International Journal of Nursing Studies 89 (2019) 46–52

Contents lists available at ScienceDirect

International Journal of Nursing Studies

journal homepage: www.elsevier.com/locate/ijns

Predictors of superficial and severe hospital-acquired pressure injuries: A cross-sectional study using the International Pressure Ulcer Prevalence™ survey

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ARTICLE INFO

Keywords:
Hospital-acquired pressure injury
Severe pressure injury
Superficial pressure injury
Risk factors

ABSTRACT

Background: Prevalence of hospital-acquired pressure injuries has declined over time. However, it is unknown if this decline is consistent for different stages of pressure injuries. It is also unknown if risk factors differ between superficial (stage 1 and 2) and severe (stage 3, 4, deep tissue, and unstageable) pressure injuries.
Objective: To examine changes in prevalence of superficial and severe hospital-acquired pressure injuries from 2011 to 2016. To evaluate differences between risk factors associated with superficial versus severe hospital-acquired pressure injuries.
Design: Retrospective analysis of the 2011–2016 International Pressure Ulcer Prevalence™ data.
Setting: Acute care hospitals in the USA.
Participants: 216,626 patients had complete data.
Methods: Prevalence of all, superficial, and severe hospital-acquired pressure injuries was calculated annually from 2011 to 2016 and linear trendlines were generated. Two logistic regressions examined risk factors for superficial and severe hospital-acquired pressure injuries.
Results: Prevalence of superficial hospital-acquired pressure injuries declined significantly from 2011 to 2016. However, prevalence of severe pressure injuries did not show a reduction. Risk factors that significantly increased the risk of both superficial and severe pressure injuries were: increased age, male gender, unable to self-ambulate, all types of incontinence, additional linen layers, longer lengths of stay, and being in an intensive care unit. Body mass index (BMI) had a U-shaped relationship, where the likelihood of having either type of pressure injury was highest for low and high BMIs.
Conclusions: A decline in superficial, but not severe, hospital-acquired pressure injuries suggests current prevention techniques might not adequately prevent severe pressure injuries. Generally, risk factors for superficial and severe pressure injuries were highly similar where all 14 of the risk factors were significant in both regression models. However, five risk factors in particular – ICU stay, presence of an ostomy, patient age, ambulatory status, and presence of a fecal management system – had substantially different effect sizes.

What is already known about the topic?

- Overall prevalence of hospital-acquired pressure injuries has declined over time.
- Over 200 risk factors for pressure injuries have been identified.

What this paper adds

- Prevalence of severe hospital-acquired pressure injuries did not decline significantly from 2011 to 2016.
- Four pressure injury risk factors – ICU stay, ostomies, ambulatory status, and fecal management systems – had a substantially larger impact on the likelihood of having severe hospital-acquired pressure injuries as compared to the impact on superficial pressure injuries.
- Additional linen layers increased the odds of both superficial and severe hospital-acquired pressure injuries.

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https://doi.org/10.1016/j.ijnurstu.2018.09.003
Received 14 February 2018; Received in revised form 9 August 2018; Accepted 4 September 2018
0020-7489/

1. Introduction

Pressure injuries are caused by pressure, or pressure in combination with shear (Brienza et al., 2015; National Pressure Ulcer Advisory Panel, 2016). Pressure injuries that develop during a patient's stay in a facility, or hospital-acquired pressure injuries, are associated with poorer health outcomes, diminished quality of life, and high costs of healthcare (Lyder et al., 2012). As the severity of the injury increases, the impact on the patient and the cost increases as well (Graves et al., 2005).

Risk factors such as immobility, skin quality, and advanced age are patient characteristics that increase their susceptibility to causal factors (Coleman et al., 2014; Defloor, 1999). These risk factors are used to assess whether a patient needs pressure injury prevention interventions. However, little is known about whether risk factors differ for superficial (stages 1 and 2) versus severe (stages 3, 4, deep tissue, and unstageable) pressure injuries (Demarre et al., 2015). The aim of the current study was to evaluate differences between superficial and severe hospital-acquired pressure injuries using a large cross-sectional sample. The following research questions were addressed:

1 What is the prevalence of superficial and severe hospital-acquired pressure injuries and how have they changed from 2011 to 2016?
2 What differences exist between risk factors associated with having superficial versus severe hospital-acquired pressure injuries?

2. Background

Prevalence of hospital-acquired pressure injuries has declined over time in the USA (He et al., 2013; VanGilder et al., 2017). Severe hospital-acquired pressure injuries declined in 2008 after the Centers for Medicare and Medicaid Services (CMS) ruling regarding nonpayment for severe hospital-acquired pressure injuries (Padula et al., 2015a,b). Those reductions were sustained after the initial decline in 2008 and prevalence remained steady from 2009 to 2012. The decline was thought to be due to increased prevention campaigns and availability of wound nursing specialists as a result of the CMS ruling (Padula et al., 2015a,b).

2.1. Superficial versus severe pressure injuries

In a review of 54 studies examining risk factors of pressure injuries using multivariate regressions, as many as 200 significant risk factors were identified (Coleman et al., 2013). Three risk factors that directly impact the patient's likelihood of developing a pressure injury are: mobility, poor tissue perfusion, and skin status (Coleman et al., 2014). Following the framework laid out by Coleman et al. (2014), indirect risk factors increase a patient's susceptibility to those direct factors. Examples of indirect risk factors studied include: incontinence, age, nutrition, diabetes, and vasopressor therapy (Bergstrom et al., 1987; Cox and Roche, 2015; Lachenbruch et al., 2016).

The complex findings regarding risk factors might be because there are two distinct types of pressure injuries: superficial and severe (Berlowitz and Brienza, 2007; Bouten et al., 2003). Superficial pressure injuries are primarily associated with abrasion, maceration and sloughing, and delamination of the skin layers. They are believed to be primarily caused by shear stresses within the skin and sustained exposure to moisture (Doughty et al., 2006; Ersser et al., 2005). Severe pressure injuries arise in the muscle layers directly adjacent to the bony prominences and are thought to be caused by sustained compression and deformation of deep tissue (Bouten et al., 2003; Oomens et al., 2015).

Differences in the etiology of the two types of pressure injuries can be detected using Braden sub-scores. Lahmann and Kottner (2011) found a strong relationship between "friction and shear" sub-scores and superficial pressure injuries (stage 2). Yet, they found a strong relationship between the "completely immobile" sub-score (a proxy for sustained pressure) and severe pressure injuries (stages 3 and 4). Due to the possible differences in etiology, Demarre et al. (2015) suggested that different risk factors likely exist for each type of pressure injury. They examined risk factors for superficial (stage 2) and severe (stages 3 and 4) hospital-acquired pressure injuries. Only presence of non-blanchable erythema was a significant risk factor for both types of pressure injury. However, the study only included 11 severe pressure injuries, so the analysis was subject to large confidence intervals.

The etiologies for superficial and severe pressure injuries must share some commonalities because pressure is the major causal factor for both (National Pressure Ulcer Advisory Panel, 2014). However, the extent to which indirect risk factors influence a patient's susceptibility to superficial and severe pressure injuries is unknown. Identification of differences in risk factors for the two injury types is critical to expand pressure injury prevention efforts. The current study is the first effort using a large database of both superficial and severe hospital-acquired pressure injuries to identify differences in the risk factors.

3. Methods

3.1. Data source

A secondary analysis from six years of pressure injury prevalence surveys was conducted using the International Pressure Ulcer Prevalence™ (IPUP) Survey. Methods and earlier results have been described previously (VanGilder et al., 2009a,b; VanGilder et al., 2010). Briefly, IPUP is voluntary and open to all facility types, allowing benchmarking of pressure injury prevalence. Each participating facility designates a survey coordinator who facilitates patient skin assessments. Data are collected over a 24-h period. The survey is always offered in February for consistency across years and facilities. Participants can choose a 24-h period in which to complete the survey from three allowable days.

Surveys from 2011 to 2016 were included in the present study because they collected similar data fields. The following fields regarding risk factors were collected: age, weight, height, length of stay, unit, number of linen layers on the bed, support surface, incontinence status, incontinence management systems in use, ambulatory status, and Braden score. The following characteristics of the pressure injury were collected: anatomical location, stage, if it was present on admission, and whether it was device related. Patients were included in the analyses if they were 18 years or older, were hospitalized in US acute care facilities, and had completed survey data for all variables used in the analyses. This study was reviewed by the Schulman International Review Board (IRB) (reference # 201606306) and found to be exempt.

3.2. Variables

The outcome variables studied were whether a patient had a superficial or severe hospital-acquired pressure injury. Stage was captured as: 1–4, deep tissue, unstageable, or indeterminable. Indeterminable pressure injuries were excluded. Stage 1 and 2 pressure injuries were defined as superficial. Stages 3, 4, deep tissue, and unstageable were defined as severe. Hospital-acquired was defined as not being present on admission.

Pressure injury risk factors included in the model were: age, gender, body mass index (BMI), ambulatory status, incontinence status, number of linen layers, length of stay, and whether the patient was in an ICU. Age was capped at 90 years due to protected health information requirements. BMI was calculated as kilograms divided by the square of height in meters (kg/m^2). Only patients with acceptable BMIs between the 0.5th percentile and the 99.5th percentile were included to minimize the effect of outliers. Incontinence was included as: urine only, fecal only, and urine and fecal. Use of incontinence management devices included: Foley catheters, ostomies, and fecal management systems. The surveys asked if patients could “Self-Ambulate,” yes or no. The number of linen layers were captured as 1–5, where 5 represented five or more layers. Length of stay had several extreme values and was top-coded at the 99th percentile to prevent undue influence of outliers.

Three variables that were not risk factors were included as controls. An annual trend controlled for whether the odds of having a pressure injury changed over time. The number of patients surveyed approximately controlled for the size of the hospital. Finally, a binary variable captured whether the patient was in a teaching facility.

A few variables were excluded from the analysis as they assessed duplicate information and including them would create collinearity concerns. Braden score was excluded because it is a composite score that implicitly accounts for incontinence status in the “moisture” category and for whether a patient can self-ambulate in the “mobility” category (Bergstrom et al., 1987). Support surface was excluded for reverse causality concerns, because patients could develop a pressure injury on a different surface than the one they were on at the time of the survey. Finally, IPUP captures over a dozen unique units, but only the effect of being in an ICU was included, because it is associated with other risk factors (Cox and Roche, 2015).

3.3. Analysis of prevalence over time by severity

Prevalence of all, superficial, and severe hospital-acquired pressure injuries were calculated annually from 2011 to 2016. Linear trendlines were calculated for each category using three linear regressions, where years 2011–2016 were coded as 0–6. Trendlines show how prevalence has changed without adjusting for other factors. Patients with both types of pressure injury were included in each trendline.

3.4. Analysis of risk factors

Two logistic regressions analyzed risk factors of superficial and severe hospital-acquired pressure injuries. In both models, patients with a hospital-acquired pressure injury were compared to patients without a hospital-acquired pressure injury of any stage. Patients with both types of hospital-acquired pressure injury were included in both models.

The parameter estimates were interpreted as estimated odds ratios (OR), which are shown with corresponding 95% confidence intervals (CIs) and p-values (P). To determine differences in effect sizes, we examined relative differences in odds ratios. BMI was included in the model as both a linear and a quadratic term to capture a curvilinear relationship (Kottner et al., 2011; VanGilder et al., 2009a,b). A negative and significant effect on the linear term followed by a positive and significant effect on the quadratic term indicates a U-shaped relationship (Aiken et al., 1991). The curvilinear relationship was graphed by predicting the probability of having each type of pressure injury for values of BMI with 95% confidence intervals (Osborne, 2014). Continuous variables were scaled such that units represented feasible amounts in clinical settings. Scaling impacts the magnitude of the effect size to aid interpretation of the results, but it does not impact p-values. It also does not impact the relative differences in odds ratios. Age was converted to 10-year increments, BMI to 5-units, length of stay to 5-days, and number of patients surveyed to 50-patients. C-statistics were run to assess the goodness of fit for both models. Variance Inflation Factors (VIF) were calculated for all variables to determine whether multicollinearity was a concern in either model. VIF values less than 10 indicate that multicollinearity is not a concern (O’Brien, 2007). All calculations were performed using Stata 14.2 software (StataCorp, 2015).

4. Results

4.1. Baseline characteristics

The 2011–2016 surveys included 636,695 patients captured from 1650 individual facilities. These facilities participated on average 4 of the 6 years for a total of 6006 individual facility surveys. This study limited the data to adults, in US acute care settings, that had complete records for all variables listed in Table 1. The final sample size was 216,626 patients, from 1046 different hospitals, for a total of 3191 individual hospital surveys. 19,893 patients had a pressure injury (9.2%). 7335 patients had a hospital-acquired pressure injury (3.4%). 5634 had a superficial hospital-acquired pressure injury (2.6%). 2217 had a severe hospital-acquired pressure injury (1.0%). 516 had both types of pressure injury.

Summary statistics are reported in Table 2.

Table 1
Description of the sample, where the final sample was comprised of adults in US acute care settings with complete records.

Description	
Patients in sample	216,626
Patients in sample with pressure injury	19,893
Pressure injury prevalence	9.2%
Patients in sample with hospital-acquired pressure injury	7335
Hospital-acquired pressure injury prevalence	3.4%
Patients in sample with a superficial hospital-acquired pressure injury	5634
Superficial hospital-acquired pressure injury prevalence	2.6%
Patients in sample with a severe hospital-acquired pressure injury	2217
Severe hospital-acquired pressure injury prevalence	1.0%

4.2. Prevalence trendlines

Fig. 1 shows unadjusted prevalence for all, superficial, and severe hospital-acquired pressure injuries from 2011 to 2016 with corresponding trendlines. The prevalence of all hospital-acquired pressure injuries decreased significantly from 4.39% in 2011 to 3.06% in 2016 with a linear trendline of y = 4.00% − 0.20% year ($P < 0.05$). The prevalence of superficial hospital-acquired pressure injuries decreased significantly from 3.57% to 2.23% with a linear trendline of y = 3.30% − 0.30% year ($P < 0.05$). The severe prevalence trend did not decline significantly from 1.10% to 1.03% with a linear trendline of y = 1.00% + 0.02% year ($P = 0.52$).

Table 2
Summary statistics for all patients, patients with a superficial hospital-acquired pressure injury, and patients with a severe hospital-acquired pressure injury. 516 patients had both types of pressure injury. Means and standard deviations (SD) are presented for continuous variables.

Variables	Entire sample		Superficial		Severe	
	(n = 216,626)		(n = 5,634)		(n = 2,217)	
Patient characteristics						
Age in years (mean, sd)	64	17	71	15	67	16
Male sex (%)	48%		54%		59%	
BMI (mean, sd)	30	8.8	28	8.7	29	9.6
Not ambulatory (%)	56%		88%		94%	
Incontinence status						
Continent (%)	66%		28%		17%	
Urine, no fecal (%)	4.9%		7.0%		4.4%	
Fecal, no urine (%)	6.5%		22%		29%	
Urine and Fecal (%)	6.1%		13%		12%	
Fecal mgmt. system (%)	0.9%		4.3%		8.1%	
Foley catheter (%)	21%		47%		59%	
Ostomy (%)	1.4%		2.8%		5.5%	
Hospital environment						
Layers of linen (mean, sd)	2.3	0.88	2.6	0.97	2.6	0.99
Length of stay (mean, sd)	6.3	10	14	15	21	20
ICU (%)	13%		24%		37%	
Hospital characteristics						
Surveyed patients (mean, sd)	205	149	200	154	228	170
Teaching hospital (%)	18%		16%		24%	

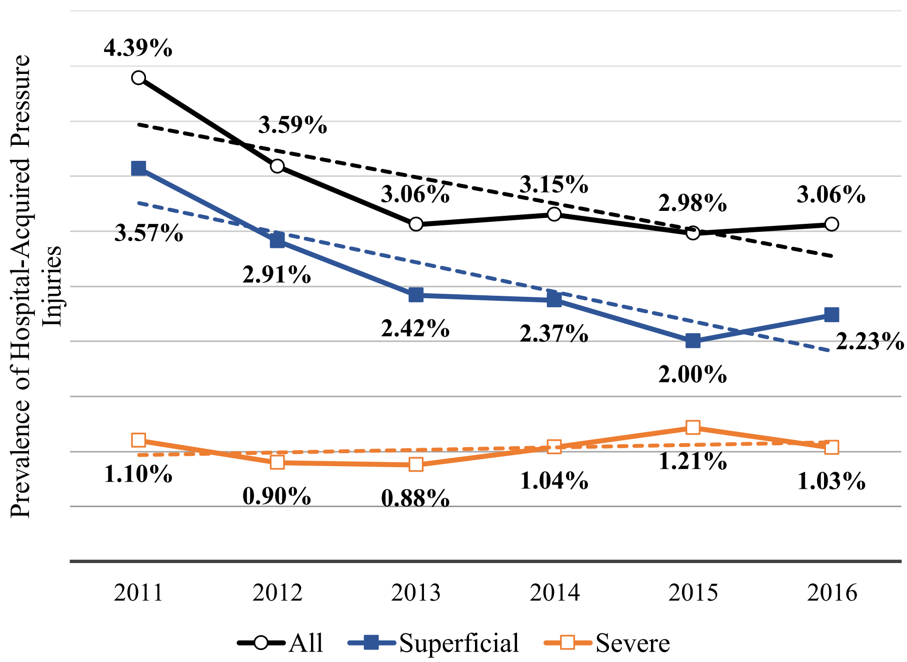

Fig. 1. Prevalence by year for all, superficial, and severe hospital-acquired pressure injuries from 2011 to 2016 with linear trendlines.

4.3. Risk factors

Results of the two regressions are reported in Table 3. C-statistics were 0.81 and 0.88, which indicated a good fit for both models (Hosmer and Lemeshow, 2000). VIFs for all variables were less than 2.00; thus, multicollinearity was not a concern.

4.3.1. Trend

Each year the adjusted odds of having a superficial hospital-acquired pressure injury decreased by 12% (OR: 0.88, P < 0.001). The odds of having a severe pressure injury did not decrease significantly (OR: 0.99, P = 0.26).

4.3.2. Patient characteristics

Every additional 10 years of age increased the likelihood of having a superficial (OR: 1.19, P < 0.001) and severe (OR: 1.08, P < 0.001) pressure injury. The effect size was 2.36 times larger for superficial pressure injuries than for severe pressure injuries. Males were more likely to have superficial (OR: 1.29, P < 0.001) and severe (OR: 1.38, P < 0.001) pressure injuries. The effect size was 1.30 times larger for

Table 3
Likelihood of having a superficial or severe hospital-acquired pressure injury, relative to not having a hospital-acquired pressure injury. OR = odds ratios; 95% CI = 95% confidence interval; P = p-value. Sample size in Model 1 was 214,891 patients and 211,508 in Model 2.

Variables	(1) Superficial			(2) Severe		
	Adjusted OR	95% CI	P	Adjusted OR	95% CI	P
Baseline odds	0.008	0.008–0.009	< 0.001	0.001	0.0007– 0.0011	< 0.001
Annual trend	0.875	0.862–0.889	< 0.001	0.986	0.962–1.010	0.255
Patient characteristics						
Age (10-years)	1.191	1.168–1.215	< 0.001	1.081	1.050–1.114	< 0.001
Male sex	1.289	1.219–1.364	< 0.001	1.375	1.255–1.506	< 0.001
BMI (5-units)	0.902	0.884–0.920	< 0.001	0.939	0.910–0.969	< 0.001
BMI^2 (5-units)	1.017	1.013–1.021	< 0.001	1.016	1.009–1.022	< 0.001
Not ambulatory	2.821	2.573–3.092	< 0.001	4.533	3.726–5.515	< 0.001
Incontinence status						
Urine only	1.625	1.445–1.828	< 0.001	1.406	1.120–1.765	0.003
Fecal only	1.881	1.732–2.042	< 0.001	2.373	2.101–2.680	< 0.001
Dual	2.001	1.815–2.206	< 0.001	2.294	1.948–2.702	< 0.001
Fecal mgmt. system	2.643	2.263–3.087	< 0.001	3.734	3.084–4.522	< 0.001
Foley catheter	1.883	1.744–2.034	< 0.001	2.317	2.038–2.633	< 0.001
Ostomy	1.583	1.329–1.885	< 0.001	2.697	2.193–3.317	< 0.001
Hospital environment						
Layers of linens	1.213	1.178–1.249	< 0.001	1.225	1.171–1.282	< 0.001
Length of stay (5-days)	1.205	1.196–1.214	< 0.001	1.259	1.247–1.271	< 0.001
ICU	1.200	1.117–1.290	< 0.001	1.826	1.642–2.029	< 0.001
Hospital characteristics						
Surveyed patients (50 patients)	0.982	0.972–0.993	0.001	1.012	0.996–1.027	0.081
Teaching hospital	0.708	0.652–0.769	< 0.001	0.944	0.841–1.059	0.420

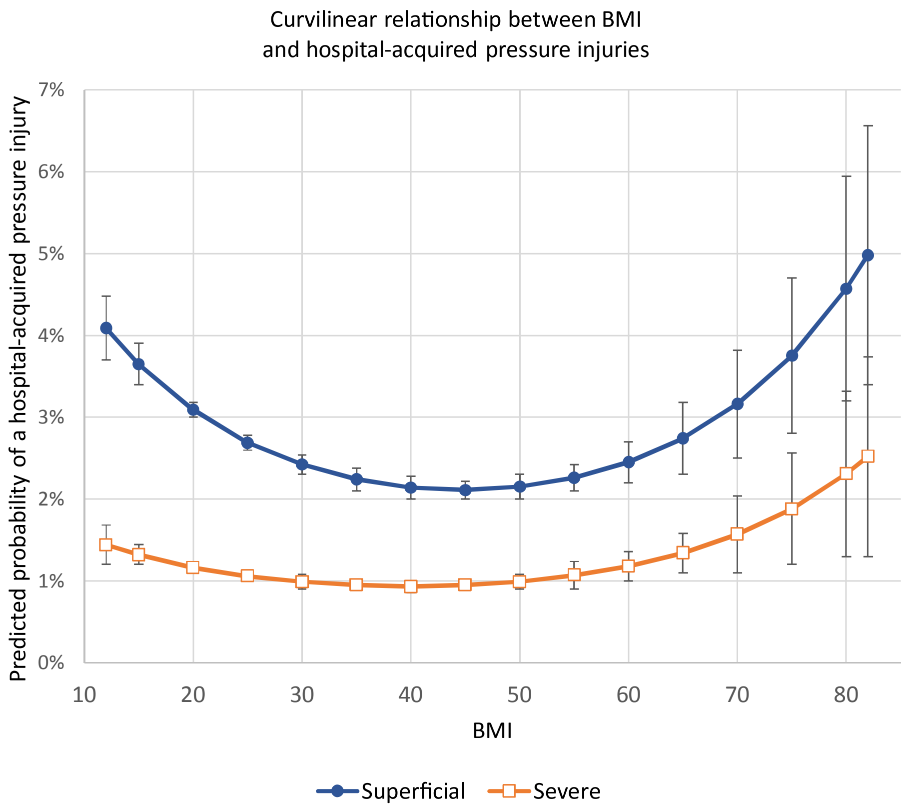

Fig. 2. Curvilinear relationship between BMI and the predicted probability of having a hospital-acquired pressure injury.

severe pressure injuries. Patients unable to self-ambulate were more likely to have superficial (OR: 2.82, $P < 0.001$) and severe (OR: 4.53, $P < 0.001$) pressure injuries. The effect size was 1.94 times larger for severe pressure injuries.

The significant negative effect of the BMI linear term (superficial OR: 0.90, $P < 0.001$; severe OR: 0.94, $P < 0.001$) and the significant positive effect of the quadradic term (superficial OR: 1.02, $P < 0.001$; severe OR: 1.02, $P < 0.001$) revealed a U-shaped relationship between BMI and the likelihood of having either type of pressure injury (Fig. 2). BMIs of 45 and 40 minimized the probability of having superficial and severe pressure injuries. A BMI of 40 corresponded to an 89th percentile patient and a BMI of 45 corresponded to a 95th percentile patient. For additional context, a patient that is 180 cm (5 feet 10 in.) and 145 kg (320 pounds) has a BMI of 45.

4.3.3. Incontinence status

Odds ratios for the various types of incontinence ranged from 1.58 to 2.64 for superficial pressure injuries ($P < 0.001$). Odds ratios ranged from 1.41 to 3.73 severe pressure injuries ($P < 0.001$). Ostomies had the largest relative difference between effect sizes on superficial and severe injuries. Patients with ostomies were 58% and 170% more likely to have superficial and severe injuries ($P < 0.001$); therefore, the effect size was 2.91 times larger for severe injuries.

4.3.4. Hospital environment

Each layer of linen increased the likelihood of either type of pressure injury by approximately 20% ($P < 0.001$). The effect size was only 1.06 times larger for severe pressure injuries. Longer lengths of stay increased the likelihood of having superficial (OR: 1.21, $P < 0.001$) and severe (OR: 1.26, $P < 0.001$) pressure injuries. The effect of length of stay was 1.26 times larger for severe injuries. Patients in ICUs were more likely to have superficial (OR: 1.20, $P < 0.001$) and severe (OR: 1.83, $P < 0.001$) pressure injuries. The effect of being in an ICU was 4.13 times larger for severe pressure injuries.

5. Discussion

This study investigated the prevalence of superficial and severe hospital-acquired pressure injuries from 2011 to 2016. Two logistic regressions were used to model risk factors of each type of pressure injury and differences were examined. One main finding of this study is that prevalence of superficial hospital-acquired pressure injuries decreased from 2011 to 2016, but severe hospital-acquired pressure injuries did not. This finding held true for the unadjusted annual prevalence numbers (Fig. 1) and in the results of the logistic regressions (Table 3). This is consistent with Padula et al. (2015a,b), who found that prevalence of severe hospital-acquired pressure injuries remained steady from 2009 to 2012 after a sharp decline in 2008 following the CMS non-payment ruling. The lack of decline suggests current prevention efforts might not be addressing the etiology of severe pressure injuries. The six risk factors with the largest impact on severe pressure injuries were (in order): ambulatory status, having a fecal management system, having an ostomy, presence of fecal only incontinence, presence of a Foley catheter, and presence of a combination of fecal and urinary incontinence. Thus, future prevention efforts aimed at preventing severe pressure injuries should include mobilization and incontinence management.

Another main finding was that risk factors for superficial and severe injuries were highly similar. All 14 of the risk factors studied were associated with both types of injury. However, the effect sizes of certain risk factors varied substantially. The five risk factors with the largest relative differences (from largest to smallest) were: ICU stay, having an ostomy, patient age, ambulatory status, and having a fecal management system.

Patients in the ICU were more likely to have either type of pressure injury. However, the effect on severe pressure injuries was approximately four times larger than the effect on superficial pressure injuries. Being in an ICU is not a direct risk factor. Rather, ICU stays are correlated with indirect factors such as vasopressor therapy and diminished sensory perception (Coleman et al., 2014; Cox and Roche, 2015). Moreover, our measure for ambulatory status is a course approximation for mobility. Patients in ICUs are less likely to be able to turn themselves in bed or make small weight shifts. Thus, it is possible that ICU stay captured the more nuanced effects of reduced mobility. Future work is needed to examine the impact of these factors individually for superficial and severe pressure injuries. ICU stay is an easily observable measure that can alert caregivers that the patient is at an increased risk of pressure injuries, especially severe pressure injuries.

Patients with ostomies were more likely to have either type of pressure injury, but the effect on severe pressure injuries was nearly three times larger than the effect on superficial pressure injuries. One possibility for the large difference is that patients with ostomies are more likely to have other comorbidities, such as cancer and Crohn's disease. This would impact their ability to heal and therefore increase their risk of developing a severe pressure injury. Second, patients with ostomies, especially those with ileostomies, often struggle with nutrient absorption, which is a key risk factor (Bergstrom et al., 1987).

Increased patient age was associated with a greater likelihood of having either type of pressure injury, but the effect on superficial pressure injuries was more than twice as large as the effect on severe pressure injuries. Increased age is associated with drier, thinner, more fragile skin that is less capable of acting as a moisture barrier (Farage et al., 2007; Waller and Maibach, 2005; Zulkowski, 2003). These factors leave patients particularly susceptible to shear and friction forces rubbing against the skin (Sopher and Gefen, 2011), which are primarily responsible for superficial pressure injuries (Doughty et al., 2006; Ersser et al., 2005; Salcido et al., 2007). Moreover, incontinence-associated dermatitis is often incorrectly classified as superficial pressure injuries (Beeckman et al., 2010). Because age is a known risk factor of incontinence-associated dermatitis (Junkin and Selekof, 2007), misclassifications could explain the larger impact on superficial pressure injuries.

Patients that could not self-ambulate were more likely to have either type of pressure injury, but the effect on severe injuries was nearly two times larger. This finding was consistent with research by Lahmann and Kottner (2011), which showed that being "completely immobile" had a stronger relationship with severe pressure injuries than it did with superficial pressure injuries. This emphasizes the need for mobility-related preventions, including attention to repositioning efforts and early mobilization, to prevent severe pressure injuries.

Patients with fecal management systems were more likely to have either type of pressure injury. However, the effect on severe pressure injuries was nearly two times larger than the effect on superficial pressure injuries. Fecal management systems often leak leaving patients at risk for skin irritation (Beitz, 2006; Junkin and Selekof, 2007). They also cause rubbing and irritation from either tubing or adhesives, which leaves the skin highly susceptible to further damage. Fecal management systems are also more likely to be prescribed to patients who have already developed severe pressure injuries and need feces diverted from the skin to allow for healing.

Finally, this was the first study to find that additional linens were associated with increased odds of having either type of pressure injury. Additional layers of linen can increase interface pressure between the patient and the support surface up to 64% and can reduce the surface's microclimate management performance (Williamson et al., 2013). This study found that an increase from one linen to six linens would roughly double a patient's risk of a pressure injury. The difference in effect sizes between superficial and severe pressure injuries was not substantial, indicating that minimizing linen utilization is important to consider for prevention of all pressure injuries.

Strong similarities exist between risk factors for superficial and severe hospital-acquired pressure injuries. However, the differences in effect sizes for certain risk factors point to the need to develop additional pressure injury prevention strategies that target patients in ICUs, patients with ostomies or fecal management systems, and those that cannot self-ambulate. These patients are at a particularly large risk of developing costly and life-threatening severe pressure injuries.

5.1. Limitations

This study had several limitations. There were limitations to using survey data. Survey coordinators sometimes left fields blank which created incomplete records and reduced the number of available records for analysis. The survey was a snapshot and it was not possible to track the same patient over time, which was needed to show causality.

Our measure of ambulatory status was course and did not reflect a mobility continuum. Future work is needed to determine the level of mobility required to mitigate the risk of pressure injuries. The sample's average length of stay was six days, which was higher than other reported numbers (Weiss and Elixhauser, 2006). Due to patient availability, short stay or same day discharge patients might have been missed by survey teams, which would yield a higher percentage of patients with longer stays. Because patients with longer stays are more likely to have hospital-acquired pressure injuries, this could inflate our prevalence numbers. Only six years of data were available to track how prevalence trended over time which was not adequate for examining non-linear relationships. Several important risk factors were omitted from the analysis (e.g. vasopressor therapy) because they were not collected in the survey. Identifying superficial pressure injuries from incontinence-associated dermatitis is challenging (Beeckman et al., 2010; Gray et al., 2007). If patients with incontinence-associated dermatitis were misclassified as having a superficial pressure injury, the impact of incontinence on superficial pressure injuries could be inflated.

Finally, the inclusion of factors in this study is based off previously studied risk factors that are collected in the survey. If factors exist that are predictive for one type of injury and not another, they might not be significantly associated with pressure injuries generally. This could cause those factors to go unnoticed in the literature. Thus, future exploratory work is needed to examine whether previously insignificant factors are a risk factor for one type, but not another.

5.2. Conclusions

Based on this large, multi-center study, results indicate that prevalence of superficial hospital-acquired pressure injuries decreased significantly from 2011 to 2016 in the USA. Prevalence of severe pressure injuries did not decrease significantly. This finding has implications for clinical practice, education, and research to ensure that prevention techniques target both superficial and severe pressure injuries. Results of the regressions suggest that superficial and severe pressure injuries share many similar risk factors. However, the magnitude of the effect sizes differed substantially for the following risk factors: ICU stay, whether the patient had an ostomy or a fecal management system, the patient's age, and ambulatory status. We recommend that future work examine risk factors of superficial and severe pressure injuries.

Author disclosures

Dr. Kayser, Dr. Lachenbruch, and Catherine VanGilder disclose that they are employees of Hill-Rom.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Funding

No funding was received.

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