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Diet quality and body mass index are associated with healthcare resource use in rural older adults

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Abstract

Healthcare resource consumption is a growing concern. The aim of this study was to examine the associations between diet quality and body mass index (BMI) with healthcare resource use (HRU) in a cohort of advanced age. 5,993 Geisinger Rural Aging Study (GRAS), participants were mailed demographic and dietary questionnaires in 2009. Of those eligible 2,995 (50%; 1,267 male, 1,728 female; mean age 81.4 ± 4.4 years) provided completed surveys. Multivariate negative binomial models were used to estimate relative risk (RR) and 95% confidence intervals (95% CI) of HRU outcomes with diet quality as assessed by the dietary screening tool (DST) score and BMI determined from self-reported height and weight. Poor diet quality was associated with a 20%

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increased risk for ER visits. Fruit and vegetable (F+V) consumption was grouped into quintiles of intake with the highest quintile serving as the reference group in analyses. The three lowest F+V quintiles were associated with increased risk for ER visits (23-31%); the lowest quintile increased risk for inpatient visits (27%). Obesity increased risk of outpatient visits; however, individuals with class I obesity were less likely than normal weight individuals to have ER visits (RR 0.84; 95% CI 0.70, 0.99). Diets of greater quality, particularly with greater F+V intake, are associated with favorable effects on HRU outcomes among older adults. Overweight and obesity are associated with increased outpatient HRU and among obese persons, with decreased ER visits. These findings suggest that BMI and diet quality beyond age 74 continue to effect HRU measures.

Keywords

Diet quality; BMI; healthcare resource use; Aging

Introduction

With the number of older individuals increasing,¹ there is an associated increase in co-morbid disease burden² and potential for substantial increases in healthcare resource use (HRU). Approximately 80% of adults over the age of 65 have at least one chronic disease^{4,5} with the potential for substantial increases in health resource utilization (HRU). Diet quality is a potentially modifiable factor that has been associated with chronic diseases. Higher overall diet quality as well as greater intakes of sub-groups including fruits and vegetables, unsaturated fatty acids, low-fat dairy, and whole grains reduce risk of chronic diseases such as obesity, diabetes mellitus, cardiovascular disease, hypertension and stroke, and some types of cancer.⁶⁻¹¹ High fruit and vegetable (F+V) intake specifically has been associated with a healthier BMI and reduced risk for coronary heart disease,¹² stroke,¹³ and cancer,^{14,15} and with lower rates of all-cause mortality,¹⁶ and in the presence of established disease, with improved disease management.¹⁷ Research relating diet quality to HRU is limited and has primarily been conducted in middle-aged adults.^{18,19}

Previous research, primarily in middle-aged adults, has shown that BMI is positively associated with outpatient and inpatient HRU²⁰⁻²² and with medical expenditures overall.^{20,23-25} The limited data on the oldest segment of the population often groups all those over 65 years together, likely underestimating the impact of obesity on health outcomes in old age. The available evidence for those 74 years is mixed, with some data linking obesity with increased medical expenditures,^{23,26} while other studies have suggested that BMI has less impact upon medical expenditures.²⁰ In the majority of studies BMIs >30 are combined, potentially attenuating the contrast of mild versus severe obesity.^{23,27}

The objective of this study was to determine the associations between measures of diet quality and BMI with HRU outcomes in adults 74 years. We hypothesized that underweight or obese individuals, as well as those with poor diet quality, would have a greater likelihood of HRU.

Subjects and Methods

The Geisinger Rural Aging Study (GRAS) began in 1994 with more than 20,000 participants 65-years.²⁶ The participants are community-dwelling individuals in rural northeastern and central Pennsylvania.²⁶ Details of the study have been published previously.²⁶ The participants have been followed as a longitudinal cohort over time, with repeated self or proxy reported surveys of age, height, weight, smoking status, self-rated health, functional status, dietary information and living situation.

All surviving GRAS participants (n=5,993) were mailed health and demographic questionnaires and the Dietary Screening Tool (DST) in 2009. After follow-up 2,995 (50%) (1,267 male, 1,728 female; mean age 81.4 ± 4.4 years) participants returned completed surveys, and were enrolled in the Geisinger Health Plan (GHP) for at least part of follow-up. The study was approved by both the Office of Research Protections at the Pennsylvania State University and at the Geisinger Health System. Surveys were reviewed for completion, and only surveys with complete dietary and BMI data were included in the analyses.

DST, BMI and Healthcare Resource Utilization

Detailed information on the DST is available.^{28,29} Briefly, this validated tool utilizes 25 food-based questions to assess diet quality.²⁹ Cognitive interviewing was conducted to ensure clarity of questions in the population of interest.²⁸ Good test-retest reliability of the DST was shown, with a coefficient of 0.83 ($p < 0.0001$)²⁹ for overall score. The DST score ranges from 0 (poor)-100 points. Responses in the present investigation were scored according to the previously validated algorithm,²⁹ with point allotment based on breakdown of major dietary components of the Healthy Eating Index-2005.³⁰ Sub-components of diet quality scores have been shown to have associations with various outcomes including development of co-morbid conditions and mortality.³¹ Because of the association between F + V intake with chronic disease, the present analysis also examined four F+V questions summed as a sub-component of the DST to determine associations between a F+V intake and HRU outcomes. The F+V sub-score ranged from 0-25 points. For analysis both the DST and the F+V sub-score are assessed by quintile. Additional sub-groups from the DST including whole grain consumption, dairy intake and sweets were considered but were not strongly associated with any of our HRU outcomes (data not shown). BMI was calculated from self-reported height and weight at baseline and categorized per NIH Guidelines.³²

Electronic health records (EHR) provided all HRU from October 2009 through December 2011. The sample almost exclusively used GHP, so the HRU are considered complete. Total counts for each type of HRU were summed, and each measure was analyzed as a separate outcome. Data for the presence of seven obesity-related chronic diseases including diabetes mellitus, hypertension, coronary artery disease, osteoarthritis, obstructive sleep apnea, depression and liver disease at baseline was also extracted from EHR. A disease burden variable was created by summing the number of diseases present for each participant.

Statistical Analysis

All data were analyzed using the Statistical Analysis Software Package (version 9.3, 2011 SAS Institute Inc., Cary, NC). Associations of diet quality, F+V, and BMI with HRU outcomes were assessed using multivariate negative binomial models. This model allows for count variables, provides adjusted point and interval estimates of relative risks (RR) with 95% confidence intervals (95% CI), and allows for over-dispersion.³³ Each participant's length of enrollment in GHP was taken into consideration as an offset variable. DST and F+V score outcomes were controlled for BMI. BMI outcomes did not differ whether controlling for overall DST or F+V sub-score, so data shown for BMI outcomes control for overall diet quality. All models were adjusted for demographic variables including age (continuous), sex, smoking status (ever/never), education (< high school *vs.* high school), weight gain (>5 pounds self-reported in previous 6 months yes/no) and weight loss (loss > 5 pounds self-reported in previous 6 months yes/no). Self-*versus* proxy reporting, living situation of participant (alone, with spouse, with son or daughter, with other family or other) and physical activity were all considered but did not contribute significantly to any of the models and so were excluded from analysis. For BMI, 18.5-24.9 served as the referent group, and for the DST and F+V subgroup the highest score quintiles were considered referent (72 and 22 respectively). Results are presented as relative risks with 95% CI. Interactions between predictors of interest (BMI, DST and F+V sub-score) and each covariate (age, sex, smoking status, weight gain, weight loss, and education) were assessed by including each individual factor (e.g. sex) and its cross product term in separate models. Interactions between predictors of interest (BMI, DST and F+V score) were also assessed.

Results and Discussion

Descriptive characteristics are presented in Table 1. Of the 5,993 remaining members of the cohort contacted in 2009, 50% (2,995) returned completed questionnaires and had HRU data and so were considered in our analyses. Compared to these 2,995 participants, non-responders and responders that did not have HRU data available were significantly older (82.8 ± 4.8 years *vs.* 81.4 ± 4.4 years, $p < 0.05$) and more likely to be female (OR 1.1; 95% CI 1.0, 1.3, $p < 0.05$). The cohort was primarily non-Hispanic white (99%), high school educated (74%) and self-reported study data (91%). Women reported significantly higher DST scores than men. Overall, there were no significant differences between men and women regarding HRU.

Nearly 90% of the participants had at least one obesity-related chronic disease. As expected, disease burden and BMI were correlated (Pearson correlation = 0.19, $p < 0.0001$), and because controlling for intermediate variables (i.e. disease) may result in biased estimates,³⁴ obesity-related disease burden was not included as a covariate in the models.

There were no associations between overall DST score and inpatient visits or days, or outpatient visits in any of the models assessed. Risk of ER visit was increased in participants with a low (unfavorable) DST score (< 49) (RR 1.21; 95% CI 1.00, 1.46, $p = 0.05$) compared to those with the highest DST scores (>72). For the F+V analyses, the lowest quintile of F+V intake was associated with increased inpatient visits (RR 1.27; 95% CI 1.00, 1.63,

$p=0.05$). The three lowest F+V quintiles were associated with an increased risk of ER visits (0-11 points: RR 1.31; 95% CI 1.05, 1.64, $p=0.02$; 12-15 points: RR 1.23; 95% CI 1.00, 1.53 $p=0.05$; 16-18 points: RR 1.26; 95% CI 1.01, 1.56, $p=0.04$). There were no significant interaction terms between any variables in any of the models.

There were no significant associations between BMI and inpatient visits or days. Obesity class I was associated with a decreased risk for ER visits (RR 0.84; 95% CI 0.70, 0.99, $p=0.04$). Overweight (RR 1.07; 95% CI 1.01, 1.13, $p=0.02$), obesity class I (RR 1.15; 95% CI 1.07, 1.22, $p<0.01$) and combined obesity classes II and III (RR 1.21; 95% CI 1.10, 1.33, $p<0.01$) were all associated with increased risk of outpatient clinic visits. There were no other associations between BMI and HRU and no interactions were found.

To our knowledge, the present study is the first to examine the association between diet quality and HRU in such an aged population. The findings do not indicate an association between overall diet quality, assessed by the DST, at baseline, and HRU over two years of follow-up except for an increased risk for ER visits among those participants reporting poor diet quality. Because ER visits are generally more costly than outpatient visits, and for adults 65 years and older the average expenditure per ER visit is over \$1,062,³⁵ reducing this type of HRU is desirable. These observations suggest a potential for favorable impact of diet quality on HRU.

High F+V intake has been associated with reduced mortality, decreased development of chronic diseases, and even reductions in physical and mental impairments in older adults.³⁶ Despite this, very little research has examined the associations between F+V intake with HRU, with even less focus upon persons of advanced age. Two studies analyzing middle aged women¹⁹ and men¹⁸ found that higher vegetable and higher fruit consumption, respectively, was associated with reduced Medicare charges over 5-37 years of follow-up. The impact of early adoption of healthful diet versus later in life is not addressed by our investigation. Since our survey is based upon consumption frequency and not portions, it is not possible to ascertain the level of intake required to see positive outcomes. However, targeting F+V intake in all age groups has the potential improve health outcomes and warrants further investigation.

Research has suggested that increased BMI is associated with increased risk of HRU in middle-aged and older adults,^{20-23,26} but few studies have focused exclusively on those 74 years. Quesenberry et al.,²⁰ found that increasing BMI was associated with increased outpatient visits, and individuals with a BMI > 35 had the highest usage, but only for those aged 74 years. For all age groups, including those 74, a J-shaped relationship was found for inpatient days with the lowest risk in those with a BMI of 25-34.9.²⁰ Studies finding associations between healthcare expenditures and increased BMI often find the largest relative rise in increased expenditures for prescription medications, an outcome not measured in the current analysis.²³

The present analysis suggests that overweight and obesity increased risk of outpatient visits while a BMI of 30-34.9 was associated with decreased risk for ER visits after controlling for demographic characteristics and DST score. Increased risk of outpatient visits with rising

BMI is not surprising since many of these visits were likely for management of co-morbid conditions. The lower risk of ER visits with class I obesity is more difficult to explain. The negative impact of class 1 obesity upon requirements for urgent care may be attenuated in those who survive to old age.^{37,38} These findings are consistent with other research suggesting that higher BMIs may decrease HRU in older adults with the exception of outpatient visits.^{20,39} While we did not find significant associations between underweight and HRU, it is likely because too few individuals in this cohort met the low BMI threshold. It is also likely that individuals living to advanced old age represent a group of survivors that are less susceptible to the negative impacts of higher BMI. Because outpatient visits make up a much smaller portion of total medical expenditures than inpatient visits, overall contribution of BMI to medical costs in adults 74 years may not be as important as other factors.⁴⁰

As detailed in the methods, due to the potential for over-adjustment,⁴¹ we did not adjust for disease burden in the present analysis. Previous research has suggested that Medicare expenditures increase with age, and at a faster rate for overweight and obese individuals.⁴² That analysis considered all individuals over 65 and differences in expenditures were still attenuated with consideration of chronic disease. It is also likely that the increase in outpatient visits observed in the present analysis with elevated BMI is at least in part attributable to chronic disease. With advanced age, BMI may play a less significant role in inpatient HRU, and overweight and mild obesity may even reduce all-cause mortality in the oldest old.⁴¹

A major strength of this study is the relatively large sample size from an under-sampled, rural, population of advanced age. The response rate (50%) is consistent with other community dwelling cohorts of older persons. We were also able to analyze descriptive data for the non-responders. HRU outcomes were extracted from EHR and are not subject to self-report bias. Several limitations should be noted. BMI was calculated from self-reported height and weight. However, for 2,221 participants in this sample, measured BMI from EHR was available and there was a strong correlation between self-reported and measured BMI (Pearson correlation = 0.91, $p < 0.0001$). This analysis was also based on healthcare use and not cost, so caution must be taken in making assumptions about expenditures. Due to the nature of the data, we were unable to identify circumstances that led to HRU. Longer follow-up time for HRU measures would be of benefit and longitudinal data could help determine risk attributable to BMI versus disease. Dietary information was self-reported and so may be subject to recall bias. Finally, this analysis was conducted in a homogenous sample of primarily non-Hispanic white rural Pennsylvanians. Because HRU varies by race,^{43,44} further analysis in more heterogeneous populations will be required to inform broad-scale recommendations.

Conclusions

In an aging population, diets of higher quality, and particularly those with greater F+V intake, are favorably associated with HRU outcomes among older adults. Overweight and obesity are associated with increased outpatient visits. In contrast, mild obesity was associated with decreased ER visits. Regular clinic visits to manage co-morbid conditions

are likely to be less costly than hospitalizations that result from poor compliance with recommended management of these conditions. Our findings suggest that BMI and diet quality beyond age 74 continue to effect HRU measures.

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Table 1
Demographic and personal characteristics overall and by gender for the Geisinger Rural Aging Study (GRAS)

	Total Sample	Males	Females	P-Value
Demographic and Personal Characteristics	N (%)	N (%)	N (%)	
N	2995 (100%)	1267 (42.3)	1728 (57.7)	
Mean Age (y) ^a	81.4 ± 4.4	81.1 ± 4.2	81.5 ± 4.8	0.09
Race ^b				<0.01
White	2911 (98.9)	1224 (98.3)	1687 (99.3)	
Non-Hispanic Black	29 (1.0)	20 (1.6)	9 (0.5)	
Other	3 (0.10)	1 (0.1)	2 (0.1)	
Education ^b				0.19
Less than High School	786 (26.8)	349 (28.1)	437 (25.9)	
High School	2144 (73.2)	894 (71.9)	1250 (74.1)	
Eversmoke ^b				0.59
Yes	114 (3.9)	51 (4.1)	63 (3.7)	
No	2831 (96.1)	1195 (95.9)	1636 (96.3)	
Self V. Proxy Report ^b				<0.01
Self-Report	2703 (90.3)	1117 (89.1)	1586 (93.0)	
Proxy	257 (8.6)	137 (10.9)	120 (7.0)	
Live With... ^b				<0.01
Spouse	1592 (53.8)	905 (72.1)	687 (40.3)	
Son or Daughter	227 (7.7)	58 (4.6)	169 (9.9)	
Other Family	52 (1.8)	18 (1.4)	34 (2.0)	
Other	52 (1.8)	22 (1.8)	30 (1.8)	
Alone	1037 (35.0)	253 (20.1)	784 (46.0)	
Body Mass Index (BMI) ^b				<0.01
<18.5 (Underweight)	62 (2.1)	12 (1.0)	50 (2.9)	
18.5-24.9 (Normal weight)	823 (27.5)	315 (24.9)	508 (29.4)	
25-29.9 (Overweight)	1248 (41.7)	610 (48.1)	638 (36.9)	
30-34.9 (Obese Class I)	639 (21.3)	271 (21.4)	368 (21.3)	
35.0 (Obese Classes II & III)	223 (7.4)	59 (4.6)	164 (9.5)	
Mean HALex Score ^a	0.74 ± 0.21	0.76 ± 0.20	0.73 ± 0.21	<0.01
DST Quintiles ^b				<0.01
49	665 (22.2)	333 (26.3)	332 (19.2)	
50-57	593 (19.8)	285 (22.5)	308 (17.8)	
58-64	603 (20.1)	258 (20.3)	345 (20.0)	
65-71	575 (19.2)	224 (17.7)	351 (20.3)	

	Total Sample	Males	Females	P-Value
Demographic and Personal Characteristics	N (%)	N (%)	N (%)	
72	559 (18.7)	167 (13.2)	392 (22.7)	
Fruit & Vegetable Score Quintiles ^b				<0.01
0-11	657 (21.9)	355 (28.0)	302 (17.5)	
12-15	593 (19.8)	246 (19.4)	347 (20.1)	
16-18	640 (21.4)	274 (21.6)	366 (21.2)	
19-21	561 (18.7)	212 (16.7)	349 (20.2)	
22	544 (18.2)	180 (14.2)	364 (20.0)	
Outpatient Visits ^a	32.3 ± 22.4	35.4 ± 22.2	35.1 ± 22.2	0.69
Inpatient Visits ^a	0.7 ± 1.1	0.7 ± 1.1	0.6 ± 1.2	0.10
Inpatient Days ^a	3.1 ± 7.1	3.4 ± 7.3	3.0 ± 6.8	0.11
Emergency Room Visits ^a	1.3 ± 2.0	1.3 ± 1.9	1.2 ± 2.1	0.55

^a P-values for continuous variables were calculated using independent t-tests

^b P-values for categorical variables were calculated using chi square testing. When cell sizes were < 5, Fisher's exact test was used.

Table 2
Relative Risks (RR) for Inpatient Visits, Inpatient Days, Emergency Room Visits, and Outpatient Clinic Visits by BMI, DST Score and Fruit & Vegetable Consumption

Variable	N	Inpatient Visit		Inpatient Days		ER ^c Visits		Outpatient Visits	
		RR (95% CI)	P-Value	RR (95% CI)	P-Value	RR (95% CI)	P-Value	RR (95% CI)	P-Value
BMI^a (kg/m²)¹									
<18.5	62	1.07 (0.66, 1.75)	0.77	1.35 (0.64, 2.83)	0.43	1.00 (0.64, 1.54)	0.99	0.95 (0.81, 1.12)	0.55
18.5-24.9	823	Ref	-	Ref	-	Ref	-	Ref	-
25-29.9	1428	0.97 (0.82, 1.14)	0.68	0.88 (0.68, 1.13)	0.32	0.89 (0.77, 1.04)	0.14	1.07 (1.01, 1.13)	0.02
30-34.9	639	0.95 (0.78, 1.15)	0.60	0.82 (0.61, 1.11)	0.19	0.84 (0.70, 0.99)	0.04	1.15 (1.07, 1.22)	<0.01
35	223	1.14 (0.87, 1.49)	0.35	0.91 (0.60, 1.38)	0.66	0.85 (0.66, 1.09)	0.20	1.21 (1.10, 1.33)	<0.01
DST^b Quintiles²									
49	665	1.14 (0.92, 1.41)	0.22	1.02 (0.73, 1.41)	0.92	1.21 (1.00, 1.46)	0.05	0.97 (0.91, 1.04)	0.43
50-57	593	1.12 (0.91, 1.39)	0.29	1.06 (0.77, 1.48)	0.86	1.04 (0.86, 1.26)	0.69	1.01 (0.94, 1.08)	0.89
58-64	603	1.05 (0.84, 1.30)	0.68	1.03 (0.74, 1.43)	0.86	1.10 (0.91, 1.34)	0.31	1.04 (0.97, 1.12)	0.25
65-71	575	0.94 (0.75, 1.17)	0.57	0.84 (0.60, 1.17)	0.30	0.99 (0.82, 1.21)	0.96	1.02 (0.95, 1.10)	0.61
72	559	Ref	-	Ref	-	Ref	-	Ref	-
Fruit + Vegetable Score Quintiles²									
0-11	675	1.27 (1.00, 1.63)	0.05	1.27 (0.92, 1.75)	0.15	1.31 (1.05, 1.64)	0.02	1.02 (0.95, 1.10)	0.54
12-15	568	1.19 (0.94, 1.52)	0.15	1.23 (0.89, 1.71)	0.21	1.23 (1.00, 1.53)	0.05	1.05 (0.97, 1.13)	0.21
16-18	663	1.11 (0.87, 1.41)	0.40	1.19 (0.87, 1.65)	0.28	1.26 (1.01, 1.56)	0.04	1.05 (0.98, 1.13)	0.16
19-21	535	0.98 (0.75, 1.26)	0.85	1.17 (0.84, 1.64)	0.35	1.02 (0.81, 1.26)	0.87	1.07 (0.99, 1.15)	0.09
22	554	Ref	-	Ref	-	Ref	-	Ref	-

^a BMI = Body Mass Index

^b DST = Dietary Screening Tool

^c ER = Emergency Room

¹ Controlled for age, sex, education, smoking status, weight gain, weight loss and DST

² Controlled for age, sex, education, smoking status, weight gain, weight loss and BMI