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Understanding the SES gradient in health among the elderly: The role of childhood circumstances

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Abstract

Individuals' socioeconomic status (SES) is positively correlated with their health status. While the existence of this gradient may be uncontroversial, the same cannot be said about its explanation. In this paper, we extend the approach of testing for the absence of causal channels developed by Adams et al. (2003), which in a Granger causality sense promises insights on the causal structure of the health-SES nexus. We introduce some methodological refinements and integrate retrospective survey data on early childhood circumstances into this framework. We confirm that childhood health has lasting predictive power for adult health. We also uncover strong gender differences in the intertemporal transmission of SES and health: While the link between SES and functional as well as mental health among men appears to be established rather late in life, the gradient among women seems to originate from childhood circumstances.

Keywords: health; wealth; socio-economic gradient; causal inference; Granger causality; individual heterogeneity; childhood health; childhood circumstances.

JEL classification: C33; I0; I12.

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1 Introduction

It is the health economics version of the classic "chicken and egg" problem: We know that people with high socio-economic status (SES) tend to be in better health and live longer than their economically disadvantaged counterparts but we are not sure which came first. Do economic resources determine health (hypothesis A)? Does health influence economic success (hypothesis B)? Or, are both health and wealth dependent on some third unaccounted factor (hypothesis C)? The body of literature dealing with this so-called socio-economic gradient in health is impressive (for overviews see Smith, 1999; Cutler *et al.*, 2011; and Stowasser *et al.*, 2012).

The traditional view that causality flows from SES to health is especially common among – but not exclusive to – epidemiologists. Often-cited causal pathways are the affordability of health services, better health knowledge and lifestyles among the higher educated, environmental hazards associated with poorly paying occupations and low-income living conditions, or the mere psychological burden that comes with a life of constant economic struggle. Economists were among the first to argue that causality may also work its way from health to economic outcomes, the most important channel being the development of human capital: Physical frailty is likely to have adverse effects on educational attainment, occupational productivity and, consequently, the accumulation of wealth. Finally, the statistical literature stresses the point that the persistent correlation between morbidity and SES may in fact be spurious and due to unobserved individual heterogeneity with a common influence on both health and wealth, see Heckman (1981b), *inter alia*. Prime candidates for such hidden third factors are genetic disposition and other family effects with an impact on preferences and health-relevant behaviors.

Discriminating among these rivalling hypotheses is important since policy recommendations will critically depend on the nature and the sources of the gradient. Methodologically, the estimation of credible causal effects in population data requires addressing the challenges of simultaneity (hypothesis A vs. hypothesis B) and unobserved common effects (hypotheses A/B vs. hypothesis C).[1] The conventional solution to both of these problems is to exploit natural experiments that provide instruments for either health or SES. While this strategy of isolating exogenous variation certainly works well on

[1] For a detailed discussion, see Stowasser *et al.* (2012).

paper, it is not always persuasive in practice. The main caveat is that convincing instruments are generally in short supply. As discussed by Stowasser *et al.* (2012), even the availability of instruments that are clearly exogenous and that have an impact on the endogenous regressor they seek to replace may cause problems if the variation they reflect is not all that *relevant* for the dependent variable of interest. Moreover, since IV strategies usually rely on rather case-specific events, any uncovered effects may well be causal in nature but of questionable external validity; Deaton (2010) discusses these issues.

For these reasons, Adams *et al.* (2003) propose an alternative approach of uncovering causal links that makes use of the entire variation in health and economic variables. Using panel data, they test for Granger non-causality of SES for *innovations* in health, which deals with the econometric challenge of distinguishing hypotheses A and B.[2] Their purely statistical causality concept deviates from "true" causality in a structural sense, as their approach does not specifically address the issue of unobserved individual heterogeneity. As a consequence, the detection of Granger causality would not necessarily imply the validity of hypothesis A, since unobserved third factors may be at work instead. However, a finding that economic status is *not* Granger causal for health and that the relationship is invariant across a wide range of SES and health histories would be informative, as this would rule out true causality as well.[3] Applying their framework to a representative sample of US Americans over the age of 70, Adams *et al.* (2003) are unable to reject the hypothesis that economic status has no causal effect on mortality and most health innovations, once health history is controlled for. Despite the fact that this result may not be overly surprising in light of the subgroup's quasi-universal access to Medicare and considering that causal links may well have been active in the past[4], their study stimulated some controversy in the literature.

On this account, Stowasser *et al.* (2012) revisit the approach introduced by Adams *et al.* (2003) and investigate whether the original findings are

[2]While Adams *et al.* (2003) studied both wealth-to-health and health-to-wealth causation, this study concentrates on the question whether hypothesis A is correct.

[3]The rationale for this reasoning is that Granger causality – or conditional dependence across time – is thought of as a necessary but insufficient condition for causality in a more structural sense.

[4]Indeed, Adams *et al.* (2003) find a steep gradient in the initial cross section, suggesting that a great deal of the relationship between health and wealth has already been determined during the (unexplained) first seven decades of respondent's life courses.

confirmed when their methodology is applied to a more encompassing set of data that covers health histories of different lengths and varying age compositions. In stark contrast to the original study, they find that it is much harder to reject the existence – or the activity – of causal links in more comprehensive samples. Importantly, this result is not exclusively driven by the inclusion of younger individuals, as the mere growth in sample size already leads to higher rejection rates of Granger non-causality, which indicates that the original results were partly driven by low test power. In light of their findings, Stowasser *et al.* (2012) discuss three avenues for improving the approach suggested by Adams *et al.* (2003). First, the underlying notion of health dynamics, with health being modelled as a first-order Markov process, falls short of reflecting the stock characteristics of latent health capital as envisioned by Grossman (1972). Second, the original approach does not account for individual heterogeneity, which makes it impossible to distinguish between true causal links and third-factor effects in case Granger causality is detected. Third, even if common effects were convincingly controlled for, the tests proposed by Adams *et al.* (2003) are only informative about the mere *presence* of causality but not of the mechanisms through which SES influences health. Although knowledge of this general link is important in its own right, the identification of specific pathways is equally critical from a policy perspective.

The present study aims at addressing these issues and gauges whether the main conclusion of Stowasser *et al.* (2012), that it is impossible to statistically reject SES-to-health causality even in a retired population aged 65 and older, is robust to these methodological refinements. The research strategy rests on the increasing availability of retrospective life-history data within large panel studies that link economic and health data, such as the U.S. *Health and Retirement Study (HRS)* used for this analysis.[5] These data innovations are the response to the rapidly growing literature on childhood health that makes the point that a meaningful analysis of the gradient should incorporate respondent's early-life information (for an overview, see Smith, 2009; Almond and Currie, 2011; and Currie, 2011). For instance, Case *et al.* (2002) suggest that part of the adult SES gradient in health originates in early childhood, as they find a strong relationship between parental economic status and childhood health that accumulates as children

[5]Comparable data collection efforts targeted at the population aged 50 and older include the *Survey of Health, Ageing and Retirement in Europe* (SHARE), the *English Longitudinal Study of Aging* (ELSA), or the *China Health and Retirement Longitudinal Study* (CHARLS).

age. In another cohort study, Case *et al.* (2005) document that these early conditions have a lasting impact on adult health and – in line with hypothesis B – other outcomes such as education, labor supply and income. As Currie (2009) notes, these findings are supported by many, albeit not all, of the myriad of studies that complement the literature by exploiting data from natural experiments.

Not only does this evidence suggest the use of available information on childhood circumstances, to avoid bias from omitted variables when studying causal pathways in adulthood – the retrospective look at the beginning of life additionally has the potential to alleviate all three of the aforementioned problems in the Adams *et al.* (2003) framework: First, it provides an opportunity to incorporate longer health histories and, thus, a more realistic model of health dynamics. Second, to the extent that retrospective data also covers information on family backgrounds and parental SES, it will be possible to proxy-control for some of the individual heterogeneity that is suspect of exerting a common influence on health and wealth. Third, controlling for both historic and contemporary variables may elucidate *when* the association between SES and health is established, which has important policy implications: If future outcomes are predetermined during childhood, resources spent on policies that aim at improving access to health care for adults and retirees may in fact be more wisely invested into educative and financial measures for young families.

In summary, the results of this study suggest that the findings of Stowasser *et al.* (2012) are largely insensitive to varying models of health histories. While SES is unlikely Granger causal for innovations in acute health insults, Granger non-causality can be statistically rejected for mental health conditions, mortality, and changes in overall health. Evidence for chronic diseases and functional health is a bit more inconclusive. However, since the detection of Granger causality for these health conditions is adversely related to sample size, it is possible that we merely observe the statistical artifact – as already reported by Stowasser *et al.* (2012) – that test power suffers considerably in small datasets. The fact that results are also quite robust to the introduction of proxy controls for individual heterogeneity lends support to a causal interpretation of the observed gradient. In line with the literature on early life circumstances, we find that childhood health has lasting predictive power for adult health. This, however, does not render contemporary factors unimportant. Finally, we uncover strong gender differences in the

intertemporal transmission of SES and health: While the link between SES and functional, as well as mental health among men is established rather late in life, the gradient among women appears to originate from childhood circumstances.

The rest of this paper is structured as follows. Section 2 presents the data used for analysis. This is followed by a brief description of the methodological framework – which closely resembles that of Adams *et al.* (2003) and Stowasser *et al.* (2012) – in section 3. The empirical analysis is presented in section 4. Section 5 concludes.

2 Data

In this paper, we use data from the *Health and Retirement Study (HRS)*, which is a representative panel of the US population aged 50 and older. The design of the analysis sample and the constructions of the variables are natural extensions of Adams *et al.* (2003) and Stowasser *et al.* (2012).[6] Due to substantial deviations in survey design, observations from the first panel wave are dropped. As a result, the main working sample consists of 8 biennial waves covering interviews conducted between 1993–2008. In the spirit of the original study by Adams *et al.* (2003), we restrict our analysis to a mostly retired population of the age of 65 and above. On average, each wave contains roughly 11,400 individuals with usable records on health outcomes, SES variables and demographic information.[7] Attritors and members of refreshment cohorts are kept in the sample for as long as they participate in the survey. This ensures that sample size is kept high enough for precise estimation and that up to 8 waves can be used simultaneously.

This study differs from Stowasser *et al.* (2012) in that it no longer estimates the incidence of 20 separate health conditions but combines some of them into disease clusters. As a result, health dimensionality is reduced to just 6 outcomes, which considerably facilitates concise interpretability of results. We consider these outcomes: The number of acute – and immediately life-threatening – conditions (cancer, heart disease, and strokes); the number of chronic diseases (lung disease, diabetes, hypertension, and arthritis);

[6] For further details on HRS, you may refer to Stowasser *et al.* (2012).

[7] Just as in Stowasser *et al.* (2012), we exclude individuals that generally failed to disclose information on their health. Gaps from insular item nonresponse are filled via simulation-based imputation. For missing wealth and income measures, we use imputations readily available in the public release files provided by the *RAND Corporation*.

the number of functional health limitations (incontinence, severe falls, hip fractures, ADL/IADL impairments, and an indicator for obesity); the number of mental illnesses (cognitive impairment, psychiatric disease, depression, and whether interviews were conducted with a proxy respondent); self-rated health status; and mortality. Summary statistics for these health indicators as well as for all SES variables used for analysis – namely wealth, income, education, dwelling condition, and neighborhood safety – are presented in appendix table A-1.

This contemporary data is complemented with information from retrospective questionnaires on respondents' health, living conditions, and family backgrounds when they were children, that has subsequently become available within HRS. While this method of retrieving information about panel members' lives before the survey's baseline year provides advantages – in the form of low cost, speed, and reduced sample attrition – over longitudinal cohort studies that follow respondents from cradle to grave, one may express doubt about the accuracy of responses. After all, interviewees are asked to recall circumstances that date back at least 50 years.[8] Yet, the growing literature on the reliability of retrospective surveys, finds recall bias to be generally negligible (see Berney and Blane, 2010; and Garrouste and Paccagnella, 2010). For instance, while Smith (2009) reports some unsystematic recall error in retrospective HRS data, he finds no evidence for "coloring" – the selective recall of health histories induced by adverse health events late in life – of responses.

Retrospective information on childhood health has been introduced to HRS in two stages. A general index of self-rated health (SRH) before age 16 – which is constructed in the same way as HRS's 5-point-scale measure for contemporary SRH – is already available since panel wave 4, hence covering a rather large share of the entire HRS population. On the other hand, effective sample sizes are considerably smaller for the multitude of detailed child-health measures introduced in wave 9, since these are only available for respondents, who were still sample members at this late stage. The latter list of variables includes 21 health conditions and whether respondents missed school for more than a month due to health problems. Once again, the individual health conditions are grouped to reduce complexity: We distinguish severe health problems (such as cancer or heart disease), less severe conditions (such as ear infections or allergies), mental health problems

[8]The HRS questionnaire defines childhood as life before the age of 16.

(such as depression or psychological problems), and classic child diseases (measles, chicken pox, and mumps).

HRS early-life data also covers the economic living conditions during childhood as well as family background measures and certain child behaviors. Again, some measures are available as early as wave 4. These include a 3-point index of self-assessed family SES, information on parental education, paternal unemployment, and whether the family ever solicitated financial help or had to move due to economic dire straits. Information on maternal labor-force participation and parental smoking were added in waves 8 and 9, respectively. In addition, starting with wave 9, HRS provides information on childhood smoking, drug and alcohol use, and whether the respondent experienced significant learning problems at school. Another pair of measures – already used by Adams *et al.* (2003) and Stowasser *et al.* (2012) – that also capture family effects, but which are not considered part of HRS's retrospective module, are the ages at death (or just the ages, in case they are still alive) of the respondents' parents. Similarly, respondents' adult height is often used as a proxy for health at birth and is correlated with the uterine environment the family provides (see Case and Paxson, 2008; and Currie, 2011).

Summary statistics for all early-life data used for analysis are provided in table 1. As indicated, the number of available observations differs considerably among variables. This needs to be taken into account when deciding which of these information to use for analysis in section 4, as statistical power will certainly suffer in case of severe sample-size loss.

3 Methodology

The econometric methods used in the present study are essentially those introduced by Adams *et al.* (2003), with some extensions introduced by Stowasser *et al.* (2012); we refer to the latter paper for a more detail discussion. The analysis builds on a dynamic model of health incidence,

$$f\left(HI_{it}^{j} | \mathbf{HI}_{it}^{k<j}, \mathbf{H}_{it-\tau}, \mathbf{S}_{it-1}, \mathbf{X}_{it-1}, I_i\right), \tag{1}$$

where i denotes the respondent and t indicates time. The dependent variable, HI_{it}^{j} measures a new incidence of a given health condition, where j stands for one of the six health clusters introduced above. As in Adams *et al.* (2003), health innovations are thought to be influenced by the following

Table 1. *HRS early-life data*
Summary statistics

Variables	N	Mean	StDev.
Childhood health			
- Poor/fair self-rated health	25,266	0.065	0.247
- No. of severe conditions	11,624	0.243	0.526
- No. of less severe conditions	11,625	0.345	0.665
- No. of mental conditions	11,693	0.068	0.289
- No. of "child diseases"	10,565	2.228	0.982
- Missed school due to health problem	11,681	0.113	0.316
Family background			
- Self-rated family SES above average	25,389	0.066	0.249
- Self-rated family SES below average	25,389	0.317	0.465
- Family needed financial help	24,994	0.125	0.331
- Moved due to financial problems	25,246	0.180	0.384
- Father's Education (in years)	24,806	8.9	3.5
- Mother's Education (in years)	26,010	9.1	3.3
- Father ever unemployed	25,045	0.290	0.454
- Mother always worked	17,633	0.171	0.376
- Mother sometimes worked	17,633	0.327	0.469
- Any parent smoked	11,677	0.634	0.482
- Both parents smoked	11,677	0.169	0.375
- Smoked as child	15,219	0.185	0.389
- Drugs or alcohol as child	11,722	0.005	0.071
- Learning problems at school	15,218	0.027	0.162
- Father's age (at death) (in years)	29,482	71.6	14.4
- Mother's age (at death) (in years)	29,482	75.3	15.1
- Adult height (in meters)	29,482	1.69	0.10

Notes: N denotes the number of respondents for who information on the respective variable is available.

explanatory variables: Instantaneous causal effects from concurrent health shocks on HI_{it}^{j} – such as the development of cancer that is followed by death within the same inter-wave spell – are captured by $\mathbf{HI}_{it}^{k<j}$, containing the incidence variables for all health indicators $(1,...,k)$ that are causally arranged upstream of indicator j.[9] Furthermore, the model controls for health histories, $\mathbf{H}_{it-\tau}$, that capture state dependence and co-morbidities, respectively. The vector $\mathbf{X}_{it-1}$ includes demographic controls. The vector of main interest, $\mathbf{S}_{it-1}$, contains lagged levels of wealth, income, educational attainment, and indicators for subpar living environments. If SES is truly causal for health

[9]Similarly to Adams *et al.* (2003), the six health indicators are grouped in the order in which instantaneous causality is most likely to flow: Acute conditions are listed first, as they can have an immediate impact on mortality. The remaining indicators are stacked as follows: Acute conditions upstream of chronic conditions upstream of functional conditions upstream of mental conditions upstream of SRH.

changes in an elderly population, we should expect significant coefficients for at least some of these variables. Moreover, the null hypothesis that

$$f\left(HI_{it}^{j}|\mathbf{HI}_{it}^{k<j},\mathbf{H}_{it-\tau},\mathbf{S}_{it-1},\mathbf{X}_{it-1},I_i\right)=f\left(HI_{it}^{j}|\mathbf{HI}_{it}^{k<j},\mathbf{H}_{it-\tau},\mathbf{X}_{it-1},I_i\right), \quad (2)$$

i.e. that past SES is not Granger causal for health deteriorations, should be rejected, while invariance tests, as described in Adams *et al.* (2003), are expected to be confirmed.

Model 1 deviates from the original specification of Adams *et al.* (2003) in the three dimensions. First, health histories are no longer assumed to be first-order Markov, as τ may take on values larger than one, to better accommodate the stock characteristics of latent health capital. This part of the analysis, in which we estimate model 1 with alternative specifications for $\mathbf{H}_{it-\tau}$, is presented in section 4.1. Second, the model acknowledges the hypothetical presence of individual heterogeneity, I_i, that may induce spurious correlation between health and SES (see hypothesis C). The analysis in section 4.2 seeks to contain the confounding influence of such common effects by using proxy controls for family backgrounds and behavioral factors. Of main interest is whether the finding of Stowasser *et al.* (2012), that SES is Granger causal for innovations in health, even in an elderly population, survives when more realistic health dynamics and a richer set of control variables are incorporated. A confirmation of their results would lend support to a causal interpretation of the observed association.

The final deviation from the original model proposed by Adams *et al.* (2003) concerns the reduction in health dimensionality by grouping certain medical conditions together. As a consequence, model 1 is fitted by ordered probit (except for mortality and the indicator for poor/fair SRH, which continue to be estimated with a probit model). To ensure the results are not driven by this modeling choice, and to provide a benchmark to which results from section 4 can be directly compared, we estimate model 1 with identical health histories and controls as in Adams *et al.* (2003). Evidently, results are largely insensitive to the aggregation of health measures and mirror the finding of Stowasser *et al.* (2012) that – with the exception of acute diseases – SES Granger causality cannot be rejected for medical events after the age of 65. These results are at least significant at the 5% level, in many cases even at the 1% or 0.1% level, although model invariance across time is not always supported in a sample that spans over all 8 available panel waves.

Table 2. *Benchmark results*
Tests for Granger non-causality

Health indicator	Test results (65+) W2-9 (N=50,993) F	M
Acute conditions		
Mortality	●	●●
Chronic conditions	●●●	●●●
Functional conditions	●●	●●●
Mental conditions	●●●	●●●
Self-rated health status	●●●	●●●

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: Granger non-causality rejected at 5% level (●), rejected at 1% level (●●), or rejected at 0.1% level (●●●). Gray symbols indicate that the corresponding invariance test is rejected at the 5% level. Blank cells indicate that Granger non-causality cannot be rejected. N denotes the number of respondent-year observations.

4 Empirical analysis

4.1 Health dynamics

The notion of health being a latent capital stock that reflects the entire history of medically relevant events is not new. Ever since Grossman (1972) proposed his seminal health production framework, most health economists acknowledge the existence of "long memory effects" of the human body and mind. Heiss (2011) confirms that this feature characterizes the HRS population, too, as he detects a surprisingly high degree of state dependence in respondents' SRH: Studying the first seven panel waves, he finds that, even if the maximum number of six lags of SRH are included to predict SRH in the seventh wave, all historic variables have significant explanatory power on their own.

In light of this, modeling health dynamics as a first-order Markov chain is unlikely to provide an appropriate description of the evolution of health, as discussed by Stowasser *et al.* (2012, p. 494):

> Intuitively, this is because the Markov model assumes that all relevant information about the whole past is captured in the observed variables one period ago. This is unrealistic since knowledge of longer histories would better capture the stock characteristics of health capital [...]. Taking functional lim-

> itations as an example, a respondent who reported difficulties with walking one year ago and no limitations previously has a different outlook than a respondent who consistently reported difficulties with walking for the last ten years.

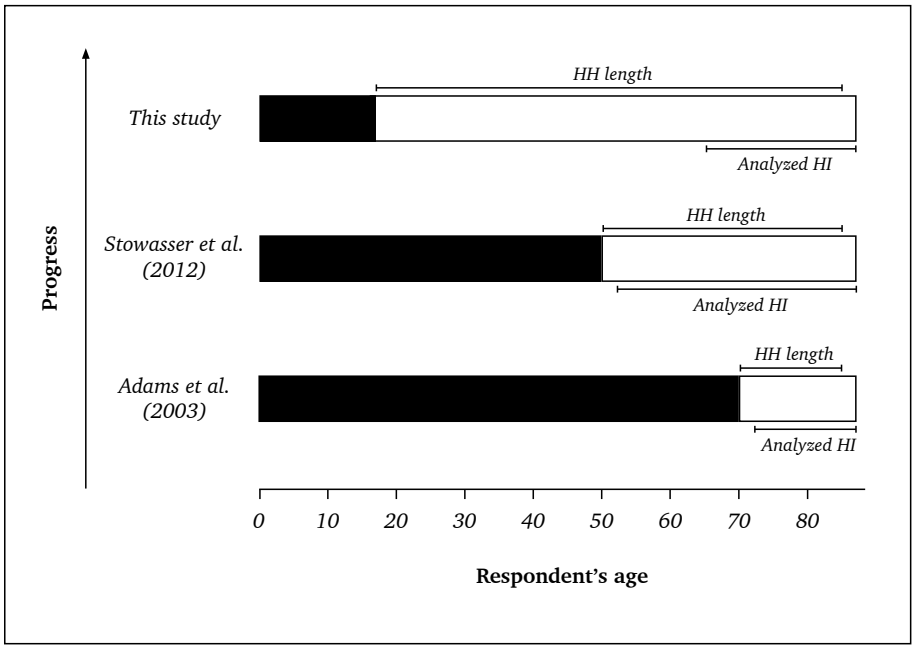
A straightforward way to improve the original Adams *et al.* (2003) model of health dynamics consists of increasing the length of health histories, model 1 controls for. While the performance of higher-order Markov models probably falls short of that of a fully-fledged *hidden* Markov model, such as Heiss (2011), they will likely pick up many of the same effects. More importantly, however, there are practical limits to this strategy: The more lags of health conditions are incorporated, the smaller the effective sample size that remains for analysis. On the one hand, it excludes all respondents that have been part of the sample for fewer waves than required by the desired history length. This may affect both sample attritors and members of refreshment cohorts, meant to keep the panel representative of the underlying population. On the other hand, the sample would even shrink if the panel was completely balanced, as each additional lag of control variables requires to drop one wave for the estimation of health innovations conditional on health histories.

As discussed by Stowasser *et al.* (2012), such large drops in sample size constitute a problem for the Adams *et al.* (2003) approach because of it will be unable to reject Granger non-causality if test power becomes too small as the sample gets smaller. Given this apparent trade-off between richer health dynamics and the risk to obtain artifactual test results, the number of lags should only be increased with great care. On this account, the knowledge of health during childhood provides a promising alternative to control for even (much) longer histories without having to forego the potential scale limits in the data.

At the same time, the availability of information on child health alleviates the closely related problem of initial conditions – that is, life before respondents enter the panel (see Heckman, 1981a). As Smith (2009) (p. 388) notes,

> [k]nowing health or economic status beginning at [survey] baseline is not sufficient because the entire prior histories of health and economic trajectories may matter for current decision making. The absence of information on pre-baseline health histories, including childhood health, means that researchers have to rely on a key untestable assumption: baseline health condi-

Figure 1. *Maximum health history lengths*
Comparison between studies



Notes: White boxes indicate known health histories. Black boxes depict unknown health histories. "HH length" denotes the maximum length of health histories that can be exploited for analysis. "Analyzed HI" stands for the age range used to analyze health incidence.

tions sufficiently summarize individuals' health histories. If they do not, new health events unfolding during the panel may be the delayed (and perhaps predictable) consequence of some knowable part of an individual's health history. If so, health events within the panel cannot be used to measure effects of new exogenous, unanticipated events.

The extent to which retrospective data enables a look into the "black box" of early life, as compared to Adams *et al.* (2003) and Stowasser *et al.* (2012), is visualized in figure 1. Note that the effective health history length is depicted to be by one wave (or 2 years) shorter than panel length theoretically permits.

Given these considerations, we gauge the sensitivity of model 1 to varying representations of health history by gradually increasing the lag length of adult health prevalence, by the inclusion of child health, and by combinations of the two. As argued above, these steps are associated with considerable reductions in effective sample size, which entails the risk of confounding any effect from longer health histories with the mere decline in test power. In order to separate these two effects, we also apply the orginal

health history specification of Adams *et al.* (2003) to these subsamples. These "dry runs" serve as the benchmarks to which results from models with more sophisticated health histories should be compared. The Granger non-causality test results for all of these specification are summarized in table 3.

The first alternative specification, models health histories as a second-order Markov process (i.e. the number of health-condition lags is increased to two), which reduces the size of the analyzable sample from 50,993 to 42,367 respondent-year observations. As is evident from comparing columns (C) and (D) with columns (A) and (B) of panel A in table 3, this has no significant impact on SES Granger causality tests. The same picture emerges when a third-order Markov model is used (see columns (G) and (H)). While with the latter specification, empirical p-values tend to be a bit higher than with the lower-ordered Markov model (as indicated by fewer dots), this is clearly not driven by the inclusion of the additional lag but by the reduction in sample size. To see this, consider that p-values also increase for the benchmark case – compare columns (E) and (F) with columns (A) and (B) – whereas the actual switch to a higher-order Markov model – compare columns (G) and (H) to columns (E) and (F) – has no systematic impact at all. Results for even higher-order Markov models are not presented here, as these imply sample sizes too low to conduct meaningful analysis that stratifies by gender.

Panel B of table 3 contains results for specifications that use child health to incorporate longer health histories. Recall from section 2 that the number of respondents with data on childhood SRH greatly exceeds that of individuals for who we have detailed information on early-life health conditions. For this reason, we add these variables in two sequential steps. Results in columns (L) and (M) are for model 1 when controlling for first-order Markov health histories – the default in Adams *et al.* (2003) – and self-rated health during childhood. Once again, Granger non-causality tests are not systematically influenced by the incorporation of longer health histories and suggest that, with the exception of acute diseases, causal links from SES to health cannot be statistically rejected. In the second step, we additionally include the more specific data on childhood health conditions, which roughly cuts the available sample size in half (49,962 to 25,175 respondent-year observations). The corresponding results in columns (P) and (Q) require some discussion: First of all, the effect of SES on mortality can no longer be stud-

Table 3. *Results for varying health histories*
Tests for Granger non-causality

Panel A: Higher-order Markov models								
Health indicator	**Test results**							
	Sample for 2nd-order Markov (N=42,367)				Sample for 3rd-order Markov (N=38,886)			
	Dry run		M2		Dry run		M3	
	F	M	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Acute conditions								
Mortality	●●●	●●●	●●	●●●	●●	●●	●●	●●
Chronic conditions	●●●	●●	●●●	●●	●●●	●	●●	●
Functional conditions	●●	●●●	●●●	●●●	●●	●●●	●●●	●●●
Mental conditions	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Self-rated health	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Panel B: Childhood health								
Health indicator	**Test results**							
	Sample for SRH (N=49,962)				Sample for Conditions (N=25,175)			
	Dry run		SRH		Dry run		HC	
	F	M	F	M	F	M	F	M
	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)
Acute conditions								
Mortality	●●	●●●	●●●	●●●	n.a.	n.a.	n.a.	n.a.
Chronic conditions	●●●	●●●	●●●	●●●	●●	●●●	●●●	●●●
Functional conditions	●●	●●●	●●	●●●		●●		●
Mental conditions	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Self-rated health	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Panel C: Third-order Markov model and Childhood health								
Health indicator	**Test results**							
	Sample for SRH (N=34,136)				Sample for Conditions (N=19,527)			
	Dry run		M3 & SRH		Dry run		M3 & HC	
	F	M	F	M	F	M	F	M
	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)
Acute conditions								
Mortality	●●	●●	●●	●●	n.a.	n.a.	n.a.	n.a.
Chronic conditions	●●●	●	●	●	●	●		●
Functional conditions	●●	●●●	●●●	●●●		●●●		●●
Mental conditions	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Self-rated health	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: Granger non-causality rejected at 5% level (●), rejected at 1% level (●●), or rejected at 0.1% level (●●●). Gray symbols indicate that the corresponding invariance test is rejected at the 5% level. Blank cells indicate that Granger non-causality cannot be rejected. N denotes the number of respondent-year observations. SRH stands for self-rated health during childhood. HC denotes childhood health conditions. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). M2 and M3 abbreviate 2nd-order and 3rd-order Markov processes, respectively. "n.a." indicates that lack in variation impedes estimation of mortality models.

ied because information on childhood health conditions is only available for respondents who were still alive in wave 9, which happens to be the most recent wave in the working sample. Furthermore, while it is true that Granger causality of SES is no longer supported for functional health conditions among women, this seems, once again, to be driven by the substantial reduction in sample size. Also note that, while the change in results for functional conditions among men (when comparing columns (O) and (Q)) seems substantial at first sight, a look at the actual p-values reveals that the change – from 0.0089 to 0.0104 – is only marginal at best.

For results in panel C of table 3, we combine both ways of accommodating health histories, which should arguably provide the most comprehensive description of the long memory effects of latent health capital – although this comes at the cost of even greater sample-size loss. Test outcomes in columns (T) and (U) are from a model with third-order Markov health histories and childhood SRH. This specification is then amended with the data on childhood health conditions (see columns (X) and (Y)). Overall, test outcomes depicted here, corroborate the findings from panels A and B. If anything, evidence for SES being Granger causal for the development of chronic conditions becomes a little weaker, as the null hypothesis of non-causality is only rejected at the 5% level for men and the 5% to 15% level for women (the corresponding p-value in column (X) equals 0.141). Similarly, results for functional conditions among females do again become barely insignificant (p=0.120). While it is certainly possible to dismiss these observations as artifactual side effects of dwindling sample sizes, one should at least note that results are generally less stable for chronic and functional conditions than for mental health and SRH.

Finally, a look at the coefficients of the underlying prediction model 1 – not reported here due to space limitations – confirms the earlier finding in the literature that even very long health histories have explanatory power for health innovations in an elderly population. For instance, Heiss' (2011) observation, that all lags of SRH have highly significant predictive power for current SRH, is confirmed even when controlling for SES and third-order Markov health-condition histories. The fact that the same holds true for SRH during childhood, hints at an astounding degree of state-dependence in latent health and confirms the long reach of childhood circumstances, established by the literature summarized in section 1. It is encouraging to ob-

serve that test results for Granger-non causality of SES are not significantly changed by accounting for these formerly omitted variables.

4.2 Common effects

As argued above, the Granger-causality framework proposed by Adams *et al.* (2003) cannot cleanly distinguish between hypotheses A and C – that is, between "true" causality and spurious correlation due to common effects. This identification problem arises because of unobserved individual heterogeneity – with respect to genetic endowment, family backgrounds, and early-life experiences – that influences both health and SES without there necessarily being a causal relationship between the two. Methodological solutions to this problem either require a set of valid instruments or the use of fixed-effects approaches. Since Adams *et al.* (2003), Stowasser *et al.* (2012), and the present paper study whether the framework proposed by Adams *et al.* (2003) can serve as a viable *alternative* to IV estimation, it would not make much sense to go down the first-mentioned route. Furthermore, while the HRS panel is certainly of sufficient length to estimate equations with individual fixed effects, it is not obvious that such models, which rely on the assumption that coefficients are constant over time, make sense when looking at health and wealth over a period spanning several decades.

For these reasons, this study follows a different strategy, which may well fall short of providing an outright solution to the problem, but which should alleviate the confounding influence of unobserved third factors. Acknowledging the fact that the underlying problem is one of omitted variables – namely unobserved individual heterogeneity – we add control variables that should provide reasonable proxies for characteristics of the family and the home environment, as the latter are likely to play a central role in shaping individual preferences, behaviors and genetic endowment. Naturally, the feasibility of this approach critically hinges on the data at hand. As extensively argued in the childhood-health literature, early-life data provides a number of variables that meet the above requirement (see – among several others – Case *et al.*, 2002; Berger *et al.*, 2009; Case *et al.*, 2005; Smith *et al.*, 2010; Mazzonna, 2011; and Kesternich *et al.*, 2012). For instance, Case *et al.* (2005) (p.384)

> [...] include a large set of variables in [the control vector] C, and assume that this set of variables is rich enough to capture all individual heterogeneity. Indeed, our ability to control for a large set of childhood characteristics is

Table 4. *Results for varying family-background controls*
Tests for Granger non-causality

Health indicator	Test results							
	Sample for tier 1 (N=42,271)				Sample for tier 2 (N=21,250)			
	Dry run		Tier 1		Dry run		Tier 2	
	F	M	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Acute conditions								
Mortality	●●	●●●	●●	●●	n.a.	n.a.	n.a.	n.a.
Chronic conditions	●●●	●●	●●●	●●	●●●	●●●	●●	●●
Functional conditions	●●	●●●	●	●●		●●		●
Mental conditions	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Self-rated health	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: Granger non-causality rejected at 5% level (●), rejected at 1% level (●●), or rejected at 0.1% level (●●●). Gray symbols indicate that the corresponding invariance test is rejected at the 5% level. Blank cells indicate that Granger non-causality cannot be rejected. N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). For definitions of tier 1 and tier 2 see text. "n.a." indicates that lack in variation impedes estimation of mortality models.

an advantage over much of the previous literature that examines health and SES dynamics.

The 15 family-background variables used to proxy-control for individual effects are listed in table 1. As was the case for childhood health conditions, the number of available observations differs substantially among variables, which is why they are also added in two sequential steps. The first tier of controls includes the four proxies for family SES, parental education, paternal unemployment status, parental age (of death) and respondents' adult height. The second tier consists of the aforementioned data to which maternal labor-force status, parental and own smoking behavior as a child, drug use, and information on learning problems in school are added. Again, we estimate benchmark dry-runs like those described in section 4.2 to distinguish the effects of adding the controls from those that are due to reductions in sample size. Results for Granger non-causality tests, conditional on model invariance, are summarized in table 4.

While p-values slightly increase across the board by the inclusion of both tier 1 and tier 2 variables, the changes in test results are not very substantial. Overall, the conclusion that Granger-non causality is statistically rejected for non-acute health events remains intact even after controlling for family backgrounds. The notable exception is functional health, for which results are a

Table 5. *Results for all controls*
Tests for Granger non-causality

Health indicator	Test results (N=16,335)			
	Dry run		Tier 1	
	F	M	F	M
	(A)	(B)	(C)	(D)
Acute conditions				
Mortality	n.a.	n.a.	n.a.	n.a.
Chronic conditions	•	•		
Functional conditions		••		•
Mental conditions	•••	•••	••	•••
Self-rated health	•••	•••	•••	•••

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: Granger non-causality rejected at 5% level (•), rejected at 1% level (••), or rejected at 0.1% level (•••). Gray symbols indicate that the corresponding invariance test is rejected at the 5% level. Blank cells indicate that Granger non-causality cannot be rejected. N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). For definition of tier 1 see text. "n.a." indicates that lack in variation impedes estimation of mortality models.

bit inconclusive. This underscores the earlier finding that the association between SES and this health dimension appears to be weaker than for other conditions.

In a final step, we estimate a version of model 1 that combines controls for family backgrounds with a more adequate model of health dynamics as developed in section 4.1. Note that, inasmuch as these longer histories capture the effect of latent health capital, they may also absorb some of the endogeneity imposed by genetic traits, with severe health problems in childhood being a signal for general frailty. To achieve the most conservative assessment for the presence of Granger causality, we model health histories as third-order Markov with controls for all available childhood health conditions and include the more encompassing second tier of early-life controls. Results are presented in table 5 and should be compared to columns (X) and (Y) of table 3 and columns (G) and (H) of table 4. Even in this most encompassing specification – that comes at the cost of an even smaller and less representative sample of just 16,335 respondent-year observations – SES Granger non-causality for mental health conditions and general health sta-

tus is clearly rejected, which lends credibility to the interpretation that these associations do in fact reflect causal relationships. While results for chronic and functional health conditions are certainly less robust, it is not entirely clear how much of the increase in p-values is driven by the introduction of controls – which would in fact suggest the importance of third factors – and how much is due to dwindling test power that may occult the presence of true, albeit relatively weaker, causal links. A conclusive answer to this question will have to wait for the addition of refreshment cohorts, which will eventually increase the number of available observations for early-life conditions as well.

4.3 Pathways between SES and health

So far, the focus of this study has been the ability of the approach introduced by Adams *et al.* (2003) to discriminate between true causality and the influence of third factors in case Granger causality is detected. While this general distinction is certainly of interest in its own right, it is equally important to go beyond broad causality tests and investigate more narrowly focused questions about the mechanisms that connect specific health outcomes to specific dimensions in SES. For this reason, we complete our analysis by discussing some key parameter estimates from the underlying prediction model, displayed in appendix tables A-2 through A-5, as they will shed light on the question of how and when links between SES and health are established.[10]

Acute health conditions

Results in table A-2 confirm our previous observation that adult SES is unlikely to be causal for the development of acute health conditions. In fact, in all of the specifications tested, there is not a single SES marker with a statistically significant impact on this health dimension. Reaffirmingly, estimates in columns (E) and (F) show that the same holds true for family SES during childhood, which is practically unrelated with the occurrence of acute health events in a population aged 65 and older.

However, childhood health appears to have predictive power for adverse health shocks among retirees: Results in Columns (C) through (F) show that the number of diseases during childhood matters for women, whereas self-

[10]Note that, as expected, the number of classic child diseases has no explanatory power for any future health outcomes and are therefore excluded from regression tables A-2 through A-5.

rated childhood health appears to be a sufficient statistic for male respondents. At the same time, the explanatory power of adult health histories is rather low, with first-order Markov processes representing an adequate modeling choice for both disease state dependence and co-morbidities: While all higher-order lags – whose parameter estimates are not displayed due to space considerations – enter the model with intuitive signs, their effects are not statistically different from zero.

Chronic health conditions

As results in table A-3 show, evidence for chronic health conditions is less clear-cut. When childhood circumstances are ignored, wealth, income and education are negatively related with the development of diseases such as diabetes or emphysemia. This gradient gets considerably weaker – but does not fully disappear – when controlling for health and family background during early life (see columns (C) through (E)). Recall that these changes may partly be due to dwindling sample sizes that reduce test power, since point estimates for income among women, wealth among men, and college education among men remain rather constant whereas standard errors increase substantially. There is no evidence that the link between SES and chronic diseases is established during childhood, as none of the family background measures exerts any significant influence on adult health outcomes.

Yet, as was the case for acute illnesses, the development of chronic diseases appears to be partly predetermined by childhood health. Having experienced severe health spells before the age of 16, significantly increases the likelihood of chronic morbidity. For men, the same is true for the number of less severe conditions. This evidence for strong intertemporal dependency is corroborated by estimates – which are again omitted to save space – of adult health histories that endorse a third-order Markov specification to model the evolution of chronic health conditions.

Functional health conditions

Mirroring the preceding analysis in sections 4.1 and 4.2, the strong link between *adult* SES and functional health detected in columns (A) and (B) of table A-4 is substantially weakened – and all but disappears for women – when early-life circumstances are added to the analysis. However, this should not automatically be taken as evidence against the general causality of SES for functional impairments. In fact, results in column (E) suggest that the SES

gradient does survive even for women but that it is already established during childhood: Having grown up in a family with low SES and having been raised by guardians that smoked, significantly impairs functional health for female retirees. Given the substantially higher labor-market participation among men, it is not surprising that their link between SES and functional health seems to work through higher education, rendering family effects insignificant in column (F).

The long reach of early life is, once again, underlined by the fact that childhood health also affects functional well-being at higher ages. For women it is the number of mental health problems that matters, whereas men are sensitive to the number of less severe illnesses when growing up. With respect to adult health histories, third-order Markov processes fare much better than short-memory models. This is especially true for chronic comorbidities and indicators for subpar self-rated health, whose lagged values – not displayed here – all enter with significantly positive signs.

Mental health conditions

Finally, the nature of the SES gradient in mental health – under inspection in table A-5 – closely resembles that of functional impairments. Again, the link appears to be established during childhood for women and later in life for men. Female retirees with mental health problems report that they suffered from learning difficulties, that they smoked as a child, and that their family had to change homes due to financial impasse.[11] In addition, mental health as a child is by far the strongest predictor for psychological and cognitive problems among elderly women. By contrast, childhood circumstances are far less consequential for men, whose mental well-being is primarily influenced by years of schooling and current financial wealth.

As was the case for chronic and for functional health conditions, the evolution of mental health is well-described by third-order Markov models whose explanatory power clearly exceeds that of lower-order processes, not reported here.

5 Conclusion

This study addresses three critiques of the methodology for studying causality in the health-wealth nexus that was introduced by Adams *et al.* (2003).

[11] Note that the two latter indicators are only marginally significant at the 10% level.

Building on Stowasser *et al.* (2012), we exploit the availability of retrospective data on early-life events, which allows for improved control of initial conditions and individual heterogeneity.

The first issue we address is the model of health dynamics. We implement higher-order Markov models and control for information on childhood health to accommodate the long memory effects of latent health capital. In line with the literature on early-life circumstances, we find that childhood health has lasting predictive power for adult health. This, however, does not render contemporary factors unimportant. Our analysis also suggests that – with the sole exception of acute health conditions – third-order Markov processes are a better description of health evolutions than shorter-memory models. At the same time, causality tests are largely insensitive to varying models of health histories.

Furthermore, we confirm the findings by Stowasser *et al.* (2012) that SES is unlikely to be causal for the development of acute health conditions but that Granger non-causality can – even in an elderly population aged 65 and older – be statistically rejected for mental health conditions, mortality and changes in overall health. Evidence for chronic diseases and functional health is somewhat inconclusive. This may simply reflect the problem that Granger-causality tests require relatively large sample sizes to obtain adequate power, as discussed by Stowasser *et al.* (2012).

The second methodological issue is the inability to distinguish between true causal links and common effects in case Granger causality is detected. The present study alleviates this concern by conditioning on early-life events that may function as proxies for unobserved individual heterogeneity, with health problems in childhood being a signal for physical frailty, and parental SES and health-relevant behaviors capturing family effects. Results from this modification closely mirror those of accounting for longer health histories. The fact that results for mental health and overall health status are remarkably robust, lends support to a causal interpretation of the observed gradient for these health dimensions.

Ultimately, however, the assessment of this issue will depend on how narrowly one wishes to define "true" causality. In our opinion, it is fair to argue that SES may even have a causal effect – in a rather wide sense – on individual heterogeneity, rendering the distinction between hypotheses A and C almost arbitrary. In fact, there is increasing evidence that personal characteristics are not as immutable as was once believed. For instance, part of

the literature on the education-health gradient argues that the years spent in education may not only change health-relevant knowledge, but also preferences, behaviors, and the way people think about their future (see Cutler and Lleras-Muney, 2008). In a similar vein, Currie (2011) reports evidence that even the activation of genetic traits – once considered the holy grail of irrevocability – may depend on environmental factors as well.

Finally, we address a third critique of the Adams *et al.* (2003) approach, the lack of a microfoundation of the pathways between SES and health. We scrutinize the underlying prediction model, which reveals pronounced gender differences in the origin of the gradient. While the link between SES and chronic illness appears to be established rather late in life, the same cannot be said about functional and mental health conditions among female retirees: For them, low family SES and mental problems as a child are the most predictive markers for health deteriorations in late adulthood, hinting at an exceptionally high degree of intertemporal and perhaps even intergenerational transmission of health and SES. In contrast to this, the SES gradient in functional and mental health for men – whose past labor-market participation is much higher than that of female HRS respondents – does not stem from childhood circumstances but is rather established during (secondary) education and adulthood.

Substantively, our findings add to the current debate about the role of early childhood circumstances for lifetime health. To the extent that future health outcomes are at least partly predetermined by childhood circumstances, public health policies should not neglect the importance to provide educative and financial support for young families. Our findings support the notion that social returns from such investments are likely to match those of measures that aim at altering the availability and use of health care in adulthood.

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Appendix: additional tables

The following tables contain regression results from our underlying prediction model and summary statistics for the dataset used in our analysis. Due to their large dimensions, they are each displayed on an individual page.

Table A-1. *Contemporary health and SES Variables used for analysis*
Summary statistics

Variable	Wave 2 (N=8,726)		Wave 3 (N=9,258)		Wave 4 (N=11,916)		Wave 5 (N=11,953)		Wave 6 (N=12,273)		Wave 7 (N=12,153)		Wave 8 (N=12,502)		Wave 9 (N=12,468)	
	Mean	StDev.	Mean	StDev.	Mean	StDev.	Mean	StDev.	Mean	StDev.	Mean	StDev.	Mean	StDev.	Mean	StDev.
Health prevalence																
No. of acute conditions	0.541	0.685	0.659	0.743	0.643	0.743	0.658	0.746	0.671	0.753	0.698	0.767	0.710	0.776	0.721	0.779
No. of chronic conditions	1.004	0.880	1.086	0.905	1.089	0.908	1.121	0.913	1.173	0.921	1.229	0.926	1.285	0.929	1.341	0.938
No. of functional conditions	1.316	1.120	1.535	1.264	1.562	1.278	1.654	1.299	1.171	1.303	1.768	1.311	1.851	1.316	1.905	1.308
No. of mental conditions	0.587	0.874	0.635	0.900	0.601	0.897	0.628	0.921	0.642	0.924	0.619	0.909	0.589	0.874	0.580	0.866
Poor/fair self-rated health	0.358	0.479	0.341	0.474	0.373	0.484	0.328	0.469	0.327	0.469	0.335	0.472	0.334	0.472	0.329	0.470
Health incidence																
No. of acute conditions			0.244	0.491	0.277	0.522	0.219	0.471	0.236	0.486	0.219	0.471	0.218	0.467	0.221	0.475
Died since last wave			0.104	0.306	0.101	0.301	0.108	0.311	0.115	0.319	0.098	0.297	0.100	0.300	0.101	0.301
No. of chronic conditions			0.198	0.453	0.206	0.441	0.205	0.444	0.199	0.436	0.227	0.458	0.224	0.461	0.215	0.447
No. of functional conditions			0.843	1.072	0.874	1.077	0.798	1.018	0.830	1.038	0.836	1.042	0.931	1.068	0.908	1.040
No. of mental conditions			0.260	0.561	0.236	0.530	0.199	0.488	0.205	0.498	0.169	0.447	0.163	0.432	0.156	0.425
SES variables																
1st quartile wealth indicator	0.255	0.436	0.230	0.421	0.227	0.419	0.219	0.413	0.214	0.410	0.215	0.411	0.217	0.412	0.212	0.409
4th quartile wealth indicator	0.183	0.387	0.221	0.415	0.255	0.436	0.275	0.447	0.291	0.454	0.306	0.461	0.330	0.470	0.328	0.470
1st quartile income indicator	0.368	0.482	0.335	0.472	0.291	0.454	0.292	0.455	0.277	0.447	0.278	0.448	0.272	0.445	0.274	0.446
4th quartile income indicator	0.117	0.321	0.144	0.351	0.161	0.368	0.167	0.373	0.169	0.375	0.176	0.381	0.177	0.382	0.193	0.394
Poor/fair housing condition	0.133	0.340	0.128	0.334	0.114	0.318	0.106	0.308	0.097	0.296	0.116	0.320	0.108	0.310	0.104	0.305
Poor/fair neighborhood safety	0.145	0.325	0.132	0.338	0.101	0.302	0.089	0.284	0.075	0.263	0.086	0.281	0.096	0.294	0.094	0.291
High school (educ. > 10 y.)	0.613	0.487	0.629	0.483	0.672	0.469	0.692	0.462	0.716	0.451	0.735	0.441	0.754	0.431	0.766	0.423
College (educ. > 14 y.)	0.147	0.354	0.156	0.363	0.172	0.378	0.180	0.385	0.193	0.195	0.199	0.399	0.206	0.404	0.218	0.413

Notes: Summary statistics are for the age-eligible sample (65+).

Table A-2. *Prediction model for acute health conditions*
Dependent variable: Number of acute health incidences

Key explanatory variables	**Ordered probit regression coefficients** (z-statistics in parantheses)					
	Dry run		Child health		Family	
	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)
Current SES						
- Wealth (1st qtl.)	0.023	0.031	0.000	0.005	0.012	0.008
	(1.02)	(1.19)	(0.08)	(1.03)	(0.24)	(1.40)
- Wealth (4th qtl.)	-0.025	-0.044	0.012	-0.015	0.012	0.001
	(-1.15)	(-1.89)	(0.32)	(-0.37)	(0.29)	(0.11)
- Income (1st qtl.)	-0.037	-0.044	-0.044	0.059	-0.026	0.018
	(-1.75)	(-1.86)	(-1.10)	(-1.31)	(-0.58)	(0.36)
- Income (4th qtl.)	-0.005	-0.030	-0.012	-0.033	-0.009	-0.072
	(-0.19)	(-0.12)	(-0.27)	(-0.69)	(-0.17)	(-1.39)
- High school	0.001	0.001	0.046	0.044	0.035	0.048
	(0.58)	(0.23)	(1.12)	(1.01)	(0.72)	(0.93)
- College	-0.038	-0.001	-0.087	-0.030	-0.090	-0.010
	(-1.52)	(-0.38)	(-1.90)	(-0.68)	(-1.81)	(-0.21)
Child health history						
- Poor/fair SRH			0.059	0.182**	-0.009	0.188*
			(0.94)	(2.67)	(-0.14)	(2.57)
- # Less severe cond.			0.034	0.054	0.050*	0.057
			(1.40)	(1.77)	(1.96)	(1.73)
- # Severe cond.			0.056	0.023	0.076*	0.030
			(1.87)	(0.65)	(2.28)	(0.80)
- # Mental cond.			0.135*	-0.129	0.180**	-0.012
			(2.45)	(-1.82)	(2.87)	(-1.52)
Family background						
- Father's age	-0.001*	-0.002**	-0.000	-0.001	-0.001	-0.002
	(-2.23)	(-2.69)	(-0.11)	(-0.88)	(-0.56)	(-1.23)
- Mother's age	-0.001**	-0.001*	-0.001	-0.001	-0.001	-0.001
	(-2.66)	(-2.03)	(-0.74)	(-1.33)	(-0.75)	(-0.44)
- Father's education					-0.007	0.009
					(-0.90)	(1.23)
- Mother's education					0.011	-0.010
					(1.33)	(-1.25)
- High family SES					0.005	0.105
					(0.07)	(1.24)
- Low family SES					0.042	-0.027
					(1.07)	(-0.64)
- Financial help					-0.033	-0.010
					(-0.56)	(-1.57)
- Need to move					0.012	0.008
					(0.67)	(0.49)
- Father unemployed					0.060	-0.027
					(1.52)	(-0.62)
- Mother employed					0.020	0.007
					(1.56)	(0.48)
- Parents smoked					0.012	-0.066*
					(0.76)	(-2.19)
- Kid smoked					0.011	0.076
					(0.18)	(1.70)
- Kid alcohol/drug					-0.000	0.152
					(-0.04)	(0.40)
- Kid trouble learning					0.079	0.067
					(1.30)	(1.05)
Adult health history	M1	M1	M3	M3	M3	M3
N	31,805	23,268	11,573	7,954	9,630	6,705
Log likelihood	-16,668.7	-13,880.9	-4,637.9	-3,889.4	-3,845.1	-3,266.6

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). SRH stands for self-rated health during childhood. M1 and M3 abbreviate 1st-order and 3rd-order Markov processes, respectively. *, **, and *** indicate statistical significance at the 5%, the 1%, and the 0.1% level, respectively.

Table A-3. *Prediction model for chronic health conditions*
Dependent variable: Number of chronic health incidences

Key explanatory variables	**Ordered probit regression coefficients** (z-statistics in parantheses)					
	Dry run		Child health		Family	
	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)
Current SES						
- Wealth (1st qtl.)	0.005	0.112***	0.023	0.138**	0.02	0.144*
	(0.20)	(3.81)	(0.57)	(2.76)	(0.23)	(2.52)
- Wealth (4th qtl.)	-0.028	0.005	-0.036	0.032	-0.048	0.051
	(-1.36)	(0.18)	(-1.10)	(0.79)	(-1.35)	(1.19)
- Income (1st qtl.)	0.065**	-0.027	0.038	-0.015	0.086*	0.010
	(3.02)	(-1.04)	(1.06)	(-0.35)	(2.16)	(0.21)
- Income (4th qtl.)	-0.012	-0.015	-0.006	-0.020	-0.007	-0.035
	(-0.49)	(-0.52)	(-0.14)	(-0.42)	(-0.17)	(-0.70)
- High school	-0.083***	-0.008	0.017	-0.003	0.066	0.003
	(-3.81)	(-0.31)	(0.45)	(-0.78)	(1.51)	(0.93)
- College	0.007	-0.092***	-0.087*	-0.100*	-0.063	-0.074
	(0.30)	(-3.58)	(-2.19)	(-2.31)	(-1.48)	(-1.58)
Child health history						
- Poor/fair SRH			-0.002	0.088	0.012	-0.136
			(-0.03)	(-1.25)	(0.17)	(-1.79)
- # Less severe cond.			0.038	0.079**	0.035	0.067*
			(1.71)	(2.64)	(1.43)	(2.07)
- # Severe cond.			0.049	0.065	0.071*	0.092*
			(1.75)	(1.90)	(2.28)	(2.51)
- # Mental cond.			0.037	0.001	0.011	0.032
			(0.72)	(0.02)	(0.19)	(0.44)
Family background						
- Father's age	-0.001*	0.001	-0.002*	0.001	-0.003*	-0.002
	(-2.35)	(0.70)	(-2.15)	(0.60)	(-2.53)	(-1.18)
- Mother's age	0.001	0.001	0.000	0.001	0.001	0.000
	(0.08)	(0.48)	(0.44)	(0.69)	(0.73)	(0.30)
- Father's education					0.001	-0.005
					(0.20)	(-0.73)
- Mother's education					-0.004	-0.004
					(-0.59)	(-0.47)
- High family SES					0.001	0.037
					(0.02)	(0.43)
- Low family SES					-0.011	0.026
					(-0.31)	(0.63)
- Financial help					-0.087	0.007
					(-1.64)	(0.11)
- Need to move					0.065	-0.023
					(1.55)	(-0.48)
- Father unemployed					0.024	0.028
					(0.69)	(0.66)
- Mother employed					-0.007	0.013
					(-0.61)	(0.92)
- Parents smoked					0.000	0.035
					(0.02)	(1.20)
- Kid smoked					-0.074	0.059
					(-1.35)	(1.34)
- Kid alcohol/drug					-0.000	-0.028
					(-0.78)	(-0.07)
- Kid trouble learning					-0.083	0.131
					(-0.58)	(1.13)
Adult health history	M1	M1	M3	M3	M3	M3
N	29,649	21,344	11,573	7,954	9,630	6,705
Log likelihood	-16,150.6	-10,997.9	-6,206.0	-4,031.0	-5,125.3	-3,389.1

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). SRH stands for self-rated health during childhood. M1 and M3 abbreviate 1st-order and 3rd-order Markov processes, respectively. *, **, and *** indicate statistical significance at the 5%, the 1%, and the 0.1% level, respectively.

Table A-4. *Prediction model for functional health conditions*
Dependent variable: Number of functional health incidences

Key explanatory variables	**Ordered probit regression coefficients** (z-statistics in parantheses)					
	Dry run		Child health		Family	
	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)
Current SES						
- Wealth (1st qtl.)	0.000	0.091***	0.024	0.081*	0.023	0.059
	(0.01)	(3.84)	(0.74)	(1.98)	(0.64)	(1.26)
- Wealth (4th qtl.)	-0.012	-0.027	0.025	-0.010	0.010	-0.006
	(-0.74)	(-1.33)	(0.99)	(-0.31)	(0.37)	(-0.17)
- Income (1st qtl.)	-0.009	0.020	-0.036	0.038	-0.016	0.043
	(-0.55)	(0.94)	(-1.29)	(1.27)	(-0.51)	(1.08)
- Income (4th qtl.)	-0.010	0.017	-0.004	0.047	-0.006	0.030
	(-0.51)	(0.72)	(-0.13)	(1.24)	(-0.17)	(0.73)
- High school	-0.044**	-0.017	-0.046	-0.009	-0.046	0.014
	(-2.61)	(-0.79)	(-1.58)	(-0.24)	(-1.34)	(0.34)
- College	-0.062***	-0.060***	-0.041	-0.119***	-0.049	-0.129***
	(-3.33)	(-2.91)	(-1.35)	(-3.43)	(-1.46)	(-3.44)
Child health history						
- Poor/fair SRH			-0.032	-0.011	-0.045	-0.027
			(-0.68)	(-0.19)	(-0.86)	(-0.44)
- # Less severe cond.			0.023	0.030	0.030	0.056*
			(1.30)	(1.22)	(1.54)	(2.09)
- # Severe cond.			0.054*	0.051	0.035	0.041
			(2.45)	(1.84)	(1.43)	(1.37)
- # Mental cond.			0.159***	0.039	0.156**	0.066
			(3.82)	(0.75)	(3.24)	(1.11)
Family background						
- Father's age	0.000	0.000	-0.001	0.001	-0.001	0.001
	(0.89)	(0.63)	(-0.74)	(1.45)	(-1.17)	(1.45)
- Mother's age	-0.000	0.001	0.001	-0.001	0.001	-0.000
	(-0.43)	(0.92)	(1.42)	(-0.68)	(1.05)	(-0.33)
- Father's education					0.000	-0.011
					(0.04)	(-1.87)
- Mother's education					0.002	0.000
					(0.44)	(0.02)
- High family SES					0.084	0.127
					(1.71)	(1.86)
- Low family SES					0.122**	-0.017
					(4.45)	(-0.50)
- Financial help					0.059	-0.001
					(1.46)	(-0.11)
- Need to move					0.072*	0.032
					(2.20)	(0.80)
- Father unemployed					-0.068*	0.026
					(-2.45)	(0.75)
- Mother employed					-0.008	-0.001
					(-0.90)	(-0.08)
- Parents smoked					0.055**	0.044
					(2.99)	(1.84)
- Kid smoked					0.035	-0.013
					(0.80)	(-0.35)
- Kid alcohol/drug					0.367	-0.049
					(0.76)	(-1.36)
- Kid trouble learning					0.009	0.031
					(0.08)	(0.31)
Adult health history	M1	M1	M3	M3	M3	M3
N	29,649	21,344	11,573	7,954	9,630	6,705
Log likelihood	-66,786.2	-22,219.3	-13,213.0	-7,589.5	-10,870.5	-6,372.4

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). SRH stands for self-rated health during childhood. M1 and M3 abbreviate 1st-order and 3rd-order Markov processes, respectively. *, **, and *** indicate statistical significance at the 5%, the 1%, and the 0.1% level, respectively.

Table A-5. *Prediction model for mental health conditions*
Dependent variable: Number of mental health incidences

Key explanatory variables	**Ordered probit regression coefficients** (z-statistics in parantheses)					
	Dry run		Child health		Family	
	F	M	F	M	F	M
	(A)	(B)	(C)	(D)	(E)	(F)
Current SES						
- Wealth (1st qtl.)	0.061* (2.40)	0.156*** (4.92)	0.065 (1.42)	0.223*** (3.83)	0.088 (1.69)	0.279*** (4.21)
- Wealth (4th qtl.)	-0.016 (-0.65)	-0.021 (-0.71)	-0.024 (-0.60)	-0.011 (-0.22)	-0.020 (-0.46)	-0.022 (-0.39)
- Income (1st qtl.)	0.072** (3.17)	0.087** (3.00)	0.006 (0.13)	0.030 (0.56)	-0.051 (-1.10)	0.028 (0.46)
- Income (4th qtl.)	-0.088** (-3.03)	-0.065 (-1.88)	-0.079 (-1.59)	0.015 (0.25)	-0.105 (-1.94)	0.030 (0.45)
- High school	-0.188*** (-8.19)	-0.174*** (-6.22)	-0.147*** (-3.58)	-0.147*** (-2.87)	-0.089 (-1.82)	-0.146* (-2.41)
- College	-0.048 (-1.72)	-0.081** (-2.65)	-0.104* (-2.09)	-0.118* (-2.04)	-0.089 (-1.64)	-0.106 (-1.70)
Child health history						
- Poor/fair SRH			0.023 (0.34)	-0.078 (-0.92)	0.029 (0.38)	-0.097 (-1.03)
- # Less severe cond.			0.061* (2.37)	0.013 (0.35)	0.064* (2.28)	0.033 (0.81)
- # Severe cond.			-0.003 (-0.08)	0.068 (1.64)	0.002 (0.07)	0.074 (1.60)
- # Mental cond.			0.296*** (5.43)	0.210** (2.88)	0.271*** (4.27)	0.156 (1.82)
Family background						
- Father's age	0.001 (1.04)	-0.000 (-0.31)	0.001 (1.19)	0.000 (0.02)	0.001 (0.74)	-0.001 (-0.36)
- Mother's age	0.000 (0.33)	0.001 (0.65)	0.001 (0.50)	0.000 (0.22)	0.001 (0.78)	-0.000 (-0.23)
- Father's education					-0.008 (-1.10)	-0.010 (-1.01)
- Mother's education					-0.009 (-1.03)	0.011 (1.05)
- High family SES					-0.038 (-0.49)	-0.018 (-1.51)
- Low family SES					0.013 (0.33)	-0.031 (-0.60)
- Financial help					0.093 (1.54)	-0.043 (-0.57)
- Need to move					-0.031 (-0.64)	0.055 (0.90)
- Father unemployed					-0.057 (-1.36)	0.034 (0.62)
- Mother employed					-0.006 (-0.45)	-0.004 (-0.25)
- Parents smoked					-0.034 (-1.20)	0.023 (0.61)
- Kid smoked					0.109 (1.73)	-0.023 (-0.40)
- Kid alcohol/drug					0.246 (0.38)	-0.215 (-0.47)
- Kid trouble learning					0.338* (2.41)	0.076 (0.52)
Adult health history	M1	M1	M3	M3	M3	M3
N	29,649	21,344	11,573	7,954	9,630	6,705
Log likelihood	-12,117.7	-7,737.3	-4,177.3	-2,410.8	-3,410.6	-1,966.7

Notes: Results are for white females (F) and males (M). Abbreviations are as follows: N denotes the number of respondent-year observations. "Dry run" stands for dry runs that use the original specification by Adams *et al.* (2003). SRH stands for self-rated health during childhood. M1 and M3 abbreviate 1st-order and 3rd-order Markov processes, respectively. *, **, and *** indicate statistical significance at the 5%, the 1%, and the 0.1% level, respectively.