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The Impact of Hospital-Acquired Conditions on Medicare Program Payments

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Research Objective: Hospital-acquired conditions, or HACs, often result in additional Medicare payments, generated during the initial hospitalization and in subsequent health care encounters. The purpose of this article is to estimate the incremental cost to Medicare, as measured by Medicare program payments, of six HACs.

Study Design: The researchers used a matched case-control design to determine the incremental increase in Medicare payments attributable to each HAC. For each HAC patient, five comparison patients were matched on diagnosis group, sex, race, and age. Using the matched sample, we estimated a hospital fixed effects log-linear regression on total Medicare payments for the episode of care, further controlling for co-morbid conditions. Care episodes included the initial hospitalization and all inpatient, outpatient, physician, home health, and hospice care that occurred within 90 days of hospital discharge.

Population Studied: All Medicare fee-for-service patients discharged alive from a hospital between October 2008 and June 2010 with one of six HACs—severe pressure ulcer, fracture, catheter-associated urinary tract infection, vascular catheter-associated infection, surgical site infection following certain orthopedic procedures, or deep vein thrombosis/ pulmonary embolism following certain orthopedic procedures—were included in the sample and matched to five similar patients without the HACs.

Principal Findings: The multivariate analysis suggests that Medicare paid an additional $146 million per year across these HAC care episodes compared with what would have been paid without the HACs.

Conclusions: HACs create a significant financial burden for the Medicare program. We compare the incremental Medicare payments for these six HACs to the current and upcoming Medicare HAC payment penalties.

Keywords: access, demand, utilization of services, hospital-acquired condition, Medicare payments, health care costs, hospitals, Medicare, quality of care, patient safety (measurement)

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Introduction

Preventable hospital-acquired conditions (HACs) often result in additional medical care costs, generated both in the hospital stay during which the preventable event occurs (the "index hospitalization") and in subsequent health care encounters that might not have been necessary, or might not have been as resource-intensive, without that preventable event. The purpose of this study is to estimate incremental Medicare payments for all inpatient, outpatient, and physician services occurring over a defined episode of care that are attributable to the preventable event. This analysis does not address incremental costs to the health care providers or societal costs attributable to HACs, but focuses instead on incremental costs to the Medicare program in the form of additional Medicare payments. To identify which costs are attributable to the HAC, we rely on a matched case-control study design. We use administrative data from Medicare claims, and we estimate a log-linear fixed-effects regression with the total Medicare episode payments as the outcome of interest. In addition to matching on demographic and diagnostic characteristics of the patients with HACs, we further control for co-morbid conditions that are related to the HACs and that can increase payments.

Prior to the implementation of the Hospital-Acquired Condition-Present-on-Admission (HAC-POA) program by the Centers for Medicare and Medicaid Services (CMS), it was difficult to accurately identify conditions that were acquired in the hospital using Medicare administrative claims data. Under the HAC-POA program, no Medicare discharge can be assigned to a higher severity (and thus higher paid) Medicare severity diagnosis related group (MS-DRG) based solely on the presence of a qualifying preventable complication if that complication was acquired during the hospital stay.[1] To implement the payment changes of the HAC-POA program, beginning in April 2008, CMS required all hospitals paid under the inpatient prospective payment system (IPPS) to add a POA indicator to the International Classification of Diseases, Ninth Revision (ICD-9) diagnosis codes appearing on the inpatient claim. The indicator can take one of five values: "Y" for present on admission, "N" for not present on admission, "W" for clinically undetermined, "U" for insufficient documentation, and "1" for exempt. If the MS-DRG grouper encounters a POA indicator of "N" or "U" on a diagnosis that is not exempt, that diagnosis code is ignored in the MS-DRG assignment, causing the discharge to be grouped to the MS-DRG that would have been assigned if the condition had not been documented on the claim.

The POA indicator implemented by the HAC-POA program allows us to accurately identify the selected conditions that were truly hospital acquired, as opposed to being acquired in a previous health care encounter or in the community. We estimated the incremental Medicare payments attributable to a HAC by matching the patients with a HAC identified with the POA indicator equal to "N" or "U" with five similar patients without a HAC. Although the HAC-POA program may reduce the MS-DRG payment for the index hospitalization, compared to what the claim would have received prior to the program, the presence of a HAC is likely to increase subsequent or "downstream" services that will result in additional Medicare payments. Our purpose is to estimate the incremental Medicare payments attributable to a large subset of the conditions that were targeted by the HAC-POA program. We do not attempt to analyze the impact of the HAC-POA program on the incidence or costs of the HACs, since identifying true hospital-acquired conditions in Medicare claims data prior to the HAC-POA program is problematic.

[1] Documentation of the full list of diagnosis codes and specific procedures included in the definitions of the HACs selected by CMS for inclusion in the HAC-POA program is available at http://www.cms.gov/Medicare/Medicare-Fee-for-Service-payment/HospitalAcqCond/downloads/hacfactsheet.pdf

Recent Literature

There is a moderate body of published literature addressing economic outcomes of adverse events in health care, much of it directed to the effects of medication errors or hospital-acquired infections (HAIs). Whether the specific outcomes of interest are accounting costs, service use, or health care payments, the key to valid estimation of effects attributable to an adverse event is the identification of an appropriate comparison group. Statistical matching is commonly used throughout the literature, alone or in conjunction with multivariate modeling. For example, Bates *et al.* (1997) studied cost and utilization effects in the index hospitalization, following 190 adverse drug events and using multivariate modeling in a nested case-control design. They found an average increase in stay of 2.2 days (roughly 20 percent) attributable to the events. Zhan and Miller (2003) used data from the 2000 National Inpatient Sample to analyze average differences in days and charges during the index hospitalization for patients identified by selected AHRQ patient safety indicators (PSIs). The authors first used matched controls based on hospital, DRG, age, race, and gender, and then, as an alternative approach, used multi-level modeling by hospital and DRG with added covariates. They found effects on the hospital stay ranging from 2 to 10 days depending on the PSI (with the largest effects for sepsis and post-operative infections). They also found that matched controls and multi-level modeling produced similar results, possibly due to the DRG-level analysis in the multi-level design. McGarry *et al.* (2004) studied post-operative days and charges for surgical patients to identify the effects of surgical site infections (SSIs) at an academic center and its affiliated community hospital, analyzing data for 69 elderly cases and 59 controls that were chosen by surgical procedure and age group, while adding covariate control for co-morbidities and other acuity measures for the final effect estimation. The median unadjusted difference in post-surgery days between SSI and control cases was 15 (22 versus 7), while the multivariate adjusted difference was 13.

Several studies using a matched design use propensity scores rather than multiple discrete characteristics for the matching process. Peng *et al.* (2006) analyzed the effect of HAIs on index hospital days and charges using data from the Pennsylvania state data reporting system, matching on a propensity score of the probability of in-house death with additional balancing on hospital characteristics. The authors found a difference of 13 days between HAIs and controls (16 versus 3), but acknowledged limitations of the matching process, because their control observations were younger and possibly less severe at time of admission. De Lissovoy *et al.*, (2009) studied the differences in days and charges attributable to post-surgical infections found in the National Inpatient Sample, with matching based on propensity scores derived from the probability of a PSI stratified by type of surgical procedure. They found an average SSI-attributable increase in hospital stays of 9.7 days, with the highest occurring for cardiovascular SSIs (13.7 days). The study that is closest to ours in research question, data, and design was published by Encinosa and Hellinger (2008) using information from enrollees in a large private insurance database. These authors examined claims payments for the index hospitalization and a 90-day follow period for 4,140 patients with PSIs, assigning 1:1 propensity-matched controls. The propensity score was computed as the probability of a PSI using clinical PSI risk factors and multivariate regression, then covariate control for DRG groups and other co-morbidities.

Many utilization measures are both outcomes and risk factors for an HAC. Length of stay, for example, is a known risk factor for falls, and long critical care stay is one of the strongest predictors for vascular catheter-associated infection (VCAI). A significant potential for endogeneity exists if these variables are used either for matching purposes or as covariates in the multivariate models. To avoid endogenous variable bias, matching should be done only on severity-related variables that are present on admission or on severity-related utilization measures (e.g., ICU days) that are measured before the HAC presents. Bates *et al* (1997) analyzed single-institution data and were able to match on pre-event length of stay, analyzing post-event stays and resource use as the outcomes of interest. McGarry *et al.* (2004) also analyzed only post-operative and post-infection resource use variables. In studies using administrative data that cannot provide pre- and post- event data, however, identification of resource use outcome measures can be made only through the average differences between cases and controls and/or the difference estimated by the coefficient on the adverse event indicator in the regression equation.

Data

This paper uses data from Medicare public use claims files, fiscal year (FY) 2009 and

2010. Inpatient claims are from the Medicare Provider Analysis and Review (MedPAR) file and claims for physician, outpatient, and other covered services are from the Medicare Standard Analytic Files. The index hospitalization samples were limited to live discharges occurring over the 21 month period between October 1, 2008 and June 30, 2010, to allow for a 90-day follow-up in FY 2010. The Enrollment Database was used to limit the study observations to beneficiaries who lived in the United States throughout the 90-day follow-up period and to exclude cases where Medicare was the secondary payer, or where beneficiaries were not enrolled in both Part A and Part B or were enrolled in Medicare managed care, at any time during the study period.

Using the criteria specified in the Federal Register (74 FR 43754), we identified all index hospitalizations that contained one of the ten initial CMS selected HACs over the 21-month period. Due to low case volumes, the analyses were limited to the five HACs with the highest volume, plus the surgical site infection (SSI) with the highest volume. The six study HACs are:

- Stage III and IV pressure ulcers ("pressure ulcers", n=1,939)
- Falls & trauma: fractures ("fractures", n=7,223)
- Catheter-associated urinary tract infection ("CAUTI", n=5,161)
- Vascular catheter-associated infection ("VCAI", n=5,501)
- Surgical site infection SSI following spinal fusion or re-fusion, arthrodesis of shoulder or elbow or other repair of shoulder or elbow ("SSI/ortho", n=311)
- Deep vein thrombosis & pulmonary embolism following total or partial hip replacement or resurfacing, or total knee replacement ("DVT/PE", n=4,364).

The outcome of interest, Medicare episode payments, was constructed from payment fields in each of the Medicare claims files. The payment measures sum all Part A and Part B amounts that are paid by CMS, including those for hospital, inpatient post-acute care, physician, outpatient, home health, and hospice services. Neither beneficiary liabilities for deductibles and coinsurance nor payments for durable medical equipment are included in these payment measures.

Methods

Similar to the Encinosa and Hellinger study, our study analyzes the effects of selected HACs on payments for all medical services delivered from the index hospitalization through a follow-up period of 90 days. Unlike the Encinosa and Hellinger study, but similar to the methods used in Zhan and Miller (2003), we identify the comparison group using multivariable matching on age, sex, race, and MS-DRG, and then add HAC risk factors as regression covariates. We present unadjusted data comparing inpatient, outpatient, and physician payments for HAC versus comparison cases. We then use present-on-admission risk factors as well as provider fixed effects as covariates in log-linear regression of total Medicare episode payments on the HAC indicators.

Episode Construction

Care episodes used in this analysis were constructed using the beneficiary identifiers and the admission and discharge dates on the index hospitalization claims, to link to any physician claims occurring during the index hospitalization, plus all other claims with a service or admission date within 90 days of the index discharge date. The choice of a 90-day follow-up period was based primarily on the literature, although we acknowledge that the appropriate follow-up period from a clinical perspective is likely to vary by type of HAC. To the extent that the follow-up period may be too long for some of the HACs, our estimate remains unbiased because it is a measure of payment differences. To the extent that 90 days may not be long enough to capture the full effect of a HAC, our estimates will be the lower bounds of the true attributable payment difference.

Matching

A pool of non-HAC claims for index hospitalizations was created for each HAC claim. Because we were not able to identify previous hospitalizations for all of our index HAC and non-HAC claims, we relied on the index hospitalization diagnosis codes and their related present on admission codes to identify and remove any non-HAC claims from the HAC-related diagnosis code comparison pool. To further prevent including true HAC cases that may not have been coded in the index hospitalization in the comparison group, we excluded from the comparison pool any episodes that contained the HAC-related diagnosis codes for any of the claims during, or 90 days after, the index hospitalization. Altogether, these exclusions removed only 3% of index claims from the comparison pools. Comparison group pools for DVT/PE and for SSI/ortho were also restricted to claims containing the same surgical procedures included by CMS in the HAC definitions. For VCAI, the pool for comparison cases was restricted to claims with documentation of vascular catheter insertion (ICD-9-CM codes 38.93 or 38.95). Although this code is not included in the CMS definition, imposing this restriction allowed us to identify comparison patients at risk for VCAI. Sixty-two percent of the VCAI HAC index claims had one of these procedure codes. In the remaining 38 percent, it is assumed that the procedure was done, but not coded on the claim, or it was coded on the claim, but not picked up by MedPAR.[2] In choosing to apply this additional restriction on the VCAI control group, we avoided introducing a bias that might have arisen if many members of the control group did not have vascular catheters and, therefore, were less severely ill (and thus less costly) than those who did have vascular catheters.

From these non-HAC pools, five index claims were matched to each index HAC claim with the same MS-DRG, sex, race, and age group. The final assigned MS-DRG after application of the HAC-POA provisions was used for matching. For example, if a beneficiary was admitted for a spinal fusion, but also had a hospital-acquired SSI, and the MS-DRG was reclassified from 460 (spinal fusion with major complications/cormorbid conditions [MCC]) to 459 (spinal fusion w/out MCC) as a result of the HAC, then matching for that beneficiary was performed using MS-DRG 459, the lower severity assignment. However, if the claim included codes for other MCCs in addition to the SSI, then the patient would have remained in MS-DRG 460 regardless of the HAC, with the match performed using MS-DRG 460.

Matches were identified with replacement. If fewer than five matches were available for a given HAC observation, comparison cases were re-weighted to reflect a 5:1 match (approximately 1 percent of HAC index cases had fewer than five matches). If more than five matches were available, then five matches were randomly selected. Ninety-day follow-up episodes were constructed for the matches.

Information on the final analysis sample and data on the distribution of key matching variables is presented in Exhibit 1. By virtue

[2] Note that prior to January 2011, CMS retained only the first six procedure codes in its claims files.

Exhibit 1. Descriptive Statistics for Matching Variables for Hospital-Acquired Conditions and Matched Control Index Hospitalizations

Multivariable matching variables	Severe pressure ulcers	Falls and trauma: fracture	Catheter-associated urinary tract infection	Vascular catheter-associated infection	SSI following certain orthopedic procedures	DVT/PE following certain orthopedic procedures
Number of Episodes with this HAC	1,939	7,223	5,161	5,501	311	4,364
Number matched comparison cases	9,834	35,184	24,984	25,743	1,539	22,443
Matching variables:						
Gender						
% Female	54	66	66	55	58	67
Race						
% White	74	91	83	74	86	90
Age Distribution						
% under 65	16	10	10	31	30	6
% 65–69	14	13	10	19	20	20
% 70–74	11	13	13	13	26	23
% 75–79	14	17	16	14	13	21
% 80–84	17	18	19	12	8	16
% 85–89	16	18	19	7	3	10
% > 90	11	11	13	3	0	4
Surgical procedure code	*None*	*None*	*None*	*38.93* *38.95*	*81.01–81.08* *81.23–81.24* *81.31–81.38* *81.83* *81.85*	*00.85–00.87* *81.51–81.52* *81.54*

(Continued)

Exhibit 1 Continued. Descriptive Statistics for Matching Variables for Hospital-Acquired Conditions and Matched Control Index Hospitalizations

Multivariable matching variables	Severe pressure ulcers	Falls and trauma: fracture	Catheter-associated urinary tract infection	Vascular catheter-associated infection	SSI following certain orthopedic procedures	DVT/PE following certain orthopedic procedures
Three most common MS-DRGs in the HAC and comparison groups, (n for the HAC group)	871: Septicemia w MCC (112)	470: Major joint replacement w/o MCC (1,038)	291: Heart failure and shock w MCC (223)	329: Major bowel procedures w MCC (342)	460: Spinal fusion w/o MCC (116)	470: Major joint replacement w/o MCC (3,188)
	003: ECMO or tracheotomy with major OR (92)	981: Unrelated OR procedure w MCC (639)	470: Major joint replacement w/o MCC (186)	871: Septicemia w MCC (223)	459: Spinal fusion w MCC (68)	469: Major joint replacement w MCC (924)
	04: Tracheotomy without major OR (51)	982: Unrelated OR procedure w CC (566)	064: Intracranial hemorrhage w MCC (126)	682: Renal failure w MCC (160)	453: Anterior/ posterior spinal fusion w MCC (27)	462: Bilateral or major joint procedures w/o MCC (157)

NOTES: HAC, hospital-acquired condition; SSI, surgical site infection; DVT/PE, deep vein thrombosis or pulmonary embolism; MS-DRG, Medicare severity diagnosis related groups; MCC, major complications/comorbid conditions; ECMO, extracorporal membrane oxygenation; OR, operating room; CC, complications/cormorbid conditions.

SOURCE: Authors' analysis of FY 2009 and FY 2010 Medicare Part A and Part B episodes of care data.

of the multi-variable matching methodology, these descriptive characteristics have the same distributions in both the HAC group and in the matched non-HAC group.

Analysis

We provide descriptive analyses of the unadjusted differences between HACs and the matched non-HAC in per-episode payments. We present the total episode payments for the HAC episode and matched non-HAC episodes, and we subdivided the episode payments into the following categories: index hospital payments, excluding outlier payments; index outlier payments; physician payments during the index hospitalization; payments for hospital transfers and readmissions within 90 days of index hospital discharge; payments for post-acute care (including long-term care hospitals (LTCHs); skilled nursing facilities (SNFs); inpatient rehabilitation facilities (IRFs) and inpatient psychiatric facilities (IPFs) within 90 days; payments for physician care within 90 days; payments for outpatient care within 90 days; and payments for home health care within 90 days. Per-episode hospice payments are not identified separately, but these payments are included in the figures for total Medicare episode payments. We also computed the share of HAC and comparison cases with any hospital readmission and the share with any post-acute care (PAC) admission.

We conducted multivariate modeling on total Medicare episode payments.[3] We used log-linear regression with provider fixed effects to estimate the incremental payment effect of each HAC while controlling for patient risk factors. For each study HAC, we identified a list of clinical risk factors that could be confounders because they are also potential cost drivers. For example, patients with a past stroke have a greater risk for pressure ulcers than patients without, and a history of stroke could also be expected to increase the care needs relative to the care needs of a patient without that history. We used several sources to identify confounding risk factors associated with each HAC, and included only those with corresponding ICD-9 codes and those with at least 40 observations in our sample. Patient risk factors were derived from the clinical literature[4] and were only included if they were coded on the index claim as POA.

Risk factors that relate to utilization are more difficult to control for, due to the potential for endogeneity. For example, length of an ICU stay is possibly the strongest predictor of acquiring VCAI, but while number of days prior to infection is a predictor, number of days post infection is an outcome. Because the Medicare claims files do not identify a date for the acquired infection, ICU days cannot be used as a covariate. As an alternative, we use a 0/1 indicator variable to identify any ICU or coronary care unit (CCU) utilization by the patient. The same approach is taken to identify use of a small number of surgical and other services. All models exclude beneficiaries who died during the index hospitalization.

It is possible, if not probable, that HACs are not randomly distributed across geographic areas or types of hospitals. Because Medicare rates vary substantially by area, and also by teaching status, we included provider fixed effects in the regressions.[5] The equations estimated had the following basic structure:

[3] We also conducted multivariate analyses on the Medicare index DRG payment (results not shown). The HACs had a small positive effect (3%–5%) on index DRG payments, except for pressure ulcer and vascular catheter. The effect on Medicare episode payments was between 4 and 18 times the effect on index DRG payments.

[4] Lists are available from the lead author on request.

[5] We also tested models including variables to capture teaching status, rural/urban location, type of ownership, bed size, wage index, and state fixed effects in lieu of provider fixed effects. The HACs remained statistically significant in these models with similar magnitude. However, the explanatory power of these models was much less than that of the models with the provider fixed effects.

$$\ln(Y_i) = \alpha + \beta HAC_i + \varphi X_i + (\mu_h + \varepsilon). \quad (1)$$

In this specification, *i* subscripts the discharge, and *h* subscripts the hospital in which the index admission took place. The outcome variable *Y* is total Medicare payments and is log-transformed, as is standard for modeling data with strongly skewed distributions. *HAC* is a dichotomous variable with a value of 1 if the HAC is recorded in the index hospitalization for that episode and *X* denotes the vector of clinical risk factors. Index hospital fixed effects (μ_h) are added to account for differences in index payments due to hospital characteristics, such as the resident-to-bed ratio, and also variations in practice patterns that can affect payments and referral patterns (e.g., LTCH use is greater at some hospitals than others). Robust standard errors (ε) are clustered by index hospital. The answer to the study question is identified by the re-transformed value of β (computed as $\exp(\beta)-1$), which can be interpreted as the proportional effect of the HAC on Medicare episode payments holding all other factors constant.

Results

Exhibit 2 presents unadjusted differences in Medicare program payments for the HAC episodes compared with the matched non-HAC episodes. For all of the selected HACs, the total Medicare episode payments are significantly higher for the HAC episodes than for the matched comparison non-HAC episodes. For almost all subsets of the episode payments, the payments for the HAC episodes are higher, and almost always significantly higher, with the exception of outpatient payments, which are statistically significantly lower for three of the six HACs when compared to the matched non-HACs.

First, we examined the proportion of HAC and matched non-HAC episodes with all-cause 90-day readmissions and the proportions with inpatient PAC transfers, including LTCH, SNF, IRF, and IPF claims. The differences between HACs and comparison cases in the proportion with at least one all-cause readmission during the episode range from 5 percentage points (CAUTI and VCAI) to 16 percentage points (SSI/ortho). For PAC transfers, the differences are as high as 26 percentage points (for fractures), 22 percentage points for pressure ulcers, and 18 percent for SSI/ortho. All of these differences are statistically significant at the $p<0.001$ level.

Next, we present the difference between the total Medicare program payments for HAC episodes of care and for matched non-HAC episodes. The smallest difference is seen among the DVT/PE episodes, with HAC episodes resulting in an average of $4,910 in additional program payments. Two of the HACs, severe pressure ulcers and SSI/ortho, had an average difference in payments of over $20,000 across the episode of care.

We separate the outlier payments for the index hospitalization from the base MS-DRG payments to highlight that, overall, about two thirds of the unadjusted payment differences for the index hospitalization are due to increased outlier payments for the claims with HACs. With the exception of DVT/PE, outlier payment differences are higher than the payment differences for the base MS-DRG payments. Note that these differences in base MS-DRG payments are largely due to differences in the characteristics of the index hospitals that affect the CMS payment algorithm. To account for this, we use index hospital fixed effects in the log-linear regression models, which controls for most of the difference in base MS-DRG payments between the HAC and matched non-HAC groups (results not shown).

For five of the six HACs (all except DVT/PE), the largest contributions to the incremental Medicare episode payments come from the index outlier

Exhibit 2. Index Hospital Plus Ninety-Day Episode Program Payment and Utilization Differentials for Selected Hospital-Acquired Conditions, Matched Samples

	Severe pressure ulcers	Falls and trauma: fracture	Catheter-associated urinary tract infection	Vascular catheter-associated infection	SSI following certain orthopedic procedures	DVT/PE following certain orthopedic procedures
Number HAC cases	1,939	7,223	5,161	5,501	311	4,364
Number matched comparison cases	9,834	35,184	24,984	25,743	1,539	22,443
% with any 90-day readmission						
HAC cases	48%	43%	42%	52%	43%	27%
Comparison group	41%	33%	38%	47%	27%	21%
Difference	7%***	10%***	5%***	5%***	16%***	6%***
% with any 90-day inpatient PAC						
HAC cases	66%	62%	57%	45%	50%	52%
Comparison group	44%	36%	40%	40%	33%	48%
Difference	22%***	26%***	17%***	5%***	18%***	4%***
Total Medicare program payments per episode						
HAC cases	$71,838	$43,877	$43,204	$65,000	$83,071	$34,744
Comparison group	$51,526	$33,418	$36,775	$54,541	$58,905	$29,835
Difference	$20,311***	$10,459***	$6,429***	$10,459***	$24,166***	$4,910***
Index payments (not including outliers)						
HAC cases	$24,808	$14,608	$14,471	$21,940	$38,630	$14,660
Comparison group	$21,706	$14,454	$14,063	$20,904	$34,110	$13,703
Difference	$3,102***	$153***	$409***	$1,036***	$4,520***	$958***

(Continued)

Exhibit 2 Continued. Index Hospital Plus Ninety-Day Episode Program Payment and Utilization Differentials for Selected Hospital-Acquired Conditions, Matched Samples

	Severe pressure ulcers	Falls and trauma: fracture	Catheter-associated urinary tract infection	Vascular catheter-associated infection	SSI following certain orthopedic procedures	DVT/PE following certain orthopedic procedures
Index outlier payments						
HAC cases	$7,399	$1,069	$1,484	$6,843	$8,759	$558
Comparison group	$1,561	$517	$608	$2,358	$2,503	$133
Difference	$5,838***	$552***	$876***	$4,485***	$6,256***	$425***
Physician payments in index admissions						
HAC cases	$4,867	$2,708	$2,917	$4,488	$7,877	$2,756
Comparison group	$2,972	$2,114	$2,206	$3,359	$5,623	$2,096
Difference	$1,896***	$594***	$711***	$1,130***	$2,254***	$660***
Hospital readmission payments						
HAC cases	$12,254	$8,662	$8,396	$13,200	$10,702	$4,898
Comparison group	$8,728	$5,939	$7,415	$11,421	$5,864	$3,554
Difference	$3,526***	$2,723***	$981***	$1,779***	$4,838***	$1,344***
Post-acute care payments						
HAC cases	$15,239	$11,090	$10,459	$10,355	$11,211	$6,785
Comparison group	$10,259	$5,391	$7,243	$9,076	$6,490	$6,022
Difference	$4,980***	$5,699***	$3,216***	$1,280***	$4,721***	$763***
Physician payments, follow-up						
HAC cases	$3,916	$2,443	$2,354	$4,065	$2,808	$1,796
Comparison group	$2,886	$2,076	$2,294	$3,429	$1,824	$1,349
Difference	$1,030***	$367***	$59	$636***	$984***	$447***

(Continued)

Exhibit 2 Continued. Index Hospital Plus Ninety-Day Episode Program Payment and Utilization Differentials for Selected Hospital-Acquired Conditions, Matched Samples

	Severe pressure ulcers	Falls and trauma: fracture	Catheter-associated urinary tract infection	Vascular catheter-associated infection	SSI following certain orthopedic procedures	DVT/PE following certain orthopedic procedures
Outpatient Part B payments						
HAC cases	$1,181	$960	$887	$2,190	$1,002	$735
Comparison group	$1,487	$1,054	$1,062	$2,216	$880	$653
Difference	–$305***	–$93***	–$175***	–$26	$122	$82***
Home Health Agency payments						
HAC cases	$1,467	$1,975	$1,751	$1,496	$1,976	$2,470
Comparison group	$1,448	$1,566	$1,482	$1,392	$1,590	$2,240
Difference	$20	$409***	$269**_	$103**_	$387***	$231***

NOTES: HAC, hospital-acquired condition; SSI, surgical site infection; DVT/PE, deep vein thrombosis or pulmonary embolism.

Statistically significant with *p<0.05, **p<0.01, and ***p<0.001

Total Medicare program payments per episode also include hospice payments, but the differences are very small and the results are suppressed to conserve space.

SOURCE: Authors' analysis of FY 2009 and FY 2010 Medicare Part A and Part B episodes of care data.

payments, the hospital readmission payments, and the post-acute care payments. Differences in readmission payments range from $981 per episode for CAUTI to $4,838 per episode for SSI/ortho. Patients with fractures have the highest differences for PAC, at $5,699 per episode, and the PAC differences are also more than $4,500 for both severe pressure ulcers and SSI/ortho.

Medicare Part B payments to physicians, both during the index hospitalization and during the 90-day follow-up period, are significantly higher for the HAC episodes of care compared to the matched controls ($p<0.001$). The difference in physician payments during the index hospitalization ranges from $594 for fractures to $2,254 for SSI/ortho, while the difference in physician payments during the follow-up period ranges from a low of $59 for CAUTI to a high of $1,030 for pressure ulcers.

It is interesting to point out that for three of the six HACs considered, Medicare Part B program payments for outpatient care were actually statistically significantly *lower* for the HAC episodes compared to their matched comparisons. Patients with severe pressure ulcers had $305 less in outpatient payments compared to matched patients without severe pressure ulcers, CAUTI patients had outpatient payments that were $175 lower, and patients with fractures had outpatient payments that were $93 lower. We hypothesize that, because these patients had significantly higher inpatient rates of readmissions and post-acute care in the 90 days following their index hospital discharge, they spent significantly more time during the follow-up period in an inpatient setting and, therefore, would not have received as much outpatient care. Only DVT/PE episodes of care had significantly higher outpatient payments of $82 per episode. Differences in Medicare payments to Home Health Agencies were small, always under $500, but statistically significant for five of the six HACs.

Multivariate results for the six selected HACs are summarized in Exhibit 3 and regression exhibits are reported in full in Appendix A. We focus our discussion on the effect estimates from the HAC indicator variables. The Appendix exhibits show, however, that nearly all of the clinical risk factors that were added to the models are individually significant predictors of episode payments, and service indicator variables are all highly significant positive predictors. Some matching variables were also included in the model as known cost drivers, although including them should not affect the coefficient on the HAC indicator, and the coefficients on the matching variables cannot be interpreted as effect measures for those variables.

In all six models, the HAC is a significant predictor of higher total Medicare episode payments ($p<0.001$), holding other risk factors and provider fixed effects constant. For comparison, Exhibit 3 shows both the unadjusted percent difference from the matched samples and the regression-adjusted percent difference after re-transforming the coefficient. The adjusted difference is lowest for DVT/PE (13.0%) and highest for fractures (45.8%). Our results also demonstrate the importance of adding covariate control after matching; of the six models, the unadjusted sample difference lies within the 95% confidence interval for the regression adjusted difference for only severe pressure ulcers and SSI/ortho. For pressure ulcers, VCAI, SSI/ortho, and DVT/PE, the matched sample differences overstate the incremental effect of the HAC, while for fractures and CAUTI, the matched sample differences significantly understate the effect.

In the third column of Exhibit 3, we translate the estimated incremental payment effects into an annualized total dollar amount for each HAC based on the payment rates and HAC incidence

Exhibit 3. Incremental Effects of a Hospital-Acquired Condition on Index Hospital Plus Ninety-Day Episode Medicare Program Payments

		Multivariate Results			
Selected hospital-acquired condition	Percent difference from matched samples (unadjusted)	Point Estimate	95% Confidence Interval	Estimated annual impact on Medicare program payments (millions)	95% Confidence Interval (millions)
Severe pressure ulcers	39.4%	32.8%	25.5%–41.2%	$18.8	$14.3–$23.5
Falls and trauma: fracture	31.3%	45.8%	42.4%–49.3%	$63.2	$58.5–$67.9
Catheter-associated urinary tract infection	17.5%	24.5%	20.6%–28.4%	$26.6	$22.4–$30.9
Vascular catheter-associated infection	19.2%	14.3%	11.2%–17.5%	$24.6	$19.3–$30.0
Surgical site infections following certain orthopedic procedures	41.0%	33.2%	20.8%–47.0%	$3.5	$2.2–$4.9
Deep vein thrombosis/ pulmonary embolism following certain orthopedic procedures	16.5%	13.0%	10.8%–15.2%	$9.7	$8.0–$11.3

NOTES: Comparison episodes chosen by 5:1 multivariable matching using the characteristics of the index claims with HACs. Multivariate results control for patient and hospital characteristics that affect payment.

SOURCE: Authors' analysis of FY 2009 and FY 2010 Medicare Part A and Part B episodes of care data.

in our analysis samples. The dollar amount was computed by multiplying the percent change in episode payments by the average episode payment for the matched comparison group, annualizing the volumes to 12 months and summing within each HAC. The final column provides the 95% confidence intervals for the estimated annual incremental payment effects. In total, these six HACs are estimated to cost the Medicare program an additional $146 million dollars through the entire care episode, with a range between $125 and $169 million. Fractures contribute $63.2 million to this total. On a per-episode basis (not shown), SSI/ortho is the most costly of the six HACs at just under $20,000, but as the lowest volume HAC it accounts for only $3.5 million in estimated additional program costs. DVT/PE is the least costly HAC on a per-episode basis (roughly $3,900), but accounts for $9.7 million of the additional program costs.

Limitations

One limitation of this study is that matching on the final assigned MS-DRG may underestimate the incremental payment effects of the HAC. We matched on the reassigned MS-DRG to compare HAC episodes to episodes for cases admitted for similar medical or surgical conditions, but without the acquired complicating condition. In FY 2010, however, only 19 percent of claims identified with a HAC were actually re-assigned to a lower-paid

MS-DRG; among our 6 study HACs, the reassigned share was as high as 42 percent for DVT/PE, but less than one percent for SSI/ortho and VCAI (77 FR 53296). CMS noted that in more than half the identified HACs, the claim was assigned to the same higher-severity MS-DRG even after removing the HAC diagnosis code because the beneficiary had other complications/cormorbid conditions (CCs) or MCCs. To the extent that any of these other complications are independent of the HAC, this would not affect the validity of the match, but to the extent that any of the other CCs or MCCs are hospital-acquired and possibly causally related to the HAC, then the HAC cases will have been matched to comparison cases that are more severe than they should be, given the state of the HAC case on admission.

About one in five discharges identified as a HAC in FY 2010 were not reassigned to a lower paying MS-DRG because the claim had already been assigned to a single or a 2-severity level MS-DRG (where all "CC/MCC" cases are grouped together or all "no MCC" cases are grouped together). For these cases, we were unable to distinguish the lower from the higher level of severity and, thus, unable to match comparison cases at similar levels of pre-HAC severity. Finally, there are some cases where severe complications from the HAC will have changed the base DRG "family" to which the claim is assigned. For example, a patient with VCAI that leads to further complications, respiratory failure, and mechanical ventilation will be assigned to an MS-DRG based on the ventilator procedure, regardless of the condition for which the beneficiary was originally admitted. Another example is a stroke patient who falls and sustains a fracture requiring major surgical repair, and is assigned to one of three MS-DRGs for "extensive OR procedures unrelated to principal diagnosis," depending on the CCs. In both of these examples, our comparison cases would be drawn from these new MS-DRGs, both of which are for very high-cost conditions. Our results should then be considered lower bounds of the true incremental costs of the HACs.

Conclusions and Discussion

This study estimates incremental Medicare program costs associated with six of CMS' initial selected HACs under the HAC-POA program. To identify cost to the Medicare program, we summed Medicare payments during the index hospitalization and for all Part A and B services within a 90-day window, following discharge from the index hospitalization, for all HAC cases and for a 5:1 sample of comparison cases matched by age, sex, race, and MS-DRG. Using multivariate modeling on the matched sample, we find that the effect of a HAC on per-episode payments ranges from a 13% increase for DVT/PE to a 45.8% increase for fractures. In total dollar amounts, the added annual cost burden to the Medicare program for just these six HACs is estimated at $146 million, well in excess of the roughly $19.5 million in DRG payment reductions that was documented for these six HACs in 2010, following the implementation of the HAC-POA program (76 FR 51475, Chart F). This $146 million estimate should be considered a lower bound of the incremental effect of a HAC on Medicare payments in recognition of the limitations of matching by MS-DRG.

Preventable infections and other health-care acquired conditions create a significant financial burden for the Medicare program and the entire health care system. Programs and policies that are successful in reducing HACs can both improve health and reduce health care costs. While further research may be needed to determine if the HAC-POA policy has led to reductions in the incidence of HACs, other quality reporting programs and payment penalties are being introduced.

A policy of reducing or denying payment for downstream medical services attributable to a HAC could be very difficult to implement in a multi-provider, fee-for-service setting. Other federal programs, however, might be able to accomplish a similar effect from a pure budgetary perspective. The Affordable Care Act (ACA, P.L. 111–148), for example, mandated that CMS implement another IPPS payment reduction related to preventable hospital-acquired conditions. This new policy requires an across-the-board 1% reduction in IPPS rates to hospitals whose risk-adjusted rates for specific preventable events are in the top quartile of the distribution of those rates across all hospitals. This is a much more significant payment penalty than the HAC-POA program; in FY 2010, CMS paid $116 billion to hospitals for inpatient services for fee-for-service beneficiaries (MedPAC, March 2012). If the one quarter of hospitals with the highest risk-adjusted HAC rates were a representative sample of all hospitals, they would have generated roughly $29 billion in CMS payments, and a 1% reduction in payment for those hospitals would translate to $290 million in CMS savings—well above the estimate of $146 million attributable to the six HACs in our analysis. What is even more important from a policy perspective, however, is that payment penalties at this level would serve as a far stronger incentive to hospitals to reduce the number of preventable adverse events and, thus, reduce the downstream spending on unnecessary services.

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Appendix A

Exhibit A1. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Pressure Ulcers

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Pressure ulcer[2]	0.284***	(0.031)
Age greater than 70^	–0.153***	(0.029)
Anemia	–0.133***	(0.039)
Anesthesia[3]	0.362***	(0.035)
Dementia	–0.336***	(0.128)
Diabetes	–0.176***	(0.032)
Renal failure	–0.001	(0.029)
Fever	–0.175*	(0.104)
Congestive heart failure	–0.034	(0.032)
Hypotension	–0.087	(0.077)
Intensive care or coronary care stay	0.251***	(0.037)
Incontinence (urinary or fecal)	–0.552***	(0.121)
Malignancy	–0.132***	(0.042)
Nutritional deficiency	0.006	(0.046)
Pneumonia	0.311***	(0.071)
Sepsis	0.083**	(0.040)
Stage 1 or 2 pressure ulcer	–0.476***	(0.140)
Stroke	0.124	(0.090)
Provider fixed effects	Yes	n/a
Robust Standard Errors	Yes	n/a
Constant	9.456***	(0.047)
Observations	11,318	—
R-squared	0.436	—

NOTES: *statistically significant difference with p<0.10, **p<0.05, ***p<0.01

^Indicates variables that were also used in the matching algorithm

[1]The dependent variable is the natural log of Medicare payments measured in dollars.

[2]Pressure ulcer is the hospital acquired condition of interest.

[3]Beneficiaries are considered to have received anesthesia if the anesthesia charge amount is greater than zero.

SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.

Exhibit A2. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Falls and Trauma: Fractures

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Fracture[2]	0.377***	(0.012)
Age greater than 85^	0.012	(0.013)
Cardiac arrhythmias	0.004	(0.014)
Confusion	–0.076***	(0.027)
Dementia	0.017	(0.053)
Female^	–0.087***	(0.011)
Incontinence (urinary or fecal)	–0.047	(0.045)
Presenting condition of confusion	0.079	(0.056)
Provider fixed effects	Yes	n/a
Robust Standard Errors	Yes	n/a
Constant	9.713***	(0.012)
Observations	41,972	—
R-squared	0.231	—

NOTES: *statistically significant difference with p<0.10, **p<0.05, ***p<0.01
^Indicates variables that were also used in the matching algorithm
[1]The dependent variable is the natural log of Medicare payments measured in dollars.
[2]Fracture is the hospital acquired condition of interest.
SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.

Exhibit A3. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Catheter–Associated Urinary Tract Infections

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Urinary catheter associated infection[3]	0.219***	(0.016)
Age greater than 70^	–0.041**	(0.017)
Functional disorders of the bladder and urinary tract obstruction	–0.085	(0.072)
Alteration of consciousness	0.058	(0.075)
Dehydration	–0.088**	(0.035)
Diabetes	–0.104***	(0.016)
Renal failure	0.175***	(0.016)
Female^	0.006	(0.014)
Intensive care or coronary care stay	0.233***	(0.015)
Incontinence (urinary or fecal)	–0.295***	(0.072)
Neurology service	0.187****	(0.035)

(Continued)

Exhibit A3 Continued. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Catheter–Associated Urinary Tract Infections

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Orthopedic service	0.000	(0.018)
Paralysis of lower extremities	0.161**	(0.069)
Surgical service	0.605***	(0.016)
Urinary retention	–0.176***	(0.057)
Urinary tract cancer	–0.155**	(0.071)
Provider fixed effects	Yes	n/a
Robust Standard Errors	Yes	n/a
Constant	9.650****	(0.023)
Observations	29,982	—
R-squared	0.318	—

NOTES: *statistically significant difference with p<0.10, **p<0.05, ***p<0.01

^ Indicates variables that were also used in the matching algorithm

[1] The dependent variable is the natural log of Medicare payments measured in dollars.

[2] Urinary catheter associated infection is the hospital acquired condition of interest.

SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.

Exhibit A4. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Vascular Catheter Associated Infections

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Vascular catheter associated infection[2]	0.134***	(0.014)
Age less than 65^3	–0.133***	(0.018)
Age 70 to 74^3	–0.009	(0.021)
Age 75 to 79^3	–0.082***	(0.022)
Age 80 to 84^3	–0.085***	(0.022)
Age 85 to 89^3	–0.132***	(0.026)
Age 90 and greater^3	–0.194***	(0.035)
Coronary care stay	0.071***	(0.013)
Male^	0.045***	(0.012)
Parenteral nutrition therapy	0.225***	(0.027)
Surgical service	0.556***	(0.014)
Tracheotomy	1.108***	(0.022)
Provider fixed effects	Yes	n/a

(Continued)

Exhibit A4 Continued. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Vascular Catheter Associated Infections

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Robust Standard Errors	No	n/a
Constant	9.475***	(0.019)
Observations	30,727	—
R-squared	0.374	—

NOTES: *statistically significant difference with p<0.10, **p<0.05, ***p<0.01

^Indicates variables that were also used in the matching algorithm

[1]The dependent variable is the natural log of Medicare payments measured in dollars.

[2]Vascular catheter associated infection is the hospital acquired condition of interest.

[3]The reference group for age is 65 to 69.

SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.

Exhibit A5. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Surgical Site Infections following Certain Orthopedic Procedures

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Infection after certain orthopedic procedures[2]	0.287***	(0.050)
Diabetes	0.058	(0.066)
Male^	0.022	(0.044)
Overweight or obese	0.052	(0.097)
Rheumatoid arthritis	0.081	(0.155)
Provider fixed effects	Yes	n/a
Robust Standard Errors	No	n/a
MSDRG fixed effects	Yes	Yes
Constant	11.126***	(0.168)
Observations	1,840	—
R-squared	0.876	—

NOTES: *statistically significant difference with p<0.10, **p<0.05, ***p<0.01

^Indicates variables that were also used in the matching algorithm

[1]The dependent variable is the natural log of Medicare payments measured in dollars.

[2]Infection after certain orthopedic procedures is the hospital acquired condition of interest.

SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.

Exhibit A6. Regression Analyses of Medicare Episode Payments and Beneficiary Episode Liabilities: Incremental Cost of Hospital-Acquired Deep Vein Thrombosis and Pulmonary Embolism following Certain Orthopedic Procedures

Regression Variables	Coefficients for regression on Ln (Part A and Part B Medicare episode payments)[1]	Standard errors for regression on Ln (Part A and Part B Medicare episode payments)
Deep-vein thrombosis and pulmonary embolism following certain orthopedic procedures[2]	0.122***	(0.010)
Acute urinary tract infection	0.08***	(0.021)
Age greater than 75^	0.148***	(0.009)
Acute myocardial infarction and/or congestive heart failure	0.166***	(0.020)
History of deep vein thrombosis	–0.090	(0.120)
Fracture of a lower extremity	0.521***	(0.014)
Malignancy	0.040	(0.031)
Overweight or obese	0.019	(0.015)
Sepsis	0.403***	(0.124)
Provider fixed effects	Yes	n/a
Robust Standard Errors	No	n/a
Constant	10.133***	(0.005)
Observations	26,757	—
R-squared	0.465	—

NOTES: *statistically significant difference with $p<0.10$, **$p<0.05$, ***$p<0.01$

^Indicates variables that were also used in the matching algorithm

[1]The dependent variable is the natural log of Medicare payments measured in dollars.

[2]Deep-vein thrombosis and pulmonary embolism following certain orthopedic procedures is the hospital acquired condition of interest.

SOURCE: RTI analysis of FY 2009 and FY 2010 Medicare episodes of care data.