Lasting Impacts of Childhood Health and Socioeconomic Circumstances on Adult Health Problems: Analysis of a Longitudinal Count Regression Model

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Abstract

Objectives. This study examines the lasting impacts of childhood health and circumstances, in addition to adult socioeconomic status on trajectories of chronic health problems in later life and how these associations vary across race/ethnicity as well as gender.

Methods. Employing a longitudinal dataset from the Health and Retirement Study (HRS), this study utilizes a random intercept count regression model to examine how circumstances associated with early life may influence chronic health trajectories in later life.

Results. The results demonstrate that poor childhood health and disadvantaged socioeconomic status (SES) are associated with the higher incidence rates of chronic health problems over time. The associations are net of adult socioeconomic status and baseline health status. The adverse effects of poor childhood health and disadvantaged socioeconomic conditions are higher for women than men. While both childhood health and SES have significant impacts on chronic health trajectories for both African American and White, no such effects have been observed among Hispanic.

Discussion. Trajectories of chronic health problems in late life continue to be shaped by childhood health and socioeconomic circumstances. The patterns of associations vary across race/ethnicity as well as gender.

Keywords: chronic health trajectories, childhood health, childhood disadvantage, socioeconomic status (SES), longitudinal count regression model.

JEL Classification: I10, I14; I18

1. Introduction

Recent research on socioeconomic determinants of health is beginning to investigate health in a dynamic context that is influenced by the cumulative impacts of life-long experiences, including exposures associated with social and economic circumstances in early life. Social scientists are now becoming increasingly interested in investigating adult health problems that are linked to early life exposures with the goal of assessing the lasting impacts of childhood circumstances on adult health. This literature suggests that better knowledge of socioeconomic disparities over the life course can offer substantial gains in understanding adult health problems as research shows that children from lower socioeconomic families experience poorer health as they age. One

possible explanation of this observation is that these children enter into their adulthood with not only poorer health, but also with lower educational attainment that, in part, contributes to lower socioeconomic status (SES) and poorer health in adult life (Case, et al, 2005). The current study examines chronic health problems in older Americans with the goal of better understanding the relative importance of early versus adult socioeconomic and health characteristics on change in chronic health status across time.

Following Haas (2008), two main theoretical perspectives have been proposed in the literature explaining how socioeconomic circumstances over the life course influence health in later life. The first is the concept of "biological embedding" which suggests that unfavorable environmental exposures (both physical and psychosocial) within home, school and neighborhoods during childhood may lead to developmental delays, poor psychosocial adjustment and higher risks of disease in adulthood. Poor childhood health and socioeconomic disadvantage may especially be detrimental to health problems in later life, regardless of adult SES and health related behavior (Hass 2006; Case et al, 2005; Goldman and Smith, 2002). The second is the "cumulative insult" theory that suggests that social, economic, and behavioral exposures accumulate over the life course and alter an individual's risk of disease and disability in later life. The current study focuses on cumulative insult theory and examines how cumulative disadvantage could influence chronic health in later life in addition to adult SES measures.

There are reasons to believe why disadvantaged SES and poor health during childhood can influence adult health in later life. For example, children with disadvantaged childhood SES are less likely to receive necessary preventive medical care than children of higher SES parents. Lack of necessary medical care could place individuals at a higher risk of poor childhood health with a greater likelihood of developing chronic health problems in adult life. It has also been suggested that childhood socioeconomic status impacts preferences for unhealthy behavior such as smoking, drinking, and other risk taking behavior in adulthood (Hayward and Gorman, 2004). Alternatively, parental education can have direct and indirect impact on their children's health. Parents with higher education may make better health investments for their children since education enhances one's ability to acquire and process information, and this has a unique impact on children's health (Currie and Moretti, 2003; Lindeboom, et al, 2006; Cantoyannis and Dooley, 2010; Johnson & Schoeni, 2011). On the other hand, children with lower parental education could experience lower childhood SES and are most likely to obtain less education themselves which may impair their ability to acquire and process health related information for better disease management during adulthood. Various components of childhood circumstances (parental education, low childhood SES, parental occupation, and childhood health) are important since they influence initial adult socioeconomic position, which in turn influences risks of developing chronic health problems in adulthood (Case, Lubotsky & Paxon, 2002; Case, et al, 2005; Brown, 2010; Luo & Waite, 2005). Recent evidence also suggests that the origin of poorer adult health among older American can be traced back into childhood years and higher rates of childhood illnesses transmit into poorer health in mid-life (Banks et al., 2011). The impacts of these early-life attributes may either be compounded by continued socioeconomic deprivation in the adulthood or ameliorated (partially or totally) by improved SES and healthy lifestyle behavior in adulthood.

Despite growing attention, there are two main important gaps in the current literature that focuses on the early life influences on adult health outcomes. The first major limitation is that very few

studies have investigated the influence of childhood health and socioeconomic circumstances on trajectories of chronic health problems in later life. More explicitly, heterogeneity of the relative contribution of childhood health and socioeconomic circumstances in determining adult chronic health problems may vary by race/ethnicity as well as gender. There is evidence that individuals with disadvantaged childhood are more likely to experience increased risks of chronic disease (Gilman et al., 2002; Hart et al., 2000). Moreover, the relationship between childhood SES and adult health addresses only a limited numbers of health outcomes with a main focus on mortality or risk of cardiovascular disease (Cohen et al., 2010), and utilizing father's education or occupation as a marker of childhood SES. This is mainly because of the lack of data on measures of childhood SES to assess unique contributions of those measures on various health outcomes in later life. Moreover, not all studies considered both childhood health and SES while examining adult health problems, making the independent contribution of SES insults experienced earlier in the life course unclear. There may be direct or indirect pathways linking childhood health to adult chronic health problems. For example, negative impacts of childhood health problems may persist into adulthood and influence the trajectory of chronic health problems in later life. The possible indirect pathway may include a negative impact of childhood health problems on educational attainment, which in turn influence adult SES and the risk of chronic diseases.

The second limitation is that of the methods used to analyze the trajectory of chronic health problems over time. Generalized linear mixed models or linear growth curve models are increasingly used as analytic approaches for this type of longitudinal analyses because of the flexibility of handling unbalanced repeated measures among sample members. However, the distribution of the number of health problems has a typical characteristic shape; these data are often positively skewed and bounded by zero. Additionally, there can be a large concentration of data points at zero, indicating individuals without related health problems. This distribution reflects that chronic health problem data are often count data representing a total number of chronic health problems that an individual develops over time. Utilizing linear mixed models (which assumes normally distributed error term) may provide a poor fit of such data and will lead to incorrect inferences. Instead, count regression approaches such as Poisson regression or negative binomial regression are more appropriate for analyzing this type of data.

The current study employs data from the Health and Retirement Study (HRS) and a mixed effect count data regression technique to estimate the differential impacts of childhood health and socioeconomic status during the life-span on chronic health trajectories among middle aged and older adults. In addition, the present study also explores how the patterns of association vary by race/ethnicity as well as gender.

1. Data and Method

2.1 Data

The HRS is a nationally representative biennial longitudinal survey which started in 1992 and was designed to investigate health and economic well-being of Americans aged 50 years or older (Juster and Suzman, 1995). The HRS maintains a steady state longitudinal design of a given cohort for a substantial period of time. In addition to its excellent array of economic instruments, the HRS also measures various aspects of respondents' health status, including self-reported general health

status, prevalence of chronic conditions and functional disabilities. Behavioral risk factors such as current and past smoking, drinking, and physical exercise are also included as measures. The survey data are de-identified and publicly available. Data from 1994-2010 were collated for examining the trajectory of chronic health problem. The current study used the RAND-HRS datasets which recode most of the HRS measures across waves to be as consistent as possible.

Sample Selection

The original HRS cohort includes 12,652 individuals. Of which, 9814 individuals were born between 1931 and 1941, and the rest were spouse respondents. To obtain comparable reports of measures used in the analysis, the present study utilized information from waves 2-10 (1994-2010). The HRS collected childhood health and socioeconomic measures beginning from the fourth wave (1998) of data collection. Therefore, the current study excluded individuals who were lost due to follow-up before 1998. Between 1992 and 1998, about 866 individuals died and 1036 were lost due to other reasons. Finally, the analysis excluded individuals less than 50 years old at baseline (N=751). This results in a final analytic sample of 10,099 individuals (80% of the initial sample). Between 1998 and 2010, 1879 respondents died. These respondents contributed to the estimation until their death.

2.2 Measures

Outcome Measure: Chronic health problems

In each HRS wave, respondents were asked to self-report if they had ever been told by their physicians that they had any of the eight chronic conditions: diabetes, arthritis, hypertension, cancer, stroke, heart problem, lung disease, and psychiatric problems as well as how these conditions progressed compared to the previous wave. A summary score ranging from 0-8 was created to represent the number of existing chronic health problems that respondents reported.

Independent Measures: Childhood socioeconomic circumstances

Smith (2004) suggests that the decline in health status among HRS respondents might have been set before their entry to the HRS sample due to negative impacts of early-life characteristics on adult health (Hass, 2006; Loucks et al., 2012). This study, therefore, investigated multiple dimensions of childhood SES available in the HRS 1998 interview. First, parental education was measured by two dummy variables indicating low parental education if mother and father education was less than 8 years of schooling. In the HRS 1998 interview, respondents were asked a series of questions designed to assess their family's SES retrospectively. An overall assessment of their childhood SES was creased as an indicator of whether the respondent's family had low SES (1=yes; 0=no). The measure of economic shocks was assessed including an indicator for whether the family received help from relatives because of financial difficulties (1=yes; 0=no). Previous research using these childhood measures has confirmed the quality of these retrospective measures (Krieger, et al, 1998).

Independent Measures: Childhood health

The examination of childhood health on adult health outcome has been limited due to the scarcity of life course data on various childhood measures. In this study, the retrospective reports of childhood health were utilized. In the HRS 1998 interview, respondents were asked the following about their childhood health status "consider your health while you were growing up, from birth

to age 16. Would you say that your health during that time was excellent, very good, good, fair or poor?" For the purpose of the analysis, childhood health was reverse coded to indicate poor childhood health status (referencing excellent, very good and good health status).

Unfortunately, this retrospective measure of self-rated childhood health does not capture specific childhood conditions that could be linked to health trajectories in later life. However, evidence suggests that childhood self-rated health is strongly associated with certain childhood health conditions such as infectious (e.g. tuberculosis, polio), autoimmune (e.g. asthma, allergies) and non-infectious (e.g. cancer, injuries) conditions that resulted in substantial physical health problems during childhood.[1] Infectious conditions were the most prevalent childhood health problems reported among HRS respondents (Blackwell et al., 2001).

Independent measures: Midlife Socioeconomic status

Two main adult socioeconomic indicators used in this study were education and financial resources measured by net assets. Education was used as a categorical variable based on years of completed schooling. This variable was coded into the following categories: 0-11 years; 12-15 years; and 16 or more years. These categories were chosen because health differentials by education level are expected to be greatest (Herd, Goesling, and House, 2007). For older adults, one would expect the cumulative effect of income on health would be more influential than the effect of income during an earlier period of time (Smith, 1997; Berkman et al., 1997). Net worth seems to be a good candidate for measuring the impact of lifetime economic status on adult health and used on a log scale in the estimation.

The HRS has one of the best measures of income and wealth collected in the United States (Hurd and Rohwedder, 2006). The survey uses the "financial respondents" to report about asset and income for the spouse and other members in the household. Moreover, HRS asks a large number of questions about income and assets (financial and non-financial) with various unfolding brackets, which reduce the nonresponse rate considerably. Further discussion on how wealth data are collected in HRS can be found in other studies (Hurd and Rohwedder, 2006). In HRS, net asset (net worth) was calculated as the sum of all assets (excluding the second home) minus all debt.

Other Measures: functional limitations and health related risk factors

A functional limitation index measured by number of limitations in activities of daily living at baseline was included in the analysis. Because functional limitation can be the consequence of underlying chronic illnesses, including these baseline measures helped control for varying health status at baseline. Self-rated health was a five category variable coded as a binary variable if "fair" or "poor", referencing if "excellent", "very good", or "good" (yes=1; no=0). The analysis also included a set of behavioral risk factors (smoking, drinking, and physical activity) and body mass index (BMI=weight in kilograms/height in meters^2) within four categories: underweight (BMI<18.5, kg/meter^2), normal weight (18.5-24.9kg/meter^2), overweight (25.0-29.9 kg/meter^2),

[1] Using HRS 1996 experimental module which captured detailed information about childhood conditions from a subset of HRS respondents, Hass (2008) found that compared to those who did not experience any limiting health conditions during childhood, those who experienced an infectious, non-infectious or autoimmune disease were 4.0 ($p<0.0001$), 5.0 ($p<0.0001$) and 13.2 ($p<0.00002$) times more likely to report having poor childhood health (fair or poor). However, this experimental module only included 735 individuals therefore limiting the ability to perform a full analysis utilizing the detailed information of specific childhood condition on chronic health trajectory.

and obese (>30 kg/meter^2). In HRS, physical activity is defined as reporting engaging 'vigorous physical activity' during 12 months prior to the interview. Between 1994 and 2002, vigorous physical activity was defined as participating in activities such as walking, gardening, dancing, heavy housework, bicycling, swimming, or jogging three times a week. From 2004-2010, question wording was slightly different and was coded as vigorous activity if participation was more than once per week.[2]

Independent Measures: Demographic controls

The analysis controls for respondents' demographic characteristics (at baseline) that may influence the chronic health trajectories. Race/ethnicity (non-Hispanic Black, Hispanic and non-Hispanic White) based on gender, age and marital status were included. Descriptive statistics of all independent covariates are presented in Table 1.

3. Empirical Analysis

The mixed effect Poisson regression model (Atkins et al., 2013; Gibbons et al., 2008; Cabrera et al., 2007) was used to examine the change in chronic health problems over time within sample respondents. Including a person-specific random intercept in the Poisson model, the expected number of chronic health problems can be modeled as

$$\begin{aligned}\mu_{ij} = E\left(y_{ij}\middle|x_{ij},\zeta_{1j}\right) &= exp\left(\beta_1 + \beta_2 x_{2i} + \cdots + \beta_k x_{kij} + \zeta_{1j}\right) \\ &= exp\{\left(\beta_1 + \zeta_{1j}\right) + \left(\beta_2 x_{2i} + \cdots + \beta_k x_{kij}\right)\} \\ &= exp\left(\zeta_{1j}\right) * exp\left(\beta_1 + \beta_2 x_{2i} + \cdots + \beta_k x_{kij}\right)\end{aligned} \quad (1)$$

Where μ_{ij} is the expected number of chronic health problems at occasion i for respondent j, y_{ij} is the number of chronic health problems and assumed to have a poisson distribution with expectation μ_{ij}, $\zeta_{1j}|\, x_{ij} \sim N(0, \psi_{11})$; where ψ_{11} is the variance of the random subject–specific intercept and ζ_{1j} are independent across person j. This variance is assumed to be normally distributed and the model assumes that the conditional distribution of the outcome given the fixed and random effects is Poisson distributed. The random intercept can be thought of as capturing the effect of any omitted individual–specific covariates (time-constant) that cause some individuals to be more prone to develop certain chronic health conditions than others. It is assumed to capture any unobserved heterogeneity in the model. It is worthy to note that both the fixed and random effects are connected to the outcome via the link function (log link in this case) and has implications for interpretation of the parameter estimates of the model. This model specification is further justified by the absence of over-dispersion in the data based on the descriptive statistics of the outcome variable (Mean=1.7 and variance=1.9), which satisfies the equi-dispersion assumption of the Poisson distribution.

[2] A limitation in question wording was that questions in 1996-2002 included physical activity due to exercise and work, but other waves exclude physical activity due to work. Because physical exercise is not the main variable of interest in this study, the potential impact of this variable is discussed on the outcome of interest without further sensitivity analysis.

4. Results

Observed changes in chronic health trajectories

Figure 1 presents the average number of chronic health conditions among sample respondents from 1994 to 2010. Over the 16-year period, the mean number of chronic health problems increased from about 1 per-respondent in 1994 to 2.65 in 2010. Figure 2 presents the trajectory of chronic health problems for ten randomly selected participants over the study period.

Determinants of change in chronic health problems

Table 2 reports the estimates of the determinants of chronic health trajectories based on the nested models. The temporal ordering in which independent measures are entered in the model is as follows: childhood circumstances entered first, followed by measures of adult SES and finally measures of adult health and health risk behavior. The logic of this variable ordering was to understand whether there was a consistent pattern by which the impact of childhood characteristics are attenuated to the addition of the control of adult SES and health measures. Model 1-4 presents estimates of the effect of childhood health, childhood SES, adult SES and adult health conditions on trajectories of chronic health problems. Model 5 then includes both childhood health and socioeconomic measures; Model 6 further adds adult SES. Finally, Model 7 (full model) includes adult health and health risk behavior (all measured at baseline). Each of these models further includes all demographic characteristics.

The regression coefficients (hence, parameter estimates) have conditional interpretation, and in this present analysis, the coefficients represent person-specific effects. Concentrating first on the fixed-effects, the subject specific rate ratios (RRs) are the exponentiated coefficients (e.g., for the intercept in model 1, $e^{-1.53} = 0.22$). The intercept RR provides the estimated chronic health problems at baseline when only childhood health is included in the model.

When each model is estimated separately in Models 1-4, early life circumstances (SES and childhood health), adult SES, health, and health behaviors are significantly associated with the trajectory of chronic health problems. Disadvantaged childhood, as measured by poor overall family SES (having a father with less than eight years of education), is associated with a higher expected number of chronic health problems (model 2). Poor childhood health is also associated with the trajectory of chronic health problems during the study period. For example, the RR of 1.28 for childhood health status indicates being in poor childhood health increases incidence rate by 28% and that incidence rate ratio over the 10-year period is estimated as 1.28^{10}, corresponding to about a 11.8 times larger, given values of other independent covariates in the model.

There is a distinct adult socioeconomic gradient in chronic condition trajectory. Individuals with higher levels of education and household wealth had substantially lower incident rate ratios for chronic health problems (Model 3). Indicators of adult health and health behaviors were also strongly associated with the baseline chronic health problems (results not shown) as well as changes in health problems (Model 4). After adding adult socioeconomic attainment (Model 6), the estimated effects of early life conditions on the expected number of chronic health problems over time attenuated. This would suggest that diminished economic conditions seem to be an important mechanism by which adverse childhood circumstances manifest themselves in regard to adult health problems.

The full model (Model 7) further includes controls for adult health status and health behavior. The association between childhood health and the expected number of chronic health problems is substantially attenuated with the inclusion of adult health and health behavior. Of the childhood SES measures, only the poor childhood SES continues to be statistically significant. The impact of childhood health is also substantially reduced when adult health and health behavior are added to the model. Again, adult SES, self-rated health and health behavior at baseline significantly influence the trajectory of chronic health problems. For every year, the model predicts health problems are increasing by $e^{0.11} = 1.11$ (i.e., an RR for each year change during the study period). In other words, it confirms that each year change in predicted health problems is 11% more than the preceding predicted value.

There were also significant age, gender, and racial/ethnic differentials in chronic health trajectory (estimates not shown in the tables, and can be obtained upon request). Older respondents and women were more likely to experience a higher expected number of health problems over time. Hispanics have higher incidence rate ratios for chronic health problems compared with non-Hispanic Blacks.

A final finding is that a significant subject-specific random intercept in each of the models estimated confirms significant within-individual variation in chronic health trajectories over time. In addition, median incidence rate ratio (IRR_{median}) or the ratio of expected chronic health problems has been calculated as 1.86[3] which indicates the presence of heterogeneity between individuals in the sample (Hesketh and Skrondal, 2008). The IRR_{median} is a measure of heterogeneity that compares the ratio of expected health problems for the same exposure (i.e. given same covariates) for an individual with the larger random intercept to the individual with the smaller random intercept. The value of IRR_{median} greater than one indicates between individual heterogeneity in the sample.

Table 3 presents the estimates of covariates of interest by gender. Differential impacts of childhood circumstances on adult chronic health problems have been observed among men and women. For example, in the sample, the incident rate ratio for poor childhood health is more than twice for women than for men (Model 1). Among other childhood factors, lower SES and having a father with less than eight years of education are significant predictors of chronic health problems for both men and women. However, having a mother with less than eight years of education is significantly associated with a higher incidence rate of chronic health problems for women, but not men. This effect remains significant after accounting for adult SES factors, although it not a significant predictor in the full model. On the other hand, none of the childhood factors remains significant after accounting for adult SES for men (Model 6). Finally, childhood poor health remains significant in the full model for women but not for men.

There is a clear positive association between poor childhood health status and incidence of chronic health problems for Whites, non-Hispanics and Black, non-Hispanics (Other and Hispanic was the reference group (estimates not shown and can be obtained from the author upon request). Lower

[3] This is calculated as: $IRR_{median} = \exp\{\sqrt{2 * \psi_{11}}\, \Phi^{-1}(0.75)\}$; where ψ_{11} (0.43) is the estimate of the individual-specific random intercept and Φ^{-1} is the 75th percentile of the cumulative distribution function of the inverse normal distribution with mean 0 and variance 1.

SES during childhood also appears to have a significant influence on the trajectory of chronic health problems between these two racial-ethnic groups (Model 2). However, childhood poor health remains the only significant predictor of the chronic health problems when adult SES factors are included in the model, and this effect becomes substantially attenuated in the full model, which includes adult health and health related behavior. Neither childhood poor health nor disadvantaged childhood socioeconomic factors have significant influence on chronic health problems among Hispanics. It is also surprising to note that household wealth as a marker of adult SES is not a significant predictor of the incidence of chronic health problem for this ethnic group.

5. Summary and Conclusion

The current study examined the impacts of childhood circumstances on the trajectory of chronic health conditions in later life. Although few studies have examined the impacts of life-long socioeconomic status on functional limitations, no previous studies have taken advantage of longitudinal data to model the impacts of early and adult life socioeconomic position on the trajectory of chronic health problems over the span of more than a decade. The present study, grounded in the life course perspective, fills the empirical gap by examining the extent to which early life factors, as well as adult SES, contribute to the trajectory of chronic health problems in later life. The results demonstrate that the trajectory of chronic health problems in adult life continue to be shaped by childhood health and socioeconomic circumstances. Poor childhood health and disadvantaged socioeconomic status are associated with the higher incidence rate of expected chronic health problems over time. These associations are net of adult socioeconomic status, health and health related behavior; though, adult health and socioeconomic status partially mediate the impacts of childhood circumstances on chronic health problems.

Another important finding is the heterogeneity in the relative contribution of childhood and adult health and SES in determining adult chronic health trajectories among various racial ethnic groups. For example, poor childhood health and disadvantaged SES do not appear to influence chronic health trajectories for Hispanics. In addition, for Whites (non-Hispanic), these effects are partially mediated by adult health and health related behavior. For African Americans, (non-Hispanic), adult health and SES completely mediate the impacts of early-life circumstances on chronic health. Similarly, impact of childhood poor health is twice larger for women than for men. Furthermore, adult health and SES completely medicate the impacts of poor childhood health and disadvantaged socioeconomic status for men, while the lasting impacts of childhood circumstances are observed for women, although these effects are partially mediated by adult health and socioeconomic circumstances.

The findings from the current study complement and extend recent literature that has linked early life circumstances to adult health and mortality indicating that poor childhood health is associated with increased risk of cardiovascular disease, mortality, and functional limitations. The present study confirms that these early life conditions are also associated with the increased risk of incidence of chronic health problems over a longer period of time. Furthermore, while Blackwell et al., (2001) found the lasting impact of childhood health on a broad range of chronic health problems in adult life by using cross-sectional data at one point in time. The present study shifts the attention towards the dynamic changes in chronic health problems over time by indicating that

childhood circumstances influence chronic health problems at a single time point, as well as the trajectory of problems over time.

One important point to note is that childhood conditions and adult socioeconomic factors are predictive of both the initial level of chronic health problems and the change in health problems over time. One reason for finding significant impacts of education and wealth on the course of chronic health problems is that the beneficial effects of education may occur through better self-management of chronic health problems. Alternatively, higher economic resources improves the ability to pay for necessary and preventive medical care services which may lower the risk of chronic health problems, as well as provide better management of those problems (Herd et al., 2007). Possible pathways linking childhood health to the deterioration of chronic health problems may be direct or indirect. A direct impact of childhood health may occur if poor health related insults accumulated over the life course and adversely influenced health status in childhood, which then persisted into adulthood. Moreover, individuals with disadvantaged socioeconomic circumstances during childhood were more likely to experience poor childhood health due to the inability to access necessary medical care. Furthermore, children with poor health status are likely to receive less education, which will result in poor SES in adulthood (by restricting employment opportunities and earning potential). Recent literature has indicated that poor childhood health exerts a substantial negative impact on adult SES attainment (Case et al, 2005; Hass, 2006). Alternatively, lower childhood socioeconomic status or childhood disadvantage may influence individuals' preferences for smoking, drinking and educational attainment (Hayward and Gorman, 2004). Impact of these behaviors on health in later life are expected to be additive over the life span.

A limitation of the current study is that although it explicitly models the changes in chronic health problems over time, the analysis assumes that the expected count of chronic health problems (structural aspect of the model) is a function of an individual-specific random intercept thus not identifying heterogeneity of the effects of covariates between an individual level. Although, an individual-specific random intercept appears to be significant in all the models, there is ample reason to suspect that some of the model covariates may likely influence the slope of the chronic health trajectory over time. Future analysis should expand this by considering the structural aspect of the model to be a function of both individual-specific random intercept as well as random slope.

Another limitation is that it is difficult to disentangle the causal pathways between childhood health and adult chronic health problems. The significant impact of childhood health on the incidence of chronic health problems may be causal in that negative insults resulting from poor childhood health may permanently alter the body's immune system that manifest itself and accumulate over the life course. On the contrary, this relationship may be confounded by some underlying genetic factors that increases the risks and predispose individuals to increased risk of chronic health problems in later life (Case, et al, 2002; Oreopoulos et al., 2006). In order to confirm the causal pathways, it is important to have detailed information on specific childhood health conditions or additional information (such as siblings' health status) that may represent more exogenous variation in childhood health and thus enabling researchers to tease apart the precise causal linkages. However, HRS does not contain detailed information on childhood health or sibling information that could allow examining this issue in further details. Furthermore, it is

difficult to disentangle the causal process as health and socioeconomic status constantly interact throughout the life-course.

The current study has found that a substantial part of the influence of poor childhood health and disadvantaged socioeconomic condition on the incidence of chronic health problems is mediated by the adult socioeconomic status, thus supporting previous research that upward social status during adulthood lessens the adverse effect of the poor childhood conditions (Luo and Waite, 2005). This implies that individuals who are able to achieve higher socioeconomic status in adult life may have substantially lower incidence of chronic health problems compared to those who are not, despite the same degree of childhood insults experienced by both groups. Thus, policies designed to compensate early life disadvantage or improve health and childhood socioeconomic status will likely have long-term pay-offs in terms of improved chronic health status over the entire life-course.

Despite these limitations, findings of the current study strengthen the need for addressing social determinants of health across the life-course in understanding chronic health trajectory over time. Overall, results suggest that early life health and socioeconomic conditions have lasting impact on the trajectory of chronic health problems in later life that are only partially mediated by adult socioeconomic factors, health and health behavior. There is heterogeneity in the relative contribution of childhood circumstances, adult health and socioeconomic status in determining chronic health trajectories in adult life. Future research would gain from investigating a broad range of childhood characteristics on trajectories of adult health outcomes.

Endnote

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Figure 1: Trend in mean number of health conditons with 95% confidence intervals

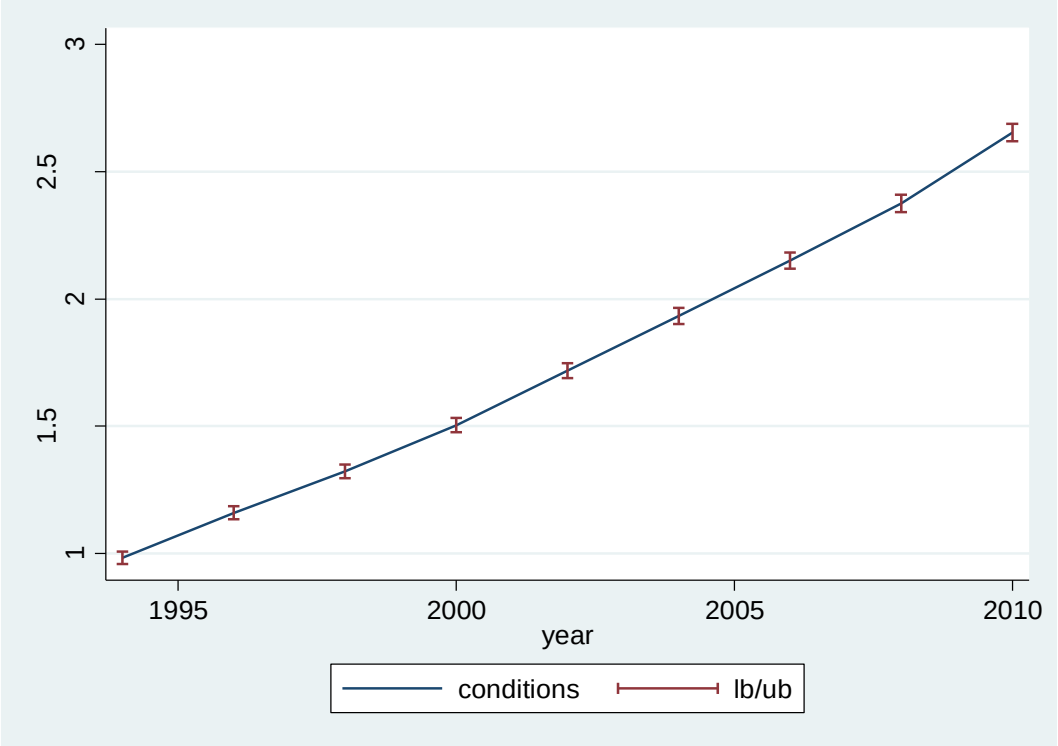

Figure 2: Trajectory of chronic health problems for ten randomly selected participants

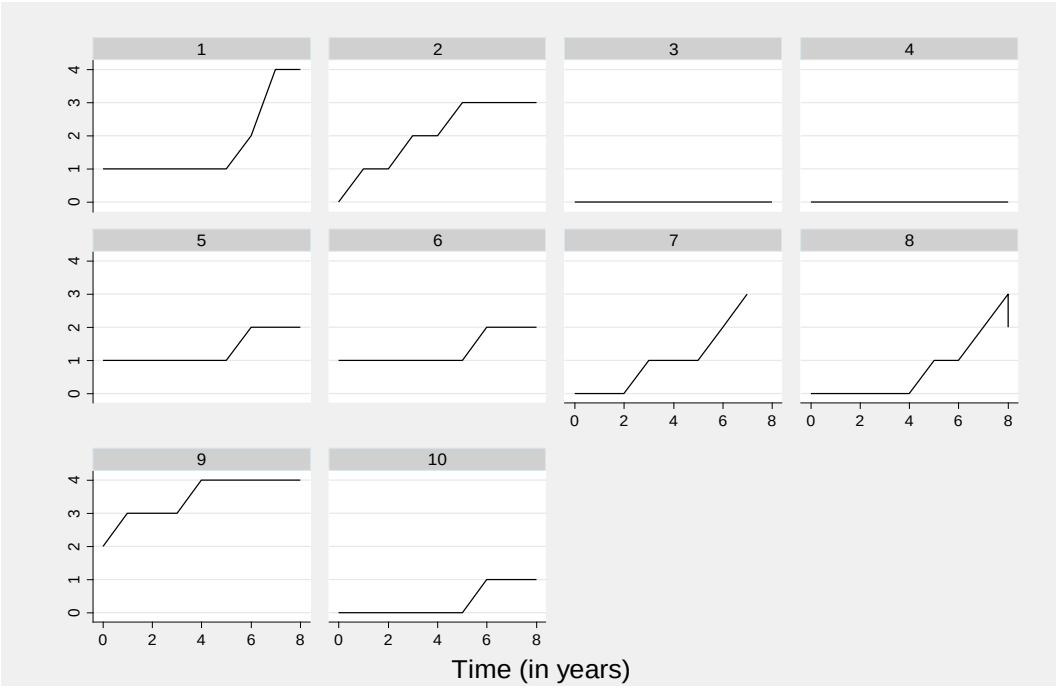

Table 1.
Summary Statistics of Study sample (N=10,099)

Variables	Frequency	Mean	SD
Chronic health problems			
1994		1.17	1.15
1996		1.34	1.22
1998		1.53	1.29
2000		1.69	1.34
2002		1.89	1.38
2004		2.08	1.43
2006		2.28	1.44
2008		2.45	1.46
2010		2.64	1.45
Childhood health and SES			
Childhood poor health	6.81		
Mother's low education (< 8 years)	31.79		
Father's low education (< 8 years)	38.35		
Family SES poor	33.15		
Financial problems	11.60		
Current SES			
Education			
≥16 years	9.90		
12-15 years	62.06		
0-11 years	27.41		
Household wealth (log)		8.67	3.77
Demographic			
Male	47.3		
White, non-Hispanic	73.8		
Black, non-Hispanic	16.5		
Hispanic	8.6		
Married	76.4		
Age (at 1994)		57.84	4.55
Health factors and behavior			
Self-rated poor health	21.83		
Current smoker	22.91		
Former smoker	39.91		
Regular exercise	21.85		
BMI			
Underweight	1.9		
Overweight	42.18		
Obese	23.34		
# Of functional limitations		0.11	0.51

Table 2. Random effects Poisson regression results of modeling chronic health problems

Variables	Model 1 IRR	Model 2 IRR	Model 3 IRR	Model 4 IRR	Model 5 IRR	Model 6 IRR	Model 7 IRR
Childhood factors							
Childhood health	1.29***				1.25***	1.18***	1.08*
Childhood-SES		1.08***			1.08***	1.06*	1.04*
Mother's education		1.04			1.03	0.97	0.99
Father's education		1.12***			1.12***	1.05*	1.02
Financial help		1.02			1.01	1.01	1.01
Adult SES							
College education			0.76***			0.78***	0.92**
>High school			0.86***			0.88***	0.96*
Ln(household wealth)			0.97***			0.98***	0.99
Adult Health and behavior							
Self-rated-poor health				1.79***			1.72***
Current smoker				1.20***			1.16***
Former smoker				1.13***			1.14***
BMI							
Overweight				1.24***			1.25***
Obese				1.62***			1.49***
Underweight				1.19**			1.19**
Physical activity				0.92***			0.92***
# of limitations				1.08***			1.07***
Random Intercept (coeff.)	0.55***	0.55***	0.52***	0.41***	0.54***	0.52***	0.42***
χ^2	16143	15694	17063	13876	15971	15716	13497

***$p<0.0001$; **$p<0.001$; *$p<0.05$; $N=10099$; IRR=incidence rate ratio from Poisson regression

Table 3. Incidence of chronic health trajectory by gender

	Female (N=5352)						Male (N=4746)					
	M-1	M-2	M-3	M-5	M-6	M-7	M-1	M-2	M-3	M-5	M-6	M-7
Variables	IRR	IRR	IRR	IRR	IRR	IRR	IRR	IRR	IRR	IRR	IRR	IRR
Childhood factors												
Childhood health	1.38***			1.34***	1.26***	1.13***	1.18**			1.17**	1.09	1.02
Childhood-SES		1.10***		1.09**	1.06*	1.03		1.09**		1.08**	1.06	1.05
Mother's education		1.08**		1.07*	0.98	1.00		0.99		0.97	0.95	0.98
Father's education		1.13***		1.15***	1.07*	1.03		1.11**		1.11**	1.03	1.00
Financial help		1.02		1.01	1.02	1.03		1.03		1.03	1.01	
Adult-SES												
College education			0.76***		0.77***	0.93*			0.75***			0.91*
>High school			0.82***		0.83***	0.94			0.91**			0.98
Ln(household wealth)			0.97***		0.97***	0.99			0.98***			0.99
Adult Health and behavior												
Self-rated-poor health						1.70***						1.76***
Current smoker						1.22***						1.10**
Former smoker						1.16***						1.14***
BMI												
Overweight						1.29***						1.24***
Obese						1.65***						1.57***
Underweight						1.25**						1.06
Physical activity						0.95*						0.89***
# of limitations						1.06*						1.11**

***$p<0.0001$; **$p<0.001$; *$p<0.05$; IRR=incidence rate ratio from Poisson regression