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The Relationship of Obesity to Hospice Use and Expenditures: A Cohort Study

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Abstract

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Background—Obesity complicates medical, surgical, nursing and informal caregiving in severe illness, but the impact of obesity on hospice utilization, location of death, and Medicare expenditures is unknown.

Objective—To describe the associations between body mass index (BMI) and hospice utilization and Medicare expenditures in the last six months of life.

Design—Retrospective cohort.

Setting—The Health and Retirement Study.

Participants—5,677 community-dwelling Medicare fee-for-service beneficiaries who died between 1998 and 2012.

Measures—Hospice enrollment, days enrolled in hospice, in-home death, and total Medicare expenditures measured in the six months before death. Generalized linear models were used to examine the association of increasing BMI and mean predicted outcome in the four measures. BMI was modeled as a continuous variable with a quadratic functional form.

Results—For a decedent with BMI of 20 kg/m², the predicted probability of hospice enrollment was 38.3% (95% CI, 36.5% to 40.2%), the predicted hospice duration was 42.8 days (95% CI, 42.3 to 43.2 days), the predicted probability of in-home death was 61.3% (95% CI, 59.4% to 63.2%), and the predicted total Medicare expenditures was \$42 803. As decedent BMI increased from 20 to 30 kg/m², the predicted probability of hospice enrollment decreased by 6.7 percentage points (95% CI, −9.3 to −4.0 percentage points), predicted hospice duration decreased by 3.8 days (95% CI, −4.4 to −3.1 days), predicted probability of in-home death decreased by 3.2 percentage points (95% CI, −6.0 to −0.4 percentage points), and predicted total Medicare expenditures increased by \$3471 (95% CI, \$955 to \$5988). For decedents with morbid obesity (BMI ≥40 kg/m²), there were larger effects; the predicted probability of hospice enrollment decreased 15.2 percentage points (95% CI, −19.6 to −10.9 percentage points), hospice duration decreased 4.3 days (95% CI, −5.7 to −2.9 days), and in-home death decreased by 6.3 percentage points (95% CI, −11.2 to −1.5 percentage points) compared to decedents with BMI of 20 kg/m².

Limitations—Baseline data was self-reported, and the interval of reported height and weight to time of death varied among participants.

Conclusion—Among community-dwelling decedents of the Health and Retirement Study, there was an independent association between obesity and reduced hospice service utilization, and in-home death, and higher Medicare expenditures in the last six months of life.

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Introduction

Seventy percent of US adults aged sixty years and older are overweight or obese.(1) Obesity is associated with shorter life expectancy, increased risk of hospitalization and higher utilization of intensive care services.(2–4) Obesity is also associated with variation in the quality of care in cancer screening, immunizations, cancer care, and intensive care.(4–8)

For individuals with obesity, there are technical and logistical issues that arise during hospitalizations, surgery, and end-of-life care that require special attention. Obesity

challenges the ability of healthcare 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, the provision of sub-optimal care, and weaker therapeutic alliances.(12–15) To date, however, no studies have examined the association between obesity and use of hospice, a cornerstone of end-of-life care.

To understand the effect of BMI on hospice utilization and Medicare expenditures at the end-of-life, we used the Health and Retirement Study to examine hospice enrollment, total hospice days, 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 individuals with obesity, we hypothesized that: first, higher BMI would be associated with decreased hospice utilization and fewer home deaths due to patient, provider, and system factors affecting referral to and enrollment in hospice services; and second, higher BMI would be associated with increased healthcare expenditures due to increased utilization of hospital and healthcare services.

Methods

Study Population

We examined survey and Medicare claims data for participants in the Health and Retirement Study (HRS) who died between 1998 and 2012, the most recent data available.(16) The HRS is a nationally representative panel survey that biennially interviews US adults over the age of 50 concerning health and financial issues. Since 1992, the HRS has enrolled more than 30,000 participants with a follow-up response rate consistently over 90%; the recruitment and survey methods have been previously described.(17) The HRS survey of each participant 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 healthcare utilization and expenditures beyond HRS-collected data. Respondents were eligible for the present 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 healthcare utilization 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, date of survey, 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, each day was classified 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/supplier, durable

medical, hospice, home health, and skilled nursing). Expenditures were adjusted to 2012 US dollars using the medical component of the US Bureau of Labor Statistics Consumer Price Index.

Other Variables

The primary independent variable of interest was BMI. We calculated each decedent's BMI 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. We used respondent-reported measures of gender, race (non-white races were collapsed due to sample size), Hispanic ethnicity, marital status (widowed, single, separated, divorced, or married), and total household assets adjusted to 2012 US dollars. We identified 28 comorbid medical conditions from one year prior to the defined end-of-life period (6 months before death) using the Elixhauser method International Classification of Diseases, 9th Revision, Clinical Modification codes from Medicare claims.(19) We used measures for the number of limitations in activities of daily living (ADL) and instrumental activities of daily living (IADL), and cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia).(20) We linked decedents with a measure of regional end-of-life expenditures (average Medicare expenditures in the last six months of life reported by the 2012 Dartmouth Atlas of Health Care by hospital referral region, separated into quintiles) using each decedent's zip code linked to its corresponding hospital referral region.(21) Cause of death was determined from the Centers for Disease and Control National Center for Health Statistics National Death Index (NDI) which categorizes causes of death by 113 ICD-10 codes. These codes were categorized as infectious, malignancy, diabetes mellitus, neurologic, cardiac, pulmonary, gastrointestinal/hepatobiliary, renal, or other. After the respondent's death, the HRS interviews proxy informants (typically surviving partner or adult children) about the respondent's end-of-life care. To examine whether obese patients were more likely to have an unexpected death, we used the exit interview question "Was the death expected at about the time it occurred or was it unexpected?" Response options include: "yes," "unsure," or "no;" responses "no" and "unsure" (N=14) were grouped together at negative responses. The interval of time between response to the last survey and time of death was calculated using the date of survey administration and date of death from NDI data.

Statistical Analyses

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 NIH obesity categories), a linear functional form, and a quadratic functional form based on theory and empirical evidence (see Appendix, Statistical Model Selection and Composition). (22) We report findings from our final models using BMI fit as a quadratic functional form based upon 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, gender, non-white race, Hispanic ethnicity, marital status, total

household assets, comorbid illnesses(19), limitations in ADLs and IADLs, cognitive function (normal, mild cognitive impairment/cognitive impairment, no dementia, or dementia), quintile of regional end-of-life expenditures, and year of death.

As 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 above model was changed to include an interaction term between BMI and the time interval from the survey-collected self-reported height and weight to death.(23) To explore the extent to which the association of BMI and the outcomes was influenced by the cause of death and proxy-reported expected death, each of these terms were added separately to the above model. We also fit models with BMI defined as a categorical variable. We also repeated the analysis with the complete, fee-for-service, decedent HRS cohort (including nursing home patients) to see if selecting community dwelling respondents biased the overall results.

We reported each outcome in terms of the mean predicted outcome (probability of hospice enrollment, days enrolled in hospice, probability of in-home death and Medicare expenditures) at five BMI levels (20, 25, 30, 35 and 40 kg/m²) and significance testing using 95% confidence intervals. The mean predicted outcome was estimated by the statistical model, for a given BMI level while holding all other covariates at their own values.(24) Probabilities were reported as percent chance of the outcome occurring between 0% and 100%. If the 95% confidence interval did not contain the null hypothesis value, the results were considered statistically significant. We used Stata version 14.0 (StataCorp) software for all analyses, specifically the “glm” and “margins” commands.

Role of the Funding Source

Informed consent was obtained from all participants in the HRS study. University of Michigan Institutional Review Board-Medical deemed this study of decedents exempt from institutional review board review. The Robert Wood Johnson Foundation, U.S. Department of Veterans Affairs, National Institute on Aging, and National Cancer Institute financially supported the authors of this article. The funding sources had no role in the design, conduct, analysis or interpretation of the data or approval of the manuscript.

Results

Of 9,859 HRS decedents who consented to Medicare linkage, we excluded 2,485 with any managed care enrollment during the last six months of life. We also excluded 1,352 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 survey (88), height or weight from the last survey (93), ZIP code (23) marital status (3), activities of daily living information (41), or cognitive function (97) (Appendix Figure 1).

The final cohort included 5,677 decedents. Of these, 424 (7%) were underweight (BMI <18.5 kg/m²), 2,509 (44%) were normal weight (BMI 18.5 to 24.9 kg/m²), 1,763 (31%) were overweight (BMI 25 to 29.9 kg/m²), 864 (15%) were obese (BMI 30 to <40 kg/m²), and 117 (2%) were morbidly obese (BMI ≥ 40 kg/m²); the median BMI was 24.7 kg/m²

(Interquartile Range [IQR] 21.5 to 28.2 kg/m²). The median age at death was 81.2 years (IQR 73.8 to 87.5 years). The median time from 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.

The overall observed incidence of hospice enrollment was 34.7%. Subjects with higher BMI had a significantly lower likelihood of hospice enrollment compared to an individual with a BMI of 20 kg/m² (Figure 1). An individual with a BMI of 40 kg/m² had a predicted probability of hospice enrollment of 23.1% (95% confidence interval [CI], 19.5% to 26.7%) compared to an individual with a BMI of 20 kg/m² who had a predicted probability of 38.3% (95% CI, 36.5% to 40.2%; Table 2). Among those who enrolled in hospice, the predicted total hospice days decreased as individual BMI increased. An individual with a BMI of 40 kg/m² spent 4.3 fewer days (95% CI, -5.7 to -2.9 days) in hospice care than an individual with a BMI of 20 kg/m². This effect was driven by decreased numbers of days spent in home hospice, and there was not a clinically significant increase in facility hospice care for patients with obesity (Appendix Table 2).

The overall observed incidence of in-home death was 59.6%. Individuals with higher BMI had a significantly lower likelihood of in-home death compared to an individual with a BMI of 20 kg/m² (Figure 1). An individual with a BMI of 40 kg/m² had a predicted probability of in-home death of 55.0% (95% CI, 51.0% to 58.9%) compared to an individual with a BMI of 20 kg/m² who had a predicted probability of 61.3% (95% CI, 59.4% to 63.2%; Table 2).

In the last six months of life, total predicted Medicare expenditures increased as BMI increased. The mean total predicted expenditures were \$42 803 (95% CI, \$41 085 to \$44 521; Table 2) for an individual with a BMI of 20 kg/m². In contrast, for an individual with a BMI of 30 kg/m², the mean total predicted Medicare expenditures were \$3471 (95% CI, \$955 to \$5988) higher compared to an individual with a BMI of 20 kg/m². Predicted expenditures for those with a BMI of 30 kg/m², 35 kg/m², and 40 kg/m² were constant, but there was also a decrease in precision related to small sample size at the upper extremes of the study sample's BMI range (Figure 1). When examining the component Medicare expenditures, these expenditures were driven by inpatient, outpatient, and physician/supplier expenditures that increased by a mean of \$4343 (95% CI, \$2008 to \$6678) for decedents with a BMI 30 kg/m² compared to the base case BMI 20 kg/m² (Table 3). However, these expenditures were offset by lower home health, durable medical, and hospice Medicare expenditures, which were decreased by a mean of \$1173 (95% CI, \$659 to \$1688) for decedents with a BMI 30 kg/m² compared to a decedent with a BMI of 20 kg/m². Because of differences in both enrollment and length of stay, predicted hospice Medicare expenditures for an individual with a BMI of 40 kg/m² (\$1321 [95% CI, \$949 to \$1692]) were 60% lower than individuals with a BMI of 20 kg/m² (\$3357; [95% CI, \$2896 to \$3818]).

To examine whether this analysis was confounded by the cause of death or whether the death was unexpected, we re-fit the model with these variables included. Diabetes- and renal-related causes of death were more common for obese and morbidly obese respondents than

normal BMI (BMI 18.5–24.9 kg/m²) respondents (Appendix Table 3). 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). The likelihood that a proxy reported the death as “expected” decreased as BMI increased: 55% of deaths were “expected” by proxies for normal weight compared to 45% for morbidly obese (Appendix Table 3). When we included an “expected death” as a model covariate, the effect sizes also remained stable (Appendix Table 4). When we included an interaction term between BMI and the time interval from survey data collection, the trends and effect sizes of the outcomes were comparable (Appendix Table 4).

The main outcomes, reported by BMI categories, are reported in Appendix Tables 5 and 6, and the trends and effect sizes of the outcomes were comparable to when BMI was modeled as a continuous variable. The main outcomes including nursing home patients were comparable to the community-dwelling study cohort and are presented in Appendix Table 7. The complete statistical model coefficients, standard errors, and constant for model predicting hospice enrollment are reported in Appendix Table 8.

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, in-home death, and increased Medicare expenditures in the last six months of life after adjustment for key sociodemographic, medical, functional status, and geographic factors. Increasing 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 of end-of-life care, here defined as enrollment in hospice, length of hospice stay, and in-home death. Additional research should focus on understanding the mechanisms underlying this vulnerability at the end of life.

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

We hypothesize that the effect of obesity on hospice enrollment may act through two mechanisms: referral behaviors and enrollment policies. First, prolonged cachexia experienced by some individuals at the end-of-life is recognized by family members and physicians as closely related with the dying process.(39) Individuals 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 individuals who may appear less robust physically. The trajectories of illness and dying may vary as a function of patient obesity within diseases. Patients with obesity may experience a more sudden decline in performance status or increase in metabolic abnormalities, which may lead to more sudden deaths than patients without obesity. 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, there is presently little available research 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 healthcare.

Second, hospice enrollment policies vary from hospice to hospice, and some policies restrict access to care for individuals with higher cost medical care.(27) Obese individuals in home hospice may require increased nursing assistance, including the need for mechanical patient lift devices to provide proper patient positioning and personal care in the terminal phase of dying.(40) The need for extra nursing personnel or mechanical lifts may make home hospice care infeasible for individuals with obesity and their caregivers.(41)

Obesity is associated with increased utilization of healthcare services and associated expenditures.(42–45) In this community-dwelling cohort, we found that Medicare expenditures for obese participants were 13% higher (a difference of \$4,343) for inpatient, outpatient, and physician expenditures but 20% lower (a difference of \$1,173) for hospice, home health, and durable medical equipment. The etiology of increased expenditures for people with obesity has been explained by the relative increased prevalence of medical conditions such as diabetes, hypertension, and coronary artery disease.(46–48) However, higher BMI presents many challenges to medical management beyond increased medical multimorbidity. Higher BMI is associated with decreased access to medical care, increased difficulty managing medical issues in an outpatient setting comparative to an inpatient setting, and more challenges transitioning from inpatient care back to home care.(49–53) Finally, there is an established record of negative provider attitudes and implicit bias against individuals with obesity, and these attitudes may continue to influence care for individuals with obesity at the end-of-life.(13, 14) Each of these factors may impede the provision of optimal medical, nursing, and supportive care for obese individuals either independently or together, thus explaining the independent effect of obesity on end-of-life healthcare expenditures.

There are several potential limitations of our study. We used a self-reported BMI measure that was collected a median of 16 months before death and the time interval from this pre-death biometric to death varied within the study cohort. A sensitivity analysis examining whether this time interval had an effect on the association of BMI and the outcomes showed this was not substantial and did not change the overall effect. We only examined community-dwelling adults using fee-for-service Medicare claims, but our results were not significantly different when nursing home-dwelling decedents were included in the sample. The study sample did not include respondents who are 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.(54) Although we controlled for the

presence of more than two dozen medical conditions, functional status (ADL and IADL limitations, and cognitive function) at the last core survey interview, cause of death, and the decedent proxy's judgment of whether the death was expected or not, 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 has identified a significant relationship in decedents between obesity and decreased probability of hospice enrollment and in-home death and, among those who were enrolled, fewer days of hospice care. The consequences of obesity for healthcare utilization and expenditures are substantial, and individuals with obesity 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 utilization and Medicare expenditures by patient BMI provide an excellent opportunity for improvement. Policy interventions could include increased reimbursement for home care services of obese individuals 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 levels of obesity. All people, regardless of body size, and their families should have equal opportunities to experience the benefits of high quality end-of-life healthcare.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA*. 2014; 311(8):806–14. [PubMed: 24570244]
2. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA*. 2003; 289(2):187–93. [PubMed: 12517229]
3. Hauck K, Hollingsworth B. The impact of severe obesity on hospital length of stay. *Med Care*. 2010; 48(4):335–40. [PubMed: 20220534]
4. Prescott HC, Chang VW, O'Brien JM Jr, Langa KM, Iwashyna TJ. Obesity and 1-year outcomes in older Americans with severe sepsis. *Crit Care Med*. 2014; 42(8):1766–74. [PubMed: 24717466]
5. Maruthur NM, Bolen S, Brancati FL, Clark JM. Obesity and mammography: a systematic review and meta-analysis. *J Gen Intern Med*. 2009; 24(5):665–77. [PubMed: 19277790]
6. Maruthur NM, Bolen SD, Brancati FL, Clark JM. The association of obesity and cervical cancer screening: a systematic review and meta-analysis. *Obesity (Silver Spring)*. 2009; 17(2):375–81. [PubMed: 18997682]

7. Harris JA, Moniz MH, Iott B, Power R, Griggs JJ. Obesity and the receipt of influenza and pneumococcal vaccination: a systematic review and meta-analysis. *BMC Obes.* 2016; 3:24. [PubMed: 27200179]
8. Griggs JJ, Sorbero ME, Lyman GH. Undertreatment of obese women receiving breast cancer chemotherapy. *Arch Intern Med.* 2005; 165(11):1267–73. [PubMed: 15956006]
9. Gupta D. Moribund obesity as a palliative care diagnosis. *J Palliat Med.* 2009; 12(6):515–6. [PubMed: 19508135]
10. Nwosu AC, Raj J, Hugel H. Palliative care and obesity: are we prepared? *J Palliat Med.* 2012; 15(1):7–8. [PubMed: 22268403]
11. Broome CA, Ayala EM, Georgeson KA, Heidrich SM, Karnes K, Wells JB. Nursing care of the super bariatric patient: challenges and lessons learned. *Rehabil Nurs.* 2015; 40(2):92–9. [PubMed: 25044311]
12. Puhl R, Brownell KD. Bias, discrimination, and obesity. *Obes Res.* 2001; 9(12):788–805. [PubMed: 11743063]
13. Puhl RM, Heuer CA. Obesity stigma: important considerations for public health. *Am J Public Health.* 2010; 100(6):1019–28. [PubMed: 20075322]
14. Budd GM, Mariotti M, Graff D, Falkenstein K. Health care professionals' attitudes about obesity: an integrative review. *Appl Nurs Res.* 2011; 24(3):127–37. [PubMed: 20974067]
15. Huizinga MM, Cooper LA, Bleich SN, Clark JM, Beach MC. Physician respect for patients with obesity. *J Gen Intern Med.* 2009; 24(11):1236–9. [PubMed: 19763700]
16. Kelley AS, Langa KM, Smith AK, Cagle J, Ornstein K, Silveira MJ, et al. Leveraging the health and retirement study to advance palliative care research. *J Palliat Med.* 2014; 17(5):506–11. [PubMed: 24694096]
17. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, Weir DR. Cohort Profile: the Health and Retirement Study (HRS). *Int J Epidemiol.* 2014; 43(2):576–85. [PubMed: 24671021]
18. Teno JM, Gozalo PL, Bynum JP, Leland NE, Miller SC, Morden NE, et al. Change in end-of-life care for Medicare beneficiaries: site of death, place of care, and health care transitions in 2000, 2005, and 2009. *JAMA.* 2013; 309(5):470–7. [PubMed: 23385273]
19. Elixhauser A, Steiner C, Harris DR, Coffey RN. Comorbidity measures for use with administrative data. *Medical Care.* 1998; 36(1):8–27. [PubMed: 9431328]
20. Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of cognition using surveys and neuropsychological assessment: the Health and Retirement Study and the Aging, Demographics, and Memory Study. *J Gerontol B Psychol Sci Soc Sci.* 2011; 66(Suppl 1):i162–71. [PubMed: 21743047]
21. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care. *Ann Intern Med.* 2003; 138(4):273–87. [PubMed: 12585825]
22. Wong ES, Wang BC, Garrison LP, Alfonso-Cristancho R, Flum DR, Arterburn DE, et al. Examining the BMI-mortality relationship using fractional polynomials. *BMC Med Res Methodol.* 2011; 11(1):175. [PubMed: 22204699]
23. Alley DE, Metter EJ, Griswold ME, Harris TB, Simonsick EM, Longo DL, et al. Changes in weight at the end of life: characterizing weight loss by time to death in a cohort study of older men. *American journal of epidemiology.* 2010:kwq168.
24. StataCorp. *Stata 14 Base Reference Manual.* College Station, TX: Stata Press; 2015. Margins Command.
25. Miesfeldt S, Murray K, Lucas L, Chang CH, Goodman D, Morden NE. Association of age, gender, and race with intensity of end-of-life care for Medicare beneficiaries with cancer. *J Palliat Med.* 2012; 15(5):548–54. [PubMed: 22468739]
26. Han B, Remsburg RE, Iwashyna TJ. Differences in hospice use between black and white patients during the period 1992 through 2000. *Med Care.* 2006; 44(8):731–7. [PubMed: 16862034]
27. Aldridge Carlson MD, Barry CL, Cherlin EJ, McCorkle R, Bradley EH. Hospices' enrollment policies may contribute to underuse of hospice care in the United States. *Health Aff (Millwood).* 2012; 31(12):2690–8. [PubMed: 23213153]

28. Obermeyer Z, Powers BW, Makar M, Keating NL, Cutler DM. Physician Characteristics Strongly Predict Patient Enrollment In Hospice. *Health Aff (Millwood)*. 2015; 34(6):993–1000. [PubMed: 26056205]
29. Casarett D, Van Ness PH, O’Leary JR, Fried TR. Are patient preferences for life-sustaining treatment really a barrier to hospice enrollment for older adults with serious illness? *J Am Geriatr Soc*. 2006; 54(3):472–8. [PubMed: 16551315]
30. Park NS, Carrion IV, Lee BS, Dobbs D, Shin HJ, Becker MA. The role of race and ethnicity in predicting length of hospice care among older adults. *J Palliat Med*. 2012; 15(2):149–53. [PubMed: 22313431]
31. Teno JM, Clarridge BR, Casey V, Welch LC, Wetle T, Shield R, et al. Family perspectives on end-of-life care at the last place of care. *JAMA*. 2004; 291(1):88–93. [PubMed: 14709580]
32. Teno JM, Shu JE, Casarett D, Spence C, Rhodes R, Connor S. Timing of referral to hospice and quality of care: length of stay and bereaved family members’ perceptions of the timing of hospice referral. *J Pain Symptom Manage*. 2007; 34(2):120–5. [PubMed: 17583469]
33. Institute of Medicine. *Dying in America: Improving Quality and Honoring Individual Preferences Near the End of Life*. Washington, D.C: 2014.
34. Wright AA, Zhang B, Ray A, Mack JW, Trice E, Balboni T, et al. Associations between end-of-life discussions, patient mental health, medical care near death, and caregiver bereavement adjustment. *JAMA*. 2008; 300(14):1665–73. [PubMed: 18840840]
35. Wright AA, Keating NL, Balboni TA, Matulonis UA, Block SD, Prigerson HG. Place of death: correlations with quality of life of patients with cancer and predictors of bereaved caregivers’ mental health. *J Clin Oncol*. 2010; 28(29):4457–64. [PubMed: 20837950]
36. Wright AA, Keating NL, Ayanian JZ, Chrischilles EA, Kahn KL, Ritchie CS, et al. Family Perspectives on Aggressive Cancer Care Near the End of Life. *JAMA*. 2016; 315(3):284–92. [PubMed: 26784776]
37. Gazelle G. Understanding hospice--an underutilized option for life’s final chapter. *N Engl J Med*. 2007; 357(4):321–4. [PubMed: 17652645]
38. Stevenson DG. Growing pains for the Medicare hospice benefit. *N Engl J Med*. 2012; 367(18):1683–5. [PubMed: 23113479]
39. Boyd K, Murray SA. Recognising and managing key transitions in end of life care. *BMJ*. 2010; 341:c4863. [PubMed: 20847023]
40. Nwosu AC, Raj J, Hugel H. Palliative care and obesity: are we prepared? *Journal of palliative medicine*. 2012; 15(1):7–8. [PubMed: 22268403]
41. Varney, S. *The New York Times*. Scaling Up.
42. Durden ED, Huse D, Ben-Joseph R, Chu BC. Economic costs of obesity to self-insured employers. *J Occup Environ Med*. 2008; 50(9):991–7. [PubMed: 18784546]
43. Quesenberry CP, Caan B, Jacobson A. Obesity, health services use, and health care costs among members of a health maintenance organization. *Archives of Internal Medicine*. 1998; 158(5):466–72. [PubMed: 9508224]
44. Dee A, Kearns K, O’Neill C, Sharp L, Staines A, O’Dwyer V, et al. The direct and indirect costs of both overweight and obesity: a systematic review. *BMC Res Notes*. 2014; 7(1):242. [PubMed: 24739239]
45. Cawley J, Meyerhoefer C. The medical care costs of obesity: an instrumental variables approach. *J Health Econ*. 2012; 31(1):219–30. [PubMed: 22094013]
46. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA*. 2003; 289(1):76–9. [PubMed: 12503980]
47. Despres JP, Lemieux I. Abdominal obesity and metabolic syndrome. *Nature*. 2006; 444(7121):881–7. [PubMed: 17167477]
48. Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. *N Engl J Med*. 2010; 362(6):485–93. [PubMed: 20147714]
49. Goodell TT. The obese trauma patient: treatment strategies. *J Trauma Nurs*. 1996; 3(2):36–44. quiz 5–6. [PubMed: 9025456]

50. Gallagher SM. Restructuring the therapeutic environment to promote care and safety for the obese patient. *J Wound Ostomy Continence Nurs.* 1999; 26(6):292–7. [PubMed: 10865613]
51. King DR, Velmahos GC. Difficulties in managing the surgical patient who is morbidly obese. *Crit Care Med.* 2010; 38(9 Suppl):S478–82. [PubMed: 20724881]
52. Chong, HS., Bell, RL. *Critical Care Management of the Obese Patient.* Wiley-Blackwell; 2012. Postoperative Care of the Obese Patient; p. 147-58.
53. Phillips J. Care of the Bariatric Patient in Acute Care. *Journal of Radiology Nursing.* 2013; 32(1): 21–31.
54. Byhoff E, Harris JA, Ayanian JZ. Characteristics of Decedents in Medicare Advantage and Traditional Medicare. *JAMA Intern Med.* 2016; 176(7):1020–3. [PubMed: 27273237]

Figure 1.

Predicted Probability of Hospice Enrollment, Total Hospice Days, Predicted Probability of In-Home Death, and Total Medicare Expenditures by Body Mass Index*

Panel A shows the predicted probability of hospice enrollment in the last six months of life as a function of participant body mass index. Panel B shows the predicted total hospice days in the last six months of life as a function of participant body mass index. Panel C shows the predicted probability of in-home death in the last six months of life as a function of participant body mass index. Panel D shows the predicted total Medicare Expenditures in the last six months of life as a function of participant body mass index.

*Adjusted for decedent age, race/ethnicity, marital status, individual Elixhauser medical conditions (28), 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), regional end of life expenditures quintile, and year of death. Gray area represents the 95% confidence interval of the estimates.

Table 1

Characteristics* of Decedents by Body Mass Index (BMI) Category

Characteristic	Underweight (BMI <18.5 kg/m ²) (N = 424)	Normal (BMI 18.5– 24.9 kg/m ²) (N = 2509)	Overweight (BMI 25– 29.9 kg/m ²) (N = 1763)	Obese (BMI 30–<40 kg/m ²) (N = 864)	Morbidly Obese (BMI 40kg/m ²) (N =117)
Age at death, mean (SD), y	83.6 (9.4)	82.3 (8.8)	79.9 (9.1)	76.8 (9.3)	72.1 (8.4)
Gender					
Female	319 (75%)	1285 (51%)	723 (41%)	462 (53%)	77 (66%)
Male	105 (25%)	1224 (49%)	1040 (59%)	402 (47%)	40 (34%)
Race					
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					
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					
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%)
Net financial worth					

Characteristic	Underweight (BMI <18.5 kg/m ²) (N = 424)	Normal (BMI 18.5– 24.9 kg/m ²) (N = 2509)	Overweight (BMI 25– 29.9 kg/m ²) (N = 1763)	Obese (BMI 30–<40 kg/m ²) (N = 864)	Morbidly Obese (BMI 40 kg/m ²) (N = 117)
Total Household Assets, median, (Interquartile Range [IQR]), thousands US\$	94 (8–295)	135 (26–422)	133 (27–347)	99 (9–303)	42 (3–123)
Chronic Disease					
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 (normal, mild cognitive impairment, or dementia)					
Normal cognitive function	147 (35%)	1026 (41%)	870 (49%)	464 (54%)	65 (56%)
Mild cognitive impairment/cognitive impairment, 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					
No Activity of Daily Living Limitations	125 (29%)	1148 (46%)	857 (49%)	368 (43%)	24 (21%)
Number of Activity of Daily Living Limitations, Mean (SD)	2.2 (2.2)	1.5 (1.9)	1.4 (1.8)	1.6 (1.9)	2.5 (1.9)
No Instrumental Activity of Daily Living Limitations	158 (37%)	1346 (54%)	1075 (61%)	503 (58%)	47 (40%)
Number of Instrumental Activity of Daily Living Limitations, Mean (SD)	1.7 (1.8)	1.2 (1.7)	1.0 (1.5)	1.0 (1.4)	1.2 (1.4)
Regional End of Life Expenditures Quintile					

Characteristic	Underweight (BMI <18.5 kg/m ²) (N = 424)	Normal (BMI 18.5– 24.9 kg/m ²) (N = 2509)	Overweight (BMI 25– 29.9 kg/m ²) (N = 1763)	Obese (BMI 30–<40 kg/m ²) (N = 864)	Morbidly Obese (BMI 40 kg/m ²) (N = 117)
Highest Quintile Regional End of Life Expenditures	111 (26%)	774 (31%)	523 (30%) <i>no. (%)</i>	226 (26%)	28 (24%)
Lowest Quintile Regional End of Life Expenditures	59 (14%)	344 (14%)	242 (14%)	143 (17%)	19 (16%)
Time from Self-Reported Height and Weight to Death, median, 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)

* Reported at last survey interview. Values that are based on ten or fewer participants were assigned a value of 10 because of privacy restrictions. In the case of single cell in a column being suppressed, the second and/or third lowest count cells will also be assigned a value of less than nearest multiple of ten to prevent the ability to calculate the value of the suppressed cell.

[†] Defined as having either the Elixhauser diagnosis of uncomplicated and/or complicated hypertension

[‡] Defined as having either the Elixhauser diagnosis of uncomplicated and/or complicated diabetes

Table 2

Predicted Probability* of Hospice Enrollment, Total Hospice Days, Probability of In-Home Death, and Total Medicare Expenditures by Body Mass Index (BMI)[†] (N=5677)

Outcome	Body Mass Index (BMI)				
	BMI 20 kg/m ²	BMI 25 kg/m ²	BMI 30 kg/m ²	BMI 35 kg/m ²	BMI 40 kg/m ²
	Mean (95% Confidence Interval)				
Predicted Probability of Hospice Enrollment	38.3 (36.5, 40.2)	35.3 (34.0, 36.7)	31.7 (30.0, 33.4)	27.5 (25.2, 30.0)	23.1 (19.5, 26.7)
Difference from BMI 20	Reference	-3.0 (-4.7, -1.3)	-6.7 (-9.3, -4.0)	-10.8 (-14.2, -7.5)	-15.2 (-19.6, -10.9)
Predicted Total Hospice Days[‡]	42.8 (42.3, 43.2)	40.4 (40.1, 40.8)	39.0 (38.5, 39.4)	38.3 (37.6, 39.0)	38.5 (37.2, 39.7)
Difference from BMI 20	Reference	-2.3 (-2.8, -1.9)	-3.8 (-4.4, -3.1)	-4.4 (-5.3, -3.5)	-4.3 (-5.7, -2.9)
Predicted Probability of In-Home Death, 95% CI, %	61.3 (59.4, 63.2)	59.7 (58.3, 61.1)	58.1 (56.2, 60.0)	56.5 (53.9, 59.2)	55.0 (51.0, 58.9)
Difference from BMI 20	Reference	-1.6 (-3.3, 0.1)	-3.2 (-6.0, -0.4)	-4.8 (-8.5, -1.1)	-6.3 (-11.2, -1.5)
Predicted Total end-of-life expenditures, 95% CI, US\$	42803 (41085, 44521)	45011 (43712, 46311)	46274 (44542, 48007)	46508 (44147, 48870)	45698 (42235, 49161)
Difference from BMI 20, US\$	Reference	2208 (718, 3698)	3471 (955, 5988)	3705 (424, 6986)	2895 (-1342, 7132)

* Predicted probabilities are calculated for representative BMI values

[†] Adjusted for decedent age, race/ethnicity, marital status, individual Elixhauser medical conditions (28), 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), regional end of life expenditures quintile, and year of death.

[‡] Among decedents who were ever enrolled in hospice (N=1,971)

Table 3

Predicted End of Life Component Medicare Expenditures (US\$) by Body Mass Index (BMI)^{*,†}

Predicted End of Life Medicare Expenditures by Component	Body Mass Index (BMI)			
	BMI 20 kg/m ²	BMI 25 kg/m ²	BMI 30 kg/m ²	BMI 40 kg/m ²
<i>Mean (95% Confidence Interval), US\$</i>				
Inpatient	23051 (21713, 24390)	24828 (23786, 25871)	25973 (24586, 27361)	26041 (23254, 28828)
Difference from BMI 20	Reference	1777 (632, 2921)	2922 (962, 4882)	3337 (758, 5918)
Outpatient	2845 (2570, 3119)	3170 (2938, 3402)	3239 (2965, 3514)	3036 (2703, 3368)
Difference from BMI 20	Reference	325 (133, 517)	395 (52, 738)	191 (-253, 635)
Physician/Supplier	7314 (6990, 7638)	7955 (7705, 8206)	8392 (8055, 8728)	8584 (8117, 9052)
Difference from BMI 20	Reference	642 (369, 914)	1078 (604, 1552)	1271 (638, 1903)
Home Health and Durable Medical	2636 (2402, 2871)	2445 (2270, 2619)	2321 (2125, 2518)	2257 (2016, 2498)
Difference from BMI 20	Reference	-192 (-374, -10)	-315 (-597, -33)	-379 (-729, -29)
Skilled Nursing	4155 (3705, 4607)	4347 (3961, 4733)	4519 (3989, 5049)	4668 (3945, 5390)
Difference from BMI 20	Reference	192 (-204, 587)	364 (-311, 1038)	512 (-388, 1413)
Hospice	3357 (2896, 3818)	3036 (2670, 3403)	2514 (2168, 2860)	1905 (1578, 2231)
Difference from BMI 20	Reference	-320 (-681, 40)	-843 (-1347, -339)	-1452 (-2007, -898)
				-2036 (-2633, -1439)

* Predicted probabilities are calculated for representative BMI values

† Adjusted for decedent age, race/ethnicity, marital status, individual Elixhauser medical conditions (28), 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), regional end of life expenditures quintile, and year of death.