The Spine Journal 19 (2019) 1340–1345

Clinical Study

Changes in healthcare delivery following spinal fracture in Medicare Accountable Care Organizations

Shaina A. Lipa, MD[a], Justin A. Blucher, MS[a], Daniel J. Sturgeon, MS[b], Mitchel B. Harris, MD[c], Andrew J. Schoenfeld, MD, MSc[d,*]

[a] *Department of Orthopaedic Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA*

[b] *Center for Surgery and Public Health, Department of Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA*

[c] *Department of Orthopaedic Surgery, Massachusetts General Hospital, Harvard Medical School, 55 Fruit Street, Boston, MA 02214, USA*

[d] *Center for Surgery and Public Health, Department of Orthopaedic Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA*

Received 23 January 2019; revised 15 April 2019; accepted 16 April 2019

Abstract

BACKGROUND CONTEXT: Accountable Care Organizations (ACOs) were designed to reduce healthcare costs while simultaneously improving quality. Given that the success of ACOs is predicated on controlling costs, concerns have been expressed that patients could be adversely affected through restricted access to surgery, including in the context of spine fracture care.

PURPOSE: Evaluate the impact of Medicare ACO formation on the utilization of surgery and outcomes following spinal fractures.

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

PATIENT SAMPLE: Patients treated for spinal fractures in an ACO or non-ACO.

OUTCOME MEASURES: The utilization of surgery as treatment for spinal fractures, in-hospital mortality, 90-day complications, or hospital readmission within 90-days injury.

METHODS: We used a pre–post study design to compare outcomes for patients treated in ACOs versus non-ACOs. Receipt of surgery for treatment of a spinal fracture was the primary outcome, with mortality, complications and readmissions treated secondarily. We used multivariable logistic regression adjusting for confounders to determine the association between environment of care (ACO vs. non-ACO) and the outcomes of interest. In all testing, beneficiaries treated in non-ACOs during 2009 to 2011 were used as the referent.

RESULTS: During 2009 to 2011, 9% (n=10,866) of patients treated in non-ACOs received surgery, whereas a similar percentage (9%; n=210) underwent surgery in ACOs. This figure decreased to 8% (n=9,857) for individuals treated in non-ACOs over 2012 to 2014, although the surgical rate remained unchanged for those receiving care in an ACO (9%; n=227). There was no difference in the use of surgery among patients treated in ACOs (OR 0.96; 95% CI 0.79, 1.18) over 2012 to 2014. Similar increases in the odds of mortality were observed for both ACOs and non-ACOs during this period. A marginal, yet significant increase in complications was observed among ACOs, although there was no change in the odds of readmission.

FDA device/drug status: Not applicable.

Author disclosure: ***SL:*** Northing to disclose; ***JB:*** Nothing to disclose; ***DS:*** Grant: CMS-OMH (F), DOD (G); ***MH:*** Nothing to disclose; ***AS:*** CMS-OMH (F); Royalties: Springer Publishers (A), Wolters Kluwer (B); Scientific Advisory Board/Other Office: JBJS (D); Grants: DoD (G), NIH-NIAMS (F), OREF (F).

Funding and Disclosure: The research in this article was supported in part by the Centers for Medicare & Medicaid Services Office of Minority Health - Health Equity Data Access Program. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Centers for Medicare and Medicaid Services, or US Department of Health and Human Services.

* Corresponding author. Center for Surgery and Public Health, Department of Orthopaedic Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA. Tel: 330-329-2594; fax: 617-278-6919.

E-mail address: ajschoen@neomed.edu (A.J. Schoenfeld).

https://doi.org/10.1016/j.spinee.2019.04.014

1529-9430/© 2019 Elsevier Inc. All rights reserved.

CONCLUSIONS: Our study found that the formation of ACOs did not result in alterations in the use of surgery for spinal fractures or substantive changes in outcomes. As ACOs continue to evolve, more emphasis should be placed on the incorporation of measures directly related to surgical and trauma care in the determinants of risk-based reimbursements. © 2019 Elsevier Inc. All rights reserved.

Keywords: Accountable Care Organizations (ACOs); Spine fracture; Healthcare reform; Quality; Value; Outcomes

Introduction

As a signature reform initiative of the Affordable Care Act, Accountable Care Organizations (ACOs) were designed for the purpose of integrated healthcare delivery and intended to reduce costs while simultaneously improving quality [1−5]. Coordinated care and reductions in expensive tests and procedures were advertised as the means through which healthcare organizations were to achieve these goals [1−4]. Given that surgical expenditures represent nearly 30% of aggregate healthcare costs [6], meaningful improvements in the efficiency of surgical care are essential for ACOs to remain viable [3,5,7]. In light of the fact that the success of ACOs is largely predicated on controlling costs, concerns have been expressed that patients could be adversely affected through restricted access to surgery in the ACO environment [8,11,12]. This phenomena had previously been encountered in the setting of other capitated healthcare initiatives, such as Health Maintenance Organizations in the 1980s and 1990s [2]. In order to reduce expenditures, while simultaneously ensuring high quality surgical care, ACOs would ideally only limit the use of low-value surgical interventions [9,10,12,13]. Unlike past reform efforts, the concordant emphasis on delivering quality care within ACOs could mitigate unintentional incentives to withhold appropriate care.

Ideally, health reform initiatives like ACOs would decrease procedural inducement [9]—defined as preference-sensitive procedures that have little demonstrable impact on outcomes—while maintaining rates of nondiscretionary interventions, such as imperative or potentially lifesaving care [10]. Studies regarding ACO performance thus far have not reported consistent results with respect to the delivery of surgical services and most of these have not been specific to spinal disorders [11−13]. For example, a recent study by Modi et al. revealed that ACOs were not more adept at restricting the performance of low value surgical procedures for knee arthritis [12], whereas Hollingsworth et al. encountered a similar situation with respect to coronary artery revascularization procedures [13]. In contrast, Schoenfeld et al. reported meaningful reductions in the use of lumbar fusion for spinal stenosis (a preference-sensitive intervention) among ACOs [14]. A similar situation is present among works evaluating the quality of care following surgery, with several observing no difference in peri-operative outcomes for hospitals participating in ACOs [15,16], whereas Borza et al. reported a reduction in hospital readmission following different elective surgical procedures in ACOs [17].

In the past, interventions following traumatic injury have been considered to be different from those performed on an elective basis given the urgent and emergent nature of many of these procedures, as well as the delineation of services within the American College of Surgeons tiered trauma system [18]. It is possible that given these realities, the incentives associated with ACOs have no direct influence on the care delivered to patients who sustain traumatic injuries. There is also the potential for ACOs to restrict the use of specific surgical services in an effort to reduce healthcare expenditures and improve efficiency [12,14,19]. Lastly, the integrated delivery model inherent to ACOs could lead to superior care for patients treated following traumatic injury.

In this context, we sought to investigate the impact of Medicare ACO formation on the utilization of surgery as a treatment for spinal fractures. Secondarily, we evaluated the influence of ACOs on postsurgical outcomes including in-hospital mortality, 90-day complications, and 90-day readmissions. We chose to use spinal fractures as a clinical scenario to model trauma care caused by prior literature documenting these injuries are associated with high-rates of morbidity and healthcare resource utilization, especially in the Medicare population [18,20]. Based on prior literature [12−16,19,21], we hypothesized that ACO formation would not lead to meaningful changes in the use of surgery or improvements in peri-operative outcomes.

Methods

This investigation was conducted using Medicare Part A and B fee-for-service claims data for the years 2009 to 2014. Data sources were obtained directly from the Centers for Medicare and Medicaid Services (CMS) under a data use agreement and consisted of Medicare Provider Analysis and Review (MedPAR) files, provider files, vital statistics, and ACO participation files. This study received an exempt determination from our Institutional Review Board before commencement and was also approved under separate application through CMS.

MedPAR records were queried using International Classification of Disease-9th revision (ICD-9) code to identify all beneficiaries treated for a cervical, thoracic, or lumbar fracture between 2009 and 2014 (805.0−805.5, 806.0 −806.5). Patients identified for inclusion then had their

MedPAR record linked with other CMS files in order to determine age at the time of treatment, biologic sex as reported by CMS, race (categorized as White or non-White; including Black [as designated by CMS], Hispanic, Asian, Native American/Pacific Islander, Mixed Race, or Other), and medical comorbidities surveyed according to the Deyo-modified Charlson criteria (age-adjusted) [22]. The receipt of surgery was evaluated via an ICD-9 procedure coding algorithm that accounted for relevant decompression, decompression and fusion with or without instrumentation, and internal fixation procedures [18]. Patients receiving stand-alone cement augmentation (eg, vertebroplasty and kyphoplasty) in the absence of another qualifying spine surgical procedure were allocated to the nonoperative group. In-hospital mortality and 90-day complications and readmissions were evaluated through review of beneficiary files and healthcare claims. Relying on the definition used by CMS, any hospital admission within 90-days of discharge from the index event associated with spinal fracture care was considered a readmission [16,17,21]. Complications were identified by ICD-9 code and consisted of infection, neurologic events (including stroke), venous thromboembolic disease, shock, sepsis, genitourinary complications, and cardio-respiratory events (Appendix 1) [16,21]. ACO participation was determined by linking Medicare claims associated with spinal fracture care to providers designated in the CMS ACO master file as participating in Pioneer or Medicare Shared Savings Program ACOs during the period 2012 to 2014. In line with prior work [14,16,19], we considered healthcare entities that formed or participated in ACOs during 2012 to 2014 as a single cohort over the course of the study. The year of treatment was obtained in order to classify care that was received in the period before, or following, passage of the Affordable Care Act (2012).

We used a pre−post study design to compare outcomes for patients treated in ACOs versus non-ACOs, using the year 2012 as the threshold to delineate the pre- (2009−2011) and posthealth reform (2012−2014) periods. Receipt of surgery for treatment of a spinal fracture was the primary outcome in this investigation, with mortality, complications and readmission events treated as secondary measures. Care received through an ACO, or non-ACO, was the primary predictor. The teaching status of the hospital where care was delivered, bed size, age at the time of injury, biologic sex, race, age-adjusted co-morbidity score, median income by ZIP code and state in which care was delivered were used as covariates to adjust for confounding.

Baseline, unadjusted comparisons between predictors, covariates and outcomes were performed using the chi-square test for categorical variables and the Kruskal−Wallis test for continuous data. We used multivariable logistic regression testing including all factors outlined above in a propensity score adjustment to account for differential case mix between ACOs and non-ACOS to determine the association between environment of care and use of surgery, in-hospital mortality, 90-day complications, and readmissions. This was performed by developing a propensity model to define preferential enrollment in ACOs among beneficiaries based on the socio-demographic and clinical characteristics outlined above. The resultant propensity score for ACO enrollment was then included in regression testing as an additional means to account for differences in case-mix between ACOs and non-ACOs. In all testing, beneficiaries treated in non-ACOs during 2009 to 2011 were used as the referent. Regression tests yielded post estimates expressed as odds ratios (OR) with 95% confidence intervals (CI) and p-values. Before study initiation, we designated statistical significance for variables that possessed OR and 95% CI exclusive of 1.0, with $p<.05$. All data preparation and analytics were performed using SAS v9.4 (SAS Institute; Cary, NC, USA).

Results

Between 2009 and 2014, we identified 245,704 Medicare beneficiaries eligible for inclusion. The average age of the cohort, as a whole, approximated 81, with 30% of the population identified as male and 93% White (Table 1). The median number of medical comorbidities was 5.0 (interquartile range [IQR] 2.0). Overall, 2% of the cohort received care for their spinal fracture in an ACO and 9% underwent surgery. There were marginal differences in the fracture types treated in ACOs and non-ACOs, none of which appeared clinically significant (Appendix 2).

When comparing the time-period 2009−2011 to 2012−2014, there were no clinically meaningful distinctions in socio-demographic characteristics between the cohorts, although given the size of the sample very small differences were still found to be statistically significant (Table 1). Two percent of patients received care in the ACO group in both time periods (2009−2011: n=2,364; 2012−2014: n=2,557). Seventeen percent of the population was also treated at a teaching hospital in both cohorts (2009−2011: n=21,334; 2012−2014: n=21,110). Nine percent of the population underwent surgery as treatment for spinal fractures in 2009

Table 1
Sociodemographic and clinical characteristics of Medicare beneficiaries treated for spinal fractures in an Accountable Care Organization (ACO) or non-ACO between 2009 and 2014E*

	2009−2011	2012−2014	p value
Age (mean, SD)	80.7 (8.1)	80.8 (8.1)	.02
Male sex (%)	36,375 (29)	36,487 (30)	<.001
White race (%)	115,535 (93)	112,550 (93)	<.001
Age adjusted Charlson co-morbidity score (median, IQR)	5.0 (2.0)	5.0 (2.0)	<.001
ACO (%)	2,364 (2)	2,557 (2)	<.001
Teaching hospital (%)	21,334 (17)	21,110 (17)	.19
Surgery (%)	11,076 (9)	10,084 (8)	<.001

SD, standard deviation; IQR, interquartile range.
* Numbers are rounded.

to 2011 (n=11,076), as compared with 8% of patients (n=10,084) in 2012 to 2014.

Differences in the use of surgical intervention for spinal fractures

During 2009 to 2011, 9% (n=10,866) of patients treated in non-ACOs received surgery, whereas a similar percentage (9%; n=210) underwent surgery in ACOs. This figure decreased to 8% (n=9,857) for individuals treated in non-ACOs over 2012 to 2014, although the surgical rate remained unchanged for those receiving care in an ACO (9%; n=227). Following adjusted regression analysis, beneficiaries treated in non-ACOs were found to have a lower odds of surgical intervention following spinal fracture in 2012 to 2014 (OR 0.95; 95% CI 0.91, 0.98; Table 2), although there was no difference in the use of surgery among patients treated in ACOs (OR 0.96; 95% CI 0.79, 1.18).

Differences in in-hospital mortality, 90-day complications and readmissions

There was no significant difference in in-hospital mortality between ACO and non-ACOs at baseline in 2009 to 2011. Mortality rates significantly increased within both healthcare environments over the period 2012 to 2014 (Table 3). Similar increases in the odds of mortality were observed for both ACOs (OR 1.35; 95% CI 1.09, 1.66) and non-ACOs (OR 1.32; 95% CI 1.27, 1.38), however.

Similarly, baseline differences in the odds of 90-day complications were absent between ACOs and non-ACOs for the period 2009 to 2011. No significant increase in complications was noted for non-ACOs, when compared with their baseline performance, for the period 2012 to 2014 (OR 1.02; 95% CI 1.00, 1.05; Table 4). A marginal, yet significant increase, in complications was observed among beneficiaries treated in ACOs from 2012 to 2014 (OR 1.18; 95% CI 1.05, 1.33).

Within the category of readmissions, no baseline differences were detected between ACOs and non-ACOs during 2009 to 2011. There was no change in the odds of readmissions for patients treated in ACOs over 2012 to 2014 (OR 1.06; 95% CI 0.95, 1.19; Table 5). There was, however, a significant reduction in readmissions for those receiving care in non-ACOs, when compared with baseline performance, during 2012 to 2014 (OR 0.84; 95% CI 0.92, 0.96).

Discussion

Only a few studies have previously focused on evaluating changes in the use of procedures and associated outcomes following surgery in ACOs [11–17,19]. All prior

Table 2
The adjusted odds of surgical intervention for spinal fractures among Medicare beneficiaries treated in Accountable Care Organizations (ACO) and non-ACOs between 2009 and 2014

Environment of care	Odds ratio	95 % confidence interval	p value
Non-ACO organizations (2009–2011)	Referent	Referent	Referent
Non-ACO organizations (2012–2014)	0.95	0.91, 0.98	.001
ACO organizations (2009–2011)	0.89	0.75, 1.07	.21
ACO organizations (2012–2014)	0.96	0.79, 1.18	.70

Table 3
The adjusted odds of in-hospital mortality for spinal fractures among Medicare beneficiaries treated in Accountable Care Organizations (ACOs) and non-ACOs between 2009 and 2014

Environment of care	Odds ratio	95 % confidence interval	p value
Non-ACO organizations (2009–2011)	Referent	Referent	Referent
Non-ACO organizations (2012–2014)	1.32	1.27, 1.38	<.001
ACO organizations (2009–2011)	1.09	0.89, 1.34	.41
ACO organizations (2012–2014)	1.35	1.09, 1.66	.005

Table 4
The adjusted odds of 90-day complications following treatment for spinal fractures among Medicare beneficiaries treated in Accountable Care Organizations (ACO) and non-ACOs between 2009 and 2014

Environment of care	Odds ratio	95 % confidence interval	p value
Non-ACO organizations (2009–2011)	Referent	Referent	Referent
Non-ACO organizations (2012–2014)	1.02	1.00, 1.05	.10
ACO organizations (2009–2011)	1.06	0.91, 1.23	.48
ACO organizations (2012–2014)	1.18	1.05, 1.33	.006

Table 5
The adjusted odds of 90-day readmissions following treatment for spinal fractures among Medicare beneficiaries treated in Accountable Care Organizations (ACO) and non-ACOs between 2009 and 2014

Environment of care	Odds ratio	95 % confidence interval	p value
Non-ACO organizations (2009–2011)	Referent	Referent	Referent
Non-ACO organizations (2012–2014)	0.94	0.92, 0.96	<.001
ACO organizations (2009–2011)	1.08	0.97, 1.21	.16
ACO organizations (2012–2014)	1.06	0.95, 1.19	.28

works have involved elective surgical procedures, only a few have considered spinal disorders [14,16] and none have involved trauma care. As a result, we sought to evaluate the impact of ACOs on alterations in care delivery and short-term outcomes among patients treated for spinal fracture. The use of Medicare data facilitated the review of patient experiences in different healthcare systems across the U.S. All Medicare part A and B beneficiaries were included in this analysis regardless of where they received their care. The inclusion of individuals treated in ACOs and non-ACOs also allowed us to account for secular trends impacting the population as a whole [9,21].

The percentage of patients treated in ACOs in our study is comparable to the rates documented in other investigations, which indicates a degree of external validity [14,16,19]. Our primary outcome consisted of change in the surgical rate over time, and we found there was no difference in the utilization of surgery for spinal fractures among patients treated in ACOs during 2012 to 2014 as compared with baseline. This finding speaks against a prominent narrative that ACO formation would lead to a confiscatory stance regarding surgery or that rationing of care might somehow take place [8,19]. Similar calumnies were raised in the context of Massachusetts health reform over the course of the last decade [21]. In a pre–post analysis published in 2015, however, Schoenfeld et al. reported that no significant differences were apparent in the use of surgical intervention for cervical fractures following the implementation of health reform efforts in Massachusetts [21]. Interestingly, an identical 1% reduction in the use of surgery after health reform initiatives was encountered in the current study as well as for that involving Massachusetts [21], even though our effort was not limited to cervical fractures and the overall rates of surgery were different. This figure may potentially represent the percentage of preference-sensitive surgeries that exist in the setting of spine fracture care. Conversely, the findings may actually be reflective of the fact that universal health reform efforts, irrespective of ACO formation, have minimal impact on surgical care delivery overall and even less influence on the use of low value surgical care. To this point, several authors have documented no changes in the use of low value surgical procedures in other surgical disciplines among ACOs [12,13]. Similar findings were also encountered for elective lumbar spine surgery, where the formation of ACOs was not found to influence the use of fusion-based procedures except in a subset of patients who were treated for spinal stenosis without spondylolisthesis [14].

Our results also show that the formation of ACOs did not result in changes in select outcomes following spine fracture care. In-hospital mortality was found to increase in line with secular trends at non-ACOs, with no significant alteration in hospital readmissions. Although we did document an increase in complications among patients treated in ACOs from 2012 to 2014, this may be caused by enhanced observation and documentation of surveillance-sensitive complications, concordant with findings in other work [21]. From a policy perspective, these results are not exceedingly surprising given that the quality incentives and current ACO payment scheme do not directly relate to the performance of surgery [3,4,7,15]. Herrel et al. previously noted a lack of improvement in quality measures among patients receiving major cancer surgery at ACO hospitals [15] and Schoenfeld et al. failed to find meaningful improvements in mortality, complication, and readmission risk among patients treated by ACOs for lumbar degenerative disorders [16]. These authors concluded that substantive changes in spine surgical care were unlikely to accrue following the formation of accountable care entities alone [16], and this also appears to be the case with the operative and nonoperative treatment of spinal trauma. As ACOs continue to evolve, a greater emphasis should be placed on incentivizing improvement in surgical care. For example, measures related to surgical outcomes could be established as an integral component of risk-based reimbursements. Initiatives designed to improve surgical and trauma care delivery might also be incorporated in the recently introduced Next Generation ACO model, where more financial risk is placed on ACOs for both cost-saving and quality performance. Approaches along these lines have the potential to pay real dividends in terms of improving healthcare for patients receiving operative and nonoperative treatment for spinal conditions, including those resulting from trauma.

Limitations to our study include the retrospective design and use of claims-based data, which are subject to inherent restrictions and a lack of clinical granularity in several respects. For example, we were unable to characterize spinal fracture morphology, indications for surgical intervention, injury severity score, and the treatment philosophy of the providers responsible for rendering care. Similarly, we are unable to define the appropriate use of the surgical procedures employed such that the preference-sensitive nature of certain interventions, or provider inducement [9] cannot be characterized. Decisions to offer and accept surgery may vary over time and for a variety of reasons (eg, acceptance regarding the advantages of surgical intervention, changes in reimbursement, etc.), many of which cannot be accounted for in this analysis. Although our study was able to capture all patients treated for spinal fractures and insured through Medicare in the years 2009 to 2014, the reality is that only a small minority of patients received care at ACO facilities. Although we used previously published criteria [14,16,19] that ensures our assessments are reflective of the performance of ACO organizations in terms of healthcare delivery for spinal fractures, it is entirely possible that many patients assigned to ACOs by Medicare received treatment at non-ACO facilities. This issue does not impact our ability to address the main study questions, however, which are focused on the institutional aspects of care delivery. Although the trauma designation of facilities providing care are not accessible in our data, many of the same characteristics associated with American

College of Surgeons trauma center certification are included in our propensity score adjustment (eg, bed size, teaching status, etc.). Healthcare entities that were early adopters of the ACO model may be fundamentally different from non-ACOs now and in the future. We realize that it is possible that our regression models cannot fully account for this fact relying on variables solely available through Medicare claims and residual confounding may be present. Lastly, whereas this analysis considered ACOs as a single group, there are invariably high and low performers within this cohort. Similarly, although our approach does account for secular trends in general, we cannot address specific organizational, institutional, or non-Federal/non-ACO initiatives that may have influenced care delivery. As our study data does not encompass the complete battery of quality measures used to assess ACO performance, we are unable to comment on any correlation between the efficiency or efficacy of these organizations and healthcare delivery following spinal trauma.

In conclusion, our study found that the formation of ACOs did not result in alterations in the use of surgery for the treatment of spinal fractures. At the same time, substantive improvements in treatment outcomes within the context of spinal fracture care were also lacking. This could stem from the absence of direct ACO incentives around improving surgical care delivery. As ACOs continue to evolve, more emphasis should be placed on the incorporation of measures directly related to surgical and trauma care in the determinants of risk-based reimbursements. This would potentially improve surgical care delivery as a whole, as well as the experience of patients treated for spinal fractures within ACOs.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.spinee.2019.04.014.

References

[1] McClellan M, McKethan AN, Lewis JL, et al. A national strategy to put accountable care into practice. Health Aff 2010;29:982–90.

[2] Brent C, James MD, Poulsen GP. The case for capitation. Harvard Bus Rev 2016. Available at https://hbr.org/2016/07/the-case-for-capitation. Accessed January 7, 2019.

[3] McWilliams JM, Hatfield LA, Chernew ME, et al. Early performance of accountable care organizations in medicare. N Engl J Med 2016;374:2357–66.

[4] McWilliams JM, Hatfield LA, Landon BE, et al. Medicare spending after 3 years of the medicare shared savings program. N Engl J Med 2018;379:1139–49.

[5] Nathan H, Thumma JR, Ryan AM, Dimick JB. Early impact of medicare accountable care organizations on inpatient surgical spending. Ann Surg 2019;196:191–6.

[6] Muñoz E, Muñoz W, Wise L. National and surgical health care expenditures, 2005-2025. Ann Surg 2010;251:195–200.

[7] Dupree JM, Patel K, Singer SJ, et al. Attention To surgeons and surgical care is largely missing from early medicare accountable care organizations. Health Aff 2014;33:972–9.

[8] Porter ME, Kaplan RS. How to pay for health care. Harvard Bus Rev 2016. Available at https://hbr.org/2016/07/how-to-pay-for-health-care. Accessed January 10, 2019.

[9] Schoenfeld AJ, Makanji H, Jiang W, Koehlmoos T, Bono CM, Haider AH. Is there variation in procedural utilization for lumbar spine disorders between a fee-for-service and salaried healthcare system? Clin Orthop Relat Res 2017;475:2838–44.

[10] Ellimoottil C, Miller S, Ayanian JZ, et al. Effect of insurance expansion on utilization of inpatient surgery. JAMA Surg 2014;149:829–36.

[11] Colla CH, Goodney PP, Lewis VA, et al. Implementation of a pilot accountable care organization payment model and the use of discretionary and nondiscretionary cardiovascular care. Circulation 2014;130:1954–61.

[12] Modi PK, Kaufman SR, Borza T, et al. Medicare accountable care organizations and use of potentially low-value procedures. Surg Innov 2018. 1553350618816594.

[13] Hollingsworth JM, Nallamothu BK, Yan P, Ward S, Lin S, Colla CH, Lewis VA, Ayanian JZ, Hollenbeck BK, Ryan AM. Medicare accountable care organizations are not associated with reductions in the use of low-value coronary revascularization. Circ Cardiovasc Qual Outcomes 2018;11:e004492. https://doi.org/10.1161/CIRCOUTCOMES.117.004492.

[14] Schoenfeld AJ, Sturgeon DJ, Harris MB, et al. Changes in the use of lumbar arthrodesis procedures within accountable care organizations. Spine. https://doi.org/10.1097/BRS.0000000000002862. Epub ahead of print September 17, 2018.

[15] Herrel LA, Norton EC, Hawken SR, et al. Early impact of Medicare accountable care organizations on cancer surgery outcomes. Cancer 2016;122:2739–46.

[16] Schoenfeld AJ, Sturgeon DJ, Blucher JA, et al. Alterations in 90-day morbidity, mortality, and readmission rates following spine surgery in Medicare Accountable Care Organizations (2009–2014). Spine J. DOI: 10.1016/j.spinee.2018.06.367.

[17] Borza T, Oerline MK, Skolarus TA, et al. Association between hospital participation in medicare shared savings program accountable care organizations and readmission following major surgery. Ann Surg. https://doi.org/10.1097/SLA.0000000000002737. Epub ahead of print March 19, 2018.

[18] Schoenfeld AJ, Belmont Jr PJ, See AA, et al. Patient demographics, insurance status, race, and ethnicity as predictors of morbidity and mortality after spine trauma: a study using the National Trauma Data Bank. Spine J 2013;13:1766–73. e1.

[19] Schoenfeld AJ, Sturgeon DJ, Dimick JB, et al. Disparities in rates of surgical intervention among racial and ethnic minorities in medicare accountable care organizations. Ann Surg. https://doi.org/10.1097/SLA.0000000000002695. Epub ahead of print February 7, 2018.

[20] Harris MB, Reichmann WM, Bono CM, et al. Mortality in elderly patients after cervical spine fractures. J Bone Joint Surg Am 2010;92:567–74.

[21] Schoenfeld AJ, Wahlquist TC, Bono CM, et al. Changes in the care of patients with cervical spine fractures following health reform in Massachusetts. Injury 2015;46:1545–50.

[22] Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45:613–9.