Arthroplasty Today 27 (2024) 101356

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

Age-Based Heuristics Bias Treatment of Displaced Femoral Neck Fractures in the Elderly

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ARTICLE INFO

Article history:
Received 7 July 2023
Received in revised form
7 February 2024
Accepted 13 February 2024
Available online xxx

Keywords:
Arthroplasty
Femoral neck fracture
Surgical decision-making
Elderly

ABSTRACT

Background: Surgeons performing arthroplasty for femoral neck fractures may rely on mental shortcuts (heuristics) when choosing total hip arthroplasty (THA) vs hemiarthroplasty (HA). We sought to quantify the extent to which age-based heuristics drive decision-making.
Methods: We identified all Medicare beneficiaries from 2017-2018 with femoral neck fractures who underwent THA or HA. We compared the likelihood of THA vs HA among patients admitted within 4 weeks before vs 4 weeks after their birthday for each age under the hypothesis that these cohorts would be similar except for numerical age. We controlled for race/ethnicity, sex, comorbidities, poverty status, and hospital census region in a multivariable regression that included facility-level cluster effects. We generated predicted/adjusted probabilities for THA vs HA for different age transition points.
Results: Thirteen thousand three hundred sixty-six elderly patients were included. One thousand eight hundred sixty-five (14%) received THA and 11,501 (86%) received HA. The likelihood of THA decreased from 50.3% among patients almost 67 to 8% among those ≥85 ($P < .001$). We found significant decreases in likelihood of THA across age transitions. The largest decrement was at age transition 69 (THA likelihood 28.7% for newly 69 vs 43.3% for almost 69, 33.7% relative change). Female gender, Black race, higher comorbidity burden, and lower socioeconomic status were also associated with a lower likelihood of THA.
Conclusions: Our data demonstrate that patient age transitions seem to influence the choice of THA vs HA. Further research is needed to develop data-driven surgical decision aids for this population.

Introduction

Heuristics are mental shortcuts used to assist with complex decision-making. Heuristics involve the intuitive, rapid, and often unconscious processing of information in order to yield a judgment in the face of uncertainty. This contrasts with the slow, effortful processing of information needed to make a deliberate judgment in the absence of heuristics. Heuristics are commonly used by health care providers and have the potential to bias clinical decisions [1,2]. The mental shortcut of discretizing age, a continuous variable, into categories (60s, 70s, 80s, 90s, etc.), can result in abrupt changes in treatment patterns for patients whose age falls near category cutoffs. For example, physicians treating myocardial infarction choose different management strategies for patients that are hospitalized 2 weeks before or 2 weeks after their 80th birthday, despite all other factors being the same [3]. Surgeons performing arthroplasty for femoral neck fractures (FNF) in the elderly may similarly rely on heuristics to decide between total hip arthroplasty (THA) and hemiarthroplasty (HA).

Controversy persists regarding optimal surgical management of displaced FNF in the elderly [4]. Advocates of THA cite improved function and quality of life outcomes compared to HA, as has been demonstrated in several randomized controlled trials [5-10].

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https://doi.org/10.1016/j.artd.2024.101356
2352-3441/

Proponents of HA cite longer operative times, higher blood loss, and higher risk of dislocation with THA without clear evidence of clinically meaningful improved function, as demonstrated in other randomized controlled trials [11-14]. The American Academy of Orthopaedic Surgeons has issued a clinical practice guideline that states that there may be a functional benefit to THA over HA, at the risk of increased complications [15]. In light of this uncertainty, many surgeons select THA vs HA on a case-by-case basis, seeking to treat healthier, more active patients with THA and frailer, lower-demand patients with HA.

Given the absence of explicit criteria to guide the THA vs HA decision, surgeons may rely on heuristics that lead to unrecognized cognitive bias. Demographic factors such as age may be substituted in place of direct assessments of functional and physiologic status to guide treatment decisions. For example, surgeons may treat a patient that is 70 years and 1 week differently from a patient that is 69 years and 51 weeks but otherwise identical, based solely on numerical age. If mental shortcuts are used in this way, decision-making may be biased in a manner potentially detrimental to patients. We hypothesized that, all else equal, surgical management of displaced FNF in the elderly will vary across arbitrary numerical age transitions.

Material and methods

Data sources and cohort selection

Medicare claims data from the Centers for Medicare and Medicaid Services were used to identify all fee-for-service (FFS) beneficiaries that were treated with a THA or HA for a diagnosis of femoral neck fracture during the calendar years 2017 and 2018. THA and HA surgery were identified by International Classification of Diseases, 10th Revision (ICD-10) procedure codes (listed below). FNF were identified by ICD-10 diagnostic codes: S72.00XX, S72.01XX, S72.02XX, S72.03XX, S72.04XX, and S72.09XX, where X represents a wildcard. Patients were required to be enrolled in FFS Medicare for at least 12 months prior to surgery in order to calculate comorbidity. Patients were identified as those that had a procedure code for primary THA or HA during a hospital admission with diagnosis code for femoral neck fracture. Patients were excluded if they had arthroplasty for fracture related to an oncologic or infectious process or if they were undergoing revision or conversion surgery, according to Centers for Medicare and Medicaid Services methodology for quality reporting [16].

We restricted our sample to patients who had a birthday within 4 weeks (i) prior to or (ii) after their surgical admission indexing them by the age of that birthday. Our overarching rationale is that, all else held constant, each pair of age-specific birthday cohorts (ie, patients 4-weeks before their nth birthday and 4-weeks after having turned age n) would be similar except for their numerical age (eg, 69 vs 70; 74 vs 75). Comparing regression-adjusted predicted probabilities for these pair-wise cohorts, therefore, would enable detection of the influence of numerical age on treatment choice once other potential confounders are controlled for. Patients who did not have a birthday within 4 weeks before or after their index admission were excluded from analyses. We use the label “almost age n” for patients that had surgery within 4 weeks prior to their birthday and the label “newly age n” for patients that had surgery within 4 weeks after their birthday, with n ranging from age 66 to 93 years old at the time of the surgery.

Outcomes

The primary outcome was the type of surgery: THA vs HA. This was identified using ICD-10 procedure codes. THA: 0SR90J9, 0SR90JA, 0SR90JZ, 0SRB0J9, 0SRB0JA, 0SRB0JZ, 0SR9019, 0SR901A, 0SR901Z, 0SR9029, 0SR902A, 0SR902Z, 0SR9039, 0SR903A, 0SR903Z, 0SR9049, 0SR904A, 0SR904Z, 0SRB019, 0SRB01A, 0SRB01Z, 0SRB029, 0SRB02A, 0SRB02Z, 0SRB039, 0SRB03A, 0SRB03Z, 0SRB049, 0SRB04A, 0SRB04Z; and HA: 0SRR019, 0SRR01A, 0SRR01Z, 0SRR039, 0SRR03A, 0SRR03Z, 0SRR0J9, 0SRR0JA, 0SRR0JZ, 0SRS019, 0SRS01A, 0SRS01Z, 0SRS039, 0SRS03A, 0SRS03Z, 0SRS0J9, 0SRS0JA, 0SRS0JZ.

Control variables

In addition to age as defined above, patients’ sex, race/ethnicity (African American/Black, Hispanic, White/non-Hispanic, other race/ethnicity), and poverty status, as proxied by dual enrollment in Medicare and Medicaid or a state buy-in program, were identified from the Medicare enrollment file. Medicare claims files were utilized to calculate comorbidity for the 12-month period prior to the index surgery using the Elixhauser algorithm [17,18].

Analysis

A multivariable probit regression model was used to assess the association between patient numerical age transitions and the outcome variable of THA vs HA, adjusting for patient’s sex, race/ethnicity, dual enrollment (a proxy for low-income status), number of comorbidities, and hospital census region. The model also accounted for clustering (ie, multiple patients treated at the same facility) by including facility-level random effects. Using coefficient estimates obtained from the multivariable regression model applied to the full sample, we then estimated the likelihood of receiving a THA for patients at each age group, contrasting each pair of age-specific transition coefficients to examine whether the likelihood of THA differed significantly across patients whose birthdays were 4 weeks before or after a given age. Lastly, we calculated adjusted/predicted probabilities of THA vs HA for different age transitions. These predicted/adjusted probabilities were calculated at the individual-level assuming all patients to be at a given age transition (eg, almost age 70 vs newly age 70) while holding all other factors constant at the original levels.

Results

Of the 84,800 FFS Medicare beneficiaries aged 66 to 93 years old undergoing an arthroplasty secondary to a femoral neck fracture during the study period who had been enrolled at least 12 months prior to their index surgery, we excluded 556 individuals due to a lack of information on the type of surgery. Of the remaining 84,244 individuals, 13,440 had a date of birth within 4 weeks before or after their surgery. Of those, 47 were excluded due to missing information on race and 27 due to missing information on Census region of residence yielding a final effective sample of 13,366 elderly patients meeting our inclusion criteria, of whom 1865 (14%) were treated with THA and 11,501 (86%) were treated with HA.

Patient characteristics, overall and by type of surgery, are shown in Table 1. The HA group was significantly older (mean age 83.0 ± 6.6 vs 78.4 ± 7.3 years, $P < .001$), more likely to be female (71.5% vs 68.7%, $P = .015$), had more comorbid conditions (3.7 ± 3.1 vs 3.0 ± 2.7, $P < .001$), and was more likely to have Medicaid (Medicaid dual enrollment 16.0% vs 9.1%, $P < .001$).

Findings from the multivariable probit model indicate that the probability of undergoing THA monotonically decreased with age. (Full results are shown in Appendix Table 1). In addition to age, the patient’s gender, race/ethnicity, comorbidity burden, and poverty status were significantly associated with surgery type. Relative to white individuals, African American/Black FNF patients (coefficient = −0.285, 95% confidence interval (CI) = −0.51

Table 1
Patient characteristics, overall, and by surgery type.

Variable	Total N = 13,366 (%)	Total hip arthroplasty N = 1865 (%)	Hip hemiarthroplasty N = 11,501 (%)	*P* value
Age at surgical admission (y)				<.001
Mean (SD)	82.3 (6.9)	78.4 (7.3)	83.0 (6.6)	
Median (IQR)	83.0 (11.0)	78.0 (12.0)	84.0 (10.0)	
Sex	n (%)	n (%)	n (%)	.015
Male	3862 (28.9)	583 (31.3)	3279 (28.5)	
Female	9504 (71.1)	1282 (68.7)	8222 (71.5)	
Race/ethnicity	n (%)	n (%)	n (%)	.087
Non-Hispanic White	12308 (92.1)	1740 (93.3)	10568 (91.9)	
Black/African American	368 (2.8)	36 (1.9)	332 (2.9)	
Hispanic	370 (2.8)	50 (2.7)	320 (2.8)	
Other	320 (2.4)	39 (2.1)	281 (2.4)	
Number of comorbidities				<.001
Mean (SD)	3.6 (3.0)	3.0 (2.7)	3.7 (3.1)	
Median (IQR)	3.0 (4.0)	2.0 (3.0)	3.0 (4.0)	
Poverty status/dual enrollment	n (%)	n (%)	n (%)	<.001
No	11352 (84.9)	1696 (90.9)	9656 (84.0)	
Yes	2014 (15.1)	169 (9.1)	1845 (16.0)	
Facility census region	n (%)	n (%)	n (%)	.894
Northeast	2153 (16.1)	302 (16.2)	1851 (16.1)	
South	5939 (44.4)	830 (44.5)	5109 (44.4)	
Midwest	2997 (22.4)	407 (21.8)	2590 (22.5)	
West	2277 (17.0)	326 (17.5)	1951 (17.0)	

to −0.06, $P = .014$) were less likely to undergo a THA. In contrast, relative to women, men were more likely to receive a THA even after controlling for age, comorbidities, and other potential confounders. A higher number of comorbidities (coefficient = 0.045, 95% CI = *P* −.056 to −0.034, <0.001) and low-income status (coefficient = −0.37; 95% CI = −0.47 to −0.27, $P < .001$) were each independently associated with a lower likelihood of undergoing a THA. There was no significant geographic variation in the likelihood of THA (Appendix Table 1).

In Table 2, we present adjusted/predicted probabilities of THA, along with their CI, for selected pairwise age transitions. The probability of undergoing THA was highest for the youngest group of the pair-wise age transition group considered (almost 67 years old) at 50.3% and lowest at 6.2% for the newly 86-year-old group. The largest absolute decrement in the probability of undergoing a THA occurred at age 69. FNF patients who had just turned 69 within the last 4 weeks were 14.6 percentage points (or 33.5%) less likely to receive a THA than their counterparts who were 4 weeks from their 69th birthday (from 43.3% to 28.7%). As shown in Figure 1, from age 70 and older, the largest relative decrements occurred at roughly 5-year increments (eg, age 75, 80) except for those aged 86, for whom the probability of receiving a THA decreased by 4.8 percentage points (from 11% to 6.2%, −43.6%) relative to patients aged 85 and 11 months at the time of their surgery.

Table 2
Regression-adjusted probabilities of undergoing THA for selected age transitions.

Age at surgery	Adjusted probability of THA[a] (vs HA)	95% CI	% Change[b]
Almost 67	50.3	50.2, 50.4	−18.3%
Newly 67	41.1	41.0, 41.3	
Almost 68	46.3	46.2, 46.5	−22.5%
Newly 68	35.9	35.8, 36.0	
Almost 69	43.3	43.2, 43.4	−33.7%
Newly 69	28.7	28.6, 28.8	
Almost 70	34.8	34.7, 34.9	−17.5%
Newly 70	28.7	28.6, 28.8	
Almost 75	24.1	24.0, 24.2	−14.5%
Newly 75	20.6	20.5, 20.7	
Almost 80	16.4	16.3, 16.5	−19.5%
Newly 80	13.2	13.1, 13.3	
Almost 85	10.3	10.2, 10.3	−14.6%
Newly 85	8.8	8.8, 8.8	
Almost 90	8.2	8.1, 8.2	−2.4%
Newly 90	8.1	8.1, 8.2	

[a] Adjusted probabilities were calculated based on a multivariable probit model that included controls for sex, race-ethnicity, comorbidities, low-income status, hospital Census region, and facility-level random effects.
[b] Percent change from "almost" age x to corresponding "newly" age x. Given the large sample size, all differences are statistically significant at the $P < .05$ level.

Discussion

Surgical management of displaced FNF in the elderly remains a controversial topic. Treatment decisions have considerable ramifications for individual patients and have impacts on resource utilization that affect the healthcare system as a whole. Elimination of arbitrary factors from treatment decisions would enable a decision-making process that prioritizes value for the individual patient. In this study of over 13,000 elderly patients with FNF treated with arthroplasty, we found evidence that arbitrary age cut-offs were associated with decision for THA vs HA. Patients had a significantly lower likelihood of THA if they underwent surgery immediately after, compared with immediately before their 67th, 68th, 69th, and 70th birthday, and thereafter at their 75th, 80th and 85th birthday.

Surgical decision-making in the management of FNF is a multifactorial process that incorporates the surgeon's experience and clinical judgment, the patient's values and preferences, and available healthcare resources. In this study, we attempt to isolate how numerical age may factor into "rules of thumb" that are not physiologically justified. The mental shortcuts described here fit within a representativeness heuristic, in which patients at a given numerical age are more or less representative of a prototypical patient that does well with a THA or a HA [19]. Decision-making shortcuts of this sort allow for efficiency and may yield an appropriate decision in many cases. Nonetheless, the finding that potentially arbitrary factors influence decisions suggests that there is an opportunity for improved decision-making in marginal cases.

Physiologic age, in contrast to numerical or chronological age, is a description of where an individual fits along the aging spectrum according to their physiologic profile [20]. Studies have suggested

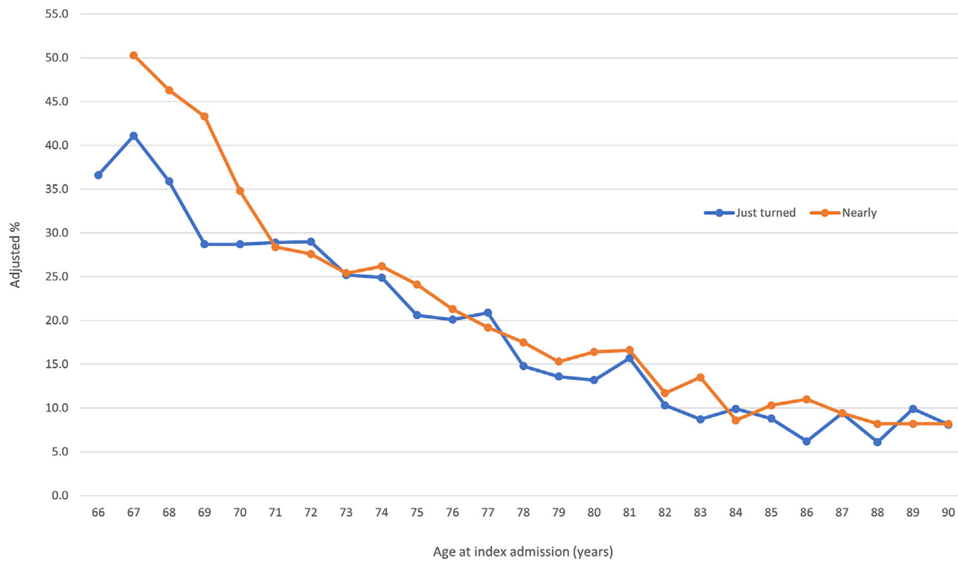

Figure 1. Adjusted/predicted probability of THA vs HA by age transitions.

that physiologic age may more accurately predict mortality in connection to age-related diseases than does numerical age [21,22]. Nonetheless, there is a correlation between advanced chronological age and adverse outcomes following arthroplasty and hip fracture management [23,24]. To our knowledge, a direct comparison of physiologic age and numerical age in predicting risk has not been performed. If the risk and benefit tradeoff of the THA vs HA decision is more dependent on physiologic age than chronologic age, then the case can be made that numerical age should not be a deciding factor in determining treatment. Even if there exists a valid role for numerical age as one part of a decision-making algorithm for HA vs THA, our analysis suggests that the age-heuristic is currently being inappropriately applied. For the age-heuristic that we identified to be valid, it would have to be true that being 8 weeks older, with all else being the same, makes a patient meaningfully less well-suited for THA vs HA. This point is especially salient when considering the 33.7% relative decrease in utilization of THA for patients that sustained FNF 4 weeks before vs 4 weeks after their 69th birthday. It seems unlikely that an 8-week (or less) age difference would be relevant, although we cannot be certain that surgeons in some circumstances did not appropriately utilize an age-based cutoff.

We found that black patients and patients with low-income status, as proxied by Medicaid dual enrollment were significantly less likely to undergo THA in comparison to non-black and nonlow-income patients, respectively. Our findings corroborate prior studies that demonstrate racial and socioeconomic disparities in hip fracture care [25,26], and in arthroplasty care in general [27,28]. These differences may also, in part, be attributable to surgeons using mental shortcuts. If a surgeon's prototypical conception of the active patient that does well with a THA is not black or low-income, then the representativeness heuristic may lead that surgeon away from choosing THA. It is also possible that direct racial bias may play a role.

This study has several limitations. This is a retrospective study of administrative data; analyses were limited to the data elements that are present, and the possibility of errors in coding cannot be excluded. The decision for THA vs HA is multifactorial and may have been affected by variables that are not observable in the dataset, such as radiographic findings or body mass index. Information on the exact reasons why surgeons elected for THA vs HA was not available; nonetheless, our adjusted analyses do reveal associations between arbitrary age transitions and treatment decisions. Although we control for the number of comorbidities ascertained 12-month presurgery using the validated Elixhauser algorithm, the index does not provide any information about the severity of disease or medical optimization prior to surgery. However, it is plausible to assume that the severity of illness is evenly distributed 4 weeks before and after a birthday, such that its omission would not bias our results. Further studies that directly examine surgeon decision-making are, however, needed.

Conclusions

Based on nationally representative data, we present evidence that treatment decisions for surgical management of FNF in the elderly vary across age transitions. The development of decision-support algorithms to optimize treatment decisions tailored to each patient may be beneficial.

Funding

This research was supported in part by a research grant from the National Institute on Aging (5-R01-AG058718).

Conflicts of interest

A. Edelstein is a paid consultant for Corin and Depuy; is an editorial board member of Arthroplasty Today; and is a board/committee member of AAHKS. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101356.

CRediT authorship contribution statement

Adam I. Edelstein: Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Joseph T. Tanenbaum:** Writing – review & editing, Conceptualization. **Emily L. McGinley:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization. **Timothy R. Dillingham:** Writing – review & editing, Supervision, Project administration. **Liliana E. Pezzin:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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Appendix Table 1
Multivariable probit model coefficients for probability of total hip arthroplasty relative to hemi hip surgery among Medicare beneficiaries with hip fracture.

Age at surgery	Coefficient	95% confidence interval	*P*-value
Newly 66	Reference	–	–
Almost 67	0.409468	−0.13701, 0.955941	.142
Newly 67	0.138803	−0.33794, 0.615548	.568
Almost 68	0.291921	−0.22214, 0.805984	.266
Newly 68	−0.02187	−0.50326, 0.459514	.929
Almost 69	0.203683	−0.29082, 0.698187	.419
Newly 69	−0.25413	−0.72605, 0.217802	.291
Almost 70	−0.05464	−0.52638, 0.417099	.82
Newly 70	−0.25548	−0.72879, 0.21784	.29
Almost 71	−0.26497	−0.73259, 0.202651	.267
Newly 71	−0.24981	−0.70172, 0.202105	.279
Almost 72	−0.2936	−0.7523, 0.165097	.21
Newly 72	−0.24605	−0.70006, 0.207966	.288
Almost 73	−0.37263	−0.8311, 0.085827	.111
Newly 73	−0.38023	−0.82644, 0.065985	.095
Almost 74	−0.34442	−0.81123, 0.122384	.148
Newly 74	−0.39021	−0.83966, 0.059247	.089
Almost 75	−0.41888	−0.8712, 0.033431	.07
Newly 75	−0.55624	−1.00626, −0.10623	.015
Almost 76	−0.52926	−0.9799, −0.07862	.021
Newly 76	−0.5773	−1.00904, −0.14557	.009
Almost 77	−0.6154	−1.05813, −0.17266	.006
Newly 77	−0.54304	−0.98852, −0.09757	.017
Almost 78	−0.69121	−1.12953, −0.2529	.002
Newly 78	−0.81606	−1.24445, −0.38767	<.001
Almost 79	−0.79465	−1.23437, −0.35493	<.001
Newly 79	−0.87921	−1.31857, −0.43985	<.001
Almost 80	−0.74037	−1.16986, −0.31089	.001
Newly 80	−0.90178	−1.33597, −0.46759	<.001
Almost 81	−0.7322	−1.16552, −0.29887	.001
Newly 81	−0.77575	−1.20294, −0.34855	<.001
Almost 82	−0.98837	−1.42361, −0.55313	<.001
Newly 82	−1.07336	−1.50706, −0.63965	<.001
Almost 83	−0.88774	−1.31514, −0.46035	<.001
Newly 83	−1.1858	−1.6393, −0.73231	<.001
Almost 84	−1.19315	−1.6324, −0.7539	<.001
Newly 84	−1.10112	−1.53153, −0.6707	<.001
Almost 85	−1.07483	−1.52164, −0.62802	<.001
Newly 85	−1.17679	−1.60866, −0.74492	<.001
Almost 86	−1.027	−1.47013, −0.58387	<.001
Newly 86	−1.38878	−1.82949, −0.94806	<.001
Almost 87	−1.13389	−1.57458, −0.6932	<.001
Newly 87	−1.1365	−1.57003, −0.70298	<.001
Almost 88	−1.21868	−1.66467, −0.77268	<.001
Newly 88	−1.40301	−1.84938, −0.95663	<.001
Almost 89	−1.22301	−1.66305, −0.78297	<.001
Newly 89	−1.10061	−1.53201, −0.6692	<.001
Almost 90	−1.2243	−1.65616, −0.79244	<.001
Newly 90	−1.22783	−1.66805, −0.78761	<.001
Almost 91	−1.52349	−1.97335, −1.07363	<.001
Newly 91	−1.26668	−1.71888, −0.81449	<.001
Almost 92	−1.22434	−1.68997, −0.75871	<.001
Newly 92	−1.04021	−1.49579, −0.58463	<.001
Almost 93	−1.47964	−1.94835, −1.01092	<.001
Newly 93	−1.51555	−2.02082, −1.01027	<.001
Almost 94	−1.46122	−1.94082, −0.98162	<.001
Race-ethnicity			
Black/African American	−0.2855	−0.51273, −0.05828	.014
Hispanic	0.171226	−0.0311, 0.373547	.097
Other	−0.02705	−0.23635, 0.182264	.8
White	Reference	–	–
Sex			
Female	Reference	–	–
Male	0.094467	0.028295, 0.16064	.005
Number of comorbidities	−0.04558	−0.05677, −0.03439	<.001
Low income status			
No	Reference	–	–
Yes	−0.3702	−0.47397, −0.26644	<.001
Facility census region			
Northeast	Reference	–	–
South	−0.08472	−0.20766, 0.03822	.177
Midwest	−0.0585	−0.19105, 0.074046	.387
West	−0.07955	−0.21946, 0.060358	.265