Patterns and Predictors of Untargeted Health Behavior Change in the First Year of the Women's Health Initiative Dietary Modification Trial

A Dissertation Presented

by

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to

The Graduate School

in Partial Fulfillment of the

Requirements

for the Degree of

Doctor of Philosophy

in

Social/Health Psychology

Stony Brook University

May 2016

Stony Brook University

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Abstract of the Dissertation

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2016

The gateway behavior hypothesis posits that changes in a health behavior that is targeted for change may promote positive changes in other untargeted health behaviors; however, previous gateway behavior studies have shown inconsistent results. The purpose of the current study was to examine the patterns and predictors of change in untargeted health behaviors in the first year of a diet modification trial. Specifically, the study explored change in untargeted physical activity, alcohol consumption, and smoking behavior in the first year of the Women's Health Initiative dietary modification trial, in which postmenopausal women were randomly assigned to either control (*n* = 29,294) or a diet modification intervention (*n* = 19,541), with the goals of decreasing percent daily fat intake and increasing fruit and vegetable servings and whole grains servings. The present investigation characterized patterns of change in untargeted behaviors from baseline to year 1 and assessed whether study arm and dietary change in the first year of the trial were associated with changes in untargeted behaviors. In addition, individual differences in the patterns of change were examined, as were sociodemographic, medical history, and psychosocial predictors of untargeted change. Results showed that, although there were increases in physical activity and decreases in alcohol consumption and smoking behavior, these changes were not consistently associated with study arm or dietary change. Moreover, although a repeated-measures latent class analysis identified three unique subgroups of participants with similar patterns of untargeted health behaviors, none of the classes showed substantial change in the probability of engagement in any of the behaviors between the two time points, and the study arms had nearly identical latent class solutions. These findings suggest that dietary change did not act as a gateway behavior for change in the untargeted behaviors and that researchers interested in changing multiple health behaviors may need to deliberately target additional behaviors.

Dedication

To my family, who have been unwavering in their love and support

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List of Abbreviations

ACS – American Cancer Society

AI/AN – American Indian/Alaskan Native

AIC – Akaike information criterion

ANOVA – analysis of variance

API – Asian/Pacific Islander

BIC – Bayesian information criterion

BLRT – bootstrap likelihood ratio test

BMI – body mass index

BRFSS – Behavioral Risk Factor Surveillance System

CaD – calcium and vitamin D

CES-D – Center for Epidemiologic Studies-Depression Scale

CHD – coronary heart disease

CT – clinical trial

CVD – cardiovascular disease

DM – dietary modification

EM – expectation-maximization

FFQ – Food Frequency Questionnaire

HRT – hormone replacement therapy

LCA – latent class analysis

LOT-R – Life Orientation Test-Revised

MAD – maximum absolute deviation

MET – metabolic equivalent

MHBC – multiple health behavior change

MOS – Medical Outcomes Study

MVPA – moderate to vigorous physical activity

NHANES – National Health and Nutrition Examination Survey

NHIS – National Health Interview Survey

OS – observational study

RMLCA – repeated-measures latent class analysis

USDA – United States Department of Agriculture

USDHHS – United States Department of Health and Human Services

WHI – Women's Health Initiative

Acknowledgments

I would first like to thank my wonderful advisor, Dr. Anne Moyer, who was a constant source of support and encouragement throughout my graduate school journey. Her warmth, generosity, and intelligence made seemingly insurmountable challenges achievable.

I am also grateful for the help and support of my dissertation committee, Dr. Marci Lobel, Dr. Matthew Lerner, and Dr. Catherine Messina. Their expertise and insight has improved my work at each step of my training. I couldn't have asked for a better committee.

Thank you to the Women's Health Initiative, and my sponsoring PI Dr. Dorothy Lane, for generously allowing me to use their dataset.

I would like to thank my Moyer labmates. It was a pleasure to be in a lab with such caring and intelligent people. Also, I have to thank Samantha Siess, who has been a wonderful colleague and friend. Our tea and muffin breaks brought me back to life during my daily mid-afternoon slump.

A big thank you to my amazing family, including my parents, Ted and Barb, my brothers, Jason, Ben, and Jon, my Aunt Viivi, my cats, Astro and Comet, and my grandparents, Charles and Margaret, for their encouragement, love, and support through the years.

Finally, I am so grateful for my incredible Mom, Barb Sarma, who was a tower of strength during my doctoral training. She was there through all the large and small struggles, whether I needed a pep talk or someone to proofread a paper. I am extremely thankful that I was able to share this journey with such a compassionate and caring person.

Chapter 1

Introduction

Health behaviors are important causes of morbidity and mortality (Fisher et al., 2011). Behavioral risk factors, including tobacco use, alcohol consumption, physical inactivity, and unhealthy diet, account for approximately 30% of cancer deaths worldwide (World Health Organization [WHO], 2015a) and are leading causes of premature death in the United States (Behrens et al., 2013; Mokdad, Marks, Stroup, & Gerberding, 2004). In addition, having more behavioral risk factors is associated with greater risk for chronic health conditions (WHO, 2011, 2015a), higher medical costs (Edington, 2001), and lower quality of life (Griffin, Sherman, Jones, & Bayl-Smith, 2014). Indeed, evidence suggests that the greater the number of risk factors, the higher the risk of all-cause mortality (Ford, Bergmann, Boeing, Li, & Capewell, 2012; Loef & Walach, 2012). Alarmingly, most adults report engaging in multiple health-risk behaviors (e.g., Berrigan, Dodd, Troiano, Krebs-Smith, & Barbash, 2003; Fine, Philogene, Gramling, Coups, & Sinha, 2004; Reeves & Rafferty, 2005), and the prevalence of health-risk behaviors has increased over time (Ford et al., 2010; King, Mainous, Carnemolla, & Everett, 2009).

Behavior Matters

Consequences of health-risk behaviors. Tobacco use, risky alcohol consumption, physical inactivity, and unhealthy diet are important behavioral risk factors for morbidity and mortality (Fine et al., 2004; Mokdad et al., 2004; Pronk, Peek, & Goldstein, 2004; WHO, 2015a). For example, tobacco use is the single largest cause of cancer and the top cause of lung cancer (U.S. Department of Health and Human Services [USDHHS], 2014a) and increases the risk of all-cause mortality (Gellert, Schottker, & Brenner, 2012). It has been linked to an increased risk for many diseases and medical events, including colorectal cancer, chronic obstructive pulmonary disease, stroke, type 2 diabetes, and rheumatoid arthritis (USDHHS, 2014a). Alcohol consumption increases the risk for several cancers, including liver, breast, and colorectal (Baan et al., 2007), with greater amounts of consumption posing the greatest health risks (Bagnardi et al., 2015; Kushi et al., 2012). Drinking moderate amounts of alcohol (e.g., one drink per day in women), however, is associated with some health benefits, including reduced incidence of type 2 diabetes (Djoussé, Biggs, Mukamal, & Siscovick, 2007) and reduced risk of coronary heart disease (CHD; Corrao, Bagnardi, Zambon, & La Vecchia, 2004). Being physically active is also associated with many health benefits, including lower risk of premature death, CHD, stroke, hypertension, type 2 diabetes, and certain cancers (Garber et al., 2011; USDHHS, 2008). In addition, consuming a healthy diet (e.g., the Mediterranean diet, including fruits, vegetables, whole grains, lean protein, and healthy fats) has been associated with lower risk of certain cancers (McCullough et al., 2011; Miller, Lesko, Muscat, Lazarus, & Hartman, 2010). Specific dietary components, such as fruit and vegetable consumption, have been associated with reduced risk of certain cancers (Kushi et al., 2012), CHD (He, Nowson, Lucas, & MacGregor, 2007), and stroke (Boeing et al., 2012; He, Nowson, & MacGregor, 2006). Furthermore, a healthful diet may indirectly reduce disease risk through reducing body weight and the risk of obesity (Mozaffarian, Hao, Rimm, Willett, & Hu, 2011; Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004).

Clearly, individual health-risk behaviors are associated with disease; however, evidence has also suggested that engagement in multiple risk behaviors has a multiplicative effect on disease risk. For example, individuals who both smoke tobacco and drink alcohol have a higher risk of certain cancers (mouth, larynx, and esophagus) than those who engage in either behavior alone (Boffetta & Hashibe, 2006; Kushi et al., 2012). It is estimated that one-third of all cancers in developed countries are linked to poor nutrition, physical inactivity, and excess body weight, all of which are preventable (World Cancer Research Fund International, 2015). Moreover, overweight and obesity, which are fundamentally caused by an energy imbalance through the consumption of excess calories and lack of physical activity, increase the risk of many health conditions, including certain cancers, type 2 diabetes, and cardiovascular disease (CVD; Guh et al., 2009; U.S. Department of Agriculture [USDA], 2015).

In addition, the number of behavioral risk factors is associated with increased risk of all-cancer incidence and mortality (Kabat, Matthews, Kamensky, Hollenbeck, & Rohan, 2015; McCullough et al., 2011; Thomson et al., 2014), type 2 diabetes (Ford et al., 2009), and all-cause mortality (Behrens et al., 2013) in a dose-response manner such that individuals with fewer risk behaviors are at lower risk. For example, using data from the Women's Health Initiative observational study, Thomson et al. (2014) examined whether postmenopausal women's adherence to the American Cancer Society's (ACS) guidelines for cancer prevention (e.g., being physically active, eating five daily servings of fruits and vegetables) was associated with reduced cancer risk and cancer mortality. Results showed that women with the highest adherence to the guidelines had a 17% lower risk of any cancer, 22% lower risk of breast cancer, 52% lower risk of colorectal cancer, and 20% lower risk of cancer-specific mortality than women with the lowest adherence.

Guidelines for and prevalence of health-risk behaviors. Guidelines are used to specify the recommended amounts of engagement in health-related behaviors needed to produce health benefits (Emmons, Shadel, Linnan, Marcus, & Abrams, 1999). For example, physical activity, particularly cardiorespiratory exercise, is strongly encouraged. The U.S. Department of Health and Human Services (2008), American College of Sports Medicine (Garber et al., 2011), and

ACS (Kushi et al., 2012) all currently recommend that adults aged 18 years and older perform at least 150 minutes per week of moderate-intensity physical activity, 75 minutes per week of vigorous-intensity physical activity, or a combination of moderate- and vigorous-intensity exercise for a total of 500 to 1,000 metabolic equivalent (MET) minutes per week. (A MET is the ratio of the rate of energy expended during an activity to the rate of energy expended while at rest (USDHHS, 2008). Thus, 1 MET is the expenditure rate while at rest.) Alcohol consumption has more nuanced guidelines: heavy alcohol consumption (more than seven drinks per week for women) is not recommended, but moderate amounts (at most seven drinks per week for women) are not discouraged, although it is not recommended that individuals begin drinking alcohol to accrue health benefits, as alcohol is a carcinogen (Kushi et al., 2012; USDA, 2015). Tobacco use, on the other hand, has clear-cut guidelines: complete abstinence is recommended (Husten, 2009). Dietary guidelines specify the desired consumption of whole foods and macronutrients. For instance, it is generally recommended that adults should eat at least five servings of fruits and vegetables per day (Kushi et al., 2012) and between 20% and 35% total fat per day (USDA, 2015).

Many people engage in at least one health-risk behavior. Approximately 50% of adults aged 18 years and over report engaging in the recommended amount of aerobic physical activity (USDHHS, 2014b, 2015). Many adults consume alcohol: 56.3% of adults aged 18 or older report drinking alcohol in the past month, 24.6% report binge drinking in the past month, and 7.1% report heavy drinking in the past month (National Institute on Alcohol Abuse and Alcoholism, 2014). Although prevalence rates for cigarette smoking have decreased over time for all age groups, declining 50% from 1965 to 2009 (American Lung Association, 2011), 22% of US adults aged 18 years and older currently report cigarette smoking (USDHHS, 2014a). The typical

US adult consumes 2.6 servings of fruits and vegetables per day, which is far below the typical daily recommendation of five servings (USDA, 2015). Fat intake has, on the other hand, decreased slightly from 1988 to 2012, with the percent of daily caloric intake from total fat among US adults decreasing from approximately 36% to 33% (USDHHS, 2014b). Nevertheless, the percentage of overweight and obese adults has continued to climb: 68.6% of US adults aged 20 years or older are overweight or obese (USDHHS, 2014b, 2015).

Moreover, behavioral risk factors appear to cluster together (Berrigan et al., 2003; Chou, 2008; Lee et al., 2012; Poortinga, 2007; Schuit, van Loon, Tijhuis, & Ocke, 2002). For example, approximately 57% of US adults have at least two of four behavioral risk factors (cigarette smoking, risky alcohol consumption, physical inactivity, or an unhealthy weight), and 17% have at least three risk factors (Fine et al., 2004). Only 3% of US adults report nonsmoking, having a healthy weight, consuming at least five daily servings of fruits and vegetables, and engaging in regular physical activity (Reeves & Rafferty, 2005). Tobacco use is particularly associated with poor behavioral profiles (Chiolero, Wietlisbach, Ruffieux, Paccaud, & Cornuz, 2006; Héroux et al., 2012), with over 90% of smokers reporting at least one additional health-risk factor (Fine et al., 2004; Prochaska, Prochaska, & Prochaska, 2013).

Multiple Health Behavior Change Interventions

Given the consequences of and prevalence of multiple health-risk behaviors, it follows that changing multiple behaviors in a single intervention may be a more efficient approach to health risk reduction. Indeed, it has been suggested that multiple health behavior change (MHBC) interventions, which target at least two health-related behaviors either simultaneously or sequentially (Prochaska et al., 2013), have greater real-world applicability, reduce the time and expense of behavior change interventions, and can lead to the accrual of more health benefits

(Prochaska, Nigg, Spring, Velicer, & Prochaska, 2010). Furthermore, it has been suggested that co-occurring behaviors share change processes that promote MHBC when targeted (Prochaska et al., 2013; Prochaska, Spring, & Nigg, 2008) and, similarly, that MHBC interventions may take advantage of the physiological and psychological synergies that exist among certain combinations of behaviors (Nigg, Allegrante, & Ory, 2002; Ory, Jordan, & Bazzarre, 2002). In light of these potential benefits, MHBC intervention research has flourished in the past decade (Goldstein, Whitlock, & DePue, 2004; Ory et al., 2002; Prochaska et al., 2010; Prochaska et al., 2013; Prochaska, 2008), showing some success (Prochaska & Prochaska, 2011; Spring, King, Pagoto, Van Horn, & Fisher, 2015).

One area of interest in MHBC intervention research concerns whether health behaviors that are not targeted in an intervention also change, a phenomenon referred to as collateral change (Spring et al., 2010), ripple effects (Wilson, 2015), and spillover (Mata et al., 2009). In part, interest in the ripple effects produced by MHBC interventions stems from the implications such effects may have on MHBC intervention design. Specifically, examination of untargeted change can inform whether interventions need to target only one behavior, or a few behaviors, due to the positive cascading effects of the intervention on untargeted behaviors (Nigg et al., 1999; Tucker & Reicks, 2002; Wilson, 2015), thereby reducing participant and resource burden relative to MHBC interventions that have a treatment component for each behavior (Prochaska & Sallis, 2004).

Furthermore, several explanations have been put forth to account for positive spillover to untargeted behaviors in behavior change interventions (Noar, Chabot, & Zimmerman, 2008; Prochaska et al., 2013; Prochaska et al., 2008). For example, Noar et al. (2008) proposed three approaches to explain how multiple behaviors may change together, including a behavior change principles approach, a global health/behavioral category approach, and a multiple behavioral approach. According to the behavior change principles approach, there is a set of theoretically based behavior change principles, or common factors, that can be similarly applied to different behaviors. Thus, individuals can learn behavior change principles that are relevant to multiple health behaviors, such as decision-making skills or social skills, and can subsequently apply these principles to a variety of health behaviors. According to the global health/behavioral category approach, changes occur in a broader category, such as a general health orientation or a disease, which, in turn, affect more behavior-specific attitudes. Changes to the behavior-specific attitudes then cause changes in actual behavior. For example, by targeting behaviors for change, an intervention may create a greater health consciousness, which may encourage other positive health behavior changes that promote health in general (Wilcox, King, Castro, & Bortz, 2000). Finally, the multiple behavioral approach focuses on the linkages among specific health behavior constructs (e.g., smoking cessation self-efficacy) and suggests that when behavior-specific constructs change, they affect similar constructs for other behaviors. For example, successful behavior change for one behavior may promote self-efficacy and motivation to change another behavior, leading to improvements in the second behavior (Emmons, Marcus, Linnan, Rossi, & Abrams, 1994).

One empirical method for demonstrating spillover, or untargeted behavior change, is to examine whether untargeted behaviors change in a MHBC intervention (e.g., Ma et al., 2015; Peters et al., 2013; Prochaska et al., 2012; Spring, Schneider, et al., 2012; Velicer et al., 2013). For example, Spring, Schneider, et al. (2012) designed a randomized controlled trial to test which combination of diet (decrease saturated fat, increase fruit and vegetable intake) and activity (increase physical activity, decrease sedentary leisure) advice would maximize change in these behaviors. Two hundred and four adults with elevated saturated fat, low fruit and vegetable intake, high sedentary leisure time, and low physical activity were randomly assigned to a 3-week intervention that targeted one of the following combinations: (1) increase fruit and vegetable intake and physical activity; (2) decrease fat and sedentary leisure; (3) decrease fat and increase physical activity; and (4) increase fruit and vegetable intake and decrease sedentary leisure. Participants were followed for 5 months post-treatment. Change in the four behaviors was assessed using a standardized composite score that weighed each behavior equally. Results showed that participants who received the treatment that aimed to increase fruit and vegetable intake and decrease sedentary leisure improved more on the composite score than participants who received the other treatments. In addition, within the increase fruit and vegetable intake and decrease sedentary leisure treatment group, there was a significant positive correlation between decreasing sedentary leisure and decreasing untargeted fat intake, suggesting that the treatment produced untargeted improvement in saturated fat intake. In other words, positive spillover was exhibited in the fruit and vegetable intake and sedentary leisure treatment group.

Other MHBC intervention studies have also demonstrated positive spillover to untargeted behaviors. For example, Velicer et al. (2013) randomly assigned middle school students to either an energy balance (increasing physical activity, increasing fruit and vegetable consumption, and limiting television time) or a substance use prevention (decreasing smoking and alcohol) intervention. The intervention lasted 3 years and involved five in-class contacts, with assessments at the end of years 1, 2, and 3. Results showed that although students assigned to the energy balance group did not receive direct treatment for the prevention of substance use behaviors, they showed significantly lower smoking and alcohol use over time, relative to participants in the substance use prevention group. Prochaska et al. (2012) also found evidence of positive spillover in their stress management and exercise intervention. Participants were randomly assigned to a control group or one of two stress management and exercise treatments, telephonic coaching or an online program. Healthy diet (i.e., low-fat and calorie control), which was not targeted, was measured at baseline and 6-month follow-up. Findings revealed that participants who received the telephonic coaching treatment were significantly more likely to be eating a healthy diet by follow-up than participants in the control group, again suggesting the positive cascading effects of the intervention on untargeted behaviors.

The gateway behavior hypothesis. A potential problem with examining spillover in MHBC interventions, or interventions that target two or more behaviors, is that it becomes difficult to determine whether it was change in one or more of the targeted behaviors that was associated with changes in untargeted behaviors. Another, perhaps purer, test of whether there is positive spillover is to examine whether change in a single health behavior, in the context of a single health behavior change intervention, is associated with change in untargeted behaviors. This approach permits the examination of gateway behaviors, or health behaviors that, when intervened upon, cause positive changes in other health-related behaviors (Nigg et al., 1999; Nigg, Lee, Hubbard, & Min-Sun, 2009).

Initial evidence that suggested the existence of gateway behaviors came from cross-sectional studies that showed the interrelationships among health behaviors (Clark et al., 2005; Costakis, Dunnagan, & Haynes, 1999; Emmons et al., 1994; Nigg et al., 1999). For example, Costakis et al. (1999) examined whether exercise stage of change predicted engagement in other health behaviors, including cigarette and smokeless tobacco use, seat belt use, use of stress management techniques, and alcohol use. (Stage of change is a theoretical construct from the transtheoretical model, and it has five stages that differ in terms of intention to engage in a behavior and actual performance of the behavior. It ranges from precontemplation, in which the individual does not engage in the behavior and does not intend to engage in the behavior, to action and maintenance, in which the participant engages in the behavior.) Costakis et al. found that participants in the action stage of exercise adoption were less likely to smoke cigarettes than respondents in the precontemplation stage of exercise. In addition, participants who were not in precontemplation for exercise were more likely to use seat belts, and participants in the maintenance stage for exercise were more likely to use stress reduction techniques than participants in the precontemplation stage. In sum, participants who were already engaging in exercise were also more likely to engage in other health behaviors. In turn, results such as these have been used as preliminary evidence for the gateway behavior hypothesis.

Theoretically, any health behavior can be a gateway behavior (Spring, Moller, & Coons, 2012), but correlational studies identified smoking cessation (Unger, 1996), physical activity (Costakis et al., 1999; Tucker & Reicks, 2002), and diet (Emmons et al., 1994) as potential gateway behaviors because of their consistent positive correlations with other health-related behaviors. Although correlational studies have made a valuable contribution to the gateway behavior literature by suggesting which behaviors may function as potential gateways, they cannot provide information about which proposed gateway behaviors are actually associated with positive changes in other health behaviors. Longitudinal studies are thus needed to more definitively answer whether gateway behaviors exist.

Experimental evidence for the gateway behavior hypothesis. A small body of literature examining whether involvement in a single health behavior intervention (e.g., targeting physical activity only) is associated with changes in untargeted behaviors has accumulated. For example, in one smoking cessation intervention for light smokers, untargeted changes in fruit and vegetable intake and in walking for exercise were examined (Berg et al., 2012). Participants were randomly assigned to receive an 8-week supply of either nicotine gum or a placebo and to receive either motivational interviewing or health education. Fruit and vegetable intake and walking for exercise were not targeted by the intervention and, along with smoking behaviors, were measured at baseline and at week 26. Results showed that participants who reduced the number of cigarettes per day and those who quit smoking at week 26 also reported greater fruit and vegetable intake at week 26, after controlling for baseline fruit and vegetable intake. Moreover, participants who reduced their smoking or quit smoking had significantly higher odds of reporting that they walked for exercise at week 26, after controlling for baseline walking. In other words, positive change in the targeted behavior (smoking) predicted positive changes in untargeted behaviors, lending support to the gateway behavior hypothesis.

Much interest has surrounded physical activity as a gateway behavior, especially for dietary changes, and most of the experimental evidence for the gateway behavior hypothesis has come from physical activity and exercise intervention research. There are several reasons that physical activity and diet may be especially likely to change together, including that individuals who are physically active also tend to consume healthier diets (e.g., Blakely, Dunnagan, Haynes, Moore, & Pelican, 2004; Tucker & Reicks, 2002), that physical activity and diet contribute to common goals (e.g., weight loss), and that physical activity and diet have complementary effects on physiology (e.g., exercise may reduce hunger; Elder & Roberts, 2007). Subsequently, researchers have examined whether participants who receive an exercise intervention also improve their dietary behaviors. Results from these studies, however, have yielded inconsistent results (e.g., Bales et al., 2012; Dutton, Napolitano, Whiteley, & Marcus, 2008; Fleig, Lippke, Pomp, & Schwarzer, 2011; Halliday et al., 2014; Mata et al., 2009; Prochaska & Sallis, 2004; Rhew et al., 2007; Wilcox et al., 2000).

Some studies have provided support for the hypothesis that physical activity is a gateway behavior (e.g., Fleig et al., 2011; Mata et al., 2009). For example, Fleig et al. (2011) examined untargeted dietary changes in an exercise intervention for rehabilitation patients. Patients who had been instructed by medical professionals to engage in regular exercise after rehabilitation were invited to participate in an exercise program during the first week of their stay in an orthopedic rehabilitation center or a cardiac center in Germany. Patients were assigned to either control or a self-regulation exercise intervention, which involved activities such as exercise goal setting. They were asked to self-report their exercise behavior and their fruit and vegetable intake, which was untargeted, at baseline and the follow-up assessment, which occurred at 6 weeks post-discharge. Results showed that, relative to the control, participants in the exercise intervention group engaged in significantly more exercise at follow-up. Moreover, exercise intervention participants had a significantly greater increase in fruit and vegetable intake, thus suggesting a positive spillover of the exercise intervention to dietary behavior.

On the other hand, some studies that have examined physical activity as a gateway behavior have not supported the gateway behavior hypothesis (e.g., Dutton et al., 2008; Wilcox et al., 2000). For example, Wilcox et al. (2000) investigated, in two samples, whether group assignment, which can be thought of as a proxy for physical activity change, and changes in physical activity in the whole sample were associated with self-directed changes in various dietary components (e.g., fruit and vegetable servings, total fat, saturated fat, fiber, protein) over 12 months among sedentary older adults. Results showed that diet changed over the year (e.g., there was a reduction in total fat intake) but was not consistently related to group assignment.

However, when participants across the intervention and control conditions were combined, a trend for greater physical activity, as measured by quartiles of change, and increased fruit servings was found, and an increase in physical activity was associated with an increased consumption of high-fat, high-cholesterol foods. Dutton et al. (2008) examined whether sedentary adult women in a physical activity trial changed their dietary behavior (fruit and vegetable servings and percent dietary fat intake) between baseline and months 3 and 12 of the trial. Results showed that group assignment and change in physical activity within the whole sample, measured in minutes per week, were not associated with changes in fruit and vegetable servings over 12 months. On the other hand, change in physical activity, although not group assignment, was associated with an increase in fat consumption from baseline to month 3, although this was not significant at 12 months.

Although much of the physical activity gateway literature has focused on spillover effects in dietary behaviors, one study examined whether changes in physical activity were associated with changes in diet and other health behaviors. Specifically, Rhew et al. (2007) examined the effect of a 12-month exercise intervention (aerobic exercise intervention or stretching control) on body fat and hormones among overweight and obese postmenopausal women. Diet (e.g., total energy from fat, fruit and vegetable servings, saturated fat, fiber) and daily alcohol intake were also measured at baseline, 3 months, and 12 months. Results showed that dietary intake was similar between the two groups across the study period; however, a significant difference between the groups in terms of average daily fat intake, after controlling for calories, was found at 3 months, such that women in the treatment group decreased their fat intake, while women in the control group increased their fat intake. This difference was not, however, present at 12 months. Women in both the intervention and control groups reduced their alcohol intake over the year, but this was not significantly different between the groups. When adherence to the intervention, measured by tertiles of minutes of exercise per week, among women in the treatment group was used to predict diet, results showed that women with low and average exercise adherence increased their fruit intake, while women with the highest exercise adherence *decreased* their fruit intake over 12 months.

Diet has also been proposed as a gateway behavior because of its relationships with other behaviors, particularly physical activity (Emmons et al., 1994), and the inconsistent evidence for the physical activity gateway hypothesis (Wilcox et al., 2000). Fewer studies have examined the diet gateway hypothesis, however, and the results are somewhat inconsistent (e.g., Foster-Schubert et al., 2012; Johannessen, Oettingen, & Mayer, 2012). For instance, Johannessen et al. (2012) examined the effect of a mental contrasting diet intervention on diet behavior among healthy undergraduate dieters. Students in the mental contrasting group were asked to imagine a diet-related desired future state (e.g., to lose weight) and to contrast it with an obstacle (e.g., time constraint) that might interfere with goal attainment. Johannessen et al. found that 2 weeks after the intervention, participants in the mental contrasting condition ate fewer calories, fewer high-calorie foods (e.g., junk food), and more low-calorie foods (e.g., fruits and vegetables). Furthermore, participants in the mental contrasting condition also reported having been more physically active in the previous 2 weeks than normal, suggesting that the effects of the diet intervention spilled over to promote positive change in physical activity.

In contrast, Foster-Schubert and colleagues (2012) conducted a 1-year weight loss intervention for overweight and obese postmenopausal women who were non-smokers, not heavy drinkers, and not regular exercisers. Some women were randomly assigned to a diet-only (low-fat, low-calorie) condition. Results showed that women in the diet-only condition decreased their relative fat intake compared with the control group. Moreover, women in the diet-only condition increased their exercise, measured in minutes per week and pedometer steps per week, but they did not differ from the control group on either measure of physical activity at the end of the 12-month intervention, suggesting that the diet gateway hypothesis was not supported.

Taken together, studies that have examined the gateway behavior hypothesis by examining change in untargeted behaviors in a single health behavior change intervention have not shown clear or consistent evidence for the gateway behavior hypothesis. Although some studies showed that positive changes in the targeted behavior were associated with positive changes in untargeted behaviors (e.g., Berg et al., 2012; Fleig et al., 2011; Johannessen et al., 2012), other studies showed that positive changes in the targeted behavior were unrelated to changes in untargeted behaviors (e.g., Foster-Schubert et al., 2011). In some cases, positive changes in the targeted behavior were associated with negative changes in untargeted behaviors (e.g., Dutton et al., 2008; Rhew et al., 2007; Wilcox et al., 2000). There were, of course, large methodological differences among these studies that may account for the discrepant results, including that the studies targeted different gateway behaviors, had different designs, and differed in their participants and overarching intervention goals. However, based on the gateway behavior hypothesis, only positive change was expected in untargeted behaviors (Nigg et al., 2009).

Explaining inconsistent evidence for the gateway behavior hypothesis. Evidence from longitudinal studies of the gateway behavior hypothesis has not clearly supported the notion that untargeted behavior change is unilaterally positive. Therefore, a more nuanced approach to examining and explaining changes in untargeted behaviors is needed. For example, some of the physical activity gateway behavior studies demonstrated that as the targeted behavior improved, an untargeted behavior deteriorated. In particular, increased physical activity was associated with consuming lower amounts of healthy foods, such as fruit (Rhew et al., 2007), and higher amounts of unhealthy foods, such as fat (Dutton et al., 2008; Wilcox et al., 2000). Although physiological explanations might be used to explain dietary changes (e.g., one eats more fat due to the increased caloric need produced by physical activity), psychological explanations also exist to explain negative changes in untargeted behaviors. One such explanation for negative change in untargeted behaviors involves a failure in the self-regulation of the untargeted behavior. The strength model of self-control asserts that individuals have limited domain-general self-regulatory resources that are depleted with use, leading to a state of ego depletion, thereby reducing the resources available for subsequent tasks that require self-regulation (Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000).

In general, research has suggested that exerting self-control by inhibiting responses to temptations depletes self-regulatory resources, which, in turn, reduces the self-regulatory resources available for subsequent self-regulation efforts (Baumeister et al., 2007; Muraven & Baumeister, 2000). More demanding self-regulation tasks are expected to deplete resources to a greater degree (Baumeister, Heatherton, & Tice, 1994). To the extent that self-regulatory resources are needed to continue to inhibit overlearned reward self-administration health behaviors, such as eating high-fat foods and smoking cigarettes, demands on self-control can increase vulnerability to these temptations (Baumeister et al., 1994; Spring et al., 2010). Indeed, several studies have found that individuals whose self-regulatory resources were depleted after engaging in an initial self-control task generally consumed more alcohol (Muraven, Collins, & Neinhaus, 2002), ate more palatable, yet unhealthy, food (Vohs & Heatherton, 2000), and were more likely to smoke cigarettes (Shmueli & Prochaska, 2009). For example, Shmueli and

Prochaska (2009) had smokers resist either sweets (high temptation) or raw vegetables (low temptation) followed by a 10-minute break, during which they could smoke. Results showed that smokers who resisted the sweets were significantly more likely to smoke during the break, suggesting that resisting the sweets, relative to resisting vegetables, had reduced the self-regulatory resources required to resist the temptation to smoke. Negative changes in untargeted behaviors can be expected when intervening on one behavior, then, because health-related behaviors all require the use of the same limited domain-general self-regulatory resources (Spring, Moller, et al., 2012).

Although positive and negative changes in the untargeted behaviors were observed in the gateway behavior studies, several studies also showed a lack of change in untargeted behaviors. It might be, as some researchers have suggested, that health behaviors are relatively independent of each other and do not reliably change together (Newsom, McFarland, Kaplan, Huguet, & Zani, 2005). This argument would suggest that gateway behavior effects do not exist and that, if change is desired in a health behavior, it must be specifically targeted.

Individual differences in untargeted health behavior change. On the other hand, it is also possible that the lack of consistent evidence for the gateway behavior hypothesis is due to the assumption that all participants will show the same pattern of untargeted behavior change in response to an intervention. This assumption is implied by the variable-oriented approaches used in previous gateway behavior studies. Variable-oriented approaches focus on relationships among variables, and it is assumed that these relationships apply across all people (Bergman & Magnusson, 1997; von Eye & Bergman, 2003). In the previous gateway behavior studies, every statistical analysis that examined change in an untargeted behavior involved the comparison of means. For example, in Wilcox et al.'s (2000) physical activity study, the intervention group's average change in untargeted fruit and vegetable intake was compared with the control group's average change. Person-oriented approaches, on the other hand, focus on individuals or homogenous subgroups of individuals. For example, person-oriented approaches consider inter-individual differences in untargeted behavior changes and allow for the examination of subgroups of participants who show similar patterns of change in untargeted health behaviors, including improvement, deterioration, and stability.

Indeed, person-oriented approaches to statistical analysis, such as latent class analysis (LCA), have become more popular in recent years in multiple health behavior research (McAloney, Graham, Law, & Platt, 2013). LCA has been used to find subgroups of participants based on cross-sectional adherence to behavioral guidelines in samples of adolescents (e.g., Childs, Davidson, Potter, & Rosky, 2016), undergraduates (e.g., Kang et al., 2014; Luo, Agley, Hendryx, Gassman, & Lohrmann, 2015), and adults (e.g., Héroux et al., 2012; Schnuerer et al., 2015).

A longitudinal extension of LCA, repeated-measures LCA (RMLCA), which identifies distinct patterns of behaviors over time (Lanza & Collins, 2006), has also become more popular in health behavior change research (e.g., Fitzpatrick et al., 2015; McCarthy, Ebssa, Witkiewitz, & Shiffman, 2015). For example, McCarthy et al. (2015) used RMLCA to identify classes of smokers based on their smoking status (any smoking or none) in the first 27 days of an 8- to 12-week smoking cessation clinical trial. A five-class model was selected, and the classes revealed that most participants were stable in smoking or abstinent classes, but approximately 25% of smokers were in classes with unstable abstinence probabilities over time. Furthermore, being in active treatment, relative to the placebo, promoted early quitting in the trial. Although McCarthy et al. used RMLCA to examine the patterns of change in the targeted behavior (smoking), it is possible to use RMLCA to examine the patterns of change in untargeted behaviors in a single health behavior change intervention. RMLCA, then, may provide a complementary approach to the variable-oriented approaches traditionally used in gateway behavior studies by examining the distinct patterns of change in untargeted health behaviors and whether targeted change is predictive of these patterns.

Additional predictors of untargeted health behavior engagement and change. Although the gateway behavior hypothesis focuses on whether change in a targeted behavior is associated with change in untargeted behaviors, there may be additional predictors of untargeted behavior change. Indeed, there are many predictors of multiple health behavior engagement that are well established, including sociodemographic, medical history, and psychosocial variables. However, relatively little research has focused on whether these are also predictors of behavior change, and studies that have examined predictors of behavior change have typically been prospective observational studies, rather than behavior change interventions. For example, studies have shown that certain sociodemographic characteristics, such as older age (e.g., 65 years and older), being non-Hispanic White or Asian, having more education, having a higher income, not being employed full-time, and being currently married, are associated with having fewer health-risk behaviors (Berrigan et al., 2003; Fine et al., 2004; Ford et al., 2010; Poortinga, 2007; Reeves & Rafferty, 2005; Sanchez et al., 2008). Studies have also shown that medical history variables, including body mass index (BMI) and the presence of chronic disease, are related to health behavior engagement such that adults with higher BMI and those who have a chronic disease, such as hypertension, also tend to have more health-risk behaviors (Fine et al., 2004; Greenlund, Daviglus, & Croft, 2009; Harrington et al., 2010; Kabat et al., 2015).

Some of these sociodemographic and medical history variables have also been found to predict the adoption of health-promoting behaviors (Hsu, Luh, Chang, & Pan, 2013; King, Mainous, & Geesey, 2007; Mulder, Ranchor, Sanderman, Bouma, & van den Heuvel, 1998). For instance, in a large sample of adults (*N* = 15,708) from the prospective epidemiologic Atherosclerosis Risk in Communities Study, King et al. (2007) determined the number of participants who adopted a healthy lifestyle, including eating five or more servings of fruits and vegetables daily, exercising regularly, maintaining a BMI between 18.5 and 29.9 kg/m^2, and not smoking, by a 6-year follow-up. At baseline, 8.5% of participants had a healthy lifestyle. Of the remaining participants who had at least one risk factor at baseline, 8.4% reported having all four of the lifestyle characteristics at the 6-year follow-up. Participants who adopted all four healthy lifestyle factors by follow-up were more likely to be older (i.e., 55 to 64 years old), be female, be a race/ethnicity other than African American, be more educated, have greater family incomes, and have no history of hypertension or diabetes.

Studies have also shown that some psychosocial variables are related to health behavior engagement and change. For example, dispositional optimism, or having positive expectancies for the future (Scheier, Carver, & Bridges, 1994), has been associated with greater engagement in healthy behaviors, including regular physical activity, moderate alcohol consumption, nonsmoking, and a high-quality diet (Hingle et al., 2014; Progovac et al., 2013; Tindle et al., 2009). There is also some evidence to suggest that optimism is associated with an increased likelihood of change in untargeted behaviors. In one study examining self-directed smoking cessation in the Women's Health Initiative, the most optimistic women were significantly more likely to quit smoking over time (Progovac et al., 2013). Greater self-reported physical functioning has also been associated with engaging in healthy behaviors, including physical activity, nonsmoking, and moderate alcohol consumption (Griffin et al., 2014; Myint et al., 2007), while current depression has been associated with engagement in more health-risk behaviors (Loprinzi & Mahoney, 2014; Verger, Lions, & Ventelou, 2009; Vermeulen-Smit, Ten Have, Van Laar, & De Graaf, 2015). In addition, social support, or the functional aspect of social relationships that involves the transaction of supportive behaviors among people (House & Kahn, 1985), has been associated with engagement in health behaviors, such as exercise, smoking cessation, and fruit and vegetable consumption (Rook, 2015; Sanchez et al., 2008; Tay, Tan, Diener, & Gonzalez, 2013; Uchino, 2009). However, social support may not always be beneficial for health behaviors, as in the case where a social norm, such as smoking during social interactions, promotes engagement in an unhealthy behavior (Smith & Christakis, 2008; Tay et al., 2013). In addition, negative social interactions can be a source of stress that may reduce engagement in health behaviors (Cohen, 2004; Sneed & Cohen, 2014).

Limitations of Previous Research

Although previous gateway behavior studies have examined whether there are changes in untargeted health behaviors, most gateway behavior studies have not considered whether changes in behaviors other than diet or exercise were related to group assignment or change in the targeted behavior. Given that health-related behaviors have at least some similarities and all use the same self-regulatory resources, it has been argued that changes can be expected in any untargeted behavior (Spring, Moller, et al., 2012). In addition, although there have been studies that examined exercise as a gateway behavior for diet (Dutton et al., 2008; Rhew et al., 2007; Wilcox et al., 2000), there has been relatively less attention paid to the examination of diet as a gateway behavior. To the extent that diet may be a gateway behavior (e.g., Wilcox et al., 2000), more research is needed to determine whether dietary change is associated with positive changes not only in physical activity but also in other untargeted health behaviors, such as smoking and heavy drinking.

In addition, previous gateway behavior studies have examined continuous changes in untargeted health-related behaviors, such as minutes per week of physical activity. However, defining meaningful change can be difficult with the use of continuous measures of health-related behaviors. For instance, an increase of 3 minutes per week of vigorous physical activity in the intervention group may be statistically significant but may not be meaningful for disease risk reduction. Behavioral guidelines are intended to specify optimal levels of health-related behaviors (Emmons et al., 1999). Examining whether study participants change their adherence to behavioral guidelines for untargeted behaviors, then, may help to clarify whether changes in behaviors with continuous measures are meaningful. In addition, categorizing behaviors according to guideline adherence is commonly used to assess patterns of multiple health behaviors (e.g., Griffin et al., 2014; Pronk, Anderson, et al., 2004) and to measure behavior change in the MHBC intervention literature (e.g., Johnson et al., 2008; Johnson et al., 2014; Lipschitz, Paiva, Redding, Butterworth, & Prochaska, 2015; Paiva et al., 2012; Yin et al., 2013). Moreover, characterizing behaviors in terms of guidelines may aid in the translation of study results into health messages, thereby increasing the results' applicability (Berrigan et al., 2003; Héroux et al., 2012; Rothman, 2002). In turn, results from gateway behavior studies may be more interpretable if change is examined not only in terms of continuous change but also in terms of change in guideline adherence.

Another limitation of previous research is the exclusive use of variable-oriented approaches, which assume that untargeted behavior change is uniform across participants. However, evidence for the gateway behavior hypothesis has been inconsistent across studies, with studies reporting positive, negative, and null relationships between change in the targeted behavior and changes in the untargeted behaviors. Although a gateway behavior may act uniformly across participants, it is also possible that individual differences exist in untargeted behavior change, such that some subgroups of participants improve untargeted behaviors, while other subgroups experience no change or deterioration. Therefore, a person-oriented approach, which focuses on inter-individual differences, may help to clarify whether untargeted behavior change is relatively uniform across participants or whether there are distinct subgroups that exhibit different patterns of untargeted behavior change.

Finally, although not a focus of previous gateway behavior studies, there may also be additional predictors of untargeted behavior change, other than group assignment and change in the targeted behavior. It is well established that particular sociodemographic, medical history, and psychosocial factors are associated with engagement in individual and multiple health behaviors. However, few gateway behavior studies to date have examined whether there are additional predictors of untargeted health behavior engagement and change. Examining these additional predictors can further inform what predicts untargeted behavior change in the context of a single health behavior intervention and can therefore inform future interventions about which participants may be especially likely to change.

Study Overview

Given the limitations of previous studies, the purpose of the current study was to investigate patterns and predictors of change in untargeted health behaviors (physical activity, alcohol consumption, and cigarette smoking) in the first year of the Women's Health Initiative (WHI) dietary modification (DM) trial. In brief, postmenopausal women were recruited for the WHI DM trial beginning in 1993 and were followed an average of 8.1 years, with the trial ending in 2005 (Ritenbaugh et al., 2003). Using previous research that suggested an association between a low-fat diet and reduced disease risk as a basis, the DM trial was designed to test the hypothesis that a low-fat dietary pattern reduces the risks of breast cancer, colorectal cancer, and cardiovascular disease. At baseline, women were randomly assigned to a control group (*n* = 29,294) or the dietary change intervention group (*n* = 19,541). Women in the intervention group received an intensive intervention in the first year aimed at changing total fat intake to 20% of daily energy, fruit and vegetables to five servings per day, and whole grains to six servings per day. Subsequent years were focused on maintaining dietary changes.

The untargeted health behaviors of interest in the present study were lack of physical activity, heavy drinking, and smoking, which, along with unhealthy diet, are referred to as the "big four" because they are important risk behaviors for morbidity and mortality (Pronk, Peek, et al., 2004). In addition, all three behaviors were measured at both baseline and year 1 of the trial, and none of these behaviors was specifically targeted by the intervention. Indeed, the DM trial was not a weight loss trial, and women in the intervention group were instructed to continue to consume the same number of calories throughout the trial (Howard, Manson, et al., 2006; Tinker et al., 1996). The current study focused on change in untargeted health behaviors that occurred in the first year of the DM trial for two reasons. First, most previous gateway behavior studies examined change over the 12 months of active intervention on the targeted health behavior, making the results from the present study easier to situate in the existing gateway behavior literature. Secondly, focusing on the first year permits an examination of concurrent changes in health behaviors (i.e., changes that occurred as diet was actively targeted). Although previous gateway behavior studies have shown inconsistent change in untargeted health behaviors during the active intervention phase, the DM intervention, described in detail below, was especially intensive compared with other studies (Assaf et al., 2015) and may therefore be more likely to show changes in untargeted health behaviors by the end of the first year of the trial.

In the present study, adherence was dichotomized according to behavioral guidelines for each untargeted health behavior: 500 or more MET-minutes per week of moderate to vigorous physical activity (Garber et al., 2011; Kushi et al., 2012; USDHHS, 2008), seven or fewer drinks per week (USDA, 2015; USDHHS, 2014b), and nonsmoking (Husten, 2009; see Table 1). It should be noted that the behavioral guidelines for physical activity (Pate et al., 1995), alcohol consumption (USDA, 1995), and smoking (Centers for Disease Control and Prevention, 1990) at the time of the DM trial were almost identical to current guidelines.

The current study took both variable-oriented and person-oriented approaches to examining untargeted health behavior change. For instance, in line with previous gateway behavior studies, continuous changes in the untargeted health behaviors were compared in the two study arms and based on targeted dietary change. The current study departed from previous studies, however, by examining whether there were changes in adherence to behavioral guidelines for the untargeted health behaviors and whether there were differences in these changes based on study arm and targeted dietary change. These categorical analyses permitted a readily interpretable characterization of change and stability, in terms of adherence to guidelines, in the untargeted health behaviors. In addition, a person-oriented approach, which has not been widely used to examine health behavior change, was used to identify the unique subgroups of participants with different patterns of untargeted health behaviors over the first year of the trial and to determine whether the study arms showed different patterns. Finally, additional predictors of untargeted health behavior engagement and change, including baseline sociodemographic, medical history, and psychosocial variables, have not been considered in previous gateway behavior studies. Therefore, the associations between these additional predictors and engagement in and change in untargeted physical activity, alcohol consumption, and smoking were also examined.

Study aims and hypotheses. The present study had the following aims and hypotheses.

Aim 1: To examine the prevalence of untargeted health behaviors at baseline and year 1. Before characterizing how the untargeted health behaviors changed individually and collectively, the prevalence of the combined untargeted health behaviors was examined both in terms of the number of health-risk behaviors and the specific combinations of health-risk behaviors. Specifically, using previous multiple behavioral risk factor studies as a guide (e.g., Chou, 2008; Fine et al., 2004; Poortinga, 2007), the proportions of women with zero through three behavioral risk factors, based on adherence to behavioral guidelines (see Table 1), and the proportions of women with each of the eight combinations of the three health-risk behaviors were examined. This provided a description of the patterns of health-risk behaviors in the sample at both time points and suggested whether there were changes in health behaviors between baseline and year 1. Study arm differences in the prevalences were also examined. Based on the gateway hypothesis, it was expected that the intervention and control groups would not differ either in the number of risk behaviors or in the combinations of risk behaviors at baseline but that there would be a significant study arm difference at year 1, such that women in the intervention group would tend to have fewer health-risk behaviors at year 1.

Aim 2: To examine continuous and categorical changes in each untargeted health behavior between baseline and year 1. As previously described, the approach of gateway behavior studies has been to examine study arm differences in the average amount of change in each untargeted health behavior. Therefore, in the current study, study arm differences were examined in each of the untargeted health behaviors with a continuous measure. The assertion of the gateway behavior hypothesis is that positive change (e.g., increase in physical activity) should occur in untargeted health behaviors among individuals in the treatment group (Nigg et al., 2009). It was expected, then, that women in the intervention group, relative to the control group, would show significantly greater improvements in their untargeted health behaviors (i.e., increase in physical activity, decrease in alcohol consumption). Moreover, dietary change was examined as a predictor of continuous change for each untargeted health behavior. It was also expected that participants who improved the most in the targeted dietary variables would show greater improvements in their untargeted health behaviors.

Secondly, categorical changes, based on changes in guideline adherence, for each untargeted health behavior were examined. Given that continuous change in an untargeted health behavior can be small but statistically significant, behavioral guidelines provide standards to evaluate the importance of change. Moreover, examining change in adherence status provides an additional perspective of how participants change their untargeted health behaviors. For example, it is possible that individuals who were nonadherent to a behavioral guideline at baseline became adherent over the first year and that individuals who were adherent at baseline deteriorated over the first year. To address whether there were changes in guideline adherence between baseline and year 1, participants were first separated according to their baseline adherence status (i.e., adherent and nonadherent). This is common practice in MHBC intervention studies where participants may have entered the study with varying health-risk behavior profiles (e.g., Velicer et al., 2013; Yin et al., 2013). Then, within each adherence group, the proportions of women who changed (e.g., quit smoking by year 1) and stayed in the same adherence category (e.g., continued to smoke) were recorded. This allowed for an examination of whether and how often positive (nonadherent to adherent) and negative (adherent to nonadherent) shifts occurred for each untargeted health behavior. Finally, study arm differences were examined to determine whether the intervention and control groups differed in the proportions of women who changed adherence categories or stayed in the same adherence category over the first year of the trial. It was expected that study arm differences would exist such that, relative to the control group, the intervention group would be more likely to stay adherent (i.e., not deteriorate) at year 1, if they were adherent at baseline, and become adherent at year 1, if they were nonadherent at baseline. The amount of targeted dietary change was also examined as a predictor, and it was expected that women who experienced the most improvement in the targeted dietary variables would also show the same pattern specified above.

Aim 3: To identify distinct subgroups of participants with different patterns of untargeted health behaviors. Although the previous aims provide information about the prevalence of and change in untargeted health behaviors, their focus is variable-oriented rather than person-oriented. To the extent that different participants may show different patterns of change, a person-oriented approach to analysis can provide complementary information about whether there are distinct subgroups of participants who show different patterns of categorical change in the untargeted health behaviors between baseline and year 1. Thus, RMLCA was used to identify distinct subgroups of women in the WHI DM trial who had different patterns of untargeted health behaviors in the first year of the trial. RMLCA has been used only occasionally in studies of health behavior change (e.g., Fitzpatrick et al., 2015; Leigh, Hudson, & Byles, 2015; McCarthy et al., 2015), and, to my knowledge, a person-oriented approach to analysis such as RMLCA has not yet been used to examine patterns of untargeted health behavior change in a single health behavior change intervention.

In addition to identifying the number of subgroups in the sample, it was also of interest to determine whether the study arms had the same latent class solution. It is possible that participants in the intervention group have different subgroups of untargeted health behavior change due to the DM intervention. Therefore, study arm differences in the RMLCA solutions were examined, and it was expected that there would be differences such that the intervention group would have subgroups showing improvement in untargeted health behaviors, as per the gateway behavior hypothesis, while the control group would not.

Aim 4: To explore additional predictors of engagement in and change in untargeted health behaviors. Although the primary research aims of the present study explore whether study arm and targeted dietary change were related to untargeted health behavior, there may be additional predictors of change in untargeted health behaviors. In general, previous gateway behavior studies have included, at most, sociodemographic covariates but have not included other variables that may predict change in untargeted health behaviors, such as medical history and psychosocial variables. Thus, in the present study, baseline sociodemographic, medical history, and psychosocial variables were included to determine whether they were related to engagement in and change in untargeted health behaviors. In particular, variables shown to be related to individual and multiple health behavior engagement, including sociodemographic (i.e., age, region, race/ethnicity, education, income, marital status, and employment status), medical history (i.e., BMI, having ever had diabetes, high cholesterol, hypertension, CVD, or cancer), and psychosocial variables (i.e., optimism, social support, social strain, current depression, and physical functioning), were examined for their association with engagement in and change in untargeted physical activity, alcohol consumption, and smoking. Based on results from studies examining predictors of health behavior engagement, it was expected that older age, non-

Hispanic White race/ethnicity, higher education, higher income, being currently married, not being employed full-time, lower BMI, lack of chronic disease, higher optimism, higher social support, lower social strain, not being currently depressed, and higher physical functioning would be associated with adherence to behavioral guidelines for the untargeted behaviors.

Significance of the Project

The present study addresses a gap in the gateway behavior literature by examining whether a diet intervention is associated with changes in untargeted physical activity, alcohol consumption, and smoking behavior. Moreover, the present study uses a novel approach by characterizing untargeted health behavior change using both variable-oriented and person-oriented approaches and by examining change in guideline adherence for untargeted health behaviors. In addition, the present study considers whether untargeted health behavior change is uniform among women in a dietary modification trial through the use of RMLCA, which can identify subgroups of participants based on their patterns of untargeted behavior change (Lanza & Rhoades, 2013). If subgroups showing different patterns of change in untargeted health behaviors are found, this may have important implications for behavior change interventions. For example, if the dietary intervention is associated with positive changes in untargeted health behaviors for some subgroups, then results may provide support for the gateway behavior hypothesis by suggesting that, for these subgroups of participants, targeting diet improved untargeted health behaviors. On the other hand, if there is a subgroup of participants who show deterioration in an untargeted health behavior by year 1, this subgroup may need to be monitored to prevent deterioration. Also, if there are subgroups of women who tend to stay similar in their untargeted behaviors in the first year of the trial, this may provide further disconfirming evidence for the gateway behavior hypothesis and suggest that each behavior requires individual attention to change in the context of a behavior change intervention. Thus, the use of various approaches in the current study may provide a richer picture of whether untargeted behavior change occurs in a diet intervention and provide information about untargeted health behavior change that may help to guide the design of future single health behavior interventions.

Beyond examining the gateway behavior hypothesis and whether there are different patterns of change in untargeted health behaviors, the present study also attempts to clarify whether there are additional predictors of untargeted behavior change. There is currently a lack of research examining whether characteristics other than group assignment and change in the targeted behavior are associated with untargeted health behavior change. Thus, the results of the present study may help to identify the characteristics of individuals who deteriorate, improve, or remain stable while being treated for one behavior. This information might, in turn, be useful for identifying participants who are likely to improve untargeted behaviors or need to be monitored for potential deterioration.

Finally, focusing on a clinical trial that exclusively examined postmenopausal women can aid in the design of age- and gender-appropriate multiple health behavior change interventions. The gender-specific dataset is, therefore, an advantage because of the well-documented differences in health behavior engagement between men and women (e.g., Ford et al., 2010; Myint et al., 2007). In addition, engagement in health-related behaviors is important for older adults. For instance, results from a systematic review of health behavioral risks and cognitive health in older adults reported that higher physical activity, moderate alcohol consumption, not smoking, higher vegetable and fish consumption, and lower saturated fat intake were related to lower cognitive deficits in old age (Lee et al., 2010). In sum, the WHI DM trial provides an excellent opportunity to shed light on the patterns and predictors of untargeted health behavior change and, in turn, potentially inform the design of future dietary modification interventions.

Chapter 2

Method

The Women's Health Initiative

The WHI was a 15-year National Institutes of Health-funded epidemiological study examining the health of postmenopausal women (Matthews et al., 1997; Tinker et al., 1996; WHI, 1998). The WHI was designed to address the paucity of clinical research examining health outcomes for older women (Johnson, Anderson, Barad, & Stefanick, 1999), and at the time, it was the largest clinical study ever initiated, enrolling 161,000 participants across 40 clinical centers between 1993 and 1998. Specifically, there were three clinical trials (hormone replacement therapy [HRT], dietary modification [DM], and calcium and vitamin D [CaD]) and an observational study (OS). Enrollment in the CaD trial occurred at the end of the first year. The clinical trials (CT) were designed to assess whether certain modifications affect the risk of common chronic diseases. Randomization was performed using a permuted block algorithm and was stratified by both clinical center and age group (Prentice et al., 2006). Women aged 50 to 79 years at the time of randomization were randomized in one of 40 clinical centers. Recruitment of minority women was a priority in the WHI, with a goal of 20% minority women overall and 60% in 10 centers. Recruitment strategies were population based (e.g., mailing lists) and convenience based (e.g., media announcements), although most clinics initially contacted participants through the mass mailing of a recruitment brochure (Hays et al., 2003). In total, 48,835 were randomized in the DM component, 27,347 in the HRT component, 36,282 in the CaD component, and 93,676 in the OS component (Anderson et al., 2003). The CT was a 2x2x2 partial factorial design in that participants could serve in multiple CTs (Matthews et al., 1997). Of women who were in the DM component, approximately 10.3% of participants were in all three, 16.5% were also in the HRT component, and 51.6% enrolled in the CaD component at year 1 (Hays et al., 2003). All 40 clinical centers and the clinical coordinating center at the Fred Hutchinson Cancer Research Center received institutional review board approval for the WHI, and all women provided informed consent (Tinker et al., 2007).

The DM trial. The rationale for the DM intervention came from animal studies, migrant studies, and epidemiologic studies that suggested that consumption of a low-fat diet may reduce the risk for certain chronic diseases (Ritenbaugh et al., 2003). The primary hypothesis of the DM trial was that a low-fat diet (i.e., 20% total fat daily intake), higher fruit and vegetable intake (five servings daily), and higher whole grains intake (six servings daily) would reduce the risk of both breast and colorectal cancers. A secondary hypothesis was that the dietary changes would reduce the risk of cardiovascular disease. A feasibility study, the Women's Health Trial, had been conducted previously (1984-1995) to determine whether postmenopausal women could reduce their dietary fat intake and maintain the change (WHI, 1998).

In the WHI, approximately 60% of women were randomized to the control or self-selected dietary pattern (comparison) group (n = 29,294), while the remaining 40% were randomized to the intervention or low-fat dietary pattern (dietary change) group (n = 19,541) at baseline. The trial was not blind for participants or interventionists, although the staff collecting dietary information was blinded. The strategy in the comparison group was to intervene as little as possible. These women completed dietary assessments to allow for comparison with the dietary change group and received a copy of *Dietary Guidelines for Americans* and other health-related materials. They were not asked to make dietary changes. Recruitment began in 1993, and the trial ended in March 2005 (Neuhouser et al., 2008), with women being followed for an average of 8.1 years (Tinker et al., 2002).

Eligibility for the DM trial. Women were excluded from the WHI if they had a medical condition with a predicted survival time of less than 3 years, had conditions that would be problematic (e.g., alcoholism, drug dependency, mental illness, dementia), or were in another randomized controlled trial (Hays et al., 2003; WHI, 1998). Women were excluded from the CT if they had competing risks (invasive cancer in the past 10 years; breast cancer at any time or suspicion of breast cancer at baseline; acute myocardial infarction, stroke, or transient ischemic attack in the previous 6 months; known chronic active hepatitis or severe cirrhosis), it was unsafe for them to participate (e.g., blood counts indicative of disease, severe hypertension, or using oral corticosteroids), or they were unwilling or unable to participate. Specific exclusion criteria for the DM trial included having special dietary requirements incompatible with the intervention, eating 10 or more main meals per week prepared outside of the home, being unable to complete a satisfactory 4-day food record, having been diagnosed with colon cancer, type I diabetes mellitus, or gastrointestinal conditions that are contraindicated with a high-fiber diet, having had a bilateral prophylactic mastectomy, and having a Food Frequency Questionnaire estimating dietary percent of calories from fat as less than 32%. Approximately 50% of participants were deemed ineligible based on the last exclusion criterion (Howard, Manson, et al., 2006; Tinker et al., 1996). See Figure 1 for a flow chart of participants to baseline.

Dietary change intervention. The intervention was provided in a group setting, with groups of eight to 15 women. Group sessions began when groups of eight to 15 women who could meet at the prescheduled date and time were gathered (Tinker et al., 2007). The group setting was time efficient for staff and provided social support for participants. Nutritionists, who were usually registered dieticians, guided the group through activities, promoted group dynamics, provided support, and ensured that session objectives were achieved. Women had a total of 18 group sessions in which they met weekly for the first 6 weeks, every other week for the next 6 weeks, and monthly thereafter for the first year. They also received an individual dietary counseling session between 12 and 16 weeks. Dietary maintenance sessions occurred approximately quarterly after the first year, in addition to optional peer-led monthly meetings.

The principles behind the intervention were nutritional and behavioral in nature. The nutritional principles were eating pattern development and dietary change skills (e.g., food preparation, social dining). There was no dietary prescription provided, such as meal plans or menus, so participants made their own dietary decisions. The behavioral principles were (1) reinforcements and motivators, (2) self-management through self-monitoring, defining the behaviors to be changed, setting quantifiable change goals, breaking complex behaviors into smaller steps, specifying an action plan, obtaining feedback, and reinforcing progress and encouraging self-praise, (3) behavioral skills training (e.g., problem solving, stress-management skills), (4) self-control or self-reliance, (5) social support, and (6) relapse prevention (Tinker et al., 1996). The nutritional and behavioral principles were integrated in 18 group sessions plus one individual session in the first year of the intervention, followed by quarterly maintenance sessions for the rest of the study. Early sessions focused on nutritional principles, whereas behavioral strategies become more central as women were maintaining dietary change. Women were also given an individualized fat intake goal (20% of her estimated daily energy intake). Notably, the emphasis of the intervention was to change dietary behavior, including to decrease fat intake and to increase fruit, vegetable, and whole grains intake, rather than to change individual nutrients (Ritenbaugh et al., 2003). In addition, the intervention did not encourage weight loss or calorie reduction. Rather, women were encouraged to replace fat calories with other sources, particularly carbohydrates (Howard, Manson, et al., 2006; Tinker et al., 1996). Furthermore, although both groups received general health-related materials, neither group was asked to make changes to health-related behaviors other than diet (Carty et al., 2011).

Measures of dietary intake. The primary method used to collect dietary information was the Food Frequency Questionnaire (FFQ; Tinker et al., 1996). Although the FFQ is a self-report measure and therefore subject to bias, it was considered a good measure of habitual eating patterns. All DM participants completed the FFQ at baseline and year 1. Thereafter, a rotating sample of approximately 30% completed the FFQ. The FFQ has three parts: adjustment questions (19 items about food type and preparation, allowing for the specification of the nutrient content of specific food items), food items (122 food items regarding the usual frequency of intake and portion), and summary questions (four questions about the usual intake of fruits and vegetables and fat added to foods and cooking, which were used to reduce measurement bias due to over-reporting total food consumption when long lists of food are presented). Participants were asked about consumption in the previous 3 months. For quality control purposes, WHI required that women complete all adjustment questions, all summary questions, 90% of the foods, and at least one-half of every food group section (Patterson et al., 2003; Patterson et al., 1999). Participants were contacted by certified dietary assessment staff if they had missing data.

Issues have been raised about the accuracy of the FFQ when compared with objective measures or biomarkers. In general, the WHI FFQ tends to underreport energy intake (Horner et al., 2002; Neuhouser et al., 2008). For example, in the DM trial, women in both groups underreported energy intake and protein intake (Neuhouser et al., 2008). In addition, women who were younger, had higher BMIs, or were Black had more underreporting (Hebert et al., 2003;

Neuhouser et al., 2008). Also, applicability to minorities and those with cognitive deficits is questionable (see WHI, 2004, for more information). Nevertheless, the WHI FFQ has been validated (Patterson et al., 1999).

DM trial results. At the end of year 1, the difference between the groups' percentage of energy from fat was 10.7%, decreasing to 8.1% at Year 6 (Prentice et al., 2006). In general, the primary and secondary hypotheses of the WHI DM trial were not supported over the follow-up period. Specifically, the low-fat dietary pattern of the treatment group did not result in statistically significant reductions in the risk of invasive breast cancer (Prentice et al., 2006), colorectal cancer (Beresford et al., 2006), or cardiovascular disease (Howard, Van Horn, et al., 2006) over 8.1 years of the trial.

Measures

Diet. The daily percent energy from fat, number of fruit and vegetable servings, and number of whole grains servings, which were collected at baseline and year 1 on the FFQ and calculated by the WHI, were used to assess dietary change in the current study. In addition, difference scores for each dietary variable were calculated by subtracting baseline from year 1, and then quartiles of change, based on the entire sample, were calculated.

Physical activity. Self-reported physical activity was collected at baseline and at year 1. Questions about physical activity were identical at both time points. Participants answered questions regarding the frequency, length, and intensity of walking, moderate exercise, and vigorous exercise (walking was explicitly not included in the other exercise questions).

Three items inquired about participants' typical walking behavior. Participants were first asked how often they walked outside the home for more than 10 minutes without stopping, with responses ranging 0 (*Rarely or never)* to 5 (*7 or more times each week*). Participants were then asked how many minutes they usually walked when they walked for more than 10 minutes without stopping, with responses ranging from 1 (*Less than 20 minutes*) to 4 (*1 hour or more*). Finally, participants who reported walking for more than 10 minutes were asked to indicate their usual speed, which included *casual strolling or walking (less than 2 miles an hour)*, *average or normal (2-3 miles an hour)*, *fairly fast (3-4 miles an hour)*, and *very fast (more than 4 miles an hour)*.

Participants were also asked about the frequency and duration of both moderate and vigorous exercise. Moderate exercise was defined as physical activity that was not exhausting, including biking outdoors, using an exercise machine, calisthenics, easy swimming, and popular or folk dancing. Vigorous or very hard exercise was defined as exercise in which "you work up a sweat and your heart beats fast," such as aerobics, aerobic dancing, jogging, tennis, and swimming laps. For each of the intensities, participants were asked how many times per week they engaged in that intensity of exercise. Responses ranged from 0 (*none*) to 5 (*5 or more days per week*). Participants were also asked the duration of their exercise for each intensity level, with responses ranging from 1 (*less than 20 minutes*) to 4 (*1 hour or more*).

Measurement of physical activity in the present study. For the purpose of the present study, moderate physical activity and vigorous physical activity were combined to assess adherence to moderate to vigorous physical activity (MVPA) guidelines. Specifically, MVPA included activities with energy expenditures of 4.0 METs or greater. METs for each activity were based on the Compendium of Physical Activities (Ainsworth et al., 1993) and were as follows: fairly fast walking = 4 METs, moderate exercise = 4.5 METs, very fast walking = 5 METs, and vigorous exercise = 7 METs. The WHI provided several computed energy expenditure variables, which were in units of MET-hours per week (kcal per kg per week) and were calculated using the following formula (WHI, 2007):

$$\text{Frequency of activity per week} * \frac{\text{minutes per session}}{60 \text{ (min/hour)}} * \text{MET for that activity (kcal/kg*hour)}$$

To align with MVPA guidelines, MET-hours per week were multiplied by 60 to produce MET-minutes per week. Then, the MET-minutes per week for fairly fast walking, very fast walking, moderate exercise, and vigorous exercise were summed to create a total MVPA score for baseline and for year 1. Adherence to MVPA guidelines was defined as engaging in at least 500 MET-minutes per week of combined moderate and vigorous physical activity (see Table 1). The test-retest reliability of physical activity variables ranged from .67 (active or not) to .77 (METs per week) among women in the OS. In a random sample of 536 OS participants that completed a second measure of the physical activity measure 10 weeks after baseline, the test-retest reliability ranged from .53 to .72, and the intra-class correlation for total physical activity was .77 (Langer et al., 2003; McTiernan et al., 2003).

Alcohol consumption. Self-reported alcohol consumption was collected on the FFQ at baseline and year 1. Specifically, women were asked to record the frequency and amount of their consumption of medium servings beer, wine, and liquor. A medium serving size was defined as 12 ounces for beer, 6 ounces for wine, and 1.5 ounces for liquor. The frequency response options were as follows: *never or less than once per month*, *1-3 per month*, *1 per week*, *2-4 per week*, *5-6 per week*, *1 per day*, *2-3 per day*, *4-5 per day*, and *6+ per day*. From these questions, the WHI calculated the average number of drinks per week. In addition to the continuous measure of alcohol consumption provided by the WHI, the present study used alcohol consumption guidelines to divide women into adherent (seven or fewer drinks per week) and nonadherent (more than seven drinks per week; see Table 1).

Smoking. Information on smoking behavior was collected at baseline and at year 1. At both time points, participants were asked whether they currently smoked cigarettes (yes or no), allowing for the classification of individuals as current smokers and nonsmokers. Information was also collected about the number of cigarettes smoked per day on average among current smokers at baseline and at year 1. Specifically, the question was, "On the average, how many cigarettes do you usually smoke each day?" Responses included the following: *Less than 1*, *1-4*, *5-14*, *15-24*, *25-34*, *35-44*, and *45 or more*. For the purpose of the current study, these categories were reduced into the following due to the small number of participants smoking fewer than four and more than 35 cigarettes: *<1-4*, *5-14*, *15-24*, and *≥25*. In addition, at baseline current smokers were asked how many years they were a regular smoker. The following categories were used in the current study: <30 years, 30-39 years, and ≥40 years. There was also information about whether women were past smokers at baseline, defined as nonsmokers who reported smoking at least 100 cigarettes in their lifetime (Ford et al., 2012). The test-retest reliability of smoking status in the OS was 0.94 (Langer et al., 2003).

Additional predictors of untargeted behaviors. Baseline sociodemographic, medical history, and psychosocial variables were examined as predictors of untargeted health behavior engagement and change in the present study.

Sociodemographic characteristics. Sociodemographic characteristics were recorded at baseline and included age at screening, region, race/ethnicity, education, family income, marital status, and employment status. HRT trial enrollment at baseline was also included.

Age. The following age groups, in years, for age at screening were used: 50-64 and 65-79.

Region. The US region in which women were residing at the time of randomization or enrollment was used. The four categories based on the US Census definition were Northeast, South, Midwest, and West.

Race/ethnicity. Six categories were used for race and ethnicity in descriptive analyses: American Indian/Alaskan Native (AI/AN), Asian/Pacific Islander (API), Black, Latino, non-Hispanic White, and Unknown (not one of the above). Due to the low proportions of AI/AN, API, and Unknown, these categories were combined into one category (other race/ethnic groups) for other analyses in the current study.

Education. Education had the following three categories: high school or less, post-high school/some college, and college degree or higher.

Family income. Total family income had the following four categories: <$20,000, $20,000-<$50,000, ≥$50,000, and Don't Know.

Marital status. Marital status was measured using four categories: never married, divorced or separated, widowed, and married/living as married.

Employment status. Employment status was measured using three categories based on women's responses to whether they were employed either full-time or part-time and whether they were retired: not working, currently employed, or retired.

HRT trial enrollment. Enrollment (yes or no) in the HRT trial at baseline was also considered.

Medical history variables. Body mass index (BMI) was recorded at baseline. Height (m) and weight (kg) were measured using standardized procedures in the WHI clinics (Anderson et al., 2003; Thomson et al., 2012). Specifically, after participants removed their shoes, their height was measured using a wall-mounted stadiometer. After participants removed their heavy clothing and emptied their pockets, their weight was measured using a calibrated balance beam or digital scale. BMI was calculated as weight (kg) divided by height (m) squared. In the present study, BMI was used to categorize women's weight status into one of three categories (WHO, 2015b): normal (<25 kg/m^2), overweight (25 to 29.9 kg/m^2), or obese (≥30 kg/m^2).

Chronic disease history was recorded at baseline, including whether participants had a history of diabetes, high cholesterol, hypertension, CVD, or cancer. These diseases were considered in the present study given their potential relationships with untargeted health behavior engagement and change. For each chronic disease, participants responded (yes or no) to the following question: "Did a doctor ever tell you that you had [chronic disease]?"

Psychosocial variables. Several psychosocial variables were measured at baseline. Of interest to the current study were the psychosocial factors of optimism, social support, social strain, depression status, and physical functioning.

Optimism. Optimism was measured using the six-item Life Orientation Test–Revised (LOT-R; Scheier et al., 1994). Each item is scored on a five-point scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). All items are then summed, yielding a total score that ranges from 6 to 30, with higher scores indicating greater optimism (Hingle et al., 2014; Tindle et al., 2009). Participants were asked for their agreement with the following statements: (1) "In unclear times, I usually expect the best," (2) "If something can go wrong for me, it will" (reverse scored), (3) "I'm always hopeful about my future," (4) "I hardly ever expect things to go my way" (reverse scored), (5) "I rarely count on good things happening to me" (reverse scored), and (6) "Overall, I expect more good things to happen to me than bad." As in previous WHI studies that have made optimism a categorical variable for ease of interpretation (Hingle et al., 2014; Progovac et al., 2013; Tindle et al., 2009), tertiles of optimism were used in the present study.

The tertiles included the following scores: 6–22, 23–25, and 26–30, which are identical to the tertiles found by Hingle et al. (2014) in their analysis of the DM trial. The LOT-R has a Cronbach's α of .78, test-retest reliability of .68, and adequate predictive and discriminant validity (Scheier et al., 1994). In the DM sample used in the current study, the LOT-R had acceptable reliability (Cronbach's α = .76).

Social support. Social support was assessed using nine items from the Medical Outcomes Study (MOS) questionnaire (Sherbourne & Stewart, 1991). Participants ranked how often certain types of support were available on a five-point scale, ranging from 1 (*none of the time*) to 5 (*all of the time*), with total scores ranging from 9 to 45. In particular, they were asked about the availability of emotional/informational support (e.g., someone to listen when you need to talk), tangible support (e.g., someone to take you to the doctor), affectionate support (e.g., someone to love and make you feel wanted), and positive social interaction (e.g., someone to do something fun with). In keeping with other WHI studies (e.g., Kroenke et al., 2012; Messina et al., 2004), social support was divided into quartiles for the purpose of the current study. Specifically, the quartiles encompassed the following scores: 9–32 (none/low), 33–37, 38–42, and 43–45 (high). Internal consistency on the social support scale was high among the DM trial participants used in the present study (Cronbach's α = .93) and was the same as that of OS participants at baseline (Kroenke et al., 2012).

Social strain. Social strain was evaluated using four items from a measure about the negative aspects of social relationships (Antonucci, Kahn, & Akiyama, 1989). Women were asked, "Of the people who are important to you, how many": (1) "get on your nerves," (2) "ask too much of you," (3) "do not include you," and (4) "try to get you to do things you don't want to." Responses ranged from 1 (*none*) to 5 (*all*). Items were summed to create a social strain score that ranged from 4 to 20, with higher scores indicating greater social strain. Similar to social support, quartiles of social strain were used: 4 (none), 5–6, 7–8, and 9–20 (high). Internal consistency for the scale in the present sample was acceptable (Cronbach's α = .71) and comparable to that found in the OS sample (Kroenke et al., 2012).

Depression status. A modified six-item version of the Center for Epidemiologic Studies-Depression Scale (CES-D) was used to assess depressive symptoms (Radloff, 1977). Participants were asked how often they experienced the following in the past week: (1) "you felt depressed (blue or down)," (2) "your sleep was restless," (3) "you enjoyed life" (reverse scored), (4) "you had crying spells," (5) "you felt sad," and (6) "you felt that people disliked you." Responses included 0 (*rarely or none of the time (less than 1 day)*), 1 (*some or a little of the time (1-2 days)*), 2 (*occasionally or a moderate amount of the time (3-4 days)*), and 3 (*most or all of the time (5-7 days)*). Scores ranged from 0 to 18, with higher scores representing more depressive symptoms. As has been done in previous WHI studies (Uebelacker et al., 2013; Wassertheil-Smoller et al., 2004; Wilcox et al., 2003), a cut-off score of five or more was used to separate women into lower and higher levels of current depressive symptoms and indicated current depression. The cut-off score of five corresponds to the cut-off score of 16 on the full 20-item CES-D. Wassertheil-Smoller et al. (2004) reported that the correlation between the six-item CES-D and the full 20-item CES-D was .88 in a population similar to the WHI. The scale had a Cronbach's α of .66 in the DM trial sample used here, which was the same as that found in the OS sample (Jones et al., 2015).

Physical functioning. Physical functioning was measured using the 10-item Physical Functioning subscale from the RAND 36-Item Health Survey (Hays, Sherbourne, & Mazel, 1993). Scores ranged from 0 to 100, with higher scores indicating greater physical functioning.

Participants were asked to indicate whether and, if so, how much their health limits certain activities, such as lifting or carrying groceries, climbing one flight of stairs, and bathing and dressing. Responses included 1 (*Yes, limited a lot*), 2 (*Yes, limited a little*), and 3 (*No, not limited at all*). Physical functioning exhibited substantial negative skew, and quartiles of physical functioning were therefore used in analyses: 0–75 (low), 76–85, 86–95, and 96–100 (high). The physical functioning scale had good internal consistency in the DM trial sample (Cronbach's $\alpha = .88$).

Analytic Strategy

In line with past research using the FFQ, women were excluded if their total daily caloric intake was not between 600 and 5,000 kilocalories, as responses are not reliable outside of this range (Patterson et al., 1999). In addition, 49.4% (n = 24,146) of DM trial participants did not complete the year 1 questionnaire that collected information about physical activity and cigarette smoking (Form 35, Personal Habits Update). This form was not collected until June 1995 of the study, at which point participants from earlier years had already passed their first annual visit (WHI, personal communication, February 2016). Women with missing data at year 1, by enrollment year, were as follows: 1994 (99.3% missing), 1995 (99.1% missing), 1996 (51.9% missing), 1997 (7.7% missing), and 1998 (6.8% missing). The decision made in the present study was to include only participants who had complete data for all study variables. The decision to use casewise deletion was made for the following reasons: (1) there is a precedent in published WHI studies to use casewise deletion when participants have missing data on outcomes of interest (e.g., Hingle et al., 2014; Thomson et al., 2014; Tinker et al., 2007), (2) due to the extent and the nature of the missing data (i.e., the missingness was related to a variable, study year, that was not included in the dataset), imputation techniques were deemed inappropriate (Collins &

Lanza, 2010), and (3) due to the large size of the remaining sample, it was assumed that statistical power would still be adequate for the analyses. Moreover, casewise deletion ensured that the same sample was used across the different aims, thereby aiding interpretation of study results.

The number of participants missing each health behavior at each time point by study arm may be seen in Table 2. Of the 23,329 participants not missing any health behavior data at baseline or year 1, other study predictors had the following numbers of participants missing data (those not listed had no missing data): race/ethnicity (48), education (170), marital status (99), employment status (136), BMI (121), high cholesterol ever (264), hypertension ever (172), CVD ever (248), cancer ever (119), optimism (519), social support (559), social strain (503), depression status (525), and physical functioning (384). In addition, 17 participants were missing dietary information at either baseline or year 1. After removing participants with missing data on these variables, the final sample included 20,380 participants, with 8,193 intervention and 12,187 control participants. Differences in study variables between women with complete and incomplete data were examined, and are reported in the Results, to enable a comparison between the reduced sample used in the current study and the full DM trial sample.

Before reporting the results of the main analyses, the descriptive statistics and bivariate relationships among study variables were examined. In particular, descriptive statistics, including means and standard deviations for continuous variables and proportions for categorical variables, were calculated for the baseline sociodemographic, medical history, and psychosocial variables. In addition, study arm differences in these variables were examined using Pearson chi-square tests. Next, means, standard deviations, and zero-order correlations were calculated for the targeted dietary variables at baseline and year 1 and for the change in the dietary variables between the two time points (year 1 minus baseline). To verify that the intervention group had significant changes in the targeted dietary variables, relative to the control group, in this subsample of the DM trial, study arm differences were examined using independent samples *t*-tests for each dietary variable at baseline and year 1 and for the change in the dietary variables between the two time points. Quartiles of change for each dietary variable were also examined for study arm differences using chi-square tests.

Descriptive statistics for each of the untargeted health behaviors at baseline and year 1 were calculated, including means and standard deviations for continuous variables and proportions for the guideline adherence variables. Study arm differences in guideline adherence were examined using chi-square tests. For smoking behavior, number of cigarettes and number of years smoking were also examined among smokers at baseline and at year 1. In addition, sociodemographic, medical history, and psychosocial predictors of adherence to guidelines were examined using separate binary logistic regression analyses, solving for the odds of adherence to the guidelines. This was done for each untargeted health behavior and for both the baseline and year 1 data, allowing for the comparison of predictors between the two time points for each untargeted health behavior. Finally, bivariate relationships among the untargeted health behaviors were examined. Specifically, chi-square tests were run for each pair of untargeted health behaviors at each time point, and the odds of adhering to the guidelines for one untargeted health behavior, given guideline adherence on a second health behavior, were calculated for both baseline and year 1. The bivariate relationships between quartiles of change for the dietary variables and the untargeted health behaviors at year 1 were also examined using chi-square tests.

Aim 1: To examine the prevalence of untargeted health behaviors at baseline and year 1. The proportion of participants with zero to three health-risk behaviors, based on adherence to behavioral guidelines, and the proportion for each of the eight specific health-risk behavior combinations were calculated, and study arm differences were examined using chi-square tests. Adherence was dichotomized for each of the health behaviors according to the guidelines for that behavior (see Table 1).

Aim 2: To examine continuous and categorical changes in each untargeted health behavior between baseline and year 1. To be consistent with previous gateway behavior studies (Dutton et al., 2008; Wilcox et al., 2000), study arm differences in the changes between baseline and year 1 in physical activity and alcohol consumption were examined using repeated-measures analysis of variance (ANOVA) with no additional predictors. Only physical activity and alcohol consumption were examined because no continuous measure of cigarette smoking was collected in the WHI DM trial. A mixed-design ANOVA was also conducted, with time, study arm, and quartiles of change in the dietary variables as independent variables, to examine whether changes in the dietary variables, and the interactions with time and study arm, were associated with continuous change in untargeted MVPA and alcohol consumption.

Then, change in adherence for each untargeted health behavior was examined. For each health behavior, an exact McNemar's test was used to determine whether there was a significant difference in the proportion of adherent participants at the two time points. Next, participants who were adherent to guidelines at baseline and those who were nonadherent to guidelines at baseline were examined separately. Specifically, the proportions of baseline adherent participants who stayed adherent and became nonadherent were recorded, and the proportions of baseline nonadherent participants who stayed nonadherent and became adherent were recorded. Then, study arm differences in year 1 adherence, within each baseline adherence group, were evaluated using chi-square tests. Finally, changes in the three dietary variables (quartiles) were examined as predictors in a binary logistic regression predicting the odds of guideline adherence at year 1 for each baseline adherence group. In the case that dietary change was a significant predictor of year 1 adherence, I reran the logistic regression for dietary change in each study arm to clarify whether dietary change was associated with year 1 adherence in both study arms.

Aim 3: To identify distinct subgroups of participants with different patterns of untargeted health behaviors. Repeated-measures latent class analysis (RMLCA) was used to determine the number of classes that would be necessary to explain the variation in untargeted health behaviors between baseline and year 1. Latent class analysis (LCA) is a latent variable model that takes a person-oriented approach by looking for subgroups of individuals that show similar patterns of individual characteristics (Collins & Lanza, 2010; Lanza, Bray, & Collins, 2013). In LCA, the latent variable is categorical and is comprised of a set of latent classes. These latent classes are measured by observed categorical indicator variables, or an individual's response to each item (e.g., adherence to MVPA, alcohol, and smoking guidelines). Individuals who show similar patterns of responses are expected to be members of the same latent class. Two parameters are estimated in LCA, and these help to define the latent classes: (a) the latent class prevalence, or the number of participants expected to be in each class, and (b) the item-response probabilities, or the probabilities of observed responses to each item, given membership in a particular latent class. Item-response probabilities closer to 1 indicate a strong correspondence between latent class membership and endorsement of the item. Individuals belong to one and only one latent class because classes are mutually exclusive and exhaustive, meaning that the latent class prevalences sum to 1.

The expectation-maximization (EM) algorithm is typically used to estimate the parameters of latent class models. EM is an iterative procedure that is used to search for the maximum likelihood (ML) parameter estimates, which represent the parameter values for which the data are most likely to be observed (Collins & Lanza, 2010; Lanza et al., 2013). The EM algorithm cycles between two steps (each cycle is referred to as an iteration): (1) an *expectation* step, in which the conditional probability that an individual belongs to a latent class, given her observed data and the provisional parameter estimates from the previous iteration, is computed, and (2) a *maximization* step, in which parameter estimates that maximize the likelihood function, with the assumption that class membership is known, are produced using the information from the expectation step. Two criteria are necessary for stopping the estimation procedure: (1) the maximum number of iterations the procedure can make (e.g., 5,000, which was used in the current study) and (2) a stopping rule based on when the search is close enough to parameter estimates that maximize the likelihood function (or minimize the log of the likelihood function). When the largest difference between estimates from two consecutive iterations becomes smaller than a specified convergence criterion, the program has converged on a maximum of the likelihood function. The stopping rule is based on a numerical convergence index, such as the maximum absolute deviation (MAD), that indicates when the theoretical maximum has been reached, and on an associated convergence criterion that defines when the estimation procedure is sufficiently close to the ML solution and can stop iterating (e.g., MAD $\leq$ .000001, which was used in the current study).

RMLCA is a longitudinal extension of LCA (Lanza & Collins, 2006). Thus, in RMLCA, a standard latent class model is fit to one or more observed variables that were assessed at multiple time points (Lanza et al., 2013). The latent classes in RMLCA, then, correspond to different patterns of categorical change over time (Collins & Lanza, 2010). In other words, the latent classes in RMLCA are defined by individuals' responses to each item across time, and it is expected that individuals with similar patterns of responding over time will be members of the same latent class (McCarthy et al., 2015).

RMLCA analytic strategy. All RMLCA analyses in the present study were conducted using PROC LCA, Version 1.3.2 in SAS (Lanza, Dziak, Huang, Wagner, & Collins, 2015). The indicator variables in the present study were dichotomized based on adherence to guidelines at baseline and year 1 (see Table 1) and included physical activity, alcohol consumption, and smoking, where 1 = adherent to guidelines and 2 = nonadherent to guidelines. The use of dichotomous variables is common in latent class models with health behavior indicators due to the dichotomous nature of behavioral guidelines (Fitzpatrick et al., 2015; Mathur, Stigler, Lust, & Laska, 2014) and the ease of interpretation (Collins & Lanza, 2010). With six indicators (three at each time point), each with two response options, there were 2^6 = 64 different possible response patterns, creating a large contingency table of possible patterns. RMLCA has the advantage of providing a parsimonious summary of this large contingency table.

First, latent class models in the full sample were examined. Due to the exploratory nature of the present analysis, a series of models were tested, beginning with one class and continuing with *k*+1 classes until convergence was not achieved. Model selection (i.e., selecting the number of classes) was aided by examining a combination of criteria (Collins & Lanza, 2010; Lanza et al., 2013). Specifically, the optimal number of classes was determined by multiple indices of model fit and classification precision, including the Akaike information criterion (AIC), the Bayesian information criterion (BIC), the bootstrap likelihood ratio test (BLRT), and entropy, and by the interpretability of latent classes. Information criteria, including AIC and BIC, provide an assessment of relative model fit, which is the determination of which of two or more models represent an optimal balance of parsimony and fit to a particular dataset. Lower values of AIC and BIC represent a more optimal balance between model fit and parsimony. The BLRT tests the improvement in fit for each additional estimated class (Nylund, Asparouhov, & Muthén, 2007). In particular, the BLRT tests the null hypothesis that a model with *k* classes is adequate relative to the alternative hypothesis that a model with *k*+1 classes is required (Dziak, Lanza, & Xu, 2011). The %LcaBootstrap macro (Dziak et al., 2011) was used in the present study to perform the BLRT to compare the fit of a model with *k* classes to one with *k*+1 classes, with a *p*-value of .01 indicating that the model with *k*+1 classes provided a better fit to the data. Classification certainty is seen when individuals have a high probability of membership in only one latent class and low probabilities in the remaining classes. Entropy, which is provided in PROC LCA as a measure of classification certainty, ranges from 0 to 1, with larger values indicating higher classification certainty. G^2, or the likelihood-ratio statistic, is also produced in PROC LCA and is a measure of absolute model fit, with larger values indicating a better fit between the latent class model and observed data.

Item-response probabilities were used to assign labels to latent classes. As has been done by other researchers (e.g., Collins & Lanza, 2010; de Vries et al., 2008; Fitzpatrick et al., 2015; Kang et al., 2014), an item-response probability of greater than .5 was used to interpret latent classes. In particular, item-response probabilities greater than .5 indicated that the class had a high probability of adherence to the behavioral recommendation.

Next, I examined whether the latent structure differed between the two study arms. First, I examined whether measurement invariance held by comparing two models: one in which all parameters were allowed to vary across groups and a second in which the item-response probabilities were constrained to be equal across groups (Collins & Lanza, 2010). In other words, measurement invariance was assumed in the second model. Measurement invariance in LCA refers to the phenomenon when individuals who belong to the same latent class, but are in different groups, have the same probability of providing any given observed response pattern. Measurement invariance implies that the latent classes have identical interpretations in both study arms. If the model with constrained parameters fits equally well as the model with freely varying parameters, this suggests that the item-response probabilities are equal across groups. AIC, BIC, and the likelihood-ratio difference test between the models were used to assess whether the model with freely varying parameters or the model with constrained parameters was a better fit to the data (Collins & Lanza, 2010). Lower AIC and BIC are associated with the preferred model. If they are lower for the model with freely estimated parameters, indicating better model fit, this suggests that measurement invariance does not hold and that the groups have different parameters. The likelihood-ratio difference test ($\Delta G^2 = G^2{}_2 - G^2{}_1$, which is distributed as χ^2 with $df = df_2 - df_1$) tests the null hypothesis that measurement invariance holds across groups, or that both models fit the data equally well. A significant likelihood-ratio difference test suggests that at least one item-response probability parameter differs between groups and that measurement invariance does not hold.

Secondly, I examined whether the number of latent classes was identical across the intervention and control groups by running separate RMLCA models for each study arm (Collins & Lanza, 2010). Moreover, I examined whether the interpretation of the selected latent class models was similar between the two study arms. If the comparison of the freely varying model and measurement invariance model indicated the measurement invariance model provided a better fit, and the separate latent class solutions for each study arm were similar, this would suggest that the two groups did not have substantially different patterns of untargeted health behavior change, and the expected intervention effect was not observed.

Aim 4: To explore additional predictors of engagement in and change in untargeted health behaviors. Additional predictors, including baseline sociodemographic, medical history, and psychosocial variables, were added to analyses for Aim 2 and Aim 3. In the categorical analyses of Aim 2, the bivariate relationships between the additional predictors and adherence status at year 1 were examined separately for baseline adherent and baseline nonadherent participants using chi-square tests. The quartiles of baseline behavior for MVPA and alcohol consumption were also calculated for each group (i.e., adherent and nonadherent). This was done to examine whether participants who were closer to becoming nonadherent (e.g., 600 MET-minutes per week of MVPA) or adherent (e.g., 400 MET-minutes per week of MVPA) at baseline were more likely to change adherence status at year 1. Predictors exhibiting significant bivariate relationships with year 1 adherence status were then simultaneously entered into a multivariate binary logistic regression predicting the odds of adhering to behavioral guidelines at year 1.

These additional predictors were also considered in relation to the classes identified in the RMLCA of Aim 3. Given that there were no a priori hypotheses about which study variables may predict class membership, this was approached solely as an exploratory analysis. To assign class membership, the posterior probabilities, which are the probabilities of latent class membership for participants conditional on their response patterns, were used (Goodman, 2007). Then, the bivariate relationships between the predictors and classes were calculated using chi-square tests. In the case that three or more classes were identified, a multinomial logistic regression analysis, with the most prevalent class as the reference, was conducted with the predictors that had significant bivariate relationships with class membership to determine which variables were significant predictors of class membership in a multivariate analysis. It should be noted that this classify-analyze approach was used only as an exploratory technique. It is not generally recommended as an approach to examining class differences because it does not account for the uncertainty in classification that is present to at least some degree in LCA (Collins & Lanza, 2010), although it is commonly used in the literature to identify predictors of class membership (e.g., Childs et al., 2016; Harrington, Dahly, Fitzgerald, Gilthorpe, & Perry, 2014; Héroux et al., 2012; Schnuerer et al., 2015; Wennman et al., 2015).

A $p < .005$ significance level was used to adjust for the size of the dataset increasing the chance of significance and to account for the large number of analyses being conducted. In logistic regression analyses, 99.5% confidence intervals were calculated, and significance values were based on the Wald chi-square statistic. The SAS System for Windows, Version 9.4 (SAS Institute, Cary, NC) was used to conduct all analyses.

Chapter 3

Results

Preliminary data exploration analyses, in which the descriptive statistics and bivariate relationships were calculated, are first presented. The main analyses examining study hypotheses begin on page 64.

Preliminary Data Exploration

Examination of missing data. Due to the amount of missing data at year 1, the data were examined for systematic differences between the full sample and the reduced sample used in the present analysis. Chi-square tests (categorical variables) and independent samples *t*-tests (continuous variables) were used to compare women with complete data at both baseline and year 1 to those who had missing data. As previously stated, the sample consisted of 20,380 participants after those with missing data were removed. There was not a significant difference between the study arms in the proportion of women with missing data, with 41.9% and 41.6% of intervention and control group participants, respectively, with complete data, $\chi^2(1, N = 48{,}835) = 0.51$, $p = .48$. Missingness was not significantly related to alcohol consumption guideline adherence at baseline or year 1 or smoking at year 1; however, women with complete data were significantly more likely to be adherent to the physical activity guidelines at baseline (22.0% vs. 20.5%), $\chi^2(1, N = 43{,}760) = 14.95$, $p < .001$, and year 1 (31.1% vs. 28.0%), $\chi^2(1, N = 24{,}869) = 17.07$, $p < .001$, and were significantly less likely to be smokers at baseline (5.9% vs. 7.3%), $\chi^2(1, N = 48{,}297) = 36.12$, $p < .001$.

Table 3 displays the means and standard deviations of the dietary variables for participants with and without missing data. Of note, women with complete data reported a significantly higher percent energy from fat at year 1, $t(43757) = 7.36$, $p < .001$, $d = 0.07$. In addition, women with complete data consumed significantly more fruit and vegetable servings per day at baseline, $t(48601) = 10.83$, $p < .001$, $d = 0.10$, and consumed significantly fewer whole grains servings per day at year 1, $t(43757) = -4.07$, $p < .001$, $d = -0.04$.

There were significant differences between women with complete data and those with missing data for the following predictors: age, region, race/ethnicity, income, marital status, employment status, high cholesterol ever, hypertension ever, optimism, social support, social strain, depression status, and physical functioning. Specifically, women with complete data were slightly older at baseline ($M = 63.35$, $SD = 6.50$) than women with missing data ($M = 61.49$, $SD = 7.02$), $t(45776) = 30.17$, $p < .001$, $d = 0.27$. In addition, women with complete data were more likely to be from the West (32.4% vs. 28.5%) and less likely to be from the South (23.9% vs. 27.6%), $\chi^2(1, N = 48{,}835) = 141.19$, $p < .001$. Women with complete data were also less likely to be Black (8.5% vs. 12.5%) or Latino (3.0% vs. 4.3%) and more likely to be non-Hispanic White

(83.7% vs. 80.1%) or in the other race/ethnic groups (4.8% vs. 3.1%), $\chi^2(1, N = 48{,}736) = 336.07$, $p < .001$. Furthermore, women with complete data were more likely to make $50,000 or more per year (38.5% vs. 34.9%), $\chi^2(1, N = 48{,}835) = 110.12$, $p < .001$, less likely to be divorced or separated (14.8% vs. 16.6%), $\chi^2(1, N = 48{,}617) = 38.91$, $p < .001$, and more likely to be retired (52.7% vs. 43.3%), $\chi^2(1, N = 42{,}880) = 372.68$, $p < .001$. Women with complete data were also more likely to have ever had high cholesterol (12.9% vs. 11.1%), $\chi^2(1, N = 43{,}164) = 33.52$, $p < .001$, or hypertension (36.5% vs. 34.6%), $\chi^2(1, N = 43{,}366) = 17.97$, $p < .001$. Finally, women with complete data were more likely to be in the upper tertile of optimism (26.7% vs. 24.8%), $\chi^2(1, N = 47{,}764) = 35.88$, $p < .001$, less likely to be in the bottom quartile of social support (26.5% vs. 28.0%), $\chi^2(1, N = 47{,}764) = 21.86$, $p < .001$, less likely to be in the top quartile of social strain (19.8% vs. 21.9%), $\chi^2(1, N = 47{,}791) = 41.08$, $p < .001$, less likely to be currently depressed (14.1% vs. 16.0%), $\chi^2(1, N = 47{,}557) = 32.53$, $p < .001$, and less likely to be in the top quartile of physical functioning (15.6% vs. 17.2%), $\chi^2(1, N = 48{,}033) = 23.95$, $p < .001$.

The aforementioned comparisons were also conducted within each study arm (i.e., comparing participants within each study arm who had complete and missing data). In general, the predictors of missingness were similar in each of the intervention and control groups relative to the whole sample. However, there were several variables that were not significant predictors of missingness in either the intervention or control group participants when examined separately, including having hypertension ever, social support, and physical functioning. In the intervention group, there were additional variables that were not significant predictors of missingness, including adherence to physical activity guidelines at baseline and year 1, smoking guidelines at baseline, and marital status. In the control group, whole grains servings at year 1 was not a significant predictor of missingness.

Sample description. Means and standard deviations were calculated for continuous variables, and proportions were calculated for categorical variables. Study arm differences were also examined for each variable using chi-square tests.

Sociodemographic characteristics. The average age of the sample at baseline was 63 years (*SD* = 6.50). Approximately 58% of the sample was 50 to 64 years old (see Table 4). Women were roughly evenly distributed among the Northeast, South, and Midwest regions, but more women in the sample (32.4%) were from the West. The vast majority of women (83.7%) in the sample were non-Hispanic White. The next largest race/ethnicity group was Black, representing about 8% of the sample. The sample was overall well educated, with approximately 80% of women with at least some postsecondary education. Moreover, most participants (81.6%) had a family income of at least $20,000 per annum. The majority of women were married or in a marriage-like relationship at baseline, although roughly 30% of women were either widowed, divorced, or separated. Approximately half of the participants were retired at baseline, while one third were employed. A minority of women participated in both the DM and HRT trials (16.5%). There were no significant differences between study arms in any of the baseline sociodemographic characteristics.

Medical history variables. The average BMI at baseline was 29 (*SD* = 6.06), indicating that overweight and obese weight statuses were common in the sample. Indeed, approximately 70% of the sample was classified as overweight or obese at baseline (see Table 5). In addition, the proportion of participants who had ever had diabetes, high cholesterol, hypertension, CVD, or cancer was generally low in the sample (see Table 5). The most prevalent of the chronic diseases was hypertension, with 36.5% of participants reporting having ever had hypertension.

The intervention and control arms did not differ in the prevalence of the BMI weight statuses or any of the chronic diseases at baseline.

Psychosocial factors variables. The average score for optimism was 23.44 (*SD* = 3.33; see Table 6). In addition, the sample had an average social support score of 36.33 (*SD* = 7.42) and an average social strain score of 6.56 (*SD* = 2.49). The average score on the CES-D was 2.20 (*SD* = 2.38). Similar to the proportion reported by previous studies using the six-item CES-D in the WHI OS sample (Uebelacker et al., 2013; Wassertheil-Smoller et al., 2004), 14% of the DM trial sample met the cut-off score of five or more, indicating current depression at baseline. Overall, the sample had an average physical functioning score of 80.91 (*SD* = 19.12). The study arms did not differ on any of the baseline psychosocial variables.

Dietary variables. Table 7 shows the study arm and total sample means and standard deviations for each of the targeted dietary variables at baseline and year 1 and for the change in each of the dietary variables between the two time points (year 1 minus baseline). All dietary variables were significantly correlated with each other at both baseline and year 1 (see Table 8). Specifically, at baseline and year 1, there were significant positive correlations between fruit and vegetable servings and whole grains servings and significant negative correlations between percent energy from fat and both fruit and vegetable servings and whole grains servings.

Study arm differences in the targeted dietary components were examined. Each of the targeted dietary components showed substantial positive skew, and square root transformations were thus used in the independent samples *t*-tests to compare study arms. There were no significant differences between study arms in any of the dietary components at baseline (see Table 7); however, at year 1, women in the intervention group had significantly lower percent energy from fat, $t(16439) = -104.92$, $p < .001$, $d = -1.53$, consumed significantly more daily servings of fruits and vegetables, $t(17008) = 39.83$, $p < .001$, $d = 0.57$, and consumed significantly more daily whole grains servings, $t(16646) = 25.08$, $p < .001$, $d = 0.36$, compared with women in the control group. Differences between the study arms in the change scores (year 1 minus baseline) for each of the dietary variables were also examined, and results mirrored the analyses examining study arm differences at year 1, such that intervention participants had, on average, a significantly greater decrease in percent energy from fat, $t(14791) = -105.78$, $p < .001$, $d = -1.58$, and a significantly greater increase in both daily servings of fruit and vegetables, $t(14534) = 43.04$, $p < .001$, $d = 0.65$, and whole grains, $t(15782) = 25.92$, $p < .001$, $d = 0.38$ (see Table 7). Finally, the same pattern of results emerged when the dietary change score quartiles were examined for study arm differences using chi-square tests, such that there was a greater proportion of intervention participants in the upper quartile for each of the dietary change variables (see Table 9).

Physical activity. At baseline, the average amount of MVPA was 316 MET-minutes per week (see Table 10). In addition, 22.0% of the sample was adherent to the MVPA guidelines of 500 or more MET-minutes per week. There were no significant differences between the study arms in adherence to MVPA guidelines at baseline. At year 1, there was an increase in the average MVPA to 453 MET-minutes per week. Moreover, 31.1% of women were adherent to the guidelines for MVPA at year 1, with a slightly greater, although not significant, proportion of women in the intervention (31.5%), relative to the control group (30.8%), reaching the recommended amount of activity.

*Predictors of MVPA guideline adherence***.** Separate binary logistic regression analyses were used to examine whether there were any sociodemographic, medical history, or psychosocial variables associated with the odds of adherence to MVPA guidelines at baseline or at year 1. Results showed that women who were 50 to 64 years old had lower odds of adherence to MVPA guidelines at baseline (see Table 11). Relative to non-Hispanic White participants, Black participants had significantly lower odds of MVPA adherence. Women who had at least some postsecondary education and those who made $50,000 or more per year had significantly greater odds of MVPA adherence at baseline. On the other hand, women from the Northeast, South, or Midwest had significantly lower odds of adherence relative to women from the West. In addition, women who were never married or divorced/separated had significantly lower odds of adherence, relative to those who were married. Women who were currently employed or who were enrolled in the HRT trial had significantly lower odds of adherence. Women who were overweight or obese had significantly lower odds of adherence relative to women with a normal weight status (see Table 12). Having CVD ever and having cancer ever were not significantly related to MVPA adherence at baseline; however, having diabetes, high cholesterol, or hypertension ever was associated with significantly lower odds of adherence. In general, participants with higher optimism, higher social support, or lower social strain had significantly greater odds of adherence at baseline (see Table 13). Women who were not currently depressed and those who had higher physical functioning also had significantly greater odds of adherence. The trends in the predictors of year 1 MVPA guideline adherence were similar to those at baseline (see Tables 14-16). However, women who had ever had CVD had significantly lower odds of MVPA guideline adherence at year 1.

Alcohol consumption. Drinking patterns were similar at baseline and year 1. On average, women in the DM trial consumed approximately two alcoholic beverages per week at both baseline and year 1 (see Table 17). Furthermore, approximately 10% of women reported drinking more than seven drinks per week and were thus nonadherent to alcohol guidelines at both baseline and year 1. There were no study arm differences in alcohol consumption adherence at either baseline or year 1.

Predictors of alcohol consumption guideline adherence. Relative to non-Hispanic White participants, participants who identified as Black, Latino, or from the other race/ethnic groups had significantly greater odds of consuming seven or fewer drinks at baseline (see Table 18). Women from the South and Midwest had significantly higher odds of adherence relative to women from the West. Women who were divorced/separated or widowed, relative to presently married women, and women who were enrolled in the HRT trial were more likely to be adherent. Women with more education and family incomes greater than $20,000 per year had significantly lower odds of adherence to alcohol guidelines. Women who were overweight or obese had significantly greater odds of adherence relative to women with a normal weight status (see Table 19). Having CVD ever and having cancer ever were not significantly related to alcohol consumption adherence at baseline; however, having diabetes, high cholesterol, or hypertension ever was associated with significantly greater odds of adherence at baseline. Generally, participants with higher optimism, higher social support, lower social strain, and higher physical functioning had significantly *lower* odds of adherence to alcohol guidelines at baseline (see Table 20). Women who were not currently depressed also had significantly lower odds of alcohol guideline adherence. The predictors of year 1 alcohol guideline adherence were similar to those at baseline (see Tables 21-23). Marital status, however, was not significantly related to year 1 alcohol guideline adherence.

Smoking. The vast majority of women (94%) were nonsmokers at both baseline and year 1 (see Table 24), although 8,422 (41%) of the sample at baseline were past smokers. Among smokers at baseline, approximately 66% of participants reported smoking between five and 24 cigarettes per day (see Table 25). In addition, 46.3% of current smokers at baseline reported smoking for 40 years or more. Approximately 65% of smokers at year 1 reported smoking between five and 24 cigarettes per day (see Table 26). No study arm differences were found in smoking status or smoking behavior at baseline or year 1.

Predictors of nonsmoking. Women who were 50 to 64 years old had significantly lower odds of being nonsmokers at baseline (see Table 27). In addition, relative to non-Hispanic White participants, Black participants had significantly lower odds of nonsmoking. Women who were not married, not retired, or enrolled in the HRT trial had significantly lower odds of being nonsmokers. On the other hand, women who had an annual family income of $20,000 or more had significantly greater odds of nonsmoking at baseline. Women who were obese at baseline were more likely to be nonsmokers at baseline, relative to women with normal weight status (see Table 28). In addition, having ever had hypertension was associated with significantly higher odds of nonsmoking, while having ever had cancer was associated with significantly lower odds of nonsmoking. Participants with higher optimism, higher social support, lower social strain, and who were not currently depressed had significantly greater odds of nonsmoking at baseline (see Table 29). Predictors of nonsmoking at year 1 were similar to the baseline predictors (see Tables 30-32).

Bivariate relationships among the untargeted health behaviors. Chi-square tests revealed that all bivariate relationships between the untargeted health behaviors at baseline and year 1 were significant. The odds of adherence to one health behavior's guidelines given adherence to guidelines for a second health behavior for both baseline and year 1 were also calculated (see Table 33). At both baseline and year 1, women who were adherent to the MVPA guidelines, relative to those who were not, had significantly lower odds of alcohol guideline adherence and significantly greater odds of nonsmoking. In addition, nonsmokers had greater odds of adherence to the alcohol guidelines, relative to smokers, at both time points.

Bivariate relationships between dietary change quartiles and year 1 untargeted health behavior guideline adherence were also examined. Results from the complete sample are presented because the results were highly similar when separated by study arm. Change in percent energy from fat was significantly associated with MVPA guideline adherence, $\chi^2(3, N = 20{,}380) = 88.39$, $p < .001$, and alcohol guideline adherence at year 1, $\chi^2(3, N = 20{,}380) = 18.17$, $p < .001$. Similarly, change in fruit and vegetable servings was significantly related to MVPA guideline adherence, $\chi^2(3, N = 20{,}380) = 32.65$, $p < .001$, and alcohol guideline adherence at year 1, $\chi^2(3, N = 20{,}380) = 21.09$, $p < .001$. Finally, change in whole grains servings was significantly associated with alcohol guideline adherence at year 1, $\chi^2(3, N = 20{,}380) = 19.03$, $p < .001$. Change in the targeted dietary variables was not related to nonsmoking at year 1.

Main Analyses

Aim 1: To examine the prevalence of untargeted health behaviors at baseline and year 1. To address aim 1, the prevalence of the number of health-risk behaviors (i.e., zero to three) and the specific combinations of health-risk behaviors at baseline and year 1 were examined. As can be seen in Table 34, the majority of women (88.5%) had zero or one health-risk behaviors at baseline, with most women (70.0%) reporting one health-risk behavior. Approximately one fifth of the sample reported adhering to all of the behavioral guidelines, while less than 1% of participants had all three health-risk behaviors. The most common combination of risk behaviors at baseline was nonadherence to physical activity guidelines, with roughly 67% of the sample showing this pattern (see Table 35). The next most prevalent combination was adherence to all the behavioral guidelines, with 18.5% adhering to all three.

Each of the remaining risk behavior combinations accounted for less than 7% of the sample. It was especially uncommon for participants to report only smoking (0.7%), heavy drinking and smoking (0.2%), or all three health-risk behaviors (0.8%). There were no significant differences between study arms either in the number of risk behaviors, $\chi^2(3, N = 20{,}380) = 2.24$, $p = .52$, or in the combinations of risk behaviors, $\chi^2(7, N = 20{,}380) = 5.84$, $p = .56$, at baseline.

Similar to baseline, the majority of participants (90.3%) had zero or one health-risk behaviors at year 1 (see Table 36). Few women (0.7%) reported all three health-risk behaviors, while approximately one quarter of participants were adherent to all the behavioral guidelines. There was also a decrease in the average number of risk behaviors between baseline ($M = 0.94$, $SD = 0.56$) and year 1 ($M = 0.84$, $SD = 0.60$). The pattern of risk behavior combinations was similar to baseline, with roughly 60% of the sample reporting only nonadherence to physical activity guidelines (see Table 37). The next most prevalent combination was adherence to all behavioral guidelines (26.4%), which represented an increase from baseline. Each of the remaining risk behavior combinations accounted for less than 5% of the sample. It was, again, especially uncommon for participants to report only smoking (0.9%) or heavy drinking and smoking (0.3%). There were no significant differences between study arms either in the number of risk behaviors, $\chi^2(3, N = 20{,}380) = 0.38$, $p = .94$, or in the combinations of risk behaviors, $\chi^2(7, N = 20{,}380) = 7.52$, $p = .38$, at year 1.

Aim 2: To examine continuous and categorical changes in each untargeted health behavior between baseline and year 1.

Change in physical activity. First, change in continuous MVPA was examined. Then, change in adherence to MVPA guidelines was examined both for women who were adherent at baseline and for women who were nonadherent at baseline.

Continuous change in MVPA. To assess the potential association between study arm and change in MVPA among women who engaged in any MVPA at both baseline and year 1, changes in physical activity between the two groups were examined using a repeated-measures ANOVA. Only women with a score of more than zero at both time points were included in this analysis (n = 8,175). Physical activity was positively skewed at both time points, so a log transformation was used. There was a main effect for time such that participants reported a significant increase in MVPA (in MET-minutes per week) from baseline (M = 696.4, SD = 656.2) to year 1 (M = 868.0, SD = 784.0), $F(1, 8173) = 425.43$, $p < .001$. However, neither the main effect for study arm, $F(1, 8173) = 0.01$, $p = .96$, nor the study arm by time interaction was significant, $F(1, 8173) = 1.08$, $p = .30$. A mixed-design ANOVA was also conducted to examine whether the amount of change in the three targeted dietary variables (quartiles) and the interactions between study arm and dietary change were associated with change in MVPA. This analysis examined the main effects for study arm, change in each dietary variable, and time in addition to each interaction. As with the previous analysis, there was a main effect for time such that participants had a significant increase in MVPA from baseline to year 1, $F(1, 8047) = 175.29$, $p < .001$, but none of the other main effects or any of the interactions among the variables was significant.

Categorical change in MVPA guideline adherence. There was a significant increase in the proportion of women who were adherent to MVPA guidelines from baseline to year 1, from 22.0% to 31.1%, $\chi^2(1, N = 20{,}380) = 774.52$, $p < .001$. This increase was found in each study arm, with a significant increase in the intervention group (22.0% to 31.5%), $\chi^2(1, N = 8{,}193) = 333.37$, $p < .001$, and the control group (22.1% to 30.8%), $\chi^2(1, N = 12{,}187) = 441.42$, $p < .001$.

Next, changes in adherence status for two groups of participants were examined: those who were adherent at baseline (n = 4,492) and those who were nonadherent to guidelines at baseline (n = 15,888).

Change at year 1 among baseline MVPA adherent participants. There were 4,492 participants who were adherent to MVPA guidelines at baseline. The majority of participants (71.6%) were still adherent to MVPA guidelines at year 1 (see Table 38), although there was an average decrease of 65.04 (SD = 844.1) MET-minutes per week of MVPA between baseline and year 1 among baseline adherent participants. Study arm, $\chi^2(1, N = 4{,}492) = 0.11$, $p = .74$, was not associated with remaining adherent to MVPA guidelines at year 1. In addition, none of the targeted dietary variables was consistently associated with remaining adherent (see Table 39).

In bivariate analyses, the following predictors were significantly associated with MVPA guideline adherence at year 1 among women who were adherent at baseline: education, income, HRT trial enrollment, BMI, social strain, current depression, physical functioning, and quartiles of MVPA at baseline. A binary logistic regression was then conducted to determine which study variables, from those related to year 1 adherence, were associated with continued MVPA guideline adherence at year 1 among women who were adherent at baseline. Table 40 shows the results of the logistic regression. BMI, social strain, physical functioning, and MVPA at baseline emerged as significant predictors of remaining adherent at year 1. Specifically, women with lower social strain and women with higher physical functioning had significantly greater odds of adherence remaining adherent at year 1. Furthermore, women who engaged in greater amounts of MVPA at baseline had significantly greater odds of remaining adherent at year 1, while women who were overweight or obese at baseline had significantly lower odds of remaining adherent at year 1.

Change at year 1 among baseline MVPA nonadherent participants. Of the 15,888 participants who were nonadherent to MVPA guidelines at baseline, most participants (80.4%) were still nonadherent at year 1 (see Table 41). There was, however, an average increase of 193.3 (*SD* = 456.6) MET-minutes per week of MVPA between baseline and year 1 among these participants. There was not a significant difference between the study arms in the proportion of participants who became adherent by year 1, $\chi^2(1, N = 15{,}888) = 2.57, p = .11$. Furthermore, changes in fruit and vegetable servings and whole grains servings were not associated with becoming adherent to MVPA guidelines at year 1 among baseline nonadherent women (see Table 42); however, women who had greater decreases in their percent energy from fat had significantly greater odds of becoming adherent at year 1, and this was evident in both the intervention and control groups when logistic regressions were run separately for each study arm.

Chi-square analyses were used to determine which additional study variables were associated with becoming adherent to MVPA guidelines at year 1, and the following variables were significant: age, region, race/ethnicity, education, income, marital status, HRT trial enrollment, BMI, diabetes ever, hypertension ever, optimism, social support, social strain, current depression, physical functioning, and quartiles of MVPA at baseline. A binary logistic regression was then conducted to determine which of these additional study variables, including change in percent energy from fat, was associated with becoming adherent at year 1. Table 43 shows the significant predictors. As with the previous analysis, women who changed their percent energy the most (i.e., were in the upper two quartiles) had significantly greater odds of becoming adherent at year 1. Women who were from the Northeast, relative to the West, were never married, or were overweight or obese at baseline had significantly lower odds of becoming adherent at year 1. On the other hand, women who were college graduates, were in the upper tertile of optimism, were in the third quartile of social strain, had higher physical functioning, or engaged in more than zero MET-minutes per week of MVPA at baseline had significantly greater odds of becoming adherent at year 1.

Change in alcohol consumption. Change in continuous alcohol consumption was first examined, and then changes in alcohol guideline adherence for both baseline adherent and baseline nonadherent participants were considered.

Continuous change in alcohol consumption. To assess the potential association between study arm and change in alcohol consumption among baseline and year 1 drinkers, changes in alcohol consumption between the two groups were examined using a repeated-measures ANOVA. Only women who drank a non-zero amount of alcohol at both time points were included (n = 10,512). Alcohol servings per day at baseline and year 1 were positively skewed, and a log transformation was used. There was a main effect for time such that participants reported a significant reduction in alcohol servings from baseline (M = 3.85, SD = 4.69) to year 1 (M = 3.81, SD = 5.21), $F(1, 10510) = 34.37$, $p < .001$. However, neither the main effect for study arm, $F(1, 10510) = 0.36$, $p = .55$, nor the study arm by time interaction, $F(1, 10510) = 0.08$, $p = .78$, was significant. A mixed-design ANOVA was also conducted to examine whether the amount of change in the three targeted dietary variables (quartiles) and the interactions between study arm, dietary change, and time were associated with change in alcohol consumption. As with the previous analysis, there was a main effect for time such that participants had a significant increase in alcohol consumption from baseline to year 1, $F(1, 10384) = 10.82$, $p < .001$, but none of the other main effects or any of the interactions among the variables was significant.

Categorical change in alcohol guideline adherence. There was a nonsignificant decrease in the proportion of heavy drinkers from baseline (9.9%) to year 1 (9.5%) in the total sample, $\chi^2(1, N = 20{,}380) = 5.24$, $p = .02$. To clarify how participants with different adherence to drinking guidelines at baseline may have changed by year 1, changes in adherence for two groups of participants were considered: those who were adherent at baseline ($n = 18{,}367$) and those who were nonadherent to guidelines (i.e., heavy drinkers) at baseline ($n = 2{,}013$).

Change at year 1 among baseline alcohol guideline adherent participants. The vast majority (96.7%) of participants who were adherent to alcohol guidelines at baseline were still adherent at year 1 (see Table 44), although there was an increase of 0.15 ($SD = 1.94$) drinks per week between baseline and year 1 among these participants. There was not a significant difference between the study arms in the proportion of women who remained adherent to alcohol guidelines at year 1, $\chi^2(1, N = 18{,}367) = 0.05$, $p = .83$; however, women who had greater decreases in percent energy from fat had significantly lower odds of remaining adherent in the first year of the study (see Table 45). When change in the dietary variables was examined separately for each study arm, results showed that change in percent energy from fat was not significantly associated with alcohol guideline adherence at year 1 among women in the intervention group but was associated with significantly lower odds among women in the control group.

The following additional study variables were significantly associated with remaining adherent to alcohol guidelines at year 1: region, race/ethnicity, education, income, BMI, having diabetes ever, physical functioning, and quartiles of drinks per week at baseline. A binary logistic regression was then conducted to determine which additional study variables, including change in percent energy from fat, were associated with continued alcohol guideline adherence at year 1 among women who were adherent at baseline. Results showed that a larger decrease in percent energy from fat was, again, associated with significantly lower odds of remaining adherent to alcohol guidelines at year 1 (see Table 46). In addition, women from the Midwest and women were who overweight or obese had significantly greater odds of remaining adherent, while women who reported drinking more than 0.21 drinks per week had significantly lower odds of remaining adherent at year 1.

Change at year 1 among baseline heavy drinkers. As can be seen in Table 47, the majority of participants (66.1%) who were heavy drinkers at baseline were still nonadherent at year 1. There was also a decrease of 1.77 (SD = 7.45) drinks per week between baseline and year 1 among participants who were heavy drinkers at baseline. Study arm was not significantly associated with the proportion of participants who drank according to alcohol guidelines at year 1, $\chi^2(1, N = 2{,}013) = 0.03$, $p = .86$, and, of the dietary change variables, only being in the second or third quartile of change in whole grains servings was significantly associated with lower odds of becoming adherent to alcohol guidelines at year 1 among baseline heavy drinkers (see Table 48), although this was not significant for either study arm when the dietary change variables were examined separately in each group.

In bivariate analyses, race/ethnicity, BMI, and quartiles of drinks per week at baseline were significantly related to adherence status at year 1 among baseline heavy drinkers. A binary logistic regression, including change in whole grains servings, showed that participants who were Black, were overweight or obese, or drank less than the highest quartile at baseline (14.04 drinks per week) had significantly greater odds of becoming adherent to alcohol guidelines by year 1 (see Table 49).

Change in smoking. There was a slight but significant decrease in the proportion of smokers from baseline (5.9%) to year 1 (5.6%), $\chi^2(1, N = 20{,}380) = 16.69$, $p < .001$. When examined by study arm, this significant decrease was found in the control group (5.9% to 5.4%), $\chi^2(1, N = 12{,}187) = 12.94$, $p < .001$, but not in the intervention group (6.0% to 5.7%), $\chi^2(1, N = 8{,}193) = 4.03$, $p = .05$. Next, changes in smoking status in two groups of participants were considered: those who were nonsmokers at baseline ($n = 19{,}172$) and those who were smokers at baseline ($n = 1{,}208$).

Change at year 1 among baseline nonsmokers. The vast majority (99.3%) of participants who were nonsmokers at baseline were nonsmokers at year 1 (see Table 50). There was not a significant difference between the study arms in the proportion of participants who started smoking in the first year of the trial, $\chi^2(1, N = 19{,}172) = 0.42$, $p = .52$, and dietary change did not predict continued smoking abstinence (see Table 51). Indeed, none of the included study variables were significant predictors of continued nonsmoking at year 1. Of the 131 participants who began smoking in the first year of the trial, 124 were past smokers at baseline, while seven were never smokers.

Change at year 1 among baseline smokers. The majority of participants (83%) who were smokers at baseline were still smokers at year 1, although 17% quit smoking in the first year of the trial (see Table 52). There was not a significant difference between the study arms in the proportion of participants who quit smoking by year 1, $\chi^2(1, N = 1{,}208) = 4.03$, $p = .04$. In addition, dietary change was not significantly associated with smoking cessation in the first year of the trial (see Table 53). Indeed, women who quit smoking at year 1 did not differ from current smokers at year 1 on any of the additional study variables, except for the number of cigarettes smoked at baseline and the number of years smoking at baseline. Specifically, women who smoked four or fewer cigarettes per day, $\chi^2(3, N = 1{,}208) = 35.29$, $p < .001$, or who had been smokers for less than 30 years, $\chi^2(2, N = 1{,}203) = 21.22$, $p < .001$, were more likely to have quit smoking by year 1. The proportion of current smokers at year 1 who reported smoking between five and 24 cigarettes per day was approximately 68% (see Table 54), similar to the proportion at baseline (66.3%). Moreover, among participants who were smokers at both time points, 746 (74.5%) women continued to smoke the same amount at year 1 as at baseline, while 103 (10.3%) women increased and 152 (15.2%) decreased the amount they were smoking. Changes in the number of cigarettes smoked did not differ by study arm, $\chi^2(2, N = 1{,}001) = 0.16$, $p = .92$, or by change in the targeted dietary variables.

Aim 3: To identify distinct subgroups of participants with different patterns of untargeted health behaviors. A repeated-measures latent class analysis (RMLCA) was used to identify distinct patterns of untargeted health behaviors at baseline and year 1. Models with one to three classes were examined. (A four-class model failed to converge.) As can be seen in Table 55, the AIC and BIC decreased as more latent classes were added. Moreover, the BLRT was significant for each additional class, indicating the model with k+1 classes provided better fit than the model with one less class. Based on the better fit of the three-class model, it was selected and interpreted.

Class prevalences and item-response probabilities for the three-class model are presented in Table 56. Class 1 had the highest prevalence, with an estimated prevalence of 85%, and was characterized by low probability of adherence to physical activity guidelines and high probability of adherence to alcohol consumption and smoking guidelines (*lack of MVPA*). Class 2 had a lower class prevalence of 10% and was defined by low probability of adherence to physical activity and alcohol consumption guidelines and high probability of nonsmoking (*heavy* *drinkers*). Finally, class 3, with a low class prevalence of 5%, was characterized by high probability of adherence to alcohol consumption guidelines but low probability of adherence to physical activity and smoking guidelines (*smokers*).

An important characteristic of the three-class model is that the baseline and year 1 probabilities for adherence to each of the three behavioral guidelines were very similar within each class. For example, the probability of nonsmoking in the lack of MVPA class at both baseline and year 1 was .99. Indeed, there were almost no substantial differences in the probability of adherence at year 1 relative to baseline in any of the classes, which suggests that, although there were unique subgroups of participants based on baseline and year 1 adherence, there was relative stability in adherence status between the time points within each class. In addition, all classes had a high probability for adherence to at least one guideline. None of the classes had a high item-response probability for adherence to MVPA guidelines at either time point, but all classes did show an increase in the probability of adherence to MVPA guidelines from baseline to year 1.

Study arm differences in latent classes. Next, I examined the general latent structure, including the number of classes, for each study arm separately to determine whether the structure differed between the study arms (Collins & Lanza, 2010). Specifically, I examined whether item-response probabilities were invariant across groups by comparing the fit of two latent class models: (1) a model in which all parameters were allowed to vary across the groups, and (2) a measurement invariance model, in which the parameters were constrained to be equal across the groups. In addition, I examined models within each study arm to determine whether a three-class solution would also be optimal for each study arm. In addition, the class prevalences and item-response probabilities for each study arm's selected solution were compared for differences.

As can be seen in Table 57, the likelihood-ratio difference test was not significant, suggesting that the null hypothesis that measurement invariance held across study arm should not be rejected and that the item-response probabilities were not significantly different across the study arms. In addition, the AIC and BIC were both lower for the model that constrained the item-response probabilities to be equal across the study arms, which further suggested that the constrained model provided a better fit.

I then ran separate models for each study arm to further examine whether and how the class solutions and item-response probabilities differed between the study arms. Tables 58 and 59 show the models for the intervention and control groups, respectively, for one to three classes. The three-class solution was selected for both study arms due to the decrease in AIC and BIC and the significant BLRT. Table 60 displays the class prevalences and item-response probabilities for the separate intervention group and control group three-latent-class solutions. The class prevalences were highly similar between the study arms, with .01 differences in the prevalences for the lack of MVPA and heavy drinkers classes. In addition, many of the item-response probabilities differed only slightly between the study arms, although a few item-response probabilities, such as those for physical activity in the smokers class, were slightly different between the study arms. Notably, however, these differences were small and did not alter the interpretation of the classes, which was the same as the model conducted in the whole sample (see Table 56).

Based on the results from the measurement invariance model test and the examination of each study arm's latent class solution, it was concluded that, although there are slight variations between the study arms, the latent structures were highly similar. As can be seen in Table 61, the latent class prevalences were the same, within rounding error, for each group when the item-response probabilities were constrained to be equal across the groups. Given that the latent structures were similar between the two groups, it was concluded that the predictors of latent class membership could be examined with measurement invariance applied in the three-class solution.

Predictors of latent class membership. The relationships between study variables and class membership, which was assigned based on participants' highest posterior probability, were examined. It is important to interpret the predictors of latent class membership with caution because an exploratory classify-analyze approach was used. However, the average posterior probabilities in each class were at least .80, indicating that there was a high probability that participants were placed in the best class. Bivariate relationships between assigned class membership and the study variables were examined using chi-square tests, and the following were significantly associated with class membership: age, region, race/ethnicity, education, income, marital status, employment status, HRT trial enrollment, BMI, diabetes ever, high cholesterol ever, hypertension ever, cancer ever, optimism, social support, social strain, current depression, and physical functioning. Changes in the targeted dietary variables were not associated with latent class membership.

Next, multinomial logistic regression analyses were conducted with all variables that had significant bivariate relationships with class membership. The most prevalent class, lack of MVPA, served as the reference group. Of the significant bivariate predictors, employment status, high cholesterol ever, hypertension ever, optimism, social support, social strain, and current depression were not significantly associated with class membership in the multivariate analysis. Table 62 shows the results for the significant predictors of class membership. Relative to women in the lack of MVPA class, women in the heavy drinkers class had greater odds of being 50 to 64 years old, having at least a college degree, earning $20,000 or more per year, and being in the top quartile of physical functioning. In addition, women in the heavy drinkers class had significantly lower odds of being from the South or Midwest, being Black, Latino, or in the other race/ethnic groups' category, being overweight or obese, or having ever had diabetes. Women in the smokers class had significantly greater odds of being Black, being unmarried, being enrolled in the HRT trial, and having ever had cancer. Moreover, women in the smokers class had significantly lower odds of being 64 years old or younger or being overweight or obese.

Discussion

The purpose of this study was to investigate patterns and predictors of change in untargeted health behaviors, including physical activity, alcohol consumption, and smoking, in the first year of the Women's Health Initiative (WHI) Dietary Modification (DM) trial. The DM trial was designed to decrease postmenopausal women's fat intake and increase their daily fruit and vegetable servings and whole grains consumption. The current study examined the gateway behavior hypothesis, which suggests that there will be positive changes in untargeted health-related behaviors when a behavior, such as diet, is intervened upon (Nigg et al., 1999; Nigg et al., 2009). It was thus expected that women in the intervention group would show positive changes in untargeted health behaviors between baseline and year 1, relative to the control group. To determine how untargeted health behaviors changed in the sample, I described the prevalence of health-risk behaviors at both time points, examined both continuous change and change in guideline adherence in the untargeted health behaviors, and identified latent classes of participants with similar patterns of untargeted behavior change. Within these analyses, I examined whether study arm predicted engagement in and change in the untargeted health behaviors. In select analyses, I also examined whether the targeted dietary change was associated with change in untargeted health behaviors. In addition, baseline sociodemographic, medical history, and psychosocial variables were included as predictors of untargeted health behaviors to determine which variables, other than study arm and targeted dietary change, may be associated with untargeted change.

Across these different approaches to examining untargeted health behavior change, there was evidence that the untargeted behaviors changed between the two time points. Moreover, these changes were generally improvements in the untargeted health behaviors, including an increase in moderate to vigorous physical activity (MVPA), a decrease in alcohol consumption, and a decrease in the number of smokers between baseline and year 1. However, study arm and targeted dietary change, which according to the gateway behavior hypothesis should be related to the changes in untargeted behaviors, were infrequently and inconsistently related to the changes. For instance, there was a reported increase in MVPA and adherence to MVPA guidelines between baseline and year 1; however, these increases occurred in both the intervention and control groups and were not related to changes in the targeted dietary variables. Moreover, results from repeated-measures latent class analysis (RMLCA), a person-oriented approach to examining untargeted behavior change, revealed that although there were distinct subgroups of participants based on their adherence to the guidelines for each untargeted behavior at both time points, the probability of adherence changed only slightly from baseline to year 1. In addition, the subgroups were highly similar for each of the study arms, and dietary change did not predict class membership. Taken together, the findings of the present study suggest that improvements in untargeted behaviors may have been a result of simply participating in the study or general historical change, rather than the DM intervention.

Furthermore, the examination of baseline sociodemographic, medical history, and psychosocial variables as predictors of untargeted behavior change did not create a clear picture. There were some variables that were consistently related to engagement in and change in a particular health behavior, such as the relationship between higher physical functioning and greater MVPA, but there were few variables that consistently predicted engagement in and change across the untargeted health behaviors. The specific findings of the study are further discussed below.

Main Findings

Prevalence of untargeted health behaviors. Results of the current study showed that the majority of the sample was adherent to guidelines for alcohol consumption and smoking and nonadherent to guidelines for MVPA at both baseline and year 1. The majority of participants had no more than one health-risk behavior at either baseline or year 1, and most were adherent to at least one behavioral guideline. The distribution of participants with zero to three health-risk behaviors was similar to the distributions reported in national samples around the time when the WHI data were collected, including the 2001 National Health Interview Survey (NHIS; Fine et al., 2004), 2000 Behavioral Risk Factor Surveillance System (BRFSS; Reeves & Rafferty, 2005) and the third National Health and Nutrition Examination Survey (NHANES), collected between 1988 and 1994 (Berrigan et al., 2003; Ford, Ford, Will, Galuska, & Ballew, 2001). For example, the proportion of women adherent to all three behavioral guidelines in the current study was 18.5% at baseline and 26.4% at year 1, similar to the 21.4% of participants in the 2001 NHIS (Fine et al., 2004) and the 24.9% of women in the third NHANES (Berrigan et al., 2003).

At both time points, the most common combination of health-risk behaviors was lack of MVPA (66.7% at baseline; 59.4% at year 1). This finding is similar to other studies of health-risk behavior prevalence. For example, using data from the third NHANES, Ford et al. (2001) reported that 60.3% of participants engaged in MVPA. In addition, using data from the 2001 NHIS, Fine et al. (2004) reported that 42.7% of participants were adherent to alcohol and smoking guidelines but were nonadherent to physical activity guidelines.

Between baseline and year 1, the mean number of health-risk behaviors decreased from 0.94 to 0.84. In particular, the proportion of participants with no health-risk behaviors increased by 7.9%, while the proportion with one health-risk behavior decreased by 6.1%. In addition, there was a notable decrease of 7.3% in the proportion of women who were nonadherent to the MVPA guidelines at year 1. Taken together, the results suggest that there were some reductions in health-risk behaviors in the first year of the trial and that there was an increase in the proportion of women who were adherent to MVPA guidelines. However, there were no study arm differences apparent in either the number of risk behaviors or the combinations of risk behaviors at year 1, which suggests that the changes in health-risk behaviors were not linked to receipt of the DM intervention.

Continuous and categorical changes between baseline and year 1. Continuous changes in the health behaviors were examined to allow for comparison with past gateway behavior studies, which have focused exclusively on average change in untargeted behaviors. Analyses revealed that there were continuous changes in the first year for both MVPA and alcohol consumption. For instance, there was a significant increase of 172 MET-minutes per week of MVPA among women who were active at both time points, but study arm and the amount of dietary change were not related to this increase. This is in contrast to the results from an unpublished report that examined continuous change in total physical activity between baseline and year 3 in the WHI DM trial (Russell, 2008). That report found that women in the intervention group, relative to the control, engaged in significantly more total physical activity (0.35 METs per week) at year 3. It is possible that the lack of a significant study arm difference in the current study is due to the shorter follow-up period, the smaller sample size, or the use of moderate to vigorous physical activity, rather than any intensity of physical activity. In addition, an increase of 0.35 METs per week is not necessarily of importance because, although it was statistically significant, 1 MET is the energy expenditure rate at rest (USDHHS, 2008), which suggests a statistically signficant but relatively unimportant increase in physical activity was found in the previous report.

A significant, albeit nominal, decrease of 0.03 drinks per week between baseline and year 1 among drinkers was found in the present study. This significant decrease in alcohol consumption did not differ by study arm or by change in the dietary components. These results are in line with results from the previous WHI DM trial analysis, which found a significant decrease in the number of drinks per week (0.55 servings) at year 3 that did not differ by study arm (Russell, 2008). Similarly, a study that examined untargeted change in alcohol consumption in the context of an exercise intervention for overweight postmenopausal women found a decrease in untargeted alcohol consumption but no difference between the intervention and control groups (Rhew et al., 2007).

In addition to examining continuous change in the first year of the trial, changes in adherence to behavioral guidelines were also examined. This approach was used because guideline adherence provides an intuitive and commonly used measure of whether changes in the untargeted behaviors are meaningful (Berrigan et al., 2003; Héroux et al., 2012; Rothman, 2002). Results from the categorical change analyses showed that there were changes in adherence for each of the untargeted health behaviors. In particular, there was a significant increase of approximately 9% in the proportion of participants meeting the MVPA guidelines at year 1, and a small but significant decrease of 0.4% in the proportion of smokers. The 0.4% decrease in the proportion of heavy drinkers in the sample was not significant. These categorical changes were similar in both study arms, further suggesting that although there were significant improvements in the untargeted health behaviors, study arm was not related to these improvements.

To account for baseline differences in adherence, categorical changes in women who were adherent and nonadherent to each behavior at baseline were examined separately. These analyses showed, in general, that participants who were adherent to a behavioral guideline at baseline tended to stay adherent at year 1, while participants who were nonadherent tended to stay nonadherent at year 1. In other words, most participants were stable in their adherence status in the first year of the trial. This was especially true of women who consumed seven or fewer drinks per week at baseline and women who were nonsmokers at baseline, with 96.7% and 99.3%, respectively, remaining adherent at year 1. Participants who were adherent to MVPA guidelines at baseline and heavy drinkers at baseline were the most likely to shift adherence status by year 1. Specifically, among baseline adherent MVPA participants, 28.4% became *non*adherent by year 1, and among baseline heavy drinkers, 33.9% reported adhering to the guideline of drinking seven or fewer drinks per week at year 1.

Study arm was not a significant predictor of change in adherence status in the first year of the trial for any of the untargeted health behaviors. There was some evidence, however, to suggest that dietary change, particularly change in percent energy from fat, was related to maintaining or improving adherence for a few of the untargeted health behaviors. For example, among women who were nonadherent to MVPA guidelines at baseline, those with a greater decrease in percent energy from fat had significantly greater odds of becoming adherent to

MVPA guidelines at year 1, which provides some limited support for the gateway behavior hypothesis because it suggests that change in diet was related to the improvement in untargeted physical activity. On the other hand, among women who were adherent to alcohol guidelines at baseline, those with a greater decrease in percent energy from fat had significantly lower odds of maintaining adherence to alcohol guidelines at year 1. When the study arms were examined separately, however, it appeared that the lower odds of adherence at year 1 were apparent only in the control group and not in the intervention group. It is not entirely clear why women in the control group who reduced their dietary fat would have lower odds of remaining adherent to alcohol guidelines. Perhaps women in the control group who reduced their dietary fat intake had to generate their own strategies for consuming less fat, whereas women in the intervention group were provided with strategies and support for reducing fat intake. In turn, it is possible that women in the control group used more self-regulatory resources to consume less fat and therefore had fewer resources to control their alcohol consumption. The other targeted dietary components (fruit and vegetable servings and whole grains servings) were not consistently related to changes in adherence status, which may not be surprising given that these goals were not as heavily emphasized as the decrease in percent energy from fat in the WHI DM intervention (L. Van Horn, personal communication, September 2015).

The lack of consistent study arm differences in either continuous change or categorical change in the present study is in line with findings from several other gateway behavior studies (e.g., Dutton et al., 2008; Foster-Schubert et al., 2012; Rhew et al., 2007; Wilcox et al., 2000). Similar to results from the present study, some previous gateway behavior studies have also found evidence to suggest that changes in the targeted behavior predicted changes in untargeted behaviors (e.g., Rhew et al., 2007; Wilcox et al., 2000); however, when these relationships were found, they tended to be inconsistent and were sometimes negative, such that the untargeted behavior deteriorated as the targeted behavior improved. This lack of clear evidence for the gateway behavior hypothesis in the current study and in previous studies supports the notion that substantial changes in health behaviors are unlikely to occur without specific targeted intervention on those health behaviors, as proposed by some researchers (e.g., Paiva et al., 2012).

Repeated-measures latent class analysis. To my knowledge, the present study is the first to use RMLCA to identify distinct subgroups of participants with different patterns of untargeted health behaviors in a single health behavior intervention. It represents a departure from the variable-oriented approaches used both in previous gateway behavior studies and in the remainder of the present study. Three distinct subgroups were identified using RMLCA: lack of MVPA (85%), heavy drinkers (10%), and smokers (5%). The results from other analyses in the present study were reflected in the class prevalences such that the most common class was characterized by a high probability of adherence to smoking and alcohol guidelines but a low probability of adherence to MVPA guidelines. Moreover, the prevalences of the classes defined by a low probability of adherence to alcohol guidelines and to smoking guidelines were small and reflected the proportions of participants found in earlier analyses in the study who were nonadherent to alcohol guidelines (approximately 10%) and to smoking guidelines (approximately 5%). It was surprising that there was not a latent class defined by adherence to the three behavioral guidelines, given that this pattern represented approximately 26% of participants at year 1 and that some health behavior LCA studies have found a healthy class in their cross-sectional analyses (e.g., de Vries et al., 2008; Schnuerer et al., 2015). However, RMLCA is intended to identify subgroups of individual who show similar patterns of adherence and, in this way, to summarize variability in individual change, rather than to produce a definitive list of all possible patterns of individual change (Lanza & Collins, 2006).

In general, the latent classes showed some changes at year 1 in the probability of adherence to certain behavioral guidelines. For instance, each latent class had an increase in the probability of adherence to MVPA guidelines between the two time points; however, these item-response probability changes were not large enough to change the interpretation of the classes. In other words, latent classes had similar probability of adherence to each behavioral guideline at both time points, and there was no evidence of substantive change within any latent class. An additional aim of the present study was to examine study arm differences in the latent class structure, including the number and interpretation of latent classes. Results showed that the latent class structure was similar for each study arm when a three-class solution was selected for both groups. In addition, the class prevalences and most of the item-response probabilities in each arm's three-class solution were almost identical. As a whole, the results of the RMLCA provide further evidence that the intervention did not promote positive changes in untargeted health behaviors.

Additional predictors of untargeted health behavior engagement and change. Finally, I examined the predictors of both engagement in and change in the untargeted health behaviors in the first year of the trial. In preliminary analyses, the bivariate predictors of guideline adherence were generally consistent at baseline and year 1 for each health behavior. For example, women with a normal BMI at baseline were more likely to be adherent to MVPA guidelines at both time points. There were also some similar trends in the predictors of adherence across the health behaviors in the bivariate analyses. For instance, women who had higher family incomes had greater odds of adherence to MVPA and smoking guidelines. In addition, higher optimism, higher social support, lower social strain, and not being depressed were associated with significantly greater odds of adherence to MVPA and smoking guidelines.

In some cases, such as those mentioned above, the additional study variables were associated with engagement in the untargeted health behaviors as predicted. There were, however, several circumstances in which these variables were associated with unhealthy behaviors. For example, having a higher income, more education, higher optimism, higher social support, lower social strain, and a normal BMI were associated with significantly *lower* odds of adherence to the alcohol guidelines at both time points. Moreover, in bivariate analyses, women who drank seven or fewer drinks per week, relative to heavy drinkers, had significantly lower odds of engaging in 500 or more MET-minutes per week at baseline and year 1. These results may seem counterintuitive at first glance, but they are consistent with results from other studies that have shown that higher alcohol consumption is associated with factors typically assumed to predict engagement in health-promoting behaviors. For example, studies that have examined other samples from the WHI have found that women who reported heavy drinking (i.e., more than seven drinks per week) were more likely to be more highly educated, have higher incomes, and have lower BMI (e.g., Espeland et al., 2006; Li et al., 2010). It may be that women who are heavy drinkers are able to afford the expense of daily alcohol consumption or that it is a socially acceptable behavior among their peers. The lower odds associated with psychosocial variables that could be considered protective from health-risk behaviors (i.e., higher optimism, higher social support, lower social strain, and not being currently depressed) suggest that heavy drinkers did not necessarily use alcohol as a method of coping or mood enhancement. Indeed, past studies have found evidence to suggest that social motives for drinking (e.g., as an activity with friends) are associated with moderate, non-problematic alcohol consumption, while coping or mood enhancement motives are associated with problematic drinking (Gilson et al., 2013; Smith, Abbey, & Scott, 1993).

Few of the additional variables were significant predictors of change in adherence to guidelines. Furthermore, few variables were significant across the three untargeted health behaviors, which suggests that there are distinct predictors of engagement in and change in distinct health behaviors. For instance, in multivariate analyses, higher physical functioning was associated with significantly greater odds of becoming adherent or staying adherent to MVPA guidelines but was not a significant predictor of any change in alcohol consumption or smoking guideline adherence. On the other hand, the one consistent predictor of categorical change was the amount of the untargeted health behavior at baseline, measured using the quartiles for each baseline adherence status group. For instance, among heavy drinkers at baseline, women who reported drinking less than 14 drinks per week (the upper quartile) were 2 to 5 times more likely to become adherent to alcohol guidelines (i.e., drink seven or fewer drinks per week) by year 1. In other words, participants who were close to achieving behavioral adherence at baseline were generally more likely to achieve adherence by year 1, while participants who were close to becoming nonadherent at baseline were less likely to remain adherent by year 1.

Finally, there were distinct predictors of class membership, which was assigned from the posterior probabilities, in the multivariate analysis, although the exploratory nature of this analysis must be kept in mind. Some of the patterns in predictors revealed in earlier analyses were also seen in the class membership predictor analysis. For instance, women with family incomes of $20,000 or more and women with college degrees had significantly greater odds of belonging to the heavy drinkers class, relative to the lack of MVPA class. This is not surprising, however, given that the classes showed that the probability of adherence remained similar between baseline and year 1.

Limitations

There are several limitations in the present study that should be considered. One limitation is the extent to which the study results are generalizable. The women in the WHI were healthy volunteers and not necessarily a representative sample of the US population. For example, the proportion of smokers in the WHI DM trial was 6.7% (Ritenbaugh et al., 2003), which was lower than the 28.4% reported in the third NHANES (Ford et al., 2001). Moreover, volunteers in clinical research are generally healthier than eligible non-volunteers and are typically highly motivated, leading to limited generalizability due to self-selection bias (Kumanyika et al., 2000). Another potential concern is cohort effects. The women in the WHI may not be representative of women today. For instance, smoking rates were higher a generation ago than now, and rates of physical activity have increased (USDHHS, 2014b). However, the WHI had fewer smokers than would be expected based on the prevalence during the study period. For instance, the percentages of smokers aged 50 to 59, 60 to 69, and 70 or older in the 1996 BRFSS were 25.8%, 17.1%, and 9.3%, respectively (Ford et al., 2010). However, the 2014 prevalence rate for women aged 65 and older was 7.5% (Jamal et al., 2015), which is similar to the rates found in the WHI.

In addition, the amount of missing data in the present analysis was substantial due to the large proportion of participants who did not complete the questionnaire about physical activity and smoking behavior at year 1. The WHI has no official historical reason why participants in the first two years of DM trial enrollment did not receive this questionnaire (WHI, personal communication, February 2016). Given the differences between the reduced sample used in the present study and the full baseline DM trial sample, the results must be interpreted with caution. On the other hand, the sample, although reduced, was still large and was still similar to the baseline sample, allowing for some confidence in the study results.

Another limitation of the present study concerns the WHI DM study measures. All of the health behaviors, including diet, were self-reported, which may have resulted in measurement bias. In general, it is recognized that smoking and alcohol consumption tend to be underreported and that physical activity tends to be overreported when measured by self-report (Newsom et al., 2005). Furthermore, as described in the Method section, although the WHI FFQ has been validated (Patterson et al., 1999), the accuracy of the FFQ, compared with objective measures, has been called into question. In particular, the WHI FFQ tends to underreport energy intake (Horner et al., 2002; Neuhouser et al., 2008). In turn, it is important to interpret the results, particularly those pertaining to dietary change, with caution. In future, it would be interesting to examine whether calibrated measures of diet and physical activity show the same pattern of results as the present analysis using self-report measures that were not corrected for measurement error (Tinker et al., 2011; Zheng et al., 2014).

Finally, there are some inherent limitations to examining untargeted health behavior change by conducting secondary analyses using a single health behavior change intervention. For example, the precise timing of any of the changes in the untargeted health behaviors is indeterminable using data from the WHI DM trial because only two time points were available from baseline to year 1. In future, ecological momentary assessment could be used to establish, with greater precision, changes in untargeted health behaviors as the targeted behavior changes. This has been done in observational studies (e.g., Conroy et al., 2015) but has not been widely used to examine untargeted health behavior change. In addition, although patterns and predictors of untargeted health behavior change can be examined in the context of a single health behavior change intervention, it is not possible to examine potential mechanisms of change. Therefore, results suggest *whether*, but not *how*, changes in untargeted health behavior occur. Measuring untargeted health behavior change in terms of adherence to guidelines may be seen as a limitation because it does not distinguish between participants who were close to achieving, or becoming nonadherent to, a recommendation. However, within the categorical change analyses, it was shown that participants who were closer to the recommendations at baseline were more likely to experience changes in guideline adherence at year 1.

Implications

Although there were limitations to the current study, the results have the potential to inform both theory and practice. As previously described, the gateway behavior hypothesis suggests that when a behavior is targeted, positive spillover effects can be expected in untargeted health behaviors (Nigg et al., 2009). Results from the present study showed that there were changes in untargeted health behaviors but that these changes were, for the most part, not related either to study arm or to change in the targeted dietary components. Specifically, there was no consistent evidence to suggest that dietary change acted as a gateway behavior for untargeted physical activity, alcohol consumption, or smoking in the present study. These results add to the existing body of gateway behavior studies that suggest that there are few consistent changes in untargeted health behaviors in the context of single health behavior interventions (e.g., Dutton et al., 2008; Wilcox et al., 2000). Although there were no consistent positive changes in untargeted health behaviors, it should be noted that there were not substantial deteriorations in any behavior. This implies that women who changed their dietary behavior were not more likely to experience concurrent decrements in other health behaviors and that, at least in the context of the first year of a dietary modification trial, untargeted health behaviors do not necessarily need to be monitored for deterioration. In addition, this suggests that, if changing dietary behaviors had depleted self-regulatory resources, this depletion was not substantial enough to cause a subsequent lapse in the control of untargeted health behaviors for most participants.

Findings from the current study support the notion that behaviors that are more similar to the targeted behavior are more likely to change (Lippke, 2014; Lippke, Nigg, & Maddock, 2012; Spring et al., 2015; Yin et al., 2013). The behavior showing the most change in the sample was physical activity, which could be due to its inherent relationship with diet as an energy balance behavior. Although change in physical activity was largely unrelated to study arm or dietary change, it is possible that the changes in physical activity that did occur were attributable to an unmeasured desire by study participants to lose weight. In other words, participants who increased their physical activity may have wanted to lose weight and that may have been a motivation for participating in the trial. In contrast, alcohol consumption and smoking are not as closely or as readily associated with diet, and this may partially explain why these behaviors experienced relatively less improvement. In addition, cigarette smoking was particularly stable, which may be due to the many challenges associated with smoking cessation (Paiva et al., 2012). In turn, these findings suggest that behaviors that are not directly related to trial goals may require direct treatment to show substantial change.

In the present study, the untargeted health behaviors were not treated in any systematic way, which provided one method of testing the gateway behavior hypothesis. Indeed, the results suggest that, at least for some untargeted behaviors, a dietary modification intervention is not on its own sufficient to change untargeted health behaviors and that, if change in these behaviors is desired, behavior-specific treatment may be necessary. However, a full behavior-specific treatment may not be necessary to promote positive changes in other behaviors. For example, some behavior change principles that could be applied to other health behaviors were taught in the intervention, such as self-monitoring and problem-solving skills (Tinker et al., 1996). Perhaps intervention participants would change their untargeted behaviors if they were taught how to apply these same skills to change other behaviors. Of course, the objective of the DM trial was not multiple health behavior change, but it is possible that, even with minimal intervention, physical activity, alcohol consumption, and smoking may have systematically changed among intervention participants. Determining the minimal intervention required to induce change in multiple health behaviors is an area of MHBC intervention research that has the potential to further reduce participant and resource burden.

Conclusion

Taken together, the results of the present study suggest that there were improvements in health behaviors that were not targeted by the intervention, including physical activity, alcohol consumption, and smoking, in the first year of the WHI DM trial. These improvements, however, were generally unrelated to the receipt of the dietary modification intervention or change in the targeted dietary variables. Moreover, although there were participants who changed their adherence to behavioral guidelines in the first year of the trial (i.e., improved and became adherent or deteriorated and became nonadherent), the vast majority of participants remained the same in terms of their adherence to behavioral guidelines. There were also few consistent additional study predictors of untargeted health behavior change. Based on the results from the current study, future interventions that aim to modify multiple health behaviors, particularly diverse behaviors or ones that are especially difficult to change, should consider the addition of behavior-specific components, rather than relying on behavior-general spillover effects.

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Table 1

Definitions of Adherence to Behavioral Guidelines

Behavior	Adherent	Nonadherent
MVPA[a]	≥500 MET-min per week	<500 MET-min per week
Alcohol consumption[b]	≤7 drinks per week	>7 drinks per week
Smoking[c]	Nonsmoker	Smoker

Note. Adherence is defined in terms of behavioral guidelines. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent.
[a]500 or more MET-minutes of moderate to vigorous physical activity per week are recommended for adults (Garber et al., 2011; USDHHS, 2008). [b]Drinking at most seven drinks per week for adult women (i.e., moderate drinking) is recommended (USDA, 2010; USDHHS, 2014b). Heavy drinking is defined as more than seven drinks per week. [c]Nonsmoking is defined as adherent to smoking guidelines (Husten, 2009).

Table 2

Number of Participants with Complete and Missing Data for Each of the Untargeted Behaviors at Baseline and Year 1

	Intervention[a]		Control[b]		Total[c]	
Behavior	*n*	%	*n*	%	*n*	%
Physical activity						
Complete	9,961	51.0	14,821	50.6	24,782	50.8
Missing B	38	0.2	49	0.2	87	0.2
Missing Y1	7,546	38.6	11,432	39.0	18,978	38.9
Missing B, Y1	1,996	10.2	2,992	10.2	4,988	10.2
Alcohol consumption						
Complete	17,598	90.1	26,048	88.9	43,646	89.4
Missing B	40	0.2	60	0.2	100	0.2
Missing Y1	1,878	9.6	3,155	10.8	5,033	10.3
Missing B, Y1	25	0.1	31	0.1	56	0.1
Smoking						
Complete	9,826	50.3	14,645	50.0	24,471	50.1
Missing B	134	0.7	157	0.5	291	0.6
Missing Y1	9,486	48.5	14,340	49.0	23,826	48.8
Missing B, Y1	95	0.5	152	0.5	247	0.5

Note. Numbers and percentages represent participants who had missing data for each health behavior separately. In total, 23,329 participants had no missing data at either time point for any health behavior, with 9,358 in the intervention group and 13,971 in the control group. B = baseline; Y1 = year 1.
[a]*n* = 19,541. [b]*n* = 29,294. [c]*N* = 48,835.

Table 3

Means and Standard Deviations for Targeted Dietary Variables among Participants with Complete and Missing Data at Baseline and Year 1

Dietary variable	Complete[a] M (SD)	Missing[b] M (SD)
Energy from fat (%)		
Baseline	37.69 (5.01)	37.83 (5.08)
Year 1*	31.07 (8.91)	30.45 (8.84)
Fruit/vegetable (servings)		
Baseline*	3.70 (1.85)	3.53 (1.80)
Year 1	4.41 (2.20)	4.37 (2.20)
Whole grains (servings)		
Baseline	1.14 (0.76)	1.16 (0.81)
Year 1*	1.19 (0.81)	1.23 (0.84)

Note. Independent samples *t*-tests were conducted to compare participants with complete and missing data on any study variable on the targeted dietary variables.
[a]n = 20,380. [b]At baseline, 232 participants were missing dietary information, so n = 28,223 and N = 48,603. At year 1, 5,076 participants were missing dietary information, so missing n = 23,379 and N = 43,759.
*$p < .001$.

Table 4

Baseline Sociodemographic Characteristics by Study Arm and for the Total Sample

Variable	Intervention[a]		Control[b]		Total[c]	
	n	%	*n*	%	*n*	%
Age group (years)						
50-64	4,754	58.0	6,973	57.2	11,727	57.5
65-79	3,439	42.0	5,214	42.8	8,653	42.5
Region						
Northeast	1,829	22.3	2,758	22.6	4,587	22.5
South	1,971	24.1	2,915	23.9	4,886	24.0
Midwest	1,753	21.4	2,547	20.9	4,300	21.1
West	2,640	32.2	3,967	32.6	6,607	32.4
Race/ethnicity						
AI/AN	20	0.2	47	0.4	67	0.3
Asian/Pacific Islander	240	2.9	386	3.2	626	3.1
Black	720	8.8	1,013	8.3	1,733	8.5
Latino	250	3.1	363	3.0	613	3.0
Non-Hispanic White	6,849	83.6	10,201	83.7	17,050	83.7
Unknown	114	1.4	177	1.5	291	1.4
Education						
High school or less	1,771	21.6	2,603	21.4	4,374	21.5
Post-high school/some college	3,216	39.3	4,881	40.1	8,097	39.7
College degree or higher	3,206	39.1	4,703	38.6	7,909	38.8
Family income						
<$20,000	1,033	12.6	1,595	13.1	2,628	12.9
$20,000-<$50,000	3,551	43.3	5,235	43.0	8,786	43.1
≥$50,000	3,166	38.6	4,686	38.5	7,852	38.5
Don't Know	443	5.4	671	5.5	1,114	5.5

(continued)

Table 4 (*continued*)

Variable	Intervention[a]		Control[b]		Total[c]	
	n	%	*n*	%	*n*	%
Marital status						
Never married	316	3.9	452	3.7	768	3.8
Divorced/separated	1,256	15.3	1,765	14.5	3,021	14.8
Widowed	1,300	15.9	2,000	16.4	3,300	16.2
Married/living as married	5,321	65.0	7,970	65.4	13,291	65.2
Employment status						
Not working	1,101	13.4	1,704	14.0	2,805	13.8
Currently employed	2,815	34.4	4,027	33.0	6,842	33.6
Retired	4,277	52.2	6,456	53.0	10,733	52.7
HRT trial enrollment						
Yes	1,315	16.1	2,049	16.8	3,364	16.5
No	6,878	84.0	10,138	83.2	17,016	83.5

Note. Chi-square tests examining differences between study arms did not find significant differences for any sociodemographic variable. AI/AN = American Indian/Alaskan Native; HRT = hormone replacement therapy trial.
[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380.

Table 5

Baseline Medical History Variables by Study Arm and for the Total Sample

Variable	Intervention[a] *n*	Intervention[a] %	Control[b] *n*	Control[b] %	Total[c] *n*	Total[c] %
Body mass index						
Normal (<25)	2,154	26.3	3,190	26.2	5,344	26.2
Overweight (25-29.9)	2,906	35.5	4,376	35.9	7,282	35.7
Obese (≥30)	3,133	38.2	4,621	37.9	7,754	38.1
Diabetes ever						
No	7,671	93.6	11,428	93.8	19,099	93.7
Yes	522	6.4	759	6.2	1,281	6.3
High cholesterol ever						
No	7,142	87.2	10,601	87.0	17,743	87.1
Yes	1,051	12.8	1,586	13.0	2,637	12.9
Hypertension ever						
No	5,231	63.9	7,708	63.3	12,939	63.5
Yes	2,962	36.2	4,479	36.8	7,441	36.5
CVD ever						
No	6,821	83.3	10,207	83.8	17,028	83.6
Yes	1,372	16.8	1,980	16.3	3,352	16.5
Cancer ever						
No	7,810	95.3	11,604	95.2	19,414	95.3
Yes	383	4.7	583	4.8	966	4.7

Note. Chi-square tests examining differences between study arms did not find significant differences for any medical history variable. CVD = cardiovascular disease.
[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380.

Table 6

Baseline Psychosocial Variables by Study Arm and for the Total Sample

	Intervention[a]		Control[b]		Total[c]	
Variable (range of scores)	*n*	%	*n*	%	*n*	%
Optimism tertile (6–30)						
6–22 (low)	2,905	35.5	4,347	35.7	7,252	35.6
23–25	3,067	37.4	4,627	38.0	7,694	37.8
26–30 (high)	2,221	27.1	3,213	26.4	5,434	26.7
Social support quartile (9–45)						
9–32 (none/low)	2,168	26.5	3,229	26.5	5,397	26.5
33–37	1,928	23.5	2,800	23.0	4,728	23.2
38–42	2,026	24.7	3,104	25.5	5,135	25.2
43–45 (high)	2,071	25.3	3,049	25.0	5,120	25.1
Social strain quartile (4–20)						
4 (none)	2,249	27.5	3,376	27.7	5,625	27.6
5–6	2,512	30.7	3,763	30.9	6,275	30.8
7–8	1,806	22.0	2,632	21.6	4,438	21.8
9–20 (high)	1,626	19.9	2,416	19.8	4,042	19.8
Depression status[d] (0–18)						
Not depressed	7,067	86.3	10,434	85.6	17,501	85.9
Depressed	1,126	13.7	1,753	14.4	2,879	14.1
Physical functioning quartile (0–100)						
0–75 (low)	2,525	30.8	3,884	31.9	6,409	31.5
76–85	1,669	20.4	2,384	19.6	4,053	19.9
86–95	2,737	33.4	4,002	32.8	6,739	33.1
96–100 (high)	1,262	15.4	1,917	15.7	3,179	15.6

Note. Higher scores indicate greater optimism, social support, social strain, depressive symptoms, or physical functioning. Chi-square tests examining differences between study arms did not find significant differences for any psychosocial variable.
[a]n = 8,193. [a]n = 12,187. [c]N = 20,380. [d]Depression was measured using the six-item CES-D, and a cut-off score of 5 was used to indicate current depression.

Table 7

Means and Standard Deviations for Dietary Variables at Baseline and Year 1 by Study Arm and for the Total Sample

	Intervention[a]	Control[b]	Total[c]
Variable (unit)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Energy from fat (%)			
Baseline	37.70 (5.03)	37.69 (4.99)	37.69 (5.01)
Year 1*	24.56 (7.53)	35.45 (6.86)	31.07 (8.91)
Change (Y1 – B)*	-13.14 (7.82)	-2.24 (6.20)	-6.62 (8.72)
Fruit/vegetable (servings)			
Baseline	3.70 (1.83)	3.70 (1.86)	3.70 (1.85)
Year 1*	5.14 (2.32)	3.92 (1.97)	4.41 (2.20)
Change (Y1 – B)*	1.44 (2.17)	0.22 (1.68)	0.71 (1.98)
Whole grains (servings)			
Baseline	1.13 (0.75)	1.14 (0.77)	1.14 (0.76)
Year 1*	1.36 (0.89)	1.08 (0.73)	1.19 (0.81)
Change (Y1 – B)*	0.23 (0.85)	-0.07 (0.74)	0.06 (0.80)

Note. Daily amounts were reported. There were no significant study arm differences at baseline. The study arm differences in each dietary variable were significant at year 1 and for the change scores (year 1 minus baseline). Y1 = year 1; B = baseline.
[a]$n = 8{,}193$. [a]$n = 12{,}187$. [c]$N = 20{,}380$.
*$p < .001$.

Table 8

Zero-Order Correlations for Dietary Variables at Baseline and Year 1 (N = 20,380)

Variable (unit)	1	2	3	4	5	6
1. Energy from fat (%)–B	–	-.25*	-.12*	.32*	-.17*	-.09*
2. Fruit/vegetable (servings) –B		–	.24*	-.13*	.56*	.19*
3. Whole grains (servings) –B			–	-.06*	.17*	.52*
4. Energy from fat (%)–Y1				–	-.46*	-.26*
5. Fruit/vegetable (servings)–Y1					–	.29*
6. Whole grains (servings)–Y1						–

Note. *df* = 20,378. B = Baseline; Y1 = Year 1.
**p* < .001.

Table 9

Quartiles of Dietary Change (Year 1 – Baseline) for Targeted Dietary Variables

	Intervention[a]		Control[b]		Total[c]	
Variable (unit)	*n*	%	*n*	%	*n*	%
Energy from fat (%) quartile[d]						
-12.61 or less	4,445	54.3	650	5.3	5,095	25.0
-12.60 to -5.40	2,456	30.0	2,639	21.7	5,095	25.0
-5.39 to -0.34	837	10.2	4,258	34.9	5,095	25.0
-0.33 or greater	455	5.6	4,640	38.1	5,095	25.0
Fruit/vegetable (servings) quartile[e]						
1.72 or greater	3,289	40.1	1,806	14.8	5,095	25.0
0.49 to 1.71	2,075	25.3	3,026	24.8	5,101	25.0
-0.45 to 0.48	1,539	18.8	3,550	29.1	5,089	25.0
-0.46 or less	1,290	15.8	3,805	31.2	5,095	25.0
Whole grains (servings) quartile[e]						
0.45 or greater	2,789	34.0	2,306	18.9	5,095	25.0
0.04 to 0.44	2,102	25.7	2,993	24.6	5,095	25.0
-0.34 to 0.03	1,688	20.6	3,407	28.0	5,095	25.0
-0.35 or less	1,614	19.7	3,481	28.6	5,095	25.0

Note. Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. Chi-square tests revealed significant differences between the study arms for each dietary variable quartile.
[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380. [d]For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. [e]For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively.

Table 10

Amount of Moderate to Vigorous Physical Activity (MVPA) and Adherence to MVPA Guidelines at Baseline and Year 1

Variable	Intervention[a]		Control[b]		Total[c]	
MVPA (MET-min/week)	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	315.7	540.2	317.6	553.1	316.5	547.9
Year 1	459.1	683.5	448.6	677.0	452.8	679.6
Adherent (≥500 MET-min/week)[d]	*n*	%	*n*	%	*n*	%
Baseline	1,804	22.0	2,688	22.1	4,492	22.0
Year 1	2,581	31.5	3,756	30.8	6,337	31.1

Note. MET = metabolic equivalent.
[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380. [d]MVPA guidelines define nonadherent as <500 MET-minutes per week of MVPA and adherent as ≥500 MET-minutes per week of MVPA. Chi-square tests showed no significant differences between study arms in MVPA adherence at baseline or at year 1.

Table 11

Associations between Sociodemographic Characteristics and MVPA Guideline Adherence at Baseline

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	0.89*	[0.81, 0.98]
65-79 (reference)	1.00	
Region		
Northeast	0.76***	[0.66, 0.86]
South	0.83***	[0.73, 0.94]
Midwest	0.79***	[0.70, 0.91]
West (reference)	1.00	
Race/ethnicity		
Black	0.73***	[0.60, 0.87]
Latino	0.83	[0.62, 1.11]
Other race/ethnic groups	1.06	[0.86, 1.32]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	1.83***	[1.60, 2.10]
Post-high school/some college	1.32***	[1.15, 1.52]
High school or less (reference)	1.00	
Family income		
≥$50,000	1.55***	[1.32, 1.82]
$20,000-<$50,000	1.16	[0.99, 1.36]
Don’t know	1.34*	[1.04, 1.71]
<$20,000 (reference)	1.00	
Marital status		
Never married	0.76*	[0.58, 0.99]
Divorced/separated	0.86*	[0.74, 0.98]
Widowed	0.90	[0.90, 1.02]
Married/living as married (reference)	1.00	

(continued)

Table 11 (*continued*)

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.94	[0.81, 1.08]
Currently employed	0.72***	[0.65, 0.80]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	0.64***	[0.56, 0.74]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.
[a]*n* adherent = 4,492. *n* nonadherent = 15,888. *N* = 20,380.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 12

Associations between Medical History Variables and MVPA Guideline Adherence at Baseline

	≥500 MET-min per week of MVPA[a]	
Variable	Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	0.45*	[0.37, 0.46]
Overweight (25-29.9)	0.66*	[0.58, 0.72]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	0.73*	[0.55, 0.76]
No (reference)	1.00	
High cholesterol ever		
Yes	0.79*	[0.72, 0.94]
No (reference)	1.00	
Hypertension ever		
Yes	0.73*	[0.64, 0.76]
No (reference)	1.00	
CVD ever		
Yes	0.94	[0.74, 0.94]
No (reference)	1.00	
Cancer ever		
Yes	0.89	[0.84, 1.26]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.

[a] n adherent = 4,492. n nonadherent = 15,888. N = 20,380.

*$p < .0001$.

Table 13

Associations between Psychosocial Variables and MVPA Guideline Adherence at Baseline

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	1.34**	[1.19, 1.51]
23–25	1.14*	[1.02, 1.28]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	1.28**	[1.12, 1.46]
38–42	1.22**	[1.07, 1.40]
33–37	1.14	[0.99, 1.31]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	1.26**	[1.10, 1.46]
5–6	1.21*	[1.05, 1.39]
7–8	1.08	[0.93, 1.26]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	1.24**	[1.08, 1.44]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	2.90**	[2.51, 3.34]
86–95	1.80**	[1.59, 2.04]
76–85	1.39**	[1.20, 1.62]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 4,492. *n* nonadherent = 15,888. *N* = 20,380.
**p* < .001. ***p* < .0001.

Table 14

Associations between Sociodemographic Characteristics and MVPA Guideline Adherence at Year 1

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	1.03	[0.95, 1.12]
65-79 (reference)	1.00	
Region		
Northeast	0.76***	[0.68, 0.86]
South	0.80***	[0.71, 0.89]
Midwest	0.84***	[0.74, 0.94]
West (reference)	1.00	
Race/ethnicity		
Black	0.78***	[0.58, 0.80]
Latino	0.76*	[0.59, 0.99]
Other race/ethnic groups	0.85	[0.70, 1.05]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	1.92***	[1.70, 2.16]
Post-high school/some college	1.34***	[1.18, 1.51]
High school or less (reference)	1.00	
Family income		
≥$50,000	1.88***	[1.63, 2.18]
$20,000-<$50,000	1.26***	[1.09, 1.46]
Don't know	1.46***	[1.17, 1.82]
<$20,000 (reference)	1.00	
Marital status		
Never married	0.62***	[0.48, 0.79]
Divorced/separated	0.82***	[0.73, 0.93]
Widowed	0.82***	[0.73, 0.93]
Married/living as married (reference)	1.00	

(continued)

Table 14 (*continued*)

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.94	[0.83, 1.07]
Currently employed	0.81***	[0.73, 0.89]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	0.64***	[0.57, 0.72]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.
[a] *n* adherent = 6,337. *n* nonadherent = 14,043. *N* = 20,380.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 15

Associations between Medical History Variables and MVPA Guideline Adherence at Year 1

Variable	≥500 MET-min per week of MVPA[a]	
	Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	0.41*	[0.37, 0.46]
Overweight (25-29.9)	0.65*	[0.58, 0.72]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	0.62*	[0.551, 0.76]
No (reference)	1.00	
High cholesterol ever		
Yes	0.82*	[0.72, 0.94]
No (reference)	1.00	
Hypertension ever		
Yes	0.70*	[0.64, 0.76]
No (reference)	1.00	
CVD ever		
Yes	0.84*	[0.74, 0.94]
No (reference)	1.00	
Cancer ever		
Yes	1.03	[0.84, 1.26]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.

[a] *n* adherent = 6,337. *n* nonadherent = 14,043. *N* = 20,380.

**p* < .0001.

Table 16

Associations between Psychosocial Variables and MVPA Guideline Adherence at Year 1

	≥500 MET-min per week of MVPA[a]	
Variable	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	1.53**	[1.37, 1.70]
23–25	1.26**	[1.14, 1.39]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	1.34**	[1.19, 1.51]
38–42	1.31**	[1.17, 1.48]
33–37	1.18*	[1.04, 1.33]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	1.51**	[1.33, 1.72]
5–6	1.39**	[1.23, 1.58]
7–8	1.35**	[1.18, 1.55]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	1.41**	[1.24, 1.61]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	3.54**	[3.10, 4.05]
86–95	2.43**	[2.17, 2.73]
76–85	1.63**	[1.42, 1.85]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 6,337. *n* nonadherent = 14,043. *N* = 20,380.
**p* < .001. ***p* < .0001.

Table 17

Drinks Per Week and Adherence to Alcohol Consumption Guidelines at Baseline and Year 1

Variable	Intervention[a]		Control[b]		Total[c]	
Drinks per week	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	2.05	3.88	2.06	3.90	2.06	3.90
Year 1	2.00	4.01	2.02	4.28	2.01	4.21
Adherent (≤7 drinks per week)[d]	*n*	%	*n*	%	*n*	%
Baseline	7,377	90.0	10,990	90.2	18,367	90.1
Year 1	7,408	90.4	11,041	90.6	18,449	90.5

[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380. [d]Alcohol consumption guidelines define nonadherent as >7 drinks per week for adult women and adherent as ≤7 drinks per week. Chi-square tests showed no significant differences between study arms in alcohol consumption guideline adherence at baseline or year 1.

Table 18

Associations between Sociodemographic Characteristics and Alcohol Consumption Guideline Adherence at Baseline

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	1.08	[0.95, 1.23]
65-79 (reference)	1.00	
Region		
Northeast	1.13	[0.95, 1.34]
South	1.49***	[1.24, 1.78]
Midwest	1.77***	[1.45, 2.15]
West (reference)	1.00	
Race/ethnicity		
Black	2.83***	[2.01, 4.00]
Latino	2.57***	[1.48, 4.44]
Other race/ethnic groups	2.40***	[1.57, 3.65]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	0.45***	[0.37, 0.55]
Post-high school/some college	0.65***	[0.53, 0.81]
High school or less (reference)	1.00	
Family income		
≥$50,000	0.34***	[0.26, 0.44]
$20,000-<$50,000	0.58***	[0.44, 0.76]
Don't know	0.61**	[0.41, 0.91]
<$20,000 (reference)	1.00	
Marital status		
Never married	1.24	[0.86, 1.79]
Divorced/separated	1.26*	[1.03, 1.53]
Widowed	1.28**	[1.06, 1.55]
Married/living as married (reference)	1.00	

(continued)

Table 18 (*continued*)

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.93	[0.77, 1.14]
Currently employed	1.05	[0.90, 1.21]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	1.28**	[1.06, 1.55]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.

[a] *n* adherent = 18,367. *n* nonadherent = 2,013. *N* = 20,380.

**p* < .005. ***p* < .001. ****p* < .0001.

Table 19

Associations between Medical History Variables and Alcohol Consumption Guideline Adherence at Baseline

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	2.60*	[2.19, 3.09]
Overweight (25-29.9)	1.38*	[1.18, 1.60]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	3.57*	[2.27, 5.64]
No (reference)	1.00	
High cholesterol ever		
Yes	1.48*	[1.19, 1.86]
No (reference)	1.00	
Hypertension ever		
Yes	1.29*	[1.12, 1.49]
No (reference)	1.00	
CVD ever		
Yes	1.18	[0.98, 1.42]
No (reference)	1.00	
Cancer ever		
Yes	0.96	[0.71, 1.30]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.
[a]*n* adherent = 18,367. *n* nonadherent = 2,013. *N* = 20,380.
*$p < .0001$.

Table 20

Associations between Psychosocial Variables and Alcohol Consumption Guideline Adherence at Baseline

	≤7 drinks per week[a]	
Variable	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	0.67***	[0.57, 0.80]
23–25	0.75***	[0.64, 0.88]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	0.68***	[0.57, 0.83]
38–42	0.77***	[0.63, 0.93]
33–37	0.81*	[0.66, 0.98]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	0.72***	[0.59, 0.89]
5–6	0.69***	[0.57, 0.85]
7–8	0.76**	[0.61, 0.94]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	0.75***	[0.61, 0.92]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	0.52***	[0.43, 0.64]
86–95	0.65***	[0.55, 0.78]
76–85	0.87	[0.71, 1.07]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at baseline. *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 18,367. *n* nonadherent = 2,013. *N* = 20,380.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 21

Associations between Sociodemographic Characteristics and Alcohol Consumption Guideline Adherence at Year 1

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	1.09	[0.96, 1.25]
65-79 (reference)	1.00	
Region		
Northeast	1.14	[0.96, 1.35]
South	1.52**	[1.26, 1.82]
Midwest	1.80**	[1.48, 2.21]
West (reference)	1.00	
Race/ethnicity		
Black	3.24**	[0.23, 4.70]
Latino	2.38**	[1.39, 4.08]
Other race/ethnic groups	2.86**	[1.80, 4.55]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	0.45**	[0.37, 0.55]
Post-high school/some college	0.70**	[0.57, 0.86]
High school or less (reference)	1.00	
Family income		
≥$50,000	0.37**	[0.28, 0.48]
$20,000-<$50,000	0.63**	[0.48, 0.82]
Don't know	0.67	[0.45, 1.01]
<$20,000 (reference)	1.00	
Marital status		
Never married	1.27	[0.87, 1.85]
Divorced/separated	1.18	[0.97, 1.44]
Widowed	1.20	[0.99, 1.56]
Married/living as married (reference)	1.00	

(continued)

Table 21 (*continued*)

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.94	[0.77, 1.14]
Currently employed	1.10	[0.95, 1.28]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	1.36**	[1.12, 1.66]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1. *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.
[a] *n* adherent = 18,449. *n* nonadherent = 1,931. *N* = 20,380.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 22

Associations between Medical History Variables and Alcohol Consumption Guideline Adherence at Year 1

Variable	≤7 drinks per week[a]	
	Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	2.96*	[2.48, 3.53]
Overweight (25-29.9)	1.65*	[1.42, 1.93]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	3.60*	[2.26, 5.74]
No (reference)	1.00	
High cholesterol ever		
Yes	1.50*	[1.20, 1.89]
No (reference)	1.00	
Hypertension ever		
Yes	1.34*	[1.16, 1.55]
No (reference)	1.00	
CVD ever		
Yes	1.09	[0.91, 1.31]
No (reference)	1.00	
Cancer ever		
Yes	0.98	[0.72, 1.34]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1. *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.
[a]n adherent = 18,449. n nonadherent = 1,931. N = 20,380.
*p < .0001.

Table 23

Associations between Psychosocial Variables and Alcohol Consumption Guideline Adherence at Year 1

	≤7 drinks per week[a]	
Variable	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	0.69***	[0.66, 0.92]
23–25	0.78***	[0.58, 0.82]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	0.73***	[0.60, 0.88]
38–42	0.81*	[0.67, 0.98]
33–37	0.82*	[0.67, 0.99]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	0.75**	[0.61, 0.93]
5–6	0.67***	[0.55, 0.82]
7–8	0.76**	[0.61, 0.95]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	0.77**	[0.63, 0.95]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	0.49***	[0.40, 0.60]
86–95	0.62***	[0.52, 0.74]
76–85	0.78*	[0.64, 0.97]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of adherence to guidelines at year 1.*OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 18,449. *n* nonadherent = 1,931. *N* = 20,380.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 24

Smoking Status at Baseline and Year 1

	Intervention[a]		Control[b]		Total[c]	
Smoking status[d]	*n*	%	*n*	%	*n*	%
Baseline						
Smoker	492	6.0	716	5.9	1,208	5.9
Nonsmoker	7,701	94.0	11,471	94.1	19,172	94.1
Year 1						
Smoker	470	5.7	663	5.4	1,133	5.6
Nonsmoker	7,723	94.3	11,524	94.6	19,247	94.4

[a]n = 8,193. [a]n = 12,187. [c]N = 20,380. [d]Chi-square tests showed no significant differences between study arms in smoking status at baseline or year 1.

Table 25

Cigarettes Per Day and Number of Years Smoking among Smokers at Baseline (n = 1,208)

Variable	Intervention[a]		Control[b]		Total[c]	
	n	%	*n*	%	*n*	%
Cigarettes per day						
<1–4	101	20.9	143	20.0	244	20.2
5–14	178	35.9	249	34.8	427	35.4
15–24	149	30.2	224	31.3	373	30.9
≥25	64	12.9	100	14.0	164	13.6
No. of years smoking						
<30	118	24.2	175	24.5	293	24.4
30-39	141	28.9	212	29.7	353	29.3
≥40	229	46.9	328	45.9	557	46.3

Note. Chi-square tests showed no significant differences between study arms in cigarettes per day or number of years smoking.
[a]*n* = 492. [a]*n* = 716. [c]*n* missing = 3.

Table 26

Cigarettes Per Day among Smokers at Year 1 (n = 1,133)

Cigarettes per day	Intervention[a]		Control[b]		Total[c]	
	n	%	*n*	%	*n*	%
<1–4	107	22.9	158	23.9	265	23.5
5–14	170	36.3	213	32.2	383	33.9
15–24	138	29.5	212	32.0	250	31.0
≥25	53	11.3	79	11.9	132	11.7

Note. A chi-square test showed no significant differences between study arms in cigarettes per day.
[a]$n = 470$. [a]$n = 663$. [c]n missing = 3.

Table 27

Associations between Sociodemographic Characteristics and Nonsmoking at Baseline

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	0.54***	[0.45, 0.64]
65-79 (reference)	1.00	
Region		
Northeast	0.92	[0.74, 1.15]
South	0.97	[0.78, 1.22]
Midwest	1.03	[0.81, 1.30]
West (reference)	1.00	
Race/ethnicity		
Black	0.52***	[0.41, 0.66]
Latino	0.77	[0.49, 1.22]
Other race/ethnic groups	1.07	[0.70, 1.61]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	1.18	[0.94, 1.50]
Post-high school/some college	0.78*	[0.63, 0.97]
High school or less (reference)	1.00	
Family income		
≥$50,000	1.77***	[1.38, 2.26]
$20,000-<$50,000	1.34**	[1.06, 1.70]
Don't know	1.49	[0.99, 2.26]
<$20,000 (reference)	1.00	
Marital status		
Never married	0.50***	[0.34, 0.73]
Divorced/separated	0.44***	[0.35, 0.54]
Widowed	0.64***	[0.51, 0.79]
Married/living as married (reference)	1.00	

(continued)

Table 27 (*continued*)

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.63***	[0.50, 0.80]
Currently employed	0.70***	[0.58, 0.84]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	0.64***	[0.52, 0.78]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at baseline. *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.

[a] n smokers = 1,208. n nonsmokers = 19,172. N = 20,380.

*$p < .005$. **$p < .001$. ***$p < .0001$.

Table 28

Associations between Medical History Variables and Nonsmoking at Baseline

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	1.66***	[1.34, 2.05]
Overweight (25-29.9)	1.21	[0.99, 1.48]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	1.21	[0.84, 1.75]
No (reference)	1.00	
High cholesterol ever		
Yes	0.94	[0.74, 1.20]
No (reference)	1.00	
Hypertension ever		
Yes	1.28**	[1.07, 1.53]
No (reference)	1.00	
CVD ever		
Yes	0.95	[0.76, 1.18]
No (reference)	1.00	
Cancer ever		
Yes	0.70*	[0.50, 0.99]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at baseline. *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.
[a]n smokers = 1,208. n nonsmokers = 19,172. N = 20,380.
*$p < .005$. **$p < .001$. ***$p < .0001$.

Table 29

Associations between Psychosocial Variables and Nonsmoking at Baseline

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	1.52*	[1.23, 1.89]
23–25	1.49*	[1.23, 1.81]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	1.80*	[1.42, 2.27]
38–42	1.70*	[1.35, 2.13]
33–37	1.40*	[1.12, 1.74]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	1.73*	[1.36, 2.21]
5–6	1.55*	[1.23, 1.95]
7–8	1.09	[0.86, 1.38]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	1.75*	[1.43, 2.15]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	1.18	[0.91, 1.54]
86–95	1.08	[0.88, 1.32]
76–85	1.12	[0.88, 1.42]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at baseline. *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 19,172. *n* nonadherent = 1,208. *N* = 20,380.
**p* < .0001.

Table 30

Associations between Sociodemographic Characteristics and Nonsmoking at Year 1

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Age		
50-64	0.55***	[0.46, 0.67]
65-79 (reference)	1.00	
Region		
Northeast	0.89	[0.71, 1.12]
South	0.98	[0.78, 1.23]
Midwest	1.07	[0.84, 1.37]
West (reference)	1.00	
Race/ethnicity		
Black	0.54***	[0.42, 0.69]
Latino	0.81	[0.50, 1.30]
Other race/ethnic groups	1.07	[0.70, 1.64]
Non-Hispanic White (reference)	1.00	
Education		
College degree or higher	1.23	[0.97, 1.57]
Post-high school/some college	0.82	[0.66, 1.03]
High school or less (reference)	1.00	
Family income		
≥$50,000	1.73***	[1.34, 2.24]
$20,000-<$50,000	1.31*	[1.03, 1.67]
Don't know	1.69*	[1.08, 2.65]
<$20,000 (reference)	1.00	
Marital status		
Never married	0.50***	[0.34, 0.73]
Divorced/separated	0.48***	[0.39, 0.60]
Widowed	0.66***	[0.53, 0.84]
Married/living as married (reference)	1.00	

(continued)

Table 30 (*continued*)

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Employment status		
Not working	0.64***	[0.51, 0.82]
Currently employed	0.72***	[0.60, 0.87]
Retired (reference)	1.00	
HRT trial enrollment		
Yes	0.67***	[0.54, 0.82]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at year 1. *OR* = odds ratio; CI = confidence interval; HRT = hormone replacement therapy trial.
[a]n smokers = 1,133. n nonsmokers = 19,247. N = 20,380.
*$p < .005$. **$p < .001$. ***$p < .0001$.

Table 31

Associations between Medical History Variables and Nonsmoking at Year 1

Variable	Nonsmoking[a] Unadjusted *OR*	99.5% CI
BMI		
Obese (≥30)	1.64**	[1.32, 2.04]
Overweight (25-29.9)	1.15	[0.94, 1.41]
Normal (<25; reference)	1.00	
Diabetes ever		
Yes	1.13	[0.78, 1.63]
No (reference)	1.00	
High cholesterol ever		
Yes	0.93	[0.73, 1.20]
No (reference)	1.00	
Hypertension ever		
Yes	1.25*	[1.04, 1.50]
No (reference)	1.00	
CVD ever		
Yes	0.97	[0.77, 1.22]
No (reference)	1.00	
Cancer ever		
Yes	0.65*	[0.46, 0.91]
No (reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at year 1. *OR* = odds ratio; CI = confidence interval; BMI = body mass index; CVD = cardiovascular disease.
[a]*n* smokers = 1,133. *n* nonsmokers = 19,247. *N* = 20,380.
*$p < .001$. **$p < .0001$.

Table 32

Associations between Psychosocial Variables and Nonsmoking at Year 1

Variable	Nonsmoking[a]	
	Unadjusted *OR*	99.5% CI
Optimism		
26–30 (high)	1.43**	[1.18, 1.75]
23–25	1.44**	[1.15, 1.78]
6–22 (low; reference)	1.00	
Social support		
43–45 (high)	1.80**	[1.40, 2.29]
38–42	1.70**	[1.21, 1.92]
33–37	1.31*	[1.04, 1.65]
9–32 (none/low; reference)	1.00	
Social strain		
4 (none)	1.74**	[1.35, 2.24]
5–6	1.49**	[1.17, 1.89]
7–8	1.03	[0.81, 1.31]
9–20 (high; reference)	1.00	
Depression status		
Not depressed	1.67**	[1.35, 2.07]
Depressed (reference)	1.00	
Physical functioning		
96–100 (high)	1.12	[0.86, 1.47]
86–95	1.09	[0.88, 1.34]
76–85	1.13	[0.88, 1.44]
0–75 (low; reference)	1.00	

Note. Individual binary logistic regressions were conducted for each variable, solving for the odds of nonsmoking at year 1. *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent = 19,247. *n* nonadherent = 1,133. *N* = 20,380.
**p* < .001. ***p* < .0001.

Table 33

Associations between Pairs of Untargeted Health Behaviors at Baseline and Year 1

Health behavior pair[a]	%	*OR*	99.5% CI
Baseline			
MVPA x moderate drinking	19.2	0.67*	[0.58, 0.77]
MVPA x nonsmoking	21.1	1.59*	[1.27, 2.01]
Moderate drinking x nonsmoking	85.2	1.84*	[1.46, 2.31]
Year 1			
MVPA x moderate drinking	27.4	0.67*	[0.58, 0.77]
MVPA x nonsmoking	29.9	1.71*	[1.39, 2.10]
Moderate drinking x nonsmoking	85.9	1.93*	[1.52, 2.45]

Note. Adherence to one behavioral guideline given adherence on the second is modeled. *OR* = odds ratio; CI = confidence interval; MVPA = moderate to vigorous physical activity.
[a]Adherence to a health behavior was defined as ≥500 MET-minutes of MVPA, ≤7 drinks per week (moderate drinking), and nonsmoking.
*$p < .0001$.

Table 34

Prevalence of Health-Risk Behaviors at Baseline

	Intervention[a]		Control[b]		Total[c]	
No. of risk behaviors	*n*	%	*n*	%	*n*	%
0	1,488	18.2	2,279	18.7	3,767	18.5
1	5,778	70.5	8,492	69.7	14,270	70.0
2	862	10.5	1,328	10.9	2,190	10.8
3	65	0.8	88	0.7	153	0.8

Note. Health-risk behaviors were dichotomized according to guidelines and included physical activity (<500 MET-minutes of moderate to vigorous physical activity per week), alcohol consumption (>7 drinks per week), and smoking (current smoker). A chi-square test did not show significant differences between study arms in the number of health-risk behaviors at baseline.

[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380.

Table 35

Prevalence of Health-Risk Behavior Combinations at Baseline

				Intervention[a]		Control[b]		Total[c]	
No. of risk behaviors	Lack of MVPA	Heavy drinking	Smoking	*n*	%	*n*	%	*n*	%
0	−	−	−	1,488	18.2	2,279	18.7	3,767	18.5
1	+	−	−	5,479	66.9	8,108	66.5	13,587	66.7
	−	+	−	233	2.8	306	2.5	539	2.6
	−	−	+	66	0.8	78	0.6	144	0.7
2	+	+	−	501	6.1	778	6.4	1,279	6.3
	+	−	+	344	4.2	525	4.3	869	4.3
	−	+	+	17	0.2	25	0.2	42	0.2
3	+	+	+	65	0.8	88	0.7	153	0.8

Note. Health-risk behaviors were dichotomized according to guidelines and included physical activity (<500 MET-minutes of moderate to vigorous physical activity per week), alcohol consumption (>7 drinks per week), and smoking (current smoker). A chi-square test did not show significant differences between study arms in the combinations of health-risk behaviors at baseline. + = presence of the health-risk behavior; − = absence of the health-risk behavior.
[a]*n* = 8,193. [a]*n* = 12,187. [c]*N* = 20,380.

Table 36

Prevalence of Health-Risk Behaviors at Year 1

No. of risk behaviors	Intervention[a]		Control[b]		Total[c]	
	n	%	*n*	%	*n*	%
0	2,168	26.5	3,218	26.4	5,386	26.4
1	5,233	63.9	7,781	63.9	13,014	63.9
2	742	9.1	1,105	9.1	1,847	9.1
3	50	0.6	83	0.7	133	0.7

Note. Health-risk behaviors were dichotomized according to guidelines and included physical activity (<500 MET-minutes of moderate to vigorous physical activity per week), alcohol consumption (>7 drinks per week), and smoking (current smoker). A chi-square test did not show significant differences between study arms in the number of health-risk behaviors at year 1. [a]n = 8,193. [a]n = 12,187. [c]N = 20,380.

Table 37

Prevalence of Health-Risk Behavior Combinations at Year 1

No. of risk behaviors	Lack of MVPA	Heavy drinking	Smoking	Intervention[a]		Control[b]		Total[c]	
				n	%	*n*	%	*n*	%
0	−	−	−	2,168	26.5	3,218	26.4	5,386	26.4
1	+	−	−	4,844	59.1	7,269	59.7	12,113	59.4
	−	+	−	297	3.6	412	3.4	709	3.5
	−	−	+	92	1.1	100	0.8	192	0.9
2	+	+	−	414	5.1	625	5.1	1,039	5.1
	+	−	+	304	3.7	454	3.7	758	3.7
	−	+	+	24	0.3	26	0.2	50	0.3
3	+	+	+	50	0.6	83	0.7	133	0.7

Note. Health-risk behaviors were dichotomized according to guidelines and included physical activity (<500 MET-minutes of moderate to vigorous physical activity per week), alcohol consumption (>7 drinks per week), and smoking (current smoker). A chi-square test did not show significant differences between study arms in the combinations of health-risk behaviors at year 1. + = presence of the health-risk behavior; − = absence of the health-risk behavior.
[a]n = 8,193. [a]n = 12,187. [c]N = 20,380.

Table 38

Amount of Moderate to Vigorous Physical Activity (MVPA) and Adherence to MVPA Guidelines at Year 1 among Baseline Adherent Participants (n = 4,492)

Variable	Intervention[a]		Control[b]		Total	
MVPA (MET-min/week)	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	1140	620.7	1153	651.9	1148	639.5
Year 1	1083	910.1	1083	890.7	1083	898.5
Adherence at year 1[c]	*n*	%	*n*	%	*n*	%
Nonadherent	517	28.7	758	28.2	1,275	28.4
Adherent	1,287	71.3	1,930	71.8	3,217	71.6

Note. MET = metabolic equivalent.
[a]$n = 1{,}804$. [a]$n = 2{,}688$. [c]MVPA guidelines define nonadherent as <500 MET-minutes per week of MVPA and adherent as ≥500 MET-minutes per week of MVPA. Chi-square tests showed no significant differences between study arms in MVPA adherence at year 1.

Table 39

Association between Dietary Change and Remaining Adherent to MVPA Guidelines at Year 1 among Baseline Adherent Participants (n = 4,492)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	26.3	1.15	[0.86, 1.52]
-12.60 to -5.40	26.0	1.37*	[1.04, 1.80]
-5.39 to -0.34	25.2	1.15	[0.84, 1.57]
-0.33 or greater (reference)	22.5	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	25.7	0.98	[0.74, 1.34]
0.49 to 1.71	24.7	1.02	[0.78, 1.34]
-0.45 to 0.48	23.8	0.95	[0.73, 1.23]
-0.46 or less (reference)	25.8	1.00	
Change in whole grains (servings)			
0.45 or greater	25.4	1.18	[0.90, 1.55]
0.04 to 0.44	25.0	1.03	[0.80, 1.34]
-0.34 to 0.03	24.1	1.08	[0.83, 1.40]
-0.35 or less (reference)	25.5	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining adherent to MVPA guidelines at year 1 are modeled. MVPA = moderate to vigorous physical activity; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 3,217. *n* nonadherent at year 1 = 1,275. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively.
*p = .002.

Table 40

Significant Predictors of Remaining Adherent to MVPA Guidelines at Year 1 among Baseline Adherent Participants (n = 4,492)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
BMI			
Obese (≥30)	28.1	0.69**	[0.53, 0.90]
Overweight (25.0-29.9)	36.0	0.73*	[0.57, 0.93]
Normal (<25.0; reference)	35.8	1.00	
Social strain			
4 (none)	29.7	1.39*	[1.04, 1.86]
5–6	31.9	1.32	[0.99, 1.75]
7–8	20.7	1.26	[0.93, 1.71]
9–20 (high; reference)	17.7	1.00	
Physical functioning			
96–100 (high)	24.1	1.67**	[1.22, 2.29]
86–95	36.4	1.35*	[1.04, 1.76]
76–85	17.9	1.05	[0.78, 1.41]
0–75 (low; reference)	21.6	1.00	
Baseline MVPA (MET-min/week)			
>1380 (high)	25.5	3.93**	[2.91, 5.30]
≤1380 to >945	25.4	2.33**	[1.78, 3.03]
≤945 to >690	24.6	1.32*	[1.03, 1.70]
500 to 690 (low; reference)	25.5	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining adherent to MVPA guidelines at year 1 are modeled. Only significant predictors are presented. Other variables in the model include: education, income, HRT trial enrollment, and current depression. MVPA = moderate to vigorous physical activity. BMI = body mass index. MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 3,217. *n* nonadherent at year 1 = 1,275.
**p* < .005. ***p* < .001.

Table 41

Amount of Moderate to Vigorous Physical Activity (MVPA) and Adherence to MVPA Guidelines at Year 1 among Baseline Nonadherent Participants (n = 15,888)

Variable	Intervention[a]		Control[b]		Total	
MVPA (MET-min/week)	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	81.6	136.1	81.1	136.6	81.3	136.4
Year 1	282.9	473.5	269.0	466.2	274.6	369.2
Adherence at year 1[c]	*n*	%	*n*	%	*n*	%
Nonadherent	5,095	79.8	7,673	80.8	12,768	80.4
Adherent	1,294	20.2	1,826	19.2	3,120	19.6

Note. MET = metabolic equivalent.
[a]*n* = 6,389. [a]*n* = 9,499. [c]MVPA guidelines define nonadherent as <500 MET-minutes per week of MVPA and adherent as ≥500 MET-minutes per week of MVPA. Chi-square tests showed no significant differences between study arms in MVPA adherence at year 1.

Table 42

Association between Dietary Change and Becoming MVPA Adherent at Year 1 among Baseline Nonadherent Participants (n = 15,888)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	24.6	1.48**	[1.24, 1.76]
-12.60 to -5.40	24.7	1.36**	[1.15, 1.60]
-5.39 to -0.34	25.0	1.21*	[1.02, 1.43]
-0.33 or greater (reference)	25.7	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	24.8	1.07	[0.91, 1.27]
0.49 to 1.71	25.1	0.96	[0.82, 1.13]
-0.45 to 0.48	25.3	0.88	[0.74, 1.03]
-0.46 or less (reference)	24.7	1.00	
Change in whole grains (servings)			
0.45 or greater	24.9	0.95	[0.81, 1.11]
0.04 to 0.44	25.0	0.94	[0.80, 1.10]
-0.34 to 0.03	25.2	0.87	[0.74, 1.02]
-0.35 or less (reference)	24.9	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of becoming adherent to MVPA guidelines at year 1 are modeled. MVPA = moderate to vigorous physical activity; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 3,120. *n* nonadherent at year 1 = 12,768. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively.
**p* < .005. ***p* < .001.

Table 43

Significant Predictors of Becoming Adherent to MVPA Guidelines at Year 1 among Baseline Nonadherent Participants (n = 15,888)[a]

Variable	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	24.6	1.49**	[1.26, 1.77]
-12.60 to -5.40	24.7	1.35**	[1.14, 1.60]
-5.39 to -0.34	25.0	1.16	[0.98, 1.38]
-0.33 or greater (reference)	25.7	1.00	
Region			
Northeast	23.1	0.80*	[0.68, 0.94]
South	24.1	0.87	[0.74, 1.03]
Midwest	21.5	0.94	[0.80, 1.11]
West (reference)	31.3	1.00	
Education			
College degree or higher	36.6	1.25*	[1.05, 1.49]
Post-high school/some college	40.4	1.15	[0.98, 1.36]
High school or less (reference)	23.0	1.00	
Marital status			
Never married	4.0	0.65*	[0.46, 0.93]
Divorced/separated	15.1	0.98	[0.82, 1.18]
Widowed	16.4	0.96	[0.80, 1.15]
Married/living as married (reference)	64.5	1.00	
BMI			
Obese (≥30)	40.9	0.71***	[0.60, 0.83]
Overweight (25-29.9)	35.6	0.85*	[0.73, 0.98]
Normal (<25; reference)	23.5	1.00	
Optimism			
26–30 (high)	25.7	1.23**	[1.04, 1.44]
23–25	37.7	1.08	[0.93, 1.25]
6–22 (low; reference)	36.6	1.00	

(continued)

Table 43 (*continued*)

Variable	%	Adjusted *OR*	99.5% CI
Social strain			
4 (none)	27.0	1.16	[0.96, 1.41]
5–6	30.5	1.10	[0.92, 1.33]
7–8	22.1	1.27**	[1.06, 1.54]
9–20 (high; reference)	20.4	1.00	
Physical functioning			
96–100 (high)	13.2	2.10***	[1.72, 2.57]
86–95	32.1	1.97***	[1.67, 2.31]
76–85	20.5	1.46***	[1.22, 1.75]
0–75 (low; reference)	34.2	1.00	
Baseline MVPA (MET-min/week)			
>135 (high)	20.6	2.75***	[2.41, 3.14]
>0 to ≤135	14.8	1.29***	[1.09, 1.53]
0 (none; reference)	64.6	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of becoming adherent to MVPA guidelines at year 1 are modeled. Only significant predictors are presented. Other variables in the model include: age, race/ethnicity, income, HRT trial enrollment, diabetes ever, hypertension ever, social support, and current depression. MVPA = moderate to vigorous physical activity; BMI = body mass index; MET = metabolic equivalent; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 3,120. *n* nonadherent at year 1 = 12,768. [b]Quartiles for change in energy from fat were calculated using change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most.
*$p < .005$. **$p < .001$. ***$p < .0001$.

Table 44

Number of Drinks Per Week and Adherence to Alcohol Consumption Guidelines at Year 1 among Baseline Adherent Participants (n = 18,367)

Variable	Intervention[a]		Control[b]		Total	
Drinks per week	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	1.01	1.59	1.02	1.59	1.02	1.59
Year 1	1.17	2.48	1.15	2.44	1.17	2.45
Adherence at year 1[c]	*n*	%	*n*	%	*n*	%
Nonadherent	244	3.3	357	3.3	601	3.3
Adherent	7,133	96.7	10,633	96.7	17,766	96.7

[a]*n* = 7,377. [a]*n* = 10,990. [c]Alcohol consumption guidelines define nonadherent as >7 drinks per week for adult women and adherent as ≤7 drinks per week. Chi-square tests showed no significant differences between study arms in alcohol consumption guideline adherence at year 1.

Table 45

Association between Dietary Change and Remaining Adherent to Alcohol Guidelines at Year 1 among Baseline Adherent Participants (n = 18,367)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	24.9	0.59**	[0.40, 0.86]
-12.60 to -5.40	25.1	0.63*	[0.44, 0.91]
-5.39 to -0.34	24.9	0.72	[0.50, 1.04]
-0.33 or greater (reference)	25.1	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	25.1	0.93	[0.64, 1.35]
0.49 to 1.71	24.9	0.78	[0.55, 1.11]
-0.45 to 0.48	24.8	0.81	[0.50, 1.15]
-0.46 or less (reference)	25.2	1.00	
Change in whole grains (servings)			
0.45 or greater	25.2	0.77	[0.54, 1.08]
0.04 to 0.44	24.9	0.76	[0.54, 1.07]
-0.34 to 0.03	24.8	0.87	[0.61, 1.23]
-0.35 or less (reference)	25.1	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining adherent to alcohol consumption guidelines at year 1 are modeled. *OR* = odds ratio; CI = confidence interval. [a]*n* adherent at year 1 = 17,766. *n* nonadherent at year 1 = 601. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively. *$p < .001$. **$p < .0001$.

Table 46

Significant Predictors of Remaining Adherent to Alcohol Consumption Guidelines at Year 1 among Baseline Adherent Participants (n = 18,367)[a]

Variable	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	24.9	0.56**	[0.39, 0.81]
-12.60 to -5.40	25.1	0.61*	[0.42, 0.88]
-5.39 to -0.34	24.9	0.74	[0.51, 1.08]
-0.33 or greater (reference)	25.1	1.00	
Region			
Northeast	22.3	1.15	[0.84, 1.60]
South	24.4	1.15	[0.82, 1.62]
Midwest	21.7	1.61**	[1.13, 2.31]
West (reference)	31.6	1.00	
BMI			
Obese (≥30)	39.7	1.65**	[1.19, 2.29]
Overweight (25-29.9)	35.3	1.45*	[1.09, 1.93]
Normal (<25; reference)	25.0	1.00	
Baseline drinks per week			
>1.35 (high)	25.0	0.02**	[0.01, 0.03]
>0.21 to ≤1.35	5.2	0.18**	[0.08, 0.41]
>0 to ≤0.21	24.0	0.68	[0.12, 3.94]
0 (none; reference)	45.8	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining adherent to alcohol consumption guidelines at year 1 are modeled. Only significant predictors are presented. Other variables in the model include: race/ethnicity, education, income, diabetes ever, and physical functioning. BMI = body mass index. *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 17,766. *n* nonadherent at year 1 = 601. [b]Quartiles for change in energy from fat were calculated using change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most.
**p* < .001. ***p* < .0001.

Table 47

Number of Drinks Per Week and Adherence to Alcohol Consumption Guidelines at Year 1 among Baseline Heavy Drinkers (n = 2,013)

Variable	Intervention[a]		Control[b]		Total	
Drinks per week	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline	11.46	5.46	11.54	5.63	11.51	5.56
Year 1	9.55	7.06	9.87	7.95	9.74	7.60
Adherence at year 1[c]	*n*	%	*n*	%	*n*	%
Nonadherent	541	66.3	789	65.9	1,330	66.1
Adherent	275	33.7	408	34.1	683	33.9

[a]*n* = 816. [a]*n* = 1,197. [c]Alcohol consumption guidelines define nonadherent as >7 drinks per week for adult women (heavy drinking) and adherent as ≤7 drinks per week. Chi-square tests showed no significant differences between study arms in alcohol consumption guideline adherence at year 1.

Table 48

Association between Dietary Change and Becoming Adherent to Alcohol Guidelines at Year 1 among Baseline Heavy Drinkers (n = 2,013)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	26.1	0.88	[0.59, 1.33]
-12.60 to -5.40	24.1	0.83	[0.56, 1.22]
-5.39 to -0.34	25.6	0.85	[0.58, 1.24]
-0.33 or greater (reference)	24.2	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	23.8	0.97	[0.64, 1.47]
0.49 to 1.71	26.5	0.70	[0.47, 1.03]
-0.45 to 0.48	26.2	1.04	[0.72, 1.51]
-0.46 or less (reference)	23.5	1.00	
Change in whole grains (servings)			
0.45 or greater	23.5	0.79	[0.54, 1.17]
0.04 to 0.44	25.8	0.68*	[0.47, 0.99]
-0.34 to 0.03	26.8	0.66*	[0.45, 0.95]
-0.35 or less (reference)	23.9	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of becoming adherent to alcohol consumption guidelines at year 1 are modeled. *OR* = odds ratio; CI = confidence interval. [a]*n* adherent at year 1 = 683. *n* nonadherent at year 1 = 1,330. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively. *$p < .005$.

Table 49

Significant Predictors of Becoming Adherent to Alcohol Consumption Guidelines at Year 1 among Baseline Heavy Drinkers (n = 2,013)[a]

Variable	%	Adjusted *OR*	99.5% CI
Change in whole grains (servings)[b]			
0.45 or greater	23.5	0.76	[0.51, 1.13]
0.04 to 0.44	25.8	0.60**	[0.40, 0.89]
-0.34 to 0.03	26.8	0.65*	[0.44, 0.96]
-0.35 or less (reference)	23.9	1.00	
Race/ethnicity			
Black	3.6	2.62**	[1.27, 5.41]
Latino	1.4	1.05	[0.33, 3.28]
Other race/ethnic groups	2.4	1.85	[0.77, 4.42]
Non-Hispanic White (reference)	92.7	1.00	
BMI			
Obese (≥30)	23.2	1.88***	[1.30, 2.73]
Overweight (25-29.9)	39.0	1.75***	[1.26, 2.42]
Normal (<25; reference)	37.8	1.00	
Baseline drinks per week			
≤7.65 (low)	24.8	4.12***	[2.66, 6.39]
>7.65 to ≤9.20	25.2	5.45***	[3.52, 8.46]
>9.20 to ≤14.04	24.8	2.50***	[1.60, 3.92]
>14.04 (high; reference)	25.2	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of becoming adherent to alcohol consumption guidelines at year 1 are modeled. BMI = body mass index; *OR* = odds ratio; CI = confidence interval.
[a]*n* adherent at year 1 = 683. *n* nonadherent at year 1 = 1,330. [b]Quartiles for change in whole grains servings were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the value of 0.45 or greater represents the upper quartile of change in whole grains servings.
**p* < .005. ***p* < .001. ****p* < .0001.

Table 50

Smoking Status at Year 1 among Baseline Nonsmokers (n = 19,172)

	Intervention[a]		Control[b]		Total	
Smoking status[c]	*n*	%	*n*	%	*n*	%
Smoker	49	0.6	82	0.7	131	0.7
Nonsmoker	7,652	99.4	11,389	99.3	19,041	99.3

[a]*n* = 7,701. [a]*n* = 11,471. [c]A chi-square test showed no significant differences between study arms in smoking status at year 1.

Table 51

Association between Dietary Change and Remaining a Nonsmoker at Year 1 among Baseline Nonsmokers (n = 19,172)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	24.9	1.24	[0.54, 2.83]
-12.60 to -5.40	25.1	1.43	[0.65, 3.14]
-5.39 to -0.34	25.1	2.32	[0.96, 5.62]
-0.33 or greater (reference)	24.9	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	25.0	0.97	[0.39, 2.38]
0.49 to 1.71	25.0	0.98	[0.42, 2.26]
-0.45 to 0.48	24.9	0.88	[0.40, 1.94]
-0.46 or less (reference)	25.1	1.00	
Change in whole grains (servings)			
0.45 or greater	25.0	2.39	[0.95, 6.00]
0.04 to 0.44	25.0	1.29	[0.61, 2.71]
-0.34 to 0.03	24.9	1.47	[0.68, 3.17]
-0.35 or less (reference)	25.1	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining a nonsmoker at year 1 are modeled. *OR* = odds ratio; CI = confidence interval.
[a]*n* nonsmokers at year 1 = 19,041. *n* smokers at year 1 = 131. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively.

Table 52

Smoking Status at Year 1 among Baseline Smokers (n = 1,208)

	Intervention[a]		Control[b]		Total	
Smoking status[c]	*n*	%	*n*	%	*n*	%
Smoker	421	85.6	581	81.1	1,002	83.0
Nonsmoker	71	14.1	135	18.9	206	17.0

[a]*n* = 492. [a]*n* = 716. [c]A chi-square test showed no significant differences between study arms in smoking status at year 1.

Table 53

Association between Dietary Change and Becoming a Nonsmoker at Year 1 among Baseline Smokers (n = 1,208)[a]

Variable (unit)	%	Adjusted *OR*	99.5% CI
Change in energy from fat (%)[b]			
-12.61 or less	25.3	0.90	[0.40, 2.04]
-12.60 to -5.40	24.1	1.33	[0.65, 2.71]
-5.39 to -0.34	23.7	1.01	[0.49, 2.11]
-0.33 or greater (reference)	26.9	1.00	
Change in fruit/vegetable (servings)			
1.72 or greater	26.2	0.87	[0.44, 1.94]
0.49 to 1.71	25.1	0.86	[0.41, 1.81]
-0.45 to 0.48	25.5	0.87	[0.42, 1.80]
-0.46 or less (reference)	23.2	1.00	
Change in whole grains (servings)			
0.45 or greater	24.9	2.16	[0.98, 4.79]
0.04 to 0.44	25.8	1.46	[0.65, 3.27]
-0.34 to 0.03	26.8	1.70	[0.78, 3.73]
-0.35 or less (reference)	22.5	1.00	

Note. A multivariate binary logistic regression was conducted. Odds of remaining a nonsmoker at year 1 are modeled. *OR* = odds ratio; CI = confidence interval.
[a]*n* nonsmokers at year 1 = 206. *n* smokers at year 1 = 1,002. [b]Quartiles for change in each targeted dietary variable were calculated using the change scores (year 1 minus baseline; see Table 7) for the whole study sample. For energy from fat, a greater decrease indicated greater change in the desired direction. Therefore, the value of -12.61 or less represents participants who were in the upper quartile of change and thus decreased their energy from fat the most. For fruit and vegetable servings and whole grains servings, a greater increase indicated greater change in the desired direction. Therefore, the values of 1.72 or greater and 0.45 or greater represent the upper quartile of change for fruit and vegetable servings and whole grains servings, respectively.

Table 54

Cigarettes Per Day at Year 1 among Participants Who Were Smokers at Both Baseline and Year 1 (n = 1,001)

	Intervention[a]		Control[b]		Total	
Cigarettes per day	*n*	%	*n*	%	*n*	%
<1–4	85	20.2	112	19.3	197	19.7
5–14	151	36.0	197	33.9	348	34.8
15–24	132	31.4	198	34.1	330	33.0
≥25	52	12.4	74	12.7	126	12.5

Note. A chi-square test showed no significant differences between study arms in cigarettes per day.
[a]$n = 420$. [a]$n = 581$.

Table 55

Model Fit Indices for Models with 1–3 Classes (N = 20,380)

Latent classes	Log-likelihood	*df*	AIC	Difference in AIC	BIC	Difference in BIC	Entropy	BLRT (*p*)
1	-45,298	57	15,455	__	15,502	__	1.00	__
2	-42,149	50	9,171	6,284	9,274	6,228	0.98	.01
3	**-39,794**	**43**	**4,475**	**4,696**	**4,633**	**4,611**	**0.93**	**.01**

Note. AIC = Akaike information criterion, measure of model fit, with smaller values indicating better fit; BIC = Bayesian information criterion, measure of model fit, with smaller values indicating better fit; Entropy = measure of the accuracy of classification of participants in latent classes and of class differentiation and ranges from 0 to 1, with higher values indicating better classification; BLRT = bootstrap likelihood ratio test, a test of the significance of differences in model fit with the addition of one more latent class. $p = .01$ indicates a significant change in model fit with a change in the number of latent classes. The three-class solution was retained (boldface).

Table 56

Latent Class Prevalences and Item-Response Probabilities for the Three-Latent-Class Model (N = 20,380)

	Latent Class					
	Lack of MVPA (85%)		Heavy drinkers (10%)		Smokers (5%)	
Behavior[a]	Baseline	Year 1	Baseline	Year 1	Baseline	Year 1
≥500 MET-min/wk	.21	.30	.33	.43	.14	.20
≤7 drinks/wk	**.99**	**.99**	.23	.25	**.84**	**.84**
Nonsmoking	**.99**	**.99**	**.99**	**.99**	.03	.05

Note. The percentages in parentheses are the latent class prevalences for each class. Values in the table are item-response probabilities, which represent the probability of adherence to the behavioral guideline for each health behavior, given membership in that particular class. Higher probability (i.e., closer to one) indicates a higher likelihood of adherence to the behavioral guideline at that time point. Item-response probabilities > .5 were interpreted as high probability of meeting a behavioral guideline and were used to interpret the classes. Boldface indicates an item-response probability of > .5. There were no grouping variables included in this model. MVPA = moderate to vigorous physical activity; MET = metabolic equivalent.

[a]Health behaviors were dichotomized according to guidelines and included MVPA (≥500 MET-minutes of MVPA per week), alcohol consumption (≤7 drinks per week), and smoking (nonsmoker).

Table 57

Fit Statistics for Test of Measurement Invariance for the Three-Class Model (N = 20,380)

	G^2	*df*	AIC	BIC	Log-likelihood
Model 1: Item-response probabilities vary between study arms	4,467	87	4,547	4,863	-39,783
Model 2: Item-response probabilities equal between study arms	4,489	105	4,533	4,707	-39,794
$G_2^2 - G_1^2 = 21.70$, $df = 18$, $p = .25$[a]					

Note. Model 1 was a three-class model in which the study arms were permitted to have freely varying item-response probabilities. Model 2 was a three-class model in which the study arms were constrained to have equal item-response probabilities. G^2 = likelihood-ratio statistic, with larger values indicating a better fit between the latent class model and observed data; AIC = Akaike information criterion, measure of model fit, with smaller values indicating better fit; BIC = Bayesian information criterion, measure of model fit, with smaller values indicating better fit.
[a]This is the likelihood-ratio difference test, which tests the null hypothesis that measurement invariance holds across groups, or that both models fit the data equally well. A significant likelihood-ratio difference test suggests that at least one item-response probability parameter differs between groups and that measurement invariance does not hold.

Table 58

Model Fit Indices for Models with 1–3 Classes with Intervention Participants Only (N = 8,193)

Latent classes	Log-likelihood	*df*	AIC	Difference in AIC	BIC	Difference in BIC	Entropy	BLRT (*p*)
1	-18,327	57	6,345	__	6,387	__	1.00	__
2	-16,993	50	3,690	2,655	3,781	2,606	0.98	.01
3	**-16,044**	**43**	**1,806**	**1,884**	**1,946**	**1,835**	**0.93**	**.01**

Note. AIC = Akaike information criterion, measure of model fit, with smaller values indicating better fit; BIC = Bayesian information criterion, measure of model fit, with smaller values indicating better fit; Entropy = measure of the accuracy of classification of participants in latent classes and of class differentiation and ranges from 0 to 1, with higher values indicating better classification; BLRT = bootstrap likelihood ratio test, a test of the significance of differences in model fit with the addition of one more latent class. $p = .01$ indicates a significant change in model fit with a change in the number of latent classes. The three-class solution was retained (boldface).

Table 59

Model Fit Indices for Models with 1–3 Classes with Control Participants Only (N = 12,187)

Latent classes	Log-likelihood	*df*	AIC	Difference in AIC	BIC	Difference in BIC	Entropy	BLRT (*p*)
1	-26,970	57	9,174	__	9,219	__	1.00	__
2	-25,128	50	5,504	3,670	5,601	3,618	0.79	.01
3	**-23,739**	**43**	**2,741**	**2,763**	**2,889**	**2,712**	**0.92**	**.01**

Note. AIC = Akaike information criterion, measure of model fit, with smaller values indicating better fit; BIC = Bayesian information criterion, measure of model fit, with smaller values indicating better fit; Entropy = measure of the accuracy of classification of participants in latent classes and of class differentiation and ranges from 0 to 1, with higher values indicating better classification; BLRT = bootstrap likelihood ratio test, a test of the significance of differences in model fit with the addition of one more latent class. $p = .01$ indicates a significant change in model fit with a change in the number of latent classes. The three-class solution was retained (boldface).

Table 60

Latent Class Prevalences and Item-Response Probabilities for Three-Latent-Class Models Run Separately for Intervention Participants (n = 8,193) and Control Participants (n = 12,187)

	Latent Class					
	Lack of MVPA		Heavy drinkers		Smokers	
Latent class prevalences						
Intervention	.85		.10		.05	
Control	.84		.11		.05	
Item-response probabilities	B	Y1	B	Y1	B	Y1
Intervention						
≥500 MET-min/wk	.21	.30	.35	.46	.17	.24
≤7 drinks/wk	**.99**	**.98**	.19	.25	**.84**	**.84**
Nonsmoking	**.99**	**.99**	**.98**	**.99**	.02	.03
Control						
≥500 MET-min/wk	.22	.30	.31	.42	.13	.18
≤7 drinks/wk	**.99**	**.99**	.26	.25	**.84**	**.84**
Nonsmoking	**.99**	**.99**	**.99**	**.99**	.03	.06

Note. Results are from two separate repeated-measures latent class analyses for the intervention and control groups. Item-response probabilities represent the probability of adherence to the behavioral guideline for each health behavior, given membership in that particular class. Higher probability (i.e., closer to one) indicates a higher likelihood of adherence to the behavioral guideline at that time point. Item-response probabilities > .5 were interpreted as high probability of meeting a behavioral guideline and were used to interpret the classes. Boldface indicates an item-response probability of > .5. B = baseline; Y1 = year 1; MVPA = moderate to vigorous physical activity; MET = metabolic equivalent. Health behaviors were dichotomized according to guidelines and included MVPA (≥500 MET-minutes of MVPA per week), alcohol consumption (≤7 drinks per week), and smoking (nonsmoker).

Table 61

Latent Class Prevalences and Item-Response Probabilities for a Three-Latent-Class Model with Study Arm as a Grouping Variable and Measurement Invariance Applied (N = 20,380)

	Latent Class					
	Lack of MVPA		Heavy drinkers		Smokers	
Latent class prevalences						
Intervention	.85		.10		.05	
Control	.85		.10		.05	
Item-response probabilities	B	Y1	B	Y1	B	Y1
≥500 MET-min/wk	.21	.30	.33	.43	.14	.20
≤7 drinks/wk	**.99**	**.99**	.23	.25	**.84**	**.84**
Nonsmoking	**.99**	**.99**	**.99**	**.99**	.03	.04

Note. Study arm was included as a grouping variable in the analysis, and item-response probabilities were constrained to be equal across the study arms. Item-response probabilities represent the probability of adherence to the behavioral guideline for each health behavior, given membership in that particular class. Higher probability (i.e., closer to one) indicates a higher likelihood of adherence to the behavioral guideline at that time point. Item-response probabilities > .5 were interpreted as high probability of meeting a behavioral guideline and were used to interpret the classes. Boldface indicates an item-response probability of > .5. B = baseline; Y1 = year 1; MVPA = moderate to vigorous physical activity; MET = metabolic equivalent. Health behaviors were dichotomized according to guidelines and included MVPA (≥500 MET-minutes of MVPA per week), alcohol consumption (≤7 drinks per week), and smoking (nonsmoker).

Table 62

Significant Predictors of Latent Class Membership (N = 20,380)

	Latent class				
	Lack of MVPA (n = 16,978)	Heavy drinkers (n = 2,377)		Smokers (n = 1,025)	
Variable	(Reference)	a*OR*	99.5% CI	a*OR*	99.5% CI
Age					
50–64		1.18**	[1.05, 1.32]	0.59**	[0.50, 0.70]
65–79 (reference)		1.00		1.00	
Region					
Northeast		0.90	[0.76, 1.07]	1.06	[0.82, 1.37]
South		0.72**	[0.61, 0.86]	0.82	[0.63, 1.06]
Midwest		0.60**	[0.50, 0.73]	0.85	[0.65, 1.12]
West (reference)		1.00		1.00	
Race/ethnicity					
Black		0.49**	[0.35, 0.68]	1.64**	[1.23, 2.19]
Latino		0.48**	[0.29, 0.81]	0.84	[0.49, 1.42]
Other race/ethnic groups		0.31**	[0.21, 0.47]	0.67	[0.42, 1.08]
Non-Hispanic White (reference)		1.00			
Education					
College degree or higher		1.55**	[1.27, 1.89]	0.89	[0.67, 1.17]
Post-high school/some college		1.22	[1.00, 1.48]	1.26	[0.98, 1.62]
High school or less (reference)		1.00		1.00	
Income					
≥$50,000		2.04**	[1.55, 2.69]	0.84	[0.60, 1.16]
$20,000-<$50,000		1.34*	[1.03, 1.73]	0.92	[0.70, 1.21]
Don't know		1.16	[0.79, 1.70]	0.75	[0.46, 1.24]
<$20,000 (reference)		1.00		1.00	

(continued)

Table 62 (*continued*)

	Latent class				
	Lack of MVPA (n = 16,978)	Heavy drinkers (n = 2,377)		Smokers (n = 1,025)	
Variable	(Reference)	a*OR*	99.5% CI	a*OR*	99.5% CI
Marital status					
Never married		0.95	[0.66, 1.37]	1.90**	[1.24, 2.91]
Divorced/separated		1.07	[0.87, 1.31]	1.74**	[1.34, 2.25]
Widowed		1.02	[0.84, 1.25]	1.70**	[1.29, 2.23]
Married/living as married (reference)		1.00		1.00	
HRT trial enrollment					
Yes		1.01	[0.84, 1.21]	1.52**	[1.21, 1.90]
No (reference)		1.00		1.00	
BMI					
Obese (≥30)		0.52**	[0.44, 0.62]	0.37**	[0.28, 0.48]
Overweight (25-29.9)		0.76**	[0.66, 0.88]	0.70**	[0.56, 0.88]
Normal (<25; reference)		1.00		1.00	
Diabetes ever					
Yes		0.37**	[0.23, 0.57]	0.71	[0.46, 1.09]
No (reference)		1.00		1.00	
Cancer ever					
Yes		1.07	[0.79, 1.44]	1.71**	[1.19, 2.46]
No (ref)		1.00		1.00	
Physical functioning					
96–100 (high)		1.43**	[1.16, 1.76]	0.74	[0.54, 1.01]
86–95		1.16	[0.97, 1.38]	0.82	[0.64, 1.05]
76–85		1.01	[0.83, 1.23]	0.85	[0.65, 1.11]
0–75 (low; reference)		1.00		1.00	

Note. MVPA = moderate to vigorous physical activity; a*OR* = adjusted odds ratio; CI = confidence interval; BMI = body mass index; HRT = hormone replacement therapy trial. Variables that were not significant have been excluded from the table for simplicity and included employment status, high cholesterol ever, hypertension ever, optimism, social support, social strain, and current depression.
*p < .005. **p < .001.

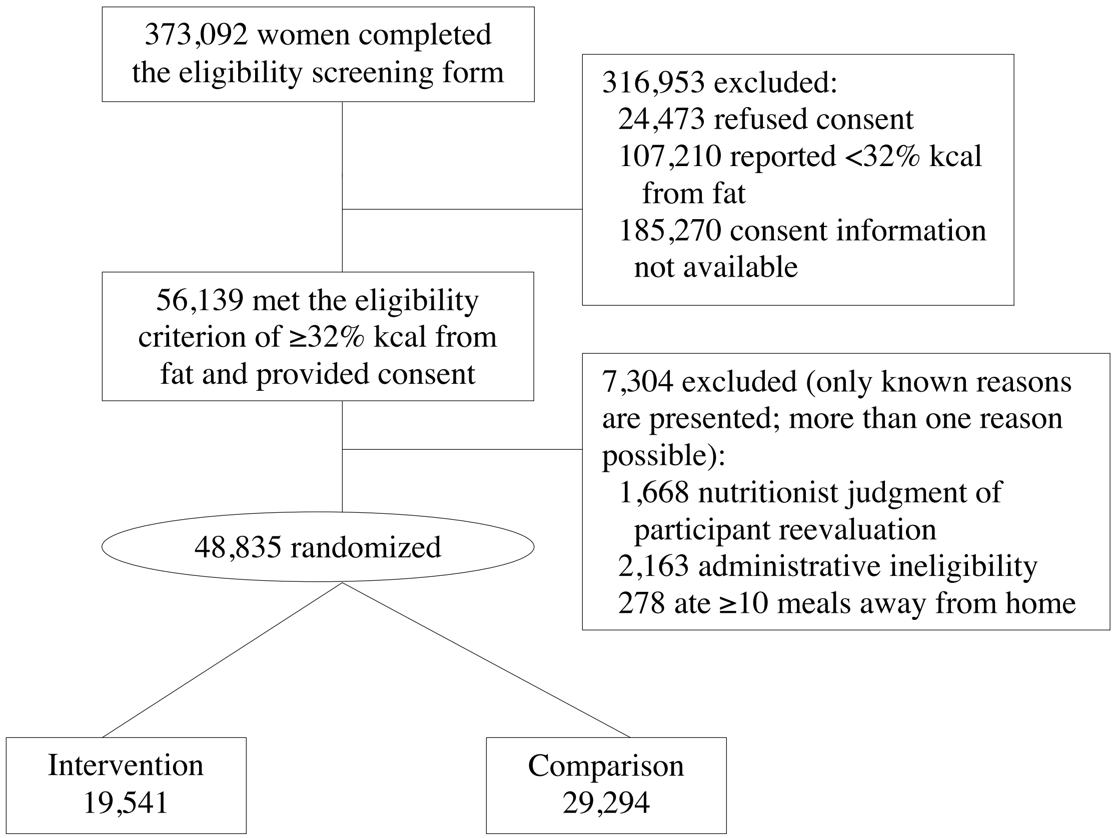

Figure 1. Participant flow through baseline of the WHI DM trial (adapted from Tinker et al., 2007, p. 1157).