

Pressure Injury Morbidity and Risk Factors in Elderly Sepsis Patients: A Retrospective Analysis of a Nationwide Inpatient Sample Database



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Abstract: *Objective:* This study evaluated the prevalence and risk factors associated with pressure injuries (PIs) among elderly sepsis patients by analyzing a comprehensive national inpatient dataset. *Methods:* A retrospective analysis was conducted using data from the National Inpatient Sample (NIS) database covering the years 2010 to 2019. Elderly patients aged 65 years and older with a diagnosis of sepsis and complete medical records were included. Patients were categorized into two groups based on the presence or absence of pressure injuries. Demographic variables, comorbidities, and complications were assessed using both univariate and multivariate logistic regression analyses to identify risk factors related to pressure injuries. *Results:* Our analysis identified 1,687,410 sepsis patients aged 65 and above, with 193,645 (10.3%) developing pressure injuries. The morbidity rate for pressure injuries exhibited a gradual decline from 12.7% in 2010 to 9.2% in 2019. Patients with sepsis who developed pressure injuries had significantly longer hospital stays, higher hospital costs, and increased in-hospital mortality (all $p < 0.001$). Among the comorbid conditions identified, diabetes, anemia, paralysis, neurological disorders, peripheral vascular disease, electrolyte imbalances, weight loss, and incontinence were associated with higher rates of pressure injuries. Patients with PIs were also more likely to experience complications such as deep vein thrombosis, septic shock, delirium, respiratory failure, and malnutrition. *Conclusion:* Despite significant global efforts aimed at reducing pressure injuries, the morbidity rate among elderly sepsis patients remains notably high at 9.2%. Therefore, it is essential to develop targeted, evidence-based interventions focused on the identified risk factors to effectively reduce the incidence of pressure injuries and improve patient outcomes.

Keywords: Elderly Patients; Sepsis; Pressure Injury; Risk Factors; Morbidity

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1 Introduction

Sepsis is a critical condition arising from an infection that triggers an overwhelming immune response, leading to widespread inflammation and substantial tissue and organ injury. This process adversely affects patient outcomes, including survival and prognosis [1]. In older adults, the

complex interplay of chronic illnesses, multiple comorbidities, compromised immune function, and frailty complicates the physiological response to sepsis, thereby increasing the likelihood of developing this condition [2]. Globally, an estimated 30-32% of sepsis cases occur in individuals aged 60 and older [3]. The ongoing trend of population

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aging, coupled with increased comorbidities and frailty, has heightened concerns regarding the risk of pressure injuries (PIs). Elderly patients with sepsis, particularly those hospitalized in intensive care units (ICUs), are at increased risk for developing PIs due to greater exposure to risk factors, while age-related physiological changes further enhance their susceptibility. Consequently, PIs have emerged as a serious complication in sepsis patients [4].

Pressure injuries are defined as localized tissue damage resulting from prolonged pressure, friction, or shear. These injuries most commonly occur over bony prominences, such as the sacrum, heels, and lateral malleoli, where sustained pressure or combined pressure and shear forces are most prevalent [5]. Key risk factors for PI development include prolonged immobility, hemodynamic instability, vasopressor use, malnutrition, altered mental status, and low serum albumin levels. Furthermore, comorbidities such as hypertension, obesity, and diabetes significantly increase the risk, particularly in patients with altered consciousness, those experiencing cardiac arrest, or individuals with multiple trauma [6, 7]. Research indicates that PI prevalence in intensive care units (ICUs) ranges from 5% to 30%, underscoring the ICU as a high-risk environment for PI development [8].

Despite considerable focus on the incidence and management of pressure injuries by healthcare professionals, our understanding of their epidemiology in elderly patients with sepsis remains limited [9]. There is a notable lack of comprehensive data on the risk factors and morbidity associated with PIs in this vulnerable population. Therefore, this study evaluated the morbidity of PIs and associated risk factors in elderly patients with sepsis through an in-depth analysis of extensive data. These findings are intended to equip healthcare providers with the necessary insights to conduct thorough risk assessments, implement effective preventive measures, and allocate medical resources prudently to reduce PI incidence.

2 Methods and Materials

2.1 Data Source and Design

This study used data from the National Inpatient Sample (NIS) database, part of the Healthcare Cost and Utilization Project (HCUP) managed by the Agency for Healthcare Research and Quality. The NIS provides a comprehensive

all-payer dataset that includes inpatient admissions across the United States of America, aggregating data from over 1,000 hospitals and representing approximately 20% of all annual inpatient visits nationwide. The extracted data for this study included patient demographics (age, smoking history, gender, and race/ethnicity), and hospital characteristics (insurance type, admission type, bed size, teaching status, geographic location, and region). Furthermore, the analysis encompassed metrics such as length of stay (LOS), information on PIs (anatomical location), occurrences of fecal and urinary incontinence, vasopressor use, mechanical ventilation, dialysis, and diagnoses and procedures coded using the International Classification of Diseases (ICD-9-CM and ICD-10-CM). Since this study utilized publicly available anonymized data, it did not require approval from an institutional review board.

2.2 Data Collection and Patient Characteristics

Data from 2010 to 2019 were obtained from the NIS database. The identification of patients with sepsis was achieved using primary procedures classified according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) (see Supplementary Material 1). The morbidity of PIs was determined using diagnostic codes from ICD-9-CM and ICD-10-CM. Patients younger than 65 years, those who died during hospitalization, and those with a length of stay of less than 24 hours were excluded (Figure 1).

In this study, patients were categorized into two groups based on the presence or absence of PIs. The analysis included patient demographics, hospital characteristics, and outcome measures, including LOS, smoking history, PI stage and location, fecal and urinary incontinence, vasopressor use, mechanical ventilation, and dialysis. Information on comorbidities and complications was extracted from the database using ICD-9-CM and ICD-10-CM diagnosis codes (Table 1). Sepsis-related complications included delirium, respiratory failure, septic shock, heart failure, cardiac arrest, acute renal failure, deep vein thrombosis (DVT), and malnutrition.

Table 1 Variables used in binary logistic regression analysis

Variables Categories	Specific Variables
Patient Demographics	Age (≥ 65 years), sex (male and female), race (White, Black, Hispanic, Asian or Pacific Islander, Native American and Other) stages of pressure injury, location of pressure injury, length of stay, smoking experience, fecal incontinence, urinary incontinence, vasopressor, mechanical ventilation, dialysis
Hospital characteristics	Type of admission (non-elective, elective), bed size of hospital (small, medium, large), teaching status of hospital (nonteaching, teaching), location of hospital (rural, urban), type of insurance (Medicare, Medicaid, private insurance, self-pay, no charge, other), location of the hospital (northeast, Midwest or north central, south, west)
Comorbidities	AIDS, deficiency anemia, rheumatoid diseases, chronic blood loss anemia, congestive heart failure, chronic pulmonary disease, coagulopathy, depression, diabetes (uncomplicated), diabetes (with chronic complications), drug abuse, hypertension, hypothyroidism, liver disease, lymphoma, fluid and electrolyte disorders, metastatic cancer, other neurological disorders, obesity, paralysis, peripheral vascular disorders, psychoses, pulmonary circulation disorders, renal failure, solid tumor without metastasis, valvular disease, weight loss
Complication	Septic shock, deep vein thrombosis, cardiac arrest, delirium, heart failure, acute renal failure, respiratory failure, malnutrition

AIDS: Acquired immunodeficiency syndrome

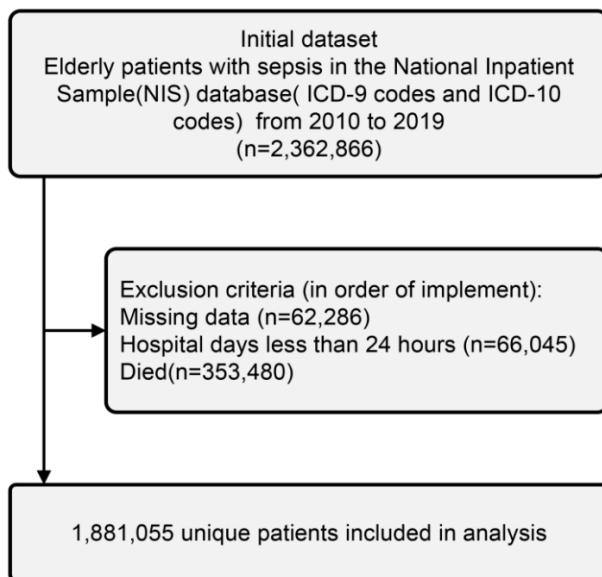


Figure 1 Flowchart of Inclusion and Exclusion Criteria

2.3 Data Analysis

Statistical analysis was performed using SPSS version 25.0. Continuous variables were assessed using independent samples t-tests, and categorical variables were compared using chi-square tests. Logistic regression analysis was conducted to determine potential risk factors associated with PIs. This model included all relevant variables from the NIS database, including patient demographics, hospital characteristics, comorbidities, and complications. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Given the large sample size, statistical significance was defined as $p < 0.001$.

3 Results

From 2010 to 2019, the NIS database identified 1,687,410 elderly patients with sepsis. Of these, 193,645 (10.3%) developed PIs during hospitalization. The annual PI morbidity rate demonstrated a decreasing trend over this period (Figure 2).

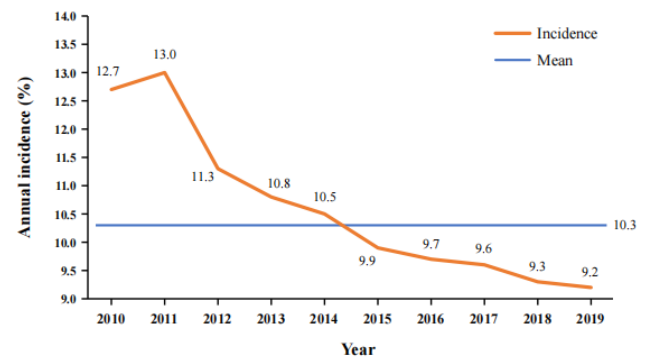


Figure 2 Annual incidence rate of pressure injuries

3.1 Patient Demographics and Hospital Characteristics

The mean age of patients was 78.4 years (range 65–113 years). The highest morbidity rate for PIs was observed in the 75- to 84-year age group. There was no significant difference in PI occurrence between genders ($p = 0.002$). Among patients with PIs, 14.1% had a history of smoking, 62.5% were Caucasian, and the mean length of stay was 11.7 days. The mean cost of hospitalization was \$106,399.90. Medicare was the primary payer, accounting

for 91.1% of cases. PIs predominantly occurred in large, urban hospitals. Older age was associated with a higher risk

of developing PIs (Table 2). Furthermore, PIs were associated with prolonged hospital stays and increased costs (Table 2).

Table 2 Characteristics and outcomes of elderly sepsis patients (2010-2019)

Characteristics	No pressure injury	Pressure injury	<i>p</i>
Total (n=count)	1,687,410	193,645	
Total incidence (%)	10.3		
Age group (%)			
65-74	40.1	35.7	<0.001
75-84	35.9	36.4	
≥85	24.1	27.9	
Gender (%)			
Female	50.7	51.1	0.002
Race (%)			
White	73.3	62.5	<0.001
Black	9.3	20.0	
Hispanic	7.4	8.0	
Asian or Pacific Islander	3.0	2.8	
Native American	0.5	0.4	
Other	6.6	6.3	
Location of pressure injury (%)			
Back	/	36.1	
Sacrum	/	48.3	
hips	/	10.0	
Ankle	/	3.1	
Heels	/	17.5	
Other	/	7.6	
Smoking experience (%)			
Yes	23.2	14.1	<0.001
Fecal incontinence (%)			
Yes	0.3	0.9	<0.001
Urinary incontinence (%)			
Yes	2.5	3.1	<0.001
Vasopressor use (%)			
Yes	2.2	3.2	< 0.001
Mechanical ventilation (%)			
Yes	8.5	11.8	< 0.001
Dialysis (%)			
Yes	2.8	4.6	< 0.001

Table 2 Continued

Characteristics	No pressure injury	Pressure injury	<i>p</i>
Number of Comorbidities (%)			
0	1.4	0.6	< 0.001
1	5.5	3.3	
2	12.2	8.8	
≥3	80.9	87.3	
LOS (median, d)	6 (4-10)	8 (5-14)	< 0.001
TOTCHG (median, \$)	45,139 (24,384 - 88,870)	60,749 (32,585-118,755)	
Type of insurance (%)			
Medicare	89.9	91.1	< 0.001
Medicaid	1.7	2.2	
Private insurance	6.6	5.1	
Self-pay	0.5	0.3	
No charge	0	0	
Other	1.2	1.2	
Bed size of hospital (%)			
Small	19.2	18.4	< 0.001
Medium	29.2	29.7	
Large	51.7	52.0	

Characteristics	No pressure injury	Pressure injury	p
Elective admission (%)	95.0	95.3	< 0.001
Type of hospital (teaching %)	56.3	59.8	< 0.001
Region of hospital (%)			
Northeast	18.7	22.2	
Midwest or North Central	21.9	20.2	
South	38.0	37.9	< 0.001
West	21.4	19.7	
Location of hospital (urban, %)	88.3	91.3	< 0.001

LOS: Length of stay, TOTCHE: Total charge

3.2 Characteristics of Pressure Injuries

The most common PI location was the sacrococcygeal region (including the tailbone and buttocks) (48.3%), followed by the back (36.1%) and the heels (17.5%). PI morbidity was higher in patients with fecal or urinary incontinence. Patients receiving mechanical ventilation, vasopressors, or renal dialysis also experienced significantly increased PI morbidity. The PI morbidity rate was 11.8% in patients receiving mechanical ventilation. Among elderly patients with sepsis and three or more comorbidities, the PI morbidity rate reached 87.3% (Table 2).

3.3 Risk Factors Associated with Pressure Injuries in Elderly Sepsis Patients

Factors associated with PIs: advanced age (75–84 years:

OR = 1.18, 95% CI = 1.17–1.19; ≥85 years: OR = 1.42, 95% CI = 1.40–1.44); female sex (OR = 0.97, 95% CI = 0.96–0.98); dialysis (OR = 1.35, 95% CI = 1.33–1.38); race (Black: OR = 2.45, 95% CI = 2.42–2.48; Hispanic: OR = 1.25, 95% CI = 1.22–1.27; Asian/Pacific Islander: OR = 1.05, 95% CI = 1.02–1.08; Native American: OR = 1.16, 95% CI = 1.08–1.24; Other: OR = 1.14, 95% CI = 1.12–1.16); multiple comorbidities (n=1: OR = 1.27, 95% CI = 1.19–1.36; n=2: OR = 1.52, 95% CI = 1.43–1.61; n≥3: OR = 2.16, 95% CI = 2.03–2.29); fecal incontinence (OR = 2.76, 95% CI = 2.60–2.93); urinary incontinence (OR = 1.19, 95% CI = 1.16–1.23); vasopressor use (OR = 1.30, 95% CI = 1.27–1.34); mechanical ventilation (OR = 1.35, 95% CI = 1.33–1.37); Medicaid payment (OR = 1.16, 95% CI = 1.12–1.19); and urban hospital location (OR = 1.19, 95% CI = 1.16–1.23). All *p*-values were <0.001, indicating statistical significance (Table 3).

Table 3 Risk factors related to pressure injury in elderly sepsis patients

Variable	Multivariate Logistic Regression		
	OR	95% CI	p
Age group (%)			
65-74	Ref	—	—
75-84	1.18	1.17-1.19	< 0.001
≥85	1.42	1.40 -1.44	< 0.001
Gender (%)			
Male	Ref	—	—
Female	0.97	0.96-0.98	< 0.001
Race (%)			
White	Ref	—	—
Black	2.45	2.42-2.48	< 0.001
Hispanic	1.25	1.22-1.27	< 0.001
Asian or Pacific Islander	1.05	1.02-1.08	0.001
Native American	1.16	1.08-1.24	< 0.001
Other	1.14	1.12-1.16	< 0.001
Number of Comorbidities			
0	Ref	—	—
1	1.27	1.19-1.36	< 0.001
2	1.52	1.43-1.61	< 0.001
≥3	2.16	2.03-2.29	< 0.001
Fecal incontinence	2.76	2.60-2.93	< 0.001
Urinary incontinence	1.19	1.16-1.23	< 0.001

Variable	Multivariate Logistic Regression		
	OR	95% CI	p
Vasopressor use	1.30	1.27-1.34	< 0.001
Mechanical ventilation	1.35	1.33-1.37	< 0.001
Dialysis	1.35	1.33-1.38	< 0.001
Type of insurance (%)			
Medicare	Ref	—	—
Medicaid	1.16	1.12-1.19	< 0.001
Private insurance	0.79	0.77-0.81	< 0.001
Self-pay	0.70	0.65-0.76	< 0.001
No charge	0.56	0.39-0.78	< 0.001
Other	1.01	0.96-1.05	0.744
Bed size of hospital			
Small	Ref	—	—
Medium	1.03	1.02-1.05	<0.001
Large	1.04	1.03-1.06	<0.001
Elective admission	1.01	0.99-1.04	0.218
Teaching hospital	1.01	1.00-1.02	0.018
Urban hospital	1.20	1.17-1.22	<0.001
Region of hospital			
Northeast	Ref	—	—

Variable	Multivariate Logistic Regression		
	OR	95% CI	p
Midwest or North Central	0.78	0.77-0.80	<0.001
South	0.81	0.80-0.82	<0.001
West	0.79	0.78-0.81	<0.001

OR: Odds ratio, CI: Confidence interval

3.4 Comorbidity Risk Factors Associated with Pressure Injuries in Elderly Sepsis

Results from Table 2 indicate that one or more comorbidities were associated with increased PI morbidity. Multivariate logistic regression analysis demonstrated that paralysis exhibited the strongest association with PI (OR = 3.67; 95% CI, 3.31–3.72), followed by weight loss (OR =

2.61; 95% CI, 2.58–2.64), other neurological disorders (OR = 1.58; 95% CI, 1.56–1.59), anemia (nutritional: OR = 1.40; 95% CI, 1.39–1.42; hemorrhagic: OR = 1.37; 95% CI, 1.31–1.43), diabetes (without complications: OR = 1.24; 95% CI, 1.22–1.25; with complications: OR = 1.44; 95% CI, 1.42–1.46), fluid and electrolyte disorders (OR = 1.21; 95% CI, 1.20–1.22), peripheral vascular disease (OR = 1.30; 95% CI, 1.28–1.32), psychoses (OR = 1.18; 95% CI, 1.15–1.21), and congestive heart failure (OR = 1.18; 95% CI, 1.17–1.19). All *p*-values were < 0.001, indicating statistical significance (Table 4).

Table 4 Relationship between pressure injury and complications

Comorbidities	Univariate Analysis		Multivariate Logistic Regression			
	No pressure injuries	Pressure injure	p	OR	95% CI	p
Preoperative comorbidities						
Acquired immune deficiency syndrome	2,149 (0.1%)	277 (0.1%)	0.068	1.07	0.94-1.22	0.301
Deficiency anemia	306,712 (18.2%)	48,210 (24.9%)	< 0.001	1.40	1.39-1.42	< 0.001
Rheumatoid arthritis/collagen vascular diseases	65,161 (3.9%)	6,295 (3.3%)	< 0.001	0.92	0.90-0.95	< 0.001
Chronic blood loss anemia	18,766 (1.1%)	3,067 (1.6%)	< 0.001	1.37	1.32-1.43	< 0.001
Congestive heart failure	505,251 (29.9%)	62,914 (32.5%)	< 0.001	1.18	1.17-1.19	< 0.001
Chronic pulmonary disease	531,170 (31.5%)	48,034 (24.8%)	< 0.001	0.75	0.74-0.75	< 0.001
Coagulopathy	230,327 (13.6%)	23,069 (11.9%)	< 0.001	0.80	0.79-0.81	< 0.001
Depression	209,193 (12.4%)	22,327 (11.5%)	< 0.001	0.93	0.91-0.94	< 0.001
Diabetes, uncomplicated	360,901 (21.4%)	44,804 (23.1%)	< 0.001	1.24	1.22-1.25	< 0.001
Diabetes, with chronic complications	294,802 (17.5%)	42,124 (21.8%)	< 0.001	1.44	1.42-1.46	< 0.001
Drug abuse	19,076 (1.1%)	1,785 (0.9%)	< 0.001	0.83	0.79-0.88	< 0.001
Hypertension	1,225,394 (72.6%)	132,023 (68.2%)	< 0.001	0.80	0.79-0.81	< 0.001

Comorbidities	Univariate Analysis		Multivariate Logistic Regression			
	No pressure injuries	Pressure injure	p	OR	95% CI	p
Hypothyroidism	308,227 (18.3%)	312,45 (16.1%)	< 0.001	0.89	0.88-0.90	< 0.001
Liver disease	75,918 (4.5%)	6,461 (3.3%)	< 0.001	0.75	0.73-0.77	< 0.001
Lymphoma	35,690 (2.1%)	2,985 (1.5%)	< 0.001	0.76	0.73-0.79	< 0.001
Fluid and electrolyte disorders	923,191 (54.7%)	122,269 (63.1%)	< 0.001	1.21	1.20-1.22	< 0.001
Metastatic cancer	78,700 (4.7%)	6,974 (3.6%)	< 0.001	0.76	0.74-0.78	< 0.001
Other neurological disorders	329,724 (19.5%)	58,420 (30.2%)	< 0.001	1.58	1.56-1.60	< 0.001
Obesity	220,628 (13.1%)	21,479 (11.1%)	< 0.001	0.87	0.85-0.88	< 0.001
Paralysis	64,593 (3.8%)	28,082 (14.5%)	< 0.001	3.67	3.61-3.72	< 0.001
Peripheral vascular disorders	169,837 (10.1%)	24,866 (12.8%)	< 0.001	1.30	1.28-1.32	< 0.001
Psychoses	63,374 (3.8%)	9,090 (4.7%)	< 0.001	1.18	1.15-1.21	< 0.001
Pulmonary circulation disorders	105,407 (6.2%)	10,558 (5.5%)	< 0.001	0.92	0.90-0.94	< 0.001
Renal failure	499,465 (29.6%)	62,559 (32.3%)	< 0.001	1.08	1.07-1.09	< 0.001
Solid tumor without metastasis	117,875 (7.0%)	9,349 (4.8%)	< 0.001	0.71	0.70-0.73	< 0.001
Valvular disease	166,568 (9.9%)	15,234 (7.9%)	< 0.001	0.79	0.78-0.81	< 0.001
Weight loss	272,029 (16.1%)	67,102 (34.7%)	< 0.001	2.61	2.58-2.64	< 0.001

OR: Odds ratio, CI: Confidence interval

3.5 Association of PIs with Complications in Elderly Sepsis Patients

Univariate analysis of complications in elderly patients with sepsis-related PIs showed that patients with PIs were more likely to develop complications, including deep vein

thrombosis, malnutrition, heart failure, delirium, and septic shock, compared with patients without PIs. Multivariate analysis revealed that patients with PIs had significantly higher odds of developing malnutrition (OR = 2.72, 95% CI 2.69–2.75), deep vein thrombosis (OR = 1.46, 95% CI 1.42–1.58), septic shock (OR = 1.34, 95% CI 1.33–1.37), delirium (OR = 1.34, 95% CI 1.33–1.36), and respiratory failure (OR = 1.20, 95% CI 1.18–1.22). All *p*-values were < 0.001, indicating statistical significance (Table 5).

Table 5 Relationship between pressure injury and complications in elderly sepsis patients

Complications	Univariate Analysis			Multivariate Logistic Regression		
	No pressure injuries	Pressure injuries	p	OR	95% CI	p
Medical complications						
Septic shock	131,950 (7.8%)	22,274 (11.5%)	<0.001	1.33	1.31-1.35	<0.001
Deep vein thrombosis	45,342 (2.7%)	8,778 (4.5%)	<0.001	1.42	1.39-1.45	<0.001
Cardiac arrest	14,579 (0.9%)	2,279 (1.2%)	<0.001	1.06	1.01-1.11	0014
Delirium	361,405 (21.4%)	53,818 (27.8%)	<0.001	1.33	1.32-1.35	<0.001
Heart failure	327,624 (19.4%)	41,147 (21.2%)	<0.001	1.09	1.08-1.10	<0.001
Acute renal failure	703,754 (41.7%)	86,423 (44.6%)	<0.001	1.02	1.01-1.03	<0.001
Respiratory failure	177,002 (10.5%)	25,587 (13.2%)	<0.001	1.20	1.18-1.22	<0.001
Malnutrition	294,562 (17.5%)	72,608 (37.5%)	<0.001	2.71	2.68-2.73	<0.001

OR: Odds ratio, CI: Confidence interval

4 Discussion

Elderly individuals represent a high-risk cohort for developing PIs. The occurrence of these injuries not only exacerbates patient discomfort but also elevates the risk of infections, potentially triggering severe complications. This risk is particularly elevated in elderly patients with limited mobility or those who are bedridden due to their increased susceptibility to chronic, long-lasting wounds. Consequently, the incidence of PIs contributes significantly to rising healthcare costs and imposes a considerable burden

on medical resources, thus posing a global public health challenge. Data from the NIS database indicated a PI prevalence of 10.3% among elderly patients with sepsis over the past decade, significantly impacting hospital length of stay, medical expenses, and mortality rates. This study is the first comprehensive investigation of PI prevalence and associated risk factors in elderly patients with sepsis using large-scale data analysis. By identifying trends in PI prevalence and summarizing the key risk factors, the insights gained here are intended to support healthcare policies, optimize nursing resource allocation, and inform effective intervention strategies.

Advanced age is an independent risk factor for PIs in elderly sepsis patients, with PI likelihood increasing with age. Aging leads to several physiological changes, including alterations in skin pH, reduced keratin production, and degradation of dermal elastic fibers. Consequently, these changes result in decreased skin moisture, elasticity, and resilience, compromising the skin's resistance to shear forces and pressure, thus rendering it more vulnerable to injury [10, 11]. The sacral region emerges as the most prevalent site for PIs in elderly sepsis patients, primarily attributable to prolonged bed rest and decreased mobility, which contribute to muscle mass and strength loss. This finding aligned with previous research indicating that the sacrococcygeal area is particularly susceptible to pressure injuries [12]. Incontinence is another critical factor influencing the occurrence of PIs. Prolonged perineal and sacral skin exposure to moisture, urine, and feces promotes skin irritation and tissue damage. This study confirmed a significantly higher PI incidence in patients with fecal incontinence [13]. Elderly sepsis patients often experience hemodynamic instability or critical illness, requiring support like mechanical ventilation, dialysis, and vasopressors. Vasopressors can induce peripheral vasoconstriction, impairing the delivery of oxygen and nutrients to the skin and thereby increasing the risk of PIs. Besides, mechanical ventilation and dialysis can contribute to prolonged immobility and compromised regional blood flow, further exacerbating the risk for PIs [12, 14]. While prior research identified male sex as a PI risk factor [15], this study found no conclusive evidence, possibly due to the predominance of female patients in the elderly sepsis population, resulting in diminished statistical significance. Similarly, no significant correlation was observed between smoking history and PI development. In terms of racial disparities, the study uncovered higher rates of PIs among Black (OR = 2.45), Hispanic (OR = 1.25), Asian/Pacific Islander (OR = 1.05), Native American (OR = 1.16), and other racial groups (OR = 1.14) compared to White patients [12]. Moreover, patients treated in urban hospitals displayed a 1.2-fold increased incidence of PIs when compared to those in suburban hospitals, likely due to higher population density and more complex comorbidities [16]. Medicaid recipients had the highest PI morbidity rates, correlating with socioeconomic disparities, as patients with lower economic status often endure a higher burden of comorbidities, elevating their risk for developing PIs [17].

Besides, this study identified several comorbidities, including anemia, diabetes, peripheral neuropathy, fluid and

electrolyte imbalances, weight loss, and paralysis, as significantly increasing the risk for PIs in elderly sepsis patients. The presence of PIs was associated with prolonged hospitalizations and increased healthcare costs. Diabetes emerged as a critical risk factor for PIs, both in the presence and absence of chronic complications. As diabetes itself is a risk factor for sepsis, it further elevates the risk of PIs through complications like peripheral neuropathy, which diminishes protective sensation against tissue damage. Neuropathy also heightens the risk for diabetic foot syndrome and Charcot's foot, resulting in bone destruction, deformity, and infections, exacerbated by vascular glycation and accelerated atherosclerosis, leading to local skin ischemia [18]. Adipose and connective tissues protect against external pressure. Weight loss and low body mass index (BMI) often indicate diminished adipose and connective tissue, increasing pressure on bony prominences and decreasing tissue tolerance. The association between weight loss, low BMI, and fluid/electrolyte imbalances suggests a compounded risk due to weakness, dehydration, and malnutrition, impairing energy metabolism, tissue repair, and skin integrity, ultimately increasing susceptibility to PIs [10, 16, 19]. Patients with paralysis, unable to reposition themselves independently, require passive range-of-motion therapy or assistive devices to mitigate pressure on tissues; indeed, insufficient movement can prolong pressure, increasing the risk of PIs. Anemia affects over 10% of older adults, with nearly two-thirds of critically ill patients in ICUs presenting with some level of anemia. In the context of sepsis, anemia can arise from multiple factors, including diminished erythropoiesis, stress-induced bleeding, hemodilution, frequent blood sampling, disrupted iron metabolism, and hemolysis [20]. This study identified anemia as a high PI risk factor in elderly sepsis patients since chronic anemia leads to tissue hypoxia and blood redistribution, affecting skin and kidneys, compromising oxygen delivery, nutrient supply, and waste elimination in fragile skin and subcutaneous tissue, thus reducing the skin's ability to withstand pressure and increasing vulnerability to PIs. Moreover, patients suffering from peripheral vascular disease and congestive heart failure experience inadequate perfusion, further exacerbating the risk of developing PIs. Elderly patients with psychiatric disorders demonstrated a comparatively higher incidence of PIs (OR = 1.18), possibly attributable to factors such as sedative medication use, increased drowsiness, decreased mobility, and poor nutritional intake [21]. Furthermore, patients with renal failure, who often require dialysis, were found to have an elevated

risk of PIs.

Interestingly, this study found obesity to be protective against PIs. The presence of thicker subcutaneous fat, particularly in the buttocks, may facilitate better weight distribution and maintain sacral region blood flow, reducing susceptibility to PIs [22]. While prior studies linked various conditions, including hypertension, connective tissue diseases, rheumatic disorders, chronic lung disease, and cancer, to PI risk, this investigation identified them as protective factors in elderly sepsis patients, warranting further exploration. Although not definitively conclusive, it has been suggested that connective tissue diseases, rheumatic disorders, and certain psychiatric conditions could heighten PI risk due to pain- or disease-related immobility; however, medication-related symptom relief and enhanced mobility may mitigate these risks [23]. Sepsis induces immunosuppression alongside complications such as hypoperfusion, systemic inflammation, and disseminated intravascular coagulation (DIC), ultimately leading to multi-organ dysfunction and increased mortality [24]. Nonetheless, treatments—including immunostimulatory therapies, anti-inflammatory agents, positive inotropic drugs, and anticoagulants—have demonstrated potential in improving outcomes for severe sepsis patients [25-27]. Therapeutic avenues such as cancer immunotherapy and positive inotropes for pulmonary diseases may influence sepsis progression, potentially alleviating complications like PIs. The complex interactions among sepsis, comorbidities, and associated risk factors necessitate multifactorial analysis rather than isolated evaluations in geriatric populations.

This study revealed that elderly sepsis patients with PIs are at increased risk for severe complications, including DVT, septic shock, cardiac arrest, acute kidney injury, heart failure, delirium, respiratory failure, and malnutrition. The pro-inflammatory and pro-thrombotic environment of sepsis, including cellular activation, platelet-fibrin thrombi deposition, and DIC, contributes to hypercoagulability. Reduced mobility in PI patients and altered consciousness further exacerbate the risk of developing DVT [28, 29]. Septic shock, a critical sepsis complication, is markedly aggravated in older adults due to declining immune function. PI-related persistent inflammation also adversely affects immune responses to new infections, potentially worsening septic shock severity [30]. Mechanical ventilation and prolonged sedation, common in elderly sepsis patients, can lead to extended bed rest, impaired mobility, and increased PI risk. Furthermore, we found that these patients exhibited

increased vulnerability to delirium, consistent with previous findings [31]. The metabolic demands and stress responses induced by sepsis require increased nutritional support to maintain bodily functions; however, poor absorption can exacerbate malnutrition, thereby diminishing immune response and metabolic activity, which heightens the risk for infection, inflammation, and delirium. The interrelationships between these complications contribute to longer hospital stays and increased healthcare costs [32-34]. Ultimately, the interplay between immune dysfunction and inflammation from sepsis can lead to critical organ failure. Given that elderly patients often present with multiple comorbidities, such as cardiovascular and chronic kidney diseases, extensive vasodilation and heightened capillary permeability can diminish perfusion to vital organs, resulting in hypoxia and subsequent organ failure. Such processes significantly contribute to respiratory failure, acute respiratory distress syndrome (ARDS), liver dysfunction, and acute kidney injury, all increasing sepsis-related mortality in this demographic [35, 36].

5 Strengths and Limitations

The NIS database provides a large dataset for identifying disease trends and risk factors. However, it has limitations that should be acknowledged. First, the absence of PI assessment variables (e.g., Braden score, serum protein, lactate levels) limited the analysis to available variables, potentially omitting important risk factors. Second, the NIS database cannot identify PI occurrence time or pathogenic factors (for example, equipment-related PIs), which may underestimate the incidence rate of PIs. Finally, like any large administrative database, coding and documentation inconsistencies or misclassifications may occur.

6 Conclusion

This study demonstrates a declining morbidity of PIs among elderly sepsis patients, with an overall morbidity of 10.3% between 2010 and 2019. Despite advances in PI assessment and prevention, PIs remain a significant concern. Managing elderly sepsis patients with comorbidities (circulatory disease, cancer, weight loss, lung disease, anemia, paralysis, and diabetes) is complex. This study informs healthcare professionals about PI risk factors in elderly sepsis patients, enabling timely risk factor identification, resource allocation, and effective preventive measures (e.g.,

adequate nutritional support and anemia correction) to significantly reduce PI morbidity.

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