SSM - Population Health 4 (2018) 189–196

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Investigating the Early Life Determinants of Type-II Diabetes Using a Project Talent-Medicare Linked Data-set

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ARTICLE INFO

Keywords:
diabetes
life-cycle
socioeconomic status
early-life predictors of disease
personality and cognitive ability

ABSTRACT

The increasing prevalence of Type II Diabetes (T2D) presents a serious health and financial public crisis. Our study examines the hypothesis that adolescents' perceptions of economic insecurity, along with absolute and relative socioeconomic status (SES), can contribute to T2D prevalence later in life. Project Talent (PT) Survey data, collected on high school students in 1960, have been linked to Medicare records from 2012, presenting a unique opportunity to examine measures gathered in adolescence and T2D prevalence later-in-life among a large, national, and diverse sample (n = 88,849). Our results provide compelling evidence that real, perceived, and relative SES in adolescence have persistent impacts on later-in-life diabetes risk, even when controlling for possible confounders such as cognitive ability, conscientiousness, and early-adulthood educational attainment.

Introduction

The prevalence of Type II Diabetes (T2D) is on the rise, increasing from 18.8M in 2010 (CDC, 2012b) to 30.3M in 2015 (CDC, 2017). As of 2012, 28% of Medicare enrollees had a formal diagnosis of diabetes (CDC, 2012a). Previous research has largely attributed the T2D epidemic to individual behaviors, such as sedentary lifestyle and poor diet (Kelly & Ismail, 2015; Volaco, Cavalcanti & Filho RP1, 2017). Unfortunately, very few interventions focusing on behavior modification alone have resulted in clinically meaningful differences in patient outcomes (Yoon et al., 2013). It is possible that existing interventions fail to address underlying environmental and psycho-social risk factors for diabetes (Chen & Paterson, 2006; Jiang, Ma, Wang & Liu, 2013; Kelly & Ismail, 2015; Lidfeldt, Li, Hu, Manson & Kawachi, 2007).

The incidence and prevalence of T2D has risen particularly among those with low socioeconomic status (SES) and racial/ethnic minorities (CDC, 2017). Because there are lifestyle risk factors associated with T2D (e.g., Connolly, Unwin, Sherriff, Bilous & Kelly, 2000), and because lifestyles do differ between demographic groups (Jokela, Elovainio, Nyberg, Tabák, Hintsa & Batty, 2014; Kivimäki, Virtanen, Kawachi, Nyberg, Alfredsson & Batty, 2015), these disparities have often been attributed to behaviors (Kelly & Ismail, 2015). However controlling for these factors does not fully attenuate the relationship between SES and T2D (Jiang et al., 2013). In addition, SES-group lifestyle differences alone do not provide a compelling explanation for why economic hardship is particularly damaging when experienced by children (Stringhini, Batty, Bovet, Shipley, Marmot & Kumari, 2013), with health effects persisting into adulthood even when controlling for adult SES (Pikhartova et al., 2014; Tversky & Kahneman, 1992).

The Project Talent (PT) Study linked to Medicare claims and utilization data provides a unique opportunity to examine many of these frequently unobserved early-life psycho-social and environmental characteristics for nearly 90,000 Medicare beneficiaries in their late 60s and early 70s. We explore the role that stress produced by low economic status in adolescence may have on later-in-lifeT2D risk after a 50-year follow-up period, while controlling for a variety of other possible explanations. Accordingly, we examine the impact of objective, relative, and perceived SES, as well as individual characteristics such as cognitive ability and personality on the prevalence of later-in-life T2D.

Literature Review

Psycho-social precursors to T2D

Kelly and Ismail (2015) provide an extensive review of the growing literature regarding the impact that stress caused by psycho-social factors can have on T2D risk. They summarize the evidence for stress from low SES in adulthood (Agardh, Allebeck, Hallqvist, Moradi & Sidorchuk, 2011), low SES in childhood (Tamayo et al., 2010), racial /

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https://doi.org/10.1016/j.ssmph.2018.01.004
Received 18 July 2017; Received in revised form 25 December 2017; Accepted 23 January 2018

ethnic minority status (Robbins, Vaccarino, Zhang & Kasl, 2001), traumatic experiences (Björntorp, 2001; Pouwer et al., 2010), and post-traumatic stress disorder (Alastalo, Räikkönen, Pesonen, Osmond, Barker & Kajantie, 2009). This research line extends results from animal studies, showing that recurrent stress creates chronic inflammation, followed by metabolic disorders, obesity, and T2D (Black, 2003). Kelly and Ismail conclude that T2D prevention research should focus on psychosocial precursors to T2D including social disparities.

Individual experiences may affect the degree to which life-events are interpreted as stressful (Cohen et al., 1995); indeed there are differences in how subjective experiences can influence people's health through physiological mechanisms such as the speed of cells' aging (Epel, Lin, Wilhelm, Wolkowitz, Cawthon & Adler, 2006). Therefore, it is surprising that Kelly and Ismail (2015) describe only two longitudinal studies examining how self-reported well-being affects diabetes risk and the results did not provide compelling evidence (Kato, Noda, Inoue, Kadowaki & Tsugane, 2009; Strodl & Kenardy, 2006). As Kelly and Ismail remark, objective stress is the better understood predictor of T2D (2015, p. 452).

Data limitations in existing studies may account for Kelly and Ismail's (2015) conclusion that subjective stress is not an important predictor of T2D. In their table describing the variables, samples, and follow-up periods of datasets currently in use, most large datasets rely on clinical or medical record data only and do not include subjective experiences (e.g., the Netherlands Medical Practice Database; N = 68,004; 25 year follow-up). Among the databases with self-reported data, several are relatively small and limited in sample scope (e.g., the Baltimore Epidemiologic Catchment Area Study; N = 1,070; 23 year follow-up) or have short follow-up periods (e.g., the Australian Women's Health Survey; N = 8,896; 3 year follow-up). There are three exceptions. First, the Japanese Public Health Center-Based Prospective Study (N = 55,826; 10 year follow-up) includes some general items on subjective stress (e.g., "How much stress do you feel in your daily life?") and measures Type A personality; Kato et al (2009) find that subjective stress increases the risk of T2D, particularly among adult men. Next, investigators using the UK-based Whitehall II study (N = 7,237; 14 years) show compelling evidence that T2D associates with work-stress (Chandola et al., 2006; Heraclides, Chandola, Witte & Brunner, 2012),clinical depression, and anxiety (Virtanen, Ferrie, Tabak, Akbaraly, Vahtera & Singh-Manoux, 2014). Both the Japanese and the Whitehall samples include only adults and therefore cannot be used to examine the impact of early life stress. Finally, only the UK 1958 Birth Cohort (N = 7,784; 45 years) includes early-life self-reported measures. Data on this cohort have been used to demonstrate that low childhood SES and poor parenting puts adults at risk for T2D (Thomas et al., 2008).

However, none of the datasets discussed above include items measuring subjective SES in adolescence or adulthood. Low subjective SES may reflect stress caused by low SES, but might also exist among individuals who are not strictly low-SES, but who feel financially insecure or concerned about their economic prospects nonetheless. Previous research has shown that low subjective SES increases susceptibility to the common cold (Cohen, Alper, Adler, Treanor & Turner, 2008), leads to lower overall health in adults (Cohen, Janicki-Deverts, Doyle, Miller, Frank & Rabin, 2012), predicts concurrent diabetes prevalence among adolescents (Goodman, Huang, Schafer-Kalkhoff & Adler, 2007), and associates with poorer health outcomes for diabetic adults (Doshi, Smalls, Williams, Wolfman & Egede, 2016). Do such perceptions and anxieties during the formative years of adolescence lead to a higher prevalence of T2D? The existing literature has left this important question unanswered.

Cognitive ability and personality in early life

Including cognitive ability and personality in models of T2D development is important for two reasons. First, it is possible that these characteristics will explain some of the relationship between the SES measures and health outcomes; if there are differences in the prevalence of these personal traits between groups, this might explain relationships observed. Second, understanding these precursors to disease may allow for earlier and more effective interventions, particularly if specific intelligence and personality profiles respond differently to interventions.

Previous research has established relationships between health outcomes and both cognitive ability and personality (e.g., Batty et al., 2007; Deary et al., 2010). For example, although IQ is well-documented as protective against early mortality and a wide range of morbidities, researchers have debated whether IQ affects health risk directly or through some other avenue, such as through adult SES and lifestyle. Since T2D and dementia are common comorbidities (Bunn, Burn, Goodman, Rait, Norton & Robinson, 2014), contemporaneous measures of cognitive ability are subject to bias; thus it is important to note that our current studies focuses on *adolescent IQ*.

Personality characteristics, generally categorized using the Big Five taxonomy (i.e., conscientiousness, extraversion, neuroticism, agreeableness, and openness) (Gosling et al., 2003), have also been studied in relation to later-in-life health outcomes (Bogg & Roberts, 2004; Deary et al., 2010). This research has found that high conscientiousness is reliably protective against early mortality and morbidity (Chapman, Fiscella, Kawachi & Duberstein, 2009; Hill, Turiano, Hurd, Mroczek & Roberts, 2011; Kern, Friedman, Martin, Reynolds & Luong, 2009; Roberts, Kuncel, Shiner, Caspi & Goldberg, 2007; Terracciano, Löckenhoff, Zonderman, Ferrucci & Costa, 2008), and this might be driven by health behaviors (Bogg & Roberts, 2004; Turiano, Chapman, Gruenewald & Mroczek, 2015). Conscientiousness has also been linked to superior diabetes control in cross-sectional studies (Wheeler et al., 2012) and reduced risk of T2D in longitudinal studies (Goodwin & Friedman, 2006; Jokela et al., 2014; Kern et al., 2009). Mixed evidence is found for the other traits (Chapman et al., 2009; Turiano, Mroczek, Moynihan & Chapman, 2013; Wilson, Krueger, Gu, Bienias, de Leon & Evans, 2005).

This study

This study's primary innovation is the window it provides into how adolescent characteristics such as subjective SES are associated with *later-in-life T2D risk*. We posit that the stress associated with SES may be a function of both *real* and *perceived* SES, and that this measure will explain some of the mechanism through which SES impacts diabetes risk. Accordingly, this paper focuses on real, relative, and perceived SES, combined with cognitive and personal characteristics. We explore pathways from economic hardship in adolescence to health outcomes in later life with the goal of providing insights into how interventions might be tailored to individuals for maximum impact.

Methodology

Data Sources

The data for this study come from a linked subset of PT participants in 1960 and Medicare claims data from 2012. In this section, we give a brief overview of each dataset and the key variables used in our analysis.

Table 1
Summary Data.

Linked to Medicare FFS[a]	Everyone in Linked Data	No T2D (2012)	T2D (2012)	P-Value T2D vs no T2D[b]
N	88,849	68,599	20,350	
Age in 1/2012 (Born 1941-1946)	66.75	66.69	66.92	< 0.001
Diabetes Status	23%	0%	100%	
Basic Demographics				
White (Medicare)	92%	93%	90%	< 0.001
Male (Project Talent)	52%	51%	55%	< 0.001
Education Obtained, 1965-9[c]				< 0.001
Graduated HS	97%	98%[b]	96%[b]	
Graduated College	33%	35%[b]	25%[b]	
SES Quartile, 1960				< 0.001
Bottom SES Quartile	20%	19%	25%	
Second SES Quartile	25%	25%	27%	
Third SES Quartile	27%	28%	26%	
Top SES Quartile	27%	28%	22%	
SES Perception, 1960				< 0.001
Perceive Poor	15%	14%	17%	
Perceive Middle Class	65%	66%	63%	
Perceive Rich	17%	17%	16%	
BMI Category, 1960				< 0.001
Underweight	9%	9%	7%	
Healthy Weight	73%	74%	68%	
Overweight	12%	11%	18%	
Obese	2%	2%	3%	
Other Characteristics, 1960				
Subjective Recent Health (Range 0-6)[d]	4.7 [1.5]	4.7 [1.4]	4.6 [1.5]	< 0.001
IQ [SE] (Range 0-283)[d]	174.7 [55.5]	177.3 [54.9]	165.9 [56.5]	< 0.001
Vigor [SE] (Range 0-7)[d]	3.6 [2.2]	3.7 [2.2]	3.5 [2.2]	< 0.001
Impulsivity [SE] (Range 0-9)[d]	4.6 [2.4]	4.6 [2.4]	4.5 [2.4]	< 0.001
Tidiness [SE] (Range 0-11)[d]	5.7 [2.9]	5.7 [2.9]	5.5 [2.9]	< 0.001
Mature Personality [SE] (Range 0-24)[d]	11.3 [5.5]	11.4 [5.5]	11 [5.3]	< 0.001

[a] Of the 377,016 individuals in the PT Base Year Data, 199,994 were included in the Medicare linkage effort. Of these, 142,582 were successfully matched. We exclude individuals who utilize a Medicare Advantage plan for any time in 2012, as their claims data are incomplete, leaving a sample of 103,643. We further limit our sample to include only those individuals for who were of standard ages in 1960, 14-19 (cohorts 1941-1946), and for whom we have data on SES (88,849).

[b] Difference between individuals with and without diabetes in 2012; chi^2 for categorical variables, t-test for continuous variables.

[c] Subset sample in for whom education data available via the 5-yr follow-up in general sample and in Medicare linkage (N = 49,647).

[d] As these variables are all on different scales, they are included as normalized (z-scored) variables in the analyses below.

Project Talent

PT is the largest study of high school students in the history of the United States, with data on a nationally representative sample of approximately 377,000 students from 1,200 schools across the country. The Base Year (BY) data was collected in 1960, and included a 2-day battery of tests and surveys on individual-, family-, and school-level characteristics. Data on aptitudes, interests, personality traits, and perceptions were also gathered. Follow-up studies were conducted 1, 5, and 11 years after the participants were slated to graduate from high-school.

Medicare Claims Data

In 2016, the PT team at the American Institutes for Research completed a linkage of a subset (n = 142,582) of the original BY participants to 2012 Medicare Claims and Expenditures data. Full details on the linkage process and results are available (Huang, Strombotne, Achorn, Mokyr Horner & Lapham, 2017). We limit our analyses to individuals who were never enrolled in a Medicare Advantage plan for any time in 2012, as their claims data are incomplete, leaving a sample of 103,647. We further limit our sample to include only those individuals born in 1941-1946 and for whom we have data on SES in the PT BY (88,849). Because there may be systematic missingness in the IQ and personality composites, we retain individuals who have missing values and place them in a separate category.

Measures

Diabetes

The outcome variable considered is whether the individual has ever been diagnosed with diabetes, according to their Medicare Claims files, by 2012. Medicare claims data are an effective way to track chronic ailments, like diabetes, for individuals who do not opt into Medicare Advantage, with demonstrated high levels of sensitivity and specificity (Mokyr Horner & Cullen, 2015). Note that the algorithm designed by CMS includes ICD-codes for both Type I and Type II diabetes; however, Type II diabetes makes up about 90-95% of diabetes cases nationally and more among older individuals (Korda & Erdem, 2014).

Objective Socio-Economic Status

We utilize an SES composite that consists of a variety of items including family income, parents' educations, and the number of books in the house (Austin & Hanisch, 1990; Bayer, 1969; Huang et al., 2017; White, 1982). For a description of the algorithm, see Appendix A. For ease of interpretation, we take a nonparametric approach, using a dummy variable for the bottom and top quartiles and comparing these individuals to the middle 50%. Note that modeling with a linear and quadratic SES variable does not meaningfully alter our results (see Appendix B).

Relative Socio-Economic Status

This variable measures one's SES compared to his/her classmates in 1960. Specifically, it measures one's SES relative to the school's average SES, normalized such that a one unit change in the variable corresponds with a change of one standard deviation.

Perceived Socio-Economic Status

We also consider perceived SES, as measured by the answer to the question: *Which best describes your family's finances?* Responses range from: 1. *Barely able to make a living* to 6. *Very wealthy*. This variable captures how an individual experiences his/her own SES; answers on the lower end indicate anxiety about economic well-being, which may exist irrespective of material wealth. Note that the correlation between perceived and actual SES is 0.320 (see Table A2), supporting the notion that low subjective SES can occur irrespective of objective SES.

Table 2
Full Sample Models.

DV: Diabetes Diagnosis	Separate Models [1]	Basic Interacted [2]	+ Addn'l SES [3]	Marginal Effects [4]
	Education Obtained, 1965-9			
Graduated High school	0.705***	N/A	0.849**	-0.0282**
[SE]	[0.0460]		[0.0555]	[0.0113]
Graduated College	0.652***	N/A	0.772***	-0.0426***
[SE]	[0.0167]		[0.0204]	[0.00410]
	Real SES Status, 1960 (Ref: Middle 50%)			
Bottom SES Quartile	1.229***	1.106***	1.068**	0.0115**
[SE]	[0.0241]	[0.0226]	[0.0308]	[0.00506]
Top SES Quartile	0.791***	0.858***	0.897***	-0.0185***
[SE]	[0.0187]	[0.0206]	[0.0290]	[0.00539]
	SES Perception, 1960 (Ref: Perceive Middle Class)			
Perceive Poor	1.249***	N/A	1.108***	0.0180***
[SE]	[0.0290]		[0.0263]	[0.00425]
Perceive Rich	1.008	N/A	1.022	0.00382
[SE]	[0.0245]		[0.0248]	[0.00421]
	Relative SES Compared to School, 1960			
z Relative SES	0.883***	N/A	0.991	-0.00147
[SE]	[0.00764]		[0.0164]	[0.00285]
	BMI Category, 1960 (Ref: Healthy Weight)			
Underweight	0.822***	0.803***	0.804***	-0.0357***
[SE]	[0.0255]	[0.0251]	[0.0252]	[0.00485]
Overweight	1.592***	1.566***	1.569***	0.0847***
[SE]	[0.0394]	[0.0391]	[0.0390]	[0.00497]
Obese	1.277***	1.139**	1.138**	0.0229**
[SE]	[0.0718]	[0.0647]	[0.0644]	[0.0104]
	Other Characteristics, 1960			
z Subjective Recent Health	0.940***	0.939***	0.945***	-0.00980***
[SE]	[0.00812]	[0.00819]	[0.00827]	[0.00151]
z IQ	0.796***	0.831***	0.856***	-0.0267***
[SE]	[0.00808]	[0.00905]	[0.00979]	[0.00197]
z Vigor	0.940***	0.952***	0.950***	-0.00875***
[SE]	[0.0102]	[0.0104]	[0.0104]	[0.00188]
z Impulsivity	1.043***	1.044***	1.041***	0.00689***
[SE]	[0.0103]	[0.0104]	[0.0104]	[0.00171]
z Tidiness	0.940***	0.955***	0.955***	-0.00799***
[SE]	[0.0103]	[0.0105]	[0.0105]	[0.00190]
z Mature Personality	1.049***	1.039***	1.051***	0.00852***
[SE]	[0.0124]	[0.0123]	[0.0127]	[0.00207]

Notes: First column shows seven separate regressions, one for each category. Coefficient are odds ratio results from logistic regressions. Cohort Effects, Sex, Race, Region (1960 and 2012). Coefficients on retained "missing" categories not presented.
N = 88,849; *p < 0.1.
*** p < 0.01,
** p < 0.05,

Personal Characteristics

For cognitive ability, we include an IQ composite built from scores on abstract reasoning, reading comprehension, and math performance. We also include several personality measures in this analysis. Although PT did not gather the Big Five, which is now the most common taxonomy for personality, the PT characteristics have been mapped onto the Big Five (Pozzebon, Damian, Hill, Lin, Lapham & Roberts, 2013). Because of the established relationship between conscientiousness and health, we focused on items that map to conscientiousness: tidiness, mature personality, and impulsivity (inverse). In addition, we include vigor, which maps to extraversion, because it may explain differences in activity levels. These variables are all z-scored (separately for men and women to allow for possible differences in the distributions) for the full PT sample such that a one-unit change represents one standard deviation. Note that an additional model including all of the personality traits available in the PT dataset is included in Appendix B; primary results do not change.

Additional Co-Variates

Gender, race/ethnicity, year of birth, and region of residence in 1960 and 2012 are included as basic demographic controls. In many models, we also control for subjective health in 1960 and whether the individual was under or over-weight in 1960 (generated using categorical variables for self-reported weight and height). In some models, we include educational attainment (graduated from high school, graduated from college) at five-years after the individual was scheduled to graduate high school. Although it is possible that some individuals will have completed college later, we use the five-year follow-up because there was substantial attrition between the 5- and 11-year follow up surveys.

Empirical Framework

Our primary interest is in the relationship between diabetes risk and SES, controlling for cognitive ability and personality traits. Thus, the primary model of interest is:

Table 3
Fully Specified Models, Stratified by SES.

DV: Diabetes Diagnosis	SES Quartile 1 [1]	SES Quartile 2 [2]	SES Quartile 3 [3]	SES Quartile 4 [4]
	Education Obtained, 1965-9			
Graduated High school	0.920	0.813	0.749**	0.926
[SE]	[0.0876]	[0.107]	[0.102]	[0.205]
Graduated College	0.818**	0.768***	0.726***	0.833***
[SE]	[0.0697]	[0.0439]	[0.0353]	[0.0384]
	SES Perception, 1960 (Ref: Perceive Middle Class)			
Perceive Poor	1.172***	1.135***	0.962	1.042
[SE]	[0.0477]	[0.0484]	[0.0521]	[0.0905]
Perceive Rich	1.058	1.038	1.080*	0.968
[SE]	[0.0642]	[0.0550]	[0.0498]	[0.0399]
	Relative SES Compared to School, 1960			
z Relative SES	0.947**	1.050	1.032	1.000
[SE]	[0.0253]	[0.0368]	[0.0331]	[0.0379]
	BMI Category, 1960 (Ref: Healthy Weight)			
Underweight	0.792***	0.821***	0.861**	0.715***
[SE]	[0.0501]	[0.0506]	[0.0525]	[0.0528]
Overweight	1.444***	1.487***	1.586***	1.743***
[SE]	[0.0743]	[0.0739]	[0.0750]	[0.0926]
Obese	1.066	1.280**	1.242**	0.989
[SE]	[0.108]	[0.133]	[0.136]	[0.143]
	Other Characteristics, 1960			
z Subjective Recent Health	0.975	0.942***	0.957**	0.906***
[SE]	[0.0175]	[0.0156]	[0.0168]	[0.0171]
z IQ	0.907***	0.869***	0.865***	0.788***
[SE]	[0.0220]	[0.0193]	[0.0186]	[0.0201]
z Vigor	0.926***	0.924***	0.947***	1.003
[SE]	[0.0233]	[0.0192]	[0.0192]	[0.0228]
z Impulsivity	1.052**	1.036*	1.065***	1.021
[SE]	[0.0243]	[0.0211]	[0.0195]	[0.0225]
z Tidiness	0.981	0.928***	0.977	0.931***
[SE]	[0.0235]	[0.0190]	[0.0208]	[0.0205]
z Mature Personality	1.023	1.085***	1.025	1.073***
[SE]	[0.0271]	[0.0247]	[0.0221]	[0.0246]

Notes: Coefficient are odds ratio results from logistic regressions. Cohort Effects, Sex, Race, Region (1960 and 2012). Coefficients on retained "missing" categories not presented.
N = 88,849;
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$.

$$(a) DRisk_{it3} = \alpha_1 IQ_{it1} + \sum \beta_j PERS_{jit1} + \sum \gamma_k SES_{kit1} + \delta_l X_{lit1} + \varepsilon_i$$

Where DRisk_{it3} indicates the risk for having developed T2D for individual i by t = 3 (2012). Here, the risk is modeled as a function of each of our primary categories of explanatory variables (IQ, personality trait j, and SES variable k), measured for person i in t = 1 (1960). The most basic set of models include only one set of explanatory variables. In some specifications, a vector of individual level characteristics are included $\delta_k X_{lit1}$. In others, we consider the mediating role that educational attainment in t = 2 (5-years post slated high school graduation) might have on the relationship between SES and these chronic conditions.

Because SES in 1960 may set individuals on different life-trajectories, we consider some models stratified by SES quartile. Stratifying these models by SES quartile allows us to address error that may not be distributed randomly across SES.

Results presented are odds ratios from logistic regressions. As always, odds ratios should be interpreted such that a coefficient of 1 indicates no change in relative risk, a coefficient between 0-1 indicates a protective impact, and a coefficient above 1 indicates increased risk. Standard errors are clustered by base-year school to account for serial correlation within school. Alternative specifications are presented in Appendix B, including risk ratios derived from Generalized Linear Model (GLM) regressions; primary results are robust to specification.

Results

Summary statistics stratified by diabetes status in 2012are presented in Table 1. The incidence of diabetes in this sample is 23%, which is close to the rate among all Medicare beneficiaries aged 65-74 in 2012, namely 25% (CMS, 2017). Differences in early life measures between those with and without diabetes are substantial and significant; those individuals who develop diabetes have lower educational attainment, lower early life SES (both real and perceived), higher early life BMI, lower subjective health, lower IQ, and personality traits that track to lower consciousness.

The first column of Table 2 shows the results from seven simple regressions with only demographic controls; the second column presents a fully interacted model excluding any variables on SES beyond the absolute measure; the third column adds subjective and relative SES and education (this is our preferred model). The coefficients are translated to marginal effects in column 4. Alternative specifications of this model are presented in Table B2.

Perceiving oneself to be poor has a coefficient of similar magnitude to being poor, suggesting this subjective measure is at least as important as actual material SES. Being in the poorest quartile increases one's risk of later-in-life T2D by 1.2 percentage points, but perceiving oneself to be poor increases one's risk by 1.8 percentage points. In addition, the effect of high BMI measures in 1960 is large. People defined as overweight or obese in 1960 have an increase in T2D of 8.5 and 10.8

percentage points respectively as compared to healthy individuals. The coefficients of interest are not fully attenuated by the inclusion of controls and the relationship between variables is consistent across the specifications.

To examine whether the relationships described above are consistent among SES levels, we present Table 3, which provides results for models stratified into SES quartiles. Here we find some differences between the SES groups. First, individuals in the lowest SES quartile are particularly sensitive to their status within their school. Second, believing oneself to be poor is only a risk factor for individuals in the lower SES groups. In addition, IQ is less protective for individuals in the lowest SES group in 1960. Risk ratios from GLM regressions replicating these models are presented in Table B3.

Discussion

Our study explores the role that subjective and real SES play in the development of later-in-life T2D, contributing to the understanding of the psychological pathways to poor health outcomes. Previous research has shown that low subjective SES can be detrimental to health (Cohen et al., 2012; Doshi et al., 2016). Indeed, we find that low perceived SES in adolescence is a risk factor for those in the lower-SES groups even 50 years later. These formative subjective experiences may account for some differences in health outcomes by SES group.

We also find that relative SES affects T2D risk such that being relatively wealthier is protective for individuals in the lower SES groups. This is consistent with previous documentation of the relationship between diabetes risk and inequality at both the national (Lynch, Smith, Hillemeier, Shaw, Raghunathan & Kaplan, 2001) and state (Pickett & Wilkinson, 2015; Rehkopf, Eisen, Modrek, Mokyr Horner, Goldstein & Costello, 2015) levels; high levels of income inequality may give individuals—except those at the very top—the perception that their economic position is tenuous (Thorbecke & Charumilind, 2002). This instability in turn this may increase risk for T2D.

In addition, previous research shows better health outcomes for individuals with higher scores for cognitive ability (Deary et al., 2010) and conscientiousness (Hampson, Edmonds, Goldberg, Dubanoski & Hillier, 2013). Our current findings are consistent with these observations, finding that cognitive ability is protective. We extend previous research to show that IQ is less protective for individuals in the lowest SES group and that the relationship between perceived SES and health outcomes is not wholly explained by IQ or personality traits.

This study has some limitations. First, despite many advantages of claims data, these data do have some weaknesses. The absence of obtaining medical care is interpreted as health, and this bias may be more problematic if individuals with relevant personal characteristics (e.g., high conscientiousness) are differentially likely to obtain preventive medical care. Also, because we have only Medicare claims data, we do not have accurate dates of onset for diabetes, we do not have accurate dates of onset for diabetes prior to Medicare. Hence a survival analysis is not feasible and these results can only be viewed as relationships with T2D prevalence in 2012. Future research should examine the relationship between these variables and the timing of the first incidence of T2D.

Additionally, there are some limitations due to the long dormant period of PT. Health behaviors and BMI in the intervening decades are currently unknown. An effort is underway to contact a subset of PT participants (who are not in the PT-Medicare data linkage) via the PT Aging Study (R01 AG056163 and R01 AG056164). These data will include extensive life-histories that may reveal mechanisms through which these personal characteristics affect diabetes risk. Similarly, the BMI from 1960 data is self-reported in one time period, and thus likely has error in the measure. Perceived SES is also captured only once; we do not know if the measure is stable over time or whether these perceptions are more important in adolescence or adulthood.

Finally, truncation is a concern. About 27% of the sample will have died between the ages of 18-72 according to Social Security actuarial tables (SSA, 2014). There is a wealth of research on how cognitive, personal, and economic features affect mortality risk, generally showing a protective effect from high cognitive ability, high conscientiousness, and high SES (Deary et al., 2010; Eyster, Stone, Lapham, Plotts & CITE?, 2011). Thus, it is likely that sicker people with low SES were disproportionally represented in this group, which may cause our study to understate the relationship between SES and T2D.

Still, our current findings illustrate the importance of real, relative, and perceived SES in adolescence on the later-in-life manifestation of T2D. Although the effect sizes are not large, the impact is still substantial. With recent estimates of 30.3M individuals with T2D in the USA costing more than $245B (CDC, 2017), even a 1% decrease in prevalence corresponds with approximately 303K fewer cases and a cost savings of about $2.5B. The health impacts of anxiety related to financial insecurity may be severe, expensive, and take decades to manifest. Interventions aimed at health behaviors in later-life alone are likely to be ineffective since they are too late and lack sufficient scope. Earlier intervention efforts aimed at reducing economic anxiety experienced by youths should be considered as a means of improving future health outcomes. This could include expanding the social safety net or experimenting with interventions that might make financial differences in school less salient, such as free school lunches for all rather than the poorest students.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at 10.1016/j.ssmph.2018.01.004.

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