Title

Intergenerational educational mobility and type 2 diabetes in the Sacramento Area Latino Study on Aging

Authors

Fernández-Rhodes, Lindsay
Ward, Julia B
Martin, Chantel L
et al.

Publication Date

2022

DOI

10.1016/j.annepidem.2021.07.006

Peer reviewed

HHS Public Access

Author manuscript

Ann Epidemiol. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:

Ann Epidemiol. 2022 January ; 65: 93–100. doi:10.1016/j.annepidem.2021.07.006.

Intergenerational Educational Mobility and Type 2 Diabetes in the Sacramento Area Latino Study on Aging

Lindsay Fernández-Rhodes[1,2], **Julia B. Ward**[2,3], **Chantel L. Martin**[2,4], **Adina Zeki Al Hazzouri**[5], **Jacqueline Torres**[6], **Penny Gordon-Larsen**[2,7], **Mary N. Haan**[6], **Allison E. Aiello**[2,4]

[1]Department of Biobehavioral Health, College of Health and Human Development, Pennsylvania State University, University Park, PA

[2]Carolina Population Center, University of North Carolina, Chapel Hill, NC

[3]Social & Scientific Systems, Inc., Durham, NC

[4]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC

[5]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York City, NY

[6]Department of Epidemiology and Biostatistics, University of California, San Francisco, CA

[7]Department of Nutrition, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC.

Abstract

United States (US) Latinos have the lowest educational attainment of any US racial/ethnic group, which may contribute to their disparate burden of Type 2 Diabetes. Herein, we aimed to examine the association between intergenerational educational mobility and Type 2 Diabetes among US Latino adults. We used data from the Niños Lifestyle and Diabetes Study (2013–2014) and the Sacramento Area Latino Study on Aging (1998–1999) to link 616 adult Latino children to

CORRESPONDING AUTHOR Lindsay Fernández-Rhodes, PhD, Department of Biobehavioral Health, Pennsylvania State University, 219 Biobehavioral Health Building, University Park, PA 16802, Phone: (814) 863-0185, fernandez-rhodes@psu.edu.

CONTRIBUTION STATEMENT

The authors all contributed at multiple stages to this manuscript. Dr. Fernandez-Rhodes completed the statistical analyses and interpreted the results and drafted the manuscript. Dr. Ward assisted with the data management and linking of SALSA and NLDS datasets. Dr. Aiello conceived of the study, collected the NLDS data, and oversaw the analytical plan and analyses. Dr. Haan was the principal investigator of SALSA and the principal investigator of the NLDS subcontract to the University of California at San Francisco. As such, Dr. Haan supervised the clinical field work and data collection for both SALSA and NLDS. Dr. Gordon-Larsen assisted with the analytical plan. Drs. Martin, Zeki Al Hazzouri, Torres, and Aiello assisted in the interpretation of the results. All coauthors contributed to the drafting of the final version of the manuscript.

DATA AVAILABILITY

The SALSA data are publicly available (https://www.icpsr.umich.edu/icpsrweb/NACDA/series/247) and the NLDS data are available upon request under data use agreement with the Aiello Research Group (http://www.aielloresearchgroup.org/research/documents-and-forms).

DECLARATIONS OF INTEREST

The coauthors have no competing interests to disclose.

their parents. Model-based standardization and robust Poisson regression were used to estimate the prevalence of prediabetes, Type 2 Diabetes, treatment and glycemic control, and describe their associations with intergenerational educational mobility. Adult children with stable high intergenerational educational attainment had a higher prevalence of prediabetes (Prevalence Ratio, PR=1.58; 95% Confidence Interval, CI=1.08, 2.34) and lower prevalence of Type 2 Diabetes (PR=0.64, CI=0.41, 0.99), as compared to those who experienced low educational attainment across generations. Downward mobility was associated with a higher prevalence of prediabetes (PR=1.54, CI=1.06, 2.23) and worse glycemic control (PR=2.20, CI=1.13, 4.30), and upward mobility was associated with a lower prevalence of Type 2 Diabetes (PR=0.39, CI=0.22, 0.70). Our findings from a predominantly Mexican-heritage community suggest that higher education across generations may buffer individuals from glycemic dysregulation. As such, higher education may be a promising public health target to address the rising burden of Type 2 Diabetes in the US.

Keywords

Social mobility; Education; SES; Type 2 Diabetes; Intergenerational; Hispanics; Latinos

1. INTRODUCTION

There are more than 19.4 million Latin American immigrants in the United States (US), many of whom have US-born children (Stepler and Brown 2016). Most of these immigrants came to the US from Mexico (63%) in search of the ‘American Dream’ (Papademetriou, Sumption et al. 2009). Yet, in the US Latino immigrants and their families face an ever-increasing number of barriers to legalization, access to social welfare programs, higher education, health care, and thus to maintaining healthy lifestyles (Portes and Zhou 1993, Schhneider, Martinez et al. 2006, Viruell-Fuentes, Miranda et al. 2012). For example, over the last several decades the prevalence of obesity and Type 2 Diabetes have increased disproportionately among US Latinos compared to non-Latino Whites (Lorenzo, Williams et al. 2006) fueling a Latino health crisis (Vega, Rodriguez et al. 2009). Although Type 2 Diabetes is a preventable cardiovascular disease risk factor (Balakumar, Maung et al. 2016), 22% of US Latino adults were living with Type 2 Diabetes between 2011–2016 (Cheng, Kanaya et al. 2019).

Simultaneously, US Latinos have the lowest average level of education of any race/ethnic group (Schhneider, Martinez et al. 2006). In fact, Mexican Americans have both the lowest educational attainment and highest burden of Type 2 Diabetes of all US Latino background groups (Everett, Rogers et al. 2011, Schneiderman, Llabre et al. 2014). These disparities may reflect the limited educational opportunities afforded to foreign-born Latinos, and structural barriers in the US that discourage socioeconomic mobility either for immigrants themselves, or for their US-born children. Individuals of higher socioeconomic position may benefit by having greater health literacy, monetary and other resources necessary to acquire health care and sustain healthy lifestyles (Agardh, Allebeck et al. 2011). Likewise, higher parental socioeconomic status may allow for more resources either to be invested in their children’s education, housing, food, and health care during critical periods of development, or to be transferred to their adult children later in life (Case, Fertig et

al. 2005, Goodman, McEwen et al. 2005). Indeed previous intergenerational research has illustrated the limitations of relying on just a participant's socioeconomic status, by showing that parental socioeconomic position also patterns an adult offspring's burden of obesity, metabolic disease (Langenberg, Kuh et al. 2006, Chichlowska, Rose et al. 2009, Gall, Abbott-Chapman et al. 2010, Gustafsson, Persson et al. 2011, Albrecht and Gordon-Larsen 2014, Chaparro and Koupil 2014, Klijs, Angelini et al. 2016), and Type 2 Diabetes (Best, Hayward et al. 2005, Zeki Al Hazzouri, Haan et al. 2015, Camelo, Giatti et al. 2016). Yet, an individual's socioeconomic position is contextualized by both time (e.g. secular trends in educational attainment) and place (e.g. country and regional context), which makes studying intergenerational educational mobility in immigrant communities particularly challenging.

In light of the health and educational disparities faced by US Latinos, we argue that a better understanding of chronic diseases in Latinos is needed—in particular as it relates to theories of early life critical periods, social mobility, or the accumulation of risk across the child's life course (Ben-Shlomo and Kuh 2002, Lynch and Smith 2005). Two previous Type 2 Diabetes studies of intergenerational educational attainment in Latino populations have been conducted to date; each relied on self-reports of parental education made by adult children (Zeki Al Hazzouri, Haan et al. 2015, Camelo, Giatti et al.2016). Neither study was able to account for the multi-nationality of educational experiences among Latino immigrants and their families, to minimize the role that nativity may have on the construction of intergenerational mobility categories. Herein, we address these limitations by examining the association between intergenerational educational mobility and Type 2 Diabetes in an adulthood cohort of predominantly US-born Mexican American adults from the Sacramento Area of California between 2013–2014. We use categories of intergenerational educational attainment as a proxy measure of socioeconomic mobility in US Latino immigrant families, given that education is more stable than income or occupation across borders and other life transitions. We use these categories to test the hypothesis that having a higher education relative to your peers across multiple generations (having experienced upwardly social mobility) would be associated in a cross-sectional manner with a lower prevalence of prediabetes, Type 2 Diabetes, and better disease management in a sample of adult US Latino children.

2. METHODS

2.1. Study sample

The Niños Lifestyle and Diabetes Study (NLDS) is comprised of the adult biologic offspring and other referred relatives of 1,789 Latino adults (60–101 years) from the Sacramento Area Latino Study on Aging (SALSA)—a population-based sample that began in 1998–1999 with followup ending in 2008 (Haan, Mungas et al. 2003). The first stage of sampling in SALSA included Census tracts with an estimated 5% or greater eligibility (self-identified Latino, ≥60 years) around the rural and urban areas of the Sacramento Valley. Then participants living in these Census tracts were contacted by bilingual staff through a number of methods, including door-to-door household enumeration, yielding a response rate of 85% (89% among all eligible households). All eligible members of the selected households were invited to participate in SALSA. Forty-four percent of the SALSA sample was living with at

least one other SALSA participant. In SALSA, 99% of the cohort had complete information on educational attainment and nativity.

Any living children or biologic relatives (aged 18 years or older in 2013–2014) of the SALSA participants were eligible to participate in NLDS (wave 1: March-November 2013; wave 2: May-November 2014) (Ward, Haan et al. 2016). Bilingual NLDS interviewers were centrally trained to conduct an initial 30-minute phone interview, and during a separate 2-hour examination anthropometrics, venous blood measurements and complete a medication inventory were collected (Ward, Haan et al. 2016). Although a subset (<60%) of the study participants recruited as part of wave 1 participated in some portion of wave 2, repeated measures are not assessed in this particular study. Our cross-sectional analysis utilized only the baseline data on the 638 non-pregnant participants who participated in at least one NLDS wave, and who were then successfully linked to a parent in SALSA (n=578 children linked to 361 SALSA parents) or in NLDS (n=60 children linked to 38 NLDS parents). Fifty-eight of the NLDS children were linked to their parents in NLDS, who themselves were children of SALSA participants; whereas, two NLDS children were linked to their parents in NLDS who were other types of biologic relatives of the original SALSA participants. In each of these 60 cases, information on parental attributes came from their NLDS parents, and not the original SALSA participants. Among the 638 offspring, 616 adult children (97%) had complete educational attainment and nativity data on both themselves and parent.

All participants provided their informed consent prior to participation. The SALSA and NLDS studies have been approved by the University of California at San Francisco, University of California, Davis; the University of Michigan; and the University of North Carolina at Chapel Hill Institutional Review Boards.

2.2. Intergenerational educational attainment exposure categories

As with prior NLDS and similar studies (Zeki Al Hazzouri, Haan et al. 2011, Albrecht and Gordon-Larsen 2014, Zeki Al Hazzouri, Haan et al. 2015, Ward, Haan et al. 2016, Crenshaw, Fernandez-Rhodes et al. 2021), we developed four categories of intergenerational educational attainment: stable high (i.e. high parent-high adult child education), upwardly mobile (low-high), downwardly mobile (high-low) and stable low (low-low). If NLDS participants had two parents in SALSA, we used information on the parent with the highest educational attainment in this analysis. As supported by previous descriptive studies of education patterns (Everett, Rogers et al. 2011), we used data-informed study and nativity-specific thresholds to more define high educational attainment relative to a participant's peers, and minimize the influence of secular and geographical trends across generations. As shown in Supplemental Figure 1, high was defined in a data-informed manner, using the nativity-specific median in years of education for SALSA (i.e. >4 years in foreign-born, >10 years in US-born), and for NLDS (i.e. >12 years in foreign-born, >14 years in US-born), separately. For example, US-born SALSA participants who reported attending school through 11th grade or higher (>10 years) were considered high given that they were born in the US before the 1940s; US-born NLDS participants who reported attending University or college for three years or more (>14 years of total education) were considered high, given that they were born at a later time in US history (1930s to the 1990s) when the pursuit

of higher education was more common. Although the exact choice of these thresholds may have influenced the resulting distribution of intergenerational educational attainment categories, we use these categories as a means to isolate those with greatest socioeconomic advantage (as measured by higher education as compared to peers) and test how it associated with prediabetes, Type 2 Diabetes burden and related outcomes across generations.

2.2.1. Type 2 diabetes—During the NLDS phone interview, participants were asked to report if, and at what age (in years), they had previously received a Type 2 Diabetes diagnosis from a doctor. During the home visit, NLDS staff conducted a medication inventory and measured HbA_{1c} and fasting blood glucose. Type 2 Diabetes was defined as having any of the following: self-report of a physician diagnosis of Type 2 Diabetes or 'high blood sugar,' HbA_{1c} level ≥6.5%, fasting glucose level >125 mg/dL, or use of Type 2 Diabetes-related medication(s) based on the therapeutic class of drugs for anti-diabetes based on the National Hospital Ambulatory Medical Care Survey (Asao, McEwen et al. 2015). Pre-diabetes was defined among those without Type 2 Diabetes as having either a HbA_{1c} level 5.7–6.4% or a fasting glucose level 100–125 mg/dL. We dichotomized individuals with Type 2 Diabetes as taking anti-diabetic medications ('treated') or as having a HbA_{1c} <7.0%, which has been described as a reasonable goal of glycemic 'control' from the American Diabetes Association (American Diabetes Association, 2018). A total of 616 adult children had completed the in-home examination and were categorized with respect to normal glucose regulation, prediabetes, or Type 2 Diabetes.

2.2.2. Covariates—As part of the SALSA home interview (Zeki Al Hazzouri, Haan et al. 2015) and NLDS telephone interview (Ward, Haan et al. 2016), participants reported key descriptives including age, gender, location of birth/education, and age at first immigration to the US. Eight adult of 616 NLDS children with Type 2 Diabetes information were missing age; another 23 were missing information necessary to determine their age at immigration and/or location of education. As such, we derived the following nativity and location of education categories: Birth Location in US (n=339), versus Mexico or Other (n=269); Education Location in US Only (n=364), versus Both US and Abroad/Abroad Only/Uncertain (n=221).

We used a directed acyclic graph to identify the confounders in the minimally sufficient set (Supplemental Figure 2). Given that categories of location of birth (Figure 1A–B) and education (Figure 1C–D) were highly related in our sample and the use of nativity/study-specific thresholds for high educational attainment, we considered location of education instead of place of nativity in our potential adjustment set and explore parental nativity as a potential modifier.

2.3. Statistical analyses

First, we applied a model-based standardization procedure (Roalfe, Holder et al. 2008) to estimate the prevalence of Type 2 Diabetes in parents and their adult children (accounting for familial clustering; adjusting for age, a quadratic term for age, gender and their interactions) based on the 2010 Sacramento County Census (https://factfinder.census.gov) as a reference of the age/gender distribution of the source population aged 50–80 years.

Second, we described the distributions of key covariates and descriptive factors in parents and adult children. Third, we used robust Poisson regression to produce less-biased estimates the prevalence ratios (PRs) of prediabetes, Type 2 Diabetes, treatment and control across intergenerational educational mobility categories accounting for family clustering (Model 0) as part of a generalized estimating equation (Liang and Zeger 1986). Next, we conducted a complete case analysis adjusting for the following covariates in Model 1: age, age^2, gender, and location of education of the adult child and parent, each separately. Additionally, we performed a sensitivity analysis to adjust for adult child, age at immigration (Model 2), defined as <20 years, ≥20 years, or US-born, as shown in Supplemental Figure 2. Missingness of exposure and covariate data did not exceed 10% across all regression models. All regression analyses were implemented as complete case analyses using SAS 9.4 (SAS Institute, Inc., Research Triangle Park, NC).

3. RESULTS

As compared to the adult children in this study, a greater proportion of their parents were born abroad (47% versus 23%), coming first to the US as adults (70% versus 31%; Table 1). Thus, fewer parents than adult children were educated exclusively in the US (60% versus 81%) or attained at least some post-secondary education (26% versus 64%). The increase in post-secondary education across generations was less marked among adult children with US-born parents (39% parents versus 67% adult children) than among adult children with foreign-born parents (11% versus 59%; Supplemental Table 1).

Using our study and nativity-specific educational thresholds, the two most common intergenerational educational mobility categories were stable low (30.2%) and downward mobility (28.6%; Table 1). Fewer adult children had stable high or upwardly mobile intergenerational educational mobility (25.0% or 16.2%). Adult children with a US-born parent (Supplemental Table 1; Figure 1A–B) were less often categorized as having downward mobility or stable low attainment across generations, as compared to adult children with a foreign-born parent. As illustrated in Figure 1A–B, a greater proportion of the adult children with stable high (79.2%) or downward mobility (87.4%) were US-born, as compared to those with stable low (70.5%) or upward mobility (66.7%).

Type 2 Diabetes prevalence was 33% among the Latino parents (age range: 44–101 years), and 24% among their adult children (age range: 18–85 years). Among adult children and parents aged 50–80 years, the age/gender-standardized prevalence of Type 2 Diabetes was more similar: 38% in parents (95% confidence interval, CI: 33–43%) versus 32% in adult children (95% CI: 30–33%). The standardized difference in the mean age of diabetes diagnosis also was similar between parents and their adult children aged 50–80 years: 54 years in parents (95% CI: 50–55 years) versus 55 years in adult children (95% CI: 53–56 years).

Nearly half of all adult children were living with prediabetes or Type 2 Diabetes (Table 1). Among the adult children living with Type 2 Diabetes, 72% reported taking Type 2 Diabetes medications, less than half (47.3%) had glycemic control (defined as HbA_{1c} <7.0%), and less than one-fifth (17.2%) were both treated and controlled.. Figure 2A illustrates that the

burden of prediabetes and Type 2 Diabetes was greatest in those with stable high and stable low educational attainment categories, respectively. Intergenerational educational mobility categories did not appear to significantly strongly pattern prediabetes after accounting for familial clustering (Model 0), but did reveal that Type 2 Diabetes prevalence was lower for adult children with upward mobility compared to stable low educational attainment (PR=0.43, 95% CI: 0.24, 0.76; Table 2). Among the adult children with stable high educational attainment, those with US-born parents appear to have a higher prevalence of prediabetes and lower prevalence of Type 2 Diabetes compared to those with foreign-born parents (Supplemental Figure 3A–B); a similar but far less marked trend with parental nativity arose for adult children with stable low educational attainment across generations.

Figure 2B illustrates how untreated and uncontrolled Type 2 Diabetes, as defined by medication inventories and HbA_{1c} values at examination, was most common in adult children with stable low and downwardly mobile intergenerational educational attainment, respectively. After accounting for family clustering, the prevalence of untreated Type 2 Diabetes was not patterned by educational mobility; whereas the prevalence of uncontrolled Type 2 Diabetes was higher for adult children with downwardly mobile compared to stable low educational attainment (PR=2.54, 95% CI: 1.32, 4.88; Table 2). Adult children of a foreign-born parent had a higher prevalence of Type 2 Diabetes, further classified as either untreated or uncontrolled, across several intergenerational educational categories (Supplemental Figure 3C–D).

After accounting for age, age^2, gender, and location of education of the parent and adult child were included in the model (Model 1 in Table 2), we observed differences in the prevalence of prediabetes for adult children with stable high (PR: 1.58, 95% CI: 1.08, 2.34) and downwardly mobile categories (PR: 1.54, 95% CI: 1.06, 2.23), as compared to stable low educational attainment across generations. Conversely, after accounting for age, age^2, gender, and location or parental and child education we observed a lower Type 2 Diabetes prevalence among adult children with stable high (PR: 0.64, 95% CI: 0.41, 0.99) and upwardly mobile educational attainment (PR: 0.39, 95% CI: 0.22, 0.70). Parental nativity-stratified results showed similar trends across educational attainment categories, with the exception that downward mobility among the children of immigrant parents was associated with a lower prevalence of Type 2 Diabetes (PR: 0.53, 95% CI: 0.29, 0.95; Supplemental Table 2). Additional adjustments for timing of immigration for the adult children did not notably alter our findings for Type 2 Diabetes or prediabetes (results not shown).

In a subsample of 143 adult children living with Type 2 Diabetes, we observed no significant differences in the prevalence of treatment across intergenerational education categories for any of the models (Model 1, Table 2). Yet, adult children with downwardly mobility had worse diabetes control after accounting for age, gender, and location of education (PR: 2.20, 95% CI: 1.13, 4.30, Model 1). Similar, but non-significant trends were observed among the children of immigrant parents (Supplemental Table 2). The magnitude of this association was robust to adjustment for the timing of immigration (results not shown).

4. DISCUSSION

This study is the first, to our knowledge, to use multigenerational-linked cohorts to compare the burden of Type 2 Diabetes across generations of predominantly US-born Mexican American adults and to describe the association between intergenerational educational mobility and Type 2 Diabetes in a cohort of predominantly US-born Mexican-heritage adults. Previous work in this cohort of adult children has only studied quantitative intergenerational patterning of cardiovascular risk factors including fasting blood glucose in the subset of participants who completed the in-home NLDS examination (Whitley, Peralta et al. 2018) or cardiometabolic measures (Crenshaw, Fernandez-Rhodes et al. 2021).

Although we initially observed a lower unadjusted prevalence of Type 2 Diabetes in the adult children than in their parents (24% in adult children, versus 33% in their parents), after age/gender-standardization the prevalence of Type 2 Diabetes were roughly comparable (32%, versus 38%). In spite of the presumably greater access to US health and social welfare programs available to a predominantly US-born cohort (Table 1), Type 2 Diabetes still remains a seemingly intractable problem for the US Latinos in our study. The moderately higher burden of Type 2 Diabetes among Latino parents of our study may relate to their unique birth cohort-related exposures or migration histories.

Adult children with stable low intergenerational educational attainment appear to face a particularly high burden of Type 2 Diabetes. Even though they had the lowest prevalence of prediabetes and uncontrolled Type 2 Diabetes, they had the highest prevalence of Type 2 Diabetes and specifically untreated Type 2 Diabetes, of all educational mobility categories. In contrast, high parental educational attainment was associated with a greater burden of prediabetes, regardless of the level of adult child education. This could indicate that either childhood is a critical period for the epigenetic programming of glycemic dysfunction, or that the use of parental resources in children as an investment in human capital corresponds later in a child's life to better management of prediabetes, or of its progression to Type 2 Diabetes. In fact, we observed prevalence patterns that suggest that adult children with both stable high and low intergenerational educational attainment and a US-born parent may transition from prediabetes to Type 2 Diabetes later in their life course. We anticipate that any potential benefit would diminish with age, as more individuals transition to developing diabetes later in life. Yet, if these cross-sectional observations were to hold true in future longitudinal or experimental studies, delayed transitions to Type 2 Diabetes could benefit public health by both diminishing the number of early onset cases and the long-term complications/weathering of the condition.

Adult children who attained higher levels of education than their peers did also had a lower prevalence of Type 2 Diabetes, which speaks to the importance of an individual's own resources in maintaining health. Among the adult children who achieved a high level of education, those with parents with lower educational attainments experienced the greatest protection against Type 2 Diabetes. It is possible that they may have begun with more favorable glycemic profiles or maintained their health through their own upward mobility, which could in turn afford them access to employment opportunities, better housing quality,

food/housing security, access to health care, and other resources necessary to maintain healthy lifestyles.

Taken together, these findings may suggest that Type 2 Diabetes prevention efforts would be best directed towards Latino children living in families characterized by low levels of parental education, many of whom may also be living near or at the poverty line in the US (Gennetian, Rodrigues et al. 2015). As downward mobility was also associated with a higher prevalence of prediabetes, it appears that this may have been due more preclinical disease in this subgroup. Although high parental educational attainment appears to protect against Type 2 Diabetes in adulthood, once an adult child develops clinical manifestations of Type 2 Diabetes their downward mobility, and the challenges that accompany it, may nonetheless place them at greater risk for poor Type 2 Diabetes management.

Our study's findings may be limited by the fact that educational attainment may not fully capture all aspects of socioeconomic status or mobility. We focus our analyses on educational attainment, instead of other measures of socioeconomic status, as it is less influenced by nativity or age-related changes in occupation, earnings or wealth (Adler and Newman 2002, Laaksonen, Rahkonen et al. 2005). Yet, some adult children in early or mid-adulthood may still have educational aspirations. In particular this may occur for the subset of NLDS adult offspring (n=60) linked to NLDS parents, who were more likely to be younger, US-born and educated than their peers. However, sensitivity analyses excluding the children of these NLDS parents did not change our overall conclusions (data not shown). Furthermore, studying educational attainment across generations allows for easy comparison with previous (Albrecht and Gordon-Larsen 2014, Zeki Al Hazzouri, Haan et al. 2015), or forthcoming studies of Latino populations, as educational data is commonly collected in administrative or health care databases. In addition, promoting higher education may be an actionable public health target and promising lever for addressing Mexican American or Latino health disparities more broadly.

We anticipate that most adult children completed their education in early to mid-life before entering into the period of greatest risk for Type 2 Diabetes (mid to late-adulthood). Yet, we cannot fully rule out the possibility of reverse causation occurring between parental-child education patterns and adult child health (Elovainio, Ferrie et al. 2011). If this were to occur an individual's glycemic health or Type 2 Diabetes risk in adolescence and early adulthood would have to affect their own educational trajectory and eventual attainment. Future work is needed to determine the extent to which the associations between educational mobility and Type 2 Diabetes may be generalized to other Latino communities in the US, or other immigrant groups across the world. Lastly, the manner in which we defined Type 2 Diabetes as being one of four indications (self-reported diagnosis, elevated fasting glucose, elevated HbA_{1c}, or current diabetic medication), precludes exploration of how individuals with prediabetes may be counselled or treated with diabetic medications, such as metformin.

Our current results support previous cross-sectional findings from the SALSA cohort on intergenerational educational attainment and metabolic syndrome or Type 2 Diabetes, which were based on educational reports from SALSA on the grandparents or great-grandparents of NLDS participants (Zeki Al Hazzouri, Haan et al. 2015). They found that parental high

educational attainment protected equally against Type 2 Diabetes regardless of their own parents' level of education (stable high PR=0.63; CI=0.41.0.95; upwardly mobile PR=0.63; CI=0.40, 0.99), but only if their parents were US-born. In our current study of a more recent generation of mainly US-born adult children, we find a similar protection for stable high educational attainment regardless of parental nativity and a greater protection for upwardly mobile adult children, especially for children of immigrant parents. These findings collectively reflect a complex interaction between trajectories of socioeconomic status and health in US Latino families. We conclude that interventions targeting contributors to social inequities in the US (i.e. immigration and social welfare policy, affordability of higher education, etc.) may be powerful targets for reducing the intergenerational patterning and persistence of Type 2 Diabetes in the Latino community.

5. CONCLUSIONS

In light of the current disproportionate burden of low educational attainment and Type 2 Diabetes faced by US Latinos (Schhneider, Martinez et al. 2006, 2016), the strong link between socioeconomic status and Type 2 Diabetes (Agardh, Allebeck et al. 2011), and an increasing climate of marginalization and discrimination of US Latinos (Portes and Zhou 1993, Viruell-Fuentes, Miranda et al. 2012), Latinos are a vulnerable US population. Our findings the Sacramento Area shed light on the complex intergenerational interaction of educational attainment and health dis/advantage across generations of Latino families. These and previous results reinforce the importance of taking an intergenerational-public health perspective to reducing Type 2 Diabetes burden and improving its treatment and control within the Latino community.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

This project would not have been possible without the help of the Aiello Research Group Staff and Anne Lee at the University of California at San Francisco for their assistance with data management and analysis. Additionally, we would like to thank the NLDS phlebotomists, interviewers, and participants for their collaboration in the study.

FUNDING STATEMENT

This work was supported by the National Institute of Diabetes and Digestive and Kidney Diseases, of the National Institutes of Health [R01DK087864]. Additional support for this work came from three other grants from the National Institutes of Health [P60MD002249, R01AG012975, DK60753]. We are grateful to the Carolina Population Center for their training support of Drs. Fernandez-Rhodes, Ward and Martin [T32-HD007168] and for their general support of Drs. Fernandez-Rhodes, Ward, Martin, Gordon-Larsen and Aiello [P2C-HD050924]. Dr. Torres was supported by the National Institute on Aging [K01AG056602].

ABBREVIATIONS

CI	Confidence interval
NLDS	Niños Lifestyle and Diabetes Study
PR	Prevalence Ratio

SALSA	Sacramento Area Latino Study on Aging
US	United States

REFERENCES

Centers for Disease Prevention and Control. (2016). Health, United States, 2015: With Special Feature on Racial and Ethnic Health Disparities, Centers for Disease Prevention and Control.

Adler NE and Newman K. (2002). “Socioeconomic disparities in health: pathways and policies.” Health Aff (Millwood) 21(2): 60–76. [PubMed: 11900187]

Agardh E, Allebeck P, Hallqvist J, Moradi T. and Sidorchuk A. (2011). “Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis.” Int J Epidemiol 40(3): 804–818. [PubMed: 21335614]

Albrecht SS and Gordon-Larsen P. (2014). “Socioeconomic gradients in body mass index (BMI) in US immigrants during the transition to adulthood: examining the roles of parental education and intergenerational educational mobility.” J Epidemiol Community Health 68(9): 842–848. [PubMed: 24847088]

Albrecht SS and Gordon-Larsen P. (2014). “Socioeconomic gradients in body mass index (BMI) in US immigrants during the transition to adulthood: examining the roles of parental education and intergenerational educational mobility.” J Epidemiol Community Health.

American Diabetes Association. (2018). “6. Glycemic Targets: Standards of Medical Care in Diabetes-2018.” Diabetes Care 41(Suppl 1): S55–S64. [PubMed: 29222377]

Asao K, McEwen LN, Lee JM and Herman WH (2015). “Ascertainment of outpatient visits by patients with diabetes: The National Ambulatory Medical Care Survey (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS).” J Diabetes Complications 29(5): 650–658. [PubMed: 25891975]

Balakumar P, Maung UK and Jagadeesh G. (2016). “Prevalence and prevention of cardiovascular disease and diabetes mellitus.” Pharmacol Res 113(Pt A): 600–609. [PubMed: 27697647]

Ben-Shlomo Y. and Kuh D. (2002). “A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives.” Int J Epidemiol 31(2): 285–293. [PubMed: 11980781]

Best LE, Hayward MD and Hidajat MM (2005). “Life course pathways to adult-onset diabetes.” Soc Biol 52(3–4): 94–111. [PubMed: 17619606]

Camelo LV, Giatti L, Duncan BB, Chor D, Griep RH, Schmidt MI and Barreto SM (2016). “Gender differences in cumulative life-course socioeconomic position and social mobility in relation to new onset diabetes in adults-the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil).” Ann Epidemiol 26(12): 858–864 e851.

Case A, Fertig A. and Paxson C. (2005). “The lasting impact of childhood health and circumstance.” J Health Econ 24(2): 365–389. [PubMed: 15721050]

Chaparro MP and Koupil I. (2014). “The impact of parental educational trajectories on their adult offspring’s overweight/obesity status: a study of three generations of Swedish men and women.” Soc Sci Med 120: 199–207. [PubMed: 25259658]

Cheng YJ, Kanaya AM, Araneta MRG, Saydah SH, Kahn HS, Gregg EW, Fujimoto WY and Imperatore G. (2019). “Prevalence of Diabetes by Race and Ethnicity in the United States, 2011–2016.” JAMA 322(24): 2389–2398. [PubMed: 31860047]

Chichlowska KL, Rose KM, Diez-Roux AV, Golden SH, McNeill AM and Heiss G. (2009). “Life course socioeconomic conditions and metabolic syndrome in adults: the Atherosclerosis Risk in Communities (ARIC) Study.” Ann Epidemiol 19(12): 875–883. [PubMed: 19804985]

Crenshaw EG, Fernandez-Rhodes L, Martin CL, Gordon-Larsen P, Haan MN and Aiello AE (2021). “Intergenerational Educational Attainment and Cardiometabolic Health in Latino Individuals Living in the United States.” Obesity (Silver Spring) 29(7): 1178–1185. [PubMed: 34096684]

Elovainio M, Ferrie JE, Singh-Manoux A, Shipley M, Batty GD, Head J, Hamer M, Jokela M, Virtanen M, Brunner E, Marmot MG and Kivimaki M. (2011). “Socioeconomic differences in

cardiometabolic factors: social causation or health-related selection? Evidence from the Whitehall II Cohort Study, 1991–2004." Am J Epidemiol 174(7): 779–789. [PubMed: 21813793]

Everett BG, Rogers RG, Hummer RA and Krueger PM (2011). "Trends in Educational Attainment by Race/Ethnicity, Nativity, and Sex in the United States, 1989–2005." Ethn Racial Stud 34(9): 1543–1566. [PubMed: 22649275]

Gall SL, Abbott-Chapman J, Patton GC, Dwyer T. and Venn A. (2010). "Intergenerational educational mobility is associated with cardiovascular disease risk behaviours in a cohort of young Australian adults: The Childhood Determinants of Adult Health (CDAH) Study." BMC Public Health 10: 55. [PubMed: 20122282]

Gennetian LA, Rodrigues C, Hill HD and Morris P. (2015) "Income Instability in the Lives of Hispanic Children."

Goodman E, McEwen BS, Huang B, Dolan LM and Adler NE (2005). "Social inequalities in biomarkers of cardiovascular risk in adolescence." Psychosom Med 67(1): 9–15. [PubMed: 15673618]

Gustafsson PE, Persson M. and Hammarstrom A. (2011). "Life course origins of the metabolic syndrome in middle-aged women and men: the role of socioeconomic status and metabolic risk factors in adolescence and early adulthood." Ann Epidemiol 21(2): 103–110. [PubMed: 21184951]

Haan MN, Mungas DM, Gonzalez HM, Ortiz TA, Acharya A. and Jagust WJ (2003). "Prevalence of dementia in older latinos: the influence of type 2 diabetes mellitus, stroke and genetic factors." J Am Geriatr Soc 51(2): 169–177. [PubMed: 12558712]

Klijs B, Angelini V, Mierau JO and Smidt N. (2016). "The role of life-course socioeconomic and lifestyle factors in the intergenerational transmission of the metabolic syndrome: results from the LifeLines Cohort Study." Int J Epidemiol 45(4): 1236–1246. [PubMed: 27170762]

Laaksonen M, Rahkonen O, Martikainen P. and Lahelma E. (2005). "Socioeconomic position and self-rated health: the contribution of childhood socioeconomic circumstances, adult socioeconomic status, and material resources." Am J Public Health 95(8): 1403–1409. [PubMed: 16006419]

Langenberg C, Kuh D, Wadsworth ME, Brunner E. and Hardy R. (2006). "Social circumstances and education: life course origins of social inequalities in metabolic risk in a prospective national birth cohort." Am J Public Health 96(12): 2216–2221. [PubMed: 17077402]

Liang K-Y and Zeger SL (1986). "Longitudinal data analysis using generalized linear models." Biometrika 73: 13–22.

Lorenzo C, Williams K, Hunt KJ and Haffner SM (2006). "Trend in the prevalence of the metabolic syndrome and its impact on cardiovascular disease incidence: the San Antonio Heart Study." Diabetes Care 29(3): 625–630. [PubMed: 16505517]

Lynch J. and Smith GD (2005). "A life course approach to chronic disease epidemiology." Annu Rev Public Health 26: 1–35. [PubMed: 15760279]

Papademetriou DG, Sumption M. and Somerville W. (2009). The Social Mobility of Immigrants and Their Children, The Migration Policy Institute.

Portes A. and Zhou M. (1993). "The New Second Generation: Segmented Assimilation and its Variants." Ann Am Acad Pol Soc Sci 530: 74–96.

Roalfe AK, Holder RL and Wilson S. (2008). "Standardisation of rates using logistic regression: a comparison with the direct method." BMC Health Serv Res 8: 275. [PubMed: 19113996]

Schhneider B, Martinez S. and Ownes A. (2006). Barriers to Educational Opportunities for Hispanics in the United States. Hispanics and the Future of America. Tienda M and Mitchell F Washington (DC), National Academic Press (US).

Schneiderman N, Llabre M, Cowie CC, Barnhart J, Carnethon M, Gallo LC, Giachello AL, Heiss G, Kaplan RC, LaVange LM, Teng Y, Villa-Caballero L. and Aviles-Santa ML (2014). "Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)." Diabetes Care 37(8): 2233–2239. [PubMed: 25061138]

Stepler R. and Brown A. (2016). Statistical Portrait of Hispanics in the United States, PewResearchCenter.

Vega WA, Rodriguez MA and Gruskin E. (2009). "Health disparities in the Latino population." Epidemiol Rev 31: 99–112. [PubMed: 19713270]

Viruell-Fuentes EA, Miranda PY and Abdulrahim S. (2012). “More than culture: structural racism, intersectionality theory, and immigrant health.” Soc Sci Med 75(2099–106).

Ward JB, Haan MN, Garcia ME, Lee A, To TM and Aiello AE (2016). “Intergenerational education mobility and depressive symptoms in a population of Mexican origin.” Ann Epidemiol 26(7): 461–466. [PubMed: 27346705]

Whitley JC, Peralta CA, Haan M, Aiello AE, Lee A, Ward J, Zeki Al Hazzouri A, Neuhaus J, Moyce S. and Lopez L. (2018). “The association of parental and offspring educational attainment with systolic blood pressure, fasting blood glucose and waist circumference in Latino adults.” Obes Sci Pract 4(6): 582–590. [PubMed: 30574351]

Zeki Al Hazzouri A, Haan MN, Kalbfleisch JD, Galea S, Lisabeth LD and Aiello AE (2011). “Life-course socioeconomic position and incidence of dementia and cognitive impairment without dementia in older Mexican Americans: results from the Sacramento area Latino study on aging.” Am J Epidemiol 173(10): 1148–1158. [PubMed: 21430188]

Zeki Al Hazzouri A, Haan MN, Robinson WR, Gordon-Larsen P, Garcia L, Clayton E. and Aiello AE (2015). “Associations of intergenerational education with metabolic health in U.S. Latinos.” Obesity (Silver Spring) 23(5): 1097–1104. [PubMed: 25809593]

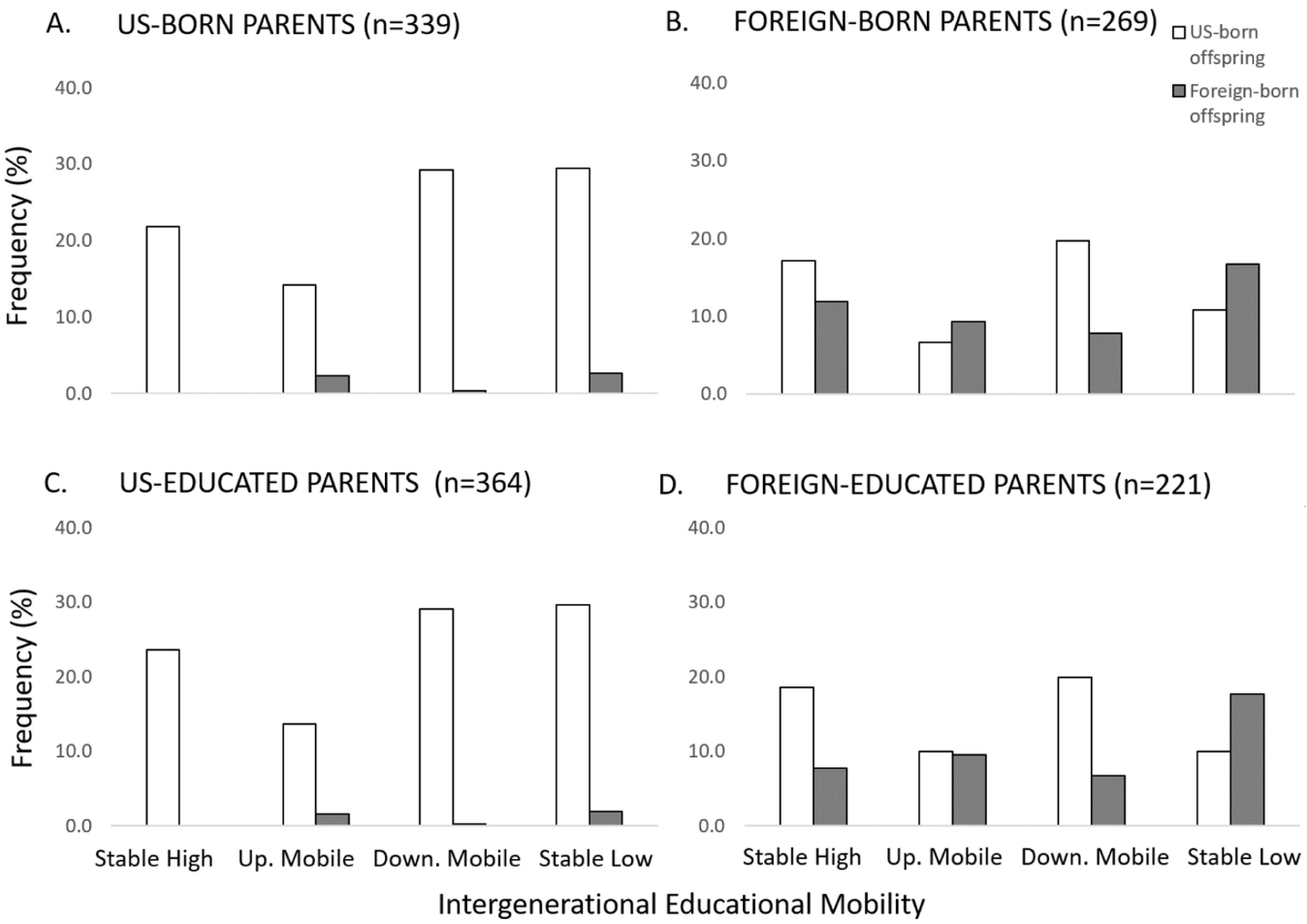

Figure 1.

Distribution of Intergenerational Educational Mobility Categories among Adult Children by Their Location of Birthand Either Their Linked Parent's Location of Birth [Panel A: United States (US)-Born; B: Foreign-Born] and Their Linked Parent's Location of Education (Panel C: US-Educated only; D: Foreign-Educated only, Foreign-Educated Mixed with US-educated, or Location Uncertain) among 608 Adult Children of the Niños Lifestyle and Diabetes Study with Information on their Prediabetes/Type 2 Diabetes Status, Age and Gender

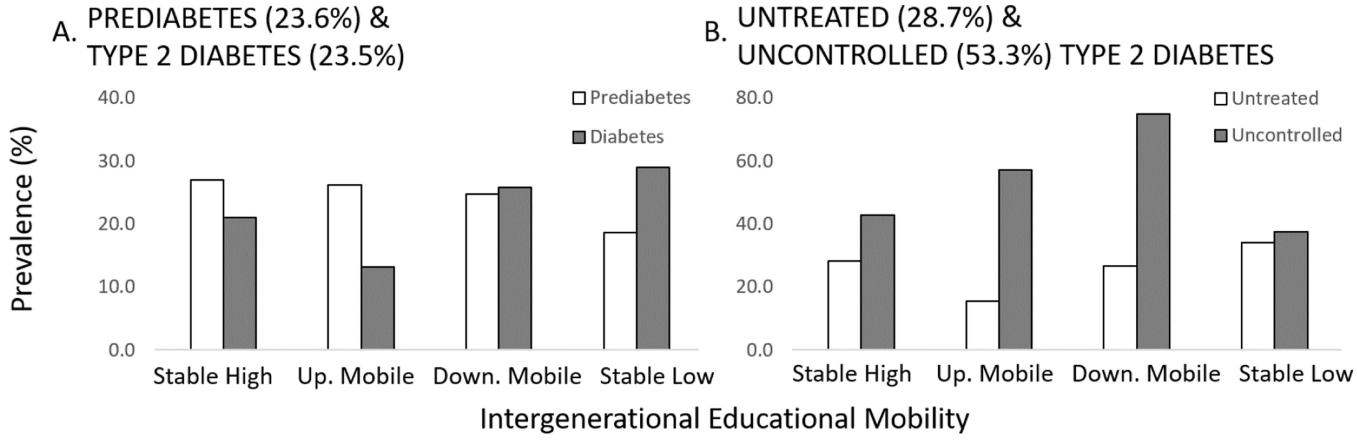

Figure 2.

Unadjusted Prevalence of Prediabetes and Type 2 Diabetes (Panel A; Based on 144 Prediabetic and 143 Individuals Living with Type 2 Diabetes / 608 Totaland Proportion Untreated with Medications or Uncontrolled Type 2 Diabetes as Indicated by Having a Percent Glycosylated Hemoglobin ≥7.0% (Panel B; Based on 41 Untreated / 143 Total with Medication Status and 49 Uncontrolled / 92 Total with Measured Glycosylated Hemoglobin) by Intergenerational Educational Mobility Categories among the 608 Adult Children of the Niños Lifestyle and Diabetes Study with Information on Age and Gender (2013–2014)

Table 1.

Descriptive Characteristics of Sacramento Area Latino Study of Aging (SALSA n=361 from 1998–1999) or Niños Lifestyle and Diabetes Study Parents (NLDS, n=38 from 2013–2014) Linked to at Least One Adult Child in NLDS (n=616) with Intergenerational Educational Mobility and Type 2 Diabetes Status at Examination

SALSA and NLDS Parents		**N**	**Mean± SD or %**
Covariates	Age (years)	399	69.3±8.1
	Gender	399	
	Male		37.6
	Female		62.4
	Country of Birth[1]	399	
	United States		52.6
	Other		5.3
	Mexico		42.1
	Time at Migration[1]	174	
	Childhood (<20 years)		29.9
	Adulthood (≥20 years)		70.1
	Country of Education	383	
	United States		59.3
	Both/uncertain		2.9
	Mexico		37.9
Socioeconomic	Educational Attainment (years)[2]	399	
Position	0–4		24.3
	5–10		33.8
	11–12		16.8
	13–14		13.0
	≥15		12.0
NLDS Adult Children			
Covariates	Age (years)	608	52.9±11.7
	Gender	616	
	Male		38.3
	Female		61.7
	Country of Birth[3]	616	
	United States		76.6
	Other		3.1
	Mexico		20.3
	Time at Migration[3]	142	
	Childhood (<20 years)		69.0
	Adulthood (≥20 years)		31.0

SALSA and NLDS Parents		N	Mean± SD or %
	Country of Education	608	
	United States		81.3
	Both/Uncertain		9.5
	Mexico		9.2
Socioeconomic	Educational Attainment (years)[2]	616	
Position	0–4		2.1
	5–10		8.8
	11–12		25.6
	13–14		27.3
	≥15		36.2
	Intergenerational Educational Mobility[2]	616	
	Stable High		25.0
	Upwardly Mobile		16.2
	Downwardly Mobile		28.6
	Stable Low		30.2
Health Outcome	Type 2 Diabetes	616	
	Normal Glucose Regulation		53.3
	Pre-Diabetic[4]		23.4
	Diabetic[5]	144	23.4
	% Treated with Medications		71.5
	% Controlled		47.3

Abbreviations: HbA1c=Percent Glycosylated Hemoglobin, SD=Standard deviations

[1]Overall 210 SALSA and NLDS parents were born in the US. Among the 186 foreign-born parents, 171 (92%) also had information about their time at migration to the US.

[2]High educational attainment was defined as being above the median years of educational attainment by nativity of SALSA parents (>4 years in foreign-born, >10 years in US-born), and nativity of their NLDS adult children (>12 years in foreign-born, >14 years in US-born).

[3]Overall 474 adult children were born in the US. Among the 144 foreign-born adult children, 142 (99%) also had information about their time at migration to the US.

[4]Pre-diabetes was defined as having either a HbA1c level 5.7–6.4% or a fasting glucose level 100–125 mg/dL, without a previous T2D diagnosis and use of anti-diabetic medications at examination as based on the National Hospital Ambulatory Medical Care Survey therapeutic class of anti-diabetic drugs.

[5]We defined type 2 diabetes using the following: HbA1c level ≥6.5%, fasting glucose level >125 mg/dl, self-report of a physician diagnosis of T2D or ‘high blood sugar’, or use of T2D-related medication(s).

Among individuals living with Type 2 diabetes, we defined treated as taking anti-diabetic medications and control as having a HbA1c<7.0% at examination, which has been described as a reasonable goal of glycemic control from the American Diabetes Association.

Table 2.

Prevalence Ratios (and 95% Confidence Intervals) of Prediabetes and Type 2 Diabetes in up to 616 Adult Children from the Niños Lifestyle and Diabetes Study (2013–2014) across Categories of Intergenerational Educational Attainment

Intergenerational Educational Attainment Category (Model 0/1 Sample Size)	Model 0[1]	Model 1[2]
	Prediabetes[3]	
Stable High (n=122/115)	1.33 (0.91, 1.94)	**1.58 (1.08, 2.34)**
Upwardly Mobile (n=87/86)	1.15 (0.75, 1.78)	1.31 (0.86, 2.01)
Downwardly Mobile (n=132/123)	1.29 (0.89, 1.86)	**1.54 (1.06, 2.23)**
Stable Low (n=131/123)	1 (ref)	1 (ref)
	Type 2 Diabetes[4]	
Stable High (n=154/144)	0.71 (0.47, 1.05)	**0.64 (0.41, 0.99)**
Upwardly Mobile (n= 100/99)	**0.43 (0.24, 0.76)**	**0.39 (0.22, 0.70)**
Downwardly Mobile (n=176/166)	0.86 (0.62, 1.20)	0.81 (0.57, 1.17)
Stable Low (n=186/176)	1 (ref)	1 (ref)
	Untreated Type 2 Diabetes[4]	
Stable high (n=32/29)	0.95 (0.70, 1.28)	0.88 (0.65, 1.20)
Upwardly mobile (n=13/13)	0.81 (0.61, 1.09)	0.79 (0.58, 1.07)
Downwardly mobile (n=45/43)	0.90 (0.69, 1.17)	0.90 (0.68, 1.20)
Stable low (n=54/53)	1 (ref)	1 (ref)
	Uncontrolled Type 2 Diabetes[5]	
Stable high (n=21/18)	1.14 (0.77, 1.70)	1.04 (0.66, 1.64)
Upwardly mobile (n=7/7)	1.46 (0.60, 3.56)	1.38 (0.60, 3.17)
Downwardly mobile (n=32/31)	**2.54 (1.32, 4.88)**	**2.20 (1.13, 4.30)**
Stable low (n=33/32)	1 (ref)	1 (ref)

Prevalence ratios (and 95% confidence intervals) in bold to a P<0.05.

[1]Adjusted for clustering within families.

[2]Adjusted for age, age^2, gender, location of offspring and parental education, and clustering within families.

[3]Pre-diabetes was defined as having either a HbA1c level 5.7–6.4% or a fasting glucose level 100–125 mg/dL, without a previous T2D diagnosis and use of anti-diabetic medications at examination as based on the National Hospital Ambulatory Medical Care Survey therapeutic class of anti-diabetic drugs.

[4]We defined type 2 diabetes as any of the following: HbA1c level ≥6.5%, fasting glucose level >125 mg/dl, self-report of a physician diagnosis of T2D or 'high blood sugar', or use of T2D-related medication(s). Among individuals living with Type 2 diabetes, we further defined treated as taking anti-diabetic medications as based on the National Hospital Ambulatory Medical Care Survey therapeutic class of anti-diabetic drugs.

[5]Among individuals living with Type 2 diabetes, we defined control as having a HbA1c<7.0% at examination, which has been described as a reasonable goal of glycemic control from the American Diabetes Association.