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Research and Applications

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Is duration of hospital participation in meaningful use associated with value in Medicare?

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ABSTRACT

Objectives: "Meaningful Use" (MU) of electronic health records (EHRs) is a measure used by Medicare to determine whether hospitals are comprehensively using electronic tools. Whether hospitals' engagement in value-based initiatives such as MU is associated with value—defined as high quality and low costs—is unknown. Our objectives were to describe hospital participation in MU, and determine whether duration of participation is associated with value.

Materials and Methods: We linked national Medicare data with MU and other hospital-level and market data. We analyzed bivariate relationships to characterize duration of participation. We estimated inverse probability-weighted multilevel logistic regressions to evaluate whether duration of participation was associated with higher likelihood of value—operationalized as having performance on 30-day readmission and inpatient spending *at* or *below* the national average.

Results: Of 2860 short-term hospitals, 59% had 4 or 5 years of MU participation by 2015; 7% had 1 or 2 years. There were differences by duration of participation across location, ownership, and size. Seventeen percent of hospitals were classified as high-value. Controlling for hospital characteristics, and holding constant market location, there was no evidence of a statistical association between duration of participation and value (odds ratio = 1.05, 95% confidence interval: 0.91–1.21; $P = .51$). Examining the 2 outcomes separately, there was a significant relationship between duration of participation and lower Medicare inpatient spending, but not 30-day readmission.

Discussion: Sustained participation in MU is associated with lower Medicare spending, but not with lower readmission rates.

Conclusion: Policy interventions aimed at increasing value may need a broader focus than EHR implementation and use.

Key words: Meaningful Use of electronic health records, health information technology, value in Medicare, 30-day hospital readmission, Medicare inpatient spending

BACKGROUND AND SIGNIFICANCE

The United States health care system has exceptionally high spending,[1–3] but underperforms on many health indicators, such as life expectancy,[4] and maternal mortality.[5] With projected growth rates averaging 5.5% a year, health spending is expected to account for 19.7% of the nation's gross domestic product by 2026.[6] Therefore, there is growing interest in quantifying and ultimately incentivizing the "value" of health care, that is, the outcomes achieved as a function of dollars spent.

Many proponents believe that electronic health records (EHRs) have the potential to increase value by transforming health care delivery, reducing health spending, and improving quality.[7–11]

Consequently, the Centers for Medicare and Medicaid Services (CMS) launched the Meaningful Use (MU) of EHRs Incentive Program in 2011. The MU Program is a pay-for-performance initiative, designed to accelerate adoption and use of certified EHRs.[10,12–14] The initiative was initially voluntary. However, as of 2015, eligible providers faced payment reductions for noncompliance with MU requirements.[10,15] The MU requirements consist of quantitative and qualitative criteria targeting quality, safety, efficiency, care coordination, patient and family engagement, reduction in health disparities, and other public health objectives.[12,16,17] The MU initiative was designed to be implemented in 3 stages: Stage 1 emphasized capturing and sharing patient data efficiently; Stage 2, which started in 2014, focused on using the EHR to support quality improvement (QI) and information exchange; and Stage 3 targets improved outcomes.[18]

In response to the financial incentives authorized under MU,[12,13,19] adoption and use of EHRs has increased among eligible providers.[20–23] However, evidence on the impact of MU of EHRs on outcomes and costs has been mixed.[24–28] For example, studies have shown that MU is related to improvements in patient satisfaction and adherence to process of care indicators,[29] and to a reduction in disparities in 30-day readmissions among African-American Medicare beneficiaries,[26] but such reduction has not been demonstrated within the broader Medicare population,[24–26] nor systematically observed across clinical conditions.[30]

One reason for these limited findings may be the fact that the initial years of the MU initiative mainly focused on data capture. Hence, it may simply have been premature to assess program performance. Additionally, prior studies have not specifically examined the duration of a hospital's participation in MU, which may represent continued growth and experience. Finally, few studies have evaluated comprehensive outcomes that summarize both quality and costs of care, notably "value", a concept that is of increasing importance in today's policy environment and consistent with current definitions from the National Quality Forum and others.[31]

OBJECTIVES

In this study, we therefore had 2 objectives: first, to describe hospital participation in MU; and second, to determine whether duration of MU participation is associated with value—defined as high quality and low costs—from the perspective of Medicare. We operationalized value as simultaneously having performance levels, *at* or *below* the national average, on the 2 broadest measures currently in use in Medicare's public reporting and value-based payment programs: 30-day hospital-wide all-cause unplanned readmission (HWR) and Medicare inpatient spending.[32] We hypothesized that, among hospitals with successful MU attestations, sustained participation is associated with higher likelihood of value.

MATERIALS AND METHODS

Study overview

We used a cross-sectional design to describe hospital participation in the Medicare EHR Incentive Program, and to evaluate whether duration of participation was associated with higher likelihood of value, assessed from the perspective of Medicare. To remove the influence of group differences that could obscure unconfounded descriptive comparisons among hospitals, we additionally adjusted for hospital-level covariates, including accreditation status, organizational characteristics (eg, ownership status and size), and patients served (eg, illness severity) in multilevel logistic regressions, weighted by the inverse of the propensity scores for early participation in MU.

Sample and data sources

We linked publicly available national Medicare data on short-term acute care hospitals, profiled on both 30-day readmission and Medicare inpatient spending, with MU data and other hospital-level and market data. We obtained these data from various CMS data sources, including the Hospital Compare Website; the Provider of Services File (2015); and the Impact File (2015). We extracted data for hospital participation in the Medicare EHR Incentive Program from the Office of the National Coordinator for Health IT's (ONC) Website. We limited our sample to only those hospitals with at least 1 year of MU attestation as well as available information on quality and costs (outlined below). We also used the Dartmouth Atlas of Health Care (2014) to match hospitals with their respective market area, represented by hospital referral region, to account for hospital clustering into health care markets.

Measures

Outcomes

We obtained performance data on risk-standardized 30-day HWR, from Hospital Compare, for the period covering July 01, 2015 to June 30, 2016. The HWR measure is publicly reported and broadly used to assess the quality of hospital care delivered to Medicare beneficiaries aged 65 and older. It represents over 55% of Medicare hospital payments across 5 clinical cohorts, including surgery/gynecology, general medicine, cardiorespiratory, cardiovascular, and neurology.[33]

We also obtained Medicare spending data from Hospital Compare. Using the October 2017 update of the Medicare Spending Per Beneficiary (MSPB) Spending Breakdowns by Claim Type File, we extracted Medicare spending per hospitalization episode for the performance period covering January 01, 2015 to December 31, 2015. The MSPB measure aggregates all Part A and B claims, including inpatient spending and any spending incurred 3 days prior to hospitalization, as well as spending in the 30 days following discharge.[34] However, we focused here on the inpatient component, because it is the most direct measure of hospital efficiency, and is not impacted by our other measure, readmission. The MSPB measure is price-standardized to remove differential payments to hospitals associated with (a) regional labor costs and hospital wage index; and (b) disproportionate share hospital (DSH) and indirect medical education.[35]

We classified all hospitals having both HWR and Medicare inpatient spending per hospitalization episode falling *at* or *below* the national average as high-value hospitals. The response variable of interest is binary, coded as 1 for high-value hospitals and 0 otherwise.

Exposure

We obtained the July 2017 update of the EHR products used for MU Attestation public use file, from the ONC Website, to extract data on hospital patterns of participation in MU. We focused on the variable called *payment year* to identify the number of successful MU attestations from program inception in 2011 through 2015. Payment year has integer values 1–5. Given that hospitals attest to

MU only once during any performance period, this effectively captures the duration of MU participation, treated as an interval scale.

Covariates

We extracted other hospital-level data on accreditation status, organizational characteristics, and patients served to adjust for potential group differences. We accounted for accreditation status by the Joint Commission (JC) because earning such recognition provides hospitals access to resources that can strengthen their QI efforts. Moreover, JC accreditation has been associated with higher health information technology adoption.[36] Similarly, we accounted for hospital location (urban/rural), teaching mission, ownership (not-for-profit/public/for-profit), and size (small/medium/large). These characteristics have been linked with the individual component outcomes, and/or adoption and use of EHRs in previous work.[20,36–39] Lastly, we accounted for hospitals' case mix index (the average diagnosis-related group [DRG] weight for inpatient discharges, which reflects average severity of illness), and their burden of caring for the uninsured and patients dually eligible for Medicare and Medicaid, as reflected by the DSH percentile. These characteristics have previously been identified as predictors of resource use.[40]

Analytic approach

We computed descriptive statistics for key hospital characteristics and examined bivariate relationships to characterize MU participation. To test our hypothesis relating duration of participation to value in Medicare, we specified a dose-response model, including a linear term in duration of participation and covariates. As it is customary in multilevel modeling, we built a series of models of increasing complexity,[41] including variables forming a coherent group one at a time.[42] To facilitate interpretation of the intercept,[41,42] we transformed the MU exposure by subtracting the constant 2 from the original metric. Rescaling the MU exposure using 2 allows a relevant zero point, corresponding to the early years of the program, that is, MU Stage 1. We transformed continuous variables into quartiles to reduce the influence of outliers and set the highest quartiles as the reference categories. We dummy-coded all categorical variables and set reference categories as indicated in the results.

Given that the primary outcome is binary, and hospitals are clustered into markets, we used a generalized linear mixed model, with a binomial distribution and a logit link, for model estimation. We assessed model fit for each group of variables, as noted above, using the Bayesian Information Criterion procedure.[43] We tested statistical significance of individual parameters using Wald-type tests and set the significance level at a 5% threshold. Our final model included all main effects and a random intercept. We used robust standard errors to adjust for hospital clustering into markets and the use of inverse probability weights, which account for unequal probability of participation in MU of EHRs when programs first started in 2011 (see Supplementary Material).

We conducted additional sensitivity analyses in which we substituted a measure of postoperative mortality for the readmission measure in order to identify high-value hospitals. While mortality is a somewhat more difficult concept to examine in relation to costs (because patients who die are often either highly expensive, if their course is prolonged, or very inexpensive, if their course is brief), we saw this as a way to determine if our findings were robust to our choice of clinical outcome. We used R software and the SAS statistical package for the analyses.[44,45] Because all data were public and de-identified, the study met the criteria for exemption from review by the Brown University Institutional Review Board.

RESULTS

Hospital characteristics and participation in MU

Our sample included 2860 short-term, acute care hospitals. Of these hospitals, 82% were accredited, and 73% were located in an urban area. Nearly 1/3 had a teaching mission (34%), were either of public (16%) or for-profit ownership (23%), or small in size (29%). Hospitals' average case mix index was 1.57, indicating moderate complexity (Table 1).

Most hospitals had 4 years (39.3%) or 5 years (20.0%) of MU attestation by 2015 (Table 1). Only a small number had 1 year (2.3%) or 2 years (4.8%) In bivariate analyses, we found differences among hospitals by duration of MU participation. For example, not-for-profit hospitals were more likely to participate for 4 or 5 years, compared with public or for-profit hospitals (61% vs 57% and 57%, respectively, $P = .017$; Table 1). Small hospitals were less likely to participate for 4 or 5 years, compared with medium or large hospitals (54% vs 60% and 64%, respectively, $P = .031$).

Hospital performance on 30-day readmission and Medicare inpatient spending

When we examined the component measures of value, we found variation in hospital performance on each. The mean 30-day HWR rate was 15.3%, with range from 11.3% to 19.2%. Similarly, median Medicare inpatient spending per episode was $9906; the interquartile range was $8517–$11 156.

In unadjusted multivariate weighted analyses, we found a statistically significant, but very small relationship between duration of participation and 30-day readmission rates (for each additional year of MU participation, beta 0.04%, 95% confidence interval [CI]: 0.00–0.07%, $P = .03$; Table 2). However, in fully adjusted regressions, this relationship was no longer significant (Table 3). Similarly, unadjusted multivariate weighted analyses showed a significant association of duration of MU participation with Medicare inpatient spending (for each additional year of MU participation, beta −2.1%, 95% CI: −3.2% to −0.9%, $P < .001$; Table 2). Fully adjusted multilevel regressions demonstrated a slightly attenuated, but still significant relationship (beta −1.6%, 95% CI −2.4% to −0.8%; $P < .0001$, Table 3). (Full regressions results are reported in Supplementary Material.)

Predictors of hospital high-value status

Seventeen percent of hospitals were classified as high-value, having performance levels on both the HWR and Medicare inpatient spending *at* or *below* the national average. Unadjusted analyses showed no statistically significant differences in high-value status by duration of MU participation (for each additional year of MU participation, odds ratio [OR] = 1.07, 95% CI: 0.93–1.22; $P = .36$, Table 2). This relationship was minimally changed after full adjustment for hospital-level covariates (OR = 1.05, 95% CI: 0.91–1.21; $P = .51$, Table 3).

However, a number of other hospital characteristics, beyond duration of MU participation, were strongly related to value. For instance, rural hospitals had higher odds of being classified as high-value than urban hospitals (OR = 1.44, 95% CI: 1.12–1.86; $P < .01$; Supplementary Material). There were no significant differences based on teaching status, but for-profit hospitals had lower

Table 1. Hospital characteristics by stage and duration of participation in MU

		MU stage 1		MU stage 2			
	All hospitals	One year of participation	Two years of participation	Three years of participation	Four years of participation	Five years of participation	P-value*
Number of hospitals	2860	65 (2.3)	137 (4.8)	962 (33.6)	1124 (39.3)	572 (20.0)	n/a
Hospital characteristics							
Accreditation and geography[a]							
Accreditation status							.172
JC accredited	2343 (81.9)	2.4%	4.9%	32.7%	39.6%	20.4%	
Not JC accredited	517 (18.1)	1.6%	4.5%	37.9%	37.9%	18.2%	
Geography							.003
Urban	2098 (73.4)	2.2%	5.1%	32.8%	38.2%	21.6%	
Not urban	762 (26.6)	2.4%	3.9%	35.8%	42.4%	15.5%	
Organizational characteristics[a]							
Medical school affiliation							.059
No affiliation	1885 (65.9)	2.5%	4.7%	34.5%	38.7%	19.6%	
Graduate/limited teaching	582 (20.4)	2.6%	5.8%	34.0%	39.2%	18.4%	
Major teaching	393 (13.7)	0.8%	3.8%	29.0%	42.2%	24.2%	
Ownership status							.017
Not-for-profit	1754 (61.3)	2.6%	5.0%	31.8%	40.5%	20.1%	
Public	462 (16.2)	1.1%	5.0%	36.6%	40.9%	16.5%	
For-profit	644 (22.5)	2.2%	4.0%	36.7%	34.8%	22.4%	
Hospital size							.031
Small (<100 beds)	816 (28.5)	2.7%	5.6%	37.4%	36.6%	17.7%	
Medium (100–399 beds)	1537 (53.7)	2.4%	4.6%	32.6%	40.0%	20.4%	
Large (over 400 beds)	507 (17.7)	1.2%	3.9%	30.8%	41.6%	22.5%	
Patients served							
CMI	1.57 (0.34)	1.59 (0.31)	1.58 (0.41)	1.58 (0.37)	1.55 (0.30)	1.59 (0.31)	.068
DSH patient	0.28 (0.17)	0.27 (0.19)	0.27 (0.16)	0.28 (0.17)	0.30 (0.17)	0.26 (0.15)	<.0001

Note: Sum total may not add up to 100% due to rounding.

CMI: case mix index; DSH: disproportionate share hospital; JC: Joint Commission; MU: Meaningful Use; n/a: not applicable.

*P-values are reported for differences across groups.

[a]Percentages are reported for categorical variables.

[b]Mean and (standard deviation) for continuous variables.

Table 2. Associations of duration of participation in MU with 30-day hospital-wide all-cause unplanned readmission, hospital inpatient spending, and value in Medicare (unadjusted)[a]

	30-Day hospital-wide readmission		Hospital inpatient spending[b]		Value in Medicare[c]	
	Estimate (s.e.) (rates, %)	95% CI	Estimate (s.e.) (log scale)	95% CI	Estimate (s.e.) (logit scale)	Odds ratio (95% CI) (odds ratio scale, $\exp^{\beta}$)
Intercept	15.18*** (0.04)	15.10–15.26	9.242*** (0.011)	9.219–9.264	−1.72*** (0.13)	
Duration of MU participation	0.04* (0.02)	0.00–0.07	−0.021*** (0.006)	−0.032 to −0.009	0.06 (0.07)	1.07 (0.93–1.22)

CI: confidence interval; MU: Meaningful Use; s.e.: standard error.

*, **, and *** indicate significance levels ≤5%, ≤1%, and <.01%, respectively.

[a]Multilevel weighted regressions with robust standard errors. Sample size: hospital ($N = 2860$); market ($N = 304$).

[b]Estimates expressed in log scale. Intercept, β_0, is estimated spending for hospitals with 2 years of MU participation, holding constant market location: \$10 322 (obtained from $\exp^{[9.242]}$). Effect estimates are interpretable as proportional differences in the outcome. For estimate values close to 0, use (100β) to obtain proportional change in spending; for values greater than 0.1, use [$100(\exp^{\beta} - 1)$]. For example, holding market location constant, each additional year of MU participation is associated with 2.1% reduction in spending; this translates into approximately a reduction of \$217 (obtained from 2.1% [\$10 322]).

[c]High-value hospitals have performance *at or below* the national average on both 30-day hospital-wide all-cause unplanned readmission (15.3%) and Medicare inpatient spending (\$9324). Intercept, β_0, is predicted odds of value for hospitals with 2 years of MU participation, holding constant market location: .179, or about 1–5 (obtained from $\exp^{[-1.72]}$). On the probability scale, this translates into a probability of .152 (15.2%). Effect estimate: holding market location constant, each additional year of MU participation is associated with a 7% increase in the predicted odds of value; however, this estimate is not statistically significant.

odds of being classified as high-value than not-for-profit hospitals (OR = 0.64, 95% CI: 0.47–0.88, $P = .01$). Small hospitals had significantly higher odds than larger ones (OR = 2.99, 95% CI: 1.61–5.57; $P < .01$). Compared with hospitals serving the sickest patients, hospitals in the first quartile of case mix (that is, those with the healthiest patients, OR = 15.7, 95% CI: 9.58–25.6; $P < .0001$)

Table 3. Predictors of 30-day hospital-wide all-cause unplanned readmission, hospital inpatient spending, and value in Medicare[a]

	30-Day hospital-wide readmission		Hospital inpatient spending[b]		Value in Medicare[c]	
	Estimate (s.e.) (rates, %)	95% CI	Estimate (s.e.) (log scale)	95% CI	Estimate (s.e.) (logit scale)	Odds ratio (95% CI) (odds ratio scale, $\exp^{\beta}$)
Intercept	15.27*** (0.08)	15.10–15.43	9.432*** (0.015)	9.403–9.461	−4.38*** (0.40)	
Duration of MU participation	0.03 (0.02)	0.00–0.06	−0.016*** (0.004)	−0.024 to −0.008	0.05 (0.07)	1.05 (0.91–1.21)
Organizational characteristics						
Ownership status						
Not-for-profit	Reference		Reference		Reference	
Public	0.05 (0.04)	−0.02 to 0.13	−0.013 (0.008)	−0.029 to 0.003	0.08 (0.15)	1.08 (0.80–1.46)
For-profit	0.27*** (0.04)	0.19–0.35	0.037*** (0.008)	0.021–0.053	−0.45** (0.16)	0.64 (0.47–0.88)
Size						
Small (<100 beds)	−0.31*** (0.07)	−0.44 to −0.17	0.025* (0.012)	0.003–0.048	1.10** (0.32)	2.99 (1.61–5.57)
Medium (100–399 beds)	−0.15** (0.05)	−0.25 to −0.05	0.001 (0.008)	−0.015 to 0.016	0.39 (0.29)	1.48 (0.83–2.61)
Large (over 400 beds)	Reference		Reference		Reference	
Patients served						
Case mix index						
Quartile 1	0.43*** (0.06)	0.30–0.55	−0.484*** (0.013)	−0.511 to −0.458	2.75*** (0.25)	15.66 (9.58–25.62)
Quartile 2	0.32*** (0.06)	0.21–0.44	−0.284*** (0.010)	−0.304 to −0.265	1.96*** (0.25)	7.09 (4.34–11.59)
Quartile 3	0.22*** (0.05)	0.11–0.32	−0.183*** (0.009)	−0.199 to −0.166	0.52 (0.28)	1.68 (0.98–2.90)
Quartile 4 (sickest)	Reference		Reference		Reference	
DSH patient						
Quartile 1	−0.38*** (0.05)	−0.48 to −0.28	0.045*** (0.011)	0.024–0.065	0.26 (0.18)	1.29 (0.90–1.86)
Quartile 2	−0.25*** (0.05)	−0.34 to −0.15	0.007 (0.008)	−0.009 to 0.024	0.35* (0.16)	1.41 (1.03–1.95)
Quartile 3	−0.20*** (0.05)	−0.29 to −0.11	0.006 (0.008)	−0.011 to 0.022	0.36* (0.16)	1.43 (1.03–1.97)
Quartile 4 (neediest)	Reference		Reference		Reference	

CI: confidence interval; DSH: disproportionate share hospital; MU: Meaningful Use; s.e.: standard error.

*, **, and *** indicate significance levels ≤5%, ≤1%, and <.01%, respectively.

[a]Multilevel weighted regressions with robust standard errors. Sample size: hospital ($N = 2860$); market ($N = 304$). Full results are reported in Supplementary Material.

[b]Estimates expressed in log scale. Intercept, β_0, is estimated spending for hospitals with 2 years of MU participation, with reference categories (not accredited, urban, nonteaching, not-for-profit, large, sickest and neediest patients), holding constant market location: $12 481 (obtained from $\exp^{[9.432]}$). Effect estimates are interpretable as proportional differences in the outcome. For estimate values close to 0, use (100β) to obtain proportional change in spending; for values greater than 0.1, use [$100(\exp^{\beta} - 1)$]. Holding constant market location, and controlling for hospital characteristics, each additional year of MU is associated with a 1.6% reduction in spending; this translates into approximately a reduction of $200 (obtained from 1.6% [$12 481]).

[c]High-value hospitals have performance *at or below* the national average *on both* 30-day hospital-wide all-cause unplanned readmission (15.3%) and Medicare inpatient spending ($9324). Intercept, β_0, is predicted odds of value for hospitals with 2 years of MU participation, with reference categories as noted above, holding constant market location: .0128, or about 1–100; this translates into a probability of .0126 (1.3%). Effect estimate: Holding market location constant, and controlling for hospital characteristics, each additional year of MU participation is associated with a 5% increase in the predicted odds of value; however, this estimate is not statistically significant.

and those in the second quartile of case mix (OR = 7.09, 95% CI: 4.34–11.6; $P < .0001$) had markedly higher odds of value. Hospitals in the second and third quartiles of DSH index, indicating a lower burden of caring for the poor, had higher odds of being classified as high-value.

Sensitivity analysis

In additional sensitivity analyses, in which we used 30-day mortality for serious treatable complications after surgery as the quality component for our measure of value, we again found no evidence of an association of duration of participation in MU with value.

DISCUSSION

We conducted a cross-sectional study to characterize hospital participation in the Medicare EHR Incentive Program, and to evaluate whether duration of MU participation was associated with higher likelihood of value in Medicare—operationalized as simultaneously having performance levels on 30-day HWR and Medicare inpatient spending per hospitalization episode falling *at or below* the national average. We found that duration of MU participation varied by hospital characteristics, but there was no evidence of a statistical association between duration of MU participation and value. Interestingly, there was a significant, modest relationship between longer duration of participation and lower Medicare inpatient spending, but not 30-day readmission. We also found that urban location and hospital characteristics, including size, and having a less-complex case mix, were associated with value.

Our findings pertaining to hospital participation in the Medicare EHR Incentive Program are, in general, consistent with those of previous work on MU. For instance, we found that, compared with large hospitals, small hospitals were less likely to participate for 4 or 5 years. This adds to prior findings from an evaluation of the first 18 months of MU, which reported that small hospitals were less likely to qualify for incentives than their large counterparts.[20]

Moreover, just as reported by the same evaluation, we found differences in MU participation by hospital ownership status, with not-for-profit hospitals leading in participating for the longest duration.

Sustained participation in MU is not related to value. Our "value" measure is comprised of an outcome component (readmission) and a cost component (inpatient spending). There was no significant relationship between MU and the readmission component itself as a continuous outcome—despite good theoretical underpinnings for MU's plausible impact on this outcome. There is evidence supporting that nearly half of all readmissions are linked with indicators of substandard care during the index hospitalization, notably unresolved issues or inappropriate therapy at discharge, in addition to poor discharge planning.[46] In theory, MU should facilitate improvements in inpatient care and in transitions to the outpatient setting,[17,47] particularly in terms of communication and coordination among providers, which is often lacking.[48,49] There was also no relationship between MU and our alternative outcome measure of postsurgical mortality, suggesting that further work is warranted to understand how MU may influence care quality both in terms of inpatient care delivery and transitions of care.

We did, however, find that MU may be associated with lower inpatient costs as assessed by Medicare inpatient payments. This may occur through many mechanisms. For example, certified EHRs may help providers adhere to evidence-based guidelines,[50,51] which may reduce the risk of major complications and, hence, lower costs. Certified EHRs may enhance the quality of documentation of patient information and coordination among providers,[17] which may prevent costly redundancies in care.[52,53] MU provides better tools for complex tasks under Stage 2, including those to improve clinical management in the inpatient setting and along the care continuum, which may improve efficiency.[54,55] On the other hand, it is also possible that having EHRs facilitates the capture and coding of a higher number of comorbidities among hospitalized patients; this would lead to an artificial reduction in risk-adjusted costs. A similar phenomenon has been reported in the readmissions literature, where higher coding of comorbidities over time has been shown to explain some of the observed drop in risk-adjusted readmissions.[56] Further study to elucidate these potential mechanisms is important.

Our study should be taken in context with prior work. For instance, a recent study examining the relationship between participation in value-based initiatives, including MU, and performance on readmissions for conditions targeted under the Hospital Readmissions Reduction Program (HRRP) demonstrated lower risk-standardized 30-day readmission rates for acute myocardial infarction, pneumonia, and heart failure among hospitals with greater value-based initiative participation.[57] Likewise, a single-state analysis comparing length of stay and readmission outcomes for Medicare and non-Medicare patients treated at MU Stage 1 hospitals to those observed at hospitals with partial- and full-EHR adoption found favorable outcomes for the former.[58] Relatedly, other work reported improvements in provider performance on processes of care associated with increased use of certified EHRs.[50]

There are policy implications for our findings. MU was designed to accelerate widespread adoption and MU of certified EHR technology to improve care quality and reduce costs.[13,19] Since the program's introduction in 2011, EHR uptake among hospitals is on the rise.[21,23] However, there are huge costs associated with implementing, maintaining, and upgrading EHRs.[59] Our findings suggest that additional policy interventions beyond MU, as currently designed, may be needed to drive improvements in the value of care delivered and received under Medicare. As CMS contemplates potential changes to MU—now renamed as the Promoting Interoperability Programs—[60] it may be important to consider how future requirements might incent both quality and cost improvement.

Our study has limitations. First, using a cross-sectional design, we cannot ascribe a causal interpretation to our findings. Despite the use of propensity score-based methods, and additional adjustments for key covariates, it is possible that there are important unmeasured differences between hospitals—be it leadership or other factors—that elect to pursue MU and those that do not that may bias our results. It is also possible that other concurrent value-based payment efforts, such as bundled payments, accountable care organizations, or the HRRP influenced our findings. Second, we only evaluated the Medicare component of the MU Program: Data on the Medicaid component are not publically available. Therefore, we do not know whether similar trends can be observed in the larger cohort of hospitals receiving EHR incentives under both components. Third, we examined a stylized concept of value: We chose to evaluate readmission and inpatient spending because of their broad and complementary nature in terms of patient populations and their use in public reporting and many current value-based payment programs. However, the concept of value is at present a somewhat fluid one, and our results may not generalize to value defined differently. Fourth, we only evaluated duration of participation. Hence, we do not know the degree to which a hospital's EHR use predated their MU attestation nor whether a hospital attests early, drops out, and then attests late. Two hospitals with similar MU data might have very different EHR maturation phases (eg, 1 had the EHR for many years, but another implemented it 1 year before MU). Finally, we did not examine specific EHR functionalities. Pinpointing the underlying functionalities involved in quality and cost improvement may be an important next step to ensure technology continues to drive towards value.[61,62] Finally, we did not examine vendor chosen by hospitals. A recent study reported differential trends in hospital performance on the attainment of 6 MU Stage 2 measures related to vendor choice.[63]

CONCLUSION

A longer duration of participation in MU was not associated with higher odds of achieving value—that is, good outcomes at low costs. However, we did find that hospitals with longer MU participation had lower inpatient costs. For EHRs to drive improvements in value, changes to the MU programs, or other policy efforts focusing on how these technologies can best be used to drive improvements in quality, may be needed.

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AUTHOR CONTRIBUTORS

YNB conceived and designed study, obtained data, conducted data analysis, contributed to results interpretation, drafted paper, and contributed to paper revisions. KEJM contributed to study design,

results interpretation, and paper revisions. YNB and KEJM approved final version to be published.

SUPPLEMENTARY MATERIAL

Supplementary Material is available at *Journal of the American Medical Informatics Association* online.

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