Under the Weather:
Health, Schooling, and Socioeconomic Consequences of Early-Life Rainfall

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July 2006

Abstract

How sensitive is long-run individual well-being to environmental conditions early in life? This paper examines the effect of weather conditions around the time of birth on the health, education, and socioeconomic outcomes of Indonesian adults born between 1953 and 1974. We link historical rainfall for each individual's birth-year and birth-location with current adult outcomes from the 2000 wave of the Indonesia Family Life Survey. Higher early-life rainfall has large positive effects on the adult outcomes of women, but not of men. Women with 20% higher rainfall in their year and location of birth attain 0.14 centimeters greater height, finish 0.15 more years of schooling, live in households with 5.2% higher expenditures per capita, and have spouses with 5.1% higher earnings. These patterns most plausibly reflect a positive impact of rainfall on agricultural output, leading to higher household incomes and better health for infant girls. We present suggestive evidence that eventual benefits for adult women's socioeconomic status are mediated by improved schooling attainment, which leads to higher spousal quality, which in turn improves socioeconomic status.

Keywords: health, human capital, education, schooling, climate, Indonesia
JEL codes: I12, I21, J13, O12, O15, Q54

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1 Introduction

Life in rural areas of developing countries is prone to many kinds of risk, such as illness or mortality of household members, crop or other income loss due to natural phenomena (weather, insect infestations, or fire, for example), and civil conflict. Negative shocks certainly create large short-run welfare losses,[1] and motivate various government interventions to help cushion their immediate impacts. In addition to their contemporaneous effects, the effects of certain types of shocks may still be felt many years or even decades later. From a public policy standpoint, it is particularly important to identify shocks that also have large long-run effects. Moreover, the mechanics underlying shocks' persistence may be of considerable economic interest. For example, a health shock may have a long-run effect simply because the health shock itself persists over time. Alternately, the health shock may not directly affect long-run outcomes, but it could in turn affect some other outcome—such as educational investment, marital status, or spousal quality—that helps determine long-run well-being.

In this paper, we focus on shocks that occur at the very beginning of life. We ask how sensitive long-run individual well-being is to environmental conditions around the time of birth. In particular, we examine the effect of weather shocks around the time of birth on the adult health, education, and socioeconomic outcomes of Indonesian women and men born between 1953 and 1974. In addition, we attempt to shed light on the intervening pathways connecting early-life rainfall to adult outcomes, illuminating the roles of health, educational attainment, and spousal quality in determining adult socioeconomic status.

The data requirements in conducting such an investigation are considerable. One requires information on weather shocks experienced by individuals several decades before, as well as detailed information on adult outcomes in the present day. We use information in the Indonesia Family Life Survey on an individual's year and location of birth, and link each individual in that survey to the location-specific rainfall data for their birth year. For individuals born in rural areas (on whom we focus), rainfall variation across space and time should generate corresponding variation in agricultural output and thus household income. While we cannot directly observe *historical* variation in crop yields and household income, existing evidence indicates that local rainfall in Indonesia positively covaries with rice output in the 1990s. If anything, the relationship between rainfall and agricultural output is likely to have been stronger in prior decades, when irrigation

[1] For example, Jensen (2000) and Hoddinott and Kinsey (2004) find negative effects of weather variation on child health in Africa.

was less widespread and thus output was more dependent on contemporaneous rainfall.

We examine the impact of early-life rainfall on a range of adult outcomes (observed in 2000), including indices of health and socioeconomic status that each combine several individual measures. We find that higher early-life rainfall leads to improved health, schooling, spousal quality, and socioeconomic status for women. Women with 20% higher rainfall in their year and location of birth attain 0.14 centimeters greater height, finish 0.15 more years of schooling, live in households with 5.2% higher expenditures per capita, and have spouses with 5.1% higher earnings. Figures 1 through 5 present the nonparametric relationships between early-life rainfall (on horizontal axes) and several outcomes for adult women (on vertical axes): a health index, years of schooling, a household socioeconomic status index, spousal years of schooling, and spousal log earnings. In all these graphs, the positive relationships are quite apparent. By contrast, for the most part we do not find relationships between early-life rainfall and adult men's outcomes. This latter result is consistent with other research that finds that girls suffer more than boys from negative shocks, in Indonesia and elsewhere.

We provide suggestive evidence on the intermediate pathways connecting early-life rainfall to adult socioeconomic status. Compared with rainfall in the birth year itself, rainfall variation in the years after the birth year has a substantially weaker relationship with adult outcomes. So it is most plausible that the initial, direct effect of rainfall is on girls' health in infancy (rather than a lagged effect on, say, school entry). Consistent with epidemiological evidence, the strong relationship we find between birth year rainfall and adult height also suggests that nutrition in infancy varies with early-life rainfall. It is likely that rainfall's effects on crop output—and thus household income—lead to variations in parents' abilities to purchase nutrition, medical inputs, and generally more nurturing environments for infant girls.

We also provide other regression-based evidence that helps compare the importance of various subsequent pathways (health, education, spousal quality) leading to adult socioeconomic status. Our evidence suggests a chain of causation that runs from early-life rainfall to infant health, to educational attainment, to spousal quality, and finally to adult socioeconomic status. We do not find evidence that adult women's health status and education levels matter directly for adult socioeconomic status, apart from indirect effects via spousal quality.

This paper is related broadly to a large body of research stressing the link between early-life conditions and later outcomes,[2] and in particular to research on 'critical-period programming.'

[2] Research using U.S. data includes Case, Lubotsky and Paxson (2002), Doblhammer (2002), Currie and Hyson (2003), Case, Fertig and Paxson (2004), Johnson and Schoeni (2005), and Currie and Moretti (2005), while

This is the notion that the fetal stage and infancy are critical periods in physical development, and that early-life shocks can have long-lasting effects on health. When facing low nutrition or other adverse health conditions, the developing fetus or infant prioritizes the brain to receive limited resources, compromising the development of other organ systems. The damage is to some extent irreversible, and the individual is thus 'programmed' for worse health later in life. However, epidemiological research marshalled in support of the hypothesis mostly consists of correlations between early and late health conditions (at the level of the individual or locality), so that such studies are open to concerns about omitted variables such as socioeconomic status.[3] Our paper provides evidence of critical-period programming: the effect of rainfall in the year of birth on adult height and other health measures (and the lack of an effect of rainfall in subsequent years) strongly suggests that infant health is the primary causal channel.

This paper is also related to other research on the impact of exogenous conditions in early life on adult outcomes. Almond (2003) finds that U.S. cohorts who were in utero during the height of the 1918 influenza pandemic fared worse as they aged than cohorts born just before and after the pandemic in terms of educational attainment, physical disability, socioeconomic status and mortality. Almond and Chay (2003) find that improvements in early-life conditions for U.S. black women born in the late 1960s led to better health in adulthood and to a lower incidence of low birth weight among these women's own children. Behrman and Rosenzweig (2004) exploit differences in intrauterine nutrient intake between monozygotic female twins, also using U.S. data. They find that fetal growth is associated with greater schooling attainment and height, but does not lead to increased BMI. Royer (2005) documents long-run and intergenerational effects of birthweight differences between twins. Lindeboom, Van den Berg, and Portrait (2005) show that poor macroeconomic conditions in early life reduce longevity in the Netherlands. Alderman, Hoddinott, and Kinsey (2005) find that rainfall shocks and exposure to war affect early-life nutrition and thereafter height and schooling levels of young adults in Zimbabwe.

This paper is organized as follows. Section 2 discusses conceptual issues in interpreting long-run effects of early-life rainfall. Section 3 reviews the evidence on the impact of rainfall on agricultural output in Indonesia. Section 4 describes the datasets we use and provides some descriptive statistics. Section 5 presents the empirical results, as well as some extensions and analyses of selection issues. Section 6 discusses the likely pathways linking early-life rainfall with adult socioeconomic status, the magnitude of the effects, and potential policy implications.

Doblhammer and Vaupel (2001) use European data.

[3]See, for example, critiques in Rasmussen (2001) and Lancet (2001).

Section 7 concludes.

2 Conceptual issues in identifying long-run effects of early-life conditions

Starting with Grossman (1972), health production functions typically consider individual health at time t, H_t to be a function of an initial health endowment K_0 as well as the history of health inputs N_0, N_1,..., N_t. Other health determinants of importance include time-invariant demographic variables X (such as gender and age), and the time histories of community infrastructure C_0, C_1,..., C_t and the disease environment D_0, D_1,..., D_t.

$$H_t = h\left(K_0, N_0, N_1, ..., N_t, X, C_0, C_1, ..., C_t, D_0, D_1, ..., D_t\right)$$

The initial health endowment K_0 is in part determined by genetic characteristics determined at conception G, but in addition environmental conditions experienced in early life R_0 may also have persistent effects on health. From the standpoint of an adult, the component of one's long-run health status that is determined early in life is for practical purposes also part of one's initial health endowment.

$$K_0 = k\left(G, R_0\right)$$

The idea that environmental conditions in a certain sensitive period of life may have long-run, irreversible effects is known in biology as "critical-period programming."[4] For example, animal studies have documented that in pigs and rats that nutritional deprivation in the period immediately after birth permanently reduces body size in adulthood, while the effect of nutritional deprivation in later periods is much more muted (see studies cited in Barker 1998). Several studies by Japanese physiologists have shown that the ambient temperature to which human beings are exposed in early years has lasting effects on a person's tolerance for heat, via effects on the lifetime number of active sweat glands (see Diamond 1991 for an overview of studies.)

Our focus in this paper is on this component of individuals' initial health endowment that is determined by environmental conditions in early life. In particular, our results identify the reduced-form relationship between early-life rainfall shocks – an important environmental con-

[4] The term "fetal origins hypothesis" has been used to refer to programming caused by conditions experienced in the fetal stage (e.g., Barker 1998), but in practice the term is often taken to include effects of conditions experienced in infancy and early childhood.

dition for rural households in developing countries – and later-life health and socioeconomic outcomes.

A brief word is also in order regarding the likely direction of any selection bias in this context. We review in section 3 below the evidence that higher rainfall should be interpreted as a positive shock to an Indonesian locality, leading to higher local-level crop output. An individual can only be included in the survey dataset we use, the 2000 wave of the Indonesia Family Life Survey, if they are still living in that year. A potential worry is that early-life rainfall could affect the likelihood of survival through 2000, and that, in addition, those whose survival was induced by rainfall could have different initial characteristics from the overall population of births in a locality in a particular year. In other words, rainfall variation could induce sample selectivity, biasing our regression estimates. As it turns out, selection is likely to bias results against finding positive long-run effects of rainfall on adult outcomes.

To be concrete, suppose that rainfall has its first direct effect on individuals via their infant health: all long-run effects on individuals will stem from this initial health effect (we argue later that this paper's results are most plausibly interpreted in this manner). From the wide range of possible long-run outcomes one could examine, focus for now on *health status in adulthood* (and assume this can be measured perfectly).

Denote by h_i the unobserved health of person i in infancy, where higher values of h_i represent better health. The solid line in Figure 6 displays the probability distribution of h_i, $f(h_i)$. The vertical line at s is a survival threshold: individuals with health below this threshold do not survive to be surveyed in the year 2000, while those with health above this threshold do survive.

Suppose that intertemporal health linkages exist, so that better infant health leads to better adult health. The vertical line at g is the initial health threshold above which individuals have 'good' health in adulthood. So all individuals with health above s do survive to be surveyed as adults, but only those with initial health above g have good health in adulthood.

If $F(h_i)$ is the cumulative distribution function, then the fraction of surveyed adults in good health, θ, is:

$$\theta = \frac{1 - F(g)}{1 - F(s)}$$

It makes sense to think of two effects of rainfall in this context. First, rainfall affects the underlying distribution of infant health. Second, rainfall affects the health threshold that infants must surpass if they are to survive through the year 2000 (a selection effect).

The first effect is a shift of the probability distribution of initial health, $f(h_i)$. Higher rainfall

R leads to higher household incomes and thus improved infant health, shifting the probability distribution rightward (for example, to the new, dashed distribution in the figure). This should lead to an increase in the fraction of adults in good health, θ:

$$\frac{\partial \theta}{\partial R} > 0.$$

The second effect is a shift in the survival threshold s. Higher rainfall leads to higher incomes and thereby a decline in the survival threshold to something like s' (to the left of s) as more vulnerable infants are kept alive. By itself, this selection effect should lead to a *decrease* in the fraction θ of adults in good health:

$$\frac{\partial \theta}{\partial R} < 0.$$

The second effect offsets the first effect somewhat, as more infants in poor initial health survive to adulthood. Therefore, for us to observe that higher early-life rainfall is associated with better health in later life (higher θ), improvements in the distribution of initial health (the first effect) must overwhelm the second (selection) effect. If we do find that early-life rainfall is positively associated with later-life health (and other adult outcomes), then the existence of any selection effect leads these effects to be lower bounds of the true causal effects.

3 Rainfall and agricultural output in Indonesia

As the focus of the empirical analysis will be on the impact of early-life rainfall on adult outcomes, it is important to establish at the outset whether higher rainfall is on net positive or negative for households *contemporaneously* (around the same time the rainfall occurs, or soon thereafter).

Rainfall is the most important dimension of weather variation in Indonesia; the country's location astride the equator means that temperature shows very little variation, either within years or across them (Library of Congress, 2003). In any particular year, the length of the wet season and the intensity of drought during the dry season vary markedly across Indonesia, and sometimes within small geographic units. The specific trajectories of the monsoons vary from one year to the next, and combined with differences in local topography lead to wide variation in precipitation across the archipelago both within year and across years (Library of Congress 2003). This variety within Indonesia is perhaps not surprising, given that the country's 13,700 islands span 5,100 kilometers from east to west and cross three time zones.

Indonesia's climate typically consists simply of one wet season and one dry season each year.

The distinguishing feature of the wet season is that at least 200 mm of rain falls per month.[5] The specific months of the wet and dry season vary across Indonesian provinces.

Secondary reports indicate that higher rainfall raises agricultural productivity in Indonesia.[6] Rice production in both the wet and dry seasons is particularly dependent on the timing of the monsoon. On a regular (though largely unpredictable) basis, there is a pronounced drought in the dry season driven by the El Niño weather phenomenon. For example, there were 10 long or short droughts (large-scale crop failure) between 1921 and 1954. The timing of planting during the primary (wet) season is based on reaching a threshold of accumulated rainfall. Generally, when planting is delayed, the season's crop yields are reduced. Delays in the onset of the monsoons in the wet season, as well as ongoing dry spells during that season lead to reduced wet season harvests. Secondary crop harvests may be reduced as well during the following dry season because of the delay in harvesting in the previous wet season (e.g. the 1997-1998 El Niño event). On the other hand, in La Niña years (when rainfall is unusually high), the planting season may begin early and yield above average harvests.

Because of the importance of the seasonal cycle of rain, food security also tends to vary seasonally. Food insecurity tends to the highest at the end of the dry season and beginning of the following wet season when stocks of food from the previous wet season are low and physical demands are high with the initiation of planting (Herdt, 1989). Accordingly, dry season droughts amplify food scarcity.

Primary empirical analysis also supports the idea that higher rainfall levels are good for agricultural output in Indonesian districts. Levine and Yang (2006) find that positive deviations of rainfall from the district-level mean lead to higher rice output in Indonesian districts during the 1990s. Statistically significant effects of rainfall only appear in districts that are not major cities (non-*kotamadya*). In addition, the impact of rainfall on rice output occurs contemporaneously (in the same calendar year), rather than with a lag.

The results in Levine and Yang (2006) have two direct implications for the individual-level empirical analyses in this paper. First, because rainfall appears to affect rice output only outside of major cities, the individual-level analysis will focus solely on individuals born in districts that are not major cities.

Second, from now on we will interpret higher current rainfall as "good" for households during

[5] This definition is based on the minimum threshold necessary for rice production and takes into account evaporation and seepage through the soil (Kishore et al., 2000).

[6] The discussion in this paragraph is drawn from Kishore et al.(2000).

the 1953-1974 period. While the Levine and Yang (2006) results are only for the 1990s, the relationship between rainfall and agricultural output should have been stronger in prior decades, when irrigation was less widespread and thus output was more dependent on contemporaneous rainfall.[7] Of course, we cannot rule out that there may be other channels linking rainfall to child nutrition and health.[8] Indeed, some of these channels may imply a *negative* impact of rainfall that would somewhat offset any positive effects via improved crop output.

4 Data sources and sample composition

4.1 IFLS data

The sample for our primary analyses consists of 4,452 women and 3,894 men born outside of major cities between 1953 and 1974 from the third wave of the Indonesia Family Life Survey (IFLS3), which was fielded in 2000. We restrict the sample to those born outside of major cities because our causal factor of interest, rainfall, should mainly have an effect in more rural areas dependent on agriculture.[9] In 1993, the IFLS began tracking more than 7,000 households living in one of 13 provinces representative of 83% of the Indonesian population.[10] Slightly more than half of the sample included in our analyses was born in either Western, Central, or Eastern Java (each of these provinces representing 17-20% of the sample). The remainder were born in roughly equal proportions in the remaining provinces included in the IFLS: North Sumatra, West Sumatra, South Sumatra, Lampung, Yogyakarta, South Kalimantan, Bali, West Nusa Tenggara, and South Sulawesi.[11] Individuals born in Jakarta are not included because we exclude those born in major cities.

The IFLS includes detailed information on district (*kabupaten*) of birth, to which we link historical rainfall data. The women in our sample were born in 173 different districts, and the

[7] Large-scale investment in irrigation in Indonesia did not begin until 1969-1970 (near the end of our sample of birth years) with the government's first five-year development plan (Helmi 2000).

[8] The allotment of parents' time—between agricultural work and child-rearing, for example—may also be a function of precipitation. Or, unusual rainfall might alter the disease environment, and disease directly affects the absorption of nutrition particularly in the vulnerable early years of rapid growth. Fluctuations in precipitation may influence other environmental conditions correlated with economic activity and public health, such as the extent of forest fires, floods and landslides, the availability of potable water, and agricultural pest control.

[9] We take the definition of major cities (*kotamadya*) used by the Indonesian statistical agency (BPS). Slightly more than three-quarters of women and men in the IFLS report being born in a district that is not a major city.

[10] The third wave includes 6,661 of the original 7,224 households interviewed in 1993 as well as an additional 3,774 "split-off" households containing 1993 IFLS1 household members no longer living within the origin household.

[11] A small number of individuals born outside the main IFLS survey provinces but residing there at the time of the survey (23 women and 26 men) are also included. Because of their small numbers, conducting the empirical analyses without these movers has essentially no effect on the coefficient estimates.

men in 175 districts.[12] We also make use of information on the month of birth to more precisely identify rainfall in the climatic season during which the person was born. The IFLS3 includes a variety of health variables, ranging from clinical measures to more subjective self-reported measures. Trained nurses collected lung capacity readings and anthropometric measures. For specific variable definitions, see the Data Appendix.

Table 1 reports selected summary statistics for the female and male samples. A health index constructed from five individual health measures has mean zero and standard deviation of 1.2 for women and 1.4 for men.[13] The separate individual health measures are listed in the next five rows of the table. 8% and 9% of women and men respectively self-report that their health is "very good", and slighly higher proportions self-report "poor" or "very poor" health status. Other measures include the natural log of lung capacity, height in centimeters, and days absent due to illness in the last four weeks. Mean height is 150.4 centimeters for women and 161.9 for men (4.9 feet and 5.3 feet, respectively).[14]

The next set of variables relates to educational human capital. Women and men average 6.2 and 7.5 years of schooling, respectively. Higher proportions of men than women report ability to read in Indonesian or other languages, and ability to write a letter in Indonesian or other languages. We also construct an index of educational human capital from the five separate education variables.

Mean per capita monthly household expenditures are roughly US$60 in both the female and male samples. This is consistent with a per capita annual income of US$728 in 2000 (World Bank, 2004). The value of assets per capita is 10-12 times larger than monthly expenditures across the two samples. Televisions and stoves are owned by roughly 6 in 10, toilets by 4 in 10, and refrigerators by 1 in 4 households across both samples. A socioeconomic status index is constructed from the natural log of per capita household expenditures, the natural log of per capita household assets, and the four individual asset indicators.

Median age in both samples is 35 years, and the mean is similar. 87% of women and 90% of men are married. The rainfall variable, deviation of log rainfall in the year of birth from the log of district mean rainfall (described further below), has a mean of -0.03 and a standard deviation

[12] In both the female and male samples, 157 of these districts are in the main IFLS provinces.

[13] The health, educational human capital, and socioeconomic status indices are the first principal components of their associated individual variables in Table 1. Factor loadings are presented in the Appendix Tables.

[14] We choose to focus on these health measures because they are representative of a range of self-reported and objective health outcomes. At the same time, they have very few missing values, allowing us to construct the health index for nearly all individuals. The empirical results are very similar when looking at an expanded set of health outcomes available in the IFLS (but that have substantially more missing values), such as ease with several activities of daily living.

of 0.30 in both samples.

4.2 Rainfall data

We obtain historical rainfall data for weather stations across Indonesia from the Global Historical Climatology Network (GHCN) Precipitation and Temperature Data (Version 2).[15] The data include monthly records for each rainfall station as well as the latitude and longitude of the station's location. For each month between 1953 and 1974, we use the station location information to match each birth district represented in the IFLS to the closest rainfall station.

Although the IFLS includes Indonesians born across the 20th century, we limit our sample to the 1953-1974 birth cohort. We choose 1953 as the first cohort for data quality reasons: while the quality of the rainfall data appears acceptable in the 1920s and 1930s (in that birth districts in the IFLS sample are rarely very far away from the nearest rainfall station), the mean distance from districts to the closest rainfall station rises substantially for about a decade after 1941, presumably reflecting upheaval during and after World War II. We therefore focus on the subsamples born in the following two decades.[16] (Unfortunately, analysis of the 1920-1940 cohort is limited by very small samples.) The 1974 birth cohort is the last cohort in our analysis, so that the youngest women in the sample are 25 or 26 upon being observed in 2000. This is an appropriate end cohort, as most Indonesian women should have completed their schooling by their mid-20s.

In calculating "rainfall in one's year of birth", we focus on rainfall in complete wet and dry seasons (rather than in calendar years), as these should be most closely related to agricultural cycles. We start by defining the months included in the wet and dry seasons in each Indonesian province.[17] Depending on the province, the wet season starts anywhere from September to December, while the dry season can start as early as March and as late as June. For example, in the province of Central Java the wet season runs from October to April, and the dry season from May to September.

Then we identify the "birth season" for each individual in the dataset, based on their reported birth month and birth province. For people born in the last month of a particular season, we let

[15] These data are produced jointly by the National Climatic Data Center, Arizona State University, and Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory and are available at http://www.ncdc.noaa.gov/oa/climate/research/ghcn/ghcn.html. Because the number of rainfall stations varies over time, data from different rainfall stations may be linked to the same district over time.

[16] Across observations born between 1953 and 1974, the median distance between the district of birth and the rainfall station during the year of birth is only 14 km., and the 95th percentile is only 70 km. The maximum is about 230 km.

[17] To do this, we combine information from secondary reports on the extent of the rainy season (Kishore et al., 2000) with our own analysis of mean monthly rainfall across all weather stations within each province.

the following season be their birth season. Figure 7 helps explain the allocation of individuals to a "birth season," taking the example of individuals born in Central Java. We consider an individual's birth season to be the dry season if he or she was born between April (the month immediately prior to the start of the dry season) and August (the second-to-last month of the dry season) inclusive. We consider a individual to be born in the wet season if he or she is born between September (the month immediately prior to the wet season) and March (the second-to-last month of the wet season). The procedure is analogous for individuals born in different provinces, except that the wet and dry seasons may be defined differently.

Having defined individual birth seasons, we then define "rainfall in one's year of birth" to be the sum of rainfall in one's birth season and in the following season (total rainfall in the 12 consecutive months of an individual's first wet and dry seasons).

In analyses of the impact of birthyear rainfall on adult outcomes, we focus on the *deviation* of birthyear rainfall from the norm for one's birth district. Specifically, the variable is the natural log of birthyear rainfall minus the natural log of mean annual rainfall in the given district. Mean district rainfall for a particular individual is calculated over 1953-1999, but excludes rainfall in the individual's birthyear.

5 Empirical results

In examining the relationship between early-life rainfall and one's adult outcomes, we seek to isolate deviation of one's adult outcomes from the mean outcomes in one's birth locale, as well as the mean outcomes of one's national birth cohort. Because particular localities in Indonesia may be subject to slow-moving changes over long periods of time (reflecting, for example, different rates of economic development), it will also be useful to isolate variation in a person's outcomes that diverges from long-running trends in one's birth district.

We estimate the following reduced-form linear relationship between adult outcome Y_{ijst} of adult i born in district j, in season s and in year t:

$$Y_{ijst} = \beta R_{jt} + \mu_{js} + \gamma_{js} TREND + \delta_{st} + \varepsilon_{ijst} \quad (1)$$

The coefficient of interest is β, the impact of birthyear rainfall R_{jt} on the adult outcome. Because parents may time children to be born in particular seasons, and parents who time births in such a way may be different from those who do not,[18] we estimate separate fixed effects for individuals born in the wet and dry season of each district: μ_{js} is a fixed effect for individuals born in district j and season s (e.g., born in district A in wet season, born in district A in dry season, etc.) Similarly, we allow the cohort effects to differ across wet and dry seasons: δ_{st} is a fixed effect for the birthyear-season combination. $\gamma_{js}TREND$ is a linear time trend specific to the district-season, which absorbs long-running linear trends in the outcome that may vary depending on the district-season ($TREND$ is a linear time trend, and the coefficient γ_{js} allows the time trend to vary across district-seasons). ε_{ijst} is a mean-zero error term.

It should be clear that the inclusion of district-season fixed effects controls for persistent effects of rainfall on the localities (and households) in which children are born. Effects of rainfall shocks on long-run income of households should be common to all individuals born in the same area and so should be absorbed by the district-season fixed effects.

Serial and spatial correlation is likely to be a problem in this setting, biasing OLS standard error estimates downward (Moulton (1986), Bertrand, Duflo and Mullainathan (2004)). In particular, the concern is about correlation among the error terms of individuals experiencing the same or similar measured rainfall shocks. So standard errors allow for an arbitrary variance-covariance structure within birth provinces (standard errors are clustered by birth province).

When discussing magnitudes of the estimated effects, I will focus on the impact of a 0.2 log point change in the rainfall variable (deviation of log rainfall from the log of district mean rainfall). 0.2 is the standard deviation of the residual when the rainfall variable is regressed on the full set of fixed effects and district-season linear time trends in equation 1, and is smaller than the standard deviation of the unadjusted rainfall variable reported in Table 1 because it is purged of cross-district variation, over-time variation, and district-season-specific linear trends.

5.1 Effect on individual outcomes

Rainfall in one's birthyear and birth district has a positive relationship with a variety of health, educational, and socioeconomic status outcomes in adulthood. A graphical view of some of the key relationships is presented in three figures. Figure 1 examines the nonparametric relationship between early-life rainfall (on the horizontal axis) and the health index (on the vertical axis). Figures 2 and 3 are similar except that the variables on the vertical axes are years of schooling and

[18] Using African data, Artadi (2005) finds that parents time births across seasons in response to seasonality in economic conditions and disease prevalence.

the household socioeconomic status index, respectively.[19] In each figure, the positive relationship between early-life rainfall and the adult outcome is quite plain.

Table 2 presents regression results from estimation of equation 1 for a variety of health and educational human capital outcomes. For each outcome, the coefficient on birthyear rainfall is presented for women (first column) and men (second column). Standard errors are presented in parentheses, and the sample size of the regression is in brackets. For brevity, regression coefficients for the large number of fixed effects and the district-season linear time trends are not shown. (This format will be followed in the subsequent results Tables 3, 4, and 5).

In the female sample, birthyear rainfall has a positive impact on health and educational human capital across a range of outcomes. The coefficient on rainfall in the regression where the health index is the outcome variable is positive and statistically significant at the 1% level. Higher birthyear rainfall also covaries with the individual components of the health index in directions that indicate better health, leading to a higher propensity to report "very good" health status, a lower propensity to report "poor" or "very poor" health status, higher lung capacity, greater height in centimeters, and fewer days absent due to illness. The coefficients in three of these five individual health variables (height as well as both self-reported health variables) are statistically significantly different from zero at conventional levels.

For women, birthyear rainfall has a positive relationship with the educational human capital index as well as with each individual component of the index. The coefficient on rainfall in the regression for years of schooling is positive and statistically significant at the 5% level.

Corresponding results for Indonesian men born in the same time span are presented in the second column. In stark contrast, there is little indication that the adult health and educational human capital outcomes of males are affected by birthyear rainfall. Coefficients on the rainfall variables in all regressions are substantially smaller in magnitude than the corresponding coefficients in the female regressions, and none of the coefficients are statistically significantly different from zero. This finding is consistent with a gender bias model in which available resources first are given to boys in good as well as in bad times. In good times, leftover resources are invested in girls, but in bad times girls are shortchanged.

Our finding of a differential effect on girls is consistent with other work that finds that girls suffer more than boys from negative shocks (and benefit more from positive shocks), in Indonesia and elsewhere. Dreze and Sen (1989) cite several studies that find that households often prioritize

[19] The graphs use a nonparametric Fan local regression method with a quartic (biweight) kernel and a bandwidth of 0.2. Dotted lines depict bootstrapped 95% confidence intervals.

boys' welfare over girls' in times of unusual hardship. Behrman (1988) finds bias in favor of boys in the intrahousehold allocation of nutrition during the lean season in India. Rose (1999) finds that the gender bias in infant mortality in India (that typically favors boys over girls) narrows when districts experience higher rainfall. Alderman and Gertler (1997) find that demand for girls' medical care is more income- and price-elastic than demand for boys' medical care in rural Pakistani households. Duflo (2003) finds that receipt of an old-age pension in South African households (in particular, receipt by women) has a positive impact on weight-for-height and height-for-age for girls, but not for boys. Using Indonesian data, Cameron and Worswick (2001) find that, in response to crop loss, families with girls are more likely to reduce educational expenditures than do families with boys. Jayachandran (2006) finds that negative shocks to air quality in Indonesia have greater effect on female than on male infant mortality.[20]

In Table 3, we examine the impact of birthyear rainfall on adult socioeconomic status and labor force outcomes, as well as marriage. For women, birthyear rainfall has a positive and statistically significant relationship with the socioeconomic status index as well as each individual component of the index: natural log household expenditures per capita, natural log household assets per capita, and separate indicators for the ownership of a television, refrigerator, toilet with septic tank, and stove. Among labor force outcomes, birthyear rainfall has a positive impact on the natural log of annual earnings that is statistically significantly different from zero at the 10% level. The coefficients on rainfall in regressions for working and hours worked in the past year are all small in magnitude and are not statistically significantly different from zero. In addition, the coefficient on rainfall in the regression where the indicator for being married is the outcome variable is small in size and is not statistically significant.

Results for men in Table 3 indicate that birthyear rainfall has little long-run effect on socioeconomic status, labor force, or marriage outcomes. All coefficients are substantially smaller in magnitude than analogous female coefficients, and none are statistically significantly different from zero. The lack of effects for men is consistent with the findings in Table 2 of no effect on health or educational human capital outcomes.

How large are these estimated long-run effects of rainfall for women? A 0.2 log point increase in birthyear rainfall leads women to be 0.7 percentage points more likely to report being in very good health status, and 0.8 percentage points less likely to report poor or very poor health status (compared to base reporting propensities of 8 percent and 12 percent, respectively). Such an

[20] Levine and Ames (2003), on the other hand, offer a contrary view, finding that the 1998 Indonesian economic crisis did not have differential negative effects on girls.

increase in birthyear rainfall also leads to 0.14 centimeters greater height, 0.15 more years of schooling, 5.2 percent higher household expenditures per capita, and 11 percent higher household assets per capita. These effect sizes are therefore not extremely large, but neither are they negligible.

5.2 Effect on spousal outcomes

The results described in the previous section indicate that exogenous variation in birthyear rainfall has substantial socioeconomic effects. It is therefore sensible to ask whether women with better birthyear rainfall match with *spouses* who have better health, educational, and labor market outcomes. The key socioeconomic outcomes examined in the previous section (consumption and asset ownership) are at the household level, and are presumably highly influenced by the characteristics of male members of the household.

Tables 4 and 5 examine the impact of an individual's birthyear rainfall on the characteristics of his or her spouse, for the subsample of married women and men. Table 4 focuses on health outcomes (and is analogous to Table 2), while Table 5 displays labor force outcomes (analogous to the labor force outcomes section of Table 3).[21]

The most striking result in Table 4 is that women with higher birthyear rainfall marry men with more years of schooling on average. In the regression for spousal years of schooling the coefficient on birthyear rainfall is positive (0.780) and statistically significant at the 5% level. The coefficient is strikingly similar in magnitude to the coefficient on rainfall in the regression for women's own years of schooling in Table 2 (0.754). On the other hand, there is little relationship between birthyear rainfall and spousal health characteristics, the educational human capital index, and the various reading and writing literacy indicators.

Results in Table 5 indicate that the spouses of women with better birthyear rainfall have better labor market performance: the coefficient on natural log of spousal annual earnings is positive and statistically significant at the 10% level. This result could be because women with higher birthyear rainfall have greater ability to attract males with higher earning capacity on the marriage market, but it could also reflect complementarity between the characteristics of husbands and wives that could enhance male earnings.

In both Tables 4 and 5, there is little evidence of a relationship between male birthyear

[21] We do not display socioeconomic status outcomes for this subsample of married men and women, because these are household-level outcomes and are therefore identical across spouses. Results for socioeconomic outcomes for these married subsamples are very similar to the results for the full samples (including unmarried individuals) presented in Table 3.

rainfall and spousal outcomes, continuing the pattern seen in previous results tables. Coefficients are mostly closer to zero (and often opposite in sign) compared to the corresponding coefficients in the female regressions. A slight oddity is that the coefficients on birthyear rainfall in the male regressions for the health index and for spousal self-reported "very good" health status are negative and statistically significant at the 10% level. These results are inconsistent with all other coefficient estimates in the male regressions of Tables 2, 3, 4, and 5, and so may be simply due to sampling variation. We examine more than three dozen outcome variables across these tables, so it would not be surprising if a handful of coefficients were statistically significant purely by chance.

The magnitude of these impacts on spousal outcomes are comparable to the magnitudes found in Tables 2 and 3. A 0.2 log point increase in birthyear rainfall for women leads them to have spouses with 0.156 more years of education and 5.1 percent higher earnings.

5.3 Extensions

5.3.1 Effect of rainfall in years adjacent to birthyear

The regression results so far have focused on the relationship between rainfall in the birthyear and adult outcomes. To aid in interpreting these results, it is useful to examine the impact of rainfall in other years before and after the birthyear on adult outcomes, as well as to see whether the coefficient on birthyear rainfall changes substantially when rainfall variables for other years are added to the regression.

Regression results are reported in Table 6 for several key outcomes from previous tables: the health index, years of schooling, the socioeconomic status index, spousal years of schooling, and spousal ln(annual earnings).[22] Each regression includes annual rainfall variables from years -4 (four years prior to the birthyear) to 4 (four years after the birthyear), including birthyear rainfall (year 0). These variables are defined analogously to the birthyear rainfall variable as 12-month rainfall during complete wet and dry seasons.

Two facts stand out in these regression results. First, coefficients on birthyear rainfall (year 0) are not substantially different from the corresponding coefficients in Tables 2-5, and all remain statistically significantly different from zero.

Second, in each regression, coefficients on rainfall in adjacent years are all smaller in magnitude than the coefficient on birthyear rainfall, and in most cases substantially smaller. Across

[22] Results for all other outcomes are very similar but are not reported for brevity.

regressions, 38 out of 40 coefficients on rainfall in adjacent years are not statistically significantly different from zero. The exception is rainfall in years 1 and 2 in the spousal years of schooling regression, which are positive in sign and are statistically significant at the 10% level.

The finding that shocks in the birthyear are more important than shocks in other years concurs with public health data in Indonesia and elsewhere that shows substantially higher mortality in infancy than in early childhood. For example, in Indonesia in 1977-1987, out of 1,000 live births, 75.2 infants died before their first birthday, but only another 36.2 died in the subsequent four years prior to their 5th birthday (Central Bureau of Statistics 1989)—in other words, more than two-thirds of under-5 mortality is accounted for by mortality in the first year of life.

Shocks to household resources and infant nutrition in the birthyear have also been shown elsewhere to have long-run consequences. Children are particularly sensitive to nutritional shocks from 6-12 months of age because weaning from breastmilk typically occurs in that period (Adair and Guilkey 1997). Hoddinott and Kinsey (2001) find that droughts in rural Zimbabwe occurring between the ages of 0 and 12 months lead to reductions in child height when measured 12 months later.

In several ways, these results help sharpen the interpretation of the previous findings (in Tables 2-5). Tables 2-5 leave open the possibility that is it not rainfall in the birthyear *per se* that matters for adult outcomes. If rainfall is serially correlated over time, then it could be that rainfall in some year before or after the birthyear has the actual impact on adult outcomes. If so, the coefficients on birthyear rainfall regressions in Tables 2-5 might simply reflect the fact that other years' rainfall were not included in the regressions (an omitted variables problem).

The fact that coefficients on birthyear rainfall in Table 6 are essentially unchanged after inclusion in the regressions of rainfall in adjacent years indicates that birthyear rainfall matters in and of itself, and not simply because it may be correlated with other years' rainfall. The differential impact of rainfall in the birthyear is consistent with other research. First of all, Levine and Yang (2006) document that rainfall shocks lead to contemporaneous effects on rice output in Indonesian districts, but do not find evidence of lagged effects.

The lack of an effect of rainfall in the years prior to the birthyear provides no indication that shocks *in utero* are importantly influencing our results, in comparison to shocks experienced in infancy. Our birthyear rainfall is defined to potentially include a few months of rainfall prior to birth (as far back as the start of one's birth season), but because harvests typically occur at the end of seasons, birthyear rainfall is best thought of as affecting post-birth household income.

5.3.2 Checking for selection

As discussed in section 2 above, it is important to consider whether selection into our sample might confound the results. Ideally, our sample would be randomly selected from the Indonesian female population born between 1953 and 1974. In fact, our sample consists of women born during this time period who survived long enough to participate in the IFLS's third survey wave in 2000. Bias could result from selective mortality between birth and 2000.

To gain a sense of the role of selection in influencing our results, we test whether rainfall shocks affect the size of female and male birth cohorts who appear in our samples at the district-birthyear-season level. Specifically, we regress the number of individuals appearing in our IFLS subsample at the birthdistrict-birthyear-season level on the birthyear rainfall variable, separately for women and men. Because we are working with count data, we report results from Poisson regressions.[23] Comparably to our individual analyses, regressions include birthyear-season and district-season fixed effects, as well as district-season-specific linear time trends. To reduce the problem of birth districts entering the sample endogenously, we only include in this analysis districts that were enumeration areas of the initial wave of the IFLS in 1993.

Results are in Table 7 for women and men separately. Coefficients on birthyear rainfall for both women and men are not statistically significantly different from zero. Point estimates are actually negative in sign, which is the opposite of what one would expect if higher birthyear rainfall led to lower mortality between birth and the survey year. Even if these coefficients were statistically significant, they would imply very small effects, as shown in the bottom three rows of the table. Relative to a mean female cell size of 0.819, a 0.20 log point positive rainfall shock leads to 0.013 fewer women in a cell, which is just a 1.6% reduction in cell size. For men, the corresponding shock leads to a 3.1% reduction in cell size. This analysis therefore provides no indication that birthyear rainfall importantly affects the likelihood of inclusion in our sample.

The fact that birthyear rainfall does not affect the likelihood of inclusion in our sample helps alleviate most concerns about sample selection, as it would be very surprising if a shock affected the *characteristics* (e.g., parental characteristics) of a district-level birth cohort without also affecting their *number*. Nonetheless, we also check whether birthyear rainfall has an association with the small number of variables in the dataset that relate to the characteristics of the parents of the sampled individuals: years of schooling and an indicator for parent currently still living.[24]

[23] OLS results (not reported) turn out to be very similar.

[24] Dehejia and Lleras-Muney (2004) find that economic conditions in the U.S. affect the composition of the population of mothers giving birth.

As parents should for the most part have completed their schooling prior to their children's birth, their children's birthyear rainfall should not have any causal effect on parental years of schooling. Any observed relationship in our data would therefore be evidence of sample selection. We are also interested in the indicator for the parent still being alive as a dependent variable, as this is the only measure we have of parents' health human capital. While this variable will in part capture parental genetic characteristics and investments in parent's health made prior to their children's birth, it could also be directly affected by children's birthyear rainfall. For example, children with better birthyear rainfall could have better economic outcomes as adults and thus directly contribute to their parents' later-life health investments. Therefore, if we find statistically significant and positive relationships between children's birthyear rainfall and the parent-alive indicator, it could either reflect positive sample selection or a direct causal effect of rainfall on parental longevity. On the other hand, a finding of no relationship is consistent with the non-existence of both sample selection and a causal effect.

We run regressions that are analogous to those in Tables 2-5, but where the outcome variables are characteristics of individuals' fathers and mothers.[25,26] Regression results are presented in Table 8. In both the female and male regressions, none of the coefficients on birthyear rainfall are statistically significantly different from zero, and most are quite close to zero. The one coefficient that seems somewhat large is the one on father's years of schooling in the male sample (0.515), but this coefficient is statistically insignificant. There is no strong indication that rainfall has compositional effects on local-level birth cohorts, either in terms of parental years of schooling or parental longevity.

6 Discussion

To this point, we have said little about the channels or pathways through which early-life rainfall leads to enhanced socioeconomic status in adulthood for women. Although it is difficult to provide watertight evidence as to these pathways, in this section we refer to previous results and also conduct additional regression analyses to provide suggestive evidence on the likely pathways

[25]Each of these parental variables is only reported by a fraction of individuals in our sample, but we find that birthyear rainfall has no large or statistically significant effect on the likelihood of reporting any of these variables (regressions not reported).

[26]For women, means (std. devs.) of mother's and father's years of schooling are 4.53 (3.14) and 4.05 (3.87), respectively. 43.5% of women's fathers and 57.9% of women's mothers are still alive. For men, means (std. devs.) of mother's and father's years of schooling are 4.54 (2.97) and 3.93 (3.74), respectively. 44.1% of men's fathers and 60.0% of men's mothers are still alive.

through which early-life rainfall affects adult socioeconomic status.

6.1 The initial effect of early-life rainfall

It is most plausible that the *initial* direct effect of birthyear rainfall is on the health of infant girls. For early-life shocks to have long-run effects on individuals, they must affect some characteristic of individuals that persists over time. The results in Table 6 indicate that the effect of birthyear rainfall on adult female outcomes is essentially unchanged when controlling for rainfall in subsequent years, and rainfall variables in subsequent years have little or no relationship with adult female outcomes. The only persistent characteristics of individuals that could plausibly be thought to be determined in the birthyear are those having to do with their health human capital: crucial stages in physical development occur in infancy that can have long-lasting health consequences (critical-period programming).

The strong relationship that we document between birthyear rainfall and various adult health outcomes supports the notion that health investments in infancy vary with early-life rainfall. In particular, the impact of birthyear rainfall on adult height is telling. It is well known that nutritional deprivation in early life can result in stunting that persists into adulthood. Indeed, adult height has been taken to reflect early-life resource availability in numerous economic studies at the micro and macro levels.[27]

By contrast, it is implausible to think that the initial direct effect of birthyear rainfall is on some non-health-related aspect of human capital, such as years of schooling. School entry does not start until several years after birth, so one would have to imagine that rainfall was highly serially correlated and that the coefficient on birthyear rainfall was picking up the effect of rainfall nearer the year of school entry. But if this hypothesis were true, then the coefficient on birthyear rainfall in the years of schooling regression should decline in magnitude when rainfall in subsequent years is included in the regression, and coefficients on rainfall in subsequent years should be positive and statistically significantly different from zero. In fact, Table 6 shows that the opposite is true: the coefficient on birthyear rainfall changes little (compared to Table 2) when controlling for rainfall in subsequent years, and rainfall variables in subsequent years have no statistically significant effects on years of schooling. Therefore, the reduced-form effect that we find of birthyear rainfall on years of schooling is most likely mediated by birthyear rainfall's effects on infant health that persist until one's school years.

[27] See, for example, Strauss and Thomas (1998), Steckel (1995), Fogel (1994), and Schultz (2002, 2005).

The impact of birthyear rainfall on infant girls' health is likely to reflect the fact that rainfall fluctuations generate contemporaneous fluctuations in local crop output and household income (discussed above in section 3), which then affects households' abilities to purchase nutrition, health inputs, and generally more nurturing environments for their infants. As previously discussed, this net effect also may reflect factors such as changes in parental time allocation and in the disease environment (some of which may be negative and thus somewhat offsetting).

6.2 Subsequent pathways to adult socioeconomic status

If the initial direct impact of early-life rainfall is on the health of infant girls, how do these infant health impacts eventually affect adult women's socioeconomic status? We provide suggestive regression-based evidence here on subsequent pathways, focusing on the roles of adult health, education, and spousal quality in influencing eventual adult socioeconomic status.

In principle, the series of potential pathways from early-life rainfall to adult women's socioeconomic status is illustrated in Figure 8. Early-life rainfall affects infant health, which in turn affects educational achievement and adult health. Adult health and educational achievement can then affect spousal quality. Finally, adult health, education, and spousal quality then may each have direct effects on adult socioeconomic status.

The shadings of the arrows in the figure summarize the conclusions from this section. Solid arrows represent the pathways that the evidence suggests may be operative. Dashed arrows are potential pathways that may also be operative, but for which we do not find empirical support. It appears most likely that early-life rainfall affects infant health, which influences educational achievement and adult health. In turn, educational achievement and adult health affect spousal quality, but it appears that education exerts the more powerful influence. Finally, spousal quality has a direct effect on adult socioeconomic status, and appears to be a more important proximate influence than either education or adult health.

The approach we use to come to these conclusions first involves regressing the socioeconomic status index on birthyear rainfall for the female sample (as in the first row of Table 3), and then successively including as controls key variables representing adult health, educational human capital, and spousal quality.[28] We then compare results across specifications to gain insight on the intermediate pathways that are operative. If inclusion of a set of variables X leads to declines

[28] The health and education variables are all variables included in Table 2 except the health index and the education index (as these are simply linear combinations of the component variables). The spousal quality variables are years of schooling and ln(annual earnings).

in the coefficient on birthyear rainfall and substantial increases in R-squared, this would suggest that the variables in X represent an important pathway toward adult socioeconomic status. In addition, if inclusion of a set of control variables X causes coefficients on other control variables Y to decline in magnitude and statistical significance, this would suggest that some part of Y's effects on adult socioeconomic status may be occurring via Y's effects on X. Without question, these regressions are open to potential concerns about omitted variables, data quality, and reverse causality. The results should therefore only be taken as suggestive.

Regression estimates are presented in Table 9. In all regressions, we include only observations with complete data on all control variables.[29] Because the inclusion of control variables reduces the sample size, we first present the baseline regression without controls in the first column. As in Table 3, the coefficient on birthyear rainfall, 0.483, is positive and statistically significant at the 1% level.

In columns 2, 3, and 4, the control variables for health, education, and spousal quality (respectively) are included in the regression. Some subset of each of these variable groups enters significantly into the regression, and with the expected signs. But the effects of these different variable groups on the coefficient on birthyear rainfall and on R-squared differ substantially. The largest effects come from inclusion of the spousal quality variables in column 4. Their inclusion leads the coefficient on birthyear rainfall to decline in magnitude by nearly half (to 0.260), while R-squared rises dramatically from 0.34 to 0.58. Inclusion of the education variables by themselves (column 3) lead to a substantial but smaller decline in the magnitude of the birthyear rainfall coefficient, to 0.334, and a smaller increase in R-squared to 0.52. Inclusion of the health variables (column 2) has the least effect, reducing the birthyear rainfall coefficient only slightly to 0.440 and raising R-squared to just 0.36.

In column 5, all three types of control variables are included in the regression. Unsurprisingly, coefficient estimates on all the control variables become smaller in magnitude and many see declines in their levels of statistical significance. The largest effect is on the health variables: two coefficients that were previously (in column 2) large in magnitude and statistically significant (on self-reported poor/very poor health and lung capacity) have become much closer to zero and are no longer statistically significant in column 5. The coefficient that remains statistically significant in column 5, that on height, has declined in magnitude by nearly two-thirds (from 0.035 to 0.013). Among the educational variables, the statistically significant coefficient on years of schooling in column 3 has declined by more than half (from 0.202 to 0.097) in column 5 but

[29] Due to the inclusion of spousal variables as controls, the regression only includes married women.

remains statistically significant.

In comparison, the spousal quality variables are proportionately much less affected by the incremental inclusion of the health and education control variables. The coefficient on spouse's ln(annual earnings) declines between columns 4 and 5 by just a tenth (from 0.515 to 0.454), while the corresponding decline in the coefficient on spouse's years of schooling is about 40% (0.135 to 0.080). It is also telling that between columns 4 and 5, the coefficient on birthyear rainfall does not decline much further (only from 0.260 to 0.233), and R-squared rises relatively little (from 0.58 to 0.61).

All told, these results provide suggestive evidence that spousal quality is the most important intervening pathway between birthyear rainfall and adult socioeconomic status. Any effects of health and education on adult socioeconomic status appear to be largely mediated by their effects on spousal quality.

Given the findings of Table 9, it is natural at this point to compare the effects of adult health and education on spousal quality. We therefore run regressions analogous to those in Table 9, but where the outcome variables are spouse's years of schooling and spouse's ln(annual earnings) for the same sample of married women, and the controls are the same health and educational variables.

Regression results are presented in Table 10. In columns 1-4, the dependent variable is spouse's years of schooling. The coefficient on birthyear rainfall in first column, without control variables, is positive (0.699) and statistically significant at the 10% level in this subsample. Columns 2 and 3 include the health and education control variables, respectively. Inclusion of the education variables leads to a large decline in the coefficient on birthyear rainfall (to 0.178) and a large increase in R-squared (from 0.36 to 0.61). By contrast, inclusion of the health variables has a much more modest effect, leading the coefficient on birthyear rainfall to fall to just 0.571 and R-squared to rise to just 0.38. In column 4, when both the health and education variables are simultaneously included in the regression, coefficients on the education variables are little changed from column 3, while those on the health variables that were significant in column 2 decline substantially in magnitude. In addition, R-squared barely rises (from 0.61 to 0.62) when health variables are added to a specification that already includes the education variables (between columns 3 and 4).

Columns 5-8 are identical to those in columns 1-4 but for having spouse's ln(annual earnings) as the dependent variable, and they tell a very similar story. The coefficient on birthyear rainfall declines more and R-squared rises more when education variables are added to the base specification (column 7) than when the health variables are added (column 6). Between columns 7 and 8, when both the health and education variables are included, coefficients on education variables are barely changed, coefficients on the health variables mostly decline in magnitude, and R-squared is little changed in comparison to the previous column that already included the education variables.

The results in Table 10 suggest that a substantial fraction of birthyear rainfall's effects on spousal quality are mediated by birthyear rainfall's effects on educational achievement, as birthyear rainfall has a much attenuated (and statistically insignificant) relationship with spousal quality once education is controlled for. The evidence for a mediating role of adult health is much weaker.

6.3 Magnitude of the effects, and potential policy implications

One way to put our results in context is to compare the estimated impact of a moderate positive rainfall shock on adult outcomes with the impact of specific development interventions. In terms of impacts on schooling, the benefits of higher rainfall are on par with the effects of direct educational interventions. Perhaps most relevant for this paper, Duflo (2001) documents the impact of building 61,000 primary schools in Indonesia between 1974-78, around the time the youngest women in our IFLS sample were born. Each new primary school built per 1,000 children increased years of schooling by 0.12-0.19 on average. Outside of the Indonesian context, Miller (2006) finds that a family planning program in Colombia raised women's education by 0.15 years by delaying age at first birth. These schooling impacts are very similar in magnitude to the impact of 20% higher rainfall in the year and location of birth, which we estimate in this paper to be 0.15 years. Of course, the total impact of higher birthyear rainfall on Indonesian women would also include direct effects on other outcomes, such as adult health.

The most direct practical implication of this paper's results is that policies shielding rural households from the negative effects of bad weather can have returns far into the future, particularly if the interventions focus on assistance for the very youngest in the population (for example, families with infants). Formal crop insurance programs can help reduce the variability of farm family incomes, but moral hazard and adverse selection problems have prevented such programs from being implemented on a wide scale in developing countries except when heavily subsidized.

In recent years, there has been increasing interest in and experimentation with weather-based index insurance, wherein insurance payouts are determined purely on the basis of weather realizations, such as the amount of rainfall.[30] Such programs are less costly to administer and have the potential to reduce or eliminate moral hazard and adverse selection problems. The results in this paper point to the potential long-run benefits of such insurance. Ongoing evaluations of such weather insurance programs should be sure to document any impacts on infant and child health, and if possible monitor longer-run benefits in terms of schooling and other socioeconomic variables of individuals born in insured households.

7 Conclusion

This paper finds that the long-run well-being of Indonesian women is highly sensitive to the environmental conditions they experienced early in life. We examine the effect of rainfall variation around the time of birth on the health, education, and socioeconomic outcomes of Indonesian adults born between 1953 and 1974. Higher early-life rainfall has positive effects on the adult outcomes of women, but not of men, which may reflect gender biases in household resource allocation. Women with 20% higher rainfall in their year and location of birth attain 0.14 centimeters greater height, finish 0.15 more years of schooling, live in households with 5.2% higher expenditures per capita, and have spouses with 5.1% higher earnings.

The most plausible explanation for these results, suggested by the patterns in our data, is that rainfall has a positive impact on agricultural output, and leads to higher household incomes and therefore better health for infant girls. Eventual benefits for adult women's socioeconomic status appear to be mediated by improved schooling attainment, which leads to higher spousal quality, which in turn improves socioeconomic status outcomes. We do not find evidence that adult women's education or health have direct effects on socioeconomic status apart from indirect effects via spousal quality.

These results have important implications for policy. Our findings point to a group—newborn infants—that is particularly vulnerable to fluctuations in economic and environmental conditions. The long-run effects of early-life conditions on health, schooling, and socioeconomic outcomes several decades later should be factored into cost-benefit analyses of programs targeting this subpopulation. As such, our findings provide additional justification for interventions—such as social insurance schemes, public health investments, or policies ensuring food security—that shield infants from the health consequences of temporary environmental and economic shocks.

[30] World Bank (2005) provides an overview of a number of weather insurance programs, while Bie Lilleor et al (2005) examines the impact of rainfall insurance in India.

8 Data Appendix: Selected variable definitions

Self-reported health status "very good" (indicator): Whether respondent reports being generally "very healthy". Other options are "fairly healthy," "in poor health" and "very sick".

Self-reported health status "poor" or "very poor" (indicator): Whether respondent reports being generally "in poor health" or "very sick". Other options are "very healthy" and "fairly healthy".

Ln (lung capacity): Natural log of the average of 3 measurements of lung capacity taken by the nurse.

Height (cm.): Height in centimeters.

Days absent due to illness: The number of days of primary daily activities the respondent reports having missed in the last four weeks "due to poor health."

Years of schooling: The number of years of schooling constructed from respondent's report of highest level of education and the highest grade completed within level. According to the Southeast Asian Minister of Education Organization, elementary (primary) school is typically six years in Indonesia, followed by three years of junior high (junior secondary) followed by three years of senior high (secondary education).

Can read newspaper in Indo. language (indicator): Whether respondent can read a newspaper in an Indonesian language.

Can read newspaper in non-Indo. language (indicator): Whether respondent can read a newspaper in a non-Indonesian language.

Can write letter in Indo. language (indicator): Whether respondent can write a letter in an Indonesian language.

Can write letter in non-Indo. language (indicator): Whether respondent can write a letter in a non-Indonesian language.

Working (indicator): Whether respondent reports last week's primary activity to be working/trying to work/helping to earn income. Also set to 1 if the respondent reported working for at least one hour during the past week, or having a job or business but temporarily not working, or working at a family owned business during the past week.

Annual earnings: Estimated total earnings in the last 12 months, reported by the first household member located who is 18 or older and who is knowledgeable about the characteristics of other household members.

Hours worked in past year: Total hours worked in past year, only for respondents with non-missing total earnings.

Per capita household expenditures: The sum of expenditures by all household members on food and nonfood items over the last month estimated and reported by the woman in charge of food preparation (female head of household or wife of household head). Total expenditures on food constructed from estimated expenditures last week on 35 specific food items (e.g. rice, eggs, sugar, etc.), cigarettes and alcohol, reported separately for goods purchased on the market and for self produced goods. Total expenditures also include: the value of food given to people outside of the household; nonfood items purchased or self produced/consumed in the last month (electricity/water/fuel/phone, personal toiletries, household items, domestic services, entertainment, transportation, sweepstakes, arisan, and similar items given to people outside the household); nonfood items purchased or self produced/consumed in the last year (clothing, household supplies/furniture, health care, ceremonies/gifts, taxes, other goods, and similar items given to people outside the household); and education expenditures for children within or outside the household in the last year (fees/tuition, schooling supplies, transportation to school, boarding).

If housing is rented, monthly rent is also included. For homeowning household, estimated rent is included.

Total household assets per capita: The sum of the present value of the following household assets that are not used mainly for farm or nonfarm business, as estimated and reported by head of household, divided by household size: house, other building, nonagricultural land, livestock, vehicles, appliances, jewelry, furniture and receivables. If the household's ownership of an asset is partial, the value is divided according to ownership share.

Owns television (indicator): Whether respondent's household has one or more televisions.

Owns refrigerator (indicator): Whether respondent's household's has a refrigerator.

Owns private toilet with septic tank (indicator): Whether respondent's household has a toilet with septic tank.

Owns stove (indicator): Whether respondent's household has a stove heated by kerosene, gas, or electricity.

Married (indicator): Whether respondent reports being currently married.

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<u>Table 1</u>: Summary statistics, women and men born 1953-1974

Variables	Women						Men					
	Mean	Std. Dev.	Min	Median	Max	Num. Obs.	Mean	Std. Dev.	Min	Median	Max	Num. Obs.
Health index	-0.02	1.18	-7.25	0.24	3.14	4,407	-0.02	1.19	-8.83	0.20	2.39	3,874
Self-rep. health status very good (indic.)	0.08					4,450	0.09					3,892
Self-rep. health status poor/very poor (indic.)	0.12					4,450	0.09					3,892
Ln (lung capacity)	5.6	0.2	4.2	5.6	6.4	4,408	6.0	0.2	4.7	6.0	6.7	3,876
Height (cm)	150.4	5.4	110.6	150.4	171.2	4,452	161.9	6.0	130.0	162.0	183.4	3,894
Days absent due to illness (last 4 weeks)	1.2	3.2	0.0	0.0	28.0	4,451	1.0	3.1	0.0	0.0	28.0	3,892
Educational human capital index	-0.16	1.98	-3.80	0.96	1.91	4,438	-0.11	1.90	-5.11	0.70	1.51	3,877
Years of schooling	6.2	4.3	0.0	6.0	16.0	4,439	7.5	4.4	0.0	6.0	16.0	3,878
Can read newspaper in Indo. language (indic.)	0.79					4,452	0.89					3,894
Can read newspaper in other language (indic.)	0.64					4,452	0.73					3,894
Can write letter in Indo. language (indic.)	0.77					4,451	0.88					3,894
Can write letter in other language (indic.)	0.63					4,452	0.71					3,893
Socioeconomic status index	-0.28	1.58	-6.37	-0.32	4.04	4,451	-0.25	1.55	-5.48	-0.32	4.07	3,894
Ln (expenditures per cap. in hh)	12.6	0.9	7.6	12.5	17.1	4,452	12.6	0.9	9.2	12.5	17.1	3,894
Ln (total assets per cap. in hh)	14.5	1.8	0.0	14.6	19.6	4,452	14.5	1.8	0.0	14.6	19.0	3,894
Owns television (indicator)	0.61					4,452	0.60					3,894
Owns refrigerator (indicator)	0.26					4,451	0.24					3,894
Owns private toilet w/ septic tank (indicator)	0.43					4,452	0.43					3,894
Owns stove (indicator)	0.60					4,452	0.60					3,894
<u>Other variables</u>												
Deviation of log rainfall from norm, year of birth	-0.03	0.30	-1.50	-0.02	0.99	4,452	-0.03	0.30	-1.62	-0.01	0.99	3,894
Age	35.6	6.2	26.0	35.0	47.0	4,452	35.7	6.2	26.0	35.0	47.0	3,894
Expenditures per cap. in hh (US$, monthly)	59.4	120.8	0.2	31.4	3176.8	4,452	63.5	134.5	1.2	33.4	3176.8	3,894
Total assets per cap. in hh (US$)	691	1,512	0	271	39,065	4,434	661	1,305	0	272	22,090	3,875
Working (indicator)	0.68					4,452	0.97					3,894
Ln (annual earnings)	14.1	1.3	8.7	14.2	17.7	2,136	14.8	1.1	8.0	14.9	18.6	3,528
Log hours worked in past year	7.3	1.0	2.1	7.5	8.8	2,133	7.5	0.8	0.1	7.7	8.8	3,527
Married (indicator)	0.87						0.90					

NOTES-- Sample is individuals born outside of major cities (*kotamadya*) between 1953 and 1974 inclusive. Age is based on reported year and month of birth. Health index is first principal component of five subsequent health variables. Educational human capital index is first principal component of five subsequent educational variables. Socioeconomic status index is first principal component of six subsequent economic variables. (Higher values of all indices are "better.") Rainfall is at the birth district (kabupaten) level, in year of birth. Deviation of log rainfall from norm is log rainfall in year of birth minus log of district rainfall norm. Rainfall norm is birth district-specific mean from 1953-1999, where mean excludes current observation's birthyear. Total household expenditures include food and nonfood items reported by the woman in charge of food preparation. Total assets include the household head's report of assets not used mainly for business. US dollar figures converted from rupiah at year 2000 (annual average) rate of 8,422 rupiah per US$.

Table 2: Effect of birthyear rainfall on adult health and education, individuals born 1953-1974
(Fixed-effects estimates)

Coefficients (std. errors) in regression of outcome on birthyear rainfall (deviation of log rainfall from norm).

	Women	Men
Health outcomes		
Health index	0.256	0.028
	(0.062)***	(0.101)
	[4,407]	[3,873]
Self-rep. health status very good (indic.)	0.036	0.022
	(0.017)**	(0.016)
	[4,450]	[3,891]
Self-rep. health status poor/very poor (indic.)	-0.040	-0.005
	(0.011)***	(0.027)
	[4,450]	[3,891]
Ln (lung capacity)	0.024	0.005
	(0.017)	(0.016)
	[4,408]	[3,875]
Height (cm.)	0.686	-0.158
	(0.323)**	(0.541)
	[4,452]	[3,893]
Days absent due to illness (last 4 weeks)	-0.205	0.034
	(0.285)	(0.254)
	[4,451]	[3,891]
Educational outcomes		
Educational human capital index	0.203	-0.072
	(0.170)	(0.243)
	[4,438]	[3,877]
Years of schooling	0.754	-0.036
	(0.323)**	(0.645)
	[4,439]	[3,878]
Can read newspaper in Indo. language (indic.)	0.033	-0.025
	(0.033)	(0.032)
	[4,452]	[3,894]
Can read newspaper in other language (indic.)	0.009	-0.004
	(0.043)	(0.049)
	[4,452]	[3,894]
Can write letter in Indo. language (indic.)	0.044	-0.023
	(0.026)	(0.036)
	[4,451]	[3,894]
Can write letter in other language (indic.)	0.016	0.009
	(0.038)	(0.042)
	[4,452]	[3,893]

Number of observations in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each coefficient (standard error) is from a separate regression of the dependent variable on birthyear rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Standard errors clustered by province of birth. All regressions include fixed effects for birthyear-season, birthdistrict-season, and birthdistrict-seaon-specific linear time trends. Health index is first principal component of five subsequent health variables. Educational human capital index is first principal component of five subsequent educational variables. (See Appendix Tables for scoring coefficients.)

Table 3: Effect of birthyear rainfall on adult socioeconomic status and labor force outcomes, individuals born 1953-1974

(Fixed-effects estimates)

Coefficients (std. errors) in regression of outcome on birthyear rainfall (deviation of log rainfall from norm).

	Women	Men
Socioeconomic status outcomes		
Socioeconomic status index	0.557	-0.116
	(0.146)***	(0.178)
	[4,451]	[3,894]
Ln (expenditures per cap. in hh)	0.259	-0.133
	(0.058)***	(0.097)
	[4,452]	[3,894]
Ln (total assets per cap. in hh)	0.548	-0.040
	(0.178)***	(0.221)
	[4,452]	[3,894]
Owns television (indicator)	0.119	-0.023
	(0.041)***	(0.038)
	[4,452]	[3,894]
Owns refrigerator (indicator)	0.078	-0.026
	(0.036)**	(0.038)
	[4,451]	[3,894]
Owns private toilet w/ septic tank (indicator)	0.092	0.016
	(0.044)*	(0.060)
	[4,452]	[3,894]
Owns stove (indicator)	0.096	-0.025
	(0.035)**	(0.037)
	[4,452]	[3,894]
Labor force outcomes		
Working (indicator)	-0.029	-0.014
	(0.030)	(0.014)
	[4,452]	[3,894]
Ln (annual earnings)	0.304	-0.115
	(0.148)*	(0.114)
	[2,136]	[3,528]
Log hours worked in past year	-0.052	0.041
	(0.060)	(0.087)
	[2,133]	[3,527]
Other outcomes		
Married (indicator)	0.011	0.003
	(0.030)	(0.020)
	[4,452]	[3,894]

Number of observations in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each coefficient (standard error) is from a separate regression of the dependent variable on birthyear rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Standard errors clustered by province of birth. All regressions include fixed effects for birthyear-season, birthdistrict-season, and birthdistrict-seaon-specific linear time trends. Socioeconomic status index is first principal component of six subsequent economic variables. (See Appendix Tables for scoring coefficients.)

Table 4: Effect of birthyear rainfall on spousal health and education, individuals born 1953-1974
(Fixed-effects estimates)

Coefficients (std. errors) in regression of outcome on birthyear rainfall (deviation of log rainfall from norm).

	Women	Men
Health outcomes		
Health index	0.037	-0.147
	(0.054)	(0.071)*
	[3,352]	[3,310]
Self-rep. health status very good (indic.)	-0.008	-0.037
	(0.018)	(0.019)*
	[3,582]	[3,363]
Self-rep. health status poor/very poor (indic.)	0.004	0.029
	(0.013)	(0.025)
	[3,582]	[3,363]
Ln (lung capacity)	0.025	0.025
	(0.018)	(0.017)
	[3,358]	[3,310]
Height (cm.)	0.826	0.340
	(0.544)	(0.450)
	[3,374]	[3,336]
Days absent due to illness (last 4 weeks)	-0.047	0.223
	(0.321)	(0.180)
	[3,577]	[3,363]
Educational outcomes		
Educational human capital index	0.084	-0.028
	(0.203)	(0.204)
	[3,574]	[3,360]
Years of schooling	0.780	-0.020
	(0.327)**	(0.506)
	[3,575]	[3,360]
Can read newspaper in Indo. language (indic.)	0.006	-0.013
	(0.028)	(0.031)
	[3,587]	[3,364]
Can read newspaper in other language (indic.)	0.021	0.013
	(0.049)	(0.043)
	[3,587]	[3,364]
Can write letter in Indo. language (indic.)	-0.001	-0.011
	(0.030)	(0.030)
	[3,587]	[3,364]
Can write letter in other language (indic.)	0.013	-0.002
	(0.046)	(0.055)
	[3,586]	[3,364]

Number of observations in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each coefficient (standard error) is from a separate regression of the dependent variable on birthyear rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Standard errors clustered by province of birth. All regressions include fixed effects for birthyear-season, birthdistrict-season, and birthdistrict-seaon-specific linear time trends. Health index is first principal component of five subsequent health variables. Educational human capital index is first principal component of five subsequent educational variables. (See Appendix Tables for scoring coefficients.)

<u>Table 5</u>: Effect of birthyear rainfall on spousal labor force outcomes, individuals born 1953-1974

(Fixed-effects estimates)

Coefficients (std. errors) in regression of outcome on birthyear rainfall (deviation of log rainfall from norm).

	Women	Men
Labor force outcomes		
Working (indicator)	0.004	-0.039
	(0.011)	(0.036)
	[3,586]	[3,363]
Ln (annual earnings)	0.256	-0.241
	(0.133)*	(0.307)
	[3,384]	[1,334]
Log hours worked in past year	-0.066	0.223
	(0.069)	(0.197)
	[3,383]	[1,332]

Number of observations in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each coefficient (standard error) is from a separate regression of the dependent variable on birthyear rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Standard errors clustered by province of birth. All regressions include fixed effects for birthyear-season, birthdistrict-season, and birthdistrict-seaon-specific linear time trends.

<u>Table 6</u>: Effect of rainfall in several years before and after birth, women born 1953-1974
(Fixed-effects estimates)

Dependent variable:	Health index	Years of schooling	Socioeconomic status index	Spousal years of schooling	Spousal Ln(earnings)
Coefficient on rainfall in:					
Year -4	0.017	-0.098	-0.105	0.079	-0.107
	(0.094)	(0.335)	(0.114)	(0.424)	(0.113)
Year -3	-0.045	-0.158	-0.076	0.392	0.119
	(0.099)	(0.257)	(0.093)	(0.312)	(0.095)
Year -2	-0.042	-0.026	-0.038	-0.239	-0.037
	(0.083)	(0.365)	(0.110)	(0.348)	(0.140)
Year -1	-0.194	0.098	-0.095	-0.437	-0.042
	(0.114)	(0.328)	(0.126)	(0.367)	(0.107)
Year 0	0.287	0.676	0.551	0.765	0.268
	(0.061)***	(0.310)**	(0.150)***	(0.298)**	(0.137)*
Year 1	-0.082	0.404	0.054	0.655	-0.066
	(0.082)	(0.275)	(0.124)	(0.354)*	(0.073)
Year 2	0.086	0.104	-0.026	0.468	-0.021
	(0.075)	(0.288)	(0.103)	(0.228)*	(0.102)
Year 3	-0.035	-0.181	0.009	-0.262	0.056
	(0.082)	(0.251)	(0.051)	(0.386)	(0.094)
Year 4	0.029	0.362	0.014	-0.024	-0.085
	(0.071)	(0.353)	(0.098)	(0.429)	(0.088)
R-squared	0.18	0.40	0.30	0.36	0.27
Num. of obs.	4,407	4,439	4,451	3,575	3,384

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each column presents coefficients (standard errors) from a separate regression of the dependent variable on various years' rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Year 0 is birth year, year -1 is year prior to birth year, year 1 is year after birth year, etc.

Table 7: Impact of rainfall shock on number of individuals in IFLS sample
(Poisson regression estimates)

Dependent variable: Number of individuals in sample in a district-year-season cell

	Women	Men
Deviation of log rainfall from norm	-0.065	-0.109
	(0.076)	(0.072)
Birthyear-season fixed effects	Y	Y
Birthdistrict-season fixed effects	Y	Y
Birthdistrict-season-specific linear time trends	Y	Y
Num. of obs.	5,016	5,016
Mean of dependent variable (a)	0.819	0.714
Impact of positive 0.20 rainfall shock on cell size (b)	-0.013	-0.022
% change in cell size due to 1-S.D. shock (a)/(b)	-1.6%	-3.1%

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Unit of observation is a birthdistrict-birthyear-birthseason cell (e.g. birthdistrict 1201 for birthyear 1970 in the wet season) between 1953 and 1974 for all birthdistricts (kabupatens) of IFLS1 (1993) enumeration areas. As in previous tables, major cities (*kotamadya*) are excluded. Dependent variable is number of individuals observed in our IFLS3 sample born in that cell. Standard errors clustered by province of birth.

Table 8: Effect of birthyear rainfall on *parental* characteristics, individuals born 1953-1974
(Fixed-effects estimates)

Coefficients (std. errors) in regression of outcome on *child's* birthyear rainfall.

	Women	Men
Mother's characteristics		
Years of schooling	0.252	-0.231
	(0.348)	(0.484)
	[2,302]	[2,094]
Currently alive (indicator)	-0.006	0.032
	(0.025)	(0.047)
	[4,429]	[3,862]
Father's characteristics		
Years of schooling	-0.095	0.515
	(0.480)	(0.356)
	[2,713]	[2,464]
Currently alive (indicator)	0.022	0.008
	(0.047)	(0.045)
	[4,428]	[3,863]

Number of observations in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is individuals born between 1953 and 1974 inclusive, observed in year 2000. Each coefficient (standard error) is from a separate regression of the dependent variable on child's birthyear rainfall (deviation of log rainfall from log of 1953-1999 district mean rainfall). Standard errors clustered by province of birth. All regressions include fixed effects for birthyear-season, birthdistrict-season, and birthdistrict-seaon-specific linear time trends.

Table 9: Controlling for channels linking early-life rainfall to women's socioeconomic status
(Fixed-effects estimates)

Dependent variable: Socioeconomic status index

	(1)	(2)	(3)	(4)	(5)
Deviation of log rainfall from norm, year of birth	0.483	0.440	0.334	0.260	0.233
	(0.114)***	(0.115)***	(0.093)***	(0.090)***	(0.088)**
Health variables					
Self-rep. health status very good (indic.)		0.064			0.015
		(0.100)			(0.082)
Self-rep. health status poor/very poor (indic.)		-0.216			-0.018
		(0.114)*			(0.098)
Log lung capacity		0.516			0.020
		(0.184)**			(0.133)
Height (cm.)		0.035			0.013
		(0.006)***			(0.005)**
Days absent due to illness (last 4 weeks)		-0.002			0.006
		(0.011)			(0.008)
Education variables					
Years of schooling			0.202		0.097
			(0.016)***		(0.013)***
Can read newspaper in Indo. language (indic.)			0.337		0.114
			(0.286)		(0.230)
Can read newspaper in other language (indic.)			-0.185		-0.112
			(0.153)		(0.159)
Can write letter in Indo. language (indic.)			-0.185		-0.080
			(0.263)		(0.205)
Can write letter in other language (indic.)			0.190		0.184
			(0.151)		(0.152)
Spousal characteristics					
Spouse's years of schooling				0.135	0.080
				(0.008)***	(0.005)***
Spouse's ln (annual earnings)				0.515	0.454
				(0.038)***	(0.040)***
R-squared	0.34	0.36	0.52	0.58	0.61
Observations	3,328	3,328	3,328	3,328	3,328

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is women born between 1953 and 1974 inclusive, observed in year 2000. Each column presents coefficients (standard errors) from a separate regression.

Table 10: Controlling for channels linking early-life rainfall to women's spousal quality
(Fixed-effects estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Spouse's years of schooling	Spouse's years of schooling	Spouse's years of schooling	Spouse's years of schooling	Spouse's ln (annual earnings)	Spouse's ln (annual earnings)	Spouse's ln (annual earnings)	Spouse's ln (annual earnings)
Deviation of log rainfall from norm, year of birth	0.699	0.571	0.178	0.139	0.250	0.225	0.176	0.165
	(0.392)*	(0.399)	(0.333)	(0.333)	(0.143)*	(0.145)	(0.113)	(0.115)
Health variables								
Self-rep. health status very good (indic.)		0.059		0.115		0.119		0.134
		(0.251)		(0.222)		(0.060)*		(0.076)*
Self-rep. health status poor/very poor (indic.)		-0.835		-0.363		-0.127		-0.055
		(0.194)***		(0.198)*		(0.060)**		(0.047)
Log lung capacity		2.025		0.830		0.336		0.123
		(0.403)***		(0.289)***		(0.174)*		(0.173)
Height (cm.)		0.093		0.044		0.016		0.009
		(0.013)***		(0.009)***		(0.005)***		(0.004)**
Days absent due to illness (last 4 weeks)		-0.001		0.015		-0.011		-0.009
		(0.024)		(0.016)		(0.006)*		(0.006)
Education variables								
Years of schooling			0.713	0.698			0.100	0.097
			(0.012)***	(0.011)***			(0.010)***	(0.010)***
Can read newspaper in Indo. language (indic.)			0.458	0.397			0.394	0.381
			(0.369)	(0.370)			(0.186)**	(0.188)*
Can read newspaper in other language (indic.)			-0.443	-0.421			-0.069	-0.059
			(0.360)	(0.358)			(0.076)	(0.078)
Can write letter in Indo. language (indic.)			-0.417	-0.380			-0.136	-0.118
			(0.285)	(0.258)			(0.206)	(0.207)
Can write letter in other language (indic.)			0.157	0.155			-0.020	-0.033
			(0.391)	(0.391)			(0.112)	(0.109)
R-squared	0.36	0.38	0.61	0.62	0.27	0.29	0.38	0.39
Observations	3,329	3,329	3,329	3,329	3,329	3,329	3,329	3,329

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Sample is women born between 1953 and 1974 inclusive, observed in year 2000. Each column presents coefficients (standard errors) from a separate regression.

Appendix Table 1: Factor loadings derived from health variables

Variable	Women	Men
Self-rep. health status very good (indic.)	0.309	0.268
Self-rep. health status poor/very poor (indic.)	-0.618	-0.591
Ln (lung capacity)	0.348	0.401
Height (cm)	0.245	0.283
Days absent due to illness (last 4 weeks)	-0.584	-0.581

NOTES-- Factors loadings for calculation of first principal component, separately for women and men. Each individual variable normalized prior to calculating factor loadings.

Appendix Table 2: Factor loadings derived from educational human capital variables

Variable	Women	Men
Years of schooling	0.383	0.354
Can read newspaper in Indo. language (indic.)	0.471	0.481
Can read newspaper in other language (indic.)	0.452	0.454
Can write letter in Indo. language (indic.)	0.474	0.483
Can write letter in other language (indic.)	0.451	0.452

NOTES-- Factors loadings for calculation of first principal component, separately for women and men. Each individual variable normalized prior to calculating factor loadings.

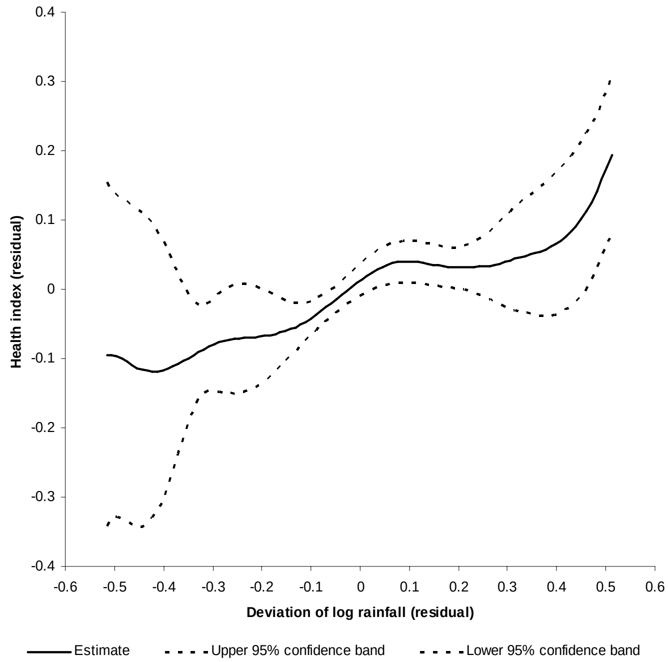
Appendix Table 3: Factor loadings derived from socioeconomic status variables

Variable	Women	Men
Ln (expenditures per cap. in hh)	0.431	0.427
Ln (total assets per cap. in hh)	0.405	0.395
Owns television (indicator)	0.425	0.432
Owns refrigerator (indicator)	0.379	0.376
Owns private toilet w/ septic tank (indicator)	0.427	0.433
Owns stove (indicator)	0.380	0.383

NOTES-- Factors loadings for calculation of first principal component, separately for women and men. Each individual variable normalized prior to calculating factor loadings.

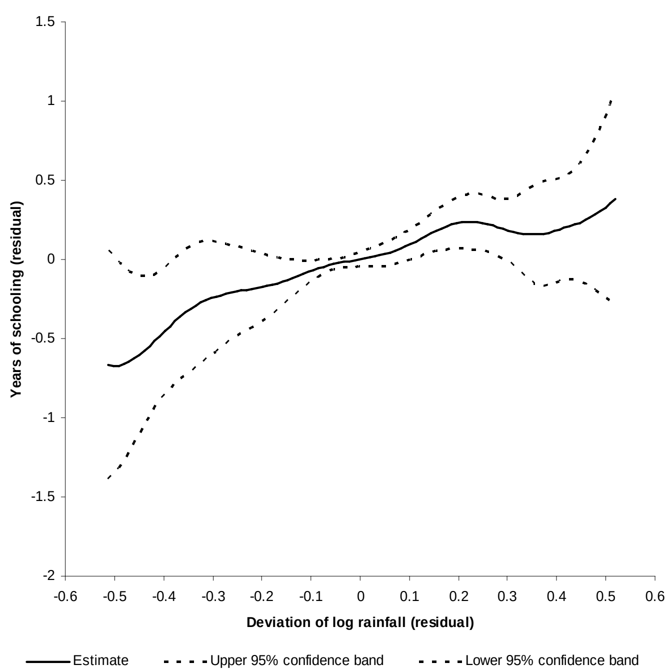
<u>Figure 1</u>: Health index on rainfall shocks in birthdistrict and birthyear

Nonparametric Fan regression, conditional on birthdistrict-season fixed effects, birthyear-season fixed effects, and birthdistrict-season-specific linear time trends.

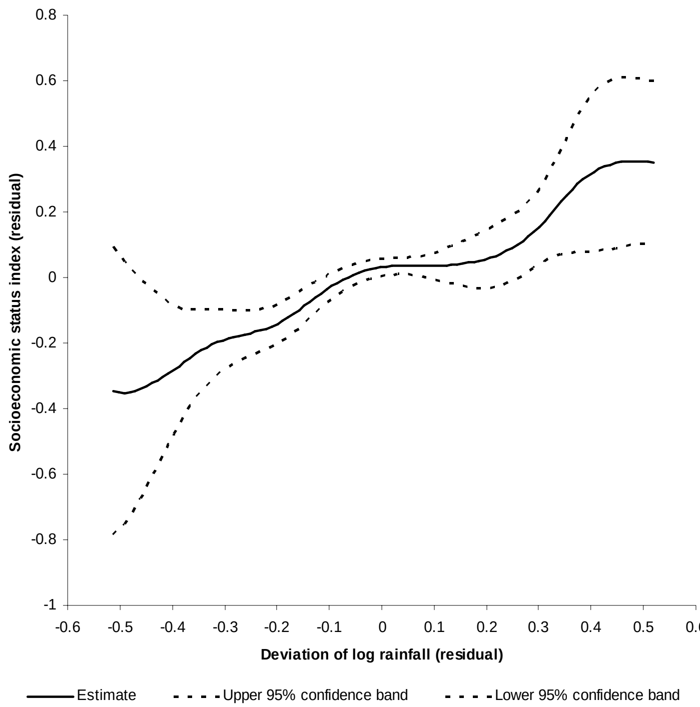


<u>Figure 2</u>: Years of schooling on rainfall shocks in birthdistrict and birthyear

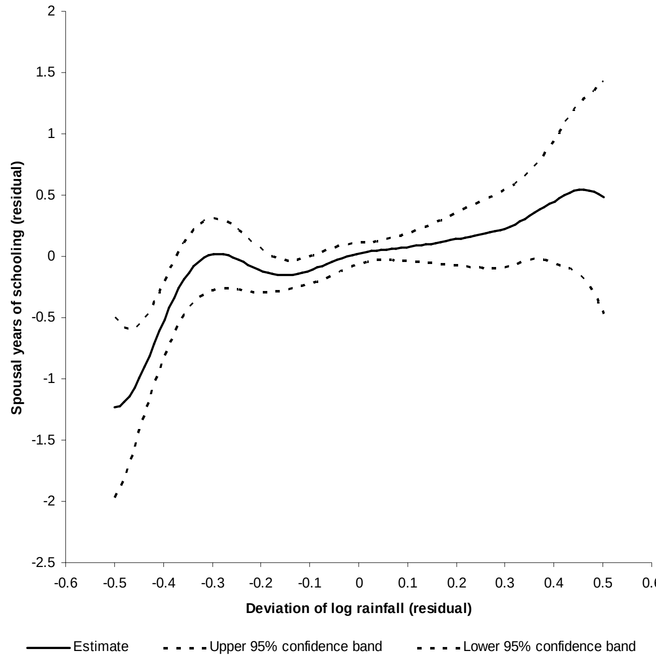
Nonparametric Fan regression, conditional on birthdistrict-season fixed effects, birthyear-season fixed effects, and birthdistrict-season-specific linear time trends.



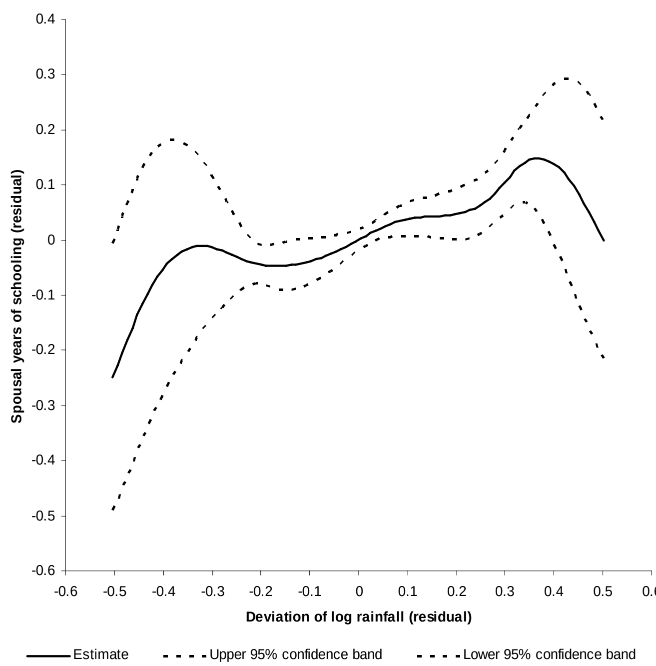
<u>Figure 3</u>: Household socioeconomic status index on rainfall shocks in birthdistrict and birthyear
Nonparametric Fan regression, conditional on birthdistrict-season fixed effects, birthyear-season fixed effects, and birthdistrict-season-specific linear time trends.



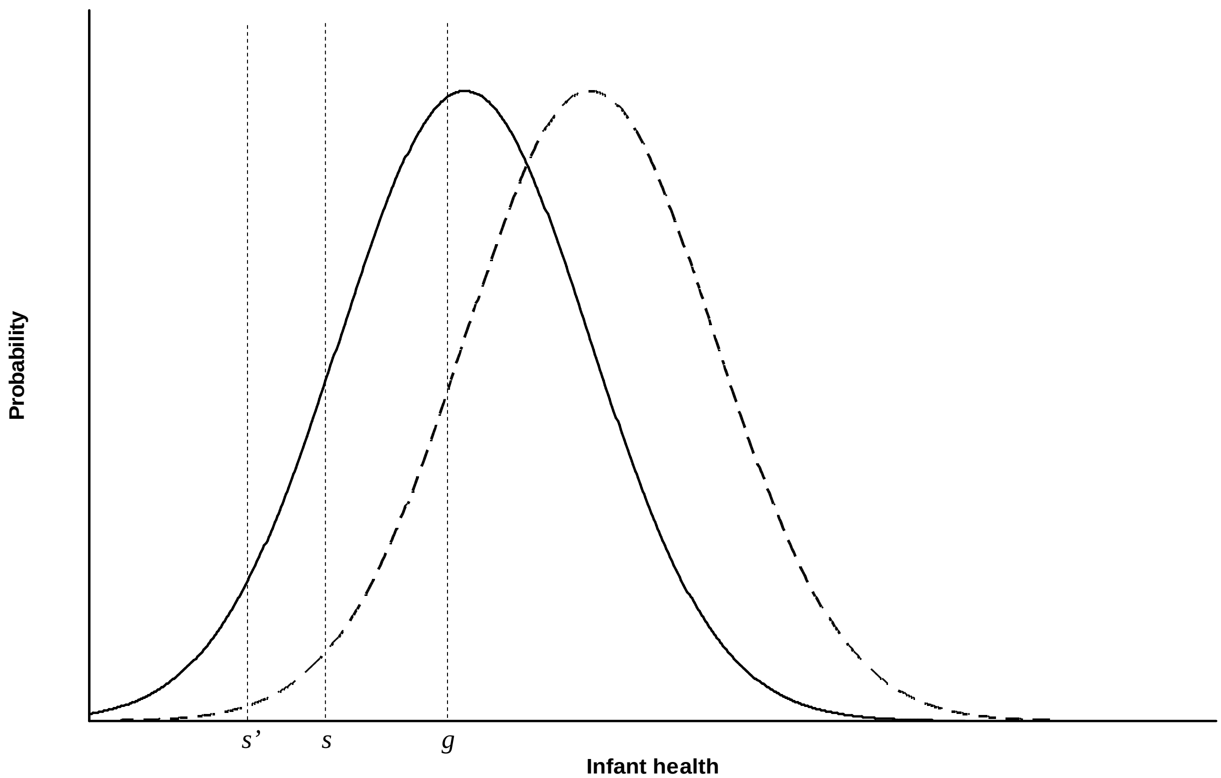
<u>Figure 4</u>: Spousal years of schooling on rainfall shocks in birthdistrict and birthyear
Nonparametric Fan regression, conditional on birthdistrict-season fixed effects, birthyear-season fixed effects, and birthdistrict-season-specific linear time trends.



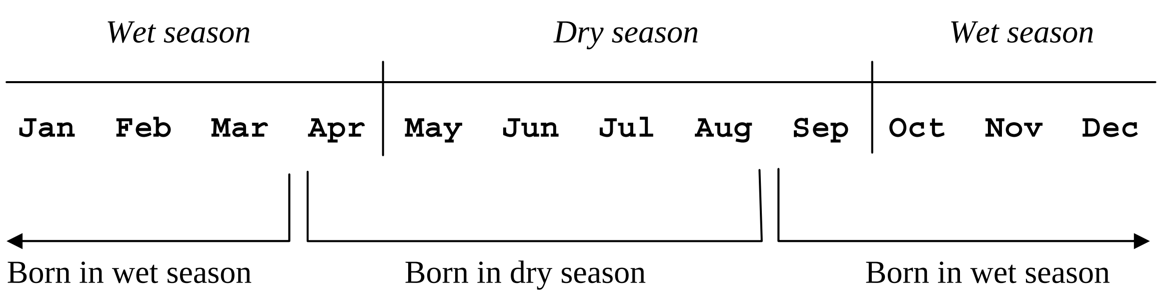
<u>Figure 5</u>: Spousal log annual earnings on rainfall shocks in birthdistrict and birthyear
Nonparametric Fan regression, conditional on birthdistrict-season fixed effects, birthyear-season fixed effects, and birthdistrict-season-specific linear time trends.



<u>Figure 6</u>: Conceptual distribution of individual health



<u>Figure 7</u>: Defining rainfall in one’s birth year (Central Java example)



<u>Figure 8</u>: Likely pathways from early-life rainfall to adult socioeconomic status for Indonesian women