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ABSTRACT

A large literature documents that childhood health shocks have lasting negative consequences for adult outcomes. This paper demonstrates that the adversity of childhood physical disability can be mediated by individuals' educational and occupational choices, which reflect their comparative advantage. We merge records on children hospitalized with poliomyelitis during the 1952 Danish epidemic to census and administrative data, and exploit quasi-random variation in paralysis incidence. While childhood disability increases the likelihood of early retirement and disability pension receipt at age 50, paralytic polio survivors obtain higher education and are more likely to work in white-collar and computer-demanding jobs than their non-paralytic counterparts.

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1 Introduction

A vast body of research documents that adverse early childhood health shocks have lasting negative consequences on adult health, human capital, and labor market outcomes (Almond et al., 2017; Currie and Vogl, 2013; Almond and Currie, 2011; Barker, 1990). The estimated long-term impacts correspond not only to biological processes, but also incorporate any changes in human behavior in response to the shock. While a burgeoning literature focuses on identifying *parental* compensating or reinforcing investments (Almond and Mazumder, 2013; Adhvaryu and Nyshadham, 2016; Sievertsen and Wüst, 2017; Bharadwaj et al., 2018), comparably less attention has been devoted to the choices made by the children themselves as they grow up. Moreover, as most studies examine shocks that impact early childhood well-being on multiple margins (e.g., both physical health and cognitive development), there is less knowledge about whether individuals' responses reflect changes in the comparative advantage *across* various inputs into the human capital production function (Cunha and Heckman, 2007; Cunha et al., 2010; Heckman and Mosso, 2014).[1]

This paper focuses on a substantial shock to childhood physical health but *not* cognitive development: paralytic poliomyelitis (hereafter, paralytic polio). Our empirical setting is the 1952 polio epidemic in Denmark's capital Copenhagen and the surrounding Copenhagen medical district. We merge unique historical medical records on the universe of children hospitalized for polio in this area during the epidemic to the 1970 Census and 1980-2013 administrative population register data. We follow childhood polio survivors as they become adults and into older ages, and study their choices regarding education and occupation. We test whether the adversity of childhood physical disability can be mediated by individuals' educational investments and occupational sorting that reflect their comparative advantage in cognitive ability relative to brawn.[2]

Our empirical approach compares the long-term outcomes of children who are hospitalized with either paralytic or non-paralytic polio. While nearly all individuals with non-paralytic polio fully recover from the infection, paralytic polio survivors are likely to suffer lasting disabilities, including a re-occurrence of symptoms (such as muscle weakness, pain, and fatigue) after a period of physical

[1] For instance, there is evidence on lasting negative effects of *in utero* and early childhood exposure to diseases that impact both physical health and brain functioning, such as influenza (Almond, 2006; Kelly, 2011; Lin and Liu, 2012), malaria (Cutler et al., 2010; Bleakley, 2010; Barreca, 2010), and pneumonia (Bhalotra and Venkataramani, 2012).

[2] For a more formal model of how investments in human capital may take into account differences in brawn, see Pitt et al. (2012).

recovery and stability ("post-polio syndrome", see, e.g. Groce et al., 2014; Tiffreau et al., 2010; Frick and Bruno, 1986; Rekand et al., 2000; Ivanyi et al., 1999; Gonzalez et al., 2010; Farbu et al., 2006; Lønnberg, 1998).

Our research design relies on the assumption that, conditional on polio infection and hospitalization, the incidence of paralysis is uncorrelated with unobservable determinants of individual outcomes. A small medical literature has documented that there are very few known risk factors that are associated with paralysis among polio patients (Abramson and Greenberg, 1955; Weinstein, 1957; Bunimovich-Mendrazitsky and Stone, 2005; Nielsen, 1999) and we control for those in our models. Importantly, we show that children's socio-economic background is uncorrelated with the incidence of paralysis in our sample.[3]

Our analysis focuses on 1,649 children born in 1938-1952 and hospitalized with polio in the Copenhagen Blegdam hospital, the primary hospital that admitted polio cases from the capital and the Copenhagen medical district. We find that paralytic polio survivors fare *better* than their non-paralytic counterparts along several dimensions. Paralytic patients are more likely than non-paralytic patients to continue formal education beyond compulsory schooling and less likely to be employed as unskilled workers at ages 18 to 32. By age 50, individuals who had childhood paralytic polio are not only more likely to have completed university, but are also in occupations that have lower physical/brawn requirements and higher computer-skills-related requirements. By selecting out of manual work and into computer-intensive jobs, paralytic polio survivors end up in occupations that experienced substantial employment and wage gains over 1960-2010 (Autor et al., 2003; Deming, 2018). In fact, although most studies find that adverse early childhood health shocks lower individuals' earnings in adulthood (see Almond and Currie, 2011 for an overview), we find no statistically significant differences in wages between paralytic and non-paralytic polio survivors. Our study suggests that paralytic patients compensate for the large negative shock to their physical health by making use of their remaining (non-brawn) skills through their educational and occupational choices. We also, however, document that paralytic polio survivors are more likely to be dependent on disability insurance than their non-paralytic counterparts, pointing to the fact

[3]Another concern, which we discuss in Section 4, is selection of individuals into the hospital. Given high public awareness of the epidemic and universal access to publicly-funded hospitals, we do not expect this to be a severe issue. We show that our hospital records include almost all registered paralytic and a large share of registered non-paralytic polio infections in the Copenhagen medical district, implying that selection into hospital admission was minimal.

that today's society carries the burden of disease from over half a century ago, even if it has been largely eradicated in developed countries (Philipson, 2000).[4]

Selective survival among polio patients may impact the interpretation of our findings. We show that although in-hospital mortality exclusively affected paralytic patients, it is largely uncorrelated with individual characteristics among them. Net of in-hospital mortality, paralytic polio patients are not more likely to die during childhood and young adulthood than non-paralytic patients on average. However, among patients from low socio-economic status (SES) backgrounds, those with paralytic polio are more likely to die at all observed ages than their non-paralytic counterparts. To address the concern that selective mortality among low-SES polio patients drives our long-run results, we perform a bounding exercise (Lee, 2009). We include all individuals who are missing in our outcome data because they are either deceased or have emigrated with the most and least favorable values of each outcome, respectively. Even if we assume that all missing individuals had the worst possible outcomes, we still find that individuals who had paralytic polio during childhood choose longer educational tracks geared toward white collar positions early in their careers than those with non-paralytic polio. However, when we examine educational attainment and occupation at age 50, the most conservative bounds yield insignificant estimates. Thus, it appears that initial educational and occupational choices of paralytic polio survivors put them on a higher education track, but some of the longer-run effects on completed education and occupation may be partially driven by selective survival.[5]

[4]Our evidence builds on a small public health literature on the medium and long-term consequences of polio among survivors. Most of these studies use small survey samples of (selected) polio survivors, who had paralytic or non-paralytic polio, and compare their outcomes to those of matched never infected individuals (Lønnberg, 1993; Farbu et al., 2001; Farbu and Gilhus, 2002; Nielsen et al., 2003, 2016). Studies on 150 to 170 polio survivors in Norway conclude that "the polio epidemics in the 1950s to a surprisingly little degree influenced social characteristics such as education, employment and professional life," even though the survey participants stated that they "regarded their physical handicap as decisive for their choice of profession" (Farbu et al., 2001, p 503). This finding may be due to three factors: (a) small sample sizes may be underpowered to detect differences in some outcomes, such as education; (b) the studies do not distinguish between occupations by their "brawn" content (e.g., the trade and office category could include manual work in a skilled trade as well as white-collar occupations); (c) the studies rely on survey reports among polio survivors, and thus sample selection based on health and socio-economic status may bias the conclusions. Indeed, consistent with the last point, Nielsen et al. (2003) document that Danish (paralytic) polio survivors have a higher long-term mortality risk than the overall population. At the same time, Nielsen et al. (2016) find that Danish polio survivors have higher educational attainment but similar total income when compared to matched controls.

[5]We do not find any statistically significant differences in effects of paralytic polio on educational or labor market outcomes between survivors from low-SES and high-SES families (similar to some past studies on other child health shocks, e.g. Currie and Hyson, 1999; Currie and Stabile, 2003).

2 The 1952 Polio Epidemic in Copenhagen

Polio pathology. Polio is a viral disease that is transmitted through oral and fecal channels. While the vast majority of polio infected individuals do not experience any symptoms, four to eight percent have mild complaints such as malaise, fever, or headache. One to two percent of individuals develop specific symptoms (such as stiffness and pain in the back and neck). Almost all non-paralytic polio patients recover completely. For up to one percent, the illness develops into paralytic polio, with paralysis of various degrees (Armstrong and Cohen, 1999; Melnick, 1996; Nielsen, 1999; Horstmann, 1963; Bunimovich-Mendrazitsky and Stone, 2005; Groce et al., 2014).

Why do some patients develop serious infections that result in paralyses, while others do not? Existing epidemiological and medical research on the determinants of polio severity remains inconclusive. The few factors that have been shown to be associated with the severity of a polio infection include age at infection, gender, family size and birth order (Weinstein, 1957; Nielsen et al., 2002; Nielsen, 1999).[6] While some small-scale studies have suggested that genetic factors may predict the risk of paralysis (Van Eden et al., 1983), other studies have not confirmed this relationship (Zander et al., 1979). In our empirical models, we only exploit the residual variation in paralysis occurrence net of the observed risk factors.

The 1952 epidemic. Prior to the introduction of the polio vaccine in 1955, Denmark experienced several epidemics. The largest epidemics in both the U.S. and Denmark occurred in 1952, with a total of 34,071 and 5,676 recorded polio cases in the two countries, respectively.[7]

This final Danish polio epidemic was centered around Copenhagen, before spreading to other parts of the country in 1953.[8] Suspected polio patients in the capital and the Copenhagen medical district were referred to a single hospital: Blegdam Hospital. Due to high public awareness of the symptoms (Warwicker, 2006) and as shown in Section 4, records from Blegdam Hospital cover up to 90 percent of recorded paralytic and non-paralytic cases of the epidemic for this area.

In the initial weeks of the epidemic (from July 24, 1952 on), the mortality rate for patients

[6] One study also suggests that muscular injections and tonsillectomy surgery in the weeks prior to or physical activity after a polio infection may contribute to the development of paralyses (Von Magnus, 1952). However, the same study concludes that those factors are of minor importance for explaining variation in polio severity.

[7] For U.S. figures, see: U.S. Department of Health and Service. (1963) accessed on `https://www.historyofvaccines.org/content/us-polio-cases-1952-1962`; Danish figures from Hamtoft (1953).

[8] There was also a minor polio outbreak in Denmark in 1961, after the introduction of the first oral polio vaccine, with 356 cases.

with respiratory paralysis (the most severe form of paralysis) was very high, at about 85-90 percent (Lassen, 1953).[9] In late August 1952, one month into the epidemic, the invention of manual ventilation reduced mortality among patients with respiratory paralysis dramatically (Ibsen, 1954; Lassen, 1953; Warwicker, 2006).[10] In total, 116 paralytic polio patients died at Blegdam hospital during 1952 (Astrup et al., 1989).[11]

After hospital discharge, paralytic polio survivors entered the national rehabilitation system that aimed to integrate polio survivors into society and the regular labor market. Children were referred to specialized centers throughout the country for physical rehabilitation and therapy (Gould, 1995).

3 Data and Sample Construction

Polio hospital records. We use records from the Blegdam hospital that contain the dates of admission and discharge, type of polio diagnosis, in-hospital mortality, and information on family structure and the occupation of the household head. Our main SES measure is an indicator for the household head being an unskilled worker.

We constrain our sample to individuals admitted and diagnosed with either non-paralytic or paralytic polio in 1952. Additionally, as data on parental background was only collected for children, we limit our sample to cohorts born in 1938 to 1952, who were 0 to 14 years old during the epidemic.

We focus on patients who resided in the capital and the surrounding Copenhagen medical district during the epidemic.[12] We omit 107 children with missing information on parental occupation, family size, or parity at the time of hospital admission. The hospital records have been linked to the central Danish Civil Registration System (CPR) and thus contain personal identifiers for those who were alive and residing in Denmark in 1968. We assume that all hospital records without

[9] The only treatment was a negative pressure ventilator, the "iron lung." Its effectiveness was low and the hospital's resources of 7 respirators were no match for the unprecedented high number of around 50 daily admissions. Lassen (1953) notes that the ratio of paralytic to non-paralytic cases was reported to be about 1:2.

[10] The procedure consisted of tracheotomy with manual bag ventilation through a rubber cuff tube, calling on hundreds of medical students to ensure round-the-clock ventilation. Among the paralytic patients who survived, only 40 percent required assistance with breathing after one month, and about 14 percent after 10 months (Pallis, 1953).

[11] These deaths include all patients admitted with polio. In our main analysis sample, we observe 50 deaths of children in the relevant age group.

[12] The capital includes the municipalities Copenhagen and Frederiksberg. Suspected cases from the entire island of Zealand (where Copenhagen is located) were admitted to Blegdam hospital (Warwicker, 2006). However, using data from the larger geographic area would raise more concerns about selection into hospital admission. Among residents of the capital and Copenhagen medical district, we observe the vast majority of polio cases in our analysis age group, as we discuss below.

personal identifiers in 1968 represent patients who died (after discharge from hospital, but at some point prior to 1968). This is a conservative measure of survival because individuals could be absent from the register data for other reasons, such as emigration.

1970 Census data. Using the personal identifier, we merge hospital records to the 1970 Census, which lets us measure outcomes in young adulthood. We observe individuals' educational attainment and occupational status in 1970 (ages 18 to 32). We create indicators for whether individuals have completed more than compulsory schooling, are enrolled in any educational program in 1970, report disability pension receipt, or are employed in an unskilled job, as defined in the Census classification.

Administrative outcomes data. We use administrative data on outcomes measured in 1980-2013. We study survivors' completed education, employment, occupation, wage earnings, and disability insurance receipt at age 50. Finally, we add information on the timing of mortality dating back to 1973. Blue-collar occupations are defined as International Standard Classification of Occupations (ISCO) 1-digit codes 6-9, which include skilled agricultural and fishery workers, craft and related trades workers, plant and machine operators and assemblers, and other elementary occupations, such as cleaners, laborers in agriculture, construction, etc.

Occupations and skills. We use the detailed occupational data from the administrative registers in combination with O*NET, a database containing skill requirements for each occupation, to identify each occupation's intensity in specific inputs. Using confirmatory factor analysis on the full set of 52 ability requirements listed in the category "worker abilities," we obtain for each occupation a score on the required ability level in four domains: "Cognitive" abilities, capturing verbal and quantitative abilities, idea generation and reasoning abilities; "Brawn," which captures physical strength, speed, gross-body coordination, and flexibility; "Spatial/Vision" which captures visual, auditory, and speech perception requirements; and "Dexterity," which distinguishes fine-motor skills such as finger dexterity from the first "Brawn" factor. We also generate a computer use indicator based on the average of "interacting with computers" and "programming" requirements.[13]

[13] We performed factor analysis on the full Danish population of our analysis cohorts at age 50. See Appendix B for details and results using skill measures used by Autor et al. (2003); Acemoglu and Autor (2011) and Deming (2018).

Sample means. Appendix Table A.1 presents means of the variables in our analysis sample. There are statistically significant differences between paralytic and non-paralytic polio survivors in a number of adult outcomes measured at the 1970 census and at age 50 in the administrative data. At the same time, out of the 736 paralytic patients in our sample, 50 died in the hospital. This selective morality may account for some of the observed differences. Thus, in the following, we more formally examine the differences in outcomes using the empirical methods described below and discuss the potential impact of selective mortality.

4 Empirical Methods

To examine the impact of the childhood paralytic polio during the 1952 epidemic, we estimate the following regression using our hospitalizations data for admitted polio cases:

$$Y_{it} = \beta_0 + \beta_1 ParaPolio_i + X_i'\rho + \gamma_t + \varepsilon_{it} \tag{1}$$

for each individual i born in year t. Y_{it} is an adult outcome, while $ParaPolio_i$ is an indicator for an individual being hospitalized with paralytic polio. We include a vector of individual-level control variables observed in the hospital records, X_i: indicators for being admitted during the height of the epidemic (August-December 1952), being male, a first-born, coming from a family of more than two children, residing in the capital, and having the head of household classified as an unskilled worker. To control for known age effects on the probability of developing paralysis, we also account for year of birth fixed effects, γ_t. ε_{it} is an unobserved error term.

Identifying assumptions. To identify the causal effect of being exposed to paralytic polio, we rely on the assumptions that among patients hospitalized for polio, the incidence of paralysis is uncorrelated with unobservable characteristics that also impact outcomes, and that there is no differential selection into hospitalization across paralysis status.

Column 1 in Table 1 shows results from a regression of paralytic polio status on individual level and geographic characteristics. Residence in the capital is negatively correlated with the likelihood of being diagnosed with paralytic polio in our sample. This finding suggests that among inner-city residents, a greater share of suspected polio cases were admitted to hospital for observation.

Our main measure of individuals' socio-economic background, an indicator for the head of the patient's household being an unskilled worker, does *not* predict the likelihood of being diagnosed with paralytic polio. Moreover, in our sample, child gender, family size, birth order, and admission in January-July 1952 (before the height of the epidemic) are all uncorrelated with paralytic polio.

Column 2 in Table 1 shows that individual-level characteristics appear to also have little relationship with the likelihood of in-hospital mortality, although we do find that individuals residing in the capital are less likely to die in the hospital than individuals outside the capital (which may be due to an over-representation of non-paralytic cases from the capital). To address this issue, we have estimated all our main models using only polio patients who are capital residents, finding very similar results (available upon request).

Finally, to show that it is unlikely that our results are driven by selective hospital admission, we compare our raw hospital records to aggregate statistics of paralytic and non-paralytic polio cases for the capital and Copenhagen medical district (Hamtoft, 1953).[14] As Appendix Table A.2 illustrates, our records contain around 90 percent of all paralytic polio cases that were registered for individuals aged 0 to 14 during the epidemic. Moreover, in the hospital records, we observe all deaths from paralytic polio that were registered. When comparing the hospital records to aggregate statistics for all age groups, we cover at least 84 percent of all registered non-paralytic cases. While the non-paralytic statistic is not available by age, anecdotal evidence suggests higher hospital admission rates for suspected polio infections in children than adults (Warwicker, 2006). Thus our coverage of children with non-paralytic polio is likely higher than 84 percent.

5 Results

Table 2 presents our main results for the effect of paralytic polio on educational and occupational outcomes. Panel A shows that, compared to non-paralytic polio survivors, individuals who had paralytic polio are 6 percentage points (15 percent) more likely to have completed more than compulsory schooling and 4 percentage points (22 percent) less likely to be unskilled workers when they are between 18 and 32 years old. The coefficients on the unskilled background indicator are opposite-signed for these outcomes, consistent with low-SES individuals being on lower educational

[14]This table contains all individuals in the hospital records, also the ones that we omit in our analysis sample (due to missing covariates).

and occupational trajectories, regardless of paralysis status. Comparing the magnitudes suggests that the experience of childhood paralysis may reduce the high-versus-low-SES gap in the likelihood of going beyond compulsory schooling by about 24 percent.

In panel B, we find that, by age 50, paralytic polio survivors are more likely to obtain a university education and are less likely to work in a blue-collar occupation than non-paralytic survivors. At the same time, paralytic polio survivors are 8 percentage points (50 percent) more likely to be on disability insurance, and are 5 percentage points (7 percent) less likely to be employed. There is no statistically significant effect on wage earnings.

We thus find evidence of greater selection into higher education despite a shortened work life in paralytic polio patients. In a standard human capital framework, such as Ben-Porath (1967), a shorter time horizon for earning income should decrease the expected returns, leading to lower investments in education. Our finding of an opposite effect suggests that there are additional factors counteracting the reduction in expected returns. The shift in comparative advantage is one such factor. Another possibility is that paralytic polio survivors derive a higher consumption value from education, if education compensates for some of the disutility of physical disability (Finkelstein et al., 2013).

Our results on selection out of brawn-based occupations, however, appear more consistent with the comparative advantage channel, due to the explicit link between skills and their use. Panel C shows that employed paralytic polio survivors are working in jobs that require less physical body strength, dexterity, or spatial and vision ability at age 50. In terms of percentiles of the entire population of the same age, paralytic polio survivors work in jobs that are 8 percentiles lower in skill requirements for physical strength, speed, coordination, and flexibility than their non-paralytic counterparts. Their occupations tend to not be any higher in the overall cognitive requirement (column 1 of panel C), despite their higher educational attainment. However, we do find that paralytic polio survivors hold jobs that are 5.6 percentiles higher in the frequency and intensity of computer use (column 5 of panel C) than non-paralytic polio survivors.

Did paralytic polio survivors "benefit" from their polio status because they got a head start on technological change over the second half of the 20th century? We study this question further by replicating the skill measures employed by Autor et al. (2003); Acemoglu and Autor (2011) and Deming (2018), in Appendix Table A.3. While we prefer our comprehensive measures that draw on the entire list of skill requirements in the factor analysis, these measures are more specific. We find that the selection out of "brawn" jobs corresponds to a selection out of both routine manual and nonroutine manual jobs, which were shown in Autor et al. (2003) to have experienced declines since 1960 and 1980, respectively. We also find that paralytic polio survivors selected into non-routine analytical jobs based on Deming's definition using mathematical reasoning. While we see that paralytic polio are more likely to choose jobs that were growing over this time period, their comparative advantage is *not* shifted toward interactive, social or service jobs, which experienced the greatest gains.

Selective mortality and heterogeneity by parental background. All the results presented so far are based on samples of survivors until 1970 and age 50, respectively. As mentioned above, mortality in the hospital only affected paralytic patients. Within that group, there is little correlation between individual characteristics and the likelihood of mortality. Moreover, when we exclude the 50 patients who die in the hospital, the remaining paralytic polio patients are not more likely to die during young adulthood than non-paralytic patients (Appendix Table A.4). This average masks heterogeneity in mortality effects, however. Table 3 shows that paralytic polio patients from low-SES backgrounds face an increased risk of early mortality.[15] This result holds both when including and excluding in-hospital mortality. By contrast, when we consider the impacts on educational and occupational outcomes, we cannot rule out that the impacts of paralytic polio are similar across children from low- and high-SES backgrounds.[16]

To address the issue of selective mortality among low-SES individuals, we implement a bounding exercise analogous to Lee (2009). We include all individuals that leave our data prior to the time of measurement with either the most or least favorable outcome, and perform our main analysis on the resulting sample with imputed variables.[17]

Table 4 presents the results from this bounding exercise for our census outcomes, while Appendix Tables A.5 and A.6 do so for outcomes at age 50. We find that the result for continuing beyond compulsory schooling is robust to the bounds, suggesting that the impacts for educational

[15] Recall that our mortality measure comprises all observed deaths after 1973 and all assumed deaths of polio-admitted individuals, who are not merged to the census or administrative register data.

[16] Results are available on request.

[17] We do not impute values for individuals who are observed in the outcome for some measures but not others, e.g., have data on their labor market status but are missing on, e.g., education.

investments in young adulthood are not purely driven by changes in sample composition due to selective mortality of the “weakest” paralytic polio survivors. However, results for outcomes at age 50 are more mixed, with the most conservative bounds often yielding insignificant effects. The most robust finding across the lower and upper bounds for this age group is that of an increased probability of being on disability insurance.

6 Conclusion

Do individuals alter educational and occupational choices in response to childhood physical disability? We examine this question in the context of paralytic polio, a crippling disease that impacts physical health, but not other inputs into human capital production. We leverage multiple sources of linked data and compare the outcomes of children who were hospitalized with paralytic and non-paralytic polio at ages 0 to 14 during the 1952 polio epidemic in Copenhagen, Denmark. We study how these individuals fare in young adulthood (in 1970) and at the peak of their careers around age 50.

Our results show that, relative to their non-paralytic counterparts, paralytic polio survivors are more likely to pursue an education that leads to a white collar job, to choose a white collar track early in their careers, and to obtain higher educational qualifications and work in jobs demanding computer-related skills and less brawn around age 50. These choices are consistent with a shift in the comparative advantage of cognitive versus physical skills for individuals affected with paralytic polio. Indeed, while prior studies show that health shocks during childhood lower individuals' earnings in adulthood, we find no differences in wages between paralytic and non-paralytic polio survivors. The fact that paralytic survivors obtain more education but do not experience any earnings gains is also consistent with the idea that education has some consumption value for the affected individuals.

Finally, we find that although there is no evidence of differential mortality between paralytic and non-paralytic patients overall, the mortality risk for paralytic patients is higher for children from low-SES than high-SES backgrounds, even in the very long run. Our results suggest that children from more advantaged backgrounds may be better able to buffer against the lasting health impacts of childhood disability than their less advantaged counterparts.

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Table 1: Predictors of Paralytic Polio and Death at the Hospital During the 1952 Epidemic

	(1) Paralytic polio	(2) Death in hospital
Male child	-0.016	0.004
	[0.024]	[0.009]
Unskilled background	-0.033	0.011
	[0.026]	[0.009]
Capital resident	-0.095	-0.027
	[0.026]	[0.009]
Firstborn	-0.029	0.012
	[0.027]	[0.010]
> 2 children in family	-0.037	0.018
	[0.029]	[0.010]
Hosp. admission Jan-July	-0.119	0.018
	[0.074]	[0.026]
Mean, dept. var.	0.446	0.030
F-test	6.551	1.491
P-value joint F-test	0.000	0.075
Adj. R^2	0.063	0.006
Observations	1649	1649

Notes: Heteroskedasticity-robust standard errors in brackets. Both models control for year of birth fixed effects. The sample includes children aged 0-14 in 1952 who reside in Copenhagen and its medical district, who are admitted to hospital with paralytic or non-paralytic polio.

Table 2: Effects of Childhood Paralytic Polio on Long-Term Outcomes

A. Young Adult Outcomes. 1970 Census

	(1)	(2)	(3)	(4)
	> Comp. School.	In Edu	Disab.Ins.	Unskilled worker
Paralytic polio	0.0604	0.0362	0.00518	-0.0374
	[0.0253]	[0.0226]	[0.00879]	[0.0202]
Unskilled background	-0.251	-0.167	0.0193	0.114
	[0.0258]	[0.0231]	[0.00897]	[0.0207]
Mean, dept. var.	0.393	0.275	0.0261	0.171
Observations	1487	1493	1493	1493

B. Education and Labor Market Outcomes, Age 50.

	(1)	(2)	(3)	(4)	(5)
	Univ.Edu	Employed	Disab.Ins.	Blue-collar Occ	Wage Earnings
Paralytic polio	0.0317	-0.0466	0.0791	-0.0546	-3863.0
	[0.0155]	[0.0268]	[0.0204]	[0.0259]	[12792.2]
Unskilled background	-0.0961	-0.0898	0.103	0.145	-72968.6
	[0.0159]	[0.0274]	[0.0209]	[0.0266]	[13065.4]
Mean, dept. var.	0.0876	0.668	0.159	0.278	237004.7
Observations	1427	1401	1417	1242	1377

C. Skill Requirements, Age 50.

	(1)	(2)	(3)	(4)	(5)
	Cognitive	Brawn	Spatial/Vision	Dexterity	Computer Work
Paralytic polio	0.980	-7.949	-6.873	-4.408	5.609
	[1.704]	[1.648]	[1.607]	[1.702]	[1.710]
Unskilled background	-11.85	4.511	3.882	6.624	-5.296
	[1.741]	[1.683]	[1.642]	[1.738]	[1.746]
Mean, dept. var.	53.01	42.77	44.77	45.26	54.87
Observations	1265	1265	1265	1265	1265

Notes: Heteroskedasticity-robust standard errors in brackets. The sample in panel A includes children admitted with non-paralytic or paralytic polio in 1952 who are observed in the 1970 census, at which they are 18-32 years old. The sample in panel B includes children admitted with non-paralytic or paralytic polio in 1952, who are observed in the administrative registers at age 50. The sample in panel C includes children admitted with non-paralytic or paralytic polio in 1952 who are observed in the administrative registers at age 50 and who have a registered occupation in any of the 5 years around age 50. We limit to children aged 0-14 in 1952 and residing in the Copenhagen medical district. All regressions control for indicators for a male child, for the child being first-born, an indicator for a large family (more than two children), an indicator for residence in the capital, and birth year indicators. "> Comp. Edu" refers to having education beyond compulsory schooling, and "Disab.Ins." stands for receipt of disability insurance.

Table 3: Heterogeneity in Effects of Paralytic Polio by SES Background on Likelihood of Missing from Outcome Data and Death by Age; excl. In-Hospital Mortality

	(1) No merge 1970	(2) Death by 45	(3) Death by 50	(4) Death by 60
Paralytic*Unskilled parents	0.0461 [0.0269]	0.0744 [0.0335]	0.0933 [0.0366]	0.103 [0.0438]
Paralytic polio	-0.0288 [0.0159]	-0.0305 [0.0199]	-0.0328 [0.0217]	-0.00150 [0.0259]
Unskilled background	-0.0156 [0.0175]	-0.0142 [0.0219]	-0.0186 [0.0239]	0.0124 [0.0286]
Mean, dept. var.	0.0663	0.108	0.132	0.209
Observations	1599	1599	1599	1599

Notes: Heteroskedasticity-robust standard errors in brackets. The sample includes all children admitted with non-paralytic or paralytic polio in 1952, except for the 50 paralytic polio patients for whom we observe an in-hospital death in the data. No merge to the 1970 Census (column 1) is interpreted conservatively as death by 1970.

Table 4: Young Adult Outcomes, Bounding Exercise. Census Data, 1970

	A. Baseline Results			
	(1) > Comp. School.	(2) In Edu	(3) Disab.Ins.	(4) Unskilled worker
Paralytic polio	0.0604 [0.0253]	0.0362 [0.0226]	0.00518 [0.00879]	-0.0374 [0.0202]
	B. Impute Outcomes of Deceased as Least Favorable			
	(1) > Comp. School.	(2) In Edu	(3) Disab.Ins.	(4) Unskilled worker
Paralytic polio	0.0440 [0.0237]	0.0211 [0.0211]	0.0527 [0.0167]	0.00326 [0.0222]
Mean, dept. var.	0.356	0.249	0.118	0.249
Observations	1643	1649	1649	1649
	C. Impute Outcomes of Deceased as Most Favorable			
	(1) > Comp. School.	(2) In Edu	(3) Disab.Ins.	(4) Unskilled worker
Paralytic polio	0.0937 [0.0246]	0.0708 [0.0233]	0.00301 [0.00793]	-0.0464 [0.0185]
Mean, dept. var.	0.451	0.344	0.0237	0.155
Observations	1643	1649	1649	1649

Notes: Heteroskedasticity-robust standard errors in brackets. For further notes, see Table 2.

A Additional Results

Table A.1: Summary Statistics by Polio Status During the Epidemic

	(1) All	(2) Non-paralytic	(3) Paralytic
Hospital records			
Year of birth	1946.91	1946.29	1947.67
Age in 1952	5.06	5.65	4.26
Age <=4	0.53	0.45	0.64
Male child	0.58	0.59	0.57
Firstborn	0.48	0.49	0.45
> 2 children in family	0.35	0.37	0.32
Unskilled background	0.34	0.35	0.32
Capital resident	0.70	0.75	0.65
Death in hospital	0.03	0.00	0.07
Census data			
In Education, 1970	0.28	0.23	0.34
Worker, 1970	0.34	0.37	0.30
Brawn Track , 1970	0.37	0.40	0.32
White collar track, 1970	0.42	0.43	0.41
Assumed death after discharge, prior 1970	0.07	0.07	0.06
Administrative data			
Age at death, no hosp. mort.	53.63	54.62	52.39
Death by 50, no hosp. mort.	0.13	0.13	0.13
Death by 60, no hosp. mort.	0.21	0.20	0.22
University Education	0.09	0.07	0.11
Basic Education	0.28	0.29	0.26
Years of Education	12.26	12.11	12.45
Disability Insurance	0.16	0.13	0.20
Employed	0.67	0.68	0.65
Wage Earnings (yearly in DKK)	237,005	239,019	234270
Blue-collar Occupation	0.28	0.30	0.24
N	1,649	913	736

Notes: The sample includes children admitted with polio to the Blegdam hospital. We limit to children aged 0-14 in 1952 and residing in the Copenhagen medical district. The characteristics in Administrative data are measured at age 50 unless otherwise specified.

Table A.2: Comparison of Raw Hospital Records and Aggregate Statisticcs for Copenhagen Medical District

	Hospital records	Aggregate data	Share covered
Paralytic cases, age 0-14	803	897	0.895
Paralytic deaths, age 0-14	54	50	1.080
Paralytic cases, all ages	1,122	1,280	0.877
Non-paralytic cases, all ages	1,356	1,619	0.838

Notes: Own calculations based on all Blegdam hospital records (including individuals with missing data on covariates, who are omitted from our main analyses) and Hamtoft (1953, 1955) for aggregate data on the capital and the surrounding Copenhagen medical district. We compare case numbers and deaths during the 1952 epidemic in two age groups.

Table A.3: Occupational Status and Skill Requirements. Administrative Data, Age 50

	A. Indicators as in Autor, Levy, Murnane (2003)				
	(1) Non-rout.cog: Analytical	(2) Non-rout.cog: Interpersonal	(3) Routine cognitive	(4) Routine manual	(5) Non-rout. manual physical
Paralytic polio	0.060	-0.049	0.070	-0.107	-0.171
	[0.048]	[0.048]	[0.047]	[0.046]	[0.048]
Unskilled background	-0.335	-0.253	0.072	0.239	0.215
	[0.049]	[0.050]	[0.049]	[0.047]	[0.050]
Mean, dept. var.	-0.143	0.104	0.086	-0.130	-0.202
Observations	1,214	1,214	1,214	1,214	1,214
	B. Indicators as in Deming (2017)				
	(1) Non-rout. Analytical	(2) Social perceptiven.	(3) Routine	(4) Service	
Paralytic polio	0.135	0.118	0.234	-0.090	
	[0.068]	[0.092]	[0.089]	[0.074]	
Unskilled background	-0.282	-0.556	0.141	-0.235	
	[0.071]	[0.095]	[0.092]	[0.076]	
Mean, dept. var.	3.863	4.475	4.648	5.202	
Observations	1,214	1,214	1,213	1,214	

Notes: Heteroskedasticity-robust standard errors in brackets. Same sample of polio-survivors with a registered occupation in any of the 5 years around age 50 as in Table 2. Panel A replicates the skill measures from Autor et al. (2003), updated for O*NET in Acemoglu and Autor (2011). Panel B replicates the skill measures from Deming (2018).

Table A.4: Effect of Paralytic Polio on Likelihood of Missing from Outcome Data by Age; excl. In-Hospital Mortality

	(1) No merge 1970	(2) Death by 45	(3) Death by 50	(4) Death by 60
Paralytic polio	-0.0135	-0.00580	-0.00185	0.0326
	[0.0132]	[0.0164]	[0.0180]	[0.0215]
Unskilled background	0.00368	0.0170	0.0205	0.0554
	[0.0135]	[0.0168]	[0.0184]	[0.0219]
Mean, dept. var.	0.0663	0.108	0.132	0.209
Observations	1599	1599	1599	1599

Notes: Robust standard errors in brackets. The sample includes all children admitted with non-paralytic or paralytic polio in 1952, except for the 50 paralytic polio patients for whom we observe an in-hospital death in the data. No merge to the 1970 Census (column 1) is interpreted conservatively as death by 1970. Columns 2-4 draw on information from the merge to the census and the administrative data (post 1980), as well as the death register starting in 1973. For further notes, see Table 2.

Table A.5: Age 50 Outcomes, Bounding Exercise. Administrative Data

	(1) Univ.Edu	(2) Employed	(3) Disab.Ins.	(4) Blue-collar Occ	(5) Wage Earnings
A. Baseline Results					
Paralytic polio	0.0317	-0.0466	0.0791	-0.0546	-3863.0
	[0.0155]	[0.0268]	[0.0204]	[0.0259]	[12792.2]
B. Impute Outcomes of Deceased as Least Favorable					
Paralytic polio	0.0220	-0.0899	0.129	0.0335	-21837.4
	[0.0136]	[0.0257]	[0.0230]	[0.0251]	[11738.0]
Mean, dept. var.	0.0765	0.568	0.277	0.456	200834.2
Observations	1635	1649	1649	1649	1625
C. Impute Outcomes of Deceased as Most Favorable					
Paralytic polio	0.0974	-0.0116	0.0547	-0.0704	14230.3
	[0.0206]	[0.0234]	[0.0177]	[0.0205]	[11512.4]
Mean, dept. var.	0.204	0.718	0.136	0.209	270210.2
Observations	1635	1649	1649	1649	1625

Notes: Robust standard errors in brackets. For further notes, see Table 2.

Table A.6: Skill Outcomes at Age 50, Bounding Exercise. Administrative Data

	A. Baseline Results				
	(1) Cognitive	(2) Brawn	(3) Spatial/Vision	(4) Dexterity	(5) Computer Work
Paralytic polio	0.980	-7.949	-6.873	-4.408	5.609
	[1.704]	[1.648]	[1.607]	[1.702]	[1.710]

	B. Impute Outcomes of Deceased as Least Favorable				
	(1) Cognitive	(2) Brawn	(3) Spatial/Vision	(4) Dexterity	(5) Computer Work
Paralytic polio	-2.656	-9.574	-8.914	-6.918	1.183
	[1.659]	[1.513]	[1.517]	[1.588]	[1.676]
Mean, dept. var.	46.03	37.45	39.12	39.54	47.59
Observations	1510	1510	1510	1510	1510

	C. Impute Outcomes of Deceased as Most Favorable				
	(1) Cognitive	(2) Brawn	(3) Spatial/Vision	(4) Dexterity	(5) Computer Work
Paralytic polio	4.023	-2.895	-2.235	-0.239	7.862
	[1.595]	[1.661]	[1.617]	[1.662]	[1.580]
Mean, dept. var.	59.01	50.43	52.10	52.52	60.57
Observations	1510	1510	1510	1510	1510

Notes: Robust standard errors in brackets. Imputing outcomes for all deceased as if they are working, at occupations that have skill requirements at the 10th or 90th percentile, respectively. For further notes, see Table 2.

B Factor Analysis for Occupational Descriptors

The administrative registers record occupations at a very detailed 6-digit level. We link these Danish codes to ISCO-88 4-digit codes. To characterize these almost 800 occupations succinctly and meaningfully, we use their task requirements in a range of domains. Drawing on O*NET, a database containing detailed occupational descriptors and skill requirements, we express each occupation's intensity in specific inputs.

O*NET, the Occupational Information Network, https://www.onetcenter.org was developed under the sponsorship of the US Dep. of Labor/Employment and Training Administration. It draws on information from the US labor market. Nevertheless, researchers apply it in other settings as well, since the work requirements are comparable in highly developed western countries, including Denmark. We draw on the following crosswalks to merge the ISCO-88 codes to O*NET's classification: The International Labor Organization (developer of ISCO codes) provides a crosswalk `http://www.ilo.org/public/english/bureau/stat/isco/isco08/` from ISCO-88 to ISCO-08, and the US Bureau of Labor Statistics offers a crosswalk `www.bls.gov/soc/ISCO_SOC_Crosswalk.xls` from ISCO-08 to SOC 2010 (Standard Occupational Classification), which leads to the O*NET classification through O*NET's own crosswalk. `http://www.onetcenter.org/taxonomy/2010/soc.html/2010_to_SOC_Crosswalk.xls`

We focus on O*NET's descriptions of worker abilities (part of worker characteristics), which are described as "enduring attributes of the individual that influence performance." O*NET lists the required *level* of a skill that is needed or required to perform the occupation, and its *importance*, on 52 abilities that cover cognitive as well as sensory, psychomotor, and physical abilities. We aggregate the descriptors in O*NET with confirmatory factor analysis on the level ratings, using the full Danish population of the birth cohorts in our analysis when they are 50 years old.

The occupational descriptors are produced with the following procedure:

1. Obtain the Danish population sample of 50-year-olds from the birth cohorts in our analysis sample, keep their Danish occupation codes. This sample will be used twice.

2. Generate a crosswalk from Danish occupation codes in the administrative registers to O*NET codes.

   (a) Connect Danish occupation codes to ISCO-88.

      i. The administrative registers record occupations at a very high level of aggregation (6-digit ISCO codes, Danish '88 version).

      ii. Use the first 4 digits of the Danish codes to use the higher level of aggregation in ISCO-88 4-digit codes. While the vast majority of all Danish 4-digit codes correspond exactly to ISCO-88, the Danish version contains some higher-order aggregation (3-digit codes) that do not have an official correspondence to ISCO-88 (14%).[18] To attribute an ISCO-88 to these occupations, we determine the most frequent 4-digit occupation that occurs in the population within the same 3-digit code. Merge the popuplation sample to the official ISCO-88 list to identify non-matches. Then tabulate the frequency to obtain the mode of 4-digit codes, and link the Danish 3-digit occupation to this empirical mode within the 3-digit group.

      iii. After attributing ISCO-88 codes to all Danish codes, collapse data on Danish code and ISCO-88 level to keep only the crosswalk.

   (b) Connect ISCO-88 to ISCO-08 (from 2008, more recent than ISCO-88). The International Labor Organization (developer of ISCO codes) provides a crosswalk[19] from ISCO-88 to

[18] An example is Danish code 2110, "Work within physics, chemistry, astronomy, meteorology, geology, and geophysics,", where ISCO-88 lists 2111 "physicists and astronomers," 2112 "meteorologists," 2113 "Chemists," etc. Those lower-order categories also exist in the Danish classification.

[19] `http://www.ilo.org/public/english/bureau/stat/isco/isco08/`

ISCO-08.

(c) Connect ISCO-08 to SOC 2010. The US Bureau of Labor Statistics offers a crosswalk[20] from ISCO-08 to SOC 2010 (Standard Occupational Classification)

(d) Connect to the O*NET classification through O*NET's own crosswalk.[21]

3. Read in the ability measures (levels) from O*NET (The Occupational Information Network, https://www.onetcenter.org)

4. Use the population sample to obtain a population distribution of O*NET measures, by merging the crosswalk to the population, then merging to the O*NET ability measures.

5. Perform exploratory factor analysis on the entire set of ability measures. We performed initial analyses on levels and importance measures either separately or jointly, and on the products of these two within type (example: one entry is given by the product of "Stamina, level" times "Stamina, importance"). Determine the number of factors to retain, with rules-of-thumb from scree plots and eigenvalues. Ultimately decided on using the levels only, and using a four-factor structure.

6. For the set of levels of all measures given by O*NET for abilities, retain 4 factors. Rotate the loadings obliquely using the promax rotation. We report the rotated factor loadings in Table B.1.

7. Predict scores on these factors, and collapse the data by occupation codes.

8. Merge the skill scores to the polio sample's occupations via the Danish occupation codes.

[20] www.bls.gov/soc/ISCO_SOC_Crosswalk.xls

[21] http://www.onetcenter.org/taxonomy/2010/soc.html/2010_to_SOC_Crosswalk.xls

Table B.1: Factor Loadings

	Cognitive	Brawn	Spatial/Vision	Dexterity
Oral Comprehension	0.867	-0.095	-0.142	-0.110
Written Comprehension	0.823	-0.232	-0.107	-0.066
Oral Expression	0.866	-0.078	-0.107	-0.195
Written Expression	0.808	-0.187	-0.064	-0.199
Fluency of Ideas	0.922	0.067	-0.094	-0.164
Originality	0.909	0.124	-0.078	-0.241
Problem Sensitivity	1.008	0.165	-0.121	-0.025
Deductive Reasoning	0.944	-0.051	-0.062	-0.042
Inductive Reasoning	0.965	0.030	-0.130	0.022
Information Ordering	0.922	-0.144	0.030	0.106
Category Flexibility	0.893	-0.138	-0.119	0.150
Mathematical Reasoning	0.814	-0.183	0.074	-0.010
Number Facility	0.800	-0.152	0.059	0.027
Memorization	0.860	-0.021	-0.027	-0.192
Speed of Closure	0.928	-0.045	0.109	0.022
Flexibility of Closure	0.872	-0.072	0.081	0.346
Perceptual Speed	0.663	-0.153	0.250	0.504
Spatial Orientation	-0.056	-0.005	1.005	-0.067
Visualization	0.581	0.115	0.232	0.419
Selective Attention	0.787	0.002	0.280	0.241
Time Sharing	0.802	0.322	0.292	-0.251
Arm-Hand Steadiness	-0.132	0.375	-0.072	0.715
Manual Dexterity	-0.282	0.241	0.036	0.704
Finger Dexterity	0.017	0.022	-0.101	0.977
Control Precision	-0.124	0.020	0.288	0.748
Multilimb Coordination	-0.157	0.419	0.243	0.435
Response Orientation	-0.032	0.249	0.470	0.408
Rate Control	-0.160	0.020	0.618	0.407
Reaction Time	-0.003	0.199	0.493	0.421
Wrist-Finger Speed	-0.352	-0.090	0.262	0.689
Speed of Limb Movement	-0.248	0.551	0.370	0.077
Static Strength	-0.179	0.649	0.177	0.224
Explosive Strength	0.282	0.649	-0.004	0.097
Dynamic Strength	-0.237	0.611	0.184	0.226
Trunk Strength	-0.150	0.860	0.049	0.010
Stamina	-0.190	0.814	0.111	0.041
Extent Flexibility	-0.308	0.646	0.022	0.263
Dynamic Flexibility	-0.477	0.395	0.153	0.052
Gross Body Coordination	-0.169	0.780	0.124	0.107
Gross Body Equilibrium	-0.041	0.680	0.234	0.141
Near Vision	0.650	-0.487	-0.119	0.419
Far Vision	0.633	0.252	0.423	-0.099
Visual Color Discrimination	0.428	0.288	0.065	0.577
Night Vision	-0.084	-0.094	1.085	-0.074
Peripheral Vision	-0.092	-0.047	1.097	-0.141
Depth Perception	0.049	0.221	0.454	0.420
Glare Sensitivity	-0.159	-0.045	0.976	0.003
Hearing Sensitivity	0.403	0.251	0.400	0.343
Auditory Attention	0.298	0.317	0.423	0.266
Sound Localization	-0.015	-0.018	1.034	-0.088
Speech Recognition	0.707	-0.091	-0.191	-0.280
Speech Clarity	0.781	0.003	-0.074	-0.401

Note: The factor loadings shown are rotated with an oblique promax rotation at power 3.