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Hospital Readmissions Among Post-acute Nursing Home Residents: Does Obesity Matter?

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Abstract

Objectives: To explore profiles of obese residents who receive post-acute care in nursing homes (NHs) and to assess the relationship between obesity and hospital readmissions and how it is modified by individual comorbidities, age, and type of index hospitalizations.

Design: Retrospective cohort study.

Setting and participants: Medicare fee-for-service beneficiaries who were newly admitted to free-standing US NHs after an acute inpatient episode between 2011 and 2014 (N = 2,323,019).

Measures: The Minimum Data Set 3.0 were linked with Medicare data. The outcome variable was 30-day hospital readmission from an NH. Residents were categorized into 3 groups based on their body mass index (BMI): nonobese, mildly obese, moderate-to-severely obese. We tested the relationship between obesity and 30-day readmissions by fixed-effects logit models and stratified analyses by the type of index hospitalization and residents' age.

Results: Forty percent of the identified residents were admitted after a surgical episode, and the rest were admitted after a medical episode. The overall relationship between obesity and readmissions suggested that obesity was associated with higher risks of readmission among the oldest old (≥85 years) residents but with lower risks of readmission among the youngest group (65–74 years). After accounting for individual co-covariates, the association between obesity and readmissions among the oldest old residents became weaker; the adjusted odds ratio was 1.061 (P = .049) and 1.004 (P = .829) for moderate-to-severely obese patients with surgical and medical index hospitalizations, respectively. The protective effect of obesity among younger residents reduced after adjusting for covariates.

Conclusions/Relevance: The relationship between obesity and hospital readmission among post-acute residents could be affected by comorbidities, age, and the type of index hospitalization.

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Further studies are also warranted to understand how to effectively measure NH quality outcomes, including hospital readmissions, so that policies targeting at quality improvement can successfully achieve their goals without unintended consequences.

Keywords

Readmission; post-acute; nursing home; obesity

The prevalence of obesity among older adults increased significantly in the last decade.[1–3] It is reported that 40% of older adults in the United States were obese in 2010.[4] As the rate of obesity in this population continues to increase, its impact will be disproportionately felt in nursing homes (NHs) because obesity itself is a risk factor for admission[5] and because obesity-related conditions are known to accelerate disability,[6] thus exacerbating the need for NH care. Obesity presents great challenges to NHs.[7] Providing optimal care to residents with obesity can be expensive as these residents may have special care needs directly related to their body weight as well as to comorbidities. Accommodating their care needs to provide optimal outcomes may require NHs to invest in additional staffing and other resources.[8–11]

One NH outcome that is currently the focus of policy makers is 30-day hospital readmissions among post-acute residents [ie, who receive skilled nursing facility (SNF) care]. Hospital readmission is a quality outcome because readmissions among SNF residents are often associated with many negative consequences, such as further deterioration in physical and functional status, and are potentially preventable and/or manageable.[12] To reduce hospital readmissions among post-acute residents, the Centers for Medicare and Medicaid Services (CMS) started to publish NH risk-adjusted hospital read-mission rates on its 2016 Nursing Home Compare (NHC) quality report card.[13] In addition, the CMS is starting to use 30-day readmission rates to adjust Medicare payments for SNFs, beginning in October 2018.[14] The success and effectiveness of these policies partially depend on how hospital readmissions are measured. Although the current CMS risk-adjustment algorithm for hospital readmissions incorporates a long list of risk factors, it does not include obesity. With the increasing prevalence of obesity in NHs, it is important to understand the relationship between obesity and readmissions.

Obesity is likely to increase the risk of readmissions among post-acute NH residents. For example, obesity has been found to be associated with longer length of hospital stay.[15–18] The complexity of the inpatient episode may increase the likelihood of readmission. In addition, obesity itself or obesity-related comorbidities, such as diabetes or cardiovascular disease, may increase the complexity level of NH care. In fact, one recently published study examined the relationship between obesity and readmissions among residents who received post-acute care in SNFs after hip fracture and found that obesity was related to higher risks of hospital readmissions.[19] The study provided valuable information regarding the potential impact of obesity on risks of hospital readmissions among NH residents. However, the study did not include many of the risk factors that CMS has used to construct the 30-day readmission measure.[13] Furthermore, the study focused on residents with hip fractures, whereas many post-acute residents are admitted to NHs after medical inpatient episodes or other surgical procedures. With the target of reducing overall hospital readmissions in NHs,

it is important to understand if obesity is an important, independent, currently omitted risk factor for hospital readmissions among all post-acute-care residents. If it is, the publically reported read-mission measures may penalize NHs with high prevalence of obese residents and provide NHs with a disincentive to admit such residents.

The main objective of this study is to examine the profiles of obese residents who receive post-acute care in NHs and to assess whether they have an increased risk for readmissions. By using national data between 2011 and 2014, we explored the relationship between obesity and hospital readmissions, and how this relationship is modified by coexisting conditions, age, and type of index hospitalizations, among residents receiving post-acute care in NH.

Methods

Data

We linked 2011–2014 National data sets, including the Minimum Data Set (MDS) 3.0, Medicare master beneficiary summary file (MBSF), and Medicare Provider and Analysis Review (MedPAR) file. The MDS 3.0 assessments are required for all Medicare- and/or Medicaid-certified NHs. Residents are assessed at least at admission, quarterly, and at discharge. The MDS 3.0 contains information on residents' demographics and detailed health conditions, such as individual weight, height, functional status, and comorbidities. The MBSF contains information on individuals' Medicare enrollment status (eg, managed care and Medicare-Medicaid dual eligibility) and diagnoses of chronic conditions (Chronic Conditions segments of MBSF).[20] The MedPAR file provides information on inpatient stays, such as type of stay (ie, acute hospital, inpatient rehabilitation facility, or SNF), admission and discharge dates, Diagnosis Related Groups (DRGs) of the acute episode, and the use of intensive care unit (ICU).

Cohort

We included all free-standing Medicare- and/or Medicaid- certified NHs in the United States. We identified individuals who were 65 years and older and who were newly admitted to the identified NHs after an acute inpatient event between July 1, 2011, and November 30, 2014. Admissions were considered to be new if there was no prior NH stay in the past 180 days. We then selected individuals who were continuously enrolled in Medicare fee-for-service for the 12 months before and 30 days after the NH admission. If a resident had multiple qualified new NH admissions during the study period, the first NH admission was selected. Residents with body mass index (BMI) lower than 20 were excluded because low body weight may pose different health risks among older adults in NHs. Our final sample included 2,323,019 unique patients from 14,765 NHs.

Variables

Following the CMS measure of 30-day readmissions, the outcome variable was defined as dichotomous, indicating whether a resident was readmitted to a hospital from an NH within 30 days of an identified NH admission. We referred to the hospitalization that led to the identified NH admission as the "index hospitalization." The main independent variable of

interest was obesity status. Residents were categorized into 3 groups based on their BMI at NH admission. Following the definition developed and used by the World Health Organization,[21] residents were identified as mildly obese (35 > BMI ≥ 30) or moderate-to-severely obese (BMI ≥ 35); otherwise they were considered to have normal BMI.

We identified a detailed list of individual covariates, including risk factors used by the CMS, at NH admission to account for potential confounding effects between obesity and hospital readmissions. These covariates included individual sociodemographic characteristics (age, gender, race, and Medicare-Medicaid dual eligibility), physical function (measured as activities of daily living),[22] cognitive function (measured by Cognitive Function Scale),[23] health conditions (eg, pain, continence, shortness of breath, pressure ulcers), treatment received (eg, feeding tube, ostomy care, insulin use) and chronic conditions or diagnoses (eg, Alzheimer's disease or dementia, congestive heart failure, and diabetes). Furthermore, we extracted the characteristics of the "index hospitalization" from MedPAR file, including type of episodes (surgical vs medical), length of stay, DRG weights (reflecting the complexity of the inpatient episode), and whether ICU service was involved. Lastly, we identified whether there were any hospitalizations within 30, 31 to 180, and 181 to 365 days prior to the index hospitalizations because prior hospitalizations may increase the risk of hospital readmissions.

Statistical Analysis

We first compared the characteristics of the index hospitalization, as well individual characteristics, across the 3 BMI groups. We then tested the relationship between obesity and 30-day readmissions within a facility by applying a set of conditional fixed-effects logit models.[24,25] We first estimated a set of fixed-effects logit models without adjusting for other covariates. This set of models captured the overall relationship between obesity and readmissions. This relationship, however, could be confounded or mediated by conditions coexisting with obesity. Therefore, we then estimated a set of models fully adjusted for all identified covariates.

We stratified all analyses by type of index hospital-izationd — residents who had a surgical vs medical inpatient episode, because these 2 types of residents could be very different regarding to their health conditions and care needs. We further stratified the analyses by residents' age (65–74, 75–84, and ≥85), as obesity may have different impacts on overall health for younger vs for older persons, and age can modify the relationship between individual characteristics, and in particular obesity and readmissions.

Lastly, we performed a sensitivity analysis to check the robustness of the findings. We identified a group of surgical residents with the 10 most common procedures [eg, "major joint replacement or reattachment of lower extremity without a major complication or comorbidity" and "hip & femur procedures (except major joint) with a complication or comorbidity"], which accounted for 55.64% of all identified surgical residents.

This study was approved by the institutional review board at the University of Rochester.

Results

Among the identified SNF residents, 40% were admitted after a surgical procedure, and the rest were admitted after a medical inpatient episode. The prevalence of obesity appeared to be higher among surgical residents than medical residents; 21% and 19% of the surgical residents had mild (BMI: 30–35) and moderate-to-severe obesity (≥35), whereas 16% and 13% of the medical residents had mild and moderate-to-severe obesity. The most common type of surgical index hospitalizations was “joint replacement and hip & femur procedures.” The distributions of the types of surgical procedures varied across 3 BMI groups. Forexample, the surgical procedure with “major joint replacement or reattachment of lower extremity without mcc” accounted for 41.62% of all the surgical procedures among moderate-to-severely obese residents, but only for 25.55% of the surgical episodes among nonobese residents. There was more heterogeneity in medical index hospitalizations. For example, the most common medical index hospitalization, “septicemia,” only accounted for 5% to 6% of the total medical index hospitalizations. Cellulitis was one of the most common types of medical hospitalization among patients with BMI ≥35 (4.18%), but not among nonobese residents (results available in Appendix 1).

Table 1 presents descriptive statistics by medical/sugical index hospitalizations and BMI groups. Residents with higher BMI were younger, more likely to be black, less likely to be cognitively impaired, and more likely to be dually eligible for Medicare and Medicare. The distribution of chronic conditions was mixed; for example, obese residents were more likely to have comorbidities such as heart failure, hypertension, and depression, but were less likely to have dementia.

The overall readmission rates varied by the type of index hospitalization and the BMI groups (Table 1). The unadjusted readmission rates were 13.4%, 11.6%, and 11.3% among surgical residents with normal BMI, mild obesity, and moderate-to-severe obesity, and were 15.9%, 16.6%, and 17.4% among medical residents with these 3 BMI categories, respectively. The characteristics of index hospitalizations varied with BMI categories as well as the type of hospitalizations. For example, among those with medical hospitalizations, obese residents’ index hospitalization appeared to be more complex, characterized by higher DRG weights (1.25 for moderate-to-severely obese vs 1.20 for nonobese residents), longer length of stay, and more ICU use. However, among those with surgical index hospitalizations, obese residents had less complex procedures than nonobese residents.

The findings from the regression analyses are presented in Table 2. The overall relationship between obesity and 30-day readmissions (ie, fixed-effects logit model without adjusting for other individual covariates) appeared to be affected by individual age. For example, the oldest old (85+) obese residents experienced higher risks of readmissions than nonobese residents within the same facility, for both surgical and medical index hospitalizations [odds ratio (OR) = 1.164, $P < .01$, and 1.137, $P < .01$, for surgical and medical residents with moderate-to-severe obesity, respectively). However, obesity seems to be a protective factor for readmissions for the youngest groups. For example, among those aged 65–74 years, obese residents were less likely to be readmitted to hospitals than nonobese residents within

the same facility (OR = 0.827, $P < .01$, and 0.963, $P < .01$, for surgical and medical residents with moderate-to-severe obesity, respectively).

The relationship between obesity and readmissions changed after adjusting for other individual risk factors, and the direction of this change varied with age and type of index hospitalizations. For example, after accounting for individual co-covariates, we detected reduced association between obesity and readmissions among the oldest old residents: the adjusted OR was 1.061 ($P = .049$) and 1.004 ($P = .829$) for surgical and medical residents with moderate-to-severe obesity, respectively. However, additional risk factors reduced the protective effect of obesity on readmissions for younger surgical residents (ie, 65–74); younger surgical residents with moderate-to-severe obesity experienced higher risks of readmissions (adjusted OR = 1.042, $P = .020$) than nonobese residents after full risk adjustment.

Findings from the sensitivity analyses were mostly consistent with the main analyses, with a few variations. The direction of the relationship between obesity and readmissions were consistent with the main analyses (results presented in Appendix 3).

Discussion

We examined the relationship between obesity and 30-day hospital readmissions in a national population of newly admitted NH residents following an acute medical or surgical inpatient hospital episode. We found significant variations in patients' characteristics between obese and nonobese residents by age and the type of hospitalizations. The relationship between obesity and readmissions also varied by the resident's age and the type of index hospitalization. Among residents who were 85 years or older, those who were obese in general had higher risks of readmissions than nonobese residents of the same age. The increased risks of readmissions among this population may be partially, but not completely, explained by coexisting conditions or characteristics of index hospitalizations. The relationship between obesity and readmissions among younger residents was mixed.

Residents aged 85 or older are most vulnerable to potentially negative consequences associated with readmissions; they are generally frail, have multiple chronic conditions and functional limitations, and are susceptible to further decline in functional status. Obesity may exacerbate the level of frailty for this population because it often coexists with higher prevalence of comorbidities and more functional limitations.[6,26,27] The higher level of frailty may contribute to higher readmission risks among these oldest old obese residents. Indeed, after accounting for many health conditions, the relationship between obesity and 30-day readmissions, especially among those with medical index hospitalization, has been largely reduced, suggesting that coexisting conditions modify the effect of obesity on hospital readmissions.

However, the comprehensive set of individual health conditions, including risk factors used by the CMS, cannot completely explain the higher readmissions experienced by these oldest old obese residents, especially among those with surgical index hospital admission. After accounting for comorbidities, the oldest old surgical residents with moderate-to-severe

obesity had 6% higher odds of readmissions compared with their counterparts with normal BMI. The remaining relationship between obesity and hospital readmission risks may be attributable to obesity itself or some uncaptured coexisting conditions. Although it is unclear which factor contributes to the remaining relationship between obesity and readmission, the findings suggest that the current CMS risk-adjustment algorithm, which does not account for resident's obesity status, may have some unintended consequences, both for NHs and for the oldest old residents who generally have higher care needs. For example, NHs may be penalized for high readmission rates, which may subsequently create access barriers for obese residents with high needs. Indeed, there are concerns that obese patients have difficulties in accessing NHs due to the burden of care for NHs.[28] Obese residents may face higher barriers in accessing high-quality NHs, which generally have more demand and longer waiting lists. Although the detected relationship between obesity and read-missions was modest, the access barriers might be more significant with the implementation of the new SNF value-based purchase policy, which may penalize NHs with high prevalence of obese residents if obesity status is not appropriately considered.

The higher likelihood of readmissions among the oldest old obese residents, although some of it can be explained by coexisting conditions, also suggests the overall higher care needs in NHs of obese residents. It is likely that the high admission rates among the oldest old obese residents can be reduced with care that appropriately accommodates their needs. However, it is unknown whether the current payment system has adequately captured the resources necessary for providing optimal care to obese residents. The provision of such care may require additional investment in equipment and staff time.[7,9,29,30] Yet, obesity status is not included in the algorithms setting prospective payment rates for SNF care, and this may create a barrier for NHs to invest in resources needed to provide high-quality care to obese residents. Unfortunately we are not able to determine the extent to which the Medicare payment rates contribute to the readmission rates among obese residents as Medicare SNF rates are set by the CMS and the case-mix adjustment algorithm is standard in the country.

Our findings also highlight the role of age and type of index hospitalizations in evaluating hospital readmission rates. Individual characteristics and health conditions vary across age groups and type of index hospitalizations. For example, surgical patients are generally younger and less likely to have physical and cognitive impairment than medical residents, suggesting these residents could have different levels of complexity and care needs. The relationship between obesity and readmission also differs by age and type of index hospitalization. For example, obesity appears to be an independent risk factor for readmissions among surgical residents aged 85 years or older, but not among medical residents younger than 75 years. Although it is unclear what leads to the inconsistent effects of obesity across different groups of obese residents, our findings suggest that age can have a multiplicative effect on the relationship between risk adjustors (eg, obesity) and readmissions. Although some of the quality measures on the CMS NHC quality report card are risk adjusted, the risk-adjustment algorithms generally assume additive relationships across the risk factors. The relationship between a risk factor and outcomes can be misleading without considering the potential multiplicative effects between risk factors. For example, NHs may be motived to seek certain residents, such as younger obese residents, so that they may benefit from the lower risks of readmission among these residents (eg, quality

measure and value-based payment). Thus, it may be important to evaluate the relationship between risk factors and hospital readmissions by age groups and the type of index hospitalizations.

There are some limitations of the study. First, although we have accounted for a detailed list of individual covariates, there can still be uncaptured health conditions confounding the relationship between obesity and hospital readmission risks. Nevertheless, our findings suggest that obese residents may have different care needs than nonobese residents, either through obesity itself or other potential coexisting conditions. Second, this study focused on new NH admissions. Residents who had previous NH stays may be sicker and at higher risks of readmissions than the population included in this study; however, it is unclear whether this may be related to obesity or not. Third, this study is only focused on the relationship between obesity and post-acute residents. The quality of NH care is multidimensional, and the relationship between obesity and quality outcomes among long-stay NH residents could be different. Fourth, although our measurement of readmission was consistent with the CMS's definition of hospital readmissions in SNFs, we did not differentiate whether the readmissions were "necessary" or "unnecessary." Lastly, this study was focused on Medicare beneficiaries, most of whom were 65 years and older; thus, we were not able to capture the relationship between obesity and readmissions among younger post-acute care population.

Conclusions/Relevance

In conclusion, we explored the relationship between obesity and hospital readmissions among newly admitted residents who received post-acute care in NHs. We found the relationship between obesity and readmissions could be affected by coexisting conditions or comorbidities and could be modified by age and the types of index hospitalization. Future studies are needed to explore other outcomes experienced by obese residents in NHs. Further studies are also warranted to understand how to effectively measure NH quality outcomes, including hospital readmissions, so that policies targeting quality improvement can successfully achieve their goals without unintended consequences.

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Appendix

Appendix 1

Most Common Diagnosis Related Groups (DRGs) for Surgical and Medical Hospitalization by Obesity Status

Most Common DRGs for Surgical Index Hospitalization by Obesity Status					
Nonobese		**Mild Obese**		**Severe Obese**	
DRG Title	**%**	**DRG Title**	**%**	**DRG Title**	**%**

Major joint replacement or reattachment of lower extremity W/O MCC	25.55	Major joint replacement or reattachment of lower extremity W/O MCC	36.76	Major joint replacement or reattachment of lower extremity W/O MCC	41.62
Hip & femur procedures except major joint W CC	11.30	Hip & femur procedures except major joint W CC	6.08	Hip & femur procedures except major joint W CC	3.97
Hip & femur procedures except major joint W/O CC/MCC	3.50	Spinal fusion except cervical W/O MCC	3.08	Spinal fusion except cervical W/O MCC	3.14
Hip & femur procedures except major joint W MCC	2.95	Major joint replacement or reattachment of lower extremity MCC	2.05	Lower extrem & humer proc except hip, foot, femur W CC	2.41
Major joint replacement or reattachment of lower extremity W MCC	2.59	Hip & femur procedures except major joint W/O CC/MCC	1.88	Major joint replacement or reattachment of lower extremity W MCC	1.95
Major small & large bowel procedures W MCC	2.20	Lower extrem & humer proc except hip, foot, femur W CC	1.82	Revision of hip or knee replacement W CC	1.83
Spinal fusion except cervical W/O MCC	1.90	Hip & femur procedures except major joint W MCC	1.63	Infectious & parasitic diseases W o.r. procedure W MCC	1.66

Most Common DRGs for Medical Index Hospitalization by Obesity Status

Nonobese		**Mild Obese**		**Severe Obese**	
DRG Title	**%**	**DRG Title**	**%**	**DRG Title**	**%**
Septicemia or severe sepsis W/O MV 96+ hours W MCC	5.11	Septicemia or severe sepsis W/O MV 96+ hours W MCC	5.64	Septicemia or severe sepsis W/O MV 96+ hours W MCC	6.20
Kidney & urinary tract infections W/O MCC	3.86	Kidney & urinary tract infections W/O MCC	3.76	Cellulitis W/O MCC	4.18
Medical back problems W/O MCC	2.65	Renal failure W CC	2.93	Heart failure & shock W MCC	3.84
Renal failure W CC	2.49	Heart failure & shock W MCC	2.89	Heart failure & shock W CC	3.65
Heart failure & shock W MCC	2.42	Heart failure & shock W CC	2.74	Renal failure W CC	3.51
Simple pneumonia & pleurisy W CC	2.38	Medical back problems W/O MCC	2.61	Kidney & urinary tract infections W/O MCC	3.40
Heart failure & shock W CC	2.36	Intracranial hemorrhage or cerebral infarction W CC	2.22	Septicemia or severe sepsis W/O MV 96+ hours W/O MCC	2.54
Intracranial hemorrhage or cerebral infarction W CC	2.30	Renal failure W MCC	2.17	Medical back problems W/O MCC	2.48
Degenerative nervous system disorders W/O MCC	2.29	Simple pneumonia & pleurisy W CC	2.16	Renal failure W MCC	2.41
Fractures of hip & pelvis W/O MCC	2.28	Cellulitis W/O MCC	2.16	Pulmonary edema & respiratory failure	2.27

W MCC, with major complication or comorbidity; W CC, with complication or comorbidity; W/O CC/MCC, without major or nonmajor complication and comorbidity. Percentages present in the table indicate the proportion within certain obesity group and type of index hospitalization, for example, “MAJOR JOINT REPLACEMENT OR REATTACHMENT OF LOWER EXTREMITY W/O MCC” accounts for 25.55% of nonobese residents from surgical hospitalization.

Appendix 2

Conditional Fixed-Effects Logit Model (Full)

Variables	Surgical			Medical		
	65–74-y-Old	75–84-y-Old	>85-y-Old	65–74-y-Old	75–84-y-Old	>85-y-Old
Main effect						
Obesity status: mild	0.961**	1.027*	1.053***	0.974*	0.985	1.026**
Obesity status: severe	1.042**	1.027	1.061**	0.923***	0.954***	1.004
Sociodemographic						
Black	1.074***	1.114***	1.079**	1.010	1.067***	1.104***
Other race	1.038	1.034	0.962	1.017	1.007	1.002
Dual status	0.993	0.974	0.965	0.959***	0.938***	0.952***
Age	0.996*	1.006***	0.998	0.997	0.994***	0.986***
Male	1.093***	1.092***	1.189***	1.038***	1.118***	1.180***
Functional status						
Cognitive Function Scale score						
2	1.839***	1.669***	1.387***	1.492***	1.355***	1.299***
3	1.520***	1.418***	1.296***	1.434***	1.352***	1.246***
4	1.207***	1.149***	1.104**	1.250***	1.218***	1.096***
Missing	3.341***	3.434***	3.131***	2.663***	2.766***	2.648***
Activities of daily living	1.089***	1.091***	1.076***	1.065***	1.064***	1.053***
Chronic conditions						
Cancer	1.201***	1.072***	0.971**	1.200***	1.090***	1.022**
Coronary artery disease: Yes	1.056***	1.073***	1.125***	1.101***	1.103***	1.126***
Coronary artery disease: missing	0.287***	0.298***	0.390***	0.409***	0.386***	0.388***
Heart failure	1.249***	1.282***	1.256***	1.214***	1.213***	1.239***
Hypertension	1.070**	1.048	1.038	1.000	0.946**	0.922***
Diabetes	1.063***	1.042***	1.008	1.024	1.013	1.012
Alzheimer's or dementia	0.897***	0.868***	0.843***	0.809***	0.802***	0.825***
COPD/asthma	1.059***	1.072***	1.042***	0.998	1.046***	1.029***
Peripheral vascular disease	1.183***	1.111***	1.033**	1.023*	1.003	0.960***
Pneumonia	1.403***	1.655***	1.808***	1.265***	1.289***	1.333***
Septicemia	1.344***	1.440***	1.722***	1.163***	1.209***	1.238***
Urinary tract infection	1.320***	1.389***	1.401***	1.154***	1.219***	1.268***
Wound infect	1.838***	2.023***	1.843***	1.182***	1.291***	1.269***
Hip fracture	1.035	1.033	1.065***	1.224***	1.396***	1.530***
Other fracture	1.182***	1.066***	1.019	0.982	0.978	1.041***
Stroke	0.987	1.003	1.017	0.917***	0.936***	0.966***
Anxiety	1.047***	1.030**	1.044***	1.001	1.013	1.012
Depression	1.012	0.984	0.942***	0.926***	0.940***	0.927***

Variables	Surgical			Medical		
	65–74-y-Old	75–84-y-Old	>85-y-Old	65–74-y-Old	75–84-y-Old	>85-y-Old
Bipolar	0.968	0.981	0.925*	0.941***	0.942***	0.946**
Psychotic disorder	1.122**	1.134***	0.933	1.127***	1.168***	1.101***
Schizophrenia	0.784***	0.899*	0.925	0.855***	0.877***	0.965
Respiratory failure	0.901**	1.023	1.276***	1.071***	1.098***	1.151***
Anemia	1.095***	1.111***	1.092***	1.197***	1.191***	1.162***
Ulcerative colitis/ Crohn's disease = 1	1.146*	1.076	0.993	1.114*	1.142***	0.986
Ulcerative Colitis/ Crohn's disease = missing	11.00***	12.85***	13.14***	8.428***	9.507***	10.14***
Viral hepatitis	1.183*	0.836	1.616**	1.121	1.170*	1.156
Seizure disorder or epilepsy	0.941*	1.015	0.993	0.885***	0.941***	0.946**
Index hospitalization						
DRG weights	1.005	1.013***	1.018***	0.989	1.022***	1.056***
Hospital length of stay: <3 d	0.558***	0.651***	0.803***	0.840***	0.815***	0.856***
Hospital length of stay: >8 d	1.572***	1.409***	1.270***	1.317***	1.297***	1.233***
Use of intensive care unit	1.197***	1.175***	1.106***	1.051***	1.101***	1.110***
Any hospitalization in prior 30 d	1.314***	1.313***	1.289***	1.387***	1.351***	1.303***
Any hospitalization in prior 31–180 d	1.238***	1.183***	1.137***	1.261***	1.234***	1.160***
Any hospitalization in prior 181–365 d	1.145***	1.150***	1.088***	1.121***	1.097***	1.061***
MDS-based other conditions						
End-stage prognosis	0.491***	0.324***	0.294***	0.264***	0.251***	0.214***
Any fall in prior 30 d						
Yes	0.990	1.038**	0.996	0.971*	0.965***	0.963***
Unable to answer	1.086*	1.152***	1.064	0.981	1.083***	1.000
Missing	0.832*	0.754***	0.709***	0.828**	0.845***	0.788***
Any fall in prior 31–180 d						
Yes	1.003	1.023	0.998	0.994	0.997	1.002
Unable to answer	1.138***	1.057**	1.078***	1.131***	1.087***	1.102***
Missing	1.207*	1.259***	1.199***	1.166**	1.104*	1.138***
Venous/arterial ulcer present	1.403***	1.412***	1.477***	1.192***	1.181***	1.247***
Infection of the foot	1.098*	1.284***	1.332***	1.050	1.163***	1.153***
Diabetic foot ulcer	1.082	1.239***	1.115	1.176***	1.217***	1.320***
Dehydrate	1.660***	1.498***	1.042	1.124	1.234***	1.125**
Internal bleeding	2.531***	2.514***	2.310***	2.124***	2.024***	2.073***
Pain frequency						
Almost constant	0.935**	0.961	1.048	1.074***	1.079***	1.088***
Frequently	0.848***	0.897***	0.968*	1.074***	1.071***	1.078***

Variables	Surgical			Medical		
	65–74-y-Old	75–84-y-Old	>85-y-Old	65–74-y-Old	75–84-y-Old	>85-y-Old
Occasionally	0.760***	0.806***	0.896***	0.981	0.971**	1.015
Rarely	0.752***	0.820***	0.806***	0.980	0.965	0.951**
Unable to answer	0.847	0.892	0.983	1.089	0.984	1.057
Surgical wound	0.931***	0.918***	0.960**	1.044**	1.039**	1.096***
Bowel continent						
Occasionally incontinent	1.269***	1.205***	1.188***	1.147***	1.142***	1.132***
Frequently incontinent	1.326***	1.279***	1.269***	1.211***	1.215***	1.171***
Always incontinent	1.190***	1.185***	1.226***	1.160***	1.144***	1.123***
Not rated	1.250***	1.116***	1.421***	1.087*	1.175***	1.132***
Shortness of breath with exertion	1.296***	1.281***	1.290***	1.232***	1.257***	1.287***
Shortness of breath when sitting rest	1.670***	1.741***	1.553***	1.439***	1.474***	1.473***
Shortness of breath when lying flat	1.034	1.119***	1.160***	1.074***	1.075***	1.118***
Parenteral/intravenous feeding	1.858***	1.872***	1.646***	1.843***	1.595***	1.454***
Feeding tube	0.947	0.919**	0.947	0.927***	0.955**	1.110***
Ostomy care	1.371***	1.381***	1.068	1.132**	1.105**	1.018
Antibiotic received: Yes	1.146***	1.049***	1.020	1.017	0.972***	0.976***
Antibiotic received: missing	0.878***	0.874***	0.823***	0.878***	0.835***	0.819***
Insulin injection	1.140***	1.166***	1.202***	1.110***	1.161***	1.145***
Year: 2012	0.949**	1.021	1.016	1.005	1.035**	1.028**
Year: 2013	0.932***	1.005	0.995	0.988	1.006	0.964**
Year: 2014	0.928***	0.957**	0.971	0.972	0.984	0.966**
Observations	276,199	365,313	230,580	251,900	499,497	601,848

*$P < .1$,
**$P < .05$,
***$P < .01$.

Appendix 3

Sensitivity Analysis: Surgical Subgroup

Variables	(1) 65–74-y-Old	(2) 75–84-y-Old	(3) > 85-y-Old
Main effect			
Obesity status: mild	0.972	1.089***	1.074**
Obesity status: severe	1.156***	1.149***	1.067
Sociodemographic			
Black	1.097*	1.103*	1.065
Other race	0.947	0.965	0.979

Variables	(1) 65–74-y-Old	(2) 75–84-y-Old	(3) > 85-y-Old
Dual status	0.969	1.037	0.969
Age	0.996	1.015***	1.002
Male	1.209***	1.166***	1.241***
Functional status			
Cognitive Function Scale score			
2	2.073***	1.766***	1.351***
3	1.439***	1.445***	1.285***
4	1.192	1.139*	1.028
Missing	3.432***	3.889***	3.014***
Activities of daily living	1.120***	1.103***	1.072***
Chronic conditions			
Cancer	1.113***	1.033	0.939***
Coronary artery disease: Yes	1.041	1.095***	1.130***
Coronary artery disease: Missing	0.196***	0.284***	0.461***
Heart failure	1.307***	1.296***	1.262***
Hypertension	1.192***	1.091*	1.151***
Diabetes	1.005	1.025	1.027
Alzheimer’s or dementia	0.923*	0.855***	0.843***
COPD/asthma	1.097***	1.103***	1.049**
Peripheral vascular disease	1.233***	1.115***	1.017
Pneumonia	1.803***	1.885***	2.153***
Septicemia	2.353***	2.706***	3.951***
Urinary tract infection	1.359***	1.494***	1.473***
Wound infect	2.892***	3.173***	2.451***
Hip fracture	1.265***	1.169***	1.105***
Other fracture	1.582***	1.251***	1.115***
Stroke	1.011	1.052**	1.013
Anxiety	1.120***	1.038*	1.039*
Depression	1.026	0.995	0.928***
Bipolar	1.084	0.967	0.995
Psychotic disorder	1.016	1.092	0.958
Schizophrenia	0.931	0.777**	0.918
Respiratory failure	1.445***	1.327***	1.199*
Anemia	1.116***	1.103***	1.054**
Ulcerative colitis/Crohn’s disease: Yes	0.979	1.067	1.071
Ulcerative colitis/Crohn’s disease: missing	14.34***	15.36***	14.20***
Viral hepatitis	1.199	0.730	1.441
Seizure disorder or epilepsy	0.907	1.051	0.944
Index hospitalization			
DRG weights	1.229***	1.145***	1.072***
Hospital length of stay: <3 d	0.755***	0.790***	0.841***

Variables	(1) 65–74-y-Old	(2) 75–84-y-Old	(3) > 85-y-Old
Hospital length of stay: >8 d	1.273***	1.204***	1.163***
Use of intensive care unit	1.188***	1.142***	1.124***
Any hospitalization in prior 30 d	1.461***	1.377***	1.401***
Any hospitalization in prior 31–180 d	1.207***	1.219***	1.114***
Any hospitalization in prior 181–365 d	1.130***	1.143***	1.087***
MDS-based other conditions			
End-stage prognosis	0.829	0.494***	0.447***
Any fall in prior 30 d			
Yes	1.102**	1.171***	1.123***
Unable to answer	1.250**	1.167**	1.167*
Missing	1.023	0.753**	0.693***
Any fall in prior 31–180 d			
Yes	0.955	1.031	0.985
Unable to answer	1.069	1.057	1.034
Missing	0.894	1.265**	1.156
Venous/arterial ulcer present	1.209	1.054	1.271**
Infection of the foot	1.846**	0.897	1.225
Diabetic foot ulcer	0.579**	1.436*	0.981
Dehydrate	2.555***	1.600**	0.966
Internal bleeding	2.864***	3.016***	2.533***
Pain frequency			
Almost constant	0.766***	0.836***	0.948
Frequently	0.663***	0.743***	0.885***
Occasionally	0.583***	0.680***	0.794***
Rarely	0.493***	0.694***	0.725***
Unable to answer	0.821	0.708***	0.966
Surgical wound	1.102*	0.938*	0.950
Bowel continent			
Occasionally incontinent	1.198***	1.243***	1.244***
Frequently incontinent	1.371***	1.321***	1.322***
Always incontinent	1.177**	1.240***	1.266***
Not rated	1.229**	1.244***	1.514***
Shortness of breath with exertion	1.282***	1.330***	1.236***
Shortness of breath when sitting rest	1.811***	1.708***	1.527***
Shortness of breath when lying flat	0.939	1.120**	1.130***
Parenteral/intravenous feeding	2.156***	2.410***	1.832***
Feeding tube	1.221	0.935	0.927
Ostomy care	1.173	1.184*	1.031
Antibiotic received: Yes	1.141***	0.961*	0.936***
Antibiotic received: missing	0.884**	0.846***	0.751***
Insulin injection	1.137***	1.160***	1.196***

Variables	(1) 65–74-y-Old	(2) 75–84-y-Old	(3) > 85-y-Old
Year: 2012	0.949	1.105***	0.990
Year: 2013	0.931	1.055	0.974
Year: 2014	0.933	0.967	0.932*
Observations	129,237	178,346	116,455
Number of facilities	4757	6514	6556

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Table 1

Individual Characteristics by Type of Index Hospitalization and Obesity Status

Variable	Surgical Index Hospitalization			Nonsurgical Index Hospitalization		
	Nonobese, % (n = 561,324)*	Mild Obese, % (n = 194,714)	Severe Obese, % (n = 172,304)	Nonobese, % (n = 986,784)	Mild Obese, % (n = 225,040)	Severe Obese, % (n = 182,853)
Main outcome						
Rehospitalization rate	13.4	11.6	11.3	15.9	16.6	17.4
Characteristics of index hospitalization						
Diagnosis-related groups (DRG) weights	2.93 (1.78)	2.88 (1.69)	2.85 (1.64)	1.20 (0.61)	1.21 (0.65)	1.25 (0.71)
Length of stay						
≤3 d	26.0	37.8	42.7	25.7	24.3	21.7
Between 4 and 7 d	42.2	36.2	33.1	46.4	46.3	45.9
≥8 d	31.8	26.0	24.2	27.9	29.4	32.4
Use of Intensive care unit (ICU)	29.5	25.4	23.6	27.7	29.1	30.6
Any hospitalization in prior 30 d	10.0	8.4	7.9	16.8	18.3	19.9
Any hospitalization in prior 31–180 d	14.4	12.4	11.9	19.8	20.9	22.3
Any hospitalization in prior 181–365 d	14.8	13.8	13.7	19.8	21.0	22.4
Sociodemographics						
Race						
White	86.6	86.7	85.5	84.6	84.2	82.7
Black	5.2	5.9	7.8	7.3	8.5	10.4
Other	8.2	7.4	6.7	8.1	7.3	6.9
Age	81.02 (7.82)	77.39 (7.26)	74.05 (6.48)	83.68 (7.78)	80.90 (7.75)	77.16 (7.49)
Male	36.0	34.7	26.1	39.9	36.4	27.9
Medicare-Medicaid dual eligibility	14.4	14.3	16.5	19.7	23.1	28.2
Functional status						
Activities of daily living (ADL)	17.10 (4.39)	16.33 (4.36)	16.34 (4.23)	17.46 (4.70)	17.15 (4.66)	17.32 (4.48)
Cognitive Function Scale score						
1	66.7	79.2	85.0	47.8	57.3	68.0
2	19.4	14.8	11.8	25.7	24.3	21.0
3	11.6	5.1	2.7	22.1	15.7	9.5
4	2.2	0.9	0.4	4.5	2.7	1.5

Variable	Surgical Index Hospitalization			Nonsurgical Index Hospitalization		
	Nonobese, % (n = 561,324)*	Mild Obese, % (n = 194,714)	Severe Obese, % (n = 172,304)	Nonobese, % (n = 986,784)	Mild Obese, % (n = 225,040)	Severe Obese, % (n = 182,853)
Missing	1.7	1.6	1.7	2.0	2.0	2.0
Chronic conditions						
Cancer	23.8	21.5	18.9	21.7	21.0	18.2
Coronary artery disease						
Yes	21.8	21.1	18.9	24.5	26.2	24.9
No	60.7	57.5	59.6	61.1	58.9	60.4
Missing	17.5	21.4	21.4	14.4	14.9	14.7
Heart failure	45.7	44.6	45.7	60.9	68.4	75.1
Hypertension	92.8	94.8	96.3	95.9	97.8	98.4
Diabetes	41.6	52.4	61.5	48.4	64.5	75.8
Alzheimer’s or dementia	30.9	18.4	11.8	52.5	43.6	31.2
Asthma/Chronic Obstructive Pulmonary Disease (COPD)	42.6	42.3	45.6	51.3	56.0	62.7
Peripheral vascular disease	37.5	34.4	31.1	44.6	46.6	46.5
Pneumonia	5.8	4.0	3.2	16.4	15.1	13.3
Septicemia	1.2	1.1	1.1	2.6	3.0	3.3
Urinary tract infection	14.4	11.3	10.6	24.0	23.9	23.9
Wound infection	3.4	4.0	5.1	1.3	1.8	3.1
Hip fracture	25.2	12.3	6.6	1.8	1.1	0.7
Other fracture	11.4	9.4	8.8	11.5	9.6	7.9
Stroke	26.4	21.5	16.6	40.5	39.4	32.4
Respiratory failure	1.7	1.4	1.7	3.3	4.0	6.1
Anxiety	32.6	31.4	31.5	37.8	38.9	39.6
Depression	44.5	44.7	47.6	53.1	56.6	59.2
Bipolar	3.3	3.6	3.8	5.1	6.2	6.7
Psychotic disorder	1.6	1.0	0.7	4.0	3.4	2.5
Schizophrenia	1.1	1.1	1.1	2.2	2.7	3.0
Anemia	32.1	29.6	28.6	25.6	24.6	25.3
Ulcerative colitis/Crohn’s disease						
Yes	0.8	0.7	0.7	0.9	0.9	0.8
No	75.4	72.4	72.7	78.2	77.9	78.2

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Variable	Surgical Index Hospitalization			Nonsurgical Index Hospitalization		
	Nonobese, % (n = 561,324)*	Mild Obese, % (n = 194,714)	Severe Obese, % (n = 172,304)	Nonobese, % (n = 986,784)	Mild Obese, % (n = 225,040)	Severe Obese, % (n = 182,853)
Missing	23.8	26.9	26.6	20.9	21.2	21.0
Viral hepatitis	0.2	0.2	0.2	0.2	0.2	0.2
Seizure disorder or epilepsy	2.6	2.1	1.8	4.3	4.2	3.8
Other conditions						
End-stage prognosis	0.5	0.4	0.3	1.2	0.9	0.8
Fall in past 30 d						
Yes	41.4	26.8	20.5	40.0	37.4	33.7
No	54.0	68.5	74.6	52.3	55.4	59.5
Unable to answer	3.0	3.0	3.1	5.8	5.3	4.9
Missing	1.6	1.7	1.8	1.9	1.9	1.9
Fall in past 31–180 d						
Yes	12.8	10.4	9.6	17.4	16.7	15.8
No	75.5	80.5	81.9	67.3	69.5	71.6
Unable to answer	9.4	6.9	6.3	12.8	11.3	10.1
Missing	2.3	2.2	2.1	2.6	2.5	2.5
Venous/arterial ulcer present	1.6	1.4	1.6	1.8	2.6	4.6
Infection of the foot	1.0	1.0	1.1	0.8	1.2	2.1
Diabetic foot ulcer	0.6	0.8	0.9	0.4	0.8	1.3
Dehydrate	0.2	0.1	0.1	0.5	0.3	0.3
Internal bleeding	0.9	0.8	0.7	1.1	1.0	1.1
Pain frequency						
0, No pain	30.7	23.1	19.1	59.0	53.0	44.8
1, Almost constant	5.4	6.9	8.2	3.8	4.9	6.8
2, Frequently	26.5	32.5	36.4	12.3	14.8	18.7
3, Occasionally	32.7	33.7	33.2	20.2	22.6	25.1
4, Rarely	4.2	3.6	3.1	4.3	4.4	4.3
Unable to answer	0.6	0.2	0.1	0.5	0.4	0.3
Surgical wound	80.7	84.5	85.1	4.5	5.2	5.6
Bowel continent						
1, Always continent	66.1	76.0	78.5	56.9	60.7	62.0

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Variable	Surgical Index Hospitalization			Nonsurgical Index Hospitalization		
	Nonobese, % (n = 561,324)*	Mild Obese, % (n = 194,714)	Severe Obese, % (n = 172,304)	Nonobese, % (n = 986,784)	Mild Obese, % (n = 225,040)	Severe Obese, % (n = 182,853)
2, Occasionally incontinent	9.7	8.0	7.8	12.1	11.9	11.6
3, Frequently incontinent	12.8	8.9	7.7	16.5	15.3	14.9
4, Always incontinent	8.3	4.6	3.8	12.9	10.5	10.0
9, Not rated	3.2	2.5	2.2	1.6	1.5	1.5
Shortness of breath with exertion	11.1	11.8	15.0	17.3	21.2	28.6
Shortness of breath when sitting at rest	3.6	3.5	4.1	6.3	7.4	9.8
Shortness of breath when lying flat	6.0	6.0	8.1	9.9	12.1	17.6
Parenteral/intravenous feeding	1.0	0.7	0.5	1.3	1.0	0.8
Feeding tube	2.6	1.3	0.9	3.3	2.3	1.7
Ostomy care	3.3	2.4	2.0	1.4	1.3	1.2
Antibiotic received						
Yes	28.3	26.8	27.7	38.7	40.2	43.1
No	66.0	67.0	66.3	55.8	54.5	51.7
Missing	5.7	6.3	6.0	5.4	5.3	5.1
Insulin injection	13.2	19.7	26.5	15.5	27.8	40.4

*DRG, Age and ADL are presented as continuous variables, and thus the numbers indicate mean (SD).

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Table 2

Main Findings From Conditional Fixed-Effects Logit Model (Odds Ratio)

Panel 1. Without Covariates: Residents with Surgical Index Hospitalization			
	65–74-y-Old	**75–84 -y-Old**	**≥85-y-Old**
	(n = 276,199)	**(n = 365,313)**	**(n = 230,580)**
Mild obese comparing to nonobese	0.795‡	0.937‡	1.083‡
Severe obese comparing to nonobese	(0.0126) 0.827‡ (0.0118)	(0.0118) 0.976* (0.0138)	(0.0182) 1.164‡ (0.0302)
Panel 2. With Covariates: Residents with Surgical Index Hospitalization			
	65–74-y-Old	**75–84 -y-Old**	**≥85-y-Old**
	(n = 276,199)	**(n = 365,313)**	**(n = 230,580)**
Mild obese comparing to nonobese	0.961†	1.027*	1.053‡
Severe obese comparing to nonobese	(0.0177) 1.042† (0.0185)	(0.0149) 1.027 (0.0175)	(0.0202) 1.061† (0.0318)
Panel 3. Without Covariates: Residents with Medical Index Hospitalization			
	65–74-y-Old	**75–84 -y-Old**	**>85-y-Old**
	(n = 251,900)	**(n = 499,497)**	**(n = 601,848)**
Mild obese comparing to nonobese	0.964‡	1.010	1.078‡
Severe obese comparing to nonobese	(0.0133) 0.963‡ (0.0118)	(0.0102) 1.052‡ (0.0114)	(0.0116) 1.137‡ (0.0177)
Panel 4. With Covariates: Residents with Medical Index Hospitalization			
	65–74-y-Old	**75–84 -y-Old**	**≥85-y-Old**
	(n = 251,900)	**(n = 499,497)**	**(n = 601,848)**
Mild obese comparing to nonobese	0.974‡	0.985	1.026†
Severe obese comparing to nonobese	(0.0150) 0.923‡ (0.0136)	(0.0110) 0.954‡ (0.0121)	(0.0121) 1.004 (0.0174)

The models in Panel 2 and 4 adjust for all covariates. The covariates are not presented in this table. The full model is presented in Appendix 2.

The numbers in the cell are odds ratios and the numbers in parentheses are exponentials of standard errors.

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$^{*}p < .1$

$^{\dagger}p < .05$

$^{\ddagger}p < .01$