LIESTYLE AND TYPE 2 DIABETES DIAGNOSIS IN CHINA: A CASE-CONTROL STUDY

Xi Pan

Doctoral Candidate

Miami University

Scripps Gerontology Center

Statement of Problem

With today's longer life expectancy, chronic diseases have become the predominant causes of mortality rather than the infectious diseases that claimed more lives when life expectancy was shorter. Type 2 diabetes, a common chronic disease, is characterized by chronic hyperglycemia with disturbances of carbohydrate, fat, and protein metabolism, which may be caused by defects in insulin secretion and/or action (Al-Daghri et al., 2010). The proportion of people with type 2 diabetes is increasing globally. It is estimated that 333 million people will have the disease by 2025, approximately twice the number of diabetics in 2003 (Yoon et al., 2006). Type 2 diabetes has been a major chronic disease problem in many developed countries for years and has become an important public health challenge in developing countries, such as China, in the last decades (Gu et al., 2003). Between the 1980s and 1990s, type 2 diabetes was very rare in China; the prevalence of the disease (approximately 1.5% in the urban population) was too low to be considered statistically or practically significant for that population (Cockram, 2000). However, more recent studies have noted that the prevalence of the disease is sharply rising, especially in urban areas. A study in Da Qing revealed that occurrence of type 2 diabetes was 3.51% in 1994, 3.4 times greater than the rate (1.04%) in 1986 (Cockram, 2000). Studies conducted in Beijing and Zhejiang between 1992 and 1993 also confirmed the increase in type 2 diabetes; the prevalence of type 2 diabetes was approximately 3 times greater than in the 1980s (Cockram, 2000).

The epidemiological trend of type 2 diabetes within China generally parallels the level of affluence and degree of urbanization and modernization. In the past decades, China has undergone rapid urbanization and westernization nationwide; rapid shifts in income and occupation led to changes in lifestyle (Yoon et al., 2006; Zimmer & Kwong, 2004). First, the Chinese diet became more westernized, characterized by energy rich foods high in sugar and animal fat. Second, widespread economic development reduced the number of occupations high in physical activity and increased sedentary time on computers and televisions either for work or for the purpose of entertainment; therefore, people became less physically active. Such a nationwide lifestyle change has contributed to the rising prevalence of type 2 diabetes in China.

The growing body of studies investigating the behavioral etiology of type 2 diabetes suggests that health behaviors are significantly and directly associated with the risk of type 2 diabetes (Xu et al., 2006; Yoon et al., 2006). Health behaviors are actions that one takes directly or indirectly affect one's health status or well-being (Bruhn, 1988). Behaviors undertaken by individuals in their daily lives can either protect them from diseases or precede the occurrence of illness (Ferraro, 2006). Some behaviors by nature are detrimental to health, such as cigarette smoking (Avogaro et al., 2004; Baliunas et al., 2009), while other behaviors can run the spectrum from healthy to unhealthy, for example, alcohol consumption, physical activity, or carbohydrate intake. Quite a number of Western studies indicate that cigarette smoking increases the risk of type 2 diabetes regardless of age, gender, and race (Padmawati, Ng, Prabandari, & Nichter; 2009; Schipf et al., 2009). Moderate amount of alcohol consumption, physical activity, and carbohydrate intake are healthy and protect individuals from developing the disease (Carlsson, Hammer, & Grill, 2005; Helmrich et al., 1991; Hu, van Dam, et al., 2001), whereas heavy alcohol consumption (Carlsson, et al., 2005; Ford et al., 2011; Mozaffarian et al., 2009) and being physically inactive with a high level of carbohydrate intake (Seike et al., 2008; Tonstad, 2009; van Dam, 2003; Willi, Bodenmann, Ghali, Faris, & Cornuz, 2007) are detrimental and increase the risk of type 2 diabetes.

Although the prevalence of type 2 diabetes is increasing rapidly in China, there is a paucity of research on behavioral risk for the disease among the Chinese population. The existing literature is predominated by studies conducted among populations in Western societies, and it is unclear that the evidence presented for Western populations is generalizable to populations in non-Western countries. Therefore, the current study examines the behavioral risks for type 2 diabetes diagnosis in the Chinese population. More specifically, this study tests how unhealthy behavior (i.e., cigarette smoking, heavy alcohol consumption, being physically inactive, and high carbohydrate intake) is associated with the risk of type 2 diabetes diagnoses among the Chinese population. Thus, this study will expand the existing literature by enhancing the understanding of how well Western models fit a non-Western sample. Additionally, the Chinese evidence contributes to those models and improves their application to middle-aged and older adults in non-Western cultures.

Background

To date, behavioral risks for type 2 diabetes are predominantly documented in Western literature. Cigarette smoking, heavy alcohol consumption, and physical inactivity are unhealthy behaviors and have been established as *risk factors* (variables related to the probability of an individual developing the disease) of type 2 diabetes among populations in Western societies (Kleinbaum, Kupper, & Morgenstern, 1982). Scholars normally compare the disease frequency between individuals who participate in unhealthy behaviors (the exposed group) to those who avoid these behaviors (the unexposed group) using the measure of *relative risk*, an indicator of the likelihood or probability of developing the disease in the exposed group relative to those who are not exposed (Blumenthal, Fleisher, Esrey & Peasey, 2001). The relative risk estimates the magnitude of the association between involvement in unhealthy behaviors and the occurrence of type 2 diabetes. These studies show that cigarette smokers, heavy alcohol drinkers, and those who are physically inactive are more likely to develop type 2 diabetes compared to those who avoid those behaviors. In addition, demographic characteristics such as age, gender, and socioeconomic factors such as education and income are related to developing unhealthy behaviors. To estimate the relationship between unhealthy behaviors and type 2 diabetes, the effect of demographic and socioeconomic characteristics are usually controlled for in studies of type 2 diabetes. This section reviews the existing literature estimating the relative risk of type 2 diabetes given unhealthy behaviors. In those studies, relative risk is measured by the prevalence rate (the proportion of the population that has the disease at a specific point in time), the incidence rate (the number of new cases of disease per unit of person-time) or the ratio of the odds of exposure among the cases (numbers exposed divided by numbers not exposed) to the odds of exposure among the controls (Blumenthal et al., 2001).

Behaviors and Type 2 Diabetes

Cigarette smoking and type 2 diabetes. The causal relationship between cigarette smoking and type 2 diabetes has been established in much existing Western literature (Padmawati et al., 2009; Schipf et al., 2009; Tonstad, 2009; Willi et al., 2007). Upon receiving a glucose load, cigarette smokers have higher insulin resistance and C-peptide activity (C-peptide is a protein that participates in insulin synthesis) than non-smokers (Cho et al., 2009; Patja et al., 2005). Biologically, nicotine has direct toxic effects on pancreatic tissue, as it causes pancreatic injury leading to impaired beta cell function and insulin sensitivity (Nakanishi et al., 2003; Patja et al., 2005). Thus, cigarette smoking increases the risk of impaired glucose tolerance and contributes to the occurrence of type 2 diabetes (Cho et al., 2009; Schipf et al., 2009). Higher rates of type 2 diabetes diagnosis are found among past or current cigarette smokers compared to non-smokers (Maty et al., 2005; Robbins et al., 2001).

The association between cigarette smoking and risk of type 2 diabetes is related to demographic factors such as age (Patja et al., 2005; Willi et al., 2007). A meta-analysis based on 25 prospective cohort studies between 1966–2007 from MEDLINE and EMBASE reveals that age strengthens the relationship between cigarette smoking and the incidence of type 2 diabetes, when studies included older participants with a mean age of 50 and older (Willi et al., 2007). In this population, current and past cigarette smokers have an increased risk of developing type 2 diabetes compared to never-smokers with hazard ratios (HR = 1.44) and (HR = 1.23), respectively (Willi et al., 2007). The relative risks for type 2 diabetes are similar in both genders: for men, HR = 1.25, and for women, HR = 1.28 (Willi et al., 2007). The process of aging accelerates nicotine impairment of pancreas, therefore increases insulin sensitivity and the risk of the disease (Haire-Joshu, Glasgow, & Tibbs, 1999).

Socioeconomic status (SES), including education and income, are related to cigarette smoking and those contribute to type 2 diabetes diagnosis (Maty, Everson-Rose, Haan, Raghunathan, & Kaplan, 2005). High smoking rates are found among individuals with lower education and income (Haire-Joshu et al., 1999). People with lower SES may lack of knowledge of the negative impact of smoking on health; in addition, they are more likely to participate in lower-paid work where they are exposed to people who smoke heavily (Ferraro, 2006). Those with high school and lower levels of education are more likely to be current, ever, and heavy smokers and less likely to quit (Haire-Joshu et al., 1999). In contrast, people with college or higher education are more likely to be never-smokers or have higher cessation rates (Haire-Joshu et al., 1999).

A similar association between cigarette smoking and the risk for type 2 diabetes is also found among populations in East Asian countries. A cohort study among 1,236,443 Korean participants aged 30–95 examines cigarette smoking and the incidence of type 2 diabetes and suggests that compared with never-smokers, current smokers, particularly male smokers who smoke 20 or more cigarettes/day, have increased risk for diabetes with adjusted hazard ratio of 1.55 [1.51–1.60] (Jee, Foong, Hur, & Samet, 2010). Similar studies conducted among Japanese participants in the same age group show that cigarette smoking has a strong association with the risk of type 2 diabetes, and this risk is approximately doubled in current smokers and tripled for heavy smokers (16–25 cigarettes/day) compared to non-smokers (Tonstad, 2009).

Alcohol consumption and type 2 diabetes. The link between alcohol consumption and the related risk of type 2 diabetes is established by many Western studies (Avogaro et al., 2004; Baliunas et al., 2009; Beulens et al., 2005; Carlsson et al., 2003; Seike et al., 2008). Risk of type 2 diabetes is associated with frequency and quantity of weekly alcohol consumption (Carlsson et al., 2003). Even though the measures of ethanol/volume of alcohol diverge across studies, alcohol consumption and the risk of type 2 diabetes are associated in a J-shaped fashion: light-to-moderate alcohol consumption (200 g/week or 200–400 g/week) is associated with the decreased risk of type 2 diabetes compared to excessive drinking and compared to no drinking (Howard et al., 2004; Nakanishi et al., 2003). This pattern is found in both prospective and cross-sectional studies in the United States and European countries (Avogaro et al., 2004; Baliunas et al., 2009; Beulens et al., 2005; Clerc et al., 2010; Fukui et al., 2005; Howard et al., 2004; Joosten et al., 2011; Liu et al., 2010). A meta-study based on 974 retrieved citations with respect to alcohol consumption and risk of type 2 diabetes suggests that compared with abstainers, light-to-moderate drinkers have a 33%– 56% lower risk for diabetes (Nakanishi et al., 2003). The protective effect of light-to-moderate drinking was more obvious among overweight (BMI ≥ 30) individuals because alcohol can biologically enhance insulin sensitivity, which could counteract obesity-induced insulin resistance (Carlsson et al., 2003). In contrast, heavy alcohol consumption (≥ 400 g/week) increases the risk of type 2 diabetes by disrupting glucose homeostasis and escalating insulin resistance (Guo et al., 2008; Roh, Shin, Choi, Lee, & Kim, 2009; Seik, Noda, & Kadowaki, 2008). Nakanishi et al. (2003) suggest that individuals who excessively consume alcohol have up to a 43% greater risk for type 2 diabetes.

Alcohol drinking differs by age, gender, body mass index (BMI), and SES (Carlsson et al., 2003). In general, older people are less likely to be heavy drinkers compared to younger or middle-aged adults; women tend to be abstainers or light drinkers, and men are more likely to consume alcohol excessively (Ajani et al., 2000; Carlsson et al., 2005; Zhang, Wang, Lu, Qiu, & Fang, 2004). In addition, heavy alcohol consumers are more likely to be have lower education and income, and they tend to be smokers and physically inactive (Carlsson et al., 2005; Zhang et al., 2004).

Carbohydrate intake and type 2 diabetes. In contrast to the large number of studies on smoking and alcohol consumption as risk factors for type 2 diabetes, studies about the role of dietary factors such as carbohydrate intake are limited (Meyer et al., 2000; Schulze et al., 2004).

Most existing literature claims that high carbohydrate intake causes obesity, which is a risk factor for type 2 diabetes (Choi & Shi, 2001; Grant et al., 2009; Wong & Wang, 2006). Obesity, characterized by high free fatty acid (FFA) and high BMI, affects glucose metabolism and decreases insulin sensitivity and therefore, increases the risk of type 2 diabetes (Abbatecola, Evans, & Paolisso, 2009; Esposito, Maiorino, Di Palo, & Giugliano, 2009).

However, findings about the direct effect of carbohydrate intake on the risk for type 2 diabetes are mixed (Meyer et al., 2000; Schulze et al., 2004). Existing evidence supports beneficial, detrimental, or neutral effects of high carbohydrate intake on glucose level. In the Nurses' Health Study and the Health Professionals Follow-up Study, higher carbohydrate intake is found to be associated with higher risk of type 2 diabetes (Hu, van Dam, & Liu, 2001; Salmeron et al., 1997; Schulze et al., 2004). These studies find that diets dense in calories and high in carbohydrates and fat, but low in fiber, especially cereal fiber, worsen energy transition and influence blood glucose response negatively (Schulze et al., 2004). However, in the Iowa Women's Health study, no effect of total carbohydrate intake was found on the risk for type 2 diabetes (Meyer et al., 2000). Suggesting a third possibility, researchers observe a moderate association between the increased carbohydrate intake and risk of type 2 diabetes among whites and African-Americans aged 45–64 in the Atherosclerosis Risk in Communities (ARIC) Study (Stevens et al., 2002).

Physical activity and type 2 diabetes. Physical activity is another important modifiable determinant of type 2 diabetes (Sigal et al., 2006). Physical activities enhance musculoskeletal glucose uptake and improve insulin resistance (Castro, Shaibi, & Boehm-Smith, 2009). Furthermore, physical activity directly works on weight reduction, directly lowers the risk for obesity, and indirectly reduces the risk for type 2 diabetes (Choi & Shi, 2001; Davis, Forrbes, & Wylie-Rosett, 2009; Nelson, Reiber, & Boyko, 2002;). Existing literature has studied the influence of frequency (how often per week) and duration of physical activities (in minutes per instance) in relation to the risk of type 2 diabetes. Based on these two features, two levels of physical activity are identified by Plotnikoff et al. (2010): moderate physical activity (activity that is not exhausting and with light perspiration for 30 minutes at least 3 times per week) and vigorous physical activity (activity with rapid heart-beat and sweating for 30 minutes at least 3 times per week). There are multiple settings for physical activity, including occupational, commuting, and leisure-time physical activity (Bauman, Allman-Farinelli, Huxley, & James, 2008; Hu et al., 2003). Most type 2 diabetes research or diabetes prevention strategies have focused on leisure-time activity (activities away from business, school, and work; see Bauman et al., 2008; Helmrich et al., 1991). A number of prospective studies claim that 150 min/week of moderate physical activity or 90 min/week of vigorous physical activity during leisure time is associated with a lower risk of type 2 diabetes (Helmrich et al., 1991; Hu et al, 2003; Hu, Pekkarinen, Hanninen, Tian, & Guo, 2001; Wannamethee et al., 2000). Particularly, moderate leisure-time physical activities (e.g., brisk walking, jogging, gardening, household chores, bicycling, and running in a non-exhausted condition) for 30 minutes at least 3 times per week are more beneficial for reducing the risk of type 2 diabetes than a high level of vigorous activities (Choi & Shi, 2001; Davis et al., 2009; Nelson et al., 2002; Wong & Wang, 2006).

Compared to the large number of studies on leisure-time physical activity, a paucity of literature has examined the frequency and duration of occupational and commuting physical activities, or the joint effect of occupational, commuting, and leisure-time physical activities on the risk for type 2 diabetes (Hu et al., 2003). Daily commuting physical activity on foot or bicycle is a major form of physical activity in some countries such as Finland, Denmark, the Netherlands, and China (Hu et al., 2003). Individuals' BMI, waist-to-hip ratio, and blood pressure are found to be improved among those who walk or cycle to and from work more than 30 minutes per day, regardless of age, smoking status, and levels of education (Hu et al., 2003; Hu, Leitzmann, et al., 2001; Lahti-Koski, Pietinen, Mannisto, & Vartiainen, 2000). Moreover, engaging in moderate or high levels of physical activity in two or three settings (occupational, commuting, and leisure-time) is significantly associated with lower risk of type 2 diabetes over physical activity in only one setting (Hu et al., 2003).

Demographic characteristics, socioeconomic status, and type 2 diabetes. Existing studies show that the risk of type 2 diabetes is affected by age, gender, and socioeconomic status (SES), reports Choi & Shi, 2001. Even though little evidence has shown that age *per se* results in insulin resistance and type 2 diabetes, advanced age aligns with the tendency of increased BMI, less physical activity, poor diet and visceral fat content which play powerful roles in enhancing insulin resistance level (Abbatecola et al., 2009; Jia et al., 2007; Meigs, Muller, Nathan, Blake, & Andres, 2003). Both men and women tend to gain weight in middle age (around 40); thus, the risk of type 2 diabetes begins to increase at this age, and it is even higher among smokers and heavy alcohol drinkers (Grant et al., 2009). The prevalence rate of type 2 diabetes begins to increase in people at age 40–49 and reaches a peak among people at age 65 in most Western societies and at age 70 in China and Japan (Choi & Shi, 2001; Qiao et al., 2003; Steven et al., 2010).

Gender is another significant factor resulting in a disparity in the risk of type 2 diabetes. Between ages 50 and 69, the prevalence of type 2 diabetes is higher among men than women, whereas the situation is opposite after age 70 (Al-Lawati, Al Riyami, Mohammed, & Jousilahti, 2002; Jia et al., 2007; Meigs et al., 2003; Ramachandran, Snehalatha, Kapur, Vijay, Mohan, & Das, 2001). A possible explanation for such a male preponderance in early ages may be that physiologically, the life span among women is longer, and women are continuously gaining weight and therefore have increasing BMI values compared to men after middle age. In contrast, men are more susceptible to the consequences of obesity, possibly due to differences in insulin sensitivity and regional fat deposition (Jia et al., 2007). In addition, women and men engage in different behaviors, which results in the inequality in the risk of type 2 diabetes between genders. Physical inactivity, smoking and alcohol consumption are significant risk factors for men, whereas obesity and high-sugar diet are predominant factors for women (Grant et al., 2009).

Socioeconomic status (SES) is another established factor associated with patterns of health behaviors and the incidence of type 2 diabetes. SES is a complex construct, usually measured by variables of education, income, and occupation. Each of the measures reflects specific constructs underlying SES characteristics; for example, income reflects economic characteristics; education determines levels of income and provides information regarding one's SES in early life course (Robbins et al., 2001). In studies of type 2 diabetes, education and income were noted as significant and consistent SES correlates of the occurrence of type 2 diabetes, regardless of gender and race (Maty et al., 2005; Robbins et al., 2001). SES influences individuals' access to "health-care services and information, availability of healthy foods and places to exercise, economic and occupational opportunities, as well as individual lifestyle choices" (Agardh et al., 2011, p.2). In developed countries, a strong inverse association is observed among education and income and the risk of type 2 diabetes for both men and women, adjusting for age and other factors. People with lower education and income normally earn less and have limited access to nutritional knowledge, and thus are more likely to eat unhealthy diets and be obese. However, existing literature suggests that a positive association between the risk of type 2 diabetes and education or income might exist in developing countries (Choi & Shi, 2001;

Robbins et al., 2001; Xu et al., 2006). In developing countries, people with higher education are more likely to consume a Westernized diet and participate in higher paid occupations, characterized by long sedentary periods of working on computers. By contrast, people with lower SES participate in more physical work and eat more fiber and less fat, and might be less likely to develop obesity and type 2 diabetes (Choi & Shi, 2001; Xu et al., 2006; Zimmer & Kwong, 2004).

In addition, existing studies suggest that the prevalence of type 2 diabetes varies between urban and rural areas (Choi & Shi, 2001; Wong & Wang, 2006). A study conducted among the Canadian population shows that the incidence of type 2 diabetes is higher among urban residents than their rural counterparts adjusting for age, gender, and SES (Choi & Shi, 2001). A Chinese study reveals that BMI and fasting serum glucose concentration is observed higher among people who live in urban areas than those who live in rural areas in China (Gu et al., 2003). In China, access to medical diagnostic technology and the extent of lifestyle westernization is greater in urban areas, which contribute to the higher diagnosis rate of type 2 diabetes in those areas. Additionally, people living in urban areas tend to earn higher income and are more likely to consume a Westernized diet with high fat and carbohydrate content compared to rural residents (Wang et al., 2007).

Type 2 Diabetes in China

The prevalence of type 2 diabetes has dramatically increased in China over the last decades due to rapid westernization in lifestyles and diet (Gu et al., 2003). Unlike Western countries, such as the United States and European countries, which experienced gradual nutritional transitions, China underwent a rapid and sudden change in nutrition and dietary structures to one that is characterized by high-energy diets (i.e., diets high in sugar, oil, and animal food). This change has accelerated the incidence of type 2 diabetes (Popkin, 1998; Yoon et al., 2006).

Chinese researchers have examined the biological etiology of this disease. They suggest that genetically, Chinese people, particularly Chinese Hans (the largest ethnic group in China) are more susceptible to type 2 diabetes due to early β-cell failure and prominent central obesity compared to other Chinese ethnicities and Western populations (Luo et al., 2001). In diabetes-related epidemiological studies, available work primarily focuses on the epidemic trend of the disease in the general Chinese population, or the impact of the disease on morbidity and mortality, illustrated in Appendix A.

As Appendix A summarizes, the existing Chinese literature is limited in some aspects. First, a majority of these studies analyze a sample in which people are from particular regions of China (e.g., north China or urban areas including Da Qing area, Shanghai, and Qingdao). They might not represent the wider Chinese population, such as people who live in the south and those who live in rural China. Therefore, the generalizability of findings presented in these studies may be limited. Second, none of these studies assesses the behavioral risk for type 2 diabetes, but only focus on mortality or morbidity related to diabetes complications. Cigarette smoking, heavy alcohol drinking, and physical inactivity have been established as risk factors of type 2 diabetes in many Western studies. However, the effect of these factors on the risks of type 2 diabetes has not been fully examined among the Chinese population. Furthermore, the influence of carbohydrate intake on type 2 diabetes diagnosis is not included in any of the studies in Appendix A. Although some Western studies have examined the association between carbohydrate intakes and risk of type 2 diabetes, the quantity of carbohydrate intake in relation to the risk of the disease is highly debated (Meyer et al., 2000; Schulze et al., 2004). Similar studies among the Chinese are still unavailable. Further investigation of the association between carbohydrate intake and risk of type 2 diabetes is necessary to understand the nutritional and dietary risk of the disease in a Chinese context. Addressing the lack of research is the first step towards expanding the existing literature on the behavioral and nutritional risks of type 2 diabetes in a non-Western context.

Therefore, the current study bridges important gaps by investigating the relative risk of type 2 diabetes diagnosis given individuals' engagement in unhealthy behaviors in China. That relative risk is measured by the odds ratio to estimate the odds of unhealthy behavior involvement among individuals with type 2 diabetes diagnosis to the odds of the exposure among those without the disease. First, this study explores the application of the Western model representing the association between unhealthy behaviors (i.e., cigarette smoking, heavy alcohol consumption, and physical inactivity) and the related risk of type 2 diabetes among the Chinese population. It is critical to understand how these behaviors are associated with the risk of type 2 diabetes in the Chinese population, and in addition, to examine if the knowledge derived from

Western studies is applicable to the Chinese culture. Second, the effect of carbohydrate intake on risk of type 2 diabetes, with the inconsistent findings in Western studies, warrants further investigation. The quantity of carbohydrate intake and risk of type 2 diabetes among middle-aged and older adults is under-studied in Chinese literature. Using a Chinese sample is optimal in examining how carbohydrate intake to provide new insights and improve related Western models. Last, for the analysis, the current study uses a sample selected from nationally representative data, which includes populations from north, south, urban, as well as rural China. Lifestyles vary between regions in China; hence, compared to the samples used in the existing Chinese literature, data collected from a wide range of regions are more representative of the characteristics of the Chinese population.

Conceptual Framework

This study is built upon the concept of behaviors and health proposed by Ferraro in his interpretation of life course epidemiology. Ferraro (2006) claims that how lifestyle, behaviors, and social status in early life influence health in later life give important insights in the field of health and aging. The application of a life course view to the study of health is referred to as life course epidemiology. Life course epidemiology does not only study the early origin of adult health and how risk factors cumulatively impact on health in later life, but it also examines the effect of health behaviors on health.

The effect of health behaviors on health is an important concept in life course epidemiology because it links health with human agency (i.e., individual choices and responsibility) and social structure (e.g., social classes and institutions), see Figure 1. Important differences in health over the life course may be shaped by behaviors over which humans have some degree of control, and the social structure, which is beyond humans' control (Ferraro, 2006). This idea conveys a critical concept that individuals have some level of control for how they behave within their social structure, and their behaviors can make a difference in their health even under the same levels of risks. In this regard, health behaviors are modifiable and can protect or damage one's health in one way or another regardless of the stage of the life course (Ferraro, 2006). Behaviors that increase the risk of disease are unhealthy behaviors, which harm individuals' health. Cigarette smoking, heavy alcohol drinking, and physical inactivity are widely recognized as unhealthy behaviors since they increase the risk of disease such as cardiovascular disease, diabetes mellitus, and hypertension (Kuh et al., 2003). In addition, the development of health behaviors is associated with socioeconomic status, which either accelerates or decelerates unhealthy behavior participation (Ferraro, 2006). Individuals with lower education and income are more likely to smoke cigarettes, consume alcohol heavily, and have a high calorie diet, all of which increase the risk of diabetes and cardiovascular disease among this population (Ferraro, 2006).

Ferraro's concept of behaviors and health is appropriate to a broad range of situations and populations. In a population-based cross-sectional cohort study of adult African-American twins enrolled in the U.S. Carolina African American Twin Study of Aging (CAATSA), researchers use Ferraro' concept to examine the associations between financial strain, engagement in risk factors of health, and physical disease (i.e., lung function, cognition, and depression). They find that participants who reported financial strain as children and as adults are more likely to be physically disable, and report more depressive symptoms than their unstrained counterparts (Szanton, Thorpe, & Whitfield, 2010).

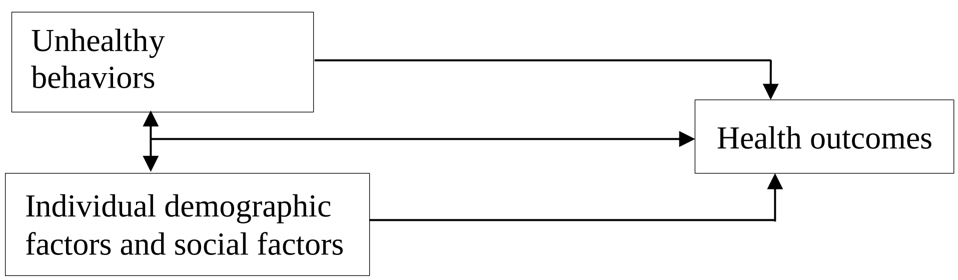

Figure 1. Conceptual framework for unhealthy behaviors and type 2 diabetes diagnosis based on Ferraro's life course epidemiology (2006).

To guide this study in addressing unhealthy behaviors relative to the risk of type 2 diabetes among middle-aged and older adults in China, a conceptual model is constructed based on Ferraro's work. This literature-based conceptual framework drives the operational model (see Figure 2) that is examined in this study.

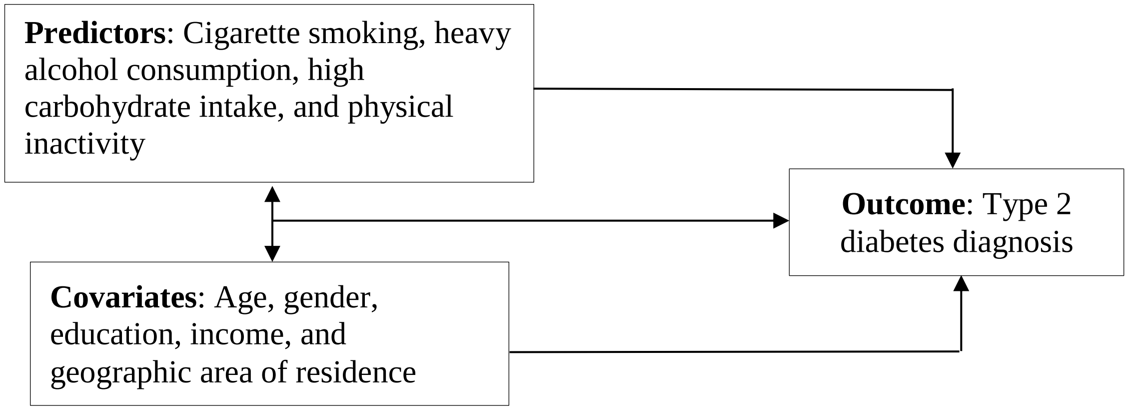

Figure 2. Operational model for unhealthy behaviors and type 2 diabetes diagnosis developed from Figure 1.

Derived from Figure 1, the operational model in Figure 2 illustrates the relationship among unhealthy behaviors, socio-demographic factors, and health outcomes, which provides theoretical support for the present study. According to Ferraro, unhealthy behaviors have a negative impact on health and might contribute to the occurrence of disease. Related to the current study, cigarette smoking, heavy alcohol consumption, high-carbohydrate intake and physical inactivity are unhealthy behaviors that contribute to the occurrence of type 2 diabetes. Furthermore, as mentioned by Ferraro, individual demographic characteristics (e.g., age, gender, education, income, and geographic areas of residence) are associated with health behaviors, which jointly as well as independently influence health (Abbatecola et al., 2009; Ferraro, 2006; Grant et al., 2009; Meigs et al., 2003). Age is found to be associated with less physical activity participation and poor diet; men are more likely to smoke and consume alcohol, whereas women tend to have high carbohydrate intake and be physically inactive (Abbatecola et al., 2009; Grant et al., 2009; Meigs et al., 2003). This operational model in Figure 2 incorporates variables representing each unhealthy behavior and sociodemographic covariates to present the hypothesized relationship between unhealthy behaviors and the risk for type 2 diabetes.

Research Questions

The purpose of this study is to investigate the applicability of findings in Western literature regarding unhealthy behaviors (e.g., cigarette smoking, heavy alcohol consumption, high carbohydrate intake, and physical inactivity) and the risk of type 2 diabetes to middle-aged and older adults in China. The research question is, "*How are unhealthy behaviors associated with the risk of type 2 diabetes diagnosis among middle-aged and older adults in China*?" It is hypothesized that unhealthy behaviors (e.g., cigarettes smoking, heavy alcohol consumption, high carbohydrate intake, and physical inactivity) increase risks for type 2 diabetes diagnosis among middle-aged and older adults in China, and these relationships are influenced by demographic and socioeconomic factors (e.g., age, gender, geographic area of residence, and SES).

Study Design

A case-control design and conditional logistic regression (CLR) are used to analyze the research question. The case-control design is widely used in epidemiology to examine exposure-disease association (Szklo & Nieto, 2000). A cohort study compares the relative risks of disease incidence (new cases) between the exposed and the unexposed cohorts. In contrast, a case-control design compares the relative risk of exposures to risk factors between disease cases and non-disease controls. In a case-control study, cases are subjects who have a disease at a given time, while controls are subjects who are free of the disease at that same time. A case-control study usually compares the odds of being cases and controls with respect to the presence of risk factors (Szklo & Nieto, 2000; Schlesselman & Stolley, 1982). Table 1 demonstrates the rationale of a case-control study.

Table 1

*Cross-Tabulation of a Defined Population by Exposure and Disease Development**

Exposure	Cases	Controls (non-cases)
Present (exposed)	**a**	**b**
Absent (unexposed)	c	d
Total	a+c	b+d

Note. *From Szklo and Nieto (2000).

As shown in Table 1, **a** is the number of individuals comprising cases with exposure in a defined population; **b** represents the number of individuals comprising non-cases with exposure;

c is the number of individuals comprising cases without exposure, and **d** is the number of individuals comprising non-cases without exposure. The purpose of a case-control study is to estimate odds ratios of the exposure to risk factors based on the occurrence of disease under study (Szklo & Nieto, 2000), see Equation 2-3. Odds ratio is the estimate of relative risk, which is calculated as the ratio of odds of exposure among cases to the odds of exposure among controls. The odds of exposure among cases is the ratio of the proportion of the exposed to the unexposed in the case group, while the odds of exposure among controls is the ratio of the proportion of the exposed to proportion of the unexposed in the control group (see Equations 2-1, 2-2).

$$\text{Odds}_{\text{exp/cases}} = \frac{\frac{a}{a+c}}{1-(\frac{a}{a+c})} = \frac{a}{c} \tag{2-1}$$

$$\text{Odds}_{\text{exp/controls}} = \frac{\frac{b}{b+d}}{1-(\frac{b}{b+d})} = \frac{b}{d} \tag{2-2}$$

$$\text{OR}_{\text{exp}} = \frac{\frac{a}{c}}{\frac{b}{d}} = \frac{a \times d}{b \times c} = \text{OR}_{\text{dis}} \tag{2-3}$$

The current study employs a case-control design rather than a cohort study because of the low disease incidence rate observed in this study. In epidemiological studies, a cohort study is one form of examining the exposure-disease association; however, a cohort study with survival analysis requires a minimum of 5% of the sample developing the disease in each follow-up measurement. The cohort study uses the hazard ratio to estimate the relative risks of disease incidence rate within a population. It is not appropriate for studies in which the population of cases or the population in each follow-up wave is less than 5% of the total sample, such as observed in this study (Clayton & Hills, 1993).

A case-control design is an alternative for estimating the association between exposure to suspect risk factors and the disease, given the occurrence of disease (Szklo & Nieto, 2000). In contrast to a cohort study, which must wait for a “sufficient” number of the disease to accrue, a case-control design is not sensitive to a small sample size; therefore, the statistical power of the estimation of odds ratio of disease is not affected (Parodi & Bottarelli, 2005). The goal of the current study is to assess the association between behavioral risks and type 2 diabetes given a type 2 diabetes diagnosis.

Methods

Data Source

This study uses the China Health and Nutrition Survey (CHNS), 1997–2009. The survey uses a multistage, cluster sampling process to draw a random sample of about 4,400 households with a total of 26,000 individuals in nine provinces that vary substantially in geography, economic development, public resources, and health indicators. All data are collected with a self-reported survey administrated by professionally trained field workers (interviewers). The baseline data were collected in 1997, with updates in 2000, 2004, 2006, and 2009. Each round of data includes economic information at both household and individual levels, individual information on socioeconomic and demographic factors, and nutrition and health measures. Health and nutrition data provide individual information on dietary intake (sugar, fat, and protein intake), body composition (e.g., weight, height, and waist circumstance), health history, and health-related behaviors (e.g., smoking, alcohol consumption, medication, and chronic diseases). This study uses all survey waves in the 12-year (1997–2009) individual level of data. The household level of data is also employed but only for income. The data on household income is merged to the individual data by unique identifier (ID variable) in both data files.

The CHNS is a cohort survey study with a repeated cross-sectional design in which separate samples are drawn from the same cohort at five different survey years (i.e., 1997, 2000, 2004, 2006, and 2009). Therefore, the same participants may be observed multiple times at different years. Five percent of the sample has multiple observations for type 2 diabetes diagnosis, while 95% is only observed once for this disease. The case-control study is cross-sectional, thus, this longitudinal data has to be transformed into a cross-sectional shape for the purpose of analysis. In a cross-sectional study, the trend or change patterns of variables over time cannot be estimated. Instead, the mean scores of variables among participants who have multiple observations are calculated. The observed scores for those who have single observations for variables are directly used in the analysis.

The total number of participants in the CHNS, 1997–2009, is 26,000. This study focuses on type 2 diabetes diagnosis among adults aged 45 and older. Therefore, children, adolescents, young adults, and individuals with type 1 diabetes are excluded. In addition, 2% (n = 228) of the remaining subjects have missing values on the outcome or explanatory variables. These observations are also excluded from the analysis. After the application of these exclusion criteria, 10,863 subjects including 5,184 (47.7%) men and 5,679 (52.3%) women with a mean age of 65 (*SD* = 13) comprise the pool from which the diabetic cases and non-diabetic controls are selected. The case pool comprises 574 participants with type 2 diabetes (potential cases), and the control pool includes 10,116 participants without type 2 diabetes (potential controls). The final sample for this study consists of 539 diabetic cases who are one-to-one or one-to-two matched with 553 non-diabetic controls.

Matching

In a case-control study, associations of interest between exposures and the outcome variable are prone to be distorted by confounding variables (Parodi & Bottarelli, 2005; Szklo & Nieto, 2000). Confounding variables, also known as "confounders," are the group of variables that have non-causal associations with both exposures and the disease (Parodi & Bottarelli, 2005; Szklo & Nieto, 2000). Matching is a necessary procedure that allows control for some confounders (Szklo & Nieto, 2000). Matching makes cases and controls as similar as possible on variables associated with both outcome and exposures (Clayton & Hills, 1993; Schlesselman & Stolley, 1982; Szklo & Nieto, 2000). Once cases are matched with controls on certain variables, the values of matched variables are held constant between cases and controls, and are not analyzed in the statistical model (Clayton & Hills, 1993).

Age and gender are commonly used to match cases with controls in studies of diabetes, because both variables are found to be strongly associated with unhealthy behaviors and the risk of type 2 diabetes (Abbatecola et al., 2009; Jia et al., 2007; Meigs et al., 2003). Age can be treated either as a continuous variable or a categorical variable. When the sample size of cases is small and the sample size of controls is large, age is usually treated as a continuous variable; then cases and controls are matched on exact age since there are enough controls that could be selected to match with cases on that age. Otherwise, when both sample sizes of cases and controls are small, age is usually treated as a categorical variable based on age range. The current study matches cases with controls on exact age and gender because the sample size of controls is large enough (Matthews & Brill, 2011). In most prospective studies, participants' age is usually measured in the same survey wave, often at the beginning of the study. However, the age profile of participants in the CHNS is different, because the time of entry into and exit from the CHNS varies among participants. To ensure comparability, age is adjusted based on the age as of 1997. This adjustment for age is used only for the purpose of matching. After this adjustment, again for the purpose of matching, age and gender are recoded as character variables and concatenated together as a new identifier variable, *age_gender*. Cases and controls are then matched on this variable.

This study uses individual matching: for each case, one or more controls with the relevant characteristics matching the cases are selected from the pool of eligible individuals (Szklo & Nieto, 2000). The study employs 1:N age-gender matching; that is, one case matches up to N controls (the maximum numbers of available controls) on the same age and gender. The matched controls are randomly selected from a pool of controls. The advantage of 1:N matching is that it can increase the statistical power in detecting associations between exposures and the health outcome of interest. In addition, it can ensure adequate sample size to support stratum-specific estimates (Hennekens & Buring, 1987; Wang, 2012).

For this study, a pool with all cases (individuals with type 2 diabetes, n = 574) and a pool of possible controls (individuals without type 2 diabetes, n = 10,289) is created. These input data files store all the potential subjects for the case-control matching. Some respondents are dropped from the study because of missing data. Figure 3 presents the process of dropping respondents and matching cases to controls. As shown in the figure, 179 subjects (6 cases from the cases pool and 173 controls from the controls pool), which accounts for approximately 2% of the total combined groups, have missing values on household income. In addition, 29 cases (5% out of 568) have missing values on BMI scores. These subjects are excluded before matching. After this exclusion, the cases pool contains 539 cases: 259 males (48%) and 280 females (52%); the controls pool contains 10,116 potential controls: 4,827 males (47%) and 5,289 females (52%). Both pools contain an *ID* variable, the matching variable of *age_gender*, explanatory variables and the outcome variable. Then, controls are selected from the pool of controls to match with each case in the pool of cases on *age_gender*. Each matched case-control pair forms one *stratum,* matched pair of case-control. This procedure continues to match each case with N control(s) until both the case pool and the control pools are empty. The matched pairs are stored in a new output data file. The final matched data file consists of 96 discordant strata including 539 cases matched with 553 (5.37% of 10,289) controls. The unmatched controls are excluded from the analysis. Among the matched case-control pairs, 69.80% (*n* = 67) are 1:1 matched (one case matched to one control), and 30.20% (*n* = 29) are1:2 matched (one case matched to 2 controls). The entire matching process is conducted with SAS statistical software (9.3).

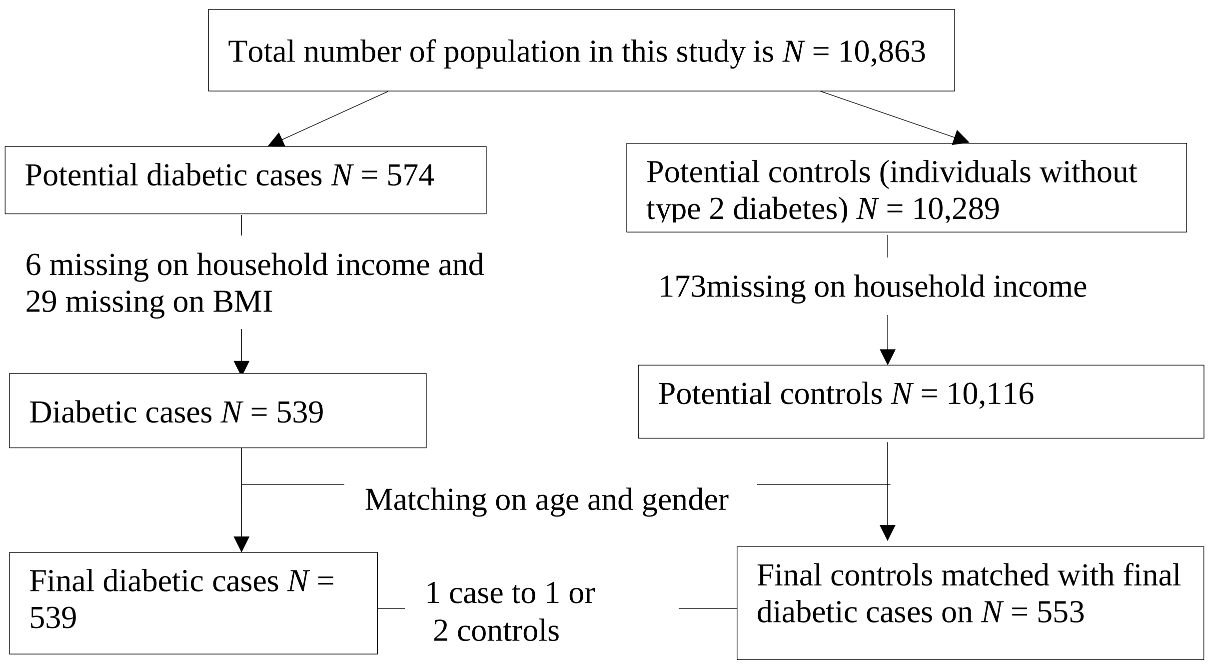

Figure 3. Numeral composition of cases and controls (including missing values) and matching process

Variables and Measurements

As presented in Figure 2, the operational model includes the measures that will be tested in this study. Variables representing unhealthy behaviors are cigarette smoking, heavy alcohol drinking, high-carbohydrate intake and physical inactivity; the outcome variable is type 2 diabetes diagnosis; covariates are age, gender, education, income, and geographic areas of residence.

Outcome variable—type 2 diabetes diagnosis. Type 2 diabetes diagnosis is measured with the interview question, "*Has a doctor ever told you have type 2 diabetes*?" The diagnosis of type 2 diabetes is confirmed by the second questions about age at which the person was diagnosed with the disease. If participants reported that they were not diagnosed with type 2 diabetes, but reported they were managing the disease or if they gave an age of diagnosis, these participants were considered to have the disease. The age at which the person was diagnosed with type 2 diabetes is measured by the question "*How old were you when you were told by the doctor about the situation (diabetes)*?" Less than 1% of respondents in the sample report no diabetes diagnosis but give an age of diagnosis. The variable of diabetes diagnosis is coded as 1 if the response to the question of diabetes diagnosis is *yes*, and 0 if *no.*

Predictors—unhealthy behaviors. Unhealthy behaviors in this study are cigarette smoking, heavy alcohol consumption, high carbohydrate intake, and physical inactivity.

Cigarette smoking. Is defined by individuals who have ever smoked cigarettes. Based on years of smoking, smoking status is coded as *current smokers*, *past smokers,* and *never-smokers*. *Current smokers* are defined as individuals who started smoking cigarettes at any point prior to or during any survey year and who were currently still smoking cigarettes in 2009. *Past smokers* are individuals who smoked cigarettes prior to or during any survey year but had already quit smoking in 2009. *Never-smokers* are individuals who never smoked before and were still not smoking in 2009. Never-smokers are the reference group in this analysis.

Alcohol consumption. Is measured by quantity and types of alcohol consumed per week in the preceding year. The ethanol content varies by types of alcohols (Liu et al., 2010). According to the Chinese Food Composition (equivalent to the U.S. FDA) in 2004, 50 grams of hard liquor contains 21.85 grams of ethanol, 50 grams of light liquor has 15.75 grams, one 640-gram-bottle of beer has 31.36 grams and 50 grams of wine has 5.2 grams (Liu et al., 2010). Thus, the average daily ethanol consumption in grams (g) is calculated by multiplying the quantity of alcohol consumption (g/week) by the standard ethanol content (g) for each type of alcohol, summing across types and then dividing by seven (7 days). For subjects who are observed at multiple time points on daily ethanol consumption (more than 98%), their individual mean score of daily ethanol consumption is calculated by adding all scores on daily ethanol consumption divided by the number of observations. The daily ethanol scores of subjects who are observed only once for daily ethanol consumption (less than 2%) are directly used. The Chinese literature indicates that average daily alcohol consumption of 50 g or more is considered heavy drinking, and average daily alcohol consumption of less than 50 g is considered moderate drinking (Liu et al., 2010). The current study employs this cut-off point to code two separate sets of dichotomous categories: *heavy drinker* (50 g or more) as *1* and *moderate drinker* (0–50 g) as *0* in one set; *abstainers* as *1* and *moderate drinker* as *0* in the other set.

Carbohydrate intake. Is the average daily individual carbohydrate intake in grams (g) between Monday and Sunday. In the CHNS, both individual and household levels of carbohydrate consumption are both collected by professionally trained interviewers. For both levels, three consecutive days were randomly selected from Monday to Sunday, during which detailed carbohydrate intake data were collected and equally balanced across seven days. During the three consecutive days, the household carbohydrate intake was determined by examining changes in food inventory from the beginning to the end of each day, in combination with a weighing and measuring technique. Scales with a maximum limit of 15 kilograms and a minimum of 20 grams were used. All processed foods (including edible oils and salt) before initiation of the household survey and remaining after the last meal were weighed and recorded. All purchases, home production, and processed snack foods were recorded. Whenever foods were brought into the household unit, they were weighed, and preparation waste (e.g., spoiled rice, discarded cooked meals fed to pets or animals) was estimated when weighing was not possible. At the end of the surveys, all remaining foods were again weighed and recorded. The number of household members was recorded at each meal. The average daily carbohydrate intake for each household member was calculated separately from other kinds of food based on the number of household member and the total household carbohydrate intake.

During the same three consecutive days, individuals were asked each day to report all food that they consumed within and outside the home on a 24-hour recall basis. The individuals' daily within-home carbohydrate intake was calculated by interviewers from the household carbohydrate intake. The individuals' daily carbohydrate intake was calculated based on the total carbohydrate intake from all food consumed (within and outside home) during the three consecutive days and equally balanced to seven days.

In this study, daily individual carbohydrate intake is used. Mean score of daily carbohydrate intake is calculated for individuals who are observed at multiple time points (less than 2%). For individuals who are only observed at one time point, their daily carbohydrate intake score at that time point is used. There is a lack of evidence on the threshold amount of carbohydrate intake related to the risk of type 2 diabetes; therefore, the variable of carbohydrate intake is treated as a continuous variable.

Physical activity. Is measured using minutes of participation in specific types of exercise per week. In the CHNS, physical activities are divided into three types based on the purposes of the activities. Physical activities during work are occupational activities; activities during leisure time are leisure-time activities; activities for commuting to work are commuting activities. Participants are asked to report the duration (how many minutes) of their engagement in occupational activities, leisure-time activities, and commuting activities per week. Occupational activities include walking, farming, dancing, lifting, and carrying heavy items (e.g., lumber and steel workers); leisure-time activities include martial arts, gymnastics, dancing, running, swimming, ball games, track and field, and *Taichi*; commuting activities are walking, biking, taking the bus, taxi, or subway, and motorcycling.

Existing literature suggests that participation in 30 minutes of leisure-time physical activity at least three times a week protects individuals from diabetes (Plotnikoff et al., 2010; Sigal et al., 2006). Hu et al. (2003) found that middle-aged and older Finnish adults who concurrently perform two or three types of activities (occupational, commuting, and leisure-time) for 30 minutes per day, three times a week (90 min/week) have a lower risk of type 2 diabetes than those who perform only one type of physical activity. Public health and diabetes-specific guidelines also suggest the protective effect of 90 min/week of physical activity on type 2 diabetes. Individuals participating in physical activity for 90 minutes or more are considered physically active; those who do less than 90 minutes are considered physically inactive (Kavanagh et al., 2010; Plotnikoff et al., 2010). However, in general, older persons are less likely to walk or cycle to and from work or be engaged in higher levels of occupational or leisure-time physical activities (Hu et al., 2003; Li et al., 2008). Thus, the 90 min/week threshold may not be suitable for older adults. Instead, 30 minutes of daily physical activity twice a week (60 min/week) is a more realistic threshold for older adults in studies of type 2 diabetes (Agurs-Collins, Kumanyika, Ten Have, & Adams-Campbell, 1997). The current study considers the total minutes of all types of physical activity per week when measuring physical activity participation. There is a lack of evidence demonstrating that the risk of type 2 diabetes decreases with every one-minute increase in physical activity. Therefore, it is conceptually meaningful to use 60 minutes as a threshold for coding the variable of physical activity dichotomously. Mean score of weekly duration (minutes) of physical activities for individuals observed at multiple time points are calculated by adding minutes of physical activity across all time points and dividing by the number of observations; for individuals who have been observed once at one time point, their total minutes of weekly physical activities at that time point are used. In the present study, weekly participation in physical activity of less than 60 minutes is considered physically inactive, coded as *1*; 60 minutes or more is considered physically active and coded as *0*.

Covariates—body mass index (BMI), demographic factors, and socioeconomic status. Body mass index (BMI) is calculated by using average weight (kg) and height (m) with the function BMI = weight (kg)/height^2 (m^2). According to Chinese criteria, individuals with BMI ≥ 28 kg/m^2 are considered "obese," 24kg/m^2 ≤ BMI < 28 kg/m^2 are "overweight," 18.5 kg/m^2 ≤ BMI < 24 kg/m^2 are "normal," and BMI < 18.5 kg/m^2 are "underweight" (Hu et al., 2007; Wang et al., 2007; Wildman, Gu, Reynolds, Duan, & He, 2004). Based on this standard, BMI ≥ 28 kg/m^2, is coded as *1*, designating "*obese*," and BMI < 28 kg/m^2, is coded as *0*, indicating "*non-obese*."

Geographic area of residence refers to rural and urban residence. In the CHNS, rural residents are predominately farmers who live in villages but not in cities or towns; urban residents refer to people who live within cities or towns and who are not engaged in farm work. Geographic area of residence is coded as *1* for urban area and *2* for rural area. For the convenience of analysis, rural area is recoded as *0*.

Socioeconomic status (SES) is measured by two separate variables: education and household income. *Education* is defined as the highest level of education that participants attained. There are six possible responses for the variable of education: *1 = finished from primary school (6 years), 2 = middle school (3 years), 3 = high school (3 years), 4 = technical or vocational degree (4 years), 5 = university or college degree (4-5 years), 6 = master or higher degree (3-6 years)*. In China, technical or vocational degree is a lower level of degree than college. Most of the participants in this study had relatively low levels of education: 5.2% of participants (*n* = 556) had technical or vocation degree; 4.5% (*n* = 484) had university or college degree; 0.1% (*n* = 8) had master or higher degree; 12.3% (*n* = 1,316) had high school degree, and 77.7% had middle school and lower degree. If the proportion of a category within a categorical variable is too small, it is appropriate to collapse that category with its adjacent categories for either practical or theoretical reasons in log-linear analysis (Allison, 1980). Therefore, in a practical sense, responses *1* and *2* are collapsed, and responses *3*, *4*, *5*, and *6* are collapsed. The variable of education is recoded dichotomously: *0 = middle school and lower*, *1 = high school and above*. After recoding, 22.3% of the participants have a high school and above degree (*n* = 2,364), while 77.7% of the participants have middle school and lower education (*n* = 8,303).

Total household income is defined as the gross annual income (in *yuan*) [according to the currency exchange rate in 2009, 1000 *yuan* equals $143] from all resources (including individual wages, farming, livestock, fishing, private business, gardening, and handicrafts) of a household in the past 12 months. In the CHNS, the household income recorded in 1997, 2000, 2004, and 2006 were corrected based on 2009 dollars to adjust for the rising cost of living; in addition the measure is adjusted for variation in household size (number of members in a household). Household income is a more realistic measure for reflecting economic status than individual income, and total household income may better reflect the income per capita in families (Xu et la., 2006). In China, older adults usually live together with their children, and parents or grandparents may have lower or no income (or a pension) in many families, particularly in rural areas (Xu et al., 2006). Therefore, the economic situation of parents or grandparents might heavily depend on their families and total household income. Mean household income is calculated for respondents who have multiple observations of household income. For respondents who only have single observations of household income, their household income is directly used in the analytical model.

Analysis

Conditional logistic regression (CLR) is used to analyze the association between unhealthy behaviors and the diagnosis of type 2 diabetes. CLR is most frequently used in matched case-control studies in which cases and controls are individually matched (Szklo & Nieto, 2000). Each matched set/pair of case-control is one *stratum*. The CLR model is analogous to regular logistic regression model:

$$P_{(y|x)} = \frac{1}{1+e^{(\beta_0+\beta_1 x)}} = \lg\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 x \ , \qquad (2\text{-}4)$$

except that the regression intercept (i.e., β_0 or the baseline risk) in the CLR model is "conditioned out" of analysis. In a case-control study, CLR is used to estimate the association of within-stratum exposures and the outcome ("Conditional Logistic Regression," 2006).Within each matched stratum, the baseline risk for the cases and controls are the same because they are matched or conditioned on the same characteristics such that the estimation of intercept β_0 should be eliminated. Instead, parameters representing exposures associated with cases and controls within the strata (pairs of cases-control, i.e., β_1, β_2, β_3 etc.) are only considered (Szklo & Nieto, 2000), see Equation 2-5

$$P_{(y|x)} = \frac{e^{\beta_0 + x_{case}\beta}}{e^{\beta_0 + x_{case}\beta} + e^{\beta_0 + x_{control}\beta}} = \frac{\beta_0}{\beta_0} \frac{e^{x_{case}\beta}}{e^{x_{case}\beta} + e^{x_{control}\beta}} = \frac{e^{x_{case}\beta}}{e^{x_{case}\beta} + e^{x_{control}\beta}} . \quad (2\text{-}5)$$

In the current study, x_{case} and $x_{control}$ in Equation 2-5 represent diabetics and non-diabetics, respectively. The diabetics and non-diabetics are matched on exact age and gender, and each matched "diabetics–non-diabetics" forms one *stratum*. Within each matched stratum, the baseline risk for diabetics and non-diabetics are the same since they are matched on the same age and gender such that the estimation of intercept β_0 in Equation 2-5 is eliminated. Parameters representing unhealthy behaviors associated with diabetes within stratum (i.e., $\beta_{smoking}$,$\beta_{alcohol}$, $\beta_{physical\ activity}$, and $\beta_{carbohydrate\ intake}$) are considered.

Furthermore, CLR is utilized to address the heterogeneity regarding the association of exposures and the outcome between cases and controls ("Conditional Logistic Regression," 2006). If both cases and controls in the pair have the same outcome (e.g., $x_{case} = x_{control} = 1$, both exposed, or $x_{case} = x_{control} = 0$, both unexposed), there is no information about the association between the covariates and the outcome (this could be due to the matching variables or due to the covariates). Only discordant strata on the outcome are informative (e.g., $x_{case} = 1$ and $x_{control} = 0$ or $x_{case} = 0$ and $x_{control} = 1$), since it is assumed to be due to the covariates, not the common matching variables ("Lecture 12," n.d.). In other words, if $x_{case} = x_{control} = 1$ (both exposed) or $x_{case} = x_{control} = 0$ (both unexposed), these matched pairs are not helpful to estimate β; only those for which $x_{case} = 1$ and $x_{control} = 0$ or $x_{case} = 0$ and $x_{control} = 1$ are meaningful for estimating β. The rationale on how discordant matched cases and controls used in CLR is demonstrated in Table 2.

Table 2

*Case-Control Pairs Used in Conditional Logistic Regression (CLR)**

	Case exposed	Case unexposed
Control exposed	n_{11}	n_{01}
Control unexposed	n_{10}	n_{00}

Note. *Matched case-control pairs must be discordant on the outcome and exposures.

The data in the current study are arranged by matched strata of diabetics (case) to non-diabetics (control) based on the same age and gender, in which more than 69.80% have one case matched with one control, and less than 30.20% have one case matched with two controls. Given exposure to unhealthy behaviors, there are 96 discordant strata (i.e., $x_{\text{diabetics}} = 1$ and $x_{\text{non-diabetics}} = 0$ or $x_{\text{diabetics}} = 0$ and $x_{\text{non-diabetics}} = 1$) that are meaningful to estimate β in Equation 2-5, which is the parameter for unhealthy behaviors.

Assuming the diabetic case of 96 discordant sets of size n_i for the ith set, i=1, …, $N(N=96)$, the jth member of the ith set has covariate vector $x_{ij}=(x_{ij1} \ldots x_{ijp})^T$ for $i = 1, \ldots, 96$; $j = 1, \ldots n_i$. According to Lachin (2011), “The members of matched sets share the characteristics (have the identical values on the matching variables) that are represented by the covariates used for matching. For the ijth member, if y_{ij} is an indicator variable representing cases (D: $y_{ij} = 1$) and controls ($\overline{D}$: $y_{ij} = 0$), a logistic regression that specifies the probability of the response π_{ij} for the ijth member is a logistic function of the covariates $\pi_{ij.}$” (p. 297). The model assumes that the covariates have a common effect on the odds of the response over all matched sets represented by the coefficient vector $\beta = (\beta_1 \ldots . \beta_p)^T$. Then model is then:

$$P_i(D|x_{ij}) = \pi_{ij} = \pi_i(x_{ij}) = \frac{e^{x_i + x'_{ij}\beta}}{1+e^{x_i + x'_{ij}\beta'}} \quad . \qquad (2\text{-}6)$$

According to Equation 2-6, unhealthy behaviors including cigarette smoking, heavy alcohol consumption, physical inactivity, and high carbohydrate intake are assumed to have a common effect across 96 discordant strata on the risk for developing type 2 diabetes.

Assuming the conditional probability of interest for the ith stratum is the probability of m_{1i} representing the covariate vectors $x_1, \ldots, x_{m1i}$ of cases and the probability of m_{2i} representing the covariate vectors $x_{(m1i+1)}, \ldots, x_{ni}$ of controls, the conditional likelihood for the ith stratum is

$$L_{i|m_{1i,n_i}} = \frac{\prod_{j=1}^{m_{1i}} \pi_i(x_{ij}) \prod_{j=m_{i1+1}}^{n_i} [1-\pi_i(x_{ij})]}{\sum_{l=1}^{\binom{n_i}{m_{1i}}} \prod_{j(l)=1}^{m_{1i}} \pi_i(x_{ij(l)}) \prod_{j(l)=m_{1i+1}}^{n_i} [1-\pi_i(x_{ij(l)})]} . \qquad (2\text{-}7)$$

In Equation 2-7, “the denominator is the sum of all possible combinations of m_{1i} of n_i cases and m_{2i} subjects of controls. Within the lth combination $j(l)$ then indicates the original index of the member in the jth position” (Lachin, 2011, p. 300). Therefore, Equation 2-7 is used to estimate the log likelihood/odds ratio (OR) of type 2 diabetes diagnosis for the ith discordant strata given exposure to unhealthy behaviors. To get the log likelihood, substituting $\pi_i(x_{ij})$ in Equation 2-7 with the probability function expressed with natural log in Equation 2-6, the adjusted Equation 2-8 is

$$L_{i|m_{1i,n_i}} = \frac{\prod_{j=1}^{m_{1i}} e^{x'_{ij}\beta}}{\sum_{l=1}^{\binom{n_i}{m_{1i}}} \prod_{j(l)=1}^{m_{1i}} e^{x'_{ij(l)}\beta}} . \qquad (2\text{-}8)$$

Thus, for *96* matched sets, the conditional likelihood is $L_{(c)}(\beta) = \prod_i L_{i|m_{1i,n_i}}$ and the log likelihood is Equation 2-9:

$$L_{(c)}(\beta) = \sum_i l_{i|m_{1i,n_i}}(\beta) . \qquad (2\text{-}9)$$

Equation 2-8 is the ultimate equation for producing the summation of odds ratios. The odds of exposure to cigarettes smoking, alcohol consumption, carbohydrate intake, and physical activity between cases and controls given type 2 diabetes diagnosis for each stratum is compared and calculated with Equation 2-8. Equation 2-9 is used to sum the odds ratios of all 96 strata to obtain the overall odds ratio estimate for the hypothesized model. The conditional logistic regression model is performed with PROC LOGISTIC and STRATA statement with 95%

confidence intervals (CI) using SAS statistical software (version 9.3).

Results

Descriptive statistics including means, standard deviations, proportions, and bivariate tests (t-test for continuous variables, Chi-square test (χ^2) for categorical variables) are used to assess the characteristics of the matching variables, the explanatory variables, and the outcome variable. Table 3 summarizes the demographic characteristics of cases and controls after matching. There are 539 cases; 259 males (48%) and 280 females (52%) matched with 553 controls comprising 265 (48%) men and 288 (52%) women from the pool of controls. The mean age of the matched cases-controls is 71(SD = 11.15). Fifty-two percent of cases live in urban China compared to 37% of controls. The numbers of individuals with college and higher education in both case and control groups are small (10% and14%, respectively). The distributions of household income are similar between cases and controls. The median household income of the cases is 27,827 *yuan* (SD = 42,157) and the mean income of controls is 27,903 *yuan* (SD = 36,334). There are more subjects whose BMI values are ≥ 24kg/m^2 (cut-off point of "overweight") among the cases than the controls. Fifty-three percent of cases are overweight or obese compared to 39% in the controls; 37% of cases have normal BMI values versus 50% in the matched controls. For cigarette smoking status, there are more past and current smokers among cases than controls (9% vs. 4% for past smokers; 13% vs. 5% for current smokers). Furthermore, 70% of subjects are abstainers in the case group and 74% in the control group; 93% of subjects are physically inactive in the case group and 97% in the control group.

As shown in Table 3, the Chi-square test (χ^2) shows that type 2 diabetes diagnosis is associated with all variables representing unhealthy behaviors as well as major demographic covariates. Specifically, type 2 diabetes diagnosis is highly significantly associated with urban residence, high school and higher levels of education, high BMI values, past and current smoking, heavy alcohol drinking, and physical inactivity ($p < .001$). Moreover, according to the *t*-test, the characteristics of household income and carbohydrate intake are significantly different between cases and controls ($p < .001$). The average daily carbohydrate intake is higher among cases, 361.2 g (SD = 211.2), than that among controls, 295.9 g (SD = 116.8).

Table 4 shows the outcomes of the CLR analysis used to investigate the association between unhealthy behaviors and type 2 diabetes diagnosis. The overall hypothesized model fits the data adequately (χ^2 = 1118.87, *df* = 9, *p* <.01). Given a specific age and gender, active cigarette smoking, high carbohydrate intake, and physical inactivity are significantly associated with higher risk of type 2 diabetes diagnosis. For every one-unit increase in average daily carbohydrate consumption, there is approximately 1% increase in the odds of being diagnosed as type 2 diabetes (*OR* = 1.01, 95% CI, 1.01–1.02). In terms of cigarette smoking, past smokers are nearly twice more likely to be diagnosed with type 2 diabetes (*OR* = 1.89, 95% CI, 1.14–3.15) than never smokers, and current smokers are almost 2.5 times (*OR* = 2.48, 95% CI, 1.49–4.12) more likely to be diagnosed with the disease than never smokers. For individuals who are physically inactive, the odds of being diagnosed with type 2 diabetes is 1.3 times more than those who are physically active (*OR* = 1.27, 95% CI, 1.12–2.15).

Furthermore, the effect of demographic characteristics or socioeconomic factors on the type 2 diabetes diagnosis is similar to findings in the Western literature. Given a specific age and gender, urban residents are approximately 2.6 times (*OR* = 2.61, 95% CI, 0.24–2.86) more likely to be diagnosed with type 2 diabetes than their rural counterparts while holding other variables constant in the model (if an odds ratio is smaller than 1, the reciprocal of that odds ratio should be used for interpretation, according to Davies, Crombie, & Tavakoli, 1998). In a like manner, given a specific age and gender, individuals with a high school and higher degree are 2.5 times (*OR* = 2.54, 95% CI, 2.23–2.89) more likely to be diagnosed with type 2 diabetes than those with middle-school or lower level of education while holding other variables constant. Despite a small odds ratio, the diagnosis of type 2 diabetes varies by household income. For every one-unit increase in the household income, there is approximately 1% increase in the odds of being diagnosed for type 2 diabetes (*OR* = 1.01, 95% CI, 1.01–1.02). For instance, for every thousand *yuan* (every $143) increase in the household income, the odds of being diagnosed for type 2 diabetes is increased by approximately 1%. In addition, the disease diagnosis varies in BMI values. The odds of being diagnosed with type 2 diabetes for individuals who are obese is 1.5 times higher (*OR* = 1.48, 95% CI, 1.09–2.01) than for those who are not obese.

Discussion

Compared to a large body of literature regarding behavioral risks for type 2 diabetes conducted in Western populations, studies for the Chinese population, particularly with a focus on middle-aged and older Chinese, are extremely limited. For this reason, building upon the conceptual model developed from Ferraro's work on health behaviors and health (2006), the current study analyzes the research question, "*How is type 2 diabetes diagnosis associated with unhealthy behaviors among middle-aged and older adults in China*?" It is hypothesized that unhealthy behaviors (e.g., cigarette smoking, heavy alcohol drinking, high carbohydrate intake, and physical inactivity) increases risks for type 2 diabetes diagnosis among middle-aged and older Chinese; such a relationship is influenced by demographic and socioeconomic factors. Findings indicate that major unhealthy behaviors are significantly associated with a higher risk of type 2 diabetes diagnosis among middle-aged and older adults in China. The study finds that past and current cigarette smokers are more likely to be diagnosed with type 2 diabetes; higher daily carbohydrate intake increases the risk of being diagnosed with the disease; and physical inactivity increases the risk for type 2 diabetes. These findings are consistent with many other Western studies, which imply that the Western model might apply to the Chinese population.

Further, the results of this study suggest that people with higher levels of educational and income are more likely to be diagnosed with the disease. Such findings differ from Western-based conclusions. These studies claim that SES is inversely associated with the risk of type 2 diabetes (Choi & Shi, 2001; Robbins et al., 2001). In China, individuals with higher SES tend to live in urban areas with sedentary occupations working on computers and spending less time in physical activities. Furthermore, their diet is more westernized. Thus, they are more likely to consume more sugar and fat, but less vegetable fiber. Medical techniques are more advanced in urban China, and people with higher SES are more likely to use health services and be able to afford medical examinations and diabetes screening tests. In contrast, individuals who live in rural areas and people with lower income are less likely to consume carbohydrates and fat but more likely to consume fiber, which lowers the risk for type 2 diabetes. In addition, the disease might be under-diagnosed in rural China due to limited access to health services and the large number of individuals with lower education and income, who may have little knowledge regarding the importance of health screening or may not be able to afford medical examinations.

However, it is also important to address potential limitations of this study. The primary limitation of the case-control design is that it is prone to biases such as selection and recall biases. The matching process of the case-control study is “artificial.” The cases are not randomly assigned to controls but paired based on certain criteria, which contributes to the selection bias. Second, the cross-sectional study design along with a higher proportion (95%) of single observations for type 2 diabetes diagnosis in this study’s sample, prohibits examination of the duration of diabetes and the trend or change patterns of unhealthy behaviors on the risk of diabetes. Therefore, the causal relationship between unhealthy behaviors and type 2 diabetes diagnosis cannot be tested in the current study. Third, the intensity of smoking (how many cigarettes are smoked) is only available for current smokers in the CHNS. The current study is not able to test the prediction of intensity and frequency of smoking for the risk of type 2 diabetes. Therefore, the result on cigarette smoking should be used and interpreted with caution. Fourth, the higher prevalence of alcohol abstainers in both cases and controls limits the ability to test prediction of alcohol consumption on the risk of type 2 diabetes. This is possibly related to a cultural preference for avoiding alcohol in order to promote health and tea drinking. In China, people, particularly older adults, drink tea more than alcohol (Ji et al., 1996). Additionally, disease-related abstinence from alcohol might be a potential cause. The mean age in the current study is 65, and it is reasonable to assume that this population may have quit alcohol drinking due to pre-existing health issues other than type 2 diabetes before being interviewed. However, this information is not available from the CHNS. Similar to alcohol abstinence, physical inactivity rate in both cases and controls is high. The uniformity of physical inactivity might potentially be related to social expectations for older adults. In the Chinese culture, older adults are expected to move slowly and stay calm (Li et al., 2008). Although physical inactivity is significantly associated with a higher risk of type 2 diabetes diagnosis, the results on physical activity have to be interpreted cautiously. Last, the use of a self-reported questionnaire to collect data on health behaviors and diabetes diagnosis is vague and imprecise. Misclassification is inevitable and usually results in a biased estimate of the association between predictors and the outcome variable.

Given these limitations, this study suggests various inquiries for future research. First, the causal relationship between health behaviors and type 2 diabetes diagnosis needs to be investigated for the Chinese population. Such an investigation can improve researchers’ understanding of the behavioral determinants of type 2 diabetes among middle-aged and older Chinese. A longitudinal model analyzing the causal relationship can better depict the development of one's lifestyle from early to the later life and dynamically investigate how individuals' lifestyles develop and how lifestyle is related to type 2 diabetes.

Second, a study with a particular focus on Chinese baby boomers, who were born during the 1950s and 1960s, would be compelling in the studying of type 2 diabetes. The Chinese baby boomers are also known as an "unlucky generation" because they experienced sharp economic and political reforms as well as the nationwide great famine in 1960. This generation suffers from mediocre education, interrupted working lives, reduced ability to save, and being in old age with only one child to help them. Their early-life experience contributes to their lower socioeconomic status and limited access to nutritional knowledge and healthcare services. Their diet might be unhealthy, and they are more likely to consume oil and animal food due to their early-life famine; they are not able to afford medical screening and treatment. These are possibly related to type 2 diabetes diagnosis. Thus, it would be interesting to explore the long-term effect of the lifestyle change on the incidence of type 2 diabetes among this population.

Third, measures of variables in studies of type 2 diabetes are worthwhile to consider regardless of culture. Both self-reported survey results and clinical records for type 2 diabetes should be used for older adults. Clinical records would be beneficial in excluding asymptomatic diabetes for screening purposes and recall bias (Hu et al., 2003). This is particularly important for older adults, since they might have problems with recall of diagnosis. Additionally, *life-long alcohol abstainers* should be distinguished from *due-to-disease alcohol abstainers* using different survey questions. These questions are critical to improve the analysis of the association between alcohol consumption and risk of type 2 diabetes by filtering the influence of pre-existing health issues. Questions on drinking patterns should be considered as one measure of alcohol consumption. Prior Western studies have claimed the importance of assessing the influence of drinking patterns on the risk for type 2 diabetes (Beulens et al., 2005; Koppes, Bouter, Dekker, Hendriks & Heine, 2005). Despite the lack of solid evidence, Western scholars assume that the risk for type 2 diabetes is different between regular drinkers and binge drinkers, and that the risk may be higher among binge drinkers. It would be interesting to learn how different the risks for type 2 diabetes between regular drinkers and binge drinkers are in a Chinese context.

Last, the perception of physical activity for health improvement and "being physically active" among the Chinese population requires more investigation in studies of type 2 diabetes. Prior literature suggests that sociocultural contexts may affect involvement in, attitude towards, and commitment to physical activity and an active lifestyle (Henderson & Ainsworth, 2003). The perception and expectation of physical activity is different between ethnic groups; for example, American-Indian women's interpretation of physical activity patterns and levels of activity for health improvement is different from that of African-American women (Henderson & Ainsworth, 2003). This evidence might also hold true for the Chinese middle-aged and older adults. The Chinese middle-aged and older adults normally participate in slow and moderate leisure-time physical activity for socialization and health promotion (Lu & Hu, 2005). Most of them have retired, and leisure-time activities are a crucial part of their life. It is meaningful to understand what leisure-time physical activity they perform and the type 2 diabetes diagnosis among this population. Therefore, questions and measures for physical activity in Chinese studies might be structured differently from those in Western studies. In addition, the criteria for being physically active, particularly for older adults, should be revisited and revised. This study shows that the 30minutes duration and twice-per-week standard might not be an appropriate cut-off point to categorizing "physically active" or "physically inactive" for middle-aged and older Chinese. Perhaps this standard can be lowered.

Finally, findings of the current study suggest the necessity of translating the research results into pragmatic applications and generating realistic strategies to narrow the gap between urban and rural healthcare in China. Education regarding health behaviors and health, particularly the long-term effects of health behaviors on health, should be promoted among middle-aged and older adults and individuals with lower education in rural China. Health intervention programs in relation to diabetes should be created and promoted in both urban and rural China. Additionally, enhancing access to affordable health services and screening tests for type 2 diabetes, particularly in rural areas, should be seriously considered by policymakers in China.

Table 3

Characteristics of Cases (Individuals with Type 2 Diabetes) and Controls (Individuals without Type 2 Diabetes), 1997–2009

Variables	Cases (individuals with type 2 diabetes) *n* (%)	Controls (individuals without type 2 diabetes) *n* (%)
	N = 539	N = 553
Age (years)	$\bar{x}^a$ = 71 (SD = 11)	
Gender		
Men (1)	259 (48%)	265 (48%)
Women (0)	280 (52%)	288 (52%)
Geographic area of residence		
Urban (1)	280 (52%) ***	205 (37%)
Rural (0)	259 (48%)	348 (63%)
Education		
College and higher (1)	75 (14%) ***	55 (10%)
Middle school and lower (0)	464 (86%)	498 (91%)
Total household income(*yuan*)	$\tilde{x}^b$ = 27,827 (SD = 42,157)*	$\tilde{x}^b$ = 27,903 (SD = 36,334)
BMI		
Obese (≥28kg/m^2) (1)	138 (26%) ***	83 (15%)
Non-obese (<28kg/m^2) (0)	401 (74%)	470 (85%)
Carbohydrate intake (g/day)	$\bar{x}^a$ = 361.2 (SD = 211.2)***	$\bar{x}$ = 295.9 (SD = 116.8)
Smoking status		
Past smokers (1)	49 (9%) ***	22 (4%)
Current smokers (1)	70 (13%) ***	28 (5%)
Never-smokers (0)	426 (79%)	503 (91%)
Alcohol consumption (g/day)		
Heavy drinkers (1)	49 (9%)*	50 (9%)
Abstainers (1)	398 (74%)	387 (70%)
Moderate drinkers (0)	92 (17%)	83 (15%)
Physical activity		
Inactive (1)	504 (93%) ***	536 (97%)
Active (0)	35 (7%)	17 (3%)

Note. *p < .05; **p < .01; ***p < .001. Continuous variables are household income, carbohydrate intake, and age; the remaining variables are categorical variables.

a. Comparisons between cases and controls.
   Associations among categorical variables are tested using Chi-square χ^2test.
   Differences in mean among numeric variables are tested using *t*-test.

b. $\tilde{x}$ is median household income. To avoid the influence of extreme values of income, the median household income is calculated and compared between case and control groups in the *t*-test.

Table 4

Outcomes of Conditional Logistic Regression (CLR) Analysis for Case-Control Study

Risk lifestyle exposures and reference groups	Estimated coefficient ($\hat{\beta}$)	SE	(OR)[++]	95% CI
Geographic area of residence Rural (1) vs. urban (0)	0.96	0.04	2.62**	[0.24, 2.86]
Education College and higher (1) vs. middle school and lower (0)	0.93	0.06	2.54**	[2.23, 2.89]
Household income (*yuan*)	0.01	0.00	1.01**	[1.01, 1.02]
BMI[+]				
Obese (1) vs. non-obese (0)	0.39	0.15	1.48**	[1.09, 2.01]
Carbohydrate intake (g/day)	0.00	0.00	1.01**	[1.01, 1.02]
Smoking status				
Past smokers (1) vs. never smokers (0)	0.63	0.26	1.89**	[1.14, 3.15]
Current smokers (1) vs. never smokers (0)	0.91	0.26	2.48**	[1.49, 4.12]
Alcohol consumption (g/day)				
Heavy drinkers (1) vs. moderate drinkers(0)	0.18	0.18	0.84	[0.59, 1.20]
Abstainers (1) vs. moderate drinkers (0)	0.22	0.07	0.80	[0.66, 1.29]
Physical activity (minutes/week)				
Inactive (1) vs. active (0)	0.24	0.14	1.27**	[1.12, 2.15]

Note. *$p < .05$; ** $p < .01$; *** $p < .001$.

CI = confidence interval.

+BMI = weight (kg)/height^2 (m^2).

++Adjusted relative odds ratio (*OR*) = odds of exposures among cases/odds of exposures among controls adjusted for age and gender.

References

Abbatecola, A. M., Evans, W., & Paolisso, G. (2009). PUFA supplements and type 2 diabetes in the elderly. *Current Pharmaceutical Design*, *15*, 4126-4134.

Agardh, E., Allebeck, P., Hallqvist, J., Moradi, T., & Sidorchuk, A. (2011). Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. *International Journal of Epidemiology*, 1-15.

Agurs-Collins, T. D., Kumanyika, S. K., Ten Have, T. R., & Adams-Campbell, L. L. (1997). A randomized controlled trial of weight reduction and exercise for diabetes management in older African-American subjects. *Diabetes Care*, *20*(10), 1503-1511.

Ajani, U. A., Gaziano, M., Lotufo, P. A., Liu, S., Hennekens, C. H., Buring, J. E., & Manson, J. E. (2000). Alcohol consumption and risk of coronary heart disease by diabetes status, *American Heart Association*, 102, 500-505.

Al-Daghri, N. M., Al-Attas, O. S., Alokail, M.S., Alkharfy, K. M., Shaik, N. A., Draz, H. M., … Sabico, S. L. B. (2010). Gender-specific associations between insulin resistance, hypertension, and markers of inflammation among adult Saudis with and without diabetes mellitus type 2. *Advances in Medical Sciences*, *55*, (2), 179-185.

Aljasem, L. I., Peyrot, M., Wissow, L., & Rubin, R. R. (2001). The impact of barriers and self-efficacy on self-care behavhiors in type 2 diabetes. *The Diabetes Educator*, *27*, (3), 393-404.

Al-Lawati, J. A., Al Riyami A. M., Mohammed A. J., & Jousilahti, P. (2002). Increasing prevalence of diabetes mellitus in Oman. *Diabet Med, 19* (11), 954–957.

Allison, P. D. (1980). Analyzing collapsed contingency tables without actually collapsing. *American Sociological Review, 45*(2), 123-130.

Anderson, R. M., Fitzgerald, J. T., Wisdom, K., Davis, W. K., & Hiss, R. G. (1997). A comparison of global versus disease-specific quality-of-life measures in patients with NIDDM. *Diabetes Care*, *20*, 299-305.

Avogaro, A., Watanabe, R. M., Dall’ Arche, A., De Kreutzenberg, S. V., Tiengo, A., & Pacini, G. (2004). Acute alcohol consumption improves insulin action without affecting insulin secretion in Type 2 diabetic subjects. *Diabetes Care*, *27*, (6), 1369-1374.

Baliunas, D. O., Taylor, B. J., Irving, H., Roerecke, M., Patra, J., Mohapatra, S., & Rehm, J. (2009). Alcohol as a risk factor for type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care*, *32*, (11). 2123-2132.

Bauman, A., Allman-Farinelli, M., Huxley, R., & James, W. P. T. (2007). Leisure-time physical activity alone may not be a sufficient public health approach to prevent obesity—a focuse on China, *the International Association for the Study of Obesity*: *Obesity Review*, *9*(suppl. 1), 119-126.

Bell, R. A., Suerken, C. K., Grzywacz, J. G., Lang, W., Quandt, S. A., & Arcury, T. A. (2006). Complementary and alternative medicine use among adults with diabetes in the United States, *Alternative Therapies in Health and Medicine*, *12*(5), 16-22.

Benyamini, Y., & Idler, E. L. (1999). Community studies reporting association between self-rated health and mortality. Additional studies 1995–1998. *Research on Aging*, *21*, 392–401.

Beulens, J. W. J., Stolk, R. P., van der Schouw, Y. T., Grobbee, D. E., Hendriks, H. F. J., & Bots, M. L. (2005). Alcohol consumption and risk of type 2 diabetes among older women. *Diabetes Care*, *28*, (12), 2933-2938.

Bjorner, J. B., Fayers, P., & Ldler, E. (2005). Self-rated health. In P. Fayers, & R. Hays, (2nd Eds). *Assessing quality of life in clinical trials: Methods and Practice* (pp. 309-323). Oxford University Press, USA.

Bjorner, J.B., Kristensen, T. S., Orth-Gomer, K., Tibblin, G., Sullivan, M., & Westerholm, P. (1996). Self-rated health: A useful concept in research, prevention and clinical medicine, *Stokholm: Swedish Council for Planning and Coordination of Research.*

Blumenthal, U. J., Fleisher, J. M., Esrey, S. A., & Peasey, A. (2001). Epidemiology: A tool for the assessment of risk. World Health Organization (WHO) *Water Quality: Guidelines, Standards and Health*, Lorna F., & Jamie B. IWA Publishing: London.

Carlsson, S., Hammar, N., Grili, V., & Kaprio, J. (2003). Alcohol consumption and the incidence of type 2 diabetes. *Diabetes Care*, *26*, (10), 2785-2790.

Carlsson, S., Hammer, N., & Grill, V. (2005). Alcohol consumption and type 2 diabetes: Meta-analysis of epidemiological studies indicates a U-shaped relationship. *Diabetologia*, *48*, 1051-1054.

Castro, F. G., Shaibi, G. Q., & Boehm-Smith, E. (2009). Ecodevelopmental contexts for preventing type 2 diabetes in Latino and other racial/ethnic minority populations. *Journal of Behavioral Medicine*, *32*, 89-105.

Clark, N. M., Becker, M. H., Janz, N., Lorig, K., Rakowski, W., & Anderson, L. (1991). Self-management of chronic disease by older adults. *Journal of Aging And Health*, *3*, (1), 3-27.

Clayton, D., & Hills, M. (1993). *Statistical models in epidemiology*. Oxford University Press.

Clerc, O., Nachen, D., Cornuz, J., Marques-Vidal, P., Gmel, G., Daeppen, J.-B., … Rodondi, N. (2010). Alcohol drinking, the metabolic syndrome and diabetes in a population with high mean alcohol consumption. *Diabetic Medicine*, *27*, 1241-1249.

Chen, Y. (2001). Chinese values, health and nursing. *Journal of Advanced Nursing*, *36*(2), 270-273.

Cho, N. H., Chan, J. C. N., Jang, H. C., Lim, S., Kim, H. L., & Choi, S. H. (2009). Cigarette smoking is an independent risk factor for type 2 diabetes: a four-year community-based prospective study. *Clinical Endocrinology*, *71*, 679-685.

Choi, B. C. K., & Shi, E. (2001). Risk factors for diabetes mellitus by age and sex: results of the National Population Health Survey. *Diabetologia*, *44*, 1221-1231.

Cochrance, J., Chen, H. H., Conigrave, K. M., & Hao, W. (2003). Alcohol in China. *Alcohol & Alcoholism*, *38*(6), 537-542.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). Applied multiple regression/correlation analysis for behavioral sciences (3rd ed.). New Jersey: Lawrence Erlbaum Associates.

Conditional logistic regression (CLR) for matched or stratified data. (2006). *University of Pennsylvania*. Retrieved from www.cceb.upenn.edu/pages/localio/EPI521/2006/v2part4.pdf

Cott, C. A., Gignac, M. A. M., & Badley, E. M. (1999). Determinants of self-rated health for Canadians chronic disease and disability. *Journal of Epidemiology Community Health*, *53*, 731-736.

Davies, H. T. O., Crombie, I. K., & Tavakoli, M. (1998). When can odds ratios mislead*? BMJ*, *316*(28), 989-992.

Davis, N., Forbes, B., Wylie-Rosett, J. (2009). Nutritional strategies in type 2 diabetes. *Mount Sinai Journal of Medicine*, *76*, 257–268.

Deakin, T. A., McShane, C. E., Cade, J. E., & Williams, R. (2005). Group based training for self-management strategies in people with type 2 diabetes mellitus, *The Cochrance Library*, *3*, 1-86.

Dong, Y., Gao, W., Nan, H., Yu, H., Li, F., Duan, W., Wang, Y., Sun, B., Qian, R., Tuomilehto, J., & Qiao, Q. (2005). Prevalence of Type 2 diabetes in urban and rural Chinese populations in Qingdao, China. *Diabetic Medicine*, *22*, 1427-1433.

Egede, L., Ye, X., Zhang, D., & Silverstain, M. (2002). The prevalence and pattern of complementary and alternative medicine use in individuals with diabetes, *Diabetes Care*, *25*(2), 324-329.

Eriksson, L., Unden, A. L., & Elofsson, S. (2001). Self-rated health. Comparisons between three different measures. Result from a population study. *International Journal of Epidemiology, 30*(2), 326-333.

Esposito, K., Maiorino, M. I., Di Palo, C., & Giugliano, D. (2009). Adherence to a mediterranean diet and glycaemic control in Type 2 diabetes mellitus. *Diabetic Medicine*, *26*, 900-907.

Estacio, R. O., Jeffers, B. W., Gifford, N., & Schrier, R. W. (2000). Effect of blood pressure control on diabetic microvascular complications in patients with hypertension and type 2 diabetes. *Diabetes Care Suppl. 2, 23*(54), 1-21.

Ferraro, K. F. (2006). Health and Aging. In Binstock, H., George, L. K., Cutler, S. J., Hendricks, J., & Schulz, J. H. (Eds.), *Handbook of Aging and the Social Science* (pp. 238-256). Academic Press.

Fayers, P. M., & Sprangers, M. A. (2002). Understanding self-rated health. *The Lancet*, *359*, 187-188.

Ferrans, E. C., Zerwic, J. J., Wilbur, J. E., & Larson, J. L. (2005). Conceptual model of health-related quality of life. *Journal of Nursing Scholarship*, *4*, 336-342.

Fisher, E. B., Brownson, C. A., O'Toole, M. L., Shetty, G., Anwuri, V. V., Glasgow, R. E. (2005). Ecological approaches to self-management: The case of diabetes. *American Journal of Public Health*, *95*(9), 1523-1535.

Ford, E. S., Zhao, G. X., Tsai, J.,& Li, C. Y. (2011). Low-risk lifestyle behaviors and all-cause mortality: findings from the national health and nutrition examination survey III mortality study. *American Journal of Public Health*, *101*, (10), 1922-1929.

Franks, P., Gold, M. R., & Fiscella, K. (2003). Sociodemographics, self-rated health, and mortality in the US. *Social Science & Medicine*, *56*, 2505-2514.

Fukui, M., Kitagawat, Y., Nakamura, N., Kadono, M., Hasegawa, G., & Yoshikawa, T. (2005). Association between alcohol consumption and serum dehydroepiandrosterone sulphate concentration in men with Type 2 diabetes: a link to decreased cardiovascular risk. *Diabetic Medicine*, *22*, 1446-1450.

Gilden, J. L., Casia, C., Hendryx, M., & Singh, S. P. (1990). Effects of self-monitoring of blood glucose on quality of life in elderly diabetic patients. *Journal of American Geriatrics Society*, *38*, 511-515.

Gong, Q., Gregg, E. W., Wang, J., An, Y., Zhang, P., Yang, W., Li, H., Li, Y., Jiang, Y., & Bennett, P. H. (2011). Long-term effects of a randomised trial of a 6-year lifestyle intervention in impaired glucose tolerance on diabetes-related microvascular complications: the China Da Qing Diabetes Prevention Outcome Study. *Diabetologia, 54,* 300–307.

Grant, J. F., Hicks, N., Taylor, A. W., Chittleborough, C. R., & Phillips, P. J. (2009). Gender-specific epidemiology of diabetes: a representative cross-sectional study. *International Journal for Equity in Health*, *8*, (6), 1-12.

Gress, T. W., Nieto, F. J., Shahar, E., Wofford, M. R., & Brancati, F. L. (2000). Hypertension and antihypertensive therapy as risk factors for type 2 diabetes mellitus. *The New England Journal of Medicine*, *342*, (3), 905-912.

Gu, D., Reynolds, K., Duan, X., Xin, X., Chen, J., Wu, X., Mo, J., Whelton, P.K., & He, J. (2003). Prevalence of diabetes and impaired fasting glucose in the Chinese adults population: International collaborative Study of Cardiovascular Disease in Asia (InterASIA). *Diabetologia*, *46*, 1190-1198.

Hao, W., Su, Z. G., Liu, B. G., Zhang, K., Yang, H. Q., Chen, S. Z.,…, Cui, C. (2004). Drinking and drinking patterns and health status in general population of five areas of China. *Alcohol & Alcoholism*, *39*(1), 43-52.

Hayahsi, T., Tsumura, K., Suematsu, C., Endo, G., Fuji, S., & Okada, K. (1999). High normal blood pressure, hypertension, and the risk of type 2 diabetes in Japanese Men. *Diabetes Care*, *22*, (10), 1683-1687.

He, Y., Jiang, B., Wang, J., Feng, K., Chang, Q., Fan, L., Li, X.-Y., & Hu, F. B. (2006). Prevalence of the metabolic syndrome and its relation to cardiovascular disease in an elderly Chinese population. *Journal of the American College of Cardiology*, *47*, (8),1588-1594.

Henderson, K. A., & Ainsworth, B. E. (2003). A synthesis of perceptions about physical activity among older African American and American Indian women. *American Journal of Public Health*, *93*(2), 313-317.

Hennekens, C. H., & Buring, J. E. (1987). *Epidemiology in Medicine*, Lippincott Williams & Wilkins.

Hoeymans, N., Feskens, E. J. M., Kromhout, D., & van den Bos, G. A. M. (1999). The contribution of chronic conditions and disabilities to poor self-rated health in elderly men. *Journal of Gerontology: Medical Science*, *54A*, (10), M501-M506.

House, J.S., & Williams, D. R. (2000). Understanding and reducing socioeconomic and racial/ethnic disparities in health. In B. D. Smedley & S. L. Syme (Eds.), *Promoting health: Interventions strategies from social and behavioral research* (pp. 81-124). Washington, DC: National Academy Press.

Howard, A. A., Amsten, J. H., & Gourevitch M. N. (2004). Effect of alcohol consumption on diabetes mellitus. *American Internal Medicine*, *140*, 211-219.

Hu, D. S., Xie, J., Fu, P. Y., Zhou, J., Yu, D. H., Whelton, P. K., He, J., & Gu, D. F. (2007). Central rather than overall obesity is related to diabetes in the Chinese population: the interASIA study, *Obesity*, *15*, (11), 2809-2816.

Hu, F.B., Leitzmann, M.F., Stampfer, M.J., Colditz, G.A., Willett, W.C., & Rimm, E.B. (2001). Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. *Arch Intern Med*, *161*, 1542–1548.

Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G., Liu, S., Solomon, C. G., & Willet, W. C. (2001). Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *The New*

England Journal of Medicine, *345*, (11), 790-797.

Hu, G., Pekkarinen, H., Hanninen, O., Tian, H., & Guo, Z. (2001). Relation between commuting, leisure time physical activity and serum lipids in a Chinese urban population. *Annals of Human Biology*, *28*, 412–421.

Hu, G., Qiao, Q., Silventoinen, K., Eriksson, J. G., Jousilahti, P., Lindstrom, J., … Tuomilehto, J. (2003). Occupational, commuting, and leisure-time physical activity in relation to risk for type 2 diabetes in middle-aged Finnish men and women. *Diabetologia*, *46*, 322-329.

Hu, F. B., van Dam, R. M., & Liu, S. (2001). Diet and risk of Type II diabetes: the role of types of fat and carbohydrate. *Diabetologia*, *44*, 805-817.

Idler, E. L., & Angel, R. J. (1990). Self-rated health and mortality in the NHANES-I epidemiologic follow-up study. *American Journal of Public Health*, *80*, (4), 446-452.

Jee, S. H., Foong, A. W., Hur, N. W., & Samet, J. M. (2010). Smoking and risk for diabetes incidence and mortality in Korean men and women. *Diabetes Care*, *33*, (12), 2567-2572.

Jenum, A. K., Holme, I., Graff-Iversen, S., & Birkeland, K. I. (2005). Ethnicity and sex are strong determinants of diabetes in an urban Western society: implications for prevention. *Diabetologia*, *48*, 435-439.

Jeon, J.-P., Shim, S.-M., Nam, H.-Y., Ryu, G.-M., Hong, E.-J., Kem, H.-L., & Han, B.-G. (2010). Copy number variation at leptin receptor gene locus associated with metabolic traits and risk of type 2 diabetes mellitus. *BMC Genomics*, *11*, (426), 1-10.

Ji B.-T., Chow, W.-H., Yang, G., McLaughlin, J. K., Gao, R.-N., Zheng, W., Shu, X.-Q., Jin, F., Fraumeni, J. F., & Gao, Y.-T. (1996). The influence of cigarrete smoking, alcohol, and green tea consumption on the risk of carcinoma of the cardia and distal stomach in Shanghai, China, *America Cancer Society*, *77*, (12), 2449-2456.

Jia, W. P., Pang, C., Chen, L., Bao, Y. Q., Lu, J. X., Lu, H. J., Tang, J. L., Wu, Y. M., Zuo, Y. H., Jiang, S. Y., & Xiang, K. S. (2007). Epidemiological characteristics of diabetes mellitus and impaired glucose regulation in a Chinese adult population: the Shanghai diabetes studies, a cross-sectional 3-year follow-up study in Shanghai urban communities. *Diabetoglogia*, *50*, 286-292.

Joosten, M. M., Chiuve, S. E., Mukamal, K. J., Hu, F. B., Hendriks, H. F. J., & Rimm, E. B. (2011). Changes in alcohol consumption and subsequent risk of type 2 diabetes in men. *Diabetes*, *60*, 74-79.

Karim, R., Buchanan, T. A., Hodis, H. N., Li, Y., & Mack, W. J. (2004). The association of smoking and subclinical atherosclerosis in Type 2 diabetes: modification by duration of diabetes. *Diabetes Medicine*, *22*, 81-87.

Kavanagh, A., Bentley, R. J., Turrell, G., Shaw, J., Dunstan, D., & Subranmanian, S. V. (2010). Socioeconomic position, gender, health behaviors and biomarkers of cardiovascular disease and diabetes. *Social Science & Medicine*, *71*, 1150-1160.

Kengne, A. P., Nakamura, K., Barzi, F., Lam, T. H., Huxley, R., Gu, D.-F., Patel, A., Kim, H. C., & Woodward, M. (2009). Smoking, diabetes and cardiovascular diseases in men in the Asia Pacific region. *Journal of Diabetes*, *1*, 173-181.

Kleinbaum, D. G., Kupper, L. L., & Morgenstern, H. (1982). In C. Beal (Eds.), *Epidemiologic research: Principles and quantitative methods*. Belmont, CA: Lifetime Learning Publications.

Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J., & Power, C. (2003). Life course epidemiology. *Journal of Epidemiology & Community Health*, *57*, 778-783.

Laakso, M. (1999). Hyperglycemia and Cardiovascular Disease in Type 2 Diabetes. *Diabetes*, *48*, (5), 937-942.

Lachin, J. M. (2011). *Biostatistical methods: The assessment of relative risks* (2nd ed.). Hoboken, NJ: John Wiley & Sons, Inc.

Lahti-Koski, M., Pietinen, P., Mannisto, S., & Vartiainen, E. (2000). Trends in waist-to-hip ratio and its determinants in adults in Finland from 1987 to 1997. *American Journal of Clinical Nutrition*, *72*, 1436–1444.

Landazuri, P., Loango, N., & Gallego, M. L. (2011). Cardiovascular risk factors in first-degree relatives of patients with hypertension. *Colombia Medical*, *42*, (1),17-25.

Lecture 12—Introduction to matching (n.d.). Retrieved from http://courses.washington.edu/b536/Archive/handouts/Lecture12.pdf

Li, G. W., Zhang, P., Wang, J. P., Gregg, E. W., Yang, W. Y., Gong, Q. H., Li, H., Li, H. L., Jiang, Y. Y., An, Y. L., Shuai, Y., Zhang, B., Zhang, J. L., Thompson, T. J., Gerzoff, R. B., Roglic, G., Hu, Y. H., & Bennett, P. H. (2008). The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. *Lancet*, *371*, 1783–1789.

Li, X. B., Song, X. Y., & Gray, R. H. (2004). Comparison of the missing-indicator method and conditional logistic regression in 1:m matched case-control studies with missing exposure values, *American Journal of Epidemiology*, *159*, 603-610.

Lieberman, L. S. (2003). Dietary, evolutionary, and modernizing influences on the prevalence of Type 2 diabetes. *Annual Review of Nutrition*, *23*, 345-377.

Liu, C. L., Yu, Z., Li, H.-X., Wang, J., Sun, L., Qi, Q.-B., & Lin, X. (2010). Association of alcohol consumption with diabetes mellitus and impaired fasting glycemia among middle-aged and elderly Chinese. *Public Health*, *10*, (713), 1-9.

Liu, G.-P., & Zhang, Z. (2004). Sociodemographic differentials of the self-rated health of the oldest-old Chinese. *Population Research and Policy Review, 23*, 117–133.

Lloyd, A., Sawyer, W., & Hopkinson, P. (2001). Impact of long-term complications on quality of life in patients with type 2 diabetes not using insulin. *Value in Health*, *4*(5), 392-400.

Lorig K. R. et al. (1999). Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization. *Medical Care, 37*, 91), 5-14.

Lorig, K. R. et al. (2001). Chronic disease self-management program: 2-year health status and health care utilization outcomes. *Medical Care, 39*, (11), 1217-1223.

Lu, L., & Hu, C.-H. (2005). Personality, leisure experiences and happiness, *Journal of Happiness Studies, 6*, 325-342.

Luo, T. H., Zhao, Y., Li, G., Yuan, W. T., Zhao, J. J., Chen, J. L., Huang, W., & Luo, M. (2001). A genome-wide search for Type II diabetes susceptibility genes in Chinese Hans. *Diabetologia*, *44*, 501-506.

Malinauskiene, V., Leisyte, P., Romualdas, M., & Kirtiklyte, K. (2011). Associations between self-rated health and psychosocial conditions, lifestyle factors and health resources among hospital nurses in Lithuania. *Journal of Advanced Nursing*, *67*, (11), 2383-2393.

Matthews, R., & Brill, I. (2011). SAS programs to select controls for matched case-control studies.

Maty, S. C., Everson-Rose, S. A., Haan, M. N., Raghunathan, Robbins, J. M., Vaccarino, V., Zhang, H., & Kasl, S. V. (2001). Socioeconomic status and type 2 diabetes in African American and non-Hispanic White women and men: evidence from the third national health and nutrition examination survey. *American Journal of Public Health*, *91*, 76-83.

Meigs, J. B., Muller, D. C., Nathan, D. M., Blake, D. R., & Andres, R. (2003). The national history of progression from normal glucose tolerance to type 2 diabetes in the Baltimore longitudinal study of aging. *Diabetes*, *52*, 1475-1484.

Mesci, B., Celik, S., Coksert Kilic, D., Tekin, M., & Oguz, A. (2010). Refined Carbohydrate restricted diet versus conventional diabetic diet in Type 2 diabetic patients treated by insulin. *Endocrine Care, VI*, 2, 203-209.

Meyer, K. A., Kushi, L. H., Jacobs, D. R., Slavin, J., Sellers, T. A., & Folsom, A. R. (2000). Carbohydrates, dietary fiber, and incident type 2 diabetes in older women. *American Journal of Clinical Nutrition*, *71*, 921-930.

Miilunpalo, S., Vuori, I., Oja, P., Pasanen, M., & Urponen, H. (1997). Self-rated health status as a health measure: the predictive value of self-reported health status on the use of physician services and on mortality in the working-age population. *Journal of Clinical Epidemiology*, *50*, (5), 517-528.

Millett, C., Gray, J., Saxena, S., Netuveli, G., & Majeed, A. (2007). Impact of a pay–for–performance incentive on support for smoking cessation and on smoking prevalence among people with diabetes. *Canadian Medical Association Journal*, *5*, 1705-1709.

Misra, R., & Lager, J. (2009). Ethnic and gender differences in psychological factors, glycemic control, and quality of life among adult type 2 diabetic patients. *Journal of Diabetes and Its Complications*, *23*, 54-64.

Molarius, A., & Janson, S. (2002). Self-rated health, chronic disease, and symptoms among middle-aged and elderly men and women. *Journal of Clinical Epidemiology*, *55*, 364-370.

Mossey, J. M., & Shapiro, E. (1982). Self-rated health: a predictor of mortality among the elderly. *American Journal of Public Health*, *72*, (8), 800-808.

Mozaffarian, D., Kamineni, A., Carnethon, M., Djousse, L., Mukamal, K. J., & Siscovick, D. (2009). Lifestyle risk factors and new-incidencediabetes mellitus in older adults: the cardiovascular health study. *Archives of Internal Medicine*, *169*, (8), 798-807.

Nakanishi, N., Suzuki, K., & Tatara, K. (2003). Alcohol consumption and risk for development of impaired fasting glucose or Type 2 diabetes in middle-aged Japanese Men. *Diabetes Care*, *26*, (1), 48-54.

Nathan, D. M., Buse, J. B., Davidson, M. B., Ferrannini, E., Holman, R. R., Sherwin, R., & Zinman, B. (2009). Medical Management of hyperglycemia in type 2 diabetes: a consensus algorithm for the initiation and adjustment of therapy. *Diabetes Care*, *32*(1), 193-203.

Nelson, K. M., Reiber, G., & Boyko, E. J. (2002). Diet and exercise among adults with type 2 diabetes. *Diabetes Care*, *25*, (10), 1722-1728.

O’Keefe, J. H., Abuannadi, M., Lavie, C. J., & Bell, D. S. H. (2011). Strategies for optimizing glycemic control and cardiovascular prognosis in patients with type 2 diabetes mellitus. *Mayo Clinic Proceedings*, *86*(2), 128-138.

Padmawati, R. W., Ng, N., Prabandari, Y. S., & Nitchter, M. (2009). Smoking among diabetes patients in Yogyakarta, Indonesia: cessation efforts are urgently needed. *Tropical Medicine and International Health, 14*, (4), 412-419.

Pan, X. R., Yang, W. Y., Li, G. W., & Liu, J. (1997). Prevalence of diabetes and its risk factors in China, 1994. *Diabetes Care*, *20*, 1664-1669.

Patja, K., Jousilahti, P., Hu, G., Valle, T., Qiao, Q., & Tuomilehto, J. (2005). Effects of smoking, obesity and physical activity on the risk of type 2 diabetes in middle-aged Finnish men and women. *Journal of Internal Medicine*, *258*, 356-362.

Phyu Phyu Aung, D. (2005). Diet and hypertension. *MJCMP*, *9*, 37-42.

Plotnikoff, R. C., Lippke, S., Courneya, K., Birkett, N., Sigal, R. (2010). Physical activity and diabetes: an application of the theory of planned behavior to explain physical activity for Type 1 and Type 2 diabetes in an adult population sample. *Psychology and Health*, *25*, (1), 7-23.

Popkin, B. (1998). The nutrition transition and its health implications in lower-income countries. *Public Health Nutrition*, *1*, 5-21.

Qiao, Q., Hu, G., Tuomilehto, J., Nakagami, T., Balkau, B., Borch-Johnson, K.,…Diabetes Epidemiology Collaborative Analysis of Diagnostic Criteria in Europe (DECODA) study group. (2003). Age- and sex-specific prevalence of diabetes and impaired glucose regulation in 11 Asian cohorts. *Diabetes Care*, *26*, (6), 1770-1780.

Rajpathak, S. N., Freiberg, M. S., Wang, C. L., Wylie-Rosett, J., Wildman, R. P., Rohan, T. E., Robinson, J. G., Liu, S., & Wassertheil-Smoller, S. (2010). Alcohol consumption and the risk of coronary heart disease in postmenopausal women with diabetes: women’s health initiative observational study. *European Journal of Nutrition*, *49*, 211-218.

Ramachandran, A., Snehalatha, C., Kapur, A., Vijay, V., Mohan, V., Das, A. K., … Diabetes Epidemiology Study Group in India (DESI). (2001). High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. *Diabetologia*, *44*, 1094–1101.

Reis, J. P., Loria, C. M., Sorlie, P. D., Park, Y. Y., Hollenbeck, A., & Schatzkin, A. (2011). Lifestyle factors and risk for new-incidence diabetes. *Annuals of Internal Medicine*, *155,* (5), 292-299.

Roh, W.G., Shin, H.-C., Choi, J.-H., Lee, Y. J., & Kim, K. (2009). Alcohol consumption and higher incidence of impaired fasting glucose or type 2 diabetes in obese Korean men. *Alcohol*, *43*, 643-648.

Rubin, R. R., & Peyrot, M. (1999). Quality of life and diabetes. *Diabetes Metabolism Research Review*, *15*, (3), 205–218.

Salmeron, J., Ascherio, A., Rimm, E. B., Colditz, G. A., Spiegelman, D., Jenkins, D. J., … Willett, W. C. (1997). Dietary fiber, glycemic load, and risk of NIDDM in men. *Diabetes Care*, *20*, 545-550.

Samuel-Hodge, C. D. et al. (2000). Influences on day-to-day self-management of type 2 diabetes among African-American women. *Diabetes Care*, *23,* (7), 928-933.

Sarkar, U., Fisher, L., & Schillinger, D. (2006). Is self-efficacy associated with diabetes self-management across race/ethnicity and health literacy?, *Diabetes Care*, *29*, (4), 823-829.

Schipf, S., Schmidt, C. O., Alte, D., Werner, A., Scheidt-Nave, C., John, U., Steveling, A., Wallaschofski, H., & Volzke, H. (2009). Smoking prevalence in Type 2 diabetes: results of the study of health in Pomerania (SHIP) and the German National Health Interview and Examination Survey (GNHIES). *Diabetic Medicine*, *26*, 791-797.

Schulze, M. B., Liu, S., Rimm, E. B., Manson, J. E., Willett, W. C., & Hu, F. B. (2004). Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. *American Society for Clinical Nutrition*, *80*, 348-356.

Sigal, R. J., Kenny, G. P., Wasserman, D. H., Castaneda-Sceppa, C., & White, R. D. (2006). Physical activity/exercise and Type 2 diabetes. *Diabetes Care*, *29*, (6), 1433-1438.

Seike, N., Noda, M., & Kadowaki, T. (2008). Alcohol consumption and risk of type 2 diabetes mellitus in Japanese: a systematic review. *Asia Pacific Journal of Clinical Nutrition*, *17*, (4), 545-551.

Smith, B. T., Lynch, J. W., Fox, C. S., Harper, S., Abrahamowicz, M., Almeida, N. D., & Loucks, E. B. (2011). Life-course socioeconomic position and type 2 diabetes mellitus. *American Journal of Epidemiology*, *173*, (4), 438-447.

Sousa V.D. (2003) Testing a conceptual framework for diabetes self-care management, *Dissertation Abstract International*, *64*, 3193

Sousa, V.D., & Zauszniewski, J. A. (2005). Toward a theory of diabetes self-care management, *The Journal of Theory Construction & Testing*, *9*(2), 61-67.

Stevens, J., Ahn, K., Jubaeri, Houston, D., Steffan, L., & Couper, D. (2002). Dietary fiber intake and glycemic index and incidence of diabetes in African–American and white adults: the ARIC study. *Diabetes Care*, *25*, 1715-1721.

Stevens, J., Katz, E. G., & Huxley, R. R. (2010). Associations between gender, age and waist circumference. *European Journal of Clinical Nutrition*, *64*, 6-15.

Stratton, I. et al. (2000). Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *British Medical Journal*, *321*, (7258), 405-421.

Szklo, M., & Nieto, F. J. (2000). *Epidemiology beyond the basics*. Gaithersburg, MD: Aspen Publisher.

Szanton, S. L., Thorpe, R. J., & Whitfield, K. E. (2010). Life-course financial strain and health in African-Americans. *Social Science & Medicine*, *71*(2), 259-265.

Taloyan, M., Wajngot, A., Johansson, S.-E., Tovi, J., & Sundquist, J. (2010). Poor self-rated health in adult patients with type 2 diabetes in the town of Sodertalje: a cross-sectional study. *Scandinavian Journal of Primary Health Care*, *28*, 216-220.

Tang, T. S., Brown, M. B., Funnell, M. M., & Anderson, R. M. (2008). Social support, quality of life, and self-care behaviors among African Americans with type 2 diabetes. *The Diabetes Educator*, *34*, (2), 266-276.

Tonstad, S. (2009). Cigarette smoking, smoking cessation, and diabetes. *Diabetes Research and Clinical Practice*, *85*, 4-13.

Unden, A. L., Elofsson, S., Andreasson, A., Hillered, E., Eriksson, I., & Brismar, K. (2008). Gender differences in self-rated health, quality of life, quality of care, and metabolic control in patients with diabetes. *Gender Medicine*, *5*(2), 162-180.

Venskutonyte, L., Malmberg, K., Norhammar, A., Wedle, H., & Tyden, L. (2010). Effect of gender on prognosis in patients with myocardial infarction and type 2 diabetes. *Journal of Internal Medicine*, *265*, 75-82.

van der Bijl, J., van Poelgeest-Eeltink, A., & Shortridge-Baggett, L. (1999). The psychometric properties of the diabetes management self-efficacy scale for patients with type 2 diabetes mellitus. *Journal of Advanced Nursing*, *30,* (2), 352-359.

van Dam, R. M. (2003). The epidemiology of lifestyle and risk for type 2 diabetes. *European Journal of Epidemiology*, *18*, 1115-1125.

Villegas, R., Liu, S., Gao, Y.-T., Yang, G., Li, H.-L., Zheng, W., & Shu, X. O. (2007). Prospective study of dietary carbohydrates, glycemic index, glycemic load, and incidence of Type 2 Diabetes Mellitus in middle-aged Chinese women. Internal Medicine, *167*, (*21*), 2310-2316.

Wang, J. Q., & Shui, A. T. Y. (2004). Diabetes self-efficacy and self-care behavior of Chinese patient living in Shanghai. *Journal of Clinical Nursing*, *13*, 771-772.

Wang, Y., Mi, J., Shan, X. Y., Wang, Q. J., & Ge, K. Y. (2007). Is China facing an obesity epidemic and the consequences? The trends in obesity and chronic disease in China. *Internationl Journal of Obesity*, *31*, 177-188.

Wang, Z. W. (2012). Optimizing 1:N Case-control match using SAS [SAS global forum]. Retrieved from http://support.sas.com/resources/papers/proceedings12/088-2012.pdf

Wannamethee, S. G., Shaper, A.G., & Alberti, K.G. (2000). Physical activity, metabolic factors, and the incidence of coronary heart disease and type 2 diabetes. *Arch Intern Med*,*160*, 2108–2116.

Wildman, R. P., Gu, D. F., Reynolds, K., Duan, X. F., & He, J. (2004). Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults, *American Journal of Clinical Nutrition*, *80*, 1129-1136.

Willi, C., Bodenmann, P., Ghali, W. A., Faris, P. D., & Cornuz, J. (2007). Active smoking and the risk of Type 2 Diabetes: a systematic review and meta-analysis. *Journal of American Medical Association*, *298*, (22), 2654-2664.

Wilsnack, R. W., Vogeltanz, N. D., Wilsnack, S. C., & Harris, T. R. (2000). Gender differences in alcohol consumption and adverse drinking consequences: cross-cultural patterns. *Addiction*, *95*(2), 251-265.

Wong, K. C., & Wang Z.-Q. (2006). Prevelance of Type 2 diabetes mellitus of Chinese Populations in Mainland China, Hong Kong, and Taiwan. *Diabetes Research and Clinical Practice*, *73*, (2), 126-134.

Wredling, R., Stalhammar, J., Adamson, U., Berne, C., Larsson, Y., Oestman, J. (1995). Well-being and treatment satisfaction in adults with diabetes: a Swedish population-based study. *Quality of Life Research*, *4*, 515-522.

Xu, Y., Pan, W., & Liu, H. (2010). Self-management practices of Chinese Americans with type 2 diabetes. *Nursing and Health Science*, *12*, 228-234.

Xu, Y., Toobert, D., Savage, C., Pan, W., & Whitmer, K. (2008a). Adaptation and testing of instruments to measure diabetes self-management in people with type 2 diabetes in Mainland, China. *Journal of Transcultural Nursing*, *19*(3), 234-242.

Xu, Y., Toobert, D., Savage, C., Pan, W., & Whitmer, K. (2008b). Factors influencing diabetes self-management in Chinese people with type 2 diabetes. *Research in Nursing & Health*, *31*, 613-625.

Xu, F., Yin, X. M., Zhang, M., Leslie, E., Ware, R., & Owen, N. (2006). Family average income and diagnosed Type 2 diabetes in urban and rural residents in regional mainland China. *Diabetic Medicine*, *23*, 1239-1246.

Yang, W. Y., Lu, J., Weng, J. P., Jia, W. P., Ji, L., Xiao, J. Z., …, He, J. (2010). Prevalence of diabetes among men and women in China. *The New England Journal of Medicine*, *362*, 1090-1101.

Yoon, K.-H., Lee, J.-H., Kim, J.-W., Cho, J. H., Choi, Y.-H., Ko, S.-H., … Son, H.-Y. (2006). Epidemic obesity and type 2 diabetes in Asia. *Lancet*, *368*, 1681-1688.

Zhang, J. F., Wang, J. C., Lu, Y. X., Qiu, X. X., & Fang, Y. (2004). Alcohol abuse in a metropolitan city in China: a study of the prevalence and risk factors. *Society for the Study of Addiction*, *99*, 1103-1110.

Zhao, H. D., Deng, J., Li, J. C., Wang, Y. J., Zhang, M., & He, H. B. (2003). Study of the relationship between cigarette smoking, alcohol drinking and cognitive impairment among elderly people in China. *Age and Aging*, *32*(2), 205-210.

Zimmer, Z. & Kwong, J. (2004). Socioeconomic Status and Health among Older Adults in Rural and Urban China. *Journal of Aging Health*, *16*, (1), 44-70.

Zhou, H. D., Deng, J., Li, J. C., Wang, Y. J., Zhang, M., & He, H. B. (2003). Study of the relationship between cigarette smoking, alcohol drinking and cognitive impairment among elderly people in China. *Age and Ageing*, *32*, 205-210.

APPENDICES

Appendix A

Summary of Type 2 Diabetes Related Studies Conducted among the Population in China

	Study Level	Time	Population of interest	Research objectives	Results
Da Qing study (northeast China)	Regional study	1986–1992 with 20-year follow-up	25–74 years old	Diet and physical exercise on the prevalence and incidence of type 2 diabetes	Combined lifestyle intervention (i.e., diet and exercises) reduced the incidence of type 2 diabetes by 51% during the active intervention period and by 43% over the 20 year period
Study in Shanghai (east coastal city)	Regional study	1998–2001	20–94 years old	Prevalence and incidence of type 2 diabetes	The relative risk of developing diabetes was significantly higher in subjects with impaired glucose regulation (IGR) than those with non-impaired glucose
International collaborative study of cardiovascular disease in Asia (InterASIA)	National study	2000–2001	35–74 years old	Prevalence and incidence of type 2 diabetes	5.2% or 12.7 million men and 5.8% or 13.3 million women in China aged 35 to 74 years had type 2 diabetes. The age-standardized prevalence of diabetes was higher in residents of northern compared to southern China and in those living in urban compared to rural areas
Qing Dao study (east coastal city)	Regional study	2001–2002	20–74 years old	Prevalence of type 2 diabetes in Chinese population in rural and urban areas of Qing Dao city	Diabetes prevalence increased with age up to the oldest age group (70–74); in subjects over 50 years of age, the prevalence reached 10%. Men tended to have a higher prevalence of known diabetes than women. Diabetes was more prevalent in the urban than the rural population