Neighborhood characteristics and lifestyle intervention outcomes: Results from the Special Diabetes Program for Indians

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A B S T R A C T

Growing evidence reveals various neighborhood conditions are associated with the risk of developing type 2 diabetes. It is unknown, however, whether the effectiveness of diabetes prevention interventions is also influenced by neighborhood characteristics. The purpose of the current study is to examine the impact of neighborhood characteristics on the outcomes of a lifestyle intervention to prevent diabetes in American Indians and Alaska Natives (AI/ANs). Year 2000 US Census Tract data were linked with those from the Special Diabetes Program for Indians Diabetes Prevention Program (SDPI-DP), an evidence-based lifestyle intervention implemented in 36 AI/AN grantee sites across the US. A total of 3394 participants started the intervention between 01/01/2006 and 07/31/2009 and were followed by 07/31/2016. In 2016–2017, data analyses were conducted to evaluate the relationships of neighborhood characteristics with intervention outcomes, controlling for individual level socioeconomic status. AI/ANs from sites located in neighborhoods with higher median household income had 38% lower risk of developing diabetes than those from sites with lower neighborhood income (adjusted hazard ratio = 0.65, 95% CI: 0.47–0.90). Further, those from sites with higher neighborhood concentrations of AI/ANs achieved less BMI reduction and physical activity increase. Meanwhile, participants from sites with higher neighborhood level of vehicle occupancy made more improvement in BMI and diet. Lifestyle intervention effectiveness was not optimal when the intervention was implemented at sites with disadvantaged neighborhood characteristics. Meaningful improvements in socioeconomic and other neighborhood disadvantages of vulnerable populations could be important in stemming the global epidemic of diabetes.

1. Introduction

It is well known that type 2 diabetes, a serious public health problem in the US, is highly prevalent among many racial/ethnic minority populations (CDC, 2017). The socioeconomic gradient in the risk of type 2 diabetes among developed countries has also been extensively documented (Agardh et al., 2011), which may account for a large proportion of the race/ethnic disparities observed domestically (Link and McKinlay, 2009; Signorello et al., 2007). Ongoing work seeks to elucidate the causal pathways for socioeconomic disparities in diabetes.

It has been proposed that an individual's socioeconomic status may affect her/his risk of developing type 2 diabetes through multiple mechanisms, including adverse fetal and early life exposures (X. Jiang et al., 2013), obesity (Stringhini et al., 2012; Wikstrom et al., 2011), lifestyle behaviors (Stringhini et al., 2012; Wikstrom et al., 2011), psychological stress (Jiang et al., 2008; Kumari et al., 2004), and chronic inflammation (Stringhini et al., 2013).

In addition to socioeconomic disparities at the individual level, racial/ethnic minorities often reside in socio-economically disadvantaged neighborhoods. Growing evidence reveals that neighborhood

conditions are associated with the risk of type 2 diabetes independent of characteristics of the individual (Auchincloss et al., 2009; Christine et al., 2015; Krishnan et al., 2010; Schootman et al., 2007). Low neighborhood socioeconomic status, high neighborhood concentrations of racial minorities, and adverse neighborhood physical and social environments have been linked to increased risk of cardiometabolic disorders (Auchincloss et al., 2009; Barber et al., 2016; Christine et al., 2015; Kershaw et al., 2015; Krishnan et al., 2010; Schootman et al., 2007). Similarly, neighborhood environment can influence the risk of diabetes through multiple pathways, such as the availability of healthy foods (Morland et al., 2002), exercise facilities (Auchincloss et al., 2009; Christine et al., 2015), and educational resources (Krishnan et al., 2010).

In order to reduce the dramatic diabetes disparities borne by racial/ethnic minorities, it is imperative to develop successful prevention strategies that can be implemented effectively among these populations. Over the past few decades, lifestyle interventions consisting of exercise and diet behavioral modifications have proven to be efficacious in preventing type 2 diabetes (Knowler et al., 2002). Yet our previous findings have shown that lifestyle intervention is less successful among participants with lower socioeconomic status (Jiang et al., 2015). It is unknown, however, whether the effectiveness of lifestyle interventions is also influenced by the characteristics of the neighborhood wherein the participants reside. The success of behavioral changes promoted by lifestyle interventions is likely to be affected by neighborhood factors. For example, increasing physical activity usually needs safe space and/or accessible exercise facilities. Thus, we hypothesize that individuals living in more disadvantaged neighborhoods would have fewer environmental resources to achieve the needed behavioral changes and, therefore, would benefit less from lifestyle interventions.

This study extended our previous research by investigating the impact of neighborhood characteristics on diabetes incidence and related behavioral outcomes of a lifestyle intervention project implemented among a diverse array of American Indian and Alaska Native (AI/AN) communities, namely the Special Diabetes Program for Indians Diabetes Prevention (SDPI-DP) demonstration project (L. Jiang et al., 2013). The SDPI-DP was funded by the US Congress to translate evidence-based diabetes prevention intervention in 36 AI/AN grantee sites across the nation. Linking each SDPI-DP grantee site to year 2000 US Census data provided us a unique opportunity to examine the association of neighborhood factors with lifestyle intervention outcomes.

2. Methods

The details of SDPI-DP are described elsewhere (L. Jiang et al., 2013). Briefly, 36 health care programs serving 80 tribes in 18 states and 11 Indian Health Service (IHS) administrative areas participated in the SDPI-DP. The participating programs implemented the 16-session *Lifestyle Balance Curriculum* adapted from the Diabetes Prevention Program (2002) and evaluated the effectiveness of the prevention activities. After a baseline assessment, participants attended the lifestyle curriculum consisting of diet, exercise, and behavior modification sessions to help reach and maintain a goal of 7% weight loss. The curriculum was delivered in group settings 16–24 weeks after baseline and was typically taught by a program dietitian and/or health educator.

Participants were recruited locally by each grant program. Eligibility criteria included being AI/AN, at least 18 years of age, and having pre-diabetes. Pre-diabetes was diagnosed as having either impaired fasting glucose (IFG, i.e., a FBG level of 100–125 mg/dl and an oral glucose-tolerance test (OGTT) result < 200 mg/dl) and/or impaired glucose tolerance (IGT, i.e., an OGTT result of 140–199 mg/dl 2 h after a 75 g oral glucose load and a FBG level < 126 mg/dl). Patients were excluded if previously diagnosed with diabetes, pregnant, receiving dialysis for end-stage renal disease, or suffered from any other condition that would prohibit successful participation. Enrollment

began in January 2006 and centralized data submission ended on July 31, 2016. This study included 3394 SDPI-DP participants who completed the baseline assessments and started the intervention by 07/31/2009.

2.1. Measures

At baseline, within a month of completing the last lifestyle class (usually 4–6 months after baseline, hereafter called the post-curriculum assessment), and annually after baseline, participants underwent a comprehensive clinical assessment to evaluate diabetes risk and incidence. At the same time, each participant completed a questionnaire encompassing sociodemographic information, health-related behaviors, and a range of psychosocial factors. The current study includes the following measures.

2.1.1. Lifestyle intervention outcomes
2.1.1.1. Diabetes incidence. The primary outcome was incident diabetes, diagnosed by an annual or semiannual glycemic measurement conducted in local or regional laboratories. An A1c ≥ 6.5%, a fasting blood glucose ≥ 126 mg/dl or a two-hour test result ≥ 200 mg/dl after a 75-g oral glucose load required confirmation by a second test, preferably within 6 weeks of the first test, established the diagnosis of diabetes. Participants were censored at diagnosis of type 2 diabetes, loss to follow-up, or end of follow-up (July 31, 2016), whichever occurred first.

2.1.1.2. Body mass index (BMI). BMI was calculated using each participant's weight and height (shoeless, in light clothing), assessed by program staff at each assessment.

2.1.1.3. Physical activity. The Rapid Assessment of Physical Activity (RAPA) is a 9-item self-report instrument with yes/no responses to questions covering a range of weekly physical activity levels (Topolski et al., 2006). Participant's activity level was categorized into five levels: 1 = sedentary, 2 = underactive, 3 = regular underactive (light activities), 4 = regular underactive, 5 = regular active.

2.1.1.4. Diet. Details about the dietary choice variables are described elsewhere (Teufel-Shone et al., 2015). Briefly, participants were asked to recall the intake of 27 different types of foods over the last 30 days. These food types were categorized as 'healthy', 'unhealthy', or 'undetermined' based on a survey of program staff members who were involved in nutrition education. The healthy food score was constructed by averaging the intake frequency of 6 healthy foods (e.g., whole grain bread, fruit), while the unhealthy food score was the mean intake frequency of 12 unhealthy foods (e.g., processed meats, sugared soft drinks).

2.1.2. Participant characteristics
Participants self-reported their age, gender, education attainment, employment status, marital status and annual household income in the baseline questionnaire.

2.1.3. Neighborhood characteristics
Thirty-six grantee sites were linked to 2000 US census data based on the delivery address of the health care program at each site. Proxies of neighborhood characteristics were obtained from American FactFinder for the census tracts corresponding to each grantee site. Based on the results of exploratory factor analysis (Appendix 1), six census variables representing neighborhood income, wealth, education, and employment status were used to construct a summary neighborhood socioeconomic score: % adults completed high school, % adults with Bachelor's or higher degree, % unemployed individuals aged 16 years and older in the civilian labor force, % below national poverty level, median household income, and median value of housing unit. We first