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Alterations in 90-day morbidity, mortality, and readmission rates following spine surgery in Medicare Accountable Care Organizations (2009–2014)

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Abstract

BACKGROUND CONTEXT: The impact of Accountable Care Organizations (ACOs) on healthcare quality and outcomes, including morbidity, mortality, and readmissions, has not been substantially investigated, especially following spine surgery.

PURPOSE: To evaluate the impact of ACO formation on postoperative outcomes in the 90-day period following spine surgery.

STUDY DESIGN: Retrospective review of national Medicare claims data (2009–2014).

PATIENT SAMPLE: Patients who underwent one of four lumbar spine surgical procedures in an ACO or non-ACO.

OUTCOME MEASURES: The development of in-hospital mortality, complications or hospital readmission within 90 days of the surgical procedure.

METHODS: The primary outcome measures included postsurgical complications and readmissions at 90 days following surgery. In-hospital mortality and 30-day outcomes were considered secondarily. The primary predictor variable consisted of ACO enrollment designation. Multivariable logistic regression analysis was utilized to adjust for confounders and determine the independent effect of ACO enrollment on postsurgical outcomes. The multivariable model included a propensity score adjustment that accounted for factors associated with the preferential enrollment of patients in ACOs, namely, sociodemographic characteristics, medical co-morbidities, hospital teaching status, bed size, and location.

RESULTS: In all, there were 344,813 patients identified for inclusion in this analysis with 97% (n = 332,890) treated in non-ACOs and 3% (n = 11,923) in an ACO. Although modest changes were apparent across both ACOs and non-ACOs over the time-period studied, improvements were slightly more dramatic in non-ACOs leading to statistically significant differences in both 90-day complications and readmissions. Specifically, in the period 2012–2014, ACOs demonstrated an 18% increase in the odds of 90-day complications and a 14% elevation in the odds of 90-day readmissions when compared to non-ACOs. There was no difference in hospital mortality between ACOs and non-ACOs.

CONCLUSIONS: Our study of Medicare data from 2009 to 2014 failed to demonstrate superior reductions in postoperative morbidity, mortality, and readmissions for beneficiaries treated in

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ACOs as compared to non-ACOs. These results indicate that meaningful changes in postoperative outcomes should not be anticipated based on organizational participation in ACOs at present.

Keywords: Accountable Care Organizations (ACOs); Complications; Healthcare reform; Mortality; Readmission; Spine surgery.

Introduction

Originating from the concept of Integrated Delivery Systems, Accountable Care Organizations (ACOs) were implemented as an integral part of the Affordable Care Act (ACA) as a mechanism to achieve the Triple Aim: enhanced access to healthcare, improved quality, and reduced costs [1–6]. Proponents of ACOs advocated that increased efficiency and reductions in unnecessary procedures and tests would result in savings to the healthcare system and many also maintained that these approaches would translate into reductions in morbidity, mortality, and unnecessary hospitalizations, including readmissions, for beneficiaries enrolled in these types of healthcare organizations [3,6,7]. Detractors remained skeptical, however, with some expressing concern that were underperforming healthcare organizations to form ACOs; the mere creation of these entities predicated on a particular reimbursement scheme would not lead to improvements in quality for patients [8].

Early evidence indicates that ACOs have been successful in reducing overall healthcare costs and implementing some preventive care measures [2,4]. However, their impact on quality and outcomes such as morbidity, mortality, and readmissions has not been substantially investigated, especially following surgery. In a recent study on outcomes following surgical intervention for a variety of cancers, Herrel et al. reported no significant differences between ACOs and non-participating organizations (non-ACOs) [7]. To the best of our knowledge, no prior work has investigated the impact of ACOs on postsurgical quality measures following lumbar spine surgery. Lumbar surgical interventions are among the most common spine procedures, especially in the Medicare population [9,10]. Over the first two decades of the 21st century, the rate of these types of surgeries among Medicare beneficiaries, especially fusion-based procedures, has increased by a factor greater than 10 [9] with the cost burden for spinal disorders exceeding that for cardiovascular care and diabetes [10]. Given the frequency with which these procedures are performed in the Medicare population, as well as the extensive costs associated with such interventions, we believed that lumbar spine procedures would provide a viable source for a study evaluating the impact of ACO formation on postsurgical outcomes.

In this context, we utilized national Medicare claims data for a period overlapping the implementation of the ACA (2009–2014) to evaluate the impact of ACO formation on outcomes in the 90-day period following spine surgery, including in-hospital mortality, complications, and readmissions. We hypothesized that postsurgical morbidity and mortality as well as readmissions would be lower among Medicare beneficiaries treated in ACOs as compared to non-ACOs.

Methods

Data source

This study was conducted using Center for Medicare and Medicaid Services (CMS) fee-for-service claims for patients who underwent lumbar interbody fusion, posterolateral fusion, decompression, or discectomy procedures between January 1, 2009 and December 31, 2014. We considered all individuals in this time period who were age 65 or older and enrolled in Medicare Part A and B. Patients younger than 65 and those enrolled in Medicare managed care programs were excluded.

CMS files utilized in this research included Medicare Provider Analysis and Review files, carrier files, patient vital statistics files, and ACO files, which were merged for those who met inclusion criteria. These types of Medicare claims data have been widely utilized in prior research, including efforts regarding variation in the use of spine surgical procedures [3,7,9,10]. Sociodemographic and clinical data for eligible patients were then abstracted including patient age at the time of surgery, biologic sex, race, age-adjusted Charlson co-morbidity score [11], median income by patient's residence ZIP code, surgical diagnosis, and procedure performed. Hospital characteristics were also obtained and consisted of ACO-enrollment status (Medicare Shared Savings Program or Pioneer) [1,7,12] in the period 2012–2014, hospital teaching status, bed size, and location. Outcome data abstracted included in-hospital mortality (mortality), postsurgical complications at 30 and 90 days following surgery, and hospital readmission at the same time-points.

Variable definition

For the purposes of this study, age was defined at the time of the surgical procedure while biologic sex was categorized as male or female based on patient self-report to Medicare. Race was also classified according to patient self-report as White, African-American (including Medicare designation as Black), Hispanic, Asian, and Other (eg, Native American, Pacific Islander, Other Race, and Mixed Race). Surgical procedures were identified using a previously described International Classification of Disease – 9th revision (ICD-9) coding algorithm and categorized as fusion (eg, interbody fusion and posterolateral

fusion), or standalone decompression (decompression or discectomy) [10,13–15]. Patients who received a discectomy or decompression and fusion procedure were classified in the category of fusion. Surgical diagnosis was also determined using ICD-9 code and then stratified based on a previously published algorithm with patients diagnosed with spinal stenosis (724.02, 724.03) in the absence of codes for spondylolisthesis (738.4, 756.12) assigned to the spinal stenosis cohort [9,10,14]. Patients diagnosed with spondylolisthesis, with or without a concomitant diagnosis of spinal stenosis, were assigned to the group with spondylolisthesis [10,14].

Beneficiary enrollment in ACOs was assigned based on the affiliation of the provider who made the surgical diagnosis and/or performed the surgical intervention based on reporting contained within the CMS ACO file. Using the implementation of the ACA as the defining temporal event (2012), we stratified times into the periods 2009–2011 and 2012–2014. Organizations were categorized as ACOs, or non-ACOs, with institutions that would enroll as an ACO in 2012–2014 considered as a group across time.

Postsurgical morbidity was designated using an ICD-9 coding algorithm that included surgical site complications (hemorrhage/hematoma, neurologic compromise, seroma, and wound infections) as well as perioperative medical events (myocardial infarction, venous thromboembolic events, delirium, renal failure, other urologic complications, respiratory complications, sepsis, and shock) [15,16]. Using CMS guidelines, we included readmissions for any cause within the 90-day postsurgical period.

Statistical analysis

The primary outcome measures for this study included postsurgical complications and readmissions at 90 days following surgery. In-hospital mortality and 30-day outcome measures were considered secondarily. The primary predictor variable consisted of ACO enrollment designation, with non-ACOs in the period 2009–2011 used as the referent. All sociodemographic, clinical, and hospital characteristics were considered covariates. Multivariable logistic regression analysis was utilized to adjust for confounders and determine the independent effect of ACO-enrollment on the outcomes of interest. The multivariable model included a propensity score adjustment [17,18] that accounted for factors associated with the preferential enrollment of patients in ACOs, specifically patient sociodemographic characteristics, medical co-morbidities, hospital teaching status, bed size, and location [12,18]. The use of the propensity score in this analysis was intended to address baseline differences in the social and medical characteristics of the populations treated by ACOs as well as distinctions between the hospitals that provide care in ACOs and non-ACOs. Subsequent multivariable logistic testing was performed to identify clinical and sociodemographic characteristics associated with the primary outcomes of 90-day complications and readmissions, similarly adjusted for ACO enrollment. The results of multivariable testing were expressed as odds ratios (ORs) with 95% confidence intervals (CI) and p-value. Statistically significant variables were defined, a priori, as those with ORs and 95% CI exclusive of 1.0 and $p < .05$ following multivariable analysis. All analyses were conducted using SAS v. 9.4 (SAS Institute, Cary, NC). This study received IRB approval prior to commencement, and all data utilized in this effort were de-identified.

Results

Between 2009 and 2014, there were 344,813 patients identified for inclusion in this analysis. The majority of patients (n = 332,890; 97%) were treated in non-ACOs, while 3% (n = 11,923) received surgery through an ACO. The demographic and clinical characteristics of those treated in ACOs and non-ACOs were similar (Table 1). Given the size of our sample, there were some significant differences at baseline, although these were not felt to be clinically meaningful. The spinal stenosis and spondylolis-

Table 1
Demographic and clinical characteristics of patients receiving spine surgery in Accountable Care Organizations (ACOs) and non-ACOs

Characteristic	ACO (n=11,923)	Non-ACO (332,890)	p-value
Age (mean, SD)	74.2 (6.4)	73.5 (6.3)	<.001
Male sex (%)	5,175 (43)	145,818 (44)	.39
Race (%)			.003
White	11,013 (92)	305,680 (92)	–
African-American	526 (4)	16,133 (5)	–
Hispanic	114 (1)	2,583 (1)	–
Asian	78 (1)	2,839 (1)	–
Other	130 (1)	3,405 (1)	–
Age-adjusted Charlson co-morbidity score (%)	–	–	<.001
0–3	6,065 (51)	174,080 (52)	–
4–6	5,051 (42)	141,687 (43)	–
≥7	807 (7)	17,123 (5)	–
Median income (IQR)	55,910 (26,446)	52,095 (26,276)	<.001
Teaching hospital (%)	3,626 (30)	71,779 (22)	<.001

Note that the values presented are rounded.

thesis diagnostic categories were the two largest in both ACOs and non-ACOs, representing 80% and 93% of the total sample, respectively. The most common diagnosis in both environments of care was spinal stenosis in the absence of spondylolisthesis (48% in ACOs and 51% in non-ACOs). Fusions were performed in 49% (n = 5,881) of patients in ACOs and among 53% (n = 181,920) of beneficiaries in non-ACOs.

In the period 2009–2011, the raw rate of mortality, 30-day complications, and 30-day readmissions in ACOs were 0.23%, 15.5%, and 10.4%, respectively, while complications had occurred in 17.4% of patients and readmissions in 15.8% at 90 days. Over the course of this same time period, within non-ACOs mortality occurred in 0.19%, 30-day complications in 13.1%, and 30-day readmissions in 9.5%. Among these organizations, 90-day complications and readmissions were documented in 14.8% and 13.5% of patients, respectively.

In 2012–2014, the raw rate of mortality, 30-day complications, and 30-day readmissions in ACOs was 0.3%, 15.4%, and 10.8%, respectively, while complications were recorded in 17.4% of patients and readmissions in 15.3% at 90 days. Among non-ACOs, mortality occurred in 0.2%, 30-day complications in 12.5%, and 30-day readmissions in 9.1%. At 90 days, complications had occurred in 14.2% and readmissions in 12.7% of patients.

Following multivariable logistic regression, no significant differences in in-hospital mortality were detected between ACOs and non-ACOs (Table 2). ACOs in 2012–2014 did demonstrate a 16% increase in the odds of complications (OR 1.16; 95% CI 1.06, 1.28) as compared to non-ACOs, but there was no significant increase in the odds of readmission (OR 1.12; 95% CI 1.00, 1.25).

Similar findings were encountered at the 90-day time period, with ACOs in 2012–2014 found to have an 18% increase in the odds of complications (OR 1.18; 95% CI 1.08, 1.29; Table 3) and a 14% increase in the odds of readmission (OR 1.14; 95% CI 1.04, 1.25) when compared to non-ACOs. At the same time, non-ACOs in 2012–2014 appreciated modest reductions in the odds of complications (OR 0.95; 95% CI 0.93, 0.97) and readmissions (OR 0.93; 95% CI 0.91, 0.95) as compared to the period 2009–2011.

Several sociodemographic and clinical characteristics were found to be associated with 90-day complications and readmissions following multivariable logistic testing that accounted for confounders as well as patient enrollment in ACOs (Table 4). Patient age, male sex, co-morbidity score, and surgery at a teaching hospital were all associated with relatively slight increases in the odds of complications and/or readmission. The most substantial risk factors for complications and readmissions were patient race, with African-Americans and Hispanics found to have elevated odds of 90-day complications (African-Americans: OR 1.39; 95% CI 1.33, 1.45; Hispanics: OR 1.16, 95% CI 1.05, 1.29) and 90-day readmissions (African-Americans: OR 1.34; 95% CI 1.28, 1.40; Hispanics: OR 1.25, 95% CI 1.13, 1.39) as compared to Whites.

Discussion

ACOs serve as one of the hallmark initiatives of healthcare reform associated with the ACA and a chief means through which reductions in healthcare spending are thought to be realized in the coming decades [1–8,12]. As ACOs were designed with the intent of improving quality and impacting costs through increased surveillance and coordination of care, many efforts have been focused at the primary care level with surgical procedures considered secondarily if at all [1,7]. As a result, the impact of ACOs on postsurgical quality including reductions in morbidity, mortality, and readmissions following interventions has not been extensively studied. Given the magnitude and expense associated with spine surgical procedures

Table 2
The adjusted odds of in-hospital mortality, 30-day complications, and 30-day readmissions among patients receiving spine surgery in Accountable Care Organizations (ACOs) and non-ACOs between 2009 and 2014

Environment of care	Odds ratio	95% confidence interval	p-value
In-hospital mortality			
Non-ACOs (2009–2011)	Referent	Referent	Referent
Non-ACOs (2012–2014)	1.02	0.87, 1.19	.79
ACOs (2009–2011)	1.07	0.65, 1.76	.80
ACOs (2012–2014)	1.63	0.88, 3.03	.12
30-day complications			
Non-ACOs (2009–2011)	Referent	Referent	Referent
Non-ACOs (2012–2014)	0.95	0.93, 0.97	<.001
ACOs (2009–2011)	1.17	1.10, 1.24	<.001
ACOs (2012–2014)	1.16	1.06, 1.28	.002
30-day readmissions			
Non-ACOs (2009–2011)	Referent	Referent	Referent
Non-ACOs (2012–2014)	0.95	0.93, 0.97	<.001
ACOs (2009–2011)	1.10	1.02, 1.18	.01
ACOs (2012–2014)	1.12	1.00, 1.25	.05

Table 3
The adjusted odds of 90-day complications and readmissions in the Accountable Care Organization (ACO) and non-ACO environment between 2009 and 2014

Environment of care	Odds ratio	95% confidence interval	p-value
90-day complications			
Non-ACOs (2009–2011)	Referent	Referent	Referent
Non-ACOs (2012–2014)	0.95	0.93, 0.97	<.001
ACOs (2009–2011)	1.19	1.12, 1.26	<.001
ACOs (2012–2014)	1.18	1.08, 1.29	<.001
90-day readmissions			
Non-ACOs (2009–2011)	Referent	Referent	Referent
Non-ACOs (2012–2014)	0.93	0.91, 0.95	<.001
ACOs (2009–2011)	1.19	1.12, 1.26	<.001
ACOs (2012–2014)	1.14	1.04, 1.25	.007

Table 4
Demographic and clinical characteristics associated with the occurrence of complications or readmissions at 90 days following spine surgery, adjusted for participation in an Accountable Care Organization (ACO)

Complications	OR	95% CI	p-value	Readmissions	OR	95% CI	p-value
Age*	1.01	1.00, 1.01	<.001	Age*	1.02	1.02, 1.02	<.001
Male sex	1.08	1.0, 1.10	<.001	Male sex	0.82	0.81, 0.84	<.001
Race (%)				Race (%)			
White	Referent	Referent	Referent	White	Referent	Referent	Referent
African-American	1.39	1.33, 1.45	<.001	African American	1.34	1.28, 1.40	<.001
Hispanic	1.16	1.05, 1.29	.005	Hispanic	1.25	1.13, 1.39	<.001
Asian	0.93	0.84, 1.17	.94	Asian	0.89	0.80, 1.00	.05
Age-adjusted Charlson co-morbidity score*	1.27	1.26, 1.27	<.001	Age-adjusted Charlson co-morbidity score*	1.24	1.23, 1.25	<.001
Teaching hospital	1.08	1.05, 1.11	<.001	Teaching hospital	1.03	1.00, 1.06	.09

Note that values are rounded. OR – odds ratio; 95% CI – 95% confidence interval.
* Estimate per 1.0 point increase.

in the Medicare population [9,10], we thought it was important to evaluate whether ACO formation resulted in statistically superior reductions in adverse events as compared to non-participating organizations.

In this investigation, we found that the formation of ACOs did not translate into substantial improvements in the rates of postoperative outcomes as compared to non-ACOs. At baseline, organizations that would form ACOs already had higher rates of complications as well as readmissions. Although modest changes were apparent across both ACOs and non-ACOs in the period following implementation of the ACA, improvements were slightly more dramatic in non-ACOs leading to statistically significant differences in our primary outcome measures: 90-day complications and readmissions. Specifically, in the period 2012–2014, ACOs demonstrated an 18% increase in the odds of 90-day complications and a 14% elevation in the odds of 90-day readmissions when compared to non-ACOs. These findings are especially meaningful considering that the design of this study allowed us to include all eligible patients receiving spine surgery through ACOs and non-ACOs. Complication and readmission rates are in line with large claims-based studies focusing on lumbar spine surgical procedures [9,10,15,19], which lends credence to the generalizability of our results. The methods used to assign patients to ACOs focused on the surgeons and organizations where care was provided using a previously published technique [17], which limits confounding that arises when a patient's primary care physician is in an ACO but surgery is received at a non-ACO facility. Furthermore, our statistical approach, including a propensity adjustment for sociodemographic and clinical differences between populations treated in ACOs and non-ACOs [12,17], enabled the generation of robust estimates that address the potential for confounding as fully as possible.

The results presented here hold important meaning for stakeholders including patients, healthcare organizations, and third-party payers. Foremost, we have demonstrated that mere participation in an ACO should not be expected to translate into superior postoperative outcomes following spine surgery. From a policy perspective, this finding should not be surprising as there is nothing within the programmatic measures or payment scheme associated with an ACO [1,2,4,7] that would deliberately impact the development of complications or mortality following surgical procedures. While unnecessary readmissions could be curtailed in the setting of an ACO, readmissions that are motivated by a postsurgical complication would probably not be effected. As the percentage of readmissions encountered in this study for ACOs remained lower than the complication rate for patients, we do not

believe that a case can be made for a large number of unnecessary readmissions in this context [15].

Results similar to our own were published by Herrel et al. in their investigation regarding the impact of ACO formation on surgery for cancer [7]. In that work, the authors reported no significant difference in 30-day mortality, readmissions, complications, or prolonged postoperative stay based on hospital participation in an ACO. Our findings, coupled with those of Herrel et al. [7], could stem from the fact that given the design of ACOs and their focus (eg, primary care, preventive measures, and reduction of unnecessary procedures) [1,2,4,6], organizational changes associated with the formation of an ACO would be unlikely to immediately influence outcomes following surgery. Alternatively, it is possible that parallel initiatives such as pay-for-performance, readmission penalties, and surveillance for "never events" have already brought adverse postsurgical event rates to a nadir, such that further quality improvement programs like ACOs would not exert a demonstrable effect. Considering that current quality improvement programs and penalties affect both ACO and non-ACO providers equally may help explain why detectable differences across both organizational models were fairly modest. In the end, if CMS and other third-party payers intend to use ACOs as a means of improving short-term morbidity and readmissions following surgery, these outcomes will likely have to be directly incentivized. In such an event, the clinical and sociodemographic characteristics identified here as independent predictors of 90-day outcomes could serve as viable risk adjustors.

There are important limitations that should be acknowledged when interpreting the results of this research. Foremost, this effort relied on claims data and ICD-9 coding schemes to identify patients eligible for inclusion as well as the outcomes of interest. Although our algorithms are based on previously published strategies [9,10,13–15] the potential for coding errors and incorrect assignation resulting in information bias should be recognized. We do recognize that events that did not result in charges to Medicare would escape notice given the design of this effort. Additionally, clinically granular information is not readily available in claims-based registries, including the rationale for readmission, indications for surgical intervention, radiographic results, the extent of the procedure performed, use of autograft and allograft, as well as surgeon experience. We are also unable to consider functional outcomes or patient-reported measures. While such details would further limit the potential for confounding, we do not feel that practice patterns related to these criteria are likely to differ between providers in ACOs and non-ACOs [12,17]. In terms of minimizing the potential for confounding, we feel that the most important criterion lies in balancing risk factors across patients enrolled in ACOs versus non-ACOs, which we were successfully able to achieve through our use of propensity adjustment. Further limitations include a reliance on Medicare data and a focus on specific, albeit very common, spine surgical interventions. The results may not necessarily be translatable to patients under age 65, non-Medicare ACOs, and individuals receiving other types of surgery including nonlumbar spinal procedures. Last, we realize that the results presented here represent but a 5-year period that encompasses the ACO implementation stage and substantive health reform efforts engendered by the ACA. It is entirely possible that as more organizations form ACOs and current ACOs become more adept at improving healthcare quality and efficiency, demonstrable improvements in postsurgical outcomes may follow. This potentiality clearly represents an important line of further research in the coming years.

In conclusion, our study of Medicare data from 2009 to 2014 failed to demonstrate superior reductions in postoperative morbidity, mortality, and readmissions for beneficiaries treated in ACOs compared to non-ACOs. There may be a number of etiologies for this phenomenon, including the fact that at present surgical interventions are not a main focus of ACO models and may only be marginally impacted by the organizational changes presently incentivized. The results of our work indicate that meaningful changes in postoperative outcomes should not be anticipated based on organizational participation in ACOs at present and, were improvements in such outcomes a definite aspiration, mechanisms directed at surgical quality would have to be emphasized in ACO models.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.spinee.2018.06.367.

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