**Economic Conditions during Early Life
and Later-life Mortality Risk in the United States***

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ABSTRACT

Background: Life course epidemiologists have increasingly linked exogenous events during gestation (e.g., wars, famines, natural disasters) to higher rates of morbidity and mortality in adulthood. In this paper, I analyze the associations between U.S. adult mortality risk from circulatory diseases and (1) economic recessions during the third trimester of gestation and (2) the cumulative exposure to recessions before the age of three. Special attention is given to the functional forms of these relationships, as well as to variation in the relationships by age, sex, and race/ethnicity.

Methods: Data from the National Health Interview Surveys-Linked Mortality Files 1986-2004 were combined with data on quarterly Gross National Product (GNP) per capita for years 1902-1956. Shared-frailty Cox proportional hazard modeling was used to analyze differential survival between ages 50 and 85.

Results: Significant associations were found to exist between economic recessions during the third trimester of gestation and later-life mortality risk. Results further reveal the association to be stronger (1) for women than for men, (2) in the non-Hispanic white population than in the non-Hispanic black population, (3) at older ages than at younger ages, and (4) for deaths from circulatory diseases than for deaths from cancers. The cumulative exposure to recessions across the first three years of life was also found to be positively associated with later-life mortality risk from circulatory diseases.

Conclusions: Findings suggest economic conditions during early life between 1902 and 1956 were significantly associated with mortality risk from heart disease and other circulatory diseases in the U.S. adult population between 1986 and 2006. The results are consistent with both existing evidence and theory implicating developmental processes in early life to be strongly associated with subsequent disease susceptibility.

Numerous studies have found measures of early-life conditions to be significantly associated with various indicators of health in older age (Barker 2012; Burdge & Lillycrop 2010; Currie 2011; Gluckman and Hanson 2008; Godfrey and Hanson 2006; McEniry 2013; Montez and Hayward 2011). Particular attention has been given to the deleterious effects of poor early-life conditions on cardiovascular disease-related health outcomes later in life. In general, findings suggest poor family resources, illness during childhood, and impaired early physiological development are significantly associated with elevated risk of cardiovascular diseases and mortality (see Case and Paxson 2010; Galobardes et al. 2004, 2008; Galobardes et al. 2006; and Godfrey and Hanson 2006 for reviews). Many of the findings in human populations have relied on retrospective survey data, wherein adult respondents are asked to report their family's social class during their childhood. Some researchers have expressed concern about the validity of these retrospective measures, as well as potential confounding between family/household socioeconomic resources, childhood health, and one's own socioeconomic resources during adulthood (Case and Paxson 2010; Elovainio et al. 2011; Haas 2007; Montez and Hayward 2011). Such concerns have spurred many researchers' use of alternative measures of early-life adversity and/or direct measures of physiological impairment such as birth weight (Barker et al. 2001), childhood leg length (Whitley et al. 2010), and/or childhood height (Case and Paxson 2010). Other research has tested the links between adult mortality risk and exogenous macro-level phenomena in early life such as month/season of birth (Buckles and Hungerman 2008; Doblhammer and Vaupel 2001; Doblhammer 2004; McEniry 2011), famines (Almond et al. 2007), epidemics (Almond and Chay 2006), natural disasters (Torche 2011), and economic downturns (Bengtsson & Lindström 2000; Cutler et al. 2007; van den Berg et al. 2006; van den Berg 2011). Regarding the latter, a series of papers by van den Berg and colleagues implicated business cycle contractions during gestation on subsequent mortality risk from cardiovascular disease in the Dutch (van den Berg et al. 2006, 2009a) and Danish populations (van den Berg et al. 2009b, 2011). While not directly tested in these studies, it has been suggested that rapid changes in early life environments may affect subsequent health and mortality risk via multiple pathways of “developmental plasticity” (Bateson et al. 2004; Burdge and Lillycrop 2010; Gluckman and Hanson 2004, 2008; Gluckman et al. 2008). For example, quickly spurred nutritional deficiencies in late-term gestation (especially when coupled with high nutritional and caloric intake later in life), maternal disease exposure, and/or household and familial stress might induce “immediate” and/or “predictive adaptive responses” by the embryo, fetus, and/or neonate (e.g., changing development trajectories and/or slowing physical growth). These adaptive responses, in turn, can adversely shape subsequent susceptibility to disease in adulthood (Gluckman et al. 2008; Gluckman and Hanson 2008; Godfrey and Hanson 2006; Thornburg et al. 2010) (see Burdge and Lillycrop 2010 for a review of potential mechanisms).

In the present study, I analyze the associations between three measures of economic conditions during early life and subsequent risk of death from cardiovascular diseases and cancers. Differential survival between ages 50-85 during the time period 1986-2006 is analyzed among cohorts born in the United States between 1902 and 1956. I measure economic conditions in early-life as: (1) whether or not the economy was in recession during the third trimester of gestation, (2) the percentage point change in business cycle from second trimester to third trimester, and (3) the cumulative quarter-years lived during economic recessions before age three. I further investigate variation in these associations by age, sex, and race/ethnicity. I test for race/ethnic variation in the association between these macro-level economic measures and later-life mortality for two reasons. First, the long-term health effects of macro-economic cycles during early life might not be exogenous. For example, fertility responses to economic uncertainty might have varied by subpopulation (Becker 1960; Buckles and Hungerman 2008). As a result, systemic fertility patterns along race/ethnic and/or social class lines might shape cohort composition in adulthood and consequently affect the associations between early-life economic conditions and later-life mortality risk. To further account for differential fertility responses to economic contractions I control for the presence of an economic recession during the quarter-year of conception. Second, I also explore race/ethnic differences in the association between third trimester recessions and adult mortality risk because the adult risk factors for cardiovascular diseases differ between the white and black populations. Because the U.S. black population endures "earlier onset of illness, greater severity of disease and poorer survival" in general, the association between macro-level economic conditions during early life and later-life mortality risk is likely to be substantively weaker among blacks than among whites (Williams et al. 2010: 71). That is, the amount of variation in mortality risk that can be accounted for by *in utero* processes is relatively smaller in the black population as a result of it experiencing a harsher environment across the entire life course. Thus, the singular effects of critical periods of development on long-term mortality risk are hypothesized to be smaller among blacks than among whites. Along these same lines, I also test sex and age differences in the association between early-life economic conditions and cardiovascular disease mortality risk in adulthood. Sex differences in adult risk factors for circulatory diseases (e.g., higher rates of smoking, alcohol intake, poor sleep patterns, and stress among men) likely impact sex differences in the association between early-life economic conditions and later-life mortality risk, and some evidence has suggested that the effect of childhood health and/or social class on later-life mortality might differ for men and women (McEniry 2013; Montez and Hayward 2011).

DATA

Data come from three sources: (1) 19 continuous waves of the National Health Interview Surveys, 1986-2004, (2) cause-specific death records at the National Death Index through December 31, 2006, and (3) National Bureau of Economic Research (NBER) quarterly data on economic recessions in the United States and U.S. Gross National Product (GNP) per capita for years 1900 to 1972, standardized to the 1972 $US, as well as quarterly data on GNP per capita for years 1986-2006, standardized to the 2005 $US. The first two sources were linked by the National Center for Health Statistics (NCHS), reweighted to account for NHIS sample changes from the matching process, and made publicly available as the National Health Interview Surveys-Linked Mortality Files (NHIS-LMF), 1986-2004. These data have several unique features that make them appropriate for the present analyses: (1) respondents self-report month and year of birth, (2) the data span multiple cohorts, which reduces colinearity between economic conditions during quarter-year of birth, age, and cohort membership, (3) a high frequency of NHIS 1986-2004 respondents are reported to have died before December 31, 2006, and (4) cause of death is available. I limit the analyses to self-reported non-Hispanic black and white men and women who were born in the United States and who are not missing information on their educational attainment (respondents with missing values of education have unreliably low mortality risk in these data, and counts of death among other race/ethnic subpopulations are too few for these analyses). To focus on older adult mortality I limit all analyses to ages 50 to 84.9 at time of interview, spanning birth years 1902 through 1956.

Cardiovascular and cancer deaths were coded in accordance to the ICD-9 (for deaths occurring 1986-1999) and ICD-10 (for deaths occurring 1999-2006). Cardiovascular deaths include categories 55-68 (all forms of heart disease) in the 113 underlying cause of death variable in the NHIS-LMF as well as categories 69-75 (deaths from cerebrovascular disease, atherosclerosis, and other disorders of the circulatory system). Cancer deaths include categories 20-43 (all forms of cancer and malignant neoplasms).

The NHIS-LMF data were then linked with NBER data on quarter-year of economic recessions and quarter-year of gross national product (GNP) during NHIS-LMF respondents' reported quarter-year of conception and the quarter-year corresponding to third trimester gestation. Data used in the present analyses are composed of U.S.-born respondents in years 1902-1956 and mortality status is followed during the time period 1986-2006. They contain the early-life experiences of those cohorts who physically developed during the most rapidly improving health conditions in the history of the United States. Indeed, rates of maternal and infant mortality fell faster across these years than at any other time in US history. Improvements in nutrition (Fogel 2004), expansion of public health projects (Cutler and Miller 2005), and rapid enhancements in disease prevention and treatment (Cutler et al. 2010; Jaychandran et al. 2010) quickly transformed the environments into which these cohorts were conceived under, born into, and raised in. Such changes have been argued to have long-lasting cohort-specific effects on US longevity (Fogel 2004; Manton et al. 1997; Masters 2012; Yang Yang 2008). Also, the rapid paces by which the physical, nutritional, and social environments changed are keys to examining the association between early-life economic conditions and later-life mortality risk. As Bateson et al. (2004: 420) point out, “individuals may be affected adversely if the environmental prediction provided by the mother” (e.g., from *in utero* nutrition, stress, and/or hormones) “and the conditions of early infancy prove to be incorrect.” Thus, the data are optimal for exploring how cyclical deviations from secular improvements in standards of living might affect subsequent mortality risk in adulthood via immediate and long-term adaptive responses *in utero* and during first years of life (Gluckman and Hanson 2008). Economic downturns during pregnancy might interrupt the developmental trajectory of the fetus *in utero*, adversely affecting subsequent physiological development and increasing risk of metabolic disease (Barker 2012; Gluckman and Hanson 2008; Gluckman et al. 2008; Godfrey and Hanson 2006).

METHODS

Adverse economic conditions during early life were measured in three ways. First, *in utero* recession (1/0) was coded 1 if the quarter-year of an NHIS respondent’s third trimester of gestation coincided with a quarter-year of US recession. Reports of US recessions by business quarters are made publicly available online by the NBER. Second, to explore the functional form of the relationship between economic recessions during third trimester gestation and later-life mortality risk from cardiovascular disease, I use the Hodrick-Prescott (HP) filter to decompose the natural log of quarterly real per capita GNP (1972 $US) into a trend component and a cyclical component. I use a smoothing parameter of 1600 because this is the typical value employed when economic data are composed of quarterly reports (Ravn and Uhlig 2002). The trend component of GNP per quarter for years 1900 to 1972 is presented in Figure 1 and the cyclical component is presented in Figure 2. While analyses are limited to quarter-years spanning 1902 through 1972, economic growth, trends, and cycles between 1900 and 1972 are shown to

(a) highlight the secular improvements in GNP across the twentieth century, and (b) to contrast the relatively stable economic cycles in post-World War II America with the turbulent cycles across the beginning of the century.

[Figures 1 & 2 about Here]

The cyclical component of the economy during the third trimester of gestation, which represents the percent deviation from the quarterly trend in log(GNP per capita), was then compared with the prior quarter-year component to derive percentage point changes in economic cycle between the second trimester of gestation and the third trimester of gestation. The high correspondence between US recessions and the change in business cycle between the two trimesters can be observed in Figure 3.

[Figure 3 about Here]

Third, the cumulative number of quarter-years lived in recessions from birth to age three (0 to 12) was used to measure the association between continued early-life exposure to adverse macro-level economic conditions and later-life mortality risk.

Shared-frailty Cox survival models were estimated using Stata 12's *stcox* program with the *shared()* option. The shared-frailty Cox model is structured as $h(t_{ij}|\alpha_i) = \alpha_i h(t_{ij})$ where the hazard at time *t* for the *j*th observation in the *i*th five-year birth cohort is conditional on the gamma distributed frailty, α, which is shared among the five-year birth cohort members. Respondents' attained age (calculated from 50 to 84.917) was used as the time metric and left censoring was accounted for by starting the exposure time at respondents' ages at time of survey.

Models control for five-year "birth cohort" (1900-1904 to 1955-1960), "season of birth" (Spring [ref], Summer, Fall, and Winter), "recession at time of conception" (1/0), "recession at age 20" (1/0), race/ethnicity (non-Hispanic black and non-Hispanic white [ref]), and the continuous measure of "trend in ln(GNP per capita) at quarter-year of birth." Adult controls include "region of residence" (Northeast [ref], Midwest, South, West), "reported height in cm at time of survey" (centered on 170), "BMI" (less than 18.5; 18.5-24.9 [ref]; 25.0-29.9; 30.0-34.9; and 35.0 or higher), "educational attainment" (less than high school, high school, some college, bachelor's degree or higher [ref]), "marital status" (divorced/separated, widowed, never married, or married [ref]), "household income" (below poverty line, above poverty line but less than $45K, income level unknown, and $45K or higher [ref]), and "current contraction in ln(GNP per capita)." All analyses were stratified by sex, and proportional weights were used to make results representative of noninstitutionalized US men's and women's survival between 1986 and 2006.

The association between recession during the third trimester of gestation and adult mortality risk from cardiovascular diseases was first compared to the respective association for deaths from cancer. It has been argued that the strength of the association is stronger for causes of death associated with metabolic syndrome, and I hypothesize the effect of recession during third trimester *in utero* to be larger for cardiovascular disease-related mortality than cancer-related mortality. I also hypothesize the association to be stronger for women than for men, for non-Hispanic whites than for non-Hispanic blacks, and stronger at older ages than at younger ages. Finally, to explore the functional form of the relationship between *in* utero recession and later-life mortality risk I refit the Cox models using restricted cubic splines with five knots across values of the percentage point difference between the third trimester cyclical component of GNP and the second trimester cyclical component. The values of these differences range from -.090 to .077, and knots were made at values -.051; -.010; .004; .015; and .040.

RESULTS

[Tables 1a & 1b about Here]

Table 1a presents descriptive statistics of the male and female NHIS-LMF-NBER 1986-2004 samples, and Table 1b presents descriptive statistics for the subsample of respondents who died during the follow-up period between time of survey and December 31, 2006.

[Table 2 about Here]

Table 2 contains log hazard estimates of the association between economic recessions during third trimester gestation and later-life mortality risk for US men and women by cause of death (cardiovascular disease vs. cancer), and cardiovascular disease mortality log hazards by age and race/ethnicity. Consistent with previous findings (van den Berg et al. 2011), the relationship between economic recessions during gestation is found to be greater for deaths from cardiovascular disease than for deaths from cancer. The difference is significant among women, .28 (95% CI .24 to .32) vs. .18 (.13 to .22) but not among men, .15 (.12 to .18) vs. .14 (.10 to .17). Further, consistent with hypotheses, the strength of the association between recessions during gestation and later-life cardiovascular disease mortality risk is estimated to be stronger in the white population than in the black population, but the results are not statistically significant. Moreover, that the association is estimated to exist in both populations – and to remain significant after controlling for recession during time of conception – indicates that the association likely does not reflect cohort composition in adulthood resulting from systematic differences in fertility responses to economic uncertainty. Finally, results suggest the association between economic recessions during third trimester gestation and later-life cardiovascular disease mortality is significantly stronger at older ages, .35 (.31 to .39) for women and .21 (.17 to .25) for men, than at younger ages, .12 (.02 to .22) for women and .12 (.04 to .20) for men. Taken together, the evidence is consistent with existing findings and supports the contention that economic recessions during gestation are significantly associated with later-life mortality risk from cardiovascular disease.

[Table 3 about Here]

Table 3 presents log hazard estimates of coefficients on US women's and men's cardiovascular disease mortality risk from shared-frailty Cox models using restricted cubic splines of economic changes during gestation instead of dummy variable indicators of recessions during gestation. Estimates of all model coefficients are presented in Table 3, including the estimated effects of cumulative exposure to recessions between birth and age three. The effect is found to be significantly and positively associated with both men's and women's later-life cardiovascular mortality risks, and the estimated hazard ratios are graphically depicted in Figure 4.

[Figure 4 about Here]

Each quarter-year of exposure to economic recession between birth and age three was estimated to have increased US women's and men's later-life cardiovascular disease mortality risk by 2.4 percent and 1.8 percent, respectively (the sex differences in estimated effect is not significant). These results are consistent with previous findings showing adverse conditions during postnatal development to be significantly associated with later life chronic disease mortality risk (Currie 2011; Montez and Hayward 2011).

[Figures 5 & 6 about Here]

Figure 5 plots US adult women's estimated hazard ratios of cardiovascular mortality risk across values of economic change between second and third trimester of gestation, and Figure 6 plots the respective hazard ratios for US adult men. These figures graphically depict the functional forms of economic recessions during third trimester gestation on later-life cardiovascular disease mortality. Four characteristics of the functional form are especially worth noting. First, relative to a 0% (reference value) change in business cycle, negative one to negative three percentage point changes are not associated with higher risk of later-life mortality from cardiovascular disease among US men and women. Second, high positive growth in GNP between second and third trimester gestation provides a large protective effect against later-life cardiovascular disease mortality risk. Specifically, relatively high percentage point changes in business cycle (i.e., three to eight percentage points) confer about 10% to 20% lower cardiovascular mortality risk among women, and about 12% to 14% lower risk among men. These values are anomalous, however, with only about 7% of the sample having experienced greater than two percentage point increases in business cycle from their second to third trimester gestation. Third, relative to stagnant business cycles, even a one to two percentage point increase in business cycle conferred about 6% lower cardiovascular mortality risk among men and about 10% lower risk among women. Such effects are substantive given that these rates of change in business cycles were experienced by about 35 to 40 percent of the samples. Thus, the general takeaway on this point is that any positive growth in business cycle between second and third trimester conferred a protective effect relative to a stagnant or a declining business cycle during gestation. Or, if we wish to think of positive economic growth as the norm, stagnant and small contractions in the business cycles between second and third trimester of gestation were found to be significantly associated with higher cardiovascular mortality risk in US adult men and men.

Finally, the association between business cycle contractions and later-life cardiovascular mortality risk unfolds in a dose-responsive manner at the lowest values of business cycle contractions between second and third trimester. That is, each percentage point drop in business cycle between -5% and -9% increases US men's and women's later-life mortality risk from cardiovascular diseases. For instance, among US adult men, relative to a stagnant business cycle between second and third trimester a -5% change is associated with about a 6% increase in mortality risk later in life, whereas a -8% change is associated with about a 14% higher mortality risk. These values of business contractions account for only about 10 percent of the sample, and thus encapsulate the extreme *in utero* experiences of rapid changes in the gestational environment.

DISCUSSION

Life course epidemiologists have long argued – and have increasingly shown – early-life indicators of adversity to be strongly associated with later-life risks of disease and mortality. Data limitations have precluded robust tests of the association in human populations, but researchers have begun leveraging exogenous shocks during gestation to illuminate how adverse conditions during early stages of development can affect subsequent health outcomes at birth (Torche 2011), across childhood (Case and Paxson 2011), and in adulthood (van den Berg et al. 2006, 2009a, 2009b, 2011). Findings have been mixed, but abundant evidence has implicated adverse conditions *in utero* and during early life to be strongly associated with chronic disease etiology in later life (Barker 2012; Burdge and Lillycrop 2010; Gluckman et al. 2008).

My present approach matched aggregate-level match macro-economic variations during gestation with individual later-life mortality risk in the US men's and women's populations between 1986 and 2006. Results provide evidence consistent with both theory and existing empirics suggesting strong associations between adverse *in utero* exposures with higher cardiovascular disease mortality risk in adulthood.

The analyses and data are not without limitations. The results presented here reflect aggregate associations between exposure to recessions in early life and later-life mortality risk from cardiovascular disease in a noninstitutionalized US sample of adults still alive between ages 50 and 84 at time of survey, 1986-2004. The data contain no individual-level information on NHIS respondents' birth outcomes (e.g., preterm, preterm, mother's natality history). Nor do they contain any information on mother's health behaviors while pregnant, maternal disease exposure while pregnant, or any other differential exposure to adverse conditions related or unrelated to economic volatility during gestation. As such, I have no way to test competing mechanisms or explanations for the aggregate association. The data similarly have no family/household-level information to indicate the immediate environment NHIS respondents were born into. I cannot discern households' differing exposure to the severity of economic downturns, or even variation in NHIS respondents' exposure by state or other geographical units that might have made some populations more vulnerable to the adversity brought about by economic recessions. Finally, the data do not contain complete cohort histories of survival, but rather reflect only the experiences of those cohort members still alive at time of the NHIS sampling.

These limitations aside, the results were robust to confounding factors both *in utero*, at birth, and in adulthood. Previous economic downturns in the United States both *in utero* and across the first years of life were found to be significantly associated with cardiovascular disease mortality later in life across a recent period of history. As prior scholars have noted, studies of this kind are not just academic exercises to discover determinants of health variation in generations long since passed. Nor are they applicable only to populations living in developing countries, where early-life conditions are notably worse than in more developed countries. On the contrary, the results support many "developmental origins" scholars' contention that harsh conditions early in life continue to significantly affect long-term susceptibility to cardiovascular disease outcomes in the United States.

TABLES & FIGURES

Table 1a. Descriptive Statistics of US Men and Women, NHIS-LMF-NBER 1986-2006

	Women		Men	
	Mean	S	Mean	S
Deceased	.172	(.378)	.223	(.417)
Died from Cardiovascular Disease	.071	(.257)	.095	(.293)
Died from Cancer	.052	(.222)	.068	(.252)
Characteristics at Birth				
Year of Birth	1939.6	(11.7)	1939.7	(11.7)
Born in Spring	.240	(.427)	.241	(.427)
Born in Summer	.264	(.441)	.263	(.440)
Born in Fall	.252	(.434)	.253	(.435)
Born in Winter	.243	(.429)	.243	(.429)
GNP Trend (log 1972$)	5.962	(.382)	5.964	(.384)
Recession at Conception	.281	(.449)	.277	(.448)
Recession in Third Trimester	.268	(.443)	.265	(.441)
Recession at Age 20	.198	(.399)	.198	(.398)
Quarter-years of Recession, 0-3	3.737	(2.674)	3.694	(2.657)
Adult Characteristics				
<High School	.189	(.391)	.199	(.399)
High School	.418	(.493)	.346	(.476)
Some College	.207	(.405)	.197	(.398)
Bachelor's Degree +	.187	(.390)	.259	(.438)
< Poverty Line	.114	(.317)	.076	(.266)
Middle Income	.486	(.500)	.476	(.499)
≥45,000	.324	(.468)	.383	(.486)
Income Not Reported	.077	(.266)	.064	(.245)
Married	.643	(.479)	.778	(.416)
Widowed	.129	(.336)	.033	(.178)
Divorced/Separated	.160	(.366)	.112	(.316)
Never Married	.068	(.252)	.077	(.267)
BMI < 18.5	.010	(.097)	.005	(.072)
18.5 < BMI < 25.0	.370	(.483)	.292	(.455)
25.0 < BMI < 30.0	.326	(.469)	.474	(.499)
30.0 < BMI < 35.0	.171	(.376)	.171	(.377)
35.0 < BMI	.124	(.329)	.058	(.234)
Height (cm)	163.645	(6.638)	178.203	(7.119)
Contraction in Current Economy	.550	(.497)	.553	(.497)
N		259,315		227,868

Table 1b. Statistics of Deceased US Men and Women, NHIS-LMF-NBER 1986-2006

	Women		Men	
	Mean	S	Mean	S
Died from Cardiovascular Disease	.413	(.492)	.424	(.494)
Died from Cancer	.300	(.458)	.306	(.461)
Characteristics at Birth				
Year of Birth	1925.9	(10.0)	1927.0	(10.3)
Born in Spring	.252	(.434)	.249	(.433)
Born in Summer	.253	(.435)	.254	(.435)
Born in Fall	.246	(.431)	.250	(.433)
Born in Winter	.249	(.432)	.247	(.431)
GNP Trend (log 1972$)	5.567	(.267)	5.592	(.277)
Recession at Conception	.202	(.402)	.372	(.483)
Recession in Third Trimester	.382	(.486)	.371	(.483)
Recession at Age 20	.202	(.402)	.196	(.397)
Quarter-years of Recession, 0-3	4.960	(2.830)	4.893	(2.895)
N		44,787		50,911

Table 2. Estimated Log Hazards of Recession during Third Trimester Gestation on Later-life Mortality Risk, US Men and Women, NHIS-LMF-NBER, 1986-2006

	Women		Men	
	b	SE	b	SE
Cause of Death				
Cardiovascular Disease	.278	(.019)	.149	(.017)
Cancer	.176	(.022)	.135	(.020)
Cardiovascular Disease Mortality				
Race/Ethnicity				
non-Hispanic black	.216	(.041)	.071	(.043)
non-Hispanic white	.291	(.021)	.163	(.019)
Age Group				
Ages [50-65)	.123	(.051)	.118	(.040)
Ages [65-85)	.347	(.021)	.211	(.020)

Model controls for five-year birth cohort, trend in GNP, season of birth (spring, summer, fall, winter), recession during quarter-year of conception, 1/3 of life before age of three spent in recession, recession at age 20, region of residence (Northeast, South, Midwest, West), race/ethnicity (non-Hispanic Black & non-Hispanic White), educational attainment (<HS, HS, SC, BA+), income level (poverty, >poverty but < 45K, >45K), marital status (widowed, divorced/separated, married, never married), Adult Height (cm), Adult BMI (<18.5, 18.5-24.9, 25-29.9, 30-34.9, 35+), and current quarter-year recession.

Table 3. Estimated Log Hazards of Early-life Economic Conditions on Later-life CVD Mortality Risk, US Men and Women, NHIS-LMF 1986-2006

	Women		Men	
	b	SE	b	SE
Region (Northeast)				
Midwest	.061	(.022)	-.037	(.020)
South	.075	(.021)	.029	(.019)
West	.094	(.025)	-.042	(.023)
non-Hispanic Black	.266	(.020)	.153	(.020)
Educational Attainment (BA+)				
<High School	.518	(.032)	.422	(.024)
High School	.298	(.031)	.298	(.023)
Some College	.233	(.035)	.225	(.027)
Income (>$45,000)				
< Poverty Line	.472	(.031)	.468	(.029)
Middle Income	.302	(.025)	.297	(.019)
Income Not Reported	.335	(.031)	.318	(.028)
Marital Status (Married)				
Widowed	.149	(.018)	.157	(.025)
Divorced/Separated	.212	(.025)	.352	(.023)
Never Married	.336	(.034)	.352	(.029)
BMI (18.5-24.9)				
< 18.5	.409	(.054)	.300	(.072)
25.0-29.9	.019	(.019)	-.006	(.017)
30.0-34.9	.207	(.022)	.223	(.021)
35.0+	.447	(.024)	.529	(.028)
Height (cm)	-.001	(.001)	-.0004	(.001)
Current Recession	-.012	(.015)	.043	(.014)
Season of Birth (Spring)				
Summer	-.019	(.021)	-.030	(.020)
Fall	.034	(.021)	-.009	(.020)
Winter	.047	(.021)	.001	(.019)
GNP Trend (1972$)	-2.352	(.136)	-1.697	(.116)
Recession at Conception	.035	(.018)	.028	(.017)
Recession at Age 20	.017	(.022)	-.044	(.020)
Cumulative Exposure to Recession	.024	(.003)	.018	(.003)
Spline 1	-4.184	(1.026)	-2.897	(.935)
Spline 2	9.860	(3.697)	7.017	(3.360)
Spline 3	-242.673	(47.516)	-152.148	(43.443)
Spline 4	654.185	(107.132)	396.124	(99.146)
Five-year Cohort Frailty	.209	(.099)	.121	(.056)

Figure 1. log(GNP) in United States, 1900-1972, and HP Decomposed Trend Component.

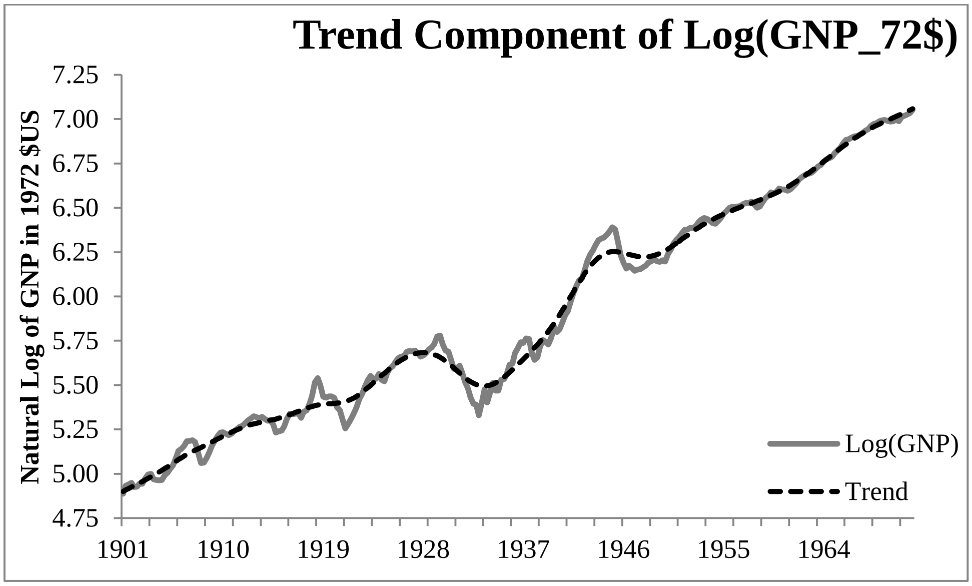


Figure 2. HP Decomposed Cyclical Component of log(US GNP), 1900-1972.

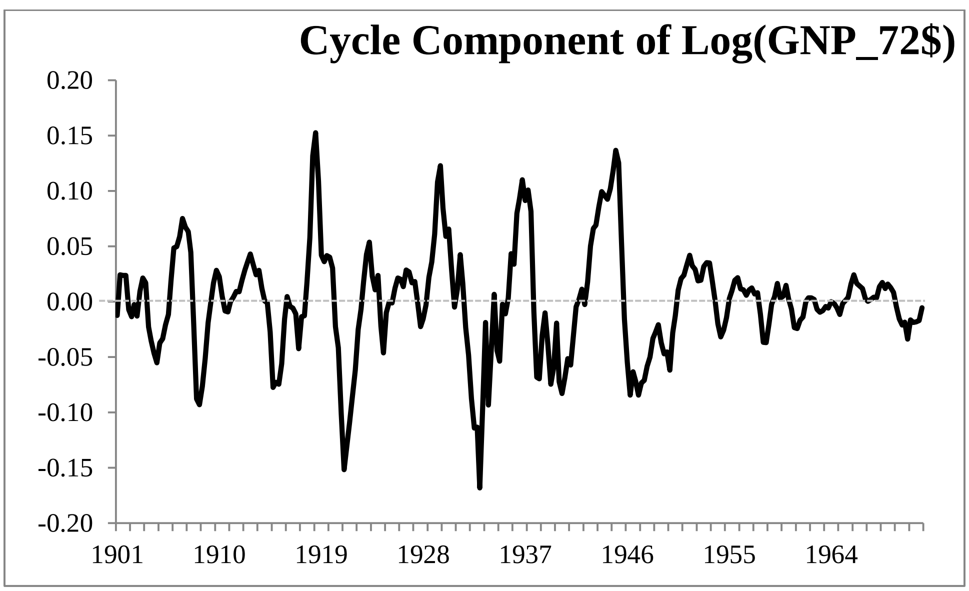
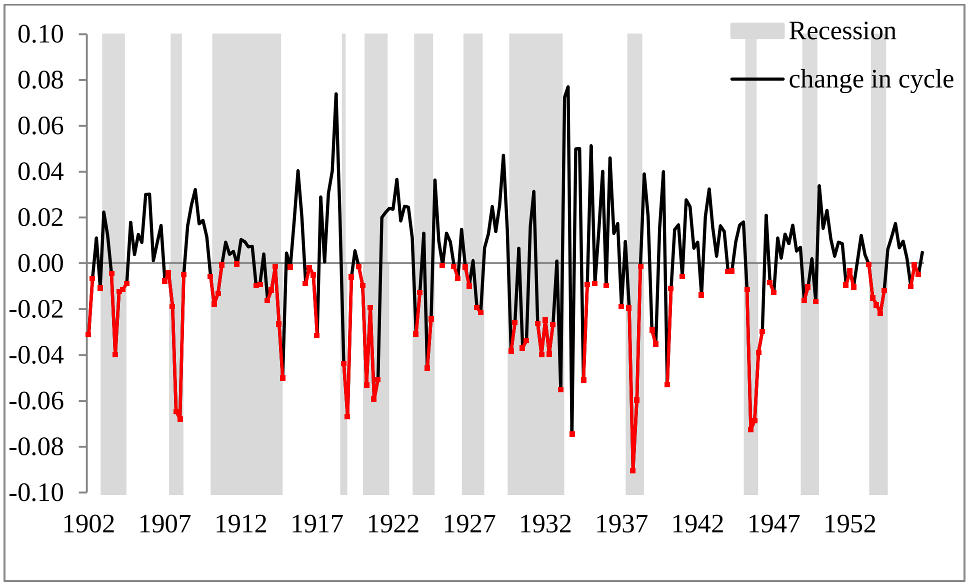


Figure 3. US Economic Recessions between 1902 and 1956 and Percentage Point Difference between HP Decomposed Cyclical Component of log(US GNP) in Third and Second Trimester Gestation.



Note: Red square marks quarter-year of negative percentage point change between second trimester business cycle and third trimester business cycle.

Figure 4. Estimated Hazard Ratios for Mortality Risk from Cardiovascular Diseases by Number of Recessions Exposed to between Ages 0 and 3, US Men and Women aged 50-85, 1986-2006.

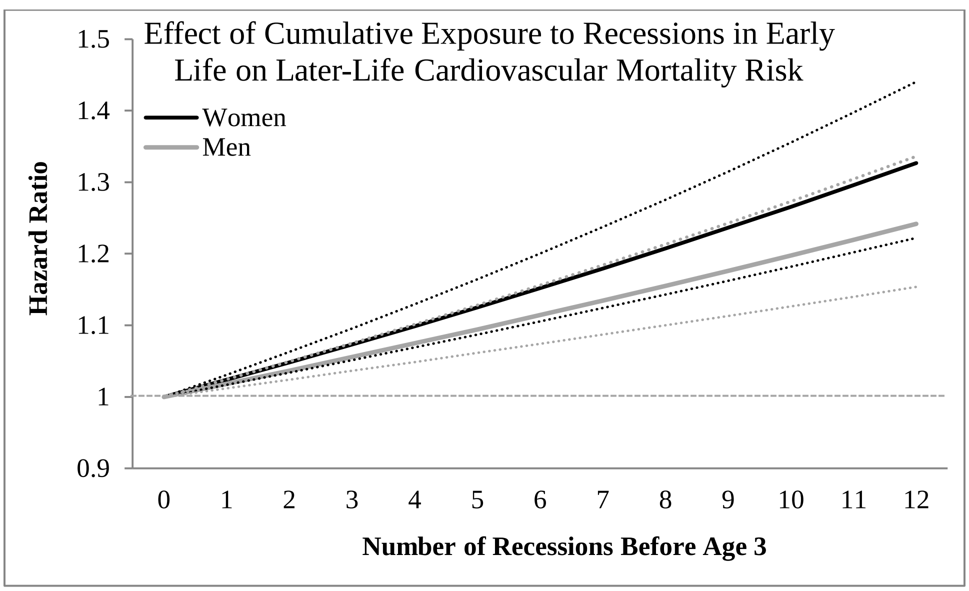


Figure 5. Estimated Hazard Ratios for Mortality Risk from Cardiovascular Disease across Change in Cyclical Component of GNP from Second Trimester to Third Trimester, US Women aged 50-85, 1986-2006.

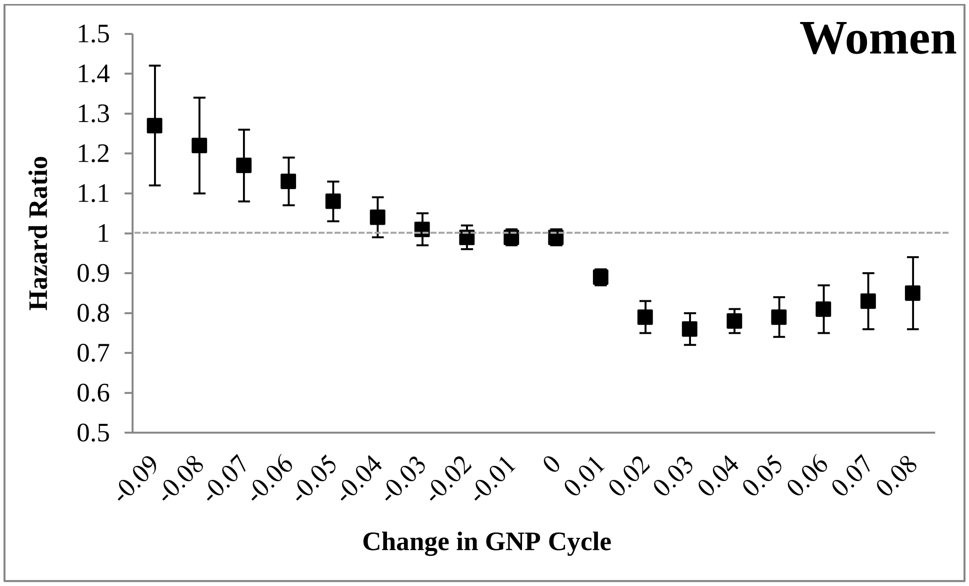
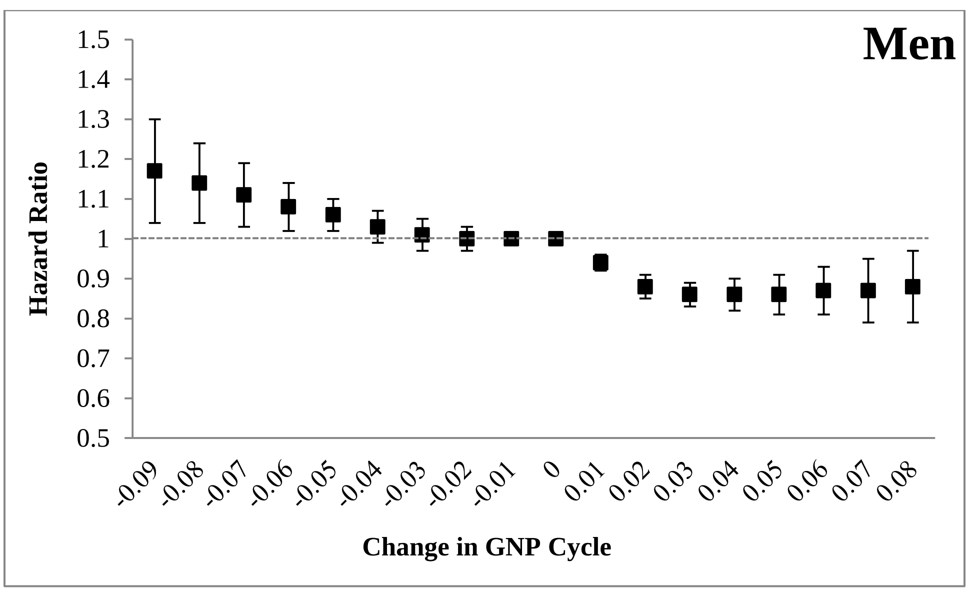


Figure 6. Estimated Hazard Ratios for Mortality Risk from Cardiovascular Disease across Change in Cyclical Component of GNP from Second Trimester to Third Trimester, US Men aged 50-85, 1986-2006.



REFERENCES

Almond, D. and K.Y. Chay. (2006) The Long-Run and Intergenerational Impact of Poor Infant Health: Evidence from Cohorts Born During the Civil Rights Era.

Almond, D., L. Edlund, H. Li and J. Zhang. (2007) Long-Term Effects of the 1959-1961 China Famine: Mainland China and Hong Kong. NBER Working Paper No. 13384.

Barker, D.J.P., T. Forsén, A. Uutela, C. Osmond and J.G. Eriksson. (2001) Size at Birth and Resilience to Effects of Poor Living Conditions in Adult Life: Longitudinal Study. *BMJ* 323(1):1-5.

Barker, D.J.P. (2012) Developmental Origins of Chronic Disease. *Public Health* 126(3):185-189.

Bateson, P., D.J.P. Barker, T. Clutton-Brock, et al. (2004) Developmental Plasticity and Human Health. *Nature* 430(6998):419-421.

Becker, G.S. (1960) An economic analysis of fertility, in Demographic and Economic Change in Developed Countries. Universities-national Bureau, UMI.

Bengtsson, T. and M. Lindström. (2000) Childhood Misery and Disease in Later Life: The Effects on Mortality in Old Age of Hazards Experienced in Early Life, Southern Sweden, 1760-1894. *Population Studies* 54(3):263-277.

Buckles, K. and D. Hungerman. (2008). Season of Birth and Later Outcomes: Old Questions, New Answers. NBER Working Paper No. 14573.

Burdge, G.C. and K.A. Lillycrop. (2010) Nutrition, Epigenetics, and Developmental Plasticity: Implications for Understanding Human Disease. *Annual Review of Nutrition* 30:315-339.

Case, A. and C. Paxson. (2010) Causes and Consequences of Early-Life Health. *Demography* 47(S):S65-SS85.

Currie, J. (2011). Inequality at Birth: Some Causes and Consequences. NBER Working Paper No. 16798.

Cutler, D.M., G. Miller, and D.M. Norton. (2007) Evidence on Early-Life Income and Late-Life Health from America’s Dust Bowl Era. *PNAS* 104(33):13244-13249.

Cutler, D.M., A. Deaton, and A. Lleras-Muney. (2006) The Determinants of Mortality. *The Journal of Economic Perspectives* 20(3):97-120.

Cutler, D.M. and G. Miller. (2005) The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States. *Demography* 42(1):1-22.

Doblhammer, G. and J.W. Vaupel. (2001) Lifespan Depends on Month of Birth. *PNAS* 98(5):2934-2939.

Doblhammer, G. (2004) The Late Life Legacy of Very Early Life. Berlin: Springer.

Elovainio, M., J.E. Ferrie, A. Singh-Mnoux, et al. (2011) Socioeconomic Differences in Cardiometabolic Factors: Social Causation of Health-related Selection? Evidence from Whitehall II Cohort Study, 1991-2004. *American Journal of Epidemiology* 174(7):779-789.

Fogel, J. (2004) Escape from Hunger and Premature Death, 1700-2100: Europe, America, and the Third World. NY: Cambridge University Press

Galobardes, B., J.W. Lynch, and G. Davey-Smith. (2004) Childhood Socioeconomic Circumstances and Cause-specific Mortality in Adulthood: Systematic Review and Interpretation. *Epidemiologic Reviews* 26(1):7-21.

Galobardes, B., J.W. Lynch, and G. Davey-Smith. (2008) Is the Association between Childhood Socioeconomic Circumstances and Cause-Specific Mortality Established? Update of a Systematic Review. *J Epidemiol Community Health* 62(5):387-390.

Galobardes, B. G. Davey-Smith, and J.W. Lynch. (2006) Systematic Review of the Influence of Childhood Socioeconomic Circumstances on Risk for Cardiovascular Disease in Adulthood. *Ann Epidemiol* 16(2):91-104.

Gluckman, P.D. and M.A. Hanson. (2004) The Developmental Origins of Metabolic Syndrome. *TRENDS in Endocrinology and Metabolism* 15(4):183-187.

Gluckman, P.D. and M.A. Hanson (2008) Mismatch: The Lifestyle Diseases Timebomb. NY: Oxford University Press.

Gluckman, P.D., M.A. Hanson, C. Cooper, and K.L. Thornburg. (2008). Effect of In Utero and Early-Life Conditions on Adult Health and Disease. *NEJM* 359(1):61-73.

Godfrey, K. and M.A. Hanson. (2006) The Developmental Origins of Health and Disease, in Health, Risk and Adversity, vol. 2 of *Studies of the Biosocial Society*, eds C.Panter-Brick and A. Fuentes. NY: Berghahn Books.

Haas, S.A. (2007) The Long-Term Effects of Poor Childhood Health: An Assessment and Application of Retrospective Reports. *Demography* 44(1):113-135.

Masters, R.K. (2012) Uncrossing the U.S. Black-White Mortality Crossover: The Role of Cohort Forces in Life Course Mortality Risk. *Demography* 49(3):773-796.

McEniry, M. (2011) Infant Mortality, Season of Birth and the Health of Older Puerto Rican Adults. *Social Science & Medicine* 72(6):1004-1015.

McEniry, M. (2013) Early-life Conditions and Older Adult Health in Low- and Middle-Income Countries: A Review. *Journal of Developmental Origins of Health and Disease* 4(1):10-29.

Montez, J.K. and M.D. Hayward. (2011) Early-Life Conditions and Later Life Mortality. Pp 187-206 in *International Handbook of Adult Mortality*, eds. R.G. Rogers and E. Crimmins. NY: Springer Publishers.

Ravn, M.O. and H. Uhlig. (2002) On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations. *The Review of Economics and Statistics* 84(2):371-380.

Thornburg, K.L., J. Shannon, P. Thuillier, and M.S. Turker. (2010) *In Utero* Life and Epigenetic Predisposition for Disease, Pp. 57-78, Ch. 3 in *Advances in Genetics, Vol. 71*

Torche, F. (2011) The Effect of Maternal Stress on Birth Outcomes: Exploiting a Natural Experiment. *Demography* 48(4)1473-1491.

van den Berg, G.J., M. Lindeboom, and F. Portrait. (2006) Economic Conditions Early in Life and Individual Mortality. *The American Economic Review* 96(1):290-302.

van den Berg, G.J., M. Lindeboom, and M. Lopez.(2009) Inequality in Individual Mortality and Economic Conditions Earlier in Life. *Social Science & Medicine* 69(9):1360-1367.

van den Berg, G.J., G. Doblhammer, and K. Christensen. (2009) Exogenous Determinants of Early-life Conditions, and Mortality Later in Life. *Social Science & Medicine* 68(9):1591-1598.

van den Berg, G.J., G. Doblhammer-Reiter, and K. Christensen. (2011) Being Born under Adverse Economic Conditions Leads to a Higher Cardiovascular Mortality Rate Later in Life. *Demography* 48(2):507-530.

Williams, D.R., S.A. Mohammed, J. Leavell, and C. Collins. (2010) Race, Socioeconomic Status, and Health: Complexities, Ongoing Challenges, and Research Opportunities. *Ann. N.Y. Acad. Sci.* 1186(1):69-101.

Whitley, E., R.M. Martin, G. Davey-Smith, J.M. Holly, and D. Gunnell. (2010) The Association of Childhood Height, Leg Length and Other Measures of Skeletal Growth with Adult Cardiovascular Disease: the Boyd-Orr Cohort. *J Epidemiol Community Health* 66(1):18-23.

Yang, Y. (2008) U.S. Adult Chronic Disease Mortality, 1960-1999: Age, Period, and Cohort Variations. *Demography* 45(2):387-416.