Heat Waves at Conception and Later Life Outcomes*

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Abstract

We ask whether children conceived during heat waves have better health and educational outcomes later in life. Using Census data from 22 countries, we show that children conceived during heat waves have higher literacy rates, attain more years of schooling, and lower rates of disability than children conceived during periods of normal temperatures. We then explore several channels through which this effect may occur using a combined AIS, DHS, and MIS data set from sub-Saharan Africa. We find evidence more educated and wealthier women are more likely to conceive a child during a heat wave, implying that part of the

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effect is explained by selection into conception by different types of parents. We also show that differential reductions in sexual activity during heat waves among higher educated parents could be driving this effect. We also find higher rates of fetal loss for children conceived during heat waves, implying that part of the result may be explained by natural selection.

JEL Codes: I1, J1, O1

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1 Introduction

What drives differences in educational and health outcomes in children, and later adults? A large body of evidence points to the importance of early life and in utero conditions, especially health conditions, in determining later life outcomes. Exogenous variation in climatic conditions are increasingly being used as proxies or instruments for variation in health conditions in infancy or in utero. Many of these studies examine the effect of rainfall or ecological disasters such as famines or storms on a variety of fertility and child outcomes.

Recently, several papers have begun to examine the effect of temperature alone on child outcomes. For example, Kudamatsu et al (2013) find that heat waves immediately after birth in Africa increase infant mortality through increased malaria prevalence and famine, and Deschenes et al (2009) find that high temperatures in utero reduces birth weight. However, there have been no studies which look at the effect of temperature in utero on long run outcomes later in life. In addition, these studies have focused on the biological channels through which temperature affects outcomes. However, it may also be the case that temperature, specifically at the time of conception, may change individuals' behavior and cause different types of parents to select into conceiving children based on the incidence of a heat wave. As a result, the correlation between heat waves in utero and outcomes may purely be caused by selection on different types of parents conceiving, rather than a negative health environment.

There are many reasons for selection into conception during a heat wave based on parental characteristics. As long as parental characteristics are transmitted to children, these differences in parental characteristics may drive the correlation between temperature and outcomes. For example, during heat waves sexual activity decreases (see Apouey and Wilde 2013). It is plausible that individuals with higher incomes may be able to more easily isolate themselves from the adverse effects of heat through higher quality housing, air conditioning, or being able to work in occupations which do not require long hours of outdoor labor. As a result, there may be a smaller reduction in sexual activity among higher SES households compared with the poor, leading to a larger fraction of children born nine months later with high SES parents.

In addition, it is hard to believe that parents purposefully plan their children around heat waves. In spite of this, Lam and Miron (1996) find large decreases in fertility nine months after a temperature spike. As a result, a disproportionate share of this reduction may happen among unwanted or mistimed pregnancies, leading to a higher fraction of intended children in the cohort conceived during a heat wave. If unintended children receive lower parental investment than planned children, this could be an additional behavioral channel through which heat waves correlate with outcomes later in life. Additionally, if the timing of a woman's planned pregnancies are based on something as trivial as a heat wave, that may be correlated with the woman being careless, impatient, not forward looking, etc., and those characteristics may then be transmitted to the child.

In addition to behavioral selection into conception based on temperature, there are also biological reasons higher SES parents may be selected into conceiving during heat waves. For example, Lam et al (1994) hypothesize that elevated temperatures at the time of conception may cause high rates of miscarriage. This could be correlated with outcomes later in life in two ways. First, if weaker fetuses are more likely to die in utero due to a temperature shock, then the stronger, healthier fetuses are more likely to survive. Second, controlling for the biological strength of the fetus itself, unborn children of higher income or healthier women may be more likely to survive an adverse temperature shock in utero. Both of these mechanisms are likely to increase the fraction of children with better characteristics, either because they are stronger or have parents with better characteristics.

Another potential selection issue is differences in the probability of conception during heat waves among different types of women. For example, if it is harder to conceive when it is hot for biological reasons, perhaps more fertile (or healthy) parents would still be able to conceive during heat waves, while less fertile parents would not. It is well known that sperm are highly sensitive to heat, and some studies show that male fecundity falls in the summer for this reason.

All of the effects mentioned thus far should show a positive correlation between heat waves at the time of conception and outcomes later in life. However, inasmuch as heat in utero is a negative health shock, children conceived during heat waves could have worse outcomes later in life according to the fetal origins hypothesis. Most of the literature on climate shocks in utero focuses on this channel – they show that rainfall shocks or famines in utero lead to reduced cognative function, health, or other outcomes later in life. If the direct effect of temperature at conception is negative, but the previously mentioned selection effects are positive, then the direction of the correlation between temperature at the time of conception and outcomes later in life is theoretically ambiguous.

This paper is divided into two main parts. The first establishes that there is in fact a correlation between heat waves specifically at the time of conception and outcomes later in life. We estimate the effect of heat waves at conception on a series of educational, health, and labor market outcomes. We focus on 22 countries from across the world for which the IPUMS census data contains information on the location, year, and month of birth, as well as at least one of our outcome variables. Using weather data from the University of Delaware, we find that children conceived during temperature extremes have higher rates of literacy, more years of education, lower rates of disability, and are less likely to be unemployed as adults. This holds for all countries in our sample, even the ones with high levels of economic development.

Estimating the effect of temperature at conception, in utero, and in infancy is not trivial. There are many reasons why absolute temperature should be correlated with outcomes even if no causal effect exists. For example, temperature could be correlated with the seasonality of birth and conception or geography, which in turn could affect child outcomes directly. In this paper, we use within-region deviations from month-specific detrended average temperatures to remove the permanent component of temperature, so only temperature shocks remain. This way, only the exogenous variation in temperature due to heat waves and cold snaps is used to identify the effect of temperature on later life outcomes. This method is similar to Lam and Miron's (1996) study on heat waves and fertility rates, and Kudamatsu et. al.'s (2013) study on malarial conditions and infant mortality.

Once we demonstrate that this correlation does in fact exist, the second part of the paper attempts to explain why. Specifically, we show evidence for or against each the channels mentioned above. For some channels, we continue to use the above census data, but for most of the channels we use and additional dataset constructed from AIS, DHS, and MIS surveys for all of Sub-Saharan Africa.[1]

We find that the parents of children born nine months after a temperature extreme have higher education, income, are more literate, and have less disability that children born nine months after a period of normal temperatures. Interestingly, we also find that when controlling for parental characteristics, the positive effect of temperature on outcomes is smaller in rich countries, but persists for poor countries. We believe this is because selection explains the entire effect for rich countries, but other effects such as the poor disease environment in poor countries also causes the effect.

Using the DHS data, we extend the work of Apouey and Wilde (2013) which find that heat waves reduce the likelihood a woman will report being sexually active to show that this effect is disproportionately large for women with lower levels of education. Also, we do not find that children conceived during heat waves are more likely to be reported as wanted than those conceived during normal temperatures. Finally, we find a higher rate of pregnancy termination for children conceived during heat waves, and similar to our results on sexual activity, that the effect is larger for women with low levels of education. As a result, we conclude that the main channels driving the correlation are differences in parental characteristics caused by heterogeneous effects of temperature on sexual activity and in-utero selection by socio-economic status.

Our paper contributes to the literature in several important ways. First, while other papers use weather shocks broadly defined (like rainfall or storms,

[1] See the appendix for a full list of countries and years.

as well as famines) as a proxy for early life health conditions to identify the effect of infant health on later outcomes, we are the first paper to focus solely on temperature. Second, while there are papers which identify the effect of temperature in utero or after birth on infant or child outcomes (see Deschenes 2009), we are the first paper to focus on the effect of temperature specifically at conception. Third, our main focus is the long run effect of temperature at conception on other health and educational variables later in life, not just in childhood or infancy. Finally, we are the first paper to our knowledge to show heterogeneous effects of temperature on sexual activity and fetal loss by education.

The paper proceeds as follows: Section 2 establishes that there indeed is a causal link between temperature at the time of conception and later life outcomes. Section 3 provides evidence about the channels. Section 4 concludes.

2 Heat Waves at Conception and Outcomes

Methodology

Estimating the effect of temperature at conception, in utero, and in early childhood on outcomes is not trivial. There are many reasons why absolute temperature should be correlated with outcomes even if no causal effect exists. For example, temperature is related to seasonality. There is a large and old literature analyzing the effect of seasonality and outcomes. Many births are timed around the seasons, the school year, holidays, summer vacations, etc. In the United States, September has more births per day than any other month. In addition, the parents of children born in the late spring tend to have higher education levels and have higher wages than of those born in the fall or winter (Buckles and Hungerman 2013).

Another reason why temperature may be related to outcomes is spatial in nature: absolute temperature may be correlated with the level of development in a region. A quick view around the globe reveals the interesting fact that locations closer to the poles tend to be more developed than those close to the equator. However, almost all of the explanations of that correlation have nothing to do with temperature, but rather historical population densities, institutions, technological progress, and disease environments, to name a few. In addition, topographical characteristics could be correlated with weather and development. For example, places along the coasts tend to have milder climates than landlocked regions, and coastal regions also have higher economic development due to lower transportation costs via naval shipping. Or locations at higher elevations could both be colder and have lower levels of economic development.

In this paper, we use within-month and within-region temperature deviations to identify the effect of heat waves on later life outcomes. By comparing the temperature in a given region in a given month against average temperatures for the same month and region, we isolate the variable component of temperature while stripping away the permanent component. We assume that these weather shocks are uncorrelated to geography, seasonality, and other similar variables which affect later life outcomes.

Formally, we estimate the following regression equation to test whether temperature at conception affects later life outcomes:

$$Y_i = \alpha_y + \theta_r + \gamma_m + \sum_{j=t-15}^{t+15} \beta_j T_{j,i} + \psi X_i + \epsilon_i, \tag{1}$$

where Y_i is the outcome of interest for individual i, α_y is a year fixed effect, θ_r is a dummy variable for being born in region r, and γ_m is a dummy variable for being born in month m. In addition, there are up to 31 temperature variables T_j, corresponding to the deviation from the month-specific average temperature in the region of birth for each month from 15 months before birth to 15 months after birth. For example, if $t-0$ (the time of birth) falls in July, then $T_{t-0,i}$ is the deviation of temperature in that July in which the child is born from the average temperature over all other July's in that region. This way, we are left with just deviations in temperature from the average temperature at that time of year, and we strip out the part of temperature which varies with the season. This is important because the seasonality of birth affects outcome for other reasons besides temperature, such as timing of births around specific holidays, the school year, summer vacation, etc.[2] Finally, X_i is a vector of other explanatory variables. In our baseline specification of the model, we do not include any other explanatory variables. Later we control for parental characteristics and gender. Theoretically, if the temperature data is truly exogenous as we believe it is, then the coefficients on the β_j should be unaffected by the exclusion or inclusion of extra explanatory variables.

One threat to our empirical methodology is the presence of global warming. To see this, consider the fact that most outcomes measured in this paper (education, health, etc.) have generally been increasing over the last century. In the presence of global warming, our temperature deviations should also be increasing over time, since we are only subtracting the average temperature over a period of rising temperatures. As a result, there could be a spurious correlation between our temperature deviation variable and outcomes. To solve this problem, we use three different methodologies to detrend the temperature data before taking the deviation. Specifically, we use linear detrending, cubic detrending (to account for non-linearities in the temperature increase), and a deviation from the moving average of the last 5 years. Each detrending method is separately applies for each region-month. The results shown in this paper use linear detrending since all three detrending methods yield similar results.

The main variable of interest is β_{t-9}. If $\beta_{t-9} \neq 0$ as we hypothesize, that implies heat waves at conception are correlated with outcomes. However, the other βs may be interesting as well. For example, we can test whether heat waves at the time of birth, or shortly after birth, affect later life outcomes. This may occur due to changes in the disease environment the infants are subjected to with increased heat, for example. The variables for temperature deviations before conception provide a placebo test for our result, since there are few, if any, theoretical reasons heat before conception should affect later life outcomes.[3]

[2]See Lam and Miron (1996) for a more detailed discussion.
[3]See Section 3 for a more detailed discussion.

The key identifying assumption in this section is that the deviation from the detrended monthly temperature in a given region at the time of conception (or later) is exogenous to outcomes later in life, and therefore the effects of heat at conception on outcomes are causal. This assumption seems fairly straightforward. However, interpreting why heat may affect outcomes is more difficult. In section 3, we analyze several possible channels for the effect of heat on outcomes.

One potential source of bias to our estimates is migration. Since we only observe the location of birth, and not the location of conception, we cannot be exactly sure that the individuals in our sample were exposed to the heat deviations at the time of conception (or in utero) in the region of their birth. This measurement error would bias our results towards zero. However, given the rates of migration observed in the census, we believe that the fraction of children who were conceived in a location different from their birth is small. In addition, since we will find significant results on the effects of temperature at conception on outcomes, this only serves to strengthen our findings.

Another problem with assuming that children are conceived precisely nine months before birth is that the timing of birth is a random variable, whose mean is around 38 weeks, or close to nine months. Some children, however, are born prematurely or late. As a result, the temperature deviation at $t-8$ or $t-10$ may actually be the correct measure of heat waves at conception for some children. As a result, the βs immediately surrounding β_{t-9} may also show significant results if heat waves at conception affect outcomes. In addition, each of the coefficients β_{t-8}, β_{t-9}, and β_{t-10} will be attenuated towards zero, and therefore underestimate (in terms of absolute value) the true impact of heat waves at the time of conception.

Data

There are many data set which contain information on temperature. Each data set has its strengths and weaknesses; Dell et al (2013) provide an extensive summary of each. For this paper, our main data on temperature comes from the weather data housed at the University of Delaware. The data set is derived from a large number of weather stations from the GHCN2 (Global Historical Climate Network), and then projected onto a 0.5x0.5 degree global grid. It contains mean monthly air temperatures and precipitation from 1900 to 2010. The benefits of using this data is the quantity of data provided. Since not every 0.5x0.5 grid cell of the earth had weather stations over the entire sample period to measure temperature, the data for missing regions is imputed using a sophisticated meteorological model. For our purposes, this is both a blessing and a curse, in that it provides a large set of temperature observations, but also introduces measurement error into the temperature deviation variable. Since the identification in our paper comes from high frequency changes in temperature, interpolations which smooth the changes could severely bias our results towards zero.

Since different weather data sets have different drawbacks, we also look at our results using 3 additional weather data sets as a robustness check. These data sets are the Climatic Research Unit (CRU) Global Climate data set, the National Climatic Data Center (NCDC) at the National Oceanic and Atmospheric Administration (NOAA) data, and ERA-40. The CRU data is similar to the Delaware temperature data, in that it is a high-resolution gridded data set from 1900-2010, and extensively uses interpolating to generate temperature data for region-months where stations did not exist. In contrast, the NOAA data is at the station level and reports weather conditions every few hours. From these hourly observations, NOAA constructs a daily temperature data set, from which we construct a data set of average temperatures for each month for each station. In contrast with the CRU or Delaware data sets, the benefit of using the NCDC data is that only regions with actual weather observations are used in the analysis – there is no imputation. However, there are two drawbacks. First, since there are few weather stations in Africa, and since for the most part they have not been in operation for long, the sample size is very restricted. Second, we may be concerned that regions with a weather station may be different than regions without a station, leading to biased estimates of the overall effect of temperature deviations at conception on outcomes. Finally, we use ERA-40, a 45 year weather reanalysis from the European Centre for Medium-Range Weather Forecasts (ECMWF). The ERA-40 augments the direct weather station observations with additional meteorological observations, including data from weather balloons, aircraft, and even satellites. Although this temperature data is only available in a very coarse grid (1.25x1.25 degrees), its strength is that the additional data sources reduce the reliance on imputation for regions and times where there are no operative weather stations. The data is available only for the years 1957-2002.

We then link the data on temperature deviations to the national censuses available from IPUMS International. The census contains data on individuals' region, month, and year of birth, as well as a variety of outcomes such as literacy, educational attainment, disability, and labor market outcomes. By necessity we restrict our analysis to those countries which have region of birth, year of birth, month of birth, and at least one of out outcomes of interest. In general, the constraining variable is month of birth – that variable is suppressed for the large majority of countries. We are left with 22 countries for our analysis.[4] Fortunately, the countries we can use in our not only have a have good geographic distribution across the globe, but also cover a wide range of income levels, which will allow us to test if the effect of heat waves on conception differs between countries with high and low levels of development.

Using the region of birth and year and month of birth, and assuming that people are conceived nine months earlier in the same region they are born in, we can find the temperature at conception for each individual in our census samples. In addition, we also use a large data set combining information on women in sub-Saharan Africa from the Demographic and Heath Surveys (DHS), AIDS Indicator surveys (AIS), and Malaria Indicator Surveys (MIS) to test different channels by which temperature at the time of conception may affect outcomes later in life. The specific survey countries and years are listed in Appendix A.

[4] The countries included are Armenia, Burkina Faso, Cameroon, Colombia, Ecuador, Egypt, El Salvador, Fiji, Guinea, Indonesia, Iraq, Jamaica, Kyrgyz Republic, Malawi, Malaysia, Mongolia, Nicaragua, Romania, Rwanda, Spain, Thailand, and Uganda.

Results

We begin by estimating equation (1) using years of schooling as the dependent variable for each of our 22 countries. Due to space constraints, we are not able to show all the results in this paper, but they are available on the online appendix. We focus on two cases, that of Jamaica and the Kyrgyz Republic. We choose theses cases because they represent two countries with very different seasonal weather patterns: Jamaica is warm year round, while the Kyrgyz Republic has a wide variance in temperature across seasons. We will find different results for the two countries, and then explain why these different results are actually consistent with temperature deviations affecting outcomes later in life.

In table 1, we report the results of our estimation of equation (1) for Jamaica. Column 1 shows the partial correlation between years of schooling and temperature of conception only, omitting all the other temperature variables for months surrounding the month of conception. We find that heat waves at the time of conception are strongly correlated with higher educational attainment later in life. Specifically, if the monthly average temperature is one degree Celsius higher than normal, that is associated with an additional 0.1 years of schooling. This is equivalent to an increase of 0.14 years for schooling for a one standard deviation increase in temperature.

In column 2, we include more temperature deviations for other months – ranging from 12 months before birth to 5 months before birth. Interestingly, not only do we find that temperature at the month of conception is positively associated with outcomes later in life, but also for the first two months after conception. This can be interpreted in two ways. First, heat waves in the first trimester are better for outcomes, or second, that since the month of conception is noisy, and on average more births occur before nine months compared to after, that we could be picking up the effect of temperature at the time of conception for premature babies. We think that the truth is a mix of both. Also, deviations in temperature before the time of conception do not affect outcomes, which is both understandable and also provides a nice placebo test for our results, lending credibility to our empirical specification.

Temperature after the first semester does not seem to matter either.

In table 2, we provide results for the Kyrgyz Republic. We find no effect of temperature at time time of conception, or at any time before or after, on educational attainment. At first glance, this may seem to invalidate our hypothesis the temperature at the time of conception affects outcomes. However, there is an important reason the results from Jamaica and the Kyrgyz Republic are different: the seasonality of temperature, and the non-linearity of the effect of temperature on outcomes.

In Jamaica, the temperature is always hot. The difference between the average in the hottest month (August, 25.9º) and the coldest month (January, 23.0º) is only 2.9º. In the Kyrgyz Republic, however, there are parts of the year where it is hot, and other parts of the year where it is very cold. The difference between the average in the hottest month (July, 16.6º) and the coldest month (January, -10.4º) is 27º.

Given the possible channels by which temperature at the time of conception affects outcomes, we would not expect to see an increase in temperature causing selection if temperatures are cool. For example, would increasing the temperature from 10º to 15º really cause a negative health shock to the fetus? Or contribute to a decline in sexual activity? Probably not. The effect on temperature at the time of conception on outcomes should be largest when the temperatures are already hot. Since it rarely becomes very hot in the Kyrgyz Republic, it is understandable that the effect of temperature could be zero.

In addition, it is possible that not only do heat waves negatively affect outcomes when it is already hot, but perhaps cold snaps when it is already cold could have a similar effect on in utero selection. Thus, it may be temperature extremes which affect outcomes, not only heat waves. If this were the case, we should find a positive effect of temperature on outcomes when it is hot, and a negative effect of temperature on outcome when it is cold.[5] Therefore,

[5] If a cold snap during an already cold month causes more in utero selection similar to a heat wave during a hot month, then an increase in temperature in a cold month should ease the selective pressure, allowing more fetuses of lower quality mothers to survive, thereby causing a negative association between outcomes and temperature.

running a regression of temperature on outcomes pooling all months together in a country which at times is both very hot and very cold like the Kyrgyz Republic, could pool the negative coefficient during cold months with the positive coefficients for hot months, making the pooled effect zero.

To explore this potential further, we estimate regressions for all months individually for each of our 22 countries. In this paper, we report results for four countries representative of four different seasonal variation in temperature, since there would not be space to include all 264 regressions. However, the full set of regressions results for all countries are available upon request.

The four countries we chose were Romania (highly seasonal temperatures with mild temperature extremes), Mongolia (seasonal temperatures, with most cold temperature extremes), Uganda (low temperature seasonality with two intense rainy seasons), and Jamaica (low temperature seasonality and one mildly rainy season). Figure 1 graphically shows the estimated coefficient on temperature at the time of conception by month in Romania, including a 95% confidence interval. Consistent with our hypothesis, during the summer when it is hot in Romania, there is a positive and statistically significant effect of temperature at the time of conception on educational attainment. During the winter the effect of temperature is lower and generally not statistically different from zero. Since Romanian winters are generally mild (the average temperature in the coldest month is only -3º) we do not see a negative coefficient on positive temperature deviations during the winter.

Figure 2 shows the results for Mongolia. Mongolia's climate is very cold for the majority of the year, with two or three very hot months during the summer. The results are consistent with our hypothesis – there is a negative and statistically significant coefficient on temperature deviations at the time on conception during the very cold parts of the year, while there are positive and significant coefficients during the hot periods. This is consistent with a story of natural selection during temperature extremes.

We find similar results for Uganda. Uganda's climate is warm all year round, with the hottest month being February (23.5º) and the coldest month being July (21.4º). The year is also punctuated by two rainy seasons in

April/May and again in October/November/December. In figure 3, the coefficients on the effect of temperature at conception are generally positive and significant, with the wetter, warmer parts of the year having higher coefficient values than the dryer, cooler seasons.

Finally, figure 4 show the results for Jamaica. Jamaica's climate is much like Uganda in that it is warm year round. There is a slight rainy season in the late summer and fall, but not nearly severe as in Uganda. Just like Uganda, the coefficient is generally positive and significant. However, there does not seem to be any seasonal pattern to the coefficients – since neither temperature or precipitation in Jamaica varies dramaticially with the seasons.

Taking all of the evidence presented together, we find a strong correlation between temperature at the time of conception and educational attainment later in life. Temperature extremes at the time of conception lead to better outcomes later in life, consistent with a story of natural selection. We also find evidence of a non-linear effect of temperature on outcomes – the higher the average temperature, the stronger the effect of a deviation from that average.

We also look at the effect of temperature on different outcomes, such as literacy rates, disability, and labor market outcomes. While there is not space to detail the results here, we find similar patterns for those outcomes as well. Those results are available upon request.

3 Channels

In the previous section, we established that heat waves at the time of conception matter – children conceived during hotter weather have better outcomes. In this section, we seek to answer why this happens. We explore different channels: (1) differences in parental characteristics for children conceived during heat waves; (2) differences in sexual activity during heat waves between high and low SES women; (3) differential rates of miscarriage and stillbirth for fetuses conceived during heat waves between high and low SES women; (4) differential infant mortality by SES group based on temperature during conception; (5) changes in wantedness around the incidence of a heat wave;

and (6) other channels.

Data: The MEASURE DHS Project

In this section, in addition to census data, we use data from the Demographic and Health Surveys (DHS), Malaria Indicator Surveys (MIS), and AIDS Indicator Surveys (AIS) for countries in Sub-Saharan Africa. These surveys are large and nationally representative. DHS, MIS, and AIS are part of the MEASURE DHS project, which is partially funded by USAID. The goal of the DHS project is to monitor the population and health situations of the target countries. DHS / MIS / AIS data contain detailed information on health and preventive health behaviors for children, women, and men. Fortunately, DHS, MIS, and AIS use the same basic questions on birth history and reproductive behaviors, making comparisons between and within countries using these surveys straightforward. A detailed list of the data sets used in this analysis is provided in the appendix of the article.

DHS / MIS / AIS do not contain any information on the temperature, but they contain the region of residence of each individual. We use the regions to merge these data with the temperature data.

Parental Characteristics

A first explanation of our result on the positive correlation between temperature at conception and later life outcomes is that women who conceive during heat waves have better characteristics than women who conceive during periods of normal temperatures. Buckles and Hungerman (2013) find that there is a significant amount of seasonality in educational attainment and marital status of women. The same could be true for temperature. For example, perhaps the type of woman whose pregnancy timing is affected by heat waves are, on average, lower quality than those who plan pregnancies independent of the weather. If this were the case, we would expect to see that women who conceived during heat waves would themselves have better outcomes, such as higher educational attainment. We may also expect them to be better off in other ways, such as having better health or earning higher wages.

To test whether mothers who conceive during heat waves have different characteristics than those who don't, we first return to the census data. In the census, individuals in a household are linked, making it possible (in some cases) to determine the characteristics of parents. Specifically, we look at whether wealth, literacy rates, years of schooling, or disability rates differ between women who conceive in heat waves vs. during periods of normal temperatures. We regress each parental characteristic on our temperature variable at the time of conception of the child, along with month and region dummies. The results are reported in Tables 4 and 5. We only report the results for Spain and a combined data set for all African countries. We do this to highlight the differences between developed and developing nations. We find that educational outcomes of mothers of children who were conceived during heat waves are higher than of children conceived during normal temperatures, both for Africa and Spain. For example, we find that children born during a one-degree increase in average temperatures in Africa have mothers who are 0.23% more likely to be literate and have 0.032 additional years of schooling. In addition, we find that mother's who conceived during heat waves in Africa are 0.75% more likely to be classified as wealthy. We find similar results for Spain.

Moreover, we can also show that women who conceive during heat waves are better educated than women who conceive during normal temperatures, using the combined DHS / MIS / AIS data. Specifically, we regress a dummy for whether the mother completed secondary education on temperature variables at the time of conception of the child, region dummies, month dummies, and country*year dummies. The results are reported in Table 6. In columns (1) and (2), the temperature data come from the University of Delaware, whereas in columns (3) and (4), they come from the CRU. We find a positive and significant association between temperature at conception (i.e. temperature 9 months before birth) and the mother's secondary education.

Taken together, our findings here suggest that parental characteristics are potentially large drivers of our main results on the positive correlation between temperature at conception and later life outcomes. The questions then becomes: "why do parental characteristics differ based on a heat wave?" We explore several possible explanations below, including differential rates of sexual activity and miscarriage/stillbirth between women with high and low educational attainment during heat waves.

Sexual Activity

In this subsection, we investigate whether sexual activity during heat waves depend on socioeconomic status. There is suggestive evidence on a correlation between temperature and sexual activity. In particular, Lam and Miron (1996) show that fertility rates fall during heat waves. Their finding does not establish that sexual activity decreases during heat waves though, since their result may just mean that it is biologically harder to conceive when it is hot outside. More importantly, as far as we are aware, the previous literature does not examine whether the impact of temperature on sexual activity depends on socioeconomic status.

We first test whether heat waves affect sexual activity generally, using two different approaches. First, we look at the frequency of internet searches for a series of sexually-themed words, and how the search frequency correlates with heat waves, in Sub-Saharan Africa. The assumption is that if heat is correlated with libido, we should find that demand for other sexual activities vary with heat, such as looking at pornography online. Insomuch as the preponderance of online searches for pornography are probably made by men, this may be a good proxy for men's sexual desire which may translate into increased frequency of intercourse, and thereby more pregnancies. We show that a one standard deviation increase in temperature correlates with a 6.5% decrease in the frequency of searches for "sex," and an 8.6% decrease in the frequency of searches for the broader set of sexually-themed words. These results are available upon request.

Second, we use the DHS / MIS / AIS surveys to examine whether heat waves have an influence on sexual activity and whether this influence varies with education. The surveys ask women ages 15-49 whether they were sexually active in the four weeks preceding the interview. In contrast with our first approach, the sexual activity variable is thus reported by women and may be less objective. We regress a dummy for whether a woman was sexually active on the temperature deviations at the time of the interview, a dummy for whether a woman had completed primary education, and another for completing secondary education, the interaction between education and temperature, region dummies, month dummies, and country*year dummies. Because the interview is done on any day of the month, the four weeks preceding the interview correspond to the interview month and the last week(s) of the month preceding the month of the interview. For this reason, the temperature deviations variables are either the temperature deviations of the month of the interview and the temperature deviations of the month before the interview separately, or the average temperature deviation over the two months. We find that sexual activity declines with temperature. For instance, in column (1), a one point increase in temperature deviation reduces the likelihood of a woman reporting being sexually active in the last four weeks by 0.29 percentage points. When we test whether the decrease in sexual activity depends on socioeconomic status in column (3), we find clear evidence that sexual activity decreases less for women with secondary education than for women with primary education, and less for women with primary education compared to those with no education. As a result, we conclude that differential sexual activity may be one factor driving the differences in parental characteristics of the cohort born nine months after a heat wave.

Terminated Pregnancies

The positive correlation between temperature at conception and later life outcomes could also be due to differential fetal losses. When they investigate the decline in fertility nine month after a heat wave, Lam et al (1994) show that that fetal loss is a main driver of the reduction in fertility. If elevated temperatures at the time of conception constitutes a health shock to the fetus which causes fetal loss, this could be correlated with outcomes later in life in two ways. First, if weaker fetuses are more likely to die in utero due to a temperature shock, then the stronger, healthier fetuses are more likely to survive. These fittest individuals are likely to be more educated and healthier in adulthood. Second, controlling for the biological strength of the fetus itself, fetus of better educated, higher income or healthier women may be more likely to survive an adverse temperature shock in utero. Both of these mechanisms are likely to increase the fraction of children with better characteristics, either because they are inherently stronger or because they have parents with better characteristics.

We are primarily interested in stillbirth and miscarriage. We cannot use data from the IPUMS censuses because they do not contain informaion on these events. Instead, we use the DHS / AIS / MIS data, with the limitation that the data contain information on "terminated pregnancies" (that includes stillbirth, miscarriage and induced abortion) and that it is not possible to distinguish stillbirth and miscarriage from induced abortion. For this reason, our results are only indicative.

First, we test whether fetuses which are conceived during heat waves are more likely to die in utero. Specifically, we regress a dummy variable for a terminated pregnancy, on the temperature deviation in the first Month the woman Reported being Pregnant (MRP) with the child, as well as the temperature deviations one, two and three months before ("Temp at MRP -1, 2 and 3"). The results are reported in Table 10. We find that there is no effect of temperature on termination.

Second, we examine whether the effect of temperature on terminated pregnancies is different for women with different educational levels. In column (3), we expand the regression to include dummies for educational attainment, and the interaction of education with temperature. We find that women with a higher education level are more likely to have a terminated pregnancy. This results could be driven by induced abortion, since the previous literature highlights a positive correlation between socioeconomic status and induced abortion in several countries in Sub-Saharan Africa (see Stockl et al., 2012, for

Tanzania, and Guttmacher Institute, 2013, for Ghana).

More importantly for our story, however, the interactions between temperature and the education dummies are both negative and significant. This implies that in our data, women who are educated are less likely to have a terminated pregnancy when the child is conceived during a heat wave. Consequently, we find some evidence for in-utero fetal selection, which could drive our results on parental characteristics – the children of the education are less likely to be terminated based on a heat wave at the time of conception.

Infant Mortality

It is also possible that the positive correlation between heat waves at conception and later life outcome is due to some selection that occurs after birth. For example, if a heat wave at the time of conception constitutes a negative health shock to the fetus, some fetuses could be weakened and be more likely to die after birth. As a consequence, only the fittest would survive, which would why their outcomes later in life are better (on average) than those of individuals conceived under normal temperatures.

We test this hypothesis by examining the effect of heat waves at conception on infant mortality. Using the birth history from DHS / MIS / AIS data, we restrict our sample to children born during the year preceding the interview. Note that these children are either alive or dead at the time of the interview. We regress a dummy for whether the child is dead at the time of the interview, on temperature at birth and during the 12 months preceding birth. We control for region fixed effect and a series of month birth dummies.

The data indicate in which region the household lives at the time of the interview, but they do not contain information on the migration history of households, so that it is not possible to know in which region the children (who were born during the 12 months preceding the interview) were conceived. This is problematic because the region of residence is the variable we use to merge the DHS / MIS / AIS data with the temperature data. In our analysis, we assume that children who are born in the year preceding the interview were conceived in the same region where the household lives at the time of the interview. For children who were not conceived in the same region where their family lives at the time of the interview, the temperature variables are thus wrong.

The results are reported in Table 11. We find no evidence that once children are born, they are more likely to die if they were conceived during a heat wave, compared with children conceived during periods of normal temperatures. This result suggests that the selection of children based on parental characteristics may only occur in utero. The models only include controls for the temperature before conception, as a falsification test. As expected, the results indicate no correlation between temperature before conception and death in infancy.

Wantedness

The correlation between heat waves at conception and later life outcomes could also arise because of the omission of a common hidden factor like wantedness. It is unlikely that planned pregnancies are planned around the incidence of a heat wave. Therefore, if sexual activity varies with heat, it is likely that any reductions in fertility due to increased temperature are due to reductions in unplanned or mistimed pregnancies. We thus want to test whether children conceived during heat waves are more likely to be wanted.

We test this hypothesis in two different ways, using the combined DHS / MIS / AIS data. First, we directly use information on reported wantedness. Specifically, the surveys ask whether the most recent birth was wanted, wanted but mistimed, or unwanted. We regress a dummy for being wanted (either wanted at the time of conception, or wanted but mistimed) on our variable for heat waves and a series of region and month fixed effects. The results, which are reported in Table 12, suggest that the probability a woman will report a child as wanted is not different for children conceived in a heat wave compared with children conceived during normal temperatures. For robustness, we use an alternative dependent variable (a dummy for being wanted at the time of conception or later, versus not being wanted) and run a similar regression. The results (not reported but available upon request) support our previous findings on the absence of correlation between temperatures and wantedness. However, these results must be interpreted with caution since there is possibly a large amount of misreporting of wanted status in the data, given the fact that the wantedness question was asked after the birth of the child already occurred.

Second, we use information on birth spacing. Birth spacing may be smaller for children who are mistimed or unwanted, since they will be conceived before a woman would optimally space her children. We again use the combined DHS / MIS / AIS surveys for all of Sub-Saharan Africa to test this hypothesis. The results (not reported but available upon request) do not provide any evidence that children conceived during heat waves are spaced longer than children conceived during periods of normal temperatures. Consequently, our tests do not provide any evidence that child intendness differs based on the incidence of a heat wave at the time of conception.

Other Channels

A few additional theories of how temperature at conception may affect outcomes are worth mentioning.

First, one may think that heat waves may be correlated with income. For example, heat waves may affect the agricultural productivity of a region, which in turn could affect income, especially in developing countries. If heat waves at conception are correlated with parental income at conception, then there could be a differential effect on maternal nutrition and health, leading to different in utero conditions for the fetus and thereby affect later life outcomes.

If this were the case, then we would expect heat waves in the months preceding conception to also affect outcomes. Since income can be smoothed, an income shock before conception would affect consumption at the time of conception as well. Since we find no effect of heat waves before conception, we conclude that heat's affect on income is not the main driver of our results.

Second, if Lam and Miron (1996) find that heat waves reduce fertility, this implies that cohort sizes of children conceived during heat waves are smaller. These smaller cohorts could lead to higher educational attainment (due to smaller class sizes and higher investments per child, for example), and higher wages in the labor market since labor supply in the cohort is smaller.

While we cannot strictly rule out this effect, it seems implausible as the main driver of the effects we find for three reasons. First, the heat waves in this study are monthly deviations, which is too short of a time frame to significantly alter the demographic structure of society. For example, a small monthly cohort conceived during a heat wave would be put into the same school class as eleven other month cohorts, some of which would be born during normal temperatures and some born during below average temperatures. It is hard to believe that monthly temperature deviations would significantly alter the size of an annual school class. Second, the magnitudes of the fertility effect from Lam and Miron are much too small to significantly alter cohort size. Finally, labor is highly substitutable between cohorts, meaning we should not expect to find a significant difference in wages simply due to reduced labor supply in one monthly cohort.

4 Conclusion

Using Census data from 22 countries and weather data from the University of Delaware, we have shown that temperature extremes at the time of conception are correlated with better outcomes later in life. In addition, using a large combined data set of African DHS, AIS, and MIS data, we have provided evidence that the behavioral selection of lower quality mothers out of conception during heat waves is an important driver of these results, rather than purely biological or other channels. Additionally, we find that in-utero selection may explain the results as well. Women who conceive during heat waves have a higher likelihood of having the pregnancy terminate before birth, and that likelihood is greater for women with lower education levels. We have also shown that sexual activity decreases in heat waves, and that those decreases are disproportionately large for lower income individuals.

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Figure 1: Romania by Month – Years of Education

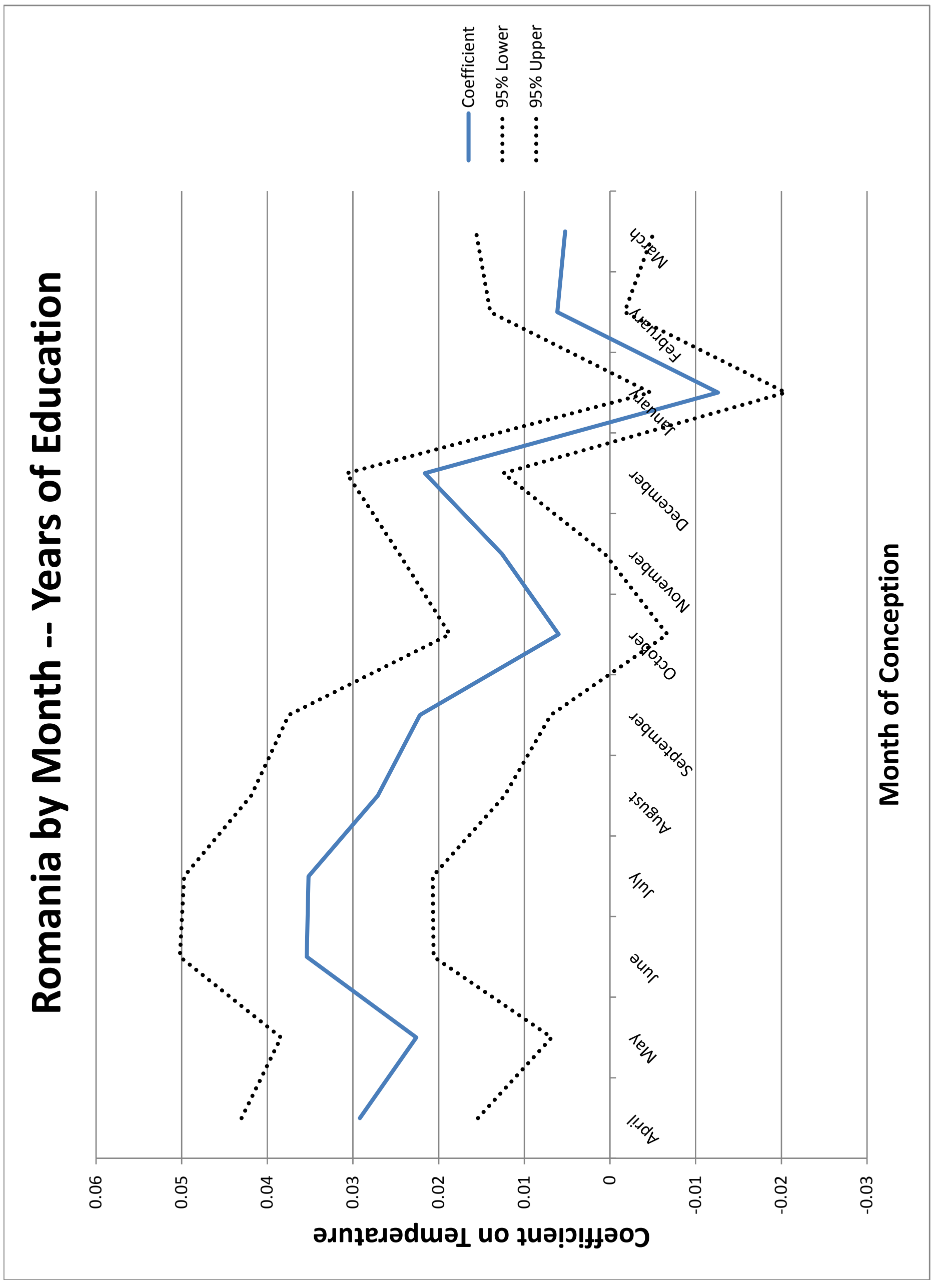

Figure 2: Mongolia by Month – Years of Education

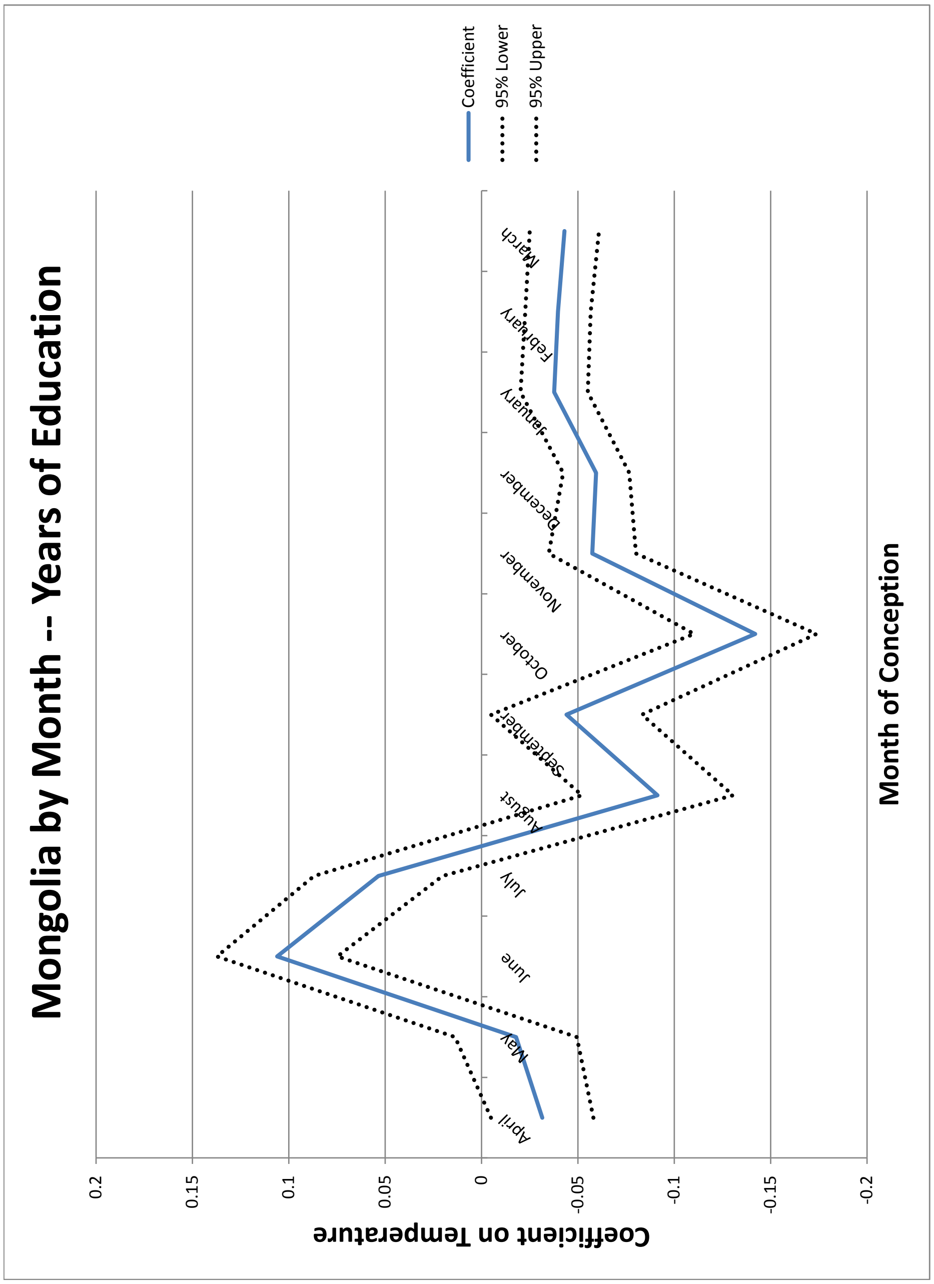

Figure 3: Uganda by Month – Years of Education

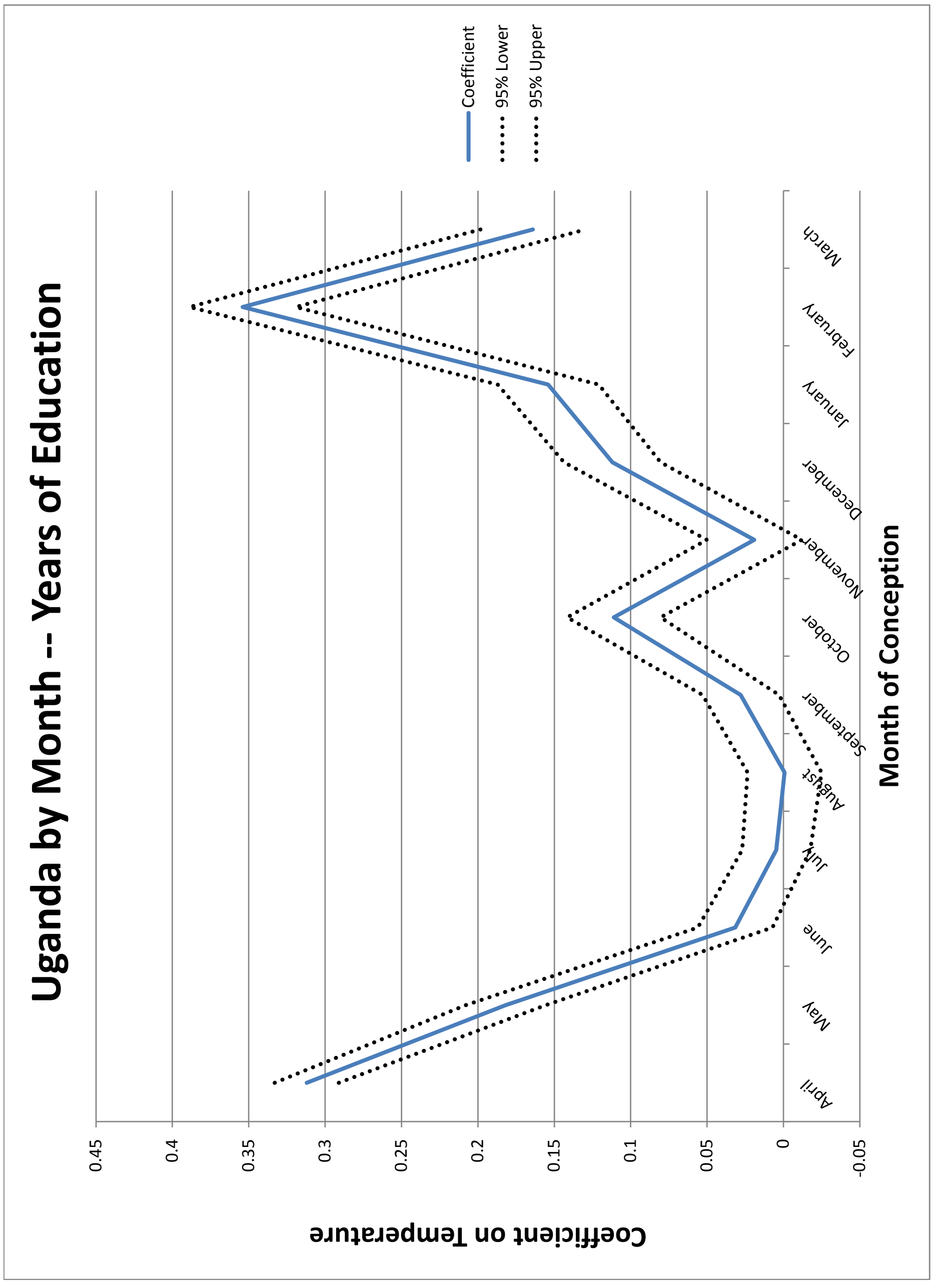

Figure 4: Jamaica by Month – Years of Education

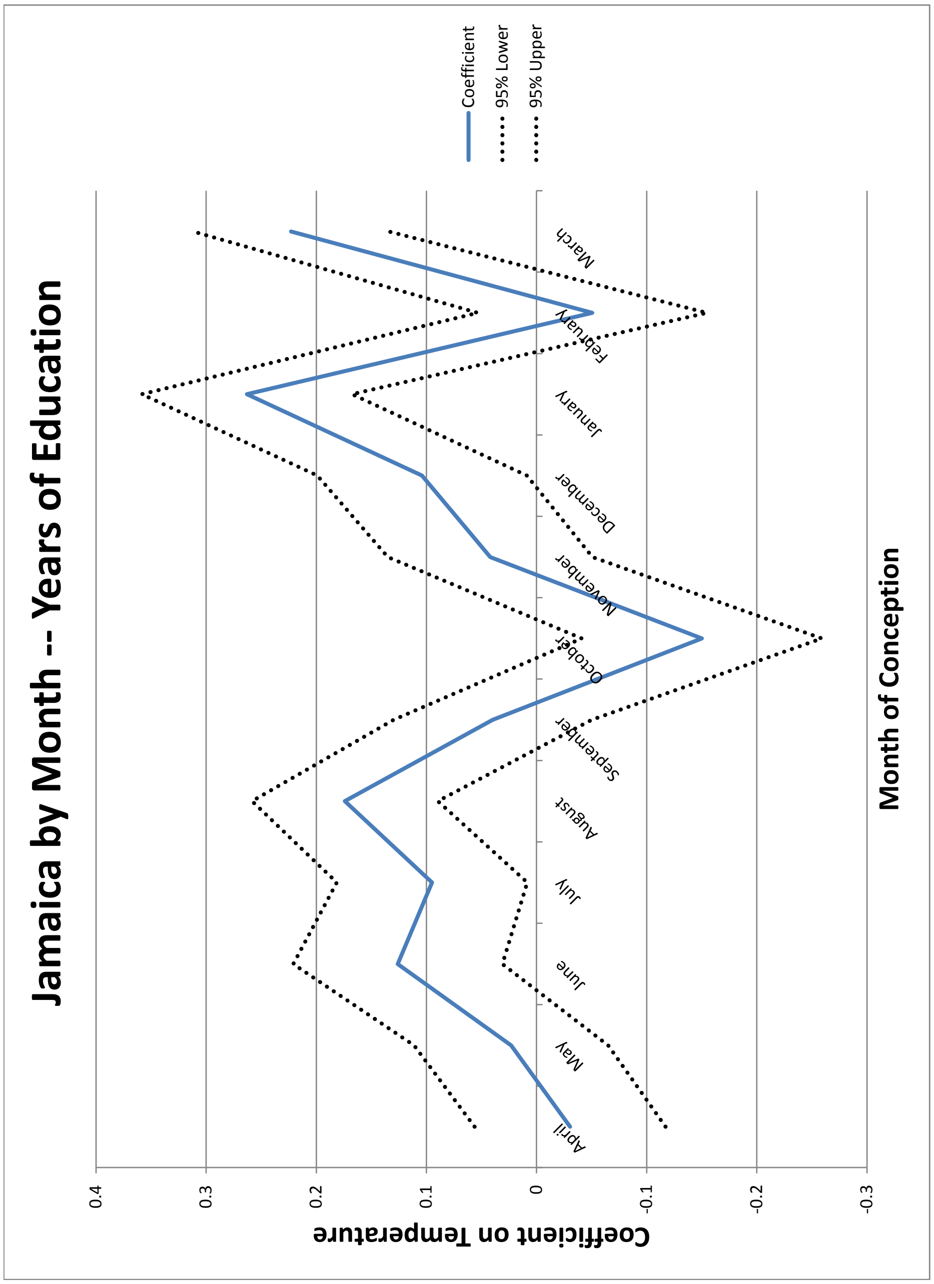

Table 1: List of Surveys from the DHS / MIS / AIS

Country	Survey and Year
Angola	MIS/2006-07, MIS/2011
Benin	DHS/2001, DHS/2006
Burkina Faso	DHS/1998-99, DHS/2003
Burundi	DHS/2010
Cameroon	DHS/2004
Chad	DHS/2004
Congo Democratic Republic	DHS/2007
Côte d'Ivoire	AIS/2005
Ethiopia	DHS/2005, DHS/2011
Ghana	DHS/1998-99, DHS/2003, DHS/2008
Guinea	DHS/1999, DHS/2005
Kenya	DHS/2003, DHS/2008-09
Lesotho	DHS/2004-05, DHS/2009-10
Liberia	DHS/2006-07, MIS/2008-09, MIS/2011
Madagascar	DHS/2003-04, DHS/2008-09, MIS/2011
Malawi	DHS/2000, DHS/2004-05, MIS/2010
Mali	DHS/2001, DHS/2006
Mozambique	DHS/2003-04
Namibia	DHS/2000, DHS/2006-07
Niger	DHS/2006
Nigeria	DHS/1999, DHS/2003, DHS/2008, MIS/2010
Rwanda	DHS/2000, DHS/2005, DHS-Intermediate/2007-08, DHS-Special/2010
Senegal	DHS/2005, MIS/2006, MIS/2008-09, DHS/2010-11
Sierra Leone	DHS/2008
Swaziland	DHS/2006-07
Tanzania	DHS/1999, DHS/2004-05, AIS/2007-08, DHS/2009-10
Uganda	DHS/2000-01, DHS/2006, MIS/2009-10
Zambia	DHS/2001-02, DHS/2007
Zimbabwe	DHS/1999, DHS/2005-06, DHS/2010-11

Table 2: Temperature and Years of Education – Jamaica

	(1)	(2)
Dependent variable	Years of schooling	Years of schooling
Temperature Data	Delaware	Delaware
Temperature at birth -12	0.0259	
	(0.00160)	
Temperature at birth -11	0.0219	
	(0.00162)	
Temperature at birth -10	0.0232	
	(0.00162)	
Temperature at birth -9	0.0404**	0.1080***
	(0.00163)	(0.0143)
Temperature at birth -8	0.0381**	
	(0.00165)	
Temperature at birth -7	0.0497***	
	(0.0164)	
Temperature at birth -6	-0.0076	
	(0.0163)	
Temperature at birth -5	0.0204	
	(0.0162)	
Observations	324,154	324,223
R-squared	0.287	0.286

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 3: Temperature and Years of Education – Kyrgyz Republic

	(1)	(2)
Dependent variable	Years of schooling	Years of schooling
Temperature Data	Delaware	Delaware
Temperature at birth -12	-0.00342	
	(0.00886)	
Temperature at birth -11	0.00917	
	(0.00895)	
Temperature at birth -10	0.00528	
	(0.00906)	
Temperature at birth -9	-0.00104	-0.00387
	(0.00920)	(0.00875)
Temperature at birth -8	-0.00468	
	(0.00905)	
Temperature at birth -7	0.01560*	
	(0.00900)	
Temperature at birth -6	0.01390	
	(0.00887)	
Temperature at birth -5	0.01220	
	(0.00885)	
Observations	37,378	37,378
R-squared	0.448	0.448

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 4: Temperature and Parental Characteristics in the Census – Africa

	(1)	(2)	(3)	(4)
Dependent variable	Mother is wealthy	Mother's years of schooling	Mother's literacy	Mother is not disabled
Temperature data	Delaware	Delaware	Delaware	Delaware
Temp. at birth - 9	0.0075**	0.0322**	0.0023**	0.0017***
	(0.0029)	(0.0163)	(0.0011)	(0.0005)
Constant	0.365***	2.603***	1.414***	1.970***
	(0.0077)	(0.0656)	(0.0051)	(0.0022)
Observations	48,388	176,823	176,823	176,823
R-squared	0.242	0.086	0.100	0.008

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 5: Temperature and Parental Characteristics in the Census – Spain

	Mother's years of schooling	Mother's literacy
Temp. at birth - 9	0.209***	0.0016***
	(0.0034)	(0.0001)
Constant	8.330***	1.973***
	(0.0615)	(0.0028)
Observations	548,722	548,992
R-squared	0.031	0.005

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 6: Temperature and Parental Characteristics in the DHS / MIS / AIS

	(1)	(2)	(3)	(4)
Dependent variable	Secondary education	Secondary education	Secondary education	Secondary education
Temperature data	Delaware	Delaware	CRU	CRU
Temperature at birth -12	-0.0011		0.0036**	
	(0.0014)		(0.0015)	
Temperature at birth -11	0.0002		-0.0005	
	(0.0014)		(0.0015)	
Temperature at birth -10	0.0036**		0.0008	
	(0.0014)		(0.0015)	
Temperature at birth -9	0.00361**	0.0059***	0.0042***	0.0067***
	(0.0014)	(0.0013)	(0.0015)	(0.0014)
Temperature at birth -8	-7.51e-05		0.0029*	
	(0.0014)		(0.0015)	
Temperature at birth -7	0.0021		0.0035**	
	(0.0014)		(0.0015)	
Temperature at birth -6	-0.0012		0.0011	
	(0.0014)		(0.0015)	
Temperature at birth -5	0.00505***		-0.0014	
	(0.0014)		(0.0015)	
Temperature at birth -4	-0.0004		0.0036**	
	(0.0014)		(0.0015)	
Temperature at birth -3	-0.0012		0.0007	
	(0.0014)		(0.0015)	
Temperature at birth -2	-0.0005		0.0016	
	(0.0014)		(0.00156)	
Temperature at birth -1	0.0041***		-0.0017	
	(0.0014)		(0.0015)	
Temperature at birth	0.0003		0.0037**	
	(0.0013)		(0.0015)	
Observations	104,722	109,082	104,722	109,082
R-squared	0.229	0.223	0.229	0.223

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 7: Heat Waves and Outcomes, Controlling for Parental Characteristics – Africa

	Ed. Attain.	Literacy
Temp. at birth - 9	0.0102**	0.0039***
	(0.0044)	(0.0014)
Constant	1.577***	0.741***
	(0.0438)	(0.0214)
Observations	95,012	49,027
R-squared	0.444	0.241

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 8: Heat Waves and Outcomes, Controlling for Parental Characteristics – Spain

	Ed. Attain.	Literacy
Temp. at birth - 9	0.0005	3.20e-05
	(0.0023)	(0.0001)
Constant	-1.051***	0.834***
	(0.0652)	(0.0062)
Observations	546,530	546,495
R-squared	0.656	0.894

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.

Table 9: Temperature and Sexual Activity in the DHS / MIS / AIS

	(1)	(2)	(3)
Dependent variable	Sexual activity	Sexual activity	Sexual activity
Temperature data	CRU	CRU	CRU
Primary edu			0.0042**
			(0.0021)
Secondary edu			-0.0489***
			(0.0024)
Temperature the month before the interview	3.33e-06		
	(0.0013)		
Temperature the month of the interview	-0.0029**		
	(0.0013)		
Average temperature over the 2 months		-0.0029	-0.0072**
		(0.0019)	(0.0029)
Primary education * Average temperature			-0.0017
			(0.0035)
Secondary education * Average temperature			0.0203***
			(0.0042)
Observations	358,371	358,371	356,910
R-squared	0.039	0.039	0.041

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of interview fixed effects

Table 10: Temperature and Terminated Pregnancies in the DHS / MIS / AIS

	(1)	(2)	(3)
Dependent variable	Termination	Termination	Termination
Temperature data	CRU	CRU	CRU
Primary edu			0.0035*
			(0.0019)
Secondary edu			0.0045*
			(0.0024)
MRP - 3	0.0013		
	(0.0010)		
MRP - 2	8.69e-05		
	(0.0010)		
MRP - 1	-0.0001		
	(0.0010)		
MRP	0.0004	0.0003	0.0049***
	(0.0010)	(0.0009)	(0.0016)
Primary edu * MRP			-0.0069***
			(0.0021)
Secondary edu * MRP			-0.0067**
			(0.0026)
Observations	78,766	78,766	78,425
R-squared	0.009	0.009	0.009

Notes. "MRP" is the Month when the woman Reports being Pregnant. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month when reports pregnant fixed effects.

Table 11: Temperature and Mortality in Early Childhood in the DHS / MIS / AIS

	(1)	(2)	(3)	(4)
Dependent variable	Death	Death	Death	Death
Temperature data	Delaware	Delaware	CRU	CRU
Temperature at birth -12	-0.0002		-0.0009	
	(0.0010)		(0.0010)	
Temperature at birth -11	-0.0004		-0.0002	
	(0.0010)		(0.00108)	
Temperature at birth -10	-0.0006		0.0007	
	(0.0010)		(0.0010)	
Temperature at birth -9	-0.0014	-0.0016*	-0.0010	-0.0011
	(0.0010)	(0.0009)	(0.0010)	(0.0009)
Temperature at birth -8	-0.0003		-0.0009	
	(0.0010)		(0.0010)	
Temperature at birth -7	-0.0021**		-0.0027**	
	(0.0010)		(0.0010)	
Temperature at birth -6	0.0016		-0.0016	
	(0.0010)		(0.0010)	
Temperature at birth -5	-0.0006		0.0006	
	(0.0010)		(0.0010)	
Temperature at birth -4	0.0006		0.0003	
	(0.0010)		(0.0011)	
Temperature at birth -3	0.0009		-0.0004	
	(0.0010)		(0.0011)	
Temperature at birth -2	-0.0005		0.0012	
	(0.0010)		(0.0011)	
Temperature at birth -1	0.0009		0.0003	
	(0.0010)		(0.00109)	
Temperature at birth	-0.0009		0.0004	
	(0.0009)		(0.0010)	
Observations	105,119	109,492	105,119	109,492
R-squared	0.008	0.008	0.008	0.008

Notes. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions include region, year, and month of conception fixed effects.

Table 12: Temperature and Wantedness in the DHS / MIS / AIS

Dependent variable	(1) Wanted then vs. later or no more	(2) Wanted then vs. later or no more	(3) Wanted then or later vs. no more	(4) Wanted then or later vs. no more
Temperature at birth -12	-0.00173		0.00015	
	(0.00160)		(0.00106)	
Temperature at birth -11	0.00068		-0.00059	
	(0.00162)		(0.00107)	
Temperature at birth -10	0.00075		0.00142	
	(0.00160)		(0.00106)	
Temperature at birth -9	0.00026	0.00020	0.00066	0.00091
	(0.00163)	(0.00152)	(0.00108)	(0.00101)
Temperature at birth -8	-0.00090		0.00105	
	(0.00163)		(0.00108)	
Temperature at birth -7	-0.00162		-0.00044	
	(0.00162)		(0.00108)	
Temperature at birth -6	0.00016		0.00167	
	(0.00162)		(0.00108)	
Temperature at birth -5	-0.00220		-0.00021	
	(0.00164)		(0.00109)	
Temperature at birth -4	-0.00203		0.00118	
	(0.00164)		(0.00109)	
Temperature at birth -3	-0.00003		0.00083	
	(0.00164)		(0.00109)	
Temperature at birth -2	0.00155		0.00066	
	(0.00163)		(0.00108)	
Temperature at birth -1	-0.00459***		-0.00206*	
	(0.00163)		(0.00108)	
Temperature at birth	0.00062		0.00121	
	(0.00162)		(0.00107)	
Observations	158,394	160,846	158,394	160,846
R-squared	0.114	0.114	0.098	0.099

Notes. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include region, year and month of birth fixed effects.