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Socioecological Correlates of Type 2 Diabetes on the United States (U.S.)-Mexico Border: An Intervention Mapping Approach

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Clinical Psychology

by

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The Dissertation of Jessica L. McCurley is approved, and it is acceptable

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DEDICATION

To the residents of *Zona Norte*, Tijuana, and to all of those who have migrated in search of a better life. These efforts are for you.

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ABSTRACT OF THE DISSERTATION

Socioecological Correlates of Type 2 Diabetes on the United States (U.S.)-Mexico Border:

An Intervention Mapping Approach

by

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Doctor of Philosophy in Clinical Psychology

University of California, San Diego, 2018
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Rationale. Diabetes prevalence has risen rapidly in the United States and Mexico in recent years. Along the U.S.-Mexico border, diabetes is 2-3 times more prevalent than elsewhere in either country. This region is home to a high concentration of migrant and deported individuals at risk for diabetes and other chronic diseases due to low socioeconomic status, housing and food insecurity, stress, and limited access to healthcare. Formal investigation of diabetes in migrants and deportees is scant, and little is known about the unique risk profiles of this population.

Objective. Utilizing a socio-ecological, community-informed approach guided by Intervention Mapping, this study aimed to 1) Assess prevalence of diabetes and prediabetes in a high-risk border population in Tijuana, Mexico; 2) Examine the relationships of psychological adversity [depression, anxiety, adverse childhood experiences (ACES)] with diabetes prevalence, and explore indirect effects of social support in this relationship; 3) Examine the relationship of neighborhood adversity (e.g., lack of access to healthy foods, violence/crime) with diabetes prevalence, and explore indirect effects of physical activity and dietary intake in this relationship; and 4) Assess the association of diabetes knowledge/cultural beliefs with diabetes prevalence, and test whether there are indirect effects through physical activity and dietary intake. Exploratory models repeated Aims 2 - 4 with two additional dependent variables, in separate models: glucose regulation (hemoglobin A1c) and a 3-level diabetes status variable (normal glucose regulation, prediabetes, diabetes) examined continuously.

Design. This cross-sectional study recruited adults from the Health Frontiers in Tijuana medical clinic, which serves large numbers of low-income migrants and deportees near the U.S-Mexico border. Glucose regulation and diabetes status were assessed by point-of-care hemoglobin A1c (HbA1c) immunoassay. Psychosocial, neighborhood, and knowledge variables were assessed using a verbally administered self-report questionnaire. Prevalence of diabetes and prediabetes and other sample characteristics were assessed using SPSS Statistics. Multivariable logistic regression conducted in MPlus was used to examine relationships of psychological adversity, neighborhood adversity and diabetes knowledge/cultural beliefs with diabetes diagnosis. Multivariable linear regression was utilized in exploratory models.

Results. Participants were N = 220 adults aged 19-83 years (M age = 47.2, SD = 11.9). The majority was male (74.5%), of Mexican nationality (89.1%), and not married or partnered (52.7%). Over 30% had elementary school education or less. Over 70% reported history of migration to the U.S.; 58.6% reported history of at least one deportation from the U.S. to Mexico. Participants reported high levels of clinically significant depression and anxiety symptoms (33.2% and 30.5%, respectively), and 49% reported ≥4 ACEs. Prevalence of diabetes was 17.3% and prevalence of prediabetes was 29.1%. Controlling for age, sex, education, and income, psychological adversity variables were not significantly associated with diabetes prevalence. Neighborhood adversity and diabetes knowledge/cultural beliefs were likewise not associated with diabetes prevalence. Indirect effects were found from depression symptoms and ACEs, through social support, to glucose regulation. Indirect effects were also found from neighborhood adversity to diabetes prevalence and glucose regulation through dietary intake, but in an unexpected direction.

Conclusion. This is the first study to our knowledge to examine prevalence and correlates of diabetes in a large number of deported Mexican migrants, an underserved and hard-to-reach population. Results revealed a high burden of physical and psychological risk, suggesting the need for integrated approaches to physical and mental health in future prevention and intervention programs. The hypothesized correlates of diabetes may not be the most impactful determinants of health in this sample due to profound socioeconomic disadvantage, housing and food insecurity, and forced deportation. Social support may play a role in the relationship of psychological adversity and glucose regulation. In low-resource populations on the U.S.-Mexico border, future studies should explore a wider range of potential determinants of

diabetes and examine mediators of relationships of psychological and neighborhood adversity with diabetes status longitudinally.

CHAPTER 1. BACKGROUND & SIGNIFICANCE

Global diabetes prevalence is increasing rapidly, and type 2 diabetes mellitus (T2DM) has reached epidemic proportions. In 2015, the International Diabetes Federation (IDF) estimated that 415 million people globally have diabetes (1 in 11 individuals), and this number is expected to rise to 642 million by 2040 (1). Of those currently living with diabetes, 75% live in low and middle-income countries and 46.5% are undiagnosed (1). The social and economic costs of diabetes worldwide are vast, comprising approximately 12% of total healthcare spending for adults (1). Early recognition of diabetes risk and the development of feasible, sustainable prevention efforts for vulnerable populations are critical elements of the public health response to this global trend.

1.1 Prevalence and Disparities along the U.S.-Mexico Border. T2DM is highly prevalent in Hispanic/Latino individuals, both in the United States and in Mexico. Prevalence estimates from Mexico vary greatly based on measurement criteria used and population measured. The 2012 Mexican National Health and Nutrition Survey ("ENSANUT"), a nationally representative sample of over 46,000 adults, documented an overall prevalence of self-reported diabetes of 9.2% (95% CI: 8.8-9.6) (2). As expected, prevalence increased markedly with age: 5% in individuals under 40, 13% in 40-59 year olds, 19.4% in 50-59 year olds, and 26.3% in 60-69 year olds (2). Self-reported diagnoses underestimate prevalence, however, as approximately 15% of Mexican nationals do not have health insurance (3) and thus are unlikely to receive regular screening and testing. A recent analysis of a subset of the nationally representative, longitudinal Mexican Health and Aging Study, which included hemoglobin A1c (HbA1c) diagnostic testing, reported a diabetes prevalence of 39.4% in individuals over 50, with 18% previously undiagnosed (4). In the United States, the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a large population-based epidemiological cohort study examining health in U.S. Hispanics/Latinos reported the prevalence of clinically-measured diabetes in Mexican Americans to be 18.3% (95% CI: 16.84–19.86) (5). In general, Mexicans and Hispanics/Latinos in the U.S. are at elevated risk for T2DM, due to a combination of factors including health behaviors (e.g., low physical activity, high sedentary time, high salt/high fat diet) (6-8), genetics (9, 10), high rates of additional predisposing factors (e.g., obesity, hypertension) (6) and poor health care access (5, 11). Compared to non-Hispanic whites, Hispanic Americans also have more frequent diabetic complications, poorer overall blood glucose control (12, 13) and higher rates of cardiovascular disease (6).

Though outdated, the most recent population-based study of diabetes prevalence in the U.S.-Mexico border region (the U.S.-Mexico Border Diabetes Prevention and Control Project, conducted in 2001–2002) reported diabetes prevalence to be up to 2-3 times higher in the border region than elsewhere in either country, with 1 in 4 border residents undiagnosed (14). A more recent community survey of Mexican and Mexican American adults in a border town in Arizona found diabetes prevalence, based on fasting glucose exam, to be 21.3%. The U.S.-Mexico Border Health Commission (2010) has named diabetes one of its six critical areas of concern in the Healthy Border 2010/2020 Strategic Framework.

Tijuana, the major urban center of the Mexican state of Baja California, borders San Diego, California and has over 1.6 million residents (15). The northernmost area of the city, called *Zona Norte*, is home to large populations of migrants, homeless individuals, deportees, substance users, and sex industry workers, given the proximity of Tijuana's red light district. Deported individuals constitute a large and growing demographic in Tijuana and other border regions, as the U.S. has deported record numbers of individuals in recent years, totaling over 300,000 per year (16). Over 40% of deported Mexican nationals are repatriated to or through

Tijuana, often several hundred per day (16). Deportees and other migrants may be at additional risk for T2DM due to low socioeconomic status (SES), poor access to healthcare, stress and adversity, and years spent living a high-risk U.S. lifestyle (e.g., increased consumption of high-fat, high-sugar foods, increased sedentary time) (17, 18). Data from the Mexico Migration Project (2007-2013) indicated that deported migrants were 2.25 times more likely to have diabetes compared to non-migrants (19). Adding complexity to the diabetes epidemic, HIV is endemic in Tijuana with prevalence rates that are double the national average (20). HIV and diabetes likely co-occur in many border residents, resulting in significant physical and mental health burden. Though reliable data on re-entry to the U.S. after deportation is difficult to achieve, up to 46% of deportees are estimated to return to the U.S. post-deportation (21). For this reason, in addition to the geographic proximity and many shared cardiometabolic risk factors in the San Diego-Tijuana urban area, the health risks of migrant individuals living in Tijuana are a US public health concern. Very little research has been conducted in diabetes prevention with migrants, deportees, sex workers, and other transient border-residing individuals in Mexico, and no studies have surveyed these populations to examine relationships of socioecological risk factors with diabetes. Studies such as the current one are needed to identify the health risk profiles and specific intervention needs of this population in order to appropriately channel public funding into prevention of diabetes and reduction of expenditures due to unrecognized, untreated disease.

1.2 Psychological Adversity. Experiences of psychological adversity (e.g., stress, depression, anxiety, trauma) are common in migrants, deportees, and others living in resource poor international border settings (22-25), as many individuals experience job loss, family separation, chronic stress, and discrimination as well as housing and food insecurity (22, 26).

Both depression and anxiety are established independent risk factors for the development of T2DM (27-32). The risk associated with these conditions may be in part conferred through their effects on social relationships, as symptoms of depression and anxiety have the potential to disrupt and undermine interpersonal relationships, but conversely, can be mitigated by strong support from others. Perceived social support has been linked to improved self-regulation and glycemic control outcomes in diabetes, and poor social support has been shown to increase risk of diabetes (33-35).

Psychological adversity in childhood has also been recognized as an important contributor to risk for adverse adult health outcomes. Adverse childhood experiences such as abuse, neglect, and trauma are associated with risk behaviors for chronic disease (e.g. physical inactivity, smoking, substance abuse)(36, 37), metabolic risk biomarkers (e.g., hypertension, obesity, high hemoglobin A1c)(38) and overall mortality (39), and have been shown to have a graded relationship with chronic diseases including ischemic heart disease, cancer, liver disease, asthma, and diabetes (40-43). In a meta-analysis that included 87,251 participants and 5879 incident cases of T2DM, exposure to adverse childhood experiences was associated with increased risk of diabetes with an odds ratio (OR) of 1.32 (95% confidence interval (CI) 1.16, 1.51)(43). The influence of neglect in childhood on diabetes risk was most prominent (pooled OR= 1.92; 95% CI 1.43, 2.57) while the effect of physical abuse was least pronounced (pooled OR 1.30, 95% CI 1.19,1.42). The pooled OR associated with sexual abuse was 1.39 (95% CI 1.28, 1.52) (43). In migrants and other vulnerable populations with high likelihood of elevated mental health symptoms, psychological adversity represents a critical risk factor for T2DM.

1.3 Neighborhood Environment. Aspects of neighborhoods and residential environments are increasingly the focus of attention in public health interventions due to evidence of their contributions to health outcomes and to social, ethnic, and geographic disparities in health (44). With regards to T2DM, neighborhood elements such as walkability, safety, aesthetic quality, pollution, and proximity to green spaces and healthy foods may affect risk for diabetes both directly, and indirectly through their influence on physical activity and dietary consumption. Results from the Multi-Ethnic Study of Atherosclerosis (MESA), a large, population based longitudinal cohort study that includes Hispanic American individuals, showed that individuals in the bottom tertile of neighborhood physical activity resources (e.g., fewest number of sports, gyms, green spaces) developed diabetes at nearly double the rate of those in the top tertile over 8.9 years (45); and those in the 90th percentile of healthy neighborhood resources had a 38% lower risk for T2DM compared to those in the 10th percentile (46). In another study, those in the highest vs. lowest quintile for neighborhood problems (e.g., crime, pollution) had a 25% greater odds of obesity (47). Perception of neighborhood safety was related to increased walking for both transport and leisure (48), and was shown to mediate associations between neighborhood social environment (e.g., crime, violence) and physical activity levels (49). High perceived neighborhood problems (e.g., crime, pollution) have been associated with hypertension, obesity, smoking, lower physical activity, and poorer emotional well-being (47, 50, 51). Given the high crime rate, minimal green space, prevalence of high-sugar, high-fat street foods, and significant air and water pollution present in urban Tijuana, it is likely that the neighborhood environment plays a significant role in both health behaviors and overall diabetes risk.

1.4 Diabetes Knowledge/Cultural Beliefs. Awareness and perception of disease risk are core factors in multiple heath behavior models that attempt to explain motivation for behavior change. Though modification of knowledge is insufficient as a singular strategy for risk reduction, knowledge and perceptions can modify self-management and risk behaviors (52-54). Diabetes knowledge has been shown to relate independently to self-management behaviors and glycemic control among individuals with diabetes (55-57), however, few studies have examined diabetes knowledge in individuals with no diabetes diagnosis, or estimated the effect of diabetes knowledge on risk for diabetes. Low diabetes knowledge in individuals with diabetes has been documented in Mexican samples in Mexico and the U.S. with studies suggesting little understanding of predisposing factors, related health behaviors, glucose and insulin function, and consequences of lack of treatment (57-60). Various inaccurate or partially inaccurate cultural beliefs of the etiology of diabetes are common. For example, the condition may be attributed to a single episode of intense emotion, such as a *susto* (fright/trauma), fear, or anger (61), or even to the use of insulin, leading to misunderstandings of how to prevent and treat the disease. Diabetes knowledge represents a modifiable risk factor for T2DM along the U.S.-Mexico border, and a potential target as one component of a future intervention.

1.5 Intervention Mapping Approach. The current study was guided by Intervention Mapping (IM), an approach to assessing health problems and designing evidence-based public health interventions (62). IM is characterized by a socioecological view of health risks and resources and a community-participatory model for the development of research aims in community settings. IM emphasizes best practices in intervention creation and is designed to ensure that theoretical models and empirical evidence guide researchers in the identification of determinants of specific health problems. Additionally, IM aims to increase external validity of interventions through early and strategic incorporation of community members' opinion and expertise. By ensuring that public health programs target concerns of importance to community members and incorporate local knowledge, skills, and resources, the IM approach increases feasibility and acceptability of interventions implemented in culturally diverse settings (62).

From the time of first publication in 1998 (63), IM has been utilized in the development of a wide array of public health interventions, including those targeting breast and cervical cancer screening, HIV prevention and self-management, obesity prevention, and return-to-work initiatives for injured workers (62). Recently, IM approaches have also been applied to diabetes-related interventions, primarily in international and culturally distinct settings. For example, the approach has been utilized to develop self-management interventions in Iran (64) and South Korea (65), prevention interventions for adults in the Netherlands (66) and for adolescent girls in South Africa (67), and a peer-support intervention for African American adults in rural Alabama (68). With an emphasis on community involvement and cultural relevance and acceptability, IM is well suited to global health settings with complex sociocultural landscapes, such as the San Diego-Tijuana international border region.

Traditionally, IM involves six distinct steps (Figure 1) which guide intervention development from needs assessment (Step 1) to program implementation (Step 5) and evaluation (Step 6). The first two steps will be implemented in the proposed study: (1) Needs and resources assessment; and (2) Identification of modifiable determinants of the health problem and targets for future intervention. Step 1 involves qualitative and experiential efforts to understand the character of the community, including its members, strengths, health vulnerabilities, and knowledge and conceptualization of the health problem, paired with quantitative measurement of potential contributors or determinants across socioecological levels. These efforts often include conducting focus groups and semi-structured key informant interviews with potential research participants and other community stakeholders. A critical piece of Step 1 is the identification of a participatory planning group, comprised of a small number of community members with experience and insight related to the health problem, to provide guidance and feedback about cultural appropriateness and relevance of study procedures. In Step 2, data gathered in Step 1 are analyzed to create clear models of correlates and potential mechanistic pathways of the health problem. Based on these findings, a list of change objectives for future intervention is specified. The product of Steps 1 and 2 is a detailed quantitative and qualitative description of the health problem, including prevalence, local knowledge and beliefs, correlates across multiple socioecological levels, and modifiable determinants of risk to be targeted by future interventions. As this dissertation project was conceptualized as an exploratory study to directly inform the creation of a novel intervention for diabetes prevention applicable to the U.S.-Mexico border community, IM is a fitting strategic framework that provides guidance and continuity between this project and future steps.

1.6 Socioecological Model. Consistent with the IM approach, the social-ecological model (SEM) (69-71) served as the conceptual framework for understanding multiple levels of influence (e.g., individual, social/community, environmental) on health (see Figure 1), and specifically on behaviors that relate to risk for diabetes and prediabetes (Figure 2). The importance of examining ecological influences on nutrition and health behaviors has been well established (71-74), as evidence has emerged linking factors such as food access and availability, built environment/walkability, and work and home environments to diabetes risk. A socioecological perspective is particularly important in low-income and low-resource communities such as the proposed study site, where residents may not have the economic or neighborhood resources needed to engage in physical activity and dietary behavior change, even if desired. Figure 3 displays variables across four socioecological levels that have been identified as potentially relevant to diabetes risk in previous research and/or through formative research efforts for this study (described below).

1.7 Formative Research. A series of qualitative focus groups and key informant interviews were conducted prior to planning and implementation of the primary study aims (Nov. 2015 – Feb. 2016) with the following goals: (1) Gain a deeper understanding of local knowledge and conceptualizations of diabetes in the Tijuana border community, (2) Identify border-specific risk factors for diabetes (e.g., migration/deportation stress, food insecurity, neighborhood safety, lack of access to preventive care) and (3) Assess relevancy, feasibility, and acceptability of proposed study methods, including issues related to recruitment, privacy/confidentiality, and data collection methodology (i.e., questionnaire length, HbA1c test willingness). Focus group participants were a convenience sample of adults presenting for free medical care at a border-area walk-in health clinic in Tijuana. Eligible participants were English or Spanish speakers who were categorized as "high-risk" for T2DM based on American Diabetes Association (ADA) guidelines for diabetes screening (45). Four semi-structured focus groups were conducted (N = 19), with saturation of key themes reached in the 4th group. Nine key informant interviews were conducted with health professionals in Tijuana (e.g., physicians, nurses, *promotoras*, nutritionists); these individuals were selected based on identified expertise in T2DM-related health promotion or medical care. All focus groups and key informant interviews were audio recorded and transcribed to text. Preliminary analysis of qualitative data was conducted in February-March 2016 and was used to make localized, context-specific adaptations to the research protocol (e.g., to populate items on the diabetes knowledge/cultural beliefs questionnaire, generate lists of common barriers and facilitators of health behaviors, adapt the physical activity and dietary intake measures to include locally relevant response options).

This dissertation study explored multi-level risk and protective factors for T2DM in a low-resource international border setting. The primary Aims and Hypotheses were as described below.

Acknowledgements. I would like to acknowledge the following co-authors, who assisted in the conceptual development of this chapter and who are assisting in writing a manuscript based on this dissertation: Linda Gallo, Paul Mills, Scott Roesch, Maria Rosario (Happy) Araneta, and Gregory Talavera.

CHAPTER 2. AIMS OF THE DISSERTATION

Aim 1. Estimate prevalence of normal glucose regulation, prediabetes, and diabetes in a high-risk U.S.-Mexico border population. **Hypothesis 1**. Prevalence of prediabetes and diabetes will be high relative to prior national estimates in Mexicans in the U.S. or in Mexico.

Aim 2a. Examine the cross-sectional relationship of three indictors of psychological adversity (depression, anxiety, adverse childhood experiences) with diabetes prevalence, adjusting for participant age, sex, income, and education. **Hypotheses 2a.** Higher depression symptoms, higher anxiety symptoms, and more adverse childhood experiences (e.g., trauma, neglect) will be associated with greater diabetes prevalence, and these associations will remain significant after controlling for demographic covariates.

Aim 2b. Explore the indirect effect of social support in the association between indicators of psychological adversity and diabetes prevalence. **Hypothesis 2b.** Social support will act as an indirect pathway through which psychological adversity relates to diabetes. Higher psychological adversity will be associated with reduced social support, and reduced social support will be associated with greater diabetes prevalence.

Aim 3a. Assess the cross-sectional relationship of neighborhood environment (e.g. access to healthy foods, walkability/exercise environment, safety) with diabetes prevalence, controlling for participant age, sex, income, and education. **Hypothesis 3a.** Adverse neighborhood environment (e.g., poor access to healthy foods, lower walkability, higher crime) will be associated with greater diabetes prevalence, and this association will remain significant after controlling for demographic covariates.

Aim 3b. Explore the indirect effects of health behaviors (physical activity, dietary intake) in the association between neighborhood environment and diabetes prevalence. **Hypothesis 3b.**

Health behaviors will act as indirect pathways through which neighborhood environment relates to diabetes. Poor neighborhood environment will be associated with adverse health behaviors (reduced physical activity, less healthy dietary intake), and adverse health behaviors will be significantly associated with diabetes prevalence.

Aim 4a. Explore the cross-sectional relationship of diabetes knowledge/cultural beliefs to diabetes prevalence, controlling for participant age, sex, income, and education. **Hypothesis 4a.** More accurate diabetes knowledge/cultural beliefs will be associated with lower diabetes prevalence, and this relationship will remain significant after controlling for demographic covariates.

Aim 4b. Assess the indirect effects of health behaviors (physical activity, dietary intake) in the relationship between diabetes knowledge/cultural beliefs and diabetes prevalence. **Hypothesis 4b.** Health behaviors will act as indirect pathways by which diabetes knowledge/cultural beliefs relate to diabetes prevalence. Less accurate knowledge/beliefs will be positively associated with adverse health behaviors (reduced physical activity, less healthy dietary intake), and adverse health behaviors will be significantly associated with diabetes prevalence.

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CHAPTER 3. METHODS

This was a cross-sectional, observational study of socioecological correlates of diabetes prevalence in migrant, deported, homeless and other individuals accessing free medical care in an area with high HIV-prevalence near the US-Mexico border.

Study site. The Health Frontiers in Tijuana (HFiT) Clinic is a free walk-in primary care clinic run collaboratively by medical students and physicians from the University of California, San Diego (UCSD) and the *Universidad Autónoma de Baja California* (UABC). The clinic is situated at close proximity to the U.S.-Mexico border in Tijuana's *Zona Norte* and is housed in the *Desayunador Salesiano "Padre Chava"* facility, which contains a migrant shelter and a soup kitchen that serves breakfast to over 1000 individuals every day. The medical clinic opens to the public weekly on Saturdays and usually one additional day during the week. The patient population is comprised of individuals of low SES with a large proportion of individuals from high-risk, vulnerable groups (i.e., homeless, deportees, injection drug users, sex workers). A recent study of 602 HFiT clinic patients indicated that approximately 40% are deportees and 55% are overweight or obese (Ojeda, unpublished data).

Participants and Recruitment. This study had the goal of recruiting, at minimum, 184 adult participants seeking free medical care in the U.S.-Mexico border neighborhoods of Tijuana.

Inclusion Criteria: Eligible participants were (1) 18 years of age or older, (2) presented to the HFiT clinic seeking free medical care, and (3) spoke Spanish or English.

Exclusion Criteria. Participants were excluded if they (1) were <18 years of age, (2) did not speak English or Spanish, (3) were in acute pain or needed immediate or intensive medical attention that prevented involvement, or (4) were unable to communicate effectively due to active intoxication, severe hearing or speech impairment, or cognitive impairment (e.g., delirium, confusion/dementia, psychosis).

Pregnancy. This study included only minimal risk data collection and no intervention or other procedure that would be potentially harmful to a pregnant female or fetus. While seldom accessible for medically underserved individuals in urban Tijuana, glucose regulation testing is informative and can be beneficial for pregnant women's health. Thus, pregnant individuals were not excluded from participation. Pregnancy testing was conducted for all women who had not undergone menopause in order to confirm pregnancy status. Women with a positive pregnancy test result were referred as needed to appropriate prenatal care services provided by the State of Baja California's ISESALUD Health Department. The inclusion of pregnant women was approved by the Institutional Review Boards of University of California, San Diego, Universidad Autónoma de Baja California, and the Health Frontiers in Tijuana clinic.

Participatory Planning Group. In alignment with the Intervention Mapping approach (62), a small participatory planning group (PPG) was established to provide insight, guidance and feedback about cultural appropriateness and relevance of all study procedures. IM stipulates that an ideal PPG consists of bilingual, bicultural individuals who have extensive exposure to both the target community (e.g., either reside or have resided for many years in Tijuana) and research protocols. The PPG for this study included a female physician and researcher (Tijuana resident), a male psychotherapist (Tijuana resident), and a female dietician (San Diego resident, has practiced in Tijuana for many years). Members of the PPG reviewed and provided feedback for the research protocol, self-report questionnaire, and all patient education/referral materials, with particular attention to cultural appropriateness and relevance.

Procedures. Institutional Review Board (IRB) approval was obtained from University of California, San Diego, Universidad Autónoma de Baja California, and the Health Frontiers in Tijuana clinic (which maintains an autonomous binational IRB) for all study procedures. Participants were recruited from the pool of individuals presenting for medical care at the HFiT clinic. As previously stated, this is a free, walk-in medical clinic open to the public and housed inside the Padre Chava soup kitchen/migrant shelter. Upon entrance to the clinic, each patient passes through registration, where they are entered into a waiting list for medical consult based on arrival time. Next, patients proceed to a vitals station for recording of weight, height, and blood pressure. Following vitals measurement, patients sit in a large waiting area, often for up to 2 hours, for their medical consult. Bilingual study staff approached participants in the waiting room in order of arrival to ask if they were interested in possible participation in a study addressing risk factors for diabetes and for permission to ask them questions to ensure eligibility. Patients who agreed were screened for inclusion and exclusion criteria. All patients who met screening criteria were invited to participate. The informed consent process was conducted privately for each interested patient. Patients who provided consent could choose to complete the study procedures while waiting for a medical consult, or after their consult was complete. If a patient provided consent but was unable to complete the study the same day, they were given a written appointment card to return the following Saturday. All data collection was conducted by trained bilingual bicultural research assistants, either in private rooms or behind privacy screens and out of earshot of other participants. After written informed consent was obtained, research assistants administered self-report questionnaires in the participant's preferred language and conducted HbA1c finger stick testing. Participants who completed the study received $10 for their time and effort.

Diabetes Assessment.

Hemoglobin A1c. HbA1c percentage is a measure of average glucose regulation over the past 3 months, and can be used as a diagnostic test for diabetes (45). HbA1c values less than 5.7% indicate normal glucose regulation (no diabetes), values from 5.7% to 6.4% indicate prediabetes, and values 6.5% or higher indicates diabetes. HbA1c percentage was assessed via finger stick blood test with rapid immunoassay analysis using the Food and Drug Administration (FDA) and National Glycohemoglobin Standardization Program (NGSP)-approved Siemens point-of-care DCA Vantage Analyzer, which provides an HBA1c percentage in 6 minutes with interassay imprecision < 3%. The HbA1c analyzer was calibrated at beginning of data collection and monthly thereafter, as well as at the start of each new lot of reagent kits, as advised by the Siemens Operation Procedures Guide. If a first rapid test was positive for diabetes (HbA1c ≥ 6.5%), the test was repeated using a new finger stick blood sample. Two tests above the diagnostic threshold of 6.5% confirmed a diagnosis of diabetes. All participants were informed of their HbA1c percentage score and categorization (normal, prediabetes, diabetes). Participants with HbA1c levels in the diabetes or prediabetes range (above 5.7%) were provided brief educational counseling and referrals for consultations with on-site physicians and nutrition/dietician. Regardless of diabetes status, all patients received a resource packet upon completion of the study that contained educational information on diabetes, prediabetes, low cost healthy food, and simple physical activity recommendations, in addition to local referrals for free medical, nutrition, and mental health consultations.

Self-Report. Included in the self-report questionnaire described below were items to assess history of diabetes testing and diabetes diagnosis, including type of diabetes and medication use, if applicable, for each participant.

Diabetes and Prediabetes. Using information from the HbA1c test and self-report, diabetes diagnosis was defined as any one of the following: confirmed HbA1c of 6.5% or higher; self-report of previous diabetes diagnosis from a medical professional; use of insulin or oral antihyperglycemics. Prediabetes was defined as HbA1c of 5.7% -6.4%.

Self-Report Assessments. Trained bilingual and bicultural research assistants verbally administered all measures using Qualtrics (Qualitrics, Provo, UT) via internet-enabled tablets. Data were identified using a unique study identification number for each participant; no other identifying information was used. The questionnaire was available in both Spanish and English. Measures were chosen based on feasibility of use in primary care settings and validity and reliability in previous use in Spanish-speaking populations.

Demographic and Health Information. A brief demographic questionnaire designed for this study assessed participant age, sex, country of birth/nationality, education, marital status, housing, employment/income, migration and deportation history (length of time in U.S., deportation history) and health history including diabetes and other major diagnoses. These data were used to characterize the sample descriptively and as covariates (defined in statistical approach).

Depression Symptoms. Depression symptoms were measured using the Patient Health Questionnaire – 8 item version (PHQ-8), a screening instrument that has demonstrated validity and reliability in the measurement of symptoms of depression both in general and in Hispanic/Spanish-speaking populations ($\alpha = .85$ in English version, $\alpha = .89$ in Spanish version) (75, 76). Respondents are asked to report the frequency with which they have experienced and been bothered by each of 8 depression symptoms in the 2 weeks prior to response (e.g., "How often in the past 2 weeks were you bothered by having little interest or pleasure in doing things?”). Answer options and scores are based on frequency: (0) Not at all, (1) Several days, (2) More than half of the days, and (3) Nearly every day. Individual items are summed to generate a total score ranging from 0 to 24, with higher scores indicating higher levels of depression. The PHQ-8 was chosen instead of the more extensively used PHQ-9 due to the fact that the 9th item, intended to measure suicidal ideation, has been shown to have poor accuracy as a suicide screen (77). Correlation between PHQ-9 and PHQ-8 scores is reported to be high (r=0.997), and sensitivity and specificity to detect major depression are similar (PHQ-9: 54%, 90%; PHQ-8: 50%, 91%) (77). To minimize participant time burden, the psychometrically equivalent and more parsimonious PHQ-8 was preferred for this study.

Anxiety Symptoms. Symptoms of anxiety were measured using the General Anxiety Disorders Questionnaire – 7 item version (GAD-7), a valid and reliable screening instrument for anxiety symptoms both in general and in Hispanic/Spanish-speaking populations ($\alpha = 0.93$ overall; $\alpha = 0.91$ in English and $\alpha = 0.94$ in Spanish versions) (78, 79). Respondents are asked to report the frequency with which they have experienced and been bothered by each of 7 anxiety symptoms in the 2 weeks prior to response (e.g., “How often in the past 2 weeks were you bothered by feeling nervous, anxious, or on edge?”). Answer options and scores are based on frequency: (0) Not at all, (1) Several days, (2) More than half of the days, and (3) Nearly every day. Individual items were summed to generate a total score ranging from 0 to 21, with higher scores indicating higher levels of anxiety.

Adverse Childhood Experiences. Adverse experiences in childhood (e.g., physical, emotional, or sexual abuse, neglect, parental alcoholism, incarceration of household member) were examined via the 10-item Adverse Childhood Experience Scale (ACES).(41) This measure was developed as part of a large-scale research initiative led by the Centers for Disease Control

(CDC) and Kaiser Permanente to understand the relationship between multiple categories of childhood trauma and health outcomes later in life (80) (http://www.cdc.gov/ace/index.htm). Respondents indicate whether they have been exposed to a series of 10 adverse events during their childhood (e.g., "Did a parent or other adult in the household often or very often push, grab, slap, or throw something at you? Or ever hit you so hard that you had marks or were injured?"). This measure has been used previously in Spanish-speaking Hispanic/Latino and Mexican populations (22, 36, 37) and has been shown to have good test-retest reliability (81).

Social Support. Perceived or functional social support was measured with the 12-item version of the Interpersonal Support Evaluation List (82). The ISEL-12 has been shown to have adequate reliability and validity in general populations and in both English and Spanish versions in Hispanic/Latino populations ($\alpha > .70$) (83, 84). Items are statements of availability of support from others for various needs (e.g., "If I were sick, I could easily find someone to help me with my daily chores."). Answer responses indicate how true or not the respondent believes the statement is for her or him: (0) definitely false, (1) probably false, (2) probably true, (3) definitely true. Item scores were summed to generate an overall social support score, ranging from 0 to 36, with higher scores reflecting greater perceived support.

Neighborhood Adversity. Adverse neighborhood environment characteristics were captured using a 30-item scale created by Escheverria, Diez-Roux, & Link (85), which has been used in multiple large population studies (e.g., Powell 2014; Walker 2015). This scale is utilized to measure perceptions of 5 components (subscales) of neighborhood environment: social cohesion (5 items), walking/exercise environment (11 items), access to healthy foods (6 items), crime/safety (3 items), and aesthetic quality (5 items). Items are statements about neighborhood qualities (e.g., "It is pleasant to walk in my neighborhood") and respondents rate agreement along a 5-point scale from (1) Strongly agree to (5) Strongly Disagree; some items are reverse-coded. Subscales have shown good reliability (all α's > .77) (85) and can been used independently in analyses or as a total score representing a single theoretical construct of neighborhood environment (85) (range 30-150). Higher scores indicate higher neighborhood adversity. Although neighborhood environment may also be assessed via objective measures such as GPS mapping or observation of built environment characteristics, there is a substantial research base supporting the associations and predictive utility of *perceived* neighborhood environment with health outcomes and health behaviors (47-51).

Diabetes Knowledge/Cultural Beliefs. A 13-item questionnaire originally created for use in a diabetes education program for high-risk Mexican American women in San Diego (86) and adapted for use in the Tijuana/U.S.-Mexico border context, was used to assess diabetes knowledge and culturally driven beliefs. Phrases regarding causes and treatments for diabetes (e.g., "Insulin causes blurred vision") are offered, and respondents answer in a True/False format. Community-specific items for Tijuana, Mexico were added to the questionnaire based on local resident feedback gained in formative research conducted for this study; for example, "Anger ("*coraje*") can cause diabetes," and "Consuming a type of worm ("*gusanitos*") can reduce blood sugar"). Total scores were generated (range 0-13), with higher scores indicating more accurate knowledge/fewer culturally informed inaccurate beliefs about diabetes.

Physical Activity. The 2nd version of the 16-item Global Physical Activity Questionnaire (GPAQ-2), (87), developed by the WHO for international use, was administered to assess moderate and vigorous physical activity across 3 domains: occupational, transportation-related, and recreation/leisure time. The GPAQ-2 has been shown to be reliable and valid in both Spanish and English (87), and to have moderate agreement with objective measures of physical activity (e.g., accelerometer data) (88). The GPAQ-2 was administered with show cards, adapted to the local context of Tijuana, to provide photographic examples of moderate and vigorous intensity activities in order to facilitate accurate response. Time spent in various activities is converted into metabolic equivalents (METs), a commonly used unit to express physical activity intensity, to generate total moderate and vigorous physical activity scores. One MET is defined as the energy cost of sitting, such as in computer use, reading, or watching television, and is equivalent to a caloric consumption of 1 kcal/kg/hour (89). Four METs are assigned to the time spent in moderate-intensity activities and PA for transportation (e.g., walking or biking to work), and 8 METs to the time spent in vigorous-intensity activities (89).

Dietary Intake. Dietary intake was ascertained using a brief, validated dietary assessment tool entitled *Starting the Conversation* (90). In this measure, participants report average intake frequency for various dietary elements during recent months (e.g., "Over the past few months, how many servings of fruit did you eat each day, on average?"). Response options are scored based on healthfulness/correspondence with recommended dietary behaviors [e.g.. for the given example, (1) 5 or more, (2) 3-4 times, (3) 2 times or less]. Dietary intake measured by *Starting the Conversation* has been shown to be correlated with serum carotenoid levels and to have improved sensitivity relative to other dietary screening measures (90). Total score (range 0-16) was generated by summing responses to the items; higher scores reflect less healthy diets.

Quality Control Procedures. Clinical data collection and questionnaire administration were conducted by the PI (Jessica McCurley), trained bilingual/bicultural research assistants, and trained medical research staff at the HFiT clinic. All study staff completed required online training in Research Ethics and Human Subjects Research. Additionally, all staff were intensively trained in protocols for the questionnaire (interview skills, tablet-based questionnaire administration) and clinical data collection. Training emphasized research ethics and skills for working with vulnerable populations (e.g., deportees, sex workers, homeless individuals). Included in training were modules to increase awareness to topics of high concern in these populations (e.g., privacy/confidentiality, literacy level, substance use/altered mental status, trauma history, recent deportation/incarceration experience). Individuals conducting the HbA1c finger stick test were health professionals (physicians, nurses) with training in blood sampling and diabetes testing and counseling. Quality control procedures including direct observation of protocol implementation were conducted in staff training and repeated periodically throughout the study.

Statistical Approach. IBM SPSS Statistics (IBM Corp. Armonk, NY) was used to calculate sample characteristics including demographic information and Aim 1 descriptive results (normal glucose, prediabetes, and diabetes prevalence). All other analyses were conducted using maximum likelihood robust (MLR) estimation in MPlus (91). MLR utilizes the full-information maximum likelihood (FIML) procedure which generates unbiased model parameter estimates and standard errors for missing outcome data (92). Assumptions regarding linearity and normality were examined for all variables, and data transformations were conducted as necessary. A statistical significance level of $p < .05$ was used for all models.

For Aim 2, multivariable logistic regression analysis was utilized to examine the relationships of psychological adversity variables (depression, anxiety, adverse childhood experiences) with diabetes diagnosis, adjusting for demographic covariates (age, sex, income, and education). Psychological adversity variables were included in the model simultaneously to account for correlations and shared variance between them (See Figure 4, blue pathway for Aim 2). For Aim 2b, the indirect (mediating) effect of social support was tested using a path analytic approach in which social support was included in the aforementioned model along with the three psychological adversity predictors and the diabetes outcome. The statistical significance of the indirect effect was determined by computing a MacKinnon's asymmetric confidence interval for each of the three pathways from adversity variable, through social support, to diabetes (93).

For Aim 3, multivariable logistic regression analysis was utilized to examine the relationship of neighborhood environment with diabetes diagnosis, adjusting for the demographic covariates mentioned above (age, sex, income, and education; See Figure 4, green pathway for Aim 3). For Aim 3b, the potential indirect (mediating) effects of health behaviors were tested using a path analytic approach, in which physical activity and dietary intake were included in the model along with neighborhood environment and the binary diabetes outcome. Again, the statistical significance of indirect effects was determined by computing a MacKinnon's asymmetric confidence interval for each health behavior pathway (93).

For Aim 4, multivariable logistic regression analysis was utilized to examine the relationship of diabetes knowledge/cultural beliefs with diabetes diagnosis, adjusting for demographic covariates (see Figure 4, red pathway for Aim 4). For Aim 4b, as in Aim 3b, the potential indirect (mediating) effects of physical activity and dietary intake were tested via path analysis. Physical activity and dietary intake were included in the model along with diabetes knowledge/cultural beliefs and the binary diabetes outcome, and statistical significance of the indirect effect was determined by computing MacKinnon's asymmetric confidence intervals (93).

Power Analysis.

Aim 1. Prevalence of normal glucose regulation, prediabetes, and diabetes. As mentioned above, diabetes prevalence estimates from Mexico vary greatly, with the 2012 Mexican National

Health and Nutrition Survey reporting a substantial age gradient in prevalence (5% in individuals under 40, 13% in 40-59 year olds, 19.4% in 50-59 year olds, and 26.3% in 60-69 year olds) (2), and a nationally representative study of adults over 50 reporting prevalence of 39.4% (4). The large U.S. population-based HCHS/SOL reported the prevalence of diabetes in Mexican-Americans to be 18.3%. The most recent population-based study of diabetes prevalence in the U.S.-Mexico border region was the U.S.-Mexico Border Diabetes Prevention and Control project, which took place in 2001-2002 and involved 4027 individuals living on both sides of the border. Data from that time period revealed a diabetes prevalence of 15.7% and a prediabetes prevalence of 14%, though estimates have undoubtedly increased in the 15 years since.

Reported prevalence rates of prediabetes likewise vary. Studies which include objective measures of glucose regulation have reported prediabetes prevalence from 44% in population-based Mexican samples of adults age 50 and over (4) to 14.6% in 18-30 year olds (94). Prevalence in a large U.S.-based sample of Mexican-American adults 18 and over (mean age 46.0) residing in an international border area was 31.6% (95).

As our sample was expected to be younger than the cited samples, a reference estimate of 12% prevalence was used for diabetes and 16% for prediabetes. A priori power analysis for the detection of prevalence was conducted using the open source calculator OpenEpi (www.OpenEpi.com), Version 3.03 (96). To detect prevalence at an estimated proportion of .12 for diabetes, with an 80% confidence level at 5% precision and with the design effect of 1, a sample size of 70 participants was needed. To detect prevalence at an estimated proportion of .16 for prediabetes, with an 80% confidence level at 5% precision and with the design effect of 1, a sample size of 89 participants was needed. For convenience samples, it is recommended to use a significantly larger sample size than would be needed under simple random sampling (e.g., design effect of 1). Thus, a sample of double the N=89 estimated participants (N=178) was decided upon. Additional power calculations were conducted (below) to estimate the sample size needed for multivariate analyses.

Aim 2. To assess Aim 2a, a logistic regression was conducted with diabetes diagnosis (yes/no) as the dichotomous outcome, depression, anxiety, and adverse child experiences as independent variables of interest, and age, sex, income, and education as covariates. For Aim 2b, social support was added to the model as a potential mediator and the indirect effect was estimated. G*Power Version 3.1 (97) was used to determine the sample size needed to run the logistic regression analyses for Aim 2a using historical effect sizes. Previous literature has shown that depression contributes significantly to likelihood of diabetes, with adjusted odds ratios ranging from 1.23 to 2.56, and large meta-analyses have reported pooled ORs of 1.60 and 1.56 (27-30). The adjusted odds ratio for diabetes associated with multiple adverse childhood experiences was 1.4 (42) in a population-based survey in the U.S., 1.32 in a large meta-analysis (43), and 1.65 when only studies including objective measures of diabetes diagnosis (vs. self-reported) were included (43). Though few studies have examined the independent association of anxiety with diabetes prevalence, multiple studies have reported a higher age-adjusted lifetime prevalence of anxiety in individuals with diabetes compared to those without (e.g., (31, 98)), and Hispanic Americans have exhibited a disparity in this regard (e.g., higher prevalence of anxiety associated with depression than their non-Hispanics white counterparts) (98). One large population-based study found both depression and anxiety to be significant risk factors for onset of T2DM and reported a combined OR of 1.6 (32). There is always likely to be shared variance in the associations of depression symptoms, anxiety symptoms, and childhood adversity with diabetes, however, it is also possible that their combined effect is larger than the sum of individual effects. Thus, based on historical findings of individual effect sizes, we used an odds ratio of 1.7 to determine sample size for Aim 2. At a power level of 0.80 and $\alpha = 0.05$, a sample size of 184 individuals was needed.

For Aim 2b, an a priori power analysis based on empirical estimates of sample sizes by Fritz & MacKinnon (99) was conducted to estimate the sample size needed to test the indirect effect psychological adversity on diabetes via social support, at a power level of 0.80 and $\alpha =$ 0.05. Based on effect sizes previously reported in the literature, a sample size of approximately 125 participants was needed if the effect size of the relationship of social support with diabetes was small to moderate, and a sample size of 405 participants was needed if that effect was small. Thus, the mediation analysis was powered at a level of 0.80 if the component representing the effect of social support on diabetes is small to medium, but not if it is small.

Aim 3. For Aim 3a, a logistic regression analysis was planned with diabetes diagnosis (yes/no) as the dichotomous outcome, neighborhood environment as the independent variable of interest, and age, sex, income, and education as covariates. As previously cited, the bottom tertile of neighborhood physical activity resources (sports, gyms, green spaces) for Hispanic individuals was associated with nearly double the rate of diabetes as the top tertile (45), and those in the 90th percentile of healthy neighborhood resources (combined score for access to healthy foods, physical activity resources, etc.) had a 38% lower risk for T2DM compared to those in the 10th percentile (46). In another study, those in the highest vs. lowest quintile for neighborhood problems (e.g., crime, pollution) had a 25% greater odd of obesity (47). Based on this historic literature, our neighborhood environment variable, which included scales for multiple aspects of neighborhood quality, was expected to have a medium size association with diabetes. An a priori power analysis for a logistic regression, conducted using G*Power 3.1.7 (97), with an alpha of 0.05 and a power of 0.80, and a medium effect size (odd ratio = 1.72) for a two-tailed test, resulted in a desired sample size of 177.

For Aim 3b, an a priori power analysis was conducted to estimate the sample size needed to test the indirect effect of neighborhood environment on diabetes via physical activity and dietary intake, at a power level of 0.80 and $\alpha = 0.05$ (99). Previous literature has shown the effects of neighborhood environment on both physical activity and diet, and of physical activity and diet on diabetes risk, to be medium in size (100, 101). Based on medium effect sizes for both components of the test for mediation, a sample size of approximately 74 participants was needed for this analysis.

For Aim 4, a final logistic regression model was planned with diabetes diagnosis (yes/no) as the dichotomous outcome, diabetes knowledge as the primary predictor of interest, and demographic covariates age, sex, income, and education. Though diabetes knowledge has been widely shown to be independently related to self-management behaviors and glycemic control among individuals with diabetes (e.g. (55), few studies have examined associations of diabetes knowledge with diabetes prevalence. One study has shown diabetes knowledge to be significantly related to HbA1c, in individuals with T2DM with higher knowledge relating to lower HbA1c, with a medium effect size (56). Though historical literature to inform this power analysis was scant, an a priori power calculation was conducted in G*Power to determine the sample size needed to detect a medium effect size, with an alpha of 0.05 and a power of 0.80. The necessary sample size generated was 177.

For Aim 4b, no literature has directly examined the effects of diabetes knowledge on physical activity and dietary intake in a sample that included individuals without diabetes. Thus, while one component of the analysis of indirect effect (the effect of physical activity and dietary intake on risk for diabetes) has historically reported medium effect sizes, the effect size for the other component of the analysis is unknown. As shown above in Aim 2b, if the unknown mediation component were to have a small effect size, the needed sample size (using the empirically generated method described in Fritz (99)) would be 405 participants, while the sample size needed for a small to medium effect size would be 125. Given that the highest sample size generated in the above set of power analyses was 184, and 405 participants would be implausible for the timeline of this study, we determined to utilize the target sample size of N=184.

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CHAPTER 4. RESULTS

4.1 Descriptive Statistics. A total of 220 individuals were enrolled in this study. Demographics and descriptive characteristics for the full sample are reported in Table 1. Participant age ranged from 19 to 83 years (M = 47.2, SD = 11.9) and 74.5% were men. The majority of participants were born in Mexico (n = 196, 89.1%), with 1.8% (n = 4) born in the U.S. and 3.2% (n = 7) born in other countries in Central and South America. Approximately one third (n = 68, 33%) completed elementary level education or less; another third (n = 69, 31.4%) completed no more than middle school education. The majority was not married or partnered (n = 116, 52.7%) and average monthly income was the equivalent of U.S. $123.20 per month (SD = $218.33). Less than half of participants reported having health insurance coverage (n = 88, 40%). Over 70% of participants reported a history of migration to the U.S. (n = 156) and 56.8% (n = 129) reported a history of at least one deportation from the U.S. Prevalence of clinically significant depression and anxiety symptoms (e.g., symptoms at a level corresponding with probable clinical diagnoses) was 36.9% and 33.3%, respectively. Participants reported an average of 3.7 (SD = 2.9, range = 0 - 10) adverse childhood experiences. Bivariate correlations of psychological and neighborhood adversity variables, diabetes knowledge/cultural beliefs, and diabetes and prediabetes prevalence are presented in Table 2.

4.2 Diabetes and Prediabetes Prevalence. Aim 1 of the study was to assess prevalence of diabetes, prediabetes, and normal glucose regulation in a low income, medically underserved community on the U.S.-Mexico border. The prevalence of diabetes in the study sample, as measured by an HbA1c percentage ≥ 6.5%, self-report of prior diabetes diagnosis by a health professional, or use of insulin or oral antihyperglycemics, was 17.3% (95% CI: 12.2, 22.3). Prevalence of prediabetes, as measured by an HbA1c percentage ≥ 5.7%, was 29.1% (95% CI:

23.0, 35.1). The prevalence of normal glucose regulation was 53.6% (95% CI: 47.0, 60.3). Of those with diabetes, 60.7% (n = 23) of cases were previously diagnosed and 39.3% (n = 15) were undiagnosed.

4.3 Regression and Path Analyses. Aims 2-4 of this study involved examination of correlates of diabetes prevalence through multivariable logistic regression and path analyses. Results of logistic regression models are presented in Table 3 and path analyses are presented in Figures 5-10. 15 cases were excluded from the analytic sample due to missing all self-report data (e.g., participant completed diabetes testing but did not complete an interview, or interview data was missing due to electronic survey error). Final analytic sample for Aims 2-4 was N = 205. Model 1A in Table 3 corresponds to Aim 2A, which hypothesized a relationship of depression symptoms, anxiety symptoms, and ACES with diabetes prevalence. After adjustment for age, sex, income, and education, neither depression symptoms, nor anxiety symptoms, nor ACES were associated with increased odds of having diabetes. A one-unit increase in each psychological adversity variable was associated with the following odds of having diabetes (all p's > 0.05): depression symptoms (OR = 0.97, 95% CI: 0.88, 1.06); anxiety symptoms (OR = 1.03, 95% CI: 0.95, 1.13); ACES (OR = 1.02, 95% CI: 0.84, 1.23). Model 1B (corresponding to Aim 2B) specified indirect relationships from depression symptoms, anxiety symptoms, and adverse childhood experiences to diabetes prevalence through perceived social support. Results of the multivariable path analysis model testing indirect effects are shown in Figure 5. Controlling for age, sex, education, and income, in the indirect effect pathway there were significant relationships between depression symptoms and social support ($B = -0.40$, $p < 0.01$) and ACES and social support ($B = -0.67$, $p < 0.05$), but not anxiety symptoms and social support. The pathway between social support and diabetes prevalence was not significant, indicating that no significant indirect effects through social support were present.

Model 2A (corresponding to Aim 3A) tested the relationship between neighborhood adversity and diabetes prevalence. After adjustment for age, sex, income and education, there was no significant relationship between neighborhood adversity and odds of having diabetes. A one-point increase in neighborhood adversity score was associated with no change in odds of diabetes (OR = 1.00, 95% CI: 0.98, 1.02). When models included adjustment for length of residence in Tijuana, results remained non-significant and no substantive changes were evident (data not shown). Model 2B specified an indirect relationship from neighborhood adversity to diabetes prevalence via dietary intake and PA (total METS per week). Results of the multivariable path analysis model are shown in Figure 6. Controlling for age, sex, education, and income, there were significant relationships between neighborhood adversity and dietary intake ($B = 0.04$ $p < 0.01$), and between dietary intake and diabetes ($B = -0.18$, $p < 0.05$). MacKinnon's asymmetric confidence interval indicated that the compound pathway of the indirect effect of dietary intake was significant [MacKinnon's CI: -0.02, -0.001]. Higher neighborhood adversity was associated with less healthy dietary intake (higher dietary intake score), and less healthy dietary intake was inversely associated with diabetes prevalence. The relationships comprising the indirect pathway through PA were not statistically significant.

Model 3A explored the relationship between diabetes knowledge/cultural beliefs and diabetes prevalence. After adjustment for age, sex, income and education, there was no significant relationship between diabetes knowledge/cultural beliefs and odds of having diabetes. A one-point increase in diabetes knowledge/cultural beliefs score was associated with 2% increase in odds of diabetes (OR = 1.02, 95% CI: 0.86, 1.20). Model 3B specified an indirect relationship from diabetes knowledge/cultural beliefs to diabetes prevalence via dietary intake and PA. Results of the multivariable path analysis model are shown in Figure 7. Of the relationships comprising the hypothesized indirect pathway, the relationships of diabetes knowledge/cultural beliefs with dietary intake and PA were not significant. The relationship of dietary intake and diabetes prevalence was significant ($B = -0.16$, $p < 0.05$), as was the relationship between PA and diabetes prevalence ($B = 0.07$, $p < 0.01$). Given non-significance of the link between diabetes knowledge/beliefs and behaviors, the compound pathway of the indirect effect was not significant.

4.4 Exploratory Analyses. Exploratory analyses were conducted to examine possible relationships of psychological and neighborhood adversity and diabetes knowledge/beliefs with glucose regulation across the continuum of normal functioning to glucose dysregulation. Models 1-3 were repeated as linear regressions, first using HbA1c as the continuous dependent variable, and then using a 3-level diabetes status variable (scored 0 = normal glucose regulation, 1 = prediabetes, 2 = diabetes) as the continuous dependent variable. Results for the linear regression analyses are included in Table 3. Similar to the logistic regression models, no linear regression model resulted in a statistically significant main effect.

When path analyses were tested to examine indirect effects of social support, dietary intake, and PA to continuous outcomes of HbA1c and the 3 level diabetes status variable, slightly different results were found. Figures 8-10 display results of these models. When Model 1B was tested with glucose regulation (HbA1c) as the continuous dependent variable, indirect effects were found from depression symptoms and ACEs, through social support, to HbA1c (Figure 8). Lower depression symptoms and ACE scores were associated with higher social support, and higher social support was associated with lower HbA1c percentage. MacKinnon's asymmetric confidence intervals indicated that the compound pathways of both indirect effects were significant (MacKinnon's CI for depression symptoms through social support: [0.003, 0.024]; CI for ACEs through social support: [0.003, 0.045]). When model 1B was repeated with 3-level diabetes status as the continuous dependent variable, indirect effects via social support were not significant (Figure 8).

Model 2B was repeated to explore the indirect effects of dietary intake and PA in the relationship of neighborhood adversity with continuous HbA1c and 3-level diabetes status dependent variables. The indirect pathway from neighborhood adversity to HbA1c via dietary intake was statistically significant (Figure 9), such that higher neighborhood adversity was associated with higher dietary intake scores (less healthy dietary intake), and less healthy dietary intake was associated with lower HbA1c percentage [MacKinnon's CI: -0.009, -0.001].

Finally, Model 3B was repeated to test for indirect effects of dietary intake and PA in the relationship of diabetes knowledge/cultural beliefs with continuous HbA1c and 3-level diabetes status, separately. No indirect effects were evident via dietary intake or PA for either dependent variable.

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CHAPTER 5. DISCUSSION

This cross-sectional study used a socioecological, intervention-mapping approach to examine prevalence and correlates of T2DM in a community-based sample of low-income, medically underserved individuals living along the U.S.-Mexico international border. Given the elevated prevalence of T2DM in the U.S.-Mexico border region (102, 103), identification of recognizable and/or modifiable T2DM correlates in this population is a critical public health goal. Prevention and management of T2DM is particularly challenging among low-income and migrating populations, whose access to health resources and ability to enact challenging lifestyle changes necessary to reduce risk is limited. This is the first study to our knowledge to assess diabetes prevalence and correlates in a community sample with large percentages of deportees (i.e., individuals who report at least one deportation from the U.S.). As over 40% of the 300,000 individuals deported from the U.S. per year are estimated to migrate back into the U.S. (21), cardiometabolic risk of individuals deported to Mexico is of public health relevance in the U.S. as well as Mexico.

5.1 Prevalence of Diabetes, Prediabetes, and Normal Glucose Regulation.

The prevalence of T2DM and prediabetes has risen markedly in both the U.S. and Mexico in recent years. Aim 1 of the study hypothesized that prevalence of diabetes and prediabetes in the study sample would be higher than in recent national estimates in Mexicans in the U.S. and in Mexico, given the additional psychosocial and neighborhood environment risk factors present in low income areas along the international border. The prevalence of diabetes in our participants – 17.3% - was similar to that of recent national samples, and not notably higher as expected. Prevalence of clinically assessed diabetes in Mexicans and Mexican Americans in the HCHS/SOL, the largest community-based sample of Hispanics/Latinos in the United States, was 18.3% (5). Prevalence in the HCHS/SOL varied greatly by age, however, from 6.7% in those aged 30-39 to 48.6% in individuals ≥ 70 across all Hispanic/Latino background groups. Reported prevalence in Mexico varies largely by study location, population, and diabetes assessment (e.g., self-report versus clinical exam). While there is no study of clinically assessed diabetes prevalence across all age groups in Mexico, the Mexican Health and Aging Study reported diabetes prevalence of 39.4% in a nationally representative sample of adults over age 50 (4). Examining only individuals over 50 in our sample, for comparison, diabetes prevalence was 27.4%.

Similarly, prediabetes prevalence of 29.1% in the study population was similar to recent national estimates and estimates reported in a similar border population. Recent studies in Mexico that included objective measures of glucose regulation reported prevalence of prediabetes from 14.6% in 18-30 year olds (94) to 44% in population-based samples of adults age 50 and over (4). Prevalence in a large cohort of Mexican American adults 18 and over (mean age 46.0) residing in a U.S.-Mexico border area of Texas was 31.6% (95). By comparison, prevalence of prediabetes in participants age 30 and under our sample was 12.5%, and in participants aged 50 and older prevalence was 35.7%.

There are several reasons why prevalence of diabetes and prediabetes may have been slightly lower than predicted in our sample, despite the potential for added risk in migrant communities and along the international border. Our sample was overwhelmingly male (> 75%) and relatively young (M = 47.2, SD = 11.9). As is common among migrants, many participants cited occupations involving agriculture or other manual labor. Thus, this sample may more physically active than a non-migrant community sample. Relatedly, given that over 70% of participants migrated from Mexico or other countries to the United States at some point in their lives, the sample may represent a particularly healthy or resilient group. Their slightly lower prevalence of diabetes and prediabetes could partially be due to the "healthy migrant effect" (104), a theorized phenomenon in which healthier and stronger individuals self select into migration experiences, resulting in migrant samples appearing more healthy than their non-migrant counterparts. Some studies have found little support for this hypothesis, however (105). Individuals who migrate internationally due to economic or political urgency or forced migration (e.g., deportation) often experience periodic or chronic poverty and food insufficiency (106, 107). Though both poverty and food insecurity are associated with obesity and diabetes in women in the U.S. and Mexico (108, 109), associations with these conditions in men are less clear. Many individuals in our majority male sample may have experienced poverty and food insecurity that limited calorie intake, while engaging in frequent manual labor, which could create an energy ratio that lowers risk for diabetes.

5.2 Psychological Adversity.

Aim 2A sought to examine the cross-sectional relationship of three indictors of psychological adversity (depression, anxiety, adverse childhood experiences) with diabetes prevalence, adjusting for participant age, sex, income, and education. Contrary to our hypothesis, none of the psychological adversity variables was significantly associated with increased odds of diabetes in our sample. Further, psychological adversity variables were not significantly associated with related dependent variables assessed in exploratory analyses: glucose regulation measured via HbA1c, or a 3-level diabetes status variable (no diabetes, prediabetes, diabetes). Given the quantity of prior evidence linking depression and ACES, in particular, with myriad adverse health outcomes across many populations, these results were surprising. Interestingly, ACES were not related to diabetes prevalence U.S. Hispanic/Latinos in the HCHS/SOL, though

ACE scores were associated with diabetes risk factors – body mass index, smoking, alcohol use – and many other chronic health conditions (110). The relationship of anxiety symptoms and diabetes prevalence in Mexican and Hispanic American individuals has been less conclusively established. One recent cross-sectional study found associations of clinically significant anxiety symptoms with both diabetes prevalence and poorer glycemic control (111) in a community sample of Mexican American individuals living near the U.S.-Mexico border. When anxiety and diabetes incidence were examined prospectively in the MESA cohort, which included a large sample of Hispanic individuals, however, trait anxiety symptoms were not associated with increases in anxiety incidence over 11.4 years (112).

Lack of sufficient power to detect significant relationships is an important consideration, as the analytic sample size is relatively small (N = 205). However, while bivariate correlations between psychological adversity variables and diabetes prevalence, HbA1c, and 3-level diabetes status were generally in the expected direction (positive correlations for all relationships except ACES and HbA1c), correlations were very weak (all ≤ .10) and not statistically significant. This suggests that factors other than the specific psychological adversity variables we measured may be more impactful in determining diabetes prevalence and glucose regulation in our sample. Indeed, the lives and health of individuals in our sample are influenced by layers of disadvantage, including legal and structural adversities (e.g., deportation/forced displacement, housing insecurity/homelessness, severe food insecurity) uncommon in other previously researched populations, including low-income individuals in the United States or Mexico. Given the direct and pervasive influence of experiences such as homelessness and forced migration on health (113, 114), depression and anxiety symptoms and the adverse childhood experiences we measured may play a smaller role in determining health outcomes. Another potential explanation is that high levels of aggregate psychological adversity reported in this sample created range restriction with regards to overall adversity that made it difficult to detect associations with diabetes. Prevalence of clinically significant depression and anxiety symptoms and ACES were high compared in this sample to previous samples of Mexican and Mexican American individuals. The prevalence of clinically significant anxiety symptoms (30.5%) was markedly higher than in a recent large sample of Mexican adults (N = 4796] living on both sides of the U.S.-Mexico border (115). In that study, prevalence in Mexican individuals with history of migration to the U.S. was 13.1%, and prevalence in those without history of migration was 6.7% (115). Similarly, the prevalence of clinically significant depression symptoms observed in our sample (33.2%) was higher than the prevalence observed in individuals of Mexican background in the HCHS/SOL (22.3%) (116), and in a large sample of urban Mexican adults (16%) (117). With regards to ACES, 49% of our sample reported 4 or more adverse childhood events, compared to 29.4% in individuals of Mexican background in the HCHS/SOL (110).

An important consideration with regards to our measurement of ACEs is the validity of the ACE scale in this population. The ACE scale does not capture adverse events specific to migration trajectories, such as traumatic events during the immigration or deportation journey, or traumatic events associated with legal status (e.g., family separation; deportation of a parent or relative) that are associated with poor psychological outcomes among Hispanic/Latinos not born in the U.S. (66, 67). Our results may indicate that history of common potentially traumatic events (e.g., car accidents, death of a loved one), without measurement and inclusion of experiences specific to immigration, may be a less relevant correlate of diabetes in low-income border communities with a high concentration of migrants and deportees (118, 119).

The finding of no significant indirect effect via social support in the relationship between psychological adversity variables and diabetes prevalence - and the subsequent finding of indirect effects in the relationships of depression and ACEs with HbA1c - are not entirely unexpected. Though social support has been shown to relate to improved diabetes self-management behaviors in both Mexican and Hispanic/Latino American individuals with diabetes (34, 120, 121), findings regarding the role of social support in glycemic control have been inconsistent. Greater perceived social support was related to lower odds of diabetes in U.S. Hispanics/Latinos in the HCHS/SOL Sociocultural Ancillary Study (122), however, higher social support was related to poorer glycemic control in individuals with diabetes (123). Though our data are cross-sectional and the sample is limited in its generalizability, our results suggest that social support may be an important factor in the relationship between depression, early life adversity, and glucose regulation prior to the occurrence of clinical diabetes. Future studies are needed which assess these relationships prospectively over time in larger samples of at-risk border residents.

5.3 Neighborhood Adversity.

Contrary to our hypothesis, perceived neighborhood adversity (excessive noise, heavy traffic, lack of access to adequate food and parks/green spaces, litter, sidewalk maintenance, and violence) was unrelated to diabetes prevalence or glycemic regulation in this sample. A growing body of evidence supports the connection between lack of neighborhood resources for healthy lifestyles (e.g., gyms, green spaces, nutritious food) and diabetes and diabetes risk factors (e.g., hypertension, smoking) in Hispanic/Latino American and Mexican individuals (45, 50). A unique feature of our study population, however, is the geographically transient nature of participants' lives. Many participants were born in states other than Baja California and over

70% of the sample reported migrating at least once to the United States in their lives. Though all were currently living in Tijuana, length of time in Tijuana ranged from a few days to over 20 years. Further, many participants were homeless or residing in shelters or other temporary housing at the time of study assessment. Therefore the immediate neighborhood environment reported in the study interview may not have been as impactful on health as with other more stationary populations. Neighborhood conditions can affect health outcomes directly, as with pollution and violence, as well as indirectly through their influences on PA, dietary consumption, and psychological stress. Risks associated with neighborhoods are conferred over time, however, and overall "dose" of risk factors related to length of time spent in the neighborhood with adversity. Our results remained unchanged after accounting for length of residence in Tijuana, but this is a rather crude way of estimating dosage of neighborhood adversity, as we have no way to characterize participants' perceptions of their neighborhoods prior to Tijuana, and thus no true assessment of overall risk. Further, as the majority of our participants resided in the northern urban center of Tijuana, an area that is similar in density, average SES, crime rate, and other neighborhood characteristics compared to more suburban and high-resource sectors of the city, restriction in the range of responses to the neighborhood adversity measure may have caused an attenuation of statistical power.

We further hypothesized that perceived neighborhood adversity would relate to diabetes prevalence indirectly through self-reported PA and dietary intake. Significant indirect effects through dietary intake but not PA were detected. Perceived neighborhood adversity was associated with poorer dietary intake as hypothesized, but poorer dietary intake was inversely associated with diabetes prevalence. As previously mentioned, neighborhood conditions affect diabetes risk through multiple direct and indirect pathways. Our results suggest that among low-income, medically underserved residents of northern Tijuana, perceived neighborhood adversity may relate to and influence dietary consumption. The finding that poorer dietary intake is inversely related to diabetes prevalence may be related to the unique demographic features of the study sample. As many of the younger, healthier individuals in the sample reported recent deportation, these individuals may be more likely to lack housing, transportation, and economic resources to select nutritious dietary options – and still be among the participants with lowest risk for diabetes due to lower age and less sedentary lifestyles. Alternately, it is possible that individuals with previously diagnosed diabetes (60% of diabetes cases identified) changed their dietary intake to be healthier in response to their diagnosis and/or medical recommendations for diabetes management. Unfortunately our sample size does not allow for a powered analysis of differences between those with newly versus previously diagnosed diabetes, but this would be an important goal for a future, larger study.

5.4 Diabetes Knowledge/Cultural Beliefs

Finally, there was no significant relationship between diabetes knowledge/cultural beliefs and odds of diabetes in this sample. Although it is widely recognized that knowledge alone is a important but insufficient component of effective behavior change, diabetes knowledge is significantly related to self-management behaviors and glycemic control among individuals with diabetes (55-57). Few prior studies have examined diabetes knowledge in individuals with no diabetes diagnosis, however, or examined the relationship of diabetes knowledge with diabetes prevalence or risk. Low diabetes knowledge, including suboptimal understanding of predisposing factors, related health behaviors, glucose and insulin function, and consequences of lack of treatment (57-60) has been reported in individuals with diabetes Mexican and Mexican American samples. Similar concerns were present in our sample. The mean diabetes knowledge/cultural beliefs score for the sample was 6.2 (SD = 2.4), indicating less than half of the 13 diabetes knowledge items were correctly identified as true or false. Again, the unique characteristics of our sample may have influenced these results. It's possible that the younger and healthier participants, many of whom have a history of migration to the U.S. as teenagers or young adults, have less diabetes knowledge due to disrupted education and health care, and lack of exposure to older family members with diabetes. However, some items included on our measure of diabetes knowledge/cultural beliefs may not be entirely false, though they are scored as such. The word "susto" (a scare or fright), for example, can be used to describe experiences from a small startle a significant emotional trauma. If interpreted as a significant emotional trauma with associated ongoing stress, it is plausible that such an experience could affect glucose regulation.

The final study aim was to assess indirect relationships from diabetes knowledge/cultural beliefs to diabetes prevalence via dietary intake and PA. While the relationships of dietary intake and PA with diabetes prevalence were significant, relationships of diabetes knowledge/cultural beliefs with dietary intake and PA were not; evidence for indirect effects was not present. Measures of PA and dietary intake may not have been strongly correlated with diabetes knowledge because of the lack of accurate diabetes knowledge was high (average of less than half of knowledge questions answered correctly). Despite accuracy of knowledge/beliefs, knowledge alone is likely not sufficient to change well-ingrained health behaviors such as eating and physical activity, or to overcome the substantive economic and structural limitations of very low-income individuals such as those in our sample.

5.5 Strengths and Limitations.

Strengths of this study include the use of an intervention mapping approach, involving formative qualitative data collection and structured community input to establish locally-relevant aims and methods of the study, and the socioecological perspective, leading to the examination of correlates across multiple levels of influence (e.g., individual, social, neighborhood/community). Further, the study utilized objective, point-of-care serum measurement of hemoglobin A1c by finger stick to assess diabetes status instead of self-report, leading to high accuracy in diabetes prevalence estimation and providing many at-rick participants with a free diabetes diagnosis and connection to care. One of the most unique strengths of the study was the effective recruitment and sampling of a difficult to access, often hidden, medically underserved population. Because very low SES populations like migrants and deportees who lack cell phones, addresses, transportation, or stable housing are rarely recruited and retained in public health research studies, current literature on disease prevalence and specific risk factors in these populations is lacking, and both medical education (e.g., education of future physicians, psychologists, and other healthcare professionals) and patient education from healthcare providers is often ill-fitting and unsustainable for patients' challenging lives.

A primary limitation of this study is the use of a convenience sample. Given this sampling strategy, prevalence estimates and correlates of diabetes and prediabetes are not generalizable to the population of individuals living in Tijuana or along the U.S.-Mexico border. The sampling approach was chosen despite its limitations due to the hidden, difficult-to-reach nature of the target population of this study – low income/low resource, medically underserved migrants and deportees. Preferred population sampling strategies (e.g., systematic and random sampling) were unlikely to secure enrollment of large numbers of individuals in the target population due to unstable/insecure housing, mobility and migration patterns, and low utilization of preventive healthcare and traditional medical clinics (for various reasons including absence of legal documents, lack of access to transportation), and were also practically infeasible. Anecdotal evidence gained from working in close proximity with this population at multiple project sites (the HFiT clinic, mobile medical units in migrant camps) indicated that the location most commonly visited by migrants and deportees experiencing income insecurity was the Padre Chava breakfast kitchen, where the HFiT clinic is located. The availability of free medical services offered by the HFiT clinic, located upstairs from the cafeteria, is announced daily during meals to all Padre Chava patrons, and the clinic is utilized by a large, rotating population of migrants and deportees. Thus, sampling from this location provided unparalleled access to a high volume of the target population. Providing further rationale, characterization of chronic disease risk factors in the population accessing the HFiT medical clinic has significant value for the medical practitioners at this clinic and at similar clinics in the border region attempting to address the complex medical needs of migrant populations. Data generated from the detailed exploration of risk factors in this population will directly inform current medical practice and future intervention strategies for migrant-serving border health clinics.

Another limitation of this study is the cross-sectional design, which limits any conclusions of causality or directionality of influence among the correlates and dependent variables of interest. The use of self-report measures of health behaviors (dietary intake, physical activity) is a methodological limitation, as measurement error may occur through under- or over-reporting of these behaviors due to social desirability or high memory demand. While self-report measures are known to correlate poorly with direct or objective measures such as accelerometer data for physical activity (124), we have utilized measures (e.g., the GPAQ) that exhibit at least moderate agreement with objective measurement (88). Direct measurement of physical activity and dietary intake was not possible in this study due to a number of feasibility limitations, including high mobility/residential instability (limiting ability to follow participants over time), low prevalence of cell phone ownership, and risk of harm to participants carrying visible tools or devices due to insecurity (e.g., robbery, theft). Similarly, only subjective assessments of neighborhood environment were included due to concerns of safety and feasibility in objective measurement of participants' neighborhoods.

The assessment of diabetes correlates in this study was neither comprehensive nor exhaustive. Risk and protective variables were selected based on demonstrated correlations with diabetes in previous research, because of their relevance to the target population (urban, low income, high concentration of migrants and deportees), and because they were identified by community members in the formative research stage as factors possibly related to diabetes in this community. Finally, HbA1c point-of-care immunoassay via finger-stick was the most feasible diagnostic tool for diabetes in this community setting, however, a preferable approach would be conducting multiple types of glucose testing (i.e., 2-hour oral glucose tolerance test in addition to HbA1c), as there may be potential for misclassification of type 2 diabetes when HbA1c alone is utilized.

5.6 Conclusions

In summary, this study utilized a community-engaged, intervention mapping approach to examine prevalence and socioecological correlates of diabetes in a low-income, medically underserved sample of at-risk individuals living along the U.S.-Mexico border. Results revealed a substantial burden of physical (diabetes and prediabetes) and psychological (depression, anxiety, ACEs) risk in this sample, suggesting the need for integrated approaches to physical and mental health in future prevention and intervention programs. Prevalence of diabetes was 17.3%, similar to recent national samples of Mexican and Mexican American individuals in the U.S. and Mexico. Psychological and neighborhood adversity variables that have been associated with diabetes prevalence in many prior studies were not significantly associated with diabetes in this sample. Diabetes knowledge and cultural beliefs were likewise not associated with diabetes prevalence. In exploratory analyses, none of these variables were significantly associated with continuous glycemic control (HbA1c) or a continuously analyzed 3-level diabetes variable (no diabetes, prediabetes, diabetes). Though the study was powered by sample size to detect statistically significant associations, range restriction in responses (e.g., high overall burden of adversity) may have attenuated power. The hypothesized correlates of diabetes may not be the most impactful determinants of health in this sample due to the substantive socioeconomic disadvantage related to poverty, housing and food insecurity, and forced deportation.

Potential indirect effects through social support, dietary intake, and physical activity were examined. Depression symptoms and ACE scores were related to HbA1c indirectly through social support, indicating that social support may play an important role in the relationship of psychological adversity and glucose regulation, potentially even prior to a diabetes diagnosis. Neighborhood adversity was related to both diabetes prevalence and HbA1c indirectly through dietary intake, but in an unexpected direction. No indirect effects through physical activity were detected.

Results of this study contribute to the small body of literature examining psychosocial, behavioral, and environmental correlates of diabetes prevalence in understudied, high-risk, individuals such as migrants and deportees who have historically been poorly incorporated into formal public health research. Future studies should examine a wider range of potential determinants of diabetes in similar low-resource samples, with particular attention to constructs not analyzed in this sample that may be more impactful for health such as housing insecurity, food insecurity, and early life adversity related to migration experiences. Studies are also needed which examine relationships between psychological and neighborhood adversity and diabetes status longitudinally over time.

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Table 1. Descriptive statistics for sample (N = 220)

	N	% (95% CI)
Female	56	25.5 (19.6, 31.3)
Male	164	74.5 (68.7, 80.4)
Marital Status		
Married/partnered	47	21.4 (15.9, 26.8)
Separated/divorced/widowed	43	19.5 (14.3, 24.8)
Single	116	52.7 (46.1, 59.4)
Nationality	207	
Mexico	196	89.1 (84.9, 93.2)
United States	4	1.8 (0.0, 3.6)
Other (all Central America)	7	3.2 (0.8, 5.5)
Education Completed		
Elementary/Grades 1-6 or less	68	30.9 (24.8, 37.1)
Middle/Grades 7-9	69	31.4 (25.2, 37.5)
High school/Grades 10-12	48	21.8 (16.3, 27.3)
More than high school	18	8.2 (4.5, 11.8)
Health Insurance Coverage	88	40.0 (33.5, 46.5)
History of migration to U.S.	156	70.9 (64.9, 80.0)
History of ≥ 1 deportation from U.S.	129	58.6 (52.1, 65.2)
Diabetes Status		
Normal glucose regulation	118	53.6 (47.0, 60.3)
Prediabetes	64	29.1 (23.0, 35.1)
Diabetes diagnosis[1]	38	17.3 (12.3, 22.3)
High depression symptoms (PHQ-8 ≥ 10)	73	33.2 (26.9, 39.5)

Table 1. Descriptive statistics for sample (N = 220), continued	N	% (95% CI)
High anxiety symptoms (GAD-7 ≥ 10)	67	30.5 (24.3, 36.6)
	N	M (SD)
Age (range 19 – 83)	207	47.2 (11.9)
Individual monthly income (in U.S. dollars)	200	114.5 (164.9)
Hemoglobin A1c (HbA1c) %	220	6.1 (1.8)
Depression symptoms (PHQ-8; range 0 - 24)	198	7.9 (6.0)
Anxiety symptoms (GAD-7; range 0 - 21)	201	7.2 (6.2)
Adverse childhood experiences (ACES; range 0 - 10)	202	3.7 (2.9)
Neighborhood adversity (range 30 – 150)	186	86.6 (20.7)
Diabetes knowledge/cultural beliefs (range 0 – 13)	197	6.2 (2.4)
Perceived social support (ISEL-12; range 0 - 36)	199	19.6 (5.9)
Dietary Intake/Food Frequency (range 0 – 16)	187	8.9 (2.9)
Physical Activity (METS per week; GPAQ-2)	206	239.6 (221.8)

Table Notes: [1]HbA1c ≥ 6.5% and/or by self-report of diabetes diagnosis from a physician or prescribed glucose-lowering medication; ACES = Adverse Childhood Exposures Scale; GAD-7 = Generalized Anxiety Disorders – 7 item checklist (scores ≥10 = clinically significant anxiety symptoms); GPAQ-2 = Global Physical Activity Questionnaire, version 2; ISEL-12 = Interpersonal Support Evaluation List – 12 item scale; PHQ-8 = Patient Health Questionnaire, Depression - 8 item version (scores ≥10 = clinically significant depression symptoms); SD = standard deviation; 95% CI = 95% confidence interval.

Table 2. Bivariate correlations of adversity variables and proposed mediators with diabetes status, prediabetes status, and HbA1c percentage.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Depression Symptoms (PHQ-8)	-									
2. Anxiety Symptoms (GAD-7)	.73**	-								
3. Adverse Childhood Events (ACEs)	.37**	.29**	-							
4. Neighborhood Adversity	.17*	.14	.28**	-						
5. Diabetes Knowledge/Beliefs	-.10	-.05	-.16*	.02	-					
6. Hemoglobin A1c %	.07	.10	-.02	-.09	-.09	-				
7. Diabetes Prevalence[1]	.04	.08	.04	.01	-.04	-	-			
8. Social Support	-.40**	-.29**	-.27**	-.23**	.07	-.07	.05	-		
9. Dietary Intake[2]	.27**	.30**	.17*	.28**	.01	.00	-.19*	-.12	-	
10. Physical Activity (Total METS per week)	-.01	-.06	.04	.00	-.12	-.07	-.13	.03	-.01	-

Table Notes: [1]Hemoglobin A1c ≥ 6.5% and/or by self-report of diabetes diagnosis from a physician or prescribed glucose-lowering medication; [2] Higher scores indicate poorer/worse diet quality; ACEs = Adverse Childhood Exposures scale; GAD-7 = Generalized Anxiety Disorders – 7 item checklist; PHQ-8 = Patient Health Questionnaire; p <.05. ** p < .01.

Table 3. Multivariable logistic and linear regression analyses of the relationship of psychological and neighborhood adversity and diabetes knowledge/beliefs with diabetes prevalence, HbA1c, and the 3-level[1] diabetes status variable.

	Diabetes		HbA1c		3-level diabetes	
	OR	95% CI	*B*	95% CI	*B*	95% CI
Model 1A[2]						
Depression symptoms (PHQ-8)	0.97	0.88, 1.06	0.00	-0.06, 0.06	-0.01	-0.04, 0.01
Anxiety symptoms (GAD-7)	1.03	0.95, 1.13	0.03	-0.02, 0.08	0.02	-0.01, 0.04
Adverse childhood experiences (ACES)	1.02	0.84, 1.23	-0.01	-0.14, 0.11	0.02	-0.03, 0.06
Model 2A						
Neighborhood adversity	1.00	0.98, 1.02	-0.00	-0.02, 0.01	0.00	-0.00, 0.00
Model 3A						
Diabetes knowledge & cultural beliefs	1.02	0.86, 1.20	-0.04	-0.14, 0.07	0.02	-0.02, 0.06

Table Notes: [1] 3-level diabetes variable (no diabetes, prediabetes, diabetes) treated continuously. [2]No diabetes was reference category; diabetes defined by HbA1c ≥ 6.5% and/or by self-report of diabetes diagnosis from a physician, and/or prescribed glucose-lowering medication. Covariates for all models = age, sex, income, education (3-level variable categorized as < high school diploma/General Education Development test (GED), high school diploma/GED, or > high school diploma/GED); ACES, Adverse Childhood Exposures Scale; GAD-7, General Anxiety Disorder 7-item scale; PHQ-8, Patient Health Questionnaire, 8-item version.

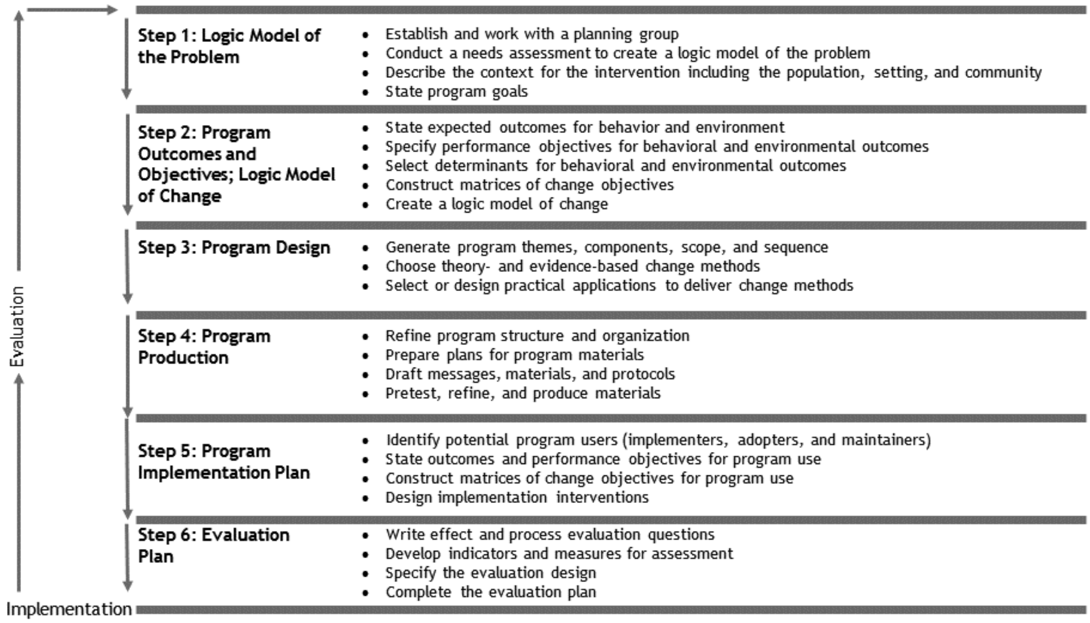

Figure 1. Intervention Mapping Steps and Tasks.

Figure 2. Dahlgren & Whitehead (1991) Socioecological model of health.

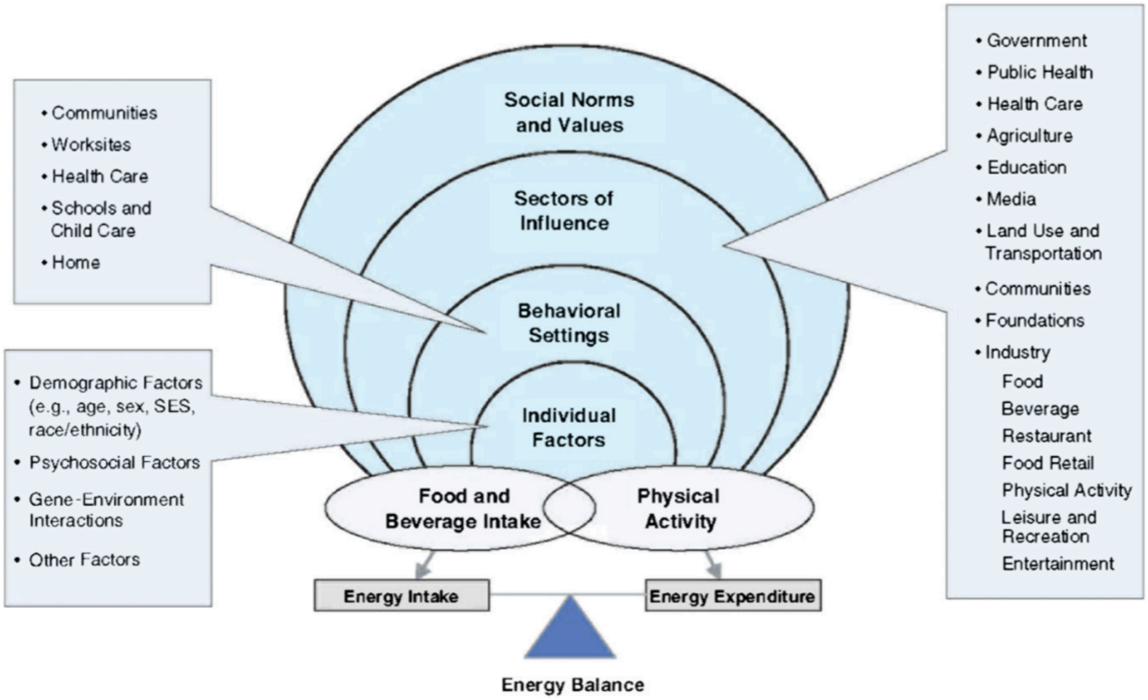

Figure 3. Hill et al. (2013) Socioecological determinants of prediabetes and type 2 diabetes.

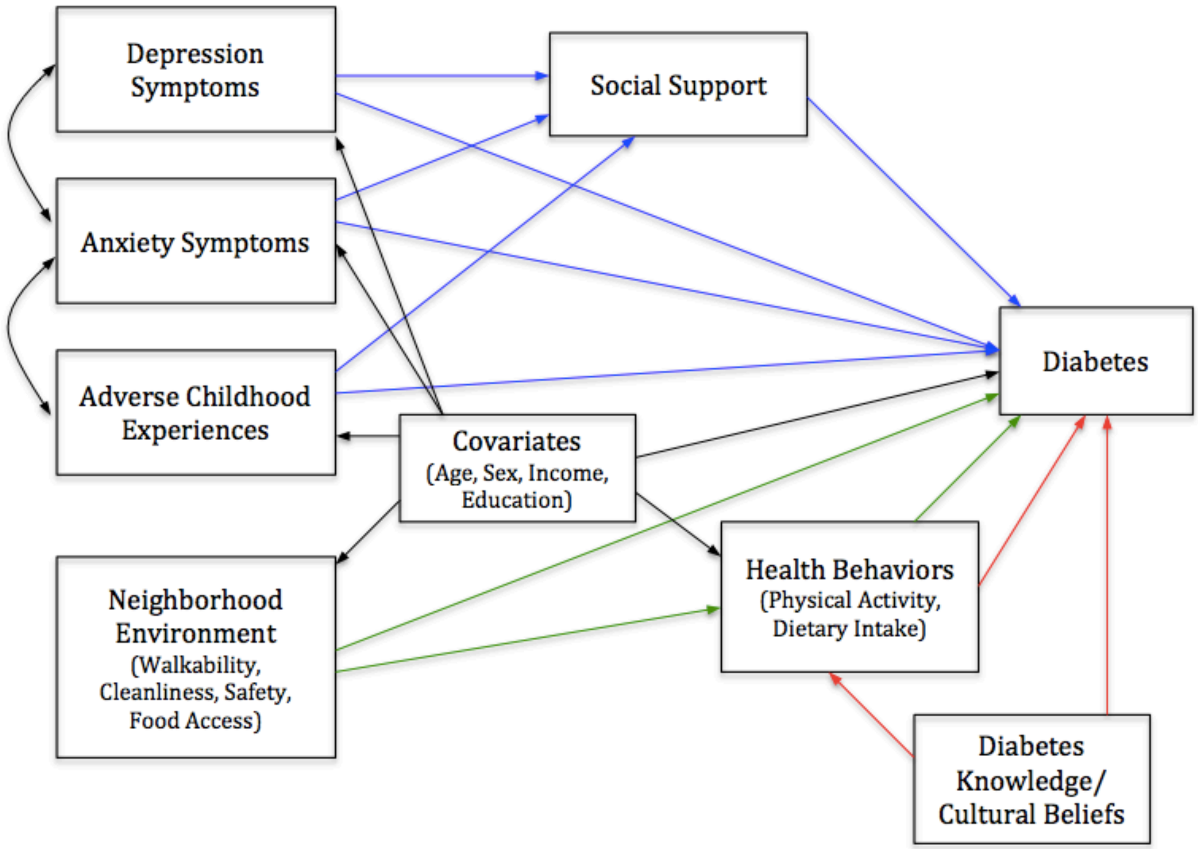

Figure 4. Conceptual model for proposed study aims. Blue arrows represent Aim 2, which will test the relationship of psychological adversity indicators (depression symptoms, anxiety symptoms, childhood adverse childhood experiences) with diabetes prevalence and the indirect role of social support in these relationships. Green arrows represent Aim 3, which will examine the relationship of neighborhood environment with diabetes prevalence and the indirect role of health behaviors in this relationship. Red arrows correspond to Aim 4, which will explore the relationship of diabetes knowledge/cultural beliefs with diabetes prevalence, and the indirect role of health behaviors. *Note:* This model displays variables and pathways to be examined in the proposed study and is not meant to be exhaustive.

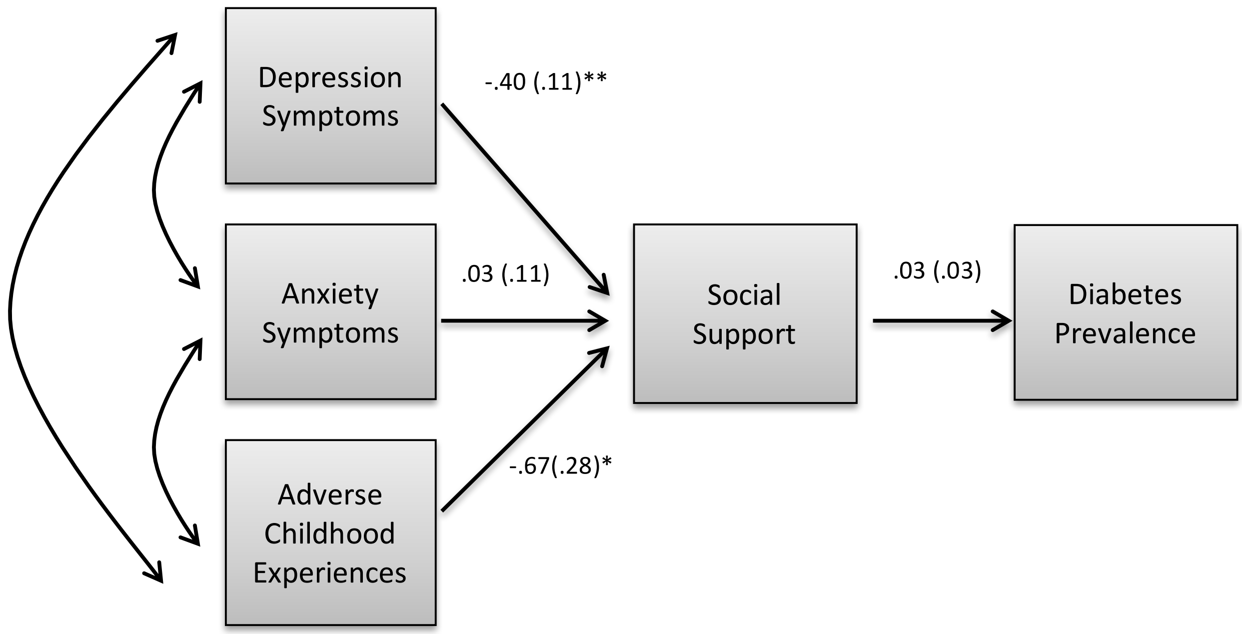

Figure 5. Results of path analysis (N = 205) examining indirect effect of social support in the relationship between psychological adversity variables and diabetes prevalence adjusting for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *$p < .05$; **$p < .01$.

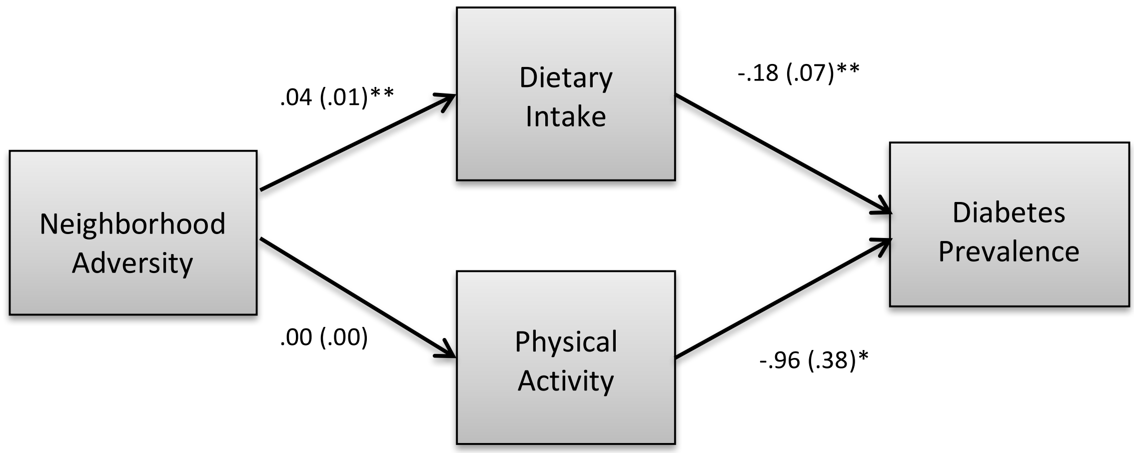

Figure 6. Results of path analysis (N=205) examining indirect effects of dietary intake and physical activity in the relationship between neighborhood adversity and diabetes prevalence adjusting for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *p-value < 0.05, **p-value < 0.01.

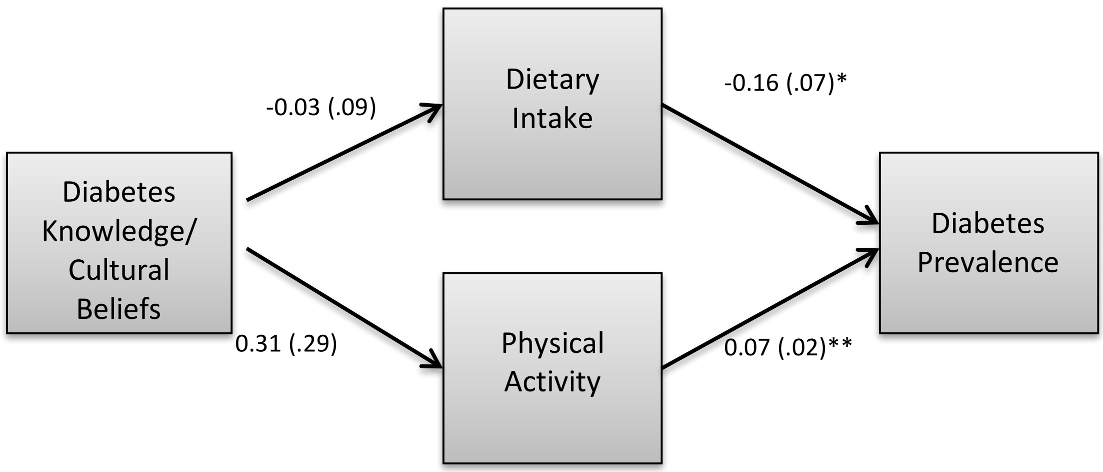

Figure 7. Results of path analysis (N=205) examining indirect effects of dietary intake and physical activity in the relationship between diabetes knowledge/cultural beliefs and diabetes prevalence adjusting for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *p-value < 0.05, **p-value < 0.01.

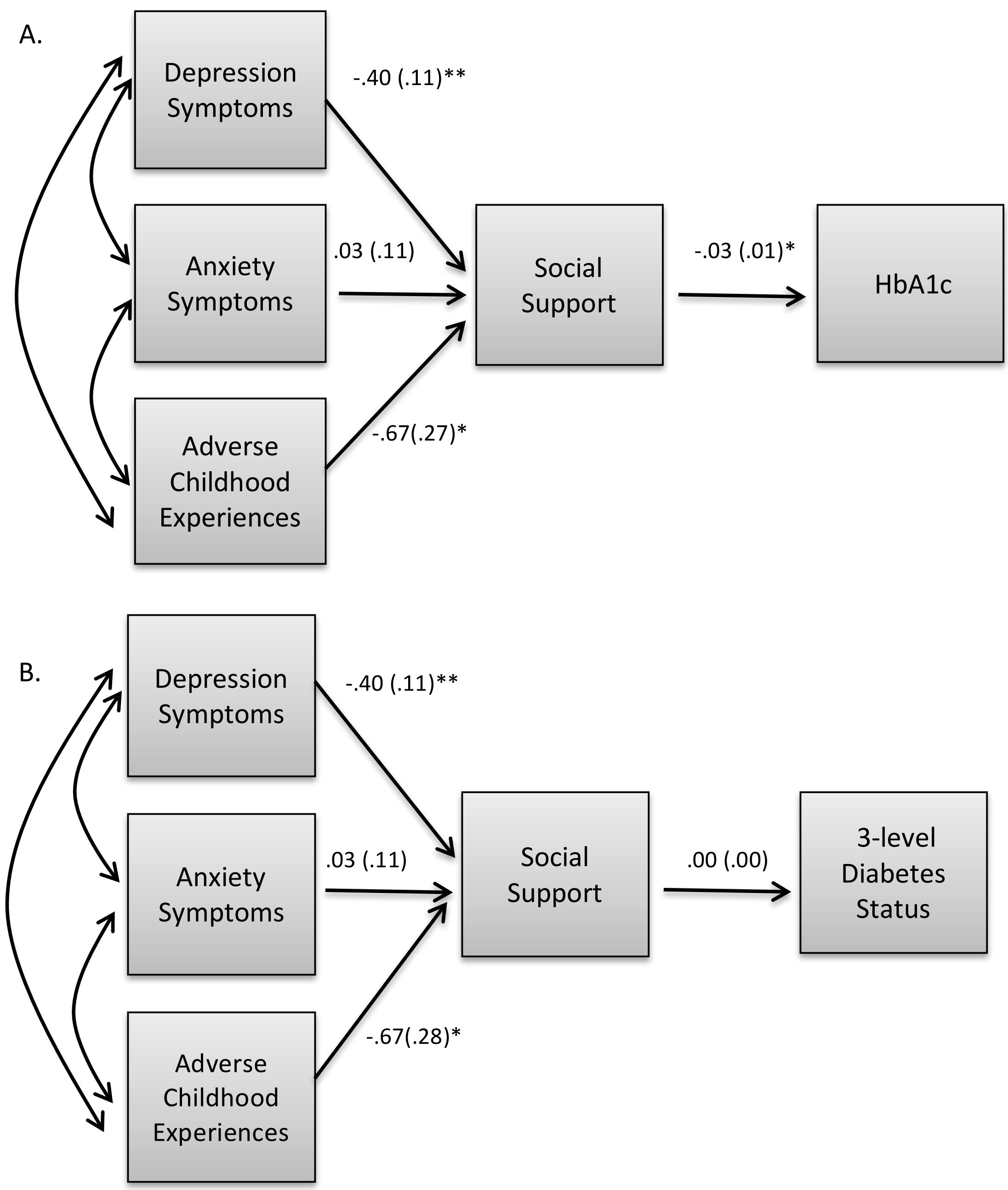

Figure 8. Results of path analysis (N=205) examining indirect effect of social support in the relationship between psychological adversity variables and continuous dependent variables: A) glucose regulation measured by HbA1c, and B) 3-level diabetes status variable examined continuously. Both models adjusted for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *p < .05; **p < .01

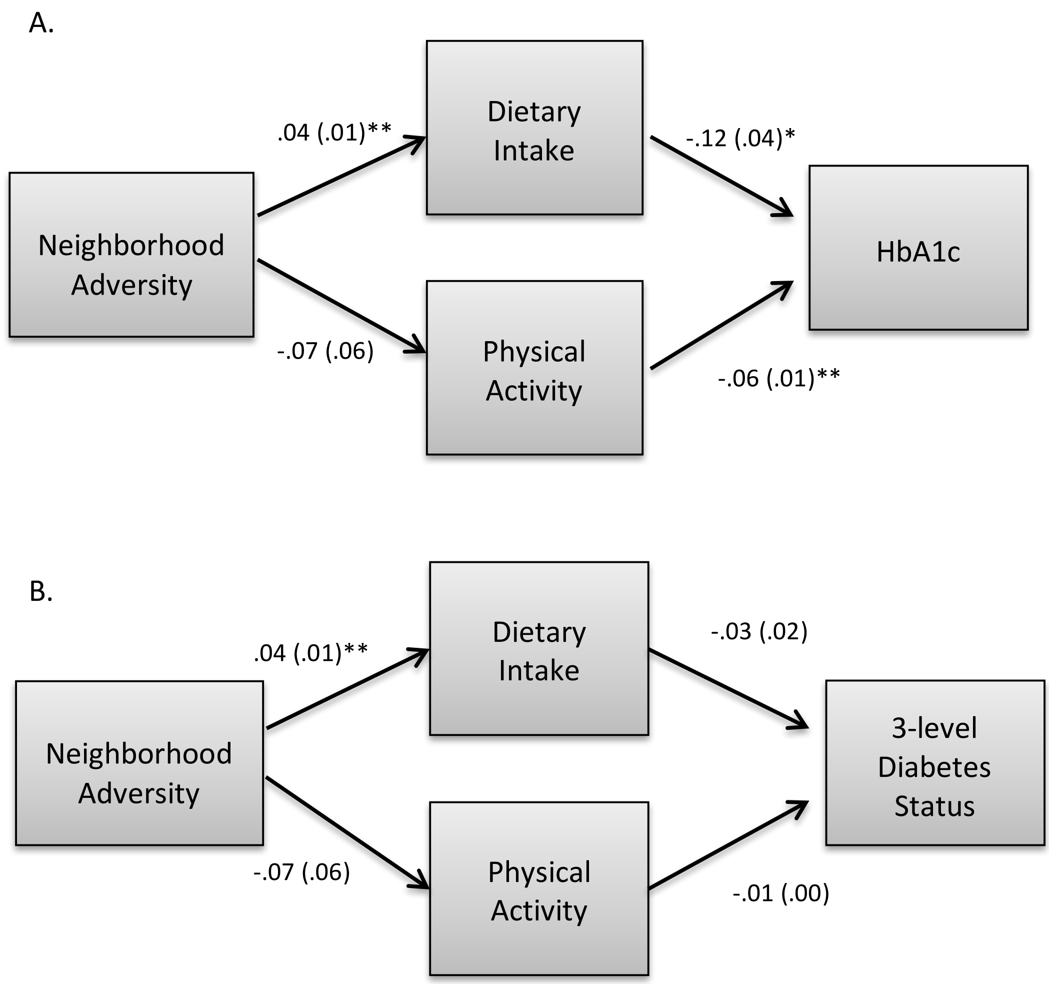

Figure 9. Results of path analysis (N=205) examining indirect effects of dietary intake and physical activity in the relationship between neighborhood adversity and two continuous dependent variables: A) glucose regulation measured by HbA1c, and B) 3-level diabetes status variable examined continuously. Both models adjusted for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *p < .05; **p < .01

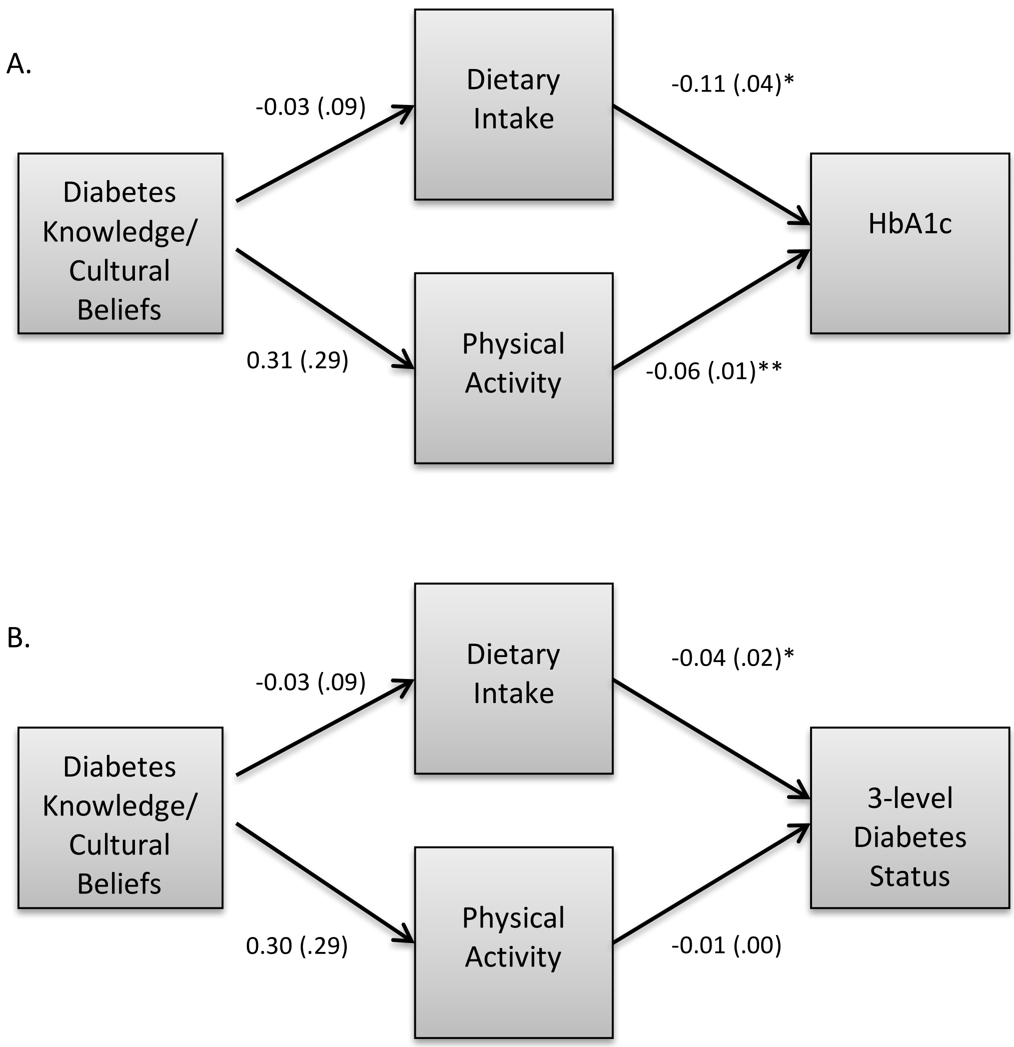

Figure 10. Results of path analysis (N=205) examining indirect effects of dietary intake and physical activity in the relationship between diabetes knowledge/cultural beliefs and two continuous dependent variables: A) glucose regulation measured by HbA1c, and B) 3-level diabetes status variable examined continuously. Both models adjusted for demographic covariates (age, sex, income, education). Structural path coefficients are shown with standard errors in parentheses. *p < .05; **p < .01