
[34].	U.S.A.	Retrospective chart review.	1787 acute adult patients.	Compression stocking-related pressure injury incidence.	Grade.	70.8%.
[56].	Australia.	Retrospective observational study.	2008 acute adult patients.	Oral pressure injuries from oral medical devices.	Anatomical location.	78.2%.
[8].	Egypt.	Prospective quasi-experimental study.	100 acute adult patients.	MDRPI incidence.	Anatomical location. Grade. Device.	75%.
[10].	Korea.	Descriptive study.	227 acute adult patients.	MDRPI incidence.	Anatomical location. Grade. Device.	83.3%.
[3].	India.	Cross-sectional point prevalence study.	146 acute adult patients.	MDRPI incidence and/or prevalence.	Grade. Device.	75%.

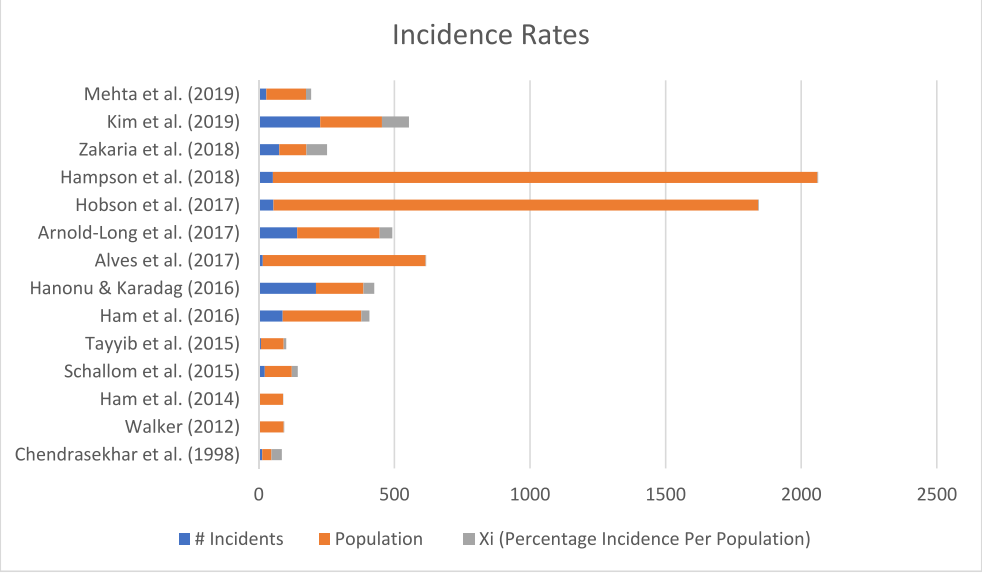

Fig. 2. Incidence within the included studies.

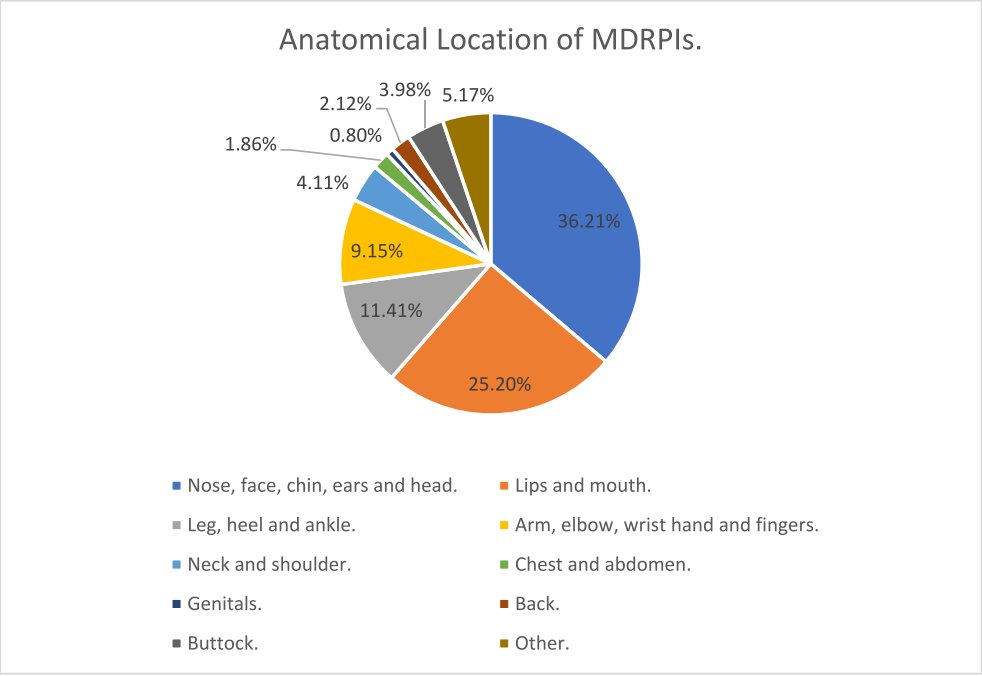

Fig. 3. Anatomical locations of MDRPIs.

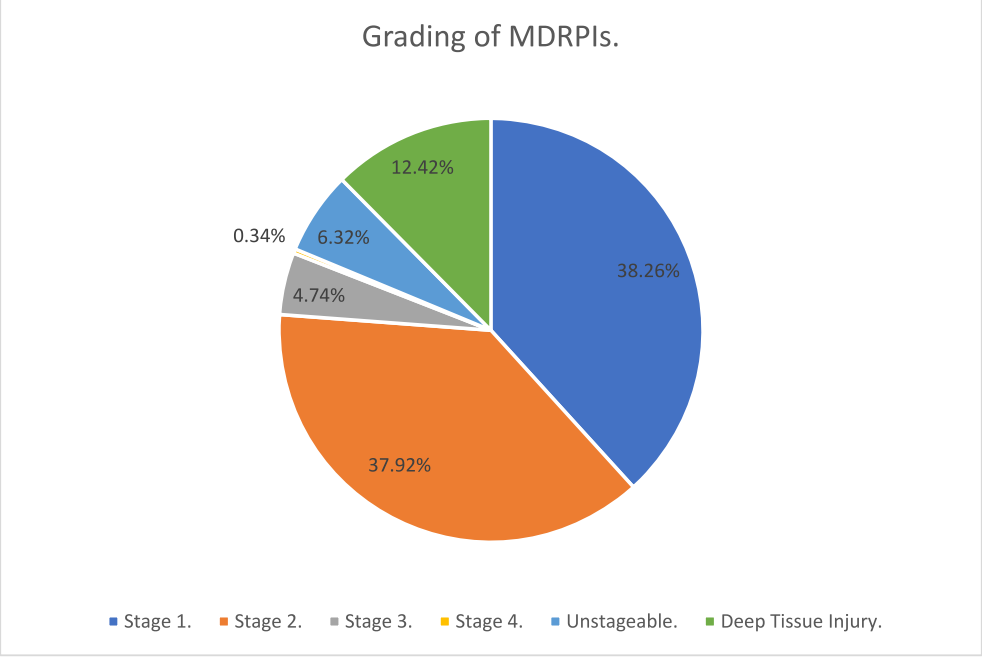

Fig. 4. Grading of MDRPIs.

Fig. 4).

3.1.8.3. Devices that caused MDRPIs. Ten studies (71.4%) that reported the medical devices that caused MDRPI development, 1386 devices were identified. The most common devices were immobilising devices (19.3%), endotracheal devices (14.32%) and nasogastric tubing (12.56%) (see Fig. 5).

3.1.9. Quality appraisal

The EBL critical appraisal checklist assessed the validity of the study of interest based on the corresponding "yes", "no" or "unclear" answers [27]. The total validity was calculated using formula (Y + N + U = T) [27]. The mean EBL score of all studies was 76.67% (SD: 4.61%; min: 66.6% [[51]], max: 83.3% [10]. A total of 85.7% (n = 12) of the studies included in this review scored a validity of 75% or greater, indicating the validity of the studies (see Table 2).

In the population section, 71.4% (n = 10), of the studies did not definitively outline the inclusion and exclusion criteria, while 35.7% (n = 5) of the studies did not include in their publication whether informed consent was obtained by the participant prior to the commencement of their research. 28.5% (n = 4) of the studies scored "no" or "unclear" as their target population was based on a convenience sample. In the data

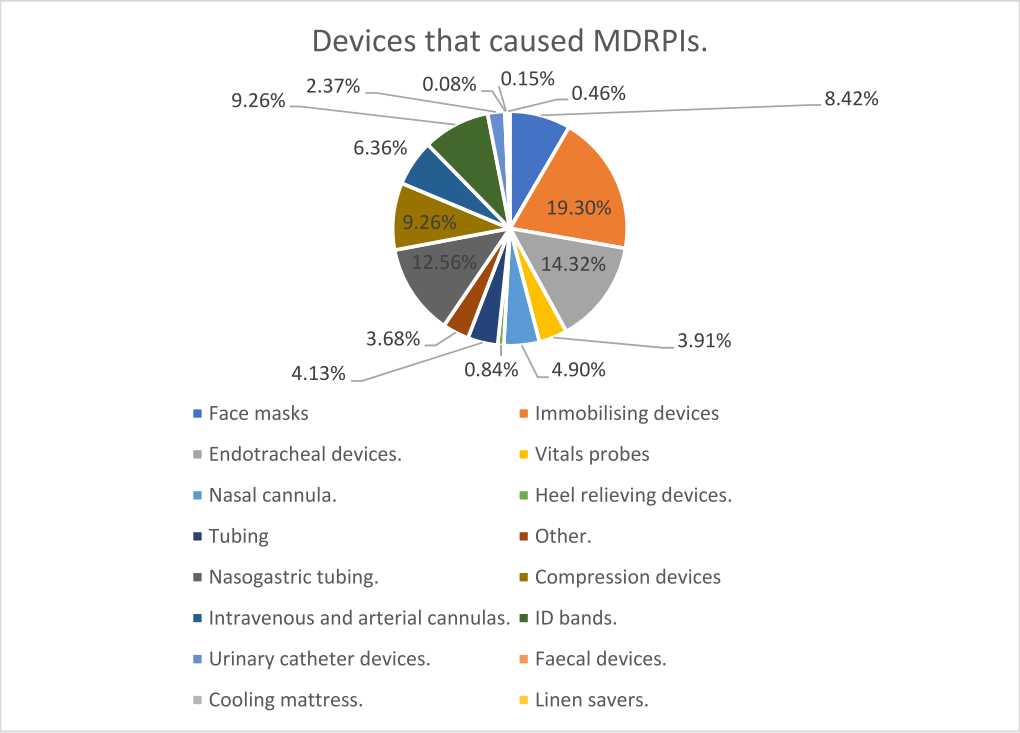

Fig. 5. Medical devices that caused MDRPIs.

collection section of the checklist, all studies scored less than 75%, displaying poor validity in their data collection methods. All studies failed to include a copy of their data collection instrument in their publication, while 35.7% (n = 5) of the studies failed to validate their data collection instruments prior to the commencement of their research.

Ten studies (71.4%) had a data collector involved in delivering a service to the target population. One study did not disclose the duration of time that the study was undertaken, which makes it unclear as to whether the study measured the outcome at a time appropriate to capture the effect, suggesting risk of bias. In study design, there were two questions that received "no" or "unclear" responses which were ethics approval not being obtained 28.5% (n = 4) and due to questioning behind the data collection methodology in 3 studies, the replicability of the stated research methodologies within the studies could be altered.

In the results section, 78.5% (n = 11) of the studies scored greater than 75% in validity. Negating areas included confounding variables 42.8% (n = 6), external validity 28.5% (n = 4), subset analysis being a major focus in the study 7.1% (n = 1) and no suggestion from the authors to continue research in the area that they have investigated 7.1% (n = 1). However, studies included in this review demonstrated face validity in the results section as they succeeded in fulfilling what they intended to do – measuring the primary outcome of their study [27].

4. Discussion

The primary aim of this systematic review was to determine the incidence of MDRPIs in adults within the acute care setting and a mean incidence of MDRPIs of 28.1% was identified. The fourteen included studies ranged from levels III-V on the hierarchy levels of evidence [57], and employed several different study designs, predominantly cohort studies, retrospective chart reviews, and cross-sectional studies. Sample sizes also varied between 34 and 2008 participants. All studies included measured the incidence of MDRIs in adults within the acute care setting as their primary outcome. Furthermore, 85.7% (n = 12) of the included studies scored greater than 75% using the EBL checklist [27] and scored as valid pieces of research.

The primary outcome of this review found that the incidence rate of MDRPI development in adults within the acute care setting is higher than previous systematic findings [13,14]. The strength of evidence that was included in the production of this review was valid, however, collectively, these studies created a heterogenous result with large variables in data, with reference to research methodology, study designs, sample sizing and reporting of MDRPIs.

In previous systematic research investigating the incidence of MDRPIs, the findings have similarly implicated the strength of the systematic evidence. [13] found that while the primary studies were reliable, the incidence result displayed heterogeneity. Similarly, [14] identified that the high variation in research methodology, sample sizing and reporting of MDRPIs led to their heterogenous MDRPI incident result. For example, the variance in sample populations was notable in this review as it was evident that one of the studies dominated the findings [10]. Based on these findings, is clear that there is a consistent pattern of heterogeneity evolving from the results and is due to several discrepancies: study designs, research methodologies, sample sizes, limited research, and unreported data from primary studies, which detracts from the issue, that is, MDRPIs. However, this highlights the demand for future research in MDRPIs to create high-quality primary studies following a consistent approach in research methodology, study design, data collection, and sample sizing. While this review could be considered as limited due to the heterogeneity of the results, it aids to provide a deeper understanding in relation to the incidence of MDRPIs in adults in the acute hospital setting, but also the areas that require addressing in future research. The secondary aim of this review investigated the common anatomical locations, staging and medical devices of MDRPIs.

In keeping with [14], this review found that the most common anatomical locations of MDRPI development were the ears, nose, face, chin, lips, and mouth. This trend could be as a result of the development of the MDRPI guidelines [58]. This notable trend could also be due to the increasing number of critically ill patients that require medical device use for therapeutic purposes that are commonly located in the lip,

mouth, nose, ear, and head region [10]. Due to poor application, fixation, offloading, adhesive tape use, pressure damage can occur through friction, pressure or shear and subsequently cause MDRPI development [10]. It is therefore vital that the correct assessment of medical device use and risk assessment is performed prior to device use.

While the NPUAP guidelines (2016) and best practice statements [32] stress the importance of risk assessment and its importance in everyday practice, Risk Assessment Tools (RAT)s that are still currently being used by healthcare professionals are the generic PI RATs, such as the Waterlow RAT [59]. While the Braden Scale [60] refers to devices as a risk of PI development, this review found that MDRPIs include fixated medical device use and require more advanced risk assessment methodologies in comparison to what is currently available from current PI RATs [6]. These methodologies require a combination of clinical judgment and MDRPI-specific clinical assessment and recognition skills. Many medical devices are fixated onto patients which prevents free skin examination [6]. In MDRPI assessment, asking patients who can give a verbal reply if they feel a reduced level of sensation or increased pain where a fixated device is present, or in patients with a reduced conscious level, non-verbal prompts in response to movement or palpation of the skin should be observed for [6]. MDRPIs can have a negative effect on the wellbeing, length of hospital stay, and treatment on the patient and it is each healthcare organization's responsibility to develop policy that stresses the risk of MDRPI development when a medical device is present in a patient's care and also to provide sufficient education to healthcare staff and patients who come into contact with medical devices (Kayser et al. 2017).

This review found that the most common grading of MDRPIs was grade 1 or grade 2 injuries. This was also trending in previous research [14]. Unlike Barakat-Johnson and colleagues (2019), there were no MDRPIs classified as mucosal injuries from the included studies in this review. Several studies in this review discussed the new MDRPI guidelines outlined by Ref. [58]; however, the uptake of classifying appropriate MDRPIs as mucosal injuries requires further attention into this area.

It is evident that the level of awareness among healthcare professionals and patients with regard to MDRPI development is poor and requires immediate action [54]. MDRPI education requires full involvement from the multidisciplinary team who prescribe and use medical devices for patients in daily practice [6]. [10] found that educational programmes for healthcare professionals based on clinical practice were fundamental to understand the importance of MDRPIs and MDRPI preventative measures.

The prevention of any healthcare issue in clinical practice demands an exceptional level of awareness and adherence to practice, however, as seen in this review and previous research, the evidence in MDRPIs is limited and displays a high level of heterogeneity. Preventative measures in MDRPI development require healthcare facilities to develop standard procedures, protocols, and guidelines for device use and should correspond with published guidelines, such as the NPUAP guidelines on the prevention of MDRPIs in the critical care setting and overview of MDRPI prevention [61]. Initiatives such as the quality improvement project in a teaching hospital in the U.S.A. to reduce respiratory MDRPIs in a critical care setting [45], need to be adopted by healthcare facilities to reduce the incidence of MDRPIs and promote effective MDRPI management and care of patients [6].

This review also investigated the various types of medical devices that caused MDRPIs. While the largest single percentage of medical devices that caused MDRPIs were immobilising devices, a collectively larger percentage of medical devices attached to the head, such as face masks, endotracheal devices, nasal cannulas, and nasogastric tubing dominate the medical devices that cause MDRPIs. This large percentage correlates with the high percentage of face, ear and head-related MDRPIs that were identified by the anatomical location review in this research and also the research performed by [14] . The evidence that has been found with regard to medical device use from this review identifies a number of medical devices that are causing MDRPIs, which has not been previously recognised. The Medical Device Directive is a reporting system utilised in Europe, however, the use of this reporting system with regard to MDRPIs is vague [6]. Since MDRPIs are evidently not regularly reported, the evidence is limited in the medical devices that routinely cause MDRPIs and skin injury and cannot guide researchers to investigate one particular type of device [6]. It is critically important that high-quality and consistent data on MDRPIs and the devices causing these injuries is collected for future research.

4.1. Implications for practice

The underreporting of MDRPIs has become an important issue among healthcare professionals and suggests that larger volumes of patients are likely to have MDRPIs than reported [22]. Recognising and creating a positive incident reporting environment for healthcare professionals is crucial in order to improve the quality of care, patient safety, and continuing professional development and education for healthcare staff [43]. This will also assist in the formation of organisational policies, protocols, and quality improvement initiatives to better equip healthcare professionals to assess and manage MDRPIs and make evidence-based clinical decisions in medical device selection [13]. These implications for practice can inform medical device manufacturing companies the specific implications of their product, which can call for a re-examination of the product to ultimately improve patient safety [30].

Additionally, in the production of policies and protocols that support healthcare professionals in the assessment and management of MDRPIs, it would be advisable to establish an MDRPI RAT separate from the currently available pressure injury assessment tools. A refined MDRPI RAT would greatly benefit and encourage healthcare professionals who assess patients' skin integrity, to routinely assess and examine the skin of patients with medical devices and improve the recognition and reporting of MDRPIs [62].

5. Conclusion

The incidence of MDRPIs in adults within the acute hospital setting is both problematic and concerning. While the results of this review display heterogeneity, it highlights the importance of vigilant assessment, management and reporting of MDRPIs. This review also indicates the varying medical devices that largely contribute towards MDRPIs, the numerous anatomical locations where MDRPIs can occur, and the prominent gradings of such injuries. While the intention of medical devices is to provide effective therapeutic care for such clientele, this review emphasizes the potential complications that can arise from the use of these products. In order to promote patient safety, quality of life and improve healthcare standards, it is recommended that further standardised methodological research is applied to this area to create evidence-based policies, protocols, risk assessment and educational quality improvement initiatives.

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Appendix A. Supplementary data

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