Evidence on early-life income and late-life health from America's Dust Bowl era

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In recent decades, elderly Americans have enjoyed enormous gains in longevity and reductions in disability. The causes of this progress remain unclear, however. This paper investigates the role of fetal programming, exploring how economic progress early in the 20th century might be related to declining disability today. Specifically, we match sudden unexpected economic changes experienced *in utero* in America's Dust Bowl during the Great Depression to unusually detailed individual-level information about old-age disability and chronic disease. We are unable to detect any meaningful relationship between early life factors and outcomes in later life. We conclude that, if such a relationship exists in the United States, it is most likely not a quantitatively important explanation for declining disability today.

disability | fetal programming | Great Depression

The health of elderly and near-elderly Americans has improved enormously in recent decades. Age-adjusted mortality rates among those ages 55 and older fell by 1.1% per year between 1960 and 2003 (1). Quality of life has improved as well. Surveys suggest that disability among the elderly declined by ≈1.7% per year between the early 1980s and the late 1990s (2) and has continued through the first half of this decade (3). Disability among the "near elderly" has not declined as much, possibly because of increasing obesity (4), but other measures of health have improved greatly (5). The value of these health improvements is large. Murphy and Topel (6) estimate that improvements in quality of life since 1970 are worth approximately $1.2 million per person for men and $820,000 per person for women. Nordhaus (7) estimates that the value of health improvements since 1950 is equal to the entire increase in material consumption over this time period.

The forces responsible for these health gains are less clear (8). Some studies argue that technological progress in medicine has been an important factor (9, 10). Other research suggests that public health measures, the 50% reduction in smoking during the past half century, for example (11), are a major contributor. A third view posits that economic progress has led to better nutrition and improved ability to withstand disease (12–15).[e] Given the prominence of the income explanation[f] and the paucity of evidence linking it to recent reductions in disability, this paper directly examines the relationship between the two.

Specifically, we investigate how economic progress early in the 20th century might have contributed to improving health among the elderly today.[g] The influence of income on health may be most powerful during vulnerable periods early in life, and early-life health might in turn have lifelong consequences, a hypothesized phenomenon termed "fetal programming."[h] David Barker, the most forceful proponent of the fetal programming hypothesis, argues that *in utero* stress due to malnutrition and infectious disease (primary causes of net nutritional deficiency) is a powerful determinant of chronic disease in old age (31–33). To maximize survival to reproductive age, the theory posits, adverse conditions *in utero* cause a developing fetus to protect some physiological systems more than others, differentially compromising functions that are operative late in the life cycle.

Evidence in support of the Barker hypothesis is mixed. Those *in utero* during the Dutch famine after World War II had higher levels of risk factors associated with heart disease than did adjacent birth cohorts (34, 35), and supportive evidence has also been found for cohorts conceived during China's Great Leap Forward (36) and France's 19th century Phylloxera plagues (37). At the same time, analyses of famines in Leningrad and Finland find no differences in later-life health associated with *in utero* conditions (34, 38, 39). Doblhammer and Vaupel (40) report that month of birth (an important correlate of the *in utero* environment) is strongly associated with life expectancy at age 50, but that this relationship has declined over time. Longevity is also greater for children born during booms rather than busts between 1912 and 2000 in The Netherlands (41).

For adverse income shocks in early development to increase old age disability, families and communities must be unable to mitigate them.[i] A small income shock might have little impact on the consumption of a family with substantial savings. Similarly, a family with access to insurance and credit, either formal (e.g., unemployment insurance) or informal (e.g., borrowing from relatives), will be able to smooth consumption across periods of volatile transitory income. Although there was tremendous financial development in

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Abbreviations: HRS, Health and Retirement Study; ADL, activities of daily living; IADL, instrumental ADL; BMI, body-mass index.

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[e]In many ways, debate about the causes of health improvement since 1950 mirrors debate about the relative importance of economic conditions (16–18) and public health interventions (19–21) in explaining late 19th and early 20th century health improvements.

[f]Although our focus is health improvement in the postwar era, Fogel (17) suggests that income growth can explain 50–80% of the long-term historical mortality decline.

[g]Income is an important determinant of the demand for calories and gross nutrition (22). The "Barker hypothesis" described in this paragraph emphasizes the role of early life net nutrition or nutritional absorption (as distinct from gross nutrition or nutritional intake) (23). Because infectious diseases explain much of the discrepancy between net and gross nutrition (24), and infections early in life can cause permanent damage independently of net nutrition (25, 26), all of our analysis accounts flexibly for birth region-year infectious disease environments.

[h]Although our focus is early-life income and later-life health, and our empirical analyses isolate this relationship, income in childhood and adulthood is of course also related to health (27, 28). In childhood, income is related to growth and physiological development, and there is a strong correlation between height and mortality (29). Income is also associated with exposure to childhood diseases linked to later-life health; Costa (13) reports that Union Army veterans enlisting in counties with higher childhood infectious disease rates were more likely to suffer chronic diseases later in life. Case *et al.* (30) report that the adverse health consequences of lower income accumulate throughout the life cycle. In adulthood, greater income allows individuals to be better nourished and more resilient to disease. Estimates from the 18th and 19th centuries, for example, suggest that adult BMI was far below levels considered optimal for longevity (17). Income today is related to access to modern medical technologies as well.

[i]Our focus is transitory rather than permanent income.

the United States before the 1930s, it is far from clear that Americans could smooth their consumption during the Great Depression using formal market-based instruments (42–44). Sector-wide economic calamities are also more difficult to smooth than are idiosyncratic family-specific economic shocks. Moreover, the larger the income shock, the more difficult consumption smoothing is as well (all else being equal).

The Great Depression and America's Dust Bowl of the 1930s provide a unique case of large unexpected changes in early-life income that can be linked to unusually detailed information about old age disability and chronic disease. Between 1929 and 1933, real income per capita in the United States fell by approximately one-third. In addition, poor land management, drought, and strong winds combined to produce severe erosion in the Great Plains, intensifying the hardships faced by farmers in the central plains (45). Using plausibly exogenous variation in agricultural yields, income, and employment induced by the Great Depression and the Dust Bowl, however, we are unable to detect any meaningful relationship between early-life economic conditions and late-life health (heart conditions, stroke, diabetes, hypertension, arthritis, psychiatric conditions, chronic lung disease, functional limitations, anthropometrics, and death within 2 years). The absence of any meaningful correlation persists with the inclusion of controls for selective mortality, birth selection, infectious disease mortality, birth region, quarter, year-fixed effects, region-specific time trends, and a variety of rich socioeconomic indicators across generations. We conclude with a discussion of why we might be unable to detect a relationship even if one actually exists, noting that even in this case, we believe economic conditions are not the most quantitatively important factor responsible for the recent disability decline among elderly Americans.

Background

The Great Depression and America's Dust Bowl in the Great Plains. Economic catastrophe struck America during the 1930s. In 1933, income was one-third lower than 4 years earlier, and one in five Americans was unemployed (46). To ease the difficulties of the Great Depression, the federal government increased social spending significantly. Real per capita relief spending rose nearly 4-fold between 1930 and 1932 (46) and tripled again by the end of the decade.

With the Great Depression in the background, American farmers suffered additional calamities during the 1930s as severe drought and wind erosion afflicted the Great Plains, creating America's "Dust Bowl." In 1934, the Soil Conservation Service reported that 65% of the Great Plains had been damaged by wind erosion, and that 15% were "severely" damaged (47). By the end of the decade, wind had stripped an average of 480 tons of fertile topsoil per acre of land, leaving previously fertile land unfertile and fundamentally changing the practice of agriculture (45, 47). Fig. 1*a* shows crop yields by region and year between 1929 and 1941, and Fig. 1 *b* and *c* show real income per capita (in 1983 dollars) and employment, respectively, during the same period.[j] We obtained agricultural yield data from the U.S. Department of Agriculture's National Agricultural Statistics Service, income data from the Bureau of Economic Analysis, and a regional employment index from Wallis (48).[k] In general, they show that relative to each region's average

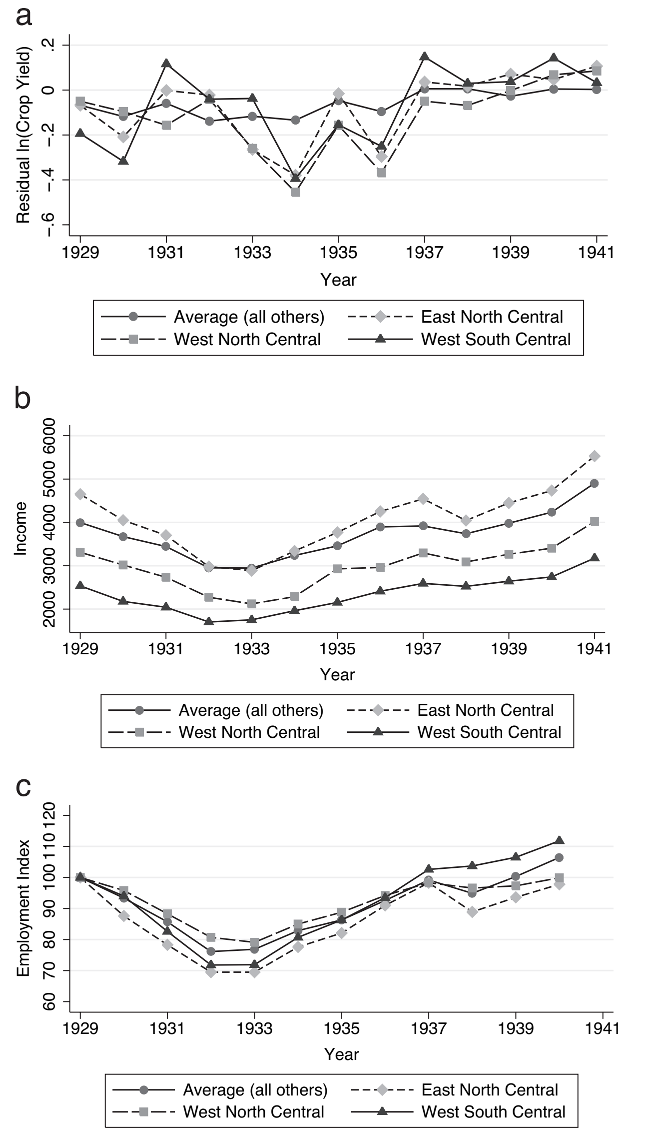

Fig. 1. Regional variation in economic conditions around the time of the Great Depression and Dust Bowl. Values for the West North Central, East North Central, and West South Central regions, which generally suffered more severe shocks during the period of interest, are presented along with the average for all other regions. (*a*) Residual crop yields for the selected regions and the average for all other regions, weighted by each crop's value relative to the total harvest. Crops used are wheat, corn, tobacco, hay, oats, and cotton. See j for a more detailed description of how these residuals were calculated. Data are from the U.S. Department of Agriculture National Agricultural Statistics Service. (*b*) Personal income in the selected regions and the average in all other regions. These data are drawn from Bureau of Economic Analysis estimates and converted to constant 1983 dollars using the gross domestic product deflator. (*c*) Values for a nonagricultural employment index in the selected regions and the average in all other regions. These data come from Wallis (48) and provide a measure of employment during the period relative to each region's level in 1929.

[j]Region-year crop yield residuals are constructed by first regressing the natural log of crop-region-year yields on crop dummies and crop-specific linear time trends separately for each region, 1900–1950. We then calculate region-year residual means using crop-specific weights. These weights are the ratio of each crop's value to the value of all crops in that region and year. To calculate each crop's value, we multiplied average regional yield and average national price during the 1920s (using data provided by the U.S. Department of Agriculture National Agricultural Statistics Service) and then multiplied this product by actual acres of that crop harvested in a given region and year. We plot these residuals by region and year in Fig. 1*a*. The states comprising each region are: New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), Middle Atlantic (New Jersey, New York, and Pennsylvania), East North Central (Indiana, Illinois, Michigan, Ohio, and Wisconsin), West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota), South Atlantic (Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia), East South Central (Alabama, Kentucky, Mississippi, and Tennessee), West South Central (Arkansas, Louisiana, Oklahoma, and Texas), Mountain (Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, and Wyoming), and Pacific (California, Oregon, and Washington). The employment index is not available for 1941.

[k]The U.S. Department of Agriculture National Agricultural Statistics Service crop yield data are available at: www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp, and the Bureau of Economic analysis personal income per capita data are available at: http://bea.gov/bea/regional/spi/default.cfm?satable=summary.

Table 1. Correlation coefficients and regional corn prices, 1930–1940

	New England	Mid-Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
New England	—	—	—	—	—	—	—	—	—
Mid-Atlantic	0.9489	—	—	—	—	—	—	—	—
East North Central	0.9540	0.9761	—	—	—	—	—	—	—
West North Central	0.9212	0.9286	0.9838	—	—	—	—	—	—
South Atlantic	0.9346	0.9672	0.9373	0.8887	—	—	—	—	—
East South Central	0.9128	0.9725	0.9165	0.8485	0.9600	—	—	—	—
West South Central	0.9297	0.9506	0.9410	0.9148	0.9496	0.9384	—	—	—
Mountain	0.9100	0.9065	0.9526	0.9740	0.8489	0.8218	0.9212	—	—
Pacific	0.8910	0.9403	0.9655	0.9658	0.8787	0.8518	0.9020	0.9708	—

over the decade, crop yields and income during the mid-1930s were particularly low in the West North Central, East North Central, and West South Central regions. A key feature of our empirical approach is the rich spatial and time variation in these environmental shocks, enabling us to distinguish their consequences from general time trends.[l]

Additional relief efforts specifically targeted the plight of American farmers. Beginning in 1933, the Agricultural Adjustment Act (AAA) paid farmers to leave some of their land fallow and required mass destruction of crops and livestock, raising crop prices and farm income (45). Although our yield measures do not fully capture crop destruction and related AAA consequences, our income measures accurately reflect early-life economic conditions.[m]

Were Agricultural Shocks Transmitted Through Consumer Prices or Farm Income? To correctly interpret relationships between agricultural shocks experienced *in utero* and later-life health outcomes, it is important to understand precisely how these shocks influenced economic outcomes. If agricultural markets are primarily local, declining crop yields in an area would raise crop prices and reduce caloric intake among all residents of that region. In contrast, if markets are national and the region represents a small share of total output, declining yields would reduce the income of farmers but leave food prices paid by consumers and nonagricultural consumption largely unchanged. In the latter case, workers on farms would be most adversely affected.[n]

Two types of evidence help us to distinguish between these scenarios. One is historical research on the economic integration of the United States. A seminal contribution by Robert Fogel (49) suggests that, as early as 1890, different regions of the country were quite closely integrated as a result of the railroad. The second piece of evidence comes from examination of regional crop prices. Where markets are integrated by trade, price changes across regions will be highly correlated. Price changes can diverge when markets are not integrated. For corn (the only major staple with regional prices available throughout the 1930s), Table 1 shows that the correlations among regional crop prices were very high during the 1930s, with correlation coefficients generally >0.9. We therefore adopt the open market view, considering the consequences of agricultural shocks for farm income and later-life health among those born in agricultural settings in Dust Bowl regions.[o]

Data and Empirical Strategy

The Health and Retirement Survey Sample. To measure late-life health, we use data from the Health and Retirement Study (HRS).[p] The HRS is an ongoing panel study of elderly and near-elderly Americans conducted every other year since 1992. The original sample was of individuals born between 1931 and 1941 and their households. In the 1998 wave, individuals born between 1924 and 1930 were added. Table 2 shows basic descriptive statistics. In our sample, we include people born in the United States between 1929 and 1941. The early restriction is because income data begin in 1929; the latter restriction avoids babies born during World War II. In 1992, this sample included 8,739 individuals. Surviving HRS participants have been reinterviewed every 2 years between 1992 and 2004. The publicly available version of the HRS reports month, year, and region of birth. Because Dust Bowl shocks were regionally correlated (agriculture was regional), regional analyses are appropriate.

Health Measures in the HRS. We examine four major dimensions of health reported in the HRS. The first is mortality. HRS tracking and a linkage to the National Death Index allow us to measure mortality very accurately during each 2-year period between survey waves. In the small number of cases when the exact death date is unknown (54 individuals), we impute death as occurring immediately after the last date at which the person was known to be alive. When we know an individual to be alive in a given year, we also create additional observations reflecting survival if that individual is missing in earlier waves.

Our second measure of health is chronic disease. In each wave, the HRS asks respondents if they have been diagnosed with arthritis, hypertension, diabetes, a psychiatric condition, or chronic lung disease, or had a stroke or heart condition, including angina, congestive heart failure, or prior heart attack. These disease measures are self-reported, and some respondents may be unaware of existing conditions. However, we suspect that inaccuracies do not vary greatly by year and region of birth. Information on chronic lung disease, stroke, and heart conditions is available for those dying between waves through exit interviews conducted with next of kin. These interviews mitigate some selective reporting that could arise if the ability to withstand such events, particularly strokes and heart attacks, depends on early-life conditions. Any selective mortality will generally bias us against finding late-life health consequences

[l]In 1934, yield declines in the East North Central, West North Central, and West South Central regions were 2.8, 3.4, and 2.9 times larger (respectively) than the mean for the rest of the nation. Corresponding relative reductions in income were 1.5, 1.6, and 1.2, and relative employment changes were 1.3, 0.9, and 1.1. In 1936, regional deviations relative to the rest of the country were 3.1, 3.8, and 2.6 (for yields), 3.4, 4.1, and 1.0 (for income), and 1.2, 0.8, and 0.9 (for employment).

[m]Our income measures also capture broader policy initiatives implemented by the Agricultural Adjustment Administration, the Federal Emergency Relief Administration, and the Farm Credit Association (45).

[n]Reduced farm income could also have general equilibrium effects, for example, lower demand for other products and services, the consequences of which again depend on the openness and size of regional markets.

[o]We also examine the direct impact of crop yields to consider cases falling between the pure open and pure closed market scenarios.

[p]The HRS is sponsored by the National Institute of Aging (Grant NIA U01AG009740) and is conducted by the University of Michigan.

Table 2. Descriptive statistics

Variable	Mean
Individual demographic characteristics	
Male	48%
Female	52%
Average age at interview	61.8 (5.5)
Health measures	
Death within 2 years	2%
Disability (any ADL or IADL)	25%
Any ADL	10%
Any IADL	21%
Diabetes	12%
Heart condition	17%
High blood pressure	42%
Chronic lung disease	10%
Major psychiatric condition	13%
Stroke	4%
Arthritis	49%
BMI	27.4 (5.2)
Height (inches)	67.1 (4.1)
Socioeconomic factors	
Father worked in farming, forestry, or fishing	18%
Father's years of schooling	9.29 (3.79)
Mother's years of schooling	9.70 (3.37)
Year and region of birth characteristics	
Crop yield residual	−.067 (.123)
Per capita personal income, 1983 dollars	3,512 (1,244)
Employment index	92 (11.7)
Births	301,834 (114,476)
Infant deaths	16,266 (6,254)
n	56,162

Percentages are shown for dichotomous variables, and means with standard deviations in parentheses are shown for continuous variables. Those born in the first half of 1929 have no personal income data available for 1928. Disability questions asked in 1992 and 1994 are not consistent over time and are excluded. Consistent ADL measures are available for 1994–2004, whereas consistent IADL measures are available for 1996–2004. Two-year mortality is unavailable for 2004 because it is the most recent period of observation.

of early-life income; we later consider the potential role of selective mortality more thoroughly.

The third dimension of health is disability, whether the person has difficulty with activities of daily living (ADLs) (bathing, eating, getting in/out of bed, dressing, and walking across a room) or instrumental ADLs (IADLs) (managing money, buying groceries, preparing meals, taking medications, and using a telephone). ADLs and IADLs are standard measures of disability in gerontology (2, 50). Our fourth measure of health is anthropometrics, height and body-mass index (BMI) (weight in kilograms divided by the square of height in meters). Both have been shown to be reflective of nutritional intake and are correlated with subsequent mortality (17, 29).

***In Utero* Economic Conditions Among 1930s Birth Cohorts.** Crop yield, income, and employment data are available on a calendar-year basis, but year of birth does not correspond well with agricultural year *in utero*. Most harvests occur between late spring and fall. Thus, the *in utero* development of a child born in the first or second quarter of a year would be influenced more by the previous year's income (or yield) than the current year's income. To match the pattern of agricultural output, we define income and yields experienced *in utero* as those from the current calendar year for those born in the third or fourth quarter of the year and from the previous calendar year for those born in the first or second quarter of the year.

Empirical Strategy. We use regression analysis to understand the impact of early-life conditions on late-life health. Denoting i as individuals, r as region of birth, y as year *in utero*, and t as the year of observation (recall that the HRS is a panel survey), we estimate equations of the form:

$$health_{\text{iryt}} = \beta_0 + \beta_1 c_{\text{ry}} + \beta_2 farmer_i + \beta_3(c_{\text{ry}} \times farmer_i) + \mathbf{X}_{ry}\gamma + \varepsilon_{\text{iryt}},$$

where *health* is a measure of health in old age, c is a measure of economic conditions (residual log-crop yield, log income, or employment rate), and $\mathbf{X}$ is a vector of control variables. We also include a dummy variable for whether the respondent's father was a farmer (*farmer*) and the interaction of that variable with economic conditions for the reasons noted above. Because $\mathbf{X}$ includes region and year of birth fixed effects as well as region-specific linear time trends, our economic condition measures capture abrupt nonlinear regional deviations from these trends. Importantly, this strips away variation in economic conditions linked to the shocks common to all areas (which would be captured in the year dummy variables) and to smoothly changing state-specific environments (which would be captured by the region-specific linear trends). Any confounding influence must have varied erratically across regions and over time in the same pattern and with the same relative magnitudes as Great Depression and Dust Bowl shocks, affecting only those *in utero* but not adjacent birth cohorts (either younger or older).

The vector $\mathbf{X}$ incorporates a rich set of covariates. In addition to region and year of birth fixed effects and region-specific linear time trends, it also includes birth region–year infectious disease mortality at ages 0–1 and 1–2 (to account for discrepancies between gross and net nutrition and the lasting direct harm of early-life infections),[q] dummy variables for 5-year age and sex groups; dummy variables for quarter of birth, dummy variables for mother's and father's level of educational attainment, and dummy variables for father's primary occupation at age 15 (in addition to farmer, 17 other occupations). We also condition our estimates of β on economic circumstances during childhood, averaging income and crop yields across the first 5 years after birth.[r]

One potential challenge to our results is selective mortality or fertility. If economic conditions *in utero* affect the composition of individuals surviving to old age, it could influence health among survivors. In particular, if sicker people are more likely to die, surviving elderly people would be healthier than average in a poor birth year, biasing us away from finding an impact of *in utero* conditions on late-life health. To partially control for this, we include the number of infant deaths in each region and year in our regressions.[s] The issue with fertility is similar. The reduction in fertility rates during the Great Depression could lead to better health outcomes, if there were a benefit from reduced cohort crowding. We include the region–year number of births in our regressions to control for

[q]Building our birth region-year infectious disease measures using the U.S. Bureau of the Census annual *Mortality Statistics*, we include deaths due to infectious diseases that primarily strike children: scarlet fever, influenza/pneumonia, meningitis, and tuberculosis. Our results are not sensitive to alternative constructions of this infectious disease mortality measure, using, for example, a broader set of infectious diseases that we can follow over a shorter period of time.

[r]Because of data constraints, we are unable to include employment during childhood. As with *in utero* exposure, we stagger the effects of income for those in the first vs. second half of the year. The HRS asks about location at birth but not as a young child. Given the significant migration of the 1930s (flight from the Midwest to the Pacific, for example), the income and crop yield variables for children may not pick up income where the person was actually living. We interpret our child income estimates based on location at birth as the reduced form of an instrumental variables analysis, instrumenting for income in place of residence with income in place of birth.

[s]Our results are not sensitive to infant mortality rates instead of infant deaths.

Table 3. Association between economic conditions *in utero* and late-life health

Dependent variable	Independent variable: Residual ln(crop yield)			Independent variable: ln(income)			Independent variable: Employment index		
	Crop yield	Farmer	Crop yield × farmer	Income	Farmer	Income × farmer	Employment	Farmer	Employment × farmer
Death within 2 years	0.0205***	−0.0134***	−0.0149	−0.0002	−0.0223	0.0023	−0.0003	−0.0068	−0.0001
	(0.0074)	(0.0016)	(0.0149)	(0.0116)	(0.02)	(0.0053)	(0.0004)	(0.012)	(0.0002)
Diabetes	0.0069	−0.019**	−0.0363	−0.0117	0.0751	−0.0105	0.0025	−0.0347	0.0002
	(0.0381)	(0.0091)	(0.0589)	(0.0572)	(0.245)	(0.024)	(0.0017)	(0.0558)	(0.0007)
Heart condition	0.0493	−0.0083	−0.0169	0.0077	0.0073	−0.0016	0.0002	0.0474	−0.0006
	(−0.0445)	(−0.0114)	(−0.0729)	(−0.0651)	(0.2397)	(0.0298)	(0.002)	(−0.0845)	(0.0008)
High blood pressure	0.0643	−0.004	−0.1348	0.0689	0.3981	−0.0537	−0.0008	−0.1537	0.0018
	(0.0612)	(0.0158)	(0.0998)	(0.0923)	(0.2277)	(0.0392)	(0.0027)	(0.0948)	(0.0011)
Chronic lung disease	0.0114	−0.0039	0.0398	−.0541	−0.0298	0.0032	0.0017	−0.0712*	0.0009
	(−0.0336)	(0.0084)	(−0.0567)	(0.0494)	(0.1408)	(0.0216)	(0.0015)	(−0.0385)	(0.0007)
Psychiatric condition	−0.0264	−0.0158*	0.027	−0.078	0.6927**	−0.055**	−0.0009	−0.0195	0
	(0.0385)	(0.0089)	(0.0648)	(0.0596)	(0.2789)	(0.0243)	(0.0017)	(0.057)	(0.0007)
Stroke	−0.0044	−0.0015	0.0009	.0079	−.0001	−.0001	0.0021**	−0.0184	0.0002
	(−0.0173)	(−0.0045)	(−0.0302)	(0.0268)	(0.0976)	(0.0125)	(0.0008)	(−0.0223)	(0.0003)
Arthritis	−0.027	0.0221	0.0132	0.0817	0.2805	−0.0356	0.004	0.0619	−0.0005
	(0.0605)	(0.0159)	(0.0975)	(0.0924)	(0.2494)	(0.0394)	(0.0027)	(0.1017)	(0.0011)
Disability	0.0153	0.0263**	0.0765	−0.034	−0.1394	0.023	−0.0012	−0.0059	0.0003
	(0.0419)	(0.0108)	(0.0648)	(0.0643)	(0.1415)	(0.0251)	(0.0018)	(0.0686)	(0.0007)
Any ADL	0.0061	0.0027	0.0381	−0.0098	0.1736	−0.0153	0.0004	−0.0601**	0.0008
	(0.0276)	(0.0068)	(0.0448)	(0.0421)	(0.2516)	(0.0166)	(0.0012)	(0.0307)	(0.0005)
Any IADL	0.0115	0.0245**	0.055	−0.0192	−0.104	0.0178	−0.0021	0.0172	0
	(0.0373)	(0.0097)	(0.0574)	(0.0574)	(0.1275)	(0.0225)	(0.0016)	(0.0628)	(0.0007)
Height	0.485	−0.0382	−0.4718	0.4815	1.3024	−0.1619	0.0038	−0.3177	0.0036
	(0.3385)	(0.0964)	(0.6057)	(0.554)	(1.8785)	(0.238)	(0.0166)	(0.6453)	(0.007)
BMI	0.3333	0.0199	−0.9127	0.2708	1.4509	−0.1714	0.005	−1.7463	0.02*
	(0.622)	(0.1707)	(1.0104)	(0.9682)	(3.277)	(0.4149)	(0.0115)	(1.0709)	(0.0116)

All cells report marginal probabilities calculated from logit estimates at the mean of the independent variables except for height and BMI cells, which report ordinary least-squares estimates. Standard errors clustered at the individual level are shown below in parentheses. Each set of three columns corresponds to a separate regression, with dependent variables shown at the left of each row. Given that 78 estimates of interest are shown, the probability of a statistically significant estimate at the $\alpha = 0.05$ if no true correlation exists is >98%. Applying an appropriate multiple comparison correction (Bonferroni's adjustment) to recover an underlying confidence level of $\alpha = 0.05$ yields a corrected significance level of $\alpha = 0.00064$. *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

this.[t] The maternal and paternal education variables should capture most of the direct effect of changes in the socioeconomic status of parents.

To account for the dichotomous nature of the health measures, we estimate logit models and report marginal probabilities evaluated at the mean of the independent variable. We cluster the standard errors at the individual level to account for the fact that we have multiple observations on most individuals.

Results

Table 3 summarizes our main results. Rows correspond to analyses with different dependent variables (shown at the left of each row), and three sets of columns show separate results for each of our three main independent variables of interest: residual ln(crop yield), ln(income), and employment. The primary marginal probabilities of interest are shown in the first and third columns of each set, the effect of economic shocks on nonfarm families and the additional effect on families used in agriculture. The resounding overall result is that essentially none of our estimates of interest is statistically distinguishable from zero.[u] This is generally true for all four of our rich measures of old-age health (death within 2 years of observation, chronic conditions, functional limitations, and anthropometrics) and for all specifications. Indeed, of the four significant estimates, one suggests that mortality is higher among those born during high-crop yield years, and another implies that stroke risk is greater among children born during low-unemployment years. Both are in the opposite direction of theoretical predictions.

The other independent variables generally have coefficients as one would expect (not reported). Children of better-educated parents are healthier in later life, as are children growing up in regions that are, on average, richer. We do not find a significant correlation between economic conditions in childhood (the first 5 years after birth) and old-age health. Similarly, estimates for childhood exposure to infectious disease are small and statistically indistinguishable from zero. Mortality risk is insignificantly higher for those born in quarter 1 and similar in the other quarters.

The coefficient estimates reported in Table 3 are small and reasonably precise. For example, for a 10% reduction in crop yields to meaningfully affect late-life disability of children of farmers, the increase in disability rates for that group would have to be only 1.3%. Thus, our finding of no impact on disability is not just a function of imprecise estimates.

Conclusions and Implications

Combining a broad range of health measures, multiple economic indicators, and a wide variety of econometric specifications and covariates, we are unable to find any statistically meaningful

[t]Although infant deaths and births are available for nearly all states and years between 1929 and 1941, the U.S. Bureau of the Census death and birth registration areas were not complete until 1933. We impute missing values using estimates from regressions on state and year fixed effects and state-specific linear time trends and then aggregate across states to create regional measures. State-year population data are not readily available for this time period, so we do not have population denominators to construct birth rates. Because we control for region fixed effects and region-specific time trends, this should not matter very much.

[u]Given that Table 3 shows 78 estimates of interest (the first and third column of each set), the probability that we will find a statistically significant estimate at the $\alpha = 0.05$ if no true correlation exists is >98%. Applying an appropriate multiple comparison correction (Bonferroni's adjustment) to recover an underlying confidence level of $\alpha = 0.05$ requires a corrected significance level of $\alpha = 0.00064$.

Table 4. Association among economic conditions and births, infant deaths, and the infant mortality rate

	Independent variable					
	Residual ln(crop yield)		ln(income)		Employment index	
	Current year	Previous year	Current year	Previous year	Current year	Previous year
Dependent variable						
ln(infant deaths)	−0.0784	0.0619	0.2043	0.1720	0.0025	0.0001
	(0.0833)	(0.0640)	(0.2442)	(0.2127)	(0.0020)	(0.0025)
ln(births)	−0.0413	0.0321	0.0805	0.1111	0.0002	−0.0001
	(0.0447)	(0.0362)	(0.1538)	(0.1242)	(0.0017)	(0.0019)
Infant mortality rate	−0.0014	0.0024	0.0105	0.0070	0.0001	0.0000
	(0.0028)	(0.0033)	(0.0089)	(0.0090)	(0.0001)	(0.0001)

Ordinary least-squares estimates are shown in each pair of cells, with standard errors clustered at the region level reported below in parentheses. Each cell corresponds to a separate regression that includes region and year fixed effects and region-specific linear time trends, with independent variables in columns and dependent variables in rows. *, $P < 0.10$; **, $P < 0.05$; and ***, $P < 0.01$.

relationship between early-life economic conditions in the 1930s and late-life health. It is worth asking the question: if such a relationship exists, why are we unable to find it?

One possible explanation is that we have imperfectly accounted for selective mortality and fertility. To probe this further, Table 4 reports estimates from regressing region-year infant deaths, births, and infant mortality rates on region-year economic conditions (measured as before), region and year fixed effects, and region-specific linear time trends. Because we cannot distinguish births and deaths by quarter, we report results linking them to both current and preceding year economic conditions. Somewhat surprisingly, we find no evidence that infant deaths or births changed with Great Depression and Dust Bowl shocks. This result suggests that selective mortality and fertility do not explain our results.

Another possibility is that the harms of agricultural shocks were offset by countercyclical health behaviors. A contentious literature suggests that mortality in the United States is procyclical, and that harmful behaviors like drinking and smoking covary positively with economic circumstances (51, 52). Brenner (53) argues that the Great Depression increased mortality, but Fishback *et al.* (46) find evidence of procyclical mortality in the United States during the 1930s.

A third possibility is that informal methods of smoothing consumption were effective in offsetting the sudden downturns of the 1930s. Although appropriately detailed consumption data are not available, the absence of infant mortality or birth effects shown in Table 4 is consistent with this interpretation. One would need more direct evidence of consumption patterns to provide support for this theory; such data are not available, however. Finally, our variables capturing economic circumstances may be measured with error. For example, relief payment schemes during the 1930s were complex and may not be fully reflected in income (46).

Many of these empirical difficulties are present in studies reporting evidence consistent with the fetal programming hypothesis, too. We therefore conclude that if economic circumstances during the early 20th century are related to old-age health today, they are likely not the most quantitatively important contributor to the recent reductions in disability among elderly Americans.

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