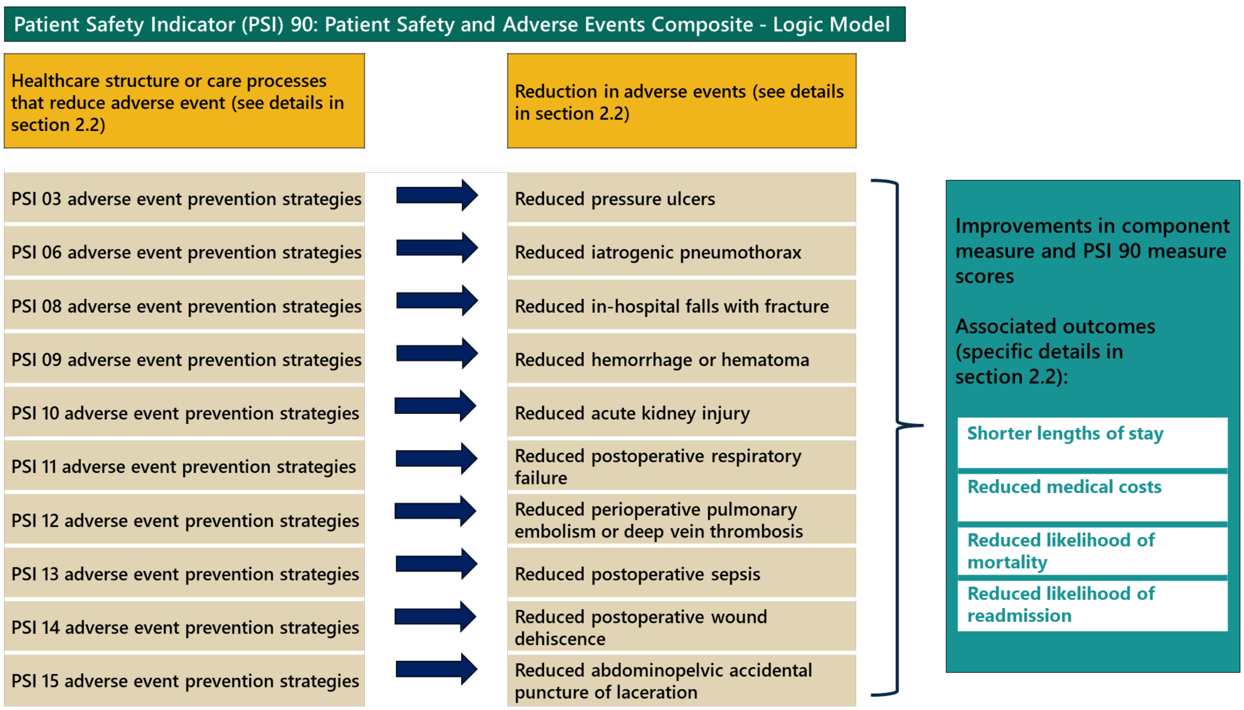
2.1 Logic Model and 2.2 Evidence of Measure Importance

2.1. Attach Logic Model

Exhibit B.1 below provides a depiction of PSI 90's logic model. As depicted in Exhibit B.1, PSI 90 is a summary of 10 hospital-level patient safety component measures. Each of these measures has its own set of healthcare structures and care processes that can potentially reduce the safety event evaluated in the component measure. Reductions in these safety events represent improvements in patient outcomes and may also lead to additional downstream benefits such as shorter length of hospital stay, reduced medical costs, reduced likelihood of readmissions and mortality.

Exhibit B.1. PSI 90 Logic Model.



2.2. Evidence of measure importance.

Evidence of the importance linking the structures, processes, and outcomes are described by individual component measure in the following sections. Recommendations to support improvements are specific to the patient safety event and described at the component measure level, rather than the composite measure level.

PSI 03 Pressure Ulcer Rate

2.1 Attach Logic Model

Table B.1. Pressure Ulcer Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 03 Pressure Ulcer	**Processes of care** • Skin assessments performed at admission and daily, with particular attention to bony prominences and skin adjacent to external/medical devices. [1, 2, 3, 4, 5] • Complete documentation of all skin lesions and pressure ulcers along with staging (including location, tissue type, shape, size, presence of sinus tracts/tunneling, undermining, exudate amount and type, presence/absence of infection, and wound edges). [1, 2, 3, 4, 5] • Documentation of skin inspections in the medical record, including skin temperature, skin color, skin texture/turgor, skin integrity, and moisture status. [1, 2, 3, 4, 5] • Nutritional assessments performed at entry to new health care settings and whenever patient status changes.[2, 5, 6] • Place patients on a pressure-reducing surface rather than a standard hospital mattress. [1, 2, 3, 4, 8, 9] • Repositioning of patients (evidence supporting cadence of reposition is mixed).[12, 13, 14] • Pressure ulcer risk assessments performed at admission and daily (using validated tool) with results documented in the patient's chart.[3] **Structures of care** • High nurse or nurse manager turnover and high nurse to patient ratios have been shown to be correlated with an increased number of pressure injuries.[12, 17, 18] • Nurses with a stronger patient safety attitude have been shown to be correlated with lower number of pressure injuries.[19] • Nurse skill mix (Staffing, education, and experience) and nurse outcomes (job satisfaction and intent-to-stay) have been shown to be correlated with lower number of pressure injuries.[7]	• Hospital-acquired pressure ulcer complications have been associated with up to 60,000 deaths each year in the U.S.[23, 24] • Patients with pressure injuries are subject to physical and emotional pain and the potential for infection and debilitation, which prolongs hospital stays and impacts recovery.[21, 22] • National cost estimates of care associated with pressure injuries range from $3.3 billion to $26.8 billion.[26, 27]

2.2. Evidence of Measure Importance

Pressure injuries are also known as pressure ulcers or bed sores.

Association with Process of Care

Multiple studies have documented evidence to prevent pressure ulcer formation for hospital patients. Specifically, evidence-based guidelines [1, 2, 3, 4] and systematic reviews[5] recommend that skin assessments be performed at admission and daily during the inpatient stay, with particular attention to bony prominences and skin adjacent to external/medical devices. These assessments should include complete documentation of all skin lesions and pressure ulcers along with staging (including location, tissue type, shape, size, presence of sinus tracts/tunneling, undermining, exudate amount and type, presence/absence of infection, and wound edges). Documentation in the medical record should include skin temperature, skin color, skin texture/turgor, skin integrity, and moisture status. In addition, evidence-based guidelines[2, 6] and systematic reviews[5] recommend that nutritional assessments be performed at entry to new health care settings and whenever patient status changes.

Baernholdt and colleagues added to the evidence base around the effectiveness of skin and risk assessments at reducing pressure ulcer rates. Using unit-level data from the National Database of Nursing Quality Indicators® 2010-2013 augmented with data on rural classifications and case mix index, they found an increase in three care interventions (skin assessment on admission; risk assessment on admission; and any risk assessment before prevalence day) were associated with a decrease in unit-acquired pressure ulcers.[7]

Evidence-based guidelines and systematic reviews also recommend that at-risk patients be placed on a pressure-reducing surface rather than a standard hospital mattress.[1, 2, 3, 4, 8] In a systematic review of 120 studies reporting on pressure ulcer risk assessment and prevention, Chou and colleagues examined the effectiveness of various interventions for reducing pressure ulcers for hospitalized patients.[9] They concluded that fair-quality randomized trials consistently found that in higher risk patients, advanced static support surfaces were associated with lower risk of pressure ulcers compared to standard mattresses (relative risk range, 0.20 to 0.60), with no clear differences among different advanced static support surfaces. Evidence on the comparative effectiveness of more advanced dynamic support surfaces was limited; some trials showed no significant differences between dynamic and static support surfaces. In lower risk populations of patients undergoing surgery, two trials found use of a foam overlay associated with a higher risk of pressure ulcers compared with a standard operating room mattress.

Evidence on the effectiveness of other preventive interventions (e.g., nutritional supplementation; repositioning; support surfaces; pads and dressings; lotions, creams, and cleansers; corticotrophin injections; polarized light therapy; and intraoperative warming therapy) is insufficient to reach reliable conclusions.[10, 11, 12] A 2020 Cochrane review of eight trials concluded that there is an absence of high-quality evidence for evaluating the effectiveness of repositioning frequency and positioning for pressure ulcer prevention.[13] Another 2020 systematic review that included both trial and observational studies assessing the effects of different repositioning regimens concluded that there is low-certainty evidence that more frequent repositioning (every 2-3 hours versus 4-6 hours; OR, 0.75; 95% CI, 0.61-0.90, p=0.03) and use of a turning team (OR, 0.49; 95% CI, 0.27-0.86, p=0.01) can reduce pressure ulcer incidence in at-risk adult patients.[14]

Some of these care strategies continue to be adopted, however, and have been shown to be effective at reducing pressure ulcer rates. Cortés and Vásquez also found via a literature review that performing postural changes can lead to lower prevalence of pressure ulcers; though, as other studies have shown, findings in the literature are somewhat inconsistent on the ideal timing or intervals for repositioning, as well as with alternating pressure air surfaces (i.e. active distribution mattresses).[12, 13, 14] An observational cohort study conducted in 38 acute care hospitals between 2010 and 2015 found that adoption of a prophylactic foam sacral dressing as part of a hospital acquired pressure ulcers (HAPU) prevention protocol resulted in reduced HAPU rates; the average hospital experienced one fewer HAPU per quarter following implementation of the dressing.[15] Elsabrout and colleagues found that a hospital-wide mattress switch-out program (i.e., replacing old or worn out mattresses with new ones or replacing existing mattresses with pressure redistribution mattresses) resulted in a 66.6 percent decrease in Stage III and IV HAPUs and a cost savings of $714,724.[16]

Association with Structures of Care

Researchers have examined the association between pressure ulcers and hospital nurse staffing characteristics, including registered nurse (RNs) turnover, positive safety attitude, education level, and skill mix. In a longitudinal study of 23 nursing units in two hospitals from October 2009 through December 2011, Warshawsky and colleagues found that patients on units with nurse manager turnover (OR 3.16; 95% CI 1.49 to 6.70) were more likely to develop pressure ulcers than patients on other units.[17] In an analysis of quarterly unit-level data from the National Database of Nursing Quality Indicators (2008-2010), including 10,935 unit-quarter observations (2,294 adult units in 465 hospitals from 47 U.S. states), Park and colleagues found a significant lagged effect of RN turnover on HAPU rates, but not a concurrent effect. For every 10 percentage-point increase in RN turnover in a quarter, the odds of a patient having a pressure ulcer increased by 4 percent in the next quarter ($p = 0.038$).[18] In their literature review, Cortés OL and Vásquez found that a low ratio of nurses per number of patients may mean less repositioning of patients is accomplished, which may result in higher prevalence of pressure ulcers at hospitals with relatively lower ratios of nurses per patients.[12]

More recently, Alanazi, Sim, and Lapkin conducted a literature review and noted four studies reported significant association between nurses' positive safety attitudes and reduced numbers of pressure injuries. Also relevant are findings that pressure injuries were less likely to be documented in the medical records when the nursing unit had a positive safety culture.[19] Baernholdt and colleagues found an increase in RN skill mix (staffing, education, and experience) and nurse outcomes (job satisfaction and intent-to-stay) were associated with a decrease in unit-acquired pressure ulcers. Regarding RN skill mix (staffing, education, and experience), a 10 percent increase in skill mix was associated with 17-18 percent and 5-6 percent decreases in ulcer rates in rural and urban units respectively.[7]

Association with Downstream Harms

Pressure ulcers continue to be a source of morbidity in the United States.[20] Patients with pressure injuries are subject to physical and emotional pain and the potential for infection and debilitation, which prolongs hospital stays and impacts recovery.[21, 22] Pressure ulcers have been historically estimated to be associated with up to 60,000 deaths each year in the US, and increasing evidence demonstrates an association between severity of pressure injuries and patient mortality.[23, 24] Certain patients are more vulnerable to poor outcomes including mortality. For example, Duchesene and colleagues found that the diagnosis of pressure ulcers among patients with end-stage renal disease was independently associated with mortality even after controlling for confounding factors ($p<0.001$).[25]

In addition to morbidity and mortality, pressure ulcers also include medical costs. National cost estimates of care associated with pressure injuries range from $3.3 billion to $26.8 billion.[26, 27]

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PSI 06 Iatrogenic Pneumothorax Rate

2.1 Attach Logic Model

Table B.2. Iatrogenic Pneumothorax Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 06 Iatrogenic Pneumothorax	**Processes of care** • Use of ultrasound guidance to support successful placement of central venous lines [5, 6, 7, 8] **Structures of care** • Use of simulation trainings for ultrasound guided CVL placement[7, 9, 10, 11, 12] • Timing trainings to align with use of the skill[9]	• Increased hospital length of stay, medical costs, and readmissions[13, 14]

2.2. Evidence of Measure Importance

Iatrogenic pneumothorax is a collapsed lung that results from medical treatment.

Association with Process of Care

The most common procedure associated with iatrogenic pneumothorax is subclavian insertion of a central venous line (CVL).[1] It is also a known complication of other invasive procedures such as pulmonary needle biopsy, positive pressure ventilation, hypoglossal nerve stimulator implantation, lung cancer surgery, and a number of other thorax and abdomen procedures.[2, 3, 4] Peer-reviewed research[5, 6] and clinical guidelines[7, 8] indicates ultrasound guidance can improve rates of successful placement of CVLs and thus reduce rates of pneumothorax.

Association with Structures of Care

Researchers have reported successful interventions around clinician education and increased experience can improve outcomes of procedures associated with iatrogenic pneumothorax.[7, 9, 10, 11, 12] Examples of these improvement processes include using simulation trainings,[7, 9, 10] and implementing targeted education to clinicians likely to perform CVL incursion timed to be conducted when the clinician will need to use the skill.[9]

Association with Downstream Harms

Researchers have shown that cases of iatrogenic pneumothorax result in increased service utilization and increased spending. Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 06 event were associated with an additional 1.41 hospital days compared to patients without an event ($p=0.006$) and an increased risk of 30-day unplanned readmissions ($OR=3.30$, $p<0.001$).[13] Using a 20 percent Medicare claims data sample to evaluate the association of between all hospital acquired conditions (HACs), including iatrogenic pneumothorax, and 90-day episode spending, Sankaran and colleagues found that all HACs were associated with significant increases in total 90-day episode spending, index hospitalization spending, inpatient and outpatient physician services spending, and postacute care spending (the researchers estimated an increase of about $3,200 per 90-day episode for iatrogenic pneumothorax).[14]

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PSI 08 In-Hospital Fall-Associated Fracture Rate

2.1 Attach Logic Model

Table B.3. In-Hospital Fall-Associated Fracture Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 08 In-Hospital Fall-Associated Fracture	**Processes of care** • Conducting risk assessment and using factors to provide personalized prevention strategy[1] • Strength and balance exercise[1] • Medication review and polypharmacy reduction (where appropriate)[1, 2] • Management of underlying acute and chronic diseases[1] • Optimize vision, nutrition, and hearing[1] • Address foot problems and appropriate footwear[1] • Vitamin D supplementation[1] • Continence management[1] • Individual education[1] **Structures of care** • Environmental modification[1]	• Longer length of stay, higher medical costs, and higher likelihood for mortality[7, 8]

2.2. Evidence of Measure Importance

This measure was recently expanded to focus on all inpatient hospital falls rather than just hip fractures. Therefore, some of the relevant literature regarding PSI 08 is related to an earlier version of the indicator. While the literature summarized below may be older, it still provides relevant information regarding the clinical evidence of PSI 08 since the measure focus has not changed drastically.

Association with Process of Care

Many evidence-based interventions for falls have been documented. *World guidelines for falls prevention and management for older adults: a global initiative* from 2022 recommends strategies for addressing falls in hospitals including using a falls risk assessment and implementing falls prevention strategies. We provide examples of these strategies in the following bullets:[1]

- Risk assessment. The recommendations include using a multifactorial falls risk assessment, using a standardized assessment to evaluate concerns about falling, conducting post-fall assessments, and using identified risk factors to provide personalize single or multidomain falls prevention strategies.
- Fall prevention strategies. The recommendations include: strength and balance exercise, medication review, management of orthostatic hypotension and cardiovascular diseases, management of underlying acute and chronic diseases, optimizing vision and hearing, addressing foot problems and appropriate footwear, vitamin D supplementation, optimizing nutrition, continence management, interventions to address concerns about falling, individual education, and environmental modification.

An additional factor that research indicates may impact falls not specifically described in the guideline is polypharmacy. Xue and colleagues conducted a prospective cohort study looked at the role of polypharmacy in treatment of fall injuries. They looked at incident fall injuries among 1764 older adults included in the Health, Aging and Body Composition Study. They found that 36 percent (636) had persistent polypharmacy over the follow up period and persistent polypharmacy increased fall injury risk (hazard ratio: 1.31 [1.06, 1.63]).[2] Using clinical data from 590 patients who underwent surgery for fractures between April 2019 and March 2021, Taniguchi and colleagues, examined the association between the number of prescribed drugs and hip fracture prevalence. They found that 55 percent of patients with extremity fractures took ≥6 prescription drugs and analysis revealed that polypharmacy was significantly associated with hip fracture.[3]

Evidence indicates that multifactorial interventions are associated with a reduction in falls. A meta-analysis by Cameron and colleagues, found multifactorial interventions in hospitals, which includes two or more categories of intervention given based on individual patient risk profile, reduces fall rates by 20 percent (rate ratio (RaR 0.80, 95% CI 0.64 to 1.01; 5 studies, 44,664 participants).[4] Morris and colleagues, conducted a meta-analysis to examine interventions used in hospitals to reduce falls. Single interventions utilized by the hospitals in the studies included education, assistive devices, rehabilitation and exercise therapies, system-based interventions, environmental modifications, and medications. Among the single interventions, education was the only intervention that showed a positive result for the odds of falling (OR 0.62 [0.47–0.83]) and the rates of falls (RaR 0.70 [0.51–0.96]).[5]

Associations with Structures of Care

Rosen and colleagues used PSI 08 (version 3.1a) to explore associations between safety climate, as measured through more than 4,500 responses to the Patient Safety Climate in Healthcare Organizations survey, and hospital safety performance. Among the 30 Veterans Affairs hospitals that participated in the survey, the rate of postoperative hip fractures was not significantly associated with the 11 dimensions of patient safety culture included in the analysis.[6]

Association with Downstream Harms

Zhan and Miller used the Agency for Healthcare Research and Quality (AHRQ) PSI software on 7.45 million discharges in the Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (2000) and found that compared to those that did not experience a PSI 08 event, those that did had a higher mean [SD] unadjusted length of stay (160.37 [0.58] vs. 50.39 [0.007]), charges ($52,224 [1784] vs. $24,594 [35]), and percent mortality (90.93 [0.92] vs. 10.70 [0.01]).[7] Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 08 event were associated with an additional 3.46 hospital days compared to patients without a PSI 08 event (p<0.001).[8]

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PSI 09 Postoperative Hemorrhage and Hematoma Rate

2.1 Attach Logic Model

Table B.4. PSI 09 Postoperative Hemorrhage or Hematoma Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 09 Postoperative Hemorrhage or Hematoma	**Processes of care** • Management of patient's coagulation related medication during the perioperative phases in alignment with patients' current medications, surgery type, and established guidelines.[1] **Structures of care** • Clinician adherence to strict surgical policies may reduce rates of bleeding and blood clots.[2]	• PSI 09 events are associated with an increased hospital and intensive care unit length of stay and associated hospital costs.[3, 4, 5, 6] • Research has established associations between PSI 09 mortality.[7, 8]

2.2. Evidence of Measure Importance

A postoperative hemorrhage or hematoma includes bleeding or blood clots requiring a procedure after surgery.

Association with Process of Care

Several guidelines and recommendations are available to support clinician decisions to manage patient risks of bleeding and clotting. Moster and Bolliger reviewed current guidelines and summarized their recommendations for non-cardiac, cardiac, and regional anesthesia procedures. Some of the topics contained in the article, along with an example recommendation, include:[1]

- Whether and when to pause vitamin K antagonists, direct-acting oral anticoagulants, and antiplatelet for con-cardiac, cardiac, and regional anesthesia procedure.
  - In patients on chronic anticoagulant therapy, vitamin K antagonists (VKAs) are typically stopped 3 to 5 days prior to surgical or invasive procedures (non-cardiac, cardiac, and regional anesthesia) to allow its anticoagulant effect to dissipate.
- Whether to use lab tests to determine whether the patient's coagulation function has been recovered before surgery.
  - In patients on chronic anticoagulation therapy using VKAs, preoperative laboratory testing is recommended for recovered coagulation function by prothrombin time (PT) or international normalized ratio (INR) due to large interindividual variations in recuperation of vitamin K–dependent coagulation factors.
- Whether and how to bridge the paused medications
  - For non-cardiac surgery patients on chronic anticoagulation therapy using VKA, the value of pre- and postoperative bridging therapy in low-risk patients has been questioned in recent studies.

Association with Structures of Care

Eid and colleagues conducted cross sectional analysis of the Agency for Healthcare Research and Quality (AHRQ) PSIs and Hospital-Consumer Assessment of Healthcare System and Processes (HCAHPS) patient satisfaction scores from 34 Veterans Affairs (VA) Medical Centers (VAMC) and 319 surrounding non-VA hospitals. They found better surgical outcomes and significantly better PSI 09 rates among the VAMCs ($P < 0.05$). These researchers noted this was likely due to strict adherence to surgical quality policies followed by VAMCs.[2]

Association with Downstream Harms

Research has identified an increased length of hospital and intensive care unit (ICU) stay and associated higher medical costs for patients who experience a bleeding complications. In a National Inpatient Sample (NIS)-based study limited to patients with breast cancer hospitalized for a mastectomy in 2011, Nwaogu and colleagues reported a 1.3 day increase in the mean length of stay ($P < 0.0001$), a $5495 increase in the mean cost per hospital stay ($P < 0.0001$), and a reoperation rate of 2.5 percent (42 of 201) associated with a bleeding complication.[3] In another analysis of patient-level Medicare claims data for patients undergoing any of 6 cancer resections in 2005-2009, Short and co-authors found that after adjusting for patient factors (age, sex, race, income), hospital factors (hospital volume, surgeon volume, surgeon specialty designation, hospital resources, patient characteristics) and tumor factors (tumor stage, site), costs increased significantly in association with postoperative hemorrhage or hematoma for four of the six types of cancer resection patients ($p<0.001$).[4] Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 09 event were associated with an additional 2.23 hospital days compared to patients without a PSI 03 event ($p<0.001$).[5] Bath and colleagues found that PSI 09 events were associated with increased length of ICU stay ($P < .001$) among patients who underwent abdominal aortic surgery from 2009-2012 (2018).[6]

Research has established associations between PSI 09, and mortality. De la Garza-Ramos and colleagues estimated the incidence of in-hospital morbidity and mortality following surgery for malignant brain tumors using the National Inpatient Sample from 2002 to 2011; patients who had experienced a hemorrhage/hematoma complication (based on an expanded list of ICD-9-CM codes [998.1–998.13] compared to PSI 09) had 3.3 times higher odds of mortality (95% CI 1.6–6.6) than those who did not experience that surgical complication.[7] Finally, Ang and colleagues used 2013 data from the Florida Agency for Health Care Administration to evaluate trauma mortality using the AHRQ PSIs. Of the 939 PSI 09 events (version 4.5) in 50,596 trauma patients, there were 101 deaths. With an adjusted “failure to prevent” observed-to-expected ratio of 3.53, PSI 09 had the strongest influence on trauma mortality among the 10 PSIs reviewed.[8]

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PSI 10 Postoperative Acute Kidney Injury Requiring Dialysis Rate

2.1 Attach Logic Model

Table B.5. PSI 10 Postoperative Acute Kidney Injury (AKI) Requiring Dialysis

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 10 Postoperative Acute Kidney Injury (AKI) Requiring Dialysis	**Processes of care** • Alignment of clinician practices with process of care included in current guidelines may prevent AKIs from occurring. These include activities such as, ensuring adequate hydration and volume status, avoidance of nephrotoxic medication, optimizing glycemia levels.[2,3] • Conducting risk assessments and working with patients to improve modifiable risk factors pre-operatively, if possible.[4] • Conducting kidney health assessment pre-operatively to support postoperative diagnosis of AKI.[4] **Structures of care** • No factors that can be impacted by hospitals were found to impact postoperative AKI.	• Studies indicate experiencing an AKI may result in patients having longer hospital length of stays, higher medical costs, and a higher risk of mortality.[5, 6, 7, 8, 9]

2.2. Evidence of Measure Importance

Postoperative acute kidney injury requiring dialysis is kidney failure requiring dialysis after surgery.

Association with process of care

Acute Kidney Injury (AKI) is widely considered a preventable postoperative complication.[1] While there is guidance published to support clinical decisions to reduce the likelihood of AKIs, these articles indicate there is not a robust evidence base supporting these recommendations yet.[2, 3, 4]

The Kidney Disease Improving Global Outcomes (KDIGO) published findings they gathered during a conference held to build on their 2012 guidelines. In the bullets below, we provide examples of the topics included and an illustration of associated clinical suggestion:[2]

- Fluid management
  - "Ensuring adequate hydration and volume status is essential in preventing and treating AKI. Oral or I.V. fluid may be administered depending on the local environment and clinical context. The administration of I.V. fluids should be guided by hemodynamic assessment for specific indications and contraindications. When deciding on fluid therapy, consideration for the clinical context and history, including timing of the insult, is critical… Because both the physiological response to fluids and the underlying condition related to AKI are dynamic over time, fluid administration should be based on repeated assessment of overall fluid and hemodynamic status and dynamic tests of fluid responsiveness."
- Nephrotoxic agents and drugs that effect kidney function
  - "Overarching nephrotoxic medication management considerations are as follows:

  - Patients should receive potentially nephrotoxic medications only if needed and only for as long as needed.
  - Potentially nephrotoxic agents should not be withheld in life-threatening conditions, owing to concern for AKI, including i.v. contrast.
  - Kidney function must be monitored in patients who are exposed to agents that are associated with kidney injury or dysfunction, to limit the risk and progression of AKI and AKD.
  - Patients and clinicians need appropriate and effective education as to the potential for kidney injury and dysfunction from nephrotoxic agents."

Gumbert and colleagues published an article on periopertive acute kidney injury which was selected for the anesthesiology continuing medical education program. Examples of the topics and associated guidance included in this article are bulleted below:[3]

- Glycemic control.
  - "…hyperglycemia is considered one of the best independent predictors of mortality and worse outcomes… Practical targets should be in accordance with the 2012 guidelines set forth by the Kidney Disease Improving Global Outcomes (110 to 149 mg/dl) or the statement from the European Renal Best Practice based on guidelines from the Kidney Disease Improving Global Outcomes (140 to 180 mg/dl)".
- Nephrotoxic drugs.
  - "Nephrotoxin-induced acute kidney injury is a considerable risk to patients in the perioperative period. Avoidance and minimizing the duration of exposure of these agents reduces the risk of acute kidney injury development."

The Acute Disease Quality Initiative and the Perioperative Quality Initiative published a joint consensus report in 2021 that included the following topics and associated guidance:[4]

- Risk assessment and targeted interventions.
  - "Use of a validated clinical risk score is a potentially useful approach to risk stratify patients for targeted interventions." "The three validated risk scores for PO-AKI include male sex, age >50 years, diabetes mellitus, hypertension, ascites, heart failure, emergent surgery, intraperitoneal surgery, poly-pharmacy, use of an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB), and increasing American Society of Anesthesiologists physical status classification score."
  - However, the article also mentions:
    - "Whether targeting modifiable risk factors for early postoperative-AKI, for example, using perioperative haemodynamic interventions, will impact the incidence of AKI later in the postoperative period, >48 h after surgery, remains uncertain."
    - "…existing validated risk scores for PO-AKI were developed using a variety of older (pre-KDIGO) definitions of AKI or were applied to select surgical settings. More generalizable prognostic clinical tools are needed to accurately risk-stratify patients preoperatively, particularly to distinguish those patients at the highest levels of risk…"

- Risk-based kidney health assessment (KHA).
  - "A KHA comprises a structured evaluation that includes previous history of AKI, current medications, cardiovascular health, haemodynamic status and markers of kidney function (i.e. serum creatinine) and kidney damage (i.e. urine dipstick). Use of a KHA in the perioperative period involves integrated assessment of patient-specific and procedure-specific risk factors, clinical context and resource setting."
  - "Although we strongly support routine use of KHAs before and after surgery, the potential clinical benefit of this approach has not been formally evaluated and so remains uncertain. However, an accepted advantage of routine perioperative KHAs is improved recognition of preoperative kidney dysfunction, which establishes a baseline for subsequent diagnosis of postoperative AKI."

Association with Structures of Care

We did not identify any studies evaluating modifiable structures of care that could improve this patient safety outcome.

Association with Downstream Harms

Multiple studies have noted that AKI could increase a patient's likelihood of mortality. Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a postoperative AKI were associated with a significantly increased risk of in-hospital mortality (OR=168.91; p<0.001).[5] In a retrospective single-center cohort of 8,887 adult patients who had a major elective non-cardiac surgery, French and colleagues found that AKI was associated with increased mortality rates. In-hospital mortality rates were lower for patients (0.3%) without AKIs compared to patients with AKI (2.0%, 3.8%, and 12.5% for those with AKI stages 1, 2, and 3).[6] Hobson and colleagues' study reported 5-year postoperative AKI mortality rate that were double than the 5-year mortality rates for patients without an AKI.[7]

Studies have also indicated an increase in hospital length of stay and medical costs for patients who experience an AKI. Gray and colleagues found that hospitalizations with a postoperative AKI were associated with an additional 6.37 hospital days compared to hospitalizations without a postoperative AKI (p<0.001).[5] Additionally, French and co-authors, in the study described above, found patients without postoperative AKI had hospital stays had a lower mean total costs of $23,896 compared to patients with AKIs ($33,042, $39,133, and $73,216 for those with AKI stage 1,2, and 3).[6]

Other studies have noted that postoperative AKI may increase likelihood of a patient being readmitted to a hospital. Sundhu and colleagues conducted a study using the Nationwide Readmissions Database on postoperative complications in patients undergoing percutaneous left atrial appendage occlusion (LAAO). The study cited AKIs as one of the leading cause of readmissions in the United States (OR 1.66; 95% CI 1.25-2.20) for patients undergoing a percutaneous LAAO.[8] Similar odds ratios were reported in Bath and colleagues' study. These researchers used Medicare data (MedPAR) from 2009 to 2012 and showed that the likelihood of 30-day readmission among patients undergoing abdominal aortic aneurysm repair was greater among patients with postoperative AKI requiring dialysis compared to patients who did not have a postoperative AKI (OR=1.88, p=0.0001).[9]

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PSI 11 Postoperative Respiratory Failure Rate

2.1 Attach Logic Model

Table B.6. PSI 11 Postoperative Respiratory Failure Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 11 Postoperative Respiratory Failure	**Processes of care** • Conducting risk assessments to identify patients who may need pre- and post-surgical interventions to reduce pulmonary complications.[1, 2, 3] • Postoperative lung expansion exercises. This includes incentive spirometry, deep breathing, intermittent positive-pressure breathing, and continuous positive airway pressure.[1, 2, 3, 4] • Use nasogastric tubes selectively.[1, 2, 3] • Use short acting neuromuscular blockage.[1, 2, 3] **Structures of care** • No factors that can be impacted by hospitals were found to impact postoperative respiratory failure.	• Length of stay was significantly longer for patients with postoperative respiratory failure compared to those without respiratory failure.[9, 10, 11] • Likelihood of hospital readmissions increased for patients who experienced postoperative respiratory failure.[12, 13] • Hospitalizations with a PSI 11 event resulted in a significant increased risk of in-hospital mortality compared to hospitalizations without a PSI 11 event.[14, 15]

2.2. Evidence of Measure Importance

Postoperative respiratory failure is not consistently defined, but is generally understood to be failure to wean from mechanical ventilation within 48 hours of surgery or unplanned intubation/reintubation postoperatively.

Association with Process of Care

There are recommended processes of care aimed to reduce the likelihood of postoperative respiratory failure, including:[1, 2, 3, 4]

- Conducting risk assessments to identify patients who may need pre- and post-surgical interventions to reduce pulmonary complications.
- Postoperative lung expansion exercises. This includes incentive spirometry, deep breathing, intermittent positive-pressure breathing, and continuous positive airway pressure.
- Use nasogastric tubes selectively to avoid aspiration.
- Use short acting neuromuscular blockage.

Research continues to evolve which factors should be evaluated prior to surgery. Recent insights are shared in the studies below:

- Stocking and colleagues conducted a retrospective matched case-control study to assess risk factors for delayed-onset (six or more days after elective surgery) postoperative respiratory failure. The study looked at 59,073 adult patients admitted one of five University of California academic medical centers for elective non-cardiac and non-pulmonary surgical procedures between October 2012 and September

2015. Compared to no postoperative respiratory failure, factors associated with late postoperative respiratory failure included: preexisting neurologic disease (OR 4.36, 95% CI 1.81–10.46), anesthesia duration per hour (OR 1.22, 95% CI 1.04–1.44), and greater maximum intraoperative peak inspiratory pressure per cm H20 (OR 1.14, 95% CI 1.06–1.22).[5]

- Sun and colleagues conducted a meta-analysis to assess literature studying the relationship between lung function damage and postoperative respiratory failure in patients with esophageal cancer. The study looked at 2,822 research subjects across nine articles from PubMed, ScienceDirect, and CNKI and other databases. Researchers found that lung function impairment has a positive relationship with postoperative respiratory failure in patients with esophageal cancer. In addition, case characteristics such as preoperative pneumonia, tuberculosis, and acute respiratory distress syndrome could aggravate the severity of respiratory failure.[6]
- Zainab and colleagues conducted a retrospective analysis to develop and validate a risk score for postoperative respiratory failure after cardiac surgery. The study looked at 4,262 patients admitted to the cardiovascular intensive care unit after major cardiac surgery between January 2013 and December 2017. Researchers found that respiratory failure can be predicted based on body mass index, previous cardiac surgery, cardiopulmonary bypass, cardiogenic shock, pulmonary disease presence, baseline functional status, hemodynamic instability, and number of blood products used intraoperatively.[7]
- In a retrospective time-matched cohort study, Attaallah and colleagues found that operative-specific risk factors including ASA status, elective case type, and surgical duration were significantly associated with postoperative respiratory failure.[8]

Associations with Structures of Care

We did not identify any studies evaluating modifiable structures of care that could improve this patient safety outcome.

Association with Downstream Harms

Several studies found that postoperative respiratory failure is associated with longer length of stay. In a multivariable analysis of NIS data from 2002-2010, Rahman and colleagues found that length of stay was significantly longer for patients with postoperative respiratory failure (median 8.0 days) compared to those without respiratory failure (median 4.0 days, $p<0.0001$).[9] Using National Surgical Quality Improvement Program data, Gajdos and colleagues found that failure to wean from ventilator and reintubation were associated with longer postsurgical length of stay in all age groups compared with participants not having these complications (median length of stay ≥19 days with complications; $p<0.001$).[10] In a smaller study (n=178), Marda and colleagues found that mean duration of intensive care unit (ICU) and hospital stay after surgery was significantly longer in patients who had postoperative pulmonary complications (PPCs), including respiratory failure, as compared to patients without PPCs (9.5 ± 14.8 days vs. 2.7 ± 1.8 days, [$p < 0.001$]; 22.6 ± 16.8 days vs. 7.6 ± 2.8 days [$p < 0.001$], respectively).[11]

Studies also found that that postoperative respiratory failure is associated with complications such as higher 30-day readmission rates and postoperative pulmonary complications. In a cross-sectional analysis of the Veterans Affairs (VA) Patient Treatment File, including 1,807,488 index hospitalizations and 262,026 readmissions, Rosen and colleagues found that 30-day readmission rates after surgical hospitalizations with a PSI 11 event (17.8%) were significantly higher than after surgical hospitalizations without a PSI 11 event (9.9%) ($p<0.0001$), with an adjusted odds ratio of 1.39 (95% CI 1.25 to 1.54). Likewise, prolonged ventilation was more frequent among readmitted patients (4.4%) than among patients who were not readmitted (2.7%, $p<0.001$).[12] Bath and colleagues used Medicare data (MedPAR) from 2009 to 2012 and found that the odds of 30-day readmission among patients undergoing abdominal aortic aneurysm repair were increased among patients with postoperative respiratory failure (OR=1.44, $p<0.0001$).[13]

Studies have demonstrated that postoperative respiratory failure is independently associated with mortality. Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 11 event were associated with a significantly increased risk of in-hospital mortality (OR=248.93; $p<0.001$).[14] Stocking and colleagues found that compared to 95 matched patients with no postoperative respiratory failure and 319 patients who developed early postoperative respiratory failure, late postoperative respiratory failure was associated with higher morbidity and mortality.[15]

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PSI 12. Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate

2.1 Attach Logic Model

Table B.7. Perioperative Pulmonary (PE) Embolism or Deep Vein Thrombosis (DVT) Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 12. Perioperative Pulmonary (PE) Embolism or Deep Vein Thrombosis (DVT)	**Processes of care** • Recommended prophylaxis strategies to prevent PE and DVTs for surgical patients are available to support clinician practice. These recommendations are complex including specifics such as level of PE/DVT and bleeding risk, and type of surgery.[1, 2, 3] **Structure of care** • Hospitals develop a formal strategy to prevent VTEs. This may include a preferred VTE and bleeding risk assessment models, clinical decisions supports, such as a linked menu of appropriate VTE prophylaxis options for each level of risk including information regarding timing with surgical procedure.[4, 5, 6] • Higher percentage of registered nurses with baccalaureate or higher degrees are potentially coordinated with lower PE and DVTs.[7]	• An estimated 60,000 to 100,000 people living in the United States die of a VTE each year. VTE is the leading cause of preventable[11] hospital deaths in the America. • Patients with a VTE have been shown to have longer lengths of hospital stays, increased likelihood of readmissions, and higher medical costs than patients without VTEs.[12, 13, 14, 15] • Short and long term medical complications of VTEs include: VTE reoccurrence, post-thrombotic syndrome (which includes swelling, pain, discoloration, and scaling in the affected limb), and chronic thromboembolic pulmonary hypertension These complications often require hospital readmissions.[12]

2.2. Evidence of Measure Importance

Perioperative pulmonary embolism (PE) or deep vein thrombosis (DVT) is the clinical term for developing blood clots in the lung or large leg vein after surgery. Collectively PE and DVT are called venous thromboembolisms (VTE).

Association with Process of Care

Recommendations are available for supporting clinician decision making regarding use and selection of VTE prophylaxis for patients undergoing surgery. These guidelines are complex and include details about the type of surgery and associated patient risks to support appropriate selection of VTE prophylaxis. We provide a non-exhaustive list of recommendations and guidelines below.

- Venous Thromboembolism Prophylaxis and Treatment in Patients With Cancer: ASCO Guideline Update (2023).[1] This guideline provides specific guidance for how to reduce the risk of VTE for patients with cancer undergoing surgery. A few examples of these recommendations include:
  - All patients with malignant disease undergoing major surgical interventions should be offered pharmacological thromboprophlaxis with either unfractionated heparin or low molecular weight

heparin unless contraindicated because of active bleeding, high bleeding risk, or other contraindications.

- Prophylaxis with UFH or LMWH should be commenced preoperatively.
- Mechanical methods may be added to pharmacologic thromboprophylaxis but should be not used as a monotherapy for VTE prevention unless pharmacologic methods are contraindicated because of active bleeding or high bleeding risk.
- A combination regimen of pharmacologic and mechanical prophylaxis may improve efficacy, especially in the highest-risk patients.
- Pharmacological thromboprophylaxis for patients undergoing major surgery for cancer should be continued for at least 7-10 days.
- Extended pharmacologic thromboprophylaxis for up to 4 weeks postoperatively should be offered to patients undergoing major open or laparoscopic abdominal or pelvic surgery for cancer who have high-risk features, such as restricted mobility, obesity, history of VTE, or with additional risk factors. In lower-risk surgical settings, the decision on appropriate duration of thromboprophylaxis should be made on a case-by-case basis.

- Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. This is a set of clinical guidelines that provide specific guidance for how to reduce the risk of VTE for patients undergoing specific surgeries. We provide examples of those recommendations by surgery type below:
  - Prevention of VTE in Nonorthopedic Surgical Patients.[2]
    - For general and abdominal-pelvic surgery patients at very low risk for VTE (< 0.5 percent; Rogers score, < 7; Caprini score, 0), we recommend that no specific pharmacologic or mechanical prophylaxis be used other than early ambulation.
    - For general and abdominal-pelvic surgery patients at low risk for VTE (~1.5 percent; Rogers score, 7-10; Caprini score, 1-2), we suggest mechanical prophylaxis, preferably with intermittent pneumatic compression (IPC), over no prophylaxis.
    - For general and abdominal-pelvic surgery patients at moderate risk for VTE (~3.0 percent; Rogers score, . 10; Caprini score, 3-4) who are not at high risk for major bleeding complications, we suggest low-molecular-weight heparin, low-dose unfractionated heparin, mechanical prophylaxis, preferably with IPC over no prophylaxis.
    - For high-VTE-risk general and abdominalpelvic surgery patients who are at high risk for major bleeding complications or those in whom the consequences of bleeding are thought to be particularly severe, we suggest use of mechanical prophylaxis, preferably with IPC, over no prophylaxis until the risk of bleeding diminishes and pharmacologic prophylaxis may be initiated.
  - Prevention of VTE in Orthopedic Surgery Patients.[3]

- In patients undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA), we recommend use of one of the following for a minimum of 10 to 14 days rather than no antithrombotic prophylaxis: low-molecular-weight heparin, fondaparinux, apixaban, dabigatran, rivaroxaban, low-dose unfractionated heparin, adjusted-dose vitamin K antagonist, aspirin, or intermittent pneumatic compression.
- For patients undergoing major orthopedic surgery (THA, TKA, Hip Fracture Surgery) and receiving low-molecular-weight heparin as thromboprophylaxis, we recommend starting either 12 hours or more preoperatively or 12 hour or more postoperatively rather than within 4 hours or less preoperatively or 4 hours or less postoperatively.

Associations with Structures of Care

Given the complexity of the guidelines and the need to balance preventing major bleeding and VTEs, it is recommended that hospitals develop a formal strategy to prevent VTEs.[4] This may include a preferred VTE and bleeding risk assessment models, and clinical decisions supports (such as a linked menu of appropriate VTE prophylaxis options for each level of risk including information regarding timing with surgical procedures).[5, 6]

One study demonstrated that hospitals with higher percentages of registered nurses with baccalaureate or higher degrees had lower rates of PSI 12.[7] Studies were inconclusive regarding the impact of hospital factors such as nurse staffing hours,[8] safety climate,[9] and the implementation of duty-hour regulations.[10]

Association with Downstream Harms

An estimated 60,000 to 100,000 people living in the United States die of a VTE each year. VTE is the leading cause of preventable hospital deaths in the America.[11]

Literature suggests that VTE-related inpatient stays, including admissions for VTE diagnosis, are associated with readmissions and healthcare expenditures. A review estimated per-patient and aggregate medical costs or expenditures related to VTE in the United States. The review found that the treatment of an acute VTE on average appears to be associated with incremental direct medical costs of $12,000 to $15,000 (2014 US dollars) among first-year survivors, controlling for risk factors. In addition, subsequent complications, such as VTE reoccurrence, post-thrombotic syndrome (which includes swelling, pain, discoloration, and scaling in the affected limb), and chronic thromboembolic pulmonary hypertension, are estimated to increase cumulative costs to $18,000–23,000 per incident case. Overall, the review estimated that the annual incident VTE events conservatively cost the US healthcare system $7–10 billion each year for 375,000 to 425,000 newly diagnosed, medically treated incident VTE cases.[12] Another study examined in-hospital costs for VTE for hospitalizations of 3,146,388 individual patients with cancer. The study found the average costs per hospitalization adjusted to 2015 dollars for patients without and with VTE were $19,994 and $37,352, respectively.[13]

The American Heart Association states that acute VTE is a leading contributor to increased length of stay.[14] Researchers in 2017 retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 12 event were associated with an additional 2.83 hospital days compared to patients without a PSI 12 event ($p<0.001$).[15]

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PSI 13. Postoperative Sepsis Rate

2.1 Attach Logic Model

Table B.8. PSI 13. Postoperative Sepsis Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 13. Postoperative Sepsis	**Processes of care** • Use recommended practices to reduce the likelihood of infections which can develop into sepsis. Best practices differ by source of infection. Three examples include: – Surgical site infection: preform intraoperative skin preparation with an alcohol-based antiseptic agent, unless contraindicated.[2] – Pneumonia: provide regular oral care.[3] – Catheter associated urinary tract infections: remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use.[4] • To identify sepsis infection quickly and manage it effectively, align clinical action with recommended best practices, such completing sepsis screening for acutely ill, high-risk patients and for those adults found to have sepsis or sepsis shock, rapidly identifying or excluding a specific anatomical diagnosis of infection that requires emergent source control and implementing any required source control interventions as soon as medically and logistically practical.[5] **Structures of care** • Better working conditions for nurses may be correlated with reducing the likelihood patients contract postoperative sepsis.[6] Lower patient to nurse ratios[6, 7] and high nurse education[6] may be associated with a higher likelihood of sepsis survival.	• Readmissions,[8] mortality,[9, 10] and medical costs[10, 11, 12] have been shown to be higher for surgical patients who experience sepsis.

2.2. Evidence of Measure Importance

Post operative sepsis is the clinical term for developing a blood stream infection after surgery.

Association with Process of Care

Sepsis can develop from an infection in the body. Preventing the infection from occurring is a strategy for preventing sepsis.[1] There are processes of care that hospitals can use to prevent infections from happening. We discuss a non-comprehensive list of infections (surgical site infections, pneumonia, and catheter associated urinary tract infection) below to illustrate there are recommended best practices that hospitals can utilize for reducing the likelihood of surgical patients experiencing these infections.

One pathway for developing postoperative sepsis is through a surgical site infection. The Centers of Disease Control and Prevention (CDC) developed a set of recommendations on how to prevent surgical site infections.[2] Some examples of the strongest recommendations in the guideline include:

- In clean and clean-contaminated procedures, do not administer additional prophylactic antimicrobial agent doses after the surgical incision is closed in the operating room, even in the presence of a drain.
- Implement perioperative glycemic control and use blood glucose target levels <200 mg/dL in diabetic and non-diabetic patients.
- For patients with normal pulmonary function undergoing general anesthesia with endotracheal intubation, administer increased FiO2 intraoperatively and post-extubation in the immediate postoperative period. To optimize tissue oxygen delivery, maintain perioperative normothermia and adequate volume replacement.
- Perform intraoperative skin preparation with an alcohol-based antiseptic agent, unless contraindicated.

A second pathway to developing sepsis is through a pneumonia infection. There is less clear evidence in best practices to reduce the incidence of post-operative pneumonia. However, five medical organizations collaborated to develop recommendations published in 2022 for preventing hospital-acquired pneumonia.[3] The activities they recommend or suggest may reduce this infection include, but are not limited to: minimizing duration of mechanical ventilation, providing regular oral care, elevating the head of the bed, providing early mobilization.

The final pathway we will review in this form is catheter associated urinary tract infection (CAUTI). CDC published a guideline in 2009 to provide recommendations to reduce CAUTIs. A few of their recommended actions include:[4]

- Use urinary catheters in operative patients only as necessary, rather than routinely.
- For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use.
- In the acute care hospital setting, insert urinary catheters using aseptic technique and sterile equipment.
- Use sterile gloves, drape, sponges, an appropriate antiseptic or sterile solution for periurethral cleaning, and a single-use packet of lubricant jelly for insertion.
- Following aseptic insertion of the urinary catheter, maintain a closed drainage system
- Maintain unobstructed urine flow.

An important aspect of sepsis care is identifying and managing the patient’s sepsis infection so that it does not lead to additional negative outcomes, such as death. The primary recommendation for managing sepsis is the 2021 Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock.[5] Some examples of the strongest recommendations and noted best practices in the guideline include:

- For hospitals and health systems, we recommend using a performance improvement program for sepsis, including sepsis screening for acutely ill, high-risk patients.
- Sepsis and sepsis shock are medical emergencies, and we recommend that treatment and resuscitation begin immediately.

- For adults with possible sepsis without shock, we recommend rapid assessment of the likelihood of infectious versus non-infectious causes of acute illness.
- For adults with sepsis or septic shock at high risk of MRSA, we recommend using empiric antimicrobials with MRSA coverage over using antimicrobials without MRSA coverage.
- For adults with sepsis or sepsis shock, we recommend optimizing dosing strategies of antimicrobials based on accepted pharmacokinetic/pharmacodynamic principles and specific drug properties.
- For adults with sepsis or sepsis shock, we recommend rapidly identifying or excluding a specific anatomical diagnosis of infection that requires emergent source control and implementing any required source control interventions as soon as medically and logistically practical.

Associations with Structures of Care

Dierkes and colleagues in 2021 reported that better working conditions for nurses were shown to reduce the odds for postoperative sepsis.[6] Additionally, the researchers found that lower patient to nurse ratios and high nurse education was also associated with a higher likelihood of sepsis survival. Specifically, researchers examined the relationship between nursing staff characteristics and postoperative sepsis incidence from 1,241,3330 general, orthopedic, and vascular surgery patients. Dierkes and colleagues found that the odds of surgical patients developing sepsis while cared for in "best" work environments were lower than for patients in "worst" work environments by 12 percent. The authors characterized work environments by using the average scores from the Practice Environment Scale of the Nursing Work Index survey. This survey assesses the following work environments (1) nurse participation in hospital affairs, (2) nursing foundations for quality of care, (3) nurse manager ability, leadership, and support of nurses, and (4) collegial nurse-physician relations. Additionally, these researchers found that an association between an additional patient per nurse and a 2 percent increase in odds of death (OR, 1.02; 95% CI, 1.00–1.04, $P = .05$), which suggests that a smaller patient-to-nurse ratio is associated with increase patient survival. In addition, the researchers found a 1-unit increase in education (representing a 10% increase in BSN-prepared nurses) was associated with 6 percent lower odds of death among postsurgical sepsis patients (OR, 0.94; 95% CI, 0.92–0.96; $P < .001$).[6] Building on this evidence, another set of researchers found that sepsis rates were significantly lower when nurses cared for fewer patients and when intensivist hours were greater.[7]

Association with Downstream Harms

Several studies have examined the relationship between postoperative sepsis and subsequent outcomes, including readmissions, mortality, and costs.

Rosen and colleagues reported that hospitalizations with postoperative sepsis had a significantly higher all-cause readmission rate (19.2 percent) than hospitalizations without PSI 13 (13.0%; $p < 0.0001$). In a multivariable analysis controlling for age, sex, comorbidities, and other PSI events, hospitalizations with a PSI 13 event had 32 percent higher odds of having a subsequent readmission (OR 1.32; 95% CI 1.12 to 1.57).[8]

Gonzalez and colleagues in 2023 examined the 30-day sepsis mortality rates for patients undergoing hip fracture surgery and found that the 30-day mortality rate was 16.2 percent in patients with sepsis and 40.8 percent in patients with septic shock.[9] Vogel and colleagues, in 2010, found that hospital mortality was significantly higher (25.88% vs. 0.81%, P<0.0001) for patients who developed postoperative sepsis than surgical patients who did not.[10]

Researchers identified increased medical costs stemming from postoperative sepsis. Vogel and colleagues in 2010 using Healthcare Cost and Utilization Project (HCUP) data found a 3.3-fold increase in hospital costs for patients who experienced postoperative sepsis compared to than who did not ($57,032 versus $17,229 P<0.0001).[10] Another study in 2011 using Veteran Affairs hospital data, Vaughan-Sarrazin and colleagues reported a similar cost, estimating a risk adjusted cost of postoperative sepsis to be $26,972 ($48,017 versus $21,045).[11] A third study in 2018 using Premiere data, researchers identified that sepsis not present on admission (but not specifically limited to postoperative sepsis) had a mean cost similar to the other studies of $51,022.[12]

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PSI 14 Postoperative Wound Dehiscence Rate

2.1 Attach Logic Model

Table B.9. PSI 14: Postoperative Wound Dehiscence Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 14: Postoperative Wound Dehiscence	**Processes of care** • Assessing and addressing patient and clinical risk factors prior to surgery.[1] • A clinician's selection of postoperative dressing should consider: keeping the wound occluded, with the correct moisture balance, and confirm the patient is comfortable with their dressing. The dressing should be able to allow range of movement for normal daily activities, be waterproof and able to stay in situ beyond 48 hours. The dressing must be easy to apply and be atraumatic upon removal. Protection of the periwound skin must also be considered with minimizing blistering.[1] • Appropriate holistic patient assessment and skin inspection using a predefined assessment checklist will aid in determining the extent and severity of the complication. Patient surgical wound assessment must adhere to local and national standards.[1] • Point-of-care fluorescence imaging is a diagnostic technology that could be of significant benefit in early identification of surgical site infections and may be a useful tool for early detection of other surgical wound complications.[1] • Developing therapeutic relationships with the patient, family and carers enables the opportunity to educate and empower the patient to self-management of their wound. The use of a patient-centric checklist when assessing the patient's home environment, access to health resources and the ability to manage their own care will guide the wound care management plan for the patient.[1] • Nursing care processes, such as teaching patients to splint the surgical site when coughing, vomiting or sneezing and suggesting to avoid heavy lifting (10 lbs or more) for 6 to 8 weeks post surgery.[2] **Structures of care** • No factors that can be impacted by hospitals were found to impact post operative wound dehiscence.	• Patients with a dehiscence have been shown to have longer lengths of hospital stays, increased risk of readmissions, and higher medical costs than patients without a dehiscence.[3, 4, 5]

2.2. Evidence of Measure Importance

Postoperative wound dehiscence is a wound that splits open after surgery on the abdomen or pelvis.

Association with Process of Care

The International Surgical Wound Complication Advisory Panel published a consensus document in 2022 that provides insight into prevention activities clinicians can consider for preventing wound dehiscence. The panel makes the following recommendations or statements:[1]

- Incorporate patient risk assessment as part of a comprehensive pre-surgical process in tandem with other validated risk assessment systems. Some examples of these risk factors include: age, psychological stress, chronic disease and comorbidities, medication and polypharmacy, radiotherapy, smoking, alcohol and substance dependency, and malnutrition.
- The most important fundamental factors in selecting a postoperative dressing are to keep the wound occluded, with the correct moisture balance, and ensure that the patient is comfortable with their dressing. The dressing should be able to allow range of movement for normal daily activities, be waterproof and able to stay in situ beyond 48 hours. The dressing must be easy to apply and be atraumatic upon removal. Protection of the periwound skin must also be considered with minimizing blistering.
- Appropriate holistic patient assessment and skin inspection using a predefined assessment checklist will aid in determining the extent and severity of the complication. Patient surgical wound assessment must adhere to local and national standards.
- Point-of-care fluorescence imaging is a diagnostic technology that could be of significant benefit in early identification of surgical site infections and may be a useful tool for early detection of other surgical wound complications.
- Developing therapeutic relationships with the patient, family and carers enables the opportunity to educate and empower the patient to self-management of their wound. The use of a patient-centric checklist when assessing the patient's home environment, access to health resources and the ability to manage their own care will guide the wound care management plan for the patient.

The panel also discusses the following topics:

- In addition to conducting risk assessments, clinicians should also mitigate risk, if possible, prior to surgery. This could include: delaying surgery, working with patients to modify risky behaviors, and selecting prophylactic products to manage risk post-surgery.
- Preoperative hydration and nutrition management, blood glucose management and early mobilization after surgery has reduced the occurrence of postoperative complications.
- Using diagnostic technology may help reduce human error related to identify surgical wound complications.
- Negative pressure wound therapy was discussed. There is conflicting evidence for use in negative pressure wound therapy for closed surgical incisions. There is more use of this technology in chronic wounds, surgical wounds healing by secondary intension, and where heavy leakage may be an issue.

Other sources have suggested additional nursing care processes are useful in preventing wound dehiscence from occurring. For example, teaching patients to splint the surgical site when coughing, vomiting or sneezing and suggesting to avoid heavy lifting (10 lbs or more) for 6 to 8 weeks post surgery.[2]

Association with Structures of Care

We did not identify any studies evaluating modifiable structures of care that could improve this patient safety outcome.

Association with Downstream Harms

Studies have examined the relationship between postoperative wound dehiscence and outcomes including length of stay in the hospital, mortality, readmissions, and healthcare costs. In a report from 2003, Zhan and colleagues reported that the second most serious event (behind postoperative sepsis) was postoperative wound dehiscence, with 9.42 extra days in the hospital, $40,323 in excess charges, and 9.63% attributable mortality.[3]

Building on the findings from 2003, Short and colleagues reported in 2014 on an analysis of patient-level Medicare claims data for patients undergoing any of 6 cancer resections for the years 2005-2009. These researchers found that after adjusting for patient (age, sex, race, income), hospital characteristics (hospital volume, surgeon volume, surgeon specialty designation, hospital resources, patient characteristics) and tumor factors (tumor stage, site), costs increased significantly, by more than 40%, for postoperative wound dehiscence among 4 of the 6 types of cancer resection patients ($p < 0.001$).[4]

Gray and co-authors retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations with a PSI 14 event were associated with an additional 3.09 hospital days compared to patients without a PSI 14 event ($p<0.001$), as well as a significantly increased risk of in-hospital mortality (OR=72.56; $p<0.001$).[5]

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PSI 15 Abdominopelvic Accidental Puncture or Laceration Rate

2.1 Attach Logic Model

Table B.10. PSI 15 Abdominopelvic Accidental Puncture or Laceration Logic Model

Indicator	Structures/ Processes of Care Associated with Lower PSI Rates	Potential Downstream Harms Associated with PSI Event
PSI 15 Abdominopelvic Accidental Puncture or Laceration	**Processes of care** • Identify the ureter during pelvic and abdominal surgeries to reduce likelihood of injury.[1, 2] • Decompress the bladder.[1] **Structures of care** • Engage surgeons and multidisciplinary teams to develop a solution to any problematic distractions.[3] • Provision of training and supervision regarding equipment use.[3]	• Abdominopelvic accidental punctures or lacerations may increate a patients length of hospital stay, medical costs, and risk for mortality.[8, 10, 11, 12] Impact on readmissions is mixed.[7, 8, 9]

2.2. Evidence of Measure Importance

Abdominopelvic accidental punctures or lacerations are accidental cuts and tears requiring a corrective procedure after an abdominal or pelvic surgery.

Much of the published literature regarding PSI 15 concerns the pre-2015 version of the indicator, previously named “Unrecognized Abdominopelvic Accidental Puncture or Laceration.” The difference between the two versions is that the current version requires a second operation whereas the earlier specification did not.

Association with Process of Care

Practical suggestions to support prevention of accidental punctures and lacerations include:

- Identify the ureter during pelvic and abdominal surgeries to reduce likelihood of injury.[1, 2] This may include preoperative ureteral radiographic imaging, but routine placement of stent in the ureter is not recommended.[1]
- Decompress the bladder. A full bladder is more likely to be injured laparoscopically.[1]

Association with Structures of Care

While there are minimal rigorous studies available to support structures of care that could reduce the likelihood of accidental punctures or lacerations, the Healthcare Excellence Canada reviewed and summarized available literature to support developing suggestions on how to prevent these accidents from happening. The articles reviewed used patient safety reporting and alert system information to identify causes of lacerations and punctures. We provide the causes shared in their article relevant to abdominal or pelvic surgery along with any suggestions provided to mitigate the cause.[3]

- Cause: Distractions. While distractions are part of care collaboration across clinicians, non-purposeful distractions can result in patient safety issues, such as lacerations. To mitigate this issue, hospitals could engage surgeons and multidisciplinary teams to develop a solution to any problematic distractions.

- Cause: Equipment errors. While clinicians cannot prevent equipment malfunctions, they can support mitigations strategies regarding user error of the equipment. These user errors include wrong application, improper use, or unapproved use of equipment. Hospital provision of training and supervision regarding equipment use could reduce the likelihood of associated safety events.

Other studies have examined the role played by factors such as procedure timing, physician rank, duty-hour regulations, and patient safety climate and have found no relationship between these factors and PSI 15 rates. For example, Shelton and colleagues analyzed 376 million patient discharges from National Inpatient Sample between 1998-2007 to evaluate the effect of the 2003 U.S. implementation of duty-hour regulations, limiting resident work hours to 80 per week, within teaching and non-teaching hospitals; non-teaching hospitals served as the control group. They found that the rates of accidental puncture or laceration prior to implementation were 30.27 and 42.27, per 10,000 discharges, in non-teaching and teaching hospitals, respectively. Rates of accidental puncture or laceration were not significantly altered after the implementation of the duty-hour regulations (non-teaching 28.62, teaching 24.65 per 10,000 discharges).[4] In another study, Chen and colleagues examined whether PSI 15 events are affected by hospital processes of care such as timing of procedure and physician rank (e.g., attending physician, physician in training). Using Veterans Affairs (VA) administrative data from October 2002-September 2007, AHRQ PSI software (version 3.1a), and medical chart review, the authors identified 95 matched case-control pairs for PSI 15. There were no significant differences found for operating room procedures performed during the weekend (n=3, 3.9%; n=4, 4.4%) or at night (n=3, 3.9%; n=7, 7.8%) between cases and controls, respectively.[5] The authors also found no association between physician rank and PSI 15 within the matched pairs – attending physicians (cases n=33, 42.3%, controls n=33, 36.7%) and trainees (cases n=41, 52.6%; controls n=53, 58.9%) had similar rates of PSI 15 events.[5] Another study found no association between safety climate across 30 VA hospitals, as measured through more than 4500 responses to the Patient Safety Climate in Healthcare Organizations survey, and rate of accidental puncture or laceration (p>0.10 for all safety dimensions reviewed).[6] However, due to small sample size, the relatively low rate of PSIs among VA hospitals, and narrow variation across hospitals in patient safety culture, statistical power to detect associations was limited.

Association with Downstream Harms

Studies indicate mixed results regarding impact of PSI 15 on readmissions. Rosen and colleagues examined whether PSI events, experienced within index hospitalizations, increased the likelihood of readmission within VA hospitals.[7] Of the 1,807,488 index medical and surgical hospitalizations, there were a total of 262,026 readmissions. Accidental puncture or laceration resulted in significantly higher rates of all-cause readmissions (15.3%) compared to those hospitalizations without an event (14.6%; p<0.0001). Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations involving an accidental puncture or laceration were associated with a significantly increased risk of 30-day in-hospital mortality (OR=2.59; p<0.001).[8] Using the American College of Surgeons -National Surgical Quality Improvement Program (ACS-NSQIP) dataset, Nandan and colleagues found that in multivariable analyses, PSI 15 events were associated with an increase in readmission rates (OR=2.17; p=0.008). However, in a multivariate analysis using AHRQ comorbidity software (version 3.5) - controlling for age, sex, comorbidities, and other PSI events -

hospitalizations with a PSI 15 event were not significantly more likely to result in subsequent readmissions (OR 1.07; 95% CI 0.99 to 1.15).[9]

One study identified higher medical costs for patients who experience accidental punctures or lacerations. Short and colleagues conducted an analysis of patient-level Medicare claims data for patients undergoing any of 6 cancer resections for the years 2005-2009. Researchers found that after adjusting for patient (age, sex, race, income), hospital (hospital volume, surgeon volume, surgeon specialty designation, hospital resources, patient characteristics) and tumor factors (tumor stage, site), costs increased significantly, by 15 percent to 21 percent for accidental puncture or laceration among 4 of the 6 types of cancer resection patients ($p<0.001$).[10]

PSI 15 events have also been linked with longer length of hospital stay. In a retrospective study using data collected from a single-hospital department of colorectal surgery, Kin and colleagues found that accidental puncture or laceration cases had more diagnoses of enterocutaneous fistula (11% vs 2%, $p < 0.001$), reoperative cases (91% vs 61%, $p < 0.001$), open surgery (96% vs 77%, $p < 0.001$), longer operative times (186 vs 146 minutes, $p = 0.001$), and increased length of stay (10 vs 7 days, $p = 0.002$).[11] Gray and colleagues retrospectively examined 57,000 inpatient discharges at six hospitals between July 2012 and June 2014 and found that hospitalizations involving an accidental puncture or laceration were associated with an additional 1.35 hospital days compared to patients without an event ($p<0.001$).[8] Bohnen and colleagues used ACS-NSQIP data from 2007 to 2012 and found that in multivariable analyses, PSI 15 events were independently associated with prolonged postoperative length of stay (OR=1.85; $p=0.001$).[12]

Researchers have also linked PSI 15 events to increased risk of mortality. Gray and colleagues found that hospitalizations involving an accidental puncture or laceration were associated with a significantly increased risk in-hospital mortality (OR=2.59; $p<0.001$).[8] Bohnen and colleagues used ACS-NSQIP data from 2007 to 2012 and found that in multivariable analyses, PSI 15 events were independently associated with increased 30-day mortality (OR=3.19; $p=0.002$).[12]

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