

USING EHR DATA TO DYNAMICALLY PREDICT INCIDENCE OF HOSPITAL-ACQUIRED PRESSURE ULCERS

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Background Hospital-acquired pressure ulcers (HAPUs) are costly to treat and can result in Medicare reimbursement penalties. Statistical models can identify patients at greatest HAPU risk and improve prevention.

Objectives To use electronic health record (EHR) data to predict HAPUs among hospitalized patients.

Methods EHR data were obtained from an academic medical center that included hospitalized patients with at least 1 skin examination between 2011–2014. These data contained encounter-level demographic variables, diagnoses, prescription drugs and provider orders. HAPUs were defined by stages III, IV or unstageable pressure ulcers not present-on-admission as a secondary diagnosis, and excluded diagnosis of paraplegia/quadriplegia. Random forests and k-means clustering were applied to reduce the dimensionality of the large dataset. A 2-level mixed-effects logistic regression of patient-encounters evaluated associations between covariates and HAPU incidence (Equation 1).

Results The approach produced a sample population of 23,054 patients with 1,549 HAPUs. The mixed-effects model predicted HAPUs with exceptional (99%) accuracy for a rare event (table 1). The greatest odds ratio (OR) of HAPU incidence was among patients diagnosed with spinal cord injury (ICD-9 907.2: OR=247.4; P<0.001). Other high ORs included osteomyelitis (ICD-9 730: OR=27.7, P<0.001), bed confinement (ICD-9 V49.84: OR=31.7, P<0.001), and prescribed topical/subcutaneous enzymes (OR=5.7, P<0.001).

Conclusions Early detection of HAPUs is feasible and the results of these statistical predictions can allow providers to better target prevention to specific patients. This model also implicates spinal cord injury as a potential risk-factor for unavoidable HAPUs. Providers may be missing opportunities to co-diagnose spinal cord injury with paraplegia/quadriplegia which could improve hospital performance measures.

Equation 1. Mixed-effects Logistic Regression Model Level-1: Encounter-level Fixed Effects

$$\text{Logit}[E(Y_{ij})] = b_0 + \beta_1 \text{Age}_{ij} + \beta_2 \text{BradenScore}_{ij} + \beta_3 \text{Rx}_{ij} + \beta_3 \text{Dx}_{ij} + \beta_3 \text{Order}_{ij} + \dots + Z_{ij}$$

Level-2: Patient/Cluster-level Random Effect

$$b_0 = \beta_0 + u_{i0}$$

Where...

i: Patient

j: Encounter

Table 1 Results of 2-level Mixed-effects Logistic Regression and population-average estimates for HAPU incidence by patient-encounter.

| Variable | 2-Level Mixed-effects Logistic Regression | | | | Population-average Estimates (GEE) | | | |
|--|---|------------|----------------|---------|------------------------------------|------------|----------------|---------|
| | Estimate | Odds Ratio | Standard Error | P-value | Estimate | Odds Ratio | Standard Error | P-value |
| Intercept | −9.469 | 0.000 | 0.331 | <0.001 | −7.016 | 0.001 | 0.175 | <0.001 |
| Age | 0.049 | 1.050 | 0.003 | <0.001 | 0.040 | 1.041 | 0.002 | <0.001 |
| Bronchoscopy | 0.513 | 1.671 | 0.248 | 0.038 | 0.408 | 1.504 | 0.190 | 0.032 |
| Culture, Stool | 0.514 | 1.672 | 0.158 | 0.001 | 0.414 | 1.512 | 0.123 | 0.001 |
| Urinalysis Chemistry Screen | 0.841 | 2.319 | 0.089 | <0.001 | 0.693 | 2.000 | 0.073 | <0.001 |
| Pre-albumin | 0.983 | 2.674 | 0.091 | <0.001 | 0.761 | 2.141 | 0.067 | <0.001 |
| Vancomycin Random Assay | 0.959 | 2.609 | 0.094 | <0.001 | 0.728 | 2.071 | 0.069 | <0.001 |
| Culture & Stain, Wound Drainage | 0.790 | 2.203 | 0.135 | <0.001 | 0.582 | 1.790 | 0.098 | <0.001 |
| Topical Sulfonamides | 1.732 | 5.653 | 0.115 | <0.001 | 1.297 | 3.660 | 0.078 | <0.001 |
| Topical/Mucous Membrane/Subcutaneous Enzymes | 3.389 | 29.622 | 0.276 | <0.001 | 2.109 | 8.236 | 0.167 | <0.001 |
| Phosphate Replacement | 0.260 | 1.297 | 0.085 | 0.002 | 0.204 | 1.227 | 0.068 | 0.003 |
| Antifungal Agent | 0.472 | 1.603 | 0.094 | <0.001 | 0.385 | 1.470 | 0.075 | <0.001 |
| Erythropoiesis-stimulating Agent | 0.995 | 2.705 | 0.134 | <0.001 | 0.768 | 2.156 | 0.098 | <0.001 |
| ICD-9 V49.84: Bed Confinement | 3.457 | 31.730 | 0.539 | <0.001 | 2.198 | 9.003 | 0.334 | <0.001 |
| ICD-9 907.2: Spinal Cord Injury | 5.511 | 247.364 | 0.500 | <0.001 | 3.814 | 45.311 | 0.318 | <0.001 |
| ICD-9 730.15: Chronic Osteomyelitis – Pelvic and Thigh Regions | 3.323 | 27.746 | 0.697 | <0.001 | 2.312 | 10.094 | 0.474 | <0.001 |
| ICD-9 730.18: Chronic Osteomyelitis – Other | 3.001 | 20.099 | 0.806 | <0.001 | 1.932 | 6.904 | 0.516 | <0.001 |
| Variance(Intercept) | 4.355 | | 0.486 | | | | | |
| Log-likelihood | −4737.36 | | | | | | | |