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Body Mass Index and Rural Status on Self-Reported Health in Older Adults: 2002-2012 Medicare Expenditure Panel Survey

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Abstract

Purpose: To ascertain whether rural status impacts self-reported health and whether the effect of rural status on self-reported health differed by obesity status.

Methods: We identified 22,307 subjects aged≥60 from the Medical Expenditure Panel Survey 2003–2012. Body mass index (BMI) was categorized as underweight, normal, overweight, or obese. The physical and mental component scores of the Short Form-12 assessed self-reported health status. Rural/urban status was defined using metropolitan statistical area. Weighted regression models ascertained the relative contribution of predictors (including rural and BMI) on each subscale.

Findings: Mean age was 70.8 years. Rural settings had higher proportions classified as obese (30.7 vs.27.6%;p<0.001). Rural residents had lower physical health status (41.7±0.3) than urban (43.4±0.1;p<0.001). Persons with obesity or underweight had lower physical health status

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(39.5±0.20 and 37.0±0.82, respectively) than normal (44.7±0.18) or overweight (44.6±0.16) [$p<0.001$]. BMI category stratification was associated with differences in physical health between rural/urban by BMI (obesity:38.4±0.4 vs.39.8±0.2;$p=0.002$; overweight:43.3±0.4 vs.44.9±0.2; $p<0.001$; normal:43.4±0.5 vs.45.0±0.2;$p=0.007$; and underweight:35.2±1.7 vs.37.4±0.9;p=0.26). Individuals classified as underweight or obese had lower physical health scores (−4.45±1.21;p<0.001 and −3.56±0.32;p<0.001) as compared to normal, while the differences were less pronounced for mental health (−2.36±0.81;p=0.004 and 0.91±0.25;p<0.001). No differences in mental health existed between rural/urban status. A BMI*rural interaction was significant for physical (5.19±2.60;p=0.047) but not mental health (−0.09±1.67;p=0.96).

Conclusions: Rural residence leads to lower self-reported physical health status compared to urban residency, particularly in older adults who were obese or underweight. No interaction was observed between BMI and rural status.

Keywords

obesity; rural; self-reported health; older adults

INTRODUCTION

Rural older adults are the fastest growing segment of the population in the United States[1]. This subgroup of patients face impediments such as reduced access to care due to transportation limitations and healthcare staffing shortages[2, 3], which can deter the use of health services[4], and constitute an understudied health disparity. Self-reported health is an important predictor of healthcare utilization and death and a surrogate for medical co-morbidity[5–7], particularly in rural areas. Poorer self-reported health status in rural residents is due, in part, to greater high-risk health behaviors[8]. Having a thorough understanding of the impact of metropolitan statistical areas and co-morbidities on self-reported health in older adults is important to target limited resources to areas of higher need.

Rural settings are associated with a 39.6% rate of obesity compared to 33.4% in urban areas[9], with the most remote areas[10] having the highest levels, exceeding general population trends[11]. Obesity contributes to increased medical co-morbidity [12] and in older adults, impacts functional status[13] leading to an increased risk of institutionalization[14] and healthcare costs[15]. Social determinants of health, such as age, race and ethnicity, urban vs. rural living status, and chronic health conditions such as obesity can affect older adults living in rural areas[9]. Independent of other medical conditions, obesity negatively affects physical and mental health[16, 17]. Both are important health quality indicators in older adults that are inconsistently evaluated in clinical settings[18, 19]. While the new Medicare Annual Wellness Visit supports systematic screening of weight and self-reported health[20], BMI as a surrogate for adiposity continues to be challenged[21]. In fact, the impact of BMI on many health risks in older adults, and particularly the effect of weight loss remains incompletely understood[22].

With a burgeoning population of older adults, rural practices will be further challenged by needing to focus on quality measures proposed by newer payment models such as the Medicare Access and CHIP Reauthorization Act (MACRA)[23]. It is unknown how BMI interacts with the relationship between rural status and self-reported health. The purpose of this study is to examine the relationship between BMI and health outcomes in older adults in rural vs. non-rural settings. We hypothesized that rural status and obesity in older adults (defined using census-based metropolitan statistical areas and body mass index, respectively) will have lower self-reported health status (rated on the Short-Form (SF) 12 scale) than individuals living in urban areas and who do not have obesity. Furthermore, we ascertained whether other co-morbid conditions were associated with self-reported health status.

METHODS

A cross-sectional analysis of data using the 2003–2012 Medicare Expenditure Panel Survey (MEPS) pooled full-year consolidated data files. MEPS is a nationally representative survey of non-institutionalized US adults conducted annually by the Agency for Healthcare Research and Quality. MEPS uses a multistage, stratified sampling procedure that oversamples race/ethnic groups and lower income individuals. MEPS uses a new panel of sample households each year from the National Health Interview Survey canvassed from the previous calendar year. Each household in MEPS is surveyed over two years with 5 interviews. For this study, we used variables obtained from the 1st interview (out of five in-person interviews) and merged them according to guidelines. All data was obtained online in January 2016 from the website (http://meps.ahrq.gov). MEPS has its own institutional review board protocol. Our institution exempted the protocol due to the de-identified nature of the data downloaded. The total sample of the merged datasets consisted of 133,248 individuals. We focused our analysis on individuals aged ≥60years and excluded those younger than this age (*n*=104,394). Of the remaining 28,854 participants, we eliminated subjects without data on BMI (n=1,118), MSA (n=3,368), physical (*n*=2,056) or mental (*n*=3) component scores (Appendix 1). Our analytical sample size consisted of 22,307 participants.

Primary Dependent Variable

Participants completed a self-reported SF-12 questionnaire consisting of both a physical component (PCS) and mental component (MCS) score, which reflects physical and mental health, respectively. This validated scale has a mean population score of 50 (standard deviation 10) in the US population. Each respondent was asked to rate their health as excellent, very good, good, fair and poor. Standard scoring algorithms are available to derive values from both scales, ranging from 0 to 100. A higher score indicates better self-reported health[24].

Primary Predictors

For each individual with a self-reported height and weight, we calculated BMI using weight (in kilograms) divided by height (in meters) squared. BMI was categorized as follows: underweight (≤18.5kg/m^2), normal (18.5–24.9kg/m^2), overweight (25.0–29.9kg/m^2) and obesity (≥30kg/m^2). Individuals were considered living in an MSA as urban, and those living in non-MSA regions as rural. An MSA is a large population area combined with adjacent communities that have a high degree of economic and social integration within the nucleus. Each MSA has one or more central counties containing the area's main population concentration, as defined by the United States Office of Management and Budget.

Covariates

Age was measured in years. If date of birth was available, age was calculated based on the difference between the date of birth and date of the first interview. If date of birth was not provided but age was provided, random assignment to month/birth year was performed or imputed according to the MEPS procedural manual. Age was also top coded at 85 years to maintain confidentiality. All inconsistencies were reviewed and resolved. Sex, marital status race, education in years, household income (in dollars) were self-reported using a standardized questionnaire. Ethnicity was determined using standard categories (white=referent) in accordance with the US Census data. All co-morbidities were assessed using a computer-assisted personal interview, which consists of self-report questions, interviewing instructions, and skip patterns based on specific topics. Information on physical and mental health conditions was asked as part of the household survey. It obtains details on each person's medical condition, whether it was due to an accident or an injury, the severity, status and treatment received. This data has been shown to have high agreement between MEPS respondents and clinician-reported conditions[25].

Statistical Analysis

Descriptive statistics for continuous variables are represented as means ± standard errors, and categorical variables as counts (%). All analyses were weighted according to the MEPS analytical plan to obtain accurate survey estimates. MEPS survey weights using the Taylor-series linearization method allowed the estimation of standard errors for this complex survey. To reflect the survey design the estimated weights, sampling strata and primary sampling unit were used in the analysis.

We compared all baseline characteristics between rural/urban regions using unpaired t-tests for continuous variables, chi-square and ANOVA for categorical variables. This statistical testing was replicated to compare those aged ≥60 years who were included in our analysis vs. those who were excluded due to missing co-variate or outcome data (n=6,547). Self-reported health scores (PCS and MCS) were compared between BMI categories using a one-way unadjusted ANOVA and between urban and rural regions using t-tests. The primary aim was to assess whether: a) rural status or BMI category were associated with self-reported health status (SF-12 subscale: PCS and MCS), separately; b) whether BMI-defined obesity has a moderating effect on SF-12 status on the main effect (rural status); c) and whether other comorbid or sociodemographic factors were associated with higher SF-12 health status. We initially created separate models with PCS and MCS as the primary outcome. Each co-variate was included separately with β-coefficients ± standard error and p-values. Subsequent multivariable modeling included all significant terms, which permitted the demonstration of the relative contribution of each variable on the outcome variable. Lastly, as the interaction between urban/rural status and BMI was integral to our hypothesis, we included this in our multivariable analysis. Analyses were conducted using STATA v.12 (College Station, TX) and a p-value of <0.05 was considered statistically significant.

RESULTS

Of the 22,307 participants in our analytical cohort, 4,482 (19.5%) were residing in a rural region. Table 1 represents the baseline characteristics of our cohort by rural/urban status. We observed that rural regions had higher rates of whites, married persons, higher smoking and obesity rates, lower income levels and higher rates of bronchitis and myocardial infarctions. Urban regions had higher PCS scores indicating better self-rated health status (43.4±0.12 vs. 41.7±0.28;p<0.001) but no differences in MCS scores (52.1±0.10 vs. 51.9±0.20;p=0.33). Generally, individuals included in the study were healthier, had higher self-reported health and had reduced impairments as compared to individuals excluded from the analysis (Appendix 1).

Table 2 demonstrates the unadjusted PCS and MCS scores of the entire analytical cohort, by BMI and by rural/urban status. Physical health status significantly differed between BMI categories overall (p<0.001), and within urban (p<0.001) and within rural regions (p<0.001). Within normal, overweight and obese categories, individuals in rural regions had significantly lower PCS than those in urban regions. Overall (when not accounting for BMI category), urban and rural regions had significantly different mean PCS scores (p<0.001) with rural regions having lower PCS than urban regions. While mental health significantly differed between BMI categories overall (p<0.001), and within urban (p<0.001) and within rural regions (p<0.001), no differences in MCS were observed between urban and rural regions (p=0.33) nor within each BMI category.

Univariate and multivariate analyses are presented in Table 3 for PCS. Notably, all variables were strongly associated with PCS score, including the presence of rural status (β=1.67±0.31;p<0.001), and underweight and obesity vs. normal (β=−7.7±0.86 and β=−5.24±0.24, both p<0.001). While the multivariable analysis demonstrated a number of variables reaching statistical significance, persons with arthritis (β=−5.54±0.23;p<0.001), depression (β=−5.4±0.28;p<0.001), chronic bronchitis (β=−4.56±0.73;p<0.001), emphysema (β=−5.82±0.50;p<0.001), underweight vs. normal (β=−4.45±1.21;p<0.001), and obesity (β=−3.56±0.32;p<0.001) demonstrated marked effects. Rural status was also statistically significant (β=0.97±0.32;p=0.003). Adding the urban/rural * BMI interaction term demonstrated that the association between urban/rural status and PCS in underweight was significant different from the association between urban/rural status and PCS in normal weight (p=0.047). Table 4 replicates this analysis using MCS as the outcome variable. Meaningfully statistical differences were observed for depression (β=−14.2±0.26;p<0.001) and underweight vs. normal BMI (β=−2.36±0.81;p=0.004) and obesity vs. normal (β=−0.91±0.25;p=0.53). Rural status was not significant (β=−0.11±0.18;p=0.53). Incorporating the interaction urban/rural * BMI term did not demonstrate any impact on urban/rural status with BMI on MCS. The overall adjusted model integrating our key predictors and interaction terms was not significant for either PCS (p=0.15) or MCS (p=0.51).

DISCUSSION

We examined whether rural status or BMI is associated with self-reported health status and whether BMI has a moderated effect. Our results indicate that rural residence is associated with lower self-reported physical health compared to urban residency in older adults, and confirmed our hypothesis that older persons with obesity have lower self-reported health in rural regions compared to urban older adults with obesity. Importantly, we observed that individuals classified as being underweight had significantly lower PCS and MCS scores particularly in rural regions. We did not observe an overall interaction in our fully adjusted models integrating BMI, rural/urban status, and the key co-variates with either physical or and mental component scores.

Our analysis was helpful in identifying factors related to self-reported physical and mental health that could be used in targeting appropriate resources in the future. While our findings are consistent with those of Andreyeva[26] who demonstrated that individuals with obesity have lower self-reported health than those without obesity, we had expected that rural status would have had a multiplicative effect on individual's health status. No significant interaction between obesity-defined BMI and rural vs. urban status was observed in PCS.

Chronic diseases known to impact self-reported physical health, even after adjusting for BMI and rural status should be targeted appropriately in future intervention studies. Our multivariable analysis deliberately determined the relative impact of comorbid and sociodemographic characteristics that could potentially impact self-reported health. While the comorbidities that were evaluated demonstrated significance, we were not surprised that chronic diseases such as arthritis, depression, lung and lung disease played important factors in self-reported physical health. Importantly, older individuals with obesity, in particular, have greater degrees of functional impairment, higher comorbidity burden, and increased mobility challenges that lead to reductions in access to care. Individuals in rural regions also had lower income and higher frequency of medical co-morbidity than individuals in urban regions. This has considerable implications in that disparities are observed within the urban-rural continuum where reduced access to care is associated with poorer healthcare conditions and outcomes.

We observed marked differences between urban and rural regions in individuals who were underweight (BMI<18.5) in self-reported physical health. Generally, individuals with frailty often have a BMI<18.5kg/m^2 and have considerably lower self-reported health than other BMI categories[27]. Frailty is associated with functional decline, institutionalization, and increased risk of death[28] and is under-recognized entity in clinical practice[29]. As older adults age, the sum of their comorbid conditions may impact their homeostatic ability to remain functional. Both individuals with low BMI and obesity are predisposed to this geriatric syndrome that is associated with low quality of life. This cohort of participants are at higher risk of falls, osteoporotic hip fractures and seek frequent medical care. Importantly, we did observe that the association between rural/urban status and PCS in underweight is significantly different from the association between rural/urban status and PCS in normal weight. The widened disparities observed in this group likely may have contributed to challenges in seeking medical care, reduced access to home visits by their practitioners, and often obtaining tertiary care at critical access hospitals, more so than in normal weight individuals. Furthermore, home health resources and caregiving is markedly variable in rural environments possibly contributing to this observed difference. Examining uptake of such services in rural areas may guide wide-scale dissemination in rural areas.

Scores on self-reported MCS were not different statistically in urban vs. rural areas, nor were they clinically different between BMI categories as represented by a difference in MCS score of (2.6 points). These results are consistent with other findings suggesting the lack of a relationship between this measure and obesity for this age group[30–32]. The MCS differs considerably from other depression measures such as the geriatric depression scale[33] or the Patient Health Questionnaire-9[34] in that it does not diagnose depression and is only a reflection of one's own perception of their overall mental health. Additional studies evaluating depression-specific measures designed for older adults would be helpful in characterizing the relationship between BMI and rural status.

Strengths

To our knowledge, this is the first study to present the differences in self-reported health between rural/urban older adults (aged 60+) for different BMI categories. A major strength of our study was that we used national data collected over a prolonged period of time that could be broadly representative of the US population living in urban vs. rural regions. We deliberately adjusted for a number of factors in our modeling. While the strength of association diminished slightly, our robust analysis with and without an interaction term allowed us to identify prospective factors that have an impact on self-reported health in rural environments.

Limitations

We acknowledge a number of limitations. First, we pooled 10 years of MEPS data to allow us to obtain reliable estimates. As such, our results are not necessarily reflective of a given time frame. Our analysis did not demonstrate that year impacted our results (data not shown). Second, the study findings are cross-sectional and do not imply causation. Longitudinal studies can provide information to imply causation and would be of particular interest to health policy makers. Third, we used non-MSA regions to designate low-resource, rural regions. We recognize that non-MSAs may contain parts of urban and rural populations and vice-versa. MSAs are defined as having at least one urbanized area with a population of at least 50,000 persons. Fourth, obesity was measured using self-reported BMI that is subject to self-reporting bias. While BMI is commonly used in clinical practice, its utility in older adults has been challenged due to its poor sensitivity[21]. Other useful measures, including waist circumference can provide further stratification, particularly in those with normal BMIs. Fifth, we caution that our cohort was relatively functional and may not be completely representative of an older population. Sixth, while our analysis may have accounted for such related comorbidities we may have omitted certain important factors of physical decline, including mobility status, muscle mass and strength, and social support, all important factors not only in self-reported health, but accessing care[35]. Last, while our scores were statistically significant, they may not necessarily be clinically significant; a minimum clinically important difference in score for PCS-12 is three points[36]. MEPS consists of a large study sample size which will yield small standard errors, and very small differences may become statistically significant.

CONCLUSIONS

Our results have implications for healthcare provision and health policy. The Medicare Annual Wellness Visit or Medicare Obesity Benefit have great promise to improving patient health in rural settings in spite of the practical administration challenges[37]. Identifying individuals with obesity or underweight, and other select co-morbid conditions may encourage the delivery of promising tools such as technology-supported home-based interventions, which focus on medical self-management for improving access to care and could be the basis for future studies for the prevention of adverse health conditions. Self-management is a priority area for the Institute of Medicine[38] and a critical component of patient-centered care which focuses on individualizing goals and personalizing plans for chronic disease which prompts an active role in one's health[39]. Routinely integrating self-reported health status in rural primary care can be important in population-health management. This measure could potentially be a helpful health indicator, particularly in health promoting and self-management interventions in at-risk populations.

Finally, findings from our study have potential implications for rural providers who may be concerned about potential reductions in reimbursements with MACRA. MACRA was designed to modernize the Medicare physician payment regimen, and reward better healthcare value and quality of care by including patient reported outcome measures as a foundation for quality measure development. Our results demonstrating worse patient-reported health among rural compared to urban obese older adults suggest that MACRA may disproportionately impact rural healthcare providers. In particular, small primary care rural practices will be especially challenged to routinely screen and address risk factors and social determinants of health. Among the potential solutions include implementing team-based care models using allied health care practitioners or mobile devices to screen for health risk and provide follow-up. Innovative solutions are needed to redesign health care by rural, isolated providers who are uniquely challenged to engage in screening and preventive care services.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BMI	Body mass index
MACRA	Medicare Access and CHIP Reauthorization Act (MACRA)
MCS	Mental Component Score
MSA	Metropolitan Statistical Area
PCS	Physical Component Score

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Table 1:

Baseline Characteristics of Older Adults Aged ≥60 Years by Rural/Urban Status

	Urban	Rural	p-value
	N=17825	N=4482	
Age, years	70.8±0.11	70.8±0.2	0.80
Female Sex, n (%)	10097 (55.5)	2512 (54.1)	0.07
Race			
White	13391 (84.9)	3767 (91.5)	
Black	2964 (9.3)	573 (5.6)	
American Indian/Alaskan	90 (0.4)	47 (1.1)	<0.001
Asian	1117 (4.1)	33 (0.6)	
Native Hawaiian	68 (0.2)	6 (0.1)	
Other	195 (1.0)	56 (1.1)	
Marital Status			
Married	9889 (57.6)	2533 (61.9)	
Widowed	4166 (22.9)	1182 (23.3)	
Divorced	2496 (13.5)	515 (10.2)	<0.001
Separated	368 (1.4)	65 (1.1)	
Never married	905 (4.5)	187 (3.6)	
Current Smoker	2095 (11.6)	631 (13.9)	0.004
Education Level, years	11.7 ± 0.07	11.4±0.14	0.07
Income Level, $	14388.44±362.39	11096.73±450.55	<0.001
Geographic Region			
Northeast	3271 (21.1)	436 (13.3)	
Midwest	3493 (20.2)	1161 (29.8)	<0.001
West	6465 (36.0)	2336 (42.7)	
South	4596 (22.7)	549 (14.1)	
BMI, kg/m^2	27.5±0.06	28.0±0.13	<0.001
% Obese	5151 (27.6)	1412 (30.7)	0.005
Co-Morbidities, n (%)			
Arthritis	3002 (47.5)	944 (50.2)	0.12
Hypertension	7536 (63.0)	1828 (65.6)	0.09
Depression	4595 (24.2)	1229(25.5)	0.25
Chronic Bronchitis	422 (4.1)	146 (6.5)	<0.001
Emphysema	630 (5.7)	177 (6.8)	0.10
Diabetes	2676 (20.1)	625 (21.4)	0.28
Myocardial Infarction	1142 (10.1)	351 (12.6)	0.003
Short Form 12 Domain			
Physical Component	43.4±0.12	41.7±0.28	<0.001
Mental Component	52.1±0.10	51.9±0.20	0.33

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All values represented are means ± standard error, or counts (percents). Values are weighted per analytical protocols.

ADL – activities of daily living; BMI – body mass index; IADL – instrumental activities of daily living; MSA – metropolitan statistical area

MSA is defined as a geographical area with a relatively high population density at its core (>50,000) and close economic ties throughout the area; Urban areas are defined as MSA regions; rural areas are defined as non-MSA regions. Obesity is defined as participants whose BMI exceeds 30.0kg/m^2

t-tests compare rural/urban status for continuous variables and chi-square for categorical variables. An ANOVA compares overall differences in categories with >2 levels (race, marital status, and geographic region0.

Table 2:

Unadjusted Relationship between Body Mass Index, Urban/Rural Status & Self-Reported Health

	Region	All Persons	Underweight	Normal	Overweight	Obese	p-value[b]
Physical	**All Regions**	43.0±0.11	37.0±0.82	44.7±0.18	44.6±0.16	39.5±0.20	<0.001
Component	**Urban**	43.4±0.12	37.4±0.92	45.0±0.19	44.9±0.18	39.8±0.22	<0.001
Score	**Rural**	41.7±0.28	35.2±1.70	43.4±0.52	43.3±0.38	38.4±0.41	<0.001
	p-value[a]	<0.001	0.26	0.007	<0.001	0.002	
Mental	**All Regions**	52.1±0.09	48.4±0.64	52.0±0.14	52.7±0.13	51.6±0.16	<0.001
Component	**Urban**	52.1±0.10	48.0±0.74	52.1±0.15	52.7±0.15	51.7±0.18	<0.001
Score	**Rural**	51.9±0.20	50.1±1.07	51.7±0.38	52.7±0.25	51.2±0.38	<0.001
	p-value	0.33	0.10	0.37	0.98	0.24	

Values are means ± standard errors (weighted)

BMI – body mass index

BMI Categories: Underweight: BMI≤18.5kg/m^2; Normal BMI: 18.5–24.9kg/m^2; overweight: 25.0–29.9kg/m^2; obese: ≥30kg/m^2.

[a] p-value represents a t-test between geographic areas.

[b] p-value presents a one-way analysis of variance between four BMI categories

Table 3:

Univariate & Multivariable Models Physical Component Scale of Short-Form 12

	Univariate Model		Multivariable Model		Multivariable Model with Interaction	
	β ± s.e.	p-value	β ± s.e.	p-value	β ± s.e.	p-value
Age	−0.39±0.01	<0.001	−0.30±0.02	<0.001	−0.30±0.02	<0.001
Female Sex	−2.13±0.20	<0.001	−0.62±0.24	0.012	−0.62±0.24	0.011
Race		<0.001				
White	Ref	---	Ref	Ref	Ref	Ref
Black	−1.77±0.28	<0.001	−1.01±0.32	0.002	−1.01±0.32	0.002
American Indian/Alaskan	−2.78±1.37	0.04	−1.14±1.53	0.46	−1.15±1.54	0.46
Asian	2.05±0.42	<0.001	−0.95±0.41	0.02	−0.93±0.40	0.02
Native Hawaiian	−2.04±1.99	0.31	−3.72±1.69	0.03	−3.73±1.67	0.03
Other	−2.62±0.98	0.008	0.59±1.33	.66	0.72±1.26	0.57
Marital Status		<0.001				
Married	Ref	---	Ref	Ref	Ref	ref
Widowed	−4.18±0.24	<0.001	0.27±0.36	0.47	0.26±0.36	0.47
Divorced	−1.69±0.29	<0.001	−1.25±0.34	<0.001	−1.25±0.34	<0.001
Separated	−2.91±0.77	<0.001	−0.93±0.92	0.32	−0.95±0.92	0.30
Never married	−1.23±0.42	0.004	−1.45±0.51	0.005	−.48±0.51	0.004
Current Smoker	−1.17±0.29	<0.001	−0.73±0.34	0.03	−0.74±0.34	0.03
Income Level ($\times 10^4$)	0.11±0.035	<0.001	0.34±0.04	<0.001	0.34±0.04	<0.001
Co-Morbidities						
Arthritis	−8.43±0.21	<0.001	−5.54±0.23	<0.001	−5.54±0.23	<0.001
Hypertension	−5.6±0.26	<0.001	−1.81±0.24		−1.80±0.24	<0.001
Depression	−7.95±0.22	<0.001	−5.4±0.28	<0.001	−5.40±0.27	<0.001
Cancer	−2.29±0.32	<0.001	−0.70±0.30	0.02	−0.69±0.30	0.02
Chronic Bronchitis	−10.3±0.69	<0.001	−4.56±0.73	<0.001	−4.55±0.73	<0.001
Emphysema	−10.3±0.51	<0.001	−5.82±0.50	<0.001	−5.79±0.51	<0.001
Diabetes	−6.26±0.30	<0.001	−3.35±0.28	<0.001	−3.35±0.28	<0.001
Myocardial Infarction	−7.55±0.41	<0.001	−3.85±0.38	<0.001	−3.85±0.37	<0.001
Rural Status	1.67±0.31	<0.001	0.97±0.32	0.003	0.25±0.56	0.66
BMI		<0.001				
Underweight	−7.7±0.86	<0.001	−4.45±1.21	<0.001	−8.58±2.31	<0.001
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Overweight	−0.11±0.21	0.59	−0.11±0.25	0.66	−0.86±0.66	0.19
Obesity	−5.24±0.26	<0.001	−3.56±0.32	<0.001	−4.28±0.77	<0.001
BMI*rural						
Under#MSA	---	---	---	---	5.19±2.60	0.047
Over#MSA	---	---	---	---	0.91±0.72	0.21
Obese#MSA	---	---	---	---	0.88±0.81	0.28

All values presented are β ± standard errors with p-values. Univariate model consists of individual baseline characteristics predictor with physical component scale of short-form 12 as the outcome. Multivariable modeling consists of all significant predictors with their β ± standard errors with p-values with and without the metropolitan statistical area * body mass index interaction term.

Table 4:

Univariate & Multivariable Models Mental Component Scale of Short-Form 12

	Univariate Model		Multivariable Model		Multivariable Model with Interaction	
	β ± s.e.	p-value	β ± s.e.	p-value	β ± s.e.	p-value
Age	−0.027±0.011	0.013	0.03±0.01	0.023	0.03±0.01	0.02
Female Sex	−1.01±0.15	<0.001	−0.049±0.19	0.80	−0.05±0.19	0.79
Race		<0.001				
White	Ref	Ref	ref	ref	Ref	Ref
Black	−1.56±0.25	<0.001	−0.82±0.24	0.001	−0.83±0.24	0.01
American Indian/Alaskan	−1.77±1.30	0.17	−1.09±1.00	0.28	−1.08±1.00	0.28
Asian	−1.16±0.37	0.002	−1.44±0.36	<0.001	−1.41±0.36	<0.001
Native Hawaiian	−1.63±2.71	0.55	−1.68±2.51	0.50	−1.69±2.52	0.50
Other	−2.31±0.75	0.002	0.054±0.71	0.94	0.07±0.72	0.93
Marital Status		<0.001				
Married	Ref	ref	Ref		Ref	Ref
Widowed	−2.00±0.21	<0.001	−0.56±0.27	0.04	−0.56±0.27	0.04
Divorced	−2.36±0.26	<0.001	−0.77±0.24	0.001	−0.77±0.24	0.001
Separated	−3.77±0.79	<0.001	−1.13±0.70	0.11	−1.13±0.70	0.11
Never married	−1.67±0.46	<0.001	−0.74±0.50	0.14	−0.74±0.50	0.14
Current Smoker	−2.44±0.30	<0.001	−0.60±0.29	0.04	−0.61±0.29	0.04
Income Level ($\times 10^4$)	0.32±0.03	<0.001			0.30±0.29	0.31
Co-Morbidities						
Arthritis	−1.95±0.22	<0.001	−0.41±0.20	0.045	−0.41±0.20	0.047
Hypertension	−1.26±0.19	<0.001	−0.21±0.19	0.26	−0.20±0.19	0.28
Depression	−14.7±0.18	<0.001	−14.2±0.26	<0.001	−14.2±0.26	<0.001
Cancer	−0.19±0.27	0.49	---	---	----	---
Chronic Bronchitis	−4.24±0.62	<0.001	−1.30±0.47	0.006	−1.30±0.47	0.006
Emphysema	−3.16±0.47	<0.001	−0.20±0.43	0.65	−120±0.43	0.64
Diabetes	−2.16±0.26	<0.001	−0.71±0.25	0.004	−0.70±0.25	0.005
Myocardial Infarction	−3.06±0.34	<0.001	−1.50±0.30	<0.001	−1.51±0.30	<0.001
Rural Status	0.23±0.23	0.33	0.11±0.18	0.53	0.41±0.33	0.21
BMI	−0.44±0.20	0.03				
Underweight	−3.66±0.65	<0.001	−2.36±0.81	0.004	−2.29±1.29	0.08
Normal	Ref	ref	Ref	Ref	Ref	Ref
Overweight	0.65±0.17	<0.001	0.53±0.21	0.01	0.42±0.34	0.21
Obesity	−0.44±0.20	0.03	0.91±0.25	<0.001	0.28±0.47	0.56
BMI*rural						
Under#MSA	---	---	---	---	−0.09±1.67	0.96
Over#MSA	---	---	---	---	0.12±0.41	0.77
Obese#MSA	---	---	---	---	0.78±0.52	0.14

All values presented are β ± standard errors with p-values. Univariate model consists of individual baseline characteristics predictor with physical component scale of short-form 12 as the outcome. Multivariable modeling consists of all significant predictors with their β ± standard errors with p-values with and without the metropolitan statistical area * body mass index interaction term.