Timing of Neighborhood Exposure and Type II Diabetes Risk:
A Developmental Analysis using the Utah Population Database

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Abstract

Available research demonstrates substantial intergenerational transmission of diabetes mellitus (DM) risk from parents to offspring, especially from genetic factors. However, there is less information about how family risk combines with neighborhood risk to influence the risk of Type II Diabetes (T2DM). Using data from the Utah Population Database (UPDB), we employ a life-course perspective to model the influence of neighborhood socioeconomic status and family risk of diabetes on the hazard rate of T2DM diagnosis. The UPDB is an unparalleled research resource: it contains longitudinal demographic, genealogical, and medical/clinical information on nearly the entire Utah population, both historic and contemporary. The objective of this paper is to explore the impact of key developmental periods of exposure to neighborhood conditions on T2DM risk. Neighborhood social environment can potentially break the intergenerational transmission of T2DM risk. Using discrete-time hazard rate models, we examine the effects of neighborhood socioeconomic status (NSES) on the hazard of T2DM diagnosis. Preliminary results indicate that the influence of NSES on T2DM risk varies along a continuum of exposure.

Introduction

Type II Diabetes (T2DM) presents a significant and growing global healthcare burden. There is increasing recognition of the prevalence of T2DM at earlier ages in the United States· Diabetes in young people has long been considered to be a reflection of Type 1 diabetes [1]. It was unusual to see T2DM in adolescents and younger adults, but this pattern changed starting in the late 1990s, when adolescent cases accounted for up to 45% of newly diagnosed cases. The CDC recently reported that, among children and adolescents during 2014–2015, the estimated number of newly diagnosed cases in the US was nearly 6,000 among those ages 10 to 19 years [2]. This level of risk, in part, reflects a significant increase in T2DM risk among adolescents from 2002 to 2015. Changes in T2DM incidence were observed across most racial and ethnic groups. In particular, the T2DM incidence rates, while stable among non-Hispanic whites, increased for all others, especially non-Hispanic blacks. Lawrence and colleagues2 used data from Kaiser Permanente to study T2DM trends and reported that the prevalence increased by 3.6% between 2001 and 2009, then by 2.5% between 2009 and 2017, among teens ages 15-19. Among young and middle-aged adults aged 20 to 44, there are similar trends in T2DM. Aggarwal and colleagues[3] used data from the National Health and Nutrition Examination Survey (NHANES) to examine, among several cardiovascular risk factors, the prevalence of diabetes (types 1 and 2) among adults aged 20 to 44 years from 2009 to 2020. They concluded that for the US, among men and women, diabetes increased among young and middle-aged adults during this period, where diabetes cases were identified via HbA1c from a non-fasting NHANES laboratory measurement. These authors report that for these adults, the prevalence of diabetes rose from 3.0% to 4.1% (a 37% increase) between 2009-2010 and 2017-2020. In general, the risk of T2DM has been rising in the US, and it is essential to consider how neighborhoods may help prevent diabetes among younger cohorts.

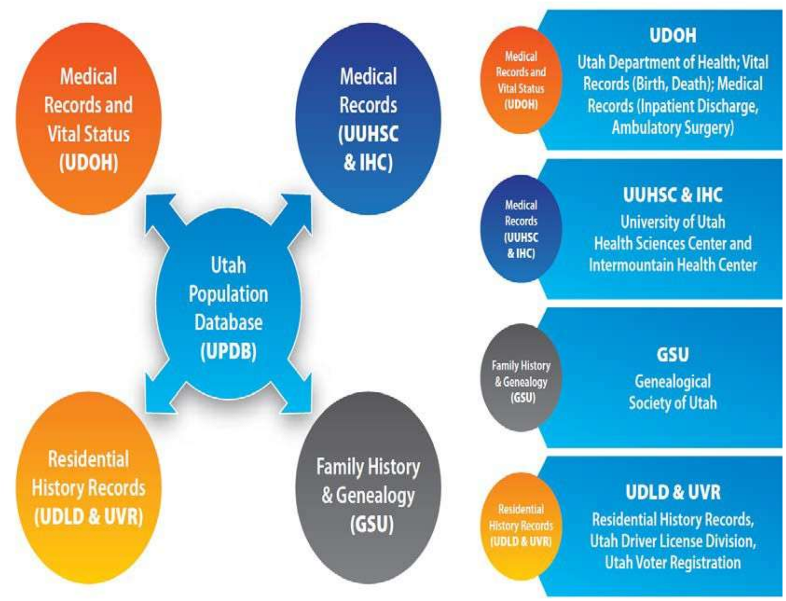
Yet, it is possible to prevent, delay, or ameliorate T2DM risks through improvements in diet and exercise, as a recent meta-analysis indicated. Increases in physical activity, even with modest weight reductions, can help prevent progression to T2DM [4,5], as demonstrated by the Diabetes Prevention Program (DPP), which showed a 58% reduction in risk with lifestyle interventions over 3 years. Further, lower T2DM risk is associated with neighborhoods designed to support physical activity[5-9] and with healthy food choices[9-11], as is often the case in high-socioeconomic-status neighborhoods[12,13]. Additionally, the effects of family history on T2DM are also well recognized.

Neighborhood socioeconomic status (NSES) has been linked to T2DM in several studies. [14,15]. Several mechanisms have been suggested, including the idea that low NSES promotes an environment that does not support positive health behaviors, increases stress levels leading to poor physical health outcomes, and may be a marker of a lack of institutional resources that encourage health access. [16] This evidence relies disproportionately on cross-sectional studies both in the United States and in Europe[17-20]. Relatively few studies have used a longitudinal lens to examine how neighborhoods contribute to increased diabetes incidence. Some exceptions include randomized assignment to low-poverty neighborhoods in both the United States[13] and Denmark[21]. Recent reviews have stressed the critical need for longitudinal observational studies linking multiple observations of neighborhoods' socioeconomic status and T2DM.[15]

The life course perspective provides a framework for exploring the complex predictors of T2DM risk[22]. Most medical investigations into T2DM fail to adequately emphasize the effects of time[23], which, by contrast, is central to the life-course framework and to our study. Although some studies explicitly call for a life-course approach to understanding diabetes risk[7], few include dynamic measures of individual, familial, and neighborhood environments. Exposure to neighborhoods may be particularly adverse at certain ages, such as during childhood and adolescence, and therefore, sensitive periods of exposure need to be considered. The life course framework helps identify both developmental and social-ecological variables that can vary over time and, when examined together, provide novel insights into the constellation of factors that affect health across the lifespan.[11]

Methods

Data for this study come from the Utah Population Database (UPDB), a unique research resource that contains longitudinal, individual-level information from demographic, genealogical, residential, and medical data sources for nearly the entire Utah population, both historic and contemporary. The UPDB is considered one of the largest and most comprehensive databases of its kind in the world, supporting hundreds of research projects. These data are linked across a range of high-quality, statewide databases, including Utah's vital records (birth and death certificates), Utah's driver's license database (including height and weight information), and Utah Healthcare Facility data (including diagnosis codes). The use of this resource has been approved by the University of Utah Institutional Review Board (IRB) for this study, as well as by the Genetic and Epidemiologic Research (RGE), a regulatory body overseeing access to UPDB. More information about this unparalleled population data is depicted in the figure below.



Individuals in UPDB were selected for analysis based on several criteria. Specifically, they: (1) were born between 1970 and 1990, (2) had residential data for 1990 and 2000, and (3) resided in the four Utah urban counties comprising the Wasatch Front in 2010[1].

Data capturing neighborhood features were measured at the census block group level, geocoded in ArcGIS, and assigned to the appropriate block groups using Federal Information Processing System (FIPS) codes. We use a composite measure to operationalize neighborhood socioeconomic status.

Neighborhood socioeconomic status. To measure SES, we included the measures described in the table below. These tract-level measures came from the 1990 and 2000 decennial censuses and the American Community Survey 2006-2010 five-year estimates, with data downloaded from NGHIS. Similar indicators have been used in other multiple-item neighborhood-level SES composites [24].

[1] The Wasatch Front consists of Davis, Salt Lake, Utah, and Weber Counties where approximately 75% of the state's population resides.

Table 1. Components of Neighborhood Socioeconomic Status	
Income	Per capita income for persons at least 15 years old
Poverty	Population in households at or below 150% of the federal poverty level; reverse-scored);
Homeownership	The rate of homeownership in the census tract
Education	The percentage of adults aged at least 25 years old with less than a high school diploma (reverse-scored
	The percentage of adults aged at least 25 years old with a four-year college degree.

Family history of diabetes. We ascertain T2DM family history by linking medical records to the individual's relatives. This allows us to determine patterns of diabetes among a person's relatives, including first-, second, and third-degree relatives. We use this to provide summary measures of familial risk using the familial standardized incidence rate (FSIR) for diabetes.

Comorbidities. We used a modified 15-item version of the Charlson Comorbidity Index that weights specific diseases based on mortality risk and sums these weights after removing diabetes from the index [25]. Disease diagnoses came from the same health data sources as T2DM and have been used in our prior work[26,27].

Ever diagnosed with T2DM. Two data sources from the UPDB are used to determine whether a person has ever been diagnosed with T2DM by age 30. First, we draw data from the Utah Inpatient Discharge Data (N=5 million events, 1996–2017). Second, we utilize data from the Utah Statewide Ambulatory Surgery Data (N=5.3 million events, 1996–2017). These data contain diagnosis and procedure codes and external injury E-codes. These records are used to create individual health histories.

Modeling strategy. Using discrete-time hazard-rate modeling techniques, data are analyzed in a person-year framework, in which having T2DM depends on neighborhood conditions and family history. Controls include birth year, education, gender, and race/ethnicity. To capture changes in the neighborhood conditions, we are guided by research focusing on neighborhood economic trajectories in the Netherlands [28]. The exposure of interest is the neighborhood's socioeconomic trajectory. To construct the trajectories, we first created cross-sectional measures of neighborhood SES (NSES) by categorizing NSES into Stable Low (the lowest tertile) and Stable High (the highest tertile) at the census tract level. Then, by comparing two consecutive cross-sectional NSES measures from 1990 and 2000, the neighborhoods were categorized into four NSES trajectories: 1) Stable High, 2) Declining to Low, 3) Improving to High, and 4) Stable Low.

Preliminary results

Table 1 presents descriptive statistics for the sample. Among individuals who were children in 1990 (aged 0–10, N=139,564), approximately 23 percent lived in stable, high NSES neighborhoods from 1990 to 2000. Slightly fewer (18%) lived in stable, low NSES neighborhoods. Among individuals who were adolescents in 1990 (age 11-17, N = 72,122), fewer lived in stable, high-NSES neighborhoods. Adolescents residing in stable, low-NSES neighborhoods accounted for a relatively similar percentage (18%). Among those who were young adults in 1990 (aged 18 to 20, N = 24,622), even smaller percentages (12%) lived in stable, high NSES neighborhoods. Those individuals living in stable, low-SES neighborhoods were consistent with the child and adolescent subsamples (18%).

Table 2 and Figure 1 present results from Cox proportional hazards models. For those individuals who were children in 1990, any combination of being in a high NSES neighborhood is associated with a lower risk of a T2DM diagnosis. For those who were adolescents in 1990, residing in a consistently high NSES neighborhood is associated with a lower risk of T2DM, while living in a consistently low NSES neighborhood is associated with a higher risk of T2DM. For young adults in 1990, moving to a higher NSES neighborhood is associated with a lower risk of T2DM, whereas remaining in a consistently low NSES neighborhood is associated with an increased risk.

Discussion.

Though preliminary, these results are poised to add to the literature on risk by affording a longitudinal lens on the connections between neighborhood socioeconomic status and T2DM risk. Further, the focus on exposure periods in childhood, adolescence, and young adulthood nuances what is known about the critical time points for social interventions to prevent the development of diabetes.

Table 1. Descriptive statistics

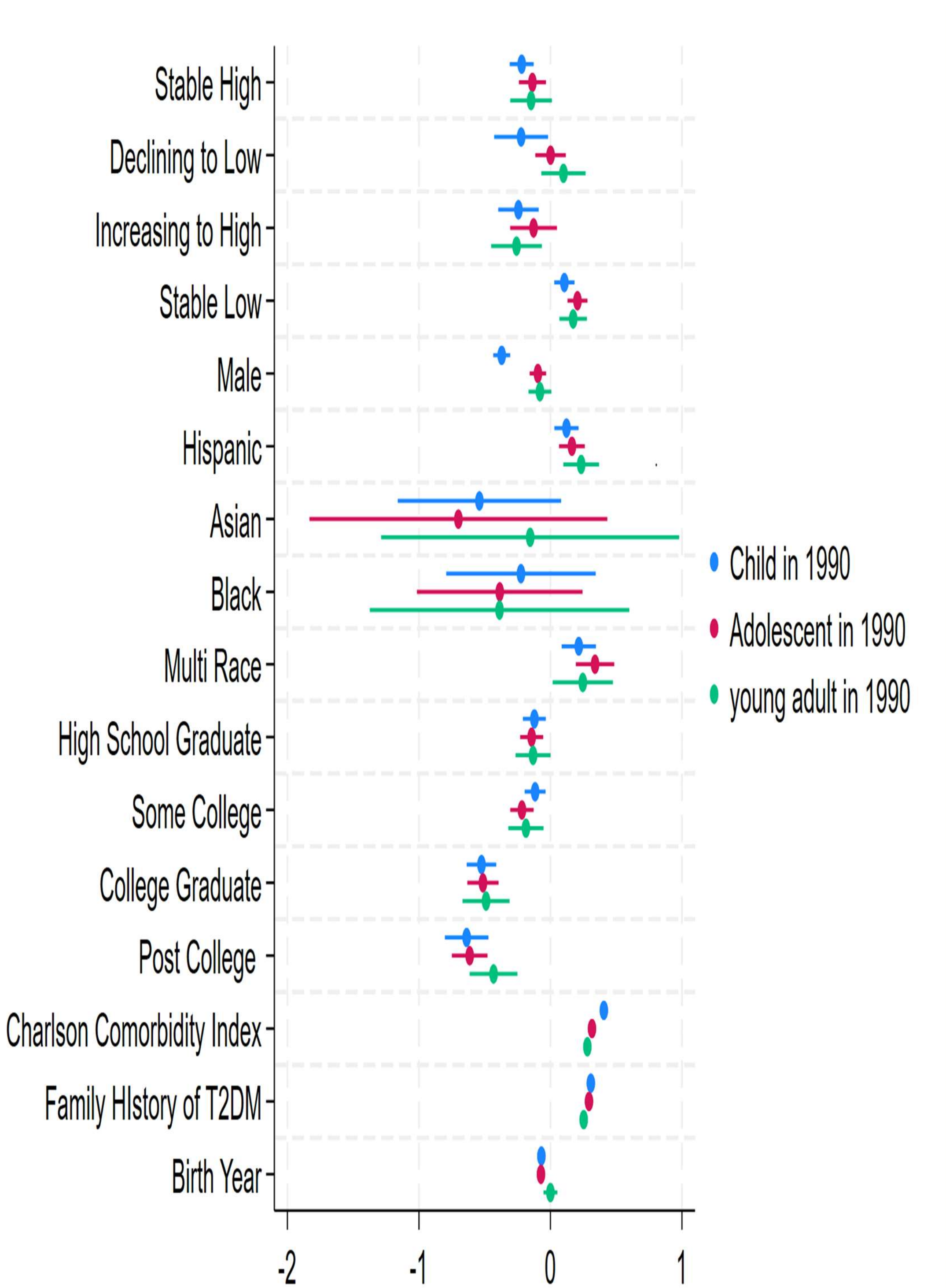
Variable	Percent			
	All N = 236,320	Child in 1990 N = 139,564	Adolescent in 1990 N = 72,122	Young Adult in 1990 N = 24,622
T2DM diagnosis	.04	.03	.06	.09
SES				
Stable High	.20	.23	.17	.12
Declining to Low	.05	.03	.10	.07
Improving to High	.05	.06	.04	.08
Stable Low	.18	.18	.18	.19
Reference category tertiles	.51	.50	.53	.54
Cohort				
Child in 1990	.59			
Adolescent in 1990	.31			
Young Adult in 990	.10			
Birth Year	1980.7	1984.8	1976.3	1970.9
Male	.51	.52	.49	.47
Race/ethnicity				
Non-Hispanic (NH) White	.88	.87	.91	.91
Hispanic, any race	.08	.09	.07	.07
NH Asian	.003	.004	.002	.002
NH Black	.002	.003	.001	.002
NH Multiracial	.03	.03	.02	.02
Race Unknown	.0004	.0001	.0004	.002
Latest Educational Attainment				
No high school diploma	.04	.04	.04	.04
High school diploma	.20	.16	.24	.28
Some college, no degree	.28	.26	.30	.32
Four-year college degree	.16	.17	.16	.14
Graduate/professional degree	.09	.07	.12	.13
Unknown	.23	.30	.13	.08
Family history of T2DM	.86	.81	.90	1.01
Charlson Comorbidity Index (CCI)	.47	.40	.54	.72

Table 2. Cox proportional Hazards model results for Type 2 Diabetes (T2DM)

Variable	Child in 1990 HR [95% CI]	Adolescent in 1990 HR [95% CI]	Young Adult in 1990 HR [95% CI]
NSES			
Stable High	**.80 [.73, .88]**	**.87 [.79, .97]**	.86 [.74, 1.01}
Declining to Low	**.80 [.65, .98]**	1.00 [.89, 1.12]	1.10 [.93, 1.30]
Improving to High	**.78 [.67, .91]**	.88 [.74, 1.05]	**.77 [.64, .94]**
Stable Low	**1.11 [1.03, 1.20]**	**1.22 [1.14, 1.33]**	**1.19 [1.07,1.32]**
Birth Year	**.93 [.92, .95]**	**.93 [.92, .94]**	1.00 [.95, 1.05]
Male	**.69 [.65,.74**	**.91 [.85, .97]**	.92 [.85, 1.01]
Race/ethnicity			
Hispanic, any race	**1.13 [1.03, .1.24]**	**1.18 [1.07, .1.30]**	**1.26 [1.10, .1.45]**
NH Asian	.58 [.31, 1.08]	.50 [.16, 1.54]	.86 [.28 2.66]
NH Black	.80 [.45, 1.41]	.68 [.36, 1.28]	.68 [.26, 1.82]
NH Multiracial (Non-Hispanic (NH) White, ref group)	**1.24 [1.09, .1.41]**	**1.40 [1.21, .1.62]**	**1.28 [1.02, .1.61]**
Latest Educational Attainment			
High school diploma	**.88 [.79, .94]**	**.87 [.79, .95]**	**.88 [.77, 1.00]**
Some college, no degree	**.89 [.82, .96]**	**.81 [.74, .88]**	**.83 [.73, .95]**
Four-year college degree	**.59 [.53, .66]**	**.60 [.53, .67]**	**.61 [.51, .73]**
Graduate/professional degree (No high school diploma ref group)	**.53 [.45, .62]**	**.54 [.47, .62]**	**.65 [.54, .79]**
Charlson Comorbidity Index (CCI)	**1.50 [1.48, 1.52]**	**1.37 [1.35, 1.39]**	**1.32 [1.30, 1.35]**
Family history of T2DM	**1.36 [1.33, 1.39]**	**1.34 [1.31, 1.37]**	**1.29 [1.26, 1.32]**

Note: The reference group for neighborhood SES comprises individuals in the top or bottom tertiles.

Figure 2. Estimates of NSES across developmental age groups



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