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FACTORS ASSOCIATED WITH PRESSURE ULCERS IN ADULTS IN ACUTE CARE HOSPITALS

by
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To be submitted in partial fulfilment
of the requirements for the degree of
Master of Science

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August 1999

Abstract

Study Aim and Objectives:

The aim of this analysis is to identify and describe the relationship of factors associated with pressure ulcers, Stage 2 or greater, in adults in acute care hospitals. The objectives are:

(1) to develop a model to describe the association of demographic and clinical factors in the presence of pressure ulcers using three years of prevalence data (1993, 1994 & 1995); and (2) to validate the model using an independent sample, namely the 1996 prevalence study.

Design:

Cross-sectional, prevalence studies

Subjects:

All adult inpatients in an acute care, university teaching hospital during one 12 hour day time period. Data were collected mid-week to reflect new admissions, and pre and post-operative cases, and in mid-September to avoid summer and winter seasonal variations.

Main Outcome Measure:

Stage 2 or greater pressure ulcers according to the Agency for Health Care Policy and Research Clinical Practice Guidelines, Pressure Ulcers in Adults: Prediction and Prevention (1992) recommendations for staging ulcers.

Data Collection Instruments:

Demographic and Clinical Profile Form, Prevalence Grid, and Braden Scale (1987).

Sample Size:

The derivation sample, 1993-95 prevalence studies, included 1,992 subjects and the validation sample, 1996 prevalence study, included 581 subjects.

Data Analysis:

Logistic regression analysis was used to derive a model that fits the data and performed well at identifying factors associated with pressure ulcers. The presence of confounders by age, gender and length of stay of each other, and of the Braden subscales was tested using the Mantel-Haenszel adjusted odds ratio. Significant two way interactions were identified by entering the entire collection of interaction terms into the model and conducting a backward, stepwise elimination procedure. Performance of the model, in terms of calibration, was statistically evaluated using the Hosmer-Lemeshow goodness of fit test statistic. The effectiveness of the model, in terms of discrimination, was assessed by considering the cut off values using two by two classification tables to measure the overall percentage of subjects correctly classified in the validation sample.

Main Results:

Ulcer prevalence varied slightly from year to year, 14.7% in 1993, 10.4% in 1994, 11.7% in 1995, and 12.2% in 1996. Univariate testing revealed that age, gender, length of stay and all six subscales of the Braden were significantly associated with pressure ulcers ($p < .01$). Factors associated with pressure ulcers using backward, stepwise logistic regressions were age, male gender,

sensory perception, moisture, mobility, nutrition, and friction/shear, as well as interactions of age and sensory perception, nutrition and gender/male, and moisture and sensory perception. This is the first study to report age as a confounding variable with moisture and length of stay, and only the second study to report statistically significant interactions. The Hosmer-Lemeshow goodness of fit test for the derivation sample, .76, and the validation sample, .79 indicated that the model was well calibrated and a good fit. The model performed well as the overall percentage of subjects correctly classified using the validation sample was 88%.

Conclusions:

Logistic regression modeling indicated that age, male gender, sensory perception, moisture, mobility, nutrition, and friction and shearing forces were associated with pressure ulcers in hospitalized adult patients. Three interactions, two negatively associated, age and sensory perception, and moisture and sensory perception, and one positively associated, nutrition and gender/male were also found to be associated with ulcers. These seven factors provide a profile of the characteristics of the population in hospitals with ulcers. As expected, patients were more likely to have pressure ulcers as they grew older when sensory perception was not a deficit. Younger subjects with ulcers were found to have more sensory perception impairments compared to older subjects with ulcers. The odds of having a pressure ulcer increased 2.6 times for male subjects with nutritional deficits compared to male subjects without

nutritional deficits. The odds of having a pressure ulcer largely increased, 34 times, for those subjects with sensory perception deficits when moisture was not a problem. The odds of having a pressure ulcer were almost double for those subjects with moisture problems compared to subjects who did not experience any moisture problems when sensory perception was not a problem. There was no significant relationship between mobility and pressure ulcers. The odds of having a pressure ulcer were more than double for male subjects with inadequate to poor nutritional status compared to female subjects. The odds of having a pressure ulcer increased by 3 times for subjects with deficits related to friction and shearing. This study adds new information to the relationship of factors associated with pressure ulcers in adults in acute care populations and to the use and relative importance of particular Braden subscales. Knowledge of these factors may help to plan hospital wide prevention programs and promote quality improvement measures in skin care.

ACKNOWLEDGEMENTS

I would like to acknowledge the nurse surveyors, team leaders, enterostomal therapists, nurse educators, Coordinator, Nursing Quality Improvement and Research Nurse Specialist, whose efforts and dedication largely contributed to the success of this research project. The tremendous commitment of the nursing leaders, Wendy Nicklin and Dr. Jo Logan, and all of the nursing directors was critical in promoting a high level of awareness and to improving patient care practices. A special thanks to Marlene Mackey, Coordinator, Nursing Quality Improvement at the OHCC for help in proof reading and retrieving journal articles.

I would also to thank my examiners, Terry Klassen, Robert Spasoff, Yue Chen, for all their comments, which helped me to improve the quality of my work. I am most appreciative of the assistance and support I have received from my thesis committee, Dr. Margaret Harrison and Dr. George Wells, Chairperson. It is always a pleasure to work with such highly dedicated professionals, who continually strive to improve clinical practice through the conduct of research.

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GLOSSARY OF ACRONYMS

AHCPR	Agency For Health Care Policy And Research
CI	Confidence Interval
df	Degrees of Freedom
DUPA	Decubitus Ulcer Potential Analyzer
HWF	Hierarchically Well Formulated
MH	Mantel-Haenszel
NPUAP	National Pressure Ulcer Advisory Panel
OHCC	Ottawa Hospital Civic Campus
OR	Odds Ratio
SD	Standard Deviation

1.0 Introduction

This thesis will contribute to the knowledge about factors associated with pressure ulcers in adults during hospitalization. A secondary analysis of a comprehensive four year data set from one large Ontario university affiliated tertiary care hospital will be analysed.[1] Available clinical practice guidelines assist in the clinical care with regard to prevention, prediction and management of the pressure ulcers.[2,3] However, the majority of guideline recommendations were supported by level C evidence, meaning they were not research based, but drawn from expert opinion and panel consensus. In particular, knowledge about specific populations and their characteristics is lacking. The adult acute care population is an important and growing group of those suffering from pressure ulcers. Recent large scale epidemiological studies have documented the extent of the problem.[4,5,6] The degree of the problem is increasing particularly in acute care settings which comprise acutely ill elderly patients and survivors of serious trauma.[7]

The aim of this thesis is to identify and describe the interactive and multivariate relationship of factors associated with pressure ulcers. These factors can be used to provide a profile to describe characteristics of adult hospitalized patients with ulcers. This information could then be used at the time of admission to monitor high risk populations and institute risk reduction and quality improvement measures. A summary of published studies on the incidence and prevalence of pressure ulcers will be presented. A critical

appraisal of factors predicting and associated with pressure ulcers will follow. The study methods, results and implications for practice and policy will be presented.

1.1 Prevalence and Cumulative Incidence Studies

The National Pressure Ulcer Advisory Panel (NPUAP)[7] defined prevalence as "the new and old cases of pressure ulcers assessed on a cross-sectional, one-time basis". Pressure ulcer prevalence quantifies the proportion of individuals in a population who have ulcers at a specific time. In 1989, it was estimated that prevalence ranged between 3% and 14% among hospitalized patients. A prevalence of 10.1% was reported by Barczak and colleagues[4] in a 1995 National Pressure Ulcer Study that included 265 acute care hospitals (n=39,874). In a 1994 national survey of 177 hospitals (n=31,530), Meehan[5] reported a prevalence of 11.1%. This proportion is slightly higher than the 9.2% prevalence Meehan[6] reported in a 1990 study of 148 hospitals (n=34,987). Three Canadian studies reported prevalence of 23.9%, 25.7%, and 29.7%.[8,9,10] Pressure ulcer prevalence indicates that ulcers continue to be a serious complication of hospitalized patients.

Cumulative incidence refers to the percentage of persons at risk who have newly developed ulcers after a certain period of follow-up.[11] Estimates of the cumulative incidence of ulcers among hospitalized patients vary widely

depending on the study design, setting and methods of data collection. Gerson[12] reported a cumulative incidence of 2.69% in a study of three acute care hospitals (n=5,648) over a period of four months. In a study of 1,320 hospitalized patients, Gosnell[13] found that 8.4% who were ulcer free upon admission developed an ulcer. Salvadalena[14] reported that 20% of patients admitted to an acute medical service developed ulcers. Appendix A includes a summary of prevalence and cumulative incidence studies reported in acute care hospital from 1970 to June, 1998 and Appendix B lists the references.

Cumulative incidence studies report risk factors that are significantly related to the development of pressure ulcers and predict occurrence.[11] Risk factors represent specific characteristics that predispose an individual to the development of pressure ulcers. Studies of ulcer prevalence report factors, demographic and clinical, that are significantly associated with ulcers. The identification of factors associated with ulcers helps to create a profile of the characteristics of ulcer patients in hospitals. These factors many include demographic characteristics, such as age, race and gender, and clinical characteristics such as moisture, immobility and nutrition.

1.2 Management of Pressure Ulcers

1.2.1 Clinical Practice Guidelines.

Concern with the problem has also translated into substantial investments of resources in both acute and long term care settings. Efforts have been made to improve the use of available evidence to ameliorate the problem. The

National Institutes of Health in the United States has developed clinical practice guidelines for the prediction, prevention, and management of pressure ulcers.[2,3] These guidelines reflect the current state of knowledge regarding the effectiveness and appropriateness of care. Recommendations based on published scientific literature, expert knowledge and panel consensus assist practitioners in the identification of adults at risk of pressure ulcers, the planning of early interventions for prevention, and the management of pressure ulcers. Recommendations include the following four goals: (1) identifying at-risk individuals who need preventive intervention and the specific factors placing them at risk; (2) maintaining and improving tissue tolerance to pressure 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.[2]

1.2.2 Braden Scale.

For individuals at risk of pressure ulcer formation, a systematic assessment using a validated risk assessment tool is recommended.[2] To prevent pressure ulcers, individuals at risk must be identified in order to plan appropriate prevention interventions. Risk assessment tools help to ensure a systematic evaluation of individual risk factors using a quantitative measure.

A number of risk assessment tools exist, only the Braden and Norton Scales have been adequately tested and are recommended in the Agency for Health Care Policy and Research (AHCPR) Clinical Practice Guidelines.[2] Of the

two tools, the Braden Scale has been more widely used to examine factors associated with pressure ulcers. The Braden Scale, Appendix C, was first tested in hospital populations and intensive care units.[15,16] Reliability studies indicate that the Braden Scale is highly reliable, especially when used by registered nurses, r=.99.[16]

The Braden Scale is derived from a conceptualization of etiological factors in pressure ulcer formation.[17] The conceptual schema identifies two major factors as responsible for pressure ulcer development: the amount and duration of pressure, and the tolerance of the tissue for pressure. The scale is made up of six subscales: mobility, activity, sensory perception, moisture, nutrition, and friction/shear. Five of the subscales are scored from 1 (least favourable) to 4(most favourable); while the friction/shear subscale is scored from 1 to 3. The lower the total score, the greater the risk of pressure ulcer development. Each level of the subscale is designed to be mutually exclusive with only one choice for each subject.

The predictive ability of the Braden has been examined by several researchers, results are inconclusive and vary depending on the cut off scores (15-19) and population studied. Earlier studies conducted by Bergstrom, Braden and colleagues[16,18] recommended a cut off score of 16 (sensitivity ranged from 83-100%, and specificity ranged from 64-90%). Several researchers have reported sensitivities (ranging from 60-69%) and specificities (ranging from 54-66%) using a cut off score of 19 in acute care populations. [10,14,19] Cut off scores

of 15 (sensitivity, 55% and specificity, 94%)[20] and 17 (sensitivity, 59% and specificity, 59%)[21] have also been reported in acute care populations. These findings are less favourable and suggest that the total Braden Scale score is not as predictive of pressure ulcer development as previously reported.[16,18] Although the Braden Scale provides a good empirical foundation, it is still evolving, more research is needed to accurately identify characteristics of acute care populations with pressure ulcers.

1.2.3 Outcome Measurement.

The use of different types of staging systems to classify pressure ulcers is a methodological barrier that prevents generalization of the data.[2] To address this problem, AHCPR[2] published recommendations for staging pressure ulcers (Appendix D), which are consistent with the recommendations of the NPUAP[7] as derived from previous staging systems proposed by Shea.[22] In using the staging system the following two limitations are cited in the guidelines: (1) identification of Stage 1 pressure ulcers may be difficult in patients with darkly pigmented skin; and (2) when eschar is present, accurate staging of the pressure ulcer is not possible until the eschar has sloughed or the wound has been debrided. In the presence of eschar, several authors have used a fifth stage, Stage X, to improve the reliability of data collection.[10,23,24] In this study the AHCPR recommendations for staging ulcers will be used, and Stage X will be included.

Difficulties in diagnosing Stage 1 pressure ulcers, nonblanchable

erythema of intact skin, in people with darkly pigmented skin has been recognized for some time. In response to this concern, the NPUAP[25] recently appointed a task force to review the definition of Stage 1 pressure ulcers.

Additional problems arise in the interpretation of study findings with the inclusion or exclusion of pressure ulcers classified as Stage 1. This helps to explain why prevalence in Canadian studies[8,9,10], which have included Stage 1, appear higher than reported in other studies.[7] Some researchers have concluded that the lack of clearly defined criteria for the identification of Stage 1 ulcers may contribute to variance between studies.[14] Difficulties in accurately capturing data on Stage 1 have also been noted.[10] This methodological limitation helps to further explain why study findings vary and results are often conflicting.[26]

One approach to address the problem described above is to define the more serious ulcers as Stage 2 or greater.[10, 26-32] Researchers recognizing the problems associated with reporting Stage 1 ulcers have coded the presence of a pressure ulcer, Stage 2 or greater as 1; and Stage 1 ulcers and the absence of ulcers as 0. In this study the coding system described above will be used.

1.3 Studies Reporting Factors Associated with Pressure Ulcers

A literature review was conducted using Medline and CINAHL on research studies of factors, risk related to pressure ulcers between 1970 and June 1998. Factors simply associated with pressure ulcers, as well as factors considered placing the patient at risk will be considered. Key words in the

search strategy included decubitus ulcers, research, risk factors and causes. Appendix E includes a brief description of each study along with methodological considerations for the proposed study and Appendix F lists the references. A second review was conducted to obtain pressure ulcer prevalence and incidence studies in adults in acute care hospitals. Key words in the search strategy included decubitus ulcers, research, prevalence and incidence. Studies were chronologically organized, and the staging systems are described in Appendix A. Reported studies in both reviews were also obtained by hand searching relevant journals and reviewing the reference list of other authors. Journal articles were restricted to the English language.

In reviewing the literature on clinical assessment and management of pressure ulcers the following factors were found to be frequently cited: age, mobility, nutrition, moisture and Braden Scale Score. Although the results are conflicting, the effect of gender has been studied and will also be included. A critical appraisal of each of these factors will be presented in the next section followed by an appraisal of studies reporting groupings of factors using models.

1.3.1 Age.

Advanced age is recognized in the literature as a factor associated with pressure ulcers. In a recent Canadian study, the percentage of patients in acute and long term care settings with pressure ulcers increased with age from 25% for patients 60 to 69 years of age, to 45% for patients over the age of 85.[9] Both prospective and retrospective studies in acute and long term care settings have

demonstrated a relationship between increasing age and pressure ulcers.[33-39]

Although most studies demonstrate that advanced age is associated with pressure ulcers, three authors have questioned and found that age was not a significant factor. In a longitudinal study of risk factors in nursing homes, Brandeis and colleagues[29] found that age was not a predictor of ulcer development. Jiricka and colleagues[40] compared subjects with ulcers to ulcer free subjects and found that age was not a significant factor among intensive care patients. Age was not found to be a predictive factor in ulcer development in subjects admitted electively for cardiovascular or neurosurgical operations.[41] In another study, age of 75 years or more was found to be not significant when using multivariable Cox regression. Other variables in the model were nonblanchable erythema, lymphopenia, immobility, dry skin, and decreased body weight.[28]

Studies are needed to investigate the interaction of age with other clinical factors, as well as to test for the confounding effects of age with other factors.

1.3.2 Gender.

Recent evidence suggests that being male may be a significant risk factor associated with pressure ulcers.[29,42,43,44] In a longitudinal study, Brandeis and colleagues[29] found male gender to be a significant risk factor in nursing homes and marginally significant ($p < .06$) in high incidence homes. Using logistic regression, Spector and colleagues[43] found that being male was associated

with the presence of pressure ulcers on admission to nursing homes. Only one study conducted in an acute care setting has reported male gender as a significant factor.[44] More studies are needed to explore the interactive and multivariate relationship of gender with other clinical factors associated with pressure ulcers.

1.3.3 Mobility.

Many researchers have demonstrated that impaired mobility is associated with pressure ulcers. Mobility was one of the 11 predictors of pressure ulcer development in a retrospective chart review of a large scale study involving long term care facilities.[27] Berlowitz and Wilking[45] identified bed or chair bound as both a factor associated with the presence of pressure ulcers using a cross-sectional study, and a factor significantly associated with the development of new ulcers using a cohort analysis.

In a prospective cohort study, Allman and colleagues[28] reported that immobility was an independent and significant risk factor for pressure ulcers in hospitalized patients whose activity is limited to bed or chair. In another study conducted in an acute care setting, Maklebust and Magnun[23] reported that impaired mobility was associated with having a pressure ulcer. Several researchers have reported that impaired mobility is also associated with pressure ulcers in high risk populations such as spinal cord injured patients.[46,47] Studies are needed to investigate the relationship and interactions of mobility with other factors.

1.3.4 Nutrition.

In a comprehensive review of the literature from 1985 to 1994, Finucane[48] concluded that the relationship between malnutrition and pressure ulcers is incomplete and contradictory. In an earlier review of the research literature from 1943 to 1989, Breslow[49] concluded that the nutritional status of patients with pressure ulcers is poor.

Nutrition has been identified as an important factor associated with pressure ulcers in long term care patients.[29,49,50] This relationship was not supported in a study of cardiovascular and neurosurgical populations.[51]

In a prospective cohort study, Bergstrom and Braden[34] found dietary protein to be one of the six best predictors of pressure ulcer development. In a secondary analysis of a prospective study of nutritional status, Waltman and colleagues[52] reported that patients with cancer appear to be at greater risk of pressure ulcers, and the incidence was related to a compromised nutritional status. To date, the impressive studies by Bergstrom, Braden, Waltman and colleagues[34,52] provide the most detailed measures of nutritional assessment (i.e. laboratory tests, anthropometric measurements, observation of dietary intake, and Braden Scale scores).

Most reported studies use retrospective data. Since retrospective chart reviews are not likely to have adequate and timely measures of dietary intake, more studies are needed using valid and reliable quantitative measures to accurately assess nutritional status. Studies are also needed to investigate the

relationship of nutrition with other factors.

1.3.5 Moisture.

Problems with moisture, particularly fecal and urinary incontinence, have been frequently cited as a significant factor.[23,29,40,42,43] In a prospective study of intensive care patients, Jiricka and colleagues[40] identified moisture as a significant predictor of skin breakdown.

One study reported both fecal and urinary incontinence as significant factors associated with pressure ulcers.[29] Brandeis and colleagues[29] followed a large cohort of elderly nursing home residents to examine the correlates of pressure ulcer development. Logistic regression and discriminant function analyses revealed bladder incontinence and fecal incontinence as independent correlates ($p < .05$). Using multivariate analysis data from 50 nursing homes, Spector and colleagues[43] reported that the presence of a urinary catheter increased the likelihood of pressure ulcer development by nearly two times, and fecal incontinence increased the likelihood by 23%.

Using logistic regression analysis, Allman and colleagues[53] reported that the odds of having a pressure ulcer increased three times in the presences of fecal incontinence. The researchers concluded that the exposure of skin to the bacteria and toxins in stool, along with the maceration associated with fecal incontinence, may contribute to the pathogenesis of pressure ulcers.

These studies would suggest that moisture from incontinence is associated with pressure ulcers. However, most studies have not used

standardized, quantitative tools to measure incontinence. More studies, addressing this limitation, are needed to explore the relationship of moisture, in terms of urinary and fecal incontinence, with other clinical factors

1.3.6 Braden Scale Score.

Several researchers have investigated Braden Scale scores as a factor associated with pressure ulcers. Braden Scale scores were identified as predictors of pressure ulcer development in three studies using logistic regression models.[33,34,54]

Evaluation of Braden Scale has resulted in a range of potential total scores with no consensus regarding the best total score to determine the risk of developing a pressure ulcer.[10,14,16,18-21,55] As well other variables such as age, are not included in the tool and thus are not factored into the risk assessment.

The Braden Scale provides a very valuable means to assessing the various factors in the individual subscales and planning a comprehensive analysis for acute care populations. The scores in the individual subscales (sensory perception, moisture, activity, mobility, nutrition, and friction/shear) are important to help further understand the problem.[10] Future studies are needed using the subscale scores to closely examine the contribution and interaction of each category or combination of categories.

1.4 Studies Reporting Groupings of Factors Using Models

1.4.1 Acute Care Settings

Seven studies have used multivariate analysis and developed models to report factors associated with pressure ulcers in acute care settings (i.e. hospitals, critical care, rehabilitation, and surgery). Interaction effects between variables were rarely incorporated into the model fitting procedure and no studies reported strategies to test for the presence of confounding variables. A brief discussion of the studies is presented below.

In two similar, prospective cohort studies Tourtual and colleagues[56] investigated predictors of hospital acquired heel pressure ulcers. Using rigorous research methods, subjects were enrolled by one team and followed by another team that was blind to the initial assessment information. The first study (n=209) was performed to examine factors contributing to heel pressure ulcer development and the second study (n=291) , conducted in a similar manner, was performed to clarify and validate the statistically significant variables from the first study. Using logistic regression, subjects with a potential problem in the friction/shear subscale (p=0.01) and who were more frequently moist on the moisture subscale (p=0.007) were more likely to develop heel ulcers. Beta coefficient, odd ratios and confidence intervals were not reported. Using a cut off point of 12 on the Braden scale, sensitivity was 14% and specificity was 94%. Using a cut off point of 16 increased the sensitivity to 49%, but decreased the specificity to 76%. No attempt to evaluate interaction effects was reported.

In a cohort study of 843 randomly selected patients from acute (n=588) and long term (n=255) care hospitals, Bergstrom and colleagues[33] examined whether demographic characteristics and primary diagnosis were factors in pressure ulcer development. Logistic regression demonstrated that lower Braden Scale scores (OR=1.3, 95% CI: 1.19-1.41), older age (OR= 0.97, 95% CI=0.95-0.98)(coding used for age variable not presented), and white race (OR=2.73, 95% CI: 1.25-5.98) could be predicted by the demographic characteristics of pressure ulcers. Findings were highly reliable, with the interrater reliability of the risk assessment measures among the nursing staff ranging from .95 to 1.0 following training and at monthly intervals. No attempt to evaluate interaction effects among the variables was reported and model performance using an independent sample was not assessed.

Allman and colleagues[28] identified factors that predicted the development of Stage 2 or greater pressure ulcers among adult patients (n=286) whose activity was limited to bed or chair. Data were collected by two research nurses who conducted skin assessments (79% agreement in small subgroup of patients) and primary care nurses who conducted risk assessments (kappa statistics ranged .34 to .78) . The association of patient characteristics hypothesized as risk factors with ulcer development was assessed by Kaplan-Meier survival analysis with log-rank test for comparison. Age of 75 years or more, dry skin, nonblanchable erythema (Stage 1 pressure ulcer), previous pressure ulcer history, immobility, fecal incontinence, depleted triceps skinfolds,

lymphopenia, and decreased body weight were significantly associated with pressure ulcer development ($p < .05$ by log-rank test). Risk ratios for predictors ($p < .05$) of pressure ulcer development after multivariable Cox regression analysis included the following: nonblanchable erythema (RR=7.52, 95% CI: 1.00 -59.12); lymphopenia (RR=4.86, 95% CI: 1.70 to 13.89); immobility (RR=2.36, 95% CI: 1.14-4.85); dry skin (RR=2.31, 95% CI: 1.02-5.21); and decreased body weight (RR=2.18, 95% CI: 1.05-4.52). The authors reported that interactions between fecal incontinence and immobility, and between age and body weight did not contribute to the predictive capability of the model. The method used to test for the presence of interactions and to determine what interactions were tested in the model was not reported. The model was not validated using an independent sample.

In an earlier study, also conducted in an acute care setting, Allman and colleagues[53] undertook a cross-sectional study (n=634) to determine the prevalence of pressure ulcers and the factors associated with having a pressure ulcer. Using logistic regression analysis, hypoalbuminemia (OR=3.0, 95% CI: 1.3-7.1), fecal incontinence (OR=3.1, 95% CI: 1.1-8.8), and fractures (OR=5.2, 95% CI: 1.1-25.5) remained significantly and independently associated with having a pressure ulcer ($p < .05$). The authors reported that no significant interactions were found. Also in this study, the authors failed to report the methods used to test for the presence of interactions and the selection process used to determine what interactions were tested. Prior to the study, the head

nurses of each inpatient unit were asked to identify all patients with pressure ulcers or at risk for them. There is recent evidence, by the same author, to suggest the under reporting of pressure ulcers by nurses using similar methods.[28] Model performance in regards to calibration and discrimination was not assessed.

Jiricka and colleagues[40] investigated the contribution of risk factors in the development of pressure ulcers in an intensive care setting. Data were collected using a convenience sample of 85 adults in a medical and surgical critical care unit of a trauma center. Although no significant differences in age, gender, history of diabetes mellitus, smoking history, or admitting medical team were found between subjects who did and did not have an ulcer, there were significant differences between groups with respect to length of stay and race. Patients with ulcers were more often found to be white, have longer ICU stays and have sustained a motor vehicle accident. To identify predictors of skin break down the scores of the six Braden subscales were entered into a stepwise, backward, multiple logistic regression model. Sensory perception (OR=2.01, 95% CI: 1.14-3.56) and moisture (OR=4.61, 95% CI: 1.70-12.52) were significant risk factors for predicting pressure ulcer development. Likewise, the scores of the Decubitus Ulcer Potential Analyzer (DUPA), a newly developed tool that includes circulation as the seventh subscale, were entered into a logistic regression model. When using the DUPA, moisture (OR=3.72, 95% CI: 1.44-9.62) and circulation (OR=1.79, 95% CI: 1.05-3.06) were found to be significant risk factors. Testing

for the presence of interactions was not reported. Other limitations to the study include a small sample size and failure to validate the model using an independent sample.

Maklebust and Magnan[23] investigated the factors associated with having a pressure ulcer using prevalence data obtained from five acute care hospitals (n=2,189). Prior to participating in the study, the nursing staff received comprehensive instructions regarding all aspects of the study. The presence of a pressure ulcer was validated by a master's prepared Clinical Nurse Specialist. Stepwise logistic regression resulted in a best-fitting model that included fecal incontinence (OR=22.0, 95% CI: 9.20-52.70), impaired mobility (OR=9.89, 95% CI; 6.12-16.00), malnutrition (OR=1.91, 95% CI: 1.39-2.62), decreased mental status (OR=1.40, 95% CI: 0.99-1.99), and a significant interaction effect between fecal incontinence and impaired mobility (OR=0.17, 95% CI: 0.07-0.43). Although this is the only study to report a significant interaction effect, the authors did not report how they determined which interactions were considered for testing in the model. Assessment information for this study included 10 factors and was dichotomized based on the nurses' general observation of the patient (factor present or absent). Although this study is the largest one conducted in an acute care setting, the assessment information must be interpreted cautiously since the data were not collected using a standardized measurement tool; presence or absence of risk factors were subjectively rated by the nursing staff.

In a retrospective chart review Rochon and colleagues[57] examined risk factors for pressure ulcers in spinal cord injured patients by developing and evaluating quantitative definitions for each of the nine general areas of risk outlined by the NPUAP.[7] A sample of 364 patients in a database were studied for over two years. Significant risk factors were entered into a stepwise logistic regression analysis. Three factors remained significant predictors of pressure ulcers: immobility as measured by a Frankel Grade (a five point scale which classifies type and extent of neurologic function) (OR=5.7, 95% CI: 2.8-11.9), malnutrition as assessed by low albumin level (OR=4.9, 95% CI: 2.8-8.6), and presence of chronic system illness as evaluated by a high co-morbidity scores using the following scores: Cumulative Illness Rating Scale points (OR=3.7, 95% CI: 2.1-6.3); Charleston Index points (OR=2.2, 95% CI: 1.3-3.8); and co-morbidity was estimated from a count of medical diagnosis codes from ICD-9-CM Medical Diagnosis (OR=4.2, 95% CI: 2.4-7.2). The model was found to correctly classify 79.2% of the patients; 92.0% of the patients without pressure ulcers were correctly classified, whereas only 36.6% of the patients with a pressure ulcers were correctly classified. The model performed better at identifying those patients without pressure ulcers as compared to those with pressure ulcers. The advantage of this comprehensive model is that each of the risk factors can be objectively measured and easily applied in a clinical practice setting. The use of discharge summary information, which may under estimate the problem associated with pressure ulcers, is a limitation of this study. The authors did not

report any information regarding testing for the presence of interactions or testing for model performance.

In a prospective study Kemp and colleagues[37] determined what factors contributed to the development of pressure ulcers during elective surgery. In a small sample of 125 patients, 15 patients (12%) developed pressure ulcers. Under reporting of ulcers may have occurred since the nurses assigned to the patients were responsible for reporting the pressure ulcers. A discriminant function analysis identified three predictors of pressure ulcer development: time on operating table, extracorporeal circulation, and age. Although the discriminant function was significant (p=.001), and the model performed well (sensitivity was 80% and specificity was 76%), performance was not evaluated using an independent sample.

1.4.2 Long Term Care Settings

Six studies have used multivariate analysis and developed models to report factors associated with pressure ulcers in long term care settings. Again, interaction effects between variables were rarely incorporated into the model fitting procedure and no studies reported strategies to test for the presence of confounding variables. A brief discussion of the studies is presented below.

In deriving a model, Berlowitz and colleagues[27] conducted the largest cohort study involving more than 30,000 residents in 74 long term care facilities. A sample assembled from a large administrative database at the U.S. Department of Veterans Affairs, was used to derive predictors of pressure ulcer

development. Using logistic regression, the following 11 clinical factors were found to be significantly associated ($p < .05$) with the future development of pressure ulcers: dependence in transferring (OR=1.3, 95%CI: 1.21-1.46), dependence in mobility (OR=1.2, 95%CI: 1.08-1.25), dependence in toileting (OR=1.1, 95%CI: 1.04-1.18), presence of a stasis ulcer (OR=3.0, 95% CI: 2.38-3.88), receipt of care for a non-pressure ulcer wound in the previous 4 weeks (OR= 2.3, 95%CI: 2.02-2.68), presence of a Stage 1 ulcer (OR=2.0, 95%CI: 1.78-2.31), presence of a terminal illness (OR=1.6, 95%CI: 1.31-1.91), institutionalization for 2 to 6 months (OR=1.3, 95%CI: 1.15-1.46), urinary tract infection (OR=1.2, 95% CI: 1.03-1.44), residence in intermediate medicine (OR=1.1, 95%CI: 1.01-1.26), and number of specialized services being received (OR=0.9, 95%CI: 0.82-0.95). This is the only reported study to use a validation sample. Model performance was assessed using the Hosmer-Lemeshow C statistic for calibration, however the area under the receiver operating characteristic curve for discrimination was not reported. The model was found to perform well in both the derivation and validation samples (Hosmer-Lemeshow C statistic, .75 and .76). Although the authors reported that interactions were tested and found to be not significant, the methods used to test for the presence of interactions and the selection process used to determine what interactions were considered were not reported. Even though large administrative databases are useful sources of information, the accuracy of data must be carefully considered when such a large number of facilities are involved.[58]

Brandeis and colleagues[59] conducted a cross-sectional analysis using a minimum data set for 2,011 nursing home residents living in 270 facilities. Logistic regression analysis determined that dependence in transfer or mobility (OR=2.0, 95% CI: 1.2-3.5), being bedfast (OR=2.3, 95% CI: 1.6-3.2), having diabetes mellitus (OR=1.6, 95% CI: 1.1-2.9), and having had a pressure ulcer in the past (OR=1.9, 95% CI: 1.4-2.8) were significantly associated with a Stage 2-4 ulcer. No interactions were found to be significant. Accuracy of data is a concern when using a large clinical data base.[59] Model performance using an independent sample was not performed.

Using a large clinical database, Brandeis and colleagues[29] studied 4232 nursing home residents over a three month period in 78 facilities. To account for the wide range of incidence rates (i.e. 0-31%), the investigators divided the homes into categories of high and low incidence and developed two risk factor models using logistic regression. In the high incidence homes (i.e. 19.3%), significant factors associated with the formation of pressure ulcers were ambulation difficulty (OR=3.3, 95% CI: 2.0-5.3), fecal incontinence (OR=2.5; 95% CI: 1.6-4.0), diabetes mellitus (OR=1.7, 95% CI: 1.2-2.5), and difficulty feeding oneself (OR=2.2, 95% CI: 1.5-3.3). Significant factors in low incidence homes (i.e. 6.5%), were ambulation difficulty (OR=3.6, 95% CI: 1.7-7.4), difficulty feeding oneself (OR=3.5, 95% CI; 2.0-6.3), and male gender (OR=1.9, 95% CI: 1.2-3.6). Although the high and low incidence homes shared several risk factors, such as ambulation and feeding activities, the main differences were that

diabetes and fecal incontinence were significant factors in the high incidence homes, and male gender was a significant factor in the low incidence homes. The authors did not report any further testing for performance of the model or for the possibility of interactions.

Bergstrom and Braden[34] conducted a prospective cohort study to examine clinical factors of pressure ulcer risk among the institutionalized elderly. Two hundred patients free of pressure ulcers were studied for 12 weeks or until discharge. Using logistic regression, the best predictors of pressure ulcer development were the Braden Scale score, diastolic blood pressure, temperature, dietary protein intake, and age. Although the model was found to be sensitive (91.0%) when attempting to predict all stages of pressure ulcers, the best specificity was found (40.8% and 51.0%) when predicting Stage 1 or $\geq$ Stage 2 ulcers. Although the percent of cases correctly classified ranged from 74.4% to 81.6%, this finding may be overly optimistic since model performance was not evaluated using an independent sample and no attempt was made to test for the presence of interactions. This comprehensive study included ongoing weekly measurements of key variables in combination with ongoing skin assessments. The rigorous manner in which data were collected by the research nurses helps to further contribute to the value of this study.

Berlowitz and Wilking[45] conducted a study to identify prospectively risk factors for pressure ulcers and to compare these results using a cross-sectional analysis from the same population of a chronic care hospital. Medical records

on patients were reviewed over a 13 month period. Of the 301 patients studied in the cross-sectional analysis, four factors were found to be significant: altered level of consciousness (OR=4.1, 95% CI: 2.1-8.1), bed or chair bound (OR=2.4, 95% CI: 1.2-4.9), impaired nutritional intake (OR=1.9, 95% CI: 1.0-3.7), and albumin (10 mg/ml) decrease (OR=1.8, 95% CI: 1.1-3.1). Of the 199 patients studied in the cohort analysis, three factors were found to be significant: cerebrovascular accident (OR=5.0, 95% CI: 1.7-14.5), bed or chair bound (OR=3.8, 95% CI: 1.0-14.0), and impaired nutritional intake (OR=2.8, 95% CI: 1.0-17.9). Impaired nutritional intake and being bed or chair bound were identified as clinical factors in both studies. Although the cross-sectional analysis revealed hypoalbuminemia as a factor associated with pressure ulcers, the cohort analysis shows no relationship between albumin and pressure ulcer development. The authors suggest that hypoalbuminemia may be a secondary phenomena versus a predisposing factor of pressure ulcer development. Several limitations of this study are important to highlight. Under reporting may have occurred since study data was obtained from medical records using a standardized form and weekly information data were obtained by the physician and head nurse in charge. Testing for the presence of interactions was not reported. Statistics to evaluate the performance of the models in terms of calibration and discrimination were not described.

In a prevalence study of almost 5,000 nursing home residents in 51 facilities, Spector and colleagues[43] examined factors associated with the

presence of pressure ulcers at time of admission to a nursing home. Significant variables were included in the logistic regression analyses. Factors related to having a pressure ulcer included older age (OR=1.009, 95% CI: 1.002-1.016), male gender (OR=1.241, 95% CI: 1.064-1.449), non-white (OR=1.491, 95% CI: 1.184-1.878), admitted from hospital (OR=1.325, 95% CI: 1.033-1.699), unable to bath (OR=1.400, 95% CI: 1.148-1.708), needs help or unable to transfer (OR=3.628, 95% CI: 2.087-6.305), urinary catheter (OR=1.951, 95% CI: 1.637-2.323), fecal incontinence (OR=1.231, 95% CI: 1.113-1.361), bed or chair fast (OR=1.286, 95% CI: 1.078-1.533), and no rehabilitation potential (OR=1.221, 95% CI: 1.010-1.476). Similar limitations as in previous studies are applicable to this study. Data obtained in this study were from medical records and performance of the model was not evaluated. Testing for the presence of interactions was not reported. Although the authors report a quarterly audit review for accuracy by the nurse consultants, the results were not reported.

There is agreement on a few factors: age, mobility, nutrition, and moisture. More information is needed regarding the interaction of factors and the effects of confounding variables.

1.5 Previous Work Locally

In 1993, a multidisciplinary Quality Improvement Skin Care Team at the Ottawa Hospital Civic Campus (OHCC) identified the need for a pressure ulcer prevalence study, and an evaluation of a risk assessment method as a first step to address the prevention and management of pressure ulcers. The Quality

Improvement Team worked with members of the Nursing Research Department and the Loeb Clinical Epidemiology Unit to design and develop the research component of their mandate. In a prospective cohort study in September 1993, the prevalence of pressure ulcers was determined, and pressure ulcer cumulative incidence was tracked during a two week follow-up period, to evaluate the accuracy of a risk assessment method.[10] In 1994, members of the Nursing Research Department at the OHCC worked collaboratively with members of the nursing department at the Ottawa Hospital, General campus and simultaneously conducted a prevalence study at both sites (n=1,020). This effort resulted in the completion of only the second Canadian study that can be generalized to other populations of adults in acute care settings.[8] The Nursing Research Department at the OHCC followed through again in 1995 with a third prevalence study of its inpatient population and a fourth similar study was conducted in the Fall, 1996.

The OHCC database has been used primarily to document prevalence and to describe demographic data associated with pressure ulcer development.[60] This data set provides a comprehensive picture of pressure ulcer development in a large tertiary care setting over several years. Analysis is needed to gain a better understanding of the interactive and multivariate nature of factors associated with pressure ulcers.

1.6 Study Aim and Objectives

The aim of this secondary data analysis is to identify and describe the

relationship of factors associated with pressure ulcers, Stage 2 or greater (break in skin integrity), in adults in acute care hospitals. The study objectives are:

1. To develop a model to describe the association of demographic and clinical factors in the presence of pressure ulcers using three years of prevalence data (1993, 1994 & 1995) from the OHCC Nursing Database.

2. To validate the model using the 1996 OHCC Prevalence Study.

1.7 Significance

This study will further describe characteristics of adults hospitalized with pressure ulcers. The analysis will also describe the contribution and interactions among the various factors, and identify specific areas to design and test clinical interventions. The study is an important contribution to helping plan hospital wide prevention programs and promote quality improvement measures in skin care.

2.0 Methods

2.1 Data Set

The analysis will be conducted on a comprehensive three year database (1993-1995), with 1,992 subjects. During one 12 hour period, every inpatient at the OHCC was examined for pressure ulcers and evaluated for risk in a standardized manner using the Braden Scale. The clinical, demographic and Braden subscale data collected provides substantive detail over several years. The data closely matches factors identified in the literature which will enable an indepth analysis of an acute care population.

This sample is adequate to develop a logistic regression model identifying factors associated with pressure ulcers assuming a prevalence of .25 (OHCC pressure ulcer prevalence rate, 25%, 1994-95), and a correlation among factors as large as .3. Using a one-tailed test with a significance level of 5% and a power of 80%, 549 subjects are needed to detect an odds ratio for risk factors as small as 1.3.[61] Sample size calculation takes into consideration the multiple correlational coefficients among the nine study factors.

Based on the work of the AHCPR Clinical Practice Guidelines,[2] and the germinal work of Bergstrom and colleagues[15,16,18] a standardized protocol that included a well recognized, research-based outcome measurement and procedure for data collection was developed and used. As a co-investigator, the author has been directly involved with developing the study proposals and conducting the studies (1993-1995). This protocol is detailed in a report of the

1993 study.[10] A summary of the study design is provided in Table 1.

2.2 Instruments

The Demographic and Clinical Profile form captured information regarding age, gender, length of stay, type of nursing unit (surgical, medical, special services, or cardiac), and any pressure reducing devices in use. Skin integrity was recorded using a Prevalence Grid, Appendix G, which listed 29 possible body sites and an additional "other" category. The assessments included "no symptom", or were staged according to a well recognized staging system (Appendix A). The Braden Scale[16,17] was selected to assess risk of pressure ulcers in a standardized manner, Appendix C.

Table 1. Pressure Ulcer Prevalence Protocol, 1993-1996

Study Design:	Cross-sectional; Prevalence
Study Population:	Adult Inpatient Population at OCH During One 12 Hour Time Period (0600-1800) Census Plus Tracking Admissions to 1800
Timing:	Mid-Week to Reflect New Admissions, Pre & Post Operative Cases Mid-September to Avoid Summer And Winter Seasonal Variations
Data Collection Instruments:	1. Demographic and Clinical Profile Form 2. Prevalence Grid 3. Braden Scale
Procedures:	*Pre-Study* Training Workshop for Surveyors Inter-rater Reliability Assessment Inform Inpatients, i.e. letter on meal trays Liaison with All Nursing Units *Study* Deploy 4 Survey Teams Across Civic Campus Track Admissions Every Two Hours Comprehensive Head-to-Toe Skin Assessment Outcome Assessment by Stages if Ulcers Present Risk Assessment Using the Braden Scale Document All Non-inclusions and Reasons
Sample Size for Current Study:	*Derivation Sample* 1993-95 (n=1,992) *Validation Sample* 1996 (n=581)

To determine reliability, a validation team comprised of two nurses reassessed a randomly selected subsample of 10% of the prevalence population in the 1993 study. Pearson's product moment correlation was used to calculate the agreement of the assessment of the survey team and validation team on total Braden scores.[10] The correlation was r = .87, indicating a strong association between assessments.

2.3 Model Derivation

Logistic regression modeling will be used to develop a model that fits the data and identifies factors associated with pressure ulcers. Odds ratio > 1 indicates a positive association of the factor with pressure ulcers.

Building a model, using cross-sectional data, will result in a valid estimate of an exposure and disease association.[62] Although logistic regression modeling is applicable to cross-sectional studies, there are limitations to analyzing the data. Whereas the data from follow-up studies can be used to predict the risk of an individual acquiring a disease, cross-sectional studies are restricted to using the data to describe estimates of odds ratios.[62]

The methods recommended by Kleinbaum[62] and Hosmer and Lemeshow,[63] will be used to build, fit and validate the model. The model will be hierarchically well formulated (HWF) as described by Kleinbaum.[62] Although any lower-order component of a higher-order term must belong to the initial HWF model, components may be dropped from the model if its corresponding higher order term is found to be not significant during the backward elimination process. The Hierarchy Principle[62] requires that all lower-order components of

significant product terms remain in all further model fitting procedures. Analysis will be performed using the Statistical Package for the Social Science (SPSS) Graduate Pack, Advanced Version 7.0, Windows 95 and Epidemiology Information (Epi Info), DOS Version 6.02.

Multivariate testing using logistic regression assesses the effect of many factors simultaneously with respect to the relationship of pressure ulcers. Logistic regression examines the relationship between dichotomous outcomes, and covariates, which may be categorical or continuous. It is therefore appropriate to use this statistical method to develop a model and identify those variables that are independently related to pressure ulcers in hospitalized patients. An important advantage of logistic regression is that it is useful in a wide variety of applications, and it can be used in situations when the assumption of multivariate normality is not satisfied.[63,64]

Covariates supported by evidence in the literature and of known biologic importance will be age (number of years), gender, length of stay (number of days), and subscale scores (1 to 4) of the Braden Scales; (sensory perception, moisture, activity, mobility, nutrition, and friction/shear). All subscales are rated from 1 to 4 with the exception of the friction and shear subscale which is rated from 1 to 3. Potential scores range from 6 to 23. The higher scores indicate higher levels of functioning and, therefore, lower levels of risk. Lower scores indicate lower functioning and, thus, higher risk.

Reverse scoring of the Braden subscales will be used in the analysis of the data. Since with the Braden Scale the lower the score, the greater the risk

of skin breakdown, the direction will be changed to be able to compare the results. Reverse scoring will be (4=1, 3=2, 2=3, 1=4 for sensory perception, moisture, activity, mobility, nutrition; 1=3 for friction/shear).

Each of the Braden subscales will be entered into the model as dichotomous variables. Dichotomous data, as compared to ordinal data, can be more easily used in clinical practice to identify patients with impairments and plan preventive measures. The following variables were created: 1,2=1 and 3,4=0 for sensory perception, moisture, activity, mobility, nutrition; and 1,2=1 and 3=0 for friction/shear.

Characteristics of the study population, in terms of age, gender and length of stay, will be described using means, 95% confidence intervals (CI), standard deviations (SD), medians, and range scores.

Univariate testing assesses the effect of each potential factor on the dependent variable. Univariate testing will be conducted to assess the effect of each variable on pressure ulcers. Categorical factors, such as gender, will be analyzed using the chi-square test. The Fisher's exact test will be used if any of the cells have fewer than an expected number of five observations. An independent sample t test (2-tail) will be used to analyze differences in age, length of stay and Braden subscale scores between ulcer free subjects and ulcer subjects. All reported p values are 2 tailed. The Levene test for homogeneity-of-variance will be used to test for the assumption of equal variances and a t-test based on separate variances will be used if homogeneity is rejected. Variables whose univariate test has p value < .25 will be considered as a candidate for

multivariate model.[63]

The dichotomous dependent variable will be an indicator of the presence of ulcers (Stage 2 or greater), or the absence of ulcers. Since Stage 1 ulcers represent a predisposing condition clinically to actual break in skin integrity it seems most reasonable to include them in the ulcer free category. The presence of a pressure ulcer, Stage 2 or greater, will be coded as 1; Stage 1 ulcers and the absence of ulcers will be coded as 0. The staging system recommended in the AHCPR Clinical Practice Guidelines[2] will be used (Appendix D).

Females will be coded as 0 and males as 1. Age (years) and length of stay (days) will be entered into the model as continuous variables and be reported on a per unit basis.

The process of stratification will be used to provide an initial examination to evaluate for both effect modication and confounding. The interaction of age, length of stay and gender with each other, and with each subscale of the Braden Scale will be stratified. If the stratum specific estimates are uniform or homogeneous, effect modification is not present. If the stratum estimates are not uniform or heterogeneous, effect modication may be present.[63,65] A description of how the association is modified by the stratification factor will be reported. Although stratification methods are useful for an initial review of the data, the most informative analysis requires the quantification of interactions effects with model procedures using logistic regression.[63]

The need to include variables in the model will be evaluated using the - 2

log likelihood and model chi-square improvement statistic likelihood ratio test to assess for statistical significance. Model fitting procedures will be conducted to determine the best model within the scientific context of the problem. The overall goal of model building is to obtain the best fitting model while minimizing the number of parameters.[63]

In conducting statistical testing of interaction terms, Kleinbaum[62] recommends a single "chunk" test for the entire collection of interaction terms be considered first. Significant interactions will be identified by entering all possible combinations of interactions terms (2 way) into the model (n=36) and conducting a backward, stepwise elimination procedure. Model entry and stay criteria will be p value of $\leq .05$ for statistical significance.[66] To ensure that the model is HWF, the lower-order terms (main variables: age, length of stay, gender, and all six Braden subscales) will be forced into the model before entering the higher-order terms (interaction terms). The final decision to include interaction terms in the model will be based on statistical and practical considerations, in terms of clinical importance.[63]

The presence of confounding variables will be tested after the interaction assessment is completed. If there is strong evidence of an interaction, the assessment of confounding is of secondary importance as the estimate of the factor depends on the specific value of the covariate.[62,63]

The presence of confounders, for age, gender and length of stay, with each other and with each subscale of the Braden Scale will be assessed using the Mantel-Haenszel (MH) adjusted OR. The presence of a confounding

variables will be determined by comparing the crude odds ratio to the adjusted odds ratio. [63,65] If the odds ratios are uniform or homogeneous, there was no confounding effect of the variable under study. The magnitude of confounding is evaluated by observing the relative difference between the crude and adjusted estimates.[65] Confounding is present if the crude and adjusted estimates differ by > 10%.[67] The presence of confounding variables will be coded as yes, likewise, the absence of confounding variables will be coded as no.

2.4 External Model Validation

Performance of the model, in terms of calibration, will be statistically evaluated using the Hosmer-Lemeshow[63] goodness of fit test statistic to evaluate whether the associations found are replicated when applied to an external sample. Calibration evaluates the degree of correspondence between the estimated probabilities produced by the model and the actual experience of patients.[68] This is accomplished by applying the beta coefficients from the derivation model to the derivation sample. The probability of success is calculated for every individual in the sample, and the resulting numbers are arranged in increasing order. The range of probability values is then divided into 10 deciles. For each decile, the observed numbers of individuals with successful outcomes are counted and the expected numbers are calculated by adding the predicted probabilities for all the individuals in each decile. Also, the number of individuals with failure outcomes is counted in each decile, and the expected numbers are computed by adding up the predicted probabilities of failure for each decile. The Hosmer-Lemeshow goodness of fit statistic is calculated using

the summation of both successes and failures in the ten deciles. Values of p near 1 indicate a good fit, and values near 0 indicate a poor fit.[66] The Hosmer-Lemeshow goodness of fit statistic has an approximate chi-square distribution with 8 df.

. The external validation sample will consist of the 1996 OCH Prevalence Study Population (n=581). The rationale for using this independent sample is that the fitted model is often found to perform in an optimistic manner when used on the derivation data set.[62]

Performance in terms of model discrimination will also be assessed. The beta coefficients from the derivation model will be applied to the validation sample. To evaluate performance, Hosmer and Lemeshow[63] proposed setting up groupings based on the values of estimated probabilities. They suggest one method which uses groups and cut points defined at the values of .1-.9. For example, the first group contains all subjects whose estimated probability is less than or equal to 0.1, and the ninth group contains those subjects whose estimated probability is less than or equal to .9.

The effectiveness of the model will be assessed by considering the best cut off values using two by two classification tables. Classification tables will be used to measure the overall percentage of subjects correctly classified.

Steps of the modeling procedure are described in Table 2.

Table 2.
Outline of the Modeling Procedure

- Univariate Testing
  - Description of Model Variables
  - Interaction Assessment Using Stratified Analysis
  - Confounding Assessment Using Mantel-Haenszel Odds Ratio
  - Model Building Procedure
    - Main Variables Using Reverse Scoring of Braden Subscales
    - Main Variable Using Dichotomous Variables for Braden Subscales
- Backward Stepwise Logistic Regression Approach
  - Proposed Models
  - Model Validation
    - Comparison of Derivation and Validation Sample
    - External Validation
  - The Hierarchically Well Formulated Model

3.0 Results

3.1 Ulcer Prevalence

Although pressure ulcer prevalence, Stage 2 or greater, varied slightly from year to year, the differences were not statistically significant (chi-square=1.29, df=3, $p > 0.05$).[60] Reported prevalence were: 14.7% in 1993, 10.4% in 1994, 11.7% in 1995, and 12.2% in 1996.

3.2 Univariate Testing

Univariate testing revealed that age, gender, length of stay and all six subscales of the Braden Scale were significantly associated with pressure ulcers. Gender was found to be significantly associated with pressure ulcers (chi-square=8.30, df=1, p=.004). Using Levene's test for continuous variables, equality for group variances was rejected for all variables ($p < .25$). The variables were tested using the t test for independent samples with equal variances not assumed, and the results are reported in Table 3. All factors were entered into the logistic model.

Table 3. Univariate Test Results*

Variable	t statistic	df	p-value	Odds Ratio	95% Confidence Intervals
Age	-7.656	336	<.01	*0-70, > 70* .44	.4250-.4540
Length of Stay	-3.564	365	<.01	*≤ 2 weeks, > 2 weeks* 2.84 *≤ 1 month, > 1 month*	2.8278-2.8569
Sensory Perception	-8.896	272	<.01	5.76	5.7495-5.7700
Moisture	-9.347	282	<.01	3.86	3.8459-3.8748
Activity	-11.086	315	<.01	4.24	4.2296-4.2587
Mobility	-11.382	288	<.01	5.30	5.2863-5.3153
Nutrition	-7.587	307	<.01	2.54	2.5212-2.5502
Friction/Shear	-12.972	290	<.01	6.04	6.0105-6.1395

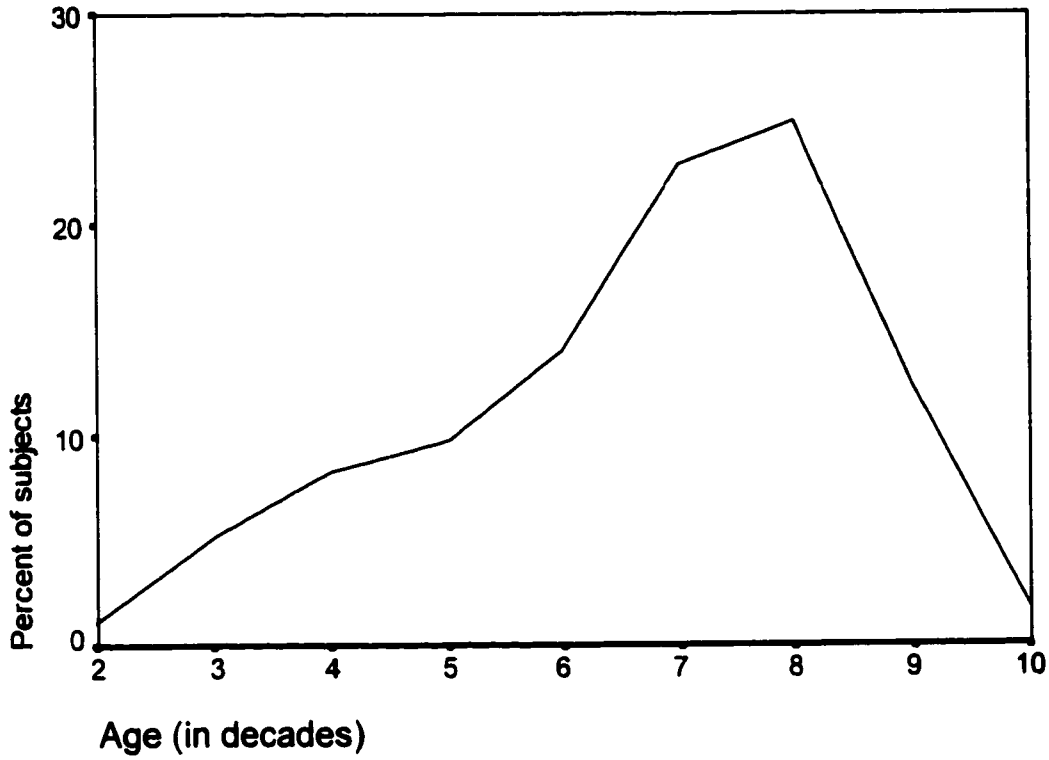
*equal variances not assumed

3.3 Description of Model Variables in the Derivation Sample

3.3.1 Age.

Subjects ranged in age from 14 to 100 years, with a SD of 17.50. The mean age of subjects was 62.5 years of age, (95% CI: 61.68-63.22) and the median age was 66 years (Table 4). The age distribution of the study population was found to be skewed to the left with over 50% of the subjects between the ages of 70 and 80, Figure 1.

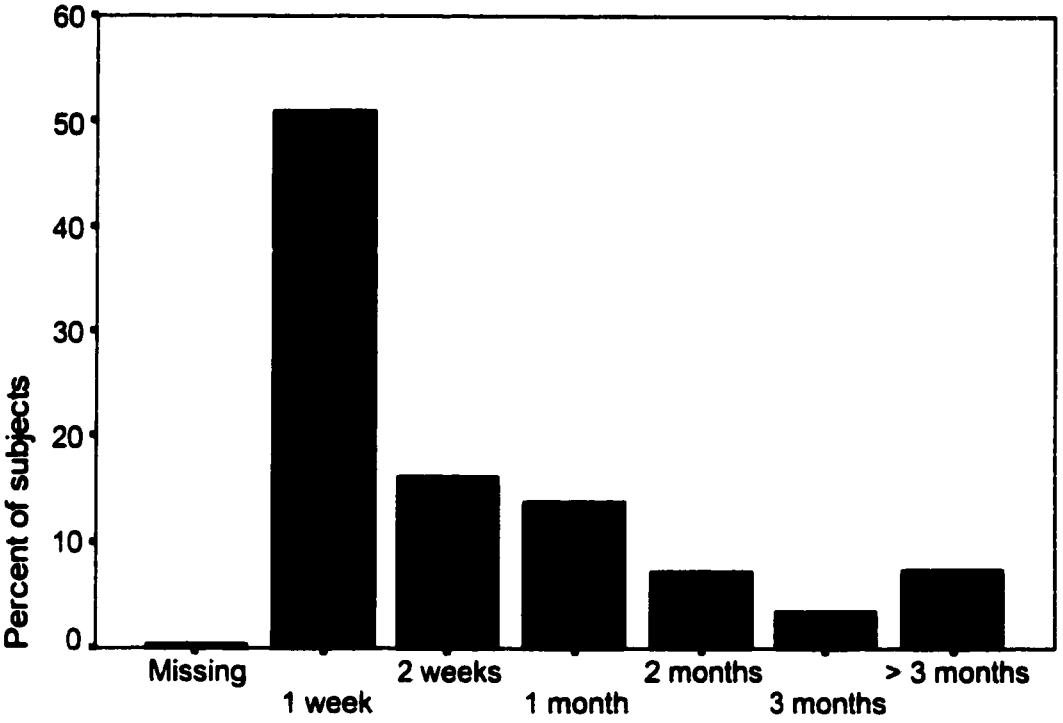
Figure 1.
Distribution of Age for All Subjects In the Derivation Sample



3.3.2 Length of Stay.

On the day of study, patients had been in hospital from 0-1579 days (day of admission counts as zero). The mean was 27.8 days (95% CI: 24.50-31.16) and the median was 7 days, Table 4 and Figure 2. The total length of stay for subjects is unknown due to the cross-sectional design of the study.

Figure 2.
Length of Stay on Study Date for All Subjects in the Derivation Sample



3.3.3 Gender.

Subjects were divided almost evenly between males and females, Table 4.

Table 4.
Characteristics of all Subjects in the Derivation Sample

Characteristic	Derivation Sample (n=1,992)
Age (years)	
Mean	62.5
SD	17.50
95%CI:	61.68-63.22
Median	66
Range	14-100
Gender	
% Male	49.2% (n=1,011)
Length of Stay (days)	
Mean	27.8
SD	75.53
95% CI:	24.50-31.16
Median	7
Range	0-1,597

3.3.4 Braden Subscales.

Table 5 includes the mean, SD, 95% CI and median scores for each of the Braden subscales. Generally the scores are high (favourable) on each subscale with the average scores ranging from 3.10 for nutrition to 3.74 for sensory perception using a four point scale. Since the range for friction/shear subscale is only 3, the mean and median were slightly lower than the other subscale scores, but on a proportional basis are in the same favourable range as for the other subscales.

Table 5.
Braden Subscale Scores in the Derivation Sample

Subscale	Mean	SD	95%CI	Median
Sensory Perception	3.74	.60	3.71-3.76	4
Moisture	3.61	.59	3.58-3.65	4
Activity	3.13	.99	3.09-3.17	3
Mobility	3.47	.86	3.43-3.50	4
Nutrition	3.10	1.0	3.06-3.14	3
Friction/Shear	2.56	.68	2.53-2.59	3

3.4 Prevalence of Ulcer Free Subjects and Subjects With Ulcers by Age Group

Figure 3 presents the prevalence of ulcer free subjects and subjects with ulcers by age group. The highest proportion of subjects with ulcers were observed between the ages of 71-80 (14.5%) and > 81 (16.6%). Subjects with ulcers were slightly older than ulcer free subjects (Table 6).

Since the median age for subjects with ulcers was 73 it seems appropriate to use persons 0-70, and > 70 years for the stratified analysis.

Figure 3.

Prevalence of Ulcer Free Subjects and Subjects With Ulcers (Stage 2 and Greater) by Age Group in Years in the Derivation Sample

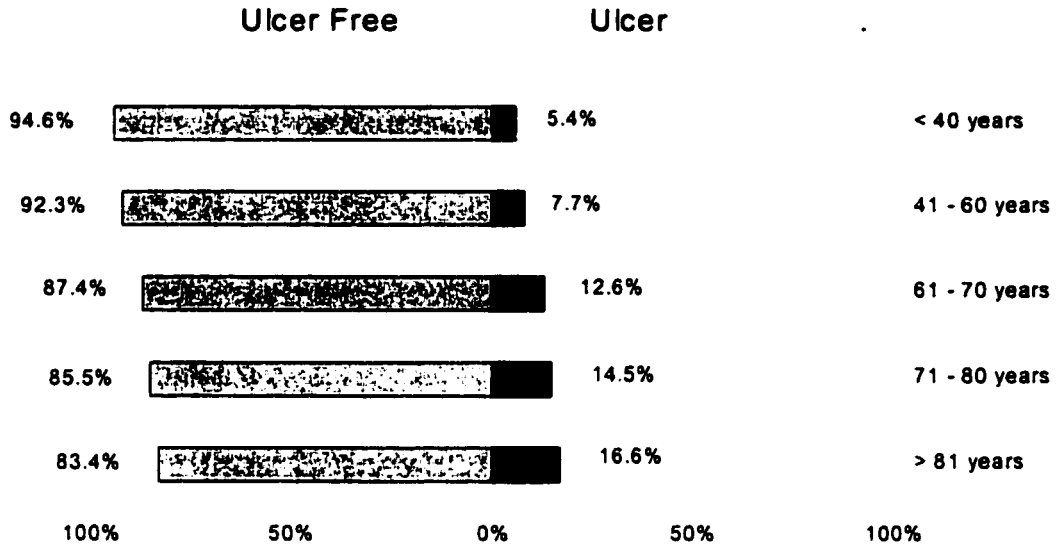


Table 6.
Comparison of Demographic Characteristics Among Ulcer Free Subjects and Subjects with Ulcers (Stage 2 And Greater) in the Derivation Sample

Subjects	Age (years) Mean(SD)	Age Median	Age Range	Subjects	Length of Stay (days) Mean (SD)	Length of Stay, Median	Length of Stay, Range
Ulcer Free (1,744)	61.4 (17.45)	65	14-100	Ulcer Free (1,736)	25.9(77.11)	6	0-1,597
Ulcer (248)	69.8(16.02)	73	19-97	Ulcer (247)	41.4(61.76)	21	0-391

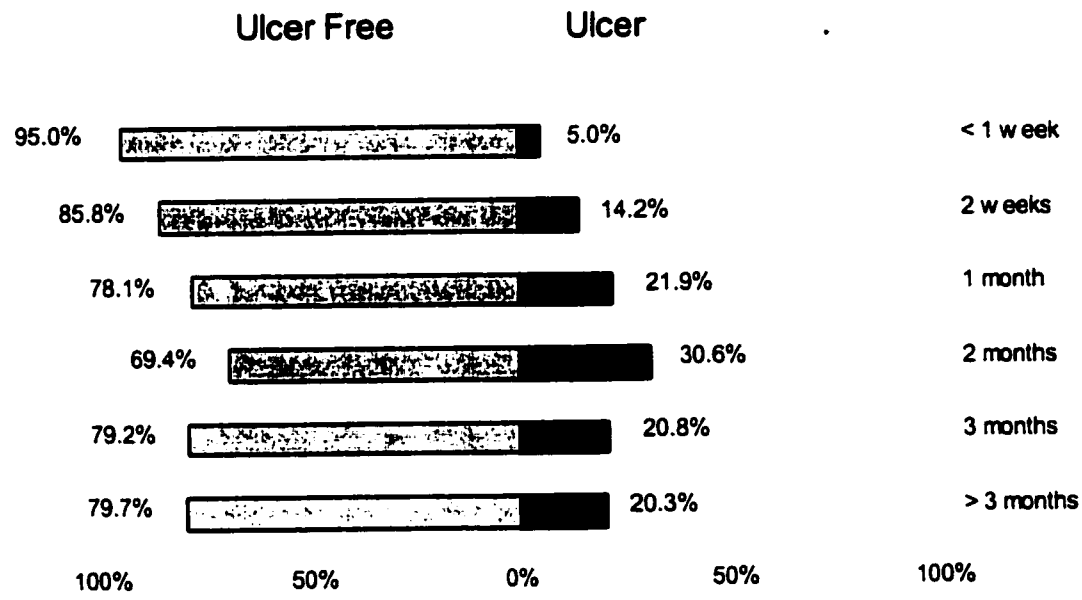
3.5 Prevalence for Length of Stay Among Ulcer Free Subjects and Subjects With Ulcers

At the time of the study subjects with ulcers were found to have had longer hospital stays as compared to ulcer free subjects, Figure 4. The median length of

stay for subjects with ulcers was 21 days. This finding suggests that between the first 2 weeks to 1 month of hospitalization was an important period to observe for pressure ulcers. A cut off period of both, 2 weeks and 1 month will be used in the stratified analysis. Two weeks is a conservative measure of a usual hospital stay.

Figure 4.

Prevalence for Length of Stay Among Ulcer Free Subjects and Subjects with Ulcers (Stage 2 and Greater) in the Derivation Sample



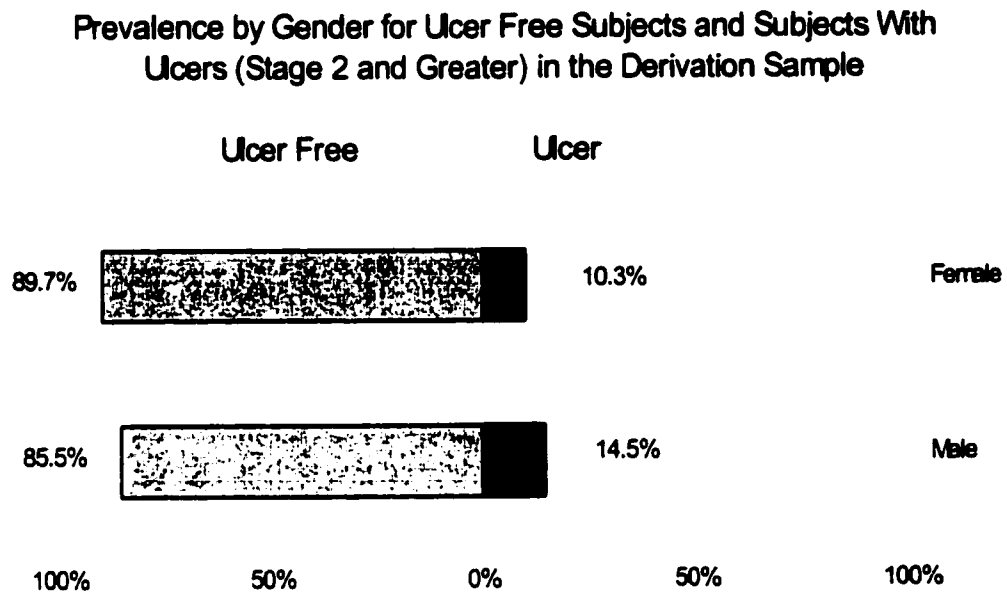
Ulcer subjects with hospital stays $\geq$ 1 month were observed to have prevalence > 20%.

3.6 Prevalence According to Gender for Ulcer Free Subjects and Subjects With Ulcers

A comparison of ulcer free subjects to subjects with ulcers by gender is presented in Figure 5. Male subjects, who had a higher proportion of ulcers as compared to females, were used as the exposure variable in the stratified analysis.

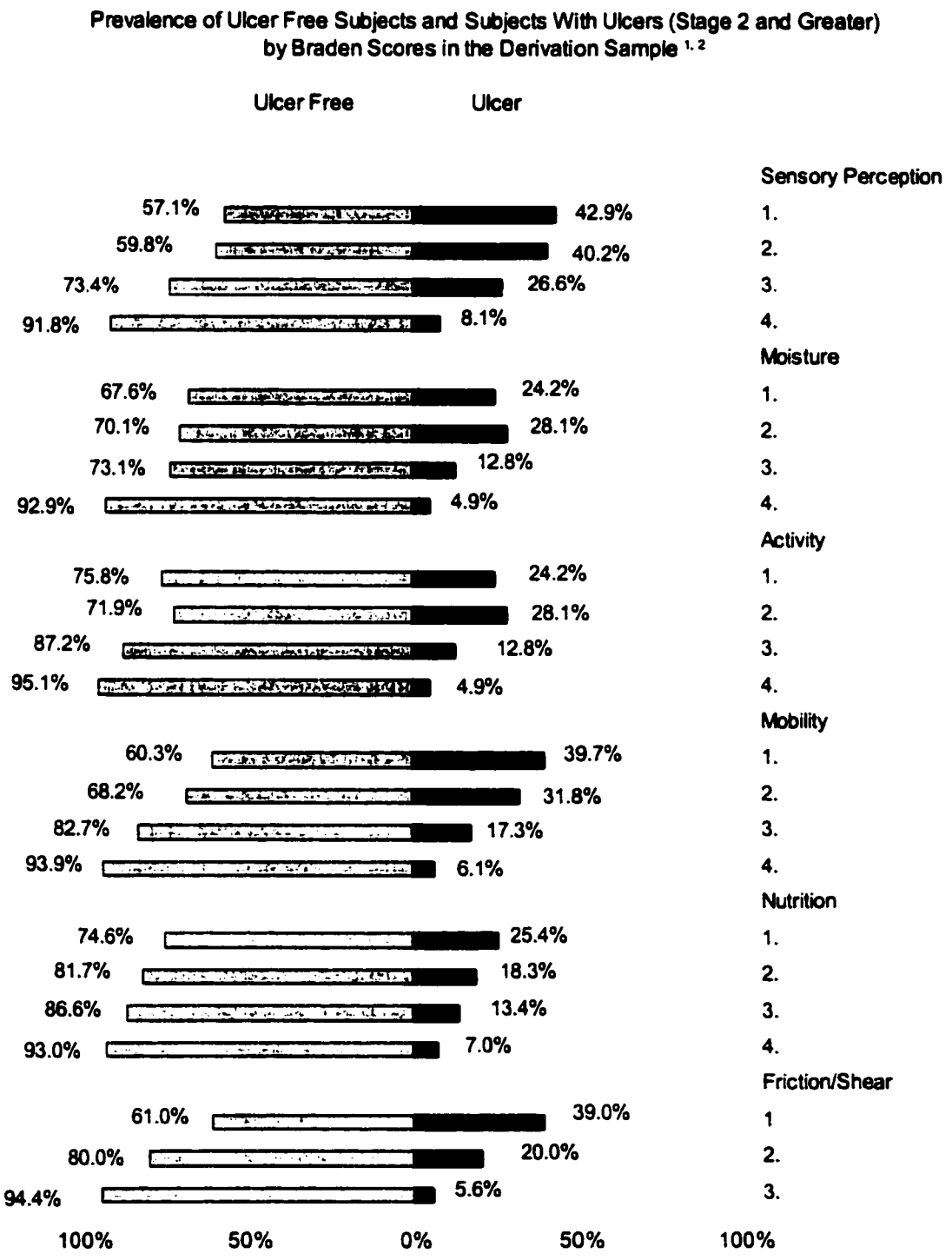
3.7 Prevalence by Braden Subscale Scores for Ulcer Free Subjects and Subjects With Ulcers

Figure 5.



The prevalence of ulcer free subjects and subjects with ulcers by Braden subscale scores is displayed in Figure 6. Higher proportions of subjects with ulcers consistently had more severe impairments as compared to ulcer subjects with no impairments. Conversely, higher proportions of ulcer free subjects were found to have no impairments as compared to ulcer free subjects with impairments. The mean scores for each of the six Braden subscales were significantly lower for subjects with ulcers as compared to ulcer free subjects, Table 7.

Figure 6.



1. Percentages do not add to 100% because of rounding error
2. A full description of each category is listed in Appendix B

Table 7.
Braden Subscale Mean Scores by Ulcer Status in the Derivation Sample

Variable	Mean Ulcer Score	SD	Mean Ulcer Free Score	SD	p-value
Sensory Perception	3.29(248)	.88	3.80(1,743)	.52	< .01
Moisture	3.09(247)	.98	3.69(1,743)	.70	< .01
Activity	2.48(248)	1.0	3.22(1,743)	.96	< .01
Mobility	2.80(248)	1.01	3.56(1,743)	.76	< .01
Nutrition	2.62(248)	1.07	3.17(1,740)	.97	< .01
Friction/Shear	1.96(248)	.80	2.64(1,742)	.62	< .01

3.8 Interaction Assessment Using Stratified Analysis

The interaction of age, length of stay and gender with each other, and with each subscale of the Braden were evaluated by using stratified analysis.

3.8.1 Age.

Age was tested by comparing subjects 0 to 70 years of age with subjects > than 70. An inspection of age stratum specific odds ratios in Table 8 showed that there is little meaningful variation in the estimated relationship over three strata i.e. moisture, length of stay, and gender/male. Differences in the odds ratio were observed in 5 of the 8 stratum specific estimates i.e. sensory perception, activity, mobility, nutrition, and friction/shear. The odds ratios were higher for persons 0-70 as compared to persons > 70 years in each of the strata with the exception of nutrition.

Table 8.
Interaction Assessment: Age (0-70 years, > 70 years)

Variable	Age, Years	Odds Ratio	95% CI
Sensory Perception	0-70	11.43	5.43-23.52
	>70	3.85	2.25-6.49
Moisture	0-70	3.49	1.53-7.34
	>70	3.41	2.27-5.07
Activity	0-70	4.89	2.88-8.24
	>70	3.63	2.57-5.14
Mobility	0-70	6.17	3.43-10.87
	>70	4.46	3.08-6.43
Nutrition	0-70	2.21	1.29-3.73
	>70	2.57	1.81-3.63
Friction/Shear	0-70	6.90	4.17-11.52
	>70	5.45	3.72-8.08
Length of Stay (≤ 2 weeks, > 2 weeks)	0-70	1.86	1.19-2.94
	>70	1.64	1.07-2.56
(≤ 1 month, > 1 month)		1.88	1.32-2.70
		1.77	0.96-3.40
Gender/male	0-70	F=2.08	1.29-3.40
	>70	M=2.32	1.57-3.46

3.8.2 Length of Stay.

Length of stay was tested by comparing those subjects who were admitted to the hospital ≤ 2 weeks and > 2 weeks (Table 9); and ≤ 1 month and > 1 month (Table 10). The odds ratios are homogeneous over the strata for nutrition (≤ 2 weeks, > 2 weeks; and ≤ 1 month, > 1 month). Differences in the odds ratios were observed in 6 of the strata. The odds of having an ulcer were consistently higher for subjects during the first 2 weeks and 1 month of hospitalization compared to subjects hospitalized for longer periods of time with the exception of nutrition and gender/male.

Table 9.
Interaction Assessment: Length of Stay (≤ 2 weeks, > 2 weeks)

Variable	Length of Stay, Days	Odds Ratio	95% CI
Sensory Perception	≤2 weeks	8.93	4.56-16.98
	>2 weeks	3.0	1.68-5.28
Moisture	≤ 2 weeks	5.51	2.97-9.87
	> 2 weeks	1.92	1.22-2.98
Activity	≤ 2 weeks	4.61	2.95-7.20
	> 2 weeks	3.17	2.13-4.71
Mobility	≤ 2 weeks	6.55	4.02-10.53
	> 2 weeks	3.24	2.13-4.89
Nutrition	≤ 2 weeks	2.36	1.50-3.67
	> 2 weeks	2.59	1.73-3.86
Friction/Shear	≤ 2 weeks	6.70	4.24-10.71
	> 2 weeks	3.55	2.33-4.57
Gender/male	≤ 2 weeks	1.28	.82-1.99
	> 2 weeks	1.90	1.29-2.81

Table 10.
Interaction Assessment: Length of Stay (≤ 1 month, > 1 month)

Variable	Length of Stay, Days	Odds Ratio	95% CI
Sensory Perception	≤ 1 month	7.78	4.49-13.28
	> 1 month	2.33	1.14-4.67
Moisture	≤ 1 month	4.97	3.10-7.84
	> 1 month	1.57	0.89-2.74
Activity	≤ 1 month	4.76	3.34-6.78
	> 1 month	2.59	1.54-4.35
Mobility	≤ 1 month	6.49	4.43-9.44
	> 1 month	2.60	1.50-4.47
Nutrition	≤ 1 month	2.52	1.77-3.57
	> 1 month	2.61	1.52-4.47
Friction/Shear	≤ 1 month	6.87	4.75-10.01
	> 1 month	2.81	1.61-5.00
Gender/male	≤ 1 month	1.45	1.02-2.05
	> 1 month	1.71	1.03-2.87

3.8.3 Gender.

Differences in the odds ratio were observed in each of the stratum specific estimates. The odds ratios were consistently higher for male with the exception of females with sensory perception deficits. Table 11 displays the results of this analysis.

Table 11.
Interaction Assessment: Gender

Variable	Gender	Odds Ratio	95% CI
Sensory Perception	Female	7.14	3.59-13.87
	Male	4.84	2.76-8.37
Moisture	Female	3.12	1.78-5.31
	Male	4.71	2.91-7.52
Activity	Female	3.70	2.37-5.77
	Male	4.69	3.20-6.87
Mobility	Female	4.64	2.88-7.39
	Male	6.02	3.97-9.07
Nutrition	Female	1.78	1.14-2.78
	Male	3.56	2.42-5.21
Friction/Shear	Female	5.85	3.64-9.55
	Male	6.35	4.27-9.52

3.9 Confounding Assessment

The presence of confounders by age, gender and length of stay of each other, and of the Braden subscales (dichotomous variables) will be tested using the Mantel-Haenszel adjusted odds ratio.

3.9.1 Age.

Age was tested by comparing subjects 0 to 70 and > 70 years. The results

are presented in Table 12. Age was a confounding variable with moisture and length of stay (estimates differed by > 10%).

Table 12.
Confounding Assessment: Age (0-70 years, > 70 years)

Variable	MH, Crude Odds Ratio	95% CI	MH, Adjusted Odds Ratio	95% CI	Confounder
Sensory Perception	3.81	2.95-4.93	3.57	2.71-4.69	no
Moisture	2.98	2.33-3.82	2.65	2.05-3.43	yes
Activity	3.38	2.69-4.24	3.14	2.52-3.90	no
Mobility	3.86	3.09-4.81	3.52	2.83-4.39	no
Nutrition	2.21	1.76-2.79	2.13	1.70-2.67	no
Friction/ Shear	4.88	3.79-6.29	4.54	3.61-5.73	no
Length of Stay(≤2 weeks,>2 weeks)	1.96	1.52-2.54	1.60	1.25-2.05	yes
(≤ 1 month, > 1 month)	1.96	1.52-2.54	1.71	1.32-2.20	yes
Gender/ male	1.98	1.53-2.56	2.01	1.57-2.58	no

3.9.2 Length of Stay.

Length of stay was tested by comparing those subjects who were admitted to the hospital ≤ 2 weeks and > 2 weeks (Table 13); and ≤ 1 month and > 1 month (Table 14).

Table 13.
Confounding Assessment: Length of Stay (≤ 2 weeks, > 2 weeks)

Variable	MH, Crude Odds Ratio	95% CI	MH, Adjusted Odds Ratio	95% CI	Confounder
Sensory Perception	3.82	2.95-4.93	2.90	2.2-3.81	yes
Moisture	2.98	2.33-3.82	2.07	1.61-2.66	no
Activity	3.40	2.71-4.27	2.83	2.28-3.51	yes
Mobility	3.88	3.11-4.84	2.98	2.40-3.70	yes
Nutrition	2.19	1.74-2.75	2.08	1.66-2.60	no
Friction/ Shear	4.75	3.67-6.14	3.56	2.83-4.48	yes
Gender/ male	1.40	1.11-1.78	1.47	1.17-1.85	no

Table 14.
Confounding Assessment: Length of Stay (≤ 1 month, > 1 month)

Variable	MH, Crude Odds Ratio	95% CI	MH, Adjusted Odds Ratio	95% CI	Confounder
Sensory Perception	3.82	2.95-4.93	3.03	2.31-3.97	yes
Moisture	2.98	2.33-3.82	2.26	1.76-2.90	yes
Activity	3.40	2.71-4.27	3.00	2.42-3.72	yes
Mobility	3.88	3.11-4.84	3.28	2.65-4.07	yes
Nutrition	2.19	1.74-2.75	2.16	1.72-2.71	no
Friction/ Shear	4.75	3.67-6.14	3.93	3.12-4.93	yes
Gender/ male	1.40	1.11-1.78	1.43	1.14-1.81	no

Length of stay was a confounding variable with four factors, sensory perception, activity, mobility, and friction/shear (moisture when length of stay ≤ 1 month, > 1 month).

3.9.2 Gender.

Gender was not found to be a confounding variable. The findings are displayed in Table 15.

Table 15.
Confounding Assessment: Gender

Variable	MH,Crude Odds Risk	95% CI	MH, Adjusted Odds Risk	95% CI	Confounder
Sensory Perception	3.83	2.97-4.95	3.72	2.82-4.90	no
Moisture	2.98	2.33-3.82	3.00	2.32-3.86	no
Activity	3.38	2.69-4.24	3.36	2.70-4.19	no
Mobility	3.86	3.09-4.81	3.86	3.10-4.81	no
Nutrition	2.21	1.76-2.79	2.26	1.80-2.84	no
Friction/ Shear	4.71	3.64-6.08	4.74	3.76-5.96	no

3.10 Model Building Procedure

3.10.1 Main Variables Using Reverse Scoring for Braden Subscale Scores.

Significant variables, p values < .05, included: age, gender/male, nutrition (1), and friction/shear(1). The Braden variables were transformed into a set of deviation contrasts. Each of the variables were compared to the overall effect. The confidence intervals for these variables are provided in Table 16. The Hosmer-Lemeshow goodness of fit test statistic indicated that the fit of the proposed model was poor (chi-square=9.80, df= 8, p=.28). The overall percentage of patients correctly classified was 87%.

Table 16.
Main Variables Entered into the Model, Braden Scale Variables Coded Using Reverse Scoring

Variable	B	S.E.	p-value	Odds Ratio	95%CI: Lower	95%CI: Upper
Age	.0164	.0051	.0014	1.02	1.0064	1.0268
Gender/male	.4832	.1541	.0017	1.62	1.1985	2.1932
Length of Stay	-.0009	.0009	.3305	.9991	.9974	1.0009
Sensory Perception						
(1)	.3723	.3995	.3513	1.45	.6632	3.1752
(2)	-.2797	.2847	.3259	.76	.4327	1.3208
(3)	-.0536	.2111	.7994	.95	.6266	1.4336
Moisture						
(1)	.2966	.2326	.2023	1.35	.8527	2.1225
(2)	-.3617	.1945	.0630	.67	.4757	1.0198
(3)	.0804	.1815	.6576	1.08	.7594	1.5466
Activity						
(1)	-.0427	.2633	.8712	.96	.5719	1.6053
(2)	-.2670	.1796	.1371	.77	.5384	1.0887
(3)	-.0463	.1461	.7511	.95	.7170	1.2712
Mobility						
(1)	.1120	.3462	.7463	1.12	.5675	2.2047
(2)	-.0236	.2329	.9193	.98	.6187	1.5417
(3)	-.0256	.1633	.8752	.97	.7077	1.3424
Nutrition						
(1)	.3798	.1791	.0340	1.46	1.0291	2.0770
(2)	-.0233	.1591	.8833	.98	.7153	1.3343
(3)	-.0533	.1498	.7219	.95	.7068	1.2716
Friction/Shear						
(1)	.9684	.2230	< .01	2.63	1.7010	4.0777
(2)	-.0373	.1496	.8030	.96	.7186	1.2915
Constant	-2.5097	.4012	<.01			

3.10.2 Main Variables Using Dichotomous Variables for Braden Subscale Scores.

Table 17 presents the model using dichotomous variables for the Braden subscales. Since dichotomous data can be more easily utilized in clinical

practice and the loss of information using dichotomous data was apparently not great, dichotomous variables for each of the Braden subscales will be used in the subsequent model building procedures. The following variables were created (1,2=1 and 3,4=0 for sensory perception, moisture, activity, mobility, nutrition; 1,2=1 and 3=0 for friction/shear).

Significant variables, $p < .05$, included: age (OR=1.02), gender (OR=1.66), sensory perception (OR=1.82), nutrition (OR=1.52), and friction/shear (OR=3.09). The odds of having a pressure ulcer in the presence of friction/shear forces were a three fold increase. Length of stay, moisture, activity and mobility were not significant, $p > .05$. Confidence intervals and p-values are provided in Table 17. The Hosmer-Lemeshow goodness of fit test statistic indicated that the fit of the proposed model was poor (chi-square=8.56, df 8, p=.38). The overall percentage of patients correctly classified was 88%.

Table 17.
Main Variables Entered into the Model, Braden Scale Variables Coded Using Dichotomous Variables

Variable	B	S.E.	p-value	Odds Ratio	95%CI: Lower	95%CI: Upper
Age	.0200	.0050	.0001	1.02	1.011	1.0302
Gender(male)	.5083	.1503	.0007	1.66	1.2383	2.2318
Length of Stay	-2.6E-05	.0008	.9742	1.00	.9984	1.0015
Sensory Perception	.5963	.2483	.0163	1.82	1.1159	2.9531
Moisture	.2870	.2043	.1602	1.33	.8927	1.9885
Activity	.1597	.2008	.4264	1.17	.7915	1.7391
Mobility	.3508	.2188	.0977	1.42	.9376	2.1512
Nutrition	.4194	.1591	.0084	1.52	1.1135	2.0776
Friction/Shear	1.1288	.2003	< .01	3.09	2.0880	4.5787
Constant	-4.4753	.3657	< .01			

3.11 Backward Stepwise Logistic Regression Approach.

To achieve a HWF model, all main variables were entered into the model. The next step involved chunk testing, a backward stepwise logistic regression approach with all possible combinations of two way interactions (n=36). Interactions with a p value $\leq$ .05 were entered and retained in the model.

Table 18 lists the nine main variables and 5 interactions in the model using the chunk testing method. Among these interactions, two were not significant as the confidence intervals included one; moisture and sensory perception, and length of stay and mobility. The Hosmer-Lemeshow goodness of fit test statistic indicated that the fit of the proposed model was poor (chi-square=8.73, df 8, p=.37). The overall percentage of patients correctly classified was 88%.

Table 18.
Interaction Assessment: Backward Stepwise Logistic Regression Approach

Variable	B	S.E.	p-value
Age	.0230	.0056	< .01
Gender/male	.2552	.1916	.1828
Length of Stay	.0016	.0013	.2435
Sensory Perception	3.6738	.9932	< .01
Moisture	.5228	.2292	.0226
Activity	.1612	.2035	.4281
Mobility	.5066	.2389	.0339
Nutrition	-.0881	.2580	.7326
Friction/Shear	1.0243	.2033	< .01
Age x Sensory Perception	-.0377	.0140	.0076
Nutrition x Gender/male	.7203	.3151	.0203
Moisture x Sensory Perception	-.9274	.4774	.0142
Length of Stay x Mobility	-.0041	.0026	.0344
Length of Stay x Nutrition	.0069	.0029	.0342
Constant	-4.5784	.4048	< .01

3.12 Proposed Models

Four different models will be proposed and evaluated in terms of model performance. A full description of each model is presented in Table 19. Variables considered in the model were: age, length of stay, gender/male, and all six subscales of the Braden Scale (sensory perception, moisture, activity, mobility, nutrition, and friction/shear).

Age, a significant factor in both univariate and multivariate analysis of the current study and strongly supported by the research literature as a significant

factor associated with ulcers, was included in each of the proposed models.

There is also evidence in the research literature to suggest that mobility, nutrition and moisture are important factors related to pressure ulcers. Because these variables are considered biologically important they will be included in each of the proposed models.

Only a few studies have reported friction and shearing forces to be related to pressure ulcers. [56,69-72] In the current study friction/shear was a significant factor in both univariate and multivariate analysis (Tables 3 &17). Therefore, it was included in each of the proposed models.

Various combinations of all five interactions in the current study were included in each of the proposed models; age and sensory perception, gender/male and nutrition, moisture and sensory perception, length of stay and mobility, and length of stay and nutrition. According to the Hierarchy Principle[62] main variables must be included in the model when interactions involving them are statistically significant. Therefore the corresponding interactions were included only when the main variables were included in the model. For example when length of stay was included in the model both interactions that included length of stay were also be included (mobility and nutrition).

Only a few researchers have tested the effects of activity, as defined by Braden and Bergstrom,[17] with pressure ulcers and the results are inconclusive.[67,71] Although in the current study activity was a significant factor in univariate but not in multivariate analysis (Tables 3 & 18) further testing is

needed to investigate the relationship of activity with other variables. Some models included activity and others excluded it.

The effect of length of stay and pressure ulcers has been poorly studied and findings conflict. Studies report both an increase in ulcers with short hospital stays[34,60] and an increase with extended hospital stays (number of days not specified in both studies).[31,40] Although in the current study length of stay was not significant in multivariate analysis (Table 17), significant interactions were observed (Table 18). Further evaluation will be important to gain a better understanding of the relationship of length of stay and pressure ulcers with other variables. Some models included this variable and others excluded it. Variables included in the proposed models are presented in Table 19.

Table 19.
Variables Included in the Proposed Models

Variable	Model 1	Model 2	Model 3	Model 4
Age	✓	✓	✓	✓
Gender/male	✓	✓	✓	✓
Length of Stay	✓		✓	
Sensory Perception	✓	✓	✓	✓
Moisture	✓	✓	✓	✓
Activity			✓	✓
Mobility	✓	✓	✓	✓
Nutrition	✓	✓	✓	✓
Friction/Shear	✓	✓	✓	✓
Age x Sensory Perception	✓	✓	✓	✓
Nutrition x Gender/male	✓	✓	✓	✓
Moisture x Sensory Perception	✓	✓	✓	✓
Length of Stay x Mobility	✓		✓	
Length of Stay x Nutrition	✓		✓	

3.13 The Hierarchically Well Formulated Model

Of the four models presented, the best model appears to be Model 2 (7 main variables, activity and length of stay excluded, and 3 interactions), Table 20. The main variables were age, gender, sensory perception, moisture, mobility, friction, nutrition, and shearing forces. Three interactions, two negatively associated, age and sensory perception, and moisture and sensory perception, and one positively associated, nutrition and gender/male were also found to be associated with ulcers. Activity was excluded because it was found to be statistically not significant. Also when added to Model 2, activity was not

significant (-2 log likelihood=1247.31, goodness of fit=1992.94, model chi-square improvement=.61, df=1, p=.44) and therefore did not contribute to the performance of the model. Since there is also a consistently high proportion of correctly classified patients when activity is excluded, we can conclude that there is no need to control for the effects of activity.

Table 20. The Hierarchically Well Formulated Model

Variable	Odds Ratio	95% CI: Lower	95% CI: Upper
Age			
Sensory Perception, not a deficit	1.03	1.0146	1.0367
Sensory Perception, deficit	.99	.9662	1.0153
Gender/Male			
Nutrition, not a deficit	1.32	.9049	1.9154
Nutrition, deficit	2.58	1.6115	4.1421
Sensory Perception			
Moisture, not a deficit	34.37	5.2340	225.6570
Moisture, deficit	10.65	1.5375	73.7938
Moisture			
Sensory Perception, not a deficit	1.72	1.1067	2.6860
Sensory Perception, deficit	.53	.2443	1.1687
Mobility	1.36	.9073	2.0313
Nutrition			
Female	1.17	.7410	1.8412
Male	2.29	1.5238	3.4480
Friction/Shear	3.02	2.1051	4.3337

Length of stay was excluded from the final model for several reasons. It was found to be not significant in Model 1, p=.26 and in Model 3, p=.24. When added to Model 2 it was also found to be not significant (-2 log likelihood=1243.39, goodness of fit=1990.42, model chi-square improvement=.06, df=1, p=.80). Although length of stay was a confounding variable (changes > 10% in the coefficients for mobility and nutrition were

observed when the main variable length of stay, and the interactions, length of stay and mobility, and length of stay and nutrition were deleted; Models 2 and 4), it provided limited information. Length of stay data revealed the number of days from the time of hospital admission to the study date. With this information we were only able to determine whether patients had acquired ulcers or were ulcer free on the study date. Therefore it did not provide the number of days from hospital admission to the time when patients acquired pressure ulcers. For these reasons it seems most reasonable to exclude it from the final model. In accordance with HWF model, deleting length of stay also required that interactions including length of stay must be deleted; length of stay and mobility, and length of stay and nutrition. A description of model variables will be presented.

3.13.1 Age

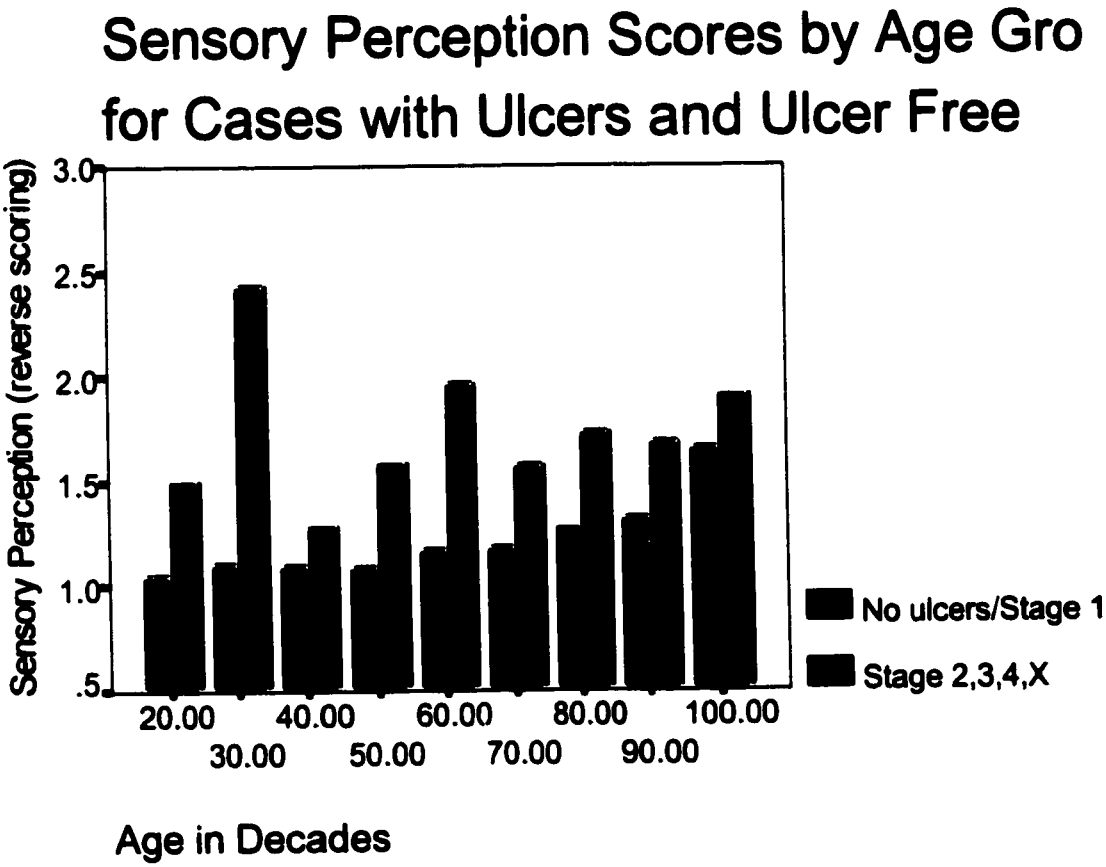
Age was found to be a highly significant variable in the model ($p < .01$). The odds of having a pressure ulcers increased with age. The coefficient for age (.0253) and its odds ratio (1.03) correspond to a 1 year increase in age.

When sensory perception was not a deficit with age there was a significant positive relationship of age with pressure ulcers as given by the odds ratio (OR=1.03) and 95% confidence intervals (1.0146-1.0367) which excluded one. However when sensory perception was a deficit the relationship of age with pressure ulcers was not significant (95% CI included 1).

As displayed in Figure 7 subjects with increasing age who were ulcer free had higher mean sensory perception scores reflecting more severe deficits

(reverse scoring). Interestingly, younger ulcer subjects (30 & 60 years) had more impairments compared to older subjects with ulcers. Ulcer subjects consistently experienced more severe sensory perception impairments compared to ulcer free subjects in all age groups.

Figure 7.



3.13.2 Gender

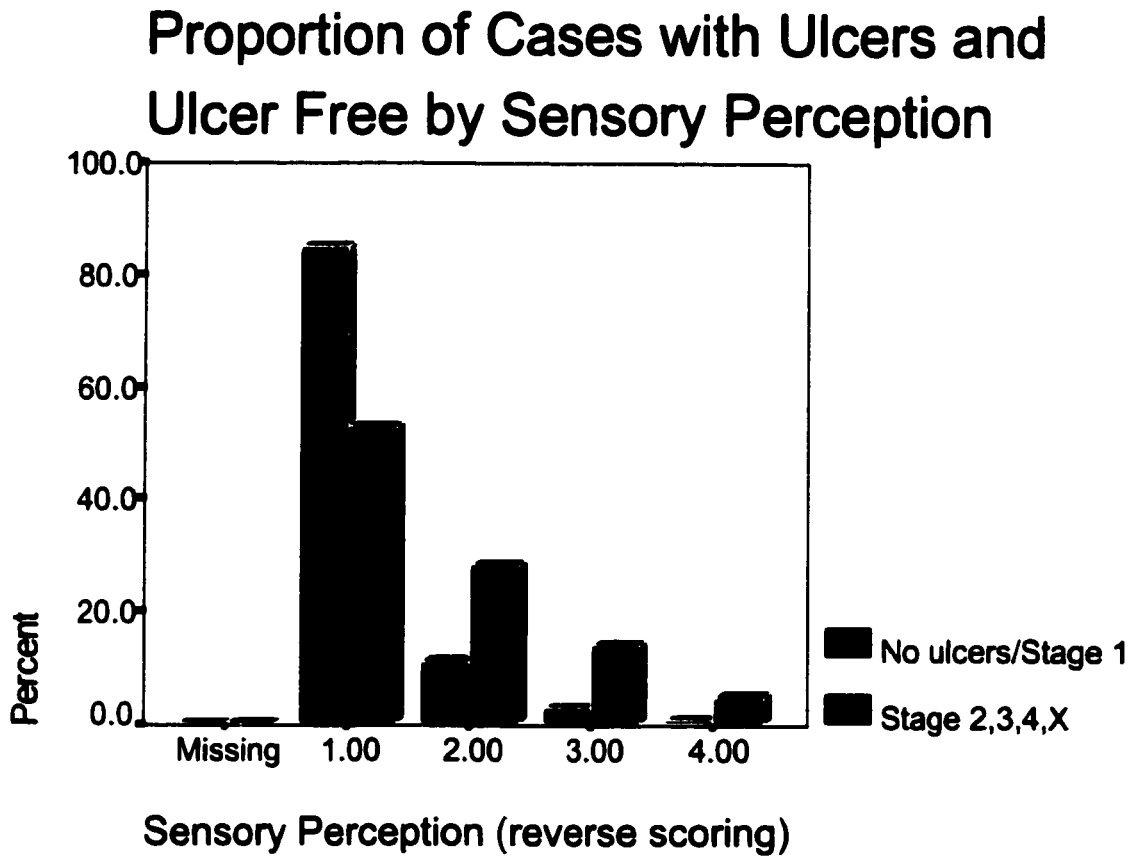
There was a significant relationship between male gender and pressure ulcers when nutrition was a deficit (OR=2.58, 95% CI: 1.6115-4.1421). The odds of having a pressure ulcer increased 2.6 times for male subjects with nutritional deficits compared to male subjects without nutritional deficits. When nutrition was not a deficit with male gender, the relationship with pressure ulcers was not significant (95% CI included 1).

3.13.3 Sensory Perception

There was a very significant positive relationship of sensory perception deficits with pressure ulcers. The interaction of sensory perception with moisture was such that when moisture was not a problem the relationship of sensory perception to pressure ulcers was greater than when moisture was a problem. The odds of having a pressure ulcer largely increased, 34 times, for those subjects with sensory perception deficits when moisture was not a problem (OR=34.37, 95% CI: 5.2340-225.6570). In the presence of moisture the odds increased 10 times (OR=10.65, 95% CI: 1.5375-73.7938).

A consistently higher proportion of subjects with ulcers (reverse scoring), compared to subjects without ulcers, experienced limitations in their ability to respond meaningfully to pressure-related discomfort. Figure 8 presents the proportion of subjects with ulcers and ulcer free by mean sensory perception score (reverse scoring). As expected a high proportion of ulcer free subjects were found to have no impairments.

Figure 8.



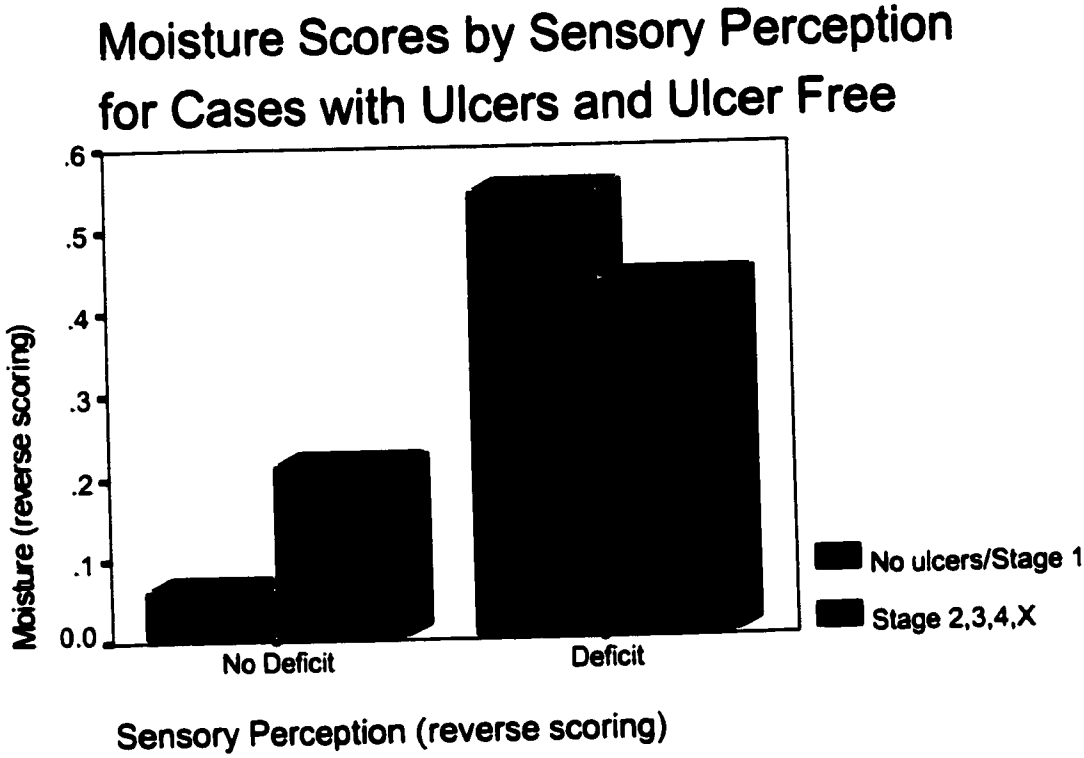
3.13.4 Moisture

The odds of having a pressure ulcer were almost double (OR=1.72, 95% CI: 1.1067-2.6860) for those subjects with moisture problems when sensory perception was not a deficit, Figure 9. When sensory perception was not a problem there was a significant positive relationship between moisture and pressure ulcers. When sensory perception was a problem the relationship with pressure ulcers was not significant (95% CI included 1).

Ulcer free subjects with sensory perception impairments had more

moisture problems compared to ulcer subjects with sensory perception impairments.

Figure 9.



3.13.5 Mobility

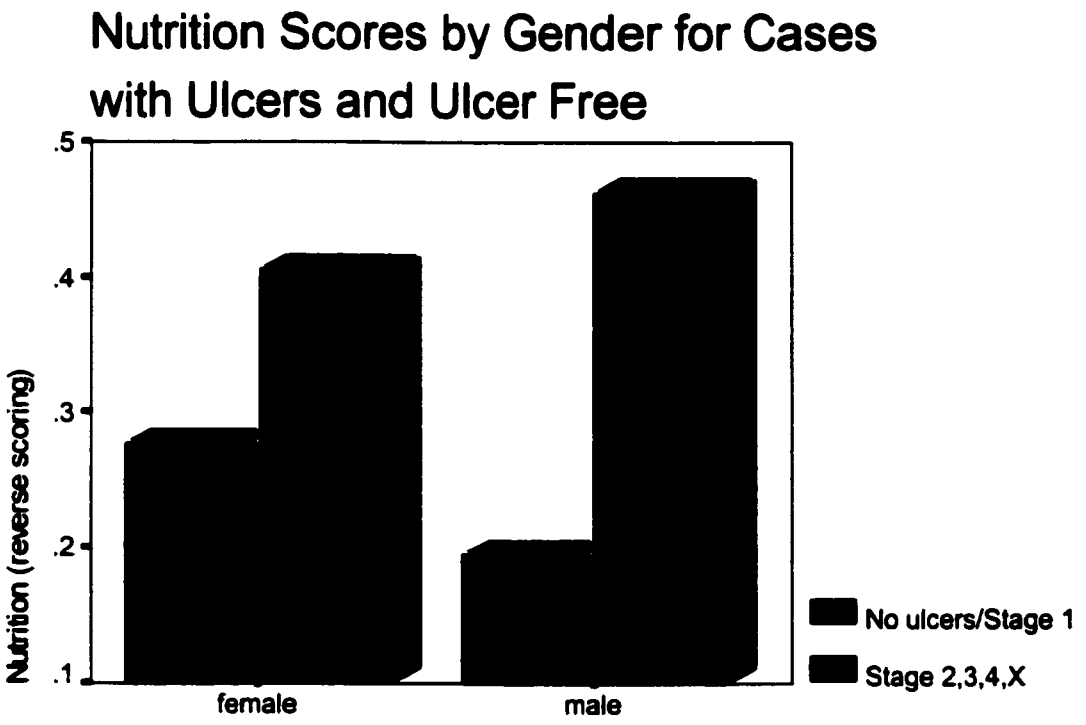
There was no significant relationship between mobility and pressure ulcers (95% CI included 1). No interactions were found.

3.13.6 Nutrition

For female subjects the relationship of nutritional deficit with pressure ulcers was not significant (OR=1.17, 95% CI: 1.5238-3.4480)(95% CI included 1). However for male gender there was a significant relationship with nutritiona

deficits (OR=2.29 95% CI: 1.5238-3.4480). The odds of having a pressure ulcer were more than double for male subjects with inadequate to poor nutritional status compared to female subjects (Figure 10).

Figure 10.



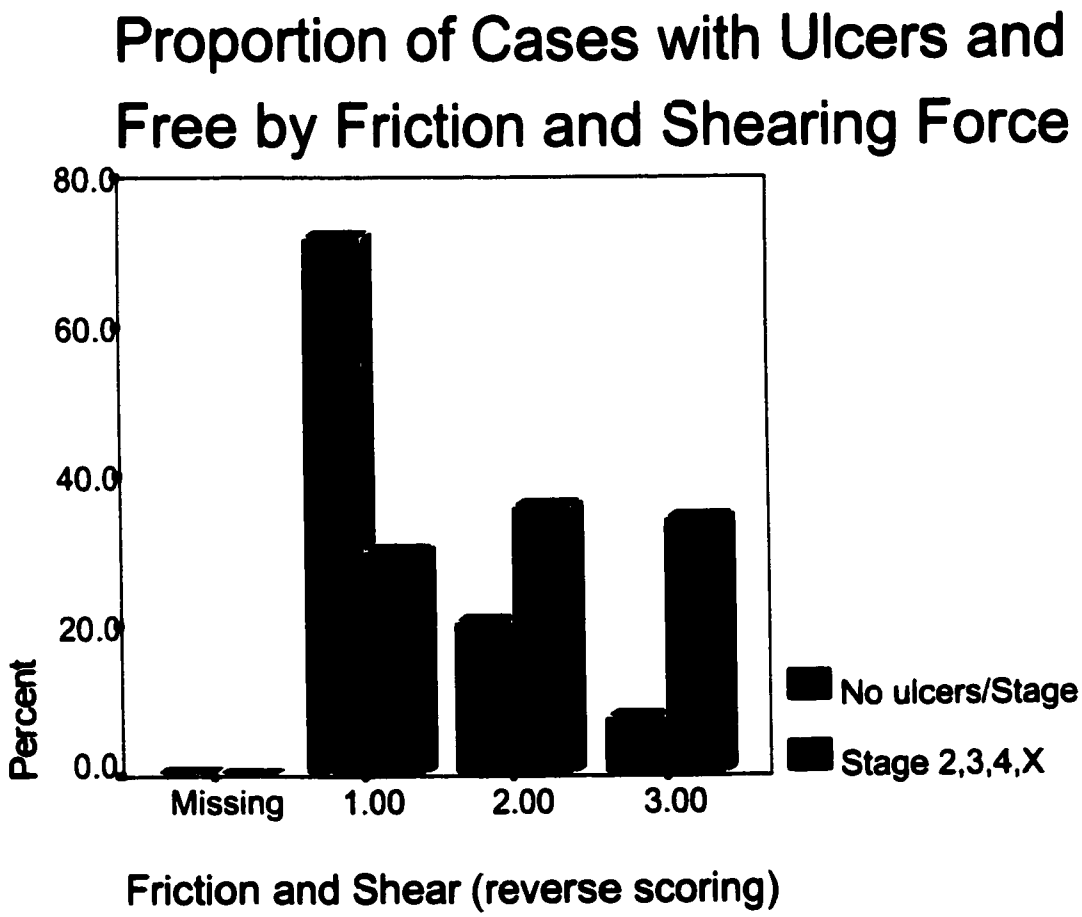
Male subjects with ulcers were found to have more problems regarding nutritional status (reverse scoring) compared to female subjects with ulcers. However, female ulcer free subjects were found to have more impairment compared to male ulcer free subjects.

3.13.7 Friction and Shear

There was a significant relationship between friction and shearing forces and pressure ulcers. The odds of having a pressure ulcer increased by 3 timesfor those subjects with deficits related to friction and shearing (OR=3.02,

95% CI: 2.1051-4.3337). Consistently higher proportions of subjects with ulcers (reverse scoring of variables), compared to subjects without ulcers, experienced problems in moving independently resulting in friction and shearing forces, Figure 11. Once again, as expected a high proportion of ulcer free subjects were found to have no impairments.

Figure 11.



3.14 Model Validation

3.14.1 Comparison of Derivation And Validation Sample

The characteristics of the derivation (Tables 4-7, Figures 3-6) and validation samples (Tables 21 -24, Figures 12-15) were similar with the exception of age.

There were no statistical differences observed between the derivation and validation sample for gender (chi-square=.889, df=1, p=.35). Subjects were divided evenly between males and females, and the proportion of subjects with ulcers was also similar (Figures 5 and 14).

There were no statistical differences observed between the derivation and validation sample for sensory perception (chi-square=1.07, df=1, p=.35), moisture (chi-square=1.07, df=1, p=.342), activity (chi-square=.56, df=1, p=.45), mobility (chi-square=.03, df=1, p=.86), nutrition (chi-square=.46, df=1, p=.50), and friction/shear (chi-square=.09, df=1, p=.76). For all subjects the mean scores for each of the Braden subscales were very similar, and the median scores were exactly the same in both samples (Tables 5 and 22). A comparison of ulcer free subjects to subjects with ulcers by Braden subscale also revealed similar results in the derivation and validation sample (Figures 6 and 15) with the exception of higher proportions in the first category (impairments) in the derivation sample.

In both samples, subjects with ulcers and more severe deficits were observed to have higher proportions of ulcers (Tables 7 and 23). Similarly, ulcer free subjects were observed to have higher proportions of no deficits as compared to subjects with ulcers.

Compared to the derivation sample the mean and median age for all subjects in the validation sample was slightly higher, by several years, as compared to subjects in the derivation sample (Tables 4 and 22). The mean age of subjects with ulcers was also slightly higher in the validation sample as compared to the mean age of subjects with ulcers in the derivation sample (Tables 6 and 24). In the validation sample the highest proportion of subjects (23.9%) with ulcers was found among the subjects who were age 81 and older, with a slightly lower proportion in this age group observed in the derivation sample (16.6%)(Figures 3 and 12). Statistical differences were found between the derivation and validation sample for age (paired t test, t=-3.42, df=70, p <.01)

There were no statistical differences observed between the derivation and validation samples for length of stay (paired t test, t=1.68, df=70, p=.10). Although the mean and median length of stay for all subjects (Tables 4 and 22) was similar in the derivation and validation samples, the mean and median length of stay was slightly longer (2 days) among subjects with ulcers in the validation sample (Tables 6 and 24). A slightly higher proportion of subjects with ulcers were observed in the second month and third month period of the

validation sample (validation: 42.4 and 35.7; and derivation, 30.6 and 20.8).

The goodness of fit test for both the derivation sample, .76 (chi-square=4.98, df=8) and the validation sample, .79 (chi-square=4.70, df=8) indicated that the model was well calibrated and a good fit.

Table 21.
Characteristics of all Subjects in the Validation Sample

Characteristic	Validation Sample (n=581)
Age (years)	
Mean	65.8
SD	16.6
95%CI:	64.5-67.2
Median	69
Range	18-104
Gender	
% Male	49.2%(n=286)
Length of Stay (days)	
Mean	27.6
SD	67.0
95% CI:	22.18-33.10
Median	6
Range	0-559

Table 22.
Braden Subscale Scores in the Validation Sample

Subscale	Mean	SD	95% CI	Median
Sensory Perception	3.76	.57	3.72-3.81	4
Moisture	3.55	.83	3.48-3.62	4
Activity	3.08	.99	3.00-3.16	3
Mobility	3.40	.87	3.33-3.47	4
Nutrition	3.19	.94	3.11-3.27	3
Friction/Shear	2.51	.71	2.45-2.57	3

Figure 12.

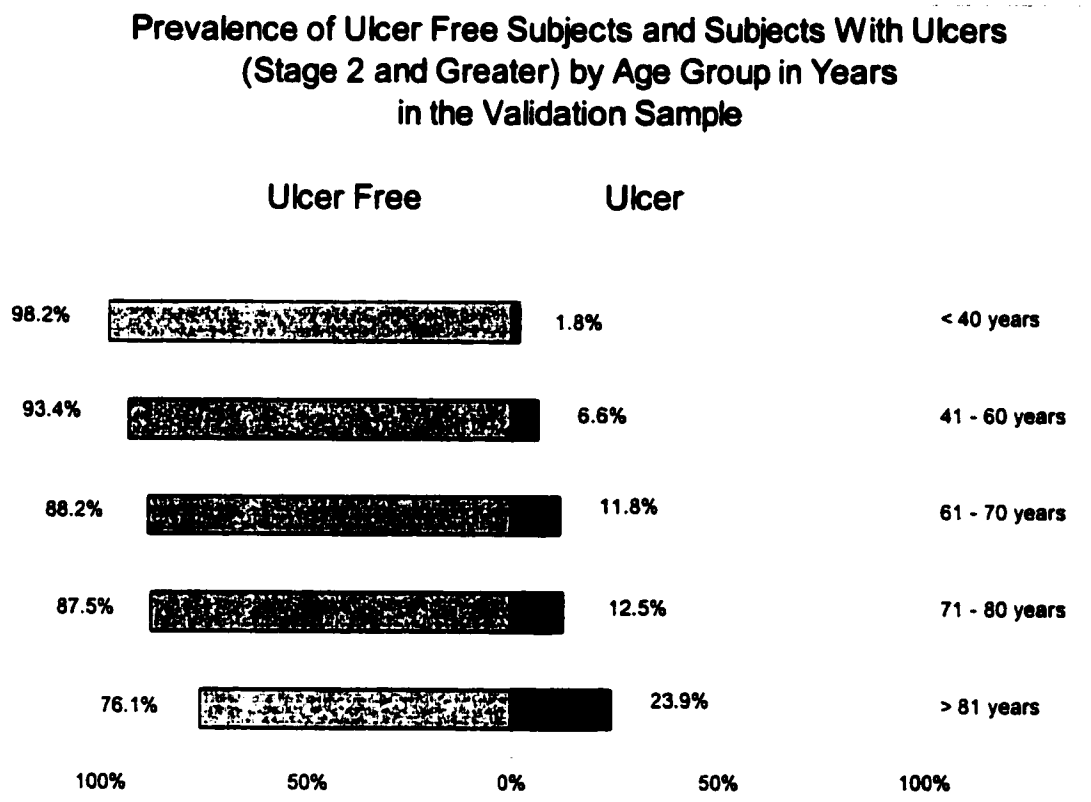


Table 23.
Comparison of Demographic Characteristics Among Ulcer Free Subjects and Subjects with Ulcers (Stage 2 And Greater) in the Validation Sample

Subjects	Age (years) Mean(SD)	Age Median	Age Range	Length of Stay (days) Mean (SD)	Length of Stay Median	Length of Stay, Range
Ulcer Free (510)	64.74(16.67)	68	18-104	26.02(69.12)	5	0-559
Ulcer (71)	73.77(13.29)	76	32-97	39.31(47.71)	23	0-254

Figure 13.

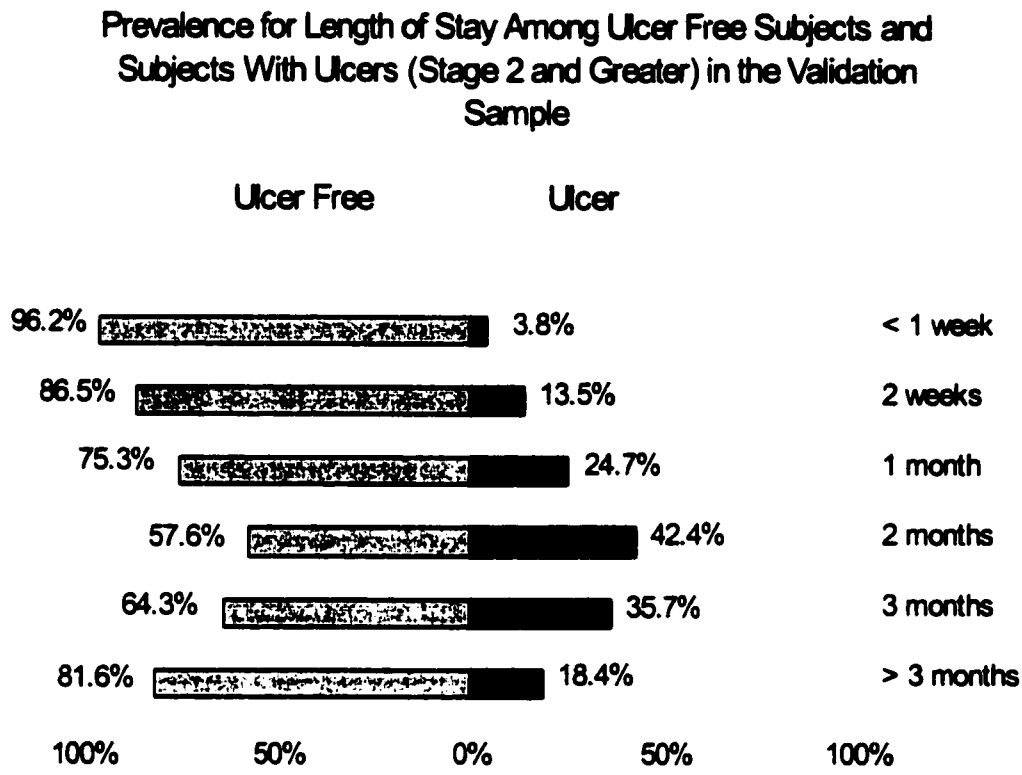


Figure 14.

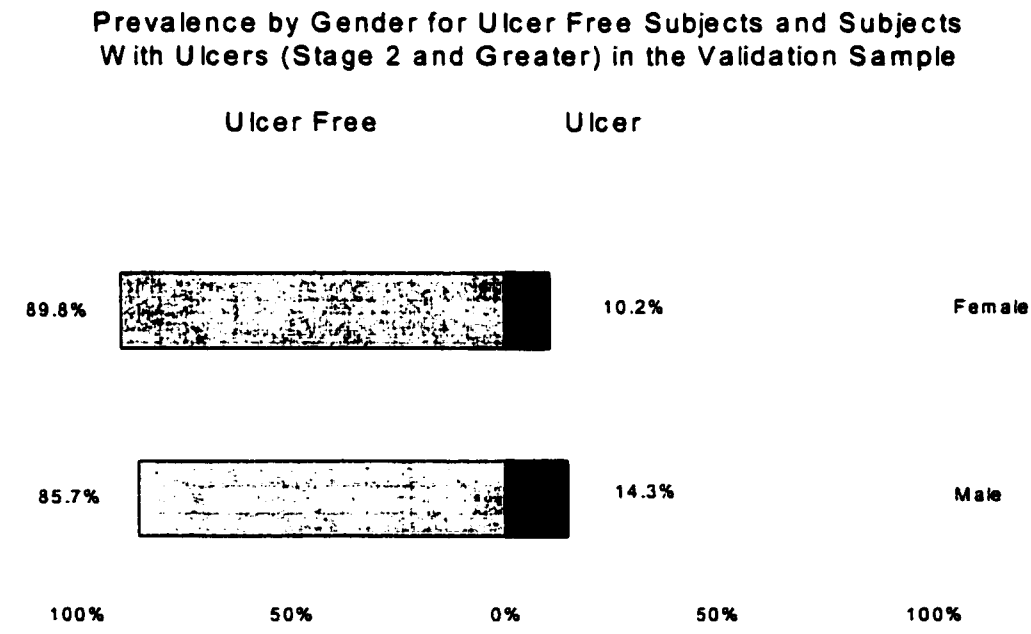
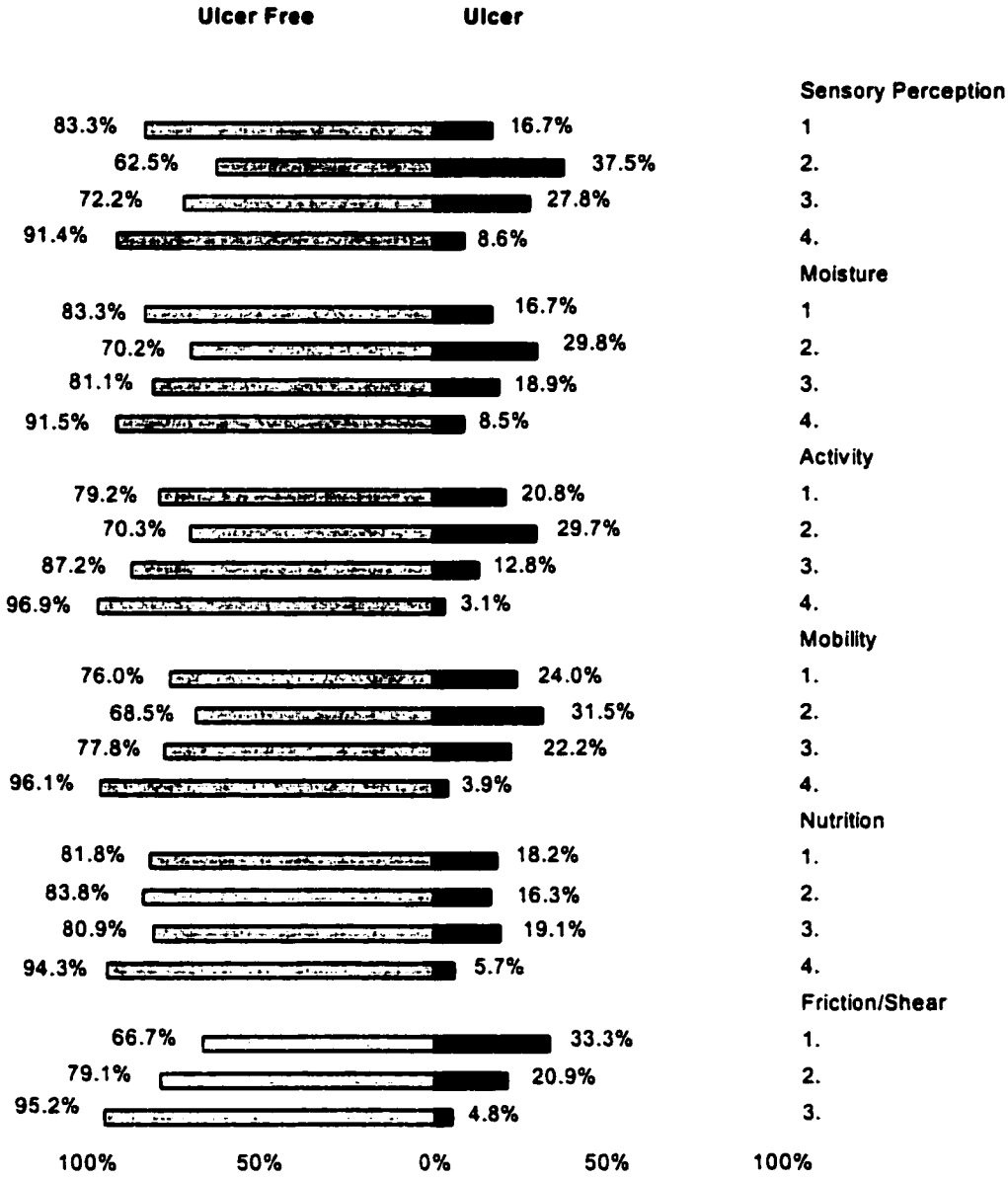


Figure 15.

Prevalence of Ulcer Free Subjects and Subjects With Ulcers (Stage 2 and Greater) by Braden Scores in the Validation Sample [1,2]



1. Percentages do not add to 100% because of rounding error
2. A full description of each category is listed in Appendix B

Table 24.
Braden Subscale Mean Scores by Ulcer Status in the Validation Sample

Variable	Mean Ulcer Score	SD	Mean Ulcer Free Score	SD	p-value
Sensory Perception	3.42(71)	.77	3.81(510)	.52	< .01
Moisture	3.15(71)	.98	3.61(510)	.79	< .01
Activity	2.38(71)	.88	3.18(509)	.96	< .01
Mobility	2.70(71)	.88	3.50(510)	.82	< .01
Nutrition	2.82(71)	.92	3.24(510)	.93	< .01
Friction/Shear	1.90(71)	.78	2.60(510)	.66	< .01

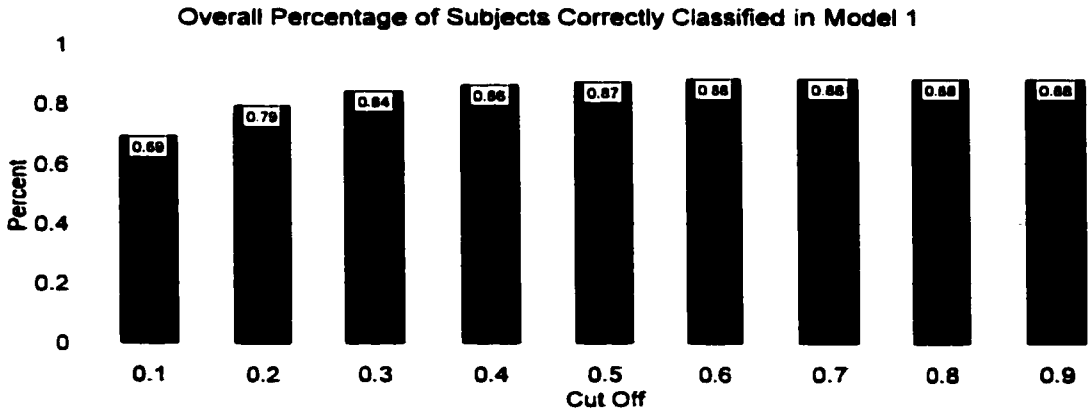
3.14.2 External Model Validation.

The external validation sample consisted of the 1996 OHCC Prevalence Study Population. The beta coefficients from the derivation model were applied to the validation sample.

Model One

The model performed well using a cut off of .6-.9, the overall percentage of subjects correctly classified was 88% (Figure 16).

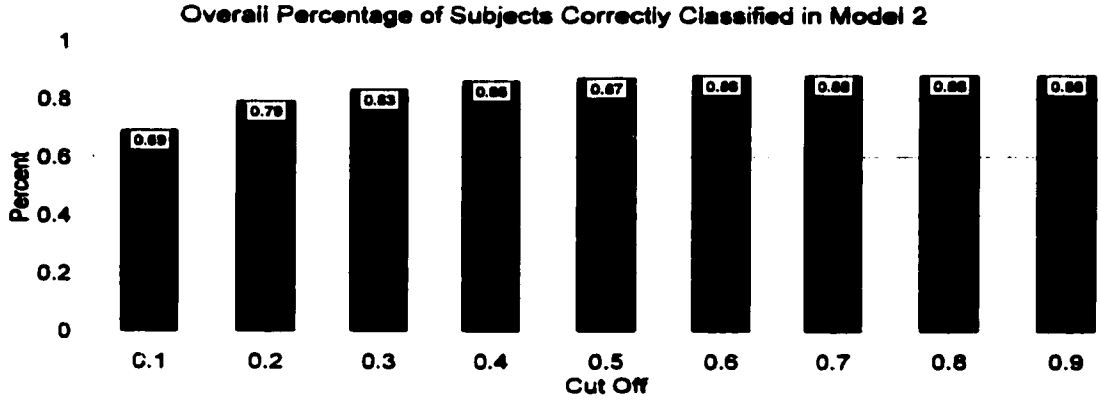
Figure 16.



Model Two.

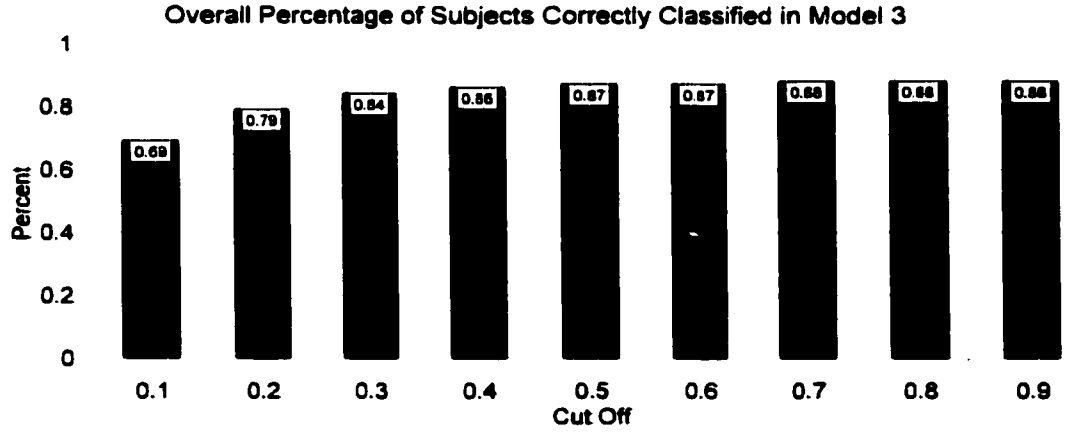
The overall percentage of subjects correctly classified was 88% using a cut off of .6-.9 (Figure 17).

Figure 17.



Model Three

Figure 18.



The model performed well using a cut off of .7-.9, the overall percentage of subjects correctly classified was 88% (Figure 18).

Model Four.

The model performed well using a cut off of .6-.9, the overall percentage of subjects correctly classified was 88% (Figure 19). Findings were consistent in all four models.

Figure 19.

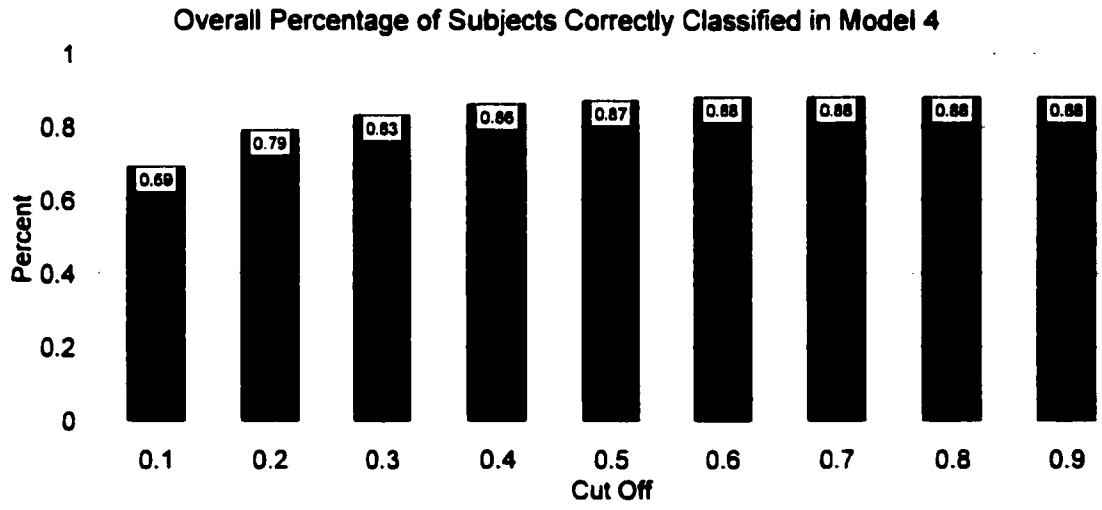
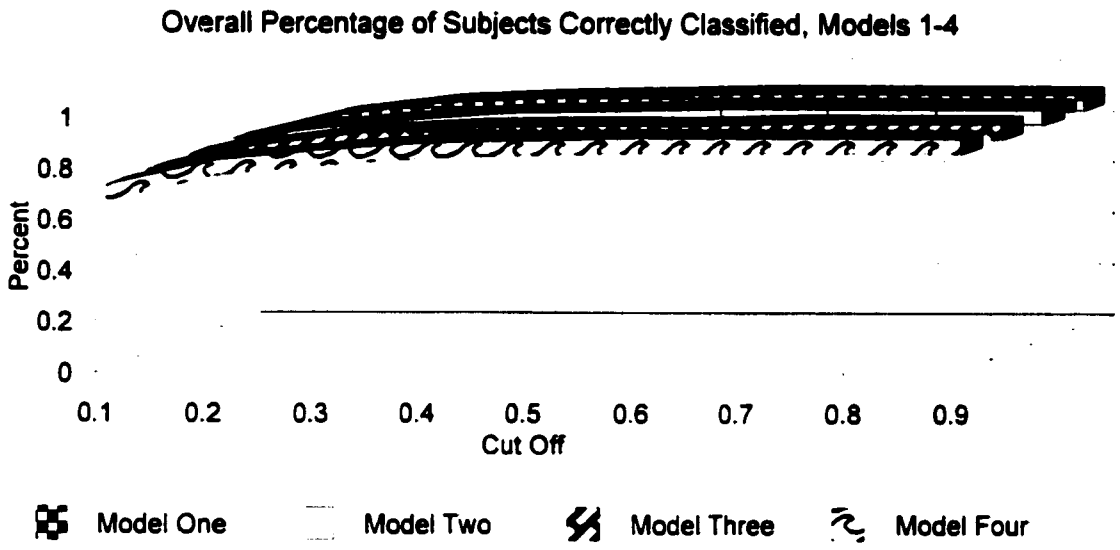


Figure 20.



The overall proportion of subjects correctly classified varied very little between models (Figure 20). Findings were also similar to the overall proportions observed in the derivation sample, 88%.

4.0 Discussion

4.1 Prevalence Study

Study data identified that pressure ulcers are a serious problem in hospitals. The prevalence of Stage 2 and greater ulcers in the current study (14.7% in 1993; 10.4% in 1994; 11.7% in 1995; and 12.2% in 1996) is consistent, although slightly higher, with other reported studies of prevalence among hospitalized patients, which ranged from 3.0% to 11.0%.[11] Study findings suggested that based on specific chart notations, 21% of patients with ulcers had acquired them prior to hospital admission.[10] A slight decrease in the 1994-96 rates, as compared to 1993 rate, may be explained by an increased awareness from year to year, among nurses and other professional and support staff at OHCC, of ulcers and prevention strategies.

Despite the implementation of effective prevention programs,[70,73-76] published reports over the last two decades provide little evidence to suggest a decrease in the overall prevalence and incidence of ulcers.[11] This is partly explained by an aging population, as older adults are often more acutely ill and considered more at risk for ulcers. In the current study, the average age of patients (derivation sample) was 62.5 years and the median age was 66. The prevalence of subjects with ulcers was 31.1% among subjects 71 years of age and older. This finding is consistent with another Canadian study that reported an average age of 67 years.[9] Meehan[5] reported that patients between the ages of 70 and 89 had 54% of the ulcers found.

4.2 Braden Scale

A key strength of the current study, as compared to most of the reported studies, is the rigorous method in which data were collected. Dedicated and specially trained survey teams of registered nurses conducted head-to-toe skin assessments and administered the Braden Scale as opposed to on duty hospital staff. Nurses were trained in an educational workshop that included an orientation to the study purpose and procedures, the use of data collection instruments, and a theoretical and practical component to stage ulcers and conduct risk assessments.[10] The training films developed by Bergstrom and Braden were also included in the workshop. The prospective nature of the study methodology helped to avoid inherent problems with chart audits. Agreement of the assessment of the survey team and validation team indicated a strong association between assessments, $r = .87$ using Pearson's product moment correlation.

Similar studies using rigorous data collection methods have been conducted by Braden, Bergstrom, and colleagues.[16-18,33,34,77] Limitations of these studies are addressed in the current study; exclusion of Stage 1 ulcers, description of the scoring method used for ulcers with eschar, evaluation of model performance using an independent sample, and testing for the presence of interactions and confounding variables.

The AHCPR[2] recommended Braden Scale, which includes 5 of the variables in the model, is a standardized tool to measure risk, is easy to use,

and has gained wide acceptance by health care professionals. A limited number of studies have reported using standardized tools such as the Braden Scale to collect data prospectively. The accuracy of the data in the current study is another strength compared to other studies. Information collected from clinical data bases and chart reviews, or subjectively reported by hospital staff is questionable in many of the reported studies.

Although researchers initially only tested and utilized the total Braden score, [32,34,37,52,54] efforts have been more recently directed at evaluating subscale levels. The current study demonstrates that each of the six subscales does not contribute equally in determining the magnitude or severity of risk. The accuracy of total score level is continuing to be evaluated in various populations as recommended by AHCPR[2] and the developers. Given the difficulties of establishing the accuracy in settings dealing with multiple and mixed populations in large tertiary teaching facilities, settings similar to the OHCC, and the clinical usefulness of planning interventions by specific deficit, recently efforts have turned to evaluating subscale levels.[10,33] To implement evidence based practice in pressure ulcer prevention, providers need to establish policy and protocols that respond to deficits at the subscale level. This research adds greatly to the knowledge of the relationship of factors associated with ulcers and to the use and relative importance of particular subscales.

4.3 Factors Included In The Model

Only recently has the contribution of the individual subscales and the

relationship with ulcers been evaluated using univariate analysis[56,70,78] and multivariate analysis.[40,56] Studies conducted by Braden and Bergstrom entered total Braden scores into the model fitting procedure and not subscale scores, therefore making comparison of individual subscales impossible.[33,34]

Logistic regression modeling indicated that age, gender/male, sensory perception, moisture, mobility, nutrition, and friction and shearing forces were associated with pressure ulcers in hospitalized adult pateitns. Three interactions, two negatively associated, age and sensory perception, and moisture and sensory perception, and one positively associated, nutrition and gender/males, were also found to be associated with pressure ulcers. These factors provide a profile to describe the characteristics of adult hospitalized patients with ulcers.

4.3.1 Age.

Age was found to be a highly significant variable in the model when sensory perception was not a deficit. On a per year basis the OR=1.03 (95% CI: 1.0146-1.0367). When sensory perception was a deficit the relationship of age with pressure ulcers was not significant. Findings suggested that patients were more likely to have pressure ulcers as they grew older. This finding is consistent with other studies that report older age to be associated with pressure ulcers.[33-37,43,51,56,73,79,80]

This is also the first reported study to test for the presence of confounding variables. Age was found to be a confounding variable with moisture and length

of stay when comparing subjects 0-70 and > 70 years. The confounding effects of age were controlled by retaining it in the model.

In the interaction between age and sensory perception, subjects with increasing age who were observed to have ulcers experienced more severe sensory perception impairments compared to ulcer free subjects. However, younger subjects with ulcers had more impairments compared to older subjects with ulcers. Impairments had greater effect with increasing age among the ulcer free subjects compared to ulcer subjects. From a clinical perspective this finding is very important and suggests that programs aimed at prevention are critical at the time of hospital admission for young populations with sensory perception impairments.

As expected the mean age of subjects in the ulcer group of the derivation sample was statistically significantly higher ($p < .01$) than the mean age of the ulcer free subjects (69.8 years, SD=16.0 and 61.4 years SD=17.5). Similarly, the mean age of the subjects in the ulcer group of the validation sample was also significantly higher ($p < .01$) (73.8 years, SD=13.3 and 64.7 years SD=16.7). These findings help to further support the earlier statement that hospitalized patients with ulcers are older and more acutely ill.

4.3.2 Gender.

Male subjects had a higher prevalence of ulcers (14.5%) as compared to female subjects (10.3%). There was a significant relationship between male gender and pressure ulcers when nutrition was a deficit, OR=2.58 (95% CI:

1.6115-4.1421). The odds of having a pressure ulcer increased 2.6 times for male subjects with nutritional deficits compared to male subjects without nutritional deficits. The relationship was not significant when nutrition was not a deficit with male gender.

Although there are no studies reporting similar findings, two studies using multivariate analysis[33,79] reported that gender was not a significant factor. However being male has been reported to be a statistically significant factor in three large scale studies using multivariate analysis.[29,42,43] This finding is rather interesting, and difficult to explain, as males generally have better tissue tolerance than females due to their muscle mass and anabolic hormones.[33]

4.3.3 Sensory Perception.

In the model OR=34.37 (95% CI: 5.2340-225.6570). There was a very significant positive relationship between sensory perception deficits and pressure ulcers. The interaction of sensory perception with moisture was such that when moisture was not a problem the relationship of sensory perception to pressure ulcers was greater than when moisture was a problem. The odds of having a pressure ulcer increased 34 times for those subjects with sensory perception deficits when moisture was not a problem. The odds increased 10 times in the presence of moisture (OR=10.65, 95% CI: 1.5375-73.7938).

This is a major finding of the current study. No other studies have reported such a highly significant relationship between sensory perception and pressure ulcers. Future investigations will be important to explore and further

evaluate these important findings.

Research concerning sensory perception and pressure ulcers has been limited. In another study, Jiricka and colleagues[40] found a significant difference between intensive care patients with and without skin breakdown when using two of the Braden subscales, sensory perception (OR=2.01, 95% CI: 1.14-3.56) and moisture (OR=4.61, 95% CI: 1.70-12.52).

Patients with sensory perception impairments have diminished ability to perceive pain or discomfort and to respond purposefully by changing position or seeking assistance in changing position.[17] This loss of sensation interferes with the perception of pain and the cue to shift weight is not present.[79] Without assistance or reminders to shift body weight and change position, patients are at risk for pressure ulcers. Sensory perception impairments are very common in hospitalized patients, particularly those with spinal cord injuries, stroke, receiving sedation or with decreased level of consciousness i.e. trauma, coma, shock.

Early assessment and preventive care for patients with sensory perception impairments is critical to address this problem. Findings from this study lend strong support to the accepted standard practice of turning patients not able to turn themselves, frequently, a minimum of once every 2 hours.

Table 25 presents a comparison among several studies of mean sensory perception scores for ulcer and ulcer free subjects using the Braden Scale. Using the t-test, sensory perception scores were identified to have a significant

difference between ulcer and ulcer free subjects in each of the studies excluding the study conducted by Goodridge and colleagues.[78] However, in this study statistical significance should be interpreted with caution due to the small number of ulcer subjects (n=32). Overall, the results are very similar except that the mean score for ulcer subjects was slightly lower in one study.[70] The Pieper result is the exception and the difference is difficult to explain, as the study population was very similar to the current study with the exception of 26 subjects from a home health agency.

Table 25. Comparison of Mean Sensory Perception Scores by Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	3.29	.88	1,743	3.80	.52	< .01
Validation	71	3.42	.77	510	3.81	.52	< .01
Pieper et al. 1998	71	2.7	.90	662	3.7	.60	<.05
Tourtual et al. 1997, 1st	56	3.38	.68	153	3.77	0.53	.0001
Tourtual et al. 1997, 2nd	63	3.56	.76	228	3.79	.51	.03
Goodridge et al. 1998	32	3.6	NR	298	3.7	NR	0.61

NR - not reported

4.3.4 Moisture.

In the model the OR=1.72 (95% CI: 1.1067-2.6860). When sensory perception was not a problem there was a significant positive relationship between moisture and pressure ulcers. The odds of having a pressure ulcer

were almost double for those subjects with moisture problems when sensory perception was not a deficit.

The impact of sensory perception on moisture with pressure ulcers was similar to its effect on the relationship of age with pressure ulcers. When sensory perception was not a problem there was a significant positive relationship between moisture and pressure ulcers. When sensory perception was a problem the relationship with pressure ulcers was not significant (OR=.53, 95% CI: .2442-1.1687)(CI included 1).

In the current study ulcer free subjects with sensory perception impairments experienced more moisture problems compared to ulcers subjects with sensory perception impairments. This finding is rather unexpected as we would expect ulcer subjects with sensory perception impairments to have more moisture problems compared to ulcer free subjects with sensory perception impairments. Perhaps more preventative measures to address the problems related to moisture were in place for ulcer subjects compared to ulcer free subjects with sensory perception impairments.

This result is consistent with findings reported in several studies using multivariate analysis which reported fecal and/or urinary incontinence as a significant factor associated with ulcers.[23,29,40,42,43,56] However, it is interesting to note that the findings in the current study were not consistent with several other multivariate studies that did not report moisture to be a significant factor associated with pressure ulcers.[45,59,80] Perhaps, these differences may be

explained by the various types of study designs and methods used to collect information about different sources of moisture. It is possible that patients with moisture problems received preventive care which may have actually stopped some ulcers from developing.

In the moisture component of the Braden Scale, several studies including the current study (Table 26), have reported similar findings. In all of the studies excluding one conducted by Goodridge,[78] mean scores for ulcer subjects were lower and different than mean scores for ulcer free subjects. In this study[78] statistical significance should be interpreted with caution due to the small number of ulcer positive subjects (n=32).

Table 26. Comparison of Mean Moisture Scores by Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	3.09	.98	1,743	3.68	.70	< .01
Validation	71	3.15	.98	510	3.61	.79	< .01
Pieper et al. 1998	71	2.9	.80	662	3.7	0.6	<. 05
Tourtual et al. 1997, 1st	56	3.52	.60	153	3.72	.59	.034
Tourtual et al. 1997, 2nd	63	3.40	.74	228	3.73	.54	.002
Goodridge et al. 1998	32	3.4	NR	298	3.6	NR	0.13

NR - not reported

4.3.5 Mobility.

In the model OR=1.36 (95% CI: .9073-2.0313). There was no significant relationship between mobility and pressure ulcers. This finding contradicts several multivariate studies which cite impaired mobility as a factor related to

pressure ulcers.[23,27,28,45]

Only a few researchers have reported results similar to the current study. Jiricka and colleagues[40] reported that mobility, among intensive care patients, was not a significant predictor of skin breakdown using a stepwise, backward, multiple logistic regression model. In an incidence study of hospitalized elderly patients, Pase[81] found that a significantly greater portion of immobile patients remained ulcer free (chi-square=57.98, $p < .05$) compared to mobile patients. It is possible that in the current study, as well as the studies described above, that some patients with mobility problems received proactive, preventative care which may have actually stopped some ulcers from developing.

In the current study and in several of the other reported studies the mean mobility scores for subjects in the ulcer group were consistently lower and significant in comparison to subjects in the ulcer free group, Table 27.

Table 27. Comparison of Mean Mobility Scores by Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	2.80	1.01	1,743	3.56	.76	< .01
Validation	71	2.70	.88	510	3.50	.82	< .01
Pieper et al. 1998	71	2.1	.90	662	3.4	.8	< .05
Tourtual et al. 1997, 1st	56	2.54	.83	153	3.06	.84	.0001
Tourtual et al. 1997, 2nd	63	2.98	.85	228	3.42	.81	.0001
Goodridge et al. 1998	32	2.9	NR	298	3.4	NR	.0003

4.3.6 Nutrition.

In the model OR=2.28 (95% CI: .1.5238-3.4480). There was a significant relationship between nutrition and male gender. The odds of having a pressure ulcer were more than double for male subjects with inadequate to poor nutritional status compared to female subjects. For female subjects the relationship of nutritional deficit with pressure ulcers was not significant (CI included 1). From a clinical perspective addressing the nutritional needs of male patients is critically important.

Although many studies report that nutrition is a significant factor associated with ulcers.[23,42,45,47,49,50,54,57,69,80] there are no studies that report a significant relationship between male gender and nutrition. Further study is needed to investigate this relationship.

The mean scores among subjects with nutritional problems, as described using the Braden Scale, in both the ulcer and ulcer free group, were slightly higher in the current study as compared to other reported studies (Table 28). This finding indicated that the nutritional status of the study population was slightly better than the nutritional status of patients in the other reported studies. Mean scores between the ulcer and ulcer free group were significantly different in all groups excluding one, the second study conducted by Tourtual.[56]

Table 28. Comparison of Mean Nutrition Scores By Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	2.62	1.07	1,743	3.17	.97	< .01
Validation	71	2.82	.92	510	3.24	.93	< .01
Pieper et al. 1998	71	2.1	.90	662	2.7	.90	< .05
Tourtual et al. 1997, 1st	56	2.18	.79	153	2.46	.91	.032
Tourtual et al. 1997, 2nd	63	2.44	.64	228	2.54	.74	NR
Goodridge et al. 1998	32	2.4	NR	298	2.9	NR	.0003

NR - not reported

4.3.7 Friction and Shear.

In the model OR=3.02 (95% CI: 2.1051-4.3337). There was a significant relationship between friction and shear forces and pressure ulcers. Patients who experienced friction and shearing forces were three times more likely to have ulcers, compared to patients who did not experience friction and shearing forces. No interactions were observed.

Friction and shearing forces are extrinsic factors that diminish the tolerance of the skin to tolerate pressure.[17] It is conceptualized in terms of the individual's ability to assist with movement or to be moved in such a way that the skin is free of contact with the surface of the linen or bedding during movement.[16]

This significant relationship between friction and shearing forces and pressure ulcers is another key finding in the current study. Only a few studies

have reported significant findings associated with friction and shearing forces.[56,69-72] Tourtual and colleagues[56] reported that using logistic regression, in a prospective study, subjects with problems related to friction and shearing ($p=0.01$) forces as described in the Braden Scale were more likely to develop heel ulcers. It is not possible to compare their findings to the current study, as the authors did not report beta coefficients, standard errors, odd ratios, and confidence intervals.

Although increased friction and decreased sensory perception do not appear to be reported often in the literature, they were identified by a group of nurses working in a rehabilitation settings as risk factors related to pressure ulcer formation in a validation study.[72]

Some researchers have found that certain medical diagnoses, such as diabetes mellitus [29,59] and cardiovascular conditions, [45,82] are significant factors associated with ulcers. Impairments in sensory perception and in friction and shearing forces are common conditions for these types of patients. Perhaps medical diagnoses are more a secondary phenomena of ulcer incidence rather than a predisposing factor. If this is true, directly measuring clinical factors, as compared to medical diagnoses, may provide a more accurate measurement of factors associated with skin breakdown.

The mean scores among subjects exposed to friction and shearing forces, as described using the Braden Scale, in the ulcer group, compared to the ulcer free group were, again, very similar with other reported studies, in both

the derivation and validation sample (Table 29). Friction and shearing forces had a significant difference between the ulcer and ulcer free subjects in each of the studies.

Table 29. Comparison of Mean Friction and Shear Scores by Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	1.96	.80	1,743	2.64	.62	< .01
Validation	71	1.90	.78	510	2.60	.66	< .01
Pieper et al. 1998	71	1.6	.6	662	2.6	0.6	< .05
Tourtual et al. 1997, 1st	56	1.89	.56	153	2.42	.61	.0001
Tourtual et al. 1997, 2nd	63	2.10	.63	228	2.50	.65	.0001
Goodridge et al. 1998	32	2.0	NR	298	2.4	NR	.0003

NR - not reported

4.3.8 Interactions.

The current study is only the second one to report significant interaction effects. Three statistically significant interactions were found, two negatively associated with ulcers, age and sensory perception with OR=.99 (95% CI: .9662-1.0153), and moisture and sensory perception with OR=.53 (95% CI: .2443-1.1687), and one positively associated, nutrition and gender/male with OR=2.29 (95% CI: 1.5238-3.4480).

In developing models, very few researchers have tested for the presence of interactions among the variables entered into the model.[23,28,42,59] The selection process used to determine which interactions were considered for entry in the

various models was poorly described. Only one of the four studies reported an interaction effect.[23]

Malkebust and Magnan[23] reported a significant, negative interaction effect (p=.001) between fecal incontinence and impaired mobility (OR=.17, 95%CI: .07-.43). The current study did not report a similar joint effect. While it is difficult to explain this difference, it is important to note that in the study conducted by Malkebust and Magnan, the risk assessment data were not collected using a valid and reliable instrument, but rather were subjectively measured by on duty staff nurses as absent or present. Perhaps the difference in findings can also be partially explained by the fact that the authors included Stage 1 ulcers, whereas the current study and the study conducted by Allman (did not report any significant interactions) excluded them. This difference in findings, combined with the overall lack of information, indicates that more studies are needed to investigate interaction effects among these factors.

4.4 Factor Excluded From The Model

4.4.1 Activity.

Activity was excluded because it was not significant and did not contribute to the performance of the model. In the Model 3 (full model), with all possible variables, the p value was .43. In the current study, activity was a statistically significant factor in univariate but not in multivariate analysis. These results are supported by findings from a similar study (univariate analysis) conducted in a hospital setting.[77] Using an adapted assessment tool developed

by Norton and Gosnell, Pajk and colleagues[77] reported that both impaired activity and impaired mobility were two of the five factors associated with skin breakdown ($p < .01$).

The activity and mobility subscales of the Braden Scale are derived from separate concepts.[17] Mobility, the ability to of an individual to change and control body position, is related to activity.[17] Activity reflects the ability of an individual to remove, by standing or walking, all pressure from skin areas not adapted to weight bearing.[17] Definitions for mobility are often poorly described in the literature and appear to overlap with activity, (less well described) in studies investigating risk factors related to pressure ulcers.

In the current study and in several other reported studies (Table 30), the mean activity scores for subjects in the ulcer group were significant and lower as compared to subjects in the ulcer free group, It is interesting to note that subjects in the current study were more physically active, as reflected in the slightly higher mean scores for both the ulcer and ulcer free subjects, in comparison to the other studies.

Table 30. Comparison of Mean Activity Scores by Ulcer Status

Authors	n	Ulcer, Mean Score	SD	n	Ulcer Free, Mean Score	SD	p-value
Derivation	248	2.48	1.0	1,743	3.22	.96	< .01
Validation	71	2.38	.88	510	3.18	.96	< .01
Pieper et al. 1998	71	1.5	.7	662	2.60	1.0	< .05
Tourtual et al. 1997, 1st	56	1.91	.88	153	2.25	1.09	.021
Tourtual et al. 1997, 2nd	63	1.98	.94	228	2.51	.94	.0001
Goodridge et al. 1998	32	2.3	NR	298	2.8	NR	.0001

NR - not reported

4.4.2 Length of Stay.

Length of stay (in number of days) was a statistically significant factor in univariate but not in multivariate analysis. In the Model 3 (full model) the p value was .24. It was excluded from the model because it was also not significant when added to Model 2 (reduced model).

In accordance with HWF, the two interactions including length of stay, length of stay and mobility, and length of stay and nutrition must also be deleted. Changes (> 10%) in the mobility and nutrition coefficients were observed when these variables were deleted.

Excluding the interaction, length of stay and nutrition (Model 2 and 4), had little impact on changing the statistical significance of nutrition in the model. Nutrition was not significant in all four of the proposed models (p values: Model 1=.80, Model 2=.51, Model 3=.73, Model 4=.57). However nutrition was included

in the final model because it was recognized as being clinically important.

Mobility was found to be significant when the interaction, length of stay and mobility, was included as in Model 1 (p=.02) and Model 3 (p=.03). However it was not significant when the interaction was excluded, Model 2 (p=.14) and Model 4 (p=.23). Mobility was included in the final model because it was also recognized as being clinically important.

Length of stay provided very limited information, the number of days from the time of hospital admission to the study date. Therefore we were only able to determine whether subjects had acquired ulcers or were ulcer free on the study date. Considering all the limitations in using the length of stay variable, it seems most reasonable to not include it in the final model.

Compared to other studies, the mean length of stay was long for subjects with ulcers, 41.4 days (SD=61.8), and for ulcer free subjects it was 25.9 days (SD=77.1). A similar trend was found in the validation sample, the mean length of stay for subjects with ulcers was 39.3 days (SD=13.3) and 26.0 days (SD=69.1) for ulcer free subjects. Pieper and colleagues[70] reported a much shorter length of stay, 19.4 days (SD=13.9) among those subjects with ulcers as compared to 9.8 days (SD=8.2) for ulcer free subjects. Tourtual[56] reported very similar findings to Pieper,[70] 21.4 days (SD=21.7) and 16.7 days (SD=14.3) among subjects with ulcers, and 8.6 days (SD=9.8) and 8.4 days (SD=9.90) for ulcer free subjects. Extended hospital stays in the current study can best be

explained by the fact that the data was cross-sectional, as compared to prospective data, and included all admitted patients, acutely ill and long term care. Long term care patients, awaiting placement in a nursing home, are known to have extended hospital stays if nursing home beds are not available.

4.5 Study Limitations

Cross-sectional studies are useful in that they identify disease associated factors related to pressure ulcers. However cross-sectional analysis identifies factors that may have developed as a result of the disease or developed as a result of the factors. A prospective cohort study in which patients initially free of pressure ulcers are followed is helpful to identify risk factors for the future development of ulcers and to determine causal relationships.

In the current study skin assessments and Braden subscale ratings were assigned by trained nurses who conducted physical assessments, chart reviews, and consulted with on duty nursing staff. The large number of data collectors may have influenced consistency in judgments concerning skin assessments and Braden Scale scores. This strategy was employed to avoid bias and potential errors such as over and under reporting which may have occurred if the nursing staff assigned to units were responsible for reporting to the study team. Although there is always the potential of recording errors and research bias with multiple data collectors, the study design required a research team to be able to collect the data within a specified short period of time.

Missing data posed a minimal threat to validity of the study as only a very

small number of cases were reported to be missing (n=15). Examples of missed data included: administration of life support measures; not able to move due to medical condition i.e. recent spinal cord injury, immediate post-operative case.

Study findings based on specific chart notation suggested that 21% of the patients with ulcers had acquired them prior to hospital admission.[1] It is important to note that among the 21% of patients with ulcers, it is not known how many ulcers were Stage 1 or greater. Validity of the results would be less affected if many of the ulcers were Stage 1 (coded as 0=ulcer free).

Prior to hospital admission patients may have been in the community or in similar acute or chronic care settings. Since community settings and living conditions are different than hospital settings it is possible that some factors associated with ulcers may be different. Little information is available about the factors associated with pressure ulcers in the community.

The Braden Scale is in its early stages of development. There may be factors that influence the intensity and duration of pressure and variables related to tissue tolerance that interact in a manner not yet fully understood.[16] These unknown factors may pose a threat to internal validity of the study. Mental status and knowledge of prevention measures have been poorly studied, and may be possible factors to consider in the design of future studies.

In this study a convenience sample, all patients admitted to the OHCC was used. Although generalizability of findings may be a concern when randomized samples are not used, the design used in this study has been used

consistently by other researchers. Therefore it is reasonable to generalize the findings to other hospitals with overall similar proportions of critical, acute and long term care patients.

Findings suggested that preventative measures may have already been in place for some patients. Ethically it would not have been appropriate to discontinue or change practice.

Moisture, one of the Braden subscale categories, can come from several different sources such as perspiration, but most commonly, fecal and urinary incontinence. In the future, it would be more helpful to identify the exact source(s) of moisture. Since many researchers have reported urinary and/or fecal incontinence as significant factors, it would be very helpful to have this information to be able to more closely compare studies, and also to be able to plan appropriate prevention interventions.

4.6 Future Directions

4.6.1. Practice Implications.

Health care agencies are under increasing pressure to reduce the incidence of pressure ulcers. Although experts agree that prevention is the key to reducing the problem of pressure ulcers, a percentage of patients may sustain skin breakdown despite high quality care.[83] To be cost-effective, pressure ulcer prevention is best provided to patients identified as at risk .[70] The AHCPR in its guideline, Pressure Ulcers in Adults: Prediction and Prevention,[2] recommends the use of a risk assessment tool. Study findings help to provide a profile of the

characteristics of the population in hospital with ulcers. Targeting such populations may prevent ulcers from becoming serious medical problems, thereby reducing needless suffering and economic spending.

Study findings help to validate current clinical practice which triggers preventive care based on Braden subscale deficits. Findings highlight the need for early intensive preventive measures for older patients and for patients with deficits related to sensory perception, moisture and friction and shearing forces. Preventive care for male patients and for patients with mobility and nutrition deficits is also very important.

Study findings will be valuable to nurses and other health care professional involved in the development of educational materials such as patient teaching aides and resource materials. The potential to further reduce the incidence of pressure ulcers using various educational strategies needs to be explored.

The purpose of this study was to develop and validate a model describing the association of demographic and clinical factors in the presence of pressure ulcers. Knowledge of factors associated with ulcers may help to further refine assessment strategies to guide clinical decision making and minimize the occurrence of ulcers. It is important to note that data in the validation sample was very similar to data in the derivation sample. Using an independent sample as the validation sample, which closely resembled the study population, helped to further contribute to the goal of validating the model.

The overall percentage of subjects correctly classified using the validation sample was rather impressive, 88%. This finding suggested that the model performed very well and has validity in classifying patients with ulcers.

This is only the second study to evaluate model performance using an independent sample. Berlowitz and colleagues[23] evaluated model performance using the Hosmer-Lemeshow C statistic, goodness of fit test, in both the derivation and validation samples (.75 and .76). This finding is consistent with the current study, where the goodness of fit test for the derivation sample, .76 and the validation sample, .79 indicated that the model was well calibrated and a good fit.

Maintenance of skin integrity is a key indicator of quality in health care settings.[84] Pressure ulcer assessments and prevention protocols need to become a standard of practice in hospital settings. The real benefit of assessments is that preventative plans to match patient's needs can be implemented to immediately reduce the occurrence of ulcers thereby reducing costs associated with treatment.

Study findings have important clinical implications for patient care. Preventative interventions are needed to deliver high quality, cost-effective care. Faced with the national statistics and high costs of ulcer treatment the need for more cost effective prevention programs is evident. This study uses sound clinical data and provides valuable information to assist health care professionals in identifying factors associated with ulcers in adult patients.

4.6.2. Policy Implications

This study adds new information to the relationship of factors associated with pressure ulcers in adults in acute care populations. It will be an important contribution to hospital quality improvement programs interested in pressure ulcer prevention. Knowledge of these factors will provide health care providers with valuable information to develop more cost effective prevention protocols as part of their quality improvement program.

Greater quality improvement efforts to monitor ulcer prevalence and incidence, and to evaluate the implementation of clinical practice guidelines, will be vital to reduce variability, establish consistent standards of practice, enhance client participation in care decisions, and reduce expense.[85]

Although optimal skin care requires support from a multi-disciplinary team, assessment and ulcer prevention is primarily a nursing responsibility. It is common for nurses to object to assessing risk for pressure ulcer development as part of a formal risk program.[86] The objection is that risk is easily identified by experienced nurses and does not require documentation. However, there is recent evidence to suggest that in the absence of a formal assessment program nurses do not consistently intervene and implement ulcer prevention protocols.[70,84] These findings lend further support for the need to formalize assessment programs.

Under-classifying persons with ulcers may result in pressure ulcer occurrence, whereas, over-classification may lead to misuse of nursing time and other scare resources. Since the common types of interventions used to prevent

ulcers can be considered moderately expensive, as compared to the high cost of treating an ulcer (special air-flow beds or gel surfaces) it is wiser to institute preventive measures in a larger number of patients than to allow those who are truly at risk to go untreated.[81] This means that in the current study a relatively small proportion of the population (12%) would receive over treatment or unnecessary preventative interventions.

Concerns regarding the cost of preventative care should not be overstated. Although the resources required for care are increased, many of the interventions used to prevent ulcers (frequent repositioning and turning, nutritional counselling, and maintaining dry skin) are not excessively high in cost. Improvements in the quality of care can be expected without placing the patient at harm or adding an unjustified financial burden to the overall hospital costs.

Oot-Giromini and colleagues[87] conducted a study and reported that treatment is 2.5 times as costly as prevention. Implementing prevention strategies for patients, at risk and not at risk, is still more cost effective than spending 2.5 times as much on managing ulcers.

The National Pressure Ulcer Advisory Panel [7] speculated that prevention of pressure ulcers is less expensive and more cost effective than the treatment of ulcers. Hu and colleagues[88] examined the cost of implementing prevention and treatment procedures and found that the overall cost of implementing AHCPR prevention guidelines was not much different from that of current practice.

Although specific costs of ulcer treatment are difficult to determine,[7] care

is expensive. Treatment cost per ulcer can range from $10,000 to $60,000 US.[89] National estimates show that 1.7 million patients in the United States annually develop pressure ulcers with associated health care costs of $8.5 billion.[42] Sixty percent of the patients develop these ulcers while in acute care hospitals.[53] Over 60,000 people are estimated to die every year as a result of pressure ulcer complications.[89]

4.6.3. Future Research

This research has laid a foundation and is a first step to a more comprehensive multi-site study using incident data. The most ideal study design would be a cohort study, in which a group of ulcer free hospital patients are followed over a period of time to assess the occurrence of pressure ulcers. Cohort studies offer several advantages for evaluating relationships between exposure and disease.[65] Bias in the selection of subjects is minimized in a prospective cohort since the outcomes of interest have not yet occurred. Since subjects are free from the disease at the time their exposure is defined, the temporal sequence between exposure and disease can be more clearly established. Cohort studies can examine multiple effects of a single exposure and provide information about health outcomes that may be related to several factors. Incidence rates of the outcomes being studied can be calculated in the exposed and nonexposed groups.

Future research efforts are needed to develop and test prevention and treatment strategies which will improve outcomes for persons at high risk or with ulcers. Ongoing research is necessary to guide clinical decisions in establishing,

implementing and evaluating programs to promote high quality cost effective care. Targeting research based interventions to high risk populations helps to ensure the most efficient use of resources.

The present scoring system of the Braden Scale requires review and revision. Findings from this study have clearly demonstrated that each scale does not contribute equally in identifying high risk individuals. Further testing of the Braden subscale scores is needed to establish appropriate threshold points for determining risk. Although age is not amenable to change, it is a significant factor in the current and numerous other studies and should be considered for evaluation in future studies. Further refinement of the Braden Scale has the potential to reduce costs, both in terms of human suffering, and health care expenses.

It is unknown what effect the long term use of risk assessment tools will have on reducing the incidence of ulcers in hospital settings. Future studies are needed to evaluate the use of scales in reducing ulcer incidence. Further study is needed to evaluate the cost versus the benefit of conducting routine pressure ulcer risk assessments. More information is also needed regarding the timing and frequency of performing risk assessments.

Pressure ulcers are a serious health care problem in acute care hospitals with aging elderly populations. This study adds new information to the relationship of factors associated with pressure ulcers in adults in acute care populations and to the use and relative importance of particular Braden subscales. Knowledge of these factors may help to plan hospital wide prevention programs and promote quality improvement measures in skin care.

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Appendix A. Reported Studies Of Prevalence And Cumulative Incidence Of Pressure Ulcers In Acute Care Facili 1970 - June, 1998

Authors	Setting	Design	n	Prev	Incid	Staging
*Goodridge et al. 1998	Acute Care Hospital (2), Long Term Care Hospital (2)	Prospective, Incidence. Research assistants monitored subjects for pu. Research nurses verified findings with research assistants; there was 100% agreement. Interrater reliability between the 3 assistants was not formally assessed.	330		9.7%	Stage 1-4, staging criteria not defined, 1 - 57.1%, 2 - 31%, 3 - 4.8%, 4 - 4.8%.
Pieper et al. 1998	Acute Care Hospital (1), Rehab (1), Home Care Agency (1)	Prospective, Incidence. Trained nurses on release time collected data. No report of reliability testing.	649		10.2%	Stage 1 (nonblanchable erythema of intact skin) -4 (full thickness skin loss with extensive destruction, tissue necrosis or damage to muchle and bone), NPUAP (1989) eschar was not staged. 1 - 20%, 2 - 40.6%, 3 - 14.1%, 4 - 12.9%, eschar - 12.4%.
Schue & Langemo, 1998	Rehab Unit, Male Patients	Retrospective, Prevalence, Incidence, Chart Review. All subjects were assessed by trained nursing staff. No report of reliability testing.	170	12%	6%	Stage 1-4, NPUAP (1989), 1 - 24%, 2 - 57%, 3 - 15%, 4 - 4%.
Barczak et al. 1997	Acute Care Hospital (265)	Prospective, Prevalence. Instructions and forms were sent to interested participants. No report of reliability testing.	39,874	10.1% Range: 1.4-36.4%		Stage 1-4, NPUAP (1989) eschar. 1989 1 - 39%, 2 - 39%, 3 - 14%, 4 - 8%, E (not reported); 1991 1 - 38%, 2 - 37%, 3 - 11%, 4 - 7%, E - 8%; 1993 1 - 38%, 2 - 38%, 3 - 9%, 4 - 7%, E - 9%; 1995 1 - 35%, 2 - 39%, 3 - 10%, 4 - 7%, E - 9%.
Grous et al. 1997	Acute Care Hospital	Prospective, Prevalence. Members of the research team collected data. No report of training methods or reliability testing.	33	45%		Stage 1-4, NPUAP (1989), 1 - 53.3%, 2 - 46.7%.

Authors	Setting	Design	n	Prev	Incid	Staging
Gruen et al. 1997	Acute Care Hospital	Prospective, Prevalence. Survey teams were fully briefed and experienced in wound management. No report of reliability testing.	360	68%		Stage 1 (erythema without broken skin); and ≥ Stage 1 (68%).
Lewicki et al. 1997	Acute Care, Cardiac Surgery	Prospective, Incidence. Trained nurses collected data. Enterostomal nurses validated the presence of all ulcers.	337		4.7%	Stage 1-4, NPUAP (1989),1 - 59.1%, 22.7%, unstaged (did not meet criteria for specific stage) - 18.2%.
Niazi et al. 1997	Acute Care Hospital, Spinal Cord Injury Unit, Patients With History Of pu.	Retrospective, Incidence, Case Controlled, Data Base.	176		35.2%	Grade 1 - 4, staging criteria not reported. Nonsurgical 1 - 3.9%, 2 - 51.0%, 3 - 38.2%, 4 - 6.9%; Surgical 1 - 0%, 6.8%, 3 - 37.8%, 4 - 55.4%.
O'Sullivan et al. 1997	Acute Care Hospital, Trauma Patients	Retrospective, Incidence, Chart Review. No report of reliability testing.	7,492		.4%	ICD-9, code 707 for pu. No breakdown reported.
Tourtual et al. 1997	Acute Care Hospital, Heel Ulcers	Prospective, Incidence; two teams of trained staff members collected data. Study 1 - interrater agreement was 98.98%. Study 2 - average item Kappa was .95. A 90-93% agreement was reported in the absence or presence of pu.	1 - 209 2 - 291		1 - 26.8% 2 - 21.7%	Stage 1-4, NPUAP (1989), 1. 1 - 94.6%, 2 - 5.4%; 2. 1 - 92.1%, 2 - 6.3%, 3 - 1.6%.
Zahid et al. 1997	Acute Care Hospital. Spinal Cord Injury Unit, Patients With History Of pu	Retrospective, Case Controlled, Incidence, Data Base.No report of reliability testing.	176		35.2%	Grade 1-4, staging criteria not reported. No breakdown reported.
Bergstrom et al. 1998	Acute Care Hospital (4), Nursing Home (2)	Prospective, Prevalence, Incidence. Trained research nurses collected data. Interrater reliability was evaluated monthly and ranged from 95-100%.	843	12.8%	7.4%-23.9% Acute Care - 8.5%	Stage 1 (nonblanchable, 48-72 hrs) -4 (break exposing and/or extending into muscle or bone), 1 - 32.4%, 2 - 67.3%, 3 & 4 - 0%.
*Fisher et al. 1998	Acute Care Hospital (2)	Prospective, Prevalence. Trained nurses collected data. Good interrater reliability in previous study at one hospital (Harrison et al. 1996)	1,128	23.9%- all stages 10.1 %- ≥ Stage 2		Stage 1-4, NPUAP adapted (1989), 1A (blanchable erythema) - 39.6%, 1B (nonblanchable erythema) - 23.6%, 2 - 23.1%, 3 - 3.5%, 4 - 1.1%, X (necrotic tissue) - 8.8%.

Authors	Setting	Design	n	Prev	Incid	Staging
*Harrison et al. 1996	Acute Care Hospital	Prospective, Prevalence. Trained nurses collected data. Correlation of the survey team and validation team assessments was r=.87.	736	29.7% -all stages 13.6% - ≥ Stage 2		Stage 1 (erythema remains reddened > 30 min after pressure relieved) -4 (involvement of muscle/bone), X - eschar, 1 - 54%, ≥ 2 - 46%.
Salzberg et al. 1996	Spinal Cord Injury Unit	Retrospective, Incidence, Data Base.No report of reliability testing.	219		80.4%	Stage 1-4, 1 & 2 - not reported, 3 or 4 - 61.2%.
Thomas et al. 1996	Acute Care Hospital	Prospective, Incidence. Research nurses collected study data. Skin assessments showed overall agreement of 79%.	286		12.9%	≥ Stage 2, NPUAP (1989), 2 - 89.2%, 3 - 10.8%, 4 - 0%.
Westrate & Bruining, 1996	Intensive Care Unit	Prospective, Prevalence. Data collection methods not reported. No report of reliability testing.	130	13.6% - short stay 42.1% - long stay		≥ Stage 2, 2 - partial thickness skin loss, 4 - necrosis, damage to muscle/bone. No breakdown reported.
Allman et al. 1995	Acute Care Hospital	Prospective, Incidence. Research nurses collected study data. Skin assessments showed overall agreement of 79%.	286		12.9%	≥ Stage 2, staging criteria only defined for stage one, 2 - 89.2%, 3 - 10.8%, 4 - 0%.
Barrois, 1995	Acute Care Hospital (150)	Prospective, Prevalence. Questionnaire sent to the nurse in charge of ward (24% response rate). No report of reliability testing.	12,050	5.2%		Grade 1 (nonblanching hyperaemia) -4 (necrosis), 1 - 39%, 2 - 19%, 3 - 21%, 4 - 21%.
Gunnewicht, 1995	Acute Spinal Cord Injury Unit	Prospective, Incidence. Nurses were assigned to collect data. Training methods not reported. No report of reliability testing.	38		21%	Grade 1 (broken skin limited to superficial epidermal/dermal layers) - 4 (extending into bones/joints). No breakdown reported.
Hunter et al. 1995	Rehab Hospital	Prospective, Prevalence. Data collection methods not reported. Interrater reliability was established, results not reported.	116	11%		Stage 1-4, NPUAP (1989), 1 - 61.1%, 2 - 22.2%, 3 - 11.1%, 4 - 5.6%.
Jiricka et al. 1995	Intensive Care Unit	Prospective, Incidence. Data collection methods were not reported. No report of reliability testing.	85		56%	Stage 1-4, NPUAP (1989), 1 - 54%, 2 - 46%.

Authors	Setting	Design	n	Prev	Incid	Staging
St Clair, 1995	Medical, Surgical & Intensive Care Unit (22)	Prospective, Incidence. Staff nurses, who were members of the wound team, participated in a training session and completed a weekly register recording all ulcers. No report of reliability testing.	3,226		1.2%	≥ Grade 2 (tissue loss to dermis, Grade 4 - extends to muscle, tendon, muscle. No breakdown reported.
Allcock et al. 1994	Acute Care Hospital	Prospective, Prevalence. Trained staff nurses collected data. Reliability was estimated using a series of pictures and ranged from 32-49%.	714	32.7%		Grades 1 (blanching hyperaemia) -7(unknown). No breakdown reported.
Clark & Watts, 1994	Acute Care Hospital	Prospective, Incidence. Trained ward staff reported pu using a form on a weekly basis. No report of reliability testing.	8,935		4.03 patients per 100 admissions	Grade 2 - 4., David et al. (1983); 0.19 patients per 100 had severe pressure ulcers (Grade 3 & 4)
Dealey, 1994	Acute Care Hospital	Prospective, Prevalence. A trained nurse from each ward collected data. No report of reliability testing.	93 - 406 89 - 399	93 - 7.9% 89 - 8.77%		Grade 1 (redness does not fade and blanches under light pressure) -5 (extend to other tissue); 1989 - 1 - 37.5%, 2 - 39.1%, 3 - 10.9%, 4 - 4.7%, 5 - 7.8%. 1993 - 1 - 23.9%, 2- 32.6%, 3- 30.4%, 4- 8.7%, 5 - 4.4%.
Gawron, 1994	Acute Care Hospital	Prospective, Prevalence. Trained nurses collected data. Percent agreement was 90-100% for staging wounds on study date.	440	12%		Staging 1-4, NPUAP (1989), 1 - 27%, 2 - 44%, 3- 9%, 4 - 0% Necrotic - 19%.
*Hamilton & Clevely,1994	Acute Care Hospital	Prospective, Incidence. Trained staff nurses reported patients who were at risk for developing pressure ulcers or had a pressure ulcer. No report of reliability testing.	Pre - 227 Post - 238	Pre - 12.8% Post - 6.4%		Stage 1 (superficial, irregular ulceration, edema, erythema) -Stage 4 (extensive ulceration involving bone) Shea Classification (1975). No breakdown reported.
Hammond et al. 1994	Spinal Cord Service	Retrospective, Incidence, Chart Review. No report of reliability testing.	468		7.5%	≥ 2 Stage, NPUAP (1989), 2 - 99% & > 2 Stage - 1%.
Maldebust & Magnun, 1994	Acute Care Hospital (5)	Prospective, Prevalence. Rained nurses collected data. All nurses received instructions. Data were collected by nurses. No report of reliability testing.	2,189	12.3%		Stage 1 (erythema that does not disappear) -4 (break extending to muscle/bone) & 9 (eschar), 1 - 29.8%, 2 - 37.5%, 3 - 14.7%, 4 - 10.7%.

Authors	Setting	Design	n	Prev	Incid	Staging
Meehan, 1994	Acute Care Hospitals (177)	Prospective, Prevalence. Data were collected by hospital staff who received staging criteria. No report of reliability testing.	31,530	11.1%		Stage 1-4, NPUAP (1989), I - 46.95%, 2 - 32.66%, 3 - 7.8%, 4 - 6%
Papantonio et al. 1994	Elective Cardiac Surgery Patients, Sacral pu	Prospective, Incidence. Staff nurses collected data. To establish consistency among the raters all participating nurses attended a lecturer on ulcer staging. Results were discussed and errors corrected.	136		27.2%	Stage 1 (intact skin with a purple or ecchymotic appearance) -3 (full thickness loss), 1 - 43%, 2 - 57%.
Pase, 1994	Community Hospital, Elderly Patients With Mobility Deficits	Prospective, Incidence. Staff nurses received instructions regarding accurate documentation of wound assessments. Data were collected by a research nurse. No report of reliability testing.	108		25%	Staging criteria not reported. No breakdown reported.
Bridel, 1993	Surgical Patients	Prospective, Incidence. Designated qualified staff within the surgical unit participated in data collection. Reliability checks were made by the researchers. No results reported.	26		54%	Grades 1 (redness) - 5 (necrosis), 2- 12.5%; 12.5% theatre generated.
Holmes et al. 1993	Deceased Population From Christian Science Sanatorium	Retrospective, Prevalence. Medical examiner's record reviewed. No report of reliability testing.	116	11%		Presence or Absence, 10 small, superficial, resolving or healing & 3 serious pu.
O'Dea, 1993	Acute Care Hospitals (7)	Prospective, Prevalence. Trained nurses collected data. No report of reliability testing.	3,213	18.6%		Stage 1 (persistent nonblanching hyperaemia) -4 (damage to muscle/bone). No breakdown reported.
Rochon et al. 1993	Spinal Cord Injured Referral Center	Retrospective, Incidence, Chart Review. No report of reliability testing.	364		22.3%	Stage 1-4, NPUAP (1989). No breakdown reported.
Carlson et al. 1992	Rehab Center , Spinal Cord Injured Patients	Prospective, Incidence. Data were based on visual inspection and patient's report of ulcers. Training methods were not reported. No report of reliability testing.	125		29% - Acute 3% - Rehab 17% - Follow-up	Stage 1-4, Shea Classification (1975), ≤ 2 - 66%.

Authors	Setting	Design	n	Prev	Incid	Staging
Cullum & Clark, 1992	Acute Care Hospital, Elderly Patients	Retrospective, Incidence. Review of Medical Records. No report of reliability testing.	51		22% - present upon admission 12% - developed pu	Grade 2 - 4, David et al (1983), present of absent. No breakdown reported.
Curry & Casady, 1992	Spinal Cord Injury Center	Retrospective, Incidence. Review of Medical Records. No report of reliability testing.	49		20.4%	Break in skin integrity. No breakdown reported.
*Foster et al. 1992	Teaching Hospitals (3), Community Hospital (1), Long Term Care Facilities (2), Community Agencies (2)	Prospective, Prevalence. Trained nurses collected data. Agreement among assessments was reported to be 86.9%.	2,364	25.7%		Stage 1 (redness does not disappear within 30 min after pressure is removed) -4 (tissue destruction extending to muscle/bone), X (eschar), 1 - 57.2%, ≥ 1 -42.6%.
Goode et al. 1992	Orthopaedic Unit, Patients With Femoral Neck Fracture	Prospective, Incidence. Data collection methods not reported. No report of reliability testing.	21		48%	Full thickness epidermal break.
Goenell et al. 1992	Acute Care Hospital	Prospective, Incidence. Trained nurses collected data. Interrater and intra rater reliability was established at a .90 level of agreement.	1320		8.4%	Stage 1 (reddened area) - 4 (deep tissue/necrosis), I - 56.3%, 2 - 36.3%, 3 - 6.8%, 4- 0.5%.
Hunter et al. 1992	Rehab Center	Prospective, Prevalence. Incidence. Researcher completed skin assessments. Data collection methods not reported. No report of reliability testing.	40	25%	0%	Shea & IAET (1987), Stage 1-4; I - 40%, 2 - 30%, 3 - 30%.
Salvadalena et al. 1992	Acute Medical Patients	Prospective, Incidence. Trained mastered prepared nurses collected data. Interrater reliability, calculated by Pearson's product moment, was correlated at > 0.9.	99		20%	Stage 1 (erythema that does not disappear within 24 hrs after pressure is relieved) -4 (extends to muscle, tendon or bone), 1 - 80%, > 1 - 20%.
Dealey, 1991	Acute Care Hospital	Prospective, Prevalence. Trained ward collected the data. No report of reliability testing.	Survey 1 - 399 2 - 396 3 - 381	Survey 1 - 8.77% 2 - 5.1% 3 - 8.1% mean = 7.32%		Grade 1-5, 2 - 32.8%, 3 - 31.4% (most frequently reported).

Authors	Setting	Design	n	Prev	Incid	Staging
Hanson et al. 1991	Hospice	Phase 1 - Prospective, Prevalence. Data obtained from patient's chart and through reports by staff. Phase 2 - Prospective, Incidence. Data obtained from staff nurses. Phase 3 - Retrospective, Incidence. Charts were audited. No report of reliability testing.	1 - 8 2 -19 2-19	13%	0%-prospective 13%- retrospective	Stage 1 (reddened area lasting > 30 min after position change) - 4 (skin break with tissue exposing muscle/bone), Shea Classification, adapted (1975). Phase 1 - one patient with Stage 2; Phase 2 - 1 - 75% & 2 - 25%; Phase 3 - 75% & 2 - 25%.
Langemo et al. 1991	Acute Care, Rehab, Skilled Care Nursing Home, Hospital-Base Home Health Agency and Hospice	Prospective, Incidence. Nursing staff collected data; training not reported. No report of reliability testing.	190		9%	Stage 1-4 , NPUAP (1989), 1 - 50%, 2 - 38.9%, 3 - 11.1%.
Vidal et al. 1991	Acute Care Hospital, Spinal Cord Injuries	Retrospective, Incidence, Chart Review. No report of reliability testing.	884		30%	Stage 1-4, Enist & Sarmiento (1973). No breakdown reported.
Kemp et al. 1990	Acute Care Hospital, Surgical Patients	Prospective, Incidence. Researchers examined patients to verify site and staging reported by staff. No report of reliability testing.	125		12%	Stage 1 (erythema that does not resolve within 20 min of pressure relief) -4 (break in skin exposing muscle/bone), IAET (1987), 1 - 70%, 2 - 26%, 3 - 4%.
Langemo et al. 1991	Acute Care, Extended Care, Rehab, Home Health Care, Hospice (5 settings)	Prospective, Prevalence. Trained staff and researchers collected data. No report of reliability testing.	368	20%		Stage 1-4, Shea Classification (1975), 1 - 37%, 2 - 39%, 3 - 16%, 4 - 8%.
Meehan, 1990	Acute Care Hospitals (148)	Prospective, Prevalence. Data collectors from hospitals received staging criteria. No report of reliability testing.	34,987	9.2%		Stage 1- 4, IAET (1987), 1 - 39%, 2 - 39%, 3 - 14%, 4 - 8%.
Eckman, 1989	Deceased Population From Funeral Homes (130)	Prospective, Prevalence. Data collectors from a random selection of funeral homes received a package of information. No report of reliability testing.	1,378	23.6%		Pre-ulcer-Grade 1-4, Shea Classification (1975), Pre-ulcer - 24.8%, 1 - 31.2%, 2 - 24%, 3 - 9.1%, 4 - 5%.

Authors	Setting	Design	n	Prev	Incid	Staging
Girvin & Griffiths-Jones, 1989	Acute Care Hospital	Prospective, Prevalence. Nurses collected data. Training methods not reported. No report of reliability testing.	1,010	10.2%		Stage, 1-4, Johnson (1985), 1 - 32.5%, 2 - 47%, 3 & 4 - ?
Kennedy 1989	Intermediate Care Facility	Retrospective, Prevalence. Pressure ulcer committee checked each patient with a pressure ulcer. Training methods not reported. No report of reliability testing.	500	1.23 -5.34%		≥ Stage 2. Staging criteria not reported. No breakdown reported.
Oot-Giromini et al. 1989	Oncology - Community Hospital	Prospective, Prevalence, Incidence. Audits were conducted. Training methods not reported. No report of reliability testing.	88 - 204 85 -176	88 - 12.8% 85 - 29.5%	2.45% 25%	Stage 1 (nonblanchable erythema) - 4 (muscle/bone involvement). No breakdown reported.
Shannon & Skorga, 1989	Spinal Cord Injury Unit, Nursing Home Care Unit	Prospective, Prevalence. Master's degree nurses and graduate nursing students completed a pre-test prior to data collection. Inter-rater reliability was 1.0	Phase 1 - Hospital: 38 Phase 2 - Spinal Cord Service and Nursing Home Care Unit: 58	Phase 1 -3.5% Phase 2 - 8.1%		Stage 1-4, Shea Classification (1975). No breakdown reported.
Clarke & Kadhom, 1988	Bedfast And Chairfast Patients In Hospital And Community	Prospective, Incidence. Diary sheet completed by nurses and relatives. Training methods not reported. No report of reliability testing.	Hospital - 88 Community - 30		Hospital - 29.5% Community - 20%	Broken skin due to pressure. No breakdown reported.
Mawson et al. 1988	Spinal Cord Injury Unit	Prospective, Incidence. Data collection methods not reported. No report of reliability testing.	39		59%	Grade 1-4, Enis & Sarmiento (1973). No breakdown reported.
Moody et al. 1988	Acute Care Hospital	Prospective, Incidence. Trained nurses collected data. No report of reliability testing.	307		Pre-education - 14.6% Post-education - 5.4%	Stage 1 (redden area) -4 (skin break to muscle/bone), modified Shea Classification, (1975). No breakdown reported.

Authors	Setting	Design	n	Prev	Incid	Staging
Kynes & Neese, 1987	Acute Care Hospital	Prospective, Incidence . Data were collected by Enterostomal Therapy Nurses. No report of reliability testing.	361	.55%		Stage 1 (reddened area remains after pressure removed 30 min) -4 (muscle/bone involvement), No breakdown reported.
Nyquist & Hawthorn, 1987	Acute Care (133 wards)	Prospective, Prevalence. Nurse in charge of unit collected data. Training methods not reported. No report of reliability testing.	2513	5.3%		Grade 1-4, Lowthian (1979), 1 - 10.7%, 2 - 52.7%, 3 - 23.2%, 4 - 13.4%.
Stotts, 1987	Acute Care Hospital, Elective Cardiovascular, Neurosurgical Patients	Prospective, Incidence. Training and testing was conducted by the principle investigator . Agreements in scores of study instruments obtained 100%.	387		17.3%	Grade 1 (redness) -4 (ulcer is through skin, and extends into muscle). No breakdown reported.
Allman et al. 1986	Acute Care Hospital	Prospective, Prevalence. Authors assessed patients identified by the nursing staff as at risk and with ulcers. No report of reliability testing.	634	4.7%		Epidermal defect or break in the skin at site of bony prominences. No breakdown reported.
Pajk et al. 1986	Acute Care Hospital	Prospective, Prevalence. Data collected by nurse auditors. Training methods not reported. No report of reliability testing.	208	19.7%		Stage 1 (reddened area disappears when pressure is relieved 15 min) -4 (extends into tissue, muscle/bone). No breakdown reported.
Robnett, 1986	Surgical-Critical Care Patients	Prospective, Incidence. Data collected by staff. Skin care standards taught during orientation of new staff. No report of reliability testing.	63		1%	Stage 1 (red, does not return to normal color 15-30 min after pressure is removed) - 4 (necrosis with involvement of muscle/bone). No breakdown reported.
Warner & Hall, 1986	Acute Care Hospital	Prospective, Prevalence. Staff nurses collected data. Patients were examined jointly by staff and research nurse to assess the reliability of reports. All seven reports of pu were confirmed, however additional pu were observed in 2 patients.	396	14%		Jordan and Clark Classification (1977). No breakdown reported.
Versluyen, 1985	Hip Fracture And Elective Hip Surgical Patients	Retrospective, Incidence, Chart Review. No report of reliability testing.	283		32%	Grade 2-4 (ulcerative pressure lesions). Staging criteria not reported. No breakdown reported..

Authors	Setting	Design	n	Prev	Incid	Staging
Thiyagarajanc & Silver, 1984	Spinal Cord Injury Center	Prospective, Incidence. Data collected using questionnaire. Training methods not reported. No report of reliability testing.	100		27%	Staging criteria not reported. No breakdown reported.
Ek & Boman, 1982	Acute. Long Term Care Patients	Retrospective, Prevalence. Data collected by the nursing staff and interviews. A letter of introduction was sent to each unit. No report of reliability testing.	1,766	4%		Skin discolouration, epithelial damage and damage to the full thickness skin. No breakdown reported.
Richardson & Meyer, 1981	Spinal Cord Center	Retrospective, Incidence. Data collection methods not reported. No report of reliability testing.	549	49.7%		Presence or absence of pressure ulcer. No breakdown reported.
*Ameis et al 1980	Surgical And Medical Patients	Prospective, Prevalence, Incidence. Data collection methods not reported. Education seminars were held for nursing staff. No report of reliability testing.	Surgical - 36 Medical - 36	Surgical - 69% Medical - 51%	Surgical: pre- 12% post - 0% Medical: pre- 29% post - 0%	Stage 1 (blanching hyperemia) -5 (open & infected). No breakdown reported.
Barbenel et al. 1980	Acute Care Hospital , Community	Prospective, Prevalence. Data collection methods not reported. Surveys were checked in 4 wards by two pairs of nurses not involved in survey. No results reported.	999	9.4%		Grade 2 (skin discolouration, persistent) -4 ( ), 2 - 5.1%, 3 - 2.2%, 4 - 1.5%.
Lowthian, 1979	Acute Care Hospital	Prospective, Prevalence. Nursing officers and research assistant collected data. Survey team collected data on non-ambulatory patients and patients identified by staff nurses who were known to have pressure ulcers. Training methods not reported. No report of reliability testing.	186	7%		Grade 1-4, $\geq$ 2 - 6.5%, 1 - (blistered black necrotic discolouration, > 15 mm in diameter), 4 - (penetration of skin > 5 mm with or without necrotic tissue).
Roberts & Goldstone, 1979	Orthopaedic Wards	Prospective, Incidence. Survey team collected data. Training methods not reported. No report of reliability testing.	64		20%	Pressure ulcer absent or present; more serious erythema.
Woodbine, 1979	Orthopaedic Patients	Retrospective, Incidence, Chart Review. No report of reliability tesing.	A - 51 B - 49		A - 94% B - 24%	Presence or absence of pressure ulcer.

Authors	Setting	Design	n	Prev	Incid	Staging
*Robinson et al. 1978	Paraplegics Discharged From Rehab Setting	Retrospective, Incidence. The investigator examined those patients who responded to a survey (63%).	106		48% -Major 29% -Less Severe Skin Breakdown	Presence or absence of pressure ulcer.
Barbenel JC et al. 1977	Acute Care Hospital, Community	Prospective. Nursing staff collected data. Training methods not reported. No report of reliability testing.	10,751		8.8% (note: reported as incidence but prev.)	Grade 2-4, Staging criteria not reported, 2 - 5.1%, 3 - 2.2%, 4 - 1.5%.
*Gerson, 1975	Acute Care Hospital (3)	Prospective, Incidence. Head Nurses completed assessment forms. Training methods not reported. No report of reliability testing.	5,648		2.69%	Presence or absence of pressure ulcer..
Rubin et al. 1974	Acute Care Hospital	Retrospective, Incidence. Data collected from supervisor's report. Training methods not reported. No report of reliability testing.	18,000		1.5%	Stage 1 (redness) - 3 (requires debridement, necrosis). No breakdown reported.
Williams, 1972	Acute Care Hospital (2); Nonambulatory Patients	Prospective, Incidence. Data collected by study team. Training methods not reported. No report of reliability testing.	26		27%	Presence or absence of pressure ulcer.
Hicks, 1971	Acute Care Hospital, surgical Patients	Retrospective, Incidence. Investigator conducted a chart review. No report of reliability testing.	100		13%	Grade 1 (threatened ulcer, redness disappears on pressure) - 3 (necrosis). No breakdown reported.

*Canadian Studies
*pu - pressure ulcer

APPENDIX B: REPORTED STUDIES OF PREVALENCE AND CUMULATIVE INCIDENCE OF PRESSURE ULCERS IN ACUTE CARE FACILITIES, 1970 - JUNE, 1998

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Appendix C. Braden Scale

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 consciousness or sedation. OR Limited ability to feel pain over most of body surface.	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 1/2 of body.	3. SLIGHTLY LIMITED: Responds to verbal commands, but cannot always communicate discomfort or 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.	Score:___ _
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. 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.	Score:___ _
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 the room at least twice a day and inside room at least once every 2 hours during waking hours.	Score:___ _
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 LIMITATIONS: Makes major and frequent changes in position without assistance.	Score:___ _

NUTRITION usual food intake pattern	1. VERY POOR: Never eats a complete meal. Rarely eats more than 1/3 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 fluids or IV's for more than 5 days.	2. PROBABLY INADEQUATE: Rarely eats a complete meal and generally eats only about 1/2 of any food offered. Protein intake includes only 3 servins of meat or dairy products per day. Occasionally will take a dietary supplement. OR receives less than optimum amount of liquid or tube feeding.	3. ADEQUATE: Eats over half of most meals. Eats a total of four servings of protein (meat, dairy products) each day. Occasionally will refuse a meal, but will usually take a supplement if offered. OR is on 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 refuse supplementation.	Score:____
FRICTION/SHEAR	1. PROBLEM: Requires moderate to maximum assistance in moving. Complete lifting without sliding against sheet 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 inbed or chair at all times.		Score:____

Appendix D. Pressure Ulcer Staging Definitions

A pressure ulcer is any lesion caused by unrelieved pressure resulting in damage of underlying tissue. This impairment of skin integrity may result from the effects of pressure, friction, shear, or maceration. Pressure ulcers usually occur over bony prominences and are graded or staged to classify the degree of tissue damaged observed.

Stage 1

Nonblanchable erythema of intact skin; the heralding lesion of skin ulceration.

Stage 2

Pressure ulcer is defined as partial thickness skin loss involving the epidermis and/or dermis. The ulcer is superficial and presents clinically as an abrasion, blister, or swollen crater.

Stage 3

Pressure ulcer involves full-thickness skin loss involving damage or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia. The ulcer presents clinically as a deep crater with or without undermining of adjacent tissue.

Stage 4

Pressure ulcer presents as a full-thickness skin loss with extensive destruction, tissue necrosis or damage to muscle, bone, or supporting structures (for example tendon or joint capsule). Note: Undermining and sinus tracts may also be associated with Stage 4 pressure ulcers.

Stage X

A pressure sore that cannot be accurately stage due to the presence of eschar or necrotic tissue covering the wound base.

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ppendix E. Reported Studies of Factors Associated with Pressure Ulcers in Adults in Acute and Long Term are Settings, 1970 - June 1998

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Schue & Langemo, 1998	Rehab Unit, Male Patients	Retrospective, Incidence, Prevalence, Chart Review	To examine pu incidence and prevalence; and contribution of each of the subscale risk factors of the Braden Scale.	Descriptive statistics, logistic regression	Stage 1-4	170	12%	6%	Logistic regression analysis determined that moisture, nutrition and friction/shear were most predictive of pu development.	Ongoing education to review preventive care may help explain low rates. Accuracy of data is a concern with retrospective chart review; under reporting of ulcers is possible. Braden subscale scores were used in multivariate analysis.
Pieper et al. 1998	Acute Care Hospital (1), Rehab (1), Home Care Agency (1)	Prospective, Incidence	To describe patients who had pu upon admission or who developed them during confinement .	Chi square, t test, ANOVA	Stage 1-4, eschar was not staged	649		10.2%	Older adults, longer lengths of stay, more comorbid conditions, lower blood hemoglobin, lower serum albumin, higher white blood cell counts, lower Braden scale scores.	Rigorous research methods were employed. Braden subscales scores were used in univariate analysis. Ulcer incidence may be under estimated as patients with eschar were excluded from analysis.
Grous et al. 1997	Acute Care Hospital	Prospective, Incidence	To identify risk factors contributing to pu development in patients undergoing scheduled, prolonged operative procedures (> 10hrs.).	Chi square & Student t test	Stage 1-4	33		45%	Placement of a warming blanket.	Small sample size using bivariate analysis.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Lewicki et al. 1997	Acute Care, Cardiac Surgery	Prospective, Incidence	To identify risk factors associated with development of pu among patients undergoing cardiac surgery.	Student t test, chi square, OR & CI	Stage 1-4	337		4.7%	*Preoperative* - greater comorbidity, lower hemoglobin, hematocrit and serum albumin levels, low preoperative Braden Risk Assessment Scale scores, diabetes mellitus. *Intraoperative* - none *Postoperative* - time required to return to preoperative body temperature, being turned only once a day, presence of intraaortic balloon pump.	Data were consistently collected by research nurse who performed assessments. Bivariate analysis; low incidence may be explained by the Hawthorne effect.
Schnelle et al. 1997	Nursing Homes (4)	Prospective, Incidence	To provide data needed to design an intervention trial to prevent or treat pu in a high risk, incontinent nursing home population.	Stepwise multiple regression analysis	Stage 1-4	100		21%	Blanchable erythema and low bed mobility were predictive of pressure ulcer severity.	Accurate identification of blanchable erythema is a well recognized problem.
Tourtual et al. 1997	Acute Care Hospital , Heel Ulcers	Prospective, Incidence	To evaluate predictors of hospital axquired heel pu. Study 1 - examine factors, Study 2 - clarify and validate variables from the lst study.	Chi square, t test, logistic regression	Stage 1-4	1 - 209 2 - 291		1 - 26.8% 2 - 21.7%	Using logistic regression, subject's with a potential problem on the Braden friction and shear item and who were more frequently moist on the Braden mositure item were more likely to develop heel ulcers.	Rigorous data collection methods were employed. Braden subscales were used in multivariate aalysis. Nutrition was not significant and requires further review. ORs and CIs were not reported. No attempt to evaluate interaction effects and model performance using an independent sample were reported.
Zahid et al. 1997	Acute Care Hospital, Spinal Cord Injury Unit, Patients With History Of pu	Retrospective, Case Controlled, Data Base	To examine specific factors that might affect the pressure ulcer recurrence rate.	Chi square, Student t test, logistic regression	Grade 1-4	176		35.2%	Patients who smoked and patients with diabetes or cardiovescular disease had higher recurrence rates.	Staging critieria not reported. Accuracy of data is a concern using a clinical data base. ORs and CIs are not reported.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Bergstrom et al. 1996	Acute Care Hospitals (4) & Nursing Homes (2)	Prospective, Incidence, Prevalence	To determine the incidence of pu, and whether demographic characteristics and primary diagnosis are factors in pu development.	Logistic Regression	Stage 1-4	843	12.8%	7.4%-23.9%	Lower Braden scores, older age and white race; gender was not significant.	Rigorous data collection methods were employed. No attempt to evaluate interaction effects among the variables was reported; model performance using an independent sample was not assessed.
Berlowitz et al. 1996	Long Term Care (74)	Retrospective, Data Base	To determine the importance of case-mix adjustment in interpreting differences in rates of pu development.	Logistic Regression	≥ Stage 2	31,150 val=17, 946		3.3%±2 .4%	Dependence in transferring, mobility & toileting; presence of a stasis ulcer, receiving wound care, presence of stage 1 ulcer, presence of terminal illness, recency of admission, urinary tract infection, residing in intermediate medicine & # of specialized services being received.	The accuracy of data must be considered when using large administrative databases. This is the only reported clinical study to use a validation sample. Model performance was assessed using the C statistic for calibration, however the area under the ROC for discrimination was not reported.
Jesurum et al. 1996	Cardio-vascular Recovery Room	Two group, randomized quasi-experimental	To determine the incidence of pu and to identify preoperative, intraoperative, and postoperative factors to predict pu formation in cardiovascular surgical patients requiring intraortic balloon pump support..	Fisher's exact test, Mann-Whitney U, Levene's test of homogeneity of variance, independent sample t test	Stage 1-4	36		16.7%	Pre-op: medical history of cerebrovascular disease or renal insufficiency, advanced age, higher APACHEII and PIRT scores, Braden score of ≤ 9 on the 1st post-op day. Post-op: lower hemoglobin level, higher serum creatinine level, and an altered level of consciousness, frequency of repositioning or lateral rotation and number of vasoactive infusions.	Small sample size using bivariate analysis. Findings may be skewed as 5 subjects with pu expired prior to discharge.
Salzberg et al. 1996	Spinal Cord Injury Unit	Retrospective, Incidence, Data Base	To develop a pu risk assessment scale for persons with spinal cord injury.	Pearson's chi square, Mantel-Haenszel test, student's t test, Mann-Whitney U test, logistic regression	Stage 1-4	219		80.4%	Restricted activity level, degree of immobility, complete spinal cord injury, urinary incontinence, autonomic dysreflexia, advanced age, the comorbidities of cardiac, pulmonary, and renal disease, impaired cognitive function, diabetes, cigarette smoking, residence in a nursing home or hospital, hypoalbuminemia, and anemia	The scale used to collect data is in its early developmental stage. literature. Further testing of the scale is recommended. A long follow-up period, 6 years, explains the high incidence. Accuracy of data is a concern as ulcers were documented by chart reviews, patient interviews and usually but not always, by direct observation.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Allman et al. 1995	Acute Care Hospital	Prospective, Incidence	To identify factors that predict the development of stage 2 or greater pu among patients whose activity is limited to bed or chair.	Univariate Kaplan-Meier Survival Analyses, RR & CI, multivariable Cox regression analysis	≥ Stage 2	286		12.9%	Nonblanchable erythema, lymphopenia, immobility, dry skin, decrease body weight.	Stage 1 excluded to improve reliability of study. Several interactions were tested; fecal incontinence and immobility, and age and body weight did not contribute to the predictive capability of the model. The model was not validated using an independent sample. The presence of confounding variables was not evaluated.
Brandeis et al. 1995	Long Term Care (270)	Prevalence, Incidence, Data Base	To describe the prevalence, incidence, and management practices related to pu.	Chi square & Fisher's exact testing, backward logistic regression	≥ Stage 2	2,011	11.2%	6.2%	Logistic regression analysis determined that dependence in transfer or mobility, being bedfast, having diabetes mellitus, and having had a pu in the past were sign associated with pu.	Stage 1 excluded to improve reliability of study. Although this is one of the very few studies to evaluate interactions among the variables, the selection process used to determine which interactions were considered is not described. Model performance using an independent sample was not performed. The presence of confounding variables was not evaluated.
Jiricka et al. 1995	Intensive Care Unit	Prospective, Incidence	To determine the relative contribution of risk factors in pu development.	Descriptive, statistics, stepwise backward multiple logistic regression	Stage 1-4	85		56%	Using the Braden subscales, moisture and sensory perception predicted skin breakdown; using Decubitus Ulcer Potential Analyzer, moisture and circulation were identified as predictors.	Only Braden/DUPA scores (adapted Braden) were entered into the model; age and length of hospital stay were not evaluated. No attempt to evaluate interaction effects and model performance using an independent sample were reported.
Brandeis et al 1994	Nursing Homes (78)	Retrospective, Data Base	To determine risk factors associated with the formation of stage 2-4 pu.	Pooled logistic regression	≥ Stage 2	4,232		6.5 (low) - 19.3% (high)	*Factors in high incidence homes*- were ambulation difficulty, fecal incontinence, diabetes mellitus difficulty feeding oneself. *Factors in low incidence homes*- were ambulation difficulty, difficulty feeding oneself, male gender.	Stage 1 excluded to improve reliability of study. Accuracy of data is a concern with clinical data bases. No further testing for performance of the model or for the possibility of interactions was conducted.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Brandeis et al. 1994	Nursing Homes (? # facilities)	Incidence, Data Base	To examine correlates of pu on admission.	Logistic regression and discriminate function analyses	Not Reported	3,601		17.7%	Malnutrition, bladder incontinence, bed or chair confined, fecal incontinence, medicare payment, black race, narcotic medications, insulin therapy, parkinson's disease, male gender.	Stage 1 excluded to improve reliability of study. Accuracy of data is a concern with clinical data bases. No further testing for performance of the model or for the possibility of interactions was conducted.
Hammond et al. 1994	Spinal Cord Injury Unit of Hospital	Incidence, Retrospective Chart Review	To determine the incidence rate and to identify the patients in a high-risk population who may have exceptional risks.	Correlations	≥ Stage 2	468		7.5%	Admission diagnosis of pressure ulcers, surgical repair of pressure ulcers, length of stay, new spinal cord injury, longstanding injury (> 10 years), and the use of condom catheters.	Stage 1 excluded to improve reliability of study. Under reporting of ulcers may have occurred; data were collected using chart review. Bivariate analysis was conducted.
Gawron, 1994	Acute Care Hospital	Descriptive, Correlational	To investigate the relationship of patient acuity level and patients' risk as measured by the Braden Scale.	Spear's p coefficient of correlation	Stage 1-4	440	12%		Patient acuity level as measured by Medicus Interact Staffing Productivity System.	Bivariate analysis was conducted.
Maklebust & Magnan, 1994	Acute Care Hospital (5)	Prospective, Prevalence	To delineate the association of various risk factors and the presence of pressure ulcers.	Fisher's exact test, chi square, stepwise logistic regression	Stage 1-4 & 9 (eschar)	2,189	12.3%		Fecal incontinence, impaired mobility, malnutrition, decreased mental status, an interaction effect between fecal incontinence impaired mobility. *The odds of having a pu increased 22 fold in the presence of fecal incontinence, but only tenfold in the presence of impaired mobility.*	A fifth stage, X, was included to improve reliability of study. Age and length of hospital stay were not considered in the model. This is the first study to report a significant interaction effect; further evaluation is needed. Data were not collected using a standardized measurement tool (subjectively evaluated by nurses as present or absent).
Papantonio et al. 1994	Elective Cardiac Surgery Patients, Sacral	Prospective, Incidence	To examine the incidence and risk factors that relate to the development of sacral pu following cardiac surgery.	T-tests, chi square, RR & CI	Stage 1 -3	136		27.2%	Factors such as older age, transfer from another hospital, and a history of diabetes, were associated with ulcer development.	Small sample size; bivariate analysis. Stage 1 ulcers may be under reported due to positioning restriction of post-op patients. Under reporting may have occurred since assessments were conducted by on-duty staff nurses.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Pase, 1994	Community Hospital, Elderly Patients With Limited Mobility	Prospective, Incidence, Chart Review	To examine the relationship between risk factors and development of pu.	Descriptive statistics, chi square	?	108		25%	No difference with respect to gender, race, mobility.	Small sample size; bivariate analysis. Outcome measurement not reported. Under reporting of ulcers may have occurred; data were collected using chart review.
Rochon et al. 1993	Spinal Cord Injured Referral Center	Retrospective, Incidence, Chart Review	To compare the demographic and clinical characteristics of patients with and without pu.	Logistic Regression	Stage 1-4	364		22.3%	Immobility as measured by a Frankel Grade of A or B; malnutrition as assessed by low albumin level and presence of chronic system illness as evaluated by a high co-morbidity score on the Cumulative Illness Rating Scale.	The strength of this comprehensive model is that each of the factors can be objectively measured and easily applied in a practice setting. Limitation of this study include the use of discharge summary information which may underestimate the problem. Information regarding testing for the presence of interactions or testing for model performance was not reported.
Sparks, 1993	Nursing Homes (2)	Case Control	To analyze risk factors in 3 groups of older adults.	Discriminant Analysis	?	108 cases			Findings suggest that 3 factors may be the best discriminators for pu risk: friction, being dependent in self care, being confined to a bed or chair.	Low reliability (.62 by Cronbach coefficient alpha) may reflect that the instrument used is still in its early developmental stage. Staging criteria not reported.
Braden & Bergstrom, 1992	Nursing Home	Prospective, Incidence	To determine if dietary intake, nutritional status, and other physical markers are risk factors.	Descriptive statistics, ANOVA, logistic regression	Stage 1-4	200		73.5%	Using logistic regression, the best predictors of pu development were the Braden Scale score, diastolic BP, temperature, dietary protein intake, and age.	Rigorous data collection methods were employed. Model performance was not evaluated using an independent sample and no attempt was reported to test for the presence of interactions or confounding variables.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Carlson et al. 1992	Rehab Center for Spinal Cord Injured Patients	Prospective, Incidence	To examine the relationship of incidence and severity of demographic and injury characteristics.	Descriptive Statistics: chi square, kendall's tau-c, Mann-Whitney U-test, t-tests, ANOVA	≥ Stage 2	125		Acute-29% Rehab-3% 1st FU 17%	No significant associations were found between demographic variables and pu incidence and severity at any interval.	Small sample size; bivariate analysis. High refusal rate (30%).
Cullum & Clark, 1992	Acute Care Hospital, Elderly Patients	Retrospective Study of Medical and Nursing Notes	To examine intrinsic factors such as serum protein and systolic BP.	Descriptive statistic, Mann-Whitney U	Present or absent	51		12%	Serum protein concentrations, patients who developed a pu (69-87) were younger than patients who remained free of pu (72-97).	Stage 1 was excluded to improve reliability of study. Small sample size; bivariate analysis. Data collection methods not reported.
Curry & Cassidy, 1992	Spinal Cord Injury Center	Retrospective Review of Medical Records	To examine if level of injury, completeness of injury and length of time immobilized contribute to development of pu.	Chi square	Break in skin integrity	49		20.4%	Prolonged length of immobilization (> 6 hours).	Stage 1 was excluded to improve reliability of study. Small sample; bivariate analysis. Pressure ulcers may be under reported; data were collected using chart review.
Goode et al. 1992	Orthopaedic Unit, Patients with Femoral Neck Fracture	Prospective, Incidence	To evaluate the contribution of specific nutritional deficiencies to risk of pu.	Descriptive statistics, Student t test.	Full thickness epidermal break	21		48%	Low concentrations of leucocyte vitamin C appear to be associated.	Stage 1 was excluded to improve reliability of study. Small sample; bivariate analysis.
Pilolan, 1992	Acute Care Hospital	Retrospective, Review of Medical Record, Case Control	To identify defining characteristics for the nursing diagnosis of high risk for impaired skin integrity.	Descriptive Statistics, chi square analysis, unpaired t test & correlation coefficients	Any degree of breakdown including redness or ulceration	114	?	?	Age >65 years, decreased level of consciousness, low activity level, low grade fever, presence of infection, incontinence, poor nutritional intake, an altered metabolic state.	Stage 1 was excluded to improve reliability of study. Small sample size; bivariate analysis. Under reporting of ulcers may have occurred; data were collected using chart review.
Schubert, 1991	Long Term Care	Correlation	To determine using the laser Doppler technique, whether there is a correlation between low systematic BP and occurrence of pu.	Dynamic skin microcirculatory changes were evaluated in patients without pu and in healthy elderly and young subjects and were correlated to systemic BP and weight to height index.	?	30			Hypotension; patients with pu had significantly lower systolic BP as compared to patients without pu. Staging criteria were not reported.	Small sample size; bivariate analysis.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Vidal et al. 1991	Acute Care Hospital, Spinal Cord Injuries	Retrospective, Incidence, Chart Review	To identify organic and/or behavioural patterns which might imply an added risk.	Chi square, Student t tests, multiple linear regression	Stage 1-4	684		30%	Multiple linear regression analysis identified high risk patients with the following factors: low level education, would not practice standing, would have spasticity, would suffer from urinary infections, would have suffered from various reccurrences of pu.	Poor description of data collection tool. The presence of ulcers may be under reported; data were collected using chart review.
Waitman et al. 1991	Long Term Care	Prospective, Incidence, Case Control	To determine differences in nutritional status, incidence of pu, and incidence of mortality.	ANOVA	Stage 1-4	33 per group		With cancer 85% Cancer Free 70%	Patients with cancer appear to be at greater risk of pressure sores, and incidence of pu is related to a compromised nutritional status.	High incidence of pu; small sample size.
Kemp et al. 1990	Acute Care Hospital, Surgical Patients	Prospective, Incidence	Determine if there was a relationship between proportion of diastolic hypotensive episodes during surgery, age, pre-op albumin levels, pre-op protein levels, pre-op Braden scores and the development of pu.	Discriminant Analysis	Stage 1-4	125		12%	Time on the operating table, extracorporeal circulation, and age emerged as the best predictors.	Model performance was not evaluated using an independent sample. The presence of interactions and confounding variables was not reported.
Berlowitz & Wilking, 1989	Long Term Care	Prospective, Prevalence, Data Base	To identify prospectively risk factors for pu and to compare these results with a cross-sectional analysis in the same population.	Stepwise logistic regression	break in the skin over a bony prominence, Stage 2	Cross-section-301 Cohort-199	33%	10.8%	Factors significantly associated with the *presence of pu* were altered level of consciousness, bed or chair bound, impaired nutritional intake, hypoalbuminemia. Factors significantly associated with the *development of a new pressure sore* were a history of cerebrovascular accident, bed or chair bound, impaired nutritional intake.	Accuracy of data is a concern with clinical data bases. Stage 1 was excluded to improve reliability of study. Under reporting may have occurred since study data were obtained from medical records and weekly information was obtained by the physician and head nurse in charge. Testing for the presence of interactions was not reported. Statistics to evaluate the performance of the models in terms of calibration and discrimination are not reported.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Copeland-Fields & Hoshiko, 1989	Rehab Setting	Validation Study	To examine the relevance of the Braden schema factors.	Fehring's (1986) Validation Model, descriptive statistics	NA	12 RNs			Critical risk factors - decreased mobility, decreased activity, decreased sensory perception, increased friction. Risk Factors - increased moisture, increased shear, decreased nutrition, decreased arteriolar pressure, decreased interstitial fluid flow.	Findings reflect perception of nurses.
Shannon & Skorga, 1989	Spinal Cord Injury Unit, Nursing Home Care Unit	Prospective, Prevalence	To report prevalence and identification of possible major factors of significance in production of pu.	Chi square, ANOVA, Cramer's contingency coefficient.	Stage 1-4	280	1-3.5% 2-8.1%		Factors associated with pressure ulcers were: cardiac/circulatory diagnosis, decreased hemoglobin, hematocrit, total protein, and albumin levels, fecal incontinence, mobility status, restraints.	Bivariate analysis.
Young, 1989	Intermediate, Long Term Care	Prevalence, Case Control	To report pu prevalence and associated characteristics.	Descriptive Statistics, frequency tables and chi square	?	118	23.6%		Poor skin turgor, prolonged capillary refill, presence of maceration, confused, stuporous, semicomatose or comatose mental status, conscious but restless or agitated, lethargic, or responsive only to painful stimuli, decreased activity and mobility status and total helpless, presence of a paralytic condition, on a formula feeding, catheterized.	Data collection methods and staging criteria not reported. Bivariate analysis.
Clark & Kadhorn, 1988	Hospital, Community	Prospective, Incidence	To investigate the time spent for pu care in community and hospital.	Descriptive statistics, discriminant analysis	Broken skin	118		29.5%	Hospital - change in condition of skin, time spent on pressure area care, appetite at end of study period, Norton score at end of study period, diagnosis, method of manual relief of pressure, observed condition of skin, age.	Stage 1 was excluded to improve reliability of study. The authors reported that insufficient information was collected (% not reported) on many of the subjects due to non-completion of diary sheets by the staff nurses.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Mawson et al. 1988	Spinal Cord Injury Unit	Prospective, Incidence	To determine the association between immobilization in the immediate post injury period and the development of pu.	Chi square or Fisher's exact test, t test.	Grade 1-4	39		59%	Factors associated with pu within 30 days of injury : loss of consciousness, duration of immobilization prior to ward admission, distance of injury site, time on spinal board, systolic blood pressure at time of admission.	Small sample; bivariate analysis.
Spector et al. 1988	Nursing Homes (51)	Prevalence, Data Base	To examine factors associated with presence of pu at admission to nursing home.	Logistic regression	Stage 1-4	4,951	20.1%		Older age, being male, nonwhite, unable to bathe, needing help transferring, being catherized, experiencing fecal incontinence, being bed- or chair fast, coming from a hospital, having no rehabilitation potential.	Accuracy of data is a concern with clinical data bases. Performance of the model was not evaluated. Testing for the presence of interactions and confounding variables was not reported.
Ek, 1987	Long Term Care Medical Ward	Prospective, Incidence	To identify predictors of pu development.	Chi square, Mann-Whitney U-test, t-test, multiple regression	Dis-colouration which is persistent, epithelial damage and damage extending through the full thickness of the skin.	515		7.6%	General physical condition, activity, mobility, nutritional status.	Under reporting may have occurred, data were collected by on duty staff nurses.
Stotts, 1987	Acute Care Hospital, Elective Cardio-vascular and Neurosurgical Patients	Prospective, Incidence	To explore age-specific characteristics present at admission.	Descriptive, ANOVA & chi square	Grade 1-4	67		?	No statistically significant age-specific characteristics for pu development present at hospital admission.	Small sample size. Under reporting may have occurred, on duty staff nurses collected the risk assessment data.
Stotts, 1987	Acute Care Hospital, Elective Cardio-vascuair and Neurosurgical Patients	Prospective, Incidence	To determine if nutritional parameters obtained at hospital admission would predict which surgical patients would develop pu.	Stepwise Regression	Grade 1-4	387		17.3%	Nutritional parameters at hospital admission are not good predictors in elective cardiovascular and neurosurgical populations.	Rigorous research methods were employed.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Allman et al. 1986	Acute Care Hospital	Prospective, Prevalence	To determine factors associated with pu.	Stepwise logistic Regression	Epidermal defects or break in skin	634	4.7%		Hypoalbuminemia, fecal incontinence, and fractures remained significant and independently associated with having a pu.	Stage 1 was excluded to improve reliability of study. Head nurses were ask to report pu; under reporting may have occurred. The selection process used to determine which interactions were considered in the model is poorly described. Model performance in regards to calibration and discrimination was not assessed.
Pajk et al. 1996	Acute Care Hospital	Prospective, Prevalence	To conduct a clinical investigation and to identify quantitatively those patients at risk for developing problems.	Chi square, t test, Pearson's correlation	Stage 1-4	208	19.7%		Altered nutritional status, impaired activity, impaired mobility, incontinence, altered mental status. Linear relationship between skin integrity and age; risk factor score and advancing age.	Bivariate analysis was conducted.
Pinchcof-sky-Devin & Kaminski, 1986	Nursing Homes (2)	Correlation	To determine if a correlational exists between deteriorating nutritional status & development of pu.	Descriptive statistics, correlation	Stage 1-4	232	?		Significant difference between nutritional status of pu patients and malnourished patients. The severity of malnutrition based on serum albumin level correlated with the stage of pu.	Data collection methods were poorly described; bivariate analysis.
Thiyagara-janc & Silver, 1984	Spinal Cord Injury Center	Prospective, Incidence	To assess factors know to predispose patients to the development of pu.	Descriptive statistics	?	100		27%	Loss of feeling, increase with age, duration of paralysis.	Staging criteria not reported; small sample, bivariate analysis.
Ek, 1982	Acute, Long Term Care	Prospective, Prevalence	To determine the incidence of pu and the characteristics of patients acquiring ulcers.	Descriptive Statistics	Skin dis-colouration, epithelial damage and damage to full thickness of the skin	1,776	4%		The persons who developed pu were predominantly women over 65 years of age, incontinent, and with poor mobility.	Under reporting may have occurred, on duty staff nurses collected the study data. Staging criteria varies from generally accepted guidelines. Bivariate analysis.

Authors	Setting	Design	Objective	Analysis	Staging	n	Prev	Incid	Significant Factors	Methodological Considerations
Goenell, 1973	Extended Care Facilities (4)	Prospective	To identify variables important in the development of pu.	Descriptive statistics	?	30		NA	Findings of the 5 variables indicated that the levels of mental status, mobility, activity and nutrition were influential factors in the probable development of pu.	Small sample; bivariate analysis. Staging criteria not reported.
Williams, 1972	Acute Care Hospital (2), Non-ambulatory Patients	Prospective Incidence	To identify factors that cause pu and describe characteristics of patient who develop them.	Chi square and stepwise regression	Present or absent	26		27%	A profile of a patient likely to develop ulcers: a thin, febrile male with an infection, who may be receiving corticosteroid therapy.	Small sample.

*pu - pressure ulcer

APPENDIX F: REPORTED STUDIES OF FACTORS ASSOCIATED WITH PRESSURE ULCERS IN ADULTS IN ACUTE AND LONG TERM CARE SETTINGS, 1970 - JUNE, 1998

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Appendix G: Skin Care Assessment Grid

Instructions :

1. Indicate the number of ulcer(s) at each site in the appropriate stage box(es)
2. Note type of dressing used according to dressing key
3. Mark a box for every assessment site.

Dressing Key - See Reference

A	E	I
B	F	J
C	G	K
D	H	

Assessment Site	No Symptom	Blanch.E	Stage I	Stage II	Stage III	Stage IV	Stage X	Dressing
1. Back of head								
2. Right ear								
3. Right scapula								
4. Right elbow								
5. Vertebrae (upper-mid)								
6. Coccyx/Sacrum								
7. Right iliac crest								
8. Right trochanter (hip)								
9. Right ischial tuberosity								
10. Left knee (inner)								
11. Right knee (outer)								
12. Right lower leg								
13. Left ankle (inner)								
14. Right ankle (outer)								
15. Right heel								
16. Right toe(s)								
17. Left ear								
18. Left scapula								
19. Left elbow								
20. Left iliac crest								
21. Left trochanter (hip)								
22. Left ischial tuberosity								
23. Right knee (inner)								
24. Left knee (outer)								
25. Left lower leg								
26. Right ankle (inner)								
27. Left ankle (outer)								
28. Left heel								
29 Left toe (s)								
30. Other (specify)								

Comments:_____