Online Review Article

Incidence and Prevalence of Pressure Injuries in Adult Intensive Care Patients: A Systematic Review and Meta-Analysis

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Objectives: To systematically assess the incidence and prevalence of pressure injuries in adult ICU patients and the most frequently occurring pressure injury sites.

Data Sources: MEDLINE, Embase, the Cochrane Library, and Cumulative Index to Nursing and Allied Health Literature.

Study Selection: Observational studies reporting incidence rates, cumulative incidence, and prevalence of pressure injuries.

Data Extraction: Two reviewers independently screened studies, extracted data, and assessed the risk of bias. Meta-analyses of pooled weighted estimates were calculated using random effect models with 95% CIs reported due to high heterogeneity. Sensitivity analyses included studies that used skin inspection to identify a pressure injury, studies at low risk of bias, studies that excluded stage 1 and each stage of pressure injury.

Data Synthesis: Twenty-two studies, 10 reporting cumulative incidence of pressure injury irrespective of stage, one reporting incidence rate (198/1,000 hospital-days), and 12 reporting prevalence were included. The 95% CI of cumulative incidence and prevalence were 10.0–25.9% and 16.9–23.8%. In studies that used skin inspection to identify pressure injuries, the 95% CI of cumulative incidence was 9.4–27.5%; all prevalence studies used skin inspection therefore the results were unchanged. In studies assessed as low risk of bias, the 95% CI of cumulative incidence and prevalence were 6.6–36.8% and 12.2–24.5%. Excluding stage 1, the 95% CI of cumulative incidence and prevalence were 0.0–23.8% and 12.4–15.5%. Five studies totalling 406 patients reported usable data on location; 95% CI of frequencies of PIs were as follows: sacrum 26.9–48.0%, buttocks 4.1–46.4%, heel 18.5–38.9%, hips 10.9–15.7%, ears 4.3–19.7%, and shoulders 0.0–40.2%.

Conclusions: Although well-designed studies are needed to ensure the scope of the problem of pressure injuries is better understood, it is clear prevention strategies are also required. (*Crit Care Med* 2018; 46:e1074–e1081)

Key Words: incidence; intensive care unit; meta-analysis; pressure ulcer; prevalence; systematic review

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Pressure injuries (PIs), also known as "pressure ulcers," are one of the most frequently occurring, costly yet potentially preventable adverse events in hospital (1). PIs can occur in various anatomic locations on the body, and their severity is classified into four categories from nonblanchable erythema (stage 1) to full thickness tissue loss (stage 4) in addition to unstageable damage, suspected deep tissue injury, and mucosal injury (1). Once a stage 2 PI occurs, the skin is broken, exposing patients to increased risk of infection. PIs are estimated to cost the United States approximately U.S. $11 billion, the U.K. £750 million, and the Netherlands up to U.S. $2.8 billion annually (1). In Australia, PIs are one of the "top five" most expensive adverse events (2), costing Australian $1.8

billion per annum (3). PIs result in poor patient outcomes such as compromised quality of life, pain, social isolation, and in severe cases can even result in death (4). From 2010 to 2013, PIs were the second most-reported adverse event in U.S. hospitals and an adverse event that caused the most deaths in hospitalized patients in the United States (5). Yet, the extent to which they occur in some high-risk populations, such as intensive care patients, is not clear. We conducted a systematic review to identify the incidence and prevalence of PI in the adult ICU population. An initial review of the literature including systematic review registries failed to identify any systematic reviews in this area, although a narrative review of literature from 2000 to 2005 identified ICU PI prevalence ranged from 4% to 49% (6), suggesting wide variability.

OBJECTIVE

Specific review questions included the following:

1) What is the incidence or prevalence of PI in adult ICU patients, irrespective of patient illness/injury?
2) What is the incidence or prevalence of PIs excluding stage 1 in adult ICU patients?
3) What is the incidence or prevalence of each stage of PI in adult ICU patients?
4) What are the most commonly occurring sites of PI in adult ICU patients?

MATERIALS AND METHODS

The review was guided by the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), the specific guidelines for reporting meta-analyses of observational studies and guidelines for undertaking systematic reviews of incidence and prevalence studies (7). The review was registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42017065330).

Eligibility Criteria

Eligible studies for inclusion had to sample adults defined as greater than or equal to 16 years. No restrictions were placed on the patient diagnosis, severity of illness, or type of ICU. Full text, peer-reviewed studies published in English were required to report data on incidence rate (i.e., density), cumulative incidence (i.e., incidence proportion), point prevalence, or period prevalence. Studies that excluded stage 1 were not included in the analysis to answer the first question but were included for questions 2 and 3. For incidence studies, patients had to be assessed for PI on ICU admission and ICU discharge. Further, studies had to be observational, cross-sectional, or cohort designs that included all patients in the unit at the time of the data collection. Clinical trials, case-control, single arm, and quasi-experimental studies were excluded because they have study-specific inclusion and exclusion criteria, unlikely to represent the ICU population in general. Quality improvement projects (e.g. clinical audits), studies focusing on one type of PI (e.g., medical device), studies where only specific subgroup of ICU patients were studied (e.g., prolonged ICU length of stay), and studies with a sample size less than 50 were also excluded. To establish contemporary prevalence and incidence data and to be more representative of current practices, the years of publication range was January 2002 to May 2017.

Search Strategy

Search terms included "pressure ulcer", "decubitus ulcer", "pressure injury", "pressure sore", "bedsore", "critical care", "intensive care", "intensive therapy", "incidence", and "prevalence". A combination of exploded Medical Subject Heading/Emtree terms using "or" and "and" per database specifications. The search strategy was developed by the author team, whose research focused on PI and intensive and critical care, in collaboration with an experienced health librarian. Databases searched on May 4, 2017 were MEDLINE (Ovid), EMBASE (.com), the Cochrane Library, and Cumulative Index to Nursing and Allied Health Literature (EBSCO). Reference lists of the articles included in the review were handsearched for other potential studies. We contacted study authors to acquire information that was not included in their articles. An example of search strategy from Medline (Ovid) is provided in **Supplementary Table 1** (Supplemental Digital Content 1, http://links.lww.com/CCM/D868).

Study Records

Search results were uploaded into Endnote (Clarivate Analytics, Philadelphia, PA) and duplicates removed. Two reviewers (W.P.C., E.L.H.) independently screened titles and abstracts against eligibility criteria. After initial screening, two reviewers independently assessed the full text of the retrieved articles for compliance with eligibility criteria (W.P.C., E.L.H.). A PRISMA flow chart of the study selection procedure was created.

Data Extraction

Data from included studies were extracted by independently by two reviewers (E.L.H. and one other from the reviewer pool of F.M.C., S.B., C.F.B., P.C.N., F.F.L.), using an adapted form of the Joanna Briggs Institute Data extraction form for prevalence and incidence studies (8). Data extracted were rechecked and adjudicated by two authors (W.P.C., L.T.).

Risk of Bias Assessment

Risk of bias in included studies was independently examined by two reviewers (E.L.H. and one other from the reviewer pool of F.M.C., S.B., C.F.B., P.C.N., F.F.L.) using a validated tool developed to assess bias in prevalence incidence studies (9). This 10-item measure examines the external (items 1–4) and internal (items 5–10) validity of the study across four domains (selection bias, nonresponse bias, measurement bias, and analysis bias) (9). It also contains a summary item that evaluates the overall risk of bias of the study, which aligns with approaches from the Grades of Recommendations, Assessment, Development and Evaluation approach (9). Discrepancies between reviewers were adjudicated by a third reviewer (W.P.C.).

Data Synthesis

A summary table was used to display data extracted from eligible studies. Meta-analyses of cumulative incidence and prevalence were conducted. The unit of analysis for questions 1–3 was the patient, but for question 4 it was the PI. Prior to pooling data from individual studies, double arcsine transformation was used to stabilize variance. This method has been shown to produce less bias results than logit transformation (10, 11). The Cochran Q test ($p < 0.05$ was considered significant) and I^2 (> 50% reflecting heterogeneity) were used to assess the heterogeneity between studies (12).

The random effect model was used due to heterogeneity among studies, and because it was greater than 75% for most analyses, only 95% CIs and not point estimates are reported. For ease of interpretation, results are reported after transforming the effect sizes back to natural proportions. To explore the heterogeneity among studies, sensitivity analyses were carried out. Sensitivity analyses were undertaken including studies excluding stage 1, each stage of PI, studies with low risk of bias, and studies that used skin inspection to identify PI. Funnel plots were used to assess the publication bias using the recommended technique for studies of proportion. Meta-analyses were conducted using MetaXL Version 5.3 (EpiGear International, Sunrise Beach, Queensland, Australia).

RESULTS

The search identified 434 articles; 392 were assessed for inclusion and 22 articles included in this review (**Fig. 1**). **Supplementary Table 2** (Supplemental Digital Content 1, http://links.lww.com/CCM/D868) contains the list of excluded studies and reasons for their exclusion. **Table 1** describes the study characteristics, and **Table 2** reports on study results. Eleven studies reported cumulative incidence (13–23), but one excluded stage 1 (23), one reported incidence rate (i.e., density) (14), and 12 reported prevalence (20, 24–34). Eleven studies recruited from greater than one hospital, and 17 studies recruited from greater than one ICU. Three studies were small ($n < 100$) (21, 24, 27), 13 studies' sample size ranged from 100 to 1,000 (14–16, 18–20, 22, 23, 25, 26, 30, 32, 33), and six were greater than 1,000 (13, 17, 28, 29, 31, 34). One sample size was not reported but subsequently supplied by the authors (25). Four studies relied on chart data (14, 15, 19, 23); the remaining 17, including all prevalence studies, specifically collected data for the study using skin inspection. The risk of bias was low in eight studies (18, 20–22, 24, 28, 29, 33). The three risk of bias criteria most frequently assessed as high risk were all related to external validity. **Supplementary Tables 3** and **4** (Supplemental Digital Content 1, http://links.lww.com/CCM/D868) contain the risk of bias and conflict of interest summaries of the 22 studies included in the review.

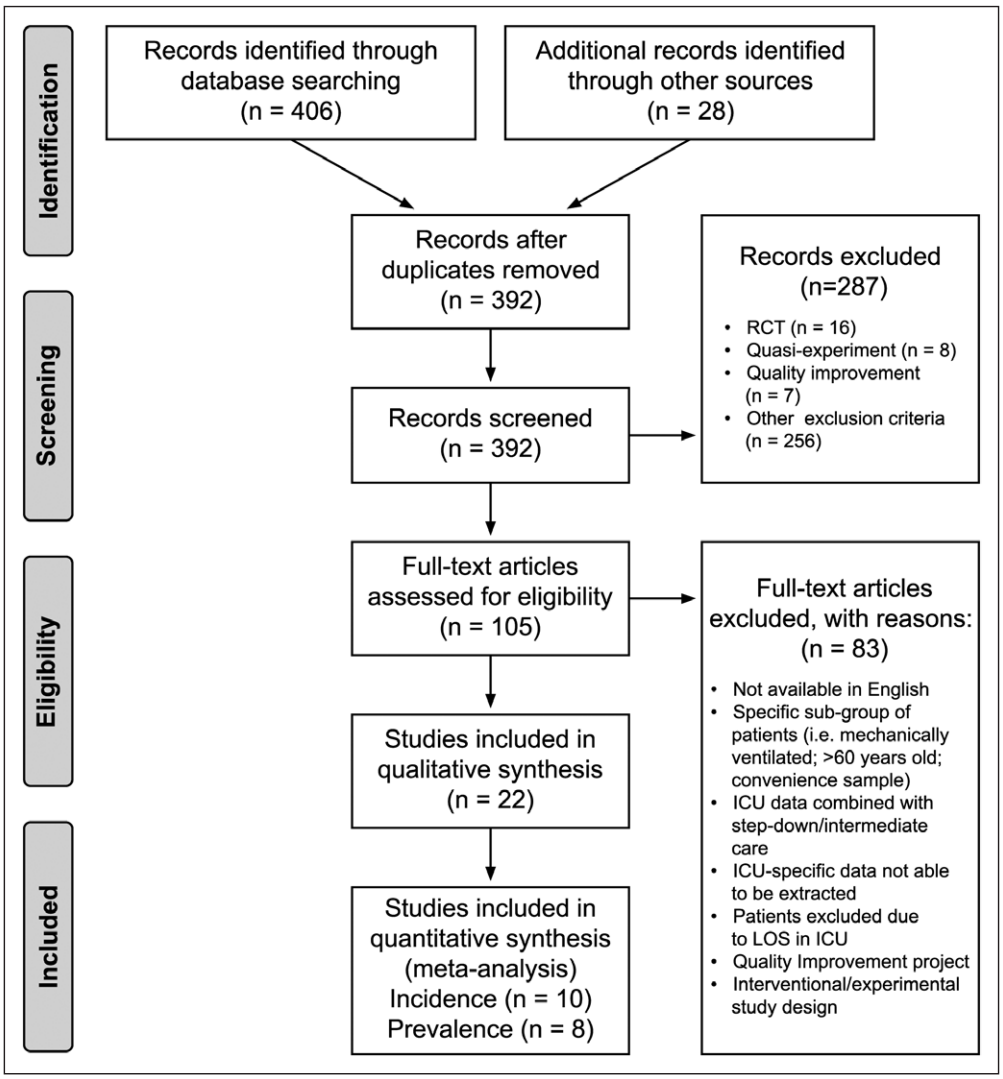

Figure 1. Preferred reporting items for systematic reviews and meta-analyses diagram. LOS = length of stay, RCT = randomized controlled trial.

Where the same data were reported in more than one publication (29–31), we only used one dataset for our analyses (i.e., Lahmann et al [31] for prevalence, Kottner et al [29] for low risk of bias and excluding stage 1 analyses). The 95% CI for cumulative incidence and prevalence of all eligible studies were 10.0–25.9% and 16.9–23.8%. **Table 3** provides a summary of the meta-analytic findings. Visual inspection of the funnel plots suggests

TABLE 1. Characteristics of Included Studies

References, Year	Country	Study Design	No. of Hospitals	No. of ICUs	Samples	Pressure Injury Identified by Skin Inspection	Risk of Bias
Ahtiala et al, 2014 (13)	Finland	Cohort (retrospective)	1	1	1,211	Yes	Moderate
Cho and Noh, 2010 (14)	South Korea	Cohort (retrospective)	1	1	715	No	High
Cox, 2011 (15)	United States	Cohort (retrospective)	1	3	347	No	Moderate
Cremasco et al, 2013 (16)	Brazil	Cohort (prospective)	1	3	160	Yes	Moderate
Leblebici et al, 2007 (17)	Turkey	Cohort (prospective)	1	Multiple[a]	4,485	Yes	Moderate
Özyürek et al, 2016 (18)	Turkey	Cohort (prospective)	1	2	323	Yes	Low
Serra et al, 2014 (19)	Italy	Cohort (retrospective)	1	1	610	No	Moderate
Shahin et al, 2009 (20)	Germany	Cohort (prospective)	2	3	121	Yes	Low
Tayyib et al, 2016 (21)	Saudi Arabia	Cohort (prospective)	2	2	84	Yes	Low
Seongsook et al, 2004 (22)	South Korea	Cohort (prospective)	1	3	112	Yes	Low
Frankel et al, 2007 (23)	United States	Cohort (retrospective)	1	1	820	No[b]	High
Amir et al, 2017 (24)	Indonesia	Cross-sectional	4	Multiple[a]	77	Yes	Low
Cardoso et al, 2010 (25)	Brazil	Cross-sectional	1	1	104	Yes	Moderate
Coyer et al, 2017 (26)	Australia	Cross-sectional	18	Multiple[a]	296	Yes[b]	Moderate
Inan and Oztunc, 2012 (27)	Turkey	Cross-sectional	1	Multiple[a]	75	Yes	Moderate
Jiang et al, 2014 (28)	China	Cross-sectional	12	Multiple[a]	1,094	Yes	Low
Kottner et al, 2009 (29)	Germany	Cross-sectional	225	Multiple[a]	1,920	Yes	Low
Lahmann et al, 2005 (30)	Germany	Cross-sectional	51	Multiple[a]	426	Yes	Moderate
Lahmann et al, 2012 (31)	Germany	Cross-sectional	256	Multiple[a]	2,237	Yes	Moderate
Patrician et al, 2017 (32)	United States	Cross-sectional	13	Multiple[a]	221	Yes[b]	Moderate
Vanderwee et al, 2011 (33)	Belgium	Cross-sectional	84	Multiple[a]	824	Yes	Low
VanGilder et al, 2009 (34)	United States	Cross-sectional	Multiple[a]	Multiple[a]	8,612	Yes	Moderate

[a]Number of hospitals or ICUs not reported.
[b]Sample excluded stage 1 pressure injury.

publication bias; however, some have questioned the validity of using funnel plots for prevalence studies (35). Only one study of 715 patients reported incidence rate for only ICU patients, which was 198 of 1,000 hospital-days (14), although another study did report combined rates with high dependency patients (13).

Five studies totalling 406 PIs reported usable data on various locations of PI (14, 18, 21, 26, 33). Frequency of PIs were as follows: sacrum 95% CI, 26.9–48.0% ($I^2 = 78\%$; $p < 0.001$; five studies total $n = 455$); buttocks 95% CI, 4.1–46.4% ($I^2 = 82\%$; $p = 0.02$; two studies total $n = 82$); heel 95% CI, 18.5–38.9%

TABLE 2. Included Studies Findings

References, Year	Cumulative Incidence, *n* (%)	Prevalence, *n* (%)	Stage of Pressure Injury Reported	Location
Ahtiala et al, 2014 (13)	151/1211 (12.5)[a]	–	No	Unable to extract ICU data
Cho and Noh, 2010 (14)	42/715 (5.9)	–	No	Not reported
Cox, 2011 (15)	65/347 (18.7)	–	Yes	Usable data
Cremasco et al, 2013 (16)	55/160 (34.4)	–	No	Not reported
Leblebici et al, 2007 (17)	213/4485 (4.7)	–	Unable to extract ICU data	Unable to extract ICU data
Özyürek et al, 2016 (18)	55/323 (17.0)	–	No	Usable data
Serra et al, 2014 (19)	189/610 (31.0)	–	Yes	Not reported
Shahin et al, 2009 (20)	4/121 (3.3)	16/121 (13.2)	Yes	Not reported
Tayyib et al, 2016 (21)	33/84 (39.3)	–	No[c]	Usable data
Seongsook et al, 2004 (22)	35/112 (31.3)	–	No	Not reported
Frankel et al, 2007 (23)	25/820 (3.0)[b]	–	No	Not reported
Amir et al, 2017 (24)	–	17/77 (22.1)[a]	Unable to extract ICU data	Unable to extract ICU data
Cardoso et al, 2010 (25)	–	34/104 (32.7)	Unable to extract ICU data	Unable to extract ICU data
Coyer et al, 2017 (26)	–	34/296 (11.5)[b]	No[c]	Usable data
Inan and Oztunc, 2012 (27)	–	22/75 (29.3)[a]	Unable to extract ICU data	Unable to extract ICU data
Jiang et al, 2014 (28)	–	130/1094 (11.9)	Unable to extract ICU data	Unable to extract ICU data
Kottner et al, 2009 (29)	–	471/1920 (24.5)[a]	No	Not reported
Lahmann et al, 2005 (30)	–	109/426 (25.6)	No	Not reported
Lahmann et al, 2012 (31)	–	521/2237 (23.3)[a]	No	Not reported
Patrician et al, 2017 (32)	–	29/221 (13.1)[a,b]	No	Not reported
Vanderwee et al, 2011 (33)	–	164/824 (19.9)	No[c]	Usable data
VanGilder et al, 2009 (34)	–	1,667/ 8,612 (19.4)[a]	No[c]	Not reported

[a]Different calculation to what was published.
[b]Sample excluded stage 1 pressure injury (PI).
[c]Data were provided on this outcome; however, it was based on the number of PI occurrences and not by patient.
Dashes indicate that the analysis was not done.

(I^2 =93%; $p < 0.001$; four studies total $n = 378$); hips 95% CI, 10.9% to 15.7% ($I^2 = 79\%$, $p = 0.003$; two studies total $n = 308$); ears 95% CI, 0.1–32.4% ($I^2 = 76\%$; $p = 0.04$; two studies total $n = 82$); and shoulders 95% CI, 0.00–40.2% ($I^2 = 86\%$; $p = 0.01$; two studies total $n = 110$).

DISCUSSION

The systematic review and meta-analysis of 22 studies identified the 95% CI of prevalence of PI in adult ICU patients was 16.9–23.8%, higher than the prevalence of 12–18% reported for all hospitalized patients when skin inspection is used (31,

TABLE 3. Meta-Analytic Pooled Estimates of the 95% CIs of Cumulative Incidence and Prevalence of Pressure Injuries

	Cumulative Incidence				Prevalence			
Pressure Injury	Studies Included	No. of Studies (and Patients)	REM 95% CI	I^2	Studies Included	No. of Studies (and Patients)	REM 95% CI	I^2
All eligible studies	(13–22)	10 (8,168)	10.0–25.9	98	(20, 24, 25, 27, 28, 31, 33, 34)	8 (13,144)	16.9–23.8	92
Studies excluding stage 1	(15, 19, 20, 23)	4 (1,898)	0.0–23.8	99	(20, 26, 29, 32–34)	6 (11,994)	12.4–15.5	62
Stage 1 studies	(15, 19, 20)	3 (1,078)	1.3–5.9	74	(20, 29)	2 (2,041)	0.0–0.1	88
Stage 2 studies	(15, 19, 20)	3 (1,078)	2.9–7.8	64	(20, 26)	2 (417)	0.1–0.1	0
Stage 3 studies	(15, 19, 20)	3 (1,078)	0.0–13.8	98	(20, 26)	2 (417)	0.0–0.1	86
Stage 4 studies	(15, 19)	2 (957)	0.0–7.4	95	–	–	–	–
Low risk of bias studies	(18, 20–22)	4 (640)	6.6–36.8	95	(20, 24, 28, 29, 33)	5 (4,036)	12.2–24.5	95
Skin inspection studies only	(13, 16–18, 20–22)	7 (6,496)	9.4–27.5	98	(20, 24, 25, 27, 28, 31, 33, 34)	8 (13,144)	16.9–23.8	92

REM = random effects model.

Dashes indicate that the analysis was not done.

33, 36, 37). Use of the gold-standard skin inspection is preferential to relying on routinely collected and coded medical record data as that latter is affected by underreporting (38, 39). The 95% CI of cumulative incidence of PI was 10.0–25.9%. Cumulative incidence studies of the general hospital population are rare; however, one cluster randomized study of a higher risk population of hospitalized patients with limited mobility in Australia reported the cumulative incidence in the control group was 11% (40), just within the CI of our study of ICU patients, another high-risk population. In a U.S. study, the cumulative incidence was less than 1% using hospital administrative data and 2% using routine surveillance data, but stage 1 PIs were excluded (39). Even if stage 1 had been included, it is likely their cumulative incidence would not have been within the 95% CI we found, reflecting that the ICU patients in our analyses developed more PIs than the general hospital population.

Given some ICU patients will develop a PI during their stay, prevention is an important aspect of clinical care. Repositioning and the use of appropriate support surfaces are cornerstones for PI prevention (1, 41). One study found the commonly accepted turning regime for critical care patients (i.e., turning patients every second hr) only happened more than 50% of the time in less than 50% of patients (42). In addition, two Cochrane reviews, one positioning for PI prevention (43) and the other on lateral positioning in ICU patients (44), make no recommendations on frequency or positioning of ICU patients as there was limited good quality evidence in these areas. Developing comprehensive programs or care bundles may be a promising approach for PI prevention (45, 46), but their effects will require evaluation. Common components of PI prevention programs include staff education, regular risk assessment, mobilization, repositioning and skin care protocols, appropriate support surfaces, and monitoring of practice (1, 45, 46).

The most commonly occurring sites for PI were the sacrum, buttocks, and heels, which is consistent with other hospital populations in general (1, 13, 24, 26–28). The supine position is often the position of choice when frequent interventions and treatments are required in ICU, which may contribute to the development and occurrence of PI in these sites. A problem lies in the practice of elevating the head of the patient's bed to 45° to prevent ventilator-associated pneumonia in patients who are mechanically ventilated as this position results in greater pressure on the sacrum and heel (1). Patients in this position tend to slide down the bed increasing their risk to exposure of the skin to the forces of friction and shear (1). Although there is no definitive evidence on the required positioning and frequency of repositioning of critically ill patients, it is clear the regular repositioning is an important prevention strategy (15).

There was significant heterogeneity among studies, which is why we did not report the point estimates. This heterogeneity may be explained by differences in measurement methods. It could also be due to regional variation in incidence and prevalence, in the delivery of PI prevention strategies or in resources, such as nurse-to-patient ratios in delivering these strategies, but this information was not provided in most studies. Despite the fact that incidence rates take into consideration the length of time patients are in ICU, only one study reported this outcome. The choice of which measure, either prevalence or incidence, should be used for audits, or research is likely dependent on the purpose of the work, with incidence being a better reflection of the effectiveness of PI prevention protocols and prevalence helping to understand resource requirements and their allocation (38). Incidence rates rather than

cumulative incidence maybe be more informative for intervention research because the longer the period of time patients are exposed to the risk of PI development (i.e., prolonged length of ICU stay), the greater the likelihood of developing a PI. Future researchers could focus on understanding regional variation, benchmarking of ICUs with similar characteristics, or assessing the effect of multifaceted PI prevention programs.

LIMITATIONS

A total of 23% of studies (5/22) relied on databases or routinely collected data, which may result in underreporting of PIs (39). In addition, interobserver variability is an issue in PI assessment (1). Yet, several studies did not report information on either training of skin assessors or on interrater reliability assessments. The significant heterogeneity among studies meant we reported on 95% CIs but not the point estimates. Using the recommended technique for plotting funnel plots of proportion (47), we did not find evidence of publication bias; however, it can be difficult to detect (35). We undertook meta-analyses of low risk of bias studies, as recommended by some (47, 48), and the results were similar to the result of the meta-analyses of all eligible studies for both incidence and prevalence, but there is no way to say which approach is best (48). We excluded non-English articles because of a lack of translation resources, although 18 of 24 studies (75%) we included were from countries that English was not the first language, and the most accessible and widely read journals are published in the English language. We also excluded studies with sample sizes of less than 50 based on a body of work examining the small study effect in meta-analyses that identified they overestimate treatment effects (49, 50). This work has not been replicated for incidence/prevalence meta-analyses to our knowledge, but it did influence our decision to exclude small studies. Small studies tend to be of low quality and high bias, with small samples not likely to reflect underlying populations (49, 50). Finally, based on the data reported in the available articles, it appeared not feasible to perform sensitivity analyses according to type of ICU.

CONCLUSIONS

Quantifying the extent of PIs, an important and costly adverse event, provides one foundation for planning future care delivery, quality improvement activities, and research targeting interventions to improve patient care. Given our meta-analyses identified up to about one in four or five patients cared for in ICU will have a PI, they remain an important issue in contemporary ICUs. Our results underscore the need for well-designed studies to ensure the scope of the problem is better understood and for continuous efforts in the field of PI prevention.

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