Evaluation of the Pressure Ulcer Prevention Clinical Decision Report for Bedside Nurses in Acute Care Hospitals

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Keywords

Electronic medical records, EMR, ICU, intervention, pressure ulcers, prevention

Summary

Background: Hospital stays for patients with pressure ulcers (PU) increased nearly 80% from 1992 to 2006. Most PU's developed during an admission, often despite preventive efforts from clinical staff. Data from Electronic medical records (EMR's) were used to prepare daily patient risk factor and PU information for nurses to help prevent PU development and exacerbations.

Objectives: The objectives of this study were to determine whether: 1) dissemination of an automated daily report with patient risk and current status of pressure ulcers ("PU Daily") helps prevent the development of pressure ulcers, and 2) using the PU Daily information impacts the severity of pressure ulcers that develop in an acute care setting.

Methods: A pre-post study with four control units was designed to determine the impact of the PU Daily in intensive care units (ICU) in a large medical center. The control units included ICU's using the same EMR and similar complexity of cases with a high risk of developing a PU. The pre-post study took place over a six month period (March – August 2009).

Results: A total of 6,735 cases were included in the study. The intervention unit showed a significant decrease ($p = 0.004$) in PU's at post-evaluation; none of the four comparison units showed a decrease at the $p<0.05$ level. The intervention led to a significant reduction in the total number of PU's documented ($p <0.000$) and the number of Stage II PU's ($p = 0.046$).

Conclusion: The intervention with the PU Daily showed a significant decrease in the total PU's and severity of PU's and allowed for implementation of interventions that help prevent the development of PU's. As EMR's become more widely available, this intervention showed a reduction in PU's. Future studies should further develop this intervention and include multiple institutions and patient populations.

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1. Background

Preventing pressure ulcers (PU) is fundamental to nursing care and described as early as in Florence Nightingale's writing in the 19th century. The National Pressure Ulcer Advisory Panel (NPUAP) defines PU's as a localized injury to the skin and/or underlying tissue usually over a bony prominence [1]. Despite intensive efforts directed at preventing the development of pressure ulcers for hospitalized patients, current rates have increased. According to the International Pressure Ulcer Prevalence Survey in the U.S. (2008–2009), overall prevalence rates of facility-acquired pressure ulcers in the acute care setting ranged from 5% to 13.5%. The incidence of new PU's for acute-care patients is around 7% with wide variability among institutions [2–4].

Electronic medical records (EMR) capture pertinent patient risk factor data that can be used as feedback to bedside nurses for implementation of timely interventions. The information nurses need to determine patient risk factors is typically spread throughout the EMR and not readily available to provide a comprehensive overview for clinical care delivery and patient risk. Use of decision support at the point of care has shown promise in reducing pressure ulcer rates [3]. Therefore, the purpose of our study is to evaluate the impact of a pressure ulcer (PU) daily feedback report with information about patients risk factors and current status of pressure ulcers for bedside nurses to help prevent the development of PU's. The daily report ("PU Daily") uses EMR data to provide a current and pertinent overview of patient risk factors and pressure ulcer status.

O'Reilly [5] and Wahl [6] used a daily electronic feedback system which incorporated components of patient specific clinical data organized to provide timely feedback to providers with favorable results. The O'Reilly [5] intervention greatly contributed to timely delivery of prophylactic antibiotics by anesthesiologists. Wahl [6] reported that patient specific feedback from an EMR based report to reduce ventilator associated pneumonia (VAP) was readily implemented. These studies demonstrate that topic specific clinical decision support applications provide actionable information for clinicians and subsequently impact patient outcomes.

2. Objective

The PU Daily was developed as an intervention to evaluate whether specific clinical information contributes to clinical decision making aimed at reducing PU's. The specific questions of this study were: 1) Does daily dissemination of the PU Daily with patient risk and current status help prevent the development of pressure ulcers? and 2) Does using the the PU Daily impact the severity of PU's? Though pertinent data about patient risk factors is often available at the hospital and unit level [7], the information is typically not readily accessible for clinical decision making. This study evaluated the impact of providing summarized patient risk information to bedside nurses to support clinical decision making aimed at preventing the onset of pressure ulcers.

2.1 Development of PU Daily

The prevention of PU's is a priority for the acute care setting as the cost of treating a pressure ulcer is estimated at 2.5 times the cost to prevent a PU [8]. Hospital stays with pressure ulcers increased nearly 80% from 1992 to 2006 and over 90% of these admissions are nosocomial in nature [9-10]. Maeda et al. [11] and VanGilder et al. [9] reported PU rates were highest in adult ICUs and ranged from 10.3% in a surgical ICU to 12.1% in a medical ICU. Russo et al. [10] reported that more than 90% of PU related stays were for treating other conditions, such as pneumonia or septicemia. Hospital stays for patients with a PU were generally longer (14.1 days) in comparison with those without a PU (12.7 days). In addition, the Centers for Medicare and Medicaid (CMS) will no longer provide additional reimbursements for patients that acquire pressure ulcers while admitted in a hospital [12]. When a PU develops, the goal is to close the ulcer as quickly as possible and prevent further ulcer deterioration, infection development, and manage the pain [13]. Prevention of PU's often does not include the use of information technology but rather typical nursing care based interventions, such as regular turning, care for bedding, and adequate nutrition. PU's cause extreme discomfort to the patient and often lead to serious, life threatening infections [1]. AHRQ [14] suggests using an inter-

disciplinary approach that includes both routinized and patient specific risk profiles. The PU Daily represents an initial step in the recommended direction by providing patient specific risk factors and PU status.

A multi-disciplinary workgroup comprised of clinical nursing staff, nutritionists, wound care specialists, database programmer, and school of nursing faculty was established to develop the PU Daily. The workgroup used evidence-based recommendations to identify pertinent information for inclusion in the PU Daily, in particular review of the literature pertaining to predictors of PU's in acute care, ICU's, demographic characteristics, and use of treatments such as use of nutrition to prevent the development of PU's. The PU Daily was developed using a similar technological approach as described in O'Reilly [5] and Wahl [6]. The available clinical data systems (EMR, clinical warehouse) provided a list of all patients who were admitted to a specific unit and clinical data about patient risk and health status. A data extract containing all identified data elements was analyzed to determine whether these data elements were predictive of PU development to determine inclusion in the PU Daily. Subsequently, the identified data elements were included in the PU Daily (▶Table 1).

The Braden subscale is the assessment tool that is widely used to determine current status and risk [15]. Please refer to ▶Table 1 for an overview of the components included in the Braden Scale. The PU Daily includes patient characteristics, select co-morbidities, and Braden sub-scales to capture changes in a patient's risk of a pressure ulcer, which is used to implement preventive activities to help prevent PU's. The Braden subscales include both the current score and the change from the initial score (+ or -). The National Pressure Ulcer Advisory Panel (NPUAP) defined various Stages I–IV, with Stage IV the most serious stage of pressure ulcer [1] (▶Table 2). Feedback reports about PU's are often at the hospital or unit level and delivered on a monthly or quarterly basis. Though such reports are informative for trending purposes, they are of little help in efforts to impact the PU related care of particular patients.

Validity of the content of the PU Daily was established using three approaches. First, evidence-based literature was carefully reviewed and patient characteristics known to be associated with PU's were identified for inclusion in the PU Daily. A multi-disciplinary workgroup consisting of clinicians, nutritionists, IT and School of Nursing faculty further established data fields and established face validity of the particular items and logic used to present the data. Finally, a logistic regression analysis was performed to evaluate the association between the prepared data elements and PU's. Data items were significantly associated with the development of PU and thus incorporated in the PU Daily. Following the results of the analyses, all identified data elements were included in the PU Daily (▶Table 1).

The feedback reports prepared for the O'Reilly [5] and Wahl [6] studies were modified to include: additional language to flag changes in Braden sub-scales (▶Table 2), information from pharmacy profiles (vasopressor use, diabetes information), additional nursing related detail (i.e. devices that contribute to the development of PU), and clinical process information (i.e. Operating Room times, type of surgery, Body Mass Index). The flow of the data in the PU Daily was arranged according to the main users (nurses) requests to represent their preference in clinical flow. Extensive testing took place to verify that the data elements included in the PU Daily were accurate and useful for clinicians. Over a period of four weeks prior to implementation all data elements were verified by clinicians and modified if needed to assure the quality of data was acceptable. Multiple iterations and quality of data checks with users rendered accurate and complete information that was suitable for use by the nurses.

3. Methods

3.1 Study Design

A pre-post cohort study design was developed to evaluate the impact of having the PU Daily available for clinical decision making. The EMR was fully implemented and in use at the time of the study in the intervention unit. Comparison units were identified that also used the EMR, an ICU or cardiac unit. Staff members who worked at either the intervention or comparison units were familiar with

the EMR and aware of the intervention. Comparison units did not incorporate the intervention, the PU Daily, in their daily clinical practice.

The pre-intervention timeframe was August 2008-March 2009 and the post-intervention timeframe was from March-August 2009. At the time of the study, the Centers for Medicare and Medicaid Services (CMS) adopted the Inpatient Prospective Payment System (IPPS) which meant that hospitals would no longer be reimbursed for care delivered to patients who developed a severe pressure ulcer (Stage III or IV) during the hospital admission [12, 15]. This legislative change drew awareness to the importance of preventing PU's. The Institutional Review Board (IRB) was consulted and indicated that the proposed study involved the use of existing data for a quality study and thus no submission to the IRB was necessary.

3.2 Setting

The study took place in a large academic medical center. The intervention unit was a cardiac ICU, the control units were: cardiology, surgical ICU, Trauma/Burn ICU, and a vascular ICU. All units used the same EMR and were aware of the increased hospital efforts to reduce pressure ulcers. The comparison units were selected as they represented ICU's, high risk patient conditions including complex surgical procedures, and cardiology patients. The patients in units with the EMR but without utilization of the PU Daily were included for comparison purposes as during the study timeframe clinicians became increasingly sensitive about pressure ulcers as the CMS IPPS rulings [16] were disseminated. However, these units were not prepared to use the PU Daily. The pre- and post- intervention changes in pressure ulcer rates were evaluated for all four comparison units.

3.3 Sample

The sample included patients without pre-existing PU's and a stay of greater than 48 hours in the participating units. All patients in the intervention unit are included in the PU Daily and benefit from the intervention, however, only those patients without a pre-existing PU, an ICU stay greater than 48 hrs, and matching clinical administrative data were included in the study. For the comparison units the same inclusion criteria were applied as to the cases of the intervention unit. After all inclusion criteria were applied, a total of 6,735 cases were included in the study.

3.4 Intervention

The intervention consisted of a daily automated feedback report (PU Daily) that contained information already present in the EMR, so no additional information needed to be added to the EMR. The PU Daily provided current information about patient demographics, PU risk factors (including Braden subscale updates), status of PU's, and implemented interventions. Please refer to ▶Table 1 for a sample of the PU Daily. The PU Daily utilization protocol was developed by a multi-disciplinary workgroup and implemented at the intervention unit [17]. In consultation with unit leadership, a small number of registered nurses were trained in using the PU Daily, specifying how to interpret the results and the preventive activities to be implemented. This approach was chosen to reduce the measurement error that has been reported with use of the Braden Scale [18]. Specially trained registered nurses used the PU Daily but also verified the accuracy of the Braden scores.

3.5 Analyses

The outcome variables measured in this study were: total number of pressure ulcers documented, total number of Stage I, Stage II, Stage III, and Stage IV pressure ulcers. The PU Stages reflect the severity of the wound, Stage I reflecting initial redness (non-blanching) of the skin, Stage II showing partial thickness skin loss presenting a shallow open ulcer, Stage III demonstrating full thickness skin loss with an open ulcer, and Stage IV a deep wound, with full thickness loss with exposed bone, tendon or muscle tissue [1]. Any PU entered into the EMR indicating a PU Stage II or greater would be referred to the hospital-based Wound Ostomy team for verification of the staging. All data elements

were received from the EMR's and entered in the EMR by clinical staff, and matched with case information from the hospital's data warehouse.

Nursing staff at the intervention unit received the PU Daily via email every morning and obtained pertinent information in an Excel™ file. The data contained in the PU Daily was current as of the midnight before early morning release and based on documentation in the EMR. Any questions were directed to dedicated workgroup members who sought to resolve any questions within a 24 hour timeframe.

Prior to implementation of the PU Daily, a logistic regression analysis was conducted to evaluate whether the proposed data elements captured in the PU Daily are associated with the development of PU's (Appendix A). This step was initiated to further validate the PU Daily. The internal analyses [13] identified that increased age and severity of illness contribute to the risk of developing a pressure ulcer. Age was collected from the demographic information. Severity of illness was obtained from the data warehouse and represents a culmination of all co-morbidities to reflect the severity of a particular case, and is measured by the case mix index (CMI). We obtained data elements from the clinical warehouse to allow for appropriate risk adjustments. Findings from this analysis revealed that the PU Daily items were significantly associated with the development of PU's, except for gender ($p = 0.265$) and one variable that captured whether the patient was turned every two hours ($p = 0.265$). It was determined that this variable was not constructed correctly and was modified prior to implementation of the PU Daily.

The study size was determined based on a six month intervention timeframe and a six month comparison timeframe prior to the intervention. Units with the same EMR system and comparable patient populations were identified to compare the findings from the intervention unit with. The inclusion criteria, no pre-existing PU's and a 48 hour stay in the unit determined the actual sample sizes.

3.6 Statistical Methods

The data management plans included data preparation to ascertain that inclusion criteria were met and that complete data were available for the analyses. Subsequent analyses focused on the research questions aimed to determine whether the intervention unit demonstrated a statistically significant ($p<0.05$) reduction in pressure ulcers and determination of the impact of the intervention on the specific stages of PU's. Demographic characteristics of the included sample are presented in ▶Table 3. Subsequent analyses focused on whether the total count of PU's changed between the pre- and post-measurement, taking into account patient risk factors that could independently influence the outcomes of interest, such as patient age, and case mix index. Univariate linear regression analyses were employed to determine the differences pre-post intervention for the units involved in the study (▶Table 4). For the intervention unit with significant differences ($p <0.05$) we established, controlling for age and case mix index, whether differences could be detected for the different types of PU Stages, length of stay and total direct costs. Results of these analyses are available in ▶Table 5. Statistical analysis took place using SAS 9.0. [19].

4. Results

The total number of cases included in the study is n = 6,735 including both the intervention and four comparison units. The five units involved in the study contributed the following number of cases, unless indicated, listed units are comparison units. Unit A- cardiac step down n = 2,860; Unit B- surgical ICU n = 1,089; Unit C-trauma-burn ICU n = 810, Unit D-Intervention unit (cardiac surgery ICU) n = 1,599; and Unit E (vascular surgery ICU) n = 377. Nearly 60% of the cases in the study were males and the average age was 58 years. Over 20% of the cases were diagnosed with diabetes. Please see ▶Table 3 for further demographic detail.

The patients in the intervention unit had the greatest surgery time (4.8 hrs). The case mix index (CMI) for all cases was 3.94, with higher CMI's for the intervention unit (6.30) and the surgical ICU (5.07). The patient population of the intervention unit was characterized by having the highest maximum surgery time (4.8 hrs) and more patients received multiple surgeries during their admis-

sion, as well as had a higher CMI. Evaluation of average length of stay shows a range of 5.7 days to 14.9 days. The average ICU length of stay ranges from 0.8 to 5.6 days. The average cost ranges from $16,223 to $49,791.

The following variables were evaluated to address the first research question whether the PU Daily intervention had an impact on the patient outcome (pressure ulcer). Univariate linear regression analyses determined whether a significant change in pressure ulcer documentation could be established. Control variables were: gender, diabetes status, use of vasopressors, age, time spent in a procedure (OR duration), and patient's case mix index. Results presented in ▶Table 4 indicate that a significant reduction ($p<0.05$) in pressure ulcers was reported for the intervention unit ($t = 2.910$, $p = 0.004$) and for $p<0.10$ for one comparison unit ($t = 1.650$, $p = 0.099$); none of the additional comparison units demonstrated significant reductions in reported pressure ulcers.

The second research question aimed to establish whether the PU Daily intervention had an impact on the severity of pressure ulcers, as reported by the various PU stages, for the intervention unit. Pre-post t-test analyses were conducted to assess whether the total number of PU's, the worst stage, and total of various stages had changed for the intervention unit following implementation of the PU Daily intervention. ▶Table 5 shows that the total number of PU's was significantly reduced ($t = 3.523$, $p <0.000$) following implementation of the intervention. The total number of Stage II PU's was also significantly reduced ($t = 1.998$, $p = 0.046$) indicating that the PU Daily intervention significantly impacted the number of patients who developed more serious pressure ulcers which often deteriorate further into Stage III and IV pressure ulcers, which require specialized treatments and/or surgery to heal the wound. Thus, the PU Daily intervention did not significantly reduce the number of patients who developed the initial stages of PU I, reddened nonblanchable skin, but successfully reduced the conversion of a Stage I PU to a Stage II PU, broken skin presenting a shallow open ulcer, which can quickly lead to more serious pressure ulcers. Thus, the PU Daily intervention both reduced the number of total PU's and prevented the development of Stage II PU's.

Subsequent analyses aimed to determine whether the impact of the PU Daily is associated with length of stay and direct hospital costs. We used the independent samples t-test to evaluate significant differences pre-post implementation of the intervention. The Levene's test for equality of variances was significant, thus we used the results indicating no equal variances are assumed. ▶Table 3 shows the descriptive data for length of stay and costs. Findings demonstrated that the total length of stay (LOS) for the intervention unit decreased from 13.2 days pre-intervention to 11.1 days post-intervention ($t = 3.043$, $p = 0.002$). The ICU LOS decreased from 5.8 days to 3.7 days after implementation of the PU Daily ($t = 6.277$, $p<0.001$). Total direct hospital costs were compared and a decrease in cost from $52,316 pre-intervention to $40,645 post-intervention ($t = 6.277$, $p<0.001$) was noted. These findings suggest that the decrease in total number of PU's and Stage II PU's was also associated with significant reductions in length of stay and costs.

In sum, findings show that the implementation of the PU Daily significantly impacted the incidence, severity and number of pressure ulcers of the intervention unit. The secondary impact from reduced pressure ulcers resulted in a reduced total and ICU length of stay and subsequent significant decrease in hospital costs.

5. Discussion

5.1 Key results

The objectives of our study were to evaluate whether implementation of the PU Daily reduced the development of PU's and impact the severity of the PU's that were present. The findings of our study indicate that the PU Daily intervention was very successful in reducing the total number of PU's and that the development of very serious pressure ulcers, Stage III and IV, seem to be interrupted by the reduction of Stage II pressure ulcers. Though the development of PU's does not always follow an identical trajectory to further deterioration, most patients do experience a Stage II (of varying duration) where initial skin breakdown takes place. Use of the information contained in the PU Daily contributed to clinical interventions that appear to interrupt the cycle of deteriorating PU's. These

findings are promising as EMR's and related clinical decision making technology is further being developed and refined.

5.1.1 Intervention

The PU Daily was based on the expertise and technical foundations from previous projects and utilized clinical expertise and analyses of existing data to determine important clinical risk factors for this specific population [5–6]. The layout of the PU Daily followed the preference of the clinicians, based on their experience of clinical work flow. The multi-disciplinary workgroup learned that many nurses felt it is impossible to know every patient's risk status and change thereof within an EMR environment. This intervention used actionable data contained in the EMR, though the PU Daily was distributed via email and the nurses would print out the report prior to starting their work. The clinicians specifically favored a printout of the PU Daily that they could easily carry with them and record patient specific detail that would not require numerous sign-ins or clicks [17].

At multi-disciplinary workgroup sessions and informal feedback from users, the researchers learned that many nurses thought with the paper printout it was easier to establish patient risk and pertinent interventions and use copies of previous days to determine the patient's trajectory. The experience provides a reminder that practicality and ease of use is important for the users of the intervention, the nurses. Understanding of essential information for clinical decision making will further benefit the development of such technology for clinical practice.

5.1.2 Limitations

We took great efforts to include other units for comparison purposes to distinguish between the impact of using an EMR and the increased hospital wide focus on reducing pressure ulcers following the release of CMS IPPS 2009 regulations at the time of the study [16]. The comparison units used the same EMR data components for regular clinical care, including the documentation of patient risk and pressure ulcer status. The nurses on the comparison units did not have the advantage of a summarized overview of current patient risk factors, changes, and PU status, though the risk factors and pressure ulcer information were available in the EMR, using multiple look-up tables and screens. The nurses at the intervention unit received additional training to assist in proper documentation and recognition of changes or unusual documentation in Braden scale items and documentation of PU's [17]. Variation in documentation and interpretation of Braden scale items and PU staging is possible. Implementing the intervention required substantive support from unit leadership and therefore the intervention could not be randomized. The content and flow of the PU Daily were designed with input from the nursing leadership of our intervention unit. We used a comparison pre-post design to evaluate similar ICU's with equivalent EMR technology, high PU risks, and exposure to the same policy related information about CMS IPPS and response by the hospital.

This innovation may be perceived as a 'step-back' from a technology perspective as the PU Daily information is printed-out rather than delivered and used via a wireless or computerized application. However, the nurses' request informed us that the print-out provides easy oversight over the total risk factors of the patient and across patients – i.e., noticing that many patients on a particular wing missed particular preventive efforts. Further development should include using additional skin related measures available from embedded sensor technology, evaluation in different healthcare delivery settings such as skilled nursing facilities, and further refinement based on the characteristics of patients. Despite the time commitment necessary to conduct the PU Daily rounds, the nurses at the intervention unit felt it was a very useful tool. Their satisfaction with this intervention was further evidenced by the request from other units to also receive the PU Daily for their use. The expressed request from the nurses for this type of information provides an important opportunity to use such clinical information to impact quality and safe patient care delivery.

6. Conclusion

This study demonstrates that the intervention unit successfully reduced the number of total PU's and the conversion of Stage I PU's to Stage II PU's. The comparison units did not show such results. The PU Daily demonstrated that bedside nurses can use timely patient specific information. The PU

Daily contributed to multi-disciplinary bedside discussions, timely interventions to prevent PU's and better use of the information contained in the EMR. Further development of the technology and broad implementation and evaluation are recommended as next steps.

Clinical relevance – Implications for clinicians

The clinical relevance of this intervention is the following: 1) bedside nurses value pertinent and timely information for clinical decision making; 2) EMR technology was used to present data in actionable format for bedside nurses to help prevent pressure ulcers; and 3) future application of this type of technology includes advancing use of technology and maintaining a close relationship with the ultimate users for optimum implementation and utilization.

Conflict of Interest

The authors declare that they have no conflicts of interest in the research.

Human Subjects Protection

The Institutional Review Board (IRB) was consulted and indicated that the proposed study involved the use of existing data for a quality study and thus no submission to the IRB was necessary.

Table 1 Sample Daily Automated Feedback – Pressure Ulcer Profile

Name	[redacted]						Name
Reg Num							Reg Num
Room							
Admit Date	2/24/2009	2/20/2009	2/18/2009	2/23/2009	2/4/2009	2/19/2009	Admit Date
LOS	2	6	8	3	22	7	LOS
LOS ICU	0	0	5	0	7	0	LOS ICU
LOS to eBraden	0	4	0	0	0	0	LOS to eBraden
First eBraden	21	21	13	20	14	18	First eBraden
Current Braden	17 (-4)	17 (-4)	16 (3)	22 (2)	19 (5)	17 (-1)	Current Braden
B-sensory	4 (0)	4 (0)	4 (2)	4 (0)	4 (2)	3 (-1)	B-sensory
B-moisture	4 (0)	4 (0)	3 (-1)	4 (0)	4 (0)	3 (0)	B-moisture
B-activity	1 (-2)	1 (-2)	2 (1)	4 (1)	3 (2)	3 (0)	B-activity
B-mobility	2 (-2)	2 (-2)	2 (0)	4 (1)	3 (1)	3 (0)	B-mobility
B-nutrition	3 (0)	3 (0)	2 (1)	3 (0)	2 (-1)	3 (0)	B-nutrition
B-friction	3 (0)	3 (0)	3 (0)	3 (0)	3 (1)	2 (0)	B-friction
q2 hr Pos misses	4	5	3	0	0	5	q2 hr Pos misses
Pressure Ulcer: Initial eAssessment (2)	02/25/09:0	02/25/09:0	02/19/09:0	02/24/09:0	02/05/09:0	02/19/09:0	Pressure Ulcer: Initial eAssessment (2)
PU: Current	02/25/09:0:	02/25/09:0:	02/25/09:0:	02/25/09:0:	02/25/09:0:	02/25/09:0:	PU: Current
PU: Stage 1					02/18/09:2: right ball of foot,Sacrum		PU: Stage 1
PU: Stage 2							PU: Stage 2
PU: Stage 3							PU: Stage 3
PU: Stage 4							PU: Stage 4
PU: Unstageable							PU: Unstageable
PU: Deep Tissue Injury							PU: Deep Tissue Injury
Age	75	80	80	55	52	85	Age
BMI	28.3		28.5	35.1	19.9	26.3	BMI
Back board used							Back board used

Table 1 Continued

First Surgery date			2/19/2009		2/4/2009		**First Surgery date**
Last Surgery date			2/19/2009		2/23/2009		**Last Surgery date**
Total Surgery Time	0	0	3.2	0	12.5	0	**Total Sur -gery Time**
Max Surgery Time	0	0	3.2	0	6.9	0	**Max Surgery Time**
# Surgeries	0	0	1	0	4	0	**# Surgeries**
1st Op Procedure			IR LEG ARTERIOGRAM		AAA ENDO – NONEMERGENT	RIGHT HAND – FOREARM AMPUTATION	**1st Op Procedure**
Diabetic	Yes	No	No	Yes	No	No	**Diabetic**
# Vasopressors	0	0	0	0	1	0	**# Vasopressors**
Devices that help prevent PU					Low-Air Loss Mattress		**Devices that help prevent PU**
Devices that contribute to PU							**Devices that contribute to PU**

Table 2 Braden Risk Assessment Scale

Scales	Score 1	Score 2	Score 3	Score 4
Sensory Perception	Completely Limited	Very Limited	Slightly Limited	No Impairment
Moisture	Constant Moist	Moist	Occasionally Moist	Rarely Moist
Activity	Bedfast	Chairfast	Walks Occasionally	Walks Frequently
Mobility	Completely Immobile	Very Limited	Slightly Limited	No Limitations
Nutrition	Very Poor	Probably Inadequate	Adequate	Excellent
Friction & Shear	Problem	Potential Problem	No Apparent Problem	
Note: Patient considered at risk if ≤17				

Table 3 Demographics of the intervention and control units

Unit	Gender				Avg. Age		Diabetes			Maximum Surgery Time		Mean Total Surgeries		Case Mix Index		Total LOS		ICU LOS		Total Direct Cost		Total Cases	
	Males	%	Females	%	Years	s.d.	N	% Yes	BMI	Hrs	s.d.	N	s.d.		s.d.		s.d.		s.d.	US $	s.d.	N	% Total
A	1,546	54.1	1,314	45.9	60.3	16.1	631	22.1	36.5	1.7	2.5	0.38	0.53	2.3014	2.4469	7.0	9.3	0.9	4.7	16,223	32,882	2,860	42.5
B	575	52.8	514	47.2	55.6	17.0	262	24.1	30.7	3.8	3.7	0.72	0.56	5.0745	4.7338	14.9	22.0	5.6	15.4	46,528	71,900	1,089	16.2
C –	556	68.6	254	31.4	45.0	21.0	112	13.8	27.6	1.0	2.0	0.32	0.62	4.1189	4.2435	12.6	15.3	3.9	9.1	36,541	50,274	810	12.0
D*	1,026	64.2	573	35.8	61.0	14.2	341	21.3	28.6	4.8	3.6	0.76	0.52	6.2977	5.2120	12.7	13.8	5.3	8.4	49,791	60,294	1,599	23.7
E	240	63.7	137	36.3	61.8	15.1	104	27.6	30.6	1.6	2.4	0.38	0.50	2.7663	3.0675	5.7	7.6	0.8	3.1	20,025	27,477	377	5.6
Total	3,943	58.5	2,792	41.5	57.9	17.2	1,450	21.5	32.0	2.7	3.3	0.52	0.57	3.9431	4.2482	10.2	14.2	3.1	8.9	31,749	52,232	6,735	100

*Intervention Unit; LOS: Length of Stay

Table 4 Univariate linear regression model to evaluate pre-post pressure ulcer incidence

					95% Confidence Intervals	
Unit	**B**	**Std. Error**	**t**	**Sig.**	**Lower Bound**	**Upper Bound**
A	0.088	0.054	1.650	0.099	–0.017	0.193
B	0.035	0.129	0.269	0.788	–0.218	0.287
C	0.154	0.126	1.218	0.224	–0.094	0.402
D*	0.156	0.054	2.910	0.004	0.051	0.261
E -	0.038	0.080	0.470	0.638	–0.120	0.195
*Intervention unit						

Table 5 Comparison PU rates pre- post intervention of PU Daily – Intervention unit*

					95% Confidence Intervals	
Intervention Unit D	**B**	**Std. Error**	**t**	**Sig.**	**Lower Bound**	**Upper Bound**
Total count PU's	0.196	0.056	3.523	0.000	0.087	**0.306**
Total worst PU's	0.062	0.054	1.147	0.252	–0.044	0.167
Total Cases PU Stage I	0.012	0.019	0.604	0.546	–0.026	0.05
Total Cases PU Stage II	0.033	0.017	1.998	0.046	0.001	0.066
Total Counts PU Stage III	0.008	0.007	1.057	0.291	–0.006	0.021
Total Counts PU Stage IV	0.000	0.005	0.087	0.931	–0.009	0.010

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Appendix A Logistic Regression Model to evaluate whether variables included in PU Daily are associated with pressure ulcers. Variables in the Equation.

	B	S.E	Wald	df	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
Age	0.021	0.003	41.324	1	0.000	1.022	1.015	1.028
Sex	0.118	0.106	1.244	1	0.265	1.125	0.914	1.385
BMI Grp 3 way first			12.968	2	0.002			
BMI Grp 3 way first (1)	-0.608	0.240	6.403	1	0.011	0.544	0.340	0.872
BMI Grp 3 way first (2)	-0.795	0.231	11.801	1	0.001	0.452	0.287	0.711
Delta Braden at Admission	-0.384	0.031	151.018	1	0.000	0.681	0.640	0.724
Delta Braden 1 Sensory	-0.239	0.081	8.788	1	0.003	0.787	0.672	0.922
Delta Braden 2 Moisture	-0.386	0.101	14.462	1	0.000	0.680	0.557	0.830
Delta Braden 3 Activity	-0.488	0.073	44.907	1	0.000	0.614	0.532	0.708
Delta Braden 4 Mobility	-0.429	0.095	20.230	1	0.000	0.651	0.540	0.785
Delta Braden 5 Nutrition	-0.175	0.085	4.251	1	0.039	0.840	0.711	0.991
Delta Braden 6 Friction	-0.790	0.114	48.091	1	0.000	0.454	0.363	0.567
Q2hr Positioning Missed	0.261	0.234	1.244	1	0.265	1.299	0.820	2.055
PU present initial evaluation	3.450	0.232	221.023	1	0.000	31.496	19.986	49.634
Constant	3.903	0.684	32.551	1	0.000	49.534		