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Incidence of Type 2 Diabetes by Place of Birth in the Multi-Ethnic Study of Atherosclerosis (MESA)

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Abstract

Incidence of diabetes among US foreign-born individuals is not well studied. Data were from the Multi Ethnic Study of Atherosclerosis. Cox proportional hazards regression was used to examine diabetes risk by race/ethnicity, place of birth, and duration of residence among foreign-born. Foreign-born Latinos had a higher risk of incident diabetes compared to US-born Latinos (hazard ratio (HR) 1.79 [95 % confidence interval (CI) 1.00–3.21]). Latinos born in Mexico (HR, 2.26 [95 % CI, 1.18–4.33]) had higher risk of incident diabetes compared to US-born Latinos. Foreign-born living in the US ≥20 years had a higher adjusted risk of incident diabetes compared to those in the US for <20 years (HR, 1.60 [95 % CI, 1.05–2.55]). Incident diabetes may be higher among foreign-born compared to native born; incident diabetes may also be higher among those immigrants who have lived in the US for longer periods of time. Future studies should characterize individuals by race/ethnicity and place of birth to account for differences in biology and time spent in the US.

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Keywords

Immigrant; Foreign-born; Diabetes incidence; Latino; Chinese

Introduction

Although diabetes prevalence and incidence continues to increase in the United States [1], the burden of diabetes varies greatly among race/ethnicity subgroups, with nationally representative data indicating African Americans having the highest prevalence followed by Latinos and whites [1]. Diabetes burden also varies among US immigrants by place of birth, with foreign-born Asians having the highest diabetes prevalence [2]. When compared to US-born individuals, diabetes prevalence is typically higher among foreign-born individuals [3]. These prevalence differences have been attributed to the multidimensional aspects associated with being foreign-born [4], and commonly measured by the number of years living in the US [5, 6] or language spoken at home [7]. Diabetes incidence estimates among the foreign-born, though, are less well known, but equally important as prevalence comparisons because the immigrant population in the US has increased four-fold in the last four decades [8] to 38.5 million or 12.5 % of the total US population [8]. Using the Multi-Ethnic Study of Atherosclerosis (MESA), we prospectively investigated differences in diabetes incidence by race/ethnicity and place of birth, and by years lived in US among foreign-born individuals.

Methods

The MESA cohort has been previously described in detail [9]. In brief, MESA is an ongoing six-center (Baltimore, MD; Chicago, IL; Forsyth County, NC; Los Angeles County, CA; Northern Manhattan, NY and St. Paul, MN), multi-ethnic (White, African American, Latino, or Chinese American), population-based longitudinal study of 6,814 middle-aged adults aged 45–84 years who were free of clinical cardiovascular disease (CVD) at baseline (July 2000–August 2002) for the development, correlates, and progression of sub-clinical cardiovascular disease. To date, three follow-up examinations have been completed at 2, 3, and 4 years (2005–2007) after baseline. The study was approved by the institutional review board at each center and written informed consent was obtained from all participants.

The longitudinal investigation presented here includes data from 4,922 participants, including 2,295 men and 2,627 women (2,160 white, 1,203 black, 966 Latino, and 593 Chinese), after excluding individuals with type 2 diabetes at baseline (n = 859), individuals with no follow-up data (n = 306), and individuals missing data for: years living in the US (n = 200), follow-up BMI (n = 94), place of birth (n = 18), and total energy intakes (n = 258). Individuals with extremely low (<600 kcal/day) or high (>6,000 kcal/day) total energy intakes were also excluded from the analysis (n = 157). Thus, in total, 727 individuals were excluded because of missing or unreliable data.

Race and ethnicity were based on participants' responses to the ethnicity and race questions from the 2000 US census. In this study, racial/ethnic groups are considered mutually exclusive and are abbreviated as white, black, Chinese, and Latino. Information on sex, age, education, place of birth, time in the US (for those not born in the US), language spoken at home were obtained using questionnaires administrated at baseline visit in English, Spanish, or Chinese.

Place of birth was categorized as US-born or foreign-born (born outside the US or in Puerto Rico [10]), based on respondent's reported country of birth. Among Latinos only, further foreign-born classification was made by specific country of birth: Mexican-born, Puerto Rican-born, and other Latino foreign-born (Dominican, Cuban, other).

Duration of years living in the US among the foreign-born was categorized as <20 years or ≥20 years because sample sizes among those living in the US for 10 years or less was too small to allow for meaningful analyses. However, longer residing immigrants are more similar to US-born with regard to weight and diabetes [5, 6], and thus this categorization is reasonable. Language spoken at home was categorized as English or other language with/without English (speaking English and another language or another language only at home). Language usage is typically correlated with education [11] and therefore, was analyzed as a covariate, rather than as an exposure.

Participants taking diabetes medications or whose glucose, after a minimum 8-h fast, was ≥126 mg/dL at any of the follow-up examinations were classified as having an incident, provisional diagnosis of diabetes, a definition based on the 2003 American Diabetes Association criteria [12]. Fasting serum glucose was measured at each exam by rate reflectance spectrophotometry using thin film adaptation of the glucose oxidase method on the Vitros analyzer (Johnson & Johnson Clinical Diagnostics, Rochester, NY) at the Collaborative Studies Clinical Laboratory at Fair-view-University Medical Center (Minneapolis, Minnesota). Reliability of the serum glucose assay over examinations was established by reanalyzing 200 samples from each of the four examinations over a short time period and then recalibrating the original observations.

Height was measured by using a stadiometer ((Accu-Hite Measuring Device; Seca GmbH & Company KG, Hamburg, Germany) with level bubble) and weight with a Detecto platform balance scale (Titus Home Health Care, Alhambra, California). Waist circumference was measured to the nearest centimeter by using a Gulick II anthropometric tape (Sammons Preston, Chicago, Illinois) at the level of the umbilicus. BMI was calculated as weight divided by height squared (kg/m^2). Physical activity was self-reported using a semi-quantitative questionnaire adapted from the Cross-Cultural Activity Participation Study [9]. For the purposes of this study, physical activity was defined as the number of MET-minutes per week spent doing intentional leisure-time exercise. Total caloric intake (kilocalories per day) was estimated from the MESA food frequency questionnaire, which was modified from the Insulin Resistance Atherosclerosis study [9].

Statistical Analyses

In all analyses, the place of birth or years lived in the US functioned as the independent variable and incident diabetes functioned as the outcome variable. Baseline characteristics were compared between US- and foreign-born groups with significance tests by χ^2 for categorical variables or t-tests for continuous variables or Wilcoxon tests for nonparametric

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comparisons. Incident diabetes defined as diabetes at follow-up examinations (examinations 2, 3, or 4) among participants free of diabetes at baseline. The time at risk was calculated from the baseline examination through the examination at which incident diabetes was diagnosed, the fourth MESA examination, or the last examination before loss to follow-up. Annualized incidence rates of diabetes per 100 person-years according to race/ethnicity and place of birth were calculated with the number of cases of diabetes as the numerator and number of person-years as the denominator.

For the primary analysis, Cox proportional hazard regression was used to evaluate the hazard of developing diabetes at follow-up by place of birth for the total sample and within race/ethnicity among participants free of diabetes at baseline. We tested for and found no evidence of interactions between place of birth and race/ethnicity (P >0.6 for all tests for interactions). Serial models were performed adjusting for demographic data and known diabetes risk factors. Analyses were adjusted for race, sex, baseline age (as a continuous variable), education (<high school, high school/some college, college graduate or more), language spoken at home (English only, other language with/without English), MESA study site, and baseline BMI (or waist circumference). In a second analysis, Cox proportional hazard regression was used to evaluate the hazard of developing diabetes according to years lived in the US (<20 years, ≥20 years) among foreign-born participants. Due to the high correlation between years lived in the US and language spoken at home, analyses were adjusted for all covariates of the primary analysis (without language spoken at home). Because previous work has shown immigrant BMI increases after migration [5], which could contribute to diabetes risk, time-varying instead of baseline BMI/waist circumference was also explored in these models. To assess potential mediators of nativity-diabetes associations, we added to the fully adjusted models covariates assessing lifestyle factors (physical activity and total caloric intake) separately, and simultaneously. Analyses were conducted using SAS statistical software version 9.2 (SAS Institute Inc, Cary, North Carolina). P <0.05 was considered statistically significant.

Results

The sex distribution was similar by place of birth (Table 1). Foreign-born individuals were more likely to be Chinese and Latino, to have a lower BMI, a more sedentary lifestyle, lower caloric intake, more likely to speak a language other than English in the home, and live in the US for a median of 25 years. On the other hand, US-born individuals were slightly older, more educated and more physically active. The mean follow-up time by place of birth was similar.

The crude annualized diabetes incidence was highest among Latinos, regardless of place of birth (Table 2). In the fully adjusted model, foreign-born Latinos had a higher risk of incident diabetes compared to US-born Latinos (hazard ratio (HR) 1.79 [95 % confidence interval (CI), 1.00–3.21, P = 0.04], Model 2, Table 2). Results did not change when time-varying BMI or waist circumference were added to the model (data not shown). Because there was insufficient power to make similar comparisons in other subgroups, there were no significant differences in adjusted incident diabetes risk among white, Chinese, or black participants (Model 2, Table 2).

We also examined incident diabetes among Latinos by specific country of birth. Latinos born in Mexico (HR, 2.26 [95 % CI, 1.18–4.33]) had higher risks of incident diabetes compared to Latino US-born individuals in the fully adjusted model (Model 2, Table 3). There were no differences in incident diabetes among Puerto-Ricans or other Latino-born individuals, regardless of place of birth (Table 3), however the number of incident diabetes cases among non-Mexican born Latinos limited power to detect meaningful differences.

Among all participants born outside the US or Puerto Rico, those living in the US ≥20 years had a higher adjusted risk of incident diabetes compared to those living in the US for <20 years (HR, 1.60 [95 % CI. 1.05–2.45], Model 2, Table 4). This remained significant regardless of adjustment for baseline or time varying waist circumference (data not shown). In a sensitivity analysis, years lived in the US was categorized as <10 years or ≥10 years, and HR were not significant (data not shown), indicating longer duration of residence (≥20 years) is a more significant predictor of diabetes risk than shorter duration.

Adding potential mediators such as physical activity and total caloric intake to fully adjusted models did not change the results (data not shown).

Discussion

We found that US-born Latinos may have a lower risk of incident diabetes compared to foreign-born Latinos. This higher risk of diabetes among foreign-born Latinos was observed among Latinos specifically born in Mexico. Additionally, we found that independent of age, foreign-born individuals living in the US for ≥20 years may have a higher risk of diabetes compared to foreign-born individuals living in the US for <20 years.

Consistent to previous work based on cross-sectional data [3], we found that diabetes incidence may be higher among foreign-born individuals, but our finding was significant only among foreign-born Latinos. This may be because Latinos have been shown to have the greatest percentage increases in BMI with increased length of stay in the US compared to other racial/ethnic groups [13]. However, our results did not change when adjusted for time-varying BMI or waist circumference as opposed to baseline BMI or waist circumference, possibly due to the older age of entry into the MESA cohort. Thus, there were little to no differences in baseline versus time-varying BMI or waist circumference across all subgroups (data not shown). Two additional explanations include that people from a similar region may have similar genetic risk [14], and thus our finding may support that genetic background may have a stronger influence on diabetes risk than exposure to the US environment [2, 15]. Finally, the effect of US exposure may vary by country of birth [16, 17]. For example, more recent immigrants to the US may be more similar to the US in terms of dietary and physical activity behaviors, and thus effects of US exposure may be less important for more recent waves of migrants [18].

In our results, BMI had the strongest association with risk for incident diabetes. Because lifestyle factors also exert at least part of their effects on diabetes risk through BMI (or as a measure of adiposity), adjustment for BMI in these models may reflect over adjustment, thus the full effect of lifestyle factors on diabetes risk may be underestimated. Our ability to investigate the mediating role of changes in diet and physical activity is limited by insufficient follow-up data. Specifically, lifestyle or dietary changes may not have manifested with the mean 4.5 years of follow-up time observed in this study. Changing diet and physical activity behaviors are often cited as potential explanations for changes in immigrant weight post-migration because they directly influence body weight. Increased length of exposure to the US environment has been shown to lead to greater dietary change [11, 19] and adoption of American dietary and physical activity patterns [20–22]. This translates into decreasing intake of traditional foods [20] and increasing fat, sugar, and caloric intake [21, 22]. For Latinos, duration of residence has been shown to be positively associated with dietary change, which in turn was positively associated with BMI [11]. However, dietary change varies by region of origin with Asian groups less likely to report significant dietary change, and Latino immigrants more likely to report high dietary change [19]. Thus weight gain among foreign-born Latinos may need further exploration with regard to incident diabetes.

We found that the risk of diabetes among Latinos may vary by place of birth. Previous researchers have hypothesized that the relationship between foreign-born characteristics and diabetes among Latinos may differ depending on specific country of origin [7]. Although our analyses adjusted for multiple variables including language spoken at home, other aspects of being foreign-born not captured in this study may be contributing factors such as changes in health behaviors (i.e. diet, physical activity), stress levels, and social networks [23, 24].

Longer duration of residence in the US is well documented in the literature as a contributing factor to increased BMI in migrant groups [25] and to diabetes [6], but this is one of the first studies to prospectively examine this association. The association between diabetes and years spent in the US was significant, regardless of adjusting for time-varying BMI or waist circumference, indicating that there are factors beyond weight change, such as lifestyle factors, contributing to the significant association.

Differences in socioeconomic status may also impact immigrant health. It has been shown that migrants are more educated than their nonmigrant counterparts [26]. Yet migrants who arrive to the US from less developed countries are coming from an environment where there is a strong positive relationship between SES and obesity, which is in contrast to observations in developed countries [27]. The majority of the immigrant stock in the US is arriving from developing nations, and thus may experience unique patterns and changes in BMI, and consequently higher diabetes risk. Recent research has shown little to no change in mean BMI with higher education or income among foreign-born Asians and Latinos, whereas among native born, there was an inverse gradient such that higher education and income corresponded with lower mean BMI [13].

There are several limitations to this study. First, the US-born Chinese population was very small, comprising less than 1 % of the total US-born study sample. This limited the statistical power to detect meaningful differences in diabetes incidence by place of birth within this specific subgroup. Similarly, the foreign-born population of blacks and overall sample size of Puerto Ricans and other Latino subgroups was somewhat small, which may have also limited power to detect meaningful differences in these groups. Second, MESA does not provide measures of body fat percentage, which may have provided different information than anthropometric measures of BMI and waist circumference. However, BMI and waist circumference are independent, strong predictors of diabetes [28, 29]. Third, although years lived in the US and language spoken in the home are commonly used as proxies of foreign-born characteristics, these variables may not fully capture the multidimensional aspects of being foreign-born. Lastly, the MESA sample is not nationally representative and at baseline, MESA participants were aged 45–84 years without evidence of existing cardiovascular disease, thus the findings of this study may not extend to other US populations or age ranges.

There are also key strengths of this study. These strengths expand upon previous research of this topic in a variety of ways: (1) the prospective design, which reduces bias and allows for use of a clinically relevant outcome; (2) direct comparison of participants representing four racial/ethnic groups; and (3) highly standardized anthropometric measurements, serum processing, and covariate assessment across study centers. Possibly most importantly, the previous, mostly cross-sectional research on diabetes in foreign-born individuals does not account for the effect of aging-related risks, whereas the prospective study design of MESA accounted for such effects.

In this study we found risk of incident diabetes may be higher among Latino foreign-born individuals compared to their US-born counterparts, and this risk was more prominent among those born in Mexico. Additionally, living in the US for 20 years or more may be associated with higher risk of diabetes in foreign-born persons compared to those with <20 years of US residence. Regardless of where they were born or how long they had been in the US, the estimated lifetime risk of developing diabetes among Latinos is approximately one in two [30]. Future studies should continue to separate foreign-born individuals by race/ethnicity or specific place of birth to account for not only the differences in genetics, but also differences in foreign-born characteristics like years lived in the US. Measures of foreign-born characteristics, such as years lived in the US and language spoken at home are commonly used in immigrant studies and warrant validation. Although the MESA sample includes individuals from both the largest (Latinos) and the fourth largest immigrant group in the US (Chinese) [8], sample sizes were still limited to detect meaningful differences. Future studies should consider enrolling larger numbers of migrants at younger ages and increasing follow-up time to better examine nativity differences in diabetes.

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Table 1

Baseline characteristics of participants by place of birth, the MESA study

Variables	Place of birth	
	United States	Outside the U.S. or in Puerto Rico
Number	3,520	1,402
Women (%)	52.8	54.8
Age, years	62.0 (10.2)	61.2 (10.3)‡
Race/ethnicity (%)		
White	56.4	8.0§
Chinese	0.7	38.5§
Black	33.5	6.6§
Latino	9.4	46.9§
Education (%)		
<High school	7.3	34.4§
High school/some college	49.7	38.9§
≥College graduate	43.07	26.7§
BMI, kg/m^2	28.4 (5.4)	26.6 (4.7)§
Waist circumference, cm	98.4 (14.2)	93.3 (12.5)§
Physical activity, MET-min/wk* (median [IQR])	1,050.0 (315.0–2,310.0)	660.0 (0.0–1,575.0)§
Total caloric intake, kcal (median [IQR])	1,423.7 (1,038.1–1,950.2)	1,241.2 (881.4–1,747.9)§
English only spoken at home (%)	96.4	17.9§
Follow-up time, years (median [IQR])	4.7 (4.5–4.9)	4.8 (4.5–5.0)‡
Years living in US (median [IQR])	NA	25.0 (15.0–35.0)

MESA Multi-Ethnic Study of Atherosclerosis, *SD* standard deviation, *BMI* body mass index, *IQR* interquartile range, *NA* not available. Data shown are means (SD) unless otherwise indicated

*Total intentional exercise, included moderate walking exercise, dance and vigorous sports

‡*P* <0.01,

§*P* <0.001 compared to US-born

Table 2

Annualized incident diabetes and adjusted hazard ratios for incident diabetes by race/ethnicity, and category of place of birth, the MESA study

	All participants		Whites		Chinese		Blacks		Latinos	
	US-born	**Outside US/ Puerto Rico**	**US-born**	**Outside US/ Puerto Rico**	**US-born**	**Outside US/ Puerto Rico**	**US-born**	**Outside US/ Puerto Rico**	**US-born**	**Outside US/ Puerto Rico**
Cases/total	267/3,520	135/1,402	125/2,046	8/114	2/26	43/567	103/1,116	9/87	37/332	75/634
Incident diabetes per 100 person- years	1.69	2.14	1.34	1.50	1.76	1.66	2.11	2.23	2.49	2.68
Models*	HR (95 % CI)									
Model 1	1.0 (referent)	1.00 (0.73–1.37)	1.0 (referent)	1.14 (0.56–2.34)	1.0 (referent)	0.67 (0.16–2.84)	1.0 (referent)	0.99 (0.50–1.97)	1.0 (referent)	1.31 (0.81–2.13)
Model 2	1.0 (referent)	1.19 (0.81–1.76)	1.0 (referent)	1.22 (0.57–2.63)	1.0 (referent)	0.67 (0.07–6.13)	1.0 (referent)	0.92 (0.42–1.99)	1.0 (referent)	1.79 (1.00–3.21)[†]

Model 1: adjusted for age, sex, education, and study site; Model 2: model 1 additionally adjusted for baseline BMI, and language spoken at home

[†] $P = 0.041$ compared to referent group (US-born)

Table 3

Adjusted hazard ratios for incident diabetes by place of birth in Latino participants, the MESA study

Models*	**HR (95 % CI)**			
	US-born	**Outside US**		
		Mexican-born	**Puerto Rican-born**	**Other Latino-born‡**
Cases/Total	37/332	30/234	9/96	36/304
Model 1	1.0 (referent)	1.73 (1.00–3.01)[a]	0.68 (0.28–1.67)	0.99 (0.53–1.85)
Model 2	1.0 (referent)	1.94 (1.02–3.67)[b]	0.74 (0.29–1.87)	1.12 (0.55–2.26)
Model 3	1.0 (referent)	1.93 (1.10–3.39)[c]	0.83 (0.34–2.02)	1.43 (0.76–2.69)

*Model 1: adjusted for age, sex, education, and study site; Model 2: model 1 additionally adjusted for language spoken at home; Model 3: model 1 additionally adjusted for baseline BMI

[a] *P* = 0.050,

[b] *P* = 0.042,

[c] *P* = 0.021 compared to referent group (US-born)

‡Other Latino-born included participants self-reported as Dominican (n = 113), Cuban (n = 37), and other Latino (n = 154)

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Table 4

Adjusted hazard ratios for incident diabetes by category of years living in the US among participants born outside the US or in Puerto Rico, the MESA study

Models*	**Years living in the US, HR (95 % CI)**	
	<20 years **N = 497**	**≥20 years** **N = 905**
Model 1	1.0 (referent)	1.47 (0.98–2.21)
Model 2	1.0 (referent)	1.60 (1.05–2.45)†

*Model 1: adjusted for age, sex, race, education, and study site; Model 2: model 1 additionally adjusted for time varying BMI, language spoken at home

†P <0.05 compared to referent group (<20 years)