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Pressure Injury Prevention in Cardiac Surgery Using Risk Factor Assessment and Standardization

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Abstract

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Keywords

Pressure injury prevention, cardiac surgery, risk factors, decubitus ulcer, risk assessment, pressure injury

Disciplines

Critical Care Nursing | Nursing | Perioperative, Operating Room and Surgical Nursing

Pressure Injury Prevention in Cardiac Surgery Using Risk Factor Assessment and Standardization

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August 5, 2021

Abstract

Cardiac surgical patients are more susceptible to pressure injury (PI) than other surgical specialties, and little is known about PI prevention (PIP) in this population. How do PIP strategies, compared to standard care, affect the incidence of PI during the post-operative recovery among adult cardiac surgery patients? The aim was to reduce the incidence of UAPI in an adult CVSICU by 5% in six weeks. The conceptual framework chosen was The Iowa Model Revised, and the theoretical framework employed was the Theoretical Model for Lesion Development. Quality improvement, single-group pretest-posttest design. Sample consisted of 69 cardiac surgery, LVAD, ECMO patients at Johns Hopkins CVSICU. The intervention was a standardized PIP bundle provided to “highest risk” patients screened before surgery. Outcome measures were UAPI count and incidence rates. Process measures were percentage of patients screened, prophylactic sacral dressing, rental bed cost. Balancing measures were PI severity, anatomic location, and time between wounds. Baseline data consisted of historic data and intervention data consisted of weekly survey observations. Implementation consisted of staff education, daily preoperative screening, weekly wound rounds. 33% of patients screened as “highest risk” and received the PIP bundle. PI count decreased from 25 to 13 during implementation and wound stages improved. Chi Square test of 2-proportions showed a reduced PI incidence of 8.56% ($Z=1.66$, $p=.048$) and 2-sample Poisson rate showed significance in count ($Z=1.95$, $p=.036$). Location changed to nose, buttocks, and occipital locations. There was an overall cost savings of \$78,660. Reducing PI lead to reduced morbidity and cost.

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Pressure Injury Reduction in Cardiac Surgery Using Risk Factor Assessment and Standardization

Most cardiac surgery procedures require multiple hours in the operating room, including time devoted to patient positioning, preparation, and sedation. During cardiac surgery, anesthesia renders patients acutely immobile, sedated, and unable to sense pain produced by prolonged pressure (Chen, Yu, et al., 2018). Upon completion of surgery, the patient may experience shearing forces on the skin, while being transferred from the operating room table to the hospital bed. Subsequent repositioning and “boosting” in the bed contribute to recurrent shearing forces to the skin throughout the patient’s recovery (Chen, Yu, et al., 2018). Coupled with compressive force from prolonged immobility and reduced proprioception, the two forces contribute to reduced tissue tolerance for pressure at the skin level (Geller & Seng, 2020). This reduction in tissue tolerance for pressure affects perfusion to the skin and underlying tissues, leading to reduced tissue tolerance for oxygen. Changes in capillary blood flow, exacerbated by vasopressor use, pre-existing conditions, and other risk factors, contribute to a mismatch of oxygen supply and demand at the tissue level (Geller & Seng, 2020). The mismatch of oxygen supply and demand at the tissue level contributes to a pressure injury (PI), an injury caused by pressure and/or shear effects (Edsberg et al., 2016).

Background and Significance

PI is a common side effect of many high-acuity surgeries, and the uniqueness of the cardiac surgery population affords a higher risk of skin breakdown compared to most other surgical specialties. Incidence of PI among cardiac surgery patients is variable according to the literature. One meta-analysis by Chen et al. (2012) stated that the pooled incidence of PI among cardiac surgery patients was 18%, whereas other studies cite an incidence as high as 29.5% (Rao

et al., 2016). Hospital-acquired pressure injuries (HAPI) complicate the patient's experience, causing pain, disability, possible infection, emotional distress, and in rare cases, death, as well as increasing the overall cost of care (Geller & Seng, 2020). The Centers for Medicare & Medicaid Services (CMS) have outlined stage III and IV HAPI as "never events," unfavorably affecting reimbursements for the treatment of HAPI (Rao et al., 2016). The costs associated with treating HAPI can be staggering, ranging from \$500 to \$70,000 per individual pressure injury, and increasing length of stay an average of 11 additional hospital days (Rao et al., 2016).

Furthermore, many American acute care facilities report their PI prevalence rates to the National Database of Nursing Quality Indicators (NDNQI) at least quarterly, and benchmark this prevalence data with other acute care institutions across the country (National Database of Nursing Quality Indicators, 2011). Non-profit organizations, such as The Leapfrog Group, benchmark and publicly report safety and quality measures, ranking a hospital's overall safety using a letter grade (e.g., "A" representing the best Leapfrog Hospital Safety Grade, followed by "B," "C," "D," and "F") based on a methodology comprised of 28 national CMS performance measures and a Leapfrog hospital survey (The Leapfrog Group, 2019). This data and grading are public information and may influence patient hospital choice and overall hospital ranking, affecting reputation, potential income, high-level research prospects, and overall reimbursement. All of these factors contribute to a need to reduce the incidence of PI, and to improve the science of PI prevention in cardiac surgery.

Problem Statement and Clinical Question

Little is known about the current state of the science regarding PI prevention strategies among cardiac surgery patients, and its current impact on patient care. Moreover, the current literature contains multiple levels of evidence, much of which is considered quality improvement

and lacks randomization. Consequently, a research question was developed using the PICOT format to examine the problem. The research question developed for this project was: (P) How do (I) PI prevention strategies, (C) compared to standard care, affect the (O) prevalence of PI during the (T) post-operative inpatient recovery among adult cardiac surgery patients?

Review of the Literature

Literature suggests that pressure injury is a major comorbid event due to cardiac surgery, and that cardiac surgery itself is a risk factor for skin breakdown (Chello et al., 2019). The mechanisms of injury lie in three distinct categories: (1) compressive and shearing forces, (2) tissue tolerance for pressure, and (3) tissue tolerance for oxygen, and that literature lacks experimental clinical trials and studies that focus on cardiac surgery patients uniquely (Chello et al., 2019). Researchers have attempted to tackle the issue using a litany of strategies and have examined the problem from many angles. The variety of research available, as well as the overall quality, is wide in scope and nature (Table 1).

Many researchers have sought to understand the current evidence and the depth of the problem, looking to analyze the current research. Ettema and colleagues (2014) systematically reviewed the literature, examining preadmission interventions in the literature that improved post-operative complications among older cardiac surgery patients. The findings of the paper included multiple post-operative complications but was unable to find pre-operative interventions proven to reduce post-operative PI (Ettema, et al., 2014). Another systematic literature review authored by Chen et al. (2012) examined 17 studies (5,451 subjects), aimed at determining incidence of PI among surgical patients using meta-analysis. The group determined that the pooled incidence of surgery-related PI among cardiac surgery patients was 0.18 (95% CI 0.14-0.22, $I^2=62.85\%$) and that the most common types of surgery-related PI occurred after

cardiac procedures (29.3%) (Chen et al., 2012). Additionally, Chello and colleagues authored a concise literature review in 2019 that summarized the current state of the literature, noting that the Braden Scale has a low predictive validity for PI among surgical patients (Chello et al., 2019). Moreover, the authors concluded that cardiac surgery itself is a risk factor, citing that there are several pre-operative, intra-operative, and post-operative risk factors. These risk factors span the peri-operative phases, and include factors such as hemodialysis, creatinine greater than 3mg/dL, vascular disease, low or high body mass index (BMI), level of mobility, use of vasopressors, and so forth (Chello et al., 2019).

Since the phenomenon of risk factor identification appears overly broad in nature, according to the literature, many nurse scientists have worked to understand the risk factors that contribute to PI development in cardiac surgery. Shen et al. (2015) performed a retrospective study of 286 patients to examine if length of surgery affected the incidence of PI and found that there was a statistical significance between length of surgery and pressure injury (195 minutes [30-330 minutes] versus 240 minutes [125-675 minutes], $p = .003$), and not the length of time on cardiopulmonary bypass (Shen et al., 2015). The group's follow up study in 2017 examined this relationship using a dose-response meta-analysis of eight observational studies, showing that length of surgery among PI positive patients was a clinically significant risk factor as well (weighted mean difference = 36.081 minutes; 95% CI, 21.64 – 50.52 minutes; $Z=4.9$, $p < .001$) (Chen, Shen, Liu, Liu, 2017). Moreover, other risk factors found to be associated with increased prevalence of PI was perioperative corticosteroid use (Chen, Shen, Xu, et al., 2015), comorbid diabetes mellitus (Kang & Zhai, 2015), respiratory failure, and stroke (Sabzi & Faraji, 2014).

Much of these authors' research results were the foundational basis of a systematic literature review by Rao and colleagues (2016) and expert opinion by Geller and Seng (2020),

discussing risk factors for PI among cardiac surgery patients. Rao et al. (2016) synthesized 12 articles and identified 30 peri-operative risk factors unique to cardiac surgery patients. Geller and Seng (2020) further delineated these risk factors from the literature, stratifying them to pre-operative, intra-operative, and post-operative risk factors. Moreover, they applied this work to the current level of the science, describing HAPI measurement, treatment, and prevention among cardiac surgery patients, as well an experiential account of risk-stratifying patients using this risk factor identification to prevent PI (Geller & Seng, 2020). This foundational work has led other researchers to explore predictive risk assessment tools using a variety of predictive models using data analytics, much with promising predictive rates, but need more wide-scale testing for generalizability (Lu et al, 2017; Chen, Yu, et al., 2018).

Additionally, the translation of this foundational work has led other researchers and nurse clinicians to attempt to improve on PI prevention using a litany of products and tools, as well as implementing evidence-based practices using quality improvement strategies. One such preventative strategy, validated in the literature through multiple studies, was the use of bordered foam silicone dressings to reduce pressure and sheer forces on the sacrum and coccyx (Brindle and Wegelin, 2012; Strauss et al., 2019). The reduction in sacral PI was remarkable using this product, and fueled further exploration into the use of silicone dressings (and other related products) to reduce PI in cardiac surgery. Concurrent work that mirrored this effort in the literature examined the use of air-fluidized therapy beds by Jackson and colleagues (2011), an air-fluidized positioning device by Brennan and Laconti (2014), and the use of an alternating inflatable head pad (Huang et al., 2018)—all showing improvements in wound prevention.

This work has caught attention in hospitals across the country, with multiple institutions using a variety of prevention methods and strategies to reduce PI in their cardiac surgery ICUs,

including the use of a “bundle” of interventions. Cooper et al. (2015) were able to reduce their PU rate by 56% and medical device-related PI by 83% by focusing on pressure-related PI and medical device-related PI concurrently. Ballesteros (2017) was able to replicate similar findings by focusing on creating a turning guideline, utilizing prophylactic sacral dressings, implementing two-person skin assessments, bed mattress appropriateness to BMI, and quantifying “hemodynamic instability” to improve turning potential using a modified turning tool. Furthermore, Floyd et al. (2016) found some success with implementing a progressive mobility program in their ICU. Although they were not able to achieve statistical significance ($p < .05$), they did see an overall reduction in hospital length of stay (mean 8.6 days pre-intervention versus mean 6.5 days post-intervention), deep vein thrombosis prevalence, and pressure ulcer prevalence (Floyd et al., 2016). Additionally, Glasgow et al. (2014) highlighted the added cost due to medical-device related PI, and how their facility implemented a standardized checklist to reduce the risk of future PI.

Organizational Assessment

The Johns Hopkins Hospital is a large, urban, tertiary medical center, located in the heart of East Baltimore, and has been a historical leader in the development of modern medicine. Founded in 1889 by a city philanthropist, Mr. Johns Hopkins, the hospital and associated medical school has served as a pillar of the medical world. Home to many medical innovations, including the Blalock-Thomas-Taussig shunt, a cardiac surgery to relieve the “blue baby” cyanosis caused by Tetralogy of Fallot (Thomas, 1998). The hospital’s continued innovation has lent itself to be a regional referral center to patients throughout the city and the state, as well as nationally and internationally. Its mission is “to improve the health of our community and the world by setting the standard of excellence in patient care”, with a vision “to lead the world in

the diagnosis and treatment of disease and to train tomorrow's great physicians, nurses, and scientists" (Day, 2018). It is ranked number one in the state of Maryland and number three in the nation, according to the U.S. News & World Report's "Best Hospitals 2020-21 Honor Roll" (2020).

As an institution, the spotlight on the successes, and opportunities, inherent in a major academic medical center shines brighter than most hospitals. The hospital once held title of "the number one hospital in the country" for twenty-three straight years, but changes in the Maryland healthcare payer system and institution-level quality indicators have influenced this number one position. According to The LeapFrog Group, the Johns Hopkins Hospital currently has been graded as a "B" in safety overall, and is considered "below average" in urinary tract infections, MRSA infections, dangerous blood clots, and patient falls with injury (2019). Moreover, when it comes to pressure injury, the Johns Hopkins Hospital is also considered underperforming, with a hospital score of 0.52, above the average hospital score of 0.49 (The Leapfrog Group, 2019).

As with other high-acuity cardiac surgery programs, the cardiovascular surgical intensive care unit (CVSICU) at the Johns Hopkins Hospital struggled with PI historically. This high-acuity intensive care unit cared for adult patients undergoing four general categories of surgery: General open heart surgeries (including coronary bypass grafting, aortic aneurysm repair/replacement, and heart valve repair/replacements), heart and lung transplant surgery, mechanical circulatory support (left ventricular assist devices [LVAD], percutaneous cardiac assist devices, extracorporeal membrane oxygenation [ECMO]), and occasional off-service surgical critical care patients. Due to the COVID-19 pandemic, the unit recently created a temporary four-bed biocontainment unit for COVID-19 patients requiring veno-venous (V-V) ECMO for refractory acute respiratory distress syndrome (ARDS), to further complicate the

problem. The number of mechanical devices used, as well as their internal positioning and securement, coupled with concurrent hemodynamic instability and pre-operative comorbidities, posed a challenge to nursing staff.

Although the CVSICU did incorporate many best practices at the bedside, the patients continued to acquire PI during the intra- and post-operative phases of care, chronically underperforming the benchmark set by the NDNQI for unit-acquired and hospital-acquired PI (Figure 1). In looking into the data further, the incidence of PI was noted to lean more heavily towards those patients with longer CVSICU length of stay (LOS) (Table 2). According to the data, the incidence of PI in the CVSICU from January until November 2020 increased once the patient's LOS reached the 5-7 day mark, with PI incidence increasing over time. Of patients with a LOS greater than 3 weeks, 66% of patients in this category had at least one PI and accounted for a large proportion of the overall PI for the CVSICU (Table 2). Therefore, nursing leadership acknowledged a need to further examine the problem among the adult cardiac surgery population, and made PI reduction a hospital strategic priority for calendar year 2021.

Key stakeholders of this quality improvement project included key personnel at The Johns Hopkins Hospital: The program director for clinical quality and Magnet (Dr. Carla Aquino), the chief of cardiac surgery (Dr. Jennifer Lawton), the director of nursing for the department of surgery (Dr. Sharon Owens), the medical co-directors of the CVSICU (Drs. Glenn Whitman and Michael Grant), the nurse managers of the CVSICU (Jennifer Moyer) and cardiovascular operating room (Mary Beth Rigel), and the senior quality and innovation coach (Scott Burkett) at the Armstrong Institute for Safety. At the front lines, the "wound team" consisted of a lead nurse champion from CVSICU (Ashley Coco), the clinical nurse specialist for CVSICU (Tim Madeira), and two wound, ostomy, and continence nurses (WOCN).

Project Purpose

The purpose of this project was to reduce the incidence of pressure-related skin injuries in the adult cardiac surgery patient population at the Johns Hopkins Hospital by 5% in 6 weeks using translation of the evidence into practice. This evidence-based project addressed three aims:

- Use historical evidence to determine the current PI burden and inform the project's design to match the needs of the clinical site.
- Standardize prevention through creation a bedside tool that “bundles” proactive pressure injury prevention (PIP) methods, devices, and patient products.
- Create a workflow using risk factor assessment to implement preventative strategies, such as immediate recovery on an air-fluidized specialty bed, and use of preventative dressings.

A preoperative screening tool was created for the project, based on risk factors specific to cardiac surgery patients (Appendix D). The overarching goal of this project was to prevent all forms of pressure injury among adult cardiac surgery patients using the evidence.

Conceptual and Theoretical Framework

Using a conceptual framework can be useful in implementing large and complex projects, because it helps identify and categorize the various components of the project. A framework guides the project and helps conceptualize all of the moving parts, and is the “how” when implementing a practice change project. For the purposes of this project, the conceptual framework chosen was *The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care* (2017) by Buckwalter et al. The original model, called the Iowa Model of Research-Based Practice to Promote Quality Care, developed in 1994 by nurses at the University of Iowa Hospitals and Clinics (UIHC), has undergone multiple revisions as medical

care has evolved (Titler et al., 2001). The purpose of the model is to guide clinicians in evaluating and infusing research findings into patient care (Buckwalter et al, 2017).

The Iowa Model is a framework that guides the nurse from start to finish during all phases of problem identification, development, implementation, and post-implementation (Figure 2). Laced with multiple decision points, the Iowa Model helps frame the processes needed for project development. After stating the question or purpose, it asks the nurse to assess if the topic is a priority, and helps the nurse consider other issues or opportunities, or form a team (Buckwalter, 2017). Once the team is formed, the next step is to assemble, appraise, and synthesize the body of evidence by conducting a systematic literature search, and weighing the quality, quantity, consistency, and risk associated with the evidence. This allows for the next step of the process, where the team designs and pilots the practice change, by means of engaging champions at the bedside, considering resources and constraints, collecting data, and having a plan to analyze the data. Once implemented and analyzed, the framework guides the nurse to assess for appropriateness for clinical practice adoption or not, and if there are further alternatives to consider for revision. Once fully implemented, the model also addresses integration and sustainability of the practice change by identifying and encouraging key personnel and processes to hardwire the change into the system (Buckwalter et al, 2017).

While the conceptual model frames the processes needed for project identification and implementation, in essence the “how” of the project, the theoretical framework is used to speak to the overall phenomenon of interest and helps inform the project. Hence, the theoretical framework is the “what” of the project. A theoretical framework provides an orderly way to view a phenomenon, convey personal convictions, and gives nurses a means of systematic thinking about nursing practice (Moran, Burson, & Conrad, 2019). Nursing theory is made up of concepts

and propositions that help to explain a phenomenon of interest. These theories can be very abstract, explaining the overall discipline of nursing (e.g., metatheory, grand theory), or can be minimally abstract and very concrete, guiding specific nursing practice (e.g., microtheory, middle-range theory) (Moran, Burson, & Conrad, 2019). For the purposes of this project, a middle-range theory was chosen to better understand nursing-related phenomena, and because of its generalizability to nursing practice and utility to bedside practitioners (Moran, Burson, & Conrad, 2019).

The theoretical framework chosen to guide the phenomenon of interest is the Theoretical Model for Lesion Development, by Garcia-Fernández et al (2014). The theory was developed through consensus review of risk factors associated with pressure ulcer risk assessment scales, using this to construct a theoretical model for identifying the etiological factors associated with skin ulcers (Garcia-Fernández et al, 2014). After reviewing fifty-six risk assessment scales and identifying eighty-three risk factors, the risk factors were classified into twenty-three different risk dimensions that explain the production mechanism of seven types of lesion: moisture, pressure, friction, combined pressure-moisture, combined pressure-friction, multifactorial lesions, and co-adjutant factors. These lesions were generically defined as dependence-related injuries (Garcia-Fernández et al, 2014).

By understanding the etiology of how these lesions occur, nurses can correct and manage the risk dimensions associated with prevention of these lesions (Figure 3). Through mastering the risks on an individual patient level, the nurse may be able to prevent the injury from occurring or be able to correctly diagnose the injury when it first occurs, and remedy the problems or risks associated with wound development. By using this framework, the project sought to apply

evidence-based interventions to prevent and/or correct the diverse types of injuries seen among cardiac surgery patients, starting in the operating room, and continuing in the ICU.

Methods

Setting and Design

The project utilized a single group, pre- and post- intervention EBP design. Six weeks of baseline data and six weeks of post-intervention data were compared. The EBP project setting was comprised of a six-bed adult cardiovascular operating room (CVOR) and an 18-bed cardiovascular intensive care unit (CVSICU) at the Johns Hopkins Hospital. PI prevention in this project followed the trajectory of the patient experience from preoperative, intraoperative, and postoperative periods.

Participants

Participants were adult patients undergoing cardiac surgery, mechanical circulatory assist device therapy (i.e., ECMO, LVAD, percutaneous devices), and heart transplant patients cared for in the CVOR and CVSICU at Johns Hopkins Hospital between the period of February to May 2021. Of note, ECMO participant population included patients undergoing veno-venous (V-V) ECMO therapy for COVID-19 lung disease. Lung transplant patients were excluded from the study.

Intervention

The intervention utilized a number of strategies from a systematic review and appraisal of the evidence. The evidence, combined with clinical expertise, unique population circumstances, and unit-level data influenced the intervention. The intervention used for this project utilized 4 key components:

- Preoperative screen for all patients before surgery or on admission to the CVSICU.

- Implement a process where “highest risk” patients recover on a rental air-fluidized specialty bed.
- Standardize PI prevention utilizing a bedside reference tool.
- Educate OR and CVSICU staff on PIP strategies, including the correct placement of sacral and pressure-point preventative dressings.

Preoperative Screen and PIP Process

The first part of the intervention was to create and utilize a pressure injury screening tool based on risk factors that were unique to the cardiac surgery patient (Appendix D). All preoperative patients on the surgery schedule were screened the night before surgery by the project team or the charge nurse and assessed for risk factors that predisposed pressure injury (Figure 4). If a patient screened positive as “highest risk”, the patient was padded with a sacral preventative dressing (standard of care that all patients receive), and ordered a rental air-fluidized specialty bed for immediate post-operative recovery from the operating room table.

Postoperatively, nurses continued to perform the standard Braden skin assessment every shift, while the project team performed a separate weekly head-to-toe assessment of all patients in the ICU to help determine if a patient needed other preventative dressings or a rental air fluidized specialty bed based on their recovery and risk factors.

Bedside Reference Tool

The first part of the intervention was to implement a tool that bundled evidenced-based interventions at the bedside to reduce pressure-related injury, device-related injury, and moisture-related injury via standardization (Appendix E). The bedside reference tool was hung in every CVSICU room to improve standardization of available preventative skin products relating to moisture, pressure, and sheer forces. The tool was organized by pressure point and

encompassed wound prevention “tips” for all pressure points. Frequent areas of device-related injury (e.g., ear from ECMO cannulas or pulse oximetry probes, etc.), and strategies for minimizing moisture related to incontinence, bleeding, or weeping wounds were also highlighted. Each pressure point contained photos and directions, highlighting a best practice (e.g. floating heels) or use of a preventative skin product (e.g. barrier cream for incontinence). In addition to these interventions, the tool incorporated the modified turning tool from Ballesteros (2017), originally developed by Brindle et al. (2013, p. 260). This tool described what a thirty-degree turn required, as well as a “weight shift” for unstable patients, and outlined the placement of pillows or wedge devices to qualify each rotation as a true “turn”.

Education of Nursing Staff and Improving Communication

The third arm of the intervention consisted of staff education to fully implement the project. The education was delivered using a number of methods: small, in-person educational in-services, use of video presentations and instructional videos, poster boards with preventative dressing information, presentations to staff in quality and safety meetings, email messages, as well as creation of written “fast fact” educational references (Appendix F). In-person staff education and feedback were also provided to staff during weekly “wound rounds”, consisting of direct verbal communication with and inclusion of the bedside nurse regarding the wound prevention plan. Communication was augmented by utilizing a dry-erase white board in each patient room to communicate weekly wound round findings (i.e. if a PI was found this week, and/or recommendations for treatment or prevention, etc.). This treatment and prevention plan were also documented as a progress note by the wound team in the electronic medical record (EMR).

Project Implementation

Staff education was an integral part of implementation in order to achieve standardization. This education included how to use the bedside reference tool and screening tool, general risk factors associated with wounds, and how to implement preventative strategies (e.g. ordering a rental air-fluidized specialty bed). Staff education consisted of multiple modalities due to COVID-19 precautions. The education included using virtual meeting platforms (i.e. Zoom or Microsoft Teams), recording short MP4 voice-over presentation videos for online staff access, creation of short instructional videos attached to a QR code, and in-person education from the wound team during rounds. For the tactile learners, staff education also included small, physically distanced, in-person education provided by a product vendor or a wound team member using a manikin in a patient bed. Display boards were created with available preventative dressings and placed in the team room for visual reference and help nurses learn the names of the various dressings. This allowed the project team to discuss the new PIP bundle and perform a demonstration of turning and proper pad placement. Staff were encouraged to return-demonstrate the correct placement of the foam dressings on the manikin and demonstrate a turn with weight redistribution. These sessions spanned the course of approximately 6 weeks and incorporated nursing staff from day shift, night shift, and weekend shift.

Implementation strategies included weekly wound team rounds with the clinical nurse specialist (CNS), wound champion(s), and certified wound/ostomy nurses. During these rounds, the group validated skin results and performed a head-to-toe skin assessment to all patients. The PIP tool was placed in every patient room upon project implementation, and the use of a dry-

erase marker board was utilized for communication of wound findings and recommendations from the wound team.

In regards to the procedural side of the patient experience, unit-based wound prevention champions educated nurses working in the operating room. This education focused on the correct placement of bordered silicone sacral dressings, and provided a one-page “fast facts” on dressing placement before surgery. The operating room team also began treating all patients as high risk for pressure injury by using the Scott Triggers pressure injury assessment tool. Moreover, OR nursing and anesthesia leadership were presented with a real-life patient case study of medical device-related pressure injury incurred while in the operating room and the first eight hours in the CVSICU, highlighting the issue among the multidisciplinary groups in both work areas. This work spawned the OR team to increase the use of gel padding in the operating room, as well utilizing a sterile leg warmer during cardiac surgeries, based on their own quality improvement work.

Email messaging was used to encourage implementation of the bundle, as well as signs placed in the team rooms and in the staff bathrooms reminding everyone of the project. The audit results from the weekly surveys were shared with staff on a weekly basis to encourage of the PIP tool utilization and best practices. Team huddles in the CVSICU at change of shift encouraged discussion of the project, allowed staff to ask questions and give feedback on the project.

Measures

One year of historical data pertaining to pressure injury informed the project’s aims and interventions. General patient demographic information was collected, including gender and service line, during the six-week post-intervention phase. Project measures included outcome measures, process measures, and balancing measures to ensure evaluation of the outcomes.

Clinical outcome measures for this project included: (a) number of CVSICU unit-acquired pressure injury (UAPI) and (b) incidence rate of CVSICU UAPI. Process measures of interest in this project included data pertaining to the usage of the (a) preoperative screening tool and (b) usage of the preventative sacral foam dressing and (c) total number and cost of air-fluidized specialty rental beds. The compliance of the tool usage was monitored using the number and frequency of patients screened preoperatively (numerator) among all cardiac surgery patients on the surgery schedule (denominator). Moreover, balancing measures were used to assure safety and project efficacy, such as (a) anatomic location of wounds, (b) stage of pressure injury, and (c) number of days between wounds.

Clinical data collection consisted of weekly rounding with a minimum of two nurse champions with validation of results performed by a certified wound ostomy nurse. The PI was documented in the EMR and later abstracted and validated by the wound team on a weekly basis during the baseline and post-intervention phases of the project.

Outcome Measures: Pressure Injury Count and Rate

For the purposes of this project, (a) UAPI count and (b) UAPI incidence rate were utilized to evaluate the effectiveness of the intervention using the definitions provided by the National Pressure Injury Advisory Panel (NPIAP), 2017. Incidence rate was calculated to assess the prospective changes over time, and evaluated the proportion of PI free individuals who developed a PI over time (NPIAP, 2017). This involved a count of individuals, not PI, and did not re-count individuals based on patient transfers between units.

Process Measures: Preoperative Screening and PIP Usage

Since risk factor assessment played such a significant role in the project's design, process measures surrounding the use of the (a) preoperative screening tool, (b) correct placement of a

preventative sacral foam dressing, and (c) rental of an air-fluidized specialty bed were collected to assess the consistency of tool usage and help evaluate the efficacy of the intervention. If the patient met “highest risk” criteria, the charge nurse implemented the PIP and ordered a rental air-fluidized specialty bed for immediate post-operative recovery. All patients screened were noted on a clipboard near the charge nurse station and audited by a project team member daily to assess the number of preoperative patients screened based on the daily surgical schedule. This data was quantified as a number and frequency, with the number of patients screened as the numerator, over the total number of patients as the denominator. Assessment of sacral dressing compliance was chosen since this is the bare minimum standard in preventive foam dressing compliance, and should be provided to all patients. Preventative sacral dressing compliance was assessed by nursing staff immediately on admission to CVSICU and documented in the EMR. The number of rented specialty beds ordered due to the preoperative screening tool were tracked before and after the intervention to assess for compliance with the screen, as well as to assess cost expenditure and return on investment (ROI). This cost was compared to the cost of PI prevention, calculated using wound cost estimates developed by Padula and colleagues (2018).

Balancing Measures: Staging, Location, and Timing of Pressure Injury

As secondary measures, capturing the (a) stage of PI (and etiology, if any), the (b) PI location, and (c) number of days between wounds, informed the project since a number of evidence-based strategies were used during implementation. Assessment of any PI was validated using the PI staging definitions from the NPIAP pressure injury staging system (2017). The number of UAPI were subdivided into stages using the NPIAP staging system, and included stage I, stage II, stage III, stage IV, unstageable, deep tissue injury (DTI), medical-device related pressure injury (MDRPI), and mucosal membrane PI (NPIAP, 2017). Location of the pressure

injury helped inform the project as equally as the other clinical outcomes, since it spoke to the population-specific sites of injury, and if they were likely related to pressure, moisture, friction, and/or a device-related mechanism.

Data Management Plan

Data collection consisted of weekly bedside rounds from the CVSICU wound champion team, validated by hospital wound nurses. Data collection was consistent in the baseline and post-implementation phases. All members of the project team had access to the data. The data was generated by the EMR and validated on a weekly basis by the wound nurses. The study team used a "SAFE" (Secure Analytic Framework Environment) virtual desktop environment to store any PHI or identifying data to protect the data using the encrypted firewall system provided by the Johns Hopkins Health System. All data was de-identified during data analysis.

Analysis

Data was exported to the SAFE desktop in a Microsoft Excel file for data analysis using MiniTab statistical software, version 19.2020.1. Data analysis was conducted by the project lead and the Safety & Innovation Coach using descriptive and inferential statistics. Wound counts were highlighted using an Individuals (Control) Chart, and Pareto charts highlighted numbers and frequencies of wounds and anatomical locations of the wounds, before and after implementation. An alpha (p) of 0.05 was used to determine statistical significance. A comparison of cost was performed using the count and cost of rental air-fluidized specialty beds versus the cost of prevention of PI according to associated wound costs deduced by Padula and colleagues (2018).

Outcome Measures: Pressure Injury Count and Rate

The number of UAPI during both phases of the project were examined and counts highlighted using a bar chart. A 2-sample Poisson rate was performed to determine if there was a statistically significant difference between the number of PIs between the baseline and intervention phases. An Individuals chart (control chart) was used to visually highlight individual PI observations for both phases, and assess for shifts in data or outlier observations. The cumulative UAPI incidence rate was obtained using a count over a count: the number of individuals developing PI divided by the total number of individuals in the CVSICU over the 6-week period, multiplied by one hundred. The incidence rate was compared during the baseline phase and the post-implementation phase. Analytical assessment of the UAPI incidence rate, before and after, required a one-sided Chi-Square test of two proportions. Chi-Square-based hypothesis testing was used to determine if the difference between the population proportions was greater than the hypothesized difference of zero.

Process Measures: Screening Rates and PIP Usage

For preoperative screening compliance, the numerator consisted of patients screened before surgery, and the denominator was all cardiac surgical patients, LVAD, heart transplant, and ECMO patients. Lung transplant patients were not included in the numerator or denominator because of exclusion criteria. Sacral dressing placement compliance used “correct placement” as the numerator, and overall population as the denominator. The number of air-fluidized rental beds, and associated cost, were also analyzed similarly. Using the approximated costs generated by Padula et al., the number of wounds will be multiplied by the approximated cost of \$2122 per DTI or stage II wound, and \$6209 for a stage III, IV, or unstageable wound, then added up for comparison (2018).

Balancing Measures: Staging, Location, and Timing of Pressure Injury

The secondary outcome measures, staging of wounds, and location of wounds, were examined using descriptive analysis, highlighting the differences at baseline and post-intervention using Pareto charts. A G-chart was chosen to monitor the number of days between rare events, in this case, the number of days between pressure injuries in the CVSICU.

Ethical Considerations

This project was acknowledged as not human subjects research (NHSR) and deemed a quality improvement initiative by the University of Pennsylvania and the Johns Hopkins University institutional review boards.

Results

During the implementation phase of the project, the study team made a few adaptations to the original implementation plan based on study progress and feedback from staff. All patients were screened preoperatively for risk factors; however, the postoperative screen was not implemented daily as originally planned due to the amount of chart review required to assess preoperative, intraoperative, and postoperative risk factors on eighteen CVSICU patients on a daily basis. This postoperative risk factor screen was incorporated into the weekly wound rounds with the wound champion team instead. This tool helped the team evaluate patients whose recovery status may have improved or worsened based on the intraoperative or postoperative course. It helped flag patients who required the PIP bundle or no longer required these interventions. Moreover, as the project developed, the study team noticed a trend of occipital wounds occurring during both project phases (n=6), so a more focused education need was uncovered during implementation. The study team addressed this trend with focused education on occipital wound prevention by creating an instructional video and performing bedside education during wound rounds and sharing the results via email.

During a period of six weeks during Spring 2021, 69 patients were screened before surgery using the preoperative risk factor screening tool and (Table 3). Patient demographic characteristics were tabulated based on gender and service line. Of the surgical population, 46 patients were male (67.6%) and 23 (33.3%) were female. Of the 69 patients screened preoperatively, 23 patients (33.3%) of the patients screened positive for being “highest risk” for pressure injury- 16 men (35.0%) and 7 women (30.0%). The majority of patients screened were screened for general cardiac surgery cases (n=61, 88.0%), along with 6 (9.0%) patients for ECMO therapy, one heart transplant, and one LVAD pump exchange. Sixty-seven patients (96.0%) were noted to have a preventative bordered sacral foam dressing on correctly, and all 23 patients (100.0%) who screened positive as “highest risk” recovered immediately on a rental air-fluidized specialty bed and had a preventative sacral dressing placed correctly. Of note, 15 out of 23 patients who screened positive were general cardiac surgery cases. All ECMO (n=6), LVAD (n=1), and heart transplant (n=1) patients were deemed high risk due to screening criteria (Table 1).

Overall, the number of PIs observed in the post-intervention period (n=13) were decreased when compared to the baseline period (n=25), a decrease of 52.0% (Figure 7). All subtypes of pressure injury saw decreases as well, except for one occipital stage III PI noted in the post-intervention phase. The most notable decrease was seen among DTIs, where there was a 50.0% decrease (pre=10, post=5), as well as stage II PI (pre=8, post=3). A 2-Sample Poisson rate test was used to determine that there was a statistically significant (p=0.036) difference in the number of pressure injuries between the baseline and intervention phases (Table 4). This is also a practical difference as the number of injuries was greatly reduced in the post-intervention phase. The individuals chart shows individual pressure injury observations in the CVSICU for both the

baseline and intervention phases of the project (Figure 5). The process showed a number of special cause variations identified within the data set. These tests for special cause were (a) one or more data point greater than 3 standard deviations from the center line indicating an outlier, and (b) nine points in a row on the same side of the center line indicating a shift in the data. At the end of the intervention phase, there were 16 consecutive days without a PI in the CVSICU.

The incidence rate for PI during the six weeks before the intervention was calculated as 17.65%, whereas the incidence rate during the six weeks after implementation was 9.09%. The difference in these two rates was 8.56%, therefore achieving the aim of the project. These two incidence rates were considered statistically significant using a Chi Square test of two proportions ($Z=1.66$, $p = 0.048$) (Table 5). Moreover, when looking at the incidence rate of PI over time using a G-chart, an improvement was noted in the number of days between pressure injury events (Figure 6). The process was stable and in control in both the baseline and intervention phases of the project.

When examining the PI count by type and stage, there were positive changes noted after implementation of the PIP bundle and screening tool. Throughout the spectrum of PI stages, there was a noted decrease in stage II, DTI, unstageable, and mucosal injury, and a slight increase in stage III wounds ($n=1$) (Figure 9). Suspected DTI went from 10 to 5 wounds, however, 3 of the 5 wounds in the post-intervention phase were related to medical devices. There was an increase noted of MDRPI in the post-intervention stage ($pre=0$, $post=3$). The location of PI was noted to see changes pre and post implementation as well, where ear ($n=7$), buttocks ($n=3$), occiput ($n=4$), coccyx/sacrum ($n=3$), and lip and heel (tied with $n=2$ each) were noted to be the top five PI locations before the intervention (Figure 8). After implementation, the location

of the wounds changed to nose (n=3), buttocks (n=3), occipital (n=2), as the top three locations, and one wound attributed to ear, coccyx/sacrum, lip, and other (Figure 8).

During the new workflow using the screening tools, rental costs associated with the air-fluidized specialty beds were calculated before and after implementation to assess for cost impact and ROI (Table 6). When looking at the number of rental beds utilized six weeks before full implementation of the risk factor screening tools, 29 beds were rented, accounting for a cost of \$20,700 billable to the healthcare facility. During the six-week period after implementation, a total number of 55 beds were rented, and accounted for a cost of \$26,920, a cost increase of \$6220 (Figure 9). In contrast, the total cost attributed to the 25 PIs noted during the baseline project phase was associated with approximately \$326,636 in cost, accounted for in the 660 patient days. The intervention phase noted 13 PIs, accounting for \$241,756 associated cost in 610 patient days – a savings of approximately \$84,880.00. Taking the cost of rental beds and the saved revenue from PI prevention, the overall saving to the institution during the implementation phase was \$78,660.

Discussion

There was an overall improvement in the UAPI count and incident rate that was found to be statistically significant over the course of this project. The screening process helped identify patients that were more likely to develop PI based on preoperative comorbid factors, such as body mass, nutrition status, length of OR case, renal clearance, and mobility. By using a screening tool, not only did these highest risk patients receive more proactive interventions, it increased awareness among staff as a whole. The use of the screening tool helped change the culture of the unit from being reactive, such as adopting an air-fluidized bed upon discovery of a PI, to a more proactive approach- adopting the technology as a preventative measure.

Moreover, utilizing a standardized PIP tool that included photos and instructions for bedside nurses to reference helped the team standardize treatment therapies and provide improved 24-hour prevention. For instance, tracheostomy plates have been a historic “culprit” of many of our MDRPIs around the neck region. Even though the evidence in the literature has supported the use of foam preventative dressings for peri-stomal prophylaxis and suture-less securement, this was a practice difficult to change at the bedside for a number of reasons. However, utilizing a tool with photos and instructions, coupled with hands-on demonstration and practice, allowed nursing staff to be more confident that the intervention was evidenced-based, reduced variations in practice, and contributed to reducing PI.

Furthermore, since there are notable differences in the adult cardiac surgery population from other ICU populations, wound champions and wound nurses collaborated to create preventative foam dressing applications to help reduce MDRPI among this population. Prophylactic dressings were used for many of the devices used in every day CVSICU care. From ECMO cannulas, balloon pump set-ups, pulse oximetry ear clips, BiPAP and CPAP straps and masks- staff found creative ways to help reduce PI using foam dressings. This included difficult skin situations associated with mouth/lip/tongue swelling, using foam dressing concepts to reduce PI by wrapping a dressing around a tube to protect the corners of the mouth, or cushion an object laying on the lower lip. This helped address our notable trend for medical-device related injury, and has spawned more discussions with our colleagues in anesthesia regarding endotracheal tube (ETT) securement and head positioning in the OR using gel products following the philosophy that cardiac surgery wounds start in the OR and progress in the ICU.

Historically, the majority of CVSICU patients suffered from deep tissue injuries, most likely found on the coccyx or sacrum. For years, our nursing team attributed this to vasopressor

use and keeping the head of bed (HOB) at a 30-degree angle for ventilator associated pneumonia (VAP) prophylaxis. However, over the past few years, our anesthesia group transitioned to more non-opioid analgesia and alternative sedation techniques as part of a national enhanced recovery after surgery (ERAS) effort. This has reduced the need for deep sedation in the CVSICU and has increased our early extubation rates within six hours of admission to the CVSICU. This trend for earlier extubation times has reduced the need for a constant 30-degree HOB needed for VAP prevention. Therefore, this has allowed nurses to attempt lowering the HOB more often than not, helping to reduce pressure and shear on the coccyx and sacral areas. This coupled with a preventative sacral dressing and an air-fluidized specialty bed for immediate use has likely helped reduce wounds at the coccyx and sacral areas. Of note, many of the wounds noted as “buttocks” were usually found among patients with moisture issues related to bleeding, incontinence, or weeping skin tears or wounds. That is why for project analysis, the team decided to examine “coccyx/sacrum” together and “buttocks” separately, to help delineate etiology better.

The project produced some results that were notable to be population-specific, and suggested that patient positioning played a major factor. Not only did the overall UAPI count and the incidence rate decrease over the intervention phase, so did the location and the staging of the wounds. Patient positioning in among cardiac surgery patients is notable for two distinct positions: (a) patients at a 30-degree angle for improved pulmonary mechanics and VAP prevention, or (b) 180-degrees supine due to hemodynamic instability and/or open chest, with or without ECMO cannulation. These two positions increase pressure at different pressure points, and depending on the patient’s immobility, sedation, level of pain proprioception, vasopressor use, and nutritional status, may prove to accelerate wound formation. In the supine position, the

pressure is distributed among different pressure points, and include the occiput, elbows, hips, and heels. Therefore, for our patients lying flat, the project team encouraged promoting turning often (using the turn guide) with help from team members, off-loading pressure points, rotating the head with turns, and use of pressure-point prophylactic dressings. Four out of the six occipital wounds were related to V-V ECMO cannulation in the right internal jugular, and all six occipital wounds were among hemodynamically unstable patients in a supine position. To address the occipital injuries, staff required more in-depth education using a fluidized head positioner and reducing occipital pressure with more complete head turns. For patients in a 30-degree position, the focus was more focused to coccyx and sacral pressure relief and moisture control. All turns in the CVSICU were encouraged to be performed using a minimum of four pillows for a successful turn, or use of a wedge positioner. However, it was notable that pillows often went missing with patient transfers to the step-down unit, so a conscious effort was made to keep more pillows in the CVSICU to ensure more availability of supply.

The proactive measures did not come without a cost. Since a third of the patients that were screened in the CVSICU during the implementation period were deemed highest risk, there was an increase of rental beds and more bed movement around the CVSICU in general. This proved to be a challenge to staff at times, depending on census and acuity, to store the “regular” ICU beds in a location accessible and reliable. Often, staff sent beds back to the bed shop, and therefore increased bed traffic from that location as well. With time, this became less of a problem and just a new work flow. However, the increase in rental bed utilization did show return on investment overall, by reducing the cost of PI to the facility and improving insurance reimbursement.

For many institutions, the concept of using a rental air-fluidized bed as prevention rather than treatment is foreign to some, because the cost of a rental bed for prevention is often seen as an unnecessary cost expenditure. However, this project showed that giving this evidenced-based therapy to patients at highest risk for wound formation actually did help reduce wound formation. Moreover, staff complimented the effort because it was easier for staff to implement because the patient was already on the bed immediately out of the operating room. Therefore, if the patient became more unstable out of the OR, the patient was already receiving maximum skin prevention therapy. Therefore, calculating the cost of this preventative project was an important facet, because it spoke to the overall cost savings and/or expenditures, and helped inform the possibility of long-term sustainability.

Implications for Practice

This project uses the assumption that wounds start in the operating room and are based on several risk factors before, during, and after surgery; and that certain patients are more susceptible to PI than others. By identifying those who possess risk factors for PI, the care team can implement interventions earlier in the patient's recovery, hopefully deterring the formation of a wound. This implies that all patients would benefit from a risk factor screen before surgery, and likely after surgery. This also means that there is validity in spending money for air-fluidized specialty beds in the beginning of ICU recovery to avert wounds among the highest risk, and also among long-term ICU patients, based on the data. Further development of a risk factor screening tool more sensitive to pressure injury among cardiac surgery patients appears to have merit for future scholarly work.

Opportunities for Sustainability

This project helps show that improvements can be made in pressure injury prevention in high-acuity cardiac surgery service-lines, and that pressure injury does not have to occur as often as it does if evidence-based interventions are bundled together. There is potential to automate a screening tool into the EMR, making the process helpful to the surgeon and clinicians before surgery and in real-time. Use of a standardized PIP tool for preventative wound care helps create a new standard of care that is more easily attainable. Long-term use of air-fluidized specialty beds in the prevention of wounds could be continually examined, and may influence future vendor contracts for future bed purchasing or renting. By monitoring the fiscal side of the prevention, a healthcare facility can capitalize on the ROI and reduce costs over time, while improving patient outcomes.

Limitations

This project lacked randomization, and was quality improvement and non-experimental, therefore it may not be translatable to other institutions. Since implementation occurred during the COVID-19 era, IRB approval was markedly delayed, affecting the duration of the implementation period. While the preoperative risk factor screen was helpful in identifying potentially high-risk patients, the tool was not validated using psychometric testing for reliability and validity. Also, of note, there lacked clear criteria for staff regarding discontinuation of the rental beds, and when to transition a patient back to a regular bed if recovery was progressing optimally.

Although ECMO patients were included in the inclusion criteria for the project, an argument can be made that V-V ECMO for COVID-19 lung disease could have been an exclusion criterion since the patient population was not true cardiac surgery in etiology. However, the decision was made to include this population in the numerator and denominator

since any patient undergoing ECMO therapy, due to cardiac surgery or a non-surgical cause, would be included pressure injury monthly reporting as a normal standard of care. Furthermore, the intervention would be applicable for any patient undergoing ECMO therapy, despite the cause of the cardiopulmonary failure.

Conclusions

Although a quality improvement project and was non-experimental, the project does inform future research in the area, namely the use of risk factor identification in the prevention of pressure injury, and the need for a validated PI prediction tool specific to the cardiac surgery population than the Braden scale. Using a screening tool to identify patients who are high risk for skin breakdown after cardiac surgery was helpful in reducing PI. This identification was helpful in tailoring interventions that were patient-centered, and specific to the individual patient. Future avenues of research should include validation of a predictive pressure injury tool more specific to the cardiac surgery population, as well as research on interventions to prevent PI in the short-term acute phase and the long-term patient population with reduced mobility and/or use of a cardiac assist device. Investing in a proactive approach to pressure injury prevention may increase some costs, but may save the institution in the end by decreasing PI prevalence and the costs associated with PI and improving insurance reimbursement.

References

- Agency for Healthcare Research and Quality. (2014, October). 5. *How do we measure our pressure ulcer rates and practices?* <https://www.ahrq.gov/patient-safety/settings/hospital/resource/pressureulcer/tool/put5.html>
- Ballesteros, C. (2017). Teamwork for prevention: Reducing HAPUs in cardiac surgery patients. *Nursing Management*, 48(7), 17-20.
<https://doi.org/10.1097/01.NUMA.0000520731.16668.89>
- Brennan, M. R., & Laconti, D. (2014). Using conformational positioning to reduce hospital-acquired pressure ulcers. *Journal of Nursing Care Quality*, 29(2), 182-187.
<https://doi.org/10.1097/NCQ.0b013e3182a79ca9>
- Brindle, C. T., & Wegelin, J. A. (2012). Prophylactic dressing application to reduce pressure ulcer formation in cardiac surgery patients. *Journal of Wound, Ostomy, and Continence Nursing: Official Publication of the Wound, Ostomy and Continence Nurses Society*, 39(2), 133-142. <https://doi.org/10.1097/WON.0b013e318247cb82>
- Buckwalter, K. C., Cullen, L., Hanrahan, K., Kleber, C., McCarthy, A. M., Rakel, B., Steelman, V., Tripp-Reimer, T., & Tucker, S. (2017). Iowa model of evidence-based practice: Revisions and validation. *Worldviews on Evidence-Based Nursing*, 14(3), 175-182.
<https://doi.org/10.1111/wvn.12223>
- Chello, C., Lusini, M., Schilirò, D., Greco, S. M., Barbato, R., & Nenna, A. (2019). Pressure ulcers in cardiac surgery: Few clinical studies, difficult risk assessment, and profound clinical implications. *International Wound Journal*, 16(1), 9-12.
<https://doi.org/10.1111/iwj.12994>

Chen, H.-L., Yu, S., Xu, Y., Yu, S., Zhang, J., Zhao, J., Liu, P., & Zhu, B. (2018). Artificial neural network: A method for prediction of surgery-related pressure injury in cardiovascular surgical patients. *Journal of Wound, Ostomy, and Continence Nursing: Official Publication of the Wound, Ostomy and Continence Nurses Society*, 45(1), 26-30.

<https://doi.org/10.1097/WON.0000000000000388>

Chen, H. L., Yu, S. J., Xu, Y., Yu, S. Q., Zhang, J. Q., Zhao, J. Y., Liu, P., & Zhu, B. (2018). Artificial neural network: A method for prediction of surgery-related pressure injury in cardiovascular surgical patients. *Journal of Wound, Ostomy, and Continence Nursing: Official Publication of the Wound, Ostomy and Continence Nurses Society*, 45(1), 26-30.

<https://doi.org/10.1097/WON.0000000000000388>

Chen, H., Shen, W., Liu, P., & Liu, K. (2017). Length of surgery and pressure ulcers risk in cardiovascular surgical patients: A dose-response meta-analysis. *International Wound Journal*, 14(5), 864-869. <https://doi.org/10.1111/iwj.12722>

Chen, H., Shen, W., Xu, Y., Zhang, Q., & Wu, J. (2015). Perioperative corticosteroids administration as a risk factor for pressure ulcers in cardiovascular surgical patients: A retrospective study. *International Wound Journal*, 12(5), 581-585.

<https://doi.org/10.1111/iwj.12168>

Chen, H., Chen, X., & Wu, J. (2012). The incidence of pressure ulcers in surgical patients of the last 5 years: A systematic review. *Wounds: A Compendium of Clinical Research & Practice*, 24(9), 234-241. <https://pubmed.ncbi.nlm.nih.gov/25874704/>

Cooper, D. N., Jones, S. L., & Currie, L. A. (2015). Against all odds: Preventing pressure ulcers in high-risk cardiac surgery patients. *Critical Care Nurse*, 35(5), 76-82.

<https://doi.org/10.4037/ccn2015434>

Day, J. (2018, August 16). Mission: The Johns Hopkins Hospital. Retrieved September 24, 2020, from https://www.hopkinsmedicine.org/the_johns_hopkins_hospital/about/mission.html

Edsberg, L. E., Black, J. M., Goldberg, M., McNichol, L., Moore, L., & Sieggreen, M. (2016). Revised National Pressure Ulcer Advisory Panel Pressure Injury Staging System: Revised Pressure Injury Staging System. *J Wound Ostomy Continence Nursing*, 43(6), 585-597. doi:10.1097/won.0000000000000281

Ettema, R. G. A., Van Koeven, H., Peelen, L. M., Kalkman, C. J., & Schuurmans, M. J. (2014). Preadmission interventions to prevent postoperative complications in older cardiac surgery patients: A systematic review. *International Journal of Nursing Studies*, 51(2), 251-260. <https://doi.org/10.1016/j.ijnurstu.2013.05.011>

Floyd, S., Craig, S. W., Topley, D., & Tullmann, D. (2016). Evaluation of a progressive mobility protocol in postoperative cardiothoracic surgical patients. *Dimensions of Critical Care Nursing*, 35(5), 277-282. <https://doi.org/10.1097/DCC.0000000000000197>

García-Fernández, F. P., Agreda, J. J., Verdú, J., & Pancorbo-Hidalgo, P. L. (2013). A new theoretical model for the development of pressure ulcers and other dependence-related lesions. *Journal of Nursing Scholarship*, 46(1), 28-38. <https://doi.org/10.1111/jnu.12051>

Geller, C. M., & Seng, S. S. (2020). How to keep patients un-HAPI: Cardiac surgery and sacral pressure injuries: Invited expert opinion: Hospital-acquired pressure injuries. *Journal of Thoracic and Cardiovascular Surgery*, <https://doi.org/10.1016/j.jtcvs.2019.12.108>

Glasgow, D., Millen, I. S., Nzewi, O. C., & Varadarajan, B. (2014). Device-related atypical pressure ulcer after cardiac surgery. *Journal of Wound Care*, 23(8), 383-386. <https://doi.org/10.12968/jowc.2014.23.8.383>

- Huang, W., Zhu, Y., & Qu, H. (2018). Use of an alternating inflatable head pad in patients undergoing open heart surgery. *Medical Science Monitor*, 24, 970-976.
<https://doi.org/10.12659/MSM.906018>
- Jackson, M., McKenney, T., Drumm, J., Merrick, B., LeMaster, T., & VanGilder, C. (2011). Pressure ulcer prevention in high-risk postoperative cardiovascular patients. *Critical Care Nurse*, 31(4), 44-53. <https://doi.org/10.4037/ccn2011830>
- Kang, Z. Q., & Zhai, X. J. (2015). The association between pre-existing diabetes mellitus and pressure ulcers in patients following surgery: A meta-analysis. *Scientific Reports*, 5, 13007.
<https://doi.org/10.1038/srep13007>
- Lu, C., Chen, H., Shen, W., & Feng, L. (2017). A new nomogram score for predicting surgery-related pressure ulcers in cardiovascular surgical patients. *International Wound Journal*, 14(1), 226-232. <https://doi.org/10.1111/iwj.12593>
- Mattson, A. (2017, January 30). NPUAP Meets with CMS to Discuss Identification and Treatment of Pressure Injuries. <https://npiap.com/news/news.asp?id=451759>
- Moran, K. J., Burson, R., & Conrad, D. (2019). *The doctor of nursing practice project*. Jones & Bartlett Learning.
- National Pressure Injury Advisory Panel. (2017, March). *Pressure Injury Stages*. National Pressure Injury Advisory Panel. <https://npiap.com/page/PressureInjuryStages>
- Rao, A. D., Preston, A. M., Strauss, R., Stamm, R., & Zalman, D. C. (2016). Risk factors associated with pressure ulcer formation in critically III cardiac surgery patients. *Journal of Wound, Ostomy & Continence Nursing*, 43(3), 242-247.
<https://doi.org/10.1097/WON.0000000000000224>

- Padula, W. V., Pronovost, P. J., Makic, M. B., Wald, H. L., Moran, D., Mishra, M. K., & Meltzer, D. O. (2018). Value of hospital resources for effective pressure injury prevention: a cost-effectiveness analysis. *BMJ Quality & Safety*, 28(2), 132–141.
<https://doi.org/10.1136/bmjqs-2017-007505>
- Sabzi, F., & Faraji, R. (2014). Factors predicts skin ulcer following coronary artery bypass. *Journal of Medicine and Life*, 7 Spec No. 2(Spec Iss 2), 29-33. <https://doi.org/JMedLife-07-29>
- Shen, W. Q., Chen, H. L., Xu, Y. H., Zhang, Q., & Wu, J. (2015). The relationship between length of surgery and the incidence of pressure ulcers in cardiovascular surgical patients: A retrospective study. *Advances in Skin & Wound Care*, 28(10), 444-450.
<https://doi.org/10.1097/01.ASW.0000466365.90534.b0>
- Strauss, R., Preston, A., Zalman, D. C., & Rao, A. D. (2019). Silicone foam dressing for prevention of sacral deep tissue injuries among cardiac surgery patients. *Advances in Skin & Wound Care*, 32(3), 139-142. <https://doi.org/10.1097/01.ASW.0000553111.55505.84>
- Titler, M. G., Kleiber, C., Steelman, V. J., Rakel, B. A., Budreau, G., Everett, L. Q., Buckwalter, K. C., Tripp-Reimer, T., & Goode, C. J. (2001). The Iowa model of evidence-based practice to promote quality care. *Critical Care Nursing Clinics of North America*, 13(4), 497-509.
[https://doi.org/10.1016/s0899-5885\(18\)30017-0](https://doi.org/10.1016/s0899-5885(18)30017-0)
- Thomas, V. (1998). *Partners of the heart: Vivien Thomas and his work with Alfred Blalock: An autobiography*. Philadelphia, PA: University of Pennsylvania Press.

U.S. News and World Report (2020, July 28). *U.S. News Best Hospitals 2020-21 Honor Roll*.

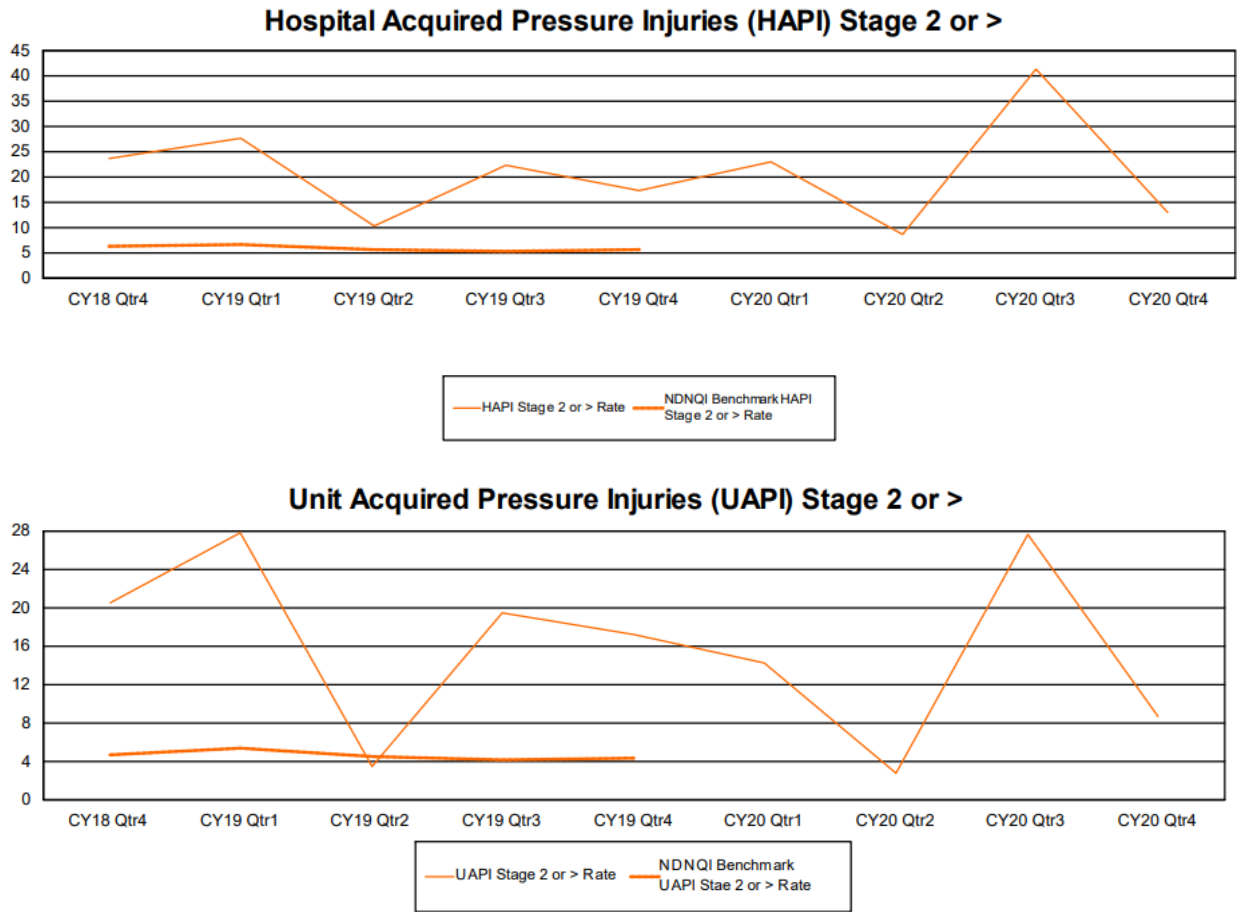
<https://health.usnews.com/health-care/best-hospitals/slideshows/the-honor-roll-of-best-hospitals>

Wang-Qin Shen, Hong-Lin Chen, Yang-Hui Xu, Zhang, Q., & Wu, J. (2015). The relationship between length of surgery and the incidence of pressure ulcers in cardiovascular surgical patients: A retrospective study. *Advances in Skin & Wound Care*, 28(10), 444-450.

<https://doi.org/10.1097/01.ASW.0000466365.90534.b0>

Figure 1

CVSICU Prevalence of HAPI and UAPI Stage 2 or Greater



Note. Hospital-acquired pressure injury (HAPI) and unit-acquired pressure injury (UAPI), stage 2 or greater, CY2018 Qtr. 4 to CY2020 Qtr. 4.

Figure 2

The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care

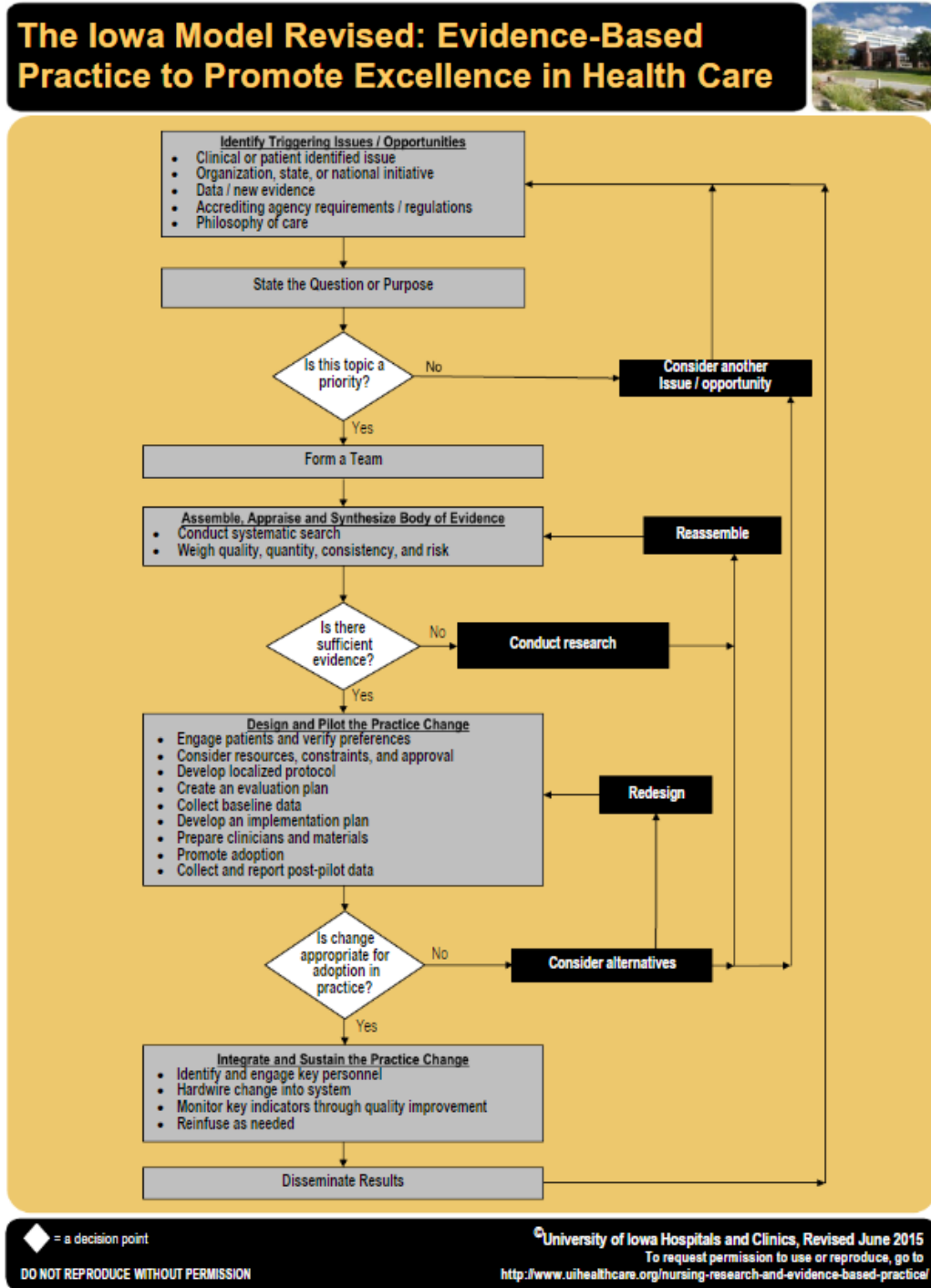


Figure 3

Theoretical Model for Lesion Development

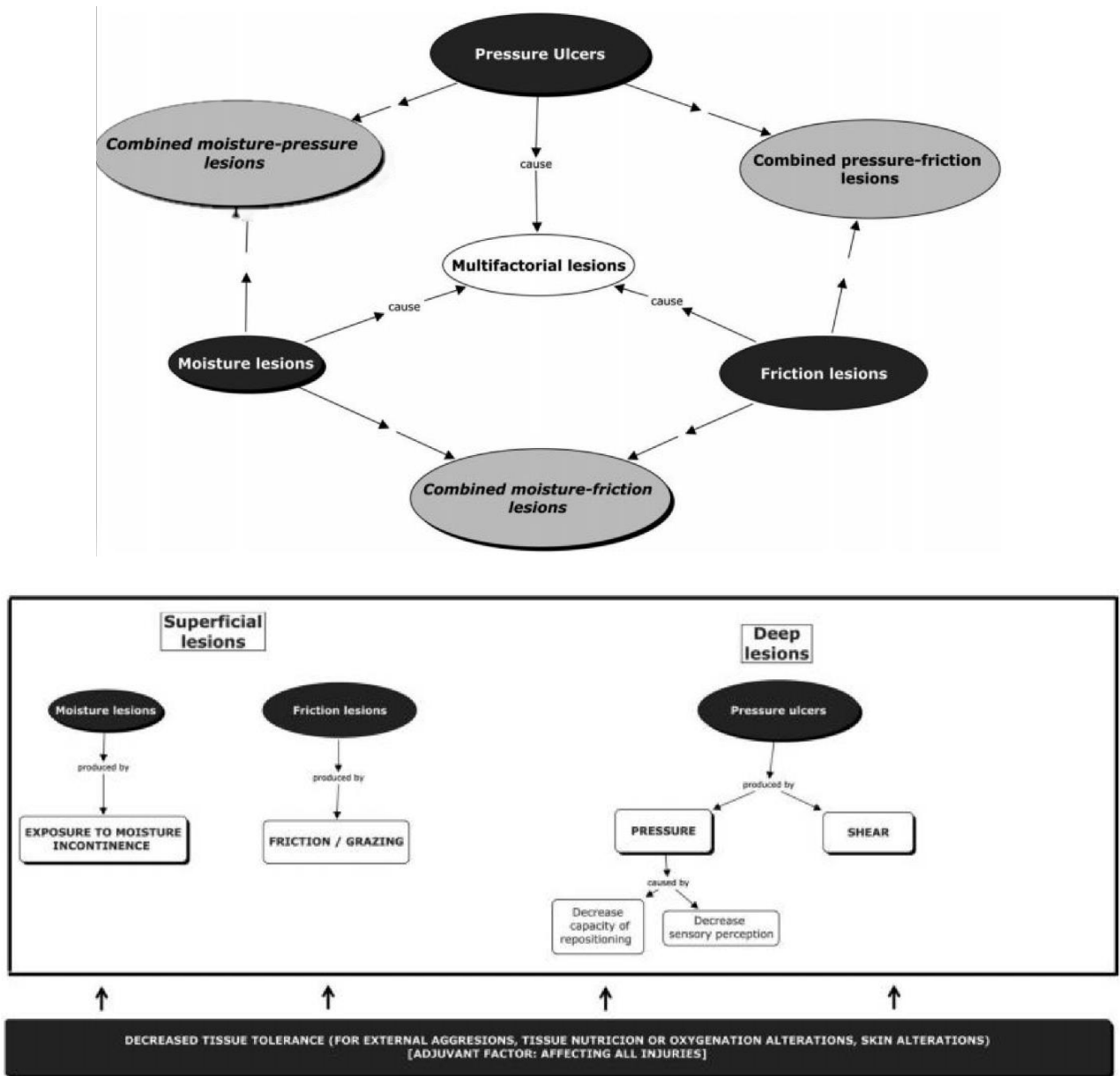


Figure 4

Process Chart for Pressure-Injury Prevention in Cardiac Surgery

Johns Hopkins Cardiac Surgery Pressure Injury Prevention Process Map

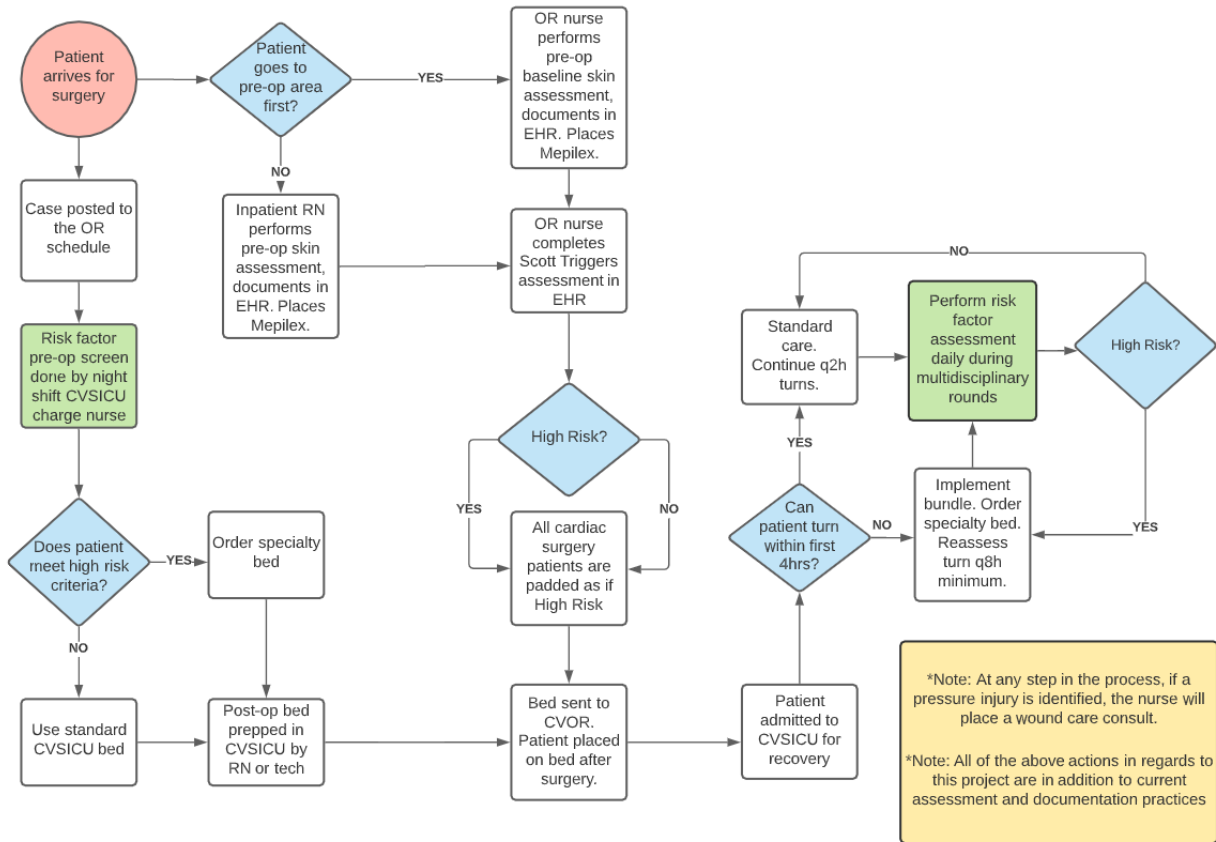
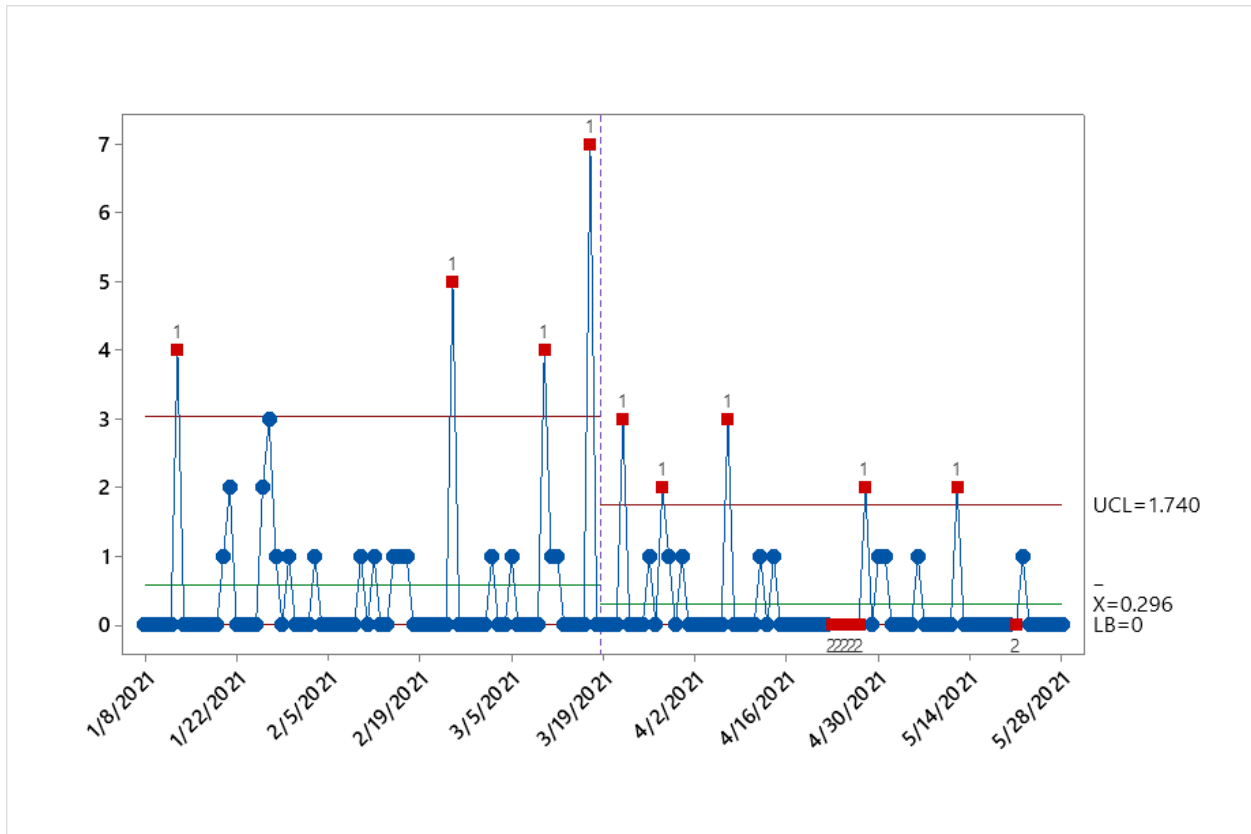


Figure 5

Individuals Chart (Control Chart) of PI Observations by Project Phase



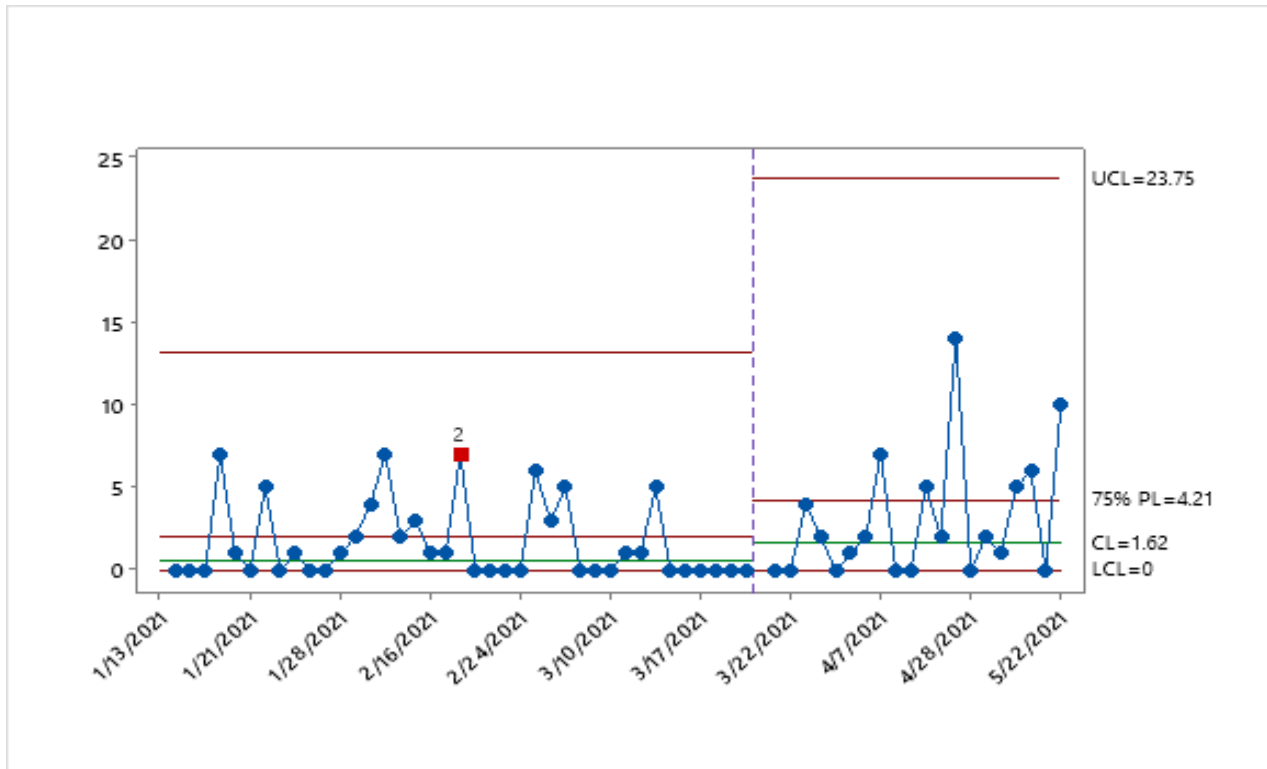
Note. The individuals chart shows individual PI observations in the CVSICU for the baseline and intervention phases of the project. The process shows a number of special cause variations identified within the data set.

^a Test 1 – One or more data point greater than 3 standard deviations from the center line indicating an outlier.

^b Test 2 – Nine points in a row on the same side of the center line indicating a shift in the data.

Figure 6

G Chart of Days between Pressure Injuries by Project Phase



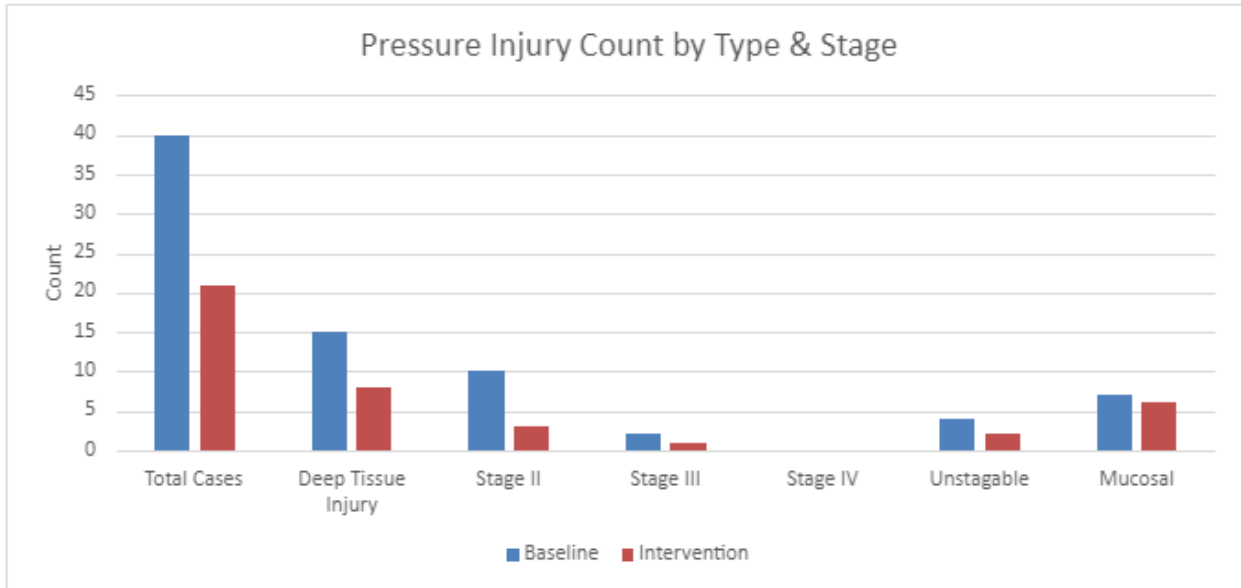
Note. A G-chart was used to monitor the number of days between rare events, in this case, the number of days between pressure injuries in the CVSICU. The process is stable and in control in both the baseline and intervention phases of the project. There are fewer pressure injuries in the intervention phase along with an increased time between these injuries.

^a The Center Line (CL) indicates the 50th percentile of the distribution, while the Upper Control Limit (UCL) signifies the expected variation in the process.

^b The Lower Control Limit (LCL) is always zero.

Figure 7

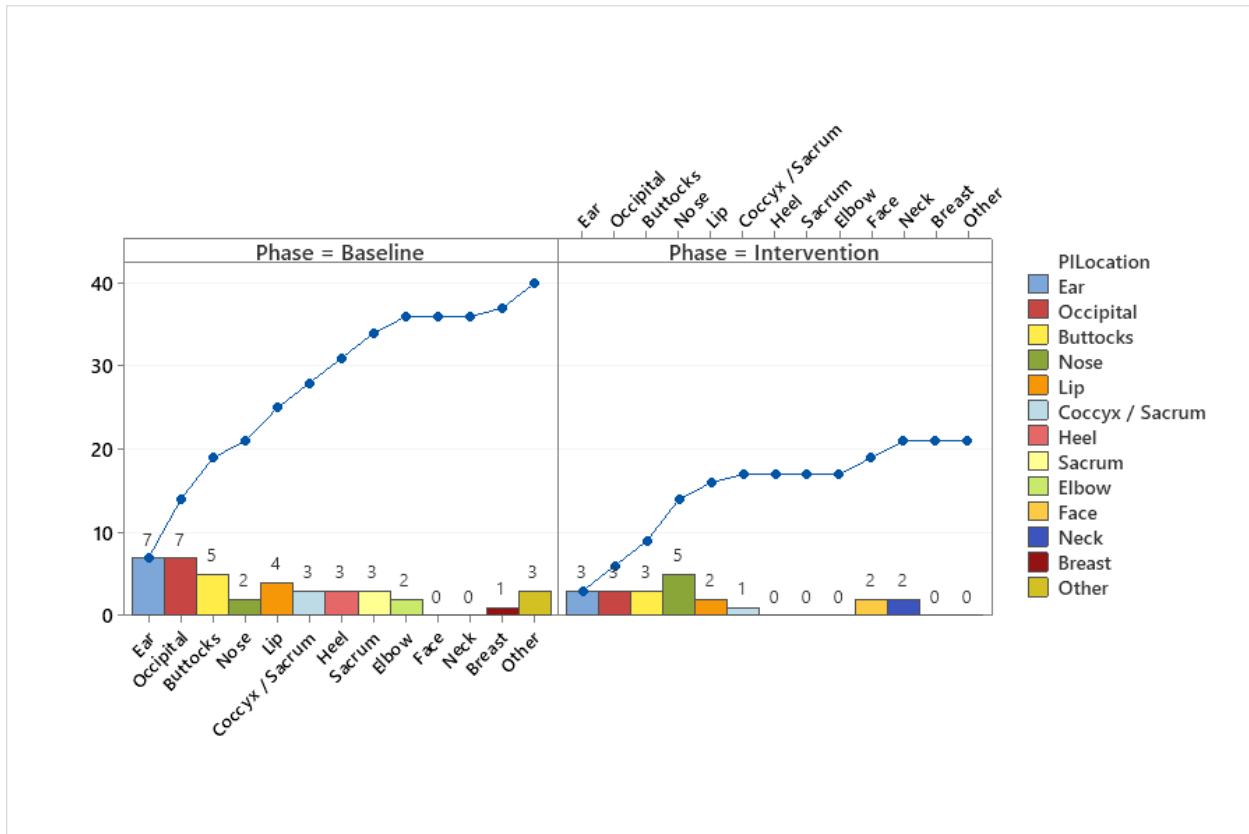
Pressure Injury Count by Type & Stage



Note. This figure describes the count of CVSICU PI during the baseline and intervention stages of the project.

Figure 8

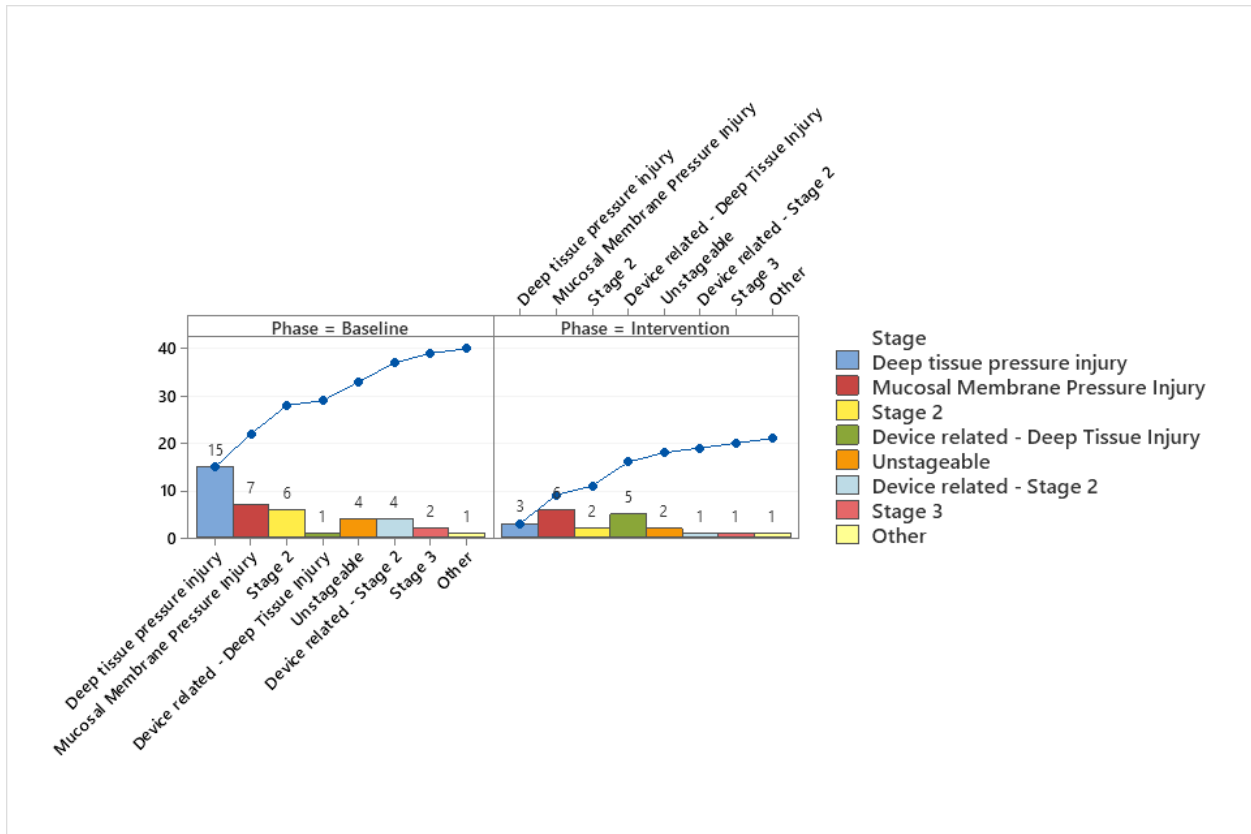
Pareto Chart of PI Location by Project Phase



Note. This figure describes the count of PI according to the anatomical location on the human body during the baseline and intervention phases.

Figure 9

Pareto Chart of PI Stage by Project Phase



Note. This figure describes the count and stage of PI during the baseline and intervention phases of the project.

Table 1*Table of Evidence*

Study	Aim, Question, Hypotheses	Setting, Sample, and Sampling	Design	Variables and Measures	Findings	Critique	Evidence Level	Conclusion
Ballesteros, 2017	Reduce incidence of HAPU using teamwork and EBP bundle.	14-bed CSICU. Hackensack University Medical Center, USA.	Non-experimental, descriptive quality improvement.	PU incidence.	Used a unit-specific turning guide to standardized turning practices. 2-person assessment, silicone sacral dressing, frequent turning/repositioning, correct mattress firmness, monthly PU incidence shared with staff. Joint effort between OR and ICU staff.	Aim unclear. Only looked at incidence, not severity of HAPU, Braden score, or other metrics.	V/C	Collaboration and teamwork with OR and ICU multidisciplinary staff were efficacious.

10 HAPUs in 5 months post-implementation. Zero HAPUs in the last recorded month.

21 HAPUs in 2016, which is 30% improvement from 2015 results.

Brennan & Laconti, 2014	Evaluate a fluidized positioning device (FPD) in 20 subjects for the period they remained in the ICU.	22-bed cardiac surgery ICU at North Shore University Hospital in NY. Convenience sampling. N=20.	Non-experimental, descriptive quality improvement.	Staff satisfaction, yearly PU incidence, cost.	60% of staff rated the FPD as “excellent”, 35% as “good”.	Methods unclear, including inclusion/exclusion. Data not adequately described and interpreted. Chart inaccurately states “rate” when Y-axis is “N”. Did not quantify	V/C	Concluded that reduced incidence of PU was noted. The majority of staff rated the product favorably.
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						family satisfaction, yet stated in discussion section. Future research opportunities not mentioned.		
Brindle & Wegelin, 2012	Hypothesis that bordered silicone dressing applied to sacral area would reduce the incidence of PU formation. Secondary aim was to tabulate clinical covariates and account for differences	14-bed CSICU at Virginia Commonwealth University. 100 subjects enrolled. Intervention group: 56 subjects, attrition of 6 subjects. Comparison group: 39 subjects, attrition of 4 subjects.	Non-randomized, quasi-experimental prospective cohort. Bedside nurses blinded. Subjects assigned to intervention or comparison groups based on bed assignment.	Twenty-two variables were measured between the intervention and comparison groups. PU incidence, Braden score, and subject demographics (age, gender, BMI, etc.) were measured, as well as patient factors (presence of Diabetes, driveline, vasoactive medications, etc.)	No significant differences in demographic characteristics (all P > 0.058). Ave. age 61.8 ± 13.2 years. Male 65.9%. Ave Braden score 11.2 ± 2.12. 8/35 (11.7%) subjects developed PU in comparison, while 1/50 (2.0%) occurred among intervention. Hazard ratio 3.6	Gap not clearly stated. Overall low incidence, not enough participants to achieve 80% power. Possible type II error. All subjects in OR received the intervention, and was later removed in ICU. May have skewed PU results.	II/C	Reduced incidence of PU with intervention. However, may have been influenced by nursing PU bundled care. Future research required with randomization, larger sample size, and adequate power analysis.

	in these covariates.							
Chello et al, 2019	To outline the current state of the evidence.	No setting noted. Authors from Rome, Italy.	Literature review.	Themes grouped into subthemes, including disease mechanisms, classification, risk assessment, cardiac surgery risk, recommendations for practice, and limitations in the literature.	Few studies exist on the topic, and there are limited recommendations. Prevention measures should focus on supporting tissue tolerance for pressure and tissue tolerance for oxygen.	Research methodology and search terms not mentioned.	V/A	Several factors contribute to high incidence of PI. Evidence of unique factors strongly associated with cardiac surgery is lacking.
Chen et al, 2012	Describe the incidence of surgery-related pressure ulcers reported in prospective longitudinal	No setting noted. Authors associated with Affiliated Hospital of Nantong University, China.	Systematic review with meta-analysis.	A pooled incidence for surgery-related PU was performed, along with incidence of subtypes (i.e. cardiac surgery, orthopedics, etc.)	17 articles included in the analysis. Pooled incidence of PU was 0.18 among cardiac surgery patients (95% CI 0.14-0.22, I ² =62.8%)	Search criteria led to lower yield of articles synthesis. Prevalence studies excluded. Only 2 cardiac cases	III/B	The pooled incidence of pressure injury may help provide a benchmark for evaluation.

	al studies over the last 5 years.	Used PubMed and Web of Science databases. 17 articles included in the analysis.				met inclusion.		Did not address all limitations.
Chen, Shen, Xu, et al, 2015	Investigate the relationship between perioperative corticosteroids and the incidence of pressure ulcers (PU) in cardiovascular surgical patients.	Affiliated Hospital of Nantong University, China. Pediatric and adult cardiac and aortic surgery patients between January-December 2012. N=286 met criteria.	Retrospective, non-experimental.	Demographics (age, gender, disease category, weight) as well as surgical factors such as length of surgery, length of cardiopulmonary bypass, vasoactive agents (pre-op, post-op) were measured. Corticosteroid use was compared to these variables.	47 of 286 patients developed PU, incidence of 16.4% [95% CI of 12.3-21.2]. 7 out of 16 patients who received corticosteroids developed a PU [95% CI=0.438, 0.198-0.701] Corticosteroids, disease category, length of surgery were 3 independent risk factors associated with	Pediatrics was included in the study, which may have affected results. Small sample size. Retrospective analysis. Needs prospective studies with larger sample to confirm results.	III/B	Perioperative corticosteroids are an independent risk factor for PU in cardiovascular surgical patients.

					PU development.			
Chen, Shen, Liu, Liu, 2017	Assess the relationship between length of surgery (LOS) and pressure ulcer (PU) risk in cardiac surgery patients.	Affiliated Hospital of Nantong University, China.	Systematic literature review with meta-analysis. Compared PU (+) groups to PU (-) groups. Also examined dose-response relationship. Observational studies included (cross-sectional, case-control, cohort) that assessed LOS and surgery-related	LOS (minutes), prevalence of PU and SRPU.	8 studies were included in meta-analysis. Mean LOS in PU(+) group ranged from 252.5 – 335.7 minutes, compared to 233.0 – 298.3 minutes in the PU (-) groups [weighted mean difference = 36.081 minutes, 95% CI, 21.640 – 50.522 minutes; Z=4.90, P=0.000].	Unclear quality rating scale used to assess the qualities of the included studies. Did not include length of cardiopulmonary bypass and the risk of SRPU. Does not address preventative strategies for pressure ulcers reduction.	III/A	Length of surgery is an important risk factor for pressure ulcers in cardiovascular surgical patients.

			pressure ulcers (SRPU).					
Chen, Yu, et al, 2018	To create an artificial neural network (ANN) model and test its power for predicting SRPI risk in cardiovascular surgical patients.	Affiliated Hospital of Nantong University, China. 149 cardiac surgery patients in sample, between January-December 2015.	Prospective cohort study.	Study findings obtained from secondary data analysis of a previously reported parent study. Data grouped into 3 parts: (1) demographic characteristics, (2) SRPU information, and (3) SRPU possible risk factors. AUC/C-index calculated for prediction ability.	37 of 149 patients acquired a PU. Univariate analysis showed age, disease category, surgery duration, perioperative corticosteroids were associated risk factors ($P < 0.10$) ANN model classified risk into 3 groups: mild, moderate, high. AUC/C-index 0.815, considered moderate predictability.	Authors cannot confirm the ANN model predicts stage 2 or greater PU since only 2 subjects experiences a stage 2 PU in the sample. Sample included children and adults, could alter results. Small sample, 140 subjects.	III/B	The ANN model provided moderate predictability .
Cooper et al, 2015	To implement preventative	Virginia Commonwealth	Case report, descriptive	Prevalence of PU, medical	Overall PU rate decreased 56% from 2012 to	Quantified acuity by presence of	V/B	Peer-to-peer feedback promotes a

	e measure to decrease rates of all hospital-acquired pressure ulcers, with a goal of zero preventable pressure ulcers.	University Medical Center, Richmond, VA. 865-bed facility, with study setting in 14-bed cardiac surgery intensive care unit.	quality improvement.	device-related PU (MDRPU). Compared with prevalence of mechanical circulatory assist device (MCAD) and ECMO therapy.	2013. Reduced MDRPU by 83% and non-MDRPU by 27%. Estimated cost savings \$84,000.	ECMO or MCAD, and not with a validated scale (e.g. APACHE II). Statistical significance not calculated. Presented in a case report style. Minimal methodology stated.		culture of shared responsibility. A proactive approach, practice surveillance, evidence-based practice, new products, and hypervigilance of staff was instrumental.
Ettema et al, 2014	Provide an overview of preoperative interventions to reduce postoperative complications in older elective	No sample noted. 31 articles appraised. Authors affiliated with University Medical Center Utrecht,	Systematic literature review without meta-analysis. Inclusion criteria included randomized control trials and cohort	Preoperative interventions.	No studies were found that uses preoperative interventions to reduce postoperative pressure ulcers in older cardiac surgery patients.	Excluded interventions that may already be part of standard care. Search focused on pre-operative interventions, and older cardiac	III/B	No studies were found that uses preoperative interventions to reduce postoperative pressure ulcers in older cardiac surgery patients.

	cardiac surgery patients.	Netherlands	studies, 1980-2011.			surgery patients, which may have reduced literature search yield.		
Floyd et al, 2016	Evaluate the effectiveness of a progressive mobility program	16-bed cardiac surgery ICU in an academic medical center in central Virginia. Elective surgery patients only. Half cardiac surgery, half thoracic surgery. Pre-intervention group (n=30) to a matched post-intervention	Retrospective, descriptive, matched-pairs design.	Demographics, surgical procedure, hospital LOS, ICU LOS, pressure ulcer prevalence, DVT/PE between the 2 groups.	Comparison did not achieve clinical significance (P < .05). Did show reduction in hospital LOS (mean 8.6 days pre-intervention, 6.5 days post-intervention), ICU readmission rate, DVT prevalence, and pressure ulcer prevalence.	Utilized thoracic surgical patients in population, which may have affected results.	III/B	Progressive mobility can improve patient outcomes.

		group (n=30).						
Geller & Seng, 2020	Summarize the definition, risk factors, stages, and outlines prevention strategies for pressure injury prevention .	No sample.	Expert opinion.	None.	No information regarding prevalence of HAPI by stage in cardiac surgery have been published. HAPI is caused by shearing force and compressive force, affecting tissue tolerance for pressure and oxygen. Risk factors exist in preoperative, intraoperative, postoperative phases. Prophylactic silicone dressing reduces risk of HAPI to sacrum.	Excellent summative article. Unknown if the authors are considered “expert” in the field.	V/A	Prevention of pressure injury outweighs the cost of treatment.

Glasgow et al, 2014	To explore the development of a medical-device related pressure ulcer in a patient.	Royal Victoria Hospital, Belfast, UK.	Case report.	Pressure injury secondary to medical device.	The case discussed an atypical grade 4-pressure injury secondary to a medical device, located to the posterior neck of a patient. Increased the LOS by 10 additional days, requiring 2 weeks of special treatment.	Case report of an individual experience. Unclear what wound staging system was used in the study. No quantification of the cost of the PU.	V/C	Vital to have a multidisciplinary approach to pressure injury prevention.
Huang et al, 2018	Compare the effectiveness of an alternating inflatable head pad compared to a gel pad in the prevention of postoperative occipital hair loss.	Yuhuangding Hospital, Yantai, China. 22-bed surgery department. 120 subjects. 60 randomized to control group, 60 experimental.	Quasi-experimental, prospective randomized control trial.	Sex, age, length of operation, Braden score on admission, BMI, diabetes, and types of operation were investigated.	120 subjects were included (74 males, 46 females). Mean age 56 years (range 34.5 – 66) No significances found between the two groups (P> 0.05). Prevalence of PU to occiput	Occipital alopecia evaluated using the hair-pull test, where 50% of occipital hairs grasped between the thumb and index finger equaled a (+) result. Single-center study.	II/B	Alternating pressure pad was more effective than a gel pad in preventing pressure ulcers and hair loss to the occiput.

					was 1.7% lower than control.			
Jackson et al, 2011	To present an aggressive care plan developed in our cardiothoracic vascular ICU for prevention of pressure ulcers in cardiac postoperative patients using an air-fluidized bed.	Saint Joseph Health System, Lexington, KY.	Pre-post retrospective observational study.	Demographics (age, gender), surgery length, vasopressors, blood products, surgery type, days of mechanical ventilation, and PU outcome were measured.	28 patients met criteria for study. 1 patient acquired 1 PU in the post-intervention group. Incidence went from 40% in August 2007 to 15% in June 2009. Approximate bed rental cost was \$18,000 for the 28 subjects. Mean length of mattress use was 7.9 days.	Unclear methodology, recruitment strategy, IRB status. Data consisted of lots of charts. No analysis was performed on a number of measured variables. No limitations of the study were noted in the article. One of the authors is an employee of Hill-Rom, and this was not stated as a disclosure in the text.	V/B	Air fluidized beds pose a possible prevention strategy to pressure ulcer reduction.

Kang & Zhai, 2015	Undertake an updated and extended analysis to assess diabetes as a risk factor for pressure ulcers in patients undergoing different types of surgery.	Jinqiu Hospital of Liaoning Province, Shenyang, China. Included RCT, cohort, and case-control studies. 13 articles included in meta-analysis.	Systematic literature review with meta-analysis.	Pre-existing diabetes mellitus was the exposure. Outcome was development of PU.	13 studies were included in meta-analysis. Pooled incidence of PU was 1.7 compared to non-diabetics [95% CI=1.40-2.15, I ² =51.1%]. Risk of PU was 2X higher among diabetics undergoing cardiac surgery [OR=2.0, 95% CI=1.42-2.82, I ² =0%].	The term “pressure injury” was not used in search criteria, which may have affected search strategy. Cardiac surgery statistics come from 4 studies, which may affect results.	III/A	Risk of PU is significantly higher among diabetics undergoing cardiac surgery.
Lu et al, 2017	Create a nomogram score and test its calibration and discrimination power for predicting surgery-related pressure	Affiliated Hospital of Nantong University, China. 149 cardiac surgery patients in sample, between January-	Prospective cohort study.	Data grouped into 3 parts: (1) demographic characteristics, (2) SRPU information, and (3) SRPU possible risk factors.	37 of 149 patients acquired a PU. Disease category, weight, surgery duration, perioperative corticosteroids (P < 0.10) were found to be independent risk	Small number of participants. Only from one facility. Need to validate the nomogram with a larger sample from other medical facilities.	III/A	A new nomogram established that provides individual prediction of SRPU. If score is ≥ 12 (0.25 probability), the patient should be

	ulcers (SRPU).	December 2015.		factors for SRPU.				considered “high risk”.
Rao et al, 2016	Identify risk factors associated with pressure injury among adult, critically ill, cardiac surgery patients.	Hospital of the University of Pennsylvania, Philadelphia, PA. 38 articles were eligible. 12 articles were selected for synthesis based on quality grading.	Systematic literature review without meta-analysis.	30 risk factors identified from the literature, organized into categories: compressive forces, shearing forces.	30 risk factors were identified from the literature. Certain risk factors were present in ≥ 1 article, such as age, limited mobility, vascular disease, severity of illness, low preoperative Braden score, low BMI, friction/shearing force, use of vasopressors.	Lacking meta-analysis of risk factor results. Unable to quantify unique risk factors to cardiac surgery patients exclusively.	III/A	Multiple factors have been identified that contribute to the high incidence of Pus in cardiac surgery patients. Evidence is limited.
Sabzi & Faraji, 2014	Present the risk factors associated with electrocautery burns and pressure injuries, along with	Imam Ali Heart Center, Kermanshah University, Iran. 60 out of 1400	Retrospective, non-experimental, case-control study.	Compared both groups to categorical and continuous variables: Hypercholesterolemia, PRBC consumption, weight, OR table	Most common PU locations were sacrum (67.5%), sacrum & buttock (17.5%), buttock (10%), and occipital (5%).	No gap in the literature mentioned. The article focused on 2 outcomes, burns and pressure injury, with	III/B	Skin evaluation should include consideration of all possible device faults or body preparation

	literature reviews for conducting a thorough electrocautery burn study.	OPCAB pts acquired a postoperative sore between December 2009-2012. Group A (electrocautery sore) = 20, Group B (pressure injury)= 40		time, smoking, age, diabetes, gender, hypertension, opium using, ejection fraction.	PU development was associated with stroke and respiratory failure. Electrocautery burns were associated with re-exploration for bleeding.	more of a focus on burns. No mention of which grading system was used for pressure injury classification .		solution interactions. Post-operative sores may be electrocautery burns or PI. More collaboration is needed between medical engineers and surgical staff in OR to reduce incidence.
Strauss et al, 2019	Examine the effect of a multilayer silicone foam dressing placed preoperatively on the incidence of postoperative sacral	Hospital of the University of Pennsylvania, Philadelphia, PA. N=300 pre, 224 post Emergent procedures, preoperativ	Quality improvement, pre/post design.	Prevalence of post-operative PI.	Pre-intervention: 7 out of 300 subjects developed PI. Post-intervention: 0 out of 224 developed PI. Statistically significant (P=0.02).	No data tables or figures. Lacked randomization. Performed at a single institution.	V/A	Results show that silicone-based dressings are a cost-effective strategy used to prevent PI among cardiac surgery patients.

	pressure injury (PI).	e length of stay >2 days, pre-existing PU were excluded from sample.			113 subjects disqualified for protocol violations.			
		Pre-intervention : March-August 2014. Post-intervention : February-April 2016.			Estimated projected cost savings of \$1,435,728 annually.			
Shen et al, 2015	Investigate the relationship between length of surgery (LOS) and the incidence of pressure ulcers (PU) in cardiovascular surgical patients.	Affiliated Hospital of Nantong University, China. N=286 patients, between January-December 2012. Pediatric and adult cardiac or	Non-experimental, retrospective case-control.	Demographics (age, gender, weight), as well as risk factors (LOS, length of cardiopulmonary bypass, vasoactive agents intraoperatively and postoperatively, corticosteroids) were examined.	47 of 286 acquired a PU. Incidence was 16.4%, with 95% CI of 12.3% to 21.2%. Most common locations were sacrum and coccyx (50.9%), heels (22.8%), ischial tuberosity (10.5%), and	Small sample size, mixed with pediatric and adults.	III/B	LOS is a risk factor for PU formation. Length of cardiopulmonary bypass length was not associated with PU.

aortic
surgery
were
included,
admitted to
the cardiac
surgery
ICU.

“other”
(15.8%).

LOS was
statistically
significant in
group with PU
compared to
group without
PU (195
minutes [30-
330min] vs 240
minutes [125-
675min],
P=.003)

Length of
cardiopulmonar
y bypass was
not significant,
even after
propensity score
matching (P=
0.830).

Table 2*UAPI from January – November 2020 in Relation to CVSICU LOS*

	Hours in CVSICU	Count of Patients	Pressure Injury Incidences	Unique Patients with PI	% of Patients with at least 1 PI
1 day	0-24	143	0	0	0
2 days	24-48	191	0	0	0
3 days	48-72	111	0	0	0
4 days	72-96	75	0	0	0
5-7 days	96-168	98	2	2	2
7-14 days	168-336	67	6	4	6
14-21 days	336-504	17	5	3	18
>3 weeks	504+	35	56	23	66
	Total	594	69	32	5

Note. This table demonstrates the count and the percentage of individual patients with at least one PI in relation to hours spent in the CVSICU from January – November 2020.

Table 3*Demographic Characteristics of Preoperative Screening and PIP Bundle Elements*

Characteristic	Description n(%)	Preoperative Screen Positive n(%)	Correct Sacral Dressing Placement n (%)	Rental Air- Fluidized Bed n (%)	Acquired PI Before Discharge n (%)
Gender					
Male	46 (67)	16 (35)	44 (96)	16 (35)	4 (9)
Female	23 (33)	7 (30)	23 (100)	7 (30)	1 (4)
Service Line					
Cardiac Surgery	61 (88)	15 (26)	59 (97)	15 (25)	3 (5)
ECMO	6 (9)	6 (100)	6 (100)	6 (100)	2 (33)
Heart Transplant	1 (1)	1 (100)	1 (100)	1 (100)	0 (0)
LVAD	1 (1)	1 (100)	1 (100)	1 (100)	0 (0)
Total	69	23	67	23	5

Table 4*Test and Confidence Interval for Two-Sample Poisson Rate: Pressure Injury Defects*

Project Phase	N	Total Occurrences	Sample Rate	Method	Z-Value	P-Value
Baseline	70	40	0.571429	Exact		0.018
Intervention	71	21	0.295775	Normal Approximation	2.48	0.013
Estimated Difference			0.275654			
95% Lower Bound for Difference			0.0580264			

Note. A 2-Sample Poisson rate test was used to determine that there was a statistically significant ($p=0.013$) difference in the number of pressure injuries between the baseline and intervention phases. This is also a practical difference as the number of injuries was reduced in the intervention phase.

Table 5*Chi Square Test of Two Proportions*

Project Phase	N	Event	Sample p	Method	Z-Value	P-Value
Baseline	150	23	0.153333	Normal Approximation	2.61	0.009
Intervention	175	11	0.062857			
Estimated Difference			0.0904762			
95% Lower Bound for Difference			0.022522			

Note. The test of two proportions was used to determine that there was a statistical difference ($p=0.009$) in incidence rate between the baseline and intervention phases. A one-sided test was used to determine that the difference between the population proportions of baseline and intervention is greater than the hypothesized difference of zero.

Table 6*Comparison of Costs between Air-Fluidized Specialty Bed Rentals and Total Cost of PI*

Phase	Rental Beds	Rental Bed Cost (\$)	Total Cases of PI	Patient Days	PI Total Cost (\$)	PI Cost/Day (\$)
Baseline	29	20,700	25	660	326,636	746.45
Intervention	55	26,920	13	610	241,756	354.15
Grand Totals	84	47,620	61	1,270	568,392	1,100
Difference	26	6220	-19	-50	-84,880	-392.30
Savings					78,660	

Note. This table describes the number of rental beds and associated costs during both phases of the project in comparison to the cost of pressure injury calculated using Padula et al. (2018).

^a The overall savings after subtracting the cost of the rental beds was \$84,880 over 6 weeks.

^b Projected savings over the course of 1 year is \$735,626.

Appendix A



**University of Pennsylvania
School of Nursing
Doctor of Nursing Practice Program**

DNP Team and Project Implementation Form

This form is to be completed by the student(s), institutional/organization project member(s), and school of nursing project lead and submitted for approval to the DNP Program Director.

Student Name: Tim Madeira

Project Title: Pressure Injury Reduction in Cardiac Surgery Using an Evidence-Based Bundle and Risk Stratification

School of Nursing DNP Project Faculty Lead: Kevin Driscoll, DNP, CRNA

Institutional/Organization DNP Project Member(s): Carla Aquino, DNP, RN

I hereby accept the following proposed project pending IRB approval (completed by student[s]):

Project Site: Johns Hopkins Hospital – Cardiovascular Surgical ICU

Project Purpose: The aim of this project is to reduce the prevalence of unit-acquired and hospital-acquired pressure injury in an adult cardiovascular surgical intensive care unit (CVSICU) by 5% in two months using risk stratification and an evidence-based bundle of pressure injury prevention (PIP) strategies.

Project Activities:

- Creation of a risk factor assessment tool specific to the adult cardiac surgery population, based on the literature, to stratify patients as "high risk" for skin breakdown.
- Pre-operative and daily assessment using the risk factor tool for all cardiac surgery patients.
- Utilize a process to employ a standardized PIP bundle for all patients who are deemed "high risk".

Participants (Describe target group; approximate # in project):

- Adult cardiac surgery patients in the CVSICU.
- Approximately 80-110 screened patients over the course of 8-weeks post-intervention

Site(s) Support (Resources):

- No financial disclosures

Data Management Plan:

- Utilizing Qualtrics survey platform, under protective license from Johns Hopkins Hospital

- No personal identifiers will be used
- 2-step authentication, password protection, and limited access to only project team members.
- Use of a Secure Analytic Framework Environment (SAFE) desktop, created for research under the protection of network security and firewalls.

Anticipated Start Date: February 1st, 2021

Anticipated End Date: April 1st, 2021

I hereby consent to serve on the DNP Project Committee. We understand that this site's participation will only take place during the project's active IRB approval period. All project activities must cease if IRB approval expires or is suspended. We understand that any activities involving Personal Private Information of Protected Health Information may require compliance with HIPAA laws and the University of Pennsylvania's policy. Our organization agrees to the terms and conditions stated above. If we have any concerns related to this project, we will contact the project team. For concerns regarding IRB policy or human subject welfare, we may also contact the UPENN IRB.

As a doctoral student member of this team, I agree to conduct the project to the best of my abilities with professionalism.

Student Signature:



As an institutional/organization member of this project team, I agree to read and review all drafts of the project within a timely turnaround (approximately 2 weeks).

Team Member Name: Carla Aquino, DNP, RN

Team Member Signature: *Dr. Carla Aquino*

Contact Information (email and phone number):

caquino6@jhmi.edu and 757-515-3828

As the School of Nursing DNP Project faculty lead, I agree to meet with the student(s) and consult throughout the project.

Faculty Lead Name: Kevin Driscoll, DNP, CRNA

Faculty Lead Signature:

Contact information (email and phone number): *driscollk9@gmail.com*
301-875-1080

APPROVED BY DIRECTOR, DOCTOR OF NURSING PRACTICE PROGRAM:

Director Signature:

Date Approved: 12/4/2020

Appendix B

Project Charter

AIM

The aim of this project is to reduce the prevalence of unit-acquired and hospital-acquired pressure injury in an adult cardiovascular surgical intensive care unit (CVSICU) by 5% in two months using risk stratification and an evidence-based bundle of pressure injury prevention (PIP) strategies.

PROBLEM

Pressure injury prevalence in the Johns Hopkins Hospital's CVSICU is historically always above benchmark when compared to other academic institutions with > 500 beds, based on the National Database of Nursing Quality Indicators (NDNQI). Both unit-acquired pressure injury (UAPI) and hospital-acquired pressure injury (HAPI) have complicated patient care in the CVSICU, and has extended length of stay, increased costs, and contributes to patient discomfort. The CVSICU pressure injury rate contributes to the hospital's overall pressure injury ranking, which is considered "underperforming" by the LeapFrog Group (2019).

IMPORTANCE

PI is a common side effect of many high-acuity surgeries, and the uniqueness of the adult cardiac surgery population affords these patients a higher risk of skin breakdown compared to most other surgical specialties. The Centers for Medicare & Medicaid Services (CMS) have outlined stage III and IV HAPI as "never events," unfavorably affecting reimbursements for the treatment of HAPI (Rao et al., 2016). The costs associated with treating HAPI can be staggering, ranging from \$500 to \$70,000 per individual pressure injury, and increasing length of stay an average of 11 additional hospital days (Rao et al., 2016). Non-profit organizations, such as The Leapfrog Group, benchmark and publicly report safety and quality measures, ranking a hospital's overall safety using a letter grade (e.g., "A" representing the best Leapfrog Hospital Safety Grade, followed by "B," "C," "D," and "F") based on a methodology comprised of 28 national CMS performance measures and a Leapfrog hospital survey (The Leapfrog Group, 2019). This public reporting can affect the hospital's overall ranking in the state of Maryland, and across the country, and contributes to the hospital's reimbursement for services and overall reputation among consumers.

EXPECTED OUTCOMES

- 1) Prevalence rate, hospital-acquired pressure injury – 5% reduction in 2 months
- 2) Prevalence rate, unit-acquired pressure injury – 5% reduction in 2 months

Deliverables:

- Standardized PIP that can be utilized by nursing staff to reduce PI.
- Pre-operative PIP tool to assess risk factors
- On-going PIP tool to assess risk factors

MEASURES

Outcome Measures:

- 1) Prevalence rate, hospital-acquired pressure injury
- 2) Prevalence rate, unit-acquired pressure injury

Process Measures:

- 1) % patients screened using the pre-operative risk assessment tool
- 2) % patients screened daily during their post-operative recovery in the CVSICU

Balancing Measures:

- 1) Severity of pressure injuries
- 2) Anatomic location of pressure injuries
- 3) Rental cost of specialty air mattress beds incurred

RISKS/BARRIERS

Risks to patients will be theoretically negligible since all patients will receive the standard of care. Patients who are risk-stratified as "high risk" for pressure injury will receive a bundle of interventions, including the use of a

specialty air mattress bed. A potential challenge that can be anticipated is the buy-in from charge nurses to perform the pre-operative screening of all patients the night before surgery. This will be monitored daily by the project's PI and will likely need on-going encouragement. Moreover, another challenge will be the daily reassessment of risk factors by the project's PI, and the compliance with using the PIP bundle, especially during off hours. Since this project asks nurses to utilize specialty rental beds and bordered silicone dressings to prevent PI rather than treat the PI once a wound has formed will be a culture shift and may incur feelings of wasting resources and money.

STAKEHOLDERS

Key stakeholders will be adult patients undergoing cardiac surgery, as well as clinical nurses in the CVSICU. Significant buy-in will be needed by nursing staff to perform the PIP bundle, as well as charge nurses to perform the pre-operative assessment on each patient the night before surgery. Other stakeholders include the co-directors of the CVSICU, as well as the nurse managers from the CVOR and the CVSICU, and the director of nursing for the department of surgical nursing. Risk factor assessment will be performed during morning rounds in the CVSICU, and feedback will be welcome by all multidisciplinary team members, the patient, and family, if present. If there are any objections to a patient receiving the PIP bundle, there will be an opportunity for discussion surrounding the clinical rationale.

SCOPE

In Scope: *Patients receiving open heart cardiac surgery, heart transplantation, left ventricular assist device (LVAD) implantation, and extracorporeal membrane oxygenation (ECMO).*

Out of Scope: *Lung transplant patients.*

SCHEDULE

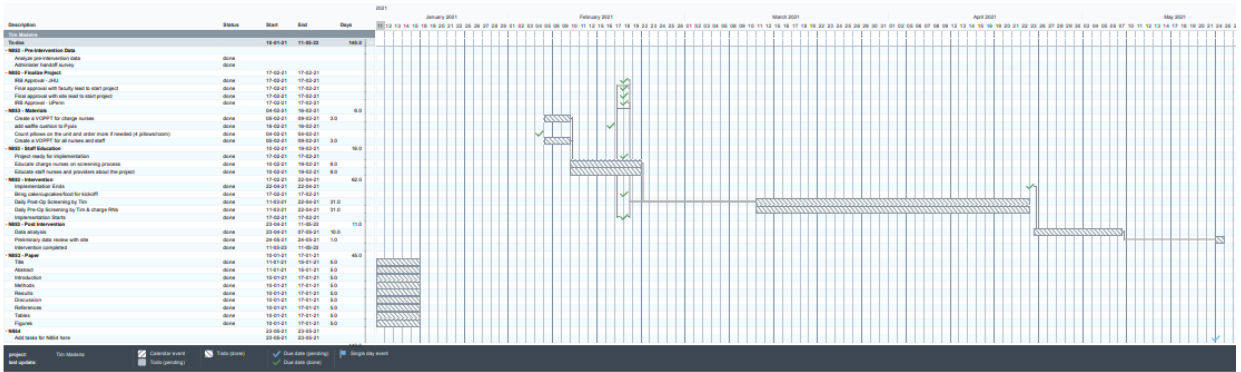
- December 2020: IRB submission
- December/January: Pre-intervention data collection.
- January 2021: Education of staff, 3rd & 4th weeks of the month.
- February 1, 2021: Implementation start
- April 1, 2021: Implementation end
- April/May 2021: Data analysis

PROJECT TEAM

<i>Team Member</i>	<i>Project Role</i>
Tim Madeira, CNS	Project Lead
Kevin Driscoll, DNP	Faculty Lead
Carla Aquino, DNP	Clinical Site Lead
Scott Burkett	Quality & Innovation Coach, Armstrong Institute
Jennifer Moyer, MSN	Nurse Manager, CVSICU
Mary Beth Rigel, MSN	Nurse Manager, CVOR
Sharon Owens, PhD	Director of Nursing, Surgery
Ashley Coco, BSN, RN	CVSICU Wound Champion
Glenn Whitman, MD	Surgical Director, CVSICU
Michael Grant, MD	Medical Director, CVSICU

Appendix C

Gantt Chart



Appendix D



Cardiac Surgery Pre-Op Screen – Pressure Injury Prevention

Preoperative Triggers for Highest Risk Patients:

If patient has any ONE major risk factor:	Or has 4 or more minor risk factors:
Expectant long OR case ≥ 6 hours* (skin to skin)	Age ≥ 70
Pre-op ICU stay > 72 hours	BMI < 14 or > 40
Spinal cord injury	Diabetes Mellitus, types 1 or 2
SOFA score ≥ 10	Vascular disease
Presence of pre-op driveline or cannula (LVAD, RVAD, IABP, ECMO)	Current smoker or within 5 years
Decreased mobility: HLM 4 or less (move to chair/commode) or baseline assist device	Active incontinence
Current or previous pressure injury	Braden scale ≤ 12 (high risk)
	Renal dysfunction (Cr >3mg/dl) or hemodialysis
	Anemia, any type
	Reduced nutrition: Albumin ≤ 3.5g/L

**rule of thumb: CABG cases are usually longer than valves because of graft harvesting. Complex case? Redo?*

Where to find these risk factors in EPIC:

Risk Factor	Where to find it in EPIC
Expectant long OR case ≥ 6 hours (skin to skin)	OR Schedule
SOFA score	CVSICU unit list (wrench this in once into your unit list)
Age, BMI, Pre-op ICU stay > 72 hours	EPIC banner (left screen)
Diabetes, spinal cord injury, vascular disease, smoking	H&P, under "Problem List"
Presence of a driveline or cannula (LVAD, IABP, ECMO)	VS Complex flowsheet or LDA Avatar
Current or previous pressure injury	Assess Complex flowsheet: Look for wound LDAs (current or completed). May also be in H&P
HLM, baseline assist device, incontinence, Braden	HLM: Daily Cares/Safety under "mobility". Braden: Assess Complex. Incontinence: Intake/Output.
Creatinine, anemia, albumin	Lab Results. You can search for each.

Instructions:

- **Charge Nurse:** Assess add-on cases and emergency cases. CNS will do all other surgery cases on the list before 6pm.
- Only screen each pre-op patient once. You do not have to rescreen "take backs" to OR.

If the patient has **1 major** pre-op risk factor, or **≥ 4 minor** pre-op risk factors, order an air mattress specialty bed to CVSICU.

- o Move regular ICU bed into hallway or storage area.
- o Place an order for a bed based on patient weight:
 - Freedom 500 bedframe (500lb capacity), order Advanced Wave mattress
- o Have specialty bed sent to CVSICU. Prep bed like regular OR bed and send to CVOR.
 Contact: www.freedommedical.com or 1-800-906-4215

The screenshot displays the EPIC Banner interface for a patient named Asiago, Veronica-VATRN. The patient's demographic information includes: Female, 20 y.o., 5/21/2000, MRN: 216000004. Clinical notes mention 'Missing Language/Interpreter Needs' and 'POLST: Missing'. Physical characteristics listed are: Ht: 162.6 cm (5' 4"), Last Wt: 59 kg (130 lb), BMI: 22.31 kg/m², and Dos Wt: 59 kg (130 lb). The patient is currently inpatient, with primary insurance listed as AETNA CHOICE POS I AND II.

The Flowsheets section is active, showing a list of assessment categories on the left and a detailed table on the right. Red circles highlight several items: 'Assess Complex' in the top navigation, 'Braden Scale' in the assessment list and table, 'Stool Status' in the table, and 'Genitourinary' in the table. A red arrow points to the 'ICU Pre-op?' label at the bottom of the patient information panel.

Category	Item	Value
Integumentary	Integumentary (WDL)	1619
	Braden Scale	
	Sensory Perceptions	
	Moisture	
	Activity	
	Mobility	
	Nutrition	
	Friction and Shear	
	Braden Scale Score	
	Pressure Ulcer Prevention Intervention(s)	
Musculoskeletal	Musculoskeletal (WDL)	
	*OLD Musculoskeletal (WDL)	
	Musculoskeletal Additional Assessments	
Gastrointestinal	Gastrointestinal (WDL)	
	*OLD Gastrointestinal (WDL)	
	Last Bowel Movement Date	
	Abdomen Inspection	
	Abdomen Palpation	
	Palpation	
	*OLD Flatus	
Stool Status	Stool Description	
	Stool Amount	
	Genitourinary	
Genitourinary	Genitourinary (WDL)	
	Genitourinary Additional Assessments	

Appendix E
















Cardiac Surgery Pressure Injury Prevention (PIP) Bundle

Instructions:




The following PIP measures are evidence-based and are designed to help reduce the risk of pressure injury (PI) related to pressure, shear, moisture, and medical devices. Cardiac surgery patients are the highest risk inpatients for PI.

Head/Occiput:

<p>Skin Assessment</p>	<p>Assess occiput for PI and alopecia every shift and on admission</p>	
<p>Z-Flo Fluidized Positioner (Pillow)</p> 		<ol style="list-style-type: none"> 1. Place a flattened positioner under the patient's head and align with the shoulders. 2. With flat hands, mold the positioner from the perimeter towards the ears to fill in the cervical spine area. Use your fingers to mold divots to create space for the ears, if needed. 3. Ensure the head and neck are in neutral alignment. <p>Head Positioning</p>  <ol style="list-style-type: none"> 1. With the head positioned to the left or right, lift the head and place an appropriately sized positioner under the head, starting at the base of the neck. 2. Create a divot for the down ear. 3. Mold the positioner toward the head. 4. Additional divots can be created to support any lines, tubes, or drains. 5. Reposition the head regularly. Micro-molds can be made to provide small weight shifts, when appropriate.
<p>ECMO Headband (aka urological catheter strap) + Mepilex Transfer or Lite</p> 	<ul style="list-style-type: none"> • A jugular ECMO cannula <u>should be secured</u> using a headband and <u>Mepilex Transfer under the headband</u>. • The face <u>can be protected</u> by a piece of <u>Mepilex Lite</u>. Date all <u>dressings and change weekly</u> and PRN soiling. • You can place <u>Mepilex Lite</u> on the <u>back of the ear</u> if the cannula is touching the pinna. 	






<p>BIPAP Face Mask</p> 	<ul style="list-style-type: none"> Any full face BiPAP or CPAP can lead to breakdown of the nose and cheeks. Ask the Respiratory Therapist about using a Protecta-Gel 
<p>Hi Flow Nasal Cannula</p> 	<ul style="list-style-type: none"> Cut 2 rectangular pieces of Mepilex Transfer and date them. Apply to the face to protect cheeks. Change with bed bath & PRN soiling. 
<p>Braided or Thick Hair</p>	<ul style="list-style-type: none"> Occipital injuries are common with bedbound, incapacitated patients, especially the ECMO population or anyone requiring deep sedation or paralysis. Braided hair can act as a pressure point, therefore parting the hair into "pigtales" allows the head to touch the bed or Z-flow, and allows visualization every shift. If the patient is on a specialty air mattress, consider <u>not using</u> a pillow. Allow the head to benefit from the specialty bed. 
<p>Ears</p>	
<p>Skin Assessment</p> 	<ul style="list-style-type: none"> Assess ears for PI every 4 hours and on admission. Assess more frequently if using an ear clip pulse oximetry probe. Rotate ear clips frequently to a new spot after each assessment. <p><u>Best Practice Tip:</u></p> <ul style="list-style-type: none"> Avoid using ear clip pulse oximetry if possible. Finger clip pulse oximetry preferred. Avoid wrapping the ear lobe with a neowrap pulse oximetry if possible.
<p>Mepilex Transfer</p> 	<ul style="list-style-type: none"> Cut a small square from the Mepilex transfer. Time & date it. Place Mepilex to the ear lobe or pinna. Change every 72 hours and PRN. Lift up to assess skin under the foam. 



Nose:

<p>Skin Assessment</p> 	<ul style="list-style-type: none"> • Assess bridge of nose and each nare for PI every 4 hours and on admission. • If the tube is secured to nose, look underneath to assess skin integrity. • The inside nare, where the tube touches the skin, is a common place for injury.
<p>Best Practice Tip</p> 	<ul style="list-style-type: none"> • Apply nasal gel pad for all full facial CPAP and BiPAP therapy (provided by RT). • Use an adhesive tube securement device for all nasogastric and nasoduodenal tubes. • Avoid pulling the tube upwards or in a position that forces the tube to touch the skin. • Time and date, write the tube length on the nose to track tube location.
<p>Tube Securement</p> 	<ul style="list-style-type: none"> • Apply Cavalon skin protectant to nose. • Position the adhesive securement at an angle, along the angle of the tube. • Pinch the securement together where the two wings split. This allows the tube to "float" away from the nare and not touch the skin. • Wrap the tube to secure. Write the time, date, and "hash mark" at the nare (in cm). • Option: Pin the tube to the gown to reduce risk of tube dislodgement when ambulating.


Elbows:

<p>Skin Assessment</p>	<ul style="list-style-type: none"> • Assess elbows every 4 hours and on admission. Does the skin blanch?
<p>Mepilex Border 3" X 3"</p> 	<ul style="list-style-type: none"> • Cover each elbow with a Mepilex border 3" X 3". Lift up to assess skin underneath then press down firmly. Time & date. Change every 72 hours and PRN. 

Mouth:	
<p>Skin Assessment</p> 	<ul style="list-style-type: none"> Assess the mouth every 4 hours and with oral care. Look for pressure points caused by the endotracheal tube (ETT).
<p>Best Practice Tip</p> 	<ul style="list-style-type: none"> Ensure that the ventilator tubing circuit is not putting added weight on the lips. Utilize <u>ventilator arm</u> to "lift" ventilator tubing off the lip. Reposition and re-tape ETT every 48 hours and PRN. Avoid positioning in extreme corners of the mouth or ventilator tubing pulling the ETT towards the corners or downwards on the lower lip. <u>Oral hygiene</u>: Q4 hours using an oral hygiene kit. CHG every 12 hours. Use the mouth moisturizer in the kit at the end of oral hygiene. <p><u>Option 1</u>: Mepilex Transfer</p> <ul style="list-style-type: none"> Peel up to assess skin under foam. Change daily. <p><u>Option 2</u>: 3"X 3" gauze</p> <ul style="list-style-type: none"> Change gauze frequently so moisture does not denude the lips. 
<p>Bite Block</p> 	<ul style="list-style-type: none"> Avoid <u>corners of the mouth</u> and the <u>sides of the tongue</u> as pressure points. Position the bite block away from the corners of the mouth as possible. Attempt to switch the site of the bite block with each ETT repositioning/re-taping (q48 hours) 

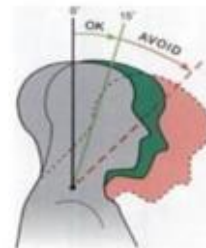
 **Rule of Thumb:** After each turn, reposition the ventilator arm last so  that you can position the tube off of the lips.

Tracheostomy:

<p>Foam Dressing</p>	<ul style="list-style-type: none"> • Provider performing tracheostomy procedure will place a barrier dressing at the time of the procedure unless contraindicated. • Dressing is used for the duration of the hospitalization while the tracheostomy is in place • Nursing staff will change the dressing Q24 hours and PRN (when saturated, soiled) • Do not use gauze dressing for tracheostomies
<p>Skin Assessment</p>	<ul style="list-style-type: none"> • RN/RT will assess the skin/area around the tracheostomy, dressing, and securement device every 8 hours with trach care • Contact provider for any signs of skin breakdown, swelling, pressure, or irritation
<p>Suture Removal</p>	<ul style="list-style-type: none"> • RT/Provider removes sutures 7 days after procedure or as ordered
<p>Neutral Positioning of the Head & Neck</p> 	<ul style="list-style-type: none"> • <u>Avoid pillows</u> if possible, or place pillows under shoulders. • Use Z-Flo head cushion if you must use a pillow. • Maintain tracheostomy tube in <u>continuous neutral position</u>. • Ensure <u>oxygen tubing</u> or <u>ventilator circuit</u> is not putting added weight on, pulling on, or twisting the tracheostomy tube. • Utilize the ventilator arm to keep the ventilator tubing from pulling tracheostomy tube out of neutral position. • Use caution when turning the patient; maintain continuous neutral position of the tracheostomy tube

Customizing the Mepilex Lite (SAP 108871) for device protection:


- Cut into quarters
- trim a little hole in the center of each quarter
- Cut a slit from edge to the hole
- Place under the skin plate/bumper of the device






Fingers:

<p>Skin Assessment</p> 	<ul style="list-style-type: none"> • Assess fingers every 4 hours and on admission. • Unwrap pulse oximeter every 24 hours to assess for PI and burns. • Rotate pulse oximetry to another finger every 24 hours. • You can label the pulse oximeter with a time and date using a white label. 
<p>Best Practice Tip</p>	<ul style="list-style-type: none"> • <u>Finger clip pulse oximetry</u> is always preferred. • Always assess if you can transition from an ear clip/finger wrap to the <u>finger clip</u>.



Abdomen:

<p>PEG Tube</p>	<ul style="list-style-type: none"> Place a <u>Mepilex Transfer</u> under and around the PEG bumper to protect the skin. Date dressing and change with routine PEG site care. 	
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Sacrum:

<p>Skin Assessment</p>	<ul style="list-style-type: none"> Assess sacrum every shift and on admission. Peel any preventative dressings down, and then reapply using the warmth of your hand. Change sacral bordered dressings every 72 hours and PRN soiling.
<p>Mepilex Bordered Sacral Dressing</p> 	<ul style="list-style-type: none"> Position patient in side-lying position (if in bed) or bent over forward slightly (if standing). Remove dressing from the packaging and label with time and date. Remove center plastic and fold it into your hand for application. Apply lower tail first, about 1 inch above than the anus. Remove plastic coverings and apply wings, making sure to activate the bordered adhesive with a warm hand and gentle pressure. Option: Flip the dressing upside <u>down</u> if patient is incontinent or has an hourglass figure. 
<p>Waffle Cushion when OOB</p> 	<ul style="list-style-type: none"> Use of a waffle cushion when OOB to the chair reduces pressure on the sacrum. High risk patients need to <u>shift their hips</u> every 30 minutes when in the chair.

Heels:

Skin Assessment	<ul style="list-style-type: none"> Assess both heels for PI every shift and on admission. Do they blanch?
Best Practice Tip	<ul style="list-style-type: none"> Elevating heels off the bed with a pillow or rolled towel is always best prevention.
<p>Mepilex Border 3" X 3"</p> 	<ul style="list-style-type: none"> Cover each heel with a Mepilex border 3" X 3". Lift up to assess skin underneath then press down firmly to reapply. Time & date. Change every 72 hours and PRN. Use green Prevalon boots for immobile and bed-bound patients. Float boots with a pillow. 

Moisture and Shear Forces

Moisture Tips	Shear Prevention
<ul style="list-style-type: none"> Avoid plastic diapers. Only use when OOB. Use only 1 Covidien airflow pad for incontinence if possible. Use lots of barrier cream to the perianal area for incontinence. Change sheets as soon as possible when soiled. Use <u>InterDry sheets</u> in skin folds to wick moisture away. Males: Use Cavalon barrier before applying Texas catheter (condom catheter) Females: Use of the Purewick if reduced mobility or incontinence. <p><i>"If you have to spread to see it, its moisture related."</i></p>	<ul style="list-style-type: none"> Once extubated, if the patient can tolerate a HOB < 30 degrees, lay the bed as flat as possible to reduce pressure on the sacral area. Reverse Trendelenburg is also an option if the patient cannot tolerate hip flexion or HOB < 30 degrees. 
<p>Barrier Creams Available:</p> <ul style="list-style-type: none"> Criticalaid: Use for moisture barrier. Criticalaid AF: Use for moisture barrier and fungal/yeast treatment (contains Miconazole). EPC Cream: Moisture barrier with zinc. Use it to coat over a wound, such as a stage II. Greer's Goo: Contains zinc, hydrocortisone, Nystatin. Use for fungal rash. 	<ul style="list-style-type: none"> Have the patient help you reposition as much as possible. Use a mechanical lift or pink sliding pad to shift people up in bed. Reverse Trendelenburg helps if the patient can tolerate it.

CVSICU Turning Guideline

Clinical Conditions That May Prevent Turning	Recommended Interventions for the Unstable Patient	Prevention is Key
<ol style="list-style-type: none"> 1. Development of a life-threatening arrhythmia with symptomatic response, not including asymptomatic atrial fibrillation. 2. Active fluid resuscitation, massive transfusions, and the use of high dose and multiple vasopressor therapy. 3. Active hemorrhage following surgery, or active cardiac tamponade. 4. Acute phase, post insertion of a life-sustaining device. 5. Unstable cannulation/insertion sites. 6. A change in baseline hemodynamic parameters that do not recover within 10 minutes of position change and is not an expected result based on diagnosis. 	<p>If the patient is deemed too unstable to turn based on the above parameters:</p> <ul style="list-style-type: none"> • Provide <u>mini turns</u>. • Weight shift the patient at least every <u>30 minutes</u>. • Reposition the patient's head, arms, and legs at least every hour; consider passive range of motion (PROM). • When turning the patient, go slow! Provide serial small turns from the supine to lateral position to achieve linen changes and hygiene checks, and reposition the patient with body wedges and pillows. • Attempt a trial turn every <u>8 hours</u> to determine the ability to resume frequent turning at least every 2 hours. • Obtain a "do not turn" order on a daily basis after reassessing the patient. Document using "unable to turn per order". 	<ol style="list-style-type: none"> 1. Frequently assess the acuity of the patient, level of immobility, as well as all risk factors. 2. Use of a sacral dressing prophylactically. 3. Air mattress with correct firmness. 4. Nutrition consult. 5. Proactive use of PIP bundle and teamwork with staff for turns and PIP suggestions. 6. Look at all insertion points for devices, tubes, and catheters. 7. Float and elevate extremities using pillows.

Adapted with permission from Brindle CT, Malhotra R, O'Rourke S, Currie L, Chadwick D, Falls P, Adams C, Swenson J, Tuason D, Watson S, Creehan S. Turning and repositioning the critically ill patient with hemodynamic instability: a literature review and consensus recommendations. J Wound Ostomy Continence Nurs. 2013 May-Jun;30(3):254-67. doi: 10.1097/WON.0b013e318290448f. PMID: 23652698.

Johns Hopkins Cardiac Surgery Pressure Injury Prevention Process Map

```

    graph TD
      Start([Patient arrives for surgery]) --> D1{Patient goes to pre-op area first?}
      D1 -- YES --> A1[OR nurse performs pre-op baseline skin assessments, documents in EHR, Places Mepilex]
      D1 -- NO --> A2[Inpatient RN performs pre-op skin assessment, documents in EHR, Places Mepilex]
      A1 --> A3[OR nurse completes Scott Triggers assessment in EHR]
      A2 --> A3
      A3 --> D2{High Risk?}
      D2 -- YES --> A4[All cardiac surgery patients are added as if High Risk]
      D2 -- NO --> D3{Can patient turn when first alert?}
      A4 --> A5[Bed sent to CVOR. Patient placed on bed after surgery]
      A5 --> A6[Patient admitted to CVSICU for recovery]
      A6 --> D4{Standard care. Continue q2h turns.}
      D4 --> D5{High Risk?}
      D5 -- YES --> A7[Perform risk factor assessment daily during Multidisciplinary rounds]
      A7 --> A8[Implement bundle. Order specialty bed. Reassess turn q2h minimum.]
      A8 --> D5
      D5 -- NO --> A9[Patient admitted to CVSICU for recovery]
      A9 --> D6{Standard care. Continue q2h turns.}
      D6 --> D5
  
```

*Note: At any step in the process, if a pressure injury is identified, the nurse will place a wound care consult.
 *Note: All of the above actions in regards to this project are in addition to current assessment and documentation practices

8

Appendix F

Staff Education Video Links and Photos

- Cardiac Surgery PIP Nursing Project: <https://web.microsoftstream.com/video/e7f54805-7f26-4123-a3b8-f2a58066eeee>
- Freedom 500 Specialty Air Mattress Beds – Overview: <https://web.microsoftstream.com/video/ad0c6cab-0157-45b7-9f8e-a2b8f7e192e0>
- How to Use a Z-Flo Positioner: <https://web.microsoftstream.com/video/18304f40-6a9d-41f0-9b70-f3410fa24464>
- Photo of CVSICU dry-erase board for communication of wound team's weekly findings:

