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Variation in the Treatment of Distal Radius Fractures in the United States: 2010-2015

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Abstract

Background: It remains unknown whether treatment trends for distal radius fracture (DRF) have changed in light of value-based care initiatives during recent years. We aimed to characterize modern practice patterns for DRF management.

Methods: We used 2009–2015 Truven MarketScan databases to extract data on several variables comprising of demographic characteristics, geographic location, and comorbidities for patients receiving treatment for a DRF. Regression analysis and Joinpoint analysis were used to assess trends over the study period. We analyzed the association of patient factors with type of treatment provided using logistic regression modeling.

Results: Among all 499,766 eligible encounters, the rate of internal fixation fluctuated around 13%. Casting/splinting remained the most frequent treatment across all populations. Treatment trends varied by age; children and adolescents were treated almost exclusively with closed treatment (mean: 97%), yet rates of internal fixation increased among adults and elderly patients. Patients age 55 to 64 were most likely to undergo internal fixation (OR: 1.89; 95% CI: 1.82–1.96). Higher median household income also significantly increased one's odds of receiving internal fixation ($p < 0.001$). Despite declining rates of external fixation and percutaneous pinning, regional variations among surgical modalities persist.

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Table, Supplemental Digital Content 1: Diagnosis and Procedure Codes used for Cohort Development, [INSERT HYPER LINK](#). This table lists all codes used in our analyses for the development of our study cohort and is intended to provide readers with additional details on our methodology.

Conclusion: The increased use of internal fixation for the treatment of distal radius fractures may be slowing. Treatment type continues to differ widely across demographic groups, underscoring the need for standardization. In accordance with value-based care initiatives, treatment decisions should be made to combine patient needs with financial implications on the health system. Comparative effectiveness data to derive optimal management strategies are still warranted.

Keywords

Distal radius fracture; healthcare utilization; open reduction internal fixation; variation; trend

As the most frequent type of upper extremity fracture observed in United States (US) emergency departments,¹ distal radius fractures (DRFs) are regularly treated by surgeons. Despite an increasing prevalence rate,² Level I evidence on DRF management is meager. The American Academy of Orthopaedic Surgeons guidelines regarding operative versus nonoperative treatment in patients over age 18 are predominantly inconclusive, except for a moderate strength recommendation that fractures with post-reduction radial shortening >3mm, dorsal tilt >10°, or intra-articular displacement >2mm be treated operatively.³ Multiple meta-analyses have been performed but results are mixed; the majority of studies find no clinically relevant enduring differences in function, range of motion, or radiographic parameters between those treated conservatively and those who underwent pinning, external fixation, or open reduction and internal fixation (ORIF).^{4–6}

Lack of consensus leads to wide treatment variations at the national level. Several studies have documented the increased use of ORIF, often with volar locking plate systems (VLPS).^{7–10} An analysis by our group detected an increase in internal fixation treatment for DRFs in Medicare beneficiaries from 3% in 1996 to 16% in 2005.⁷ Data from 2007 showed a 17% ORIF rate.¹¹ Among American Board of Orthopedic Surgery candidates, who are likely younger surgeons, use of ORIF increased from 42% in 1999 to 81% in 2007.¹² Manufacturers took notice of this trend and now more than two dozen companies produce DRF plating systems.¹³ Designs are consistently being tweaked and updated, with each iteration commanding an increased cost.¹³ Patient-reported outcomes are not helpful in distinguishing between treatment types. Studies using a variety of upper extremity health and quality of life instruments indicate that internal fixation procedures provide better subjective results soon after surgery, but there are no differences by 6 or 12 months after surgery.¹⁴ Moreover, there is little evidence to suggest that the benefits of ORIF outweigh the added cost to payers.¹⁵

Given the concerted efforts by physicians and policy-makers to combine evidence- and value-based care, it becomes increasingly important to understand and regularly monitor treatment trends. Although previous investigations have examined shifts in treatment for DRF, these studies are limited to outdated or single locality samples. In the present study, we analyze a large US database of private insurance claims to characterize more recent trends on the population level across age groups. Use of ORIF was of particular interest, because it is the most expensive of all the treatments.¹⁶ We also analyzed numerous patient-level factors to test if the odds of internal fixation for specific demographic groups has altered

over time. We hypothesized that ORIF remains the most popular surgical intervention among adults, and that the utilization rate of ORIF continues to grow despite little evidence to support its use over other methods.

Methods

We used data from the 2009–2015 Truven MarketScan Commercial Claims and Medicare Supplemental Research datasets. The Commercial Claims dataset collects information on individuals and their dependents with employer-sponsored private health plans. The Medicare Supplement set captures Medicare beneficiaries who have purchased supplemental insurance via one of the reporting companies. About 32% of fee-for-service Medicare beneficiaries had a Medicare supplemental plan in 2015.¹⁷ As one of the largest and longest-running proprietary health databases, MarketScan data are collected directly from employers and health plans, and include details on policy holders, their spouses, and their dependents.¹⁸ Researchers can track patients longitudinally and across health plans. Though a convenience sample, the MarketScan datasets includes details on over 43 million insured patients of all ages across the nation, enough to create a nationally representative sample of commercially insured individuals.¹⁸

Using a combination of International Classification of Diseases, Ninth and Tenth Revision (ICD-9, ICD-10) and Current Procedural Terminology (CPT) codes to develop our cohort (a full list is provided as a Supplemental Digital Content 1, See Table, which shows the Diagnosis and Procedure Codes used for Cohort Development, [INSERT HYPER LINK](#)), we extracted claims for all encounters with a diagnosis for a closed DRF. We excluded any patient with bone cancer because these patients require special operative considerations and not all treatment options may be suitable. To eliminate prevalent fracture (fractures that occurred before the study observation period began) we excluded any individual who did not undergo at least one of four treatment options (closed treatment, external fixation, percutaneous pinning, or open reduction), within two weeks of the initial diagnosis. Although it is possible that a patient could receive treatment outside of our specified window of time (2 weeks), we have found in our own practice that almost all patients are treated within an average of 9 days of fracture, making 14 days a logical end point. Finally, we excluded patients without continuous enrollment in the database for one year prior to their DRF encounter because it is impossible to assess for preoperative comorbid conditions in such cases. A flowchart of the cohort selection process is provided in Figure 1.

Because patients may have claims for multiple treatments during the DRF episode, we developed a hierarchical system for classification to eliminate any possibility of overlap. We assigned patients into one of the four treatment groups based on the invasiveness of the treatment, categorizing each by most invasive treatment received. Closed treatment was at the bottom of the hierarchy. In other words, all patients placed in the closed treatment group received only casting/splinting, with or without manipulation, and nothing else. Increasing in invasiveness, next came external fixation, percutaneous pinning, and, finally, open treatment. A patient who underwent both closed and open treatment within two weeks, for example, was categorized into the open treatment group. Because it is rare that a patient would

undergo open reduction without internal fixation, we assumed all patients who underwent open treatment to have received a subsequent internal fixation procedure.

To supplement our findings, we extracted details on patient age, sex, insurance type, comorbidities, location, median household income, injury date, and treatment type. Age is presented as a categorical variable (0–8, 9–17, 18–34, 35–44, 45–54, 55–64, and 65). Because the MarketScan databases report primarily on commercially insured patients, insurance type was categorized as either fee-for-service, managed care, or other. Region was designated as northeast, north central, south, west, or unknown. The Charlson Comorbidity Index (CCI) was used to calculate the number of preoperative comorbid conditions for each patient. Developed by Charlson et al. in 1987, the CCI is a validated measure of 1-year mortality and disease burden.¹⁹ The CCI can be used in statistical analyses to limit confounding bias of common comorbidities.

We calculated the frequency of each treatment modality, stratifying by both calendar year and age group. Significance was assessed with Chi-squared tests or Fisher's exact test as appropriate. We performed a Joinpoint regression to calculate the average annual percent change and assess for significant changes in treatment rates over time. Joinpoint Analysis was developed to provide more accurate rate estimates for cancer surveillance.²⁰ The Joinpoint Regression Program analyzes data from multiple years to determine a best-fit. It differs in that rather than trying to fit a single straight line, multiple line segments representing change rates are tested. This is used to account for specific changes in the rate to present a more precise trend over time as opposed to a single slope value to represent the entire study period. The point where segments meet are called "joinpoints".²¹ Average annual percent change (APC) represents a single summary measure of the trend over time, computed as a weighted average of the annual percent change values derived in the Joinpoint model. Associated p-values are estimates of the probability of the data being at least as extreme as previously observed data.²² We created logistic regression models to predict the odds of receiving ORIF against all other treatments, as well as specifically against percutaneous pinning/external fixation or closed treatment. Significance level for all analyses was set at $p < 0.05$. All analyses, except for the Joinpoint Regression, were completed using SAS analytic software, Version 9.4.

Results

Of 499,766 encounters in our analysis cohort, 55% were for female patients, 91% had no reported comorbidities, and 83% used fee-for-service payment plans (Table 1). Patients under 18 years of age comprised the largest group in our sample ($n=272,533$, 55%). Our cohort did not demonstrate the typical binomial distribution observed in other epidemiological studies of DRF; only 14% of cases were 65 years or older. Because MarketScan data on older adults are restricted to those who select employer-paid Medicare supplemental insurance, only a small portion (about 1/3 of total Medicare beneficiaries) are represented.

Frequency and rate of each fixation method stratified by year and age is presented in Table 2. Because the number of MarketScan-participating insurance plans and the number of

individuals enrolled in these plans vary from year-to-year, treatment trends in this analysis are best as assessed using proportions. In general, the rate of internal fixation for all individuals in the study cohort fluctuated around 13%, rising only slightly from 12% in 2010 to about 15% in 2015 (Figure 2). As expected, rates of percutaneous pinning and closed reduction decreased; utilization rates of external fixation remained consistently low (around 0.2%) throughout the five-year time span. The rate of ORIF use was greatest among middle-age adults between the ages of 35 to 64 years (mean of 32%).

Age played a large role in dictating treatment method. Children and adolescents were treated almost exclusively with closed treatment (mean of 97% across all study years). This is not unexpected considering that young patients' increased ability for uniform, rapid healing and ongoing bone growth processes enhance their ability to heal without invasive mediation.²³ Adults had markedly higher rates of utilization for ORIF. For example, the mean rate of receiving ORIF was 30% for individuals 18 to 64 years old and 22% for those 65 or older. Nonetheless, closed treatment remained the predominant fixation method regardless of age.

Joinpoint analysis (Table 3) revealed that among all encounters in our study cohort, none of the observed changes in usage rates for any fixation method were statistically significant. Likewise, although females had a substantially higher rate of ORIF use (19% in females compared to 9% in males in 2015), utilization rates exclusively among female or male patients did not change significantly over the study period. Because treatment mix for patients under 18 was vastly different than those for adult patients, we will focus the remainder of our analysis on adults. We did observe a significant increase in ORIF use when considering adult patients alone. Rate of percutaneous pinning among all adult populations decreased significantly. For example, the average APC among patients between 35 and 44 was 5.3% and -16.0% for ORIF and percutaneous pinning, respectively. Rate of closed treatment also decreased significantly among all adult age groups except for those 65 or older.

Table 4 summarizes odds of receiving ORIF compared to other treatments for adults. When comparing odds of ORIF with odds of receiving any other treatment, there was no difference between sexes. Significant differences were observed between different regions and median household incomes. As median household income increased, the odds of receiving ORIF increased. Those with the highest odds of receiving ORIF compared to all other treatment methods were individuals between 55 and 64 (OR: 1.89, 95%CI: 1.82–1.96).

Despite diminishing rates of external fixation and percutaneous pinning, discrepancies in the odds of receiving ORIF compared to odds of receiving an alternate surgical intervention persist among demographic groups. Patients in the highest median household income group had significantly increased odds of receiving ORIF over pinning or external fixation (OR: 2.63; 95%CI: 2.17–3.23), as compared to patients with the lowest household incomes. Finally, when comparing the odds of undergoing ORIF to the odds of closed reduction and a cast/splint, we found that patients with one or more comorbid conditions had slightly, but significantly, lower odds (OR: 0.95; 95%CI: 0.93–0.98) of receiving open reduction.

Discussion

Our analysis revealed that, from 2010 to 2015, use of ORIF for DRFs in a privately insured population of all ages fluctuated around 13%. Because our sample was not limited to a specific age group, we were able to examine treatment patterns across all ages and reveal updated trends for both the commercially insured population in general and for specific populations. Specifically, the rate of ORIF use among adults, including those over 65 years of age, has continued to display an upward trend; however, this rate is not growing as quickly as previously reported throughout the past two decades. In addition, the type of treatment received still varies widely among demographic groups and regions, highlighting the need for compared effectiveness data and standardization efforts.

We suspect that our observed trends in treatment for the adult population stem from a combination of physician and patient preferences. Approximately 90% of DRFs are treated by surgeons; of those treated by a different provider type (i.e., emergency medicine or family medicine), almost none undergo surgery.⁷ It is possible that increasing use of ORIF among adults may stem from a surgeon's preference to perform the operation deemed most elegant or complex. Alternatively, surgeons, particularly those who are younger, may not have received formal training in older modes of fixation. A recent survey of hand surgery program directors found that external fixation and ORIF of distal radius/ulna fractures were rated as having a 53% and 11% exposure gap in existing competency-based training programs, respectively.²⁴ Of note, only 66% of program directors ranked external fixation of distal radius/ulna fractures as an essential practice, whereas 95% agreed that ORIF is an essential component of clinical training. Considering the lack of consensus among surgeons and the rise of the patient-centered care movement, it is also likely that patients are requesting a specific treatment option for benefits like timing or practicality.

Our analysis of subgroups revealed that treatment type and trend varied substantially by age. We found that the largest proportion of patients receiving closed treatment, and lowest proportion undergoing ORIF, were those in the younger age groups. Children and young adult patients, those age 18–34 years, have not yet experienced age-related bone weakening and thus are able to maintain reduction with only casting.²⁵ Older patients (65+) were shown to have lower rates of ORIF use compared to individuals between 35 and 64. Patients over age 65 are more likely to sustain low-energy DRFs, which may be more amenable to casting.^{26,27} Furthermore, the perceived low functional demand of these patients may deter physicians from recommending more invasive treatment.²⁸ We did find that there is a greater proportion of older adults being treated with ORIF than previously reported in the literature, however. Our prior analysis of all Medicare beneficiaries revealed that in 2007, 17% of DRFs were treated with ORIF.¹¹ In our current cohort, 23% of patients age 65 years and older received ORIF in 2015. This difference could suggest a further increase in internal fixation use among older patients plans in particular. It may also be artifact of different populations between individuals covered by Medicare alone and those with supplemental plans. Despite the overlap between these group, extrapolating our findings to all individuals over 65 across the US is beyond the scope of our study.

Additional patient-level factors, such as having a higher median household income, were correlated with greater likelihood of receiving ORIF. Higher income patients may be more willing to support the use of a costlier intervention. Those with a higher income may also be more motivated to return to work sooner and select operative intervention. In addition, we found that having comorbidities decreased one's odds of surgery. This finding is logical because sicker patients are likely directed away from surgical treatment by their providers. Previous investigations report that white patients, female patients, and patients treated by younger surgeons all have greater odds of receiving internal fixation.^{11,29,30}

This analysis has limitations inherent to all database studies. Primarily, we must rely on the accuracy of coded information. To prevent miscoding, we only included claims that had a relevant diagnosis and a relevant procedure. Also, because this is a database of insurance claims, the only way that providers and facilities receive reimbursement for services rendered, the coding is likely to be accurate. We also lacked clinical detail that may be helpful to further explain our results. As more recent claims coded using ICD-10 become available, we will be able to more finely define our analysis cohort based on clinical presentation. In addition, because MarketScan receives claims from private insurers our cohort is likely more white and of higher socioeconomic status than the general US population. The MarketScan datasets do not include patients who are uninsured, insured through Medicaid, or Medicare beneficiaries who do not purchase a supplemental insurance plan. For the elderly population in particular, the dataset is limited to the subset of individuals who purchase a supplemental insurance plan, which may not be generalizable to entire Medicare population. Still, this dataset was useful to our analysis because we were interested in assessing population-level trends in treatment for all ages and could track patients longitudinally to assess for comorbidities. Finally, MarketScan compiles their data using convenience sampling; therefore, participating insurers may not be consistent between years. Nonetheless, the dataset maintains a representative sample of commercially insured individuals through its large sample size.

Despite these limitations, the implications of this analysis are important. Identifying patients with greater odds of internal fixation can help physicians understand current practice trends and inform future strategies to reveal a superior treatment option. Secondly, our study adds to the ongoing push for value-centered care by presenting updated utilization patterns across age groups. Combined with future high-level evidence on patient outcomes and cost of care, our findings serve to inform physicians and patients of how DRFs are being treated and what options exist to best suit their needs. We show that there is some indication that use of ORIF for the treatment of DRF may not be increasing as much as previously reported. This may suggest that patients and physicians have developed an increased awareness for the implications of costlier treatment avenues. Nonetheless, further measures to reduce variation may be justified to cut potentially discretionary spending until an optimal treatment is revealed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:
Flowchart of Cohort Development *Specified procedures include closed treatment, external fixation, percutaneous fixation, or open treatment. DRF, distal radius fracture

Figure 2:
Rate of Internal Fixation According to Year by Age Group

Table 1.**Baseline Characteristics of Study Sample**

	n	(%)
Total number receiving treatment	499,766	--
Characteristic		
Sex		
Male	226,615	(45.3)
Female	273,151	(54.7)
Age		
0–8	80,777	(16.2)
9–17	191,756	(38.4)
18–34	30,884	(6.2)
35–44	19,890	(4.0)
45–54	37,664	(7.5)
55–64	67,141	(13.4)
65	71,654	(14.3)
Region		
Northeast	100,969	(20.2)
North Central	122,711	(24.6)
South	176,013	(35.2)
West	89,969	(18.0)
Unknown	10,104	(2.02)
Type of Insurance		
Fee-for-service	415,944	(83.2)
Managed care	55,856	(11.2)
Missing	27,966	(05.6)
Median Household Income		
< 40k	11,785	(2.4)
40k × < 50k	119,564	(23.9)
50k × < 60k	191,238	(38.3)
60k × < 70k	67,267	(13.5)
70k	25,461	(5.1)
Missing	84,451	(16.9)
Charlson Comorbidity Score		
0	453,391	(90.7)
1–3	20,770	(4.2)
4–8	17,515	(3.5)
>8	8,090	(1.6)

k, thousand

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Table 2.Frequency and Percentage of Fixation Method by A) Year and B) Age Group[±]

	ORIF		Percutaneous Pinning		External fixation		Closed treatment		P-Value
Total	n=65,390		n=13,304		n=1,113		n=419,959		
A) Calendar year									
2010	10,475	(11.9)	2,705	(3.1)	230	(0.3)	74,943	(84.8)	<0.001
2011	12,624	(12.7)	2,871	(2.9)	287	(0.3)	83,302	(84.1)	
2012	12,903	(12.3)	2,792	(2.7)	216	(0.2)	89,333	(84.9)	
2013	10,894	(13.9)	1,975	(2.5)	160	(0.2)	65,627	(83.4)	
2014	10,943	(14.2)	1,818	(2.4)	151	(0.2)	64,028	(83.2)	
2015	7,551	(14.7)	1,143	(2.2)	69	(0.1)	42,726	(83.0)	
B) Age Group									
0–8	346	(0.4)	1,124	(1.4)	2	(0.0)	79,305	(98.2)	<0.001
9–17	2,505	(1.3)	4,836	(2.5)	14	(0.0)	184,401	(96.2)	
18–34	6,465	(20.9)	959	(3.1)	60	(0.2)	23,400	(75.8)	
35–44	6,100	(30.7)	545	(2.7)	73	(0.4)	13,172	(66.2)	
45–54	12,086	(32.1)	1,140	(3.0)	181	(0.5)	24,257	(64.4)	
55–64	22,260	(33.2)	2,255	(3.4)	351	(0.5)	42,275	(63.0)	
65	15,628	(21.8)	2,445	(3.4)	432	(0.6)	53,149	(74.2)	

[±]Numbers in parentheses are the raw percentage.

ORIF, open reduction internal fixation

Table 3.

Joinpoint Analysis of Rate of Fixation Methods from 2010 to 2015

	Percentage (%)						Trend	
	2010	2011	2012	2013	2014	2015	Average APC	
Total								
ORIF	11.9	12.7	12.3	13.9	14.2	14.7	4.4	(2.2 to 6.7)
Percutaneous pinning	3.1	2.9	2.7	2.5	2.4	2.2	−6.3	(−6.9 to −5.7)
External fixation	0.3	0.3	0.2	0.2	0.2	0.1	−11.7	(−19.6 to −2.9)
Closed treatment	84.8	84.1	84.9	83.4	83.2	83.0	−0.5	(−0.8 to −0.1)
Male								
ORIF	7.5	8.2	8.0	8.7	8.8	8.8	3.1	(1.2 to 5.0)
Percutaneous pinning	2.9	2.9	2.8	2.7	2.6	2.5	−2.8	(−3.8 to −1.8)
External fixation	0.2	0.2	0.1	0.1	0.1	0.1	−9.3	(−12.7 to −5.8)
Closed treatment	89.4	88.8	89.1	88.5	88.5	88.6	−0.1	(−0.4 to 0.00)
Female								
ORIF	15.5	16.5	16.0	18.1	18.6	19.3	4.6	(2.5 to 6.8)
Percutaneous pinning	3.2	2.9	2.5	2.3	2.2	2.0	−9.3	(−10.9 to −7.7)
External fixation	0.4	0.4	0.3	0.3	0.3	0.2	−12.3	(−22.1 to −1.3)
Closed treatment	80.9	80.2	81.3	79.3	78.9	78.5	−0.6	(−1.2 to −0.1)
18–34 age group								
ORIF	18.9	20.1	20.0	22.0	22.2	24.2	4.8	(3.1 to 6.6) [*]
Percutaneous pinning	3.8	3.7	3.3	2.7	2.5	2.2	−11.0	(−13.5 to −8.4) [*]
External fixation	0.1	0.3	0.2	0.2	0.3	0.2	0.9	(−19.3 to 26.1)
Closed treatment	77.1	76.0	76.6	75.2	75.1	73.4	−0.9	(−1.4 to −0.3) [*]
35–44 age group								
ORIF	27.7	29.0	29.8	32.2	33.4	35.9	5.3	(4.3 to 6.3) [*]
Percutaneous pinning	3.7	2.9	3.2	2.3	1.9	1.4	−16.0	(−22.4 to −9.0) [*]
External fixation	0.3	0.6	0.5	0.3	0.3	0.1	−18.7	(−47.4 to 25.8)
Closed treatment	68.4	67.4	66.6	65.1	64.5	62.7	−1.	7(−2.0 to −1.3) [*]
45–54 age group								
ORIF	29.8	30.4	32.0	33.2	34.2	35.2	3.5	(3.0 to 4.0) [*]
Percutaneous pinning	4.0	3.6	3.2	2.7	2.0	1.8	−15.4	(−18.7 to −11.9) [*]
External fixation	0.6	0.7	0.5	0.4	0.2	0.4	−13.2	(−26.8 to 3.0)
Closed treatment	65.6	65.3	64.3	63.8	63.6	62.7	−0.9	(−1.1 to −0.7) [*]
55–64 age group								
ORIF	30.3	31.7	32.8	35.1	34.9	35.4	3.3	(1.8 to 4.8) [*]
Percutaneous pinning	4.4	3.9	3.3	3.3	2.7	2.4	−11.8	(−13.1 to −10.5) [*]

	Percentage (%)						Trend	
	2010	2011	2012	2013	2014	2015	Average APC	
External fixation	0.7	0.6	0.5	0.5	0.5	0.3	-12.6	(-21.5 to -2.6) *
Closed treatment	64.6	63.8	63.4	61.4	61.9	61.9	-0.9	(-1.6 to -0.3) *
65 age group								
ORIF	20.2	21.2	20.9	22.8	23.8	22.6	2.9	(0.5 to 5.4) *
Percutaneous pinning	4.6	4.0	3.4	2.7	2.9	2.5	-11.5	(-15.8 to -7.0) *
External fixation	0.8	0.8	0.6	0.6	0.5	0.3	-13.0	(-20.3 to -5.1) *
Closed treatment	74.5	74.0	75.2	74.0	72.8	74.5	-0.2	(-0.9 to 0.6)

* $P < 0.05$

APC, annual percent change; ORIF, open reduction internal fixation

Table 4.Odds of Receiving Open Reduction Internal Fixation Among Adults (n=177,373)[‡]

Parameter	Logistic regression			Multinomial logistic regression					
	Any Other Treatment			Percutaneous Pin or External Fixation			Closed Treatment		
	OR	95% CI	P-Value	OR	95% CI	P-Value	OR	95% CI	P-Value
Sex									
Male	1	Reference	--	1	Reference	--	1	Reference	--
Female	1.00	(0.97–1.02)	0.77	0.93	(0.87–0.99)	0.026	1.00	(0.97–1.02)	0.98
Age									
18–34	1	Reference	--	1	Reference	--	1	Reference	--
35–44	1.67	(1.59–1.75)	<0.001	1.59	(1.39–1.79)	<0.001	1.67	(1.59–1.75)	<0.001
45–54	1.82	(1.75–1.89)	<0.001	1.52	(1.37–1.69)	<0.001	1.85	(1.75–1.92)	<0.001
55–64	1.89	(1.82–1.96)	<0.001	1.42	(1.30–1.59)	<0.001	1.92	(1.85–2.00)	<0.001
65	1.06	(1.03–1.11)	0.001	0.92	(0.83–1.01)	0.088	1.08	(1.03–1.11)	<0.001
Region									
Northeast	1	Reference	--	1	Reference	--	1	Reference	--
North Central	1.29	(1.20–1.30)	<0.001	0.69	(0.62–0.77)	<0.001	1.28	(1.23–1.33)	<0.001
South	1.43	(1.37–1.49)	<0.001	0.87	(0.79–0.97)	0.010	1.45	(1.41–1.52)	<0.001
West	1.28	(1.23–1.33)	<0.001	0.74	(0.66–0.82)	<0.001	1.30	(1.27–1.35)	<0.001
Type of Insurance									
Fee-for-service	1	Reference	--	1	Reference	--	1	Reference	--
Managed care	0.93	(0.91–0.97)	<0.001	1.14	(1.04–1.25)	0.004	0.93	(0.90–0.96)	<0.001
Median Household Income[±]									
< 40k	1	Reference	--	1	Reference	--	1	Reference	--
40k × < 50k	1.15	(1.08–1.22)	<0.001	1.56	(1.37–1.82)	<0.001	1.12	(1.04–1.19)	<0.001
50k × < 60k	1.14	(1.06–1.20)	<0.001	1.96	(1.72–2.22)	<0.001	1.10	(1.02–1.16)	0.008
60k × < 70k	1.16	(1.09–1.25)	<0.001	1.96	(1.67–2.27)	<0.001	1.14	(1.05–1.22)	0.001
70k	1.19	(1.10–1.28)	<0.001	2.63	(2.17–3.23)	<0.001	1.14	(1.05–1.23)	0.001
Number of comorbidities									
0	1	Reference	--	1	Reference	--	1	Reference	--
1	0.95	(0.93–0.98)	<0.001	0.95	(0.89–1.01)	0.093	0.95	(0.93–0.98)	<0.001

[‡] Odds ratios provided indicate the odds ratio of one receiving ORIF compared to the odds ratio of receiving the specified treatment(s). An OR >1 signifies that one is more likely to receive ORIF in relation to the compared fixation method. Cases with missing values for region, type of insurance, or median household income were excluded in analysis.

[±] In US Dollars

CI, confidence interval; k, thousand; OR, Odds ratio; ORIF, open reduction internal fixation; US, United States