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The Incidence of Pressure Ulcers in Surgical Patients: A Systematic Review

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ABSTRACT

The aim is to assess the incidence of pressure ulcers among adults undergoing surgery. Systematic review methodology was employed. Databases including Cochrane, Ovid Medline, Embase, EBSCO, CINAHL Plus and Scopus were searched in August 2024. The data extracted were imported into Excel for analysis. Simple descriptive statistics were used for the analysis purposes. The data are presented using means and standard deviations. The evidence-based Librarian checklist was used for the quality appraisal. The Systematic Review Protocol was registered in PROSPERO (CRD42023449194). A total of 35 studies were included. The mean pressure ulcer incidence was 17.22% (range from 0.05% to 74.2%). Studies from orthopaedics, mainly including patients undergoing hip surgeries, reported the highest pressure ulcer incidence. The most commonly reported pressure ulcer grade was stage one, and the most common anatomical locations were the sacral region and heels. Pressure ulcers remain a significant concern for surgical patients, especially those undergoing orthopaedic and cardiac surgeries. Most develop in early stages, often affecting the sacral and heel regions. However, gaps in data make it difficult to fully synthesise the scope of the problem. Standardised reporting and targeted prevention efforts are essential to reducing incidence and improving patient care.

1 | Introduction

The European Pressure Ulcer Advisory Panel (EPUAP), National Pressure Injury Advisory Panel (NPIAP) and Pan Pacific Pressure Injury Alliance (PPPIA) define a pressure ulcer (PU) as a localised injury or damage to the skin or underlying tissue due to pressure, shear or both [1]. The incidence rate of PUs among hospitalised patients ranges from 0.4% to 38%, with an average incidence rate of around 17% [2, 3]. Furthermore, among surgical patients specifically, the incidence rate of PUs has been reported as ≤ 58% [4].

Despite the use of advanced prevention modalities, PUs remain a global health problem, causing pain and discomfort, difficulty in healing, and often, severe infections and prolongation of treatments [5–7]. Furthermore, PUs can significantly impact the affected person's physiological and psychological life [8, 9]. This may lead to decreased quality of life, irreparable complications

Summary

- There view focused on the incidence of pressure ulcers in adults following surgery.
- From the findings of 35 different studies, about 17% of surgical patients developed pressure ulcers, and the rate ranged from 0.05% to 74.2%.
- Hip surgeries had the highest rates of pressure ulcers, and the majority of ulcers were stage 1.
- The most affected areas were the sacrum and heels.

and, worryingly, may also lead to death [5, 7, 10] PUs also cause additional hospital stays and create a substantial economic burden on healthcare systems around the world [11]. In the United States alone, researchers report an annual cost of 26.8 billion dollars for the management of PU [12]. Whereas in the United Kingdom, the treatment cost is between 1.4 to 2.1 billion British pounds [13]. The cost of PU treatment in an Australian health system is around 9.11 billion Australian dollars per annum [14].

PUs are a complex phenomenon and the aetiology can be multifactorial and is influenced by intrinsic factors such as age, immobility, body weight or other comorbidities and extrinsic factors such as shear force or friction, temperature variations and moisture [15]. The perioperative period is a potential time for developing PUs due to the duration of surgery and anaesthesia [16]. Indeed, a literature review identifies a large number of risk factors within the perioperative period; however, the duration of surgery and hypothermia are the most contributing factors for PU formation [17]. The use of volatile anaesthetic agents, application of various medical equipment, robotic procedures, and specific surgical positioning are an inevitable part of perioperative patient treatments, and these increase the risk of PU development [18, 19]. In addition, the use of muscle relaxants and antinociception also causes varying degrees of immobility that lead to PU development whilst under surgical anaesthesia [20].

The Association of Perioperative Registered Nurses (AORN) suggests that perioperative PUs are often avoidable with intelligible preventive methods, interdisciplinary collaboration, and teamwork. Thus, perioperative nurses should understand risk categories and apply evidence-based safety precautions, as this may reduce the occurrence of PUs in the perioperative population [21]. Furthermore, strategies such as the perioperative pressure ulcer prevention programme (PPUPP) aid in staff education, adequate patient assessment, and the use of appropriate supportive devices to alleviate these occurrences. The National Institute for Health and Care Excellence (NICE) guidelines for preventing PUs also recommend using pressure redistributing devices to reduce the incidence of PU in adults. An alternative preventive strategy is applying prophylactic silicone dressings (PSD) a PSD acts as a protective layer when applied to body areas such as the sacrum or heels. It helps to manage humidity and reduce friction. The international guidelines also recommend the use of PSD as a component of PU prevention [1].

Surgical patients are at risk of developing PUs. Indeed, a recent study [22] among the perioperative population ($n = 3840$) identified an incidence of 5% thus confirming the risks and urging for an appropriate preventive strategy. The latest systematic literature review of perioperative PUs (including 11 studies) also recommends further studies in this area [23]. Therefore, the overall aim of this paper is to systematically review the existing literature and assess the up-toto-date evidence pertaining to the incidence rate of PUs in adult patients undergoing surgery. The findings will facilitate planning and implementing a better preventive strategy for this particular population.

2 | Methods

2.1 | Design

The design was a systematic review that followed the PRISMA guidelines [24]. The systematic review protocol was registered a priori in PROSPERO 2023 (CRD42023449194).

2.2 | Research Question

The question for this systematic review was developed using the PEO framework, which is a derivative of the PICO framework originally developed by [25]. The PEO was as follows:

- Population: adults undergoing surgery
- Exposure: pressure ulcer risk
- Outcome: pressure ulcer incidence

Therefore the question was:

'What is the incidence of pressure ulcers among adults undergoing surgery?'

2.3 | Outcomes

The primary outcome was the PU incidence rate. The secondary outcomes included the type of surgery, stage of pressure ulcers, and anatomical location of PU development.

2.4 | Inclusion Criteria and Exclusion Criteria

The inclusion criteria were literature written in English, including adults 18 years or older undergoing surgery, and non-experimental studies. A date limitation of study publication was not applied. The exclusion criteria were studies involving paediatrics or persons less than 18 years of age, studies including those with existing PUs, and studies conducted outside the operating theatre or surgical environment.

2.5 | Search Strategy and Databases

A systematic search was performed on multiple databases to identify all relevant literature from the year 1986 to August 2024. The databases were Cochrane, Ovid Medline, Embase, EBSCO CINAHL Plus and Scopus. Reference lists of identified studies

were also examined to find further relevant studies for this review. Furthermore, a manual search of grey literature (i.e., Open Grey www.opengrey.eu) was also performed. Other searches included research reports, conference proceedings, dissertations, abstracts, and books. Search terms used were pressure ulcers, pressure injury, injury, pressure, pressure injuries, incidence (MeSH Headings), epidemiology, and adults undergoing surgery (MH)-operation, procedure, surgical treatment.

2.6 | Data Extraction

The data extracted from the retrieved articles included the following: author, year, country, setting, sample size, study design, risk assessment methods used, population, PU grading system used, PU incidence rate, type of surgery, stages of PU and anatomical location of pressure ulcer. A single researcher extracted these data independently onto an Excel spreadsheet, and a second researcher verified the extracted data.

2.7 | Critical Appraisal

The Evidence-Based Librarianship (EBL) Critical Appraisal Checklist was used to critically appraise all the included studies [26]. The results for this appraisal are obtained by calculating the rating of the subcategory section of each domain. There are four domains, population (Section A), data collection (Section B), study design (Section C) and Results (Section D). The subcategory section of these domains was assessed using a yes (Y), no (N), unclear (U) or a not (T) applicable rating. If Y/T < 75% or if $N+U/T \geq 25\%$ then it is most likely an indication that the section identifies significant omissions and the validity of the study is questionable. If the calculation was as follows: $(Y+N+U=T)$, if Y/T ≥ 75% or if $N+U/T < 25\%$ then it indicates a high-quality study.

2.8 | Data Analysis

The data extracted were imported into Excel for analysis. Simple descriptive statistics were used for the analysis purposes. The data are presented using frequencies, percentages, means, and standard deviations (SD) to describe the data obtained. This synthesised data represents the incidence rate of PU among adults undergoing surgery. Sub-groups were created to represent various types of surgery, stages of PU, and anatomical location of PU. A meta-analysis was not undertaken because of the significant clinical and methodological heterogeneity within the studies. These include different methods of data collection, inconsistency in the assessment and verification of the presence of a pressure ulcer, and the nature of the surgical procedures the patients were undergoing.

3 | Results

3.1 | Study Selection

A total of 5257 articles were retrieved from the searches. After removing duplicates, 319 studies were examined further, and 105 full-text articles were assessed for eligibility. At the final stage of screening, 35 were identified (Figure A1) as meeting the inclusion criteria, and these studies form the basis of this systematic review [27–61].

3.2 | Study Characteristics

The data extracted from each study are presented in Table A1.

3.2.1 | Years of Publication

The studies spanned the years 1986–2024.

3.2.2 | Geographical Location

The studies were conducted across 16 countries. The United States has the highest representation, contributing 22.7% ($n=8$) [27, 29, 35, 40, 47, 52, 57, 58] of the total studies. This is followed by China, which accounts for 14.3% ($n=5$) [30, 33, 45, 54, 59] of the research output. Australia [31, 42, 44] Turkey [50, 51, 60] and the Netherlands [36, 39, 49] each contribute 8.6% ($n=3$), whilst the United Kingdom [41, 61] and Brazil [38, 55] represent 5.7% ($n=2$) of the studies. In addition, 9 other countries (Taiwan [34], Japan [28], Italy [56], Czech Republic [32], Ireland [43], Singapore [46], South Korea [53], Sweden [48] and Switzerland [37]) are represented, contributing 2.9% ($n=1$).

3.2.3 | Population and Sample Size

All participants were surgical patients, and the total number of participants in all 35 studies was 970 193. The largest sample size was 592 174 in a study from the United States [29], and the smallest sample size was 29 in a study from Japan [28].

3.2.4 | Clinical Settings

Across the 35 studies, five distinct clinical settings were reported from where data were collected. The surgical (operating) settings dominated, accounting for 71.43% ($n=25$) [28, 30, 32, 33, 35–38, 40, 43, 45, 46, 48–56, 58–61] of the total studies. An analysis of hospital records/database analysis followed at 11.43% ($n=4$) [27, 29, 39, 57]. The acute setting [31, 34], tertiary care settings [42, 44] and other settings [41, 47] accounted for 5.72% ($n=2$).

3.2.5 | Study Designs

All 35 studies were non-experimental. Among these, prospective studies were the most frequently employed research design 48.57% ($n=17$) [28, 31, 36, 38, 40, 41, 44–46, 48–50, 52, 53, 56, 58, 61], followed by retrospective studies 34.29% ($n=12$) [27, 29, 30, 32, 33, 35, 37, 39, 42, 54, 57, 59]. Cross-sectional studies [47, 51, 60] and Other study designs [34, 43, 55] utilised 8.57% ($n=3$) in each study.

3.2.6 | Pressure Ulcer Grading System

The most frequently used grading systems were the NPUAP, employed in 23% ($n = 8$) of studies [38, 46, 49, 52, 53, 56, 57, 59]. The EPUAP and NPUAP [28, 30, 31, 34, 43, 44, 51] were used in 20% ($n = 7$) of studies, and EPUAP [36, 39, 41] were 8.6% ($n = 3$). The other categories reported were 3% ($n = 1$) [45], and 46% ($n = 16$) of studies [27, 29, 31–33, 35–37, 40–42, 47, 48, 54, 55, 58, 60, 61] did not specify the grading system.

3.2.7 | The Data Collection Methods

The data collection methods across the studies were diverse, with direct patient examination and assessment being among the most frequently used methods, utilised in 46% ($n = 16$) [31, 34, 36, 40, 41, 43, 45–50, 52, 55, 56, 61] of studies. Collection of data from existing medical records/database/information system contributed to 31.43% ($n = 11$) [27, 29, 30, 32, 33, 35, 37, 39, 42, 54, 57] of studies. Combined patient assessments and use of medical records represented 17.14% ($n = 6$) [28, 44, 53, 58, 59, 60], and other methods and interviews accounted for 5.71% ($n = 2$) [38, 51].

3.2.8 | The Duration of Follow-Up

The follow-up durations across studies varied; 20% ($n = 7$) followed up for 72 h (three days after surgery) [30, 40, 43, 51, 52, 57, 60]. In other studies, 8.60% ($n = 3$) participants were followed up to the discharge from PACU [31, 34, 46], 48 h (2 days) [36, 44, 49] and up to discharge from hospital [41, 47, 48]. 5.71% ($n = 2$), up to the 6th post-operative day [50, 56], 1 week follow-up [58, 59] and up to 30 days post op period [28, 61]. A smaller number of studies (2.86%; $n = 1$) tracked patients for 1 day after surgery [38], up to 6 months after surgery [37] and until the pressure ulcer healed [45]. A total of 28.6% ($n = 10$) [27, 29, 32, 33, 35, 39, 42, 53–55] of studies do not specify their duration of follow-up.

4 | Results of the Primary Outcome

4.1 | Pressure Ulcer Incidence

All studies reported the primary outcome [27–61] of PU incidence (Figure 1) and the rate substantially varied across the studies, from 0.05% [29, 35] to 74.2% [61]. The mean (SD) PU incidence was 17.2% (±18.93%). The highest incidence rate of PU was observed in a 1986 study from the United Kingdom focused on patients who had undergone orthopaedic surgery [61]. This study, with a sample size of 89 patients, reported a PU incidence of 74.2% [61]. The next highest PU incidence rate was reported in a 2021 study from South Korea [53], where patients had an incidence of 64.63% out of a total sample size of 147 patients. The lowest incidence rates were from the United States [29, 35], with two studies reporting each with 0.05%.

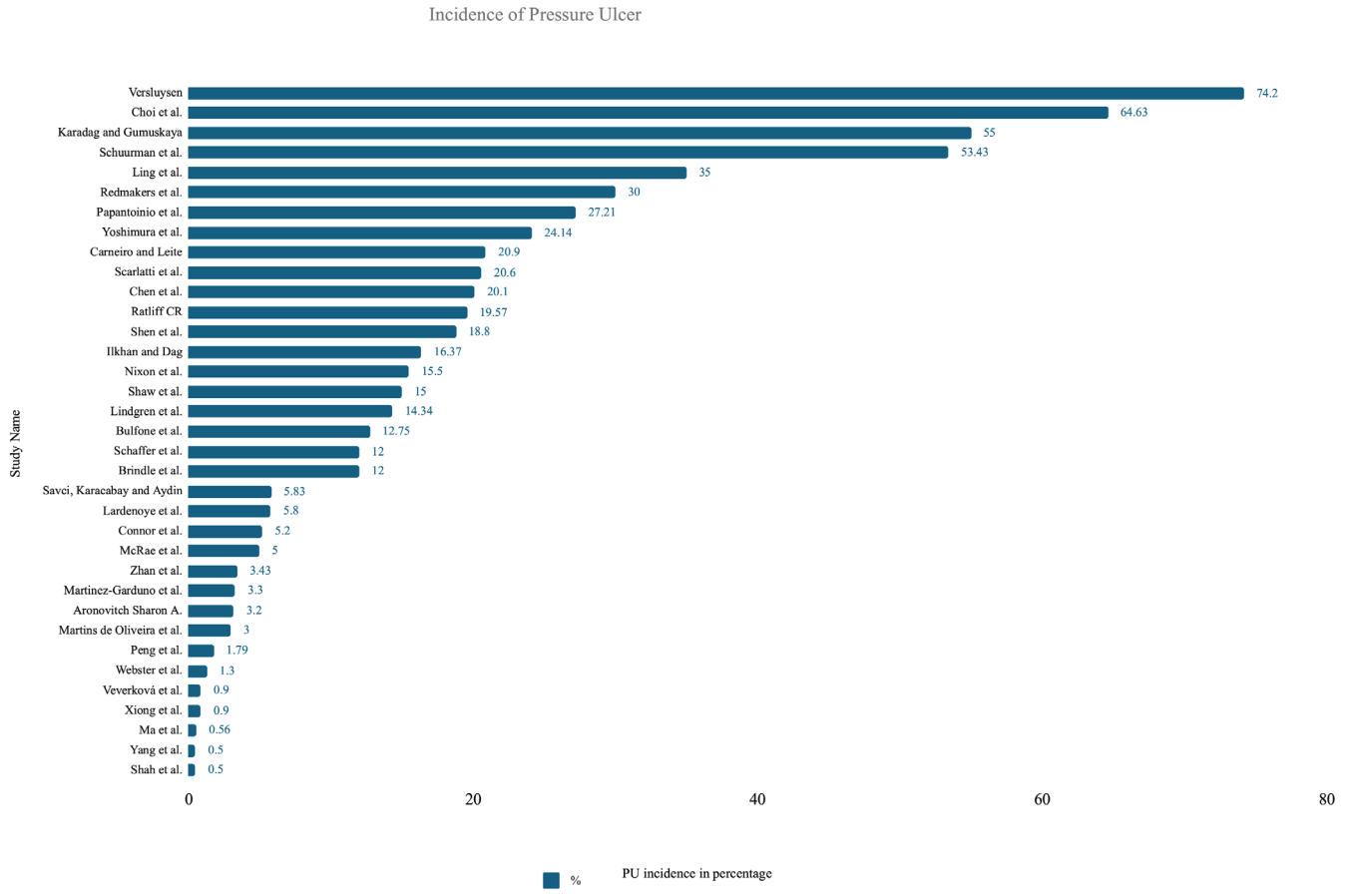

FIGURE 1 | PU incidence.

4.2 | Type of Surgery and Incidence of Pressure Ulcers

A total of 77.14% ($n=27$) studies [27–29, 32–40, 43, 45, 47, 49, 51–61] reported the incidence rate of PUs based on the type of surgery the patients had undergone (Table 1). The analysis reveals that PU incidence was highest (80%) among those undergoing orthopaedic surgery [27, 29, 34, 39, 43, 45, 49, 51, 53, 58, 60, 61]; among these, 93.24% ($n=5$) were reported to have undergone hip surgeries [27, 29, 39, 49, 61]. A PU incidence of 8% was reported in those undergoing Cardiac surgery [33, 34, 36, 37, 40, 51, 54–58] which included 11.75% ($n=2$) undergoing coronary artery disease surgery [54, 55], 9.17% ($n=1$) undergoing valvular heart disease surgery [54], 8.88% ($n=2$) undergoing ventricular assist devices surgeries [37, 57], 1.72% ($n=1$) undergoing total artificial heart surgeries [57], 1.15% ($n=1$) undergoing thoracic aneurysm [54] and congenital heart disease surgeries [54], and the remaining were other cardiac surgeries. Among those undergoing vascular surgery [35, 47, 49, 56], the incidence was 4%, and for those undergoing spinal surgery [53], the incidence was 2%. For neuro surgeries [28, 34, 38, 45, 56, 58–60] the incidence was 1.64% ($n=8$), and among 'other surgeries' [38, 49] the incidence was reported at 1.29% ($n=2$). Among other types of surgery, the incidence was 0.82% ($n=2$) for abdominal/laparotomy/bowel surgeries [49, 51], 0.79% ($n=1$) for general surgery [34], 0.65% ($n=3$) for urological surgeries [45, 52, 60] and 0.42% ($n=1$) for limb amputation [49]. The lowest incidence rate of PU was observed among trauma [32] (0.16%, $n=1$), ENT (0.12%, $n=2$) [45, 60], obstetrics/gynaecology (0.07%, $n=1$) [45], inflammatory surgeries (0.05%, $n=1$) [32], tumour surgery (0.05%, $n=1$) [32] and surgeries aimed at correcting bleeding (0.02%, $n=1$) [32].

TABLE 1 | Type of surgery and PU incidence.

Type of surgery	Sum of (PU incidence) number	% (of PU) each surgical category (%)
Ortho surgery	3414	80
Cardiac surgery	349	8
Vascular surgery	162	4
Spinal surgery	95	2
Neuro surgery	70	1.64
Other surgeries	55	1.29
Bowel or laparotomy/ abdominal	35	0.82
General surgery	34	0.79
Urological surgery	28	0.65
Limb amputation	18	0.42
Trauma surgery	7	0.16
ENT	5	0.12
Obstetrics gynaecology	3	0.07
Inflammatory surgeries	2	0.05
Tumour surgery	2	0.05
Bleeding surgeries	1	0.02

4.3 | Stages of Pressure Ulcer

A total of 27 (77.14%) [28, 30, 31, 34, 36–41, 43–53, 55–60] studies reported on the stages of PUs (Table 2). The majority of PUs (55.25%; $n=22$) were reported as Stage 1 [28, 30, 31, 34, 36, 38, 40, 43–46, 48–53, 55, 56, 58–60], whilst 36.28% ($n=17$) were reported as Stage 2 [30, 31, 36, 38, 39, 41, 45–49, 53, 55–59]. A smaller percentage were Stage 3 (2.92%' $n=7$) [36–38, 47–49, 57], whilst 0.73% ($n=3$) were reported as Stage4 [37, 41, 49]. A total of 1.75% ($n=2$) were reported as Deep Tissue Injury [47, 57], 1.53% ($n=1$) Stage 2&3 [40], 1.09% ($n=1$) were Stage 3&4 [39] whilst 0.44% ($n=3$) were reported as unstageable [30, 57, 58].

4.4 | Anatomical Locations of Pressure Ulcers

A total of 57.14% ($n=20$) studies [28, 30, 32, 37, 38, 41, 43–48, 50, 52, 54–59] reported the anatomical locations of PU development. The analysis indicates that the sacral region [32, 41, 43, 47, 48, 50, 52, 56, 57] was the most frequently affected (8.51%, $n=9$), followed by the heel (8.25% $n=10$) 35% [32, 41, 43, 45, 47, 48, 54, 57–59] of PUs. The coccyx region [41, 50, 54, 57] accounted for 6.91% ($n=4$) of incidences, whilst the sacrococcygeal area [30, 45, 55, 58] was affected in 6.78% ($n=4$) of cases. The trunk (frontal and dorsal) [38] was affected in 5.59% ($n=1$) of cases and the buttocks [55, 57, 58] in 5.06% ($n=3$) of cases (Figure 2, outline of the anatomical locations of the PUs).

5 | Quality Appraisal of the Included Studies

The quality appraisal was conducted by using the EBL checklist [26]. The overall mean score of the included studies was 75.1% (SD: 5.8%; range: 61.5% [47] to 88.5% [60]). A total of 65.7% ($n=23$) [28, 30, 31, 33, 34, 36, 38, 40–46, 50–57, 60] studies scored ≥75%, indicating that they are valid studies. The remaining studies (34.2%, $n=12$) [27, 29, 32, 35, 37, 39, 47–49,

TABLE 2 | Stages of PU.

Stages of PU	Number	%
Stage1	757	55.25
Stage 2	497	36.28
Stage 3	40	2.92
Deep tissue injury	24	1.75
Stage 2 and 3	21	1.53
Stage 3 and 4	15	1.09
Stage 4	10	0.73
Unstageable	6	0.44

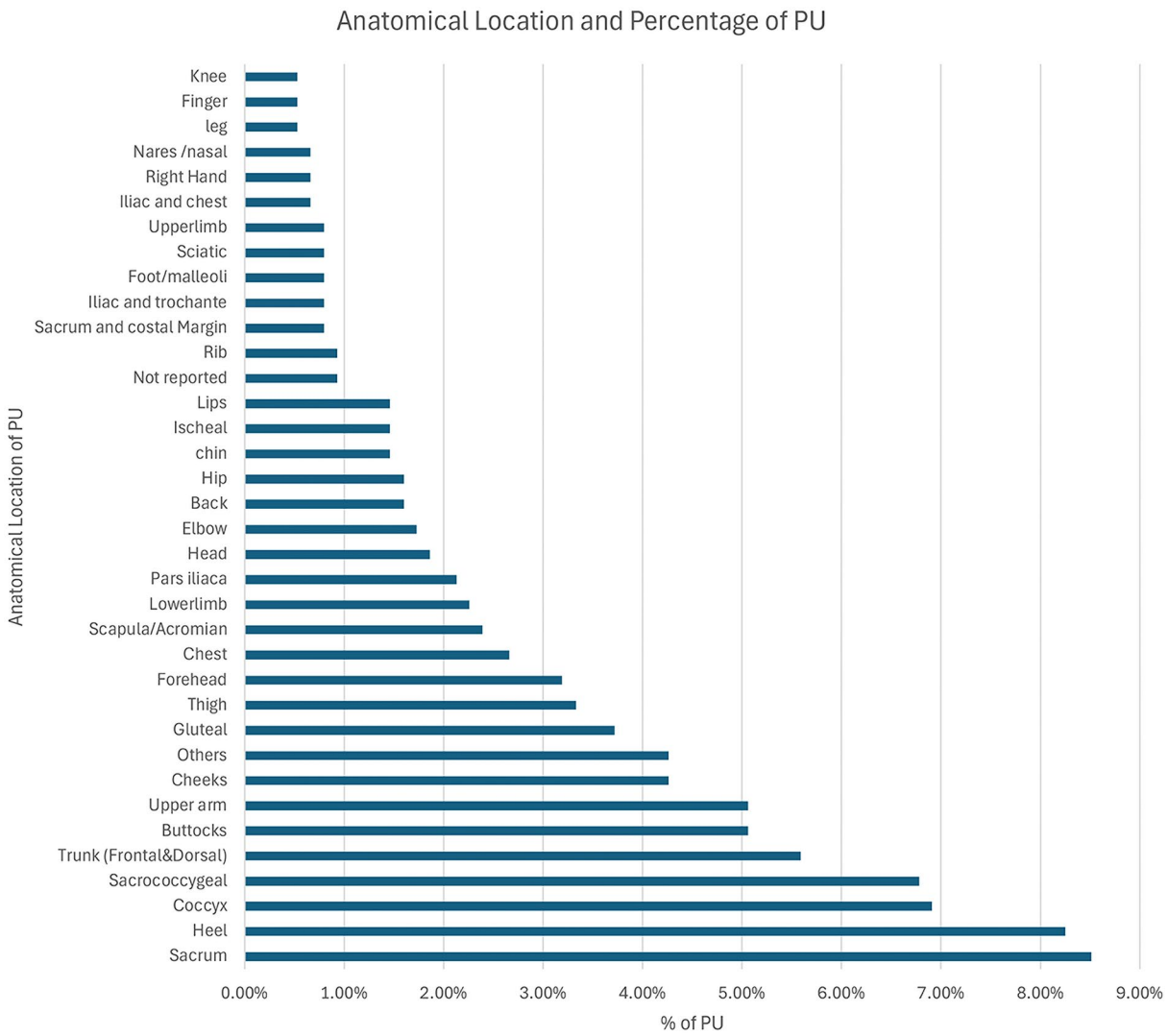

FIGURE 2 | Anatomical location of PU.

58, 59, 61] scored < 75% and therefore did not meet the validity cut off score.

6 | Discussion

6.1 | Summary of the Key Findings

This systematic review analysed the incidence of PUs among adults undergoing surgery across various clinical settings and surgical types. The mean (SD) PU incidence was 17.22% (±19%). A previous systematic review among surgical patients in 2012 [62] also reported a mean incidence of 15%, indicating that PUs remain a persistent concern for the surgical population [22]. The incidence of PUs varied substantially across the studies, with the highest incidence at 74.2% [29], and the lowest incidence reported as 0.05% [35]. This wide variability highlights the significant differences in PU incidence depending on the clinical context, a finding borne out by a previous systematic literature review [23]. The authors proposed that further studies are needed to clarify contradictions found in the literature [23].

7 | Type of Surgery and PU Incidence

This review also examined the incidence of PUs by type of surgery and revealed that the highest incidence of PUs occurred among patients undergoing orthopaedic surgery. Among these, hip surgeries reported the highest incidence rate. Certain orthopaedic surgeries frequently require patients to remain in immobile positions for extended periods and involve positioning challenges and extensive tissue manipulation, thus elevating the risk of PUs. A previous case–control study [4] examined the relationship between the 'time in the operating room and PU formation'. They reported that the extended surgery lasting more than 4 h increases the incidence rate of hospital-acquired pressure ulcers, with 5% of these occurring within 24 h post-surgery and 58% appearing after the fifth hospital day [4]. A high incidence of pressure-related skin injuries (43.7%) was reported previously in a retrospective analysis of patients undergoing spinal surgery in a prone position [63]. Furthermore, previously reported rates of PUs resulting from surgery in the prone position range from 5% to 66% [64].

Other surgeries with a high incidence were cardiac surgeries. A recent systematic review of cardiac surgery reported an

incidence rate of 24.06% among open-heart surgical patients [65]. Another study among patients undergoing cardiovascular surgery identified risk factors for PU development, such as preoperative haemoglobin, albumin levels, and intraoperative mean body temperature [66]. The other type of surgeries with a higher incidence of PUs among those undergoing vascular surgery and spinal surgeries; this could be attributed to the complexity and duration of these procedures [17], which increase the risk of PU development. In contrast, surgeries with lower PU incidences typically involve less extensive tissue manipulation or shorter durations, emphasising the correlation between the type of surgery, the time in the operating room, and the occurrence of PUs [4].

8 | PU Staging and Anatomical Locations

The review also studied different stages of PUs and found that most PUs detected were in the early stages. This finding is consistent with previous studies [67]. A systematic review examining the prevalence of postoperative pressure ulcers indicated a high prevalence rate, with stage 1 ulcers reported in higher numbers than other stages [67].

According to the results obtained in this current review, the sacral region was the most common anatomical site for PUs, followed by the heel and then at the coccyx region. These findings align with known pressure points [2] where patients, particularly those who are immobile or have prolonged operative and post-operative times, are more prone to developing PUs [22]. Studies show that prolonged immobility during surgery, where patients remain in one position for extended periods, significantly increases the risk of developing PUs due to restricted blood flow and tissue ischemia [29, 30, 33]. Additionally, anaesthesia prevents patients from feeling discomfort and adjusting their position, which exacerbates the risk [38]. Reduced mobility during the postoperative period, either due to pain or specific positioning requirements, further increases the likelihood of PU developments [22, 29]. Pressure redistributing tools, such as foam dressings, reduce friction and shear forces; a recent review and meta-analysis indicate that sacral foam dressings reduce sacral pressure injuries [68]. PUs are often misattributed to postoperative care, but they primarily result from patient immobility and outdated support surfaces in the operating room [69]. A new alternating pressure overlay system may effectively address this issue of Operating Room Acquired Pressure Injuries (ORAPI) [69]. Literature suggests that OR nurses need more awareness and knowledge of pressure injuries, emphasising the need for regular, unit-based training on ORAPI prevention and management [70].

9 | Limitations and Recommendations

The findings confirm the need for improving surgical patient outcomes and reducing the burden of PUs in the surgical population [44]. It also outlines the critical need for effective preventive strategies to mitigate the significant health, emotional, economic, and clinical impacts [32, 46, 50]. Therefore, a focus on surgical care settings is necessary, particularly given the impact of PUs on recovery from surgery and the subsequent effects on length of stay and achievement of key quality indicators in this population [4, 15–19, 22, 23].

This review consists of studies from multiple settings and different continents, thereby enhancing the generalisability of its findings. However, the inconsistency in settings and methodologies added complexity and variability in retrieval and separating the study elements. The variability was noticed in study follow-up and found that the majority of the studies reported 3–4 days follow-up, and a few studies extended up to one-week follow-up to the patient discharge. There was also incompatibility in the use of grading systems; some studies did not specify their grading system or did not employ a specific grading system at all. The lack of comparability of how studies collect data on PUs makes it challenging to interpret the data fully [71]. The data on the type of surgery performed was available only for 77.14% of the studies, and this may have influenced the incidence of PU in the type of surgeries. Additionally, the stages of PU were reported in only 77.14% of studies, limiting the ability to comprehensively assess these injuries' severity and progression. Furthermore, anatomical locations were documented in just 57.14% of studies, restricting the capacity to analyse location-specific patterns and their clinical implications. These gaps in data may have affected the overall generalisability of our findings. Whilst our analysis provides valuable insights, future research should aim to improve data completeness to enhance the robustness of conclusions in this field.

10 | Conclusion

The results of this review indicate that PUs are a significant concern in the surgical population. The available data suggest a higher incidence of PUs among patients undergoing orthopaedic surgeries, cardiac surgeries, vascular surgeries and spinal surgeries. However, given the identified data gaps, such as incomplete reporting of surgical types, PU stages, and anatomical locations, these findings should be interpreted with caution. Most reported PUs were in the early stages of development, with the sacral region and heel being the most frequently affected areas. Whilst our analysis highlights the need for targeted preventive measures, the variability in data reporting underscores the necessity for further research with more comprehensive and standardised documentation. These findings provide a foundation for improving PU prevention strategies in the adult surgical population whilst recognising the inherent limitations of the current evidence base.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data openly available in a public repository that issues datasets with DOIs.

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Appendix A

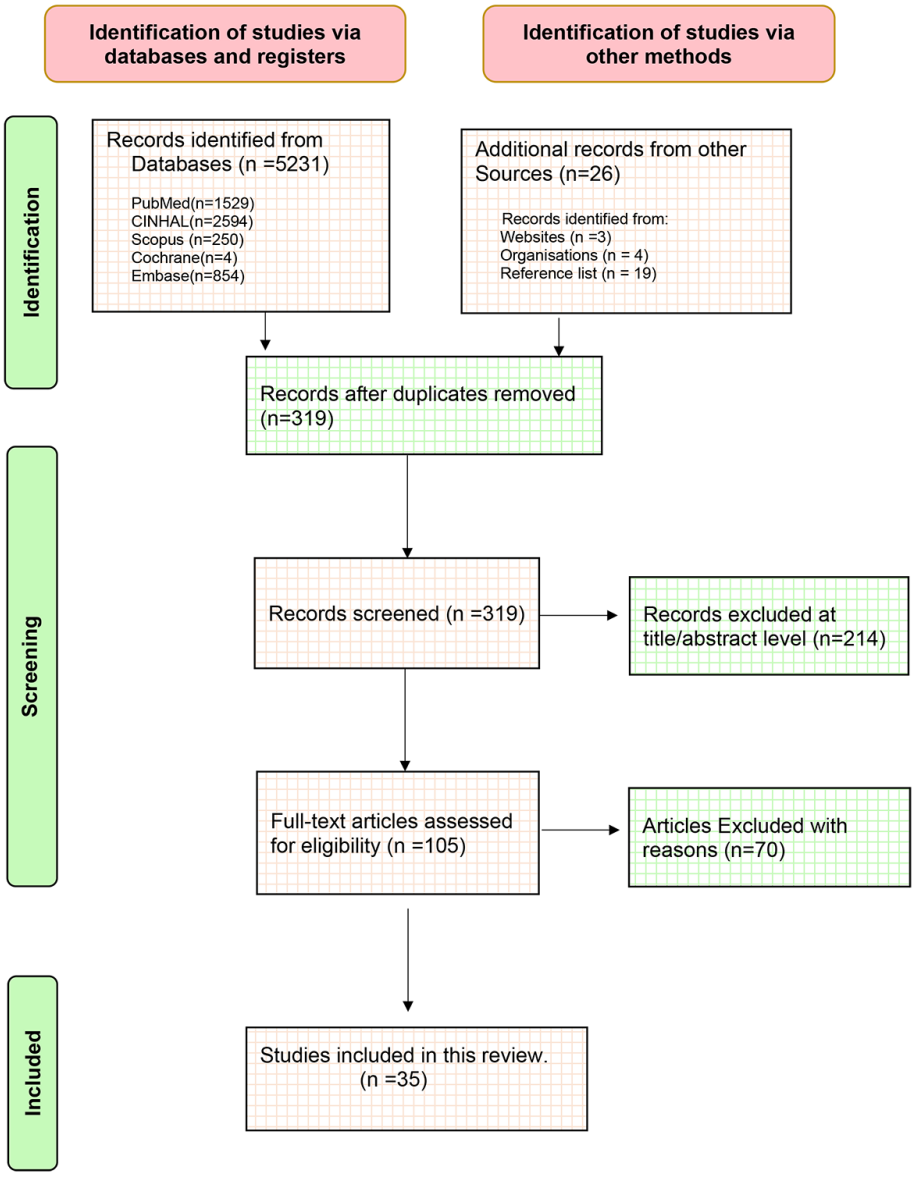

FIGURE A1 | PRISMA flow diagram.

TABLE A1 | **Data of included studies.**

Data of included studies								
No	**Author**	**Year**	**Country**	**Sample size**	**Setting**	**Design**	**Population**	**Data collection methods**
1	Webster et al.	2015	Australia	474	Acute Hospital	Prospective study	Adult Surgical patients; surgery lasting > 30 min	Patient Examination and assessments
2	Shaw et al.	2014	Taiwan	297	Acute Teaching Hospital	Observational follow up	Adult elective Surgical patients; surgery lasting > 30 min	Patient Examination and assessments
3	Martinez-Garduno et al.	2019	Australia	150	Large Tertiary referral Hospital	Prospective study	Adult surgical patients on the elective surgical schedule	Medical record documentation and direct skin observation
4	McRae et al.	2014	Australia	74	Tertiary referral Hospital	Retrospective study	> 65 years or older individuals admitted to vascular surgery and urology units and hospitalised for atleast 72 h.	Medical record review
5	Karadag and Gumuskaya	2006	Turkey	84	Surgical settings of University hospital	Prospective study	Adult surgical patients with general anaesthesia and surgery > 2 h	Patient Examination and assessments
6	Zhan et al.	2007	United States	71 081	Nation-wide inpatient sample discharge abstracts	Retrospective study	Patients who had undergone total, partial or revision hip replacements	Hospital discharge abstract/ database
7	Xiong et al.	2019	China	5136	Surgical unit. Wuhan Union Hospital	Retrospective study	18 years or older undergoing hepatobiliary, pancreas, spleen and gastro-intestinal surgery	Medical record and Information system
8	Yoshimura et al.	2015	Japan	29	Acute hospital Operating room	Prospective study	Elective surgical patients underwent surgery in Park-Bench position	Patient skin assessment and medical chart reviews
9	Papantoinio et al.	1994	United States	136	Cardiac surgical setting	Prospective design	Adult elective cardiac surgical patients	Patient skin assessment
10	Lardenoye et al.	2009	Netherlands	4747	General Surgical Ward Settings	Prospective study	Surgical ward patients	Patient assessment and evaluation
11	Connor et al.	2010	United States	498	Academic centre Hospital (Urology Specific OR)	Prospective study	English speaking adults undergoing urology surgery admitted for minimum 24 h of post-operative inpatient care.	Patient examination and assessment
12	Scarlatti et al.	2011	Brazil	199	Surgical settings, private general hospital	Longitudinal case series study	Surgical patients who are conscious, age above 18 years, and be scheduled for surgeries of size II and/or III, regardless of the specialty	Interviews and physical examinations to evaluate skin integrity
13	Bulfone et al.	2012	Italy	102	Teaching hospital, surgical setting	Longitudinal study	Major surgical patients undergoing surgery more than 2 h and are able to observe for minimum 6 days after surgery	Patient examination

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**Author**	**Year**	**Country**	**Sample size**	**Setting**	**Design**	**Population**	**Data collection methods**
14	Shen et al.	2015	China	Total sample - 286 Adults-239 Paediatric-47	Cardiac surgery intensive care unit	Retrospective study	Adults (239) and Paediatric (47) patients undergoing Cardiac surgery and aortic surgery	Medical record review
15	Veverková et al.	2016	Czech Republic	3431	Surgical clinic	Retrospective study	Patients who are hospitalised and undergoing surgery	Electronic databases of the Hospital Information System
16	Shah et al.	2016	United States	3.00E+05	Acute/surgical	Retrospective study	Patients undergoing major open vascular surgery operations	Data from NIS (Nationwide Inpatient Sample)"
17	Ling et al.	2019	Singapore	114	Acute tertiary hospital-major operating theatre urology complex	Prospective study	Elective surgeries under general anaesthesia during office hours in the major operating theatre and urology complex	Patient examination
18	Chen et al.	2020	China	Total sample size-288 Adult-214 paediatrics-74	Medical university Hospital, cardiovascular surgical unit	Retrospective study	Patient undergoing surgery for coronary artery disease, Valvular heart disease, Congenital heart disease, and thoracic aortic aneurysm	Medical chart review
19	Brindle et al.	2020	United States	265	Cardiac surgery settings Database	Retrospective study	Adult (> 18 years) patient undergoing ventricular assist devices and total artificial hearts	database/electronic health care record review
20	Choi et al.	2021	South Korea	147	Spinal surgical unit, orthopaedic hospital in Korea	Prospective study	Elective spinal surgical (first time) patients who underwent surgery in the prone position.	Patient examination & medical chart review
21	Martins de Oliveira et al.	2022	Ireland	231	Surgical settings - two academic teaching hospitals	Non-experimental, comparative, descriptive cohort study design	Adults surgery patients with no existing PU and expected to be in hospital for more > 24 h after surgery.	Patient examination
22	Yang et al.	2022	United States	#####	Nationwide Inpatient Sample (NIS) database	Retrospective analysis	Patients who had Total hip arthroplasty and are > 18 years old.	Data base review
23	Schaffer et al.	2023	Switzerland	42	Cardiac surgery unit	Retrospective study	Patients who had a Left ventricular assist device implantation	Database and medical records
24	Ma et al.	2022	China	18 309	Operating room, Tertiary general Hospital	Prospective study	Elective surgical patients with no existing PU	Patient examination

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**Author**	**Year**	**Country**	**Sample size**	**Setting**	**Design**	**Population**	**Data collection methods**
25	Carneiro and Leite	2011	Brazil	182	Surgical centre unit of university public hospital	Exploratory, descriptive, cohort study	Cardiac surgery patients	Patient evaluation
26	Schuurman et al.	2009	Netherlands	204	Cardiothoracic surgical setting	Prospective study	Elective cardiothoracic surgery patients older than 18 years expected post operative ICU stay of minimum 48 h	Patient skin assessment
27	Nixon et al.	2007	United Kingdom	97	Single centre large acute hospital.	Prospective study	Elective major vascular or general surgery OR acute orthopaedic, with age of 55 or over and expected length of stay 5 day or more	Patient examination
28	Ilkhan and Dag	2023	Turkey	342	General acute Surgical settings	Descriptive cross-sectional study	Patient underwent general, orthopaedics and cardiovascular surgery and above the age of 18	Face-to-face interviews and patient evaluation
29	Redmakers et al.	2007	Netherlands	722	Trauma centre hospital records.	Retrospective analysis	Patient treated with hip fractures	Hospital medical record
30	Lindgren et al.	2005	Sweden	286	University Hospital surgical setting	Prospective study	Patient undergoing surgery, 17 years of age or older with an expected hospital stay of atleast 5 days and operating table time of 1 h	Patient skin assessment
31	Aronovitch Sharon A.	2007	United States	281	Acute care surgery setting through Wound, Ostomy & continence nurses society	Prospective study	> 18 years of age and scheduled for an inpatient surgical procedure of atleast 3 h	Patient Data collection sheet and post operative assessments
32	Ratliff CR	2020	United States	46	Trauma centre inpatient vascular service	Descriptive, cross sectional	Vascular surgery major limb amputation	Patient assessments
33	Savci, Karacabay and Aydin	2024	Turkey	309	Operating room/surgical setting	Cross sectional study	Patients Undergoing elective surgical procedure	Patient assessments and Patient description form
34	Peng et al.	2024	China	1728	Neurosurgery Unit	Retrospective study	Patient undergoing neurosurgery involving craniotomy and are above 18 years old	Electronic medical records and patient assessments
35	Versluysen	1986	United Kingdom	89	Orthopaedic surgery unit	Prospective study	Patient with Femur fractures aged 70–94	Patient examination

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
1	EPUAP & NPUAP	Not specified	On the day of surgery up to the time of discharge from PACU	6 (1.3%)	Not specified	Stage 1: 4 (67%), Stage 2: 2 (33%)	Not specified	78.5
2	EPUAP & NPUAP	Braden scale	Immediately after surgery; 30 min post Op in PACU	44 (15%)	General: 7 (15.91%), Neuro: 3 (6.82%), Ortho: 28 (63.64%), Cardiac: 6 (13.64%)	Stage 1: 44 (100%)	Not specified	78.6
3	EPUAP & NPUAP	Water low scale	Up to 48 h post operatively	5 (3.3%)	Not specified	Stage 1: 1 (0.7%)	Left knee: 1 (20%)	75
4	Not specified	Not specified	Not specified	4 (5%)	Not specified	Not specified	Not specified	82.1
5	Not specified	Braden Scale	Up to 6th day post operatively	46 (55%)	Not specified	Stage 1: 46 (100%)	Gluteal: 28 (37.4%), Scapula: 14 (18.7%), Between iliac and trochanter: 6 (8.0%), Sacrum: 5 (6.7%), Elbow: 4 (5.3%), Coastal region: 3 (4.0%), Lumbar: 3 (4.0%), Widespread on the back: 3 (4.0%), Popliteal area: 3 (4.0%), Axilla: 3 (4.0%), Heal: 1 (1.3%), Coccyx: 1 (1.3%), Occipital: 1 (1.3%)	78.5
6	Not specified	Not specified	Not specified	2438 (3.43)	Hip surgery: 2438 (100%)	Not specified	Not specified	64.3
7	EPUAP & NPUAP	self-designed intraoperative risk assessment scale	Up to 72 h post operatively	45 (0.9%)	Not specified	Stage 1: 31 (83.78%), Stage 2: 5 (13.51%), Unstageable: 1 (2.70%)	Sacrococcygeal: 24 (53.3%), Sciatic: 6 (13.3%), Hip: 4 (9%), Foot: 1 (2.2%), Forehead: 1 (2.2%), Others: 9 (20%)	85.7
8	EPUAP & NPUAP	Braden Scale	Up to 30 days after surgery	7 (24.14%)	Neurosurgery: 7 (100%)	Stage1: 7 (100%)	Fourth and eighth Rib: 7 (100%)	75
9	Not specified	Braden Scale	Up to 72 h	37 (27.21%)	Cardiac surgery: 37 (27.21%)	Stage 1: 16 (43%), stage 2 and 3: 21 (57%)	Not specified	75

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
10	(International Association of Enter- ostomal Therapists) Modified score of the NPUAP	Not specified	Up to 2 days (the Previous night and 1 day)	275 (5.8%)	Hip: 154 (10.8%), Limb amputation: 18 (8.8%), Bowel or laparotomy 32 (1.6%), Peripheral vascular surgery: 12 (0.9%), Other: 30 (0.3%)	Stage 1: 147 (53%), Stage 2: 98 (35.6%), Stage 3: 26 (9.5%), Stage 4: 4 (1.5%)	Not specified	71.4
11	NPUAP	Braden Scale	Up to 3 days Post Operative period	25 (5.2%)	Urological: 25 (5.2%)	Stage 1: 25 (100%)	Sacral: 6 (20%), Flank: 4 (16%), Back: 3 (12%), Other: 12 (52%)	78.6
12	NPUAP (translated to Portugal)	Not specified	Up to 1 day Post Operative period	41 (20.60%)	Neuro surgery: 16 (36%), Other: 25 (64%)	Stage 1: 47 (63.5%), Stage 2: 26 (35.1%), Stage 3: 1 (1.4%)	Head: 13 (17.5%), Frontal Trunk: 26 (35.1%), Dorsal Trunk: 16 (21.6%), Upper limb: 2 (2.8%), Lower limb: 17 (23%)	82.1
13	NPUAP	Not specified	Up to six days Post Operative period	13 (12.75%)	Cardiac surgery: 5 (38.4%), General surgery: 4 (30.8%), Neuro surgery: 2 (15.3%), Vascular surgery: 2 (15.3%).	Stage 1: 12 (92.31%), Stage 2: 1 (7.69%)	Cheeks: 2 (15.3%), Sacrum: 2 (15.3%), Elbow: 2 (15.3%), Others: 7 (53.85%)	75
14	Not specified	Braden Scale	Not specified	45 (18.8%) (adults)	Cardiac surgery: 45 (100%)	Combine data: No separate paediatric adult data available	Combine data: No separate paediatric adult data available	78.6
15	Not specified	Norton Scale	Not specified	31 (0.90%)	Trauma: 7 (21.68%), Tumour: 2 (5.16%), Inflammatory: 1.28 (4.13%), Bleeding: 0.40 (1.3%)	Not specified	Heel: 17 (46%), Buttocks: 12 (32.4%), Sacrum: 7 (19%), Scapulae: 1 (3%)	64.3
16	Not specified	Not specified	Not specified	143 (0.5%)	Vascular: 143 (100%)	Not specified	Not specified	67.9

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
17	NPUAP	Not specified	Up to immediate post anaesthetic care unit.	40 (35%)	Not specified	Stage1: 24 (59%), Stage 2: 16 (41%)	Cheeks: 30 (75%), forehead: 17 (43%), chin: 7 (18%), eyelids: 3.2 (8%), lips: 1.2 (3%)	75
18	Not specified	Not specified	Not specified	43 (20.1%) (adult)	Coronary artery disease: 3 (1.29%), Valvular heart disease: 32 (13.76%), Congenital heart disease: 4 (1.72%), Thoracic aortic aneurysm: 4 (1.72%)	Only Combined paediatric and adult data available	Coccyx: 22 (50.8%), Heels: 10 (23.0%), Elbow: 7 (16.4%), Other: 4 (9.8%)	78.6
19	NPUAP	Braden Scale	64–58 days	32 (12%)	Ventricular assist devices: 26 (81.25%), Total artificial hearts: 6 (18.75%)	Stage 2: 8 (17.7%), Stage 3: 3 (6.7%), Mucosal injury: 10 (22.2%), Unstageable: 4 (8.9%), Deep Tissue injury: 20 (44%)	Buttocks: 11 (24.4%), Coccyx: 7 (15.6%), Lip: 5 (11.1%), sacrum: 3 (6.7%), Occiput:: 3 (6.7%), nares: 3 (6.7%), heel: 1 (2.2%), Ischium: 1 (2.2%), breast: 1 (2.2%), Ear: 2 (4.4%)	78.6
20	NPUAP & Reaper Oral Mucosa Pressure Injury Scale (ROMPIS)	Not specified	Not specified	95 (64.63%)	Spinal surgery: 95 (100%)	Stage 1: 107 (84.5%), Stage 2: 3 (15.5%)	Not specified	82.1
21	EPUAP & NPUAP	Braden scale	Up to 3 days Post Operative period	7 (3%)	General: 4 (50%), Orthopaedic: 4 (50%)	Stage 1: 7 (100%)	Left Heel: 4 (50%), Sacrum: 4 (50%)	75
22	Not specified	Not specified	Not specified	311 (0.5%)	Total hip arthroplasty: 311 (100%)	Not specified	Not specified	68
23	Not specified	Not specified	Up to 6 months	5 (12%)	Left ventricular assist device implantation: 5 (100%)	Stage 3: 2 (40%), Stage 4: 3 (60%)	Sacral: 4 (80%), Ischial: 1 (20%)	71.4

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
24	General staging/ classification criteria of Device-related pressure injury: A Quick Practice Guide	Not specified	Up to wound is healed	103 (0.56%)	Orthopaedics: 65 (63.11%), General surgery: 11 (10.68%), Cardio thoracic surgery: 9 (8.74%), Obstetrics gynaecology: 3 (2.91%), Urology: 3 (2.9%), Burns: 2 (1.94%), ENT: 4 (3.88%), Neuro: 6 (5.83%)	Stage 1: 76 (73.53%), Stage 2: 27 (25.74%)	Upper arm: 36 (26.47%), Finger: 4 (2.94%), Front arm: 1 (0.74%), Thigh: 25 (18.38%), Pars iliaca: 16 (11.76%), Heel: 3 (2.21%), Pretibial: 2 (1.47%), Knee: 2 (1.47%), Ankle: 2 (1.47%), Toe: 1 (0.74%), Forehead: 5 (3.68%), Nasal part: 2 (1.47%), Lower jaw: 2 (1.47%), Forehead: 1 (0.74%), Auricle: 1 (0.74%), Chest: 20 (14.71%), Abdomen: 1 (0.74%), Acromion: 1 (0.74%), Back: 3 (2.94%), Sacrococcygeal region: 4 (2.94%), Hip: 4 (2.94%)	75
25	Not specified	Not specified	Not specified	38 (20.9%)	Cardiac (coronary) surgery: 38 (100%)	Stage 1: 35 (97.2%), Stage 2: 1 (2.7%), Staging data of 2 PUs are not reported.	Sacrum coccyx: 20 (55.55%), left buttock: 5 (13.8%), right hand: 4 (11.11%), left leg: 3 (8.33%), left hand: 1 (2.77%), right scapula: 1 (2.77%), left malleolus: 1 (2.77%), right arm: 1 (2.77%)	75
26	EPUAP	Not specified	Up to 48 h post operatively	109 (53.43%)	Cardiothoracic surgery: 109 (100%)	Stage 1: 65 (59.3%), Stage 2: 41 (37.6%), Stage 3: 3 (2.8%)	Not specified	78.6
27	EPUAP	Not specified	Up to patient discharge	15 (15.5%)	Not specified	Stage 2: 23 (88.46%), Stage 4: 3 (11.54%)	Heels: 9 (34.62%), Sacral: 10 (38.4%), Buttock: 7 (27%)	75

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
28	NPUAP/EPUAP	3S Intraoperative Risk Assessment Scale (RAS)	Up to 72 h Post Operative period	56 (16.37%)	Ortho: 36 (25%), Abdominal: 3 (2.56%), Cardiovascular: 17 (21%)	Stage 1: 56 (100%)	Not specified	75
29	EPUAP	Not specified	Not specified	214 (30%)	Hip fracture surgery: 214 (100%)	Stage 2: 199 (27.6%), Stage 3/4: 15 (2.1%)	Not specified	71
30	Not specified	The risk assessment pressure sore scale	Up to 12 weeks or until discharge	41 (14.34%)	Not specified incidence of PU in each Type of surgery	Stage 1: 39 (68.4%), Stage 2: 14 (24.6%), Stage 3: 4 (7%)	Head: 1 (1.8%), Back/shoulder: 3 (5.3%), Arm: 2 (3.5%), Hip: 3 (5.3%), Sacrum: 17 (29.8%), Ischial tuberosity: 8 (14%), Leg: 1 (1.8%), Heel: 11 (19.3%), Foot/malleoli: 4 (7%), Not reported: 7 (12.3%)	71.4
31	Not specified	Modified Knoll Risk assessment tool	1 week	9 (3.20%)	Ortho: 4 (44.4%), Cardiac: 3 (33.3%), General: 1 (11.1%), Neurology: 1 (11.1%)	Stage 1: 2 (22.2%), Stage 2: 6 (66.7%), Unstageable: 1 (11.11%)	Sacral/coccyx: 3 (33.33%), Heel: 2 (22.22%), Buttock-3 (33.33%), chin: 1 (11.1%), face: 1 (11.1%)	71.4
32	Not specified	Braden Scale	Up to discharge from hospital	9 (19.57%)	Vascular: 9 (100%)	Stage 2: 4 (44.4%), Deep tissue injury: 4 (44.44%), Stage 3: 1 (11.1%)	Sacral: 6 (66.67%), Ischial: 1 (11.1%), Heel: 2 (22.22%)	61.5
33	Not specified	Braden Scale	Up to 72 h Post Operative period	18 (5.83%)	Ortho: 13 (72.2%), Neurosurgery: 4 (22.2%), Otolaryngology: 1 (5.6%)	Stage 1: 18 (5.8%)	Not specified	88.5

(Continues)

TABLE A1 | (Continued)

Data of included studies								
No	**PU grading system**	**Risk assessment methods**	**Duration of follow up**	**PU incidence *n* (%)**	**Type of surgery *n* (%)**	**Stages of PU *n* (%)**	**Anatomical location of PU *n* (%)**	**Quality appraisal result (%)**
34	NPUAP	Braden scale	7 days	31 (1.79%)	Neurosurgery: 31 (100%)	Stage 1: 8 (26%), Stage 2: 23 (74.1%)	Sacrum and Costal margin: 6 (19.35%), Iliac and chest: 5 (16.12%), Upper limb: 4 (13%), Chin: 3 (9.6%), Heel: 2 (6.45%), Knee: 1 (3.22%), Hip: 1 (3.22%), Scapula: 1 (3.22%)	73
35	Not specified	Not specified	Up to 15 days	66 (74.2%)	Femoral fracture surgeries (Hemiarthroplasty, internal fixation, external reduction and hip replacements): 66 (100%)	Not specified	No specific data reported for each anatomical location (Sacrum, Heel and Buttock)	74