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ORIGINAL RESEARCH

Body Mass Index, Comorbidities, and Ambulatory Care Visits: The REGARDS Study

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BACKGROUND: Individuals with obesity have more ambulatory care usage than individuals with normal weight and overweight. There is limited information on whether this is consistent across provider specialties and whether comorbidities explain the associations.

METHODS AND RESULTS: Among REGARDS (Reasons for Geographic and Racial Differences in Stroke) cohort study participants with Medicare fee-for-service coverage (n=9648), we identified ambulatory visits over 5 years. We used marginalized zero-inflated Poisson models to calculate ratios of means by body mass index (BMI), adjusted for demographics and health behaviors, and inverse odds weighting to evaluate mediation by diabetes, hypertension, dyslipidemia, stroke, coronary heart disease, atrial fibrillation, heart failure, chronic kidney disease, depressive symptoms, cancer, arthritis, and sleep apnea. The mean age of participants was 71.7±7.3 years, 35.1% were Black individuals and 64.9% White individuals, and 51.1% were women. Participants had a mean of 37.8 total, 16.0 primary care, 3.4 cardiology, 1.9 orthopedics, 0.9 pulmonology, and 0.4 endocrinology visits. Compared with individuals with BMI 18.5 to <25 kg/m^2 (n=2613), participants with BMI ≥35 kg/m^2 (n=1259) had 23% (95% CI, 21%–24%) more ambulatory visits. Participants with BMI ≥35 kg/m^2 had 26% more primary care, 20% more cardiology, 74% more orthopedics, 62% more pulmonology, and 85% more endocrinology visits. Comorbidities partly explained associations with overall, primary care, and orthopedics visits (39%, 38%, and 15%, respectively) and largely explained associations with cardiology, pulmonology, and endocrinology visits.

CONCLUSIONS: Understanding which specialty visits are associated with higher BMI can help with workforce planning and allocation of resources.

Key Words: ambulatory care ■ body mass index ■ health services ■ medicare ■ obesity ■ overweight

Individuals who have obesity, often defined in the United States as a body mass index (BMI) of ≥30 kg/m^2, are at elevated risk for cardiovascular diseases, diabetes, osteoarthritis, obstructive sleep apnea, and some types of cancer.[1,2] Individuals with obesity also have higher usage of health care services, including ambulatory care visits, and higher health care costs as compared with both individuals with normal weight (BMI ≥18.5 kg/m^2 and <25 kg/m^2) and overweight (BMI ≥25 kg/m^2 and <30 kg/m^2).[3–12] However, ambulatory care is a broad category that includes office visits with primary care and various specialist physicians. There is limited information on whether BMI is differentially associated with ambulatory care provided by different

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CLINICAL PERSPECTIVE

What Is New?

- Individuals with Medicare health insurance, which covers adults aged ≥65 years and those with disabilities and end-stage renal disease, with higher body mass index had greater numbers of ambulatory care visits overall and of primary care, cardiology, orthopedics, pulmonology, and endocrinology specialty visits.
- Comorbidities partly explained associations of body mass index with overall, primary care, and orthopedics visits and largely explained associations with cardiology, pulmonology, and endocrinology visits.

What Are the Clinical Implications?

- Better understanding of how patients in the Medicare program with overweight and obesity interact with the health care system can provide guidance for workforce planning and training, development of care pathways, and allocation of health care resources.

Nonstandard Abbreviations and Acronyms

REGARDS Reasons for Geographic and Racial Differences in Stroke

medical specialties. Additionally, the role of comorbidities associated with obesity in driving greater health care usage is unclear. Better understanding of how and why patients with obesity interact with the health care system can provide guidance for which medical specialties and which comorbidities to target to provide health care for the ≈43% of American adults who have obesity.[13]

The objectives of this study were to examine usage of primary and specialty ambulatory care visits by BMI and to explore the extent to which observed associations of BMI with ambulatory care visits were explained by obesity-related comorbidities among participants with Medicare coverage (aged ≥65 years and those with disabilities or end-stage renal disease) in the large national REGARDS (Reasons for Geographic and Racial Differences in Stroke) study.

METHODS

Because of the sensitive nature of the data collected for this study, requests to access REGARDS study data from qualified researchers trained in human subject confidentiality protocols may be sent to the REGARDS study at regardsadmin@uab.edu. The data use agreement with the Centers for Medicare and Medicaid Services does not allow the authors to share participant-level data on Medicare claims. Data management and statistical code is available upon request to the corresponding author.

Study Population

The REGARDS study is a prospective cohort of 30 239 individuals who were aged ≥45 years at the time of recruitment in 2003 to 2007, initially designed to investigate why Black individuals and those in the southeastern United States have high rates of stroke death.[14] The REGARDS study includes community-dwelling Black and White adults with minimal inclusion criteria (eg, residence in the 48 continental United States; self-identification as Black or White race and not Hispanic, Latino/a/-x, or Spanish origin; not being treated for cancer at the time of enrollment, and not a resident of, or on the waiting list for, a nursing home). Potential participants were identified using commercial lists, with oversampling of Black individuals and those living in the Southeast relative to the population of the United States. The original recruitment goal was for approximately half of participants to be Black and half residents of the Southeast[14]; in total, 41.5% of REGARDS participants identified as Black, and 55.5% were residents of the Southeast. At baseline, participants completed a computer-assisted telephone interview, followed by an in-home examination conducted by a trained health technician.

Approximately one third of REGARDS participants were linked to Medicare claims and had Medicare fee-for-service health insurance coverage at baseline.[15] Medicare is a federal health insurance program that covers individuals aged ≥65 years and people with disabilities or end-stage renal disease in the United States. For the current analyses, we excluded REGARDS Medicare-linked participants who did not have fee-for-service coverage for the year before the baseline in-home visit date to ensure that comorbidities could be identified using Medicare claims data. We also excluded participants who participated in privately managed Medicare Advantage plans because complete claims were not available for those individuals. Additionally, we excluded 107 participants with BMI <18.5 kg/m^2 at baseline, because the small number of individuals limited our ability to characterize this population, and 78 participants with missing data needed to calculate BMI. After applying these criteria, 9648 participants were included in these analyses (Figure S1).

All REGARDS study participants provided written informed consent for research. The REGARDS study was reviewed and approved by the institutional review boards at participating institutions. This analysis was reviewed and determined to be exempt by the University of Alabama at Birmingham Institutional Review Board. Two authors (E.B.L. and L.H.) had full access to all of the data in the study and take responsibility for their integrity and the data analysis.

Body Mass Index

BMI was calculated in kg/m^2 from height measured using an 8-foot metal tape measure and weight without shoes measured using a calibrated scale during the in-home visit at baseline. BMI was categorized as 18.5 kg/m^2 to <25 kg/m^2 (normal weight), 25 kg/m^2 to <30 kg/m^2 (overweight), 30 kg/m^2 to <35 kg/m^2 (class I obesity), ≥35 kg/m^2 (class II and III obesity).[16]

Obesity-Associated Comorbidities

Diabetes, hypertension, dyslipidemia, stroke, coronary heart disease, atrial fibrillation, chronic kidney diseases, depressive symptoms, and history of cancer at baseline were assessed through REGARDS study interviews, in-home measurements, and laboratory testing. Diabetes was defined as fasting glucose ≥126 mg/dL (≥200 mg/dL for the minority of participants who were not fasting) or self-reported use of diabetes medications. Blood pressure was measured twice using standardized protocols, and hypertension was defined as average blood pressure ≥130/80 mm Hg or self-reported use of antihypertensive medications. Dyslipidemia was defined as total cholesterol ≥240 mg/dL, estimated low-density lipoprotein cholesterol ≥160 mg/dL, or high-density lipoprotein cholesterol ≤40 mg/dL, or self-reported use of lipid-lowering medication. History of stroke was self-reported. History of coronary heart disease was defined as self-reported myocardial infarction or coronary revascularization, or evidence of prior myocardial infarction on ECG. History of atrial fibrillation was defined as self-report or atrial fibrillation on ECG. Presence of chronic kidney disease was defined as estimated glomerular filtration rate[17] <60 mL/min per 1.73 m^2, albumin-to-creatinine ratio >30 mg/g, or self-report of dialysis. Depressive symptoms were measured using the Center for Epidemiologic Studies–Depression 4-item scale and dichotomized as scores ≥4 or <4.[18] History of cancer was defined as self-report of ever being diagnosed with cancer (individuals currently undergoing cancer therapy were not eligible for enrollment in REGARDS).

Because the REGARDS study did not collect baseline history of heart failure, arthritis, or sleep apnea, we used Medicare claims from the 365 days before the in-home visit to identify these conditions. Heart failure was defined as 1 inpatient claim or 2 outpatient or carrier claims linked to ambulatory physician evaluation and management claim at least 30 days apart with *International Classification of Diseases*, *Ninth Revision* (*ICD-9*) diagnoses of 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, or 428.X. Arthritis was assessed using the Chronic Conditions Warehouse definition.[19] Sleep apnea was defined as an *ICD-9* diagnosis code of 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, or 780.57.

Other Covariates

Age, race, education, physical activity, and cigarette smoking were assessed through self-report during the baseline computer-assisted telephone interview. Region of residence was characterized as stroke buckle (coastal areas of North Carolina, South Carolina, and Georgia), stroke belt (remaining areas of North Carolina, South Carolina, and Georgia as well as Alabama, Mississippi, Tennessee, Arkansas, and Louisiana), and non–stroke belt (remaining continental United States), in accordance with the REGARDS sampling strategy.[14]

Ambulatory Care Visits

We followed participants for ambulatory care visits through Medicare claims data. Ambulatory care visits were defined as claims for physician evaluation and management services delivered in an outpatient setting (see Table S1 for details). We identified specialty (primary care, cardiology, orthopedics, oncology, pulmonology, rheumatology, nephrology, endocrinology, geriatrics, or pain management) using Medicare provider specialty codes. Additionally, we examined the number of physician specialties seen in ambulatory care visits (cardiology, orthopedics, oncology, pulmonology, rheumatology, nephrology, endocrinology, geriatrics, or pain management; range, 0–9).

Statistical Analysis

We calculated descriptive statistics for confounders and comorbidities by BMI category. There were no missing data in the analysis cohort. We examined ambulatory care visits, overall and separately by specialty, and number of specialties seen during follow-up windows of 1, 2, 5, and 10 years from the baseline in-home study visit, focusing on the 5-year follow-up window. Follow-up was censored at the end of the follow-up window, loss of Medicare fee-for-service coverage, or death, whichever was earliest. In the primary analyses, we included all participants in each follow-up window, whether or not they had complete follow-up for the entire period. We calculated the mean number of ambulatory visits, overall and separately by specialty, by BMI category in each follow-up window.

The number of ambulatory care visits was zero-inflated (ie, a larger number of people had no visits than would be expected when a Poisson or negative binomial distribution is applied). Therefore, we used marginalized zero-inflated count models with Poisson distributions and robust variance estimation to calculate the ratio of the mean number of ambulatory care visits and number of specialties seen in each BMI group compared with the reference group, those with BMI 18.5 to <25 kg/m^2.[20–22] The marginalized zero-inflated models produce parameters with marginal or population-wide interpretation; in other words, the ratios of means reflect variable relationships across the entire population, not the theoretical subgroup who might have a visit as in typical zero-inflated count models.[23] The models also produce valid CIs in the setting of zero inflation. Additionally, the robust variance estimators were used to account for potential overdispersion (ie, a variance that is greater than the mean).[24] For each outcome (number of ambulatory visits overall and separately by specialty and number of specialties), we created a model adjusted for demographic and health behavior characteristics that may be confounders of the association between BMI and number of ambulatory care visits: age, sex, race, region, education, income, physical activity, and cigarette smoking. To test for linear trends across BMI categories, we modeled BMI as a score where 18.5 kg/m^2 to <25 kg/m^2=1, 25 kg/m^2 to <30 kg/m^2=2, 30 kg/m^2 to <35 kg/m^2=3, and ≥35 kg/m^2=4.

We conducted a series of sensitivity analyses to explore the potential impact of variable length of follow-up because of death or transfer to Medicare Advantage coverage and transition to nursing home residence because nursing home residents have barriers to receiving ambulatory specialty care.[25] Specifically, we created models with the natural logarithm of follow-up time as an offset term, models with offset terms additionally censoring individuals who became nursing home residents,[26] and models limited to individuals who were observed for the entire follow-up window.

To determine whether obesity-associated comorbidities (diabetes, hypertension, dyslipidemia, stroke, coronary heart disease, atrial fibrillation, heart failure, chronic kidney disease, depressive symptoms, cancer, arthritis, and sleep apnea) explained or mediated differences in number of ambulatory care visits and number of specialties seen, we calculated the indirect association (the association between BMI and number of ambulatory care visits or number of specialties seen that are attributable to the comorbidities) and the direct association (the association between BMI and number of ambulatory care visits or number of specialties seen that are not attributable to the comorbidities) using the inverse odds weighting approach with bootstrapped CIs during the 5-year follow-up window.[27,28] When the ratio of means without considering mediation by comorbidities (ie, the total association) was >1, the 95% CIs for the total association did not include 1, and the direct association and the indirect association were in the same direction, we also calculated percentage mediated. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC). Marginalized zero-inflated Poisson models were constructed using SAS PROC NLMIXED, as previously described.[22]

RESULTS

The mean age of participants was 71.7±7.3 years (88.1% aged ≥65 years), 35.1% were Black individuals and 64.9% were White individuals, 51.1% were women, and 38.0% reported no physical activity (Table 1). Prevalence of diabetes, hypertension, heart failure, chronic kidney disease, depressive symptoms, arthritis, and sleep apnea were higher among individuals with higher BMI. Prevalence of dyslipidemia and coronary heart disease were highest among participants with BMI 30 to <35 kg/m^2. History of cancer was most common among participants with lower BMI. The median follow-up ranged from 8.39 years among participants with BMI 18.5 to <25 kg/m^2 to 6.72 years among participants with BMI ≥35 kg/m^2; 63.6% of participants had ≥5 years of follow-up.

The mean number of ambulatory visits and number of specialties seen by BMI category over 5 years are presented in Figure 1 and Table S2. Table S2 also includes mean number of ambulatory visits by BMI category over 1, 2, and 10 years of follow-up. At 5 years of follow-up, mean number of overall ambulatory, primary care, orthopedics, pulmonology, rheumatology, nephrology, endocrinology, and pain management visits and the number of specialties seen was highest among participants with BMI ≥35 kg/m^2. Mean number of cardiology visits was highest among participants with BMI 30 to <35 kg/m^2. Geriatrics and oncology visits were highest among participants with the lowest BMI.

Adjusting for age, sex, race, region, education, income, physical activity, and cigarette smoking, the mean number of overall, primary care, cardiology, orthopedics, pulmonology, endocrinology, and pain management ambulatory visits and the mean number of specialties seen was higher among participants with a higher BMI category (Table 2). We did not find evidence of associations of BMI category with oncology, rheumatology, nephrology, or geriatrics ambulatory visits. The patterns of associations of BMI category with ambulatory visits were similar across follow-up periods (Table S3), when including the natural logarithm of time as an offset in models to account for variable follow-up (Table S4) and when censoring participants who became nursing home residents (Table S5). When limited to the 6189 participants who had complete follow-up for 5 years, the mean number of visits was higher, but associations between BMI category and mean number of visits were similar (Table S6).

Table 1. Characteristics of REGARDS Study Participants With Medicare Coverage at Baseline (2003–2007) by Body Mass Index Categories

	Body mass index*			
	18.5 to <25 kg/m^2 (n=2613)	25 to <30 kg/m^2 (n=3729)	30 to <35 kg/m^2 (n=2047)	≥35 kg/m^2 (n=1259)
Demographics				
Age, y	73.3±7.3	72.4±6.9	70.8±6.7	67.7±7.3
Race				
Black (non-Hispanic, Latino/a/-x, or Spanish origin)	673 (25.8)	1173 (31.5)	844 (41.2)	688 (54.6)
White (non-Hispanic, Latino/a/-x, or Spanish origin)	1940 (74.2)	2556 (68.5)	1203 (58.8)	571 (45.4)
Sex				
Female	1361 (52.1)	1609 (43.1)	1087 (53.1)	873 (69.3)
Male	1252 (47.9)	2120 (56.9)	960 (46.9)	386 (30.7)
Region				
Stroke buckle	611 (23.4)	853 (22.9)	495 (24.2)	333 (26.4)
Stroke belt	994 (38.0)	1328 (35.6)	716 (35.0)	425 (33.8)
Non-belt	1008 (38.6)	1548 (41.5)	836 (40.8)	501 (39.8)
Education				
Less than high school	335 (12.8)	562 (15.1)	375 (18.3)	304 (24.1)
High school graduate	689 (26.4)	966 (25.9)	577 (28.2)	384 (30.5)
Some college	654 (25.0)	983 (26.4)	541 (26.4)	316 (25.1)
College graduate and above	933 (35.7)	1212 (32.6)	554 (27.1)	255 (20.3)
Income				
<$20 000	528 (20.2)	729 (19.5)	512 (25.0)	442 (35.1)
$20 000–$34 999	736 (28.2)	1104 (29.6)	566 (27.7)	365 (29.0)
$35 000–$74 999	702 (26.9)	1055 (28.3)	552 (27.0)	250 (19.9)
≥$75 000	257 (9.8)	335 (9.0)	149 (7.3)	45 (3.6)
Refused	390 (14.9)	506 (13.6)	268 (13.1)	157 (12.5)
Health behaviors				
Physical activity				
None	880 (34.3)	1222 (33.4)	836 (41.7)	643 (51.9)
1–3 times/wk	838 (32.7)	1193 (32.6)	678 (33.8)	375 (30.2)
≥4 times/wk	847 (33.0)	1246 (34.0)	490 (24.5)	222 (17.9)
Cigarette smoking				
Current	413 (15.9)	334 (9.0)	188 (9.2)	112 (8.9)
Past	1032 (39.7)	1843 (49.6)	999 (48.9)	571 (45.6)
Never	1155 (44.4)	1537 (41.4)	854 (41.8)	570 (45.5)
Comorbidities				
Diabetes	317 (12.6)	786 (21.8)	655 (33.2)	567 (46.4)
Hypertension	1795 (68.9)	2924 (78.6)	1748 (85.7)	1151 (91.5)
Dyslipidemia	1353 (53.9)	2411 (66.6)	1384 (70.0)	792 (65.7)
Stroke	234 (9.0)	352 (9.5)	184 (9.0)	126 (10.0)
Coronary heart disease	583 (22.7)	1000 (27.3)	575 (28.7)	317 (25.6)
Atrial fibrillation	310 (12.1)	401 (11.0)	218 (11.0)	137 (11.2)
Heart failure	104 (4.0)	167 (4.5)	123 (6.0)	120 (9.5)
Chronic kidney disease	732 (28.0)	1047 (28.1)	638 (31.2)	450 (35.7)
Depressive symptoms	245 (9.4)	357 (9.6)	237 (11.6)	230 (18.4)
Cancer	354 (13.5)	545 (14.6)	252 (12.3)	122 (9.7)
Arthritis	402 (15.4)	647 (17.4)	418 (20.4)	369 (29.3)
Sleep apnea	36 (1.4)	109 (2.9)	112 (5.5)	146 (11.6)

*Numbers in table are mean±SD or n (%). REGARDS indicates Reasons for Geographic and Racial Differences in Stroke.

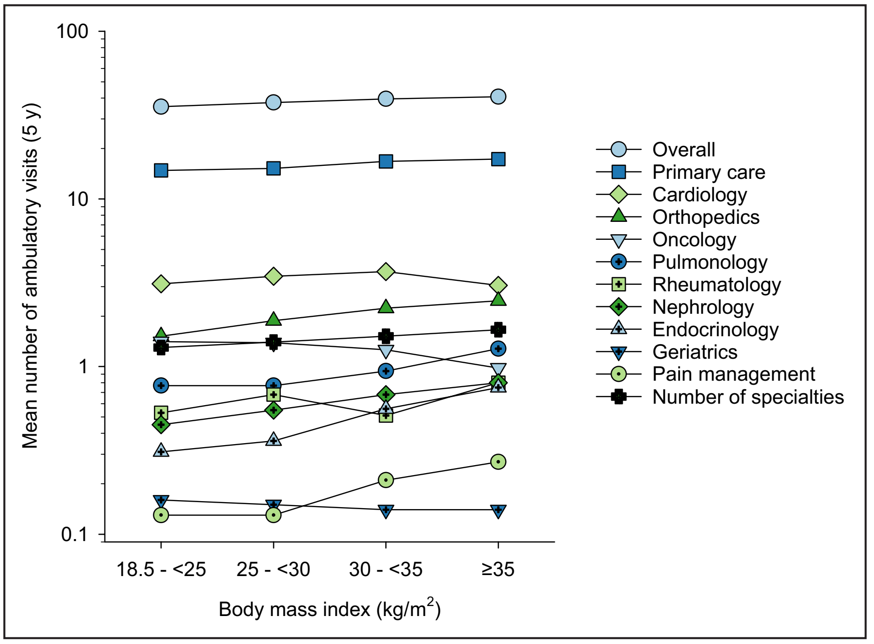

Figure 1. Mean number of ambulatory care visits and number of specialties seen at 5 years of follow-up by BMI among participants in the REGARDS study.
BMI indicates body mass index; and REGARDS, Reasons for Geographic and Racial Differences in Stroke.

Figure 2 illustrates the total association between BMI categories and ambulatory care visits, the component of the association between BMI and the number of ambulatory care visits that is attributable to the comorbidities (ie, the indirect association), and the component of the association between BMI and number of ambulatory care visits that is not attributable to the comorbidities (ie, the direct association). Details of the indirect, direct, and total associations and percentage mediated, when appropriate, are presented in Table S7. Compared with participants with BMI 18.5 to <25 kg/m^2, participants with BMI ≥35 kg/m^2 had 23% more overall ambulatory visits, of which 39% of the association was explained by the comorbidities examined, and 74% more orthopedics visits, of which 16% of the association was explained by the comorbidities. Participants with BMI ≥35 kg/m^2 saw 34% more types of specialists, of which 42% of the association was explained by the comorbidities. Associations between BMI and pain management visits also appeared to be partly mediated by comorbidities, but the CIs were wide. Comorbidities appeared to largely or completely mediate the associations between BMI and cardiology, pulmonology, and endocrinology visits.

DISCUSSION

In this population of Black and White US adults with Medicare fee-for-service health insurance coverage (average age, 72 years), we found that participants with obesity had greater mean numbers of ambulatory care visits overall and for some specialties, including primary care, cardiology, orthopedics, pulmonology, endocrinology, and pain management (Figure 3). Participants with obesity also had visits with more types of physician specialists than participants with lower BMI. However, we did not find evidence for associations of BMI category with oncology, rheumatology, nephrology, or geriatrics ambulatory visits. Our findings are consistent with prior findings that total and ambulatory health care usage is higher among individuals with obesity compared with those with normal weight.[3–12] This study builds upon prior research to examine the types of specialty ambulatory visits associated with BMI, which is not well described in prior literature. Additionally, we found that the obesity-associated comorbidities we assessed partly mediated the associations between BMI and overall, primary care, orthopedics, and pain management ambulatory visits and number of specialties seen and largely or completely mediated the associations between BMI and cardiology, pulmonology, and endocrinology ambulatory visits.

Studies have documented higher health care costs, which result from greater health care usage, among individuals with obesity compared with those with normal weight or overweight.[11,12] While costs are an important consideration for policy and budget purposes, they do not fully capture specific health care needs or experiences of patients. Although prior studies have examined ambulatory care usage and associated costs by

Table 2. Association of Body Mass Index With Number of Ambulatory Care Visits at 5 Years of Follow-Up Among Participants in the REGARDS Study

	Body mass index (kg/m²)				
	18.5 to <25	25 to <30	30 to <35	≥35	*P* trend
Overall					
Ratio of means (95% CI)*	Reference	1.07 (1.06–1.09)	1.15 (1.14–1.17)	1.23 (1.21–1.24)	<0.001
Primary care					
Ratio of means (95% CI)	Reference	1.05 (1.03–1.07)	1.18 (1.15–1.20)	1.26 (1.23–1.29)	<0.001
Cardiology					
Ratio of means (95% CI)	Reference	1.08 (1.00–1.15)	1.28 (1.19–1.37)	1.20 (1.09–1.30)	<0.001
Orthopedics					
Ratio of means (95% CI)	Reference	1.34 (1.24–1.44)	1.56 (1.43–1.68)	1.74 (1.58–1.89)	<0.001
Oncology					
Ratio of means (95% CI)	Reference	1.03 (0.89–1.16)	0.98 (0.82–1.13)	0.85 (0.68–1.02)	0.18
Pulmonology					
Ratio of means (95% CI)	Reference	1.03 (0.88–1.17)	1.22 (1.03–1.41)	1.62 (1.35–1.89)	<0.001
Rheumatology					
Ratio of means (95% CI)	Reference	1.42 (1.16–1.68)	0.84 (0.65–1.03)	1.19 (0.90–1.49)	0.87
Nephrology					
Ratio of means (95% CI)	Reference	1.10 (0.86–1.36)	1.16 (0.90–1.42)	1.18 (0.88–1.48)	0.11
Endocrinology					
Ratio of means (95% CI)	Reference	1.11 (0.86–1.36)	1.56 (1.19–1.93)	1.85 (1.36–2.34)	<0.001
Geriatrics					
Ratio of means (95% CI)	Reference	0.90 (0.57–1.24)	0.84 (0.46–1.22)	1.02 (0.48–1.56)	0.85
Pain management					
Ratio of means (95% CI)	Reference	1.21 (0.81–1.62)	1.77 (1.11–2.44)	1.90 (1.14–2.66)	<0.001
Number of specialties					
Ratio of means (95% CI)	Reference	1.09 (1.04–1.14)	1.19 (1.13–1.26)	1.34 (1.25–1.42)	<0.001

REGARDS indicates Reasons for Geographic and Racial Differences in Stroke.
*Ratios of means adjusted for age, sex, race, region, education, income, physical activity, and cigarette smoking.

BMI,[3,4,7–9] little is known about the types of ambulatory care received. To address this gap and add to the literature, the current investigation focused on ambulatory care visits overall and by physician specialty and the number of specialties seen. The greater number of primary care, cardiology, orthopedics, pulmonology, endocrinology, and pain management ambulatory visits observed among participants with higher BMI parallels the association of BMI with conditions that may require treatment by these specialties. We did not find associations between BMI and oncology, rheumatology, nephrology, or geriatrics ambulatory visits. There are several types of cancer for which obesity is a risk factor[1,2]; however, cancer and cancer therapies may result in weight loss, obscuring any association between BMI and oncologist visits. Similarly, individuals who lose weight because of sarcopenia or cachexia may be preferentially referred to geriatricians. Whether the patterns of ambulatory care by BMI differ on the basis of age and other demographic characteristics, geriatric conditions, or social determinants of health is an area for future investigation.

Disentangling the effects of obesity and the comorbid conditions that often accompany obesity is both an area of scientific interest and a challenge for study design and statistical analysis. Adjustment for chronic conditions that may be on the causal pathway between obesity and health outcomes can result in overadjustment and underestimation of the effects of obesity.[29] In a prior study, inclusion of chronic conditions in models attenuated the association between BMI and health care usage, which may indicate that the chronic conditions explain this association.[6] However, simple adjustment for mediating factors is not the optimal approach for exploring causal pathways. We have extended prior findings through a formal mediation analysis in which we examined the total association between BMI and ambulatory care visits, the direct associations not explained by comorbidities, and the indirect association explained by comorbidities. The association of BMI with cardiology, pulmonology, and endocrinology ambulatory care was largely explained by the comorbidities assessed, while the associations of BMI with primary care, orthopedics, pain management, and number of

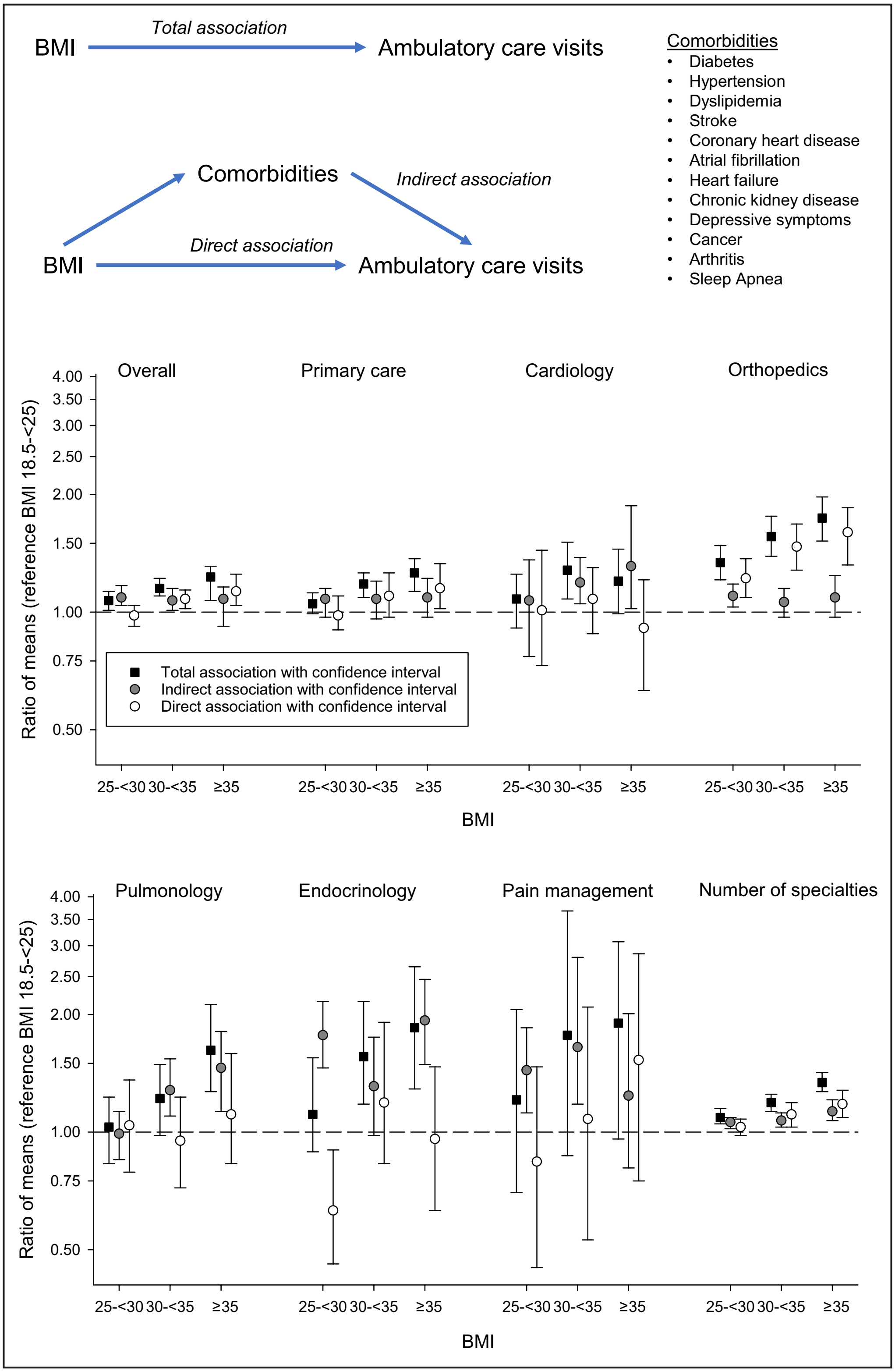

Figure 2. Mediation of the association of BMI with number of ambulatory care visits at 5 years of follow-up by obesity-associated comorbidities among participants in the REGARDS study. Estimates are ratios of means compared with the group with BMI 18.5 to <25 kg/m^2, with bootstrapped confidence intervals. BMI indicates body mass index; and REGARDS, Reasons for Geographic and Racial Differences in Stroke.

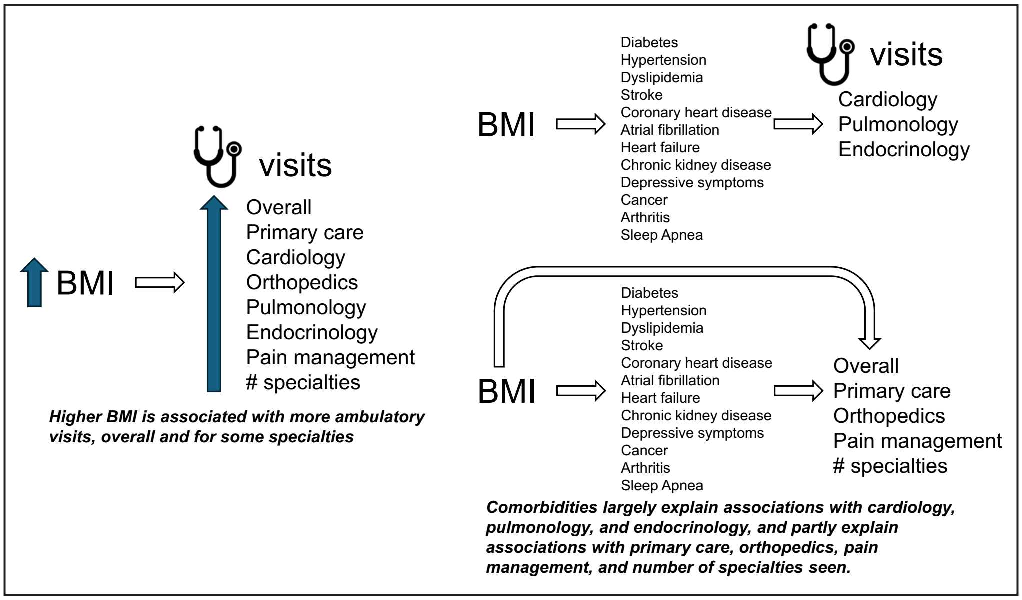

Figure 3. Summary of associations of BMI with ambulatory care visits.
BMI indicates body mass index.

specialties seen were only partly explained by comorbidities. These differences by specialty may be due to comorbidities related to BMI that we were not able to capture through the REGARDS study or Medicare claims (eg, nonalcoholic fatty liver disease and gallbladder disease), to nonspecific symptoms, or to lack of nuanced data needed to fully characterize comorbidity subtype and severity. In addition, most of the comorbidities were measured at the same time as the 1-time assessment of BMI. It is therefore possible that the comorbidities influenced BMI. This is particularly likely for history of cancer, which was more common in the lower-BMI groups.

Although management of obesity-related comorbidities by primary care and specialist physicians, when necessary, is clearly important, participants in this study may not have had optimal access to health care professionals and services best suited to treating obesity and preventing the development and progression of obesity-related comorbidities. For individuals who would benefit from weight loss, weight management guidelines from the American College of Cardiology, American Heart Association, and the Obesity Society recommend referral to registered dietitians or other nutrition professionals.[16] However, Medicare coverage for nutrition therapy is limited to individuals with diabetes or kidney disease and generally includes 3 hours of services in the year after diagnosis and 2 hours in subsequent years.[30]

The guidelines also recommend prescription of high-intensity behavioral weight loss interventions, which are usually led by nonphysician health professionals, such as registered dietitians and counselors, or by trained interventionists who are not licensed health professionals.[16] Beginning in 2012, Medicare began covering intensive behavioral therapy for obesity delivered in a primary care setting by a primary care practitioner.[31] However, <1% of Medicare beneficiaries eligible for intensive behavioral therapy for obesity have claims for this service, and only 1.2% of eligible primary care practitioners had billed Medicare for this service by 2019.[32,33]

Recent clinical trials have demonstrated benefits of sodium–glucose cotransporter-2 inhibitors and glucagon-like peptide-1 receptor agonists for weight loss, glycemic control among people with diabetes, blood pressure lowering, and prevention of cardiovascular disease events, and some glucagon-like peptide-1 receptor agonists have been approved for the indication of weight loss.[34,35] However, many of these trials included participants with significantly lower average age than the current study population and the broader population of people with Medicare coverage. Multidisciplinary clinics including physicians, nurses, dietitians, mental health professionals, and exercise physiologists or trainers to provide dietary therapy, structured physical activity, psychotherapy, and pharmacologic therapy, are a promising option to address both obesity and its comorbidities.[36] However, health care delivery systems and payment incentives must be aligned to provide this care, and settings outside of individual primary care visits, potentially including telehealth and group health care visits, may be needed.

Strengths of this study include the large population of Black and White individuals from across the United States with BMI measured using a standard protocol, in contrast to use of self-report or administrative codes to assess BMI in some prior studies. In addition, we detected ambulatory care visits through Medicare, which pays for most care received by eligible individuals. There are also limitations. We could not include participants with privately managed Medicare Advantage coverage or those without Medicare coverage. Nearly all participants included in this study of individuals with Medicare coverage were aged ≥65 years and the remaining participants were eligible because of disabilities or end-stage renal disease, which limits generalizability. These findings are also not generalizable to individuals who identify as Hispanic, Latino/a/-x, or Spanish origin or as a race other than Black or White or outside the United States where medical care is structured differently. The length of follow-up was variable because of death or changes from Medicare fee-for-service to Medicare Advantage coverage; the median length of follow-up was longest for participants with BMI 18.5 to <25 kg/m^2. Our results were robust when examining different follow-up windows and in several sensitivity analyses that included using offset terms to account for variable follow-up and limiting the analyses to participants with complete follow-up.

In summary, in this population with Medicare coverage who were aged 65 or had disabilities or end-stage renal disease, individuals with higher BMI had greater mean numbers of ambulatory care visits overall and of primary care, cardiology, orthopedics, pulmonology, endocrinology, and pain management specialty visits and a greater number of specialties seen. Comorbidities partly explained associations of BMI category with overall, primary care, pain management, and orthopedics visits and number of specialties seen and largely explained associations with cardiology, pulmonology, and endocrinology visits. Understanding which specialty visits are associated with higher BMI can help with workforce planning, design of multidisciplinary clinics and health care benefits for treatment of obesity and obesity-associated comorbidities, and training of physicians and other health care professionals to provide care for people with overweight and obesity.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S7
Figure S1

REFERENCES

1. Bray GA, Heisel WE, Afshin A, Jensen MD, Dietz WH, Long M, Kushner RF, Daniels SR, Wadden TA, Tsai AG. The science of obesity management: an endocrine society scientific statement. *Endocr Rev*. 2018;39:79–132. doi: 10.1210/er.2017-00253
2. Dai H, Alsalhe TA, Chalghaf N, Ricco M, Bragazzi NL, Wu J. The global burden of disease attributable to high body mass index in 195 countries and territories, 1990–2017: An analysis of the Global Burden of Disease Study. *PLoS Med*. 2020;17:e1003198. doi: 10.1371/journal.pmed.1003198
3. Kamble PS, Hayden J, Collins J, Harvey RA, Suehs B, Renda A, Hammer M, Huang J, Bouchard J. Association of obesity with healthcare resource utilization and costs in a commercial population. *Curr Med Res Opin*. 2018;34:1335–1343. doi: 10.1080/03007995.2018.1464435
4. Suehs BT, Kamble P, Huang J, Hammer M, Bouchard J, Costantino ME, Renda A. Association of obesity with healthcare utilization and costs in a Medicare population. *Curr Med Res Opin*. 2017;33:2173–2180. doi: 10.1080/03007995.2017.1361915
5. Cecchini M, Sassi F. Preventing obesity in the USA: Impact on health service utilization and costs. *PharmacoEconomics*. 2015;33:765–776. doi: 10.1007/s40273-015-0301-z
6. Musich S, MacLeod S, Bhattarai GR, Wang SS, Hawkins K, Bottone FG Jr, Yeh CS. The impact of obesity on health care utilization and expenditures in a medicare supplement population. *Gerontol Geriatr Med*. 2016;2:2333721415622004. doi: 10.1177/2333721415622004
7. Peterson MD, Mahmoudi E. Healthcare utilization associated with obesity and physical disabilities. *Am J Prev Med*. 2015;48:426–435. doi: 10.1016/j.amepre.2014.11.007
8. Wang F, McDonald T, Reffitt B, Edington DW. BMI, physical activity, and health care utilization/costs among Medicare retirees. *Obes Res*. 2005;13:1450–1457. doi: 10.1038/oby.2005.175

9. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Aff*. 2009;28:W822–W831. doi: 10.1377/hlthaff.28.5.w822
10. Ward ZJ, Bleich SN, Long MW, Gortmaker SL. Association of body mass index with health care expenditures in the United States by age and sex. *PLoS One*. 2021;16:e0247307. doi: 10.1371/journal.pone.0247307
11. Kim DD, Basu A. Estimating the medical care costs of obesity in the United States: Systematic review, meta-analysis, and empirical analysis. *Value Health*. 2016;19:602–613. doi: 10.1016/j.jval.2016.02.008
12. Kent S, Fusco F, Gray A, Jebb SA, Cairns BJ, Mihaylova B. Body mass index and healthcare costs: a systematic literature review of individual participant data studies. *Obes Rev*. 2017;18:869–879. doi: 10.1111/obr.12560
13. Fryar CD, Afful CM. Prevalence of overweight, obesity, and severe obesity among adults aged 20 and over: United States, 1960–1962 through 2017–2018. Centers for Disease Control and Prevention. Accessed February 23, 2023. www.cdc.gov/nchs/data/hestat/obesity-adult-17-18/obesity-adult.htm.2021.
14. Howard VJ, Cushman M, Pulley L, Gomez CR, Go RC, Prineas RJ, Graham A, Moy CS, Howard G. The REasons for Geographic And Racial Differences in Stroke study: objectives and design. *Neuroepidemiology*. 2005;25:135–143. doi: 10.1159/000086678
15. Xie F, Colantonio LD, Curtis JR, Safford MM, Levitan EB, Howard G, Muntner P. Linkage of a population-based cohort with primary data collection to medicare claims: The Reasons for Geographic and Racial Differences in Stroke Study. *Am J Epidemiol*. 2016;184:532–544. doi: 10.1093/aje/kww077
16. Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, Hu FB, Hubbard VS, Jakicic JM, Kushner RF, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Circulation*. 2014;129:S102–S138. doi: 10.1161/01.cir.0000437739.71477.ee
17. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 2009;150:604–612. doi: 10.7326/0003-4819-150-9-200905050-00006
18. Melchior LA, Huba GJ, Brown VB, Reback CJ. A Short Depression Index for Women. *Educ Psychol Meas*. 1993;53:1117–1125. doi: 10.1177/0013164493053004024
19. Chronic Condition Data Warehouse. Accessed December 11, 2024. http://www.ccwdata.org/chronic-conditions/index.htm
20. Preisser JS, Long DL, Stamm JW. Matching the statistical model to the research question for dental caries indices with many zero counts. *Caries Res*. 2017;51:198–208. doi: 10.1159/000452675
21. Preisser JS, Das K, Long DL, Divaris K. Marginalized zero-inflated negative binomial regression with application to dental caries. *Stat Med*. 2016;35:1722–1735. doi: 10.1002/sim.6804
22. Long DL, Preisser JS, Herring AH, Golin CE. A marginalized zero-inflated Poisson regression model with overall exposure effects. *Stat Med*. 2014;33:5151–5165. doi: 10.1002/sim.6293
23. Preisser JS, Stamm JW, Long DL, Kincade ME. Review and recommendations for zero-inflated count regression modeling of dental caries indices in epidemiological studies. *Caries Res*. 2012;46:413–423. doi: 10.1159/000338992
24. White H. Maximum Likelihood Estimation of Misspecified Models. *Econometrica*. 1982;50:1–25. doi: 10.2307/1912526
25. Shaver NS, Lapenskie J, Smith GA, Hsu AT, Liddy C, Tanuseputro P. How often, where, and by which specialty do long-term care home residents receive specialist physician care? a retrospective cohort study. *J Appl Gerontol*. 2021;40:837–846. doi: 10.1177/0733464819901255
26. Yun H, Kilgore ML, Curtis JR, Delzell E, Gary LC, Saag KG, Morrisey MA, Becker D, Matthews R, Smith W, et al. Identifying types of nursing facility stays using medicare claims data: an algorithm and validation. *Health Serv Outcome Res Methodol*. 2010;10:100–110. doi: 10.1007/s10742-010-0060-4
27. Tchetgen Tchetgen EJ. Inverse odds ratio-weighted estimation for causal mediation analysis. *Stat Med*. 2013;32:4567–4580. doi: 10.1002/sim.5864
28. Nguyen QC, Osypuk TL, Schmidt NM, Glymour MM, Tchetgen Tchetgen EJ. Practical guidance for conducting mediation analysis with multiple mediators using inverse odds ratio weighting. *Am J Epidemiol*. 2015;181:349–356. doi: 10.1093/aje/kwu278
29. Global BMI Mortality Collaboration, Di Angelantonio E, Bhupathiraju S, Wormser D, Gao P, Kaptoge S, Berrington de Gonzalez A, Cairns B, Huxley R, Jackson C, et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet*. 2016;388:776–786. doi: 10.1016/S0140-6736(16)30175-1
30. Center for Medicare and Medicaid Services. Medical Nutrition Therapy (180.1). 2002 Accessed September 3, 2024. https://www.cms.gov/medicare-coverage-database/view/ncd.aspx?NCDId=252&ncdver=1&bc=AAAAQAAAAAAA&
31. Center for Medicare and Medicaid Services. Intensive Behavioral Therapy for Obesity (210.12). 2011 Accessed September 3, 2024. https://www.cms.gov/medicare-coverage-database/view/ncd.aspx?NCDId=353
32. Agarwal SD, Basu S, Landon BE. The underuse of Medicare's prevention and coordination codes in primary care: A cross-sectional and modeling study. *Ann Intern Med*. 2022;175:1100–1108. doi: 10.7326/M21-4770
33. Ozoor M, Gritz M, Dolor RJ, Holtrop JS, Luo Z. Primary care provider uptake of intensive behavioral therapy for obesity in Medicare patients, 2013–2019. *PLoS One*. 2023;18:e0266217. doi: 10.1371/journal.pone.0266217
34. Joseph JJ, Deedwania P, Acharya T, Aguilar D, Bhatt DL, Chyun DA, Di Palo KE, Golden SH, Sperling LS. Comprehensive management of cardiovascular risk factors for adults with type 2 diabetes: a scientific statement from the American Heart Association. *Circulation*. 2022;145:e722–e759. doi: 10.1161/CIR.0000000000001040
35. Popoviciu MS, Păduraru L, Yahya G, Metwally K, Cavalu S. Emerging role of GLP-1 agonists in obesity: a comprehensive review of randomised controlled trials. *Int J Mol Sci*. 2023;24:10449. doi: 10.3390/ijms241310449
36. Foster D, Sanchez-Collins S, Cheskin LJ. Multidisciplinary team-based obesity treatment in patients with diabetes: Current practices and the state of the science. *Diabetes Spectr*. 2017;30:244–249. doi: 10.2337/ds17-0045