DIFFERENCES IN DIABETES MELLITUS ONSET FOR OLDER BLACK, WHITE, AND MEXICAN AMERICANS

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Objectives: Our research examines the differences in estimated odds of developing diabetes mellitus for White, Black, and Mexican Americans age 51 and over for a period of 11 years.

Design, Setting, and Participants: Longitudinal data came from 14,783 respondents of the Health and Retirement Study (1995–2006) who reported being diabetes-free at the first time period. Discrete-time survival models were used to analyze ethnic variations in the probability of developing diabetes.

Main Outcome Measure: Estimated odds of developing diabetes mellitus.

Results: The odds of newly diagnosed diabetes increased between 1995 and 2006, with 11% cumulative incidence for all study participants. The probability of incident diabetes among Black Americans was .01 during the period of 1995/96–1998, which increased to .03 during 1998–2000 and remained at .03 throughout subsequent periods, with cumulative incidence over the 11 years at 12%. In contrast, for Mexican Americans the probability more than doubled from .02 in 1995/96–1998 to .05 in 2004–2006, with cumulative incidence at 19%. White Americans had 11% cumulative incidence during the 11 year period.

Conclusions: Relative to White Americans, Mexican Americans had significantly elevated odds of developing diabetes throughout the 11-year period of observation even after controlling for differences in demographic, socioeconomic, and time-varying health characteristics. (*Ethn Dis*. 2013;23[3]:310–315)

Key Words: Ethnic Differences, Diabetes Mellitus Incidence, Discrete-Time Survival Analysis

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INTRODUCTION

The public health burden and high social cost of diabetes is extensively documented and recognized as a domestic and international epidemic.[1–4] In the United States, diabetes alone accounts for $174 billion in treatment costs, over 3 million hospital stays and 300,000 deaths annually.[3,5] At the current pace, by 2050, 1 in 3 US adults will be diagnosed with type 2 diabetes mellitus (T2DM).[5] In addition, diabetics are at increased risk of diabetic complications and comorbid conditions, including disability, depression, cognitive impairment and low quality of life.[2]

Race/ethnic differences in T2DM morbidity, complications, and exacerbations have been documented for older adults in the United States, with various studies pointing to higher T2DM morbidity for Black, Asian, and Hispanic adults compared to White adults.[6–8] Individual behavioral risk factors that contribute to racial/ethnic differences in T2DM include family history, adiposity, and sedentary lifestyles.[3,9,10] However, the vast majority of current research has been cross-sectional with little information concerning how the incidence of T2DM varies across racial/ethnic groups over an extended period of time.

This study examines differences in the odds of developing T2DM for White, Black, and Mexican Americans aged ≥51 years over a period of 11 years, while taking into consideration changing health conditions.

Although there is acknowledgement that T2DM often co-occurs with other chronic diseases and physical limitations among the elderly,[2] there is little effort to account for changing health status in T2DM incidence. This study examines differences in the odds of developing T2DM for White, Black, and Mexican Americans aged ≥51 years over a period of 11 years, while taking into consideration changing health conditions.

METHODS

Data and Measures

This study used biennial data from the Health and Retirement Study (HRS). The design of the HRS has been documented elsewhere.[11] The study respondents are a nationally-representative sample of community-based adults aged ≥51. In our study, we estimate the odds of T2DM onset for those HRS participants who were diabetes-free at the first time period. Consequently, we excluded 2195 individuals already diagnosed with T2DM at the first time period from the analyses (13% of total individuals, 11% of Whites, 22% of Blacks, and 22% of Mexican Americans). The HRS has been approved by the University of Michigan's Health Sciences IRB. Consistent with on-going HRS practice respondents are read a confidentiality statement when first contacted, and give

Table 1. Descriptive characteristics at first interval, HRS 1995–2006

	Total *N*= 14,783		White *n*= 12,256 (83%)		Black *n*= 1918 (13%)		Mexican *n*= 609 (4%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	64.2	10.4	64.5	10.3	63.2	10.5	62.1	9.8
Female	.6	.5	.6	.5	.6	.5	.5	.5
Education, years	12.1	3.3	12.6	2.8	10.7	3.7	7.0	4.6
Proxy, t-1	.1	.2	.1	.2	.1	.3	.1	.3
Married, t-1	.7	.4	.8	.4	.5	.5	.8	.4
Income, t-1	61.2	84.8	66.9	89.9	37.6	50.0	25.6	27.5
BMI, t-1	27.2	4.9	26.7	4.5	29.0	5.8	27.7	4.1
Function, t-1	.4	1.3	.3	1.2	.6	1.7	.6	1.5
SRH, t-1	2.6	1.1	2.5	1.1	2.9	1.1	3.0	1.1
CESD, t-1	1.6	1.9	1.6	1.8	2.0	2.1	2.3	2.3
Comorbidities, t-1	1.2	1.0	1.1	1.0	1.4	1.1	.7	.7
Smoker, t-1	.1	.3	.1	.3	.2	.4	.0	.1
Proxy, Δ	.0	.2	.0	.2	.0	.2	.0	.3
Marital, Δ	.0	.1	.0	.1	.0	.2	.0	.1
Income, Δ	−.8	82.6	−.9	89.1	−1.2	42.8	1.9	25.7
BMI, Δ	.1	1.8	.1	1.7	.0	2.0	.2	1.6
Function, Δ	.2	1.3	.2	1.2	.2	1.6	.2	1.5
SRH, Δ	.3	.9	.3	.9	.2	1.0	.3	1.1
CESD, Δ	.4	2.0	.4	1.9	.4	2.2	.5	2.6
Comorbidities, Δ	.2	.4	.2	.4	.2	.5	.1	.3
Smoker, Δ	.1	.3	.1	.4	.3	.4	.2	.4

BMI, body mass index; SRH, self-reported health; CESD, Center for Epidemiological Studies Depression Scale; t-1, previous period/lagged period; Δ, change between current (t) and previous period time point (t-1).

oral or implied consent by agreeing to be interviewed. Due to the incompatibility of key independent variables across waves, we analyzed HRS data from 1995–2006 with Stata 10.[12]

Diabetes Mellitus

Self-reported T2DM was used to measure disease status. Self-reported health and disease status have been well established and validated[13,14] and are widely used in aging research. In addition, nationally representative data collection instruments provide consistent estimates of incidence for chronic illness with concrete clinical endpoints when compared to studies utilizing administrative health record data.[15] Consistency in the reporting of T2DM for individuals over time was verified with additional information from the HRS. For example, if an individual gave conflicting wave-by-wave reports of T2DM diagnosis, we utilized reported use of oral or injectable diabetes medication when T2DM was first reported to verify the diagnosis.

Demographic and Socioeconomic Factors

Various controls for demographic and socioeconomic factors are included as separate time-constant and time-varying covariates in the analysis. The principal covariates of interest in the analyses are indicators for Black and Mexican ethnicity. Mutually-exclusive indicator variables for non-Hispanic White, non-Hispanic Black and Mexican-ethnicity individuals were constructed. Age was a continuous variable measured at each time interval. Education was measured as a continuous variable denoting years of schooling (range 0–17). Income was inflation-adjusted to 2006 levels, re-scaled (reported per 1000s of dollars) to facilitate estimation, and included in the analyses as lagged (previous period) income and change in income between waves. Marital status was also constructed as a lagged time-varying covariate and change score. The change in marital status (range −1 to 1) reflects dissolution/widowhood, no change, and acquisition of partners at each point in time over the study period.

Health Status

Self-rated health (SRH) was measured with a 5-point scale (1=excellent, 2=very good, 3=good, 4=fair and 5=poor). Functional status (0–11) incorporated activities of daily living (ADL, 0–6) and instrumental activities of daily living (IADL, 0–5), with higher scores reflecting increasing difficulty. Depressive symptoms were measured with the Center for Epidemiological Studies Depression Scale (CES-D, 0–9) with higher scores reflecting higher depressive symptoms. Lagged comorbidity was a count of chronic diseases (stroke, heart disease, arthritis, lung disease, hypertension, and cancer, 0–6).

We included SRH, functional limitations, depressive symptoms, and chronic disease comorbidities covariates as time-varying lagged values and change scores in analyses. Both, previous period health information (lagged

Table 2. Discrete-Time Hazard Model Results for New Diabetes Diagnosis, HRS 1995-2006

	M_1[a]		M_2		M_3	
Covariates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Black	1.62	1.43, 1.84	1.37	1.19, 1.58	1.10	.92, 1.31
Mexican-American	2.10	1.75, 2.53	1.49	1.20, 1.86	1.80	1.38, 2.33
Proxy, t-1			.93	.75, 1.15	.93	.71, 1.23
Proxy, Δ			.93	.71, 1.23	.88	.61, 1.28
Age			.98	.98, .99	.98	.97, .99
Education			.96	.95, .98	1.00	.98, 1.02
Female			.77	.70, .86	.77	.67, .87
Married, t-1			1.01	.89, 1.14	1.00	.86, 1.16
Married, Δ			1.12	.88, 1.43	1.27	.95, 1.70
Income, t-1			1.00	1.00, 1.00	1.00	1.00, 1.00
Income, Δ			1.00	1.00, 1.00	1.00	1.00, 1.00
BMI, t-1					1.09	1.08, 1.10
BMI, Δ					.97	.94, .99
SRH, t-1					1.31	1.21, 1.41
SRH, Δ					1.39	1.29, 1.51
CESD, t-1					.98	.94, 1.02
CESD, Δ					.96	.93, 1.00
Function, t-1					.96	.91, 1.02
Function, Δ					.99	.94, 1.04
Comorbidities, t-1					1.21	1.14, 1.28
Comorbidities, Δ					1.36	1.21, 1.53
Smoker, t-1					.85	.70, 1.03
Smoker, Δ					.59	.43, .81
	Prob(hazard)		**Prob(hazard)**		**Prob(hazard)**	
Period 1 (1995/1996–1998)	.03		.03		.01	
Period 2 (1998–2000)	.03		.03		.02	
Period 3 (2000–2002)	.03		.03		.03	
Period 4 (2002–2004)	.04		.04		.03	
Period 5 (2004–2006)	.04		.04		.03	
Log-likelihood	−7762.84		−7116.33		−4875.71	
Wald χ^2	19,539.65		17,945.86		12,028.50	
Probability> χ^2	.00		.00		.00	

BMI, body mass index; SRH, self-reported health; CESD, Center for Epidemiological Studies Depression Scale; t-1, previous period/lagged period; Δ, change between current (t) and previous period time point (t-1).

[a] See text for model description.

time-varying) and net health changes (change scores) were conceptualized as contributing unique predictive information in models of new T2DM cases. Lagged covariates better specify the time sequencing of associations between time-varying covariates and T2DM onset, and were constructed as health status in the previous period (time t-1) and predicted odds of T2DM onset at time t. Change scores were constructed as the difference between time t and time (t-1). Positive change scores reflected an increase in health grievances, while negative scores denoted improvement. A change score of zero denoted no change in health conditions across adjacent periods.

Health Behaviors

In addition to physical and mental health measures, we also incorporated several behavioral risk factors for T2DM into our model. We included body mass index (BMI) as lagged and change score covariates. The BMI was calculated using respondents' self-reported weight for each interview year and height reported at baseline. Lagged current smoker was included as a binary variable, as well as a change score covariate.

DATA ANALYSIS

Using discrete-time survival analysis[16] we estimated the incidence of T2DM among non-diabetics during the 11 years of observation (1995–2006). Specific date of T2DM diagnosis is not readily available in the HRS, therefore it is problematic to directly calculate incidence rates or estimate continuous time survival models of incidence. However, our discrete-time survival analyses result in estimates of onset comparable to a continuous time model. The discrete-time hazard represents the risk of event occurrence in each discrete time period among people in the risk set.

We used Stata macros developed by Dinno[17] to estimate the model using the logit link and adjust for clustering within households. This model presents the log-odds of T2DM diagnosis in each discrete

time period as a function of predictors and has the attributes of a baseline logit hazard function. In contrast to Cox regression where proportional hazard is assumed, this model assumes proportional odds. Model 1 (M_1) estimates the T2DM hazard and includes covariates for race/ethnic group. Model 2 (M_2) incorporates demographic and time varying socioeconomic covariates, and Model 3 (M_3) adds time varying health status covariates. Table 2 reports the model results as odds ratios and predicted probabilities of the hazard for new T2DM diagnosis.[17] Figures 1 and 2 present the predicted probabilities of the hazard function by race/ethnic group for M_1 and M_3, respectively.

To handle missing data at follow-up due to item non-response[18] we employed multiple imputation of incomplete multivariate data under a normal model software (NORM) for instances where respondents answer ''don't know'' or ''refused'' to any question. While the HRS makes great efforts to minimize missing data, multiple imputed data sets are equipped to handle item missing and provide sufficient relative efficiency even in cases with high fractions of missing data.[19] Specifically, three complete data sets were imputed and analyses were replicated on each of these data sets. Following standard algorithms, estimates were then averaged across imputed data sets to calculate single point estimates and standard errors.

RESULTS

Table 1 details sample descriptive statistics collected at the baseline interview. The mean age for our total sample was 64 years, and 57% were female. In our analytic sample, 12,256 (83%) of respondents were White, 1918 (13%) were Black and 609 (4%) were Mexican American. Relative to White Americans, Black Americans had less education and lower household income with Mexican Americans faring the worst. Black and Mexican Americans also reported poorer health status at baseline compared to White participants in terms of depressive symptoms, functional limitations, and greater self-rated ill health.

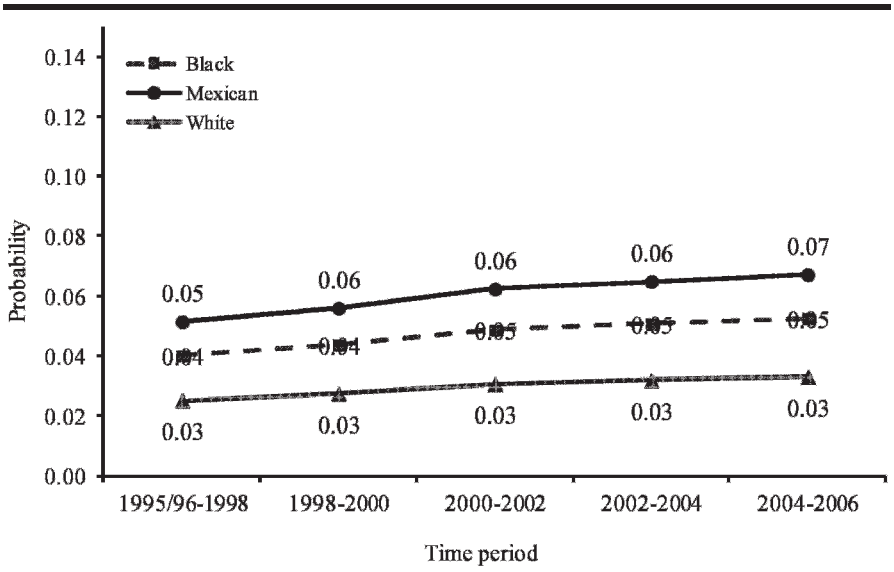

Fig 1. Conditional probability of new diabetes diagnosis in race/ethnic-only model (M_1), HRS data 1995–2006

Table 2 presents the discrete-time hazard model results for the risk of developing T2DM as odds ratios, as well as the predicted probabilities of T2DM. Models M_1-M_3 demonstrate differences in newly diagnosed cases of T2DM by race/ethnic group. Model M_1 details significantly higher odds of T2DM for Black individuals (OR 1.619, 95% CI 1.427, 1.837). These differences persist-

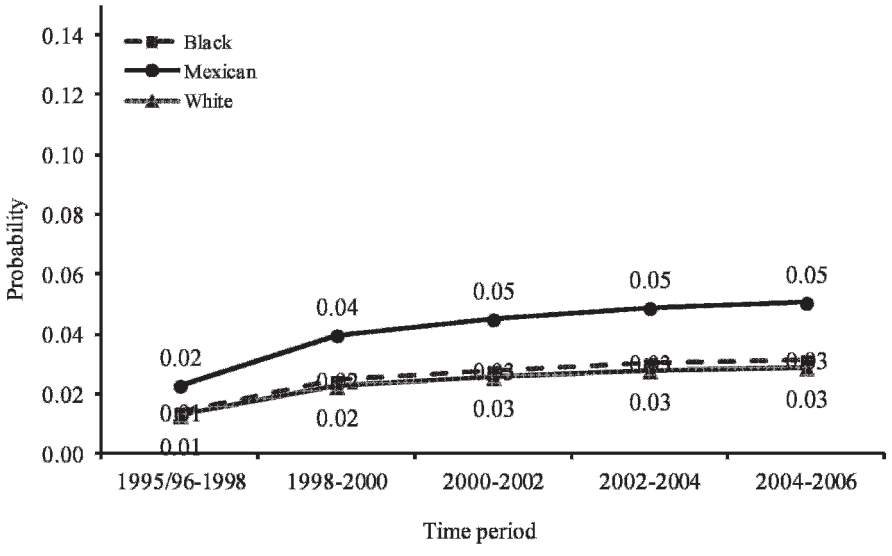

Fig 2. Conditional probability of new diabetes diagnosis in time-varying health adjusted model (M_3), HRS data 1995–2006[a]
[a]Conditional hazard probabilities evaluated at zero change scores and the means of all other M_3 covariates

ed once we accounted for differences in demographic and socioeconomic covariates in M_2 (OR 1.367, 95% CI 1.186, 1.575). However, once we adjusted for changing health status, Black respondents no longer had significantly higher odds relative to Whites in M_3 (OR 1.095, 95% CI .916, 1.309).

Throughout the observation period, Mexican Americans had significantly higher odds of newly diagnosed T2DM relative to Whites. Model M_1 shows significantly higher odds of T2DM onset for Mexican-ethnicity individuals (OR 2.104, 95% CI 1.750, 2.530). This difference, albeit attenuated, remained significant even after we accounted for demographic and socioeconomic factors (in M_2, OR 1.494, 95% CI 1.199, 1.863). Once we adjusted for changing health profiles in M_3, Mexican-origin individuals continued to exhibit significantly higher odds relative to Whites (OR 1.795, 95% CI 1.381, 2.332).

Figure 1 plots the gross differences in the probability of new T2DM diagnosis by race/ethnicity based on M_1 results. Whites demonstrated the lowest probability of T2DM onset, which was constant at .03 from the first to the final period. In contrast, Black and Mexican Americans had an increasing probability of T2DM diagnosis over the 1995–2006 period: .04 to .05 for Blacks, and .05 to .07 for Mexican-ethnicity individuals. Figure 2 plots the differences by race/ethnicity in the probability of T2DM onset net of socioeconomic and health differences included in M_3. For Mexican Americans, the probability was .02 during the period of 1995–1998, which increased to .05 in 2000–2002, and remained at this level through the final period, 2004–2006. In contrast, among White and Black Americans the probability was .01 during 1995–1998 and .03 by 2004–2006. After taking changing health status into account, we no longer saw a significant difference in new T2DM cases between Black and White Americans. However, the difference between Mexican and White Americans persisted.

DISCUSSION

Our study moves beyond the cross-sectional analysis of T2DM prevalence as well as longitudinal studies that only consider transitions between two points in time, and examines T2DM onset for middle-aged and older individuals in the United States. In addition, it involves the comparison of T2DM incidence for both Black and Mexican to White Americans while considering intrapersonal changes in health status for individuals over time. This research identifies how interval-by-interval changes in T2DM risk differ for Black, Mexican, and White Americans over an 11-year period. The cumulative incidence of developing T2DM over the entire period for the aggregate sample was 11% (11% cumulative incidence for White Americans, 12% cumulative incidence for Black Americans, and 19% cumulative incidence for Mexican Americans).

The odds of incident T2DM increased over time for all individuals in the HRS. One potential explanation for a secular increase in risk of receiving a diagnosis of T2DM could stem from the reduction of diagnostic criteria set by the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. In 1997, the fasting blood glucose levels considered sufficient for a T2DM diagnosis were reduced to >125 mg/dL from >140 mg/dL.[7] Although this new criterion would not influence the relative ethnic disparities in risk between Mexican and White participants, it could affect the overall shape of the baseline hazard of T2DM. This would be largely governed by the length of time physicians take to adopt the new standard. It is possible that the jump observed between the 1995/96–1998 and 1998–2000 time intervals could be at least partially explained by the change in diagnostic criteria.

Our research suggests that there are distinct patterns of changes in the incidence of T2DM between Black and Mexican Americans. Consistent with previous findings in the literature,[6,8] we observed that T2DM incidence for Mexican Americans nearly doubled that for their White counterparts. Interestingly, accounting for changing health status and BMI magnifies the increase in odds of T2DM diagnosis for Mexican Americans. Although Blacks demonstrate higher risk of incident T2DM compared to Whites, once we account for changing health status, the Black-White difference in onset for older individuals dissipates. We cannot say the same for Mexican Americans. These results extend beyond the literature by tracing ethnic-specific trends in T2DM incidence after accounting for age-related changes in health profiles.

This research has several limitations. First, because HRS tracks individuals from middle age into old age, it is not able to capture earlier-life selective mortality and T2DM onset that may result in underestimating the risk of incident T2DM for Mexican and Black Americans. Second, an important concern in relying on self-reported disease diagnoses is the reliability of responses in subsequent respondent re-interviews.[20] Specific procedures to explore the extent of inconsistencies across an individual's longitudinal record and provide more time-consistent disease indicators is reflected in these analyses. Although the majority of the study population is Medicare age-eligible, additional analyses (not shown) included time-varying health insurance coverage. Even after controlling for potential shifts in and out of health insurance coverage, incident T2DM remained elevated for Mexican Americans relative to White Americans.

Finally, there could be selective attrition that might bias results. If minorities in the HRS are more likely to drop out and not return to the study, the differences between ethnic groups could be understated. We explored death from HRS data supplemented

…we observed that T2DM incidence for Mexican Americans nearly doubled that for their White counterparts.

by the National Death Index registers in additional analyses (not shown) for our analytic sample of initially diabetes-free respondents, and found that both Mexican-ethnicity and Black participants had similar mortality risk with respect to Whites during this time period. The race/ethnic differences presented here are unlikely to be a result of differences in mortality. We also explored models accounting for nativity (not shown) that yielded similar findings to the models presented here.

Relative to White Americans, Mexican Americans had a significantly elevated risk of T2DM throughout the 11-year period of observation. Our results corroborate the need for early detection and comprehensive disease management efforts into old age, particularly for Mexican-ethnicity individuals in the United States. Monitoring and controlling T2DM through medication adherence and lifestyle change is a resource-intensive endeavor for both individuals diagnosed with the disease as well as the health system charged to provide care for them.[2] Prevention and early detection of the disease, particularly for minorities most at risk of developing T2DM, is imperative.

These results suggest that older Americans with T2DM also contend with multiple chronic conditions that require coordinated efforts for managing medical comorbidities.[21] This is of particular concern given potential complicating conditions associated with T2DM, which include cardiovascular disease, peripheral vascular disease, cerebrovascular disease, hypertension, and lower extremity amputations.[2] Understanding race/ethnic differences in T2DM acuity and co-occurring disease case mix are important areas for further study.

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Statistical expertise: Ye
Acquisition of funding: Quiñones, Liang
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Supervision: Liang, Ye