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ORIGINAL RESEARCH

The Relationship of Obesity to Hospice Use and Expenditures

A Cohort Study

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Background: Obesity complicates medical, nursing, and informal care in severe illness, but its effect on hospice use and Medicare expenditures is unknown.

Objective: To describe the associations between body mass index (BMI) and hospice use and Medicare expenditures in the last 6 months of life.

Design: Retrospective cohort.

Setting: The HRS (Health and Retirement Study).

Participants: 5677 community-dwelling Medicare fee-for-service beneficiaries who died between 1998 and 2012.

Measurements: Hospice enrollment, days enrolled in hospice, in-home death, and total Medicare expenditures in the 6 months before death. Body mass index was modeled as a continuous variable with a quadratic functional form.

Results: For decedents with BMI of 20 kg/m^2, the predicted probability of hospice enrollment was 38.3% (95% CI, 36.5% to 40.2%), hospice duration was 42.8 days (CI, 42.3 to 43.2 days), probability of in-home death was 61.3% (CI, 59.4% to 63.2%), and total Medicare expenditures were $42 803 (CI, $41 085 to $44 521). When BMI increased to 30 kg/m^2, the predicted probability of hospice enrollment decreased by 6.7 percentage points (CI, −9.3 to −4.0 percentage points), hospice duration decreased by 3.8 days (CI, −4.4 to −3.1 days), probability of in-home death decreased by 3.2 percentage points (CI, −6.0 to −0.4 percentage points), and total Medicare expenditures increased by $3471 (CI, $955 to $5988). For morbidly obese decedents (BMI ≥40 kg/m^2), the predicted probability of hospice enrollment decreased by 15.2 percentage points (CI, −19.6 to −10.9 percentage points), hospice duration decreased by 4.3 days (CI, −5.7 to −2.9 days), and in-home death decreased by 6.3 percentage points (CI, −11.2 to −1.5 percentage points) versus decedents with BMI of 20 kg/m^2.

Limitation: Baseline data were self-reported, and the interval between reported BMI and time of death varied.

Conclusion: Among community-dwelling decedents in the HRS, increasing obesity was associated with reduced hospice use and in-home death and higher Medicare expenditures in the last 6 months of life.

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Seventy percent of U.S. adults aged 60 years or older are overweight or obese (1). Obesity is associated with shorter life expectancy, increased risk for hospitalization, and higher use of intensive care services (2–4), as well as variation in the quality of cancer screening, immunization, cancer care, and intensive care (4–8).

For obese persons, technical and logistical issues arise during hospitalizations, surgery, and end-of-life care that require special attention. Obesity challenges the ability of health care providers and caregivers to conduct thorough physical assessments, assist with mobility and self-care, recognize frailty and malnutrition, and perform certain indicated procedures (8–11). In addition, weight stigma has been found to modify patients' and providers' behaviors, potentially resulting in delayed diagnoses, suboptimal care, and weaker therapeutic alliances (12–15). To date, however, no studies have examined the association between obesity and hospice use, a cornerstone of end-of-life care.

To understand the effect of body mass index (BMI) on hospice use and Medicare expenditures at the end of life, we used the HRS (Health and Retirement Study) to examine hospice enrollment, days enrolled in hospice, decedents' place of death, and Medicare expenditures as a function of participant BMI, controlling for demographic, medical, functional, and geographic factors. In the context of the unique challenges to care for obese persons, we hypothesized that higher BMI would be associated with decreased hospice use and fewer in-home deaths due to patient, provider, and system factors affecting referral to and enrollment in hospice services, and that higher BMI would be associated with increased health care expenditures due to increased use of hospital and health care services.

METHODS

Study Population

We examined survey and Medicare claims data for HRS participants who died between 1998 and 2012, the most recent data available (16). The HRS is a nationally representative panel survey that biennially interviews U.S. adults older than 50 years about health and financial issues. Since 1992, the HRS has enrolled more than 30 000 participants, with a follow-up response rate consistently greater than 90%; the recruitment and survey methods have been previously described (17). The HRS survey covers a wide range of personal- and household-level data, including detailed medical, economic, and social characteristics (16). We studied decedents who had previously consented to linkage of survey data with their Medicare claims data to give additional information on health care use and expenditures beyond HRS-collected data. Respondents were eligible for the current study if they had complete fee-for-service Medicare Parts A and B claims data for the last 180 days of life. To focus on health care use among a community-dwelling population, we excluded respondents in nursing care facilities at the last survey wave. We also excluded respondents with missing information on BMI, survey date, marital status, geographic location, functional status, or cognitive function.

Outcomes

Participants with any Medicare hospice claims were considered hospice enrollees. For each patient, any day with a Medicare claim for hospice was counted as a day of hospice services (18). Using the Medicare Provider Analysis and Review claims files, we classified each day as at home (no facility claims) or in a facility (claims for hospital, skilled-nursing, or long-term acute care). We calculated total Medicare spending during the last 180 days of life across all domains in Medicare files (inpatient, outpatient, physician or supplier, durable medical, hospice, home health, and skilled nursing). Expenditures were adjusted to 2012 U.S. dollars using the medical component of the U.S. Bureau of Labor Statistics Consumer Price Index.

Other Variables

The primary independent variable of interest was BMI, which we calculated for each decedent using self-reported height and weight from the last survey interview before death. We defined the probable date of death using Medicare claims data linked to the National Death Index. Respondent-reported measures of sex, race (nonwhite races were collapsed due to sample size), Hispanic ethnicity, marital status (widowed, single, separated, divorced, or married), and total household assets (adjusted to 2012 U.S. dollars) were used.

We identified 28 comorbid medical conditions from 1 year before the defined end-of-life period (6 months before death) using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), codes from Medicare claims (Elixhauser method [19]). We used measures for the number of limitations in activities of daily living (ADLs) and instrumental activities of daily living (IADLs) and for cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia) (20). Decedents were linked with a measure of regional end-of-life expenditures (average Medicare expenditures in the last 6 months of life as reported in the 2012 Dartmouth Atlas of Health Care by hospital referral region, separated into quintiles), with each decedent's ZIP code linked to its corresponding hospital referral region (21).

Cause of death was determined from the National Death Index, which categorizes causes of death according to 113 ICD-10 codes. These codes were categorized as infectious, malignancy, diabetes mellitus, neurologic, cardiac, pulmonary, gastrointestinal or hepatobiliary, renal, or other. After the respondent's death, proxy informants (typically a surviving partner or adult children) are interviewed about the respondent's end-of-life care. To examine whether obese patients were more likely to die unexpectedly, we used the exit interview question, "Was the death expected at about the time it occurred or was it unexpected?" Response options included "yes," "unsure," or "no"; the latter 2 (n = 14) were grouped as negative responses. The time between response to the last survey and death was calculated using the date of survey administration and the date of death from National Death Index data.

Statistical Analysis

We modeled hospice enrollment, days enrolled in hospice, in-home death, and Medicare expenditures using generalized linear models. The models used a binomial distribution and logit link for hospice enrollment and in-home death, a Poisson distribution and log link for total hospice days, and a gamma distribution and log link for expenditures. We examined possible models for the functional form of BMI included as a categorical variable (using National Institutes of Health obesity categories), a linear functional form, and a quadratic functional form based on theory and empirical evidence (see the **Appendix**, available at Annals.org) (22). We report findings from our final models using BMI fit as a quadratic functional form based on theory, previous evidence about how BMI should vary with each outcome, and comparisons of overall model fit as well as discrimination and calibration testing. Models controlled for age at death, sex, nonwhite race, Hispanic ethnicity, marital status, total household assets, comorbid illnesses (19), limitations in ADLs and IADLs, cognitive function, quintile of regional end-of-life expenditures, and year of death.

In sensitivity analyses, to explore the extent to which the association of BMI and the outcomes was influenced by the length of time between the collection of BMI information and death, the aforementioned model was changed to include an interaction term between BMI and the time from collection of self-reported height and weight to death (23). To explore the extent to which the association of BMI and the outcomes was influenced by cause of death and proxy-reported expected death, each of these terms was added separately to the model. We also fit models with BMI defined as a categorical variable. In addition, we repeated the analysis with the complete HRS cohort of deceased fee-for-service beneficiaries (including nursing home residents) to see whether selecting community-dwelling respondents biased the overall results.

We report each measure in terms of the mean predicted outcome (probability of hospice enrollment, days enrolled in hospice, probability of in-home death, and Medicare expenditures) at 5 BMI levels (20, 25, 30, 35, and 40 kg/m^2) and significance testing using 95% CIs. The mean predicted outcome was estimated by the statistical model for a given BMI while holding all other covariates at known values (24). Probabilities were reported as the percentage chance of the outcome occurring (0% to 100%). If the 95% CI did not contain the null hypothesis value, the results were considered statistically significant. We used Stata, version

14.0 (StataCorp), for all analyses, specifically the glm and margins commands.

Ethics

Informed consent was obtained from all participants in the HRS. The University of Michigan Institutional Review Board–Medical deemed this study of decedents to be exempt from institutional review board approval.

Role of the Funding Source

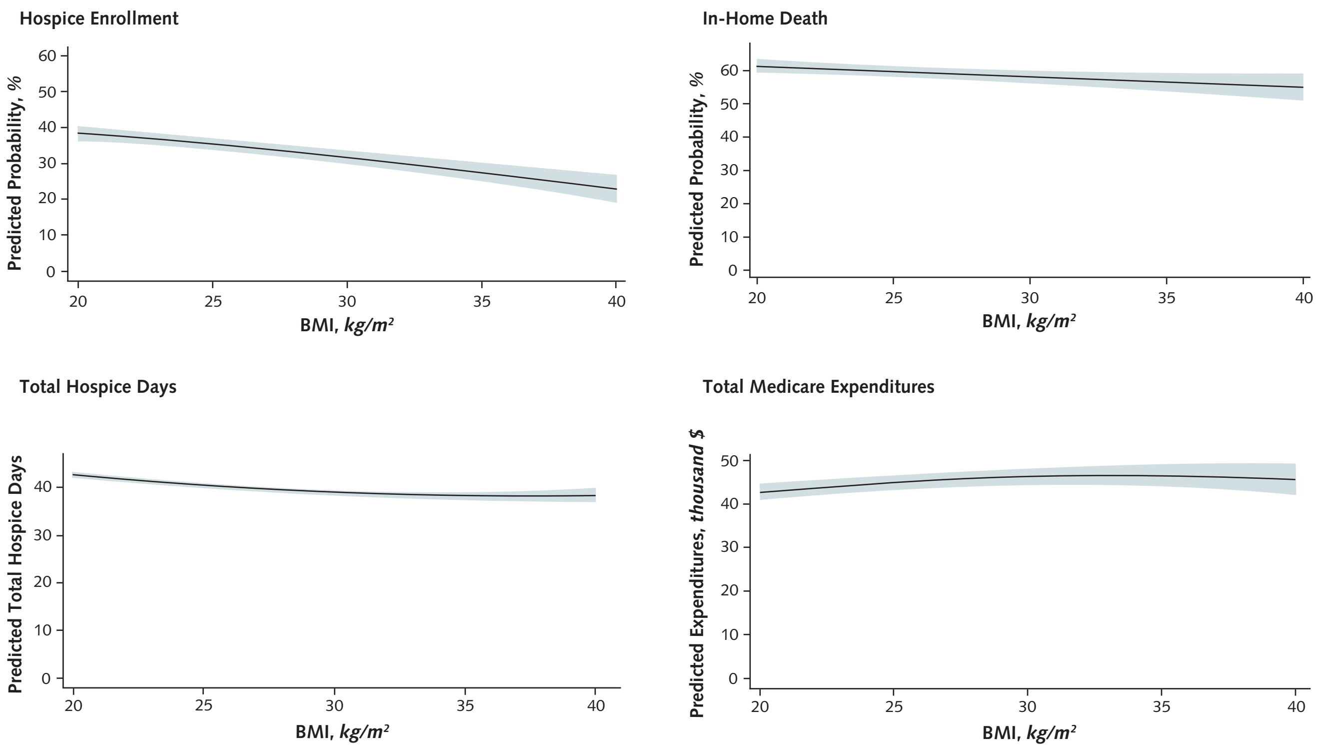
The Robert Wood Johnson Foundation, the U.S. Department of Veterans Affairs, the National Institute on Aging, and the National Cancer Institute provided

Table 1. Characteristics of Decedents, by BMI Category*

Characteristic	BMI Category				
	Underweight (<18.5 kg/m²) (*n* = 424)	**Normal (18.5-24.9 kg/m²) (*n* = 2509)**	**Overweight (25-29.9 kg/m²) (*n* = 1763)**	**Obese (30-39.9 kg/m²) (*n* = 864)**	**Morbidly Obese (≥40 kg/m²) (*n* =117)**
Mean age at death (SD), *y*	83.6 (9.4)	82.3 (8.8)	79.9 (9.1)	76.8 (9.3)	72.1 (8.4)
Sex, *n (%)*					
Female	319 (75)	1285 (51)	723 (41)	462 (53)	77 (66)
Male	105 (25)	1224 (49)	1040 (59)	402 (47)	40 (34)
Race, *n (%)*					
White	345 (81)	2128 (85)	1448 (82)	673 (78)	82 (70)
Black	≤70 (≤17)	316 (13)	257 (15)	164 (19)	≤30 (≤25)
Other	≤10 (≤2)	65 (3)	58 (3)	27 (3)	≤10 (≤9)
Ethnicity, *n (%)*					
Non-Hispanic	400 (94)	2384 (95)	1626 (92)	804 (93)	≤110 (≤94)
Hispanic	24 (6)	125 (5)	137 (8)	60 (7)	≤10 (≤9)
Marital status, *n (%)*					
Married/partnered	134 (32)	1173 (47)	962 (55)	459 (53)	58 (50)
Widowed	237 (56)	1062 (42)	603 (34)	303 (35)	33 (28)
Separated/divorced	32 (8)	204 (8)	154 (9)	74 (9)	≤20 (≤16)
Never married	21 (5)	70 (3)	44 (3)	28 (3)	≤10 (≤9)
Median total household assets (IQR), *thousand $*	94 (8–295)	135 (26–422)	133 (27–347)	99 (9–303)	42 (3–123)
Chronic disease, *n (%)*					
Hypertension†	210 (50)	1392 (55)	1067 (61)	564 (65)	81 (69)
Diabetes‡	44 (10)	517 (21)	564 (32)	400 (46)	70 (60)
Congestive heart failure	113 (27)	689 (27)	517 (29)	294 (34)	52 (44)
Chronic pulmonary disease	154 (36)	682 (27)	500 (28)	265 (31)	47 (40)
Metastatic cancer	19 (4)	147 (6)	143 (8)	61 (7)	≤10 (≤9)
Weight loss	67 (16)	200 (8)	79 (4)	41 (5)	≤10 (≤9)
Cognitive function, *n (%)*					
Normal	147 (35)	1026 (41)	870 (49)	464 (54)	65 (56)
Mild cognitive impairment/cognitive impairment or no dementia	123 (29)	799 (32)	527 (30)	247 (29)	36 (31)
Dementia	154 (36)	684 (27)	366 (21)	153 (18)	16 (14)
Functional status					
Activities of daily living					
No limitations, *n (%)*	125 (29)	1148 (46)	857 (49)	368 (43)	24 (21)
Mean limitations (SD), *n*	2.2 (2.2)	1.5 (1.9)	1.4 (1.8)	1.6 (1.9)	2.5 (1.9)
Instrumental activities of daily living					
No limitations, *n (%)*	158 (37)	1346 (54)	1075 (61)	503 (58)	47 (40)
Mean limitations (SD), *n*	1.7 (1.8)	1.2 (1.7)	1.0 (1.5)	1.0 (1.4)	1.2 (1.4)
Quintile of regional end-of-life expenditures, *n (%)*					
Highest	111 (26)	774 (31)	523 (30)	226 (26)	28 (24)
Lowest	59 (14)	344 (14)	242 (14)	143 (17)	19 (16)
Median time from self-reported height and weight to death (IQR), *y*	1.1 (0.5–1.7)	1.2 (0.6–1.9)	1.4 (0.8–1.9)	1.3 (0.7–1.9)	1.4 (0.8–1.9)

BMI = body mass index; IQR = interquartile range.
* Reported at last survey interview. Values based on ≤10 participants were assigned a value of ≤10 because of privacy restrictions. In the case of a single cell in a column being suppressed, the cells with the second- and/or third-lowest counts were also assigned a value of less than the nearest multiple of 10 to prevent the ability to calculate the value of the suppressed cell.
† Defined as Elixhauser diagnosis of uncomplicated and/or complicated hypertension.
‡ Defined as Elixhauser diagnosis of uncomplicated and/or complicated diabetes.

Figure. Predicted probability of hospice enrollment, predicted total hospice days, predicted probability of in-home death, and predicted total Medicare expenditures in the last 6 mo of life, as a function of participant BMI.



Results are adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living, number of instrumental activities of daily living, cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia), quintile of regional end-of-life expenditures, and year of death. Shaded areas represent 95% CIs. BMI = body mass index.

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RESULTS

Of 9859 HRS decedents who consented to linkage of survey data with Medicare claims data, 2485 with any managed care enrollment during the last 6 months of life were excluded. We also excluded 1352 decedents who reported living in a nursing facility at the last survey wave and participants with missing information from the last survey on date of the survey (n = 88), height or weight (n = 93), ZIP code (n = 23), marital status (n = 3), ADLs (n = 41), or cognitive function (n = 97) (**Appendix Figure**, available at Annals.org).

The final cohort included 5677 decedents. Of these, 424 (7%) were underweight (BMI <18.5 kg/m^2), 2509 (44%) were of normal weight (BMI of 18.5 to 24.9 kg/m^2), 1763 (31%) were overweight (BMI of 25 to 29.9 kg/m^2), 864 (15%) were obese (BMI of 30 to 39.9 kg/m^2), and 117 (2%) were morbidly obese (BMI ≥40 kg/m^2); the median BMI was 24.7 kg/m^2 (interquartile range [IQR], 21.5 to 28.2 kg/m^2). The median age at death was 81.2 years (IQR, 73.8 to 87.5 years), and the median time from the last respondent survey to death was 15.6 months (IQR, 8.2 to 22.6 months). Sample characteristics by BMI category are reported in **Table 1**. A complete description of all medical comorbidities by BMI category is reported in **Appendix Table 1** (available at Annals.org).

The overall observed incidence of hospice enrollment was 34.7%. Participants with higher BMI had a significantly lower likelihood of hospice enrollment than those with a BMI of 20 kg/m^2 (**Figure**). Participants with a BMI of 40 kg/m^2 had a predicted probability of hospice enrollment of 23.1% (95% CI, 19.5% to 26.7%), whereas those with a BMI of 20 kg/m^2 had a predicted probability of 38.3% (CI, 36.5% to 40.2%) (**Table 2**). Among those who enrolled in hospice care, the predicted total hospice days decreased as BMI increased. Participants with a BMI of 40 kg/m^2 spent 4.3 fewer days (CI, −5.7 to −2.9 days) in hospice care than those with a BMI of 20 kg/m^2. This effect was driven by decreased numbers of days spent in home hospice care, and we found no clinically significant increase in facility hospice care for obese patients (**Appendix Table 2**, available at Annals.org).

The overall observed incidence of in-home death was 59.6%. Participants with higher BMI had a significantly lower likelihood of in-home death than those with a BMI of 20 kg/m^2 (**Figure**). Participants with a BMI of 40 kg/m^2 had a predicted probability of in-home death of 55.0% (CI, 51.0% to 58.9%), whereas those with a BMI of 20 kg/m^2 had a predicted probability of 61.3% (CI, 59.4% to 63.2%) (**Table 2**).

In the last 6 months of life, total predicted Medicare expenditures increased as BMI increased. The mean total predicted expenditures were $42 803 (CI, $41 085 to $44 521) (**Table 2**) for participants with a BMI of 20 kg/m^2 and were $3471 (CI, $955 to $5988) higher for those with a BMI of 30 kg/m^2. Predicted expenditures for those with a BMI of 30, 35, or 40 kg/m^2 were constant, but there was also a decrease in precision related to small sample size at the upper extreme of the sample's BMI range (**Figure**). The component Medicare expenditures were driven by inpatient, outpatient, and physician or supplier expenditures that increased by a mean of $4343 (CI, $2008 to $6678) for decedents with a BMI of 30 kg/m^2 versus those with a BMI of 20 kg/m^2. However, these were offset by lower home health, durable medical, and hospice Medicare expenditures, which decreased by a mean of $1173 (CI, $659 to $1688) for decedents with a BMI of 30 kg/m^2 versus those with a BMI of 20 kg/m^2. Because of differences in both enrollment and length of stay, predicted hospice Medicare expenditures for participants with a BMI of 40 kg/m^2 ($1321 [CI, $949 to $1692]) were 60% lower than for those with a BMI of 20 kg/m^2 ($3357 [CI, $2896 to $3818]) (**Table 3**).

To examine whether this analysis was confounded by cause of death or proxy-reported expected death, we refit the model with these variables included. Diabetes- and renal-related causes of death were more common for obese and morbidly obese respondents than for those with normal BMI (18.5 to 24.9 kg/m^2) (**Appendix Table 3**, available at Annals.org). When we included the decedent's cause of death as a covariate, we observed trends and effect sizes that were consistent with the results from the original model (**Appendix Table 4**, available at Annals.org). The likelihood that a proxy reported the death as "expected" decreased as BMI increased: 55% of deaths were expected by proxies for normal-weight participants compared with 45% for morbidly obese participants (**Appendix Table 3**). When we included expected death as a model covariate, the effect sizes also remained stable (**Appendix Table 4**). When we included an interaction term between BMI and time from survey data collection, the trends and effect sizes of the outcomes were similar (**Appendix Table 4**).

The main outcomes are reported by BMI categories in **Appendix Tables 5** and **6** (available at Annals.org), and the trends and effect sizes of the outcomes were similar to when BMI was modeled as a continuous variable. The main outcomes with nursing home residents included were similar to those in the community-dwelling cohort and are presented in **Appendix Table 7** (available at Annals.org). The coefficients, SEs, and constants for the model predicting hospice enrollment are shown in **Appendix Table 8** (available at Annals.org).

DISCUSSION

In this large national sample of older American decedents, we found that increased BMI was independently associated with decreased hospice enrollment, duration of hospice services, and in-home death and increased Medicare expenditures in the last 6 months of life, after adjustment for key sociodemographic, medical, functional status, and geographic factors. In-

Table 2. Predicted Probability of Hospice Enrollment, Total Hospice Days, Probability of In-Home Death, and Total Medicare Expenditures, by BMI (*n* = 5677)*

Outcome	BMI				
	20 kg/m^2	25 kg/m^2	30 kg/m^2	35 kg/m^2	40 kg/m^2
Predicted probability of hospice enrollment, %	38.3 (36.5 to 40.2)	35.3 (34.0 to 36.7)	31.7 (30.0 to 33.4)	27.5 (25.2 to 30.0)	23.1 (19.5 to 26.7)
Difference vs. BMI of 20 kg/m^2	Reference	−3.0 (−4.7 to −1.3)	−6.7 (−9.3 to −4.0)	−10.8 (−14.2 to −7.5)	−15.2 (−19.6 to −10.9)
Predicted total hospice days†	42.8 (42.3 to 43.2)	40.4 (40.1 to 40.8)	39.0 (38.5 to 39.4)	38.3 (37.6 to 39.0)	38.5 (37.2 to 39.7)
Difference vs. BMI of 20 kg/m^2	Reference	−2.3 (−2.8 to −1.9)	−3.8 (−4.4 to −3.1)	−4.4 (−5.3 to −3.5)	−4.3 (−5.7 to −2.9)
Predicted probability of in-home death, %	61.3 (59.4 to 63.2)	59.7 (58.3 to 61.1)	58.1 (56.2 to 60.0)	56.5 (53.9 to 59.2)	55.0 (51.0 to 58.9)
Difference vs. BMI of 20 kg/m^2	Reference	−1.6 (−3.3 to 0.1)	−3.2 (−6.0 to −0.4)	−4.8 (−8.5 to −1.1)	−6.3 (−11.2 to −1.5)
Predicted total end-of-life expenditures, $	42 803 (41 085 to 44 521)	45 011 (43 712 to 46 311)	46 274 (44 542 to 48 007)	46 508 (44 147 to 48 870)	45 698 (42 235 to 49 161)
Difference vs. BMI of 20 kg/m^2	Reference	2208 (718 to 3698)	3471 (955 to 5988)	3705 (424 to 6986)	2895 (−1342 to 7132)

BMI = body mass index.
* Predicted outcomes were calculated for representative BMI values and were adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia), quintile of regional end-of-life expenditures, and year of death. Values are means (95% CIs).
† Among decedents who were ever enrolled in hospice (*n* = 1971).

Table 3. Predicted End-of-Life Component Medicare Expenditures, by BMI*

Component	BMI				
	20 kg/m²	25 kg/m²	30 kg/m²	35 kg/m²	40 kg/m²
Inpatient	23 051 (21 713 to 24 390)	24 828 (23 786 to 25 871)	25 973 (24 586 to 27 361)	26 389 (24 495 to 28 284)	26 041 (23 254 to 28 828)
Difference vs. BMI of 20 kg/m²	Reference	1777 (632 to 2921)	2922 (962 to 4882)	3337 (758 to 5918)	2990 (−375 to 6354)
Outpatient	2845 (2570 to 3119)	3170 (2938 to 3402)	3239 (2965 to 3514)	3036 (2703 to 3368)	2608 (2213 to 3004)
Difference vs. BMI of 20 kg/m²	Reference	325 (133 to 517)	395 (52 to 738)	191 (−253 to 635)	−236 (−751 to 279)
Physician/ supplier	7314 (6990 to 7638)	7955 (7705 to 8206)	8392 (8055 to 8728)	8584 (8117 to 9052)	8516 (7830 to 9202)
Difference vs. BMI of 20 kg/m²	Reference	642 (369 to 914)	1078 (604 to 1552)	1271 (638 to 1903)	1202 (376 to 2029)
Home health and durable medical equipment	2636 (2402 to 2871)	2445 (2270 to 2619)	2321 (2125 to 2518)	2257 (2016 to 2498)	2248 (1895 to 2601)
Difference vs. BMI of 20 kg/m²	Reference	−192 (−374 to −10)	−315 (−597 to −33)	−379 (−729 to −29)	−388 (−837 to 60)
Skilled nursing	4155 (3705 to 4607)	4347 (3961 to 4733)	4519 (3989 to 5049)	4668 (3945 to 5390)	4791 (3736 to 5845)
Difference vs. BMI of 20 kg/m²	Reference	192 (−204 to 587)	364 (−311 to 1038)	512 (−388 to 1413)	635 (−570 to 1840)
Hospice	3357 (2896 to 3818)	3036 (2670 to 3403)	2514 (2168 to 2860)	1905 (1578 to 2231)	1321 (949 to 1692)
Difference vs. BMI of 20 kg/m²	Reference	−320 (−681 to 40)	−843 (−1347 to −339)	−1452 (−2007 to −898)	−2036 (−2633 to −1439)

BMI = body mass index.
* Predicted expenditures were calculated for representative BMI values and were adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia), quintile of regional end-of-life expenditures, and year of death. Values are means (95% CIs) presented in U.S. dollars.

creasing BMI was associated with higher expenditures for inpatient, outpatient, and physician claims, although these were partially offset by lower hospice, durable medical equipment, and skilled-nursing expenditures in this community-dwelling population. Obesity was a risk factor for lower-quality end-of-life care, which we defined as enrollment in hospice, longer length of hospice stay, and in-home death. Additional research should focus on the mechanisms underlying this vulnerability at the end of life.

In this study, we showed that higher BMI was a strong negative predictor of hospice enrollment; the predicted probability of hospice enrollment was 40% lower for decedents with a BMI of 40 kg/m² than for those with a BMI of 20 kg/m². Hospice enrollment has previously been shown to vary by sex, race, ethnicity, primary diagnosis, location before enrollment, referring physician, patient preferences with regard to life-sustaining treatment, and site of death (25–30), but this is, to our knowledge, the first study to identify obesity as an independent risk factor for disparity in the use of hospice services. Previous studies have shown that hospice use is associated with improved quality of care for patients and their families, with reduced psychiatric morbidity and increased ratings of perceived health care quality in bereaved caregivers (31–36), heightening concerns about the effect of underuse of hospice care in this population (33, 37, 38).

We hypothesize that obesity may affect hospice enrollment through 2 mechanisms: referral behaviors and enrollment policies. First, prolonged cachexia experienced by some persons at the end of life is recognized by family members and physicians as being closely related to the dying process (39). Those who do not experience profound cachexia may be less likely to be recognized as appropriate referrals for palliative or hospice services by providers compared with more cachectic persons, who may appear less physically robust. The trajectories of illness and dying may vary as a function of patient obesity within diseases. Obese patients may have a more sudden decline in performance status or increase in metabolic abnormalities, which may lead to more sudden deaths than in nonobese patients. In this study, the effect of obesity was not substantially moderated by whether the death was expected or the cause of death was known. However, little research is available on the association between trajectories of illness and obesity, and this may be an important factor in the provision of high-quality end-of-life health care.

Second, enrollment policies vary among hospice services, and some restrict access to care for persons with higher-cost medical needs (27). Obese patients in home hospice care may require increased nursing assistance, including mechanical lift devices to provide proper positioning and personal care in the terminal phase of dying (10). The need for extra nursing personnel or mechanical lifts may make home hospice care infeasible for obese patients and their caregivers (40).

Obesity is associated with increased use of health care services and associated expenditures (41–44). For obese participants in this community-dwelling cohort, we found that inpatient, outpatient, and physician Medicare expenditures were 13% higher (a difference of $4343), but hospice, home health, and durable medical equipment expenditures were 20% lower (a difference of $1173). Increased expenditures for obese persons have been attributed to the relatively increased prevalence of medical conditions, such as diabetes, hypertension, and coronary artery disease (45–47). However, higher BMI presents many challenges to medical management beyond increased medical multimorbidity. It is associated with decreased access to medical care, increased difficulty managing medical issues in an outpatient setting versus an inpatient setting, and more challenges in transitioning from inpatient care back to home care (48–52). Finally, there is an established record of negative provider attitudes and implicit bias against obese persons, and these attitudes may continue to influence care for obese persons at the end of life (13, 14). Each of these factors may impede the provision of optimal medical, nursing, and supportive care for obese persons, either independently or together, thus explaining the independent effect of obesity on end-of-life health care expenditures.

Our study has several potential limitations. We used a self-reported BMI measure that was collected a median of 16 months before death, and the time from collection of this biometric to death varied within the study cohort. A sensitivity analysis examining whether this interval affected the association between BMI and the outcomes showed that this was not substantial and did not change the overall effect. We examined only community-dwelling adults using fee-for-service Medicare claims, but our results did not differ significantly when nursing home residents were included in the sample. The sample did not include respondents who were enrolled in managed care Medicare plans; this group may have substantially different characteristics and resource use at the end of life, which may limit the generalizability of these results (53). Although we controlled for the presence of more than 2 dozen medical conditions, functional status (limitations in ADLs and IADLs and cognitive function) at the last core survey interview, cause of death, and the proxy informant's judgment of whether the death was expected, residual confounding may have inadequately controlled for differences in medical conditions and trajectories of illness that are affected by obesity.

These potential limitations notwithstanding, this study identified a significant relationship in decedents between obesity and decreased probability of hospice enrollment and in-home death, as well as fewer days of hospice care among those who were enrolled. The consequences of obesity for health care use and expenditures are substantial, and obese persons are vulnerable to suboptimal end-of-life care. As stakeholders look for opportunities to improve the value of care by increasing quality and decreasing low-value services, the disparities in hospice use and Medicare expenditures by patient BMI provide an excellent opportunity for improvement. Policy interventions could include increased reimbursement for home care services of obese patients who require multiple support personnel, reimbursement for patient lifts and other special durable medical equipment in health care facilities, or concurrent palliative care for select patients with severe obesity. All people—regardless of body size—and their families should have equal opportunities to experience the benefits of high-quality end-of-life health care.

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Appendix: Statistical Model Selection and Composition

The statistical model development process began with a conceptual model of how obesity may affect end-of-life decision making. On the basis of the conceptual model, we selected from among the many variables available in the HRS to make an inclusive yet parsimonious selection of variables to include as confounders.

On the basis of the distributions of the dependent variables, we used 3 separate statistical models to properly describe dependent variables that were dichotomous (hospice enrollment and in-home death), continuous count data (number of days in hospice), and continuous and skewed data (total Medicare expenditures). On the basis of the known distributions, we chose generalized linear models with various response probability distributions and link functions: a binomial distribution and logit link for hospice enrollment and in-home death, a Poisson distribution and log link for total hospice days, and a gamma distribution and log link for expenditures.

The primary independent variable was BMI. In choosing the functional form that BMI would take in the models, we first examined previous literature about how BMI affects health care outcomes. Although there are few data about health care use (most models treat it as a categorical variable), published literature about BMI and mortality described a nonlinear function form, second-order or higher (22, 54, 55).

Next, on the basis of our hypothesized relationship between the outcomes and BMI, we believed that BMI would approximate a functional quadratic form. Specifically, we believed that as BMI increased, there would be increasing challenges of prognostication for providers and perhaps family, as well as challenges in the use of home-based care or provision of hospice services. We did not expect these challenges to increase in a linear manner as BMI increased; rather, we expected the effect to be relatively constant for more severe BMI values.

We used the traditional World Health Organization BMI categories as the basis of our model, as part of a modified splines analysis, to examine the functional form of the outcomes in relation to BMI in a nonparametric form. As we noted in our sensitivity analysis using World Health Organization/National Institutes of Health BMI categories (**Appendix Tables 5** and **6**), this functional form is roughly quadratic, with an increasing relationship that levels off at the more severe BMI categories. We also explored the functional form of BMI as a cubic term to determine whether there was any advantage in terms of model fit when using higher-order forms of BMI.

To help choose the most appropriate functional form of BMI (categorical, linear, quadratic, or cubic), we examined the overall model fit, the calibration across deciles of predicted probabilities to ensure that the model had randomly distributed residuals (observed vs. predicted values), and its discrimination across the range of BMI values.

On the basis of this analysis, we used a quadratic functional form for our primary independent variable in the final models. We reported the mean predicted probability of the outcomes for the study sample when BMI was held at 5 levels (20, 25, 30, 35, or 40 kg/m^2) and the rest of the variables were held at known values. We used the same quadratic functional form for BMI, regardless of the outcome, to allow the model to be as simple and understandable to readers as possible.

Our analysis also included 4 variations on the aforementioned statistical model and covariates. First, we examined the association of BMI and the predicted outcomes if an interaction term between the quadratic BMI term and the interval between the last survey and death was added to the full model. Second, we examined the association between BMI and the predicted outcomes if a covariate measuring cause of death was added to the full model. Third, we examined the association between BMI and the predicted outcomes if a covariate quantifying whether the survey proxy reported the decedent's death as "expected" was added to the full model. Finally, we included all available HRS decedents (including those who reported being in a nursing home at the last survey before death) to examine whether exclusion of these respondents led to substantial selection bias in the study sample.

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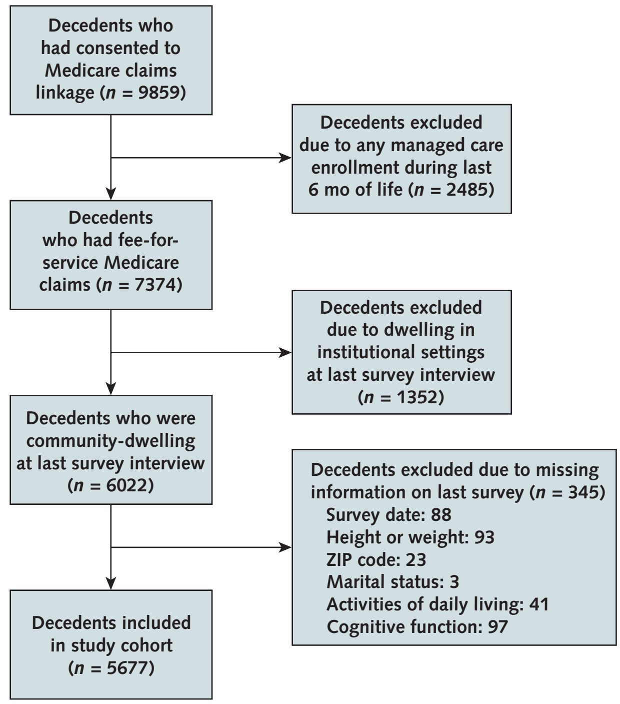
Appendix Figure. Study flow diagram.



Appendix Table 1. Medical Comorbidities of Decedents, by BMI Category*

Comorbidity	BMI Category				
	Underweight (<18.5 kg/m²) (*n* = 424)	**Normal (18.5–24.9 kg/m²) (*n* = 2509)**	**Overweight (25–29.9 kg/m²) (*n* = 1763)**	**Obese (30–39.9 kg/m²) (*n* = 864)**	**Morbidly Obese (≥40 kg/m²) (*n* = 117)**
Congestive heart failure	113 (27)	689 (27)	517 (29)	294 (34)	52 (44)
Cardiac arrhythmia	114 (27)	778 (31)	518 (29)	234 (27)	29 (25)
Valvular disease	56 (13)	317 (13)	209 (12)	107 (12)	14 (12)
Pulmonary circulation disorder	14 (3)	104 (4)	91 (5)	49 (6)	19 (16)
Peripheral vascular disorder	57 (13)	443 (18)	337 (19)	146 (17)	21 (18)
Hypertension, uncomplicated	201 (47)	1323 (53)	1021 (58)	531 (61)	76 (65)
Hypertension, complicated	48 (11)	313 (13)	238 (14)	149 (17)	21 (18)
Paralysis	≤10 (≤2)	58 (2)	36 (2)	27 (3)	≤10 (≤9)
Other neurologic disorder	40 (9)	216 (9)	148 (8)	63 (7)	≤10 (≤9)
Chronic pulmonary disease	154 (36)	682 (27)	500 (28)	265 (31)	47 (40)
Diabetes, uncomplicated	39 (9)	495 (20)	549 (31)	384 (44)	68 (58)
Diabetes, complicated	11 (3)	183 (7)	225 (13)	153 (18)	33 (28)
Hypothyroidism	66 (16)	305 (12)	199 (11)	108 (13)	19 (16)
Renal failure	48 (11)	320 (13)	259 (15)	158 (18)	33 (28)
Liver disease	≤10 (≤2)	76 (3)	72 (4)	37 (4)	≤10 (≤9)
Peptic ulcer disease, excluding bleeding	13 (3)	44 (2)	27 (2)	11 (1)	≤10 (≤9)
Lymphoma	≤10 (≤2)	57 (2)	46 (3)	18 (2)	≤10 (≤9)
Metastatic cancer	19 (4)	147 (6)	143 (8)	61 (7)	≤10 (≤9)
Solid tumor without metastasis	66 (16)	470 (19)	384 (22)	164 (19)	15 (13)
Rheumatoid arthritis/collagen disorder	20 (5)	112 (4)	81 (5)	43 (5)	≤10 (≤9)
Coagulopathy	20 (5)	153 (6)	114 (6)	46 (5)	≤10 (≤9)
Weight loss	67 (16)	200 (8)	79 (4)	41 (5)	≤10 (≤9)
Fluid and electrolyte disorders	111 (26)	546 (22)	343 (19)	194 (22)	26 (22)
Blood loss anemia	≤10 (≤2)	78 (3)	53 (3)	14 (2)	≤10 (≤9)
Iron deficiency anemia	53 (13)	251 (10)	164 (9)	94 (11)	17 (15)
Alcohol abuse	≤10 (≤2)	38 (2)	32 (2)	14 (2)	≤10 (≤9)
Psychosis	12 (3)	78 (3)	50 (3)	23 (3)	≤10 (≤9)
Depression	43 (10)	230 (9)	177 (10)	98 (11)	18 (15)

BMI = body mass index.
* Values are numbers (percentages). Values based on ≤10 participants were assigned a value of ≤10 because of privacy restrictions.

Appendix Table 2. Predicted Total In-Home Hospice Days and Total Out-of-Home Hospice Days, by BMI (*n* = 1971)*

Predicted End-of-Life Outcome	BMI				
	20 kg/m²	**25 kg/m²**	**30 kg/m²**	**35 kg/m²**	**40 kg/m²**
Mean predicted total in-home hospice days (95% CI)	42.0 (41.6 to 42.4)	39.5 (39.2 to 39.9)	38.0 (37.6 to 38.5)	37.4 (36.8 to 38.1)	37.7 (36.4 to 39.0)
Difference vs. BMI of 20 kg/m²	Reference	−2.5 (−2.9 to −2.1)	−4.0 (−4.6 to −3.4)	−4.6 (−5.5 to −3.7)	−4.4 (−5.8 to −3.0)
Mean predicted total out-of-home hospice days (95% CI)	0.7 (0.6 to 0.8)	0.9 (0.8 to 0.9)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	0.8 (0.6 to 1.0)
Difference vs. BMI of 20 kg/m²	Reference	0.1 (0.1 to 0.2)	0.2 (0.1 to 0.3)	0.2 (0.1 to 0.3)	0.1 (−0.1 to 0.3)

BMI = body mass index.
* Predicted numbers of hospice days were calculated for representative BMI values and were adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia), quintile of regional end-of-life expenditures, and year of death.

Appendix Table 3. Causes of Death and Proxy-Reported Expected Death, by BMI Category*

Characteristic	BMI Category				
	Underweight (<18.5 kg/m²) (*n* = 424)	**Normal (18.5–24.9 kg/m²) (*n* = 2509)**	**Overweight (25–29.9 kg/m²) (*n* = 1763)**	**Obese (30–39.9 kg/m²) (*n* = 864)**	**Morbidly Obese (≥40 kg/m²) (*n* = 117)**
Cause of death, *n* (%)					
Cardiac	131 (31)	812 (32)	576 (33)	290 (34)	25 (21)
Malignancy	74 (17)	507 (20)	392 (22)	176 (20)	20 (17)
Pulmonary	67 (16)	262 (10)	138 (8)	56 (6)	12 (10)
Diabetes	≤10 (≤2)	51 (2)	46 (3)	41 (5)	≤10 (≤9)
Neurologic	11 (3)	91 (4)	38 (2)	≤20 (2)	≤10 (≤9)
Renal	≤10 (≤2)	46 (2)	29 (2)	26 (2)	≤10 (≤9)
General infectious disease	≤10 (≤2)	34 (2)	37 (2)	≤20 (2)	≤10 (≤9)
Gastrointestinal/hepatic	≤10 (≤2)	13 (1)	18 (1)	≤10 (1)	≤10 (≤9)
Other	71 (17)	367 (15)	240 (14)	102 (12)	≤10 (≤9)
Unknown	42 (10)	326 (13)	249 (14)	133 (15)	29 (25)
Proxy-reported expected deaths, *n* (%)					
Yes	263 (62)	1369 (55)	899 (51)	384 (44)	53 (45)
No	133 (32)	931 (37)	702 (40)	388 (45)	≤60 (≤51)
Unknown	28 (6)	209 (8)	162 (9)	92 (10)	≤10 (≤8)

BMI = body mass index.
* Values based on ≤10 participants were assigned a value of ≤10 because of privacy restrictions. In the case of a single cell in a column being suppressed, the cells with the second- and/or third-lowest count were also assigned a value of less than the nearest multiple of 10 to prevent the ability to calculate the value of the suppressed cell. Percentages may not sum to 100 due to rounding.

Appendix Table 4. Predicted Probability of Hospice Enrollment, Total Hospice Days, and Probability of In-Home Death, by BMI, With Additional Model Covariate for Cause of Death, Expected Death, or Interaction Between Measured BMI and Time From Survey to Death*

Predicted End-of-Life Outcome	BMI				
	20 kg/m²	**25 kg/m²**	**30 kg/m²**	**35 kg/m²**	**40 kg/m²**
Original model with addition of "cause of death" covariate (*n* = 4897)					
Predicted probability of hospice enrollment, %	36.2 (34.4 to 38.0)	33.6 (32.3 to 35.0)	30.2 (28.4 to 32.0)	26.2 (23.7 to 28.6)	21.7 (18.0 to 25.5)
Difference vs. BMI of 20 kg/m²	Reference	−2.6 (−4.4 to −0.9)	−6.0 (−8.7 to −3.3)	−10.1 (−13.5 to −6.7)	−14.5 (−19.0 to −10.0)
Predicted total hospice days	42.2 (41.7 to 42.6)	40.5 (40.1 to 40.9)	39.0 (38.4 to 39.5)	37.6 (36.8 to 38.3)	36.3 (34.9 to 37.7)
Difference vs. BMI of 20 kg/m²	Reference	−1.7 (−2.1 to −1.2)	−3.2 (−3.9 to −2.5)	−4.6 (−5.6 to −3.6)	−5.9 (−7.4 to −4.3)
Predicted probability of in-home death, %	60.0 (58.0 to 62.0)	58.4 (56.9 to 59.8)	56.8 (54.8 to 58.8)	55.3 (52.5 to 58.2)	54.0 (49.8 to 58.2)
Difference vs. BMI of 20 kg/m²	Reference	−1.7 (−3.5 to 0.1)	−3.3 (−6.3 to −0.3)	−4.7 (−8.7 to −0.8)	−6.0 (−11.2 to −0.9)
Original model with addition of "expected death" covariate (*n* = 5194)					
Predicted probability of hospice enrollment, %	36.9 (35.2 to 38.7)	34.9 (33.5 to 36.2)	31.9 (30.2 to 33.7)	28.3 (25.9 to 30.7)	24.1 (20.3 to 27.9)
Difference vs. BMI of 20 kg/m²	Reference	−2.1 (−3.8 to −0.4)	−5.0 (−7.6 to −2.4)	−8.6 (−11.9 to −5.2)	−12.8 (−17.3 to −8.3)
Predicted total hospice days	43.1 (42.7 to 43.6)	41.0 (40.6 to 41.4)	39.1 (38.6 to 39.6)	37.5 (36.7 to 38.2)	36.0 (34.7 to 37.3)
Difference vs. BMI of 20 kg/m²	Reference	−2.1 (−2.6 to −1.7)	−4.0 (−4.7 to −3.3)	−5.7 (−6.6 to −4.7)	−7.1 (−8.5 to −5.7)
Predicted probability of in-home death, %	60.7 (58.7 to 62.6)	59.0 (57.6 to 60.4)	57.4 (55.4 to 59.4)	55.9 (53.1 to 58.7)	54.5 (50.4 to 58.6)
Difference vs. BMI of 20 kg/m²	Reference	−1.7 (−3.4 to 0.1)	−3.3 (−6.2 to −0.3)	−4.8 (−8.7 to −0.9)	−6.2 (−11.3 to −1.1)
Original model with addition of interaction term between BMI and time from survey to death (*n* = 5677)					
Predicted probability of hospice enrollment, %	38.3 (36.5 to 40.2)	35.3 (33.9 to 36.6)	31.6 (29.9 to 33.3)	27.4 (25.0 to 29.7)	22.8 (19.3 to 26.4)
Difference vs. BMI of 20 kg/m²	Reference	−3.1 (−1.3 to 4.8)	−6.8 (−9.4 to −4.1)	−11.0 (−14.3 to −7.6)	−15.5 (−19.8 to −11.2)
Predicted total hospice days	43.8 (43.4 to 44.2)	40.3 (40.0 to 40.6)	38.4 (38.0 to 38.8)	37.8 (37.1 to 38.4)	38.6 (37.3 to 39.9)
Difference vs. BMI of 20 kg/m²	Reference	−3.5 (−3.9 to −3.0)	−5.4 (−6.1 to −4.7)	−6.0 (−6.9 to −5.1)	−5.2 (−6.6 to −3.7)
Predicted probability of in-home death, %	61.1 (59.2 to 63.0)	59.8 (58.4 to 61.1)	58.2 (56.3 to 60.1)	56.4 (53.8 to 59.1)	54.4 (50.4 to 58.4)
Difference vs. BMI of 20 kg/m²	Reference	−1.3 (−3.1 to 0.4)	−2.9 (−5.8 to 0.0)	−4.7 (−8.4 to −0.9)	−6.7 (−11.6 to −1.8)

BMI = body mass index.
* Predicted probabilities and predicted numbers of hospice days were calculated for representative BMI values and were adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function, quintile of regional end-of-life expenditures, and year of death. Values are means (95% CIs).

Appendix Table 5. Predicted Probability of Hospice Enrollment, Total Hospice Days, Probability of In-Home Death, and Total Medicare Expenditures, by 4 Categories of BMI (*n* = 5677)*

Predicted End-of-Life Outcome	**BMI Category**			
	Underweight (<18.5 kg/m²) (*n* = 424)	**Normal (18.5–24.9 kg/m²) (*n* = 2509)**	**Overweight (25–29.9 kg/m²) (*n* = 1763)**	**Obese (≥30 kg/m²) (*n* = 981)**
Mean probability of hospice enrollment (95% CI), %	39.3 (34.9 to 43.8)	37.0 (35.2 to 38.8)	34.2 (32.1 to 36.3)	27.8 (25.0 to 30.5)
Difference vs. normal BMI	−2.3 (−7.1 to 2.5)	Reference	−2.9 (−5.7 to −0.1)	−9.2 (−12.6 to −5.9)
Mean total hospice days (95% CI)†	47.1 (46.1 to 48.2)	40.5 (40.1 to 40.9)	41.7 (41.2 to 42.2)	37.6 (36.8 to 38.4)
Difference vs. normal BMI	6.6 (5.5 to 7.7)	Reference	1.2 (0.5 to 1.9)	−3.0 (−3.9 to −2.0)
Mean probability of in-home death (95% CI), %	61.5 (56.8 to 66.2)	60.8 (58.9 to 62.7)	58.8 (56.6 to 61.1)	57.1 (53.9 to 60.3)
Difference vs. normal BMI	0.7 (−4.3 to 5.7)	Reference	−1.9 (−4.9 to 1.1)	−3.7 (−7.5 to 0.1)
Mean total Medicare expenditures (95% CI), $	40 463 (36 625 to 44 301)	44 005 (42 269 to 45 742)	45 755 (43 668 to 47 843)	45 283 (42 494 to 48 073)
Difference vs. normal BMI	−3542 (−7631 to 546)	Reference	1750 (−905 to 4405)	1278 (−2068 to 4624)

BMI = body mass index.
* Adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function, quintile of regional end-of-life expenditures, and year of death.
† Among decedents who were ever enrolled in hospice (*n* = 1971).

Appendix Table 6. Predicted Probability of Hospice Enrollment, Total Hospice Days, Probability of In-Home Death, and Total Medicare Expenditures, by 6 Categories of BMI (n = 5677)*

Predicted End-of-Life Outcome	BMI Category					
	Underweight (<18.5 kg/m^2) (n = 424)	**Normal (18.5–24.9 kg/m^2) (n = 2509)**	**Overweight (25–29.9 kg/m^2) (n = 1763)**	**Class I Obesity (30–34.9 kg/m^2) (n = 628)**	**Class II Obesity (35–39.9 kg/m^2) (n = 236)**	**Class III Obesity (≥40 kg/m^2) (n = 117)**
Mean probability of hospice enrollment (95% CI), %	39.4 (34.9 to 43.8)	37.1 (35.3 to 38.8)	34.2 (32.1 to 36.3)	28.6 (25.3 to 32.0)	27.6 (22.1 to 33.0)	22.9 (15.5 to 30.3)
Difference vs. normal BMI	2.3 (−2.5 to 7.1)	Reference	−2.9 (−5.7 to −0.1)	−8.4 (−12.3 to −4.5)	−9.5 (−15.3 to −3.7)	−14.2 (−21.9 to −6.5)
Mean total hospice days (95% CI)†	47.1 (46.0 to 48.1)	40.5 (40.1 to 40.9)	41.7 (41.1 to 42.2)	38.4 (37.5 to 39.4)	32.8 (31.3 to 34.2)	44.4 (41.8 to 47.0)
Difference vs. normal BMI	6.6 (5.4 to 7.7)	Reference	1.2 (0.5 to 1.9)	−2.1 (−3.2 to −1.1)	−7.8 (−9.3 to −6.3)	3.9 (1.2 to 6.6)
Mean probability of in-home death (95% CI), %	61.5 (56.8 to 66.2)	60.8 (58.9 to 62.7)	58.8 (56.6 to 61.1)	57.5 (53.6 to 61.3)	59.3 (53.0 to 65.5)	50.0 (40.9 to 59.2)
Difference vs. normal BMI	0.7 (−4.3 to 5.7)	Reference	−2.0 (−5.0 to 1.0)	−3.3 (−7.7 to 1.0)	−1.5 (−8.1 to 5.1)	−10.8 (−20.2 to −1.4)
Mean total end-of-life expenditures (95% CI), $	40 453 (36 617 to 44 288)	44 007 (42 271 to 45 743)	45 761 (43 674 to 47 848)	45 920 (42 460 to 49 380)	42 334 (37 134 to 47 533)	47 837 (39 474 to 56 200)
Difference vs. normal BMI	−3555 (−7640 to 531)	Reference	1754 (−900 to 4408)	1913 (−1985 to 5811)	−1674 (−7207 to 3860)	3830 (−4778 to 12 437)

BMI = body mass index.
* Adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, number of activities of daily living and instrumental activities of daily living, cognitive function, quintile of regional end-of-life expenditures, and year of death.
† Among decedents who were ever enrolled in hospice (n = 1971).

Appendix Table 7. Predicted Probability of Hospice Enrollment, Total Hospice Days, Probability of In-Home Death, and Total Medicare Expenditures, by BMI, in the Full Available Population (n = 6975)*

Outcome	BMI				
	20 kg/m²	25 kg/m²	30 kg/m²	35 kg/m²	40 kg/m²
Predicted probability of hospice enrollment, %	37.7 (36.2 to 39.3)	35.3 (34.1 to 36.6)	32.1 (30.5 to 33.7)	28.3 (26.1 to 30.5)	24.1 (20.7 to 27.4)
Difference vs. BMI of 20 kg/m²	Reference	−2.4 (−3.9 to −0.9)	−5.6 (−7.9 to −3.3)	−9.4 (−12.4 to −6.4)	−13.7 (−17.7 to −9.7)
Predicted total hospice days†	46.5 (46.1 to 46.9)	42.8 (42.5 to 43.1)	40.6 (40.2 to 41.0)	39.8 (39.1 to 40.4)	40.1 (39.0 to 41.3)
Difference vs. BMI of 20 kg/m²	Reference	−3.7 (−4.1 to −3.3)	−5.9 (−6.4 to −5.3)	−6.7 (−7.5 to −5.9)	−6.4 (−7.7 to −5.1)
Predicted probability of in-home death, %	62.8 (62.2 to 64.5)	61.4 (60.2 to 62.7)	60.0 (58.3 to 61.7)	58.5 (56.1 to 60.9)	57.1 (53.5 to 60.7)
Difference vs. BMI of 20 kg/m²	Reference	−1.4 (−2.9 to 0.1)	−2.9 (−5.3 to −0.4)	−4.3 (−7.6 to −1.0)	−5.8 (−10.0 to −1.5)
Predicted total end-of-life expenditures, $	41 533 (40 050 to 43 016)	42 705 (41 556 to 43 855)	43 444 (41 945 to 44 943)	43 726 (41 684 to 45 768)	43 543 (40 509 to 46 576)
Difference vs. BMI of 20 kg/m²	Reference	1172 (−89 to 2433)	1911 (−208 to 4030)	2193 (−601 to 4987)	2009 (−1676 to 5695)

BMI = body mass index.
* Predicted probabilities were calculated for representative BMI values and were adjusted for decedent age, race/ethnicity, marital status, 28 Elixhauser medical conditions, total household assets, limitations in activities of daily living and instrumental activities of daily living, cognitive function, quintile of regional end-of-life expenditures, and year of death. This cohort includes 5677 community-dwelling decedents and 1298 nursing home–dwelling decedents. These totals exclude 345 community-dwelling decedents and 54 nursing home–dwelling decedents who were excluded from the study cohort because of missing covariate data. Values are means (95% CIs).
† Among decedents who were ever enrolled in hospice (n = 2412).

Appendix Table 8. Coefficients, SEs, and Constant for Statistical Model Predicting Hospice Enrollment

Covariate	Coefficient	SE
Body mass index	0.006	0.033
Body mass index (squared)	−0.001	0.001
Congestive heart failure	−0.031	0.080
Cardiac arrhythmia	−0.145	0.075
Valvular disease	0.215	0.096
Pulmonary circulation disorder	0.164	0.147
Peripheral vascular disorder	−0.086	0.083
Hypertension, uncomplicated	0.046	0.068
Hypertension, complicated	−0.119	0.112
Paralysis	0.091	0.205
Other neurologic disorder	0.236	0.111
Chronic pulmonary disease	0.038	0.072
Diabetes, uncomplicated	0.094	0.082
Diabetes, complicated	−0.004	0.119
Hypothyroidism	−0.068	0.094
Renal failure	0.094	0.111
Liver disease	0.402	0.172
Peptic ulcer disease, excluding bleeding	−0.024	0.234
Lymphoma	0.646	0.201
Metastatic cancer	0.948	0.140
Solid tumor without metastasis	0.940	0.087
Rheumatoid arthritis/collagen disorder	−0.223	0.150
Coagulopathy	−0.004	0.130
Weight loss	−0.032	0.124
Fluid and electrolyte disorders	0.100	0.084
Blood loss anemia	−0.303	0.192
Iron deficiency anemia	−0.017	0.106
Alcohol abuse	−0.086	0.249
Psychosis	0.064	0.181
Depression	0.024	0.104
Female sex	0.178	0.069
Age at death	0.019	0.004
Race		
White	–	–
Black	−0.605	0.099
Hispanic ethnicity	−0.280	0.150
Other	−0.301	0.195
Marital status		
Married	–	–
Never married	−0.617	0.207
Widowed	−0.002	0.075
Separated/divorced	−0.132	0.119
Quintile of regional end-of-life expenditures		
1	–	–
2	−0.177	0.107
3	−0.151	0.103
4	0.177	0.106
5	−0.330	0.100
Activities of daily living		
0	–	–
1	0.029	0.090
2	0.119	0.104
3	−0.116	0.129
4	0.257	0.142
5	0.274	0.162
6	0.303	0.156
Instrumental activities of daily living		
0	–	–
1	−0.035	0.093
2	0.055	0.115
3	0.063	0.146
4	0.106	0.156
5	0.432	0.162
Cognitive function		
Normal cognitive function	–	–
Mild cognitive impairment/cognitive impairment or no dementia	0.130	0.075
Dementia	0.046	0.099
Total household wealth per 1 U.S. dollar	<0.001	<0.001
Year of death	0.111	0.008
Constant	−223.9	15.332