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**Global prevalence and incidence of pressure injuries in hospitalised adult patients: a
systematic review and meta-analysis**

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Abstract

Background: Pressure injuries are frequently occurred adverse event in hospitals, affecting the well-being of patients and causing considerable financial burden to healthcare systems. However, the estimates of prevalence, incidence and hospital-acquired rate of pressure injury in hospitalised patients vary considerably in relevant published studies.

Objectives: To systematically quantify the prevalence and incidence of pressure injuries and the hospital-acquired pressure injuries rate in hospitalised adult patients and identify the most frequently occurring pressure injury stage(s) and affected anatomical location(s).

Design: Systematic review and meta-analysis.

Data sources: Medline, PubMed, Embase, Cochrane Library, CINAHL and ProQuest databases from January 2008 to December 2018.

Review methods: We included studies with observational, cross-sectional or longitudinal designs, reporting pressure injury among hospitalised adults (≥ 16 years) and published in English.

Outcomes were point prevalence, incidence of pressure injuries and the hospital-acquired pressure injuries rate reported as percentages. Two reviewers independently appraised the methodological quality of included studies. Heterogeneity was assessed by using the I^2 statistic and random effects models were employed. Sources of heterogeneity were investigated by subgroup analysis and meta-regression.

Results: Of 7,489 studies identified, 42 were included in the systematic review and 39 of them were eligible for meta-analysis, with a total sample of 2,579,049 patients. The pooled prevalence of 1,366,848 patients was 12.8% (95% CI 11.8-13.9%); pooled incidence rate of 681,885 patients was 5.4 per 10,000 patient-days (95% CI 3.4-7.8) and pooled hospital-acquired pressure injuries rate of 1,893,593 was 8.4% (95% CI 7.6-9.3%). Stages were reported in 16 studies (132,530 patients with

12,041 pressure injuries). The most frequently occurred stage were Stage I (43.5%) and Stage II (28.0%). The most affected body sites were sacrum, heels and hip. Significant heterogeneity was noted across some geographic regions. Meta-regression showed that the year of data collection, mean age and gender were independent predictors, explaining 67% variability in the prevalence of pressure injuries. The year of data collection and age alone could explain 93% of variability in hospital-acquired pressure injuries rate.

Conclusion This study suggested that the burden of pressure injuries remains substantial with over one in ten adult patients admitted to hospitals affected. Superficial pressure injuries, such as Stage I and II, are most common stages and are preventable. Our results highlight healthcare institutions' focus on pressure injuries globally and supports the need to dedicate resources to prevention and treatment on pressure injuries.

Registration number: PROSPERO CRD42019118774.

What is already known about the topic?

- Pressure injuries are a significant clinical and economic issue, detrimentally affecting patients' physical and psychosocial quality of life and are costly to healthcare systems.
- Two previous systematic reviews summarising the evidence for the prevalence and/or incidence of pressure injury in the hospital settings have methodological limitations; both also failed to include the unstageable and deep tissue injury stages of pressure injury in their reviews.

What this paper adds?

- This paper provides up-to-date pooled estimates of: i) pressure injury prevalence of 12.8% (95%CI 11.8-13.9); ii) incidence rate of 5.4 per 10,000 patient-day; and iii) rate of hospital-acquired pressure injury of 8.5% (95%CI 7.6-9.3), in hospitalised adult patients, worldwide.
- Globally, Stage I and Stage II pressure injuries represent over half of all pressure injuries among hospitalised adults. The most frequently affected anatomical locations are the sacrum followed by heels and hips.
- Substantial heterogeneity exists among the studies of pressure injury prevalence, incidence and hospital-acquired rate. Subgroup analysis shows significant variations across geographic regions. Meta-regression identified year of data collection, patients' mean age and gender were statistically significant independent predictors of the prevalence of pressure injury.

Keywords

- Incidence
- Pressure ulcer
- Prevalence
- Systematic review
- Meta-analysis

1. Introduction

Pressure injuries, also referred to as pressure ulcers, are one of the most frequently occurring adverse events in hospitalised patients worldwide (NPUAP, 2014; Padula et al., 2018). Pressure injuries are defined as areas of localised injury to the skin and underlying tissue, usually over a bony prominence, as a result of pressure, or pressure in combination with shear (NPUAP, 2014). They are classified according to the severity and level of tissue injury from Stage I ‘nonblanchable erythema’ to Stage IV ‘full thickness tissue loss’. Two other stages ‘unstageable’ and ‘deep tissue injury’ are now acknowledged.

Pressure injuries are associated with negative impacts on patients and healthcare systems, causing increased risk of nosocomial infection, pain and disability, prolonged hospitalisation, resulting in both morbidity and mortality (Coleman et al., 2013; Ferris et al., 2019) and high financial costs for healthcare facilities (Dealey et al., 2012; Padula et al., 2019).

Pressure injury prevalence and incidence are indicators of the burden of the condition and quality of care (Baharestani et al., 2009; Burston et al., 2014; Vanderwee et al., 2007). Point prevalence is defined as the number of patients with a pressure injury at a specific point in time (usually on a specific day); incidence rate is defined as the number of patients with a new pressure injury within a specific person-time; hospital-acquired pressure injury rate measures the number of patients with pressure injuries at a specific point in time that were acquired in the hospital (NPUAP, 2014). Establishing global prevalence and incidence of pressure injuries is important in understanding the extent of the condition, inform decision makers and improve planning and delivery of healthcare. However, the use of different pressure injury definitions and data collection procedures challenges researchers who conduct meta-analysis (Tubaishat et al., 2018). In order to address this problem, the European Pressure Ulcer Advisory Panel introduced a valid and reliable methodology to perform pressure injury prevalence studies in 2007 (Vanderwee et al., 2007) and international consensus on pressure injury definition was reached (NPUAP, 2014). Since then, the method has been translated and modified into various languages (Gallagher et al., 2008; Jiang et al., 2014; Tannen et al., 2008; Tubaishat et al., 2013), so data from epidemiological studies throughout the world become more comparable.

There are two published systematic reviews reporting prevalence and/or incidence of pressure injury in hospital settings (Al Mutairi et al., 2018; Tubaishat et al., 2018). Some limitations were found after careful examination, such as the methodological limitations (e.g. not appropriately assessing the risk of bias in included studies); analysing only four stages of pressure injuries (Stage I to IV) which overlooks the occurrence of the “unstageable” and “deep tissue injury”. And neither review undertook meta-analysis. Thus, in this systematic review and meta-analysis, we aimed to answer the following questions: 1) What is the prevalence and incidence of pressure injury and the hospital-acquired pressure injury rate of all stages in hospitalised adult patients? 2) What is the most common stage(s) and affected anatomical location(s) of pressure injury in hospitalised adult patients?

2. Methods

2.1 Search strategy and selection criteria

Databases including Medline (via Ovid), EMBASE, Cochrane Library, CINAHL (via EBSCO), and ProQuest Nursing & Allied Health were searched. PubMed was used as supplementary source of Medline to get newly published and ahead of print studies. Initial keywords included “pressure injury”, “pressure ulcer”, “pressure sore”, “decubitus ulcer”, “bed ulcer”, “bed sore”, “bedsore”, “prevalence”, “incidence”, “epidemiology”, “rate”, “frequency”, “occurrence”, and “density”. The Medical Subject Heading (MeSH) or Emtree terms of each keyword and combinations by using Boolean operators such as ‘AND’ and ‘OR’ were explored in each database. The search strategy was developed by the research team in collaboration with a health information specialist. Reference lists of relevant reviews and every included study were hand searched for potential additional studies. Because an internationally recognised definition of pressure injury and a methodology of how to determine pressure injury was published in 2007 (Vanderwee et al., 2007), we only included studies published since 2008 to try to review data that was more consistent in measurement. Date range of the search was from January 1st, 2008 to December 7th, 2018. Search strategies used are presented in *Appendix 1*.

2.2 Study selection

This systematic review followed the recommendations from Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. We included studies that reported all

stages of pressure injury in the hospitalised adult population, which we have classified to be 16 years and older because 16-year-olds can be admitted to adult wards in some hospitals. To be regarded as “whole hospital”, studies must have reported data on at least surgical, medical and ICU patients. We included studies with observational, cross-sectional or longitudinal design and peer-reviewed, full text published in English. No restrictions were placed on patients’ diagnosis, severity of disease or geographic location. Studies with outcomes of point prevalence, incidence rate and the rate of hospital-acquired pressure injury reported as percentages or as rates were included. Specific operational definitions and formulas for pressure injury outcomes are provided in *Appendix 2*. We excluded studies focused on specific subgroups (e.g. patients with spinal cord injury, older patients or only patients at risk) and any non-hospital settings. We excluded studies that reported period prevalence because hospitalised patients were followed up for differing lengths of time in these studies, which does not meet the definition of period prevalence (*Appendix 2*). We excluded experimental studies and case control studies because they have specific inclusion and exclusion criteria, which are unlikely to represent the general hospitalised population. We also excluded studies that excluded Stage I or only focused on specific type of pressure injury (e.g. medical device related pressure injury, heel pressure injury); sample size less than 20 (i.e., very small hospitals or very small samples from bigger hospitals); and animal studies. A PRISMA flow chart of search results and screening process for included studies was created (*Figure 1*). An explicit study protocol is available on PROSPERO with the registration number of CRD42019118774.

2.3 Data extraction and quality assessment

Data extraction was performed by two reviewers: ZL extracted data to a modified Joanna Briggs Institute data extraction form for prevalence and incidence studies (Joanna Briggs Institute, 2014) and FL double checked the extraction for accuracy. Discrepancies between the two reviewers were resolved by discussion or by the involvement of a third reviewer (WC). Three main categories of data were extracted: characteristics of the samples, methodological characteristics of each study, and prevalence, incidence estimates of pressure injury and the rate of hospital-acquired pressure injury, including numerator (number of patients and number of pressure injury or hospital-acquired pressure injury), denominator (number of defined total population or person-time), stages and anatomical

locations. Where the same dataset was reported in more than one articles (Baath et al., 2014; Gunningberg et al., 2013), the dataset was considered as duplicate, thus only one article (Baath et al., 2014) was included in our review and meta-analysis. If one study reported pressure injury prevalence or incidence data collected in different countries or in different time episodes, we extracted the data as independent data layers. We stratified data into six geographic regions (Asia, Australia, Europe, Middle East, North America and South America). A few authors were contacted via e-mail for further details or to help to resolve any uncertainties.

Two reviewers (ZL and WC) independently conducted the quality assessments and discrepancies between them were resolved through discussion, until consensus was reached. Quality of included studies were assessed by using Hoy's risk of bias tool, which was designed for assessing bias in prevalence studies (Hoy et al., 2012). This tool comprises 10 items plus a summary assessment. Item 1 to 4 assess the external validity of the study (domains represent selection and nonresponse bias). And item 5 to 10 assess the internal validity of the study (domains represent measurement bias and analysis bias). Each item was assigned a score of 1 (yes) or 0 (no). Scores were summed across items to generate an overall quality score that ranged from 1 to 10 (Hoy et al., 2012) and the cut-off values of low (8-10), moderate (5-7) or high (≤ 4) risk of bias (Hahnel et al., 2017) was used.

2.4 Data analysis

Summary tables of extracted data were created to describe the characteristics and findings of included studies. Meta-analyses of point prevalence, incidence of pressure injury and hospital-acquired pressure injury rate was conducted. The unit of analysis for the pressure injury prevalence, incidence, rate and stages was patients, but for the anatomical locations was the number of pressure injuries. Unadjusted estimates were calculated and 95% confidence intervals (CI) were determined based on the crude numerators and denominators provided in individual studies. Before pooling data, Freeman-Tukey double arcsine transformation was used to stabilize variance and improve their statistical properties (Barendregt et al., 2013). Heterogeneity was assessed by using *I*-squared statistic (I^2), which describe the percentage of total variation across studies that is due to heterogeneity rather than chance (Higgins et al., 2003). I^2 value of less than 25%, 25-75%, or more than 75% indicates low,

moderate or substantial heterogeneity (Higgins et al., 2003). If moderate or high heterogeneity was identified among studies, random effect model was employed to obtain a crude summary estimate for prevalence, incidence and hospital-acquired rate, otherwise the fixed effect model was used. Forest plots were used to reflect the meta-analysis results, including the 95% confidence intervals in each study.

Sensitivity analyses (i.e., removing studies at high/moderate risk of bias) was pre-specified and was undertaken to test if the meta-analysis findings were robust (Higgins JPT, 2019). Pre-specified subgroup analyses (i.e. geographic region) and meta-regression (i.e., age and gender) was used to explore potential sources of variance across included studies. Because of the characteristics of the data we extracted, we also did meta-regression for year of data collection. Publication bias was identified by using funnel plot and the asymmetry was tested by using Egger's linear regression method ($p < 0.10$ is considered as significant) (Egger et al., 1997). All analyses were done using the Meta package in R (Version 3.6.0).

3. Results

The initial systematic search identified 7,489 citations after removal of duplicates. After screening titles and abstracts, 275 articles remained. After full text examination, 41 studies were included. One additional eligible study was identified from the reference list of included studies. Thus, a total of 42 studies were included in this systematic review. Five study authors were contacted via e-mail for more information and two of them provided the required data (Tubaishat et al., 2011; VanDenKerkhof et al., 2011). Thus, 39 studies were available to conduct meta-analysis. The screening process of studies was depicted in Figure 1. More specific information on the reasons for excluding the 241 studies is presented in *Appendix 3*.

Attach Figure 1 here: Flowchart of study selection

Attach Table 1: Characteristics of included studies (n=42)

Attach Table 2: Findings of included studies (n=39)

3.1 Study characteristics

The characteristics of the 42 included studies was described in *Table 1*. Pressure injury prevalence and/or incidence estimates were collected from 19 different countries. Most of them came from

Europe (n=19, 45%) and North America (n=11, 26%). The rest were from Asia (n=5, 12%), Middle East (n=4, 10%), South America (n=2, 5%) and Oceania (Australia n=1, 2%). The majority of studies (n=30, 70%) recruited patients from more than one hospital and four used national census (Baath et al., 2014; Barrois et al., 2008; Kottner et al., 2009; Vanderwee et al., 2011). Data collectors were trained in half studies (n=21, 50%) and visual skin inspection was used in most studies (n=37, 88%).

Table 2 provided the data extracted from the 39 studies for meta-analysis, including outcomes of pressure injury point prevalence, incidence and hospital-acquired pressure injury rate. The total sample size was 2,579,049 and patients' mean age ranged from 48.6 to 75.5 years old. Although only recently published studies (2008-2018) were included to gain a contemporary understanding of the pressure injury burden in hospitalised adult patients, data over twenty years (1994-2016) were reported among these included studies. Prevalence of pressure injury was reported in 35 studies (89.7%) that included 1,366,848 individuals (Amir et al., 2017; Baath et al., 2014; Barrois et al., 2008; Bredesen et al., 2015; Briggs et al., 2013; Cardoso et al., 2010; Clark et al., 2017; Drake et al., 2010; Feng et al., 2018; Gallagher et al., 2008; Galvan-Martinez et al., 2014; Gottrup et al., 2013; Gunningberg et al., 2008; Gunningberg et al., 2011; Hurd et al., 2009; Inan et al., 2012; Jenkins et al., 2010; Jiang et al., 2014; Kasikci et al., 2018; Kottner et al., 2010; Kottner et al., 2009; Lahmann et al., 2010; Mehta et al., 2015; Shahin et al., 2010; Sj et al., 2013; Swanson et al., 2011; Tannen et al., 2008; Tubaishat et al., 2013; Tubaishat et al., 2011; VanDenKerkhof et al., 2011; Vanderwee et al., 2011; VanGilder et al., 2017; Vangilder et al., 2008; Wann-Hansson et al., 2008; Zhou et al., 2018). Pressure injury incidence rate was reported in four studies (10.2%) totalling 681,885 patients with about 5,901,107 patient-days (Jackson, 2011; Jenkins et al., 2010; Rondinelli et al., 2018; Stausberg et al., 2010). Hospital-acquired pressure injury rate was reported in 15 studies (38.4%) including 1,893,593 patients (Amir et al., 2017; Bergquist-Beringer et al., 2013; Bredesen et al., 2015; Feng et al., 2018; Gallagher et al., 2008; Gunningberg et al., 2011; Hurd et al., 2009; Jiang et al., 2014; Lahmann et al., 2010; Sj et al., 2013; VanDenKerkhof et al., 2011; VanGilder et al., 2017; Vangilder et al., 2008; Wann-Hansson et al., 2008; Zhou et al., 2018).

3.2 Quality assessment of included studies

The overall risk of bias of the 42 included studies was low in 16 (38%) studies, moderate in 20 (48%) studies and high in 6 (14%) studies. *Appendix 4* present details of the risk of bias results and analyses of all included studies. Among the 35 prevalence studies, 15 (43%) studies were at low risk of bias; while in the 15 studies that reported hospital-acquired pressure injury rate, six studies (40%) were at low risk of bias. None of the four incidence studies were at low risk of bias. High risk of bias was most frequently seen in three criteria of external validity (Item 1, 2, and 4) that focus on selection bias and non-response bias. Selection bias was likely because most studies were conducted in a single site, and no evidence that the study's target population was representative of the national population was provided. Also, the sampling frame was not clearly reported in about half of the studies. The amount of and reasons for missing data were also not specified. In addition, the non-response rate was rarely reported in most studies. One risk of bias criterion (Item 7) assessing the internal validity was also at high risk because most studies did not report the inter-rater reliability. Conflict of interests and ethical approval summaries of each study is also provided in *Appendix 5*.

In terms of publication bias, we carefully scrutinised the similarity of datasets during study selection and excluded studies reporting duplicate datasets to reduce potential bias. A funnel plot was used to assess the bias for included studies (*Appendix 6*). We assessed the asymmetry of the funnel plot by using Egger's linear regression test and showed no statistically significance among the included studies ($slope=0.331$, $t=1.016$, $p=0.313$).

Attach Table 3: Summary of meta-analysis and subgroup analysis results

Attach Table 4: Summary of meta-analysis of PI and HAPI stages proportion

3.3 Meta-analysis of the prevalence, incidence of pressure injury and hospital-acquired pressure injury rate

Table 3 summarised the meta-analysis results. In the 35 prevalence studies, ten reported prevalence estimates in more than one data collection time point (Baath et al., 2014; Cardoso et al., 2010; Gunningberg et al., 2008; Jackson, 2011; Kottner et al., 2010; Kottner et al., 2009; Lahmann et al., 2010; Sj et al., 2013; VanDenKerkhof et al., 2011; VanGilder et al., 2017; Vangilder et al., 2008), and one other study reported prevalence in two different countries (Tannen et al., 2008). These datasets were counted separately, which led to 81 data layers contributing to the prevalence analyses.

The overall pooled pressure injury prevalence was 12.8% (95% CI 11.8-13.9%). Prevalence after excluding Stage I was also reported in twenty studies (57%), which was 8.0% (95% CI 7.4-8.6%). In the four incidence rate studies, two of them contributed 1-year incidence for 2 years (Jackson, 2011) and 4 years (Stausberg et al., 2010) respectively. Thus, 8 data layers were included in the meta-analysis and the pooled incidence rate was 5.4 per 10,000 patient-days (95%CI 3.4-7.8). In the 15 hospital-acquired pressure injury rate studies, 49 data layers were identified for meta-analysis. The pooled hospital-acquired pressure injury rate was 8.4% (95% CI 7.6-9.3%) and 5.1% (95% CI 4.6-5.6%) after Stage I was excluded. Of all the patients with a PI, 61.8% (95% CI 59.3-64.3%) were hospital-acquired pressure injuries.

Forest plots of pooled prevalence, incidence and hospital-acquired pressure injury rate are provided in *Appendix 7*. There was considerable amount of heterogeneity existed when pooling prevalence ($I^2 = 99.7, p < 0.01$), incidence ($I^2 = 98.9, p < 0.01$), and hospital-acquired pressure injury rate ($I^2 = 99.5, p < 0.01$). In order to detect the sources of heterogeneity, we conducted subgroup analysis and meta-regression (*Table 3*) to assess the demographic and methodological characteristics of included studies as we stated in the Method section.

3.4 Meta-analysis of pressure injury stages and anatomical locations

Sixteen studies including 132,530 patients with 12,041 pressure injuries and 485 hospital-acquired pressure injuries were included in the meta-analysis of pressure injury stage (Amir et al., 2017; Baath et al., 2014; Barrois et al., 2008; Bredesen et al., 2015; Clark et al., 2017; Drake et al., 2010; Gallagher et al., 2008; Galvan-Martinez et al., 2014; Gunningberg et al., 2008; Gunningberg et al., 2011; Jenkins et al., 2010; Jiang et al., 2014; Mehta et al., 2015; Tubaishat et al., 2013; Tubaishat et al., 2011; Wann-Hansson et al., 2008) and data was presented in *Appendix 8*. The meta-analysis results are summarised in *Table 4*. Of all patients with a pressure injury, Stage I and Stage II accounting for 43.5% (95% CI 38.0-49.1%) and 28.0% (95% CI 24.7-31.5%) respectively. Stage III and Stage IV pressure injury occurred less frequently, accounting for 12.8% (95% CI 10.9-14.9%) and 9.9% (95% CI 7.5-12.5%). Deep tissue injury (DTI) and unstageable pressure injury occurred the least at 2.4% (95% CI 0.9-4.5%) and 7.8% (95% CI 6.1-9.6%) of all pressure injury. For patients with a hospital-acquired pressure injury, Stage I and Stage II were also the most commonly occurring:

accounting for 54.3% (95% CI 47.8-60.6%) and 29.0% (95% CI 19.2-40.0%) respectively. More severe stages, like Stage III, Stage IV occurred less frequently.

Seven studies provided usable anatomical locations data of a total of 9,016 pressure injuries (Amir et al., 2017; Barrois et al., 2008; Cardoso et al., 2010; Inan et al., 2012; Kasikci et al., 2018; Vanderwee et al., 2011; Zhou et al., 2018). The most affected anatomical locations were: sacrum 37.3% (95% CI 36.1-38.6%) ($I^2=41.5\%$; six studies total $n=5,929$); heels 29.5% (95% CI 22.2-37.3%) ($I^2=97.1\%$; five studies total $n=8,442$); and hip 7.8% (95% CI 3.0-14.4%) ($I^2=94.7\%$; four studies total $n=3,818$).

3.5 Sensitivity analysis, subgroup analysis and meta-regression

After removing the high and moderate risk of bias studies, the pooled pressure injury prevalence and hospital-acquired pressure injury rate in only low risk of bias subgroup was similar to the overall estimates (Table 3). The prevalence in 15 low risk of bias studies was 13.3% (95% CI 9.7-17.4%). While the hospital-acquired pressure injury rate in the six low risk of bias studies was 8.4% (95% CI 4.9-12.7%).

Substantial heterogeneity was seen across the contributing studies when pooling prevalence, incidence and hospital-acquired pressure injury rate (Table 3). Geographic region subgroup analysis was conducted to explore the heterogeneity. When assessed by region, the prevalence of pressure injury in Europe and North America were 14.5% (95% CI 12.6-16.5%) and 13.6% (95% CI 12.6-14.5%) respectively but with considerable heterogeneity. The prevalence in studies in Middle East, South America and Australia were 12.6% (95% CI 11.1-14.1%), 12.7% (95% CI 9.1-16.8%) and 9.0% (95% CI 6.7-11.5%). Only in the Middle East subgroup, the heterogeneity was moderate ($I^2 = 43.3$); the rest were high. Asian studies provided the lowest prevalence of 3.0% (95% CI 2.0-4.1%) but also with substantial heterogeneity. The incidence rate was only reported in studies from North America at 7.7 (95% CI 6.4-9.1) per 10,000 patient-day and Europe at 3.0 (95% CI 0.8-6.4) per 10,000 patient-day. In terms of hospital-acquired rate, substantial heterogeneity existed among these region subgroups. Europe had the highest rate at 14.4% (95% CI 11.9-17.0%). The rate in North America

and Australia were 8.3% (95% CI 7.5-9.2%) and 6.3% (95% CI 4.2-8.9%) separately. Asia had the lowest rate of 1.1% (95% CI 0.5-1.9%).

From the meta-regression analysis, the association between pressure injury prevalence and study characteristics including data collection year, mean age, and gender (female %) were assessed by univariate and multivariate mixed-effect meta-regression analysis. Scattering plots are provided in *Appendix 9*. The three characteristics were all statistically significant in the multivariate meta-regression model (Intercept: 13.175 (95% CI 6.408-19.942), $p < 0.001$; data collection year, estimate: -0.007 (95% CI (-0.010)-(-0.003)), $p < 0.001$; mean age, estimate: 0.016 (95% CI 0.011-0.020), $p < 0.001$; and gender (female%), estimate: -1.383 (95% CI (-1.834)-(-0.930)), $p < 0.001$), which yielded a significant model that explained 66.9% of the variance between studies. The overall pressure injury prevalence was lower in more recent years, in younger people and in studies with higher female percentage. As for hospital-acquired pressure injury rate, the multivariate meta-regression model showed that the rate decreased with the year of data collection (estimate: -0.010 (95% CI (-0.012)-(-0.008)), $p < 0.001$) and increased with patient's mean age (estimate: 0.009 (95% CI 0.005-0.012), $p < 0.001$), which yielded a significant model (Intercept: 19.700 (95% CI 15.259-24.141), $p < 0.001$) that explained 92.8% of the variance. However, gender was not significant in the hospital-acquired pressure injury rate model.

4. Discussion

4.1 Principle findings

We conducted a systematic review and meta-analysis to estimate pressure injury prevalence, incidence and hospital-acquired pressure injury rate in hospitalised adult patients from a global perspective. We included 39 studies in the meta-analysis, which included over 2.5 million patients worldwide. The most frequently reported outcome was point pressure injury prevalence (35 studies), which provides an indication of how widespread pressure injury was in hospital settings. The burden of pressure injury was identified to be substantial with the overall prevalence of 12.8% in hospitalised adult patients. The overall incidence rate was 5.4 per 10,000 patient days, yet only four studies (10%) reported this outcome. This could reflect that more resources are required to accurately conduct incidence studies when comparing to prevalence studies. In the hospital settings, to obtain an

incidence rate needs to follow an open cohort (i.e., different patients in the different time period) (Vandenbroucke et al., 2012), which can be more time consuming and increases the complexity of the analysis. But incidence could provide a more accurate understanding of the risk of developing new pressure injury and quality of care for hospitalised patients. Hospital-acquired pressure injury rate is an indicator to reflect the effectiveness of preventive care in hospitals (Baharestani et al., 2009). The overall pooled hospital-acquired pressure injury rate in our review was 8.5%, and about 62% of pressure injuries were hospital-acquired, indicating the ongoing need to focus on prevention as well as the need to dedicate resource to treatment. In addition, only 16 (38%) studies were judged to be of good methodological quality. Variance in low risk of bias studies was also detected in the sensitivity analysis and we found very similar prevalence and hospital-acquired rate in these two groups, which reflect the stabilisation of the overall results.

Superficial Stage I and II were most common pressure injuries among hospitalised patients. We identified that about half of all pressure injuries and hospital-acquired pressure injuries were Stage I. Although there is no skin lesion in Stage I, their existence is a risk factor for higher stages of pressure injury development (Coleman et al., 2013). Thus, healthcare providers need to take actions in preventing superficial stages from occurring or worsening. Regarding severe pressure injuries including Stage III and IV, deep tissue injuries and unstageable, they only occupied around 30% of all pressure injuries and 18% of hospital-acquired pressure injuries. However, it was estimated that the effect on severe pressure injuries was four times larger than the effect on superficial pressure injuries (Stage I/II) (Kayser et al., 2019). The treatment cost per case was estimated ranged from \$2995 to \$3260 (Stage III/IV) in the US (Padula et al., 2019) and from £9041 (Category III) to £14,108 (Category IV) in the UK (Dealey et al., 2012). Severe pressure injuries are also significantly associated to prolonged hospital stay, impose considerable financial burden and even death (Kayser et al., 2019; Makary et al., 2016). Therefore, the need for preventative strategies are important in hospitals to reduce the potential financial burden. Regarding to pressure injury locations, the most effected location were the sacrum, heel and hip, which is consistent with prior studies (W. P. Chaboyer et al., 2018; Liu et al., 2019).

4.2 Comparison with other studies

Two previous reviews synthesised evidence aimed to identify the prevalence and/or incidence of pressure injury in hospital settings (Al Mutairi et al., 2018; Tubaishat et al., 2018). However, neither conducted a rigorous quality evaluation of included studies and both considered meta-analysis unfeasible due to the methodological variances; instead, they relied on mean-prevalence or incidence counting and narrative synthesis. Although some argue that the mean counting shows the central tendency of prevalence and incidence (Saha et al., 2008), the mean counting for prevalence and incidence outcomes could be misconducted. For example, due to the differing follow-up period in different studies, outcomes such as period prevalence and incidence cannot be simply added up across studies and get a mean value.

In this review, we also found that epidemiological definitions of pressure injury seem to be blurred when reporting the prevalence, incidence and hospital-acquired pressure injury rate in current published studies. Therefore, we had to disregard terms the author used when we extracted data and set clear operational definitions for outcomes (*Appendix 2*). For instance, we excluded period prevalence studies because we were sceptical about the unclear follow-up period reported in current period prevalence studies. So as to the cumulative incidence and incidence rate, both are only meaningful when reported with clear follow-up time, which means the starting point of follow-up (time zero) and endpoint should be clearly stated in the studies, such as the 4-day incidence (2.8%) in Jeckin et al (Jenkins et al., 2010). In terms of hospital-acquired pressure injury rate, some studies used terms such as pressure injury incidence (Jiang et al., 2014; VanDenKerkhof et al., 2011) or hospital-acquired pressure injury prevalence (Bredesen et al., 2015; Lahmann et al., 2010). We identified that all reported hospital-acquired pressure injury rates in the primary studies were collected along with prevalence (1-day) and no follow-up. So, the rate should be one type of prevalence, but hospital-acquired pressure injuries were also new cases that occurred in the hospitals (between admission and the survey day). Given this, the hospital-acquired pressure injury rate did not fit the classic definition of prevalence nor incidence. We used the term of hospital-acquired pressure injury rate in this review to be consistent with current guideline (NPUAP, 2014). Future researchers should rigorously define and distinguish which indicator they want to report. Because collecting cumulative incidence or incidence rate (i.e. incidence density) will probably involve more human and other resources to follow

patients for a specific period. Therefore, hospital-acquired pressure injury rate is a more pragmatic indicator for routine monitoring comparing to incidence.

4.3 Exploration of subgroup analysis findings and meta-regression findings

The prevalence, incidence and hospital-acquired pressure injury rate from different countries were pooled in this meta-analysis, and as expected, high heterogeneity was identified across included studies. In order to detect the sources of variance, we conducted subgroup analysis and meta-regression to assess the clinical and methodological characteristics of the included studies.

Through geographic region subgroup analysis, we found that both pressure injury prevalence and hospital-acquired pressure injury rate varied across regions. High heterogeneity exists in studies from developed countries in Europe and North America, yet they also reported the highest prevalence and hospital-acquired pressure injury rates. Only Middle East studies showed lower heterogeneity, which may be related to the small sample size in the 4 included studies (Table 3). Asian studies reported the lowest prevalence and hospital-acquired pressure injuries rate. And three out of the five included Asian studies were from China, accounting for 98% of all Asian sample. This reported lower rate in Asia could be related to case mix, such as characteristics of the patients admitted to hospitals in China. Less acuity ill patients may be admitted as compared to patients in developed countries. In China, because of a lack of sound basic community health facilities, hospitals are the first care location when people get sick (Zhou et al., 2018). And since 2008, the Health Ministry of China established the hospital adverse event reporting system (Long et al., 2011), which made hospital-acquired pressure injuries a sensitive indicator of nursing care quality in hospitals nationwide. For one thing, nurses may pay extra attention to patients' skin integrity and pressure injury prevention. For example, patient repositioning compliance rate was 90% in a recent Chinese national study (Liu et al., 2019), which is much higher than Sweden (44.3%) (Baath et al., 2014) and Australia (66.4%) (W. Chaboyer et al., 2017). For another, because pressure injury can be a quality of care indicator, it may act as a barrier for pressure injury reporting. For example, in some hospitals or countries, the individual reporting hospital-acquired pressure injury as well as the ward or hospital are both fined monetarily, which may also influence reporting, especially the reporting of Stage I pressure injury.

Through meta-regression, heterogeneity was explored by data collection year, mean age and gender. Regarding the year of data collection, in both prevalence and hospital-acquire pressure injury rate models, over twenty years of pressure injury data (1994-2016) were presented in included studies. We found that both prevalence (0.7% drop per year) and hospital-acquired pressure injury rate (1.0% drop per year) were decreased significantly in the past two decades. This is not surprising given the international focus on patient safety and adverse events (Shekelle et al., 2013; Sullivan et al., 2013; World Health Organization, 2002). The World Health Organisation called for actions to prioritise patient safety in healthcare facilities in early twentieth and urged the member states to allocate necessary resources for developing national policies and programs to promote patient safety (World Health Organization, 2002). Several countries have established national surveillance systems to track pressure injury and other adverse events. For example, an annual national prevalence survey of pressure injury was conducted in German since 2001 (Stausberg et al., 2010). In England, the National Health Service (NHS) also implemented the NHS thermometer to track pressure injury and other adverse events (Power et al., 2012). Sweden (Baath et al., 2014) and the US (Makary et al., 2016) both have strong surveillance systems. However, for some countries, data only came from a small number of studies and may be biased.

In terms of mean age, the prevalence and hospital-acquired rate were also significantly increased with patients' age in the meta-regression models. This finding fits existing knowledge that increasing age is one risk factor of pressure injury development. Hospitalised older patients tend to have poor skin status, poor nutrition, and decreased mobility (Coleman et al., 2013; Rasero et al., 2015). Incontinence risk in the elderly group could also influence the skin status and increase pressure injuries risk (Rasero et al., 2015). Thus, our meta-regression findings support the view that older adults are vulnerable patient group and need to be targeted in pressure injury prevention efforts. Gender is another risk to consider. In our review, more males incurred a pressure injury in the prevalence model, but not in the hospital-acquired pressure injury rate model. In Coleman's review, the effect of gender on pressure injury development also remains unclear (Coleman et al., 2013). Thus, the extent to which gender is a risk factor for pressure injury is not clear yet.

Despite the high heterogeneity in this review, previous evidence has shown that meta-analyses are preferred to narrative syntheses for deriving a precise estimate of the outcomes (Barendregt et al., 2013). Additionally, higher heterogeneity is expected in meta-analysis of epidemiological studies, because the large sample size may cause high I^2 (Rucker et al., 2008). By undertaking the subgroup analyses and meta-regression, an amount of heterogeneity could be explained in this paper. For one thing, different geographic region can account for some of the variance of prevalence and rate. For another, data collection year, mean age and gender were independent predictors, explaining 67% variability in the prevalence of pressure injuries. The year of data collection and age alone explain 93% of variability in hospital-acquired pressure injury rate.

4.4 Policy, clinical and research implications

Findings of this review support the need for both policies and consistent application of pressure injury prevention strategies. Improvement in pressure injury prevention practices in national policies (Baath et al., 2014; Padula et al., 2019; Power et al., 2012) may help to explain the time trend of decreasing prevalence and hospital-acquired pressure injury rate over time. For instance, Sweden commenced its national patient safety initiative in 2007 with a priority of reducing pressure injuries (Baath et al., 2014) and the Centres for Medicare & Medicaid Services (CMS) in the US initiated a non-pay policy to reduce hospital-acquired pressure injury by stop paying for the ancillary care of hospital-acquired pressure injuries in hospitals since 2008 (Padula et al., 2019). However, according to Padula's research (Padula et al., 2019), the CMS policy only worked for a short time and the hospital-acquired rate in acute care even increased afterwards. The international practice guidelines (NPUAP, 2014) also advocate several preventing strategies, such as regular repositioning, using support surface and skin protection, but evidences have shown their use were suboptimal (Baath et al., 2014; W. Chaboyer et al., 2017). The high prevalence of pressure injury and hospital-acquired pressure injury rate we detected in our review suggests some pressure injury preventing initiatives and policies may be not enough or ineffective. Our results support the need for continuing focus on prompting pressure injury prevention in healthcare systems, such as providing pressure injury educations for front-line nursing staff, introducing guideline-based practice protocols and improving the implementation of preventive strategies. But our findings also show healthcare facilities need to

dedicate human and other resources to treatment, as about one in ten in the hospitalised patients will have a pressure injury.

The findings of this review have implications for future researchers. In this review, most studies used visual skin assessment (n=36, 87.8%) to collect data in this review, which was also recommended as the gold-standard to identify pressure injury in prevalence studies (Vanderwee et al., 2007). However, only half of the studies provided training for data collectors and the inter-rater reliability was poorly reported. This lack of reporting then calls into question the accuracy of the results (CH Hennekens, 1987). Future researchers should carefully plan the trainings for data collectors and clearly reported the inter-rater reliability after the trainings. Methodological quality weaknesses related to external validity were also commonly seen in included studies. Future researchers should consider strategies to enhance the generalisability of the findings (i.e., external validity). For example, using random sampling or a census to improve the representation of the target population; clearly reporting the sampling frame; and using strategies to limit non-response rate will help to enhance the quality of future studies.

4.5 Strengths and limitations of the study

Our systematic review has several strengths. To the best of our knowledge, this is the first systematic review with comprehensive meta-analysis that quantifies the pressure injury prevalence, incidence and hospital-acquired pressure injury rate in hospitalised adult patients, including all stages. A comprehensive review protocol was used, and we adhered to PRISMA guidelines. We searched multiple electronic databases and used rigorous approach to select studies, extract and appraise data. We also set operational definition for the outcomes, distinguishing these outcomes with clear and reproducible formulas. Furthermore, we also controlled the effect of multiple-publication bias in the analysis by avoiding inclusion of duplicate publications that might have skewed the interpretation of the prevalence incidence estimates.

There are also some limitations to this review. Firstly, we excluded non-English papers due to lack of resources. However, our review included 27 studies (65.9%) from countries that English was not their first language and English is the most accessible language in most worldwide journals. Secondly,

pooling the prevalence and incidence rate by meta-analysis may be considered controversial by some researchers because of the high heterogeneity (Tubaishat et al., 2018). But, it is recognised that I^2 is influenced by sample size; large sample like ours, there is bound to be high I^2 near 100% (Rucker et al., 2008). In addition, we explored the possible factors that caused variance and yielded reasonable models to explain this heterogeneity (Higgins JPT, 2019). With the update of a standard pressure injury definition and data collection procedure (NPUAP, 2014), meta-analysis seemed appropriate.

5. Conclusions

This review underscores the global prevalence and incidence of pressure injury over the last two decades. Quantifying the extent of pressure injury in hospitalised patients gives an indication of the global burden of the condition and provides a foundation for planning future care delivery, hospital resource allocation and promoting prevention intervention to reduce pressure injury. Reliable and accurate prevalence and incidence data for pressure injury are of paramount importance when planning both prevention and treatment. Our meta-analyses showed pressure injury remain an important issue in hospitals in many countries of the world and highlights the need for ongoing attention on pressure injury.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declared and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Contributors

All authors conceived the study and were responsible for designing the protocol. ZL, WC, and FL designed the study. ZL did the literature search and together with WC and FL, selected the studies, extracted the relevant information and conducted quality appraisal. LT provided critical guidance on meta-analysis. ZL wrote the first draft of the paper. All authors critically revised successive drafts of the paper and approved the final version.

Ethical approval Not required.

Table 1 Characteristics of included studies (n=42)

Author, Year	Country	Region	Design	Number of hospitals	Skin assessment	Data collection	Risk of bias
(Amir et al., 2017)	Indonesia	Asia	Cross-sectional	4	Yes	2 trained nurses as a team; 1-day (2012)	Moderate
(Baath et al., 2014)	Sweden	Europe	Cross-sectional	290	Yes	2 trained nurses; 1 specific week, Sur-1(2011Mar), Sur-2(2011Oct), Sur-3(2012Mar)	Low
(Barrois et al., 2008)	France	Europe	Cross-sectional	1075	No	Head nurses of wards filled questionnaire; Over 1 week (2004)	Low
(Bergquist-Beringer et al., 2013)	USA	North America	Retrospective cohort	1419	Yes	Trained nurses; 1-day (2010)	Low
(Bredesen et al., 2015)	Norway	Europe	Cross-sectional	6	Yes	2 trained nurses as a team; 1-day (2012)	Low
(Briggs et al., 2013)	UK	Europe	Cross-sectional	9	Yes	Trained nurse; 1-day (2009-2010)	Moderate
(Buttery, 2009)	UK	Europe	Cross-sectional	44	Yes	Facility's nurses; (2005-2008)	High
(Cardoso et al., 2010)	Brazil	South America	Cross-sectional	1	Yes	1 researcher; 2 study days (2004)	High
(Clark et al., 2017)	UK	Europe	Cross-sectional	66	Yes/No †	2 nurses and 1 data collector as a team; 5-day (2015)	Moderate
(Drake et al., 2010)	USA	North America	Cross-sectional	1	Yes	25 trained nurses; 1-day (2007)	Moderate
(Feng et al., 2018)	China	Asia	Cross-sectional	9	Yes	2 trained nurses as a group; 1-day (2015)	Moderate
(Gallagher et al., 2008)	Ireland	Europe	Cross-sectional	3	Yes	2 trained surveyors as a team (1 doc and 1 nurse) (8 teams); 2-day (Not report)	Low
(Galvan-Martinez et al., 2014)	Mexico	South America	Cross-sectional	3	Yes	Trained nurses; (Not report)	Moderate
(Gottrup et al., 2013)	Denmark	Europe	Cross-sectional	2	Yes/No ‡	1 doctor and one/two wound-care nurses as a team (2 teams); 1-week (2010)	High
(Gunningberg et al., 2008)	Sweden	Europe	Cross-sectional	1	Yes	2 trained nurses; 1-day (2002, 2006)	Low
(Gunningberg et al., 2011)	Sweden	Europe	Cross-sectional	5	Yes	2 trained nurses; 1-day (2009)	Low
(Hurd et al., 2009)	Canada	North America	Cross-sectional	13	Yes	Trained advanced nurses; 1-or 2-day (2006-2007)	Moderate
(Inan et al., 2012)	Turkey	Middle East	Cross-sectional	1	Yes	3 trained researchers; 1-day (Not report)	Low
(Jackson, 2011)	USA	North America	Retrospective cohort	1	No	Hospital records; Two 1-year periods, SST (2007-2008), BS (2008-2009)	Moderate
(Jenkins et al., 2010)	USA	North America	Cross-sectional	1	Yes	Assessment team (wound nurses, department managers and RNs); 1-day prevalence; 4-day incidence (2009)	Moderate
(Jiang et al., 2014)	China	Asia	Cross-sectional	12	Yes	2 trained nurses as a group; 10-h, 4 consecutive times from April-July (2011)	Low
(Kasikci et al., 2018)	Turkey	Middle East	Cross-sectional	5	Yes	Trained researchers and interviewers; 6-day (2016)	Low
(Kottner et al., 2009)	Germany	Europe	Cross-sectional	225	Yes	2 trained nurses; 1-day (2001-2007)	Moderate
(Kottner et al., 2010)	Germany	Europe	Cross-sectional	19(2008), 15(2009)	Yes	2 trained nurses; 1-day (2008-2009)	Low
(Lahmann et al., 2010)	Germany	Europe	Cross-sectional	39(once), 32 (twice), 11 (thrice).	yes	Trained nurses; 1-day (From 2001 to 2004)	Moderate

Author, Year	Country	Region	Design	Number of hospitals	Skin assessment	Data collection	Risk of bias
(Mehta et al., 2015)	India	Asia	Cross-sectional	1	Yes	2 trained surveyors; 1-day (2013)	Low
(Rondinelli et al., 2018)	USA	North America	Retrospective cohort	35	Yes/No [‡]	Assessment team (WOCN nurses/ frontline nurses); 2.5 years period (Jan 1, 2013- Jun 30, 2015)	Moderate
(Shahin et al., 2010)	Germany	Europe	Cross-sectional	22	Yes	Trained nurses; (2007)	Moderate
(Sj et al., 2013)	Australia	Australia	Cross-sectional	1	Yes	2 trained nurses as a group with over 100 multidisciplinary staff members; 1-day (2009-2012)	Low
(Swanson et al., 2011)	USA	North America	Cross-sectional	1	Yes/No [‡]	Trained nurses; 1-day (2008)	High
(Stausberg et al., 2010)	Germany	Europe	Retrospective cohort	1	Yes/No [§]	2 trained nursing experts; 1-year period. (2003-2007)	Moderate
(Tannen et al., 2008)	Germany & Netherlands	Europe	Cross-sectional	39 (Germany) 60 (Netherlands)	Yes	Trained nurses; 1 week (2004)	Moderate
(Tubaishat et al., 2011)	Jordan	Middle East	Cross-sectional	2	Yes	The first author (AT); 1-day (Not report)	Low
(Tubaishat et al., 2013)	Jordan	Middle East	Cross-sectional	3	Yes	The first author (AT); 1-day (Not report)	Low
(VanDenKerkhof et al., 2011)	Canada	North America	Cross-sectional	1	Yes	Trained nurses; 1-day (1994-2008)	Moderate
(Vanderwee et al., 2011)	Belgium	Europe	Cross-sectional	84	Yes	2 trained nurses; 1-day (2008)	Low
(Vangilder et al., 2008)	USA	North America	Cross-sectional	394(2003), 555(2004), 533(2005)	Yes	Trained caregivers; 1-day (2003-2005)	Moderate
(VanGilder et al., 2017)	USA	North America	Cross-sectional	562(2006), 542(2007), 765(2008), 743(2009), 766(2010), 753(2011), 772(2012), 727(2013), 749(2014), 748(2015)	Yes	Clinical teams; 1-day (2006-2015)	Moderate
(Vowden et al., 2009)	UK	Europe	Cross-sectional	Multiple*	No	1-week (2007)	High
(Wann-Hansson et al., 2008)	Sweden	Europe	Cross-sectional	1	Yes	2 trained nurses; 1-day (2004)	Low
(Woo et al., 2017)	Canada	North America	Prospective cohort	Multiple*	No	Health outcomes for better information and care (HOBIC) database from 2010-2013	High
(Zhou et al., 2018)	China	Asia	Cross-sectional	25	Yes	Trained nurses/ET/nurse specialists; 1-day (2015)	Moderate

* Number of hospitals not reported;

† Only 593 (79.3%) had their skin assessed;

‡ No further information was provided about how they conducted skin assessment, however, skin assessment was mentioned in the method

§ Patients were physically inspected by two trained nursing experts in only some randomly chosen wards.

Table 2 Findings of included studies (n=39)

Author, Year	Sample size, N (collection year/episodes)	Mean age (Range)	Female %	Prevalence % (n/n)		HAPI [†] rate %	Incidence
				All stages	Excluding Stage I		
(Amir et al., 2017)	1132	48.7	40.0%	8.0 (91/1132)	6.5 (74/1132)	4.5 (51/1132)	..
(Baath et al., 2014)	16466 (2011, Mar)	(17->80)	53.3%	16.6 (2737/16466)	8.3 (1363/16466)	..	..
	8265 (2011, Oct)	≥18	..	14.4 (1193/8265)	7.0 (578/8265)	..	..
	14540 (2012, Mar)	≥18	..	16.1 (2343/14540)	8.0 (1168/14540)	..	..
(Barrois et al., 2008)	37307	F:72.3 M:70.1	62.4%	8.9 (3314/37037)	6.2 (2279/37037)	..	..
(Bergquist-Beringer et al., 2013)	710626	63	52.0%	..	..	3.6 (25928/710626)	..
(Bredesen et al., 2015)	1209	(18->89)	44.1%	18.2 (220/1209)	7.2 (87/1209)	15.1 (182/1209)	..
(Briggs et al., 2013)	3397	65.8 (18-103)	50.9%	14.8 (502/3397)	..	..	..
(Cardoso et al., 2010)	376 (Day-1)	..	..	11.4 (43/376)	..	..	..
	340 (Day-2)	..	..	10.3 (35/340)	..	..	..
(Clark et al., 2017)	8365	..	55.7%	8.9 (748/8365)	..	..	..
(Drake et al., 2010)	..	59 (18-83)	51.0%	14.4 (52/362)	10.5 (38/362)	..	..
(Feng et al., 2018)	13176	54.42	48.0%	1.8 (233/13176)	..	0.9 (126/13176)	..
(Gallagher et al., 2008)	672	Median: 69 (16-94)	52.1%	18.5 (124/672)	9.4 (63/672)	14.2 (96/672)	..
(Galvan-Martinez et al., 2014)	294	48.6 (31-85)	56.8%	17.0 (50/294)	..	..	..
(Gottrup et al., 2013)	830	..	..	3.3 (28/830)	..	..	..
(Gunningberg et al., 2008)	612 (2002)	18->89	49.3%	23.9 (146/612)	8.0 (49/612)	..	..
	632 (2006)	18->89	51.3%	22.9 (145/632)	12.0 (78/632)	..	..
(Gunningberg et al., 2011)	1192	67.8 (18-99)	52.5%	14.9 (177/1192)	..	11.6 (138/1192)	..
(Hurd et al., 2009)	3099	..	..	21.8 (677/3099)	..	17.3 (537/3099)	..
(Inan et al., 2012)	404	51.2	48.3%	10.4 (42/404)	..	..	..
(Jackson, 2011)	21174 (2007/2008)	62 (17-93)	..	..	..	..	201/21174 in 1-year (LOS [‡] :39.72 days)
	20666 (2008/2009)	60 (17-93)	..	..	..	..	167/20666 in 1-year (LOS:44.23 days)
(Jenkins et al., 2010)	310	75.5 (48-95)	..	15.8 (49/310)	6.5 (20/310)	..	4/140 in 4-day (LOS:3.84 days)
(Jiang et al., 2014)	39952	18->89	41.7%	1.6 (631/39952)	1.1 (450/39952)	0.6 (251/39952)	..
(Kasikci et al., 2014)	832	56.6	46.9%	12.7 (106/832)	6.7 (56/832)	..	..

Author, Year	Sample size, N (collection year/episodes)	Mean age (Range)	Female %	Prevalence % (n/n)		HAPI [†] rate %	Incidence
				All stages	Excluding Stage I		
(2018)							
(Kottner et al., 2009)	2757 (2001)	67.0	57.5%	13.9 (384/2757)	6.4 (177/2757)	..	..
	6532 (2002)	65.3	57.3%	11.4 (745/6532)	4.8 (315/6532)	..	..
	8731 (2003)	64.9	55.9%	10.4 (910/8731)	4.8 (417/8731)	..	..
	7492 (2004)	64.6	55.5%	10.2 (763/7492)	4.8 (359/7492)	..	..
	6594 (2005)	65.9	55.8%	11.0 (724/6594)	6.8 (451/6594)	..	..
	4491 (2006)	65.4	55.3%	6.7 (299/4491)	3.8 (170/4491)	..	..
	3650 (2007)	64.7	55.2%	7.3 (266/3650)	3.9 (142/3650)	..	..
(Kottner et al., 2010)	3574 (2008)	64.1	50.9%	6.4 (229/3574)	3.7 (133/3574)	..	..
(Lahmann et al., 2010)	2930 (2009)	66.6	52.1%	7.1 (208/2930)	3.7 (109/2930)	..	..
	6865(1/1) *	70.1	55.7%	23.1 (1586/6865)	11.0(756/6865)	13.2 (907/6865)	..
	7938(1/2) *	68.3	56.6%	24.2 (1921/7938)	11.6(921/7938)	13.5 (1072/7938)	..
	7579(2/2) *	67.5	67.8%	19.3 (1643/7579)	10.1 (766/7579)	9.9 (751/7579)	..
	1945(1/3) *	74.1	68.2%	35.7 (695/1945)	14.0 (273/1945)	26.3 (512/1945)	..
	1973(2/3) *	74.2	63.0%	28.2 (557/1973)	11.5 (227/1973)	17.4 (344/1973)	..
	1802(3/3) *	73.1	59.1%	18.5 (334/1802)	8.7 (157/1802)	11.3 (204/1802)	..
(Mehta et al., 2015)	358	19->89	30.4%	7.8 (28/358)	6.7 (24/358)	..	..
(Rondinelli et al., 2018)	453050	65.4	..	..	..	..	..
(Shahin et al., 2010)	4067	65.2	55.2%	7.1 (290/4067)	..	..	..
(Sj et al., 2013)	388 (2009)	..	..	11.6 (45/388)	..	8.2 (32/388)	..
	349 (2010)	..	..	6.0 (21/349)	..	3.4 (12/349)	..
	401 (2011i)	..	..	12.0 (48/401)	..	9.5 (38/401)	..
	408 (2011ii)	..	..	9.3 (38/408)	..	7.4 (30/408)	..
	327 (2012)	..	..	6.4 (21/327)	..	4.0 (13/327)	..
(Stausberg et al., 2010)	49904 (2003/2004)	48.7	..	..	..	..	280/49904 in 1-year (LOS:6.75 days)
	47424 (2004/2005)	48.9	..	..	..	..	195/47424 in 1-year (LOS: 6.96 days)
	46214 (2005/2006)	49.4	..	..	..	..	249/46214 in 1-year (LOS:7.05 days)
	43134 (2006/2007)	49.4	..	..	..	..	282/43134 in 1-year (LOS:7.23 days)
(Swanson et al., 2011)	326	60.4 (19-99)	49%	15.3 (50/326)	..	..	..
(Tannen et al., 2008)	8515 (Germany)	64.8	55.3%	9.0 (767/8515)	..	..	..
	10237 (Netherlands)	65.9	51.9%	18.1 (1853/10237)	..	..	..
(Tubaishat et al., 2011)	302	18->89	41.7%	11.9 (36/302)	6.6 (20/302)	..	..
(Tubaishat et al., 2011)	295	49.1 (18-87)	45.1%	16.3 (48/295)	8.8 (26/359)	..	..

Author, Year	Sample size, N (collection year/episodes)	Mean age (Range)	Female %	Prevalence % (n/n)		HAPI [†] rate %	Incidence
				All stages	Excluding Stage I		
(VanDenKerkhof et al., 2011)	1019 (1994)	≥16	51.9%	14.8 (151/1019)	10.0 (102/1019)	13.2 (134/1019)	..
	678 (1995)	≥16	49.9%	13.9 (94/678)	11.8 (80/678)	10.8 (73/678)	..
	581 (1996)	≥18	50.8%	13.8 (80/581)	12.2 (71/581)	12.2 (71/581)	..
	493 (1997)	≥20	42.0%	13.6 (67/493)	10.3 (51/493)	11.4 (56/493)	..
	898 (1998)	≥16	49.8%	17.0 (153/898)	13.1 (118/898)	13.6 (121/898)	..
	826(1999)	≥16	54.0%	15.1 (125/826)	9.8 (81/826)	12.3 (102/826)	..
	1010 (2000)	≥16	50.8%	15.0 (152/1010)	9.4 (95/1010)	13.1 (132/1010)	..
	840 (2001)	≥16	51.7%	15.5 (130/840)	11.1 (93/840)	12.9 (108/840)	..
	961 (2002)	≥17	51.3%	16.2 (156/961)	11.1 (107/961)	13.7 (132/961)	..
	821 (2003)	≥16	54.2%	16.4 (135/821)	10.6 (87/821)	12.2 (107/821)	..
	882 (2004)	≥16	50.7%	15.2 (134/882)	9.1 (80/882)	12.6 (111/882)	..
	798 (2005)	≥17	53.0%	13.9 (111/798)	8.6 (69/798)	11.5 (92/798)	..
	987 (2006)	≥17	50.4%	14.0 (138/987)	7.9 (78/987)	11.7 (115/987)	..
	1012 (2007)	≥16	49.1%	12.8 (130/1012)	8.9 (90/1012)	10.6 (107/1012)	..
	1079 (2008)	≥16	47.2%	13.7 (148/1079)	9.0 (97/1079)	11.9 (128/1079)	..
(Vanderwee et al., 2011)	19968	19->89	55.6%	12.1 (2419/19968)	6.9 (1396/19968)	..	..
(Vangilder et al., 2008)	55885(2003)	63.7-64.2	46.2%-47.6%	15.4 (8615/55885)	10.0 (5589/55885)	6.9 (3872/55885)	..
	76291(2004)	63.7-64.2	46.2%-47.6%	15.3 (11672/76291)	10.0 (7629/76291)	7.7 (5912/76291)	..
	74401(2005)	63.7-64.2	46.2%-47.6%	14.6 (10857/74401)	9.4 (6994/74401)	7.3 (5395/74401)	..
(VanGilder et al., 2017)	76199 (2006)	64.9	52.9%	13.3 (10148/76199)	8.9 (6805)	6.4 (4886)	..
	72490 (2007)	64.8	53.0%	13.4 (9724/72490)	9.1 (6606)	6.4 (4634)	..
	83914 (2008)	64.8	53.7%	13.1 (10993/83914)	9.2 (7720)	6.0 (5035)	..
	87004 (2009)	64.4	53.6%	11.9 (10355/87004)	8.6 (7524)	5.0 (4362)	..
	92375 (2010)	64.3	53.6%	11.2 (10346/92375)	8.2 (7575)	4.6 (4249)	..
	91678 (2011)	64.1	52.8%	10.4 (9535/91678)	7.8 (7151)	4.2 (3850)	..
	90660 (2012)	64.1	52.9%	9.3 (8463/90660)	7.1 (6416)	3.6 (3253)	..
	83030 (2013)	64.1	52.6%	9.1 (7556/83030)	7.1 (5895)	3.2 (2657)	..
	84127 (2014)	63.8	51.6%	9.3 (7824/84127)	7.3 (6141)	3.3 (2776)	..
	85822 (2015)	64.4	51.6%	8.8 (7585/85822)	7.0 (6050)	2.9 (2511)	..
(Wann-Hansson et al., 2008)	535	71.2	55%	26.9 (144/535)	..	13.2 (71/535)	..
(Zhou et al., 2018)	25264	54.6	46.3%	1.1 (267/25264)	..	0.2 (39/25264)	..

* The data were collected from different episodes. For example, (1/2) means they collected twice in the same hospital and this layer is the first-time results. (2/3) means they collected three times in the same hospitals, and this is the second-time results.

† HAPI: Hospital-acquired pressure injuries

‡ LOS: Length of stay

Table 3 Summary of meta-analysis results

Items	Study (n)	Layer (n)	Patients (n)	Pooled estimates*	95% CI	I^2 (%)	P
PIs prevalence							
Overall	35	81	1,366,848	12.8%	11.8-13.9%	99.7	<0.01
Excluding Stage I	20	60	1,284,568	8.0%	7.4-8.6%	99.3	<0.01
Low risk of bias studies	15	19	149,775	13.3%	9.7-17.4%	99.8	<0.01
Region subgroups (PI prevalence)							
Europe	16	32	211,392	14.5%	12.6-16.5%	99.4	<0.01
North America	7	32	1,070,868	13.6%	12.6-14.5%	99.5	<0.01
Asia	5	5	79,882	3.0 %	2.0-4.1%	98.0	<0.01
Middle East	4	4	1,833	12.6% [†]	11.1-14.1%	43.3	0.15
South America	2	3	1,010	12.7%	9.1-16.8%	70.5	0.03
Australia	1	5	1,873	9.0%	6.7-11.5%	71.3	<0.01
PIs incidence rate	4	8	681,885	5.4/10,000 patient-days	3.4-7.8/10,000 patient-days	98.9	<0.01
Region subgroup (PI incidence rate)							
Europe	1	4	186,685	7.6/10,000 patient-days	6.4-9.1/10,000 patient-days	87.5	<0.01
North America	3	4	495,200	3.0/10,000 patient-days	0.8-6.4/10,000 patient-days	99.3	<0.01
HAPI rate							
Overall	15	49	1,893,593	8.4%	7.6-9.3%	99.5	<0.01
Excluding Stage I	8	38	1,137,828	5.1%	4.6-5.6%	99.3	<0.01
Low risk of bias studies	6	6	754,186	8.4%	4.9-12.7%	99.8	<0.01
Region subgroup-(HAPI rate)							
Europe	5	10	31,710	14.4%	11.9-17.0%	97.3	<0.01
North America	5	30	1,780,486	8.3%	7.5-9.2%	99.7	<0.01
Asia	4	4	79,524	1.1%	0.5-1.9%	98.8	<0.01
Australia	1	5	1,873	6.3%	4.2-8.9%	77.6	<0.01

*Random effect model ($I^2 > 50\%$, $P < 0.05$);† Fixed effect model ($I^2 < 50\%$, $P > 0.05$)

Abbreviations:

PI: Pressure injury;

HAPI: Hospital-acquired pressure injury;

CI: Confidence interval

Table 4 Summary of meta-analysis of PI and HAPI stages proportion

Items	Study (n)	Layerr (n)	PI stage (n) / Patients with PI (n)	Pooled estimates*	95% CI	I^2	P
PI stages							
Stage I	16	19	5201/12,041	43.0%	42.1-43.9%	96.7%	<0.01
Stage II	16	19	3503/12,041	28.0%	24.7-31.5%	91.9%	<0.01
Stage III	15	18	1614/11,989	12.8%	10.9-14.9%	85.5%	<0.01
Stage IV	15	18	1540/11,989	9.9%	7.5-12.5%	93.1%	<0.01
Deep Tissue Injury	4	4	30/1,319	2.4%	0.9-4.5%	62.5%	0.05
Unstageable	4	4	107/1,319	7.7% [†]	6.3-9.2%	13.3%	0.33
HAPI stages							
Stage I	3	3	260/485	53.6% [†]	49.2-58.1%	47.8%	0.15
Stage II	3	3	145/485	29.0%	19.2-40.0%	83.6%	<0.01
Stage III	3	3	38/485	8.4%	3.5-15.0%	79.2%	<0.01
Stage IV	3	3	20/485	3.3%	1.1-6.6%	60.2%	0.08
Deep Tissue Injury	1	1	5/251	2.0%	0.6-4.2%	..	..
Unstageable	1	1	10/251	4.0%	1.9-6.8%	..	..

*Random effect model ($I^2 > 50\%$, $P < 0.05$) [†] Fixed effect model ($I^2 < 50\%$, $P > 0.05$)

Abbreviations: PI: Pressure injury; HAPI: Hospital-acquired pressure injury; CI: Confidence interval.

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Figure(s)

Figure 1: Flowchart of study selection

Notes: *1 study reported both prevalence and incidence of pressure injury
 †14 studies reported both prevalence of pressure injury and rate of hospital-acquired pressure injury
 ‡1 study reported only rate of hospital-acquired pressure injury