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TITLE: The Influence of Indigenous Status and Community Indigenous Composition on Obesity and Diabetes among Mexican Adults

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ABSTRACT

In many high-income countries, indigenous populations bear a higher burden of obesity and diabetes than non-indigenous populations. Less is known about these patterns in lower- and middle-income countries. We assessed the hypothesis that obesity and diabetes were less prevalent among indigenous than non-indigenous adults in Mexico, home to the largest indigenous population in Latin America, and investigated explanations for differences. In a related line of inquiry, we examined whether adults in communities with higher versus lower percentages of indigenous residents were buffered against these conditions. We assessed whether differences were partially explained by lower development in higher-indigenous communities.

The analysis included 19577 adults aged 20 and older from the Mexican Family Life Survey (2002), a nationally representative survey of Mexican households and communities. We used multilevel logistic regression to estimate the odds of obesity and diabetes by indigenous status and community percent indigenous.

Results suggest that indigenous adults had significantly lower odds of obesity and diabetes than non-indigenous adults. This advantage was not explained by the lower socioeconomic status of indigenous individuals, but may be related to indigenous cultural resources, in that the advantage was stronger for older adults and in rural areas. A higher percentage of indigenous individuals in communities provided protection against both health conditions for all residents. These differences were not accounted for by variation in community development by community percent indigenous.

Findings suggest that an opportunity may exist to prevent disparities in obesity and diabetes from developing by indigenous characteristics in Mexico. Identifying the sources of

protective effects of individual and community indigenous characteristics relative to these health conditions should be a priority, given global implications for prevention.

INTRODUCTION

In many high-income countries, indigenous populations bear a higher burden of obesity and diabetes than non-indigenous populations (Yu & Zinman, 2007). These disparities, along with rapidly changing nutritional environments and patterns of physical activity worldwide, have raised concerns about prevalence of these conditions among indigenous groups in lower- and middle-income countries (Gracey & King, 2009; Yu & Zinman, 2007). Few large-scale studies have focused on the risk of obesity and diabetes by indigenous status in these settings, particularly in countries where these conditions are becoming major public health issues. Insight into these patterns as well as sources of differences between groups may inform strategies for obesity and diabetes prevention in both indigenous and non-indigenous populations in lower- and middle-income countries.

We examine variation in obesity and diabetes by indigenous status in Mexico, as well as socioeconomic and cultural explanations for group differences. Mexico is an important case for investigation. A middle income country, Mexico is home to the largest indigenous population in Latin America, estimated at 10% to 13% of the population (approximately 10 to 13 million) (Bando & López-Calva, 2006; Navarrete Linares, 2008). Mexico's indigenous population is also one of the region's most diverse, with 62 languages spoken (Navarrete Linares, 2008). Obesity and diabetes have reached alarming levels in the general population, attributed in part to economic development and impacts on nutrition and energy expenditure (Rivera, Barquera, Campirano, Campos, Safdie, & Tovar, 2002). Approximately 29.9% of Mexican adults are obese and 7.5% have diabetes (Barquera, Campos-Nonato, Hernandez-Barrera, Flores, Durazo-Arvizu, Kanter, et al., 2009; Olaiz-Fernández, Rojas, Aguilar-Salinas, Rauda, & Villalpando, 2007).

Indigenous status, obesity, and diabetes in Mexico

There is reason to expect that indigenous status offers some protection against obesity and diabetes in Mexico. Small area studies have found lower prevalence in some indigenous groups relative to national studies of the general population, ranging from 7% to 20% for obesity and from no cases to 6.9% for diabetes (Guerrero-Romero, Rodriguez-Moran, & Sandoval-Herrera, 1997; Rodriguez-Moran, Guerrero-Romero, Brito-Zurita, Rascon-Pacheco, Perez-Fuentes, Sanchez-Guillen, et al., 2008; Schulz, Bennett, Ravussin, Kidd, Kidd, Esparza, et al., 2006; Valencia, Bennett, Ravussin, Esparza, Fox, & Schulz, 1999). In addition, fruit and vegetable intake, which reduces obesity and diabetes risk, is higher among indigenous adults (Ramírez-Silva, Rivera, Ponce, & Hernández-Ávila, 2009). Obesity prevalence is lower in states with large indigenous populations and overweight is less common among indigenous children (Barquera, et al., 2009; Morales-Ruán, Hernández-Prado, Gómez-Acosta, Shamah-Levy, & Cuevas-Nasu, 2009).

Moreover, living standards of indigenous households are low relative to non-indigenous households, due to a long history of political and social marginalization (Bando & López-Calva, 2006; Navarrete Linares, 2008; Yashar, 1998). Unlike in high-income countries, socioeconomic disadvantage in Mexico may deter adoption of unhealthy lifestyles, due to lower affordability of energy-dense foods and less access to sedentary employment and pastimes (Buttenheim, Wong, Goldman, & Pebley, 2010; Fernald & Adler, 2008; McLaren, 2007; Smith & Goldman, 2007). Social and material deprivation may thus provide a buffer against obesity and diabetes for indigenous relative to non-indigenous adults.

Indigenous cultural resources may also provide some defense against these conditions. These resources may support consumption of diets traditional to the region, which are higher in complex carbohydrates, fiber, and vegetable proteins and lower in fats (Boyce & Swinburn, 1993; D. Williams, Knowler, Smith, Hanson, Roumain, Saremi, et al., 2001). Struggles for political autonomy among indigenous groups in Mexico in the 1990s were in part an attempt to preserve indigenous culture through, for example, promotion of rights to maintain indigenous languages and official recognition of indigenous skills (Hall & Patrinos, 2005; Minority Rights Group International, 2008). Qualitative research has highlighted adaptations to maintain identity and cohesion as Latin American indigenous populations negotiate multicultural contexts, as well as historical continuity of indigenous languages (Armstrong-Fumero, 2009; Delugan, 2010; Slaney, 1997). If cultural resources contribute to lower obesity and diabetes risk in indigenous adults, these resources may be more intact in older populations and among those living in rural areas, given lower exposure to acculturation pressures (Popkin, 1999; Rodriguez-Moran, et al., 2008).

Community indigenous composition and obesity and diabetes in Mexico

In addition to indigenous status, we examine differences in obesity and diabetes prevalence by community indigenous composition, as well as related mechanisms. A large literature has investigated community-level influences on unhealthy weight and lifestyle-related conditions in lower- and middle-income countries, such as community size or geographic region (Barquera, et al., 2009; Monteiro, Conde, & Popkin, 2001; Olaiz-Fernández, et al., 2007; Popkin, 1999). To our knowledge, there has been no examination of the association between community indigenous makeup and obesity and diabetes in lower- and middle-income countries, despite extensive research on area minority composition and health in high-income countries (Chang, Hillier, & Mehta, 2009; Eschbach, Ostir, Patel, Markides, & Goodwin, 2004; Odoms-Young, Zenk, & Mason, 2009). An understanding of these patterns may offer points of intervention at the community level for obesity and diabetes prevention.

In Mexico, development has not been experienced equally in communities with larger versus smaller indigenous populations (Hall & Patrinos, 2005; Stephen, 1997). Indigenous communities tend to be located in rural, isolated areas characterized by low development (Hall & Patrinos, 2005). Organized political action by indigenous groups in the 1990s attempted to call attention to the deplorable living conditions in these communities and the ineffectiveness of trade liberalizations to address these disparities (Hall & Patrinos, 2005). Political and social disempowerment of indigenous groups may have contributed to fewer resources dedicated to development in communities with a higher share of indigenous households (Sieder, 2002).

While heightening risk of many health conditions, lower development in communities with larger indigenous populations may constrain environmental changes linked to poorer nutrition and sedentariness. In more developed communities in Mexico, food retail is dominated by supermarkets, discounters, and convenience stores, which make available a wide range of processed foods at lower prices (Hawkes, 2005, 2006). Limited transportation infrastructure in less developed communities may require more energy expenditure in daily routines and present barriers to distribution of goods and services linked to unhealthy lifestyles (Briceño-Garmendia, Estache, & Shafik, 2004; Robert, 1999).

In addition to development-related mechanisms, cultural resources in communities with higher proportions of indigenous residents may buffer all residents against obesity and diabetes. Such communities may foster shared norms and values and maintain and disseminate knowledge supporting maintenance of traditional lifestyles, including dietary and physical activity patterns (Bermudez, et al., 2008; Wahlqvist & Lee, 2007; Wutich & McCarty, 2008).

Current study

We extend the research on indigenous characteristics and health by examining hypotheses at the individual and community levels, using a nationally representative dataset of Mexican households and communities. We expected to find lower prevalence of obesity and diabetes among indigenous than non-indigenous adults. We determine whether differences were partly explained by greater socioeconomic disadvantage among indigenous adults. We also assessed whether cultural resources contribute to group differences, by examining whether any indigenous advantage was stronger in older versus younger adults and in rural versus urban areas. At the community level, we hypothesized that a higher proportion of indigenous individuals in communities is associated with lower obesity and diabetes risk for all residents and examined whether differences were due in part to lower levels of development in such communities. We assessed whether these associations were modified by indigenous status, under the assumption that shared cultural resources in higher-indigenous communities would disproportionately benefit indigenous adults due to greater contact with indigenous networks. Analyses of the cultural hypothesis at the individual and community levels were exploratory, given that available data did not support ruling out alternative mechanisms.

METHODS

Data source

Data come from the first wave (2002) of the Mexican Family Life Survey, a longitudinal study of Mexican households and communities. The survey is ideal for the present examination, in that it oversampled rural communities in which indigenous populations are more likely to live and is representative at the regional level, including the south, where most indigenous communities are located. It contains extensive data on socioeconomic status (SES), enabling a more rigorous test of explanatory mechanisms linked to socioeconomic determinants than is possible with other nationally-representative datasets.

The MxFLS employed a stratified, multistage sampling design. Households were sampled within *localidades*, a sampling unit employed in the Mexican census, which ranged in size from rural areas to cities (Rubalcava & Teruel, 2007). For the purposes of this analysis, communities were defined as *localidades.*

Detailed interviews concerning sociodemographic and other health-related characteristics were attempted with all household members aged 15 years or older or with a proxy. An informed individual provided demographic data for each household member as well as information on household expenditures. All household members were also asked to participate in a health assessment. In addition, the survey collected data on community characteristics from community leaders. The overall response rate was 97% of eligible households (Bianchi, Evans, Hotz, McGarry, & Seltzer, 2007). The response rate for household-level modules was 95%; 91% of individuals responded to the individual interview modules utilized in this analysis (including 8% proxy responses) and participated in anthropometric measurement (Rubalcava & Teruel, 2007).

The analytic sample included 19577 adults in 8379 households and 150 communities. Of 21448 sampled adults, we excluded 1414 individuals younger than 20 years of age; 352 pregnant or breastfeeding women; 99 individuals not residing in the surveyed household; and 6 adults with missing community identifiers.

Variable definition

Outcomes

Obesity was defined as a body mass index (BMI) of 30.0 kg/m^2 or higher, based on measured height and weight. We selected obesity as the focal measure of unhealthy weight, given that BMI-based measures are widely tracked relative to the obesity epidemic worldwide (Nishida & Mucavele, 2005). However, because waist circumference may be more predictive of diabetes in Mexican-origin individuals, we conducted a sensitivity analysis using this measure (Janssen, Katzmarzyk, & Ross, 2002; Wei, Gaskill, Haffner, & Stern, 1997). A high-risk circumference was defined as >102 cm for men and >88 cm for women.

Diabetes was based on self-reports of diagnosis by a health professional, a commonly used operationalization of diabetes (Borrell, 2005; Oza-Frank & Narayan, 2010; Pabon-Nau, Cohen, Meigs, & Grant, 2010). Although this variable did not distinguish between type 1 and type 2 diabetes, most reporting a diagnosis likely had type 2 (Palloni & McEniry, 2007). Self-reported diabetes is dependent on access to a clinician for diagnosis and so likely underestimates true diabetes prevalence. Research from a national study of Mexican adults suggests that self-reports yield a reasonably accurate measure of diabetes (sensitivity of 80%) (Aguilar-Salinas, Monroy, Gomez-Perez, Chavez, Esqueda, Cuevas, et al., 2003). This level of sensitivity compares favorably to that found in higher-income countries (Goldman, Lin, Weinstein, & Lin, 2003; Gregg, Cadwell, Cheng, Cowie, Williams, Geiss, et al., 2004). Given dependence of diabetes diagnosis on clinician access, we included healthcare variables in models for diabetes. We also conducted a sensitivity analysis restricted to insured adults.

Indigenous status

The term “indigenous” is highly contested; it generally incorporates concepts related to ancestral occupation of land, separation from colonizing peoples, language, culture, self-identification, and group recognition (Nettleton, Napolitano, & Stephens, 2007). In Mexico, official estimates have until recently been based on language, which has been argued to underestimate population size (Navarrete Linares, 2008). In response to pressure from indigenous peoples’ organizations, the government included a question on self-identification in the 2000 Census, which identified a significant indigenous population who do not speak an indigenous language (Minority Rights Group International, 2008; Navarrete Linares, 2008). Given this change, we used a definition based on self-identification, in response to the question, "Do you recognize yourself as part of an indigenous ethnic group?" Because this question was not asked of proxy respondents, indigenous status was based on ability to speak an indigenous language for individuals for whom proxy responses were used (8% of the sample). As a conservative test of the indigenous status hypotheses, we conducted a sensitivity analysis using the language-based definition (defining those who self-identified as indigenous, but did not speak an indigenous language, as non-indigenous). Fewer individuals were classified as indigenous based on language ability than group identification (9% versus 12%, respectively).

Individual-level mediators

Mediation by SES was assessed via household economic status, occupational status (agricultural, manual, and non-manual), and education (in categories, based on years of completed schooling). We derived the variable for household economic status from a series of questions about household expenditure or consumption of food and non-food goods and services, including purchases, household production or acquisition, and the opportunity cost of household assets (Deaton & Zaidi, 2002). Research has suggested that consumption expenditure is a superior measure of resources relative to income in developing countries (Deaton & Zaidi, 2002). Household food expenditure may be one pathway to differential obesity and diabetes risk by indigenous status, through lower caloric access in indigenous households. Differential access to non-food goods that reduce energy expenditure, like motorized transportation, may be another. The variable was annualized and adjusted for household size and was modeled in quartiles.

We also assessed any further mediation by lifestyle indicators, to assess more proximal pathways from indigenous status to obesity and diabetes, whether through socioeconomic or cultural characteristics. Measures included hours per week spent in physically-active leisure-time and domestic activities (e.g., collecting water or firewood) and smoking status (current versus never/former smoker). As a proxy for access to a higher-calorie diet, we defined a binary variable for living in a household in the highest quintile of expenditure on energy-dense foods (meats, soft drinks, processed foods, etc.), controlling for non-food consumption expenditure (in quartiles). Models for diabetes included obesity.

In models for diabetes, we adjusted for health insurance (insured from any source versus uninsured) and for household expenditure on healthcare in the three months preceding the survey (in 1000s of pesos), as a proxy for healthcare utilization. We also included a variable for household participation in *Progresa* (now called *Oportunidades*), a poverty alleviation program which increases access to preventive healthcare (Bando & López-Calva, 2006). Inclusion of these variables, which depend on income and are associated with indigenous status, may mask mediating effects of SES. Because preliminary analysis suggested that this was not the case, we included healthcare variables in models to address any residual confounding. As stated earlier, we also conducted a sensitivity analysis limited to adults with health insurance.

Additional covariates included sex, age, age^2, marital status (married/in a consensual union versus divorced, separated, widowed, or never married), and household size (logged).

Community-level variables

Community percent indigenous was based on an aggregate of indigenous status, defined continuously (per 10%). Such aggregates have been found to perform well relative to census data in studies in lower- and middle-income countries (Yabroff & Gordis, 2003). Indicators of community development included measures for infrastructure and community SES. Infrastructure measures included binary variables for paved (versus unpaved) roads throughout most of the community and presence versus absence of public transportation, as well as percent household ownership of motorized vehicles (per 10%). Community SES was operationalized by median household consumption expenditure (in 1000s of pesos), an aggregate of the household-level variable. Higher household economic status in communities may signal an attractive market for industrialized food products and labor-saving devices (Hawkes, 2006). Covariates included community size (<2500, 2500 to 100000, or 100000 or more residents), region (south, central, or north), and, in models for diabetes, number of health facilities and community participation in *Progresa/Oportunidades* to account for improvements in community preventive services (Bando & López-Calva, 2006).

Multiple imputation of missing data

A multiple imputation procedure was used to impute missing information on all variables (Royston, 2004). Seventy-eight percent of the sample had data on obesity; missing data was due mainly to absence at the time of the health assessment. Five percent refused to provide measurements, and a nominal percentage was missing due to illness or disability, problems with supplies, or other reasons. Data for self-reported diabetes were available from 74% of the sample. In terms of key independent variables, 90% had data on indigenous status and 93% on occupational status. Data on height, weight, and diabetes diagnosis were imputed for those for whom data on these characteristics were provided by proxy (8% of the sample), as for others missing data on these outcomes. Data on household consumption expenditure were available for 63% of the sample; for individual items in the index, missingness ranged from 5% to 7%. Very little data (<1%) were missing for education or community-level mediators.

All variables used in the analysis at the individual, household, and community levels were included in the imputation model. Five imputed datasets were generated (Royston, 2004).

We also included variables for interactions tested in the analysis (indigenous status and age, community size, and community percent indigenous).

Analysis

We generated descriptive statistics for individuals overall and by indigenous status, and for communities overall and by community percent indigenous. For the latter analyses (Tables 2 and 3), community percent indigenous was divided into categories for ease of comparison. The majority of communities (112 of 150) had a small proportion of indigenous adults (<10%). Remaining communities were divided into two groups (10% to <30% and ≥30%). Chi-squared and *t*-tests were used to compare differences by indigenous status and community percent indigenous. Tests at the individual level took account of clustering of individuals within communities. Descriptive statistics for individuals (Tables 1 and 3) were weighted to take into account unequal probabilities of selection and household non-response, providing unbiased estimates of population characteristics. Those for communities (Table 2) were unweighted because community-level weights were not available; statistics presented in Table 2 thus represent characteristics of sampled communities.

We used multilevel logistic regression to estimate odds of obesity and diabetes by indigenous characteristics. For regression analysis (Table 4), community percent indigenous was defined continuously, per 10% indigenous. We first examined the association between indigenous status and each outcome, adjusting for demographic covariates and community size (obesity and diabetes) and for healthcare variables (diabetes only). We then added SES variables to assess mediation of these associations (Model 2), followed by adjustment for lifestyle indicators (Model 3). Next, we added community percent indigenous and community-level covariates (Model 4), followed by community development indicators to assess mediation of the association between community indigenous composition and obesity or diabetes (Model 5). We then tested for interactions between indigenous status and age, community size, and community percent indigenous and report these results in the text.

All models included a random intercept for community. Because preliminary analysis suggested that clustering of individuals within households did not substantively affect results, we did not model clustering at the household level. Community size, which was used to construct weights (rather than weights themselves) was included in all models; where weights are a function of independent variables included in the model being estimated, unweighted estimates are preferred, in that they are considered consistent, unbiased, and more efficient than weighted estimates (Chambers & Skinner, 2003; Winship & Radbill, 1994). All analyses were conducted in Stata 11.0 (StataCorp, 2009).

RESULTS

Indigenous adults (Table 1) had a significant advantage over non-indigenous adults for obesity (21% versus 28%, $p<0.001$) and diabetes (4% versus 7%, $p<0.001$). Results also highlight the substantially lower SES and healthcare access of indigenous versus non-indigenous adults, regardless of measure.

Markedly lower levels of community infrastructure and community SES (Table 2) were evident in communities with higher percentages of indigenous residents; most differences were significant at $p<0.05$ (see table for exceptions). Communities with the highest percent indigenous were concentrated in rural areas and in southern and central Mexico.

Obesity (Table 3) was significantly less prevalent among adults living in communities with the highest percent indigenous than in communities with lower percentages (20% versus 28%, $p<0.01$). A similar pattern was evident for diabetes (5% among adults in communities with the highest percent indigenous, versus 6% and 7% for the other categories; $p<0.01$).

Multivariate results

Compared to non-indigenous adults (Table 4, Model 1), indigenous adults in Mexico had approximately 30% lower odds of obesity (OR 0.70, 95% confidence interval (CI) 0.60-0.81) and approximately half the odds of diabetes (OR 0.52, 95% CI 0.40-0.68). Contrary to our hypothesis, little of this association was explained by differences in SES in the two populations (Model 2). Associations also changed little after accounting for lifestyle indicators (Model 3). When limited to those with health insurance (data not shown), the gap in the odds of diabetes by indigenous status decreased somewhat but remained significant (OR 0.59, 95% CI 0.39-0.87), suggesting that differences found in the full sample were not due solely to healthcare disparities. The protective influence of indigenous status on both outcomes was enhanced when indigenous status was defined as ability to speak an indigenous language (data not shown; for obesity, OR=0.58, 95% CI 0.49-0.68; for diabetes, OR=0.47, 95% CI 0.35-0.63).

When community percent indigenous was added (Model 4), odds ratios for indigenous status increased from 0.70 to 0.82 for obesity (95% CI 0.69-0.97) and from 0.57 to 0.66 for diabetes (95% CI 0.48-0.92) but remained statistically significant. In keeping with expectations, for each 10% increase in the community indigenous population, odds of obesity (OR 0.93, 95% CI 0.90-0.97) and diabetes (OR 0.95, 95% CI 0.90-0.99) reduced. Accounting for community development indicators did little to alter results (Model 5). Results were similar when community percent indigenous was defined based on indigenous language (data not shown).

The indigenous advantage relative to diabetes was stronger for adults over 45 years of age compared to those aged 45 years and younger (data not shown; p for interaction=0.01). There association between indigenous status and obesity differed for the smallest (rural) versus the largest (most urban) communities (p=0.03), with a stronger negative association in the former. This comparison was just over marginal significance for diabetes (p=0.10). There was no interaction between indigenous status and community percent indigenous for either outcome.

Results for waist circumference were similar to those for obesity for indigenous status (OR 0.69, 95% CI 0.57-0.83) and community percent indigenous (OR 0.94, 95% CI 0.91-0.97). Differences were not mediated by SES or community development.

DISCUSSION

This analysis identified a substantially lower likelihood of obesity and diabetes among indigenous than non-indigenous adults in Mexico, based on a nationally representative sample. Associations were not attributable to the greater socioeconomic disadvantage of indigenous adults. Lower likelihood of both conditions was found in communities with a higher percentage of indigenous residents. Although these communities were less developed, accounting for development-related characteristics did little to alter these associations. Differences by indigenous status for obesity and diabetes narrowed after accounting for community indigenous composition, suggesting that indigenous status may capture in part the greater propensity of indigenous adults to live in higher-indigenous communities. The indigenous advantage was stronger for older than younger adults for diabetes and for adults in rural versus the most urban communities for obesity. The benefit of living in a community with a higher percentage of indigenous residents for lowering obesity and diabetes risk was similar for indigenous and non-indigenous adults.

Our finding concerning indigenous status stands in contrast to wide disparities found in higher-income countries (Ayach & Korda, 2010; Barnes, Adams, & Powell-Griner, 2010; Schulz, et al., 2006). Research on the Pima Indians in the US, for example, has found as much as a five-fold greater prevalence than that reported in studies of the general US population; similar disparities have been found in Canada (Ayach & Korda, 2010; Cowie, Rust, Ford, Eberhardt, Byrd-Holt, Li, et al., 2009; Schulz, et al., 2006). Disparities have also been found in obesity by indigenous status in these settings (Barnes, et al., 2010). Results from this study suggest that an opportunity may still exist to prevent such disparities from developing in Mexico, through expanded prevention activities in indigenous populations and communities. Although Mexico may not follow a trajectory towards the inequities in these conditions observed in higher-income countries, disparities in many other health outcomes by indigenous status in Mexico give cause for concern regarding the emerging epidemics of obesity and diabetes (San Sebastián & Hurtig, 2007). Moreover, research has found greater coexistence of over- and undernutrition in indigenous families in Mexico and in rural areas and in the south, where higher-indigenous communities are located (Barquera, Peterson, Must, Rogers, Flores, Houser, et al., 2007). This suggests that indigenous families and communities may not be faring well as Mexico undergoes nutritional transition. Given these patterns, increased intervention in indigenous populations and communities may represent an important cautionary step concerning disparities prevention. Results from this study provide a baseline for monitoring changes in prevalence of these conditions by indigenous characteristics in Mexico in intervening years since data collection as well as in the future as the epidemics of obesity and diabetes unfold.

Research that uncovers the sources of any indigenous advantage relative to obesity and diabetes is urgently needed. We found little explanatory effect of SES or community development; however, available data did not support measurement of some aspects of these constructs. For example, due to discrimination, indigenous adults may be assigned to jobs requiring greater physical exertion within occupational classes than non-indigenous adults, which would not have been captured by our broad measure of occupational status. Although our variable for household economic status incorporated food expenditure, it may have been insufficient to measure lower energy access or food insufficiency in indigenous households over longer periods. At the community level, our indicator of road development did not measure full road capacity, but rather only whether most roads were paved. Additional investigation into socioeconomic mechanisms is of crucial importance, particularly given research that suggests that cash transfers in the *Oportunidades* program has resulted in greater obesity among adult recipients (Fernald, Gertler, & Hou, 2008). If SES explains the observed indigenous advantage in obesity and diabetes, this may inform strategies to maintain healthier lifestyles in indigenous populations and communities as poverty alleviation efforts proceed. A recent report by the United Nations Development Program highlighting disadvantages in human development in Mexican indigenous communities reinforces this as an important area for future research (Programa de las Naciones Unidas para el Desarrollo México, 2010).

Research is also needed concerning alternative mechanisms, particularly cultural resources of indigenous populations and communities. Commitment to maintaining cultural distinction may foster identity and norms that enable indigenous individuals to sustain traditional lifestyles, through, for example, valuing and sharing knowledge around production and preparation of foods from local indigenous food systems (Damman, Eide, & Kuhnlein, 2008; Kuhnlein, Erasmus, & Spigelski, 2009). These processes may shape preferences and increase opportunities for consumption of indigenous foods. Research on the Pima Indians found that preferences for indigenous versus Anglo diets reduced diabetes incidence (D. Williams, et al., 2001). Communities with larger indigenous populations may strengthen cultural processes. Stronger indigenous agrarian networks may sustain production and increase availability of indigenous foods (Kuhnlein, et al., 2009). More frequent contact with indigenous social networks may bolster norms and knowledge around these foods and provide increased opportunity for consumption in social settings.

Our finding of a stronger association between indigenous status and diabetes for older adults may indicate cultural processes at work, in that they may have had less exposure to acculturative forces eroding indigenous lifestyles than younger adults. We also found a stronger indigenous advantage in the smallest versus the largest communities for obesity, where lifestyle-related acculturation pressures may have been weaker; this is consistent with a recent study that found differences in obesity and diabetes prevalence in indigenous groups in remote rural versus urban environments (Popkin, 1999; Rodriguez-Moran, et al., 2008). These analyses were considered exploratory, in that we were unable to rule out alternative explanations linked to age or community size, such as social mechanisms related to discrimination or poverty or, for age, processes linked to biological aging. Moreover, we found no interaction between indigenous status and community percent indigenous. If community cultural resources are behind patterns observed here, indigenous adults residing in higher-indigenous communities should arguably benefit disproportionately, given greater contact with indigenous networks and associated norms than their non-indigenous neighbors. Additional research on cultural mechanisms is essential; with increasing urbanization and generational shifts in lifestyles, the opportunity may soon be lost to capture insights around protective mechanisms that may yield benefits for indigenous Mexicans, the broader Mexican population, and other populations globally. Examination of migration-related mechanisms may also be fruitful, given research that has found associations between community migration patterns and health-related lifestyles in Mexico, as well as differential migration by indigenous status (Buttenheim, Goldman, Pebley, Wong, & Chung, 2010; Programa de las Naciones Unidas para el Desarrollo México, 2010).

Because obesity and diabetes have genetic as well as environmental determinants, research has investigated genetic susceptibility to obesity and diabetes in indigenous populations in order to shed light on disparities in high-income countries (Baier & Hanson, 2004; R. C. Williams, Long, Hanson, Sievers, & Knowler, 2000). It has been speculated that some ethnic groups have an energy-conserving genotype enabling efficient food utilization in eras of frequent food shortages, but which could predispose individuals to obesity and insulin resistance in the presence of an increased food supply (Carulli, Rondinella, Lombardini, Canedi, Loria, & Carulli, 2005; Neel, 1970). Results from this analysis support the notion that environmental determinants may counterbalance any genetic risk for obesity and diabetes in indigenous populations. This is consistent with conclusions from researchers finding variation in prevalence of these conditions in indigenous populations with similar genotypes residing in different environments (Schulz, et al., 2006).

Limitations

This analysis was subject to limitations. We were unable to rule out healthcare-related explanations for the indigenous advantage for diabetes. However, results for obesity lend confidence to those for diabetes, in that the former was based on objective measurement and the conditions are closely related. Findings may be negatively biased if non-reporting of indigenous status was correlated with higher obesity or diabetes risk. Variables included in the analysis may not have accurately captured lifestyle differences by indigenous status. Results may not apply equally across indigenous subgroups. Some measures of community development were reported by community leaders and were subject to reporting bias. We were unable to account for unobserved characteristics that may affect community choice, which, if associated with obesity and diabetes, might be mistaken for community effects (Subramanian, Lochner, & Kawachi, 2003).

Despite these limitations, this investigation contributes to our understanding of indigenous status and health in important ways. Results point to an indigenous advantage in relation to obesity and diabetes among Mexican adults, which contrasts with disparities observed in higher-income countries. Findings also highlight the health impacts of living in communities with differing proportions of indigenous residents, which furthers knowledge of the ways in which the health of indigenous and non-indigenous populations are intertwined. Identifying sources of lower obesity and diabetes risk in indigenous populations and communities in Mexico may hold implications for global prevention and offer insights into ways to temper obesity and diabetes risk.

Table 1. Sociodemographic and health-related characteristics of adults aged 20 years and older, Mexican Family Life Survey, Wave 1 (2002), N=19577[a]

	All	Indigenous adults	Non-indigenous adults	p value[b]
Sociodemographic characteristics				
Indigenous (%)	13	--	--	--
Age, years, mean (SD)	42 (16)	44 (17)	41 (16)	<0.001
Male (%)	47	48	47	0.63
Marital status (%)				<0.001
Married/consensual union	69	76	68	
Divorced/separated/widowed	11	10	11	
Never married	20	14	21	
Household size, mean (SD)	5 (2)	5 (3)	5 (2)	<0.001
Has health insurance (%)	48	31	50	<0.001
Household healthcare expenditure in last three months, pesos, mean (SD)	622 (2710)	351 (1091)	662 (2869)	<0.001
Household participates in *Progresa/Oportunidades* (%)	12	39	8	<0.001
Socioeconomic status				
Education (%)				<0.001
No formal education	13	26	11	
1st-3rd grades	15	26	14	
4th-5th grades	6	9	6	
6th grade	17	14	17	
7th-9th grade	20	11	21	
10th-12th grades	13	6	14	
More than high school	16	8	17	
Occupational status (%)				<0.001
Agriculture	9	22	7	
Other manual	29	22	30	
Non-manual	26	16	27	
Had not worked in paid employment in past year	37	40	36	
Total per capita annual household consumption expenditure, pesos, median (IQ range)	12837 (15110)	7991 (9967)	13545 (15709)	<0.001
Non-food per capita annual household consumption expenditure, pesos, median (IQ range)	6483 (10240)	3300 (5964)	7050 (10618)	<0.001

Table 1. (continued)

	All	Indigenous	Not indigenous	p value[b]
Health behavioral indicators				
Hours per week spent in physically active activities, mean (SD)	4 (10)	10 (16)	3 (8)	<0.001
Smoker	15	8	16	<0.001
Health conditions				
BMI, mean (SD)	27.3 (5.1)	26.5 (5.0)	27.4 (5.1)	0.005
BMI category (%)				0.008
Underweight (<18.0)	3	4	2	
Normal (18.0 to <25.0)	31	37	31	
Overweight (25.0 to <30.0)	39	38	40	
Obese (30.0 or more)	27	21	28	
Diabetes (%)	7	4	7	<0.001

[a] All percentages were pooled across multiply imputed datasets. Data are weighted to represent the adult population of Mexico aged 20 years and older using weights provided by the MxFLS. Categories may not sum to 100 due to rounding error.

[b] Statistical significance of the difference between indigenous and non-indigenous individuals based on Pearson chi-square tests (for sets of categorical variables) or *t*-tests (continuous variables).

Table 2. Distribution of community characteristics in sampled communities: Mexican Family Life Survey, Wave 1 (2002), N=150[a]

	All communities	Community percent indigenous		
		<10%	10% to <30%	≥30%
No.	150	112	18	20
Community infrastructure and community SES				
Most roads paved, n (%)[b]	80 (53%)	63 (56%)	11 (61%)	6 (30%)[d]
Percent household ownership of motorized vehicles, mean % (SD)	30% (17%)	35% (16%)	26% (15%)[d]	8% (6%)[d,e]
Public transportation, n (%)[c]	92 (61%)	78 (70%)	12 (67%)	2 (10%)[d,e]
Median per capita annual household consumption expenditure, pesos, mean (SD)	13283 (7123)	14292 (7358)	14082 (5484)	6909 (2302)[d,e]
Other community characteristics				
Community size, n (%)				
<2500	75 (50%)	52 (46%)	6 (33%)	17 (85%)[d,e]
2500 to <100000	38 (25%)	28 (25%)	7 (39%)	3 (15%)[d,e]
100000 or more	37 (25%)	32 (29%)	5 (28%)	--
Regional location, n (%)				
South	32 (21%)	12 (11%)	9 (50%)[d]	11 (55%)[d]
Central	61 (41%)	49 (44%)	5 (28%)[d]	7 (35%)[d]
North	57 (38%)	51 (46%)	4 (22%)[d]	2 (10%)[d]
Members of community participate in *Progresa/ Oportunidades*, n (%)	117 (78%)	83 (74%)	14 (78%)	20 (100%)[d,e]
Number of health facilities in community, mean (SD)	14 (28)	16 (31)	14 (19)	1 (2)[d,e]

[a] Characteristics were averaged across imputed datasets and are unweighted. Categories may not sum to 100 due to rounding.
[b] Paved with asphalt or concrete versus covered with soil, gravel, or other material.
[c] Versus no public transportation within community.
[d] Statistically significantly different from communities with <10% indigenous at p <0.05.
[e] Statistically significantly different from communities with 10% to <30% indigenous at p <0.05.

Table 3. Obesity and diabetes among adults aged 20 years and older by community percent indigenous: Mexican Family Life Survey, Wave 1 (2002), N=19577[a]

	All communities	Community percent indigenous		
		<10%	10% to <30%	≥30%
BMI category				
Underweight (<18.0)	3	2	2	4
Normal (18.0 to <25.0)	31	31	28	40
Overweight (25.0 to <30.0)	39	39	42	36
Obese (30.0 or more)	27	28	28	20
Diabetes (%)	7	7	6	5

[a] All percentages were pooled across multiply imputed datasets. Data are weighted to represent the adult population of Mexico ages 20 years and older using weights provided by the MxFLS.

Table 4. Odds ratios of obesity and diabetes among adults aged 20 years and older, Mexican Family Life Survey, Wave I (2002), N=19577 [a]

	Model 1[b]	Model 2[c]	Model 3[d]	Model 4[e]	Model 5[f]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Obesity[g]					
Indigenous (*ref: not indigenous)*	0.70 (0.60 to 0.81)	0.70 (0.60 to 0.82)	0.70 (0.60 to 0.82)	0.82 (0.69 to 0.97)	0.82 (0.69 to 0.97)
Community percent indigenous (per 10%)				0.93 (0.90 to 0.97)	0.94 (0.90 to 0.98)
Diabetes[h]					
Indigenous (*ref: not indigenous)*	0.52 (0.40 to 0.68)	0.55 (0.42 to 0.72)	0.57 (0.43 to 0.74)	0.66 (0.48 to 0.92)	0.66 (0.48 to 0.92)
Community percent indigenous (per 10%)				0.95 (0.90 to 0.99)	0.94 (0.90 to 0.99)

OR: Odds ratio. CI: Confidence interval.
[a] Multilevel logistic regression models.
[b] Adjusts for age, age^2, sex, marital status, household size (logged), and community size (obesity and diabetes) and health insurance, household healthcare expenditure, and household participation in *Progresa/Oportunidades* (diabetes only).
[c] Adds education, occupational status, and household consumption expenditure.
[d] Adds lifestyle indicators (hours/week physically active, high household consumption expenditure on energy-dense and foods, and smoking (obesity and diabetes), and obesity (diabetes only).
[e] Adds community percent indigenous (shown) and regional location (obesity and diabetes), and community household participation in *Progresa/Oportunidades* and number of health facilities in the community (diabetes only).
[f] Adds road material, percent household ownership of motorized vehicles, public transportation, and median household consumption expenditure.
[g] Obesity is defined as a body mass index of 30.0 kg/m^2 or greater.
[h] Diabetes is defined as a self-report of diagnosis.

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