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Early Life Health and Cognitive Function in Old Age

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Early Life Health and Cognitive Function in Old Age

By Anne Case and Christina Paxson*

Child health in the United States improved dramatically over the 20th century. Data from the National Center for Health Statistics indicates the infant mortality rate was 23 times greater in 1900 than in 2004. The mortality rate of one- to four-year-old children, although lower in absolute terms, had a larger proportionate decline: the value in 1900 was 66 times that in 2004.

The proximate cause of the mortality decline was a reduction in infectious disease. Between 1900 and 1998, the percentage of deaths of children aged 1 to 19 years old due to infectious disease is estimated to have declined from 61.6% to 2% (Bernard Guyer et al. 2000). Major causes of child death included diarrhea, pneumonia and other respiratory infections, diphtheria, typhoid, measles, scarlet fever, whooping cough and tuberculosis (Guyer et al. 2000). The mortality decline was accompanied by reductions in morbidity among surviving children. There were also declines in the prevalence of a host of illnesses, such as hookworm and trachoma, that were not deadly but which impaired children's quality of life (C. Hoyt Bleakley 2007; Shannen K. Allen and Richard D. Semba 2002). Early life exposures to infectious disease may also have adverse effects on health and wellbeing into old age. If true, then the benefits of the 20th-century decline in infectious disease in the United States are still being realized.

We examine whether the disease environments experienced by American children in the first half of the 20th Century are associated with their cognitive abilities at older ages. We match region-level historical data on mortality from a variety of infectious diseases, as well as total infant mortality, with information on the cognitive function of older Americans followed by the *Health and Retirement Study* (HRS). We find evidence that the burden of disease in early life—measured using either mortality rates by-cause or the overall infant mortality rate—is significantly associated with performance on cognitive tests in old age.

I. Background

An extensive literature documents how the disease environment in the prenatal period and early childhood influences adult health outcomes. Dora L. Costa (2000) discusses why childhood exposures to diseases such as measles and typhoid can affect cardiac and respiratory function later in life. Caleb E. Finch and Eileen M. Crimmins (2004) review evidence that infections can lead to chronic inflammation, which in turn influences morbidity and mortality in adulthood. Other research highlights the role of prenatal and early life nutrition on long-term health outcomes (see, for example, David Barker 1997). Childhood infections and malnutrition are interrelated, and it may be that they work in concert to impair health later in life.

Although much of this research focuses on physical health outcomes, some studies suggest that the early disease environment also influences cognitive outcomes. Some infections may affect brain development among children, presumably resulting in impairment throughout life (see, for example, P.A. Holding and R.W. Snow, 2001, on the effects of malaria on the developing brain.) Early life infections may also speed cognitive decline in old age, possibly through the effects of infection on later life cardiovascular health (Costa, 2005) or the effects of inflammation on adult neurogenesis (C. T. Ekdahl et al. 2003).

An important issue has been to identify the periods in early life when disease exposures are particularly harmful. Douglas Almond (2006) conducted a careful study of the long-term effects of the 1918 influenza pandemic on the health, educational attainment and economic status of those exposed early in life. He finds that prenatal exposure to influenza was particularly harmful, whereas exposure after birth was not. That influenza exposure influenced educational attainment suggests a possible effect on cognitive ability. However, it is unknown whether other infectious diseases pose particular risks during the prenatal period, or whether the experiences of

the very severe 1918 influenza generalize to other influenza exposures. In the research that follows, we pay particular attention to the issue of the timing of exposure to infectious disease.

II. Data

Our data on cognitive function at older ages come from the HRS, a longitudinal study sponsored by the National Institute on Aging, conducted by the Institute for Social Research at the University of Michigan. Since its inception in 1992, the HRS has been documenting the physical and mental health and life circumstances of a cohort of men and women in the US over the age of 50. The measures of cognitive function that we use began to be collected in Wave 3 of the study (1996), and for this reason we restrict our analysis to Waves 3 to 7, which were collected in even years between 1996 and 2004. To reduce heterogeneity, we further restrict our analysis to non-Hispanic black and white men and women between the ages of 50 and 90 for whom no proxy respondent was used.

We use two markers of cognitive function. "Delayed word recall" records the number of words that the respondent remembers approximately five minutes after having heard a list of 10 nouns read aloud. This measure has a sample mean of 4.60 and a standard deviation of 2.10. "Counting backward" is an indicator the respondent can count backward by ones from 86 to 77. This assessment, which was conducted in waves 3 to 6, has a "pass rate" of 87.5 percent.

We examine the association between cognitive function and infant mortality, and mortality rates by-cause within census region of birth for typhoid, malaria, measles, influenza, and diarrhea. (Diarrhea deaths are for those under the age of 2.) Mortality data from 1900 to 1936 are from Grant Miller's data archive on the National Bureau of Economic Research website (available at http://www.nber.org/data/vital-statistics-deaths-historical). Data from 1937 to 1950 are from the Vital Statistics of the United States documents (downloaded from the Centers for

Disease Control website). Mortality rates are expressed as the number of deaths per 100,000 population, and infant mortality rates are the number of infants deaths (under 1 year, exclusive of stillbirths) per 1000 live births. We aggregated mortality rates to the level of the nine Census regions (New England, Mid-Atlantic, East-North Central, West-North Central, South Atlantic, East-South Central, West-South Central, Mountain, and Pacific).

Infant mortality and by-cause mortality rates vary substantially across regions and over time. To illustrate, Figures 1 and 2 show typhoid and measles mortality in three regions (Mid-Atlantic (MA), West-North Central (WNC), and East-South Central (ESC)). Although all of the diseases we examine decline over this period, their initial levels differ across regions. For example, in the early part of the 20th century, typhoid mortality is highest in the south, whereas measles mortality is highest in the mid-Atlantic region (among the three regions shown.) Typhoid shows relatively small year-to-year fluctuations, whereas measles mortality has the saw-tooth pattern that is characteristic of this disease. (A complete set of figures will be made available on our website at a later date.)

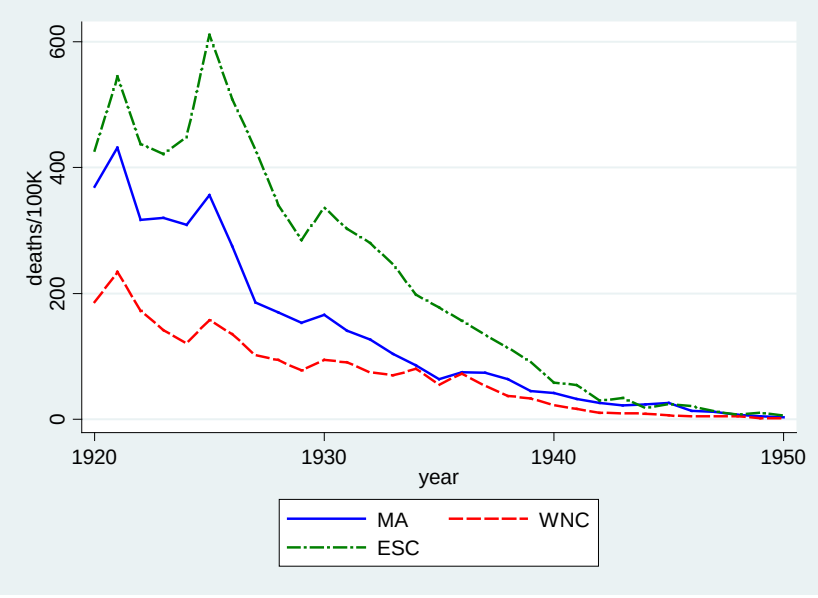

Figure 1: Typhoid mortality in three regions

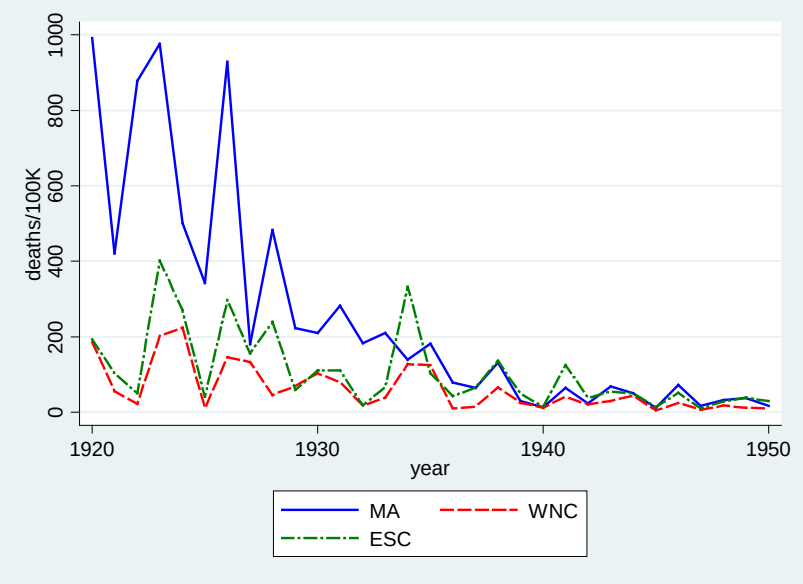

Figure 2: Measles mortality in three regions

III. Results

We start by documenting differences in cognitive test scores across regions. Table 1 shows the results of regressions of our two cognitive outcomes on a set of indicators for the region of birth. All regressions include indicators for age at examination (in 5-year categories), race, and sex. The second regression for each outcome also includes indicators for the current region of residence. The mid-Atlantic region, which has the highest scores after adjusting for age, sex and race, is the omitted category. The results indicate that southern regions have the lowest scores. However, there are substantial differences even among non-southern regions.

Table 1—Cognitive function across regions

	No controls for current region of residence		With controls for current region of residence	
	Delayed word recall	Counting backward	Delayed word recall	Counting backward
New England	–0.167	–0.010	–0.206	–0.017
	(0.054)	(0.007)	(0.075)	(0.010)
East-North Central	–0.128	–0.014	–0.091	–0.012
	(0.037)	(0.005)	(0.051)	(0.007)
West-North Central	–0.156	–0.010	–0.131	–0.015
	(0.041)	(0.007)	(0.062)	(0.008)
South Atlantic	–0.335	–0.057	–0.379	–0.041
	(0.040)	(0.006)	(0.048)	(0.007)
East-South Central	–0.358	–0.048	–0.362	–0.030
	(0.047)	(0.007)	(0.062)	(0.009)
West-South Central	–0.309	–0.054	–0.315	–0.041
	(0.046)	(0.007)	(0.068)	(0.010)
Mountain	–0.000	–0.029	–0.169	–0.044
	(0.071)	(0.011)	(0.084)	(0.012)
Pacific	–0.009	–0.015	–0.216	–0.028
	(0.058)	(0.008)	(0.072)	(0.010)
F-test (p-value): region of birth	15.09	18.77	10.80	6.01
indicators jointly insignificant	(0.000)	(0.000)	(0.000)	(0.000)
Observations	63624	51733	63311	51616

Table 2 presents results from OLS regressions on the association between delayed word recall and log of mortality rates in early life. Each column presents the results of three OLS regressions, all of which include indicators for age at examination (in 5-year categories), race, sex, and census region of birth. In the top panel, delayed word recall is regressed on the log of the infant mortality rate in the cohort member's year of birth (column 1), or the log of the mortality rate from different diseases (typhoid, in column 2, malaria in column 3, and so on), all measured in the year of birth. The middle panel shows similar regressions, with the exception that measures of mortality in both the year of birth and the second year of life are included. The third panel shows regressions on mortality in the second year of life, and includes (in addition to

the controls listed above) indicators for the current census region in which the individual resides. Standard errors, in parentheses, are clustered at the individual level.

Table 2—Delayed word recall in the HRS and disease environment in early life

		Deaths per 100,000 population from:				
	Infant mortality rate	Typhoid	Malaria	Measles	Influenza	Diarrhea
In birth year	–0.209	–0.056	–0.014	–0.003	0.009	–0.057
	(0.073)	(0.018)	(0.017)	(0.013)	(0.018)	(0.027)
In birth year	0.108	0.026	–0.014	–0.003	0.019	0.009
	(0.171)	(0.042)	(0.024)	(0.013)	(0.019)	(0.046)
In 2nd year of life	–0.371	–0.088	0.000	–0.002	–0.042	–0.088
	(0.168)	(0.038)	(0.021)	(0.013)	(0.020)	(0.045)
In 2nd year of life	–0.277	–0.069	–0.009	–0.002	–0.040	–0.082
	(0.071)	(0.016)	(0.015)	(0.013)	(0.019)	(0.027)
Observations	59412	62029	61583	62029	62029	59686

The top panel shows a significant association between word recall at older ages and the log infant mortality rate, and the mortality rates for typhoid and diarrhea in the year of birth. However, the results in the second panel indicate that in all cases, the inclusion of log mortality rates at age 2 erases the impact of the disease environment in the birth year. Instead, it is the disease environment at age 2 that is significantly correlated with cognitive function. This is true for overall infant mortality, typhoid, influenza and diarrhea. These results are in contrast to those of Almond (2006) who finds that individuals who were *in utero* during the 1918 influenza pandemic have worse educational, economic and health outcomes in adulthood.

The final panel of Table 2 shows results that include log mortality rates at age 2 alone, as well as a set of indicators for the census region of *current* residence. (The inclusion or exclusion of the indicators for the current region of residence makes little difference to the results.) These indicate that a halving of the infant mortality rate—which occurred between 1920 and 1940—is

associated by an improvement on the delayed word recall test of 0.2 words, or nearly a tenth of a standard deviation.

We also estimated models that included all causes of mortality at once. Although the causes are jointly significantly different from zero, the point estimates for individual diseases are imprecisely estimated. Mortality rates within a census region are highly correlated, making it unwise, with these data, to claim that it was one disease (say, typhoid) rather than another (say, malaria) that is responsible for the significant association between measures of cognitive function and the disease environment. However, these results do support the idea that the disease environment in early childhood, as opposed to during the prenatal period, is associated with cognitive outcomes later in life.

We present a similar analysis for successfully counting backward from 86 to 77 in Table 3. Here, we have omitted the middle panel, and the second panel contains only the log mortality rates in the second year of life without indicators for the current region of residence. (However, there inclusion makes no difference to the results.) We find weaker associations between this measure of cognitive ability and the disease environment in early life. Typhoid and malaria are significantly associated with an inability to count backwards, while measles, influenza and diarrhea show no such effects. Indeed, influenza shows a positive association with successful counting. The inability to count backwards is fairly uncommon—the test is "failed" fewer than 15 percent of the time—and failure may represent severe cognitive decline that the disease environment in early life cannot predict.

Table 3—Counting backward in the HRS and disease environment in early life

		Deaths per 100,000 population from:				
	Infant mortality rate	Typhoid	Malaria	Measles	Influenza	Diarrhea
In birth year	–0.000	–0.004	0.001	0.002	0.009	0.009
	(0.013)	(0.003)	(0.003)	(0.002)	(0.003)	(0.005)
In 2nd year of life	–0.015	–0.005	–0.007	0.003	0.007	0.005
	(0.013)	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)
Observations	48455	50930	50581	50930	50930	49327

Changes in the disease environment within a census region may be correlated with other changes—such as changes in the quality of schools of health care facilities—that influenced cognitive development. It may be these other changes, rather than the disease environment, that leads to correlation between measures of cognitive ability at older ages and the disease burden in early life. That our results are robust to the inclusion (exclusion) of census region indicators suggests that these correlations are not simply picking up level differences in disease burden and level differences in cognitive function across space. However, they do not eliminate the possibility that we are picking up the impact of other changes taking place in census regions over time. Our results are not robust to adding census region-specific time trends. This is not terribly surprising, given that the level of variation in our data is at the census region-year level. However, it leaves the results open to multiple interpretations, and provide only suggestive evidence that the disease environment in early life affects cognitive ability in old age.

We do not have good measures of the quality of educational or health care facilities in individual's places of birth. However, we do know individuals' educational attainment, and can examine whether the associations between cognitive outcomes and the early disease environment are altered when we control for education. A finding that education "accounts" for the

association between the disease environment and later cognitive outcomes could itself have several interpretations. It could be that educational attainment reflects school quality or other early childhood factors that are correlated with the disease environment. It could also be that disease burden impairs cognitive development in childhood, leading to lower educational attainment. We cannot distinguish between these two possibilities. However, a finding that the disease environment is associated with later-life cognitive outcomes even controlling for education would be consistent with the health literature, discussed above, that posits that infections experienced early in childhood produce chronic disease later in life.

In regressions that control for by-cause mortality and HRS cohort member's educational attainment, we find controlling for year and place of birth, educational attainment is significantly associated with only two measures of the early life disease environment: it is negatively associated with malaria mortality, but (unexpectedly) positively associated with diarrhea mortality. More important, adding years of education to our regressions for delayed word recall does little to alter our findings. Delayed word recall is still negatively and significantly associated with infant mortality, typhoid and influenza. These findings suggest that the early life disease environment is not simply "standing in" for educational quality. Furthermore, to the extent that the early life environment influences cognitive outcomes later in life, it does not do so through its effect on educational attainment.

These results, although suggestive, have several implications. First, to the extent that the disease environments American children experience have both improved as well as converged across regions, we should expect the regional differences in cognitive ability in old age to be smaller among the next cohorts of elderly individuals. This will be testable as later-born cohorts of individuals are brought into the HRS. (Currently, same-aged individuals in Waves 3-7 of the

HRS are observed only over a 10-year span of birth years, a period which is too short to examine this hypothesis.) Second, these results suggest that the benefits of reductions in childhood exposures to infectious disease in developing economies may extend far into the future.

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