



Interrelationships between self reported physical health and health behaviors among healthy US adults: From the NHANES 2009–2016

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ABSTRACT

Objectives: Individuals who engage in regular physical activity, consume a healthy diet, have a normal body mass index (BMI), as well as avoid smoking and heavy alcohol consumption have lower risks of morbidity and mortality. While self-reported health is a strong predictor of morbidity and mortality, data are sparse about the interrelationship of concurrent healthy behaviors and self-reported health.

Study design: Cross-sectional study design.

Methods: The sample included 7,267 individuals aged 30–50 years without diabetes, heart failure, cancer, myocardial infarction, stroke and emphysema from 2009 to 2016 of the National Health and Nutrition Examination Survey (NHANES). We used latent class analyses to identify concurrent healthy behaviors and explore interrelationships of class membership with self-reported health after adjusting for covariates using SAS® 9.4 software.

Results: Two mutually exclusive classes were found, “fewer healthy behaviors” and “more healthy behaviors”. “Fewer healthy behaviors” class members were less adherent to healthy guidelines while “more healthy behaviors” class members were more adherent. The two classes varied by smoking status, diet, and physical activity but not by BMI or alcohol consumption. Individuals in the “more healthy behaviors” class were associated with self-assessments of good (OR: 2.08; 95% CI: 1.15–3.79), very good (OR: 3.22; 95% CI: 1.78–3.79) and excellent (OR: 4.09; 95% CI: 2.11–7.94) health compared to those in the “fewer healthy behavior” class.

Conclusions: We revealed two mutual exclusive classes with differing patterns of healthy behavior adherence. The class of individuals with more concurrent healthy behavior recommendations were more likely to self-assess their health more favorably.

1. Introduction

Individuals who adhere to recommended healthy behavior guidelines including regular exercise, a healthy diet, a normal body mass index (BMI), as well as avoidance of smoking and excessive alcohol consumption have lower risk of morbidity and mortality [1–9]. Recommendations from the Centers for Disease Control and Prevention and other US health agencies suggest that individuals engage in either 150 min a week of moderate-intensity or 75 min a week of vigorous-intensity aerobic physical activity [9], do not smoke cigarettes [10,11], consume a plant-based diet with moderate amounts of dairy, meat, processing, and reduced sugar [12], maintain a BMI between 18.5 and 24.9 [13];

and drink less than 14 alcoholic drinks if male (i.e. 12 oz of beer, 5 oz glass of wine or 1.5 oz of liquor) per week and 7 alcoholic drinks per week if female [12]. Despite the health benefits of these five behaviors or characteristics, less than 6% of Americans perform all five [14].

Self-reported health (SRH) is a measure elicited from health surveys that asks respondents to describe their health on a scale ranging from poor to excellent. SRH is a strong predictor of morbidity and mortality [15–18]. For example, in a 20-year, longitudinal study of 24,336 subjects, all-cause mortality was two and a half times higher among those who rated their health as poor as compared to those who reported their health as very good [19]. Studies have demonstrated a stable association between SRH and health outcomes across cultures, communities and

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different age groups [18–20]. SRH has also been shown to predict morbidity, mental health, and subclinical illness as well as identify at-risk individuals and discover undetected illness [19,21,22].

While other studies have observed a positive association between healthy behaviors and SRH, none have done so in a nationally representative sample of US, healthy adults. For example, the Inter99 study randomized clinical trial found after 5 years of follow-up, that increased physical activity was highly associated with self-reported physical health and that a healthier diet was highly associated with self-reported mental health [23]. Tsai also found in a sample of US adults from the BRFSS, that in those individuals who participated in 4 out of 4 healthy behaviors as compared to those individuals who participated in less than 4 healthy behaviors (defined as not currently smoking, not currently drinking excessively, physically active and consuming fruits and vegetables five or more times per day) that there was 33% increased likelihood of self-reporting optimal health [24]. In a large Norwegian sample, Jepsen found that respondents reporting adverse lifestyle behaviors including obesity, smoking and excessive intake of alcohol were more likely to report poor self-reported health while conversely those reporting strenuous physical activity also reported higher levels of self-reported health [25].

In this current study, we proposed using latent class analysis (LCA) to identify heterogeneous classes based on adherence to specific healthy behaviors/characteristics, namely diet, smoking, alcohol consumption, physical activity and BMI and using a nationally representative sample, we identified these heterogeneous classes among respondents of NHANES 2009–2016 between the ages of 30 and 50 years without a known medical condition and assessed the association between these distinct classes and SRH. We hypothesized that distinct classes of healthy behavior would emerge and that the classes with better adherence to healthy behaviors would be associated with positive assessments of SRH.

2. Methods

2.1. Population

The National Health and Nutrition Examination Survey (NHANES) is an on-going cross-sectional survey, conducted with a three-stage cluster design to produce a random, anonymous nationally representative sample of the civilian, noninstitutionalized US population [26,27]. The NHANES program collects sociodemographic, dietary and health-related information through interviews and medical, dental, physiological and laboratory tests [28]. We conducted the analysis among 7,267 adults aged 30–50 years who did not have a history of diabetes, heart failure, cancer, myocardial infarction, stroke and emphysema from survey cycles 2009 to 2016. Publicly available datasets available from NHANES do not involve identifiable human subjects and is therefore exempt from local IRB review.

2.2. Healthy behavior and characteristics measures

Smoking status was derived from the questions asked during the NHANES interviews. These questions were, “Have you smoked at least 100 cigarettes in your entire life?” (Yes/No) and “Do you now smoke cigarettes?” (Everyday/Some Days/Not at all). Respondents who answered “No” to the first question were categorized as “Never smokers”. Respondents who answered “Yes” to the first question and “Not at all” to the second question were categorized as “Former smokers”. Respondents who answered “Yes” to the first question and “Everyday” or “Some Days” for the second question were categorized as “Current Smokers”. “Refused” or “Don’t Know” responses were coded as missing.

Alcohol consumption was derived from questions asked during the NHANES interviews. These questions were, “In any one year, have you had at least 12 drinks of any type of alcoholic beverage? By a drink, I

mean a 12 oz. beer, a 5 oz glass of wine or 1.5 oz of liquor” (Yes/No), “In the past 12 months, how often did you drink any type of alcoholic beverage? How many days per week, per month or per year did you drink?” (Range: 0–366) and “In the past 12 months, on the days that you drank alcoholic beverages, on average, how many drinks did you have?” (Range: 1–25). Respondents that answered “No” to the first question were categorized as “Less than 12 drinks a year”. For respondents that answered affirmatively to the first question, the average number of drinks was calculated from the responses to the second and third questions. Men with ≤ 14 drinks per week and women with ≤ 7 drinks per week were categorized as “At or below recommended guidelines”. Men with >14 drinks per week and women with >7 drinks per week were categorized as “Above recommended guidelines” [12]. “Refused” or “Don’t Know” responses were coded as missing.

Physical activity was derived from questions asked during the NHANES interviews. These questions were “In a typical week, do you do any vigorous-intensity sports, fitness or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 min continuously?” (Yes/No) and “In a typical week, do you do any moderate-intensity sports, fitness or recreational activities that cause a small increase in breathing or heart rate such as brisk walking, bicycling, swimming or volleyball for at least 10 min continuously?” (Yes/No). If the respondent’s answers were “no” to both questions, the respondent was categorized as having “No physical activity”. If the respondent’s answers were affirmative to either question, information on how many minutes per day and the number of days per week they performed vigorous and/or moderate exercise was then assessed. Respondents with <150 min a week of moderate-intensity or <75 min a week of vigorous-intensity physical activity were classified as “Less than recommended physical activity”. Respondents with ≥ 150 min a week of moderate-intensity, 75 min a week of vigorous-intensity physical activity aerobic, or a combination of both, were classified as “At or above recommended physical activity” [9]. “Refused” or “Don’t Know” responses were coded as missing.

Dietary consumption was assessed by the Healthy Eating Index (HEI-2015) [29]. HEI-2015 is a scoring metric used to measure diet quality and assess compliance to the U.S. Dietary Guidelines for Americans [30]. The HEI-2015 has several components representing all major food groups, including fruits, vegetables, grains, milk, meat and beans, oils, saturated fat, sodium, and calories from solid fats, and alcoholic beverages. Food components are given maximum and minimum points per 1,000 calories giving each participant a corresponding HEI score. Dietary data were obtained from a 24-h dietary recall questionnaire and HEI scores were then calculated from that data. Respondents with a score of less than 51 were categorized as having a “poor diet”. Respondents with a score between 51 and 80 were categorized as having a “diet that needs improvement”. Respondents with a score of greater than 80 were categorized as having a “good diet” [12].

Body Mass Index (BMI), which is referred to as a healthy characteristic, was obtained through medical examinations and was categorized as “underweight” (<18.5 kg/m²), “normal weight” (18.5–24.9 kg/m²), “overweight” (25.0–29.9 kg/m²) and “obese” (≥ 30 kg/m²) [13]. “Refused” or “Don’t Know” responses were coded as missing.

We defined an individual as being “adherent” to a particular healthy behavior or characteristic if they were defined as a former or never smoker, had alcohol consumption at ≤ 14 alcoholic drinks per week for men and ≤ 7 alcoholic drinks per week for women, performed ≥ 150 min a week of moderate-intensity or 75 min a week of vigorous-intensity physical activity aerobic, had an HEI-2015 score of 51 or greater; and had a normal BMI. We summed the number of healthy behaviors performed with possible values ranging from 0 to 5 [14].

Self-reported health was assessed during the household interview by asking respondents, “How is your general health condition?” The choices were “Poor”, “Fair”, “Good”, “Very good”, and “Excellent.” “Refused” or “Don’t Know” responses were coded as missing.

The sociodemographic covariates included in the analysis were

gender (Male/Female), age (continuous in years), race/ethnicity (White non-Hispanic/Black non-Hispanic/Mexican/Other Hispanic/Other Race), education (Less than High School diploma/High Diploma/Some college or AA degree/College degree or higher), and income status (Less than \$20,000/Greater than or equal to \$20,000). We also assessed insurance coverage (Yes/No) and whether they had a routine place for healthcare (Yes, one or more places/No).

2.3. Statistical analysis

Analyses accounted for the complex survey design of the NHANES. Descriptive statistics were generated for the health-related behaviors, self-reported health and covariates using frequency/percentages or median/interquartile ranges (IQR), where appropriate.

Latent class analysis (LCA) was used to identify mutually exclusive classes based upon a subject's responses to the health-related behavior inquiries. LCA estimates two different parameters, first is a posterior probability of membership into a latent class and second are item response probabilities. Modeling was performed in a step-wise fashion, testing up to a 3-class model. Model fit statistics included the Log Likelihood (LL), Bayesian Information Criterion (BIC), entropy and the Lo-Mendel-Rubin Adjusted Likelihood Ratio test (LMR aLRT). The optimal number of classes was selected based upon having a lower LL/BIC, high entropy (≥ 0.7) and a statistically significant LMR aLRT (< 0.05) [31,32]. The degree to which item response probabilities were close to 0 or 1 (homogeneity) and the degree to which they were distinguished from one another (latent class separation) was also considered. Respondents were categorized into classes for which they had the highest posterior probability of membership based upon their responses to the health-related behaviors. Missing values on the health-related behaviors in LCA models were addressed with full-information maximum likelihood estimation and all available information was used to estimate parameters. Item response probabilities of the health behavior indicators by class were plotted graphically as stacked bar charts. Descriptive statistics of self-reported health and covariates by resulting classes were generated. Differences in distribution were tested by Rao-Scott Chi-Square Test and Wilcoxon rank sum test for categorical and continuous variables, respectively.

Logistic regression was used to assess the association between self-reported health, adjusted by covariates, and membership into resulting classes. Self-reported health, sociodemographic, insurance coverage and routine place for care were tested independently (unadjusted models) prior to inclusion into the final model. Covariates with p-values ≤ 0.1 in their respective unadjusted model were included in the final adjusted model. Odds ratios (OR) and their 95% confidence intervals (CI) were reported. Statistical significance was set at $p < 0.05$.

Statistical analyses were performed in SAS version 9.4 (SAS Institute Inc, Cary, NC) and Mplus version 8.5 (Muthen & Muthen, Los Angeles, CA).

3. Results

3.1. Population characteristics

The unweighted overall response rate from our survey ranged from 61.3% to 79.4% for interview data and 58.7%–77.3% for examination data [33]. The final unweighted and weighted sample size was 7,267 and 75,871,168, respectively. The weighted median age of our sample was 39.3 years, gender was equally distributed and the majority of respondents were white, earned more than \$20,000 per year. Most respondents also reported having some college experience or a college degree, and had insurance coverage as well as a place for routine healthcare. In addition, most respondents were “never smokers” and did not drink excessive alcohol, but almost half had a “poor diet”, reported no physical activity, and most were overweight or obese. Over 30% of respondents reported performing four or five healthy behaviors, while

Table 1

Unweighted and weighted sociodemographic, health-related and physical characteristics of the sample (n = 7,267).

	Sample N (%)	Weighted N (%)
Age in Years, Median (IQR)	39.0 (34.0, 45.0)	39.3 (34.0, 44.6)
Gender		
Male	3,504 (48.2%)	37,583,297 (49.5%)
Female	3,763 (51.8%)	38,287,871 (50.5%)
Race		
Non-Hispanic White	2,744 (37.8%)	46,194,023 (60.9%)
Non-Hispanic Black	1,428 (19.7%)	8,942,320 (11.8%)
Mexican American	1,165 (16.0%)	8,228,222 (10.8%)
Other Hispanic	791 (10.9%)	5,455,693 (7.2%)
Other Race	1,139 (15.7%)	7,050,910 (9.3%)
Income		
< \$20,000 per year	1,079 (14.8%)	7,585,456 (10.4%)
$\geq$ \$20,000 per year	5,820 (80.1%)	65,324,709 (89.6%)
Missing	368 (5.1%)	368
Education		
Less than HS	1,542 (21.2%)	11,808,118 (15.6%)
HS Grad	1,500 (20.6%)	14,861,905 (19.6%)
Some College or AA	2,055 (28.3%)	22,325,603 (29.5%)
College Graduate	2,162 (29.8%)	26,804,588 (35.4%)
Missing	8 (0.1%)	8
Insurance		
Yes	5,124 (70.5%)	58,105,983 (76.6%)
No	2,140 (29.4%)	17,717,416 (23.4%)
Missing	3 (0.0%)	3
Has Routine Place for Care		
Yes, one or more places	5,731 (78.9%)	61,810,143 (81.5%)
No	1,536 (21.1%)	14,061,025 (18.5%)
Smoking Category		
Never Smoker	4,426 (60.9%)	45,395,103 (59.9%)
Former Smoker	1,177 (16.2%)	14,309,583 (18.9%)
Current Smoker	1,660 (22.8%)	16,142,638 (21.3%)
Missing	4 (0.1%)	4
Healthy Eating Index Category		
Poor Diet	3,231 (44.5%)	34,054,292 (49.9%)
Diet Needs Improvement	3,090 (42.5%)	32,974,854 (48.3%)
Good Diet	124 (1.7%)	1,276,354 (1.9%)
Missing	822 (11.3%)	822
Alcohol Category		
Reported less than 12 drinks a year	1,054 (14.5%)	9,014,935 (15%)
At or Below Guidelines	4,077 (72.4%)	44,443,493 (73.8%)
Above Guidelines	498 (6.9%)	6,764,446 (11.2%)
Missing	1,638 (22.5%)	1,638
Exercise Category		
No Physical Activity	3,395 (46.7%)	31,767,234 (41.9%)
Below Guidelines	1,181 (16.3%)	13,412,754 (17.7%)
At or Above Guidelines	2,679 (36.9%)	30,583,843 (40.4%)
Missing	12 (0.2%)	12
Body Mass Index Category		
Underweight	76 (1.0%)	709,048 (1%)
Normal Weight	1,940 (26.7%)	20,137,014 (27.6%)
Overweight	2,353 (32.4%)	25,346,090 (34.8%)
Obese	2,598 (35.8%)	26,646,011 (36.6%)
Missing	300 (4.1%)	300
Number of concurrent healthy behaviors		
0 Healthy Behaviors	61 (0.8%)	690,413 (1.2%)
1 Healthy Behavior	510 (7.0%)	5,105,210 (8.8%)
2 Healthy Behaviors	1,480 (20.4%)	15,895,391 (27.3%)
3 Healthy Behaviors	1,845 (25.4%)	19,033,311 (32.6%)
4 Healthy Behaviors	1,169 (16.1%)	13,158,989 (22.6%)
5 Healthy Behaviors	341 (4.7%)	4,444,942 (7.6%)
Missing	1,861 (25.6%)	1,861
Self-Reported Health		
Poor	99 (1.4%)	855,654 (1.3%)
Fair	1,006 (13.8%)	8,261,641 (12.7%)
Good	2,548 (35.1%)	26,017,344 (40.1%)
Very Good	1,743 (24.0%)	21,977,264 (33.8%)
Excellent	686 (9.4%)	7,824,409 (12%)
Missing	1,185 (16.3%)	1,185



Fig. 1. Item response probability by class.

10% reported performing zero or only one healthy behavior. 46% of respondents reported having very good or excellent health while 14% reported having poor or fair health (Table 1).

3.2. Latent class model fit selection

The 2-class model was selected as the model with the optimal number of classes based upon the BIC, entropy and LMR aLRT p-value of the final model. While the 3-class model had the lowest BIC (62428.100) and LL (-31058.456), the entropy was only 0.560 and the LMR aLRT was non-significant. The model fit statistics of the optimal model had a BIC of -31299.938, LL of 62804.371, LMR aLRT p-value of 0.0006 and an entropy of 0.778. The classification probabilities for the latent class membership for Classes 1 and 2 were 0.842 and 0.959, respectively.

3.3. Classes of healthy behaviors

The two mutually exclusive groups that emerged from our sample and were Class 1 (26.1%) described as being further away from established health guidelines ("fewer healthy behaviors" class), and Class 2

(73.9%) described as being closer to established health guidelines ("more healthy behaviors" class).

Most respondents in the "fewer healthy behaviors" class were current smokers (73.5%), had a poor diet (65.0%), reported no physical activity (53.9%), were overweight or obese (71.5%), but had alcohol consumption within the recommended guidelines (74.0%). Most respondents in the "more healthy behaviors" class were never smokers (82.4%), had a diet that needed improvement (53.2%), met alcohol consumption guidelines (75.1%). 43.9% met the recommended guidelines for physical activity and most (71.3%) were categorized as overweight or obese. Fig. 1 illustrates the distribution of the item response categories for the healthy behaviors.

3.4. Population characteristics by healthy behavior class

Respondents in the "fewer healthy behaviors" class had a median age of 39.2 years and were 56.1% male, 66.2% white. 82.7% reported household income of greater than \$20,000 per year, 66.4% had insurance coverage with 78.2% having a routine place for health care and 15.3% had a 4-year college degree. Nearly 80% of the respondents in

Table 2
Characteristics by latent class (survey weighted).

	Fewer Healthy Behaviors Class (26.1%)	More Healthy Behaviors Class (73.9%)	p-value
Age in Years, Median (IQR)	39.2 (34.0–44.4)	39.4 (34.1–44.6)	NS
Gender			
Male	56.1% (53.5%–58.7%)	47.2% (45.8%–48.7%)	<0.0001
Female	43.9% (41.3%–46.5%)	52.8% (51.3%–54.2%)	
Race			
Non-Hispanic White	66.2% (61.9%–70.5%)	59% (54.8%–63.3%)	<0.0001
Non-Hispanic Black	13% (10.7%–15.3%)	11.4% (9.5%–13.2%)	
Mexican American	8.6% (6.3%–10.9%)	11.6% (9.1%–14.2%)	
Other Hispanic	5.3% (3.8%–6.9%)	7.8% (6.1%–9.5%)	
Other Race	6.9% (5.4%–8.4%)	10.1% (8.6%–11.7%)	
Income			
< \$20,000 per year	17.3% (15.1%–19.5%)	8% (6.9%–9.1%)	<0.0001
≥ \$20,000 per year	82.7% (80.5%–84.9%)	92% (90.9%–93.1%)	
Education			
Less than HS	21.4% (18.8%–23.9%)	13.5% (11.6%–15.5%)	<0.0001
HS Grad	31.3% (28.5%–34%)	15.5% (14%–17%)	
Some College or AA	32% (29.2%–34.9%)	28.5% (26.6%–30.5%)	
College Graduate	15.3% (12.3%–18.3%)	42.4% (39.3%–45.6%)	
Insurance			
Yes	66.4% (63.4%–69.5%)	80.2% (78.1%–82.4%)	<0.0001
No	33.6% (30.5%–36.6%)	19.8% (17.6%–21.9%)	
Has Routine Place for Care			
Yes, one or more places	78.2% (75.6%–80.8%)	82.6% (81.4%–83.8%)	<0.0001
No	21.8% (19.2%–24.4%)	17.4% (16.2%–18.6%)	
Concurrent Adherence to Healthy Behavior Guidelines			
0 Healthy Behaviors	4.6% (2.9%–6.3%)	0% (0%–0%)	<0.0001
1 Healthy Behavior	31.7% (29.2%–34.2%)	0.7% (0.4%–1%)	
2 Healthy Behaviors	43.4% (40.5%–46.3%)	21.6% (19.9%–23.3%)	
3 Healthy Behaviors	16.4% (14.3%–18.5%)	38.3% (36.4%–40.2%)	
4 Healthy Behaviors	3.9% (2.3%–5.6%)	29.1% (27.1%–31%)	
5 Healthy Behaviors	0% (0%–0%)	10.3% (8.7%–11.8%)	
Self-Reported Health			
Poor	2.4% (1.4%–3.3%)	0.9% (0.6%–1.3%)	<0.0001
Fair	19.4% (17%–21.8%)	10.3% (9.1%–11.6%)	
Good	46.2% (42.7%–49.6%)	37.9% (35.8%–40%)	
Very Good	25.2% (22.1%–28.3%)	36.9% (34.8%–39.1%)	
Excellent	6.9% (5.1%–8.7%)	13.9% (12.4%–15.3%)	

this “less healthy class” reported adherence to two healthy behaviors or less and 32% reported their health as very good or excellent. Respondents in the “more healthy behaviors” class had a median age of 39.4 years, were 52.8% female, and 59.0% white. 92% reported household income of greater than \$20,000 per year, 80.2% had insurance coverage, with 80.2% having a routine place for health care and 42.4% had a 4-year college degree. Most participants in this class (77.7%) reported adherence to three or more healthy behaviors, and over 51% reported their health as very good or excellent (Table 2).

3.5. Association of membership in the “more healthy behaviors” class and self-reported health

We modeled odds ratios regarding factors associated with membership in the “more healthy behaviors” class. In the final adjusted model, membership in the “more healthy behaviors” class was associated with self-assessments of good (OR: 2.08; 95% CI: 1.15–3.79), very good (OR:

Table 3
The unadjusted and adjusted association of membership in the “more healthy behaviors” class and self-reported health.

	Unadjusted Odds Ratio (95% Confidence Interval)	Adjusted Odds Ratio (95% Confidence Interval)
Primary Independent Variable		
Self-Reported Health		
Excellent	5.02 (2.67–9.44)	4.09 (2.11–7.94)
Very Good	3.66 (2.12–6.32)	3.22 (1.78–5.84)
Good	2.05 (1.14–3.69)	2.08 (1.15–3.79)
Fair	1.33 (0.75–2.37)	1.45 (0.79–2.66)
Poor (referent level)	–	–
Covariates		
Age (per unit increase)	1.00 (0.99–1.02)	1.01 (0.99–1.02)
Gender		
Female	1.43 (1.27–1.61)	1.25 (1.08–1.45)
Male (referent level)	–	–
Race		
Other Race	1.66 (1.26–2.18)	1.35 (0.97–1.89)
Other Hispanic	1.65 (1.36–2.01)	2.76 (2.07–3.68)
Mexican American	1.52 (1.22–1.89)	3.87 (2.96–5.06)
Non-Hispanic Black	0.98 (0.83–1.16)	1.51 (1.24–1.83)
Non-Hispanic White (referent level)	–	–
Income		
≥ \$20,000 per year	2.42 (2.05–2.84)	1.77 (1.47–2.14)
< \$20,000 per year (referent level)	–	–
Education		
College Graduate	4.38 (3.39–5.67)	4.51 (3.31–6.14)
Some College or AA	1.41 (1.15–1.72)	1.66 (1.29–2.12)
HS Grad	0.78 (0.66–0.92)	0.93 (0.74–1.17)
Less than HS (referent level)	–	–
Insurance		
Yes	2.05 (1.69–2.49)	1.54 (1.24–1.92)
No (referent level)	–	–
Has Routine Place for Care		
Yes, one or more places	1.32 (1.11–1.58)	1.03 (0.83–1.28)
No (referent level)	–	–

Boldface indicates statistical significance ($p < 0.05$).

3.22; 95% CI: 1.78–3.79) and excellent (OR: 4.09; 95% CI: 2.11–7.94) health. The “more healthy behaviors” class was also associated with identifying as a racial/ethnic minority [Mexican American (OR: 3.87; 95% CI: 2.96–5.06); Other Hispanic (OR: 2.76; 95% CI: 2.07–3.68); Non-Hispanic Black (OR: 1.51; 95% CI: 1.24–1.83)], being female (OR: 1.25; 95% CI: 1.08–1.45), having a household income of greater than \$20,000 (OR: 1.77; 95% CI: 1.47–2.14), having higher educational attainment (College Graduate [OR: 4.51; 95% CI: 3.31–6.14]; Some College or AA [(OR: 1.66; 95% CI: 1.29–2.12)]), and having health insurance (OR: 1.54; 95% CI: 1.24–1.92). (Table 3).

4. Discussion

Our analysis found two mutually exclusive classes defined as closer to recommended health guidelines (healthy) and further away (less healthy) from health guidelines. These classes varied in their adoption of healthy behaviors relating to smoking, diet, and physical activity but were similar with regards to BMI (overweight or obese) and alcohol consumption (at or below guidelines). In addition, we found that individuals in the class that adhered more closely to recommended health guidelines were more likely to self-assess their health favorably.

The positive association between diet quality, exercise and smoking avoidance and self-reported health from this study is consistent with the findings from Tsai and Pisinger, while the poor correlation between BMI and excess alcohol consumption and self-reported health found in this study is consistent with findings from Valencia-Martin who found that alcohol consumption including heavy drinking, did not affect self-

reported health, [23,24,34]. Results from Visscher who reported that the majority of obese subjects in their surveys do not recognize obesity as a risk factor for common chronic diseases. Visscher explains that part of this confusion might occur because obese persons often underestimate their own weight and may not consider themselves obese [35]. It is therefore possible that while diet, exercise and smoking avoidance have robust and consistent associations with self-reported health, obesity and heavy alcohol consumption may have a less consistent or non-existent association with self-reported health.

There were limitations to our findings. First, there was the possibility of misclassification error from self-reported data regarding the five behaviors/characteristics presented. Offsetting this concern is available findings from previous NHANES status that found that self-reported smoking status is 95% accurate when compared to laboratory measurements, such as cotinine status [36], that self-reported exercise is highly correlated with accelerometer data [37], and self-reported alcohol consumption status is accurate for light to moderate drinkers, which comprises the majority of our sample [38]. Such associations provide assurance that the observations found in this analysis are unlikely the result of non-differential misclassification error. Secondly, our data can also only be generalized to adults 30–50 years of age who are free of common illnesses. Finally, our latent class assignments are only an approximation for grouping health behaviors and group membership might be influenced by residual confounding. Despite these limitations, there were some notable strengths to our analytic approach. The methods of data collection performed by the CDC and the sampling methodology used to generate estimates provide precise inferential information regarding the US population. We also prospectively targeted our analysis to exclude people with significant health conditions as well as children, young adults, and the elderly to avoid confounding, reverse causation and to generalize our findings to a group of otherwise “healthy” middle aged adults.

5. Conclusions

Our findings provide important information regarding the relationship of greater adherence to recommended health-related guidelines and positive assessments of self-reported health. Our results also suggest that some healthy behaviors (diet, exercise and smoking) may have a larger influence on one's self-reported health than others (high BMI and alcohol consumption). Additional research should attempt to confirm these findings and apply them to novel interventions that improve adherence to dietary, exercise and smoking guidelines.

Our work in relation to public health practice:

- We identified two distinct group with differences in adherence to the health-related behaviors of diet, exercise and smoking avoidance, but not BMI and alcohol consumption.
- The group with better adherence to health-related behaviors had a more positive assessment of their self-reported health.
- Our results are consistent with previous research which suggests a positive association between self-reported health and diet, exercise and smoking and an unclear association between self-reported health and BMI and alcohol consumption. Such findings may have implications for public health interventions.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Authors Deanna Ware, David C. Landy, Anna Rabil and Eric M. Hecht have no financial disclosures.

Charles Hennekens reports that he serves as an independent scientist in an advisory role to investigators and sponsors as Chair or Member of Data Monitoring Committees for Amgen, British Heart Foundation, Cadila, Canadian Institutes of Health Research, DalCor, and Regeneron;

to the Collaborative Institutional Training Initiative (CITI), legal counsel for Pfizer, the United States Food and Drug Administration, and UpToDate; receives royalties for authorship or editorship of 3 textbooks and as co-inventor on patents for inflammatory markers and cardiovascular disease that are held by Brigham and Women's Hospital; has an investment management relationship with the West-Bacon Group within SunTrust Investment Services, which has discretionary investment authority; does not own any common or preferred stock in any pharmaceutical or medical device company.

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