Pressure Injury Risk Prediction: Moving the Science Forward

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Objectives

- Understand the predictive validity of the Braden Scale
- Describe new methods for risk prediction
- Evaluate best practice for pressure injury prediction and subsequent pressure injury prevention
- Give examples of 'high risk' for pressure injury patients who are at moderate risk according to the Braden Scale

Surgical Critical Care Patients

- HAPI incidence 5-10%
- This is the HIGHEST risk group among hospitalized patients
- Reasons for increased risk are multifactorial
- Across studies of ICU patients, age, mobility/ activity, and perfusion are consistent risk factors*

*Alderden, J., Rondinelli, J., Cummins, M., Pepper, G., & Whitney, J. (2017). Risk factors for pressure injuries among critical care patients: A systematic review. *International Journal of Nursing Studies*, 71, 97–114.

Pressure Injury Risk Assessment

- AHRQ: conduct and document structured risk assessment upon admission and with changes in status
- Aimed at identifying individuals susceptible to pressure injuries
- Target appropriate interventions

Structured Risk Assessment: The Braden Scale

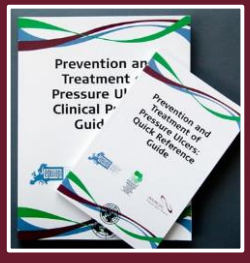
Braden Subscales
- Moisture (1-4)
- Mobility (1-4)
- Friction/shear (1-3)
- Nutrition (1-4)
- Activity (1-4)
- Sensory Perception (1-4)

Braden Total Scores:
- Mild Risk: 15 +
- Moderate Risk: 13-14
- High Risk: 10-12
- Severe Risk: ≤9

Braden Scale Total Score Among ICU Patients

The Braden Score	Why do we do Risk Assessment?
• The Braden total score scale lacks predictive validity among ICU patients*	• Target appropriate interventions to prevent pressure injury development
• High sensitivity, low specificity	• Important for interventions that are not feasible for every patient due to cost or time
• Most patients are "high risk"	
• Unable to differentiate	

*Cox J. (2012). Predictive power of the Braden Scale for pressure sore risk in adult critical care patients: A comprehensive review. *Journal of Wound, Ostomy & Continence Nursing, 39*(6), 613–621; quiz 622–613. doi:10.1097/WON.0b013e31826a4d83
Hyun, S., Vermillion, B., Newton, C., Fall, M., Li, X., Kaewprag, P., . . . Lenz, E. R. (2013). Predictive validity of the Braden Scale for patients in intensive care units. *American Journal of Critical Care, 22*(6), 514–520.
Lima-Serrano, M., Gonzalez-Méndez, M. I., Martín-Castaño, C., Alonso-Araujo, I., & Lima-Rodríguez, J. S. (2016). Predictive validity and reliability of the Braden Scale for risk assessment of pressure ulcers in an intensive care unit. *Medicina intensiva* (English version). doi:10.1016/j.medin.2016.12.014



Maybe Sub-Scale Scores are an Answer?

What is the Relationship Between Braden Scale Subscale Scores and Pressure Injury Development?

Sample	Analysis
• 6,376 surgical ICU patients at the University of Utah	• Survival analysis to determine the hazards of developing a pressure injury with Braden scale subscale scores
• Admitted between 2008-2013	• Lowest risk category was the reference
• 8% had ≥stage 1 HAPI	• This type of analysis takes into consideration changes over time
• 4.4% had ≥stage 2 HAPI	

Study Results: Subscale Scores and HAPI Risk

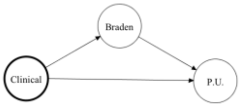
- With the exception of the friction and shear subscale, **midrange** risk subscale scores were associated with increased risk for pressure injury development*
- For example, patients who were "often moist" were twice as likely to develop a PI as patients who were "constantly moist"

*Alderden, J., Cummins, M., Pepper, G. A., w Zhang, Y. Y., Butcher, R., & Thomas, D. (2017). Mid-range Braden subscale scores are associated with increased risk for pressure injury among ICU patients. Journal of Wound, Ostomy, and Continence Nursing, 44(5), 420–428.

Why are mid-range Braden subscale scores associated with increased risk for HAPI?

- Is the Braden scale a 'cue' for nurses to intervene for high Braden scale risk patients?
- Will extending interventions to moderate risk Braden scale risk patients work to decrease pressure injuries?

Mediation Model:

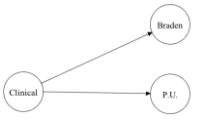


Is the Braden scale a 'cue' for nurses to intervene for high Braden scale risk patients?

Perhaps Not.

- When Braden scale scores were blinded (only collected and viewed by research staff) patients with the highest risk Braden scale scores still received the most aggressive intervention.
- The authors concluded that formal risk assessment was needed to identify patients at moderate risk*

Confounding model: pressure injuries and the Braden scale have a common cause



*Bergstrom, N., Braden, B., Kemp, M., Champagne, M., & Ruby, E. (1996). Multi-stie study of the Incidence of Pressure Ulcers and the Relationship between Risk Level, Demographic Characteristics, Diagnosis, and Prescription of Preventative Interventions. Journal of the American Geriatrics Society 44:22-30.

Stay Tuned…

Changes Made	Evaluation
• The U. Utah surgical ICU clinical protocol was adjusted to extend maximal intervention to moderate risk patients	• New data from 2014-2018: pressure injury incidence, population characteristics, risk patterns in relation to Braden scale scores • Preliminary data show no decrease in HAPI incidence

Summary: Braden Scale Total Score Among ICU Patients

The Facts

- The Braden scale total score lacks predictive validity
- Mid-range, as opposed to high risk, Braden scale subscale scores are associated with increased risk for pressure injury
- We don't yet have an evidence based way to identify highest risk ICU patients

Pressure Injury Risk Assessment among ICU Patients

The Future:

- We need a way to identify highest risk ICU patients
- Target interventions that are not feasible for every patient due to time or cost
- Also consider documentation fatigue

Machine Learning

NETFLIX amazon.com

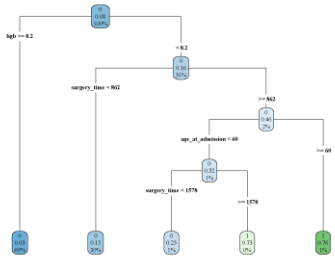
Machine Learning: The Computer Learns

Why Machine Learning

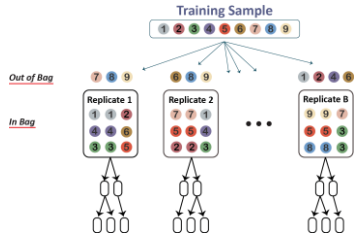
- Effective use of big data
- Resistance to outliers
- No scaling
- Not corrupted by moderately correlated data

Random Forest

- Decision tree predicts a target value based on input values
- Random forest: builds multiple decision trees
- Goal= unseen record accurately classified
- Collects sub-samples of data with replacement (bootstrap aggregation)



Bootstrap Aggregation: Sub-Samples with Replacement

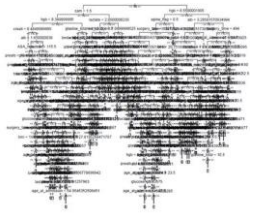


Adapted from: Izmirlian, G. (2004). Applications of the random forest classification algorithm to a SELDI-TOF proteomics study in the setting of a cancer prevention trial. Annals of the New York Academy of Sciences 1020: 154-174.

Predicting Pressure Injuries: A Machine Learning Approach

- Knowledge discovery in databases approach
- 6,376 surgical ICU patients at the University of Utah
- Admitted between 2008-2013
- 8% had ≥stage 1 HAPI
- 4.4% had ≥stage 2 HAPI
- Variables selected based on clinician input and literature search
- Daily level format
- Only include variables that are readily available in the EHR

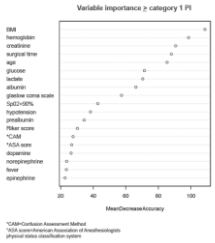
Our Random Forest Model



- Estimated out of bag error rate:
  - 4.2% stage 1 and greater
  - 2.87% stage 2 and greater
- Area under the receiver operating characteristic curve= 0.79*

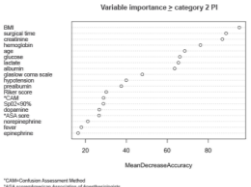
*Alderden, J., Pepper, G. A., Whitney, J., Wilson, A., Richardson, S., Butcher, R. . . . Cummins, M. (2018). Predicting pressure injuries among critical care patients: A machine learning model. American Journal of Critical Care 27(6): 461-468.

Variable Importance (Stage 1 and Greater)



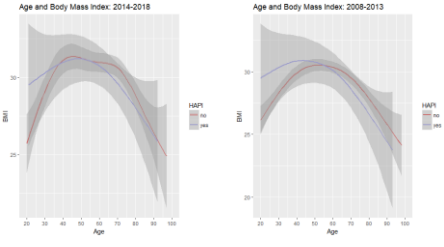
- Body mass index
- Hemoglobin
- Surgical time
- Age
- Glucose

Variable Importance (Stage 2 and Greater)



- Body mass index
- Surgery time
- Creatinine
- Hemoglobin
- Age

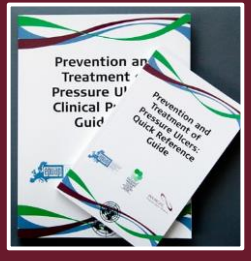
Complex Relationships Among Variables



Next Steps

- Test the model in a clinically similar data set
- Improve the model– new variables
- Simplify
- Adapt and update to optimize specificity
- **Deploy the model within the electronic health record for clinical decision support**

Best Practice for Pressure Injury Risk Assessment



*Alderden, J., Rondinelli, J., Cummins, M., Pepper, G., & Whitney, J. (2017). Risk factors for pressure injuries among critical care patients: A systematic review. International Journal of Nursing Studies, 71, 97–114.

Best Practice for Risk Assessment

NPUAP Guidelines:

"Do not rely on a total risk assessment tool score alone as a basis for risk based prevention. Risk assessment scale subscale scores and other risk factors should also be used as a guide to risk based planning" p.44

- Across studies of ICU patients, age, mobility/ activity, and perfusion are consistent risk factors*

Case Study #1

Braden Scale	
Sensory Perceptions	3
Moisture	3
Activity	2
Mobility	2
Nutrition	3
Friction and Shear	2
Braden Scale Score	15

Wound (LDAs)

Case Study #2

Braden Scale	
Sensory Perceptions	2
Moisture	1
Activity	2
Mobility	2
Nutrition	2
Friction and Shear	2
Braden Scale Score	11

Case Study #3

Braden Scale	
Sensory Perceptions	3
Moisture	3
Activity	2
Mobility	2
Nutrition	2
Friction and Shear	3
Braden Scale Score	15

Unavoidability

- Most pressure injuries are avoidable
- Some pressure injuries are unavoidable
- Accurate risk assessment is also needed to study unavoidable pressure injuries

Questions?

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Knowledge discovery in databases process

- Data mining can be used for predictive modeling with a large data set
- Data mining is just one step in the KDD process