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Are Evidence-based Practices Associated with Effective Prevention of Hospital-acquired Pressure Ulcers in U.S. Academic Medical Centers?

William V. Padula, PhD, MS, MSc,

Assistant Professor, Department of Health Policy & Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

Robert D. Gibbons, PhD,

Professor, Department of Public Health Sciences, University of Chicago, Chicago, IL

Robert J. Valuck, PhD, RPh,

Professor, Department of Clinical Pharmacy, University of Colorado, Aurora, CO

Mary Beth F. Makic, PhD, RN,

Associate Professor, College of Nursing, University of Colorado, Aurora, CO

Manish K. Mishra, MD, MPH,

Assistant Professor, Department of Community and Family Medicine, Geisel School of Medicine at Dartmouth, Hanover, NH

Peter J. Pronovost, MD, PhD, FCCM, and

Professor, Departments of Anesthesiology, Critical Care and Surgery, Johns Hopkins School of Medicine, Baltimore, MD

David O. Meltzer, MD, PhD

Professor, Department of Medicine, University of Chicago, Chicago, IL

William V. Padula: wpadula@jhu.edu; Robert D. Gibbons: rdg@uchicago.edu; Robert J. Valuck: robert.valuck@ucdenver.edu; Mary Beth F. Makic: marybeth.makic@ucdenver.edu; Manish K. Mishra: manish.mishra@dartmouth.edu; Peter J. Pronovost: ppronovo@jhmi.edu; David O. Meltzer: dmeltzer@medicine.bsd.uchicago.edu

Abstract

Background—In 2008, the Centers for Medicare and Medicaid Services (CMS) established nonpayment policies resulting from costliness of hospital-acquired pressure ulcers (HAPUs) to hospitals. This prompted hospitals to adopt quality improvement (QI) interventions that increase use of evidence-based practices (EBPs) for HAPU prevention.

Objective—To evaluate the longitudinal impact of CMS policy and QI adoption on HAPU rates.

Methods—We characterized longitudinal adoption of 25 QI interventions that support EBPs through hospital leadership, staff, information technology, and performance and improvement. Quarterly counts of HAPU incidence and inpatient characteristics were collected from 55 UHC

hospitals between 2007–2012. Mixed-effects regression models tested the longitudinal association of CMS policy, HAPU coding and QI on HAPU rates. The models assumed level-2 random-intercepts and random effects for CMS policy and EBP implementation to account for between-hospital variability in HAPU incidence.

Results—Controlling for all 25 QI interventions, specific updates to EBPs for HAPU prevention had a significant, though modest reduction on HAPU rates (−1.86 cases/quarter; $p=0.002$) and the effect of CMS nonpayment policy on HAPU prevention was much greater (−11.32 cases/quarter; $p<0.001$).

Conclusions—HAPU rates were significantly lower following changes in CMS reimbursement. Reductions are associated with hospital-wide implementation of EBPs for HAPU prevention. Given that administrative data were used, it remains unknown whether these improvements were due to changes in coding or improved quality of care.

Keywords

Pressure Ulcers; Medicare; Quality Improvement; Preventive Care; Evidence-based Practice; Policy

INTRODUCTION

Hospital-acquired pressure ulcers (HAPUs) are important to patients, policymakers, and health systems in the U.S and globally. In April of 2007, the Centers for Medicare and Medicaid Services (CMS) announced changes to the Inpatient Prospective Payment System that would withhold payment for a number of hospital-acquired conditions not present-on-admission (POA), including HAPUs.(1, 2) This nonpayment policy was not enacted until October, 2008, giving hospitals 18 months to make adjustments to HAPU prevention protocols. In January, 2009, CMS established new coding requirements of hospital-acquired conditions that included use of a POA status indicator, further differentiating HAPUs as an important measure of hospital quality.(3, 4) And in October, 2014, CMS added a new 1% reimbursement penalty for hospitals performing in the lowest-quartile with respect to hospital-acquired condition rates.(5)

HAPUs are the most costly of all hospital-acquired conditions, ranging from \$500 to over \$130,000 per patient, which translates into \$11 billion in direct medical costs and is one of the highest rates of settlement costs among U.S. hospitals and long-term care facilities.(6–8) HAPU rates, measured through administrative data, have declined from a spike of 7% in 2004 to 4.5% as of 2012, although these rates have not declined steadily.(9, 10) Decreases in these rates are likely a function of changes in coding POA status as well as changes in quality of care.(11)

Improved adherence to evidence-based practice (EBP) guidelines for HAPU prevention could have impacted quality of care.(12) The EBP guidelines endorsed by the Agency for Healthcare Research & Quality and the National Pressure Ulcer Advisory Panel consist of several steps: (1) skin check and risk assessment with a validated instrument such as the Braden Scale; (2) repositioning; (3) managing moisture and incontinence; (4) nutrition; (5) new beds and other support surfaces; and (6) actions to reduce friction and shear.(13, 14)

These guidelines were first published in 2003, and updated again in 2005 and 2010.(15–17) Yet for a variety of reasons, many patients do not consistently receive these practices.(18) According to Nelson et al., quality improvement (QI) interventions can improve adherence to implementation of EBP guidelines through four domains of hospital culture: leadership; staff; information technology; and performance and improvement.(19) A complete QI strategy may contain interventions from multiple domains that are bundled together to culturally integrate and improve consistent implementation of EBPs.(20)

Given recent updates to the CMS reimbursement policy and coding procedures, there is an interest in knowing if changes in routine practice, linked to QI interventions, lead to appreciable decreases in HAPU rates. The study followed an observational cohort of hospitalized patients using hospital-level administrative data to measure HAPU rates over time, and analyze associations to QI adoption and CMS policies. It was hypothesized that declining HAPU rates were associated with increased adoption of QI interventions after CMS policies were modified.

METHODS

Study Design

This is a hospital-level, retrospective observational cohort study of U.S. academic medical centers that participated in data sharing through UHC (www.uhc.edu, Chicago, IL) and responded naturally to updates in CMS policy between October, 2007 and June, 2012. The UHC represented a cooperative of over 200 academic medical centers that centrally housed administrative data on hospitalized patients. These de-identified, quarterly hospital-level data were available for download through queries in the UHC Clinical Database and Resource Manager.

After the Colorado Multiple Institutional Review Board approved this study as exempt human subject research, hospital data on HAPU outcomes and inpatient characteristics were acquired from UHC. These data were managed longitudinally by hospital-quarter. Counts of HAPUs were obtained from UHC data according to Agency for Healthcare Research and Quality Patient Safety Indicator #3 (PSI-03, v. 3.1, ©2007).(21) This indicator defined HAPUs as stage III or IV pressure ulcers (ICD-9 707.23 and 707.24) not POA after five days length-of-stay.

Patient characteristics were gathered from UHC, which provides hospital-level aggregate data by each quarter, including: age (counts by category: 18–30; 31–50; 51–64; 65); sex (counts of male and female); length-of-stay (mean); in-hospital mortality (count); intensive care unit admission (count); case-mix index (hospital-level case-mix per quarter); and medical or surgical status (counts of each). Patient-level information were not available. Hospitals were also classified according number of beds, as well as periods of time when hospitals received Magnet recognition from the American Nurses Credentialing Center as a way to control for hospitals with excellence in nursing quality.(22)

Data Sources

UHC data were merged with data on the hospital-level adoption patterns of QI interventions according to the four domains of hospital culture by Nelson et al. and a framework of 25 QI interventions designated for HAPU prevention.(19, 20) In a study previously described by Padula et al., Certified Wound, Ostomy and Continence Nurses from a representative sample of 55 UHC hospitals were surveyed to provide longitudinal information about their own adoption patterns of each of the 25 QI interventions for HAPU prevention to the nearest quarter between 2007–2012.(23) These hospitals indicated whether EBPs for HAPU prevention were standardized in nursing, as well as which of 25 QI interventions across four domains – leadership, staff, information technology, and performance and improvement – were used as part of a HAPU prevention bundle. As hospitals indicated which QI interventions were associated with HAPU prevention, they reviewed documentation to reference start and end dates of interventions to the nearest quarter.

Not all of the 55 hospitals were available for observation during all quarters since certain hospitals in the study did not participate in UHC data pooling until after 2007. Each year, more hospitals joined UHC: 48 hospitals in 2007; 51 in 2008; 54 in 2009–2010; and 55 by 2011. As data on QI adoption were merged with HAPU outcomes, hospitals only contributed data to the analysis when they became UHC members.

Analysis

We used two-level mixed-effects Poisson regression models to regress HAPU rates over time by QI intervention and changes in CMS policy.(24) We organized these data as a series of quarterly, hospital-level measurements of HAPU counts and other patient outcomes by hospital. Since UHC did not provide patient-level data, individual means were not included in the model. Changes in counts of HAPUs were studied over time, nested within hospitals, using offsets to control for variability in the number of patient hospitalizations between hospitals according to inclusion criteria in PSI-03.

The mixed-effects models were developed and tested in two iterations using SuperMix (Scientific Software International, Skokie, IL, ©2005–2014). The first model iteration began by studying the level-1 fixed-effects of each of the 25 categorical QI interventions on HAPU rates. Each QI intervention was coded as a dichotomous variable for each hospital, where 0 indicated a quarter when a specific QI intervention was not adopted and 1 indicated when it was in use. This model also controlled each of the following covariates available from UHC in addition to those already described: time (continuous by quarter); age; sex; length-of-stay (continuous by day); in-hospital mortality rate; intensive care unit admission; case-mix index; medical or surgical status; beds (count); Magnet Recognition (dichotomous); and a standardized EBP protocol for HAPU prevention (dichotomous).

The model also controlled for two binary policy interruptions which varied from 0 to 1 when the policy was enacted: (1) CMS nonpayment policy in starting in October, 2008; and (2) inclusion of the POA status indicator in January, 2009. Included in the model design were a random-intercept and level-two random-effects for both of these aforementioned policy interruptions. We used random-effects since hospitals began at different points in the process

towards improving HAPU prevention efforts and HAPU rates varied between hospitals. Additionally, we assumed that CMS policies would have variable impact on progress at different hospitals.

A complete model that included all covariates was tested first in Equation 1,

$$\text{Log}[E(Y_{ij})] = (\beta_0 + u_{i0}) + \beta_1 \text{quarter}_j + \beta_2 \text{QI}_{ij} + (\beta_3 + u_{i1}) \text{policy}_j + \dots + Z_{ij} \quad \text{Equation 1}$$

where i was the hospital and j was incremental quarter between the 4th quarter of 2007 and 2nd quarter of 2012. The expected value of Y_{ij} HAPU counts was dependent upon the mean intercept (β_0) and subject-specific intercept (u_{i0}), as well as the fixed-effect of time (β_1), each of 25 QI interventions (β_2), and the mean (β_3) and subject-specific impacts of policy interruptions (u_{i1}). Z_{ij} represented the individual-specific error term which varied over time. Between-subject changes in counts of HAPU rates were offset by the total number of hospitalized patients.

The second model iteration was developed ad-hoc to study the effect size of only statistically significant QI interventions on HAPU rates from the first model with time-interactions, while also controlling for significant covariates and CMS nonpayment policy (Equation 2). A random-intercept and level-two random effects were tested for statistically significant QI interventions as well as significant policy interruptions. This model iteration also tested for interactions between the effects of time and policy interruptions on the effect sizes of QI at reducing HAPUs.

$$\text{Log}[E(Y_{ij})] = (\beta_0 + u_{i0}) + \beta_1 \text{quarter}_j + \beta_2 \text{QI}_{ij} + (\beta_3 + u_{i1}) \text{policy}_j + \beta_4 \text{quarter}_j \times \text{QI}_{ij} + \beta_5 \text{policy}_j \times \text{QI}_{ij} + \dots + Z_{ij} \quad \text{Equation 2}$$

For each of the two model iterations, the best form of each model was determined according to a likelihood-ratio test based on seven mean-variance adaptive Gauss-Hermite quadrature points. The simplest model with improved log-likelihood and QI interventions that had statistically significant reductions on HAPU counts was then selected. Independent and exchangeable autocorrelation structures were also compared. Furthermore, we used a Lowess smoother to evaluate the descriptive changes in HAPU rates over time.

RESULTS

The U.S. academic medical centers in this UHC sample recorded 5,208 HAPU cases from a large cohort of 1,590,022 hospitalized patients between 2007–2012 (Table 1). Most of these cases had a prolonged length-of-stay and were elderly, male, included intensive care unit admissions or surgical services, and higher case-mix index.

A plot of HAPU rates indicated that coding of PSI-03 was relatively high in 2007 through early-2008 in this hospital cohort. According to a Lowess smooth line plot, the rate of HAPUs decreased between hospitals over time, almost to zero by 2012 (Figure 1). These reductions suggest that much of the variance in HAPU rates was associated with changes in policy and coding POA status. Further evaluations also quantified the effect size of QI interventions on this rate reduction.

Longitudinal Data Analysis

In general, a large increase in the number of QI interventions adopted by each hospital – from about 7 per hospital in 2007 to over 15 in 2012 – coincided with CMS policy changes and could be linked to an association with decreased HAPU rates (Figure 2a). A mixed-effects model of HAPU rates by hospital-quarter showed significant reductions with advancing time, whether viewing HAPU rates from a pre- or post-CMS policy standpoint (Table 2). This model also controlled for age, CMS policy and case-mix index. Other covariates (e.g. sex and death) were omitted following backwards stepwise regression to improve log-likelihood and eliminate insignificant covariates. For instance, length-of-stay was omitted due to insignificance ($p = 0.05$), possibly due to the issue that the study sample controlled for 5 days length-of-stay or greater according to PSI-03. The model viewing observations between 2007–2012 identified CMS policy change as the single greatest factor of changes in HAPU rates. Interestingly, POA coding changes noted in 2009 did not result in significant changes in HAPU incidence, perhaps because HAPUs had stabilized as a result of accurately identifying all baseline cases that were POA in conjunction with CMS nonpayment policy enactment in October, 2008.

Of all QI interventions tested in the first model, only updates to the existing pressure ulcer prevention protocol (“Prevention Protocol”) showed statistically significant reductions in HAPU rates. In fact, in 2007 there were 24 hospitals using this QI intervention, and the amount increased to 43 hospitals by 2012 (Figure 2b). Thus, it would be tested in a second model. “All-Staff Meetings,” or frequent town hall style meetings to discuss updates in prevention guidelines were actually associated with increases in HAPU rates.

The second mixed-effects model only controlled for the QI intervention “Prevention Protocol” in addition to time, case-mix index, CMS policy and patient age. Time-interaction terms were omitted since these covariates were not significant. This model employed random-effects for the intercept, QI intervention and CMS policy, and applied an exchangeable autocorrelation structure ($X^2 = 10.7$, $p < 0.05$). This model calculated an increased effect size of changes in updates to the prevention protocol while controlling for other covariates, and significantly improved log-likelihood (Table 3). That is, hospitals adopting the QI intervention for “Prevention Protocol” saw a 27% reduction, or 1.86 fewer HAPU cases per quarter. CMS policy was associated with a greater reduction of 11.32 HAPUs cases – more than a 100% decrease – suggesting that this policy intervention was followed by the most dramatic decreases in PSI-03 flags.

DISCUSSION

We performed a series of multivariable longitudinal data analyses about adoption patterns of QI interventions to support implementation of EBPs for HAPU prevention. Several factors were identified in reducing HAPU rates in academic medical centers from 2007 through 2012. This decrease may have had much to do with mounting pressure of CMS nonpayment policy that was enacted in October, 2008, which was the largest observed factor in HAPU rate reductions. It may also have had to do with overlapping changes to coding pressure ulcers POA in 2009, such that more pressure ulcers were discovered in the first 4 days of hospitalization. Following CMS nonpayment policy, the rate of HAPUs fell on average by

11 cases per quarter. The only significant QI intervention associated with HAPU reductions was “Prevention Protocol.”

This QI intervention suggested that hospitals investing time for hospital leadership (e.g. nursing quality educators) and skin team leaders to train frontline providers (e.g. RNs, PTs, etc.) about updates to EBPs for HAPU prevention saw improved outcomes. Hospitals that adopted “Prevention Protocol” witnessed an average reduction of 1.18 HAPU cases per quarter. This reduction in HAPUs could result in significant financial gain for an institution, which could incur direct costs of \$130,000 for a single stage III/IV HAPU case, as well as potentially much more in legal settlements.(7) In addition, updates to a prevention protocol that translate commonly scripted guidelines into direct, more interpretable information for each hospital’s providers and culture could be cost-effective.(25)

Based on a timeline of publications by the Wound, Ostomy and Continence Nursing Society, EBPs that were first published in 2003 had addenda published in 2005 and 2010, and could have impacted longitudinal adoption of QI interventions for hospitals in this study.(15–17) Updates to pressure ulcer staging were also noted in 2007, which could have helped differentiate a low-stage pressure ulcer from a full-thickness wound not POA that would qualify for PSI-03.(26) At this rate, detailed EBPs for HAPU prevention changed rapidly as new technologies and techniques were discovered. It was also recommended that hospitals which intended to become Magnet centers of excellence for HAPU prevention had to develop a QI program and appoint formal leaders among nursing staff to learn about EBP updates and disseminate this information to other hospital providers.(27)

There are a number of limitations to this study. First, the period when QI interventions began taking effect after adoption was not certain. We assumed immediate effect following the first quarter of initiation, but there could have been lag between initiation and effectiveness. A sensitivity analysis addressed the inherent issues of recall bias and lag effect by measuring effect sizes for altered start- and end-dates by one quarter in either direction, but this additional analysis returned no significant changes in results. Second, patient-level data were not available from UHC, so we assumed that within each hospital, QI interventions were initiated consistently between patients.

Third, response bias potentially limited survey responses to hospitals observing positive effects following QI adoption, compared to hospitals with net-zero or negative outcomes. While many additional UHC hospitals contacted were initially willing to participate, these contacts indicated that they did not have the time to complete the survey or they did not have permission from their administrations to divulge information about QI strategies despite the survey’s anonymity. This issue would suggest that actually many more UHC hospitals were investigating QI strategies for HAPU prevention.

Fourth, the study lacked a control group that did not face the effects of CMS nonpayment policy or coding changes. The model controlled for time, thereby minimizing the between-hospital effects of these policies and assigning each hospital as its own control. Additionally, two hospitals sampled never adopted new QI interventions between 2007–2012, which offered a helpful comparator within the statistical models.

Fifth, there may have been issues concerning reliability of UHC data due to transcription errors or oversight in coding at the level of data entry. The use of administrative data makes reliability of coding PSI-03 questionable. This flag depends on billing coders to accurately extract all data that qualify a patient for a Stage III/IV HAPU not POA, including the inclusion and exclusion criteria of PSI-03. Meddings et al. noted that these types of data sources combined with PSI-03 do not accurately portray the rate of HAPUs, especially across changes in policy.(28) Since UHC data were most accessible for this study design, we utilized a method that we believed best controlled for time-dependent changes in coding policy as published in CMS proceedings. However, despite our attempt to control for it in regression, we cannot evaluate the extent that coding independently has on HAPU rate reductions likely due to the collinearity of changes in POA status with CMS nonpayment policy. We acknowledge that it likely has a large effect on changes in HAPU rates independent of nonpayment policy and QI interventions.

Future research should examine the independent effect of coding on reductions in PSI-03, or for that matter, other patient quality and safety indicators. It would be interesting to determine if hospitals that effectively updated their prevention protocols also were better at coding HAPUs properly, among other things. This provides a strong incentive to test interactions between updates to prevention protocols and accurately coding pressure ulcers as POA.

In conclusion, HAPU rates were significantly lower following changes in CMS policy over reimbursements. Reductions were associated with hospital-wide implementation of and updates to EBPs for HAPU prevention. Given that administrative data were used, it remains unknown whether these improvements were due to changes in coding or improved quality of care.

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Legend: Gray dots indicate quarter when CMS nonpayment policy was established in October, 2008.

Figure 1.

Smoothed locally weighted regression of aggregate quarterly weights and scatterplot of hospital-level HAPU rates relative to all hospitalized patients according to Agency for Healthcare Research and Quality PSI-03 inclusion criteria, while noting CMS nonpayment policy during October, 2008.

Gray dots indicate quarter when CMS nonpayment policy was established in October, 2008.

Figure 2a. **Figure 2b.** **Figure 2.**

(a) Mean number of QI interventions per hospital between all observed hospitals per quarter relative to changes in CMS reimbursement policy between 3rd quarter of 2007 and 2nd quarter of 2012; (b) Number of hospitals using the Leadership QI intervention, Prevention Protocol, per quarter relative to changes in CMS reimbursement policy between 3rd quarter of 2007 and 2nd quarter of 2012.

Table 1

Patient characteristics among a sample of 55 UHC hospitals, 2007–2012.

Characteristic	N	%
UHC Hospitals	55	
Hospital-quarters	1119	
Nursing Magnet Hospitals	28	51%
Total Inpatient Admissions	1,590,022	
Age		
18–30	168,728	11%
31–50	385,282	24%
51–64	462,510	29%
65	574,167	36%
Female	776,492	49%
Medical	871,497	55%
Surgical	681,496	43%
Total HAPU Cases	5,208	
Age		
18–30	268	5%
31–50	850	16%
51–64	1,597	31%
65	2,495	48%
Female	2,217	43%
Medical	1,979	38%
Surgical	3,208	62%

HAPU indicates hospital-acquired pressure ulcer.

Table 2

Results of a mixed-effects Poisson regression of hospital-level HAPU rates, controlling for longitudinal adoption patterns of all QI interventions as well as changes in CMS nonpayment policy.

Variable	Estimate	Standard Error	P
<i>Intercept</i>	1.5250	0.1445	<0.001
<i>Time</i>	−0.0323	0.0067	<0.001
<i>Program Mission</i>	0.1100	0.0929	0.2362
<i>Prevention Awareness</i>	0.0194	0.0926	0.8340
<i>Leadership Initiatives</i>	−0.1536	0.1039	0.1391
<i>Admin Support</i>	−0.0007	0.0981	0.9943
Prevention Protocol	−0.1808	0.0845	0.0325
<i>Benchmarking</i>	0.0426	0.0932	0.6474
<i>Wound Team</i>	0.0395	0.0725	0.5855
<i>Performance Measures</i>	0.0065	0.0818	0.9369
<i>Team Huddles</i>	0.0651	0.1050	0.5353
<i>All-Staff Meetings</i>	0.2541	0.1159	0.0283
<i>Wound/QI Team</i>	0.0011	0.0780	0.9887
<i>Prevention Education</i>	0.0002	0.0920	0.9987
<i>Staff Training</i>	0.1219	0.0916	0.1834
<i>Data Tracking</i>	−0.0590	0.0796	0.4587
<i>EHR Risk Assess</i>	−0.1175	0.1238	0.3423
<i>Electronic Alarm</i>	0.0366	0.0974	0.7070
<i>EHR Implementation</i>	−0.0650	0.1126	0.5640
<i>Braden Scale</i>	0.0624	0.0823	0.4484
<i>Visual Tools</i>	−0.0833	0.0994	0.4020
<i>Beds</i>	0.0869	0.0778	0.2644
<i>HAPU Staging</i>	−0.0378	0.0960	0.3409
<i>Skin Care</i>	−0.0820	0.0861	0.1224
<i>Incontinence</i>	0.1339	0.0867	0.8296
<i>Repositioning</i>	−0.0331	0.1539	0.3976
<i>Nutrition</i>	−0.1267	0.1498	0.9188
<i>Age 31–50</i>	0.0513	0.0079	<0.001
<i>Age 51–64</i>	0.0571	0.0049	<0.001
<i>Age >65</i>	0.0420	0.0030	<0.001
<i>Case-mix Index</i>	0.0467	0.0044	<0.001
<i>CMS Policy (October, 2008)</i>	−1.1355	0.1507	<0.001
<i>Present-on-Admission Indicator (January, 2009)</i>	−0.0219	0.1399	0.8758

Log-likelihood = −1855.86

Bold indicates statistically significant at 95% confidence

Grey indicates statistically significant QI interventions for reducing HAPUs

Time is measured quarterly from 3rd quarter of 2007 to 2nd quarter of 2012

Table 3

Results of a mixed-effects Poisson regression of hospital-level HAPU rates, controlling for longitudinal adoption patterns of updates to the “Prevention Protocol” and CMS nonpayment policy.

Variable	Beta-estimate	Standard Error	P
<i>Intercept</i>	−5.408	0.088	<0.001
<i>Time</i>	−0.045	0.006	<0.001
<i>Prevention Protocol</i>	−0.2701	0.0889	0.002
<i>Age 31–50</i>	0.047	0.009	<0.001
<i>Age 51–64</i>	0.053	0.005	<0.001
<i>Age >65</i>	0.038	0.003	<0.001
<i>Case-mix Index</i>	0.044	0.004	<0.001
<i>CMS Policy</i> (October, 2008)	−1.054	0.101	<0.001
Variance(<i>Intercept</i>)	0.062	0.148	<0.001
Variance(<i>Prevention Protocol</i>)	0.244	0.062	<0.001
Variance(<i>CMS Policy</i>)	0.025	0.061	<0.001

Log-likelihood = −1859.14

Bold indicates statistically significant at 95% confidence

Grey indicates statistically significant QI interventions for reducing HAPUs

Time is measured quarterly from 3rd quarter of 2007 to 2nd quarter of 2012