Variability in Discharge Disposition Across US Trauma Centers After Treatment for High-Energy Lower Extremity Injuries

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Objective: To evaluate the association between patient- and center-level characteristics and discharge to an inpatient facility versus home after treatment for lower extremity trauma, as well as examine the variability in discharge disposition across clinical centers after controlling for these factors.

Design: This is an analysis of data collected prospectively across 5 multicenter studies of extremity trauma.

Setting: US Trauma Centers.

Participants: Patients 18–80 years with lower extremity trauma treated at 1 of 55 participating centers.

Main Outcome Measure: Discharge disposition.

Results: Among 2365 patients treated at 1 of 55 centers across 13 states, 673 (28.5%) were discharged to an inpatient facility, and 1692 (71.5%) were discharged home. Individuals who were older, female, unmarried, insured, higher body mass index, history of severe alcohol abuse, Gustilo type IIIB or IIIC open injuries, bilateral, spine and upper extremity injuries, higher injury severity score scores, or intensive care unit stay were more likely to be discharged to an inpatient facility. Even after accounting for patient- and center-level characteristics, there was substantial variation in discharge disposition across centers (likelihood ratio test: $P < 0.001$).

Conclusion: Variation in discharge disposition may represent a potential for improvement in resource utilization and cost savings. Further studies are needed to examine the relationship between utilization of postdischarge inpatient facility after trauma and outcomes.

Key Words: rehabilitation, high-energy trauma, resource utilization, discharge disposition

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Discharge to an inpatient facility after orthopaedic surgery requires substantial resources and is a significant driver of treatment cost. For example, inpatient rehabilitation accounts for 49% of the total cost of femoral neck fractures[1–3] and 36% of the cost of joint arthroplasty.[4,5] In a cost-effective high-value health care system, with value defined as health outcomes achieved per dollar spent,[6] discharge to an inpatient facility would be based on established clinical factors. However, there are no guidelines for discharge practices after orthopaedic surgery resulting in substantial variation. There is a growing body of literature that suggests more health care service use is not always associated with improved outcomes.[7–20] For some patients, inpatient rehabilitation may offer no added value. Although use of these services has been studied in patients undergoing elective arthroplasty,[18,21–25] little is known about discharge to inpatient rehabilitation among patients surgically treated for a traumatic orthopaedic injury. Compared with patients receiving elective surgery, trauma patients are typically of lower socioeconomic status and have different clinical needs after treatment, both in terms of complex comorbidities and mobility issues. An important first step in determining the value of inpatient rehabilitation services in this patient population is to identify the factors associated with discharge disposition and describe the variability in practice.

The purpose of this study was to evaluate the association between patient- and center-level characteristics and

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discharge to an inpatient facility versus home after treatment for lower extremity trauma (LET), as well as examine the variability in discharge disposition across clinical centers. We hypothesized that we will detect substantial variation in discharge disposition across centers even after accounting for patient-, injury-, and center-level characteristics.

METHODS

Study Population

The study population included 2819 patients, 18–80 years of age, with LET. They were enrolled in 1 of 5 ongoing prospective multicenter studies of extremity trauma in the United States as of March 1, 2017. Human subjects' research protocols were followed, with institutional review board approvals filed by the principal investigator (PI) of each study. The 5 studies involved include the following:

1. The FIXIT study is a randomized trial comparing 12-month outcomes after treatment of open tibial shaft fractures with modern external ring fixation versus internal fixation.[26] Eligible patients include men and women 18–64 years of age with an open diaphyseal or metaphyseal tibia fracture.
2. The OUTLET study is a prospective, multicenter observational study comparing 18-month outcomes after limb salvage versus early amputation among patients 18–60 years of age with distal tibia, ankle, and foot injuries.[27]
3. The PAIN study is a three-armed, prospective, double-blind, multicenter randomized trial designed to evaluate the effect of standard pain management versus standard pain management plus perioperative nonsteroidal anti-inflammatory drugs or pregabalin in patients 18–85 years of age with upper and lower extremity fractures.[28] For this analysis, we included data on patients with open injuries to the femoral shaft; open or closed fractures of the supracondylar femur, tibial plateau, tibial shaft, or pilon; unilateral type I, II, or IIIA ankle fractures associated with dislocation; and unilateral open type I and II closed tibial plafond, calcaneus, and talus fractures.
4. The Oxygen study is a phase III, double-blind, prospective randomized clinical trial with a primary goal of assessing the efficacy of 2 different concentrations of perioperative oxygen in the prevention of surgical site infections in adults with closed or open tibial plateau, pilon (tibial plafond), or calcaneus fractures at high risk of infection and definitively treated with plate and screw fixation.[29]
5. The VANCO study is a phase III prospective, randomized clinical trial to assess the efficacy of locally administered vancomycin powder in the prevention for SSI after fracture surgery. Eligible patients included adults 18–80 years of age with closed or open tibial plateau or pilon (tibial plafond) fractures at high risk of infection and definitively treated with plate and screw fixation.[30]

Patients were treated for a lower extremity injury at 1 of 55 US trauma centers. Patients were excluded from this analysis if they died while in the hospital (n = 3), had incomplete information on discharge status (n = 25), or were missing demographic, preinjury health or injury severity data (n = 426). A total of 2365 individuals treated at 55 US centers were included in the present analysis.

Data Collection

Discharge disposition was recorded prospectively at the time of discharge from the initial hospitalization for treatment of the injury. For this analysis, patients were considered discharged to an inpatient facility if they were discharged to an inpatient rehabilitation facility (n = 421), a skilled nursing facility (n = 217), a nursing home (n = 8), or other subacute rehabilitation facility (n = 27), or discharged home (with or without services).

Data including patient demographics, preinjury health status, and injury characteristics were collected consistently across all studies according to standards adopted by METRC. Variables included in the model were hypothesis-driven, based on studies of both arthroplasty and trauma patients.[24,25,31–38] Patient demographics included age, sex, race and ethnicity, marital status, education, health insurance, and occupation. Preinjury health was characterized by body mass index (BMI), tobacco use, alcohol abuse, self-reported health status, and a diagnosis of depression. BMI, alcohol abuse, and depression diagnosis were obtained from patient medical records. Tobacco use and health status were obtained from interviews with participants shortly after study enrollment. Injury severity was characterized by Gustilo type,[39] time in an intensive care unit (ICU), injury severity score (ISS)[40] and presence of a bilateral injury, and injuries of the spine, head, and upper extremity. Gustilo type was classified by the treating surgeon at time of initial treatment. Injuries were categorized as closed, open crush, type I, II, or IIIA, and type IIIB or IIIC. Information about ICU stay was obtained from medical records. ISS scores were computed from abbreviated injury scale (AIS) codes obtained by the trauma registrar at each institution for all sustained injuries. Bilateral injury was defined using AIS codes associated with pelvic fractures and lower extremity skeletal injures that were a severity of 2 or greater. Injuries of the upper extremity, spine, and head were defined using AIS codes associated with these body regions.

Financial relationships between the treating inpatient institution and skilled nursing and/or rehabilitation facilities were ascertained from a survey completed by the PI at each of the 55 participating centers. The PI was instructed to report if their institution had a financial relationship with at least one of the following facilities: acute rehabilitation, subacute rehabilitation, skilled nursing facility, or other acute rehabilitation institution as specified by the center.

Statistical Analysis

Analyses were conducted using a multivariable logistic regression model with patient demographics, preinjury health status, injury severity, and financial relationship with an inpatient facility as covariates and with clinical center treated as a random effect. A model allowing the variance of the random effect to depend on the presence of a financial relationship was considered, but a likelihood ratio test (a statistical procedure for comparing the goodness-of-fit of competing models) did not reveal evidence of a dependence

($P = 0.49$). Results for a model with a common variance are presented, including estimates of covariate effects (in terms of adjusted odds ratios) along with 95% percent confidence intervals (CIs). Variability in discharge disposition across centers, after adjustment for covariates, was assessed by using a likelihood ratio test to evaluate whether the variance of the random effect was greater than 0. Using the model along with the distribution of demographic, health and injury characteristics, and financial relationship status, center-specific standardized estimates of the probability of discharge to an inpatient facility are computed. All statistical analyses were performed using Stata (College Station, TX).

RESULTS

Among 2365 patients treated at 1 of 55 centers across 13 states, 673 (28.5%) were discharged to an inpatient facility, and 1692 (71.5%) were discharged home. The average number of patients per center was 43 (median 17, range 1–324). Individuals who were older, female, unmarried (divorced, widowed, or separated); had higher BMI; were insured; had a history of alcohol abuse; sustained a high-grade open injury (Gustilo IIIB or IIIC); had a bilateral injury, upper extremity injury, or spine injury; had higher ISS scores; or had an ICU stay were more likely to be discharged to an inpatient facility (Table 1). The adjusted odds ratio of being discharged to an inpatient facility is 1.05 (95% CI: 1.04–1.06) for patients of a given age versus those 1 year younger; 1.36 (95% CI: 1.06–1.76) for women versus men; 1.45 (95% CI: 1.13–1.85) for unmarried (divorced, widowed, and separated) versus married; 1.05 (95% CI: 1.04–1.07) for patients of a given BMI versus those 1 unit lower; 2.43 (95% CI: 1.54–3.85) for Medicaid, 8.98 (95% CI: 5.00–16.13) for Medicare, 2.01 (95% CI: 1.35–2.98) for private insurance, 2.45 (95% CI: 1.49–4.02) for other insurance, and 2.42 (95% CI: 1.41–4.14) for workers comp versus no insurance; 1.59 (95% CI: 0.88–2.87) for those who do versus do not abuse alcohol; 2.37 (95% CI: 1.64–3.43) for Gustilo type IIIB or IIIC injuries versus closed injuries; 1.05 (95% CI: 1.03–1.07) for patients of a given ISS score versus those 1 unit lower; 2.31 (95% CI: 1.75–3.05) for bilateral versus unilateral lower extremity injuries; 2.21 (95% CI: 1.68–2.91) for those with versus without upper extremity injuries; 2.05 (95% CI: 1.41–2.97) for those with versus without spine injuries; and 2.83 (95% CI: 2.05–3.91) for patients who spent at least 1 day in the ICU versus no ICU stay. Patients treated at a center with a financial relationship had 1.64 (95% CI: 0.90–2.99) higher adjusted odds of discharge to an inpatient facility compared with those treated at a center without one. However, patients were not necessarily discharged to the facility that had a financial relationship with the hospital.

There was variation in discharge disposition across centers after controlling for patient-level factors (demographic and socioeconomic variables as well as injury characteristics) and presence of a financial relationship between the tertiary care facility and an inpatient facility (likelihood ratio test: $P < 0.001$). As shown in Fig. 1, the adjusted probability of discharge to an inpatient institution ranged from 12% to 52% across tertiary care centers.

DISCUSSION

The results of this study demonstrated substantial variation in discharge disposition and utilization of inpatient facility resources across centers after treatment for high-energy LET, even after accounting for patient characteristics, such as age and medical comorbidities, the type and severity of injuries, and financial relationship with inpatient facilities. This represents a first step toward understanding utilization of this expensive and limited resource among orthopaedic trauma patients. Further prospective studies are needed to (1) determine the source for this variation and clarify whether there is a component of unwarranted or supply-sensitive variation[41] and (2) identify the clinical factors that predict which patients will derive benefit from inpatient resources after discharge.

Discharge to inpatient facilities ranged from 12% to 52% across centers (mean 28%), which is lower compared with rates reported in one study among lower-limb trauma patients living in California. This retrospective study used data from the California State Inpatient Database that captures nearly all admissions in the state of and found that 58% of patients were discharged to an inpatient facility.[31] Interestingly, rates of discharge to inpatient facilities observed in this study were more comparable with rates reported among patients undergoing elective joint arthroplasty (26%–65%).[21,22,24,25,35–38,42–47] Consistent with the arthroplasty literature, we found that age, sex, and marital status were associated with discharge disposition. In addition to these factors, we found that health insurance and measures of injury severity were independently associated with discharge to an inpatient facility.[24,25,35,36,38,46,48–50] This is not surprising given that, unlike patients undergoing elective surgery, there is no opportunity for discharge planning before admission for surgical treatment of a traumatic injury and often, both the severity of the injury and complexity of the surgery dictate the postoperative course of care.

Ideally, patients would be discharged to an inpatient facility based on clinical need. However, in this study, health insurance was associated with discharge disposition independent of clinical factors such as injury severity and health status. Patients with health insurance are more likely to be discharged to an inpatient facility compared to patients with no insurance. Although insurance status has little effect on clinical decision-making in the acute trauma setting, this analysis suggests that financial resources are associated with discharge disposition. These findings are consistent with other acutely injured populations including patients with brain injury and severe burns.[32–34] In addition, patients were 1.64 times more likely to be discharged to an inpatient facility if they were admitted to institutions who self-identified as having a financial relationship between the tertiary care facility and one or more inpatient facilities than if the inpatient centers did not have a financial relationship. The measure used in this study was a general indicator of financial relationship, and although there appears to be a strong association with discharge status, it was coupled with considerable uncertainty. More research is needed to better understand the nature and consequences of relationships between tertiary care centers and inpatient facilities.

TABLE 1. Association of Patient-, Injury-, and Center-Level Characteristics With Discharge to an Inpatient Facility

	Discharged to an Inpatient Facility	Adjusted Odds Ratio (OR) (95% CI)
Demographics		
Age, years, mean (SD)	47.3 (15.2)	1.05 (1.04–1.06)*
Age categories:		
18–30	121/608 (19.9)	
31–40	104/473 (22.0)	
41–50	131/551 (23.8)	
51–60	183/499 (36.7)	
>60	134/234 (57.3)	
Gender		
Male (Ref)	421/1622 (25.9)	—
Female	252/743 (33.9)	1.36 (1.06–1.76)
Race/ethnicity		
White (Ref)	490/1632 (30.0)	—
Black	136/488 (27.9)	1.81 (0.98–1.83)
Hispanic	43/239 (17.9)	1.01 (0.64–1.62)
Other	4/6 (66.7)	10.37 (0.83–128.4)
Marital status		
Divorced, Widowed, or Separated (Ref)	350/1196 (29.3)	—
Married; living with or without partner	323/1169 (27.6)	0.69 (0.54–0.88)
Education		
Less than High School (Ref)	62/254 (24.4)	—
High School or GED	266/1031 (25.8)	0.95 (0.61–1.48)
Some college	345/1080 (31.9)	1.37 (0.87–2.14)
Health insurance		
None (Ref)	67/484 (13.8)	—
Medicaid	100/294 (34.0)	2.43 (1.54–3.85)
Medicare	104/155 (67.1)	8.98 (5.00–16.13)
Other	72/242 (29.8)	2.45 (1.49–4.02)
Private	283/999 (28.3)	2.01 (1.35–2.98)
Workers Comp	47/191 (24.6)	2.42 (1.41–4.14)
Occupation		
Laid off, school, home or other (Ref)	235/649 (36.2)	—
Working or active duty military	438/1716 (25.5)	0.95 (0.71–1.27)
Preinjury health		
BMI, mean (SD)	30.7 (7.8)	1.05 (1.04–1.07)*
BMI categories:		
Underweight (<18.5)	7/28 (25.0)	
Normal weight (18.5–24.9)	163/696 (23.4)	
Overweight (25–29.9)	184/755 (24.4)	
Obese (30–39.9)	244/724 (33.7)	
Morbidly obese (40+)	75/162 (46.3)	
Tobacco use		
Former smoker or never smoked (Ref)	433/1423 (30.4)	—
Current	240/942 (25.5)	0.88 (0.68–1.14)
Alcohol abuse		
No (Ref)	638/2274 (28.1)	—
Yes	35/91 (38.5)	1.59 (0.88–2.87)
Health status		
Fair or poor (Ref)	96/231 (41.6)	—
Excellent, very good, or good	577/2134 (27.0)	0.75 (0.51–1.10)
Depression		
No (Ref)	568/2091 (27.2)	—
Yes	105/274 (38.3)	1.15 (0.81–1.64)

(*continued on next page*)

TABLE 1. (*Continued*) Association of Patient-, Injury-, and Center-Level Characteristics With Discharge to an Inpatient Facility

	Discharged to an Inpatient Facility	Adjusted Odds Ratio (OR) (95% CI)
Injury severity		
Gustilo type		
Closed (Ref)	322/1263 (25.5)	—
Open crush, I, II, IIIA	218/741 (29.4)	1.08 (0.81–1.44)
IIIB, IIIC	133/361 (36.8)	2.37 (1.64–3.43)
Bilateral injury		
No (Ref)	435/1777 (24.5)	—
Yes	238/588 (40.5)	2.31 (1.75–3.05)
Upper extremity injury		
No (Ref)	420/1819 (23.1)	—
Yes	253/546 (46.3)	2.21 (1.68–2.91)
Spine injury		
No (Ref)	520/2084 (24.9)	—
Yes	153/281 (54.5)	2.05 (1.41–2.97)
Head injury		
No (Ref)	565/2129 (26.5)	—
Yes	108/236 (45.8)	1.14 (0.77–1.69)
ISS score, mean (SD)	13.1 (9.9)	1.05 (1.03–1.07)*
ISS categories:		
0–8	224/1207 (18.6)	
9–12	179/612 (29.3)	
13–17	100/250 (40.0)	
18+	170/296 (57.4)	
ICU stay		
None (Ref)	426/1871 (22.8)	—
At least 1 day	247/494 (50.0)	2.83 (2.05–3.91)
Hospital characteristic		
Financial relationship		
None (Ref)	153/700 (21.9)	—
Relationship with a postacute inpatient facility	520/1665 (31.2)	1.64 (0.90–2.99)

*OR computed for the continuous variable.

There are important cost implications associated with variation in discharge disposition among orthopaedic trauma patients because postacute care represents a sizeable component of the overall cost of care[1–4] and has the potential to play an important role in overall recovery. These costs may be justified if inpatient stays improve patient outcomes. Several studies among arthroplasty patients, however, suggest that patients discharged to inpatient facilities have higher hospital readmission rates and a higher rate of adverse event rates compared with patients discharged home.[43,45,46,50] The Bundled Payments for Care Improvement initiative was introduced to address the high cost of care associated with treatment for arthroplasty and transition the responsibility for cost-containment to care providers. This initiative led to a decline in inpatient admissions and a concomitant reduction in hospital length-of-stay and readmission rates. There may be similar opportunities to improve the value of postacute care for trauma patients; however, additional studies are needed to examine the relationship between utilization and patient outcomes. Given the momentum toward transitioning financial responsibility of postacute care from insurers to hospital systems and/or physicians, determining which patients benefit the most will be important in efforts to optimize resource utilization. As the Centers for Medicare & Medicaid (CMS) and other insurers continue to evaluate the value of alternative payment models, developing a better understanding of the value of postacute care among orthopaedic trauma patients is critical.

Study Limitations

This study has several limitations. First, discharge disposition was only recorded after the initial hospitalization for treatment of the fracture. Patients undergoing staged procedures were likely discharged home between admissions, and whether they were discharged to an inpatient facility after the hospitalization for definitive fixation is unknown. Second, patients enrolled into 1 of the 5 METRC studies at a given center may not be representative of the entire orthopaedic trauma population treated at that center. Although this may affect the probability of discharge to an inpatient facility at some institutions, it likely does not negate the observed variability in discharge practices across centers. Third, other

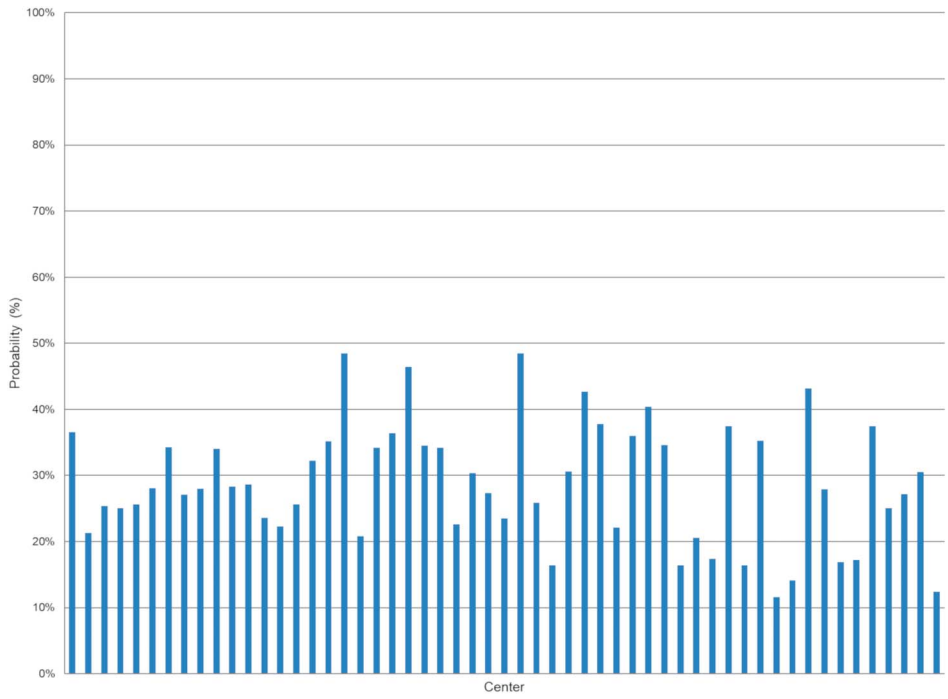

FIGURE 1. Adjusted probability of discharge to an inpatient facility across 55 centers ordered from smallest to highest volume (1–325 patients).

factors that may affect discharge location such as weight-bearing status, home layout and access to home equipment, family support (aside from marital status), and household income were not captured. Bilateral injuries and injuries to the spine and upper extremity that impacts weight bearing were included in the model and found to be associated with discharge to an inpatient facility. Although we could not directly address home modification and equipment needs such as hospital beds, we did account for insurance status that plays a role in access to these resources. Fourth, the definition of inpatient facility used in this study was broad, including discharge to several types of institutions. The factors associated with discharge disposition may differ between inpatient rehabilitation facilities, skilled nursing facilities, and other acute care institutions. However, the goal of this article was to identify factors associated with discharge to inpatient facility of any type and to describe the variability in discharge practices across multiple centers. Finally, the definition of financial relationship between tertiary care facility and inpatient nursing or rehabilitation facility was broad, making it difficult to understand the exact nature of these relationships. Sites that reported having a financial relationship with an inpatient facility may or may not specifically discharge patients to those facilities. The purpose of including this measure was to control for effects that financial relationships may have had on discharge practices. Further studies are needed to explore the effect of these financial relationships in a more detailed manner.

To the best of our knowledge, this is the first study evaluating discharge disposition patterns across a large number of centers after treatment for LET. This study leveraged data collected prospectively using standardized methods on thousands of traumatically injured patients treated in hospitals across the United States. The variability in discharge disposition we observed across centers is likely due to differences in health systems, local policies, and provider practices not captured in this analysis. As health care expenditures continue to rise, these results highlight an opportunity for clinicians and policy makers to improve the value of care provided to patients sustaining these injuries.

REFERENCES

1. Burgers PT, Hoogendoorn M, Van Woensel EA, et al. Total medical costs of treating femoral neck fracture patients with hemi- or total hip arthroplasty: a cost analysis of a multicenter prospective study. *Osteoporos Int.* 2016;27:1999–2008.
2. Zielinski SM, Bouwmans CA, Hetveld MJ, et al. The societal costs of femoral neck fracture patients treated with internal fixation. *Osteoporos Int J.* 2014;25:875–885.
3. Birkmeyer JD, Gust C, Baser O, et al. Medicare payments for common inpatient procedures: implications for episode-based payment bundling. *Health Serv Res.* 2010;45:1783–1795.
4. Bozic KJ, Ward L, Vail TP, et al. Bundled payments in total joint arthroplasty: targeting opportunities for quality improvement and cost reduction. *Clin Orthop.* 2014;472:188–193.
5. Snow R, Granata J, Ruhil AV, et al. Associations between preoperative physical therapy and post-acute care utilization patterns and cost in total joint replacement. *J Bone Joint Surg Am.* 2014;96:e165.
6. Porter ME. What is value in health care? *N Engl J Med.* 2010;363:2477–2481.
7. Wennberg J, Gittelsohn A. Small area variations in health care delivery. *Science.* 1973;182:1102–1108.
8. Wennberg J, Gittelsohn A. Variations in medical care among small areas. *Sci Am.* 1982;246:120–134.
9. Wennberg JE, Freeman JL, Culp WJ. Are hospital services rationed in New Haven or over-utilised in Boston? *Lancet.* 1987;1:1185–1189.

10. Sheikh K, Bullock C. Rise and fall of radical prostatectomy rates from 1989 to 1996. *Urology.* 2002;59:378–382.
11. Lu-Yao G, Albertsen PC, Stanford JL, et al. Natural experiment examining impact of aggressive screening and treatment on prostate cancer mortality in two fixed cohorts from Seattle area and Connecticut. *BMJ.* 2002;325:740.
12. Shao YH, Albertsen PC, Shih W, et al. The impact of PSA testing frequency on prostate cancer incidence and treatment in older men. *Prostate Cancer Prostatic Dis.* 2011;14:332–339.
13. Lucas FL, Siewers AE, Malenka DJ, et al. Diagnostic-therapeutic cascade revisited: coronary angiography, coronary artery bypass graft surgery, and percutaneous coronary intervention in the modern era. *Circulation.* 2008;118:2797–2802.
14. Zhang Y, Baicker K, Newhouse JP. Geographic variation in Medicare drug spending. *N Engl J Med.* 2010;363:405–409.
15. Zhang Y, Baicker K, Newhouse JP. Geographic variation in the quality of prescribing. *N Engl J Med.* 2010;363:1985–1988.
16. Naughton C, Bennett K, Feely J. Regional variation in prescribing for chronic conditions among an elderly population using a pharmacy claims database. *Ir J Med Sci.* 2006;175:32–39.
17. Busato A, Matter P, Künzi B, et al. Supply sensitive services in Swiss ambulatory care: an analysis of basic health insurance records for 2003–2007. *Health Serv Res.* 2010;10:315.
18. Fisher ES, Wennberg DE, Stukel TA, et al. The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care. *Ann Intern Med.* 2003;138:273–287.
19. Fisher ES, Wennberg DE, Stukel TA, et al. The implications of regional variations in Medicare spending. Part 2: health outcomes and satisfaction with care. *Ann Intern Med.* 2003;138:288–298.
20. Sirovich BE, Gottlieb DJ, Welch HG, et al. Regional variations in health care intensity and physician perceptions of quality of care. *Ann Intern Med.* 2006;144:641–649.
21. Mahomed NN, Koo Seen Lin MJ, Levesque J, et al. Determinants and outcomes of inpatient versus home based rehabilitation following elective hip and knee replacement. *J Rheumatol.* 2000;27:1753–1758.
22. Waddell J, Johnson K, Hein W, et al. Orthopaedic practice in total hip arthroplasty and total knee arthroplasty: results from the Global Orthopaedic Registry (GLORY). *Am J Orthop.* 2010;39:5–13.
23. Hayes JH, Cleary R, Gillespie WJ, et al. Are clinical and patient assessed outcomes affected by reducing length of hospital stay for total hip arthroplasty? *J Arthroplasty.* 2000;15:448–452.
24. Inneh IA, Clair AJ, Slover JD, et al. Disparities in discharge destination after lower extremity joint arthroplasty: analysis of 7924 patients in an urban setting. *J Arthroplasty.* 2016;31:2700–2704.
25. Bozic KJ, Wagie A, Naessens JM, et al. Predictors of discharge to an inpatient extended care facility after total hip or knee arthroplasty. *J Arthroplasty.* 2006;21:151–156.
26. O'Toole RV, Gary JL, Reider L, et al. A prospective randomized trial to assess fixation strategies for severe open tibia fractures: modern ring external fixators versus internal fixation (FIXIT study). *J Orthop Trauma.* 2017;31(suppl 1):S10–S17.
27. Bosse MJ, Teague D, Reider L, et al. Outcomes after severe distal tibia, ankle, and/or foot trauma: comparison of limb salvage versus transtibial amputation (OUTLET). *J Orthop Trauma.* 2017;31:48–55.
28. Castillo RC, Raja SN, Frey KP, et al. Improving pain management and long-term outcomes following high-energy orthopaedic trauma (pain study). *J Orthop Trauma.* 2017;31(suppl 1):S71–S77.
29. O'Toole RV, Joshi M, Carlini AR, et al. Supplemental perioperative oxygen to reduce surgical site infection after high-energy fracture surgery (OXYGEN study). *J Orthop Trauma.* 2017;31(Suppl 1):S25–S31.
30. O'Toole RV, Joshi M, Carlini AR, et al. Local antibiotic therapy to reduce infection after operative treatment of fractures at high risk of infection: a multicenter, randomized, controlled trial (VANCO study). *J Orthop Trauma.* 2018;31(suppl 1):S18–S24.
31. Metcalfe D, Davis WA, Olufajo OA, et al. Access to post-discharge inpatient care after lower limb trauma. *J Surg Res.* 2016;203:140–144.
32. Sacks GD, Hill C, Rogers SO. Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care. *J Trauma.* 2011;71:1011–1015.
33. Farrell RT, Bennett BK, Gamelli RL. An analysis of social support and insurance on discharge disposition and functional outcomes in patients with acute burns. *J Burn Care Res.* 2010;31:385–392.
34. Kane WG, Wright DA, Fu R, et al. Racial/ethnic and insurance status disparities in discharge to posthospitalization care for patients with traumatic brain injury. *J Head Trauma Rehabil.* 2014;29:E10–E17.
35. Munin MC, Kwoh CK, Glynn N, et al. Predicting discharge outcome after elective hip and knee arthroplasty. *Am J Phys Med Rehabil.* 1995;74:294–301.
36. de Pablo P, Losina E, Phillips CB, et al. Determinants of discharge destination following elective total hip replacement. *Arthritis Rheum.* 2004;51:1009–1017.
37. Sharareh B, Le NB, Hoang MT, et al. Factors determining discharge destination for patients undergoing total joint arthroplasty. *J Arthroplasty.* 2014;29:1355–1358.e1.
38. Schwarzkopf R, Ho J, Snir N, et al. Factors influencing discharge destination after total hip arthroplasty: a California state database analysis. *Geriatr Orthop Surg Rehabil.* 2015;6:215–219.
39. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg Am.* 1976;58:453–458.
40. Baker S, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma Acute Care Surg.* 1974;14:187–196.
41. Wennberg JE. Unwarranted variations in healthcare deliver: implications for academic medical centres. *BMJ.* 2002;325:961–964.
42. Slover JD, Mullaly KA, Payne A, et al. What is the best strategy to minimize after-care costs for total joint arthroplasty in a bundled payment environment? *J Arthroplasty.* 2016;31:2710–2713.
43. Ponnusamy KE, Naseer Z, El Dafrawy MH, et al. Post-discharge care duration, charges, and outcomes among Medicare patients after primary total hip and knee arthroplasty. *J Bone Joint Surg Am.* 2017;99:e55.
44. Dundon JM, Bosco J, Slover J, et al. Improvement in total joint replacement quality metrics: year one versus year three of the bundled payments for Care Improvement Initiative. *J Bone Joint Surg.* 2016;98:1949–1953.
45. Keswani A, Weiser MC, Shin J, et al. Discharge destination after revision total joint arthroplasty: an analysis of postdischarge outcomes and placement risk factors. *J Arthroplasty.* 2016;31:1866–1872.e1.
46. Fu MC, Samuel AM, Sculco PK, et al. Discharge to inpatient facilities after total hip arthroplasty is associated with increased postdischarge morbidity. *J Arthroplasty.* 2017;32:S144–S149.e1.
47. Shah CK, Keswani A, Chi D, et al. Nonelective primary total hip arthroplasty: the effect of discharge destination on postdischarge outcomes. *J Arthroplasty.* 2017;32:2363–2369.
48. Forrest G, Fuchs M, Gutierrez A, et al. Factors affecting length of stay and need for rehabilitation after hip and knee arthroplasty. *J Arthroplasty.* 1998;13:186–190.
49. Dunlop DD, Manheim LM, Song J, et al. Age and racial/ethnic disparities in arthritis-related hip and knee surgeries. *Med Care.* 2008;46:200–208.
50. Nichols CI, Vose JG. Clinical outcomes and costs within 90 days of primary or revision total joint arthroplasty. *J Arthroplasty.* 2016;31:1400–1406.e3.

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