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## Lifestyle Therapy Changes and Hypercholesterolemia: Identifying Risk Groups in a Community Sample of Blacks and Whites

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### Abstract

**Objective**—To examine diet and exercise lifestyle therapy change (LTC), behaviors and their relation to hypercholesterolemia in a community sample of Blacks and Whites.

**Design**—Latent class analysis (LCA) was employed to identify homogeneous subgroups of community dwelling Blacks and Whites related to LTC for hypercholesterolemia. LCA is a statistical technique used to identify subgroups of individuals who share a similar pattern of responses to a set of observations. The relation between hypercholesterolemia and latent class membership was assessed.

**Participants**—Adults age 18 and over who participated in a county-level adaptation of the Behavioral Risk Factor Surveillance System.

**Main Outcome Measure**—Hypercholesterolemia (absence or presence).

**Results**—Eleven unique latent classes of LTC behavior emerged from LCA models. Exercisers and Fat Reducers represented between 19% and 29% of each race-sex group. Latent class membership probabilities varied substantially across race and sex. Only Black women had a class of Contemplators (21.5%). Overall, men and Blacks with self reported hypercholesterolemia were more likely to engage only in fat reduction but not increase in vegetable consumption, reduction of fat or regular exercise (odds ratios range from 1.8–3.5).

**Conclusions**—The distribution of diet and exercise related LTC behaviors in relation to self-reported hypercholesterolemia can help to identify, understand and tailor culturally and sex specific interventions based on the proportions of men and women in different latent classes.

### Keywords

Hypercholesterolemia; Latent Class Analysis; Lifestyle Therapy Changes

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*Design concept of study:* BeLue, Lanza, Figaro

*Acquisition of data:* BeLue

*Data analysis and interpretation:* BeLue, Lanza, Figaro

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## Introduction

Hypercholesterolemia is a major risk factor for heart disease. Maintaining low levels of cholesterol, specifically low-density lipoprotein cholesterol, has been linked to a reduction in cardiovascular complications such as hypertension, atherosclerosis, and coronary death.<sup>1</sup> In addition to cholesterol-lowering pharmacologic therapy, lifestyle changes such as eating less fat, eating more fruits and vegetables, and exercising more are important for moderating cholesterol levels.<sup>2,3</sup>

Although no racial and ethnic disparities have been documented in the prevalence or incidence of hypercholesterolemia,<sup>4,5</sup> African Americans are more likely to have poor cardiovascular outcomes than are Whites.<sup>6</sup> Furthermore, African Americans do not necessarily differ from Whites in their receipt of medical management of high cholesterol.<sup>7</sup> However, African Americans as a group are less likely to engage in the recommended lifestyle changes for reducing cholesterol levels than are Whites and are more likely to report barriers to those changes.<sup>8–10</sup>

By examining behaviors such as fruit and vegetable intake, dietary fat intake, and exercise behavior simultaneously, a more complete assessment of an individual's cardiovascular risk-related behaviors can be obtained. However, this is a complex set of behaviors; individuals may adhere to some lifestyle behaviors and not to others. This complexity can make it difficult to summarize cardiovascular risk-related behaviors in a population, and to examine the relation between hypercholesterolemia and this set of behaviors. Capturing this can assist in the creation of comprehensive interventions that are patient-specific.

Interventions that target multiple lifestyle changes are ideal<sup>11–13</sup> but are challenging for patients to implement and maintain.<sup>14</sup> Therefore, better understanding the effect of multiple lifestyle behaviors on the management of hypercholesterolemia can help inform more effective intervention strategies. We examine participation in dietary and exercise behavior associated with the management of cholesterol in a community-based sample of Blacks and Whites.

## Method

### Participants

The data used for this study are from a county-level adaptation of the Behavioral Risk Factor Surveillance System (BRFSS) developed by the Centers for Disease Control and Prevention (CDC). In the first 7 months of 2001, the Metropolitan Public Health Department of Davidson County, Tennessee, conducted a local adaptation of the BRFSS. Adults aged  $\geq 18$  years who were not institutionalized were eligible to participate in the telephone interview. The survey contained items from the CDC's BRFSS survey, including questions on participant demographics such as age, sex, and race and indicators of lifestyle behaviors, including exercise, fruit and vegetable intake, and fat intake. The sample used for analysis consisted of 7014 respondents who returned fully completed surveys and reported their race as either Black or White. The response rate was  $>40\%$ , which is within the typical range of response rates for CDC BRFSS state surveys.

### Measures of Eating and Exercise Behavior

The transtheoretical model and its stage of change (SOC) for increasing fruits and vegetables, reducing fat and increasing exercise were used as indicators of exercise and eating behavior.<sup>15–17</sup> SOC assumes, for a particular behavior, such as smoking cessation, that individuals belong to one of the following five stages: 1) precontemplation (do not plan to change the behavior); 2) contemplation (thinking about changing the behavior, and although not yet made a commitment to take action, plan to within the next six months); 3) preparation (have the

intention to change behavior and plan to take necessary action within the next 30 days); 4) action (have engaged in the behavior change but have done so for less than six months); and 5) maintenance (have maintained the behavior change for at least six months and are working to prevent relapsing into previous behavior patterns).

### Measures of Body Mass Index, Cholesterol Status, Age, Education

Self-reported body mass index (BMI) was assessed as weight in kilograms/height in meters squared. A BMI in the range of 18.5 and 24.9 was considered normal; BMI  $\geq 25$  but  $< 30$  was considered overweight, while a BMI  $\geq 30$  was considered obese.<sup>18</sup> For this study, BMI was dichotomized as normal/underweight vs overweight/obese. Hypercholesterolemia was based on self-report of whether a physician had ever diagnosed the participant as having high cholesterol.

Age was measured as a continuous variable (range 18–90). Level of education was measured as 1) less than high school, 2) completed high school, or 3) greater than high school. Race was measured as self-reported White, Black, or other. Only those who self-reported their race as either Black or White were included in the study.

### Statistical Analysis

Descriptive statistics including frequencies were employed to describe demographic and cholesterol status (high or normal), and SOC for each behavior. Chi-square tests were used to examine separately the relationship between SOC for each behavior and sex and race.

Lifestyle therapy change (LTC) for multiple diet and exercise behaviors constitutes a multivariate issue; for example, one individual might be in maintenance stage for all three behaviors, while another individual might be in maintenance stage for the two dietary behaviors but precontemplation for increased exercise. This complexity can make it difficult to summarize LTC related behaviors in a population, and to examine the relation between high cholesterol status and this set of behaviors. Latent class analysis (LCA) is a statistical technique<sup>24,25</sup> used to identify latent classes or subgroups of individuals from a set of items. The model posits that the population is comprised of two or more mutually exclusive and exhaustive latent classes based on multiple observed variables.

In our study, LCA was used to establish 1) the optimal number of latent classes necessary to represent heterogeneity across individuals in their responses to the SOC observed variables for all three behaviors and 2) latent class sizes and characteristics. Latent class models were fit separately for race-sex groups as research has shown that eating and exercise behaviors may differ substantially by sex<sup>8,10,19</sup> and race.<sup>10,20–23</sup> All analyses were conducted using SAS version 9.1 (SAS Institutes Inc, Cary, NC) and its Proc LCA version 1.1.3;<sup>24,25</sup> Proc LCA and the corresponding user's guide are available for download at no cost at the following website: <http://methodology.psu.edu/>.

Parameter estimates are derived by maximum likelihood estimation procedures. Two sets of parameters are estimated in a latent class model: latent class membership probabilities and item-response probabilities given a latent class. The latent class membership probabilities represent the distribution of individuals on the outcome of interest. In this case, these probabilities describe the proportion of individuals in the population expected to have each profile of LTC-related behaviors. The item-response probabilities represent the probability of each response to the manifest variables (in our case, variables that measure LTC) conditional on membership in a particular latent class. These parameters map the manifest items onto the latent classes, providing a basis for interpreting each latent class. Resultant latent classes represent groups of individuals who share a common set of stages in the behaviors, reflecting

overall diet-exercise related behavior (ie, current behavior and intentions in increasing fruits and vegetable intake, reducing dietary fat intake, and increasing exercise).

Each latent class can be labeled in a manner that is consistent with the item-response probabilities. Once the latent class structure is obtained, one or more covariates can be added to the model in order to examine how they relate to latent class membership.<sup>26,27</sup> In this study, cholesterol status (high or normal) served as the covariate of interest. Latent class models obtained from the procedure outlined above serve as the dependent variable for a multinomial logistic regression model of latent class membership on high cholesterol status (yes vs no). We conducted latent class regression for each race-sex group.<sup>24</sup> Age (age greater or less than 40), level of education and the presence of other metabolic risk factors including diabetes, hypertension and BMI classification were controlled for in all models.

## Results

### Sample Demographics

The mean age of participants was 45.9 (sd = 17.6) at the time of the survey. Twenty-four percent of the sample was Black, 64% female, and 86% completed high school or greater, of which 53% completed college. Fifty-six percent of the sample was overweight or obese and 24.8% of the sample self-reported having high cholesterol. Individuals were more likely to be in action phase for increasing exercise (20%) than for dietary behaviors (11% and 4% for dietary fat reduction and increasing fruit and vegetable intake, respectively). Increasing fruit and vegetable intake appears to be the most difficult behavior to undertake, with 36% of the sample still in precontemplation. Table 1 shows the proportion of individuals by race and sex in each SOC separately for each LTC behavior. Chi-square analyses indicate statistically significant race and sex differences in SOC for all three LTC behaviors (see Table 1).

Overall, several classes were common to all race and sex groups including: Maintainers, with at least one-fourth of each race-sex group, Exercisers and Fat Reducers, comprising between 19% and 29% of each race-sex group, and Exercisers/Produce eaters, with about 10% of each race-sex group expected to belong to this class. The last class common to all race-sex groups is the Fat Reducers, which comprised between 6% and 10% of each race-sex group.

### Latent Classes of Lifestyle Change Therapy Behaviors

A total of eleven unique latent classes of exercise and eating behavior emerged across the four race-sex models: 1) Maintainers: individuals in maintenance phase for all three behaviors; 2) Healthy Eaters: individuals in maintenance phase for eating behaviors, but in precontemplation/contemplation or preparation for exercise; 3) Fruit and Vegetable Eaters: individuals in maintenance for increasing fruits and vegetables, but in precontemplation/contemplation or preparation for exercise; 4) Exercisers/Fruit and Vegetable Eaters: individuals in maintenance phase for exercising and increasing fruits and vegetables but in precontemplation/contemplation or preparation for fat reduction; 5) Exercisers/Fat Reducers: individuals in maintenance for exercising and decreasing fat, but in precontemplation/contemplation or preparation for increasing fruit and vegetable; 6) New Exercisers/Fat Reducers: individuals in action for increasing exercise and in maintenance for reducing fat, but in precontemplation/contemplation or preparation for increasing fruits and vegetables; 7) Fat Reducers: individuals in maintenance for fat reduction, but in precontemplation/contemplation or preparation for exercise and fruits and vegetables increase; 8) Exercisers: individuals in maintenance for exercise, but in precontemplation/contemplation or preparation for fat reduction and fruits and vegetables increase; 9) Pre-contemplators: individuals in precontemplation for all behaviors; 10) Contemplators: individuals in precontemplation/

contemplation for all behaviors; 11) Near Maintainers: individuals in a combination of preparation, action or maintenance for eating and exercise behaviors.

Each race-sex model comprised a different subset of the 11 latent classes of eating and exercise behavior. Table 2 presents the proportion of the sample in each race-sex group expected to belong in each of the latent classes listed above. Dashed lines in the table indicate that latent classes did not emerge for that particular group. Note that some of the latent classes (eg, Maintainers) were identified in all four race-sex groups; while others were specific to certain race-sex groups (eg, Contemplators were specific to Black women in this analysis). Tables showing the item-response probabilities for each race-sex group are available from the first author upon request.

### Relation between Eating and Exercise Behavior and High Cholesterol

Note that separate models were fit for each race-sex group with hypercholesterolemia as a predictor of latent class. The Maintenance latent class was selected as the reference class for the multinomial logistic regression equations used to assess the relation between each covariate and latent class membership. All other latent classes represent higher-risk behavior in one or more of the LTC behaviors. Each odds ratio reflects the change in the odds of membership in a particular eating-exercise behavior risk class relative to the Maintenance class for adults with that risk factor (ie, high cholesterol status). A *P* value for each covariate indicates whether a significant overall relation between latent class membership and the covariate exists. An odds ratio of 1.0 indicates that adults with that risk factor (eg, high cholesterol) are no more likely to engage in the LTC behavior class in question as compared to the Maintenance class. Odds ratios >1.0 represent increased odds of membership in that latent class (relative to the Maintenance latent class) and is associated with reporting the risk factor; high cholesterol. Several notable odds ratios that represent patterns of relations among hypercholesterolemia status and LTC related behaviors latent class membership are discussed below (Table 3).

### Results for Women

Compared to the Maintenance class, both Black and White women are more likely to belong to the Fat Reducers class (1.5 times and 1.8 times, respectively). White women are also more likely to be Healthy Eaters than Maintainers (OR = 1.5). Black women with a diagnosis of high cholesterol are less than half as likely to be Contemplators (OR = 0.4), Exercisers/Produce Eaters (OR = 0.4) or New Exercisers/Fat Reducers (OR = 0.4).

### Results for Men

Similar to women, men diagnosed with high cholesterol are more likely to be a Fat Reducer as opposed to belonging to the Maintenance class. This phenomena is more pronounced for men than women, as Black men are three and a half times (OR = 3.5) as likely to be a Fat Reducer than to belong to the Maintenance class and White men are more than twice as likely (OR = 2.4) to be a Fat Reducer as opposed to a Maintainer. In addition, Black men with high cholesterol are less than half as likely to be Produce Eaters (OR = 0.4) or Near Maintainers (0.4) relative to Maintainers.

### Discussion

This study demonstrates that latent class size and structures related to LTC among individuals with hypercholesterolemia differ among race and sex groups. White women belonged to the largest number of classes (8), while White men belonged to the fewest number of classes (6). Seven classes were identified for both Black women and men. Furthermore, latent class membership varies by race and sex.

Several latent classes are unique to specific race-sex groups. The Healthy Eaters and Precontemplators latent classes were unique to White women. A defined subset of individuals who engage only in healthy eating, or who were in precontemplation for all 3 behaviors were identified only among White women. Only Black women belonged to a class of Contemplators. This is a rather substantial class (21.5%), suggesting that a large proportion of this group is contemplating behavior change in all 3 behaviors. Only Black men's behavior profile includes a Near Maintenance latent class. These men are actively eating healthy and engaging in exercise behaviors. These differences in latent class structure are indicative of potentially different intervention needs across race-sex groups.

Individuals with self-reported high cholesterol are more likely Fat Reducers vs Maintainers. The likelihood of being a Fat Reducer vs a Maintainer is even greater for men compared to women and greatest for Black men. Although it is recommended that patients with high cholesterol engage in dietary fat reduction, increases in fruit and vegetable intake and exercise are also important in moderating cholesterol.<sup>28</sup>

Our findings suggest that health education and patient management efforts targeted toward preventing and managing hypercholesterolemia in community and clinical settings may be improved by taking into consideration the unique challenges of different racial and sex groups. Understanding barriers for change in multiple behaviors and targeting the behavioral changes that are most challenging within race and sex groups is most likely to benefit public health initiatives. While these programs must avoid stereotyping groups, data suggesting that men are most likely to be Exercisers, for example, can be used judiciously, to target healthy eating messages to this subgroup. Such a targeted intervention approach has potential to maximize impact.

The primary limitation of this study is that data on cholesterol status were self-reported without laboratory corroboration. However, this likely underestimates the proportion of the sample with hypercholesterolemia, which would dampen the effects found here. Furthermore, this study was performed in a southern US metropolitan area; therefore, the results of our study may only reflect the target city and similar southeastern US cities. However, hypercholesterolemia, obesity and related conditions disproportionately affect this area of the United States. Also, the survey response rate was relatively low at only 40%, which may potentially bias comparisons; however, this response rate is neither out of range for BRFSS and other random digit dialing phone surveys, nor would we expect the response rate to be related to reporting of high cholesterol or LTC behaviors.

In conclusion, LCA analysis of this sample showed important differences in racial and sex groups regarding their exercise and nutritional responses to a known diagnosis of hypercholesterolemia. LCA can thus be employed as a way to summarize the heterogeneity of LTC behavior in relation to high cholesterol status in this sample and in similar populations. An LCA framework can be used to identify subgroups with common characteristics that may then be amenable to particular interventions. Lastly, because individuals in a particular latent class share behavioral characteristics, they may also benefit from similar intervention strategies. Further studies should investigate this approach and its public health improvement possibilities.

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Table 1

Distribution of lifestyle therapy behaviors across race and sex groups

Sex	Fat Reduction (%)		Increase Exercise(%)		Increase F&V(%)	
	Male	Female**	Male	Female*	Male	Female*
Precontemplation	32	21	13	15	43	32
Contemplation	2	2	3	4	3	4
Preparation	5	7	6	8	14	17
Action	10	12	17	22	4	4
Maintenance	51	58	61	50	36	43
<b>N = 7014</b>						
<b>Race</b>			<b>White</b>	<b>Black*</b>	<b>White</b>	<b>Black*</b>
Precontemplation	25	24	14	14	37	34
Contemplation	2	2	3	5	3	5
Preparation	6	9	7	10	15	20
Action	10	15	19	25	4	5
Maintenance	57	50	57	46	41	36

F&V = fruits and vegetables.

\*  $P < .0001$  as indicated by chi-square tests.

**Table 2**

Latent class membership probabilities: percent of each group expected to belong to each latent class

Latent Class	White Women (n = 3323)	Black Women (n = 1204)	White Men (n = 1992)	Black Men (n = 495)
Maintainers	27.8	28.0	24.7	27.1
Exercisers/fat reducers	20.3	27.1	28.7	19.6
Fat reducers	8.2	7.7	6.4	9.5
Exercisers/produce eaters	10.9	8.1	9.4	9.0
Produce eaters	—	4.0	3.3	3.2
Exercisers	10.9	—	27.4	25.9
New exercisers/fat reducers	6.5	3.6	—	—
Near maintenance	—	—	—	5.8
Healthy eaters	8.6	—	—	—
Pre-contemplators	6.9	—	—	—
Contemplators	—	21.5	—	—

Note: Interpretation of latent classes varies slightly across race-sex groups; comparisons should be made qualitatively.

Note: Dashed lines indicate latent classes that were not identified within that race-sex group.

**Table 3**

Odds ratios reflecting increase in odds of membership in a particular LTC risk class relative to the Maintainers class for adults characterized as having high cholesterol

Latent Class- Reference Maintainers	White Women $P<.0001$	Black Women $P=.0005$	White Men $P=.0002$	Black Men $P=.0003$
Exercisers/fat reducers	0.7	0.8	1.3	1.2
Fat reducers	1.8	1.5	2.4	3.5
Exercisers/produce eaters	0.7	0.4	1.1	1.4
Produce eaters	—	0.8	1.2	0.4
Exercisers	0.7	—	1.4	0.5
New exercisers/fat reducers	1.2	0.4	—	—
Near maintenance	—	—	—	0.4
Healthy eaters	1.5	—	—	—
Pre-contemplators	1.1	—	—	—
Contemplators	—	0.4	—	—

Dashed lines indicate latent classes that were not identified within that race-gender group.

Odds ratios >1.0 reflect higher odds of membership in that class relative to the maintainers class, given self-report of high cholesterol.

Age, level of education, BMI, and the presence of diabetes and hypertension were controlled for in all models.