MODIFIABLE CONTRIBUTORS TO RURAL DISPARITIES IN TYPE 2 DIABETES AND CARDIOVASCULAR DISEASE

By

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To my parents, Coleen Kivlahan and Bernard Ewigman; to my best friends; and to my grandfather, LB Ewigman

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The prevalence of both type 2 diabetes and cardiovascular disease (CVD) are greater in rural than urban areas. Obesity, smoking, and physical inactivity are known modifiable contributors to both diseases and are also more prevalent in rural areas. The current study utilized a nationally representative database, the Medical Expenditures Panel Survey (MEPS), to test the hypothesis that modifiable lifestyle factors contribute significantly to the association between (1) rurality and diabetes and (2) rurality and CVD. After controlling for nonmodifiable contributors (e.g. demographics, access to health care), rurality and diabetes were not statistically related (p = .082). However, when modifiable contributors were controlled for, the odds ratio decreased (from OR = 1.23 to 1.14) at a significant level (p = .007). For CVD, the association with rurality lost significance only after modifiable factors were added to the model (p = .049 to p = .278). Adding modifiable contributors to the model significantly decreased (p = .01) the odds ratio of having CVD among rural vs. urban populations by 44%. These results support the hypothesis that the association between rurality and both diseases were partially predicted by modifiable contributors beyond nonmodifiable factors. The higher rates of obesity, smoking and physical inactivity seen in rural areas may be contributing to the higher rates of these diabetes and CVD

in rural areas. Effective interventions targeting these factors in rural areas may help ameliorate the rural/urban disparities in type 2 diabetes and CVD.

CHAPTER 1
INTRODUCTION

Overview of the Problem

The prevalence of type 2 diabetes and cardiovascular disease (CVD) is greater in rural than urban areas. Contributors such as obesity, smoking and physical inactivity are known lifestyle contributors to both diseases and are also more prevalent in rural areas. The purpose of the current study is to examine the role of modifiable lifestyle contributors in predicting the prevalence of self-reported type 2 diabetes and CVD in rural and urban populations. The proposed study attempts to quantify the unique contribution of lifestyle factors to these diseases in rural and urban populations on a national level. Understanding this contribution is a first step in determining the role of lifestyle interventions in reducing rural disparities in diabetes and CVD.

Background

We will review the (a) disease burden of diabetes and CVD, (b) national rural/urban differences in the prevalence of these diseases and (c) their contributors in “nonmodifiable” and “modifiable” terms. Sociodemographic risk factors for diabetes and CVD, such as age, region of the country and educational status can be categorized as “nonmodifiable” because of the poor understanding of their association with chronic diseases and the relative difficulty of altering the negative health consequences of these factors. Similarly, access to care is a relatively “nonmodifiable” factor. In comparison, lifestyle factors are “modifiable” in that there is a canon of efficacy and, to a lesser extent, effectiveness literature on the benefit of intervening upon lifestyle factors to improve health outcomes.

The comparatively higher prevalence of diabetes and CVD in rural populations appears to be caused by a combination of nonmodifiable and modifiable factors (Gamm et al., 2003). As will be discussed, rural areas are characterized by both sociodemographic and lifestyle contributors to diabetes. Some (Lee et al., 2007) have argued that higher rates of obesity and chronic diseases are due to disease-promoting environments while others contend that lifestyle factors play a unique role (Patterson et al., 2004). Gamm et al. (2003) has conjectured that as rural areas adopt healthier lifestyles, the higher rates of these diseases will be primarily explained by sociodemographic factors. Currently, however, the unique contribution of these factors has not been examined empirically on a national level. Currently, it has not been shown that modifiable, lifestyle factors contribute to the higher rates of diabetes and CVD in rural populations. This is an important step towards justifying interventions targeting the contributing lifestyle factors in rural areas.

Type 2 Diabetes

Type 2 diabetes differs from type 1 diabetes in that it is usually adult onset, generally treated with oral medications and is largely driven by lifestyle factors (ADA, 2008). Type 2 diabetes is a debilitating chronic disease characterized by the inability to break down and utilize glucose (ADA, 2008). High glucose levels can eventually result in a host of secondary medical complications such as CVD, renal disease and retinopathy. Approximately 16 million Americans have type 2 diabetes (Mainous et al., 2004) and diabetes accounts for over 300,000 deaths in the United States annually (ADA, 1998). The health care cost of diabetes was $100 billion in 1997 (Mokdad et al., 2001). Moreover, strong evidence exists that both the prevalence and incidence have been increasing rapidly (Mokdad et al., 1999; Mokdad et al., 2000; Geiss et al., 2006).

National estimates for the prevalence of diagnosed diabetes in recent years are between five to eight percent of the population (Mokdad et al., 2001; Stagnitti & Pancholi, 2004; Narayan et al., 2006). However, when the known underreporting bias and lack of detection are taken into account, the prevalence is closer to ten percent (Mokdad et al., 2003; Engelgau et al., 2004;

Harris et al., 1998). Narayan et al. (2006) predict that the prevalence of diabetes will double from 2005 to 2050.

Changes in the incidence of diabetes are even more alarming. From 1997 to 2003, the incidence, or new cases, of diabetes increased by 41% (4.9 to 6.9 per 1,000; Geiss et al., 2006). Furthermore, evidence suggests that the increasing incidence of diabetes is being driven by lifestyle factors such as obesity and lack of exercise. Geiss et al. (2006) found that the new cases in 2002-2003 were significantly more likely to be obese than new cases in 1997-1998. This finding underscores the connection between diabetes and lifestyle contributors such as obesity and lack of exercise (Sullivan et al., 2005).

Cardiovascular Disease

CVD refers to a cluster of diseases including coronary heart disease, congestive heart failure and related symptoms of angina, hypertension, stroke and myocardial infarction (AHA, 2008). An important determinant of CVD is lifestyle factors such as cigarette smoking, lack of exercise and obesity (Khot et al., 2003; Alexander et al., 2003). A majority of patients with coronary CVD have these risk factors (Khot et al., 2003). Although CVD can be prevented, treated and in some cases even reversed by lifestyle changes (Ornish et al., 1990), CVD accounts for 900,000 deaths annually and is still the leading cause of death (Cooper et al., 2000; NCHS, 2008). In 2005, the national financial burden of CVD was estimated at nearly $400 billion (CDC, 2005).

Approximately one of every three Americans has one or more types of CVD (AHA, 2008). Despite the high prevalence of most types of CVD, its prevalence has been decreasing since the 1960s (with the exception of congestive cardiovascular failure) and continues to decrease (Cooper et al., 2000). The incidence of most types of CVD has remained stable overall, with increases in certain subgroups and rural populations. Findings in the incidence of CVD must be considered in the context of increasing rates of adverse health conditions such as obesity (Cooper et al., 2000).

Yusuf et al. (2004) found that over 90% of the population attributable risk for CVD can be accounted for by unhealthy lifestyle alone in 95% of people. Similar to diabetes, CVD ameliorates in response to lifestyle intervention. In the Lifestyle Heart Trial, Ornish and colleagues (1990, 1998) found that a five year intensive lifestyle intervention including smoking cessation, improvement in diet and physical activity led to an overall reversal of CVD, including a 91% reduction in anginal events and a 5 year sustained weight loss of 12.8 lbs compared to minimal change in the control group (Ornish et al., 1990; 1998). Lifestyle factors play a crucial role in the onset of CVD.

Rural/Urban Differences in Prevalence of Diabetes and Cardiovascular Disease

Defining rurality. “Rural” areas are defined by their low population density and are typically characterized by high rates of poverty and lower access to services and commodities (Census Bureau, 2007). An “urban” area refers to a central city and surrounding area with a combined population of 50,000 or more and at least 1,000 inhabitants per square mile (Census Bureau, 2007). One of the most commonly used classification system and the one used in this paper for “urban” is metropolitan statistical area (MSA) versus non-metropolitan statistical area (non-MSA) for “rural” as defined by the federal Office of Management and Budget standards to Census 1990 data. These standards generally define MSAs as an urban core with at least 50,000 people and a total population (including the surrounding area) of 100,000. Approximately 20% of the US population is rural or non-MSA (Larson et al., 2003).

Type 2 Diabetes in Rural Populations

The prevalence of type 2 diabetes is disproportionately higher in rural areas, as compared to urban ones. According to the 1995 National Health Interview Survey (NHIS), the self-reported prevalence of diabetes in urban populations is 3.2% compared to 3.6% for rural populations (Cooper et al., 2000; Pearson et al., 1998; Barnett et al. 2000; Gamm et al., 2003). Another NHIS estimate suggests that the self-reported prevalence of diabetes in rural areas was 17 percent higher than in central cities and 11.7 percent higher than in all other classifications of urban areas (Gamm et al., 2003).

Although recent estimates of diabetes incidence in rural vs. urban populations appear to be unavailable, the overall incidence of diabetes is increasing rapidly among certain subgroups. An analysis of people with previously diagnosed diabetes, the National Health and Nutrition Examination Survey III indicated that the prevalence of diabetes is highest among rural African Americans (9.5%), as compared with urban African Americans (6.0%), rural whites (6.5%) and urban whites (4.5%; Mainous et al., 2004). From these prevalence rates, an approximation of the national prevalence of previously diagnosed diabetes in rural areas is 8% compared to 5.25% in the national urban population (Mainous et al., 2004). Another indication that the rural disparity in diabetes is still extant is that new cases of diabetes are characterized by risk factors associated with rurality. Specifically, the incident diabetic cases from 1997-2003 in the NHIS were characterized by older age and obesity status (Geiss et al., 2006).

“Nonmodifiable” Contributors to Diabetes in Rural Populations

Higher rates of diabetes in rural areas are partially caused by nonmodifiable factors. Below we review the contribution of these factors to the prevalence of diabetes in rural populations.

Socioeconomic and demographic

Important sociodemographic risk factors help explain higher rates of diabetes in rural areas. Lower income and educational status, for example, has an inverse trend with the prevalence *and* incidence of diabetes (Geiss et al., 2006; Mokdad et al., 2001; Mokdad et al., 2003). Although the mechanism by which lower socioeconomic status is not specifically known, chronic stress, potentially manifesting as the disturbance of the Hypothalamic-Pituitary-Adrenal axis, has been proposed as an independent mediator of the SES – diabetes association (Rosmond, 2003). Aging has a similar trend with diabetes, however, it only partially accounts for the rising prevalence (Dabney & Gosschalk, 2003). Socioeconomic variables such as low income and educational status as well as higher age are positively associated with rural status (Gamm et al., 2003).

Race and ethnicity

Race is another risk factor for diabetes. Overall, African Americans have the highest rates of diabetes (Mokdad et al., 2001; Mainous et al., 2004). Compared to white men, for example, black men are 100% likelier to have or develop diabetes (Bracanti et al., 2000). Although rural areas have lower proportions of minorities, minority and rural status may have an additive effect on risk for diabetes (Mainous et al., 2004). Data from the third NHANES show rural blacks as having the highest prevalence of diabetes compared to urban blacks, rural whites and urban whites (9.5% vs. 6.0%, 6.5%, and 4.5% respectively; Mainous et al., 2004).

Access to care

Having a usual source of care is seen as an entry point for getting preventive services, which is particularly important for the management of chronic diseases (Larson et al., 2003). Rurality is also associated with a lower likelihood of having health insurance, getting prompt and even routine care (Bolin & Gamm et al., 2003). Rural residents have fewer outpatient visits per year (Larson et al., 2003; Gamm et al., 2003) as well as fewer physicians and hospitals per capita (280 per 100,000 vs. 156 per 100,000; Merwin et al., 2006). Thus rural residents are more likely to live farther away from a usual source of care as compared to urban residents (Larson et al., 2003; Gamm et al., 2003). Almost thirteen percent of rural households have no source of regular care and report fewer ambulatory visits than urban (Pearson et al., 1998; Larson et al., 2003).

The inability to get routine and preventive primary care is problematic because it can lead to late diagnosis and improper management (Bolin & Gamm et al., 2003). This could contribute to the higher prevalence of diabetes through fewer preventive services, late diagnosis and improper management.

Obesogenic environment

Another important structural contributor to diabetes in rural populations is what Lee et al. (2007) refers to as an 'obesogenic' environment—characterized by poor access to physical activity and healthy foods at the same time ready access to unhealthy foods. Given the strong association between diabetes and obesity, 'obesogenic' environmental contributors could partially explain the rural/urban disparity in diabetes (Lee et al., 2007). In California, the ratio of fast food restaurants and convenience stores versus supermarkets and produce venders (Retail Food Environment Index, or RFEI) significantly predicts the prevalence of diabetes even after controlling for demographic characteristics (Designed for Disease, 2008). Rural areas are less likely to have supermarkets than urban areas, so a similar pattern with diabetes could be inferred in rural areas (Kaufman, 1999). Although these structural factors are potential determinants of diabetes, it is crucial to focus on the modifiable contributions to diabetes in rural settings.

"Modifiable" Contributors to Diabetes in Rural Populations

The etiology of type 2 diabetes is also partially explained by modifiable lifestyle behaviors. Obesity and obesity-related lifestyle contributors such as not adhering to physical activity recommendations and a healthy diet are crucial predictors of diabetes (Sullivan et al., 2005; Hu et al., 2001).

Obesity appears to be the strongest lifestyle predictor of diabetes. First, obesity and diabetes prevalence are highly correlated. In 2001, national data suggested that the prevalence of diabetes in normal weight individuals is 4.1%. The prevalence increased according to increases in weight classification (i.e. Overweight = 7.3%, Obese Class 2 = 14.9%, Obese Class 3, 25.6%; Mokdad et al., 2003). Second, there is strong evidence that obesity leads to higher rates of incident diabetes. Geiss et al. (2006) showed that from 1997 to 2003, the incidence of diabetes increased by 41%. In a follow-up study, Narayan et al. (2006) found that obesity was the main contributor to the increase in incidence. Third, there is a direct correlation between weight gain and risk of diabetes. Mokdad (2001) estimated from 1990-1998 using the BRFSS that every 1-kg increase in self-reported weight was associated with 9% increase in the risk of having diabetes. Given these trends between obesity and diabetes, it is particularly concerning that in the 1998 National Health Interview Survey, the prevalence of obesity in rural populations was 20.4% compared to 17.8% in urban (Patterson et al., 2004).

Lack of exercise is another lifestyle predictor of diabetes (Hu et al., 2001). Although physical inactivity is a known cause of obesity, it also predicts diabetes independently of BMI (Sullivan et al., 2005). Improvements in physical activity and diet in clinical trials have been shown to reduce incident diabetes and related risk factors (Mokdad et al., 2001; Sullivan et al., 2005). Similar to obesity, lack of exercise, as well as poor diet, are more prevalent among rural populations (Patterson et al., 2004; Lee et al., 2007).

Cardiovascular Disease in Rural Populations

Until the late 1970s, CVD was less prevalent in rural than urban populations (Pearson et al., 1998). Although the rates of CVD began to decline in urban areas during the latter part of the 20th century, rural areas did not experience the same downward trend. Several factors potentially explain this shift: 1) the increasing mechanization of traditionally physically strenuous rural occupations, 2) the ‘late adoption’ of healthy lifestyles more prominent in urban areas, and 3) better access to modern medical technologies to treat and prevent CVDs in urban areas (Pearson et al., 1998; Patterson et al., 2004). By the 1980s, rurality was a clear risk factor for CVD and by

1996, CVD was 1.34 times more prevalent in rural areas (98.8 per 1,000) compared to urban (72.6 per 1,000; Pearson et al., 1998; Gamm et al., 2003).

“Nonmodifiable” Contributors to Cardiovascular Disease in Rural Populations

The association between CVD and sociodemographic factors is well established (Cooper et al., 2000). The major nonmodifiable risk factors for CVD associated with rural status are age, educational status and poverty (Cooper et al., 2000). CVD is by far the largest cause of mortality among people over 65 (NCHS, 2008). Moreover, the highest proportions of people over the age of 65 reside in rural areas (12% in central counties vs. 15% in most rural counties; Eberhardt et al., 2001).

Socioeconomic and demographic

CVD rates are higher in populations with lower incomes and education (Cooper et al., 2000; Diez-Roux et al., 1997). Being poor and living in poorer neighborhoods is associated with CVD beyond individual-level variables such as race (Cooper et al., 2000; Diez-Roux et al., 1997). Although rates of poverty are high in inner cities, rural areas are also characterized by poverty (Eberhardt et al., 2001; Lee et al., 2007; Pearson et al., 1998). Rural populations also have a higher proportion of people with less than a high school education (Patterson et al., 2004). Additionally, CVD prevalence is strongly correlated with educational status within rural populations (Pearson et al., 1998). Similar to diabetes, chronic stress is a proposed mediator of the association between socioeconomic status and CVD (Kaplan & Keil, 1993).

Race and ethnicity

On a national level, race is also a notable predictor of CVD. African American men have the highest burden of CVD (National Center for Health Statistics; NCHS, 2008; Gamm et al., 2003). Although there are fewer minorities in rural areas, the prevalence of hypertension among rural African Americans (23%) is higher than (a) urban African Americans (20%), (b) rural whites (13%) and (c) urban whites (10%; Mainous et al., 2004).

Access to care

Limited access to care also contributes to the higher rates of CVD in rural populations. Rural areas have fewer physicians and health care centers per capita as noted earlier (Merwin et al., 2006). As discussed, people in rural areas are more likely to have to drive greater distances to access care than urban counterparts (Gamm et al., 2003). Additionally, rural persons are less likely than urban counterparts to have had their blood pressure checked in the previous five years or to have taken action to lower it (Gamm et al., 2003). All of these gaps in care experienced by rural populations potentially lead to (a) late diagnosis, (b) inadequate management of chronic CVD, (c) higher mortality rates due to CVD as a result of longer travel times for care (Bolin & Gamm et al., 2003).

"Modifiable" Contributors to Cardiovascular Disease in Rural Populations

The strongest and most consistent risk factors for CVD are smoking, type 2 diabetes, hypertension and hyperlipidemia. Only 15-20% of CVD patients lack any of these risk factors (Khot et al., 2003). Smoking, diabetes, hypertension and hyperlipidemia are all more prevalent in rural populations (Eberhardt et al., 2001; Gamm et al., 2003; Mainous et al., 2004; Cooper et al., 2000).

Obesity is another strong risk factor for CVD as well as hypertension, hyperlipidemia and diabetes. For example, among women in the Nurse's Health Study who developed diabetes, pre-diagnosis weight gain increased their future risk of coronary CVD (Cho et al., 2002). Obesity is also a direct predictor of coronary CVD and other types of CVD (Must et al., 1999).

Closely related to obesity, physical inactivity is a predictor of CVD. Physical activity has been shown to reduce the risk of cardiac events, high blood cholesterol and blood pressure levels

(Ornish et al., 1998; Khot et al., 2003; Hu et al., 2001; Lee et al., 2001). Sedentary women who became physically active in middle age showed a lowered risk of coronary events (Manson et al., 1999). As with obesity, physical inactivity is more prevalent in rural versus urban populations (Patterson et al., 2004; Lee et al., 2007)

Although obesity and related health behaviors are intimately linked to three of the four conventional risk factors, perhaps the strongest determinant of CVD is smoking (Khot et al., 2003). Smoking alone was responsible for 180,000 deaths related to CVD in 1990 and also appears to decrease the time of onset for coronary CVD (Cooper et al., 2000; Jousilahti et al., 1999; Office of the Surgeon General, 2004; Khot et al., 2003). Additionally, being a smoker increases risk of CVD by 1.5 to 3 fold (Jousilahti et al., 2000; Kannel et al., 1999). A recent meta-analysis revealed that smoking cessation leads to a 36% risk reduction in cardiac mortality regardless of age, sex and type of cardiac event (Critchley & Capewell, 2003). It has been suggested that higher rates of smoking is a result of lower educational status and lower access to health education resources in rural areas (Eberhardt et al., 2001).

The conventional risk factors, as well as other contributors to CVD such as obesity and physical inactivity are disproportionately higher in rural populations (Cooper et al., 2000; Eberhardt et al., 2001; Pearson et al., 1998; Gamm et al., 2003). Moreover, rural persons are less likely than urban to have their blood cholesterol levels checked in the last 5 years and take action to reduce their high blood pressure, CVD (Pearson et al., 1998; DHHS, Healthy People 2010, 2000). Although rural areas have higher prevalence of lifestyle risk factors and worse preventive care, CVD can be prevented and treated through lifestyle interventions (Ornish et al., 1998). Thus, understanding whether lifestyle contributors predict the higher rates of CVD in rural populations is essential in determining if lifestyle interventions can ameliorate the rural/urban disparity.

Summary

The causes of chronic diseases such as diabetes and CVD are multifaceted. “Nonmodifiable” and “modifiable” contributors to these diseases are common in rural areas. To our knowledge, there has not been a national assessment of the relative contributions of these factors to the higher rates of diabetes and CVD in rural populations. Understanding the contributions of modifiable factors to diabetes and CVD may help in identifying appropriate targets for intervention in rural areas.

Current Study

The current study attempts to measure the unique contribution of modifiable factors in explaining the higher rates of diabetes and CVD in rural populations. We propose the following primary hypotheses:

1. Controlling for modifiable factors will weaken the association between rurality and diabetes even after considering nonmodifiable factors.

2. Controlling for modifiable factors will weaken the association between rurality and CVD even after considering nonmodifiable factors.

CHAPTER 2
DATA AND METHODS

Data Source

The Medical Expenditure Panel Survey (MEPS) is jointly sponsored by the Agency for Health Care Policy and Research and the National Center for Health Statistics. The MEPS consists of a set of large-scale, nationally representative surveys which document utilization, cost and insurance information among the civilian non-institutionalized U.S. population. The household component (MEPS-HC) provides detailed information on demographics, health conditions/status, medical care utilization, access to care and income. The MEPS-HC utilizes a sampling frame, or a set of units from which the sample was drawn, from respondents to the National Health Interview Survey (NHIS) as well as an overlapping panel design of sample households which entails an initial contact and five interviews for data collection over a 2 ½ year period (AHRQ, 2003; Sullivan et al., 2005). Data collection continues in the subsequent year with a new sample of households, creating “overlapping panels of survey data” (Cohen et al., 1999). Combining these data with other panels allows for “continuous and current estimates of health care expenditures” (Cohen et al., 1999). Each household interview consists of computer-assisted personal interviewing technology as well as utilization and cost information on medical care for 2 calendar years (Cohen et al., 1999).

Sampling from the National Health Interview Survey ensures a nationally representative sample of the US civilian non-institutionalized population with oversampling of Hispanics and African Americans (Cohen et al., 1999; Sullivan et al., 2005). As a result of the disproportionate sampling of minorities and its complex sampling procedure, MEPS data are weighted (Cohen et al., 1999). The weights are derived from the previous year’s NHIS weights and are based on demographic probabilities to correct for complete or partial non-response, differences between

NHIS and MEPS eligibility, and corrections to better match the Current Population Survey ranging from the regional to person level (Cohen et al., 1999). The MEPS-HC utilizes stratification, clustering and multiple stages of selection to further adjust for complex sampling (Cohen et al., 1999). Participants from the MEPS-HC provide names of their medical providers and employers during the survey. The Medical Provider Component of MEPS (MEPS-MPC) validates medical care and condition information at the person level based on this information. Diagnoses of medical conditions in the MEPS-MPC are based on ICD-9 clinical modification codes (Sullivan et al., 2005).

The current study used data from the 2005 MEPS, which samples from the 2004-2005 National Health Interview Survey, to establish the unique contribution of lifestyle contributors to the higher rates of diabetes and CVD in rural populations.

Variables

Dependent Variables

The primary outcomes of the present study were the presence of type 2 diabetes and CVD (including myocardial infarction, congestive cardiovascular failure, angina, cardiovascular disease, hypertension, stroke and other cardiovascular conditions) in urban and rural populations as measured by ICD-9 codes in the MEPS-MPC. Although CVD can refer to a broad cluster of disorders of the heart and arteries, the operationalization of CVD in the current study is consistent with the American Heart Association definition (AHA, 2008). As part of the MEPS-HC, respondents were asked if they had ever been diagnosed as having type 2 diabetes or various forms of CVD. From this self-reported information, medical providers and facilities are contacted for corroboration of these self-reported diseases and information is collected in the MEPS-MPC. ICD-9 codes are generated in the MPC data files by disease and were assimilated into variables that flagged the respective conditions. Presence of diabetes and CVD are based off of these flag variables (AHRQ, 2003).

Independent Variables

Metropolitan Statistical Area (MSA) status, the proxy for rurality, was the predictor of interest. MSA status is assigned according to the OMB standards of the Census 1990 data based on the respondent's address. Counties placed along the urban-rural continuum are categorized as MSA/urban (includes metro and near-metro, see Appendix A: 1-6) and non-MSA/rural (includes near-rural and rural, see Appendix A: 7-9; AHRQ, 2003).

Mediator Variables

The primary aim of this study is to determine whether the lifestyle factors of obesity, smoking and exercise predict rural/urban differences in diabetes and CVD while controlling for nonmodifiable factors (i.e. demographics, access to care, etc.).

Obesity

For adults over age 18, body mass index (BMI) [weight in kg/height in m] was calculated using self-reported height and weight (which are not included for public use because of confidentiality concerns). Obesity constitutes a BMI greater than or equal to 30.

Physical Activity

Physical activity was measured by asking respondents if they engaged in moderate or vigorous physical activity for 30 minutes three or more times per week.

Smoking Status

Smoking status was measured by asking respondents if they currently smoke cigarettes (Sullivan et al., 2005).

Control Variables

To examine the lifestyle contributors to the higher rates of diabetes and CVD, sociodemographic (income, race, gender, age, education, geographic region) and access to care (usual source of care, distance to usual source of care) variables were used to control for *de facto* differences in morbidity of diabetes and CVD not due to lifestyle factors.

Socioeconomic status

Lower socioeconomic status is generally measured by income/poverty level and educational status and is a well-established risk factor for diabetes and CVD (Braveman & Tarimo, 2002). Given that rural areas are characterized by lower socioeconomic status, socioeconomic status is a *de facto* contributor to these diseases in rural areas (Lee et al., 2007). In MEPS, poverty status is measured as family income as a percent of the federal poverty line (poor, near poor, low income, middle income and high income). Education is measured as the years of education when first entering MEPS (no school/kindergarten only, grades 1-8, grades 9-11, grade 12, 1 yr of college, etc. up to 5+ years of college).

Age

Age is strongly associated with disease morbidity and rural status (Gamm et al., 2003; Iezzoni, 2003). Age is measured by difference in years from self-reported date of birth and 12/31/05.

Sex

Sex is related to differences in disease morbidity and is thus important to control for statistically. Sex is measured by self report.

Marital status

Marital status is associated with a poorer prognosis of heart disease in women (Orth-Gomer et al., 2000) whereas, among men, being married is generally protective of health (Lillard

& Panis, 1996). Thus, marital status by gender interactions may represent *de facto* differences in heart disease and potentially diabetes. Marital status is measured by self report as of 12/31/05 (married, widowed, divorced, separated, never married).

Region of the country

Regional differences in morbidity of both CVD and diabetes exist, thus region of the country is also a predictor to disease morbidity (Cooper et al., 2000). Region is determined by census region criteria (Northeast, Midwest, South, West).

Race and ethnicity

Racial and ethnic difference in diabetes and CVD are stark (Cooper et al., 2000; Iezzoni, 2003). For example, African American men have the highest rates of CVD and rural African Americans have higher rates than their urban counterparts (Mainous et al., 2004). African Americans have two times the risk of diabetes-related deaths than white counterparts (Clark, 1998). Race is self reported and consists of white (no other race reported), black (no other race reported), American Indian/Alaska native (no other race reported), Asian (no other race reported), native Hawaiian/Pacific islander (no other race reported) and multiple races reported. Compared to non-Hispanic white people, Hispanics have a worse CVD risk profile but paradoxically lower CVD mortality (Swenson et al., 2002). In terms of diabetes, Hispanics (particularly Mexican Americans and Puerto Ricans) have roughly double the prevalence of diabetes than non-Hispanic whites. Hispanic ethnicity was measured as Hispanic vs. non-Hispanic (Flegal et al., 1991).

Physical limitations

Another individual predictor of disease morbidity that is also more prevalent in rural areas is physical limitation (Mainous & Kohrs, 1995). Physical limitation is measured by self report and operationalized as any limitation in walking.

Access to care

Access to care is another important assessment of extant differences in morbidity of CVD and diabetes. An accurate assessment of access to care in rural populations is the time it takes to get to a usual source of care (Larson et al., 2003). In MEPS, this is measured by self-reported minutes it takes to drive to the reported usual source of care (less than 15 minutes, 15 to 30 minutes, 31 to 60 minutes, 61 to 90 minutes, 91 to 120 minutes, more than 120 minutes).

Statistical Analyses

To identify the self-reported prevalence of diabetes and CVD, we estimated the number of rural and urban persons flagged by the diabetes and CVD dummy variables. We then dichotomized variables based on disease presence and conducted a proportion analysis and a simple Chi Square analysis to determine if the difference was significant.

Given the dichotomous nature of diabetes and CVD and our research question of estimating the relative contribution of our independent variables, logistic regression was deemed an appropriate statistical analysis. Logistic regression transforms the dependent variable, in this case diabetes and CVD, into logit variables which express the natural log odds of the dependent variable occurring or not occurring. The odds ratio (OR) then, represents the ratio of the odds of the dependent variable occurring in one group of a particular independent, e.g. urban status, versus the odds of it occurring in another group, e.g. rural status. An odds ratio of one indicates that the dependent variable is equally likely under both conditions of the independent variable.

We tested the goodness of fit of our model for both diabetes and CVD using the Hosmer-Lemeshow goodness-of-fit test. Based on the Hosmer-Lemeshow test our models fit the data overall although tended to slightly overpredict for those with the greatest probability of having CVD.

We used separate logistic regressions to determine the odds ratio between (1) MSA (rural) status and diabetes and (2) MSA status and CVD controlling for nonmodifiable variables (sociodemographic and access to care). To assure nationally representative estimates and to adjust for the complex sample design of MEPS, person-level, sample and variance adjustment weights were used (Sullivan et al., 2005).

To determine the unadjusted association of rural status and diabetes and CVD, we first determined the OR for the regressions (1) MSA (rural) status and diabetes and (2) MSA status and CVD without any covariates. In order to understand the contribution of nonmodifiable (sociodemographic and access to care) factors to the rural – disease association, we recomputed the model controlling for nonmodifiable factors and re-estimated the OR. Finally, as a test of our primary hypotheses, we recomputed the model controlling for both nonmodifiable and modifiable (obesity, smoking and physical activity for CVD; obesity and physical activity for diabetes) factors and re-estimated the OR. By comparing the model with nonmodifiable factors alone to the model with both nonmodifiable and modifiable factors, we were able to determine whether controlling for modifiable factors would significantly weaken the association between rurality and each disease, thereby implying that modifiable factors help explain the rural disparity in these diseases. In other words, we set up a mediational test of modifiable factors on the association between rurality and each disease.

Due to collinearity, several variables were either combined (i.e. Midwest + West = Western; never married + separated + widowed = not married) or not used as covariates in the analysis (African American, married, Northeast). Additionally, several variables were modified to ameliorate the fit of our model. For diabetes, age was divided into 5 categories by years (18-25, 26-35, 36-45, 46-54 and 56-65). To adjust for the over-prediction of CVD, we used the square of age and obesity, and we divided education into less than high school, high school and more than high school.

To test our mediational hypothesis, we determined the significance of the difference of the odds ratio between the two models (the original model with only nonmodifiable factors vs. the model with both nonmodifiable and modifiable factors) we used an Adjusted Wald Test. Although the Wald Test is generally used to test the significance of individual regression coefficients, it can be adjusted to test the significance of the difference between any two dichotomous variables. We created two arbitrary dichotomized variables that were coded opposite of each other (i.e., D = 0 when G = 1, *vice versa*) and created interaction variables for both nonmodifiable and modifiable variables. To test for the significance of adding modifiable variables to the model, we coded all of the nonmodifiable interaction variables as ‘D’ & ‘G’ and the modifiable variables as ‘G’ only. We then used an Adjusted Wald Test to test thef significance of the difference between ‘G’ and ‘D’ (‘G’ minus ‘D’).

All of the above analyses used the survey procedures of Stata 10 statistical software (StataCorp, 2002).

CHAPTER 3
RESULTS

Diabetes

Participant Characteristics

The sample with diabetes used to test the association with rurality consisted of 2,007 respondents. Among people with diabetes, 85% were either overweight or obese, 37.5% were physically active and 21% were rural (compared to the overall sample proportion of 18%). The crude proportion of people with diabetes among urban was 5.5% compared to 7.2% among rural populations. For the proportion of diabetes, CVD, obesity, physical inactivity and smoking by urban vs. rural, please see Table 3-1.

Association with Modifiable Contributors

Obesity was associated with self-reported diabetes ($p < .001$); the association of physical activity and diabetes was marginally significant ($p = .06$; see Table 3-4).

Association with Rurality

A logistic regression analysis determined that the unadjusted associated between rurality and diabetes was significant (OR = 1.37, p = .003). When controlling for nonmodifiable contributors, the association lost significance (OR = 1.23, p = .082). Although rurality and diabetes were not statistically related when nonmodifiable contributors were accounted for, there was an additive effect of modifiable contributors on the association between rurality and diabetes. When modifiable contributors were added to the model (already controlling for nonmodifiable contributors), the association further weakened (from OR = 1.23, p = .082 to OR = 1.14, p = .265). Thus, both nonmodifiable and modifiable factors appear to contribute to the rural/urban differences in the prevalence of diabetes.

Change in Odds Ratios

A logistic regression analysis showed that the unadjusted odds ratio of diabetes was 38% higher among the rural population than for the urban one (OR = 1.37, p = .003). When controlling for nonmodifiable contributors, the odds ratio dropped to 18% higher for rural compared to the urban (OR = 1.23, p = .082). As previously stated, adding modifiable contributors weakened the odds ratio of having diabetes and being rural to approximately 14%, representing a 38.5% decrease in the odds ratio (OR = 1.14, p = .265). The Adjusted Wald Test showed that this decrease in odds ratio was significant (p = .007). See Table 3-2 for changes in the odds ratio in the association between rurality and diabetes when controlling for (a) nonmodifiable and both (b) nonmodifiable and modifiable contributors.

Cardiovascular Disease

Participant Characteristics

The sample with CVD used to test the relationship with rurality consisted of 5,577 respondents. In the sample, 77.7% of those with CVD were overweight/obese, 47.8% were physically active, 15.9% were smokers and 19.8% were rural. The overall prevalence of CVD among rural urban was 20.8% compared to 16.6% among urban populations. For the proportion of diabetes, CVD, obesity, physical inactivity and smoking in urban vs. rural, please see Table 3-1.

Association with Modifiable Contributors

Obesity and physical activity were independently associated with self-reported CVD (both ps < .001); however, the association between being a current smoker and CVD was not significant (p > .05; see Table 3-5).

Association with Rurality

In a logistic regression analysis, the unadjusted relationship between rurality and CVD was significant (OR = 1.27; p = .001). The association was weakened but still significant after controlling for nonmodifiable contributors (OR = 1.16; p = .049). However, addition of the modifiable contributors to the model rendered the odds ratio non-significant (OR = 1.09; p = .278).

Change in Odds Ratios

Logistic regression showed the unadjusted odds ratio of having CVD among the rural population was approximately 29% higher than for the urban one (OR = 1.29, $p < .001$). When controlling for nonmodifiable contributors, the odds ratio dropped to approximately 16% higher for rural compared to the urban population (OR = 1.16, $p = .049$). Adding modifiable contributors further weakened the odds ratio of having CVD and being rural to approximately 9%, representing a 44% decrease in the odds ratio (OR = 1.09, $p = .278$). The Adjusted Wald Test revealed that this decrease in the odds ratio was significant ($p = .01$). See Table 3-3 for changes in the odds ratio in the association between rurality and CVD when controlling for (a) nonmodifiable and both (b) nonmodifiable and modifiable contributors.

Table 3-1. Diabetes, CVD, obesity, smoker status, physical activity by urban versus rural

	Rural		Urban	
	Percentage	Confidence Intervals	Percentage	Confidence Intervals
Self Reported Diabetes	7.15%	.062 - .081	5.49%	.051 - .059
Self Reported CVD	20.76%	.191 - .224	16.65%	.159 - .174
Overweight/Obese	74.41%	.731 - .758	71.20%	.704 - .721
Current Smoker Status	25.64%	.235 - .278	19.39%	.184 - .204
Mod/Vig Physical Exercise (3x/wk)	57.40%	.561 - .587	57.85%	.540 - .617

Table 3-2. Changes in odds ratios after controlling for nonmodifiable and modifiable contributors to the association between rurality and diabetes

Rurality - Diabetes	OR	*P*	% Change in OR	*p* of Change from Previous Model
Unadjusted Association	1.37	0.003	-	-
With Non-Modifiable	1.23	0.082	38%	0.015
With Non-Modifiable and Modifiable	1.14	0.276	39%	0.007

Table 3-3. Changes in odds ratios after controlling for nonmodifiable and modifiable contributors to the association between rurality and CVD

Rurality-CVD	OR	*p*	% Change in Odds	*p* of Change from Previous Model
Unadjusted Association	1.27	0.001	-	-
With Non-Modifiable	1.16	0.049	44%	0.012
With Non-Modifiable and Modifiable	1.09	0.278	44%	0.010

Table 3-4. Odds ratios of all nonmodifiable and modifiable variables predicting diabetes

Diabetes	OR	*p*
Rural	1.14	0.27
Western Region	1.37	0.04
South	1.34	0.08
Young Adult	0.08	0.00
Mid Young Adult	0.12	0.00
Mid Adult	0.30	0.00
Mid Old Adult	0.59	0.00
Sex	1.14	0.19
White	0.61	0.00
Hispanic	1.57	0.00
Divorced	0.89	0.36
Other Marital	0.88	0.34
Years of Education	0.93	0.00
Poverty Category	0.88	0.00
Walking Limitation	1.77	0.00
Time Takes to get to Usual Source of Care	1.07	0.20
BMI	1.09	0.00
Physical Activity (x3/wk, mod to vig)	0.85	0.06
Current Smoker	1.04	0.73

Table 3-5. Odds ratios of all nonmodifiable and modifiable variables predicting CVD.

CVD	OR	*p*
Rural	1.09	0.28
Western Region	0.97	0.71
South	1.33	0.00
Age	1.15	0.00
Age Squared	1.00	0.07
Sex	1.29	0.00
White	0.62	0.00
Hispanic	1.06	0.50
Divorced	1.10	0.28
Other Marital	1.05	0.53
Less than High School Education	1.23	0.02
High School Education	1.26	0.00
Poverty Category	1.01	0.64
Walking Limitation	1.39	0.00
Time Takes to get to Usual Source of Care	1.12	0.00
BMI	1.10	0.00
BMI Squared	1.15	0.19
Physical Activity (x3/wk, mod to vig)	0.82	0.00
Current Smoker	0.92	0.33

CHAPTER 4
DISCUSSION

The current study examined the unique contributions of various nonmodifiable and modifiable factors to the rural/urban disparities in type 2 diabetes and cardiovascular disease (CVD). Although it is known that both types of contributors to these diseases are more common in rural areas, to our knowledge, no studies have evaluated the relative contribution of these factors using a national sample. Assessing the unique contribution of modifiable factors is important because of the implication that special efforts targeting modifiable factors in the rural population might reduce the rural/urban disparity in diabetes and heart disease.

The present analysis examined the unique contribution of three specific modifiable lifestyle factors (obesity, current smoking, physical activity) to the association between (1) rurality and diabetes and (2) rurality and heart disease. Consistent with our original hypotheses, modifiable lifestyle factors contributed significantly to the variance of the association of both diseases with rurality. However, the specific pattern of contributions appears to vary by disease.

For diabetes, nonmodifiable factors (sociodemographic and access to care) fully mediated the association with rurality. However, when modifiable factors were added to the rurality-diabetes model, the *p* value decreased (p = .134 to = .276). Correspondingly, when modifiable factors were added to the model already accounting for nonmodifiable factors, there was a statistically significant reduction in the odds ratio. Thus, although the high observed rates of diabetes in rural areas is largely due to nonmodifiable factors, modifiable factors are also at play. Given the connection between many nonmodifiable factors associated with rurality (e.g. poverty, age, low access to care etc.) and diabetes, it follows that these are significant contributors to the rural/urban disparity in diabetes. However, factors such as obesity and physical inactivity are also known contributors to diabetes and are associated with rurality. In the present study, these modifiable factors also appear to play a role in the rural disparity in diabetes. Traditionally, a mediator is defined as an explanatory factor between a significantly associated predictor and outcome variable (Baron & Kenny, 1986). In this case, rurality and diabetes were no longer associated after controlling for nonmodifiable contributors. Although modifiable contributors would not be considered a mediator by the traditional definition (Baron & Kenny, 1986), modifiable factors significantly reduced the association between diabetes and rurality even after controlling for nonmodifiable contributors. Thus modifiable contributors help explain the higher rates of diabetes in rural vs. urban populations on a national level.

The results for heart disease are consistent with a substantial contribution of modifiable lifestyle factors. The association between rurality and heart disease remained significant after accounting for all of the nonmodifiable factors. This is a surprising finding given the strong association of nonmodifiable factors (e.g. race, age) to heart disease that are also associated with rural status. Additional factors associated with rurality predicted heart disease beyond nonmodifiable factors. Indeed, adding modifiable factors to the model rendered the association of rurality with heart disease non-significant. Moreover, the reduction in the odds ratio was also significant. Thus, it appears that modifiable factors potentially explain the rural/urban disparity in heart disease above and beyond nonmodifiable contributors.

An example of a longitudinal cohort study that supports the results of the current study is the Nurses' Health Study. Among 84,129 women, those who with "healthy lifestyles" (not smokers, not overweight, consumed a healthy diet, exercised moderately or vigorously for half an hour a day and consumed moderate amounts of alcohol) had an incidence of coronary events 80% lower than in the rest of the population (Stampfer et al., 2000). These results independently predicted lower coronary event incidence beyond nonmodifiable factors such as age and other medical risk (Stampfer et al., 2000). Findings from this prospective cohort study suggest that coronary events can be prevented through targeting modifiable lifestyle factors such as obesity, smoking and physical inactivity (Stampfer et al., 2000). Taken together with the results of the current study, providing interventions that specifically target healthy lifestyles in the rural population has the potential to reduce the incidence of coronary events in rural residents and thereby decrease the observed rural/urban differences in CVD.

Limitations

Several limitations of the present study should be considered. First, all of the variables of interest were based on self report, and thus the potential for a social desirability bias exists. For example, obese people tend to underreport their weight (Stevens et al., 1998), potentially underrepresenting the role of obesity in predicting self-reported diabetes and CVD. Additionally, given the self report of conditions, clinical verification of diabetes and CVD were not available, thus introducing the possibility of recall bias. However, systematic recall bias has not been implicated as a function of rural vs. urban areas (Larson et al., 2003). Second, the availability of modifiable variables in the MEPS was limited. For example, no variables measure (1) smoking history, (2) diet quality or (3) sedentary behavior. Although these variables would provide a wider range of modifiable contributors, obesity and current smoker status are both major causes of diabetes and CVD. Another potential limitation of the study is the use of non-discrete disease outcomes such as hypertension, angina, and stroke (versus the aggregate classification of CVD). This limits the generalizability to the plethora of studies that focus on discrete cardiovascular diseases. In the overall sample of adults for 2005, 7,276 people reported ever having a diagnosis of hypertension, angina and stroke (combined). This is most likely an overestimate of the current sample because we used data from people who reported a CVD diagnosis “this year”. Additionally, given the high co-occurrence of these conditions and the cardiovascular diseases, our results may not be different even if excluding hypertension, angina and stroke. Lastly, our operationalization of CVD is consistent with the definition used by the American Heart Association (AHA, 2008). Another limitation is the operationalization of “nonmodifiable” and “modifiable” variables. Although lifestyle are traditionally considered “modifiable”, non-lifestyle predictors of morbidity, such as better access to health care is also potentially “modifiable” (Gamm et al., 2003). Moreover, it is likely that a combination of “nonmodifiable” and “modifiable” variables, are contributing to higher rates of diabetes and CVD in rural areas. Finally, the current analysis was cross-sectional and consequently can not address the causal relationship between modifiable factors and the higher rates of disease in rural areas. However, given the sufficient evidence that modifiable factors lead to both diabetes and CVD, our results imply that these factors contribute to the rural/urban disparity in these diseases on a national level.

Implications

The higher rates of unhealthy lifestyle behaviors in rural areas appear to be contributing significantly to the higher rates of diabetes and CVD in rural areas. These results suggest that the rural/urban disparity in the prevalence of diabetes and CVD would be reduced if modifiable lifestyle factors were equivalent between the rural and urban population. Indeed, if these modifiable lifestyle factors were equivalent between rural and urban areas, it would theoretically result in approximately 200,000 fewer cases of diabetes and 550,000 fewer cases of CVD in rural areas (when extrapolated to the US rural population of 50 million; Eberhardt et al., 2001). Given the high costs of these diseases, targeting modifiable lifestyle behaviors in rural areas could decrease the economic impact of diabetes and CVD in rural areas and in the country as a whole.

Finally, given the strong association of obesity and both diabetes and CVD (see Table 3-4 and Table 3-5), focusing on obesity may be an appropriate target for interventions and policies.

Thus, as we will discuss later, weight loss programs such as Treatment of Obesity in Underserved Rural Settings (TOURS; Perri et al., 2008) represents an example of the type of intervention that could be used to target the higher rates of diabetes and CVD in rural areas.

The demonstration of modifiable factors independently contributing to national disparities implies that, in order to reduce the rural/urban disparity in these diseases, policy and research should focus on contributors to unhealthy lifestyle behaviors in rural areas.

To understand how to reduce the incidence of diabetes and CVD in rural areas, it is necessary to understand contributors to unhealthy behaviors in rural areas; identify potential interventions to improve adherence to a healthful lifestyle in rural areas; execute clinical translational research to determine effective interventions for rural areas; and develop a national model to create partnerships with rural counties to assist in the implementation of these interventions.

The first step in targeting the rural/urban disparity in diabetes and CVD is to understand contributors to the higher rates of unhealthy behaviors in rural areas. One potential contributor to higher rates of unhealthy behaviors is lack of education. As noted, rural residents have lower education (Gamm et al., 2003) and fewer outpatient health visits (Larson et al., 2003). Additionally, rural health providers are burdened by high patient volume and low access to continuing medical education (Pearson et al., 1998). Consequently rural residents have less exposure to health education and promotion. Additionally, there are cultural factors associated with being rural that influence unhealthy behaviors. For example, it is customary in rural America for meals to be highly caloric and nutritionally unbalanced (Flora et al., 2004). Traditionally, high caloric intake was sustainable because of the physically demanding nature of rural labor (Pearson et al., 1998). However, the increasing mechanization of farming has disrupted the caloric equation among many rural residents, leading to higher rates of obesity (Pearson et al., 1998). In addition to cultural contributors, being among people who engage in unhealthy behaviors increases an individuals' risk of adopting these behaviors. For example, over a 32 year period in the Framingham Heart Study, individuals who had a friend become obese had a 57% greater chance of becoming obese than those who did not (Christakis & Fowler, 2007). There are also environmental contributors to these unhealthy behaviors in rural areas. For example, rural areas have limited access to supermarkets (Kaufman, 1999) or environments conducive to physical activity (Eyler, 2003). Moreover, rural populations have been described as 'slow adopters' of healthy behaviors (Pearson et al., 1998). Through the Framingham Heart Study and other research, innovations about the care and prevention of chronic diseases are disseminated first to urban areas for the reasons discussed above (Pearson et al., 1998). Another potential contributor to unhealthy behaviors in rural areas is untreated depression. For example, one known predictor of unhealthy behaviors is untreated depression (Strine et al., 2008). Although rural populations have similar rates of depression as urban, the treatment rates are lower in rural areas (Hauenstein et al., 2006). Thus, the higher prevalence of untreated depression may be an underlying predictor of unhealthy behaviors in rural settings. Hartley (2004) posed the challenge of identifying contributors to unhealthy behaviors in rural populations as a question: "Why does rural residence (culture, community, and environment) reinforce negative health behaviors?" By understanding contributors to the higher rates of unhealthy behaviors in rural populations, interventions aimed at improving lifestyle behaviors can be designed to be more effective in rural communities.

The next step in improving the chronic disease burden in rural areas is identifying efficacious interventions to improve lifestyle behaviors. Chronic diseases are largely driven by lifestyle behaviors and are amenable to intervention. Ornish et al.'s (1990, 1998) results suggest that 90% of patients with heart disease can benefit significantly from lifestyle interventions (without additional medical treatment). An example of this type of an efficacious intervention is the Diabetes Prevention Program (DPP). The DPP demonstrated that intensive lifestyle changes (particularly weight loss and physical activity) decreased overall incidence of diabetes by 58% (compared to 31% for Metformin, or a control group) over an approximately 3 year period (Diabetes Prevention Program Research Group, 2002). This intervention included a large number of elderly, lower educated and low income people, making it more applicable to rural settings. Another example of an efficacious intervention is the Coronary Health Improvement Program (CHIP; Aldana et al., 2005). This program was developed from the Ornish et al. (1990) Lifestyle Heart Trial and consists of groups of people and printed material on lifestyle improvement. A randomized clinical trial of this intervention showed improvement in diet and physical activity in the experimental group compared to a control group (Aldana et al., 2005). Compared to many interventions, the CHIP is relatively cost effective (Aldana et al., 2005) and may be appropriate given the limited resources in rural counties.

Rural areas are characterized by low income, low education (Gamm et al., 2003) and the host of cultural and environmental obstacles to healthy behavior previously discussed. Most efficacy clinical trials are done in urban areas with higher income/educated, highly motivated participants. Thus the generalizability of interventions such as the Lifestyle Heart Trial is low for rural persons. The prevalence of poor lifestyle behaviors in the rural population highlights the challenge of effecting sustained changes in lifestyle necessary to reduce incidence of diabetes and CVD in rural areas. Additionally, rural communities have limited infrastructure, training and funds to support many interventions. Taken together, there is a need for clinical translation of efficacious to effectiveness interventions that can work in rural areas.

TOURS was a weight loss study designed specifically for rural settings and provided extended care follow-up to promote the maintenance of healthy behaviors (Perri et al., 2008). Extending care appears to be of particular import because participants regained one-third to one-half of lost weight within a year (Perri et al., 2008). TOURS demonstrated an average weight loss of 10.0 kg in the initial 6 month intervention. After this initial period, participants were randomized to 26 biweekly extended-care sessions of face-to-face, telephone or weight-control information (control group of either). Participants in the face-to-face and telephone conditions regained significantly less weight than those in the control group. Additionally, the telephone condition was more cost effective compared to the face-to-face extended care group ($2554 vs. $2125; Perri et al., 2008). Our findings support the dissemination of interventions such as TOURS in rural settings on a national level. Given our results of the important contribution of obesity to both diseases in rural areas, TOURS stands out as a model for lifestyle interventions that might lead to the greatest impact on reducing diabetes and CVD in the rural population. In particular, implementing cost-effective programs for sustaining weight loss, such as the TOURS telephone intervention might produce significant ‘return on investment’ with respect to the incidence of diabetes and CVD. However, given the financial constraints of rural counties, more research on the financial viability of disseminating such interventions is needed.

Lastly, developing a national model to create partnerships with rural counties to assist in the implementation of these interventions is necessary. Hartley (2004) has suggested that Wagner et al.’s (2001) Chronic Care Model (CCM) is appropriate for managing the population health of rural areas. A key element of this model is that successful interventions involve (a) activated patients, (b) prepared practitioners and (c) community resources with respect to local or regional idiosyncrasies (Hartley, 2004). Disseminating effective (therapeutically and financially) interventions in rural areas will certainly require these elements. Effectively disseminating the necessary interventions to rural populations to alleviate the burden of chronic disease will also necessitate partnerships and support from a national organization such as the Office of Rural Health Policy, the US Department of Agriculture's Office of Rural Development and other funding sources such as State Rural Development Councils, the National Rural Health Association, state offices of rural health and state/local health departments.

Finally, given the strong association of obesity and both diabetes and CVD (see Table 3-4 and Table 3-5), focusing on obesity rather than current smoking or physical activity may be an appropriate target for interventions and policies.

Future Research

Future directions for this line of research include further examining the unique contribution that obesity in particular appears to be playing in the rural/urban disparity. Better specifying this contribution will enable national policies to prioritize funding for effective interventions. Additionally, a replication of this study that includes smoker history and diet quality would further explicate the contribution of modifiable factors to these diseases in rural populations. Finally, an important line of research is to identify factors that predict the higher rate of poor lifestyle factors in rural areas. As discussed, there are many causes of the higher rates of unhealthy behaviors among rural populations. Regardless, there are no studies that attempt to quantify the relative contributions of such factors to the higher rates of unhealthy behaviors. Identifying these contributors would provide a framework by which to design effective interventions in rural areas.

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BIOGRAPHICAL SKETCH

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