ENHANCING BRADEN PRESSURE ULCER RISK ASSESSMENT IN ACUTELY ILL ADULT VETERANS

By

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To the military veterans who have faithfully served their country

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LIST OF ABBREVIATIONS

AHRQ	Agency for Healthcare Research and Quality
AMDA	American Medical Directors Association
ARNP	Advanced Practice Registered Nurse
CHF	Congestive Heart Failure
CMS	Centers for Medicare and Medicaid Services
CVA	Cerebrovascular Accident
CWS	Certified Wound Specialist
DM	Diabetes Mellitus
EPUAP	European Advisory Panel
FNP	Family Nurse Practitioner
GS	Graduate student
ICU	Intensive Care Unit
IHI	Institute for Healthcare Improvement
IRR	Inter-rater Reliability
JCAHO	Joint Commission for Accreditation of Healthcare Organizations
LOS	Length of Stay
LPN	Licensed Practical Nurse
NA	Nursing Assistant
NGC	National Guideline Clearinghouse
NIH	National Institutes of Health
NPV	Negative Predictive Value
NPUAP	National Pressure Ulcer Advisory Panel
O.R.	Operating Room
OR	Odds Ratio

PPV	Positive Predictive Value
PU	Pressure Ulcer
PURAS	Pressure Ulcer Risk Assessment Scale
PURS	Pressure Ulcer Risk Screening
RAS	Risk Assessment Scale
RN	Registered Nurse
RNAO	Registered Nurses Association of Ontario
SAWC	Society for Advancement of Wound Care
UK	United Kingdom
US	United States
UTI	Urinary Tract Infection
VA	Veterans Administration
WHS	Wound Healing Society
WOCN	Wound, Ostomy, and Continence Nurses Society

Abstract of Dissertation Presented to the Graduate School
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Preventing pressure ulcers is a significant health care challenge. Pressure ulcers increase inpatient length of stay, mortality, and complication rates. They reduce quality of life and pose a worldwide economic quandary. Many pressure ulcer risk factors have been identified over the past 20 years, yet current pressure ulcer risk assessment tools such as the Braden Scale for Predicting Pressure Sore Risk do not account for several of the most significant risk factors.

The purpose of this retrospective study was to determine the pressure ulcer predictability of the Braden score alone, the Braden score + significant medical factors, and significant medical factors alone. Medical factors investigated in this study include those reported in recent literature as significant pressure ulcer risk factors: diagnosis of gangrene, anemia, diabetes, malnutrition, osteomyelitis, pneumonia/pneumonitis, septicemia, candidiasis, bacterial skin infection, device/implant/graft complications, urinary tract infection, paralysis, senility, respiratory failure, acute renal failure, cerebrovascular accident, and congestive heart failure; as well as age, race, hospital and intensive care unit length of stay days, surgery, operating room time in hours, smoking status, and a history of previous pressure ulcers. This study also examined differences between Braden scores and other associated risk factors in 213 acutely ill veterans with (n=100) and without (n=113) pressure ulcers in north Florida during January-July 2008.

A predictive model determined the Braden total score correctly classified 68% of total sample (65% veterans with PU, 70% veterans without PU). Adding four significant medical factors correctly classified 78% total sample (74% with PU, 82% without PU). A predictive model with these four factors alone (presence of pneumonia/pneumonitis, candidiasis, severe nutritional compromise, and surgery) correctly classified 83% veterans with PU, and 72% veterans without PU (77% total sample correctly classified). These findings suggest that identifying patients with severe nutritional compromise, the presence of pneumonia/pneumonitis, candidiasis, and surgery during hospitalization may be better able to identify veterans likely to develop pressure ulcers than current Braden risk assessment alone. More research is needed in this area to validate these findings in a larger sample, and provide direction for interventional studies, with an ultimate goal of reducing incidence of pressure ulcers.

CHAPTER 1
INTRODUCTION

Statement of the Problem

Pressure ulcers are defined as, "localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear and/or friction" (NPUAP Press Release, 2007). Preventing pressure ulcers is one of the most significant challenges facing health care today (Armstrong, Ayello, Capitulo, Fowler, Krasner, Levine, Sibbald, & Smith, 2008). Pressure ulcers increase inpatient length of stay, mortality, and complication rates (Maklebust, 2005; Reddy, Gill & Rochon, 2006). Pressure ulcers reduce quality of life and pose a considerable worldwide economic quandary (Lyder, 2002; Maklebust, 2005; Spilsbury et al., 2007; Fogerty et al., 2008). The Joint Commission for Accreditation of Healthcare Organizations (JCAHO, 2008) reports approximately 2.5 million patients develop pressure ulcers each year in the United States (US), with a total estimated medical cost of up to $40,000 per ulcer, and approximately 60,000 deaths per year attributable to pressure ulcer complications. The United Kingdom (UK) estimates annual medical costs of pressure ulcers were 750 million pounds in 1998 (Banks, Graves, Bauer, & Ash, 2009). Scientific advances, superior medical technology, and innovative quality of care interventions have dramatically improved health care in the United States over the past 20 years (Vincent, Fink, Marini, Pinsky, Sibbald, et al., 2006). However, to date, pressure ulcer risk assessment and preventive measures have not significantly reduced overall national pressure ulcer prevalence or incidence during those same 20 years (Thomas, 2001; VanGilder, MacFarlane & Meyer, 2008).

Thomas (2001) poses an explanation for the unchanging incidence of pressure ulcers as "a failure of known effective prevention treatment to be applied, or the failure of prevention strategies to be effective despite being applied" (p. 298). Effective preventive measures may not

be applied if individuals are not appropriately identified as being at risk. Risk-screening tools are useless if they: 1) are not applicable to the population being screened, 2) do not accurately account for significant risk factors, 3) are used inconsistently, or 4) are scored incorrectly (Thomas, 2001; Papanikolaou, Lyne, & Anthony, 2007). Furthermore, Thomas listed risk factors from epidemiological studies available from 1989 to 1995, but admits that other significant risk factors may be unaccounted for in these studies (Thomas, 2001). This suggests that the data on which current preventive treatment measures are based may be out dated. Studies are needed to verify that modern day risk factors are accounted for, so that appropriate interventional studies may follow.

Background of the Problem

Pressure ulcers have also been known as "bedsores" for hundreds of years. The term *decubitus ulcer* has also been used historically to describe pressure ulcers. Florence Nightingale in her fundamental book "Notes on Nursing" (1860 /reprinted 1976) brought attention to prevention of pressure ulcers as primarily the responsibility of nursing when she said, "If he *(the patient)* has a bedsore, it is generally the fault not of the disease, but of the nursing" (p. 8). From the 1800's when Florence Nightingale charged nurses with the responsibility for preventing pressure ulcers, most of the medical community has been comfortable to leave this burden on the shoulders of nurses. More recently, however, the International Expert Wound Care Advisory Panel (Armstrong, Ayello, Capitulo, Fowler, Krasner, Levine, Sibbald, & Smith, 2008) challenged not only nursing but also the entire healthcare industry with an immediate need to "focus on the prevention of pressure ulcers."

Identifying Risk

The focus of pressure ulcer prevention has historically revolved around identifying risk factors and providing preventive interventions aimed at reducing those factors. An accurate

identification of what places a person at risk for developing a pressure ulcer is crucial in order to identify those at risk and initiate appropriate prevention interventions. The National Pressure Ulcer Advisory Panel (NPUAP) lists Identifying pressure ulcer risk factors and conducting valid/reliable risk assessments as one of the top 4 competencies for registered nurses in preventing pressure ulcers (NPUAP competency-based RN curriculum for preventing pressure ulcers, 2001). Lyder (2003) reports over 100 pressure ulcer risk factors have been identified in the literature. The Wound Healing Society's (WHS) Pressure Ulcer Prevention Guidelines (Stechmiller, Cowan, Whitney, Phillips, Aslam, et al., 2008) highlight the need for accurate identification of current risk factors in specific populations and a multidisciplinary approach to formulate prevention plans. Some common risk factors listed in the WHS prevention guidelines as identified in previous studies include: immobility, friction, shear, incontinence, moisture, age, altered level of consciousness, poor nutrition, poor perfusion, and certain skin conditions. The WHS guidelines stress the need for consistent use of pressure ulcer risk screening (PURS) tools (Stechmiller et al., 2008).

Risk Assessment Tools

Pressure ulcer risk screening tools such as the Norton Scale have been available since the 1960s (Norton, 1996). Pressure ulcer risk assessment tools presently utilized worldwide are the Norton Scale published in England in 1962, the Waterlow Scale published in England in 1984, and the Braden tool published in the US in 1987 (Papanikolaou, Lyne, & Anthony, 2007). The most widely used and tested of all risk assessment tools is the Braden Scale for Predicting Pressure Sore Risk developed by Barbara Braden and Nancy Bergstrom in the 1980s (Bergstrom, Braden, Laguzza, & Holman, 1987; Bryant, & Nix, 2007). The Braden Scale is a well-tested instrument with six subscales used by health care providers to assess risk factors present that are associated with pressure ulcer development (Stotts & Gunningberg, 2007; Stotts & Wu, 2007).

The Braden Scale has been reported to have good inter-rater reliability with Cronbach's alpha between 0.83 to 0.99. Some studies report Braden specificity is between 64 and 90% (with cut off risk scores of 18 or less) and sensitivity ranging from 83 to 100% (Ayello, 2007). Other studies suggest that nurses tend to over score rather than underscore when using the Braden tool, underestimating pressure ulcer risk (Stotts & Gunningberg, 2007). At least one literature review of 31 studies regarding psychometric properties of the Braden Scale concluded that most of the interrater reliability measures (such as Pearson's product-moment correlation and Cohen's kappa) reported for the Braden tool were inappropriate measures (Kottner & Dassen, 2007). Laura Bolton (2007) extensively reviewed the clinical evidence regarding the reliability and validity of the Braden, Norton, and Waterlow pressure ulcer (PU) risk assessment tools vs. "nurse clinical judgment" across all settings (long- term care, rehabilitation, acute care, ICUs, hospice, and pediatric care). She reports a meta-analysis of twenty studies (most of which were conducted in the 1990s or early 2000s) examining the Braden Pressure Ulcer Risk Assessment Scale (PURAS) across all settings results with an average sensitivity of 57% and specificity of 68% with a positive predictive value (PPV) of the "at risk" score of 23% and the negative predictive value (NPV) of the "not at risk score" of 91%. Five studies (conducted in the 1970s and 1980s) examining the Norton PURAS across all patient settings (home, hospital, and rehabilitation facilities) revealed an average sensitivity of 47% and specificity of 62% with a PPV of the "at risk" score of 18% and the NPV of the "not at risk score" of 87%. Six studies examining the Waterlow PURAS across all settings (conducted in the 1980s and 1990s) reveal an average sensitivity of 82% and specificity of 27% with a PPV of the "at risk" score of 16% and the NPV of the "not at risk score" of 89%. Bolton (2007) compared this cumulative data to three studies that examined 'nurse clinical judgment' across all settings, reporting an average

sensitivity of ‘nurse clinical judgment’ of 51% and specificity of 60% with a PPV (the nurse accurately judging a patient to be “at risk”) of 33% and the NPV (the nurse accurately judging the patient to be “not at risk”) of 76%. Bolton (2007) concluded that the Braden tool is superior to the Norton and Waterlow scales in specificity and sensitivity, and is valid for predicting PU risk in multiple health care settings and countries. However, Bolton also concluded that, “No evidence supports assessing pressure ulcer risk on individuals in good clinical condition, as evidenced by low pre-operative and postoperative day 5 validity of the Braden Scale.” (Bolton, 2007, p. 378).

In addition, Pancorbo-Hildago, Garcia-Fernandez, Lopez-Medina, & Alvarez-Nieto (2006) conducted a systematic review of 33 studies regarding pressure ulcer risk assessment scales available for use today such as the Braden or Norton scales and found that the use of these scales has not changed the incidence of pressure ulcers, but likewise concluded that they are still “better risk prediction tools than nurses clinical judgment” (p. 108). Unfortunately, further limitations have been identified with the Braden, Norton, and Waterlow pressure ulcer risk assessment tools. Literature suggests critical cut-off scores for each of the risk assessment scales (indicating at what point an individual is determined to be “at risk”) are disputable, and inconsistently applied (interpreted differently from setting to setting). In addition, the risk factors which comprise the subscale categories of each tool (such as sensory, activity, moisture, nutrition, mobility, and friction in the Braden Scale) have equal weights attributed to them, which may be statistically limiting. For example, certain Braden subscale factors (such as mobility) may be more important than other subscale factors for predicting risk (Berlowitz et al., 2001), and one subscale only has a possible score of 1 to 3 (friction/shear) while the other subscales have a possible score of 1 to 4. Furthermore, it has been suggested that certain Braden subscale definitions (such as patient’s

dietary intake or frequency of skin being moist) are more difficult for nurses to determine or appropriately quantify than other Braden subscale factors such as activity level (Papanikolaou, Lyne, & Anthony, 2007). Schoonhoven et al. (2006) criticized current pressure ulcer risk assessment tools by stating, "Neither risk factors nor the weights attributed to them have been identified using adequate statistical techniques" (p. 65). This necessitates a re-evaluation of pressure ulcer risk screening tools for relevancy and effectiveness to current populations. Papanikolaou, Lyne, & Anthony (2007) recommends, "differential weighted scoring techniques, advanced statistical methods, and large data sets be used to develop data driven and more robust risk assessment scales." (p. 285). Kottner & Dassen (2007) recommend that Braden tool interrater reliability be calculated and reported using intraclass correlation coefficients in combination with overall percentage of agreement, instead of current reporting methods. In addition, patient acuity, medical technology, nursing hours at the bedside (Hall, Doran, & Pink, 2004; Kramer & Schmalenberg, 2005), nursing practice environments (Lake & Friese, 2006), and pressure ulcer risk factors identified in scientific research (Fogerty et al., 2008) have changed in the past twenty years. Therefore, a modern statistical analysis is needed in a predictive model, demonstrating possible interactions among currently identified risk factors and determining predictive contributions of each risk factor (including those comprising the Braden subscales) so that interventions may be directed at those risk factors that pose the strongest association with the development of pressure ulcers, particularly those that are modifiable.

Purpose of the Study

The purpose of this retrospective descriptive study was to determine the pressure ulcer predictability of the Braden score alone, the Braden score + significant medical factors, and significant medical factors alone. Medical factors investigated in this study include those reported in recent literature as significant pressure ulcer risk factors: diagnosis of gangrene,

anemia, diabetes, malnutrition, osteomyelitis, pneumonia/pneumonitis, septicemia, candidiasis, bacterial skin infection, device/implant/graft complications, urinary tract infection, paralysis, senility, respiratory failure, acute renal failure, cerebrovascular accident, and congestive heart failure; as well as age, race, hospital and intensive care unit length of stay days, surgery, operating room time in hours, smoking status, and a history of previous pressure ulcers. This study also examined differences between Braden scores and other associated risk factors in 213 acutely ill veterans with (n=100) and without (n=113) pressure ulcers in north Florida during January-July 2008.

The aims of this research included: 1) to determine the predictability of the Braden Scale total score on the development of pressure ulcers in an inpatient acutely ill adult veteran population; 2) to determine if the addition of other significant medical factors (diagnosis of gangrene, anemia, diabetes mellitus , malnutrition, osteomyelitis, pneumonia/pneumonitis, septicemia, candidiasis, bacterial skin infection, complication of device or implant/graft, urinary tract infection, paralysis/CVA, senility, respiratory failure, acute renal failure, congestive heart failure, history of previous pressure ulcer, age, race, length of inpatient hospital and ICU stays, surgery, time in operating room, and smoking status) to these Braden total scores enhance the model's predictability of pressure ulcer development in an inpatient acutely ill adult veteran population; and 3) to determine if selected medical factors alone are significantly able to determine the development of pressure ulcers in an acute inpatient adult veteran population.

This retrospective descriptive study in an acutely ill adult inpatient veteran population in north Florida from January-June 2008 determined the difference between Braden scores and other associated risk factors in veterans with and without pressure ulcers. Because this population is predominantly male, gender was not examined as an independent variable. Logistic

regression statistical analysis was utilized to determine how predictive Braden total scores were in a pressure ulcer predictive model (as well as examine each of the Braden sub-scores) with and without the inclusion of other medical factors. The results of this study enhance the current knowledge of pressure ulcer risk factors and the assessment tools used to screen for them and provide direction for future studies, with an ultimate goal of reducing incidence of pressure ulcers.

Significance of the Study

The most common pressure ulcer risk-screening tool in use today is the Braden Scale for Predicting Pressure Sore Risk (see Appendix A). This is the main pressure ulcer risk-screening tool utilized in Veteran's Administration Health Care facilities nationwide. The Braden Scale was published in 1987 (Bergstrom, Braden, Laguzza, & Holman, 1987; Bryant, & Nix, 2007). However, it has not changed significantly since first publication and does not account for important medical factors (such as age, race, length of stay, specific medical diagnoses, or smoking status) described in more recent literature as strongly associated with the development of pressure ulcers (Ayello, 2007; VanGilder, MacFarlane, & Meyer, 2008; Fogarty et al., 2008). A systematic review of thirty-three studies involving pressure ulcer risk assessment scales (Pancorbo-Hildago, Garcia-Fernandez, Lopez-Medina, & Alvarez-Nieto, 2006) and a methodological review of risk assessment scales for pressure ulcers (Papanikolaou, Lyne, & Anthony, 2007) suggest there is great variability within the positive predictive value (PPV) and negative predictive value (NPV) of currently used risk assessment scales (RAS) between settings and health care providers. Furthermore, they point out the deficit of scientific work investigating the subscale categories (risk factors which comprise the scoring components of the scales) and appropriateness of cut-off ("at risk") values of the scales, which vary among settings. Bergstrom,

Braden, Kemp, Champagne, & Ruby (1998) report Braden scores of 18 or below should be used as the "at risk" cut-off score (www.bradenscale.com).

In addition, there is limited data published in the literature describing current pressure ulcer risk factors among inpatient veterans in acute care settings. Further research is needed to examine this population as well as investigate the significance of other risk factors for pressure ulcer development described in scientific literature that are not accounted for by the common pressure ulcer risk assessment tools utilized today, such as specific 'high risk' medical diagnoses described by Fogerty et al. (2008).

Clinical Importance of this Study

An international expert panel published a consensus paper in 2008, which highlighted recent changes in the U.S. Centers for Medicare and Medicaid Services (CMS) financial reimbursement amounts based on admission diagnosis codes for acute care and long-term care facilities (beginning in October 2008) that will no longer reimburse higher rates for patients that develop stage III or IV pressure ulcers after admission (Armstrong et al., 2008). This is thought to provide additional motivation to acute and long-term care facilities to evaluate and improve their pressure ulcer prevention programs. This discussion is significant, as it stresses the urgency of a consensus among health care providers and particularly the wound care community in providing quality research as well as relevant, research-based toolkits, and accurate protocols that address: risk assessment and documentation, patient education, clinician training, and evidence-based effective intervention measures. Limitations of the plan mentioned in the CMS consensus paper include the lack of randomized control trials to know which interventions are most effective, and a lack of risk assessment tools that are not only valid and reliable, but also up-to-date, accurate, easy to use, do not require intense training, and are applicable to current populations. In addition, Armstrong et al. (2008) point out that, "Competence of the provider in

assessment is critical to do an accurate skin (*and risk*) assessment" (p. 470). Skin and risk assessment is pivotal to pressure ulcer prevention. From the days of Florence Nightingale until the present, nurses have been the primary provider of accurate skin/risk assessments. However, under the new CMS ruling, this responsibility is going to also fall to the admitting physician/provider. Therefore, it is imperative that plans for effective pressure ulcer prevention incorporate a multidisciplinary approach involving all levels of care from the nursing assistant to the physician (Ho & Bogie, 2007; Howe, 2008; McInerney, 2008).

Thomas (2001) suggests there may be few instances where pressure ulcers are unavoidable. However, most pressure ulcers are considered to be avoidable, therefore, preventable (Jalali & Rezaie, 2005; Bryant & Nix, 2007). The Centers for Medicare & Medicaid Services (CMS) reported 257,412 cases of preventable pressure ulcers (listed as secondary diagnosis) during the fiscal year 2007 (Armstrong et al., 2008). It is essential for the entire medical community to address this health issue in ways that will reduce these numbers.

Limitations of the Study

This study is limited to adult veterans ages 47 to over 85 within an acute hospitalization setting in the Southeastern United States. The generalizability of this study is limited by the fact that this is a veteran population, is mostly male (97%), over half of the subjects were over the age of 72, and the location is limited to veterans residing in the North Florida/South Georgia region.

CHAPTER 2
REVIEW OF THE LITERATURE

Etiology of Pressure Ulcers

Historically, pressure ulcers have been described in the medical literature since at least the 1500's when Fabricius Hildanus first documented his understanding of the causes and clinical characteristics of bedsores. He highlighted the role of "internal supernatural" and "external natural" factors that interrupt the supply of blood and nutrients to tissue as causes of bedsores. Mechanical pressure and incontinence were first identified as key factors in the development of pressure ulcers by French surgeon de la Motte in 1722 (Defloor, 1999).

Research regarding the role of tissue ischemia in the formation of pressure ulcers and factors affecting the interruption of blood supply to human tissues have been published in the US since at least 1930 when Landis recorded capillary closing pressures (the level of external pressure required to occlude capillary blood and lymph circulation to/from tissues) of the average finger to be 32 mm Hg and it was suggested that any external pressure higher than this could lead to tissue ischemia or necrosis (Kosiak, 1961; Defloor, 1999; Lyder, 2006). Defloor (1999) describes research done by Husain (1953), Kosiak (1959 & 1961), Lindan & Greenway (1965) Jonker (1978), Braden & Bryant (1990), Bennet & Lee (1985), Sideranko et al. (1992) and Sparks (1993) which built on the early work done by Landis (1930) to ultimately demonstrate that forces sufficient to exceed capillary closing pressures is different according to an individual's diastolic blood pressure, weight, body build, age, body position or posture (sitting, supine, or side-lying), nutritional status, and tissue perfusion. Furthermore, the internal effects of medications such as corticosteriods (decreased collagen production & angiogenesis), psychological or physiological stress (increased cortisol levels and protein energy demands), diabetes (decreased sympathetic nervous system function, capillary basement membrane

thickening, increased blood viscosity, impaired microcirculation), dehydration (decreased skin elasticity), and body temperature (increased metabolic rate & tissue oxygen demands with fever) have also been described as influencing an individual's risk for pressure ulcer development by affecting tissue tolerance (Defloor, 1999; Lyder, 2006). Recently, work by Fogerty et al. (2008) has shown that in addition to advanced age, certain medical diagnoses, specifically related to infection and multisystem failure have been predictive of pressure ulcer formation in large populations.

Tissue Tolerance

The concept of "tissue tolerance" attempts to explain external factors (such as moisture and the presence of friction and/or shearing forces) and internal factors (such as age, nutrition, interstitial fluid levels, collagen and elastin levels, low arteriolar pressure or poor perfusion/oxygenation) which results in unique physical characteristics of an individual's skin and underlying tissues that make them more or less susceptible to tissue damage by sustained forces of pressure (Braden & Bergstrom, 1987). This idea of tissue tolerance maintains that if tissue tolerance is low, shorter duration of pressure will result in damage to tissues and likewise, if tissue tolerance is high, the individual is less susceptible and tissue damage would only occur with longer duration of sustained pressure applied (Braden & Bergstrom, 1987; Defloor, 1999). The main ideas supporting the term tissue tolerance was developed in the 1970s and 1980s based upon studies in animal models such as Dinsdale (1974) that demonstrated friction combined with pressure produced tissue damage faster than either friction or pressure when applied independently. "Tissue tolerance" was listed as a major independent variable in Braden & Bergstom's 1987 *Conceptual schema for the study of the etiology of pressure sores* (Braden & Bergstrom, 1987; Bergstrom, Braden, Laguzza, & Holman, 1987). Defloor (1999) quoted a 1994 article by Meijer et al., in which they stated, "individual susceptibility to pressure and shear

forces" are as important as the actual external forces of pressure and shearing in the development of pressure ulcers. However, Defloor was critical of any idea that tissue tolerance should be included in a causal model as an independent variable rather than an intermediate variable stating, "Tissue tolerance cannot cause pressure sores – the existence of pressure and/or shearing force is needed" (Defloor, 1999, p. 207).

External Forces of Pressure

Defloor (1999) introduced a conceptual scheme for pressure ulcer development that differentiated *compressive force* vs. *shearing force* as two independent interactive variables and *tissue tolerance for pressure* vs. *tissue tolerance for oxygen* as two intermediate variables with *pressure sores* as the dependent variable. In this model, tissue mass, age, dehydration, protein and vitamin C deficiency, and stress are factors contributing to *tissue tolerance for pressure*; temperature, medication, protein deficiency, smoking, blood pressure, and presence of certain diseases (that affect oxygen supply, reactive hyperemia, and vascular occlusion) are factors contributing to *tissue tolerance for oxygen*. Studies suggest that major alterations in the normal functioning of these human mechanisms or the cumulative effects of minor changes in several of these mechanisms/factors combined with sustained external pressure (forces perpendicular to the skin) and/or the presence of external moisture (fecal or urinary incontinence, excess perspiration) and/or friction and shear forces (slipping, sliding or rubbing forces parallel to the skin) will result in the development of pressure ulcers (Defloor, 1999; Baranoski, 2006).

Berlowitze & Brienza (2007) suggest that deep tissue injury may be responsible for pressure ulcers as a result of "stress (pressure) and strain (deformation) in soft tissue" dependent on 4 contributing factors: "ischemia caused by capillary occlusion, reperfusion injury, impaired lymphatic function, and prolonged mechanical deformation of tissue cells" and that "superficial

(skin) injuries are not caused by pressure." Interestingly, they theorize skin injuries caused by friction/shear and moisture are mainly "superficial lesions" and should not be considered pressure ulcers (Berlowitze & Brienza, 2007, p.37). Baranoski (2006) describes the differences between the two main theories of pressure ulcer etiology being that one is a top-to-bottom model: injury begins from skin destruction on the outside of the body at the surface level and progresses inward toward deeper tissues (such as Defloor theorized); and the other theory is an inward to outward model: suggesting that tissue damage begins inward (deep tissue) and moves outward (such as Berlowitz & Brienza suggested). Baranoski (2006) suggests that there is more current scientific data (such as ultrasound examination of deep tissue) to support the inward to outward model. If this *deep tissue injury* (Gefen, 2008) view is adopted among clinicians, it may affect pressure ulcer staging, pressure ulcer risk assessment tools (where moisture/incontinence are presently considered significant risk factors) and ultimately pressure ulcer prevention measures.

Pressure ulcer research has identified several key physiological factors responsible for the development of pressure ulcers in the human body (tissue tolerance vs. external forces of pressure or friction/shear). However, there is a lack of research data that has determined the exact amount of time in which a pressure ulcer will develop in all persons. Gefen (2008) conducted a review of research findings from animal, human and in vitro studies and reported findings that indicate pressure ulcers may develop in high-risk individuals in less than one hour of sustained pressure to vulnerable body tissue (Gefen, 2008).

Current Definition and Staging of Pressure Ulcers

The National Pressure Ulcer Advisory Panel (NPUAP) defines a pressure ulcer as, "localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result

of pressure, or pressure in combination with shear and/or friction" (NPUAP Press Release, 2007). The degree of tissue damage is communicated through the use of a staging system from Stage I (less obvious tissue damage) to Stage IV (damage may extend to bone), with 'Unstageable' (depth of tissue damage is undeterminable) and 'Deep Tissue Injury' (DTI) discoloration (depth of tissue damage likely deeper than physically obvious) recently added as descriptors (Black, Baharestani, Cuddigan, Dorner, Edsberg, & Langema, et al., 2007). The most common sites for pressure ulcer development are the sacrum, buttocks and heels ((Perneger, Heliot, Rae, Borst, & Gaspoz, 1998; Lyder, 2003; Vangilder, MacFarlane, & Meyer, 2008).

The Cost of Pressure Ulcers

Literature describes higher mortality rates in individuals with pressure ulcers (Redelings et al., 2005). Length of hospital stay has been reported to be five times higher in patients with pressure ulcers versus those without pressure ulcers with similar admitting diagnoses (Graves, Birrell & Whitby, 2005). Pressure ulcers also increase medical complication rates such as sepsis, which occurs in as much as 30% of patients with pressure ulcers (Johns Hopkins: Lyder, 2000). In addition, sepsis has been reported in almost 40% of all pressure ulcer related deaths (Whittington & Briones, 2004). As reported before, JCAHO attributes approximately 60,000 deaths per year to pressure ulcer complications (JCAHO, 2008). Whittington & Briones (2004) estimate annual medical costs in the United States (US) associated with treating pressure ulcers exceed $5 billion dollars annually. Fogerty et al. (2008) estimates this cost to be higher at $10,845 per patient, exceeding a total $18.5 billion dollars annually. This cost does not include the cost of legal litigation in pressure ulcer cases, which is increasing. Reddy, Gill & Rochon (2006) report legal settlements favor long-term care residents in as much as 87% of cases against long term care facilities "for failure to prevent pressure ulcers" (p.974). Furthermore, Jalali &

Rezaie (2005) suggest it may cost as little as $500 to prevent a pressure ulcer, indicating prevention "is more cost-effective than treatment" (Jalali & Rezaie, 2005, p.92).

Incidence and Prevalence of Pressure Ulcers

The incidence of pressure ulcers deals with the number of new pressure ulcers which develop in a particular population over a specified period of time, while the prevalence of pressure ulcers deals with a snapshot picture of how many cases of pressure ulcers exists in a population of interest at one particular reference point/date. It is a national concern that despite national pressure ulcer prevention guidelines and directives, the incidence and prevalence of pressure ulcers in the United States (US) has not significantly changed over the past 20 years.

Whittington & Briones (2004) reported a pressure ulcer prevalence of 17% in 2,200 nationwide non-veteran acute care facilities in 1999. Using the same acute care facilities sample, they reported a prevalence rate of 14% in 2001 and a 16% prevalence rate in 2004. In addition, Whittington and Briones (2004) reported a pressure ulcer incidence rate of 8% among the acute care facilities in 1999 and incidence rates of 7% for both 2001 and 2004. They concluded that incidence rates of new pressure ulcers in acute care facilities varied widely among institutions but averaged around 7% over the 6 years of the study from 1998 to 2004. In another article, "Results of Nine International Pressure Ulcer Prevalence Surveys: 1989 to 2005" VanGilder, MacFarlane, & Meyer (2008) reported 148 acute care and long-term care facilities were first surveyed in 1989 and reported 9.2% overall prevalence of pressure ulcers in a sample of 34,987 patients. In 1995, 265 facilities were surveyed and reported an overall pressure ulcer prevalence rate of 10.1% in a sample of 39,874 acute and long-term care patients. Between 1999 and 2005, pressure ulcer prevalence remained at 14.8% to 15.2% of the total sample reported (n=85,838) in 651 total acute and long-term care facilities. The overall pressure ulcer prevalence rate reported in 394 acute care facilities in 2003 was 15.4%, with a nosocomial prevalence rate of 6.9% in the

same facilities. The overall pressure ulcer prevalence rate reported in 533 acute care facilities in 2005 was 14.6%, with nosocomial pressure ulcer prevalence of 7.3% in the same facilities (VanGilder, MacFarlane & Meyer (2008). The National Pressure Ulcer Advisory Panel (NPUAP) reported in 2001 that incidence rates were as high as 17% for home care, up to 38% for acute care, and up to 23.9% for long-term care facilities. The NPUAP also reported 2001 prevalence rates as high as 29% for home care, up to 18% for acute care, and up to 28% for long term care facilities (NPUAP, 2001). These data indicate that US pressure ulcer prevalence rates have not improved at all since the 1980s (VanGilder, MacFarlane, & Meyer, 2008).

Thomas (2001), Maklebust (2005), and Meaume & Faucher (2007) re-iterate that unchanging incidence/prevalence rates may be due to ineffective prevention strategies, problems with prevention measure implementation, unidentified risk, or lack of consistent pressure ulcer prevention staff education measures. Furthermore, published data is limited on incidence and prevalence of pressure ulcers and risk factors among veteran populations except for veterans with spinal cord injuries or disorders (Garber & Rintala, 2003; Smith, Guihan, LaVela, & Garber, 2008) and veterans in long-term care facilities (Berlowitz, Brandeis, Anderson & Brand, 1997; Berlowitz et al., 1999; Brown, 2003; Hickey et al., 2005). Garber & Rintala (2003) report findings of Yarkony and Heinemann (1995) that 32% of veterans with a spinal cord injury (SCI) developed at least one pressure ulcer within 20 years post-SCI and Carlson et al. (1992) reported 29% of veterans with SCI developed pressure ulcers during acute care admissions. Smith, Guihan, LaVela, & Garber (2008) reported 36% of 2,574 SCI respondents to a survey self-reported pressure ulcers during the previous year (2002-2003). However, more research is needed among the acute care inpatient (and outpatient) veteran populations. Acute care inpatient veterans may be at higher risk for pressure ulcers than their non-veteran neighbors due to their

higher average age (38.9% of veterans > 65 years old vs. 14% of non-veterans > 65 years old) and prevalence of disability within veterans (26.8% of veterans have disability vs. 16.1% of non-veteran population) per US Census Bureau 2006 American Community Survey Data Set.

Guidelines and Mandates to Prevent Pressure Ulcers

The Veterans Health Administration (VHA) Handbook policy 118.2 titled, Assessment and Prevention of Pressure Ulcers (2006) provides mandated comprehensive guidance for interdisciplinary approaches to assessment, reassessment, prevention and documentation of pressure ulcers relevant to all areas of VHA clinical practice (inclusive of Acute Inpatient, Long Term Care Patients, and Outpatient populations). National policies on pressure ulcer risk, including VHA policies, include a directive to perform accurate skin assessments and pressure ulcer risk assessment using the Braden or other widely accepted tool (NPUAP, 2001; VHA Handbook, 2006). The Agency for Health Care Policy and Research (AHCPR) was established in 1989 as a result of United States (US) legislation (Public Law 101-239 of the Omnibus Budget Reconciliation Act of 1989). The AHCPR was charged to "enhance the quality, appropriateness, and effectiveness of health care services and access to these services" within the US and its territories (AHCPR, 1992, publication No. 92-0047). One of the first Clinical Practice Guidelines published in 1992 by the AHCPR was Clinical Practice Guideline #3 entitled, *Pressure Ulcers in Adults: Prediction and Prevention* (AHCPR publication No. 92-0047). The Guideline was a result of a systematic review of 800 scientific manuscripts available from a literature search of that time. A panel of experts further analyzed and refined the guideline, as did peer-review and organizational reviewers. The focus of the 1992 guideline is summarized in its 4 overall goals: "(1) identifying at-risk individuals who need prevention and the specific factors placing them at risk, (2) maintaining and improving tissue tolerance to pressure ulcers in order to prevent injury, (3) protecting against the adverse effects of external mechanical forces (pressure, friction, and

shear), and (4) reducing the incidence of pressure ulcers through educational programs." The guideline went on to describe specific nursing interventions aimed at accomplishing these goals (National Guideline Clearinghouse Archives, retrieved 8/8/08). The AHCPR name was changed to Agency for Healthcare Research and Quality (AHRQ) but the intention of the guideline remained the same, to be evidence-based and revised and updated as needed to reflect new research findings. Unfortunately, this guideline was recently removed from the National Guideline Clearinghouse (NGC) web site because it no longer met the NGC Inclusion Criteria (for current date or content) and has yet to be replaced with a revised AHRQ guideline. However, more recent evidence-based clinical practice guidelines *have* been posted on the NGC web site from other sources. These include: The Wound, Ostomy and Continence Nurse's Society (WOCN) *Guideline for the Prevention and Management of Pressure Ulcers* published in 2003 and updated in 2004; The Registered Nurses Association of Ontario (RNAO) Guideline entitled *Risk Assessment and Prevention of Pressure Ulcers*, published in 2002 and revised in 2005; A Guideline entitled, *Preventing Pressure Ulcers and Skin Tears* by Ayello & Sibbald (2008) published in: *Evidence-based Geriatric Nursing Protocols for Best Practice, 3rd Edition* which was an update of a Guideline first published on the NGC website in 2003; and the American Medical Directors Association (AMDA) Guideline entitled, *Pressure Ulcers in the Long-term Care Setting* first published in 1996 and revised in 2008. Another evidence-based Guideline for the prevention of pressure ulcers is The Wound Healing Society's (WHS) *Guidelines for the Prevention of Pressure Ulcers* published by Stechmiller et al. in 2008. Most recently, the NPUAP (National Pressure Ulcer Advisory Panel) in collaboration with the EPUAP (European Pressure Ulcer Advisory Panel) developed an international guideline for pressure ulcer prevention on the NPUAP website at: www.npuap.org (2009). What all of these guidelines

have in common is the directive for health care providers to appropriately identify individuals at risk of pressure ulcers, to use an accurate risk assessment tool (several guidelines specifically mention the Braden Scale), and to present a plan (intervention) to prevent pressure ulcers. In addition, the Institute for Healthcare Improvement (IHI) developed a national initiative called, *5 Million Lives Campaign*. It listed the prevention of pressure ulcers "by reliably using science-based guidelines for their prevention" as one of the 12 necessary national interventions for healthcare to focus on beginning in 2006 (Duncan, 2007). Duncan (2007) proposed six key elements to pressure ulcer prevention which fall into either of two steps: "(1) identify patients at risk, and (2) reliably implement prevention strategies for all patients who are identified as being at risk." The predominant message is clear: an accurate identification of those individuals who are at risk of pressure ulcers is critical.

Pressure Ulcer Risk

The first step to prevent the development of pressure ulcers is to identify who is most likely to develop them (who are at greatest risk) – with the ultimate goal to implement effective prevention measures. Risk factors are those factors or conditions that are noted to be most strongly associated with the outcome of interest. In order to provide evidence-based preventive measures to prevent the development of pressure ulcers, an effective means of identifying those at highest risk is imperative. Current risk assessment tools may require further development, improved statistical evaluation, and possibly modification in order to remain applicable to present day populations (Defloor & Grypdonck, 2005; Armstrong et al, 2008; Fogerty et al., 2008). In addition, studies such as Anthony, Reynolds, & Russell (2000) demonstrating serum albumin enhanced the pressure ulcer predictability of the Waterlow Risk Assessment Score, suggest that considering risk factors not accounted for on current risk assessment tools will enhance their pressure ulcer predictability.

Common Risk Factors

Within the past 20 years, major risk factors identified (see Table 2-1 for examples) for pressure ulcer development include increased age, impaired mobility, decreased physical activity, poor nutrition, urinary and/or fecal incontinence, sensory impairment, friction, shear, moisture, low BMI, altered level of consciousness, poor perfusion and certain skin conditions (Allman, 1997; Ayello & Lyder, 2001; Lyder, 2006; Reddy, Gill, & Rochon, 2006; Stechmiller et al., 2008). Several studies have identified additional risk factors that include smoking status, diabetes mellitus (DM), coronary artery disease (CAD), renal failure, intensive care unit (ICU) stay greater than 3 days, ventilator dependency, pneumonia/pneumonitis, fever/sepsis, obesity, female gender, and peripheral vascular disease (PVD) (Berlowitz et al., 2001; Lyder, 2006; de Souza, & Santos, 2007). Several studies suggest ethnicity or race may be a significant risk factor, with people of darker skin tones having up to 5 times higher risk than their lighter skinned neighbors (Fogerty et al. (2008). Unfortunately, conflicting data from smaller studies do not show significant differences between age or race or nutritional values among those with pressure ulcers vs. those without pressure ulcers (Smith, Guihan, LaVela, & Garber, 2008). Significant limitations of most pressure ulcer predictive studies are: small sample sizes, convenience sampling, potential bias due to under-reporting of pressure ulcers or inappropriately considering skin tears or other non-pressure related skin conditions as pressure ulcers, confounding variables not examined, and lack of scientific rigor such as is seen in randomized controlled trials (VanGilder, MacFarlane, & Meyer, 2008).

Fogerty et al. (2008) conducted a very large case-control study reviewing admission and discharge data from over six million subjects (Nationwide Inpatient Sample) to identify risk factors and demographic differences between those who developed pressure ulcers and those that did not. Some may describe their study as a nested case-control (Gordis, 2004) because they

identified a cohort (inpatients in the NIS dataset), followed them from their hospital admission until hospital discharge (during 2003), and separated them into 2 groups: those who developed pressure ulcers (cases) and those that did not (controls). There were 94,758 incident pressure ulcers documented among a final discharge sample of 6,610,787 persons. Utilizing multivariate logistic regression analysis on 45 common diagnoses identified in persons with pressure ulcers, they reported odds ratios (estimate of relative risk) for the most significant risk factors associated with developing pressure ulcers. Analysis was also conducted stratifying the sample by age, race and gender. Age over 75 years was the strongest pressure ulcer risk factor identified with an Odds Ratio (OR) of 12.63. Other strong risk factors identified by Fogerty et al. (2008) included over 28 medical diagnoses with an Odds Ratio over 2.0, indicating two or more times the average risk for pressure ulcers among individuals with these diagnoses. Age 59 to 75 years was a strong risk factor (OR 5.99, no Confidence Interval reported), and African American race (OR 5.71, 95% CI 5.35-6.10). Fogerty et al. also reported a statistically significant interaction between race and age, such that as African Americans age, their risk of developing pressure ulcers increases faster than the risk Caucasians experience as they age, indicating noteworthy racial disparities. Other significant findings identified in their study highlight some of the strongest risk factors are non-modifiable (age, paralysis, race) while others are potentially modifiable (infection, nutritional deficiencies). Therefore, exploration is needed to determine when interventions are most effective in those persons with non-modifiable risk factors (such as age > 75), or if perhaps interventions should be initiated in *all* persons over 75 years old or *all* persons identified with particular diagnoses. Investigations are also needed that examine the most effective preventive interventions to reduce or eliminate the identified modifiable risk factors (infection and nutritional deficiencies) and ways to accurately identify them in patients.

Age as a risk factor

One particular population of interest is our elderly population because pressure ulcers disproportionately affect the aging population. Many pressure ulcer studies indicate a strong positive association between older age and the development of pressure ulcers (Bergstrom et al., 1998; Fisher, Wells, & Harrison, 2004; Whittington, K., & Briones, R., 2004; Maklebust, 2005; Schoonhoven et al., 2006; Scott et al., 2006; Lyder, 2006; Fogerty et al., 2008; Stechmiller et al., 2008). Almost 80% of all pressure ulcer related deaths occur in persons over 75 years old (Whittington & Briones, 2004). The US Census Bureau in a press release March 13, 2001 reported there were 3.1 million people over 65 years old in the US in 1900, 34.6 million in 1999, with numbers projected to reach 54 million persons by the year 2020 and 87 million by 2040. Pressure ulcer development is a critical problem that is growing. Even though data exists to suggest that not all pressure ulcers in the elderly are avoidable and some pressure ulcers develop as a result of multiple systems failure and end-of-life physical decline (Thomas, 2001; Padula, Osborne, & Williams, 2008), the data also supports that *most* pressure ulcers are preventable. Therefore, unless effective interventions are identified and implemented, this national problem threatens to become epidemic. Identification of the strongest and most accurate pressure ulcer risk factors is imperative in the present day population in order to select patients for appropriate prevention interventions. It is also important to identify if advanced age alone is a strong enough risk factor to implement preventive interventions for all individuals over a certain age group and/or to evaluate whether current preventive measures actually reduce incident pressure ulcers in this vulnerable population.

Race or ethnicity as a pressure ulcer risk factor

Lyder (2006) cites the lack of sufficient non-white populations in the majority of pressure ulcer studies as a problem resulting in conflicting data regarding race or ethnicity as a risk factor

for pressure ulcers. However, more recently, the large study conducted by Fogerty et al. (2008) suggests there are racial disparities among individuals with pressure ulcers and ethnicity or race may be a significant pressure ulcer risk factor, with people of darker skin tones having up to 5 times higher risk than their lighter-skinned neighbors. Fogerty et al. reported African American race with an Odds Ration of 5.71 (95% CI 5.35-6.10) in addition to a statistically significant interaction between race and age, such that as African Americans age, their risk of developing pressure ulcers increases faster than Caucasian's risk as they age. Maklebust (2005) describes at least one explanation for higher pressure ulcer rates among darker-skinned individuals than among lighter-skinned persons. She theorized that dark skin does not exhibit noticeable early hyperemic pigment changes (blanchable erythema) with superficial pressure that is classically identified as a hallmark to impending pressure damage at a point when interventions (turning/relieving the pressure off of the effected body part) may reverse these pressure effects. In darker skinned persons, the tissue damage related to unrelieved pressure may not be noticeable until the damage is much deeper and not reversible (Maklebust, 2005, p.369

Smoking as a pressure ulcer risk factor

Smoking has been identified as a strong risk factor for pressure ulcer development in the scientific literature (Lyder, 2002), but too often is not examined as a risk factor in pressure ulcer studies (Fisher, Wells, & Harrison, 2004; Meaume & Faucher, 2007; Padula, Osburn, & Williams, 2008). The most plausible reason for smoking being related to pressure ulcer development is the effects of smoking on tissue oxygen perfusion due to the actions of nicotine on the microvasculature of the skin and increased blood viscosity in smokers (Tur, Yosipovitch & Oren-Vulfs, 1992; Monfrecola, Riccio, Savarese, Posteraro, & Procaccini, 1998). Other ways smoking impairs tissue tolerance and wound healing has been explored in several studies such as done by Sørensen, Zillmer, Ågren, Ladelund, Karlsmark, and Gottrup (2009) that demonstrated

higher transepidermal water loss in smokers vs. non smokers ($p<0.01$) and epidermal blister levels of matrix metalloproteinase 8 (MMP-8) twice as high in smokers as in non smokers ($p<0.01$). However, conflicting data exists suggesting that while smokers experience impaired wound healing (Padubidri, Yetman, Browne, Lucas, Papay, Larive, & Zins, 2001), nicotine may stimulate angiogenesis in the *repair* of ischemic tissue (Martin, Mousa, S.S., Shaker, & Mousa, S.A., 2009).

Low BMI or serum albumin as a pressure ulcer risk factor

Scientific findings are controversial regarding Body Mass Index (BMI) scores as a risk factor for pressure ulcers. Several studies suggest that low BMI is associated with higher prevalence of pressure ulcers, and that higher BMI scores may have a protective affect (Berlowitz et al., 2001, Lyder 2006). Mechanisms behind this association are likely due to low BMI as an indicator of inadequate nutrition and/or depletion of lean muscle mass (Lyder, 2006) and the resulting decreased subcutaneous fat (body padding) and higher peak pressures noted over bony prominences of cachectic persons (Defloor, 1999). Some of these findings suggest that while high BMI may afford a protective effect (lower peak pressures due to diffuse area of pressure with greater surface area), a very high BMI (morbidly obese with BMI over 28) may be a potential risk due to greater surface areas of increased pressure, immobility and friction/shear forces. In addition, low serum albumin (or pre-albumin) levels, while not the most accurate overall nutritional marker, can indicate a nutritional compromise and it has been suggested that low levels of serum albumin may be useful in predicting pressure ulcers (Anthony, Reynolds, & Russell, 2000).

Inpatient length of stay as a pressure ulcer risk factor

Length of stay (number of days) has been identified in several studies as an independent positive predictor of pressure ulcers, whereby the greater number of days spent in the hospital,

the greater risk of acquiring a pressure ulcer. At the very least it is a confounding variable (Theaker, C., Mannan, M., Ives, N., & Soni, N, 2000; Fisher, Wells, & Harrison, 2004). Likewise, hours spent in a operating room (OR) and number of days in an intensive care unit (ICU) have also been shown in several studies to be strongly associated with pressure ulcer development, such that the greater the hours spent in the OR/the greater number of days in ICU, the greater risk of pressure ulcer development (Fisher, Wells, & Harrison, 2004).

Medical diagnoses as pressure ulcer risk factors

Fogerty et al. (2008) demonstrate a strong association between more than 17 medical diagnoses and the development of pressure ulcers within a very large nationwide sample of over 6 million subjects admitted to acute care facilities in the US, with 94, 758 persons from the sample developing pressure ulcers. These diagnoses include (listed in descending order): diagnosis of gangrene (OR 10.94, 95% CI 10.43-11.48), paralysis (OR 10.30, 95% CI 9.96-10.96), septicemia (OR 9.78, 95% CI 9.33- 10.26), osteomyelitis (OR 9.38, 95% CI 8.81-9.99), nutritional deficiencies (OR9.18, 95% CI 8.81-9.99), pneumonitis (OR 8.70, 95% CI 8.33-9.09), urinary tract infection (OR 7.17, 95% CI 6.96-7.38), bacterial infection/bacterial skin infection (OR 5.71/3.24, 95% CI 5.49-5.93/3.12-3.38), senility (OR 4.84, 95% CI 4.62-5.07), candidiasis (OR 4.63, 95% CI 4.41-4.86), respiratory failure (OR 4.47, 95% CI 4.21-4.76), acute renal failure (OR 4.16, 95% CI 4.00-4.33), cerebrovascular accident or failure (OR 4.04, 95% CI 3.83-4.27), diabetes mellitus with complications (OR 2.63, 95% CI 2.54-2.73), congestive heart failure (OR 2.63, 95% CI 2.55-2.73), anemia (OR 2.62, 95% CI 2.52-2.73), and complication of device, implant or graft (OR 2.48, 95% CI 2.35-2.61).

The purpose of identifying a risk factor is to be able to intervene with preventive measures. Identifying the strongest pressure ulcer risk factors is the first step toward being able to provide evidence-based interventions and thereby lower the likelihood of someone developing a pressure

ulcer. Pressure ulcer risk assessment tools provide a tangible way to quantify potential risk so that interventions may be reserved for those at highest risk and avoid unnecessary interventions with higher financial expenditures on those who do not need them (Defloor & Grypdonck, 2005). Research is needed that enhances or improves current risk assessment tools in such a way as to identify those individuals at highest risk. Research is also needed to determine the most effective evidence-based preventive interventions and evaluate preventive measures currently utilized, with an ultimate goal of reducing the incidence rates of pressure ulcers in high-risk populations.

Pressure Ulcer Risk Assessment Tools

Common pressure ulcer risk assessment tools in use today are largely based on earlier tools such as the Norton Scale published in 1962. Doreen Norton (along with Rhoda McLaren and Dr. Norman Exton-Smith) developed the Norton Scale in Great Britain during the 1950s (Norton, 1996). It is the first of all of the pressure ulcer risk assessment scales; indeed it is one of the earliest risk assessment scales of any kind. At first, Doreen Norton and her colleagues devised a data collection tool with columns to describe all factors noted in every patient that "might be relevant to pressure ulcer development" (p.39) such as a patient's weight, build, appetite, medications, preventive measures (14 different skin care products), treatment measures, site and condition of skin, and skin changes. They developed a rating 'scale' (at a time when rating scales were uncommon) with 5 elements that had weighted descending values for each element from 4 to 1. The "elements" or factors in their tool were listed as column headings for general physical condition (Norton later said she intended this heading to include overall nutritional state), mental condition, mobility, activity, and incontinence (Norton, 1996). Norton reports the tool was scored '4' for a normal or good function in each factor and '1' for very poor or bad function, with a total possible high score of 20 (patient in good overall condition) and low score of 5 (patient in poor overall condition). Norton explains, "A *descending* scale was selected because it

correlated with a *decline* in the patient's condition" (p.39). The Norton conceptual model is a simple model based on their observed factors of general physical condition, mental condition, mobility, activity, and incontinence quantified with a Likert-type scale for each of these factors totaled as one independent variable and "pressure ulcer RISK" as the dependent or outcome variable. This model proposed that lower total scores have a strong association with higher pressure ulcer risk (Norton, 1996).

Building on early pressure ulcer research done by Norton and others, the Braden Scale for Predicting Pressure Sore Risk (see Appendix A for the full tool and Table 2-2 for an abbreviated description of the subscales) was first published in 1987 (Bergstrom, Demuth, & Braden, 1987; Bergstrom, Braden, Laguzza, & Holman, 1987), and is probably the most widely used pressure ulcer risk assessment tool available today. The theoretical framework is based on a physiological model depicting factors that contribute to the development of pressure ulcers. It includes factors affecting intensity and duration of pressure (decreased mobility, decreased activity, and decreased sensory perception), which combine with intrinsic factors (age, nutrition, vascular perfusion) and extrinsic factors (increased moisture, increased friction, and increased sheer forces) that affect tissue tolerance (Pieper, 2007). The Braden Scale is publicized as the most extensively tested and studied of the assessment tools. The Braden Scale has a potential score ranging from 6 to 23 derived from total scores of its six subscales (sensory/perception, mobility, activity level, moisture/incontinence, nutrition, and friction/shear). Lower scores on the Braden Scale indicate greater risk for pressure ulcer development. Very high risk = 9 or below; High risk = 10-12; Moderate risk= 13-14; and Mild risk = 15-18 (see Table 2-2). There is literature by Braden to suggest that if a person has other major risk factors present (advanced age, fever, poor nutrition, or hemodynamic instability) their score should be advanced to the next highest level of

risk, yet observational studies suggest nurses do not routinely do this. Research suggests that nurses frequently underestimate the level of pressure ulcer risk (Bergstrom et al., 1987; Braden & Bergstrom, 1994; Ayello & Braden, 2002; Stotts & Gunningberg, 2007).

Jalali and Rezaie (2005) report sensitivity of risk assessment tools to be "the percent of individuals who developed a pressure ulcer who were assessed (by the tool) to be at risk" and specificity to be "the percent of individuals who do not develop a pressure ulcer who were assessed (by the tool) not to be at risk" (p.94). They report sensitivity and specificity for the Norton scale to be 49% and 100%, the Braden scale was 53% and 100% respectively, which differs slightly from other reports of Braden sensitivity and specificity of 57% and 68%, respectively (Pancobo-Hildalgo et al., 2006; Bolton, 2007).

Defloor (1999) criticized Braden & Bergstrom's conceptual model because it did not include factors identified in other studies as strongly associated with pressure ulcer development, such as "specific diseases, dehydration, protein deficiency, body build, position, etc." He described his own conceptual scheme of pressure sore formation, utilizing known risk factors and pathophysiology and expanding on the factors listed in the Braden & Bergstrom model. Defloor also noted that more research is needed especially in regards to factors such as smoking and low serum protein levels, as well as the influence of preventive measures.

Pressure ulcer risk assessment tools provide a tangible way to quantify potential risk so that interventions may be reserved for those at highest risk and avoid unnecessary interventions and higher financial expenditures on those not at risk (Defloor & Grypdonck, 2005). Research is needed that enhances or improves current risk assessment tools in such a way as to identify those individuals at highest risk as well as determine if preventive measures currently utilized have any significant affect on the incidence of pressure ulcers in high-risk populations.

Current Understanding of Pressure Ulcer Risk Prediction

With regard to pressure ulcer risk prediction, using data collected from research studies on populations twenty years ago poses a problem for application to the current population. Most of the updated pressure ulcer prevention guidelines available on the National Guideline website (www.guidelines.gov) are still based on those risk factors identified over twenty years ago and these may not carry the same relevance today (RNAO, 2005; AMDA, 2008). Vincent et al. (2006) describes medical technology and clinical procedure advances as well as process of care (organizational/policy) changes within the emergency medicine and intensive care unit (ICU) arenas over the past 25 years. In addition, more patients are having procedures done on an outpatient basis so fewer patients with "minor" conditions are being admitted to the hospital (Edelman, Weiss, Ashton, & Wray, 1995; CDC, Ambulatory Surgery in the US: 1995). These changes are likely to alter acuity levels, numbers of patient transfers within facilities, and length of stays for patients being admitted to hospitals. Essentially, these factors are apt to change the "face" of the inpatient population and impact characteristics of those at risk of a pressure ulcer.

Research Gaps

As stated previously, the risk assessment tools commonly used in acute care in the United States are the Braden and Norton scales. Doreen Norton (1996) conducted her research involving 600 patients (average age 79) in the geriatric firm of a London hospital (over a 2-year period of time) in the 1950s. Her scale is based on observed factors in that population. Predictive statistical analysis of each factor was not done. Barbara Braden (Bergstrom, Braden, Laguzza, & Holman, 1987) built on what Norton had done and modified her scale to fit observed factors of the 1980s. She also suggested the "at risk" cut off score should be 16. Only predictive (criterion-related) validity was reported as sensitivity and specificity for each possible total score of the Braden Scale (9 to 23), indicating a maximum 100% sensitivity and 64 to 90% specificity when using

total score of 16 or less as the critical “at risk” score for developing a pressure ulcer. Bergstrom, Braden, Laguzza, & Holman (1987) reported an inter-rater reliability of the Braden Scale between RN, GS, LPN, and NA staff on each unit (that tested the scale) using Pearson Correlations (86 RN/GS pairs had the highest IRR: r= .99, p<.001, 88% agreement; and NA had the lowest IRR: r=.84, p<.001, 12 to 46% agreement). Predictive statistical analysis, amount of contribution or weights of each subscale factor within the tool was not reported. Interestingly, a more recent study suggests that, even after specific in-depth training on how to use the Braden Scale, nurses produced reliable Braden Scores only 65% of the time after training (Magnan & Maklebust, 2008).

While the Norton and Braden risk assessment tools were derived from factors identified in predictive models of pressure ulcer development in the 1960s and 1980s (and mostly in rehabilitation or long term care settings), there have been no new widely accepted tools based on current pressure ulcer predictive studies within the past 20 years. This is a significant gap in the research. In order to suggest innovative pressure ulcer prevention interventions, one must start with identifying (or verifying) the strongest predictors of pressure ulcer development in present-day populations and settings. A true reflection of current risk factors for specific populations, evidence based risk assessment tools, and ways to improve the accurate use of risk assessment tools are needed (Armstrong et al., 2008). Fogerty et al. (2008) has provided us with extremely valuable pressure ulcer predictor information in current day inpatient non-federal populations. This information needs to be examined further and research is needed to apply that information to the veteran population and investigate these and other factors identified in scientific literature associated with pressure ulcer development to determine if these factors should be accounted for

in addition to or *in place of* those factors indicated on current risk assessment tools being used in veteran facilities.

Table 2-1. Examples of previous research identifying pressure ulcer risk factors.

Researchers	Year	Population	Sample Size	Method	Strongest Risk Factors Identified
Schoonhoven, L., Grobbee, D., Donders, A., et al.	2006	Adult pts in 2 acute care hospitals in Netherlands	1,229 (121 developed stage II to IV pressure ulcers)	Prospective Cohort	Age, weight at admission, abnormal appearance of skin, friction & shear, planned surgery in coming week
Fisher, A., Wells, G., Harrison, M	2004	1993 to 1996 acute care hospitals	1,992 derivation sample, 581 validation sample	Prevalence	Age, male gender, sensory perception, moisture, mobility, nutrition, friction/shear,
Young, J., Nikoletti, S., McCaul, K. Et al.	2002	1998 to 2000 in Western Australia	1,394	3 Cross sectional prevalence studies	Age, Braden Score
Theaker, C., Mannan, M., Ives, N., & Soni, N.	2000	Adult ICU patients in UK facility	286 (77 developed stage I to IV pressure ulcers)	Prospective	Norepinephrine infusion, APACHE II score, fecal incontinence, anemia, length of stay

Table 2-2. Abbreviated Braden scale subscales.

	1	2	3	4
Sensory Perception	Completely limited	Very limited	Slightly limited	No impairment
Moisture	Constantly moist	Very Moist	Occasionally moist	Rarely moist
Activity	Bedfast	Chairfast	Walks occasionally	Walks frequently
Mobility	Completely immobile	Very limited	Slightly limited	No limitation
Nutrition	Very poor	Probably inadequate	Adequate	Excellent
Friction and Shear	Definitely a problem	Potential problem	No apparent problem	-- blank --

Total Score: 9 or less = very high risk, 10-12 = high risk, 13-14= moderate risk, 15-18=at risk, over 18=not at risk (references: Bergstrom, Demuth, & Braden, 1987; Bergstrom, Braden, Kemp, Champagne, & Ruby, 1998; Stotts, 2007) See Appendix A for full Braden Scale for Predicting Pressure Ulcer Risk

CHAPTER 3
RESEARCH METHODS

Design, Sampling and Setting

This retrospective descriptive study in an acutely ill adult inpatient veteran population in north Florida from January-June 2008 determined the differences between Braden scores and other associated risk factors in veterans with and without pressure ulcers. This study was designed to determine the pressure ulcer predictability of the Braden score alone, the Braden score + significant medical factors, and significant medical factors alone. A predictive model using logistic regression was considered in the methodology of this study. Medical factors investigated in this study include those reported in recent literature as significant pressure ulcer risk factors: diagnosis of gangrene, anemia, diabetes, malnutrition, osteomyelitis, pneumonia/pneumonitis, septicemia, candidiasis, bacterial skin infection, device/implant/graft complications, urinary tract infection, paralysis, senility, respiratory failure, acute renal failure, cerebrovascular accident, and congestive heart failure; as well as age, race, hospital and intensive care unit length of stay days, surgery, operating room time in hours, smoking status, and a history of previous pressure ulcers.

Because this population is predominantly male, gender was not examined as an independent variable. Logistic regression statistical analysis was utilized to determine how effective Braden total scores were in a pressure ulcer predictive model (as well as examine each of the Braden sub-scores) with and without the inclusion of other medical factors. A separate predictive model was examined using only the most robust medical factors associated with pressure ulcer incidence in this sample (without the Braden score) in an attempt to develop the most parsimonious predictive model. The results of this study enhances the current knowledge of

pressure ulcer risk factors and risk screening/assessment tools and provides direction for future studies, with an ultimate goal of reducing incidence of pressure ulcers.

The research was conducted entirely at the North Florida / South Georgia Veteran's Health Administration acute inpatient facilities. Purposive sampling was used. All patient records from the North Florida / South Georgia Veteran's Administration from January 2008 through June 2008 were reviewed to obtain data listed on the data collection sheet (see Appendix B) until all veterans who developed pressure ulcers during their hospitalization were identified and at least the same number of veterans hospitalized in the same facility but who did not develop pressure ulcers during their hospitalization were documented. From general estimates of 10 subjects per variable within the regression analysis and an estimated 10 or less final variables, the sample size of 210 was determined sufficient. Furthermore, power analysis was conducted by a statistician prior to the conclusion of data collection to assure adequate sample size to reach .80 (80%) power. If the risk factors were present in at least 20% of subjects, the study should have adequate power to detect risk factors with odds ratios of 3.5 or greater. If the risk factors were present in at least 50% of the subjects, the study should have adequate power to detect risk factors with odds ratios of 2.5 or greater (with a sample of at least 100 cases and at least 100 controls). Over 500 electronic patient records were reviewed to obtain the minimum number of 100 subjects with incident pressure ulcers and at least the same number of subjects hospitalized during the same time without incident pressure ulcers but who had enough recorded data in their chart to complete the study data collection sheets (see Appendix B), resulting in a total study sample of 213 adult veterans admitted to the North Florida/South Georgia Veteran's Administration acute care facility between January 2008 and through the end of June 2008. Veterans Administration Nursing Outcomes Database (VANOD) records were examined to

obtain the records of all those veterans who developed pressure ulcers while hospitalized during the selected dates. This resulted in 100 cases with pressure ulcers. VANOD database and admissions records were then examined to obtain records of patients hospitalized during the same time frame but who did not develop pressure ulcers (10 or more subjects per month) and whose Braden Scores were less than 19. These subjects were randomly selected by going down an alphabetical list of admissions for each month during the same time period. This resulted in 113 subjects without pressure ulcers. Exclusion criteria for the study were: non incident pressure ulcers and missing more than 6 required fields from the data collection sheet. Over 240 charts were excluded due to missing 6 or more key components of the data collection tool, as were over 20 patients that were listed by reports as having developed pressure ulcers while hospitalized but further examination of admission documentation actually recorded the pressure ulcer as present on admission. This resulted in more than 287 records being excluded. No subject was included more than once. All data collected on those patients with pressure ulcers was recorded only if documented prior to pressure ulcer development.

Procedure

Internal Review Board (IRB) approval for this retrospective data analysis as an exempt study (no personally identifying information to be recorded) was obtained from both the University of Florida (UF) and the Veteran's Administration (VA). As an exempt retrospective analysis, no informed consent was necessary. Data was collected using the Veteran's Administration (VA) Computerized Patient Record System (CPRS) accessed at the VA in Gainesville, Florida. Medical data already collected and stored within the patient record system was reviewed, starting with those patients admitted to the North Florida/South Georgia VA acute care facility anytime during January 2008 to June 2008 identified by Veterans Administration Nursing Outcomes Database (VANOD) records, prevalence surveys and tracking logs as having

developed a pressure ulcer during their admission. Next, random patient admissions were reviewed from the same time period January to June 2008 excluding those patients who were identified as having developed pressure ulcers, or having data previously collected, or missing more than 6 required fields on the data collection sheet. The patient records were examined and only the non-identifying data listed on the data collection sheet (Appendix B) was recorded. Data from the data collection sheet was entered onto a spreadsheet stored on a secure file on the VA intranet and a VA security-approved jump drive (for transport during data analysis). The completed data collection sheets, as well as the data spreadsheet and jump drive, were stored in a locked location at the North Florida South Georgia VA facility.

Data Collection

Data was collected using a Data Collection Tool (see Appendix B). Data from the patient data records of the VA was queried using the top 17 diagnoses identified in the Fogerty et al. study (2008). These diagnoses were reported as binary coded categorical variables with no (not present) coded as 0 and yes (diagnosis was present) coded as 1. The diagnoses were reported as present during the hospitalization if these diagnoses were identified using International Classification of Diseases version 9 (ICD-9) as a discharge diagnosis. Typically up to 10 discharge diagnoses were recorded on the discharge summary of patients within this study, with 4 discharge diagnoses recorded in this study being the least number and 11 discharge diagnoses recorded as the most for one subject. Since the average number of discharge diagnosis codes was between 4 and 10, there was concern that many active and pertinent diagnoses would not be accurately captured. To address this concern, the patient's medical record for the hospitalization under review was examined and the diagnoses or medical factors examined in this study were recorded as present in the subject if there was any evidence provided in medical provider assessment documentation, specialist consults with diagnosis confirmation, active disease

problem lists, or laboratory and diagnostic studies (such as radiological images interpreted by a radiologist) as well as by discharge ICD9 codes. One individual, the primary investigator, who is an advanced registered nurse practitioner and board certified in family practice as well as a certified wound specialist, accomplished all data collection and medical record reviews.

Reported diagnoses included: gangrene (785.4 and related codes); anemia (280.0 and related codes), diabetes mellitus with complications (250.1-250.9); malnutrition (260, 261, 262, 263.0-263.9, 995.85); osteomyelitis (730.0-730.9); pneumonia or pneumonitis (480.0, 486, and related codes); septicemia (038.1-038.9, 998.59 and related codes); candidiasis codes (111.8, 112.0, 112.2, 112.84, 112.89); bacterial skin infection or cellulitis (682.6, 682.7, 686.9, 998.51 and related codes); complication of device or implant/graft (996.0-996.89, 429.4-429.9); urinary tract infection (098.0, 098.2, 131.00, 559.0, 597.80); paralysis (045.0, 300.11, 332.0 and related codes); senility (259.8, 290.10 and related codes); respiratory failure (348.8, 518.81-581.84), acute renal failure (403.91, 404.02 and related codes), cerebrovascular (437.8), and congestive heart failure (428.0, 428.1, 428.9). There were no mycosis (031.9) codes found. Since some diagnoses are commonly similar or conceptually related, certain diagnoses were examined separately and then combined – counting overlapping cases only once if they had both diagnoses (CVA + paralysis; pneumonia/pneumonitis + respiratory failure). In addition, hemoglobin and hematocrit were also recorded but are considered in the diagnosis of anemia, so only diagnosis of anemia was used in analysis. Similarly, low body mass index (BMI) and low serum albumin or pre-albumin levels were recorded, but since these indices are included in the registered dietician's nutritional assessment, it was decided to select the registered dietician nutritional assessment of 'severe nutritional compromise' as a proxy for malnutrition and not use the lab

indices in the final predictive models, so that cases would not be counted more than once for factors that were similar conceptually.

A diagnosis or documented history of previous pressure ulcer prior to current admission (707.0—707.9) was also queried and included as a coded categorical independent variable (no=0 / yes=1). Age, race, and length of stay for hospital admission, ICU or operating room time (if applicable) were also recorded. Age was reported as a continuous scale variable in number of years (up to maximum age of 85). All ages over 85 were recorded only as '85 or older' to further protect the identity of these individuals. Gender was reported as a total sample frequency in demographics but was not considered as a variable in the statistical analysis due to the >85% male veteran population within the VA system. Race/ethnicity was reported as a categorical variable (African American / Caucasian / Other). Length of hospital stay and ICU stay (if applicable) was reported as a continuous variable (number of days), while time in operating room (if applicable) was reported as number of hours, rounded to one decimal place.

The outcome or dependent variable was reported as a dichotomous coded variable (did not develop a pressure ulcer was recorded as 0, and did develop a pressure ulcer was coded as a 1). The incidence of pressure ulcers was identified by any diagnosis of pressure ulcer (including suspected deep tissue injury discoloration or DTI and unstageable pressure ulcers) during the current acute inpatient admission that was substantiated by detailed skin and wound assessments by a licensed nurse or physician and/or wound specialist consult assessment. All subjects identified as having developed a pressure ulcer were further reported as frequencies by stage and location of pressure ulcer. Patient records were crosschecked with prevalence data collected quarterly by the VA system.

Non-identifiable data was recorded directly from the computerized patient data system onto a data collection tool (see Appendix A) and then onto an Excel spreadsheet, transformed onto an SPSS data set. If individual records were missing more than six pieces of required information on the data collection sheet (except for laboratory values), the record was not used in the sample.

A total of 108 veterans in the total sample did not have sufficient data recorded in their medical record to determine if they had any history of previous pressure ulcers. Since there were 108 subjects out of 213 with missing data on history of previous pressure ulcers, this variable was not included in the regression analysis. A total of 71 veterans reported recent weight loss just prior to hospitalization but 95 veterans did not have this data recorded in their medical record nor had recent weights recorded to determine this information, so this variable was also not included in final analysis due to the large number of missing cases. Similarly, serum pre-albumin laboratory values were only recorded in 58 total subjects within the sample, so this variable was not included in final data analysis.

The National Institutes of Health (NIH) report that body mass index (BMI) is a number calculated by dividing weight in pounds by height in inches squared and multiplying by a conversion factor of 703. This number is used as an indicator of body fat to screen people for health risk weight categories (http://www.nhlbisupport.com/bmi/). BMI is not an adequate measure of total nutrition. However, since a nutritional assessment performed by a registered dietician (RD) at the VA includes classifying the patient's nutritional compromise (none, mild, moderate, or severe) based on a combination of anthropometric, biological, clinical, and dietary history data that includes BMI, nutritional history, unintentional weight loss as a percent of usual body weight, percent of ideal body weight, diet, serum albumin, and total lymphocyte count

(Lowery, Hiller, Davis, & Shore, 1998), a decision was made to run this variable in the predictive models alone and run another separate LR model with the BMI factor. The RD nutrition assessment of severe malnutrition was selected as a proxy for a diagnosis of malnutrition, since it was determined to be a more accurate appraisal of nutrition than ICD9 code diagnoses. The diagnosis of urinary tract infection (599.0) occurred 5 times concurrently with urogenital candida infection, so the ICD-9 diagnosis code of 112.2 (urogenital candidiasis) was captured under the category of candidiasis but if the patient had a separate diagnosis code of 599.0, the case was also left in the UTI category.

Data Analysis

Descriptive statistics (means, standard deviations and ranges for age, hospital and ICU length of stay, total Braden scores, albumin, hemoglobin, hematocrit, total body mass index or BMI, and total hours in operating room) were reported for the total sample as well as for each outcome group (those that did vs. did not develop pressure ulcers). Frequencies were reported for race, smoking status, recent weight loss, BMI category, surgery during hospitalization, patient history of previous pressure ulcer, nutrition category as determined by a registered dietician (RD), and each predetermined high-risk diagnosis as identified by Fogerty et al. (2008). These include: gangrene, anemia, diabetes with complication, osteomyelitis, pneumonia/pneumonitis, sepsis/septicemia, bacterial skin infection, complications of device or implant/graft, urinary tract infection, malnutrition, paralysis, senility, respiratory failure, acute renal failure, cerebrovascular accident, and congestive heart failure. Candidiasis (any site candida infection) is recorded instead of mycosis (ICD-9 031.9) because there were no 031.9 ICD-9 codes recorded in any of the charts. The frequencies of all of these diagnoses were reported for the total sample as well as each of the two outcome groups. Bivariate analysis was conducted to examine significant differences between *with pressure ulcer* and *without pressure ulcer* groups. Differences between

groups with regard to scale variables were examined using independent samples t-tests statistics. Differences between groups with regard to categorical variables were examined with Chi-squared and Mann-Whitney U statistics. Variables were entered into logistic regression models only if significant bivariate differences were noted. Independent samples t-tests were used to look for differences between group means for age, Hgb/Hct, BMI, prealbumin, albumin, length of hospital and ICU stays, hours in the operating room (if applicable), total Braden Scores, and Braden Subscores. Non parametric statistics such as Chi-square and Mann-Whitney U statistics were calculated to explore differences between the two outcome groups for race, smoking status, patient history of previous pressure ulcer, surgery, severe nutritional compromise, and each pre-determined medical diagnosis. The data was analyzed comparing differences between those individuals that actually did develop a pressure ulcer and those that did not develop a pressure ulcer within the sample group of adult acute inpatient veterans.

Multivariate analysis in this study included examination of the standardized residuals and DfBeta's for outliers and influential cases for scale independent variables (age, total Braden Scores, length of stay in days, length of ICU stay in days, and hours in the operating room). Any case with a standardized residual (ZRE) >3 was judged to be an outlier, but this did not represent more than 5% of cases with ZRE scores over 2.0, so was not determined to be potentially threatening regarding possible bias due to outliers (Field, 2005). Any case identified as an outlier was examined for possible data entry error or miscalculation. If the case was determined to be valid, it was left in the analysis. As there were no DfBetas >1 reported in the analysis, no cases were considered influential cases for this study (Field, 2005). Logistic regression (LR) analysis was used to determine how effective a pressure ulcer predictive model was using Braden total scores with and without the inclusion of other medical factors identified in the scientific

literature. Whether a patient did or did not develop a pressure ulcer was the dichotomous (binary) categorical dependent variable. Independent variables (Braden total scores and sub-scores, and specific medical factors) that were found to have a significant association with pressure ulcers were loaded in the logistic regression (LR) model in a stepwise and forward LR approach as determined by previous literature and the SPSS software.

A registered dietician (RD) nutritional assessment at the VA includes classifying the patient's nutritional compromise (none, mild, moderate, or severe) based on a combination of anthropometric, biological, clinical, and dietary history data such as: BMI, nutritional history, unintentional weight loss as a percent of usual body weight, percent of ideal body weight, diet, serum albumin, and total lymphocyte count (Lowery, Hiller, Davis, & Shore, 1998). An a priori decision was made to run the RD nutritional assessment of severe nutritional compromise as a proxy variable for malnutrition in the predictive models by itself (without other nutritional indicators such as BMI or albumin) and run another LR model with BMI if necessary. Any factor that was not found to be a significant predictor within the LR was deleted from the model and the model re-run in order to determine the most parsimonious model. In the event that two factors were similar in concept and may have subjects counted for both factors (such as CVA and paralysis or pneumonia/pneumonitis and acute respiratory failure) the factors were run separately in different models and if both were significant predictors, were run in another model as a combined new factor (with overlapping cases counted only once). If only one of the variables similar in concept was found to be a significant predictor, it was selected as the variable to run in the final model. For example, CVA/paralysis was combined to form a new variable, while pneumonia/pneumonitis was run alone and acute respiratory failure was eliminated from final analysis as it was not a significant predictor. Factors where >20% of the sample did not have the

recorded data were not included in the LR analysis (history of previous pressure ulcers, history of recent weight loss, and pre-albumin levels).

The first step of logistic regression (LR) was to run a predictive model with total Braden scores entered in step one as a predictor alone. Next in a separate LR, the Braden sub-scores (sensory perception, moisture, activity, mobility, nutrition, friction) were run as independent variables (predictors) entered all together in forward LR method in step one. Thirdly, in a separate LR model, the Braden total score was entered in step one (forced entry), with nutrition category of severe nutritional compromise by RD entered in step two. Fourth, Braden total scores were entered in the first step of a LR model (see Table 4-5) and then all other significant factors (surgery, BMI, candidiasis, hospital los, CVA/paralysis, sepsis, UTI, pneumonia/pneumonitis, and senility/dementia) were entered in the second step of LR in a forward LR method by SPSS. In models 5 through 7 the most parsimonious model (based on the least amount of significant variables that could most accurately predict the subjects who developed pressure ulcers within the sample) was run first with and then without entering the Braden total scores in step one.

Binary logistic regression analysis was conducted using SPSS version 17.0. Binary logistic regression was utilized in SPSS for statistical analysis of the data to examine significant predictors of pressure ulcers within the identified high risk population. Data analysis was run again by a statistician using the same data set with SAS software program to assure similar outcomes. Classification tables and goodness of fit statistics were examined for each final predictive model (with total Braden scores, Braden sub-scores, both with and without other significant medical factors, and those medical factors alone). Significant differences in the models were explored to determine if the identified diagnosis codes or other variables enhanced the predictive ability of the Braden Score.

Assumptions

Assumptions to be met for logistic regression (non-parametric) analysis include representative sample (as random as possible), independence of scores, no empty cells, and muticollinearity. Representativeness of the purposive sample was met due to the sample size (n > 200) and relatively random selection of subjects. Subjects were selected to include all patients that developed pressure ulcers while inpatient from January 2008 to June 2008, and then randomly from each of the same months among patients that did not develop pressure ulcers but had Braden scores 18 or less, until over 200 total sample size was achieved. Independence (cases must be independent of each other) was met because there were no repeated measures and all data collected was from individual participants. In cases where conceptually similar variables were counted (such as pneumonia/pneumonitis and respiratory failure), the two variables were examined separately in the models, as well as combined in a new variable (CVA/paralysis) with the overlapping cases only counted once. Empty cells must be avoided in bivariate crosstabs analysis. In the event of a large number of missing cases, such as where history of weight loss or history of previous pressure ulcer was not recorded in many charts, the variables were not included in final analysis. The assumption of normality does not apply to logistic regression (LR), so no distribution histograms or Shapiro-Wilk statistics were reported.

Additional Analyses

Within the first month of data collection, it was noted that the ICD9 discharge diagnosis codes did not always reflect all of the actual pertinent diagnoses present during hospitalization, so the investigator went back to the IRB with a request to collect additional data to include chart review of active problem lists, specialist consults, labs, provider progress notes and assessments which would identify if the patient had the diagnosis of interest present during hospitalization prior to any development of pressure ulcer. Appendix E reports specific medical diagnoses by

ICD9 code recorded in the veteran's medical record upon discharge for the total sample versus how many actual diagnoses were present in the medical record during that hospitalization as evidenced by documentation in the provider notes, active problem list or labs during that hospital stay (as well as discharge diagnosis code list). The frequency of diagnosis is reported for both groups within the sample (without pressure ulcers vs. with pressure ulcers).

CHAPTER 4
RESULTS

Characteristics of the Sample

The total sample included 206 male (97% of sample) and 7 female subjects (3% of total sample). Gender was not included in the statistical analysis because the majority of veterans are male, but is reported in the sample demographics. Fifty-nine veterans in the sample were smokers and 1 veteran did not have smoking status recorded. Twenty nine (13.6%) veterans in the total sample were African Americans, 171 (80.3%) were Caucasians, and 10 veterans (4.7%) had their race listed as “other” in the medical record. Three veterans within the sample did not have any race data recorded. All subjects that did not have information documented on the specific factor of interest listed in Table 4-1 are listed as “missing cases from sample” in the table.

Age of subjects in the total sample ranged from 47 years of age to >85 years of age, with 50% of the total sample over the age of 72. All subjects over 85 years of age were listed as ’85 or older’ in order to protect potentially identifiable data and maintain the exempt status of the IRB approval for the study. Age and other continuous numerical (or scale) variables are described for the entire sample in Table 4-2. The mean age of the total sample was 71years of age (SD 10.6, range 47 to > 85 years old). Hospital length of stay in days ranged from 2 to 110 days with an average for the total sample of 11.72 days. Intensive care unit (ICU) length of stay in days averaged 8 days for the entire sample. Operating room (OR) time in hours averaged 4.7 hours with a range of 0.5 – 12 hours for the total sample. Hemoglobin (Hgb) levels averaged 9.94 g/dL for the total sample. Hematocrit (Hct) levels average 30.5% for the total sample. Twenty seven (12.7%) veterans had a diagnosis of cerebrovascular accident (CVA). Sixteen (7.5%) veterans had a diagnosis of paralysis. Seven veterans (3.3%) had a diagnosis of osteomyelitis. Thirty five

(16.4%) veterans had a diagnosis of senility or dementia. Forty (18.8%) veterans had a diagnosis of sepsis or septicemia. Eighty six (40.4%) veterans had a diagnosis of urinary tract infection. Seven (3.3%) veterans had a diagnosis of gangrene. One hundred and ninety eight (93%) of the veterans in the total sample had some diagnosis or lab report during their hospitalization diagnostic of anemia. Ninety one (42.7%) of the veterans in the sample had a diagnosis of diabetes mellitus with complication. Fifty (23.5%) veterans had a diagnosis of pneumonia or pneumonitis. Thirty eight (17.8%) veterans had a diagnosis of candidiasis or candida fungal infection (skin, urogenital, esophagitis, or thrush). Twenty seven (12.7%) veterans had diagnosis of bacterial skin infection or cellulitis. Thirty four (16%) veterans had diagnosis of graft or device complication. Thirty one (14.6%) veterans had diagnosis of acute respiratory failure. Seventy three (34.3%) veterans had diagnosis of acute renal failure. Fifty five (25.8%) veterans had a diagnosis of congestive heart failure (CHF) during the hospitalization. Seventy nine (37.1%) of veterans within the sample had a body mass index (BMI) over 28. One hundred and eight (50.7%) of veterans within the sample had a BMI between 19 and 28. Twenty four (11.3) veterans had a BMI below 18. Two hundred and two veterans within the sample had a nutritional assessment by a registered dietician (RD). Thirty nine (18.3%) veterans had a diagnosis by RD of mild nutritional compromise, 124 (58.2%) had a diagnosis by RD of moderate nutritional compromise, and 39 (18.3%) had a diagnosis by RD of severe nutritional compromise. Three veterans in the sample had no nutritional compromise as determined by RD evaluation.

The study sample includes a total number of 36 (17%) veterans that had surgery during their hospitalization and 177 veterans that did not have surgery (see Table 4-1). Seventy six veterans had no history of previous pressure ulcers. Twenty nine veterans did have a previous history of pressure ulcers. However, a total of 108 veterans in the sample did not have this

information recorded. A total of 71 veterans reported recent weight loss just prior to hospitalization but 95 veterans did not have this data recorded in their medical record nor had recent weights recorded to determine this information. Serum albumin levels averaged 2.97 g/dL for the total sample. Serum pre-albumin laboratory values averaged 9.67 mg/dL for the total sample, but pre-albumin levels were only recorded in 58 total subjects. Please see Table 4-3 for frequencies of medical diagnoses by medical chart review (including ICD 9 codes).

Comparison of Groups

Comparisons of the veterans who did develop pressure ulcers during hospitalization versus those veterans who did not develop pressure ulcers during their acute hospitalization are made with the following tables and figures. Table 4-4 describes the means and standard deviation of other numerical, continuous (scale) variables for both groups (with/without PU) as well as two-tailed t-test results for significant differences between means of several of the scale variables (age, hospital length of stay in days, ICU length of stay in days, operating room time in hours, serum albumin, serum prealbumin, hemoglobin in g/dL, hematocrit %, and Body Mass Index). Table 4-4 examines the t-test for significant differences between average total Braden Risk Assessment scores and each separate Braden Scale sub-score of: sensory perception, moisture, activity, mobility, nutrition, and friction/shear.

Average age of veterans with PU was 71.5 years. Average age of veterans without PU was 70.5 years (see Table 4-4). The difference in mean ages of veterans within the two groups was 1.5 years, which was not statistically significant ($p = 0.522$). Hospital length of stay in days ranged from 2 to 110 days with an average for the veterans without PU of 8.5 days, and those with PU averaged 15.4 days. The mean difference was 6.92 days, which was statistically significant ($p = 0.000$). Intensive care unit (ICU) length of stay in days averaged 5.72 days for the veterans without PU and 8.87 days for veterans with PU. The mean difference is 3.15 days,

which was statistically significant (p = 0.039). Operating room (OR) time in hours averaged 3.4 hours for the veterans without PU and 5.15 hours for veterans with PU. The mean difference is 1.35 hours, which was not statistically significant (p = 0.394). Hemoglobin (Hgb) levels averaged 10.43 g/dL for the veterans without PU, and 9.39 g/dL for the veterans with PU; the mean difference (1.02 g/dL) is statistically significant (p=0.000). Hematocrit (Hct) levels averaged 32.0% for veterans without PU and 28.8% for the veterans with PU; the mean difference (3.2%) is statistically significant (p=0.000). Serum albumin levels averaged 3.26 g/dL for the veterans without PU, and 2.66 g/dL for those with PU; the mean difference (0.6 g/dL) is statistically significant (p=0.000). Pre-albumin levels averaged 12.21 mg/dL for the veterans without PU, and 8.44 mg/dL for those with PU; the mean difference (3.77 mg/dL) is statistically significant (p=0.021). Body mass index (BMI) averaged 27.7 for the veterans without PU, and 25.5 for those with PU; the mean difference (2.2) is statistically significant (p=0.029). Total Braden scores averaged 14.6 for the veterans without PU, and 13 for those with PU; the mean difference (1.6) is statistically significant (p=0.000). Braden sensory perception sub-score averaged 2.86 for the veterans without PU, and 2.65 for those with PU; the mean difference (0.21) is not statistically significant (p=0.062). Braden moisture sub-score averaged 3.18 for the veterans without PU, and 3.10 for those with PU; the mean difference (0.08) is not statistically significant (p=0.395). Braden activity sub-score averaged 2.02 for the veterans without PU, and 1.31 for those with PU; the mean difference (0.71) is statistically significant (p=0.000). Braden mobility sub-score averaged 2.43 for the veterans without PU, and 2.09 for those with PU; the mean difference (0.34) is statistically significant (p=0.000). Braden nutrition sub-score averaged 2.12 for the veterans without PU, and 2.02 for those with PU; the mean difference (0.10) is not statistically significant (p=0.292). Braden friction sub-score averaged 2.12 for the veterans

without PU, and 1.79 for those with PU; the mean difference (0.33) is statistically significant (p=0.000).

Table 4-5 examines the differences between groups (those without pressure ulcers vs. those with pressure ulcers) in the sample regarding the frequency of specific categorical demographic and medical factors. Comparison between groups was examined using Chi-squared statistic and the level of significance of this test is reported for each factor. Racial distribution of the sample includes 29 African American veterans (14 without PU, 15 with PU), 171 Caucasian veterans (87 without PU, 84 with PU), 10 listed as other ethnicity (9 without PU and 1 with PU), and 3 veterans who did not have any race recorded (no pressure ulcers were present in these three veterans). The difference in racial distribution as a whole among those veterans that did develop pressure ulcers and those that did not was statistically significant (p=0.033). A total of 36 veterans had surgery during their hospitalization (12 without PU, 24 with PU), and 177 veterans that did not have surgery (101 without PU, 76 with PU); the group difference is statistically significant (p=0.009). A total of 59 veterans within the sample were current smokers (35 without PU, 24 with PU), and 153 veterans reported they were not current smokers (77 without PU, 76 with PU); the group difference is not statistically significant (p=0.321). A total of 202 veterans (95% of the total sample) had a nutritional evaluation done by a Registered Dietician (RD). Eleven veterans (5%) did not have a nutritional evaluation by a RD during their hospitalization. Of those subjects who had a nutritional evaluation, 3 were determined to have no nutritional compromise (none of the 3 developed pressure ulcers); 39 (19%) were determined to have mild nutritional compromise (30 without PU, 9 with PU); 124 (61%) were determined to have moderate nutritional compromise (64 without PU, 60 with PU); and 39 subjects were determined to have severe nutritional compromise (8 without PU and 31 with PU); the group

difference is statistically significant (p=0.000). Body Mass Index (BMI) was examined as both a scale numerical variable and as a categorical variable with 2 extremes and one midlevel BMI range labeled 'Normal or Average' for the purpose of this study: Low BMI <19 (underweight), Normal BMI 19-28, and High BMI > 28 (obese). Only 2 veterans did not have any BMI calculated or recent weight documented to calculate a BMI from. There were 24 veterans with Low BMI <19 (8 without PU, 16 with PU), 108 veterans with Normal BMI 19-28 (53 without PU, 55 with PU), 79 veterans with High BMI > 28 (50 without PU, 29 with PU); the group difference is statistically significant (p= 0.023). Recent weight loss was recorded on only 71 veterans (47 veterans had stable weights recorded for the 3 months prior to admission) and 95 veterans had this data missing in their chart. Of the 71 veterans with recent weight loss documented, 25 did not develop a PU during hospitalization and 46 did develop a PU during their hospitalization; the group difference is statistically significant (p= 0.000). The total sample (213 veterans) only had 29 (14%) with previous pressure ulcers documented in their chart. Six (2.6%) of these 29 veterans did not develop pressure ulcers, while 23 did develop PU (79%); the group difference is statistically significant (p=0.000). Please see Table 4-5 for each diagnosis (anemia, cerebrovascular accident or CVA/paralysis, congestive heart failure or CHF, osteomyelitis, gangrene, sepsis, diabetes mellitus or DM with complications, bacterial skin infection, urinary tract infection or UTI, pneumonia/pneumonitis, senility/dementia, candidiasis, device or graft complication, acute respiratory failure, and acute renal failure) and the corresponding frequencies and group differences of these diagnoses in the total sample. Those diagnoses that demonstrated statistically significant differences between groups were: CVA/paralysis (p = 0.001), sepsis (p = 0.029), pneumonia/pneumonitis (p = 0.000), acute respiratory failure (p = 0.001), senility/dementia (p = 0.039), candidiasis (p = 0.000), and UTI (p

= 0.000). The diagnosis of urinary tract infection (599.0) occurred 5 times concurrently with urogenital candida infection, so the ICD-9 diagnosis code of 112.2 (urogenital candidiasis) was captured under the category of candidiasis but if the patient had a separate diagnosis code of 599.0, the case was also left in the UTI category. Out of curiosity, these 5 cases were removed from both variables and each run separately only counting the 5 cases once, but it did not affect the data analysis, so all 5 cases were left in under both variables.

Pressure Ulcer Characteristics

The veterans with pressure ulcers were typically identified with stage II pressure ulcers or worse. Only 5 veterans with pressure ulcers were reported as having developed stage I pressure ulcers, 74 veterans developed stage II pressure ulcers, 5 veterans developed stage III, no veterans were identified as having developed stage IV pressure ulcers, 13 veterans developed suspected Deep Tissue Injury, and 3 veterans developed unstageable pressure ulcers. The most frequent anatomical location of the pressure ulcers in the group of veterans in the sample who developed pressure ulcers during their hospitalization was the sacrum/coccyx area (n=52), and buttocks (n=25), followed by heel (n=8), hip (n=1), 'other sites' (n=9), and multiple sites of pressure ulcers (n=5). Please see Table 4-6 for pressure ulcer stages and locations.

Regression Analysis

Logistic regression was first run entering the total Braden score as a predictor variable in step one and "developed pressure ulcer" as the dependent variable. Goodness of Fit statistics (-2 log likelihood) were examined for every model and classification tables were examined for how accurately the model was able to predict cases. Please see Table 4-7 for Logistic regression analysis results. This first 'Braden only' model (Model 1) accurately classified 68% of the total sample (70% accuracy in the no PU group and 65% accuracy in the PU group). Secondly, the significant subscales of the Braden were entered in step one of a separate LR model (activity,

mobility, and friction entered in forward LR method). The SPSS statistical program eliminated mobility as a predictor variable from the model (Model 2), as it did not reach appropriate significance. The Braden activity and friction subscale scores in a predictive model by themselves could accurately classify 72% of total sample (65.5% without PU were correctly classified and 80% with PU were correctly classified). Thirdly, total Braden scores was entered in step one (forced entry) and RD nutritional evaluation (nutritional compromise by categories of none, mild, moderate, severe) was entered in step two of a separate LR model (Model 3). This was done in a separate model so that other indices (if significant) which are already considered in the RD nutritional evaluation (such as BMI) could be entered in a separate model and the strongest predictor selected for final regression models. The total Braden + RD nutritional compromise categories in a model (Model 3) could accurately predict 73% of total sample (74% no PU/ 70% yes PU groups). Next a separate LR model (Model 4) was run with total Braden scores entered in step 1 (forced entry) and all other significant variables (surgery, pneumonia/pneumonitis, CVA/Paralysis, UTI, ICU los, hospital los, Hct, BMI category, sepsis/septicemia, senility/dementia, albumin, candidiasis) entered in step 2 in a forward LR method in SPSS. In this model (Model 4), SPSS eliminated BMI, ICU los, Hct, albumin, sepsis/septicemia, senility/dementia, and hospital los as significant contributors to the predictive model. Only pneumonia/pneumonitis, candidiasis, surgery, UTI, and CVA/paralysis were left in the model. In the fifth model, Braden scores as a predictor variable was entered in step 1 of the LR (forced entry) and pneumonia/pneumonitis, candidiasis, surgery, severe nutritional compromise by RD eval, CVA/paralysis, and UTI were entered in step 2 in a forward LR method in SPSS . This model (Model 5) could accurately predict 80.8% of total sample (85% no PU/ 76% of yes PU group). In an attempt to select the most parsimonious model with the least

number of variables that could predict the most cases, the sixth model was run with total Braden scores entered in step 1 (forced entry) and only the strongest of the previous model's predictors entered in a forward LR method in step 2 (pneumonia/pneumonitis, candidiasis, surgery, severe nutritional compromise by RD evaluation). This model could accurately predict 78.4% of total sample (82.3% no PU and 74% of the yes PU group). The final model was run without the total Braden score since the Braden total score in several models did not achieve adequate level of significance in step 2. Model 7 was run with only pneumonia/pneumonitis, candidiasis, surgery and severe nutritional compromise by RD evaluation (a proxy for malnutrition). These four predictor variables entered into step 1 in forward LR fashion were able to correctly classify 77% of the total sample, with 71.7% of the no pressure ulcer group correctly classified, and more importantly, 83% of the with pressure ulcer group correctly classified (see Table 4-7).

The relative risk of incident pressure ulcers for veterans in the sample with low Braden total scores is estimated with an odds ratio of 0.784 (95% confidence interval 0.675 - 0.910, p=0.001), such that for every point change lower in the Braden score (from 18), the veteran in the sample was 1.3 times more likely to develop a pressure ulcer. The relative risk of incident pressure ulcers for veterans in the sample with a diagnosis of pneumonia or pneumonitis is estimated with an odds ratio of 7.9 (95% CI 3.4 – 18.61, p <0.001), indicating a veteran in the sample with pneumonia/pneumonitis was almost 8 times more likely to have a pressure ulcer than someone without either of these diagnoses. The relative risk of incident pressure ulcers for veterans in the sample with a candidiasis diagnosis (skin, esophageal, urinary, or blood candidiasis) is estimated with an odds ratio of 9.5 (95% CI 3.4 – 26.4, p 0.000), indicating a veteran in the sample with candidiasis was 9 times more likely to develop pressure ulcers than those that did not have this diagnosis. The relative risk of incident pressure ulcers for veterans in

the sample with a severe nutritional compromise is estimated with an odds ratio of 4.98 (CI 1.9-12.9, p 0.001), such that veterans who were evaluated by a registered dietician and assessed to have severe nutritional compromise were almost 5 times more likely to have a pressure ulcer develop than those veterans who had no, mild or moderate nutritional compromise. Finally, the occurrence of surgery during hospitalization also added to the risk of pressure ulcer development. The relative risk of incident pressure ulcers for veterans in the sample who had surgery during their hospitalization is estimated with an odds ratio of 5.8 (CI 2.5 – 13.8, p 0.000), suggesting that surgery during hospitalization for the veterans in our sample increased their risk of pressure ulcer almost 6 times that of the veterans that did not have surgery (see Table 4-8).

Table 4-1. Pressure ulcer study sample demographics.

	Total sample n=	% Sample	Missing cases from sample
Male	206	97%	-
Female	7	3%	-
Race:	-		3
African American	29	14%	-
Caucasian	171	80%	-
Other race	10	5%	-
Surgery	36	17%	0
Smokers	59	28%	1
BMI by category:	-		2
Low BMI <19	24	11%	-
Norm 19 to 28	108	51%	-
High BMI >28	79	37%	-
Recent wt loss	71	33%	95/44%
Previous PU	29	14%	108/51%
RD Nutrition Assessment:	202	95%	11/5%
Mild compromise	39	18%	-
Moderate compromise	124	58%	-
Severe compromise	39	18%	-
Anemia	198	93%	0
CVA/paralysis	34	16%	0
CHF diagnosis	55	26%	0
Osteomyelitis diagnosis	7	3%	0
Gangrene	7	3%	0
Sepsis	40	19%	0
DM w/complications	91	43%	0
Bacterial skin infection	27	13%	0
Urinary tract infection	91	43%	0
Pneumonia/pneumonitis	50	23%	0
Senility/Dementia	35	16%	0
Candidiasis	38	18%	0
Device/graft complication	34	16%	0
Acute Resp failure	31	15%	0
Acute Renal failure	73	34%	0

Table 4.2. Total sample scale variable descriptive statistics.

Variable	N	Mean	Median	Std. Deviation	Minimum	Max
Age	213	70.97	72	10.644	47	85
Total Braden score	213	13.86	14	2.482	8	19
Hosp los	213	11.72	8	10.924	2	110
ICU los	82	7.84	5	8.1	1	44
OR time	35	4.72	4.5	2.525	.5	12.0
Hemoglobin	213	9.9404	10	1.88824	5.90	14.60
Hematocrit	212	30.4981	30.75	5.65602	18.60	45.20
Albumin	204	2.9735	3	.76820	1.10	4.70
Prealbumin	58	9.6724	9	5.91278	3.00	26.00
BMI	211	26.6256	25.5	7.21859	13.70	59.50

Table 4-3. Recorded medical diagnoses by chart review.

Diagnosis	ICD9 Codes	Total # subjects with diagnosis (including ICD9, labs, active problem list, and provider notes)
Acute Renal Failure	584.9, 586.0 403.91, 404.02	73
Acute Resp. Failure	518.81	31
Anemia	280.0, 280.9, 285.21, 285.22, 285.29, 285.9	198
CHF	428.0, 428.1, 428.9	55
CVA	437.8, 438.20, 438.89	27
Device or Graft complications	E878, 996.0-996.89, 999.31, 429.4-429.9	34
DM with complications	250.00, 250.01, 250.13, 250.30-250.80	91
Gangrene	785.4	7
Malnutrition (moderate or severe by RD)	262, 273.8, 269.9, 262, 263.9	170 mod + severe 39 severe only
Candidiasis	111.8, 112.0, 112.2, 112.84, 112.89	38
Osteomyelitis	730.0-730-9, 730.17, 730.27	7
Paralysis	332.0, 344.01, 344.1, 342.91, 342.90, 358.00	16
Pneumonia or Pneumonitis	480.0, 481, 482.0, 482.9, 486	50
Senility or Dementia	290.40, 294.10, 331.0, 331.82, 780.09, 780.97	35
Sepsis	038.10, 038.42, 038.9, 785.52, 995.91, 995.92	40
Bacterial skin infection	681.00, 681.1, 682, 682.2-682.7, 686.9, 998.51	27
UTI	559.0, 597.80, 098.0, 098.2	91

Table 4.4. Comparison of mean differences between groups.

Variable	Mean No PU	Mean Yes PU	Mean Diff	T	Sig. (2 tail) p
Age	70.5	71.5	1.5	-.642	.522
Hosp los (days)	8.48	15.4	6.92	-4.67	.000
ICU los (days)	5.72	8.87	3.15	-2.1	.039
OR time (hrs)	3.80	5.15	1.35	-.890	.394
Hemoglobin	10.42	9.4	1.02	4.13	.000
Hematocrit	32	28.8	3.2	4.26	.000
Albumin	3.3	2.7	0.6	6.08	.000
Prealbumin	12.2	8.43	3.77	2.09	.021
BMI	27.7	25.5	2.2	2.2	.029
Total Braden	14.6	13	1.6	5.148	.000
Braden sensory	2.86	2.65	0.21	1.874	.062
Braden moisture	3.18	3.10	0.08	.852	.395
Braden activity	2.02	1.31	0.71	6.635	.000
Braden mobility	2.43	2.09	0.34	4.016	.000
Braden nutrition	2.12	2.02	0.10	1.057	.292
Braden friction	2.12	1.79	0.33	4.320	.000

Table 4-5. Differences between groups for predictor variables.

Total sample=213 No PU = 113 Yes PU = 100	Total sample n=x / % sample	NO PU n/% this group	YES PU n/%this group	Chi-Square Statistic	Sig. p
Race:					
African American	29/14%	14/12%	15/15%	-	-
Caucasian	171/80%	87/77%	84/84%	-	-
Other race	10/5%	9/8%	1/1%	8.726	.033
Yes Surgery	36/17%	12/11%	24/24%	6.763	.009
No Surgery	177/83%	111/98%	76/76%	-	-
Yes severe nutritional compromise	39/18%	8/7%	31/31%	20.295	.000
No severe nutritional compromise	174/82%	105/93%	69/69%	-	-
BMI by category:				9.528	.023
Low BMI <19	24/11%	8/7%	16/16%	-	-
Norm 19 to 28	108/58%	53/46%	55/55%	-	-
High BMI >28	79/37%	50/44%	29/29%	-	-
Yes CVA/paralysis	34/16%	9/8%	25/25%	11.48	.001
No CVA/paralysis	179/84%	104/92%	75/75%	-	-
Yes Sepsis	40/14%	15/13%	25/25%	4.782	.029
No Sepsis	173/81%	98/86%	75/75%	-	-
Yes UTI	91/43%	33/29%	58/58%	12.479	.000
No UTI	122/57%	80/71%	42/42%	-	-
Yes Pneum/pneumonitis	50/23%	10/9%	40/40%	28.657	.000
No pneumonia/pneumonitis	163/77%	103/91%	60/60%	-	-
Yes Senility/Dementia	35/16%	13/12%	22/22%	4.256	.039
No Senility/Dementia	178/84%	100/88%	78/78%	-	-
Yes Candidiasis	38/18%	6/5%	32/32%	25.784	.000
No Candidiasis	175/82%	107/95%	68/68%	-	-
Yes respiratory failure	31/15%	8/7%	23/23%	10.813	.001
No acute resp failure	182/85%	105/93%	77/77%	-	-
Yes acute renal failure	73/34%	35/31%	38/38%	1.163	.281
No acute renal failure	140/66%	78/69%	62/62%	-	-

Table 4.6. Pressure ulcer descriptions.

	n= x (% of pressure ulcer group)
Number of subjects with PU	100
Number of Stage I PU	5 (5%)
Number of Stage II PU	74 (74%)
Number of Stage III PU	5 (5%)
Number of Stage IV PU	0
Number of DTI PU	13 (13%)
Number of Unstageable PU	3 (3%)
Location of pressure ulcers:	
Buttocks	25 (25%)
Heel	8 (8%)
Hip	1 (1%)
Sacrum/coccyx	52 (52%)
Multiple locations	5 (5%)
Other location (ankle, knee, foot, etc)	9 (9%)

Table 4-7. Logistic regression analysis results of models.

Model and Step	Variable Name	% Total Cases Correctly Classified	% No PU Correctly Classified	% Yes PU Correctly Classified	Model -2 log Liklihood	Model Chi-Square Statistic	Sig. p
1/1	Total Braden	67.6%	69.9%	65%	269.635	24.852	.000
2/1	Only 2 Braden Subscales: Activity Friction	72.3%	65.5%	80%	243.005	51.481	.000
3/1 3/2	Total Braden + RD Nutrition Eval	72.3%	74.3%	70%	240.021	54.466	.000
4/1 4/2	Total Braden + Pneumonia + Candidiasis + Surgery + UTI + CVA/Paralysis	78.9%	81.4%	76.3%	174.761	100.986	.000
5/1 5/2	Total Braden +Pneumonia +Candidiasis +Surgery +Severe RD Maln + CVA/Paralysis +UTI	80.8%	85%	76%	191.890	102.597	.000
6/1 6/2	Total Braden +Pneumonia +Candidiasis +Surgery +Severe RD Maln	78.4%	82.3%	74%	201.456	93.031	.000
7/1	+Pneumonia +Candidiasis +Surgery +Severe RD Maln	77.0%	71.7%	83%	212.239	82.248	.000

Table 4-8. Relative risk of pressure ulcers by predictors in final model.

	Odds Ratios	95% CI	Sig. p
Braden total scores	0.784	0.675-0.910	0.001
Pneumonia/ pneumonitis	7.9	3.4-18.61	0.000
Candidiasis	9.5	3.4-26.4	0.000
Surgery	5.8	2.5-13.8	0.000
Severe Maln by RD	4.98	1.9-12.9	0.001

CHAPTER 5
DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

The aims of this retrospective descriptive study include: 1) to determine the predictability of the Braden Scale total score on the development of pressure ulcers in an inpatient acutely ill adult veteran population, 2) to determine if the addition of other significant medical factors (diagnosis of gangrene, anemia, diabetes mellitus , malnutrition, osteomyelitis, pneumonia/pneumonitis, septicemia, candidiasis, bacterial skin infection, complication of device or implant/graft, urinary tract infection, paralysis/CVA, senility, respiratory failure, acute renal failure, congestive heart failure, history of previous pressure ulcer, age, race, length of inpatient hospital and ICU stays, time in operating room, and smoking status) to these Braden total scores enhance the model's predictability of pressure ulcer development in an inpatient acutely ill adult veteran population, and 3) to determine if selected medical factors alone are significantly able to determine the development of pressure ulcers in an acutely ill inpatient adult veteran population.

The overall conclusion from this analysis was that a logistic regression model of pressure ulcer development in acutely ill veterans indicated 5 predictors able to determine a statistically significant risk of pressure ulcer development. Specifically, the logistical analysis indicated that high risk Braden total scores (mean =13), the presence of a diagnosis of pneumonia/pneumonitis, candidiasis, a severe nutritional compromise as determined by a registered dietician (RD), or surgery during hospitalization can be predictive of the development of pressure ulcers in acutely ill veterans. The analysis included a predictive model using binary Logistic Regression, which determined that the Braden total score alone was correctly able to classify 68% of the sample (70% subjects which did not develop pressure ulcers were correctly classified and 65% cases that did develop pressure ulcers were correctly classified in this 'Braden score only' model). Please see Table 4-7. Adding the presence of pneumonia/pneumonitis, candidiasis, severe nutritional

compromise and surgery during hospitalization was able to correctly classify an additional 10% of the sample (78% of total sample correctly classified: 82% without PU, 74% with PU). The final five-factor model summary -2 Log likelihood statistic indicated a good fit of the model to the data (Table 4-7). This analysis supports the notion that accounting for at least 4 additional medical factors to the Braden total scores will enhance the model's predictability of pressure ulcer development in an inpatient acutely ill adult veteran population. The diagnosis of pneumonia/pneumonitis or candidiasis was the highest influential medical factor next to total Braden scores for the model.

The odds ratios of the four strongest pressure ulcer risk predictors: pneumonia or pneumonitis odds ratio of 6.9 (95% CI 2.9 – 16.75, p <.001), candidiasis odds ratio 9.0 (95% CI 3.2-25.7, p .000), severe nutritional compromise odds ratio of 4.98 (CI 1.9-12.9, p .001), and surgery during hospitalization odds ratio of 5.8 (CI 2.5 – 13.8) were consistent with Fogerty et al. (2008) that reported OR of 9.18 (95%CI 8.81-9.99) for a malnutrition diagnosis, OR of 3.47 and 8.70 (95%CI 3.33-3.61 and 8.33-9.09) for diagnosis of pneumonia or pnuemonitis, respectively; and an OR 4.63 (95%CI 4.41-4.86) for a diagnosis of mycosis. Fogerty et al. did not list their ICD9 codes for mycosis, but the ICD9 code book lists diagnosis codes of 111.9, 117.9, 112.0, 117.9, 112.1, 111.8, and 111.9, most of which are typically classified as candidiasis. So, for the purpose of this study candidiasis (ICD9 codes 111.8, 112.0, 112.2, 112.84 and 112.89) was used as the mycosis predictor variable, and the odds ratio of 9.0 is twice that of the Fogerty et al. study. Perhaps this is because more true diagnosis of candidiasis were identified by chart review, or perhaps because Fogerty et al. (2008) only used one or two of the related discharge diagnosis codes.

The findings of this study are also consistent with those other studies that suggest that the occurrence of surgery is a significant risk factor for pressure ulcers (Aronovitch, 2007; Uzun & Tan, 2007). There is some evidence that several factors may have a combined effect (evidence

by slight changes in odds ratios for some factors with the addition of other factors in the model). For example, diagnosis of pneumonia/pneumonitis odds ratios fluctuated a bit from OR 6.9 to 8.5 with the addition of other factors.

Other interesting findings of this study include the Braden sub-scores which had demonstrated a stronger inverse relationship to pressure ulcer development in correlational examination than the Braden total score. Activity, mobility, and friction sub-scores of the Braden Scale were strongly associated with pressure ulcers independent of the Braden Total score. The activity sub-score of the Braden demonstrated a stronger association with development of pressure ulcers than the total Braden score (Pearson Correlation -.415, $p<.001$ versus -.334, $p<.001$ for the Braden total score), indicating as activity sub-scores decreased, the risk of pressure ulcers increased. Friction sub-score (Pearson Correlation -.285, $p<.001$), and mobility sub-score (Pearson Correlation -.266, $p<.001$) also demonstrated significant inverse associations with pressure ulcer development but not as strong as the total Braden score or the activity sub-score, and they did not retain their significance in logistic regression models. The LR model that was run with the Braden subscores of activity and friction was the second strongest model at correctly classifying veterans in the sample who did develop pressure ulcers (80% accuracy with PU; 72.3% total sample accuracy; 65.5% accuracy classifying the without PU group). This supports findings in another study by Kottner, Halfens, & Dassen (2009) who suggest the Braden subscale items of moisture, sensory perception and nutrition contain the largest amount of measurement error (p. 1307). This may be due to the ambiguous and vague descriptions and instructions for use of the Braden tool for pressure ulcer risk measurement (see Appendix A), or may indicate the need for further staff instruction on the proper use of the tool.

Recommendations for Practice

Several striking implications are suggested from the analysis of data from this study. Most strikingly, the total Braden Score, while still able to correctly classify 68% of the cases in the study, was only able to correctly classify 65% of those with pressure ulcers. This implies that the Braden score alone may not be the strongest prediction model of pressure ulcer risk. Since other sub-scores of the Braden were not significantly associated with the development of pressure ulcers (sensory perception sub-score, nutrition sub-score, and moisture sub-score) in many analyses, it may suggest that there is a deficit in the appropriate scoring of these factors and a need for further education in the best way to quantify risk in these categories. These sub-scores, if inappropriately scored may reduce the overall predictive ability of the total Braden score. Activity, friction, and mobility sub-scores of the Braden Scale were all significantly associated with pressure ulcer development on Pearson Correlations, but not all of these were able to maintain that significance during logistic regression analysis. The activity sub-score of the Braden Scale was the most strongly associated factor with pressure ulcer development in logistic regression models (OR.348, CI .212-.570, p .000), indicating a 2.9 times greater risk of pressure ulcer development for every point below 4 on the activity scale. In fact, it was the overall strongest predictor of pressure ulcers regardless of other factors in the models. This indicates that nurses who use the Braden Scale may be better able to quickly determine a patient's activity level as scored by the Braden Scale because the scoring mechanism is far more concrete and delineated for Activity (bed bound, chair bound, walks occasionally, walks frequently) than some of the other Braden sub-scores, where scoring directions are more vague. Moisture, for instance may be difficult to note if the patient is 'constantly moist' versus 'very moist' or 'occasionally moist' versus 'rarely moist'. Perspiration, fever, wound exudates, urinary or fecal incontinence may produce varying degrees of skin moisture that may be difficult to fit to one

category. These findings are consistent with Berlowitz et al. (2001) who found mobility (perhaps more a measure of activity as measured by 'activities of daily living' in their study) and urinary incontinence to be somewhat difficult to measure or quantify but both were still strongly associated with the development of pressure ulcers. These findings imply that better, more consistent education is needed for nurses who are conducting pressure ulcer risk assessments (Lyder & Ayello, 2007) and that simpler, more concrete and direct methods of risk assessment would be appropriate, with less chance of variance of interpretation.

The presence of severe nutritional compromise has been implicated as a pressure ulcer risk factor in numerous studies (Banks, Graves, Bauer, & Ash, 2009; Fogerty et al., 2008; Fisher, Wells, & Harrison, 2004). The nutrition sub-score of the Braden Scale was more weakly correlated to the registered dietician's assessment of nutritional compromise (r=.220) than it was to serum albumin (r=.326), indicating that nurses may be relying on inadequate factors to assess nutritional status. Langkamp-Henken, Hudgens, Stechmiller & Herrlinger-Garcia (2005) suggest that mini-nutritional assessment (MNA) and screening scores are far more accurate than other measures of nutritional status commonly used by nurses (such as amount of intake queried using the Braden tool) or laboratory indices (such as serum albumin) alone. In this research study, a registered dietician did a full nutritional assessment (more extensive than the MNA) of 95% of subjects. The north Florida/south Georgia VA has registered dieticians who typically complete a full nutritional assessment within 48 hours of admission. The resulting classification of a patient's nutritional status (no compromise, mild compromise, moderate compromise, and severe compromise) takes into account anthropometric (BMI, etc), biological (serum albumin, total lymphocyte count, etc), clinical, and dietary history data and is readily available for nurses to view in the medical record. This was deemed the best assessment of overall nutritional status and

the classification of severe nutritional compromise was the most strongly associate with pressure ulcer development than any other nutritional factor collected in this study. Since a severe nutritional compromise was strongly associated with pressure ulcer development, it is suggested that MNA or RD nutritional assessments be utilized for determining a more accurate nutritional risk of pressure ulcer development rather than nutrition subscales of the Braden tool.

Recommendations for Future Research

Lyder (2003) reported that over 100 pressure ulcer risk factors have been reported in the literature. This study examined only several of what was determined to be the strongest predictors of pressure ulcers identified in the literature. More research is needed to validate the findings of this study in a larger population (examining medical risk factors of severe malnutrition, pneumonia/pneumonitis, candidiasis, surgery and the development of pressure ulcers). In addition, more research is needed to examine factors that were significantly associated with pressure ulcer risk in this study and consistent with other research studies (such as UTI, history of previous pressure ulcers, sepsis, race, anemia), but were not able to maintain their significance during LR in this study (possibly due to sample size). Similarly, age and smoking status have been identified as pressure ulcer risk factors in the literature but were not found to be significant predictors in this study. Reasons for this need to be explored further but may include a somewhat narrow age range of the veteran population and the large number of smokers in younger persons. More research is also needed in developing a risk assessment tool that is not vague in its components and does not allow room for variance in user interpretation. A dynamic medical risk factor determinant tool or "check off" list where factors are queried with "yes" or "no" only questions may be better suited for timely pressure ulcer risk assessment and re-assessment. In addition, it would be beneficial if the tool described appropriate interventions for each "yes" factor. For example, if the tool queried, "Does the patient experience urinary

incontinence?" and the answer was yes, the tool would direct the use of a barrier cream. This hypothetical tool needs to be dynamic in so far as it needs to be modifiable and reassessed on a regular basis (perhaps every 3 to 5 years) with the top 4 to 5 medical factors present in the literature replacing factors queried in the tool (if necessary). Questions in the tool with yes/no answers should be based on these most significant risk factors identified in the literature. Questions could be simply phrased such as, "Has the person been identified with candidiasis, pneumonia/pneumonitis, or surgery during this admission?" or, "Does a MNA or RD nutritional assessment show severe nutritional compromise?" or, "Is the person able to lift all four extremities off of the bed unaided and hold it up for a count of ten?" or, "Is the person bedbound or chair bound except for transfers?" This tool should be developed and tested for validity and reliability (perhaps a Cowan pressure ulcer risk assessment questionnaire?).

The next logical research step suggested by the results of this study is to perform a larger retrospective review with at least 500 subjects in a different veteran population collecting data on the 4 most significant medical factors as well as those that were not able to sustain statistical significance through all steps of the LR or had too many missing cells (UTI, history of previous pressure ulcer, recent history of weight loss, CVA/paralysis) or had too few subjects in each category (race, sepsis, gangrene, etc). If the final *four factor only* pressure ulcer predictive model (pneumonia/pneumonitis, candidiasis, surgery, severe nutritional compromise) can be validated through other larger studies, it could represent significant clinical improvement in pressure ulcer risk assessment (quicker, more concrete, less room for provider interpretation, increased inter-rater reliability).

Limitations

One crucial discovery during early data collection for this study was that most actual medical diagnoses are not adequately captured in the discharge diagnoses ICD9 list for billing

and recording purposes in the patient's medical record (see Table 4-6). Typically only 4 to 10 discharge diagnoses were recorded on the discharge summary. Often, important diagnoses that were present during the hospitalization were not recorded on discharge summary. This necessitated a revised data collection data tool early in the data collection to capture medical diagnoses by provider notes/specialist assessment, and diagnostic results/radiologist report. The revised data collection tool was resubmitted to the IRB and approved and used for all data collection (see appendix B). This has enormous implications for all data analysis where medical diagnoses are reviewed and obtained from either admission or discharge data or coded databases. There is a very real threat to the validity of findings if the correct diagnoses are not captured and/or under reported. Fogerty et al. (2008) had an enormous sample (six million persons) in their predictive model regarding medical diagnoses and pressure ulcer development. However, they relied solely on ICD9 diagnosis codes listed in the patient's discharge medical record (National Inpatient Sample). If many actual diagnoses that patients experience during acute inpatient hospitalizations are not captured or coded corrected, this poses a significant limitation to the interpretation of their data analysis.

Another potential limitation of this study is the sample size of 213. The statistical power analysis done prior to data collection determined that the sample was adequate to achieve 80% power if the risk factor was present in at least 20% of the population and the odds ratio was at least 3.5. This may have limited the predictive ability of the factors in the model that potentially had an odds ratio of less than 3.5. A larger sample could potentially demonstrate more factors in this study that would significantly add to the predictive model. In addition, the missing data in so many subjects with regard to history of previous pressure ulcer and history of recent weight loss

eliminated them from the analysis, and they may be important factors to consider in future studies.

Conclusions

In conclusion, this study does demonstrate support for the idea suggested by Fogerty et al. (2008) that medical factors such as surgery and malnutrition, and diagnoses such as pneumonia/pneumonitis and candidiasis present in the patient during hospitalization can enhance (if not surpass) the Braden Scale in a pressure ulcer predictive model (see Table 4-8). Findings from this study suggest that identifying patients with severe nutritional compromise, the presence of pneumonia/pneumonitis and/or candidiasis, and the event of surgery during hospitalization may be better able to identify veterans at high risk of pressure ulcers than current Braden risk assessment scores alone. In all LR models run with the Braden scale and the addition of other significant factors within this study, the predictive accuracy of the Braden scale was improved (improved 4 to 7 % for total model accuracy, improved up to 13% for accuracy in predicting the NO PU group, and improved accuracy up to 18% in predicting PU in the YES PU group) with the addition of other medical factors such as diagnosis of pneumonia/pneumonitis. More research is needed to validate these finding and to explore relevancy of current risk assessment techniques as well as provide direction for interventional studies (for example: which are the most effective pressure ulcer prevention interventions?), with an ultimate goal of reducing incidence of pressure ulcers.

APPENDIX A
BRADEN SCALE FOR PREDICTING PRESSURE SORE RISK

BRADEN SCALE FOR PREDICTING PRESSURE SORE RISK

Patient's Name _____ Evaluator's Name_____ Date of Assessment

SENSORY PERCEPTION ability to respond meaningfully to pressure-related discomfort	**1. Completely Limited** Unresponsive (does not moan, flinch, or grasp) to painful stimuli, due to diminished level of con-sciousness or sedation. OR limited ability to feel pain over most of body	**2. Very Limited** Responds only to painful stimuli. Cannot communicate discomfort except by moaning or restlessness OR has a sensory impairment which limits the ability to feel pain or discomfort over ½ of body.	**3. Slightly Limited** Responds to verbal commands, but cannot always communicate discomfort or the need to be turned. OR has some sensory impairment which limits ability to feel pain or discomfort in 1 or 2 extremities.	**4. No Impairment** Responds to verbal commands. Has no sensory deficit which would limit ability to feel or voice pain or discomfort..				
MOISTURE degree to which skin is exposed to moisture	**1. Constantly Moist** Skin is kept moist almost constantly by perspiration, urine, etc. Dampness is detected every time patient is moved or turned.	**2. Very Moist** Skin is often, but not always moist. Linen must be changed at least once a shift.	**3. Occasionally Moist:** Skin is occasionally moist, requiring an extra linen change approximately once a day.	**4. Rarely Moist** Skin is usually dry, linen only requires changing at routine intervals.				
ACTIVITY degree of physical activity	**1. Bedfast** Confined to bed.	**2. Chairfast** Ability to walk severely limited or non-existent. Cannot bear own weight and/or must be assisted into chair or wheelchair.	**3. Walks Occasionally** Walks occasionally during day, but for very short distances, with or without assistance. Spends majority of each shift in bed or chair	**4. Walks Frequently** Walks outside room at least twice a day and inside room at least once every two hours during waking hours				
MOBILITY ability to change and control body position	**1. Completely Immobile** Does not make even slight changes in body or extremity position without assistance	**2. Very Limited** Makes occasional slight changes in body or extremity position but unable to make frequent or significant changes independently.	**3. Slightly Limited** Makes frequent though slight changes in body or extremity position independently.	**4. No Limitation** Makes major and frequent changes in position without assistance.				
NUTRITION usual food intake pattern	**1. Very Poor** Never eats a complete meal. Rarely eats more than ⅓ of any food offered. Eats 2 servings or less of protein (meat or dairy products) per day. Takes fluids poorly. Does not take a liquid dietary supplement OR is NPO and/or maintained on clear liquids or IV's for more than 5 days.	**2. Probably Inadequate** Rarely eats a complete meal and generally eats only about ½ of any food offered. Protein intake includes only 3 servings of meat or dairy products per day. Occasionally will take a dietary supplement. OR receives less than optimum amount of liquid diet or tube feeding	**3. Adequate** Eats over half of most meals. Eats a total of 4 servings of protein (meat, dairy products per day. Occasionally will refuse a meal, but will usually take a supplement when offered OR is on a tube feeding or TPN regimen which probably meets most of nutritional needs	**4. Excellent** Eats most of every meal. Never refuses a meal. Usually eats a total of 4 or more servings of meat and dairy products. Occasionally eats between meals. Does not require supplementation.				
FRICTION & SHEAR	**1. Problem** Requires moderate to maximum assistance in moving. Complete lifting without sliding against sheets is impossible. Frequently slides down in bed or chair, requiring frequent repositioning with maximum assistance. Spasticity, contractures or agitation leads to almost constant friction	**2. Potential Problem** Moves feebly or requires minimum assistance. During a move skin probably slides to some extent against sheets, chair, restraints or other devices. Maintains relatively good position in chair or bed most of the time but occasionally slides down.	**3. No Apparent Problem** Moves in bed and in chair independently and has sufficient muscle strength to lift up completely during move. Maintains good position in bed or chair.					
				Total Score				

APPENDIX B
COWAN DATA COLLECTION TOOL

Please DO NOT include any private information on the patient, such as name or identification number.

Age in years_____(all ages over 85 will just be recorded as "85 or older").

Developed Pressure ulcer during admission? (circle one) : DID / or DID NOT

Worst Stage: Stage I Stage II Stage III Stage IV DTI Unstageable

Location: sacrum-coccyx / heel / buttocks / hip / ischium / other

Gender (circle) Male / Female / not listed Ethnicity (circle) African American / Caucasian / Other

Total Lowest Braden Score during admission (prior to pressure ulcers): _____

Subscale scores: Sensory 1 / 2 / 3 / 4	Moisture: 1 / 2 / 3 / 4	Wound Consult done? Y / N
Activity: 1 / 2 / 3 / 4	Mobility: 1 / 2 / 3 / 4	Specialty mattress ordered? Y/N
Nutrition: 1 / 2 / 3 / 4	Friction: 1 / 2 / 3	Nutrition supplem ordered? Y/N

Length of inpatient admission in days: _____ Length of ICU stay in days: _____

Have surgery during current admission? Y / N Time in operating room in hours: _____

Smoking (circle one) Not Current Smoker / Currently Smokes / Not listed

Presence of following diagnosis codes during admission or at discharge?

Gangrene (785.4): YES / NO / APL (active problem list) / PN (provider notes) / LB (labs/radiology)

Anemia (280.0 and related codes) YES / NO / APL / PN / LB

Actual lowest Hgb during admission _____ Actual lowest HCT during admission _____

Diabetes mellitus w/ complications (250.1-250.9) YES / NO / APL / PN / LB

Malnutrition (260, 261, 262, 263.0-263.9, 995.85); YES / NO / APL / PN / LB BMI: <19 /19-28/ >28

Lowest albumin _____ Lowest Pre-albumin _____

Nutrition Consult: Y / N Compromised?: None / Mild / Mod / Severe

Osteomyelitis (730.0-730.9); YES / NO / APL / PN / LB

Pneumonia/pneumonitis (112.4, 480.0, 486, and related codes); YES / NO / APL / PN / LB

Septicemia (038.1, 998.59 and related codes); YES / NO / APL / PN / LB

Candidiasis (111.8, 112.2 and related codes) YES / NO / APL / PN / LB

Bacterial Bacterial skin infection (686.9, 998.51 and related codes); YES / NO / APL / PN / LB

Complication of device or implant/graft (996.0-996.89, 429.4-429.9); YES / NO / APL / PN / LB

Urinary tract infection (098.0, 098.2, 131.00, 559.0, 597.80); YES / NO / APL / PN / LB

Paralysis (045.0, 300.11, 332.0 and related codes); YES / NO / APL / PN / LB

Senility (259.8, 290.10 and related codes); YES / NO / APL / PN / LB

Respiratory failure (348.8, 518.81-581.84), YES / NO / APL / PN / LB

Acute renal failure (403.91, 404.02 and related codes), YES / NO / APL / PN / LB

Cerebrovascular accident (437.8), YES / NO / APL / PN / LB

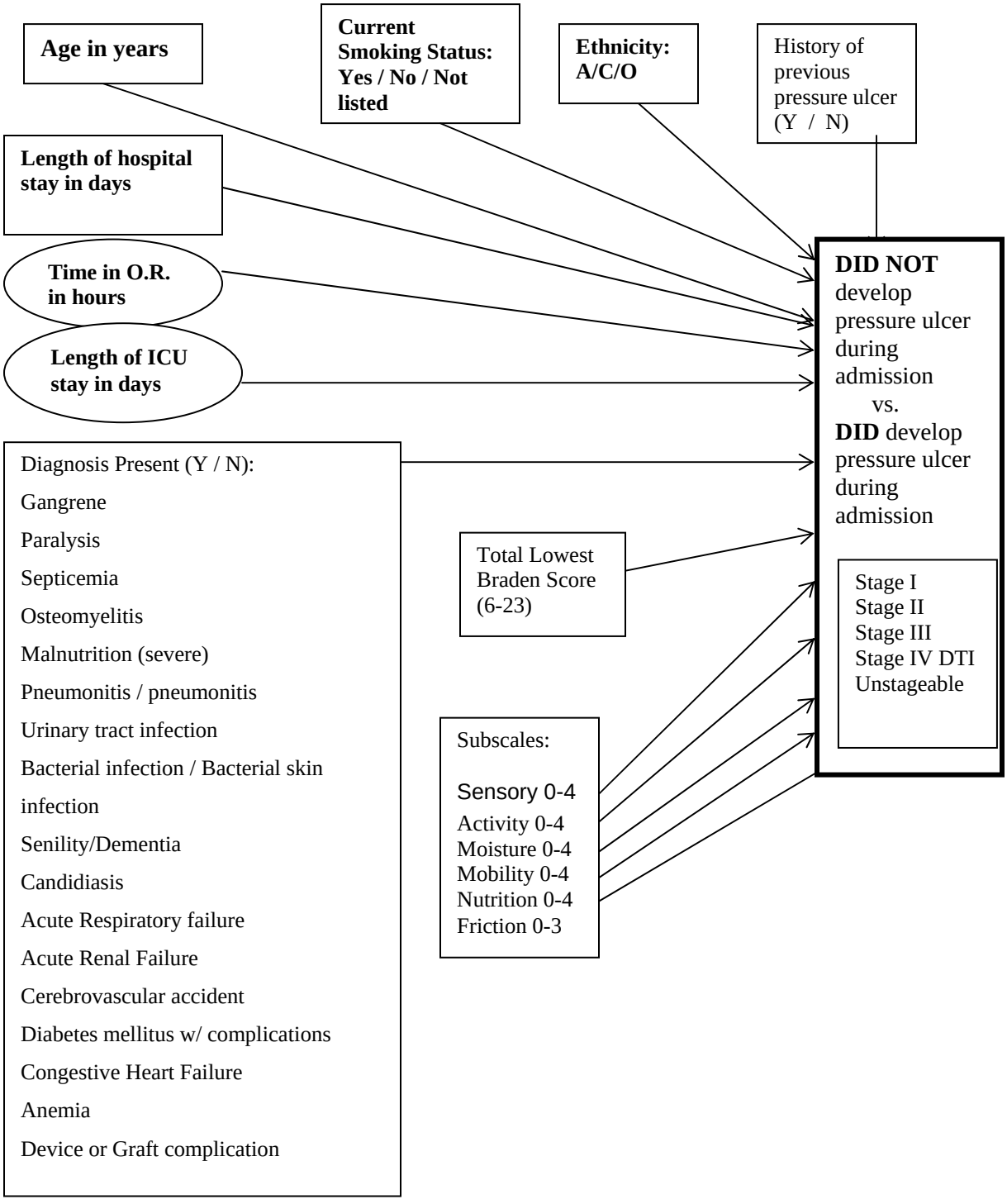
Congestive heart failure (428.0, 428.1, 428.9) YES / NO / APL / PN / LB

History of previous pressure ulcer – prior to current admission (707.0—707.9) YES / NO / Unknown

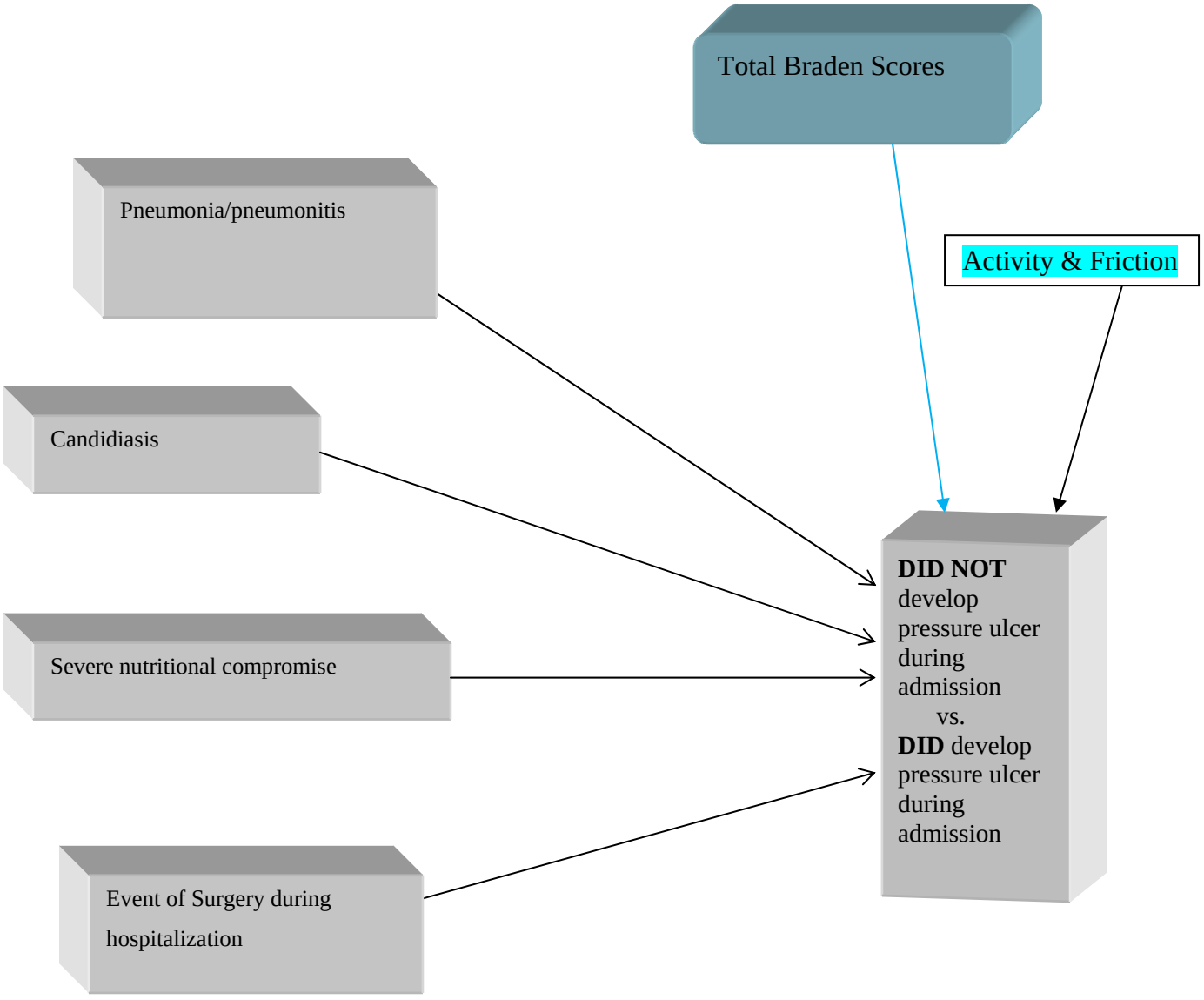
Actual diagnosis codes listed at discharge: _____

APPENDIX C

PRESSURE ULCERS IN ACUTELY ILL VETERANS – A PRELIMINARY MODEL



APPENDIX D
PRESSURE ULCERS IN ACUTELY ILL VETERANS – A FINAL MODEL



APPENDIX E
DIFFERENCES IN CAPTURING DIAGNOSES

Diagnosis	ICD9 Codes	Number of subjects with this ICD9 code listed at discharge	Number of subjects with diagnosis evident during hospitalization from chart review (including ICD9 codes, labs, active problem list, and provider notes)
Acute Renal Failure	584.9, 586.0 403.91, 404.02	No PU: 28 Yes PU: 30	No PU: 35 Yes PU: 38
Acute Resp. Failure	518.81	No PU: 7 Yes PU: 20	No PU: 8 Yes PU: 23
Anemia	280.0, 280.9, 285.21, 285.22, 285.29, 285.9	No PU: 28 Yes PU: 20	No PU: 102 Yes PU: 96
CHF	428.0, 428.1, 428.9	No PU: 22 Yes PU: 19	No PU: 28 Yes PU: 27
CVA	437.8, 438.20, 438.89	No PU: 1 Yes PU: 2	No PU: 6 Yes PU: 21
Device/Graft complications	E878, 996.0-996.89, 999.31, 429.4-429.9	No PU: 14 Yes PU: 14	No PU: 16 Yes PU: 18
DM with complications	250.00, 250.01, 250.13, 250.30-250.80	No PU: 14 Yes PU: 8	No PU: 50 Yes PU: 41
Gangrene	785.4	No PU: 3 Yes PU: 0	No PU: 4 Yes PU: 3
Malnutrition (Severe)	262, 273.8, 269.9, 262, 263.9	No PU: 2 Yes PU: 2	No PU: 8 Yes PU: 31
Candidiasis	031.9, 111.8, 112.0, 112.2, 112.84, 112.89	No PU: 4 Yes PU: 9	No PU: 6 Yes PU: 32
Osteomyelitis	730.0-730-9, 730.17, 730.27	No PU: 3 Yes PU: 3	No PU: 3 Yes PU: 4
Paralysis	332.0, 344.01, 344.1, 342.91, 342.90, 358.00	No PU: 2 Yes PU: 5	No PU: 4 Yes PU: 12
Pneumonia or Pneumonitis	480.0, 481, 482.0, 482.9, 486	No PU: 7 Yes PU: 32	No PU: 10 Yes PU: 40
Senility or Dementia	290.40, 294.10, 331.0, 331.82, 780.09, 780.97	No PU: 9 Yes PU: 11	No PU: 13 Yes PU: 22
Sepsis	038.10, 038.42, 038.9, 785.52, 995.91, 995.92	No PU: 11 Yes PU: 12	No PU: 15 Yes PU: 25
Bacterial skin infection	681.00, 681.1, 682, 682.2-682.7, 686.9, 998.51	No PU: 11 Yes PU: 10	No PU: 13 Yes PU: 14
UTI	559.0, 597.80, 098.0, 098.2, 112.2	No PU: 25 Yes PU: 37	No PU: 33 Yes PU: 58

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BIOGRAPHICAL SKETCH

Linda Cowan was born in Florida. Except for a few years living in Malaysia as a child with her parents, she spent a great deal of her life in Miami, Florida. She attended Jackson Memorial Hospital School of Nursing as well as Miami-Dade Community College in the late 1970s and early 1980s. She was employed as a registered nurse for over 20 years before going back to graduate school in 2001. Linda completed her Masters degree in Nursing in 2004 and began the doctoral program at the University of Florida in 2005. She majored in Nursing Sciences with a minor in Epidemiology, and she completed a Public Health Certificate in April, 2008 through the graduate program at the UF College of Public Health & Health Professions. She is currently employed full time at the North Florida/South Georgia Veterans Health Administration (VA) as a Wound and Ostomy Consultant and Certified Wound Specialist (CWS). She is also licensed by the state of Florida as an Advanced Registered Nurse Practitioner with a board certification in family practice. She currently resides in the North Florida area with her husband and children (the youngest of which also attends college). She is a member of the Southern Nursing Research Society (SNRS), the American Public Health Association (APHA), Sigma Theta Tau, Gerontological Society of America (GSA), the Wound, Ostomy and Continence Nurses Society (WOCN), and the Wound Healing Society (WHS), where she serves on the Education Committee. She has participated in several research studies involving wound care over the past 7 years. She graduates from the University of Florida with her Doctor of Philosophy in Nursing in May, 2010. Her career goals include continuing research, teaching, scientific publication, and assisting to establish a wound and ostomy professional multidisciplinary training center at the VA.