TOO HOT TO HANDLE: THE EFFECTS OF HIGH TEMPERATURES DURING PREGNANCY ON ENDOWMENT AND ADULT WELFARE OUTCOMES

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Declaration

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.

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Contents

Summary

This thesis is co-authored with my classmate Teng Li. We examine the effects of high temperatures during pregnancy on birth weight and later outcomes for rural Chinese. Exposure to hot weather causes lower birth weight, and, in adulthood, non-negligible adverse effects on educational attainment, cognitive abilities, and height. Under the assumption of no adaptation and avoidance behaviour Back-of-the-envelope predictions suggest that by the end of the 21st century, newborns on average will weigh 10-50 grams less, and losses in education years and height will be 0.10-0.40 years and 0.14-0.55 cm, respectively. We also find that the adverse effects of high temperatures are more likely to be consistent with physiological effects than income effects.

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1 Introduction

The rise in of greenhouse gas concentrations caused by anthropogenic emissions is associated with global warming. By the end of the 21st century, average global temperatures are expected to be 0.5°F to 8.6°F higher than 2000 levels (Intergovernmental Panel on Climate Change 2013).[1] Estimating the costs related to climate change is of great importance for policy makers who seek to design rational climate-change-mitigation policies.

A developing literature in economics finds that hot weather during pregnancy causes negative effects on birth outcomes (Deschenes, Greenstone and Guryan 2009; Barreca, Deschenes and Guldi 2015). Barker's fetal origins hypothesis (Barker 1995) suggests that early life conditions may have persistent and profound effects on later outcomes. For instance, using the Islamic holy month of Ramadan as an exogenous shock, Almond and Mazumder (2011) and Almond, Mazumder and Ewijk (2015) find that restricted maternal nutrition has negative effects on their children's health status and academic performance. Nilsson (2014) shows that as alcohol availability increases, prenatally exposed children have worse labor market outcomes and lower educational attainment. An important question that has yet to be answered is whether the adverse effects of hot weather during the prenatal period on birth outcomes are further related to adult welfare outcomes, and to what extent. To fill this gap, in this study we examine the effects of high temperatures on

[1]Based on predicted data by the National Aeronautics and Space Administration (NASA), Figure 1 displays a vivid example, which contrasts the global daily maximum near-surface air temperature on the 1 July 2000 (panel a) and 2100 (panel b). It shows that in 2100 the high temperatures in some places (e.g., North Africa and Arabian Peninsula) could approach 320 K (around 116°F), assuming that greenhouse gas emissions will peak around 2100.

educational attainment, cognitive abilities, height, and annual income for Chinese individuals born in rural areas between 1950 and 1994.[2]

Combining individual characteristics from the China Family Panel Studies (CFPS) with weather information, we find that hot weather during pregnancy triggers significant reductions in adult welfare in multiple dimensions. Specifically, adults who experienced one standard deviation more high-temperature days (around 34 days) during the prenatal period attain 0.29 fewer years of schooling, are 7.59% and 4.83% standard deviations lower for word- and math-test scores, respectively, and are 0.40 cm shorter.[3] In addition, the impacts seem to be concentrated in the second trimester. High temperatures in the first and third trimester do not have statistically significant effects. Furthermore, we find a large effect on birth weight for high temperatures during pregnancy. A one standard deviation increase in the number of high-temperature days (around 34 days) leads to a loss of 73.86 grams of birth weight (12.35% standard deviation). Given the strong relationship between birth weight and children's development and adult outcomes (e.g., Figlio et al. 2014 and Behrman and Rosenzweig 2004), this finding suggests that the adverse high-temperature effect on birth weight could be the channel for high-temperature effects on adult outcomes.

Such effects, however, have not been taken into account when calculating the costs of global warming. Based on climate projections provided by the National Aeronautics and

[2] Weather information pre-1950 is not available.

[3] We also find that the effect of high temperatures during the gestational period on personal annual income is negative but not precisely estimated.

Space Administration (NASA), we perform back-of-the-envelope predictions for birth- and adult outcomes of individuals born in rural areas of China in 2100. Compared to those born in 2000, *ceteris paribus*, babies born at the end of the 21st century will weigh 10-50 grams less on average. Further, in adulthood the losses in educational attainment and height will be 0.10-0.40 years and 0.14-0.55 cm, respectively.[4]

We propose two hypotheses that may explain why hot weather affects birth outcomes. The first draws on evidence from medical research (see Strand, Barnett and Tong 2011 for a detailed review). Due to the extra physical strain, a pregnant woman is more susceptible to ambient heat stress. By influencing the physical health conditions of pregnant women, high temperatures play an important role in fetal size and development.[5] Moreover, Berry, Bowen and Kjellstrom (2010) argue that high temperatures could affect mental health directly by exposing people to trauma or indirectly by physical health. Above a threshold of 26.7°C (around 80°F), Hansen et al. (2008) observe a positive relationship between temperature and hospital admissions for mental and behavioral disorders. Economists recently show a few pieces of evidence that parental mental problems could cause low birth weight, e.g., Duncan, Mansour and Rees (2016), Mansour and Rees (2012), and Persson and Rossin-Slater (2016).

Another possibility, referred to as the income effect, is that high temperatures affect household resources and nutrition for pregnant women by influencing crop yields—the

[4]Magnitudes are based on the point at which greenhouse gas emissions will peak. For the lower bound, we assume that greenhouse gas emissions will peak at 2040, while for the upper bound greenhouse gas emissions will peak at the end of the 21st century.

[5]For details, see discussion section.

main income source in rural areas (Hollinger and Angel 2009; Schlenker and Roberts 2009; Burgess et al. 2011). For instance, Schlenker and Roberts (2009) find that temperatures above about 85°F cause damages to corn and soybeans yields. Distinguishing the two possible channels is crucial for policy implications. Two pieces of evidence suggest that income effects are unlikely to be driving our results. First, areas with high proportions of heat-tolerant crops (corn and sugarcane) do not significantly mitigate estimated temperature sensitivity during pregnancy. Second, simultaneously controlling for weather conditions during (a) the last year growing season before birth and (b) the prenatal period, we find that the former has no significant effects on birth weight or adult outcomes.

The current study contributes to the literature in several ways. First, our paper provides the first evidence for the long-term persistent effects of high temperatures during the prenatal period on adult outcomes, along with two working papers by Carrillo, Fishman and Russ (2015) and Isen, Rossin-Slater and Walker (2015). Deschenes, Greenstone and Guryan (2009) use data from 49 states in the U.S. and find that exposure to days above 85°F during pregnancy has a moderate negative effect on birth weight. Whether the effect is further related to adult outcomes (e.g., human capital, physical conditions, etc.), as the authors claim, is an important—but unanswered—question. Using a developing country context—China, our study shows that adults' educational attainment, word- and math-test scores, and height are negatively affected by hot weather in *utero*.

Evaluating the adverse impacts of hot weather is highly relevant in China, especially for about 600 million rural residents, because they in those areas have limited access to avoidance behaviors such as air conditioners (Brooks, Adger and Kelly 2005; Feng, Krueger and Oppenheimer 2010). For instance, as late as 2009, each household in rural China owned only 0.12 air conditioning units (China Statistical Yearbook 2010). In contrast, around 87% households in the United States were equipped with at least one air conditioning unit in 2004 (Barreca et al. 2016). The limited access to avoidance behaviors may amplify the impacts of high temperatures in rural China.

To compare, Isen, Rossin-Slater and Walker (2015) employ the U.S. data and find that hot weather during pregnancy reduces annual income but does not affect educational attainment. Another study by Carrillo, Fishman and Russ (2015) shows that 1°C increase in average temperature during pregnancy reduces income and education attainment in Ecuador. Additionally, besides educational attainment and income, we also examine the effects of high temperatures on more dimensions of adult outcomes, including cognitive abilities and physical conditions. Furthermore, our study provides a detailed discussion of the potential mechanisms that explain why hot weather affects birth outcomes. Several pieces of evidence support that income effects are not the key channel.

Second, our study contributes to a growing literature which studies the relationships between early life conditions and later outcomes (see Currie and Almond 2011 for a comprehensive review). Several influential studies have examined the consequences of early life shocks, such as the influenza pandemic (Almond 2006), Chernobyl disaster (Almond, Edlund and Palme 2009), and hurricanes (Currie and Rossin-Slater 2013), and find that such shocks have persistent and profound effects on well-being in later life.

The unusual nature of these events, however, raises concern about the generalizability (Maccini and Yang 2009; Almond and Mazumder 2011). Recent studies start to examine the effects of typical events in early life, such as rainfall (Maccini and Yang 2009), alcohol availability (Nilsson 2014), and nutrition restriction caused by Ramadan (Almond and Mazumder 2011). We complement this strand of literature by investigating the effects of high temperatures during pregnancy—another typical variation in early life—on birth weight and later outcomes.

Lastly, from a broader perspective, our findings may add to the literature that explains the positive correlation between latitude and economic development. Many scholars have found convincing evidence that economic activities are correlated with geography indirectly through historical channels (see Wacziarg and Spolaore 2013 for a review). Some studies, however, show alternative direct explanations for such phenomena, e.g., a high burden of disease (Sachs and Malaney 2002) and the pests and parasites that thrive in hot climates (Masters and McMillan 2001). Based on our findings, we may provide another explanation, i.e., high temperatures affect newborn endowment, and further human capital, which is crucial for economic development (Romer 1986).

Section 2 describes our data and variable definitions. Section 3 introduces the econometric approach. Section 4 presents the main findings, while Section 5 discusses the possible channels behind the impacts, implements robustness checks, and predicts the effects of global warming. We conclude in Section 6.

2 Data and descriptive analysis

2.1 Data source

Welfare outcomes and birth weight. Our major source of data on adult outcomes is the China Family Panel Studies (CFPS) 2010, a nationally representative, annual longitudinal survey of Chinese communities, families, and individuals.[6] The studies were launched in 2010 by the Institute of Social Science Survey (ISSS) of Peking University and cover 25 provinces that represent 95% of the total population of China (Xie 2012).[7]

Many adult outcomes are included in the survey—e.g., years of schooling, word- and math-test scores, height, and annual income. In specific, the interviewers investigate individuals' education levels, which consist of eight categories, i.e., illiterate/semi-illiterate, primary school, junior middle school, senior middle school, junior college, college, master's degree, and doctoral degree. The year of schooling is then imputed on the basis of the education levels by the survey. The two test scores—word- and math-test scores—reflect individuals' cognitive abilities. In the word and math tests designed by the CFPS, respondents are required to read as many Chinese characters as possible and to solve basic math questions, including arithmetic operation, exponents, logarithms, permutation and combination, etc.[8] For the sake of interpretation, the scores have been standardized in our

[6]The CFPS is a biennial survey, designed to be complementary to the Panel Study of Income Dynamics (PSID) in the United States.

[7]The 25 provinces are Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, and Gansu. Figure A.1 in the appendix shows their geographic distribution.

[8]See the CFPS (2010) user's manual for a detailed description.

empirical analyses. Height reflects individuals' physical conditions. The annual income is the interviewees' total personal income in 2010.[9]

The data set provides ample information on demographic status as well, such as date of birth (month and year), gender, race, county of birth, birth order, number of siblings, and parental characteristics—e.g., age, educational attainment, etc. Based on the date of birth, we define each individual's prenatal period as nine months before the birth, or around 270 days in total.[10] The whole period is typically divided into three trimesters. Socio-economic information may help us capture family heterogeneity across different areas with different climates.[11]

In addition, relying on interviewees' own birth weight data, we examine the channel for high-temperature effects on adult outcomes. During the survey, interviewees were required to report their own birth weight if they remembered. It is a custom in China that doctors tell the parents their newborn's birth weight. Thus people could know their own birth weight from their parents. In the data set, a limitation is that only one third of the interviewees remembered their birth weight. We then examine the correlations between birth-weight-missing indicator and demographic status. It shows that individuals whose

[9] In our sample, there are many cases that several members in one family are all agricultural workers. Therefore, it is difficult to measure the personal income precisely. We acknowledge this problem and treat our findings about the effects on personal income as only suggestive evidence.

[10] The prenatal period is inevitably measured with error, as the exact birthdate and gestational length are not available. The nine-month gestation period is supported by Deschenes, Greenstone and Guryan (2009). In addition, Patel et al. (2004) find that the median gestational age at delivery is about nine months in Asians. But we acknowledge that high temperatures could also increase the probability of preterm birth (Schifano et al. 2013). To check the sensitivity of our results to the defined gestational length, we switch the nine-month period to eight months in regressions. Table A.1 presents the effects of high-temperature days during the eight months before birth, and we note that most estimates remain stable.

[11] For instance, Buckles and Hungerman (2013) find that the relationship between season of birth and later outcomes is driven by maternal characteristics.

parents are better educated have a higher probability to remember their birth weight. This implies that the adverse effects of high temperatures during pregnancy on birth weight may be underestimated in this study, because the effects are likely to be larger for individuals with worse family background.[12]

Weather data. Weather data are from the China Meteorological Administration and the National Oceanic and Atmospheric Administration (NOAA) and include 1,509 different weather stations across China. The data set contains daily maximum and minimum temperature and precipitation. High-temperature days are defined as the number of days with daily maximum temperatures higher than 85°F.[13] To ensure the accuracy of the weather readings, our key variable is defined as the average of the number of high-temperature days of all the weather stations whose distance to the county's centroid are less than 80km and that do not vary in elevation by more than 200 meters. Using alternative distance thresholds, such as 60 km and 100 km, does not change our main results.[14] Hereafter, we refer simply to "high-temperature" or "hot-weather" days. In our sample, a representative rural pregnant woman is exposed to about 48 hot-weather days out of nine months of pregnancy. Other meteorological controls include the number of low-temperature days and total precipitation during pregnancy. Low-temperature days are defined as the number of days with daily minimum temperatures lower than 32°F.

[12]In Table A.2, we further examining the adverse effects of high temperatures during pregnancy for the two group individuals—with and without birth weight data. And we do not find any statistically significant differences. See details in the main results section.

[13]To test the sensitivity of the estimates to the temperature threshold, we apply different thresholds, ranging from 70°F to 90°F. See the main results section for detailed analysis.

[14]Corresponding results are summarized in Table A.3 and A.4 in the appendix.

In our analysis, we restrict our sample to individuals born in rural areas, which comprise 84.05% of the original CFPS sample. Since individuals in rural areas in general work outside frequently and have limited ways to avoid ambient heat, such as air conditioners, they are more likely to suffer from hot weather. Furthermore, observations without exact information on birth place are excluded. The remaining sample contains 10,685 individuals in 143 counties across 25 provinces (see Figure A.1). Sample statistics are summarized in Table 1.

2.2 Descriptive regional patterns

If ambient heat stress during the prenatal period is an important determinant of welfare outcomes, we would expect that individuals in warmer regions have worse adult outcomes on average. In this subsection, we first depict the relationships between temperature and adult outcomes across provinces. Next, we examine the correlations between temperature and birth weight across provinces, as the high-temperature effects on adult outcomes are possibly caused by the high-temperature effects on birth weight.[15]

Welfare outcomes against temperature. Panels (a) through (d) in Figure 2 plot the mean years of schooling, word- and math-test scores, and height, respectively, against the number of hot-weather days (>85°F) for a representative gestational period across

[15] Importantly, the correlations depicted below only serve as the motivation for this project. They do not imply any causal interpretations. They could be explained by other factors. For instance, northerners in China are on average taller than Southerners, and this may be explained by differences in cuisine or genetics, rather than high temperatures.

provinces.[16] Relative to the southern provinces (blue circle markers in Figure 2), provinces in the north (red square markers) suffer hot weather less frequently.[17] The four figures indicate that hot weather during pregnancy may be further related to welfare losses in adulthood. Specifically, Panels (a)-(c) display interesting regional patterns that adults born in warmer places (lower latitudes in general) have fewer schooling years and lower word- and math-test scores. Panel (d) shows the same regional pattern that the warmer the area, the greater the loss in height. This phenomenon in China—the higher the latitude, the taller the people—is also documented by Buxton (2013). Our findings suggest that low birth weight caused by climate may explain this geographical distribution of height to some extent.

Birth weight against temperature. In Figure 2, Panels (e) and (f) plot mean birth weight and low-birth-weight likelihood (<2,500 grams, LBW hereafter) for each province against the number of high-temperature days in a representative gestational period. The regional pattern of birth weight is striking and consistent with that of adult outcomes: Typically, babies born in the southern provinces gain less weight and are more likely to suffer from LBW. For perspective, Guangdong, Guangxi, and Fujian provinces, which are located in the southest China, are the warmest areas of China, with around 90 days with a maximum temperature higher than 85°F in a typical year. Compared to a representative baby in China, babies born in these three provinces weigh less by 3.6%, 8.7%, and 11.4%,

[16] Beijing is excluded from these panels, since the average years of schooling and word- and math-test scores for individuals in Beijing are far beyond those in other provinces.

[17] We use an official geographical dividing line—the Huai River-Qin Mountains—to define northern and southern China provinces.

respectively.

3 Empirical framework

To exploit how high-temperature exposure during pregnancy affects adult outcomes, we employ the following specification:

$$Y_{ijmt} = \beta HighTemp_{ijmt} + W_{ijmt}^{'}\gamma + X_i^{'}\delta + \mu_j + \lambda_t + \eta_m + \theta_{pt} + \epsilon_{ijmt}. \quad (1)$$

Here, *i* references individual, *j* represents county, p indicates province, and birth month and year are denoted by *m* and *t*, respectively. The dependent variables, Y_{ijmt}, are adult outcomes, including schooling years, standardized word- and math-test scores, height, and annual income.[18] The variable of interest in Equation (1) is $HighTemp_{ijmt}$, the number of hot-weather days during the gestational period. Other meteorological factors (W_{ijmt}), such as the number of cold-weather days and total precipitation during the gestational period are controlled. We add a vector of individual characteristics, X_i, including gender, race, birth order, number of siblings, and parental age at delivery and educational attainment, to capture individual heterogeneity. To account for any time-invariant county-level factors, we control for μ_j, a county fixed effect. λ_t and η_m represent birth year and month fixed effects, capturing common shock over years and seasonality patterns.

In addition, the province-year fixed effects, θ_{pt}, are added. The two-way fixed effects

[18]We use this specification to examine the effects of high-temperature on birth weight as well.

could capture the nonlinear changes in the determinants of human capital formation. As during our sample period, China enacted several policies that likely created nonlinear province-specific differences over time, for instance, the collectivization of land (late 1950s), the Three Years of Great Chinese Famine (1959-1961), the Cultural Revolution (1966-1976), and 9-year Compulsory Education (1986). Concerning the regional and year specific seasonality, we also add the year-month and province-month fixed effects as a robustness check in appendix. The results are shown in Table A.5. The estimates are reasonable robust but are not as precise. ϵ_{ijmt} denotes an idiosyncratic random error term. To allow for potential temporal and spatial autocorrelations, standard errors are clustered at the county level.[19]

Furthermore, if families can non-randomly sort across geographic regions, then it is unclear whether a causal interpretation can be implied. In other words, richer families may have sorted to areas that produce more abundant crops, which are also areas where there is less exposure to heat in *utero*. In such a case, less exposure to ambient heat during pregnancy is correlated with better adult outcomes. However, before 1990s in China, people are severely restricted on migration and relocation, especially for rural residents (Chen and Zhou 2007). The residence registration system, called "Hukou" system, is the main limitation on regional mobility. To further address the concern, we replace

[19]We also check the robustness of inferences. Our regression sample includes 10,685 individuals born in different counties, years, or months. We randomly assign individuals born in a placebo time and place, and re-estimate Equation (1) 1,000 times. If the standard errors were consistent, the rejection rate of the null hypothesis of no effect should be around 5% of the time when the threshold for the absolute t-statistic is 1.96. As shown in Figure A.2, cases with an "effect" significant at the 5% level are around 5% of all placebo estimates. The appendix also reports standard errors that allow for autocorrelation within province. As shown in Table A.6, the inferences remain unchanged.

the province-year fixed effects with county-year fixed effects in the main specification to check the robustness of our results.

To further examine the validity of our main specification, we regress observable characteristics on the high temperature days including the fixed effects in our main specification. The results in Table 2 show that most of the t-values of the coefficients of high temperature days are far below than one. That indicates that, conditional on those fixed effects in our main specification, the high temperature days are not correlated with any of the observable characteristics. And such result suggests the exogeneity of high temperature days in our main specification.

As suggested by the epidemiological literature, high-temperature exposure in different trimesters may have heterogeneous effects on birth weight and then further on adult outcomes. In the following specification, we allow for such heterogeneity:

$$Y_{ijmt} = \sum_{T=1}^{3} \beta^T HighTemp_{ijmt}^T + \sum_{T=1}^{3} \gamma^T W_{ijmt}^{\prime T} + X_i^{\prime}\delta + \mu_j + \lambda_t + \eta_m + \theta_{pt} + \epsilon_{ijmt}, \tag{2}$$

where $HighTemp_{ijmt}^T$ denotes the number of hot-weather days in each trimester. $T = 1$, 2, and 3 denote the first, second, and third trimester, respectively. W_{ijmt}^T consists of the number of cold-weather days and total precipitation in each trimester. The other notations are the same as those in Equation (1).

4 Main Results

This section reports estimates of the effects of ambient heat stress during pregnancy on later-life well-being, such as education years, cognitive abilities, height, and annual income. Moreover, employing the available adults' birth weight data, we examine the channel of high-temperature effects on adult outcomes. Additionally, the heterogeneous effects of high temperatures across trimesters on all outcomes are outlined.

4.1 Effects on adult outcomes

We begin our analysis by presenting the effect of ambient heat during pregnancy on adult outcomes, which are shown in Table 3 to 6.[20]

Educational Attainment. Like the subsequent tables in this subsection, Table 3 presents four specifications, indicating the impacts of ambient heat on educational achievements. In column (1), we include other weather controls and the county, birth year, and birth month fixed effects. Column (1) shows that the effect of high temperatures during pregnancy on educational attainment is negative and significant at the 10% level. By adding individual characteristics, Column (2) shows that one additional high-temperature day lowers the average education years by about 0.006 years. And the effect is significant at the 5% level. Column (3) further includes the county-specific linear and quadratic trends, partialling out time-varying characteristics associated with both dependent and

[20]Individuals who did not survive due to exposure to ambient heat in the prenatal period are not included in our sample. We may underestimate welfare losses because of such selection (Black, Devereux and Salvanes 2007).

independent variables and are trending linearly and quadratically during the analysis period. The coefficient remains stable and statistically significant. Finally, in column (4) we replace the county-specific trends with the province-year fixed effects, which nonparametrically capture the nonlinear changes in the determinants of human capital formation. At this more stringent specification, the coefficient shows that a one standard deviation increase in high-temperature days (34.49 days) lowers the average years of schooling by 0.29(=0.0085*34.49) years (7.18% standard deviation). It indicates that without province-year fixed effects, the adverse effects would be underestimated. Moreover, precipitation does not have significant effect on educational attainment. Cold weather in pregnancy somehow have a positive influence on education years.[21] In addition, males, individuals with higher educational achievements parents, and younger children in one family tend to have longer years of schooling. The number of siblings (family size) is negatively correlated with the educational attainment, consistent with the findings in Black, Devereux and Salvanes (2005).

We have thus far defined the "high temperature" as a daily maximum temperature higher than 85°F. We acknowledge that this threshold is arbitrary to some degree. To test the sensitivity of the estimates to the temperature threshold, we apply different thresholds, ranging from 70°F to 90°F. Panel (a) in Figure 3 summarizes the coefficients and 90% confidence intervals for estimates of the effects on schooling years using thresholds from 70°F to 90°F, respectively. As can be seen, the coefficients for high-temperature days

[21] The positive effect of cold weather during pregnancy is similar to that in Isen, Rossin-Slater and Walker (2015).

are significantly negative across different thresholds, implying that the effects of high temperatures during pregnancy are not sensitive to the temperature thresholds.

Cognitive Abilities. Next, we examine the adverse effects of hot weather on adult cognitive abilities measured by standardized word- and math-test scores. As shown in Table 4, columns (1) through (4) replicate the specifications from Table 3. Without any background information controls, column (1) reveals that hot weather in the prenatal period has statistically significant adverse effect on word-test score. Compared to that in column (1), the richer specifications in columns (2) through (4) show that the absolute values of point estimates increase slightly. As the last column shows, adults who experienced one standard deviation more high-temperature days in the prenatal period are 7.59% standard deviations lower for word-test score. And the effect is significant at the 5% level. What's more, the effects of low temperatures and total rainfall are not statistically different from zero. Furthermore, females, individuals with lower educational achievements parents, and elder children in one family perform worse in the word test.

Table 5 statistically summarizes the effect of high temperatures during pregnancy on the math-test score. Column (1) reports that adults who were exposed to one additional high-temperature day *in utero* stage are 0.09% standard deviations lower for math-test score, but this estimate is not statistically significant. In column (4), the richer specification, the estimate becomes statistically significant at the 10% level. We find that a one standard deviation increase in high-temperature days during the prenatal period lowers the math-test score by 4.83% standard deviations. Moreover, the effect of cold weather during pregnancy is again positive. Total rainfall during pregnancy does not significantly influence the math-test performance. Additionally, males, individuals with higher educational achievements parents, and younger children in one family tend to have higher math-test scores.

Panels (b) and (c) in Figure 3 display the sensitivity tests of temperature thresholds. For the word-test score, the negative effects of high temperatures are statistically significant across different thresholds. But the effect on math-test performance becomes statistically significant at the 10% level only when the threshold is beyond 80°F.

The temperature on the survey day may affect respondents' test performance. And if it was also correlated with the high temperature days during pregnancy, it may cause some bias for the results about word-test and math-test. Therefore, as a robustness check, we include county specific survey month fixed effects to partly control for weather situation during survey[22]. The coefficients show in Table A.7 are reasonably robust. And the results are still statistical significant for word-test.

Height. Table 6 displays four specifications the same as preceding tables, indicating the impacts of ambient heat on height. Column (1) implies that hot weather during pregnancy has negative (but insignificant) effect on height. By adding personal background controls and county-specific trends, the estimates become more precise. Replacing the county-specific trend with province-year fixed effects in column (4), the absolute value of the high-temperature-days coefficient increases slightly. The point estimate shows that

[22] We only have survey month information without knowing the exact survey date

a one standard deviation increase in high-temperature days lowers the average height by 0.40 cm (5.16% standard deviation). Moreover, panel (d) in Figure 3 shows that the negative effect of high temperatures on height is not sensitive to the temperature threshold. Additionally, we find that cold weather does not have a significant effect, while the rainfall during prenatal period seems to have a marginally significant negative effect on height. Furthermore, males, Han Chinese, and individuals with higher educational achievements parents tend to be taller than others on average.

Labor Market Outcomes. Table A.8 assesses the impact of hot weather on personal annual income.[23] As shown in the tables above, individuals who were exposed to high temperatures during the prenatal period attain fewer education years and have worsen cognitive abilities, which are crucial determinants for labor market outcomes. In the analysis sample, about 76% (8077 out of 10685) individuals report their annual income in 2010. In columns (1) through (4), the sign of the high-temperature-days coefficients is consistently negative. Although the coefficients are not statistically significant at the traditional level, the adverse effect is economically significant. Column (4), the more stringent specification, shows that a one standard deviation increase in high-temperature days during pregnancy lowers the annual income by 4.48%.What's more, other weather controls do not have significant effects on the labor market performance. Males and individuals with higher educational achievements parents tend to earn more annual income. Additionally, we find that the younger the individuals in one family, the more they earn. This pattern

[23]As we have discussed in the data section, the personal income variable is not measured precisely. Here the results are only suggestive evidence.

is consistent with those in previous tables, i.e., younger children in one family have more educational attainment and better cognitive abilities. Family size also negatively affects the labor market performance.

As we discussed in the model part, families may non-randomly sort across geographic regions within a province, for which case the province-year fixed effects are unable to capture. The fact that during our sample period, people in rural China are severely restricted on migration and relocation, does address the concern to some extent. We further replace the province-year fixed effects with county-year fixed effects to check the sensitivity of our estimates. As Table A.9 shows, after controlling county-year fixed effects, the coefficients of high-temperature days during pregnancy are consistently negative for all adult outcomes. The results are relatively robust. Compared to the estimates with province-year fixed effects, those in Table A.9 increase slightly. But as the models are more demanding of the data, the estimates are less precise.

4.2 Effect on birth weight

In this subsection, we examine the effect of ambient heat during pregnancy on birth weight—a possible important channel explaining high-temperature effects on adult outcomes. The adverse effect of ambient heat during pregnancy on birth weight is presented in Table 8. Columns (1) through (4) repeat the specifications from Table 3 and reveal large and precisely estimated effect of hot weather in the prenatal period on birth weight. In particular, the richest specification in column (4) shows that birth weight is 2.14 grams (around 0.07%) lower for one additional high-temperature day. And the effect is statistically significant at the 5% level. To compare, Deschenes, Greenstone and Guryan (2009) find that each additional day>85°F lowers birth weight by 0.0025%. The magnitude is much smaller than our estimate, which is possibly because living conditions in the US were much better than those in China during the sample period. Such adverse influence is not negligible. A one standard deviation increase in high-temperature days leads to a 73.86 grams drop in birth weight, which is about 12.35% standard deviation. Moreover, cold weather does not have significant effect on birth weight, whereas high rainfall affects it negatively. Males and individuals with higher educational achievements parents and who live in small families have higher birth weight.

Table 9 presents for effects of high temperatures on LBW incidence. Without any family background controls, column (1) implies that high temperatures in the prenatal period has statistically significantly increase the risk for LBW. Relative to that in column (1), the more stringent specifications in columns (2) through (4) show that the point estimates remain stable. Column (4) indicates that one extra hot-weather day significantly increases the risk for LBW by 0.12 percentage points. In addition, the effect of low temperatures is not statistically different from zero, but precipitation increases the risk. For family background controls, gender and father's education achievements significantly affect the risk for LBW.

As mentioned above, about one-third of individuals in the full sample remembered their own birth weight. And birth weight is less likely to be missing for individuals from better-educated families. This suggests that our estimated effects of high temperatures during pregnancy may be biased downwards since the effects are likely to be larger for individuals with worse family background. In Table A.2, we examine whether the impacts of hot weather are smaller for individuals with non-missing birth weight data. As row (1) indicates, the interaction term between high-temperature days and birth-weight-non-missing indicator is not statistically significant for any adult outcomes. This finding implies that birth weight does not appear to be missing in a systematic way that would influence our results.

We also run sensitivity checks by using different definitions of high-temperature days. Panels (a) and (b) in Figure 4 show the coefficients and 90% confidence intervals for estimates of birth weight and low-birth-weight incidence using thresholds from 70°F to 90°F, respectively. As can be seen, the effects of high temperatures during pregnancy are not sensitive to the temperature thresholds.

4.3 Trimester heterogeneity

In subsequent analyses in this section, we allow for heterogeneous effects of ambient heat across trimesters. Table 10 illustrates the effects of high temperatures in each trimester. In each regression, we include all personal background controls, birth-month fixed effects, and province-year two-way fixed effects. Columns (1) through (4) present the results for adult outcomes. Noticeably, the adverse effects of hot weather are more significant and larger in the second trimester for all outcomes. Specifically, individuals who were exposed to one standard deviation more high-temperature days in the second trimester (around 21.86 days) attain 0.30 fewer education years, are 7.21% and 5.68% standard deviations lower for word- and math-test scores, and are 0.36 cm shorter, respectively. However, high temperatures in other trimesters do not have significant effects on these adult outcomes.

In addition, we observe similar patterns for birth weight. Column (5) shows that high-temperature days in the second trimester significantly lower birth weight. A one standard deviation increase in the number of high-temperature days in the second trimester leads to a loss of 68.83 grams of birth weight (12.14% standard deviation). Moreover, column (6) shows that one additional hot-weather day increases the probability of low-birth-weight incidence by 0.14 percentage points in the second trimester. Such sensitivity to temperature fluctuation during the second trimester has also been documented by medical research (Murray et al. 2000; Elter et al. 2004). However, as we do not have precise birth date or gestational length, trimesters are defined with errors. Therefore, we cautiously conclude that pregnant women are more sensitive to ambient heat in the second trimester.

5 Discussion

5.1 Physiological vs. income effects

Our results thus far have presented the effects of high temperatures during pregnancy on adult outcomes and birth weight. Two channels may account for such impacts. One possibility is that hot weather has adverse physiological influences on pregnant women due to physical and mental strain.[24] By affecting the pregnant woman's health, heat stress further triggers negative impacts on newborns—e.g., low birth weight. In addition to physiological effects, high temperatures may also cause damage to crop yields (Hollinger and Angel 2009; Schlenker and Roberts 2009; Burgess et al. 2011), which determine family resources in rural areas and influence newborns' endowment through income effects, as suggested by Maccini and Yang (2009).

Hollinger and Angel (2009) find that heat stress is more likely to cause damage to crops when temperatures approach or exceed 85 °F. Moreover, how crops respond to hot weather varies. Specifically, C4 plants, including corn, sugarcane, and sorghum, are more adaptable to hot weather due to the efficient way they retain water in a hot environment. In contrast, C3 plants (barley, rice, wheat, etc.) are more sensitive to heat stress. If income effects matter, people living where C4 (C3) plants are widely cultivated would be less (more) affected by high temperatures during pregnancy. To test the income channel, we employ the following specification:

$$\begin{aligned} Y_{ijmt} = {} & \beta HighTemp_{ijmt} + \zeta C4PlantArea_{pt} + \kappa HighTemp_{ijmt} * C4PlantArea_{pt} \\ & + W'_{ijmt}\gamma + X'_{i}\delta + \mu_j + \lambda_t + \eta_m + \theta_{pt} + \epsilon_{ijmt}. \end{aligned} \quad (3)$$

[24] Strand, Barnett and Tong (2011) suggest that a pregnant woman may be sensitive to heat stress because (i) the capacity to lose heat by sweating is lessened due to the reduced ratio of surface area to body mass, (ii) weight gain triggers more heat production, (iii) core temperature increases with accumulated fat deposition, and (iv) the increased body composition and metabolic rate of the fetus cause a rise in maternal heat stress (Prentice et al. 1989; Wells and Cole 2002).

Here, p references province. $HighTemp_{ijmt}$ denotes number of days with a daily maximum temperature higher than 85°F during pregnancy. $C4PlantArea_{pt}$ represents the corn and sugarcane proportion of crop acreage within each province-year cell.[25] The other notations are the same as those in Equation (1). If high temperatures affect people through the income channel, we would expect the coefficient of interaction term κ to be significantly positive. As shown in Table 11, the interaction terms are not statistically significant for any outcomes; neither do they have a consistent direction of impacts. Also, the coefficients for high-temperature days change slightly. The results provide no support for the existence of income effects before birth, consistent with the findings of Maccini and Yang (2009).[26]

Worried about that the the change of the C4 proportion within the county captures some other unobserved regional characteristics such as adaptation ability, we use the C4 proportion in 1950 to avoid such problem. And the results shown in Table A.10 convey a very similar pattern compared to Table 11.

In addition to temperature, precipitation is another crucial factor for crop yields. If total precipitation in the previous year's growing season significantly affected adult out-

[25]County-level plant area data are not available before 1997. Instead, we use plant-area data from the Thematic Database for Human-earth System (http://www.data.ac.cn/zrzy/DH55.asp?name=&pass=&danwei=). It provides the plant area of each crop within each province from 1949 to 2000. There are two C4 crops (corn and sugarcane) in the dataset; the other 8 crops are C3 plants.

[26]Changes in the proportion of C4 plants within province may capture some unobserved regional characteristics. For instance, people may realize that C4 plants are more adaptable to high temperatures. If climate is getting warmer, they may choose to plant more C4 plants. To address this concern, we use a exogenous measurement, C4 plants proportion in 1950 in Equation (3) instead. As Table A.10 shows, our conclusions are unaffected.

comes and birth weight, income effects could not be ruled out. To test the effects of weather conditions during the growing season, we simultaneously control for high-temperature days during pregnancy and total precipitation during the last year's growing season before birth in regressions for all outcomes.[27] We also add high-temperature days during the last year's growing season before birth as a control.[28] The first row in Table 12 shows that the coefficients of high-temperature days during pregnancy do not change much, compared to those in Tables from 3 to 6 and from 8 to 9. Also, total rainfall and high temperatures in the last year's growing season before birth has no significant impact on any outcome. Based on these results, we conclude that the adverse effects of high temperatures are more likely to be consistent with physiological effects than income effects.

5.2 Nonlinear effects of hot weather

In this subsection, we explore the nonlinear effects of high temperatures on adult outcomes and birth weight. If ambient heat adversely affected embryos (or fetuses) only beyond a certain level of accumulated high-temperature days, it would change welfare implications, since high frequency of high-temperature days is not that common. We employ the partially linear model, allowing the key variable to be nonlinear:[29]

$$Y_{ijmt} = f(X_{ijmt}) + Z^{'}\gamma + \epsilon_{ijmt}. \tag{4}$$

[27]The growing season is from April to September (Deschenes and Greenstone 2007).

[28]The definition of high-temperature days in the last year's growing season is those with a daily maximum temperature above 85°F, similar to that in Table 11.

[29]The partially linear model was first applied by Engle et al. (1986).

where X_{ijmt} represents the number of hot-weather days during pregnancy. $f(.)$ is the unspecified nonlinear component, estimated by kernel regression with optimal bandwidth.[30] Z represents other controls and fixed effects in Equation (1). To estimate Equation (4), we use the Robinson difference estimator (Robinson 1988). As $E(\epsilon|X_{ijmt}, Z) = 0$ implies $E(\epsilon|X_{ijmt}) = 0$, we have:

$$E(Y_{ijmt}|X_{ijmt}) = f(X_{ijmt}) + E(Z|X_{ijmt})\gamma. \tag{5}$$

Combining Equations (4) and (5) yields

$$Y_{ijmt} - E(Y_{ijmt}|X_{ijmt}) = (Z - E(Z|X_{ijmt}))\gamma + \epsilon_{ijmt}. \tag{6}$$

Conditional moments are estimated by kernel regression. The OLS estimator of γ in Equation (6) is $\sqrt{N}$-consistent and asymptotically normal. Equation (5) suggests

$$f(X_{ijmt}) = E(Y_{ijmt}|X_{ijmt}) - E(Z|X_{ijmt})\gamma. \tag{7}$$

Given estimated conditional moments and OLS estimates $\widehat{\gamma}$, $f(.)$ can be consistently estimated by kernel regression. We further perform the significance testing for nonparametric regression proposed by Racine (1997) to check the significance level of the nonparametric relationships.[31]

[30]The Epanechnikov kernel function is applied here.

[31]The null hypothesis of the significance testing is $\frac{\partial E(Y_{ijmt}|X_{ijmt})}{\partial X_{ijmt}} = 0$, i.e., the conditional mean of the

Panels (a) through (d) of Figure 5 present the adult welfare outcomes estimates from Equation (4).[32] The y-axis represents the dependent variable partialled out from the parametric fit. The relationships shown in the figure are striking (significant at the 1% level): When the number of high-temperature days during pregnancy increases, years of schooling, word- and math-test scores, and height decrease monotonically.

The effect of high temperatures during pregnancy on birth weight is presented in Panel (e) of Figure 5. The non-parametric relationship is significant at the 1% level. The adverse effect on birth weight seems to decline almost linearly when there are fewer than 100 high-temperature days; Again, estimate beyond 100 high-temperature days is not precise.

5.3 Predicting the impacts of climate change on birth weight and adult outcomes

We take our estimated effects of high-temperature days during pregnancy on schooling years, height, and birth weight—namely, the estimates reported in Tables 3, 6, and 8—to conduct back-of-the-envelope calculations based on climate predictions by the NASA with a view to drawing implications from our results. The NASA predicts downscaled climate scenarios for the globe by the General Circulation Model (GCM) conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5).[33] Two of the four

dependent variable is orthogonal to the variable of interest.

[32]As Robinson (1988) points out, the nonparametric estimators of $E(Y|X_{ijmt})$ and $E(Z|X_{ijmt})$ are not reliable if the density of X_{ijmt} is close to zero at x. Therefore, all regressions in Figure 4 are performed on a trimmed sample, in which 3% observations with the lowest estimated density are excluded.

[33]The CMIP5 GCM is supported by the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5).

greenhouse-gas-emission scenarios, known as Representative Concentration Pathways (RCPs), are included—RCP 4.5 and 8.5.[34] Daily temperature predictions contain projections from 21 climate models and are error-corrected through comparisons performed against historical data.[35] Hereafter, our predictions rely on the ACCESS1-0 model.[36]

Assuming that greenhouse gas emissions will peak around 2040 (RCP 4.5 scenario), we predict that, holding all else equal, babies born in rural areas of China in 2100, on average, will weigh 10 grams less than those born in 2000 due to global warming.[37] Further, those individuals in adulthood will suffer 0.10 fewer years of schooling and 0.14 cm decrease in height.[38] In an even more pessimistic case (RCP 8.5 scenario), greenhouse gas emissions will peak around 2100 and birth weight loss will rise sharply to 50 grams.[39] Likewise, losses in education years and height will increase to 0.40 years and 0.55 cm, respectively. The above predictions are based on a strong assumption that all other related factors will remain constant—i.e., the same purchasing power, medical technologies, and access to air conditioners (Barreca et al. 2016 and Zivin, Hsiang and Neidell 2015). As

[34]RCPs are possible greenhouse-gas-concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC). Specifically, RCP 4.5 presumes that global annual greenhouse gas emissions (measured in CO2-equivalents) will peak around 2040, then decrease. In RCP 8.5, emissions keep increasing throughout the 21st century.

[35]The 21 models are ACCESS1-0, BCC-CSM1-1, BNU-ESM, CanESM2, CCSM4, CESM1-BGC, CNRM-CM5, CSIRO-MK3-6-0, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, INMCM4, IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, MPI-ESM-LR, MPI-ESM-MR, MRI-CGCM3, and NorESM1-M.

[36]The magnitude of predictions based on other models is similar.

[37]Under the RCP 4.5 scenario, the number of high-temperature days during pregnancy increases by 12.35 days on average.

[38]As cold weather in the analysis does not have significant effects on most outcomes, it is not taken into account in this back-of-the-envelope predictions.

[39]Under the RCP 8.5 scenario, the number of high-temperature days during pregnancy increases by 47.87 days on average.

other factors are being improved in China, however—especially in rural areas—the effects of global warming may be alleviated.

6 Conclusions

In this paper, we examine the long-term effects of high temperatures during the prenatal period on education attainment, cognitive abilities, physical conditions, and labor market outcome. Additionally, we investigate whether prenatally exposed children have worse endowments—birth weight. Our results indicate that hot weather in early life not only trigger adverse birth outcomes, but have persistent and profound effects in later life. By enduring one additional standard deviation of hot-weather days *in utero* (about 34 days), individuals attain 0.29 fewer years of schooling, are 7.59% and 4.83% standard deviations lower for word- and math-test scores, and grow to be 0.40 cm shorter. The impacts seem to be concentrated in the second trimester. Moreover, children who were prenatally exposed to frequent heat stress have statistically significant lower birth weight and higher risk for LBW. This finding implies that the adverse high-temperature effect on birth weight could be the possible channel of high-temperature effects on adult outcomes.

The adverse effects of high temperatures during pregnancy have not been taken into account when calculating the costs of global warming. Our back-of-the-envelope predictions suggest that at the end of the 21st century, newborns in rural China on average will weigh 10-50 grams less, and losses in education years and height will be 0.10-0.40 years and 0.14-0.55 cm, respectively, compared to those born in 2000.

We also examine the possible mechanisms behind the adverse effects of hot weather during pregnancy. Since (i) places with a high proportion of heat-tolerant crops (corn and sugarcane) do not mitigate any estimated temperature sensitivity during pregnancy, and (ii) total precipitation and high temperatures during the last year's growing season before birth have no significant effects on either later outcomes or birth weight, we argue that our results are more likely to be driven by physiological effects than income effects.

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Table 1: Summary statistics

Variable	Mean	Std. Dev.	N
Education Years	6.67	4.04	10685
Standardized Word-test Score	0	1	10685
Standardized Math-test Score	0	1	10685
Annual Income (2010 CNY)	9648.6	20412.61	9841
Height (cm)	164.39	7.68	10685
Birth Weight (gram)	2971.5	566.75	3223
Low Birth Weight Dummy (<2,500 grams)	0.09	0.29	3223
Age	36.27	11.57	10685
Female	0.48	0.5	10685
Han Chinese	0.9	0.29	10685
Mother's Education Years	2.27	3.52	10685
Mother's Age at Birth	27.16	6.12	10685
Father's Education Years	4.37	4.26	10685
Father's Age at Birth	29.67	6.91	10685
Birth Order	2.21	1.47	10685
Number of Siblings	2.73	1.79	10685
High Temp Days	48.31	34.49	10685
High Temp Days (1st trimester)	15.06	21.28	10685
High Temp Days (2nd trimester)	16.41	21.86	10685
High Temp Days (3rd trimester)	16.84	22.53	10685
Low Temp Days	60.49	51.33	10685
Low Temp Days (1st trimester)	20.87	29.47	10685
Low Temp Days (2nd trimester)	18.92	28.23	10685
Low Temp Days (3rd trimester)	20.7	29.64	10685
Precipitation	6.27	0.92	10685
Total Precipitation(1st trimester)	4.79	1.31	10685
Total Precipitation(2nd trimester)	4.87	1.29	10685
Total Precipitation(3rd trimester)	4.81	1.34	10685

Notes: The sample contains 10,685 individuals in 143 counties across 25 provinces. All individuals in the sample were born in rural areas. High-temperature days are defined as those with a daily maximum temperature higher than 85°F. For convenience of interpretation, word- and math-test scores are standardized. In the sample, around 30% individuals did not report annual income, either because they did not work at the survey year or because they have already retired.

Table 2: Balanced check on observable characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:	Female	Han	Education Years (Mo)	Age at Birth(Mo)	Education Years(Fa)	Age at Birth(Fa)	Birth Order	Number of Siblings
High Temp Days	-0.0004	-0.0001	0.0007	0.0065	-0.0001	0.0049	0.0007	-0.0012
	(0.0005)	(0.0002)	(0.0028)	(0.0052)	(0.0035)	(0.0053)	(0.0012)	(0.0013)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	10685	10685	10685	10685
R-Squared	0.107	0.649	0.324	0.166	0.294	0.190	0.256	0.463

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 3: The impact of high temperatures during pregnancy on educational attainment

	(1)	(2)	(3)	(4)
Dependent Variable:	Eduy	Eduy	Eduy	Eduy
High Temp Days	-0.0053*	-0.0059**	-0.0058**	-0.0085**
	(0.0030)	(0.0027)	(0.0026)	(0.0035)
Low Temp Days	0.0036	0.0043*	0.0040*	0.0052**
	(0.0024)	(0.0023)	(0.0023)	(0.0024)
Precipitation	0.0898	0.0621	0.1004*	0.0733
	(0.0579)	(0.0566)	(0.0524)	(0.0703)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	10685	10685	10685	10685
R-Squared	0.269	0.332	0.370	0.404

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 4: The impact of high temperatures during pregnancy on word-test score

Dependent Variable:	(1) Word Test	(2) Word Test	(3) Word Test	(4) Word Test
High Temp Days	-0.0016**	-0.0017**	-0.0015**	-0.0022**
	(0.0007)	(0.0007)	(0.0007)	(0.0009)
Low Temp Days	0.0006	0.0007	0.0005	0.0008
	(0.0006)	(0.0005)	(0.0006)	(0.0006)
Precipitation	0.0005	-0.0045	0.0063	-0.0028
	(0.0115)	(0.0109)	(0.0128)	(0.0151)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	10685	10685	10685	10685
R-Squared	0.306	0.348	0.382	0.416

Notes: An observation is an individual born in a rural area. For convenience of interpretation, word-test score is standardized. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 5: The impact of high temperatures during pregnancy on math-test score

Dependent Variable:	(1) Math Test	(2) Math Test	(3) Math Test	(4) Math Test
High Temp Days	-0.0009	-0.0011	-0.0008	-0.0014*
	(0.0008)	(0.0007)	(0.0007)	(0.0009)
Low Temp Days	0.0007	0.0009	0.0006	0.0011*
	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Precipitation	0.0212*	0.0145	0.0236*	0.0047
	(0.0120)	(0.0114)	(0.0137)	(0.0145)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	10685	10685	10685	10685
R-Squared	0.267	0.328	0.365	0.396

Notes: An observation is an individual born in a rural area. For convenience of interpretation, math-test score is standardized. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 6: The impact of high temperatures during pregnancy on height

	(1)	(2)	(3)	(4)
Dependent Variable:	Height	Height	Height	Height
High Temp Days	-0.0050	-0.0083**	-0.0100**	-0.0115**
	(0.0054)	(0.0039)	(0.0039)	(0.0048)
Low Temp Days	-0.0043	0.0039	0.0057	0.0043
	(0.0052)	(0.0036)	(0.0038)	(0.0042)
Precipitation	-0.1082	-0.1706**	-0.1807**	-0.1883*
	(0.1088)	(0.0822)	(0.0856)	(0.0993)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	10685	10685	10685	10685
R-Squared	0.105	0.532	0.550	0.576

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 7: The impacts of high temperatures during pregnancy on adult outcomes and birth weight for urban-born individuals

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0032	0.0013	0.0018	-0.0006	2.1692	-0.0002
	(0.0081)	(0.0018)	(0.0017)	(0.0154)	(2.3643)	(0.0010)
Low Temp Days	-0.0034	-0.0031	-0.0015	0.0224	-1.3228	0.0006
	(0.0060)	(0.0012)	(0.0013)	(0.0122)	(2.0120)	(0.0008)
Precipitation	-0.0781	-0.0092	0.0103	-0.6436	-106.0663	0.0715
	(0.2835)	(0.0812)	(0.0645)	(0.6065)	(122.5447)	(0.0443)
Demographics Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2314	2314	2314	2314	1198	1198
R-Squared	0.676	0.617	0.622	0.768	0.604	0.594

Notes: An observation is an individual born in an urban area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 8: The impact of high temperatures during pregnancy on birth weight

	(1)	(2)	(3)	(4)
Dependent Variable:	Birth Weight	Birth Weight	Birth Weight	Birth Weight
High Temp Days	-1.8112**	-1.7947**	-1.8779**	-2.1416**
	(0.7474)	(0.7578)	(0.8265)	(1.0533)
Low Temp Days	-0.2537	-0.0364	-0.4772	-0.4953
	(0.6882)	(0.6898)	(0.7285)	(0.8746)
Precipitation	-22.1543	-23.2652	-52.5685*	-64.7445*
	(23.9229)	(22.3179)	(27.8025)	(33.2134)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	3223	3223	3223	3223
R-Squared	0.224	0.244	0.324	0.414

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 9: The impact of high temperatures during pregnancy on risk for LBW

	(1)	(2)	(3)	(4)
Dependent Variable:	LBW	LBW	LBW	LBW
High Temp Days	0.0010**	0.0009**	0.0010*	0.0012*
	(0.0005)	(0.0005)	(0.0005)	(0.0007)
Low Temp Days	-0.0001	-0.0002	0.0001	0.0001
	(0.0003)	(0.0004)	(0.0004)	(0.0004)
Precipitation	0.0093	0.0106	0.0149	0.0320*
	(0.0131)	(0.0131)	(0.0151)	(0.0192)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	3223	3223	3223	3223
R-Squared	0.147	0.150	0.236	0.322

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 10: The impacts of high temperatures during pregnancy on adult outcomes and birth weight by trimester

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days (1st trimester)	-0.0011	-0.0008	0.0002	-0.0057	-0.7833	0.0007
	(0.0047)	(0.0011)	(0.0012)	(0.0070)	(1.5058)	(0.0008)
High Temp Days (2nd trimester)	-0.0137***	-0.0033***	-0.0026**	-0.0165***	-3.1487**	0.0014*
	(0.0045)	(0.0011)	(0.0010)	(0.0062)	(1.3787)	(0.0008)
High Temp Days (3rd trimester)	-0.0051	-0.0011	-0.0004	0.0011	-0.5627	0.0003
	(0.0058)	(0.0014)	(0.0014)	(0.0075)	(1.8109)	(0.0010)
Weather Controls	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	3223	3223
R-Squared	0.404	0.417	0.397	0.577	0.415	0.324

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Each trimester consists of three months. Demographic controls include gender, race, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table 11: Does a high proportion of heat-tolerant crops mitigate the adverse effects of high temperatures during pregnancy on all outcomes?

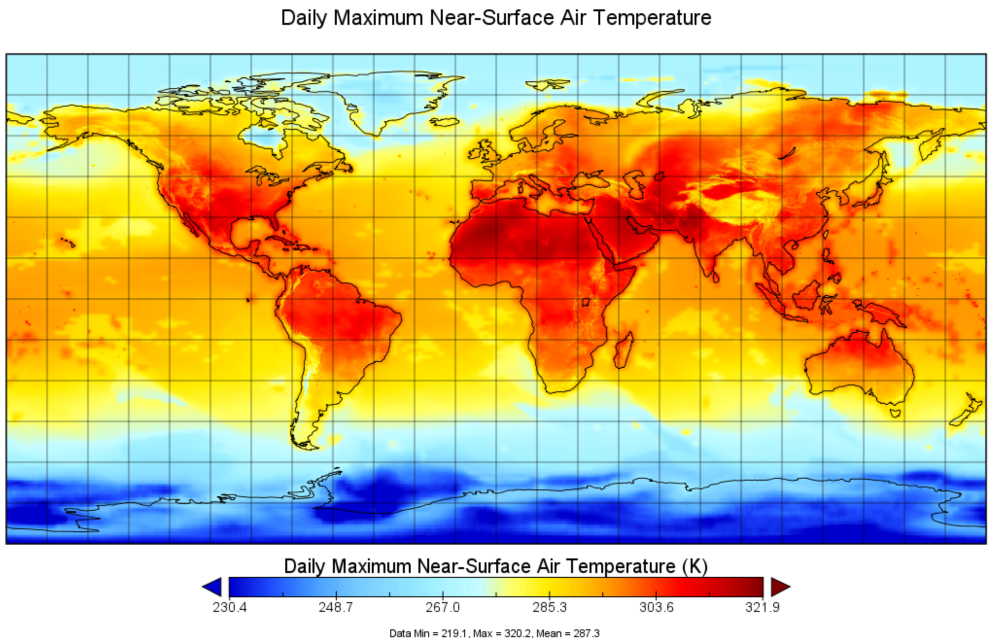
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0096**	-0.0031***	-0.0019*	-0.0097	-1.5064	0.0014*
	(0.0041)	(0.0010)	(0.0010)	(0.0065)	(1.2999)	(0.0008)
High Temp Days X C4	0.0100	0.0082	0.0047	-0.0166	-5.9332	-0.0024
	(0.0220)	(0.0059)	(0.0053)	(0.0365)	(8.0442)	(0.0049)
Low Temp Days	0.0055**	0.0011	0.0012*	0.0037	-0.7229	-0.0000
	(0.0026)	(0.0007)	(0.0007)	(0.0047)	(0.9130)	(0.0004)
Precipitation	0.0724	-0.0039	0.0040	-0.1863*	-62.5677*	0.0329*
	(0.0705)	(0.0150)	(0.0144)	(0.0995)	(33.7894)	(0.0196)
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10660	10660	10660	10660	3219	3219
R-Squared	0.403	0.416	0.395	0.576	0.414	0.322

Notes: An observation is an individual born in a rural area. C4 Plant Area represents corn and sugarcane proportion of crop acreage within the province. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. 25 observations are missing from the main regression sample, because crop-area information is missing for Shanghai in 1993. Demographic controls include gender, race, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

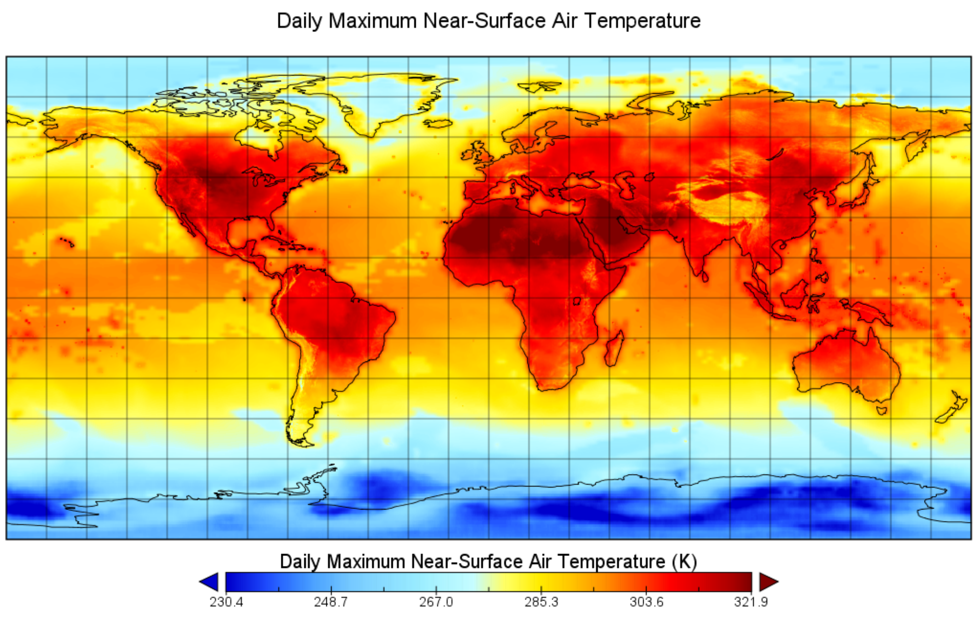
Table 12: The effects of precipitation and high temperatures in the last year's growing season before birth on all outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0081**	-0.0023**	-0.0016*	-0.0102**	-2.2555**	0.0012*
	(0.0036)	(0.0010)	(0.0009)	(0.0049)	(1.0652)	(0.0007)
Low Temp Days	0.0047*	0.0008	0.0010	0.0037	-0.5471	0.0001
	(0.0025)	(0.0006)	(0.0006)	(0.0043)	(0.8527)	(0.0004)
Precipitation	-0.0005	-0.0320	-0.0191	-0.1185	-99.3756**	0.0435
	(0.0944)	(0.0264)	(0.0233)	(0.1316)	(45.7902)	(0.0290)
HTD in Growing Season(-1)	-0.0019	-0.0008	0.0003	-0.0042	0.2397	-0.0004
	(0.0070)	(0.0019)	(0.0017)	(0.0112)	(2.0331)	(0.0012)
Prec. in Growing Season(-1)	0.0486	0.0069	0.0130	0.0090	19.8794	-0.0200*
	(0.0590)	(0.0153)	(0.0161)	(0.0875)	(20.0782)	(0.0116)
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10515	10515	10515	10515	3202	3202
R-Squared	0.406	0.419	0.398	0.577	0.418	0.324

Notes: An observation is an individual born in a rural area. HTD in Growing Season(-1) means high-temperature days in the last year's growing season. Prec. in Growing Season(-1) denotes log precipitation in the last year's growing season. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. 170 observations are missing from the main regression sample, because weather information before their birth years is not available. Demographic controls include gender, race, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

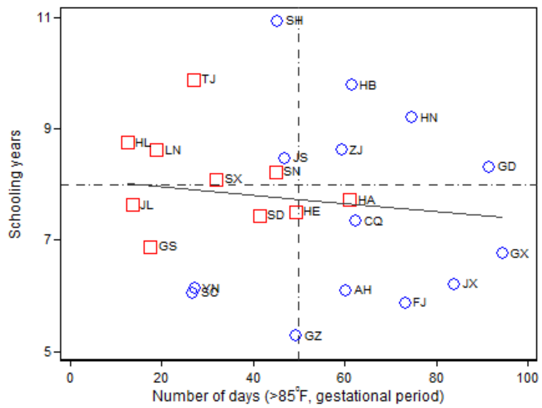


(a) 2000

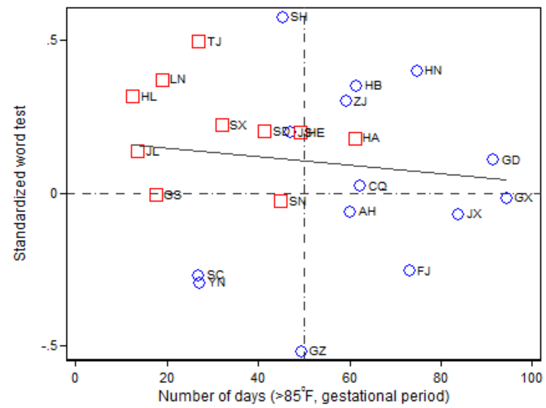


(b) 2100

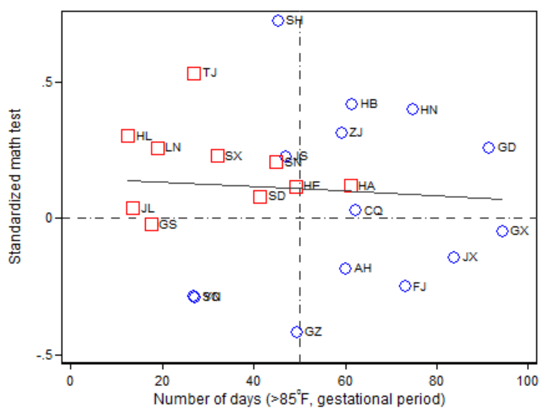
Figure 1: The global daily maximum near-surface air temperature on the 1st July, 2000 (panel a) and 2100 (panel b).



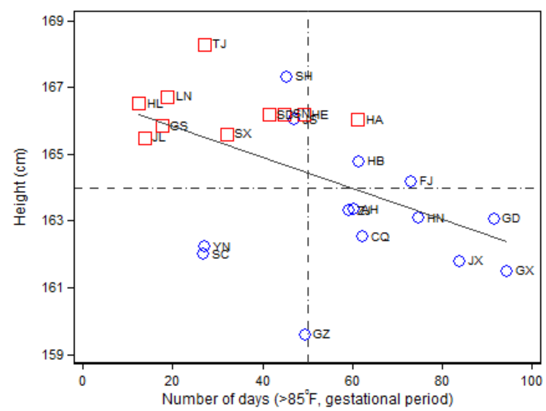
(a) Education years



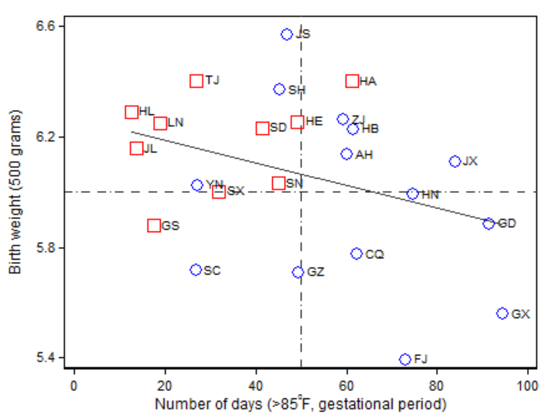
(b) Word-test score



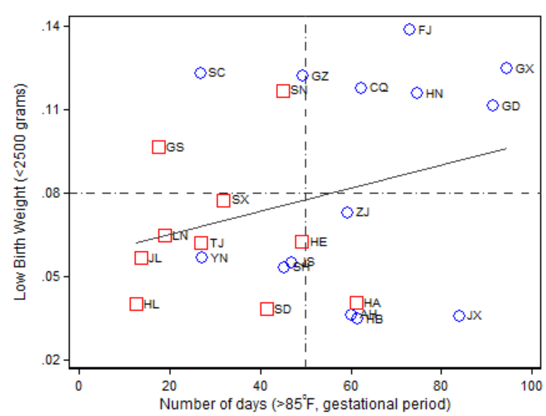
(c) Math-test score



(d) Height



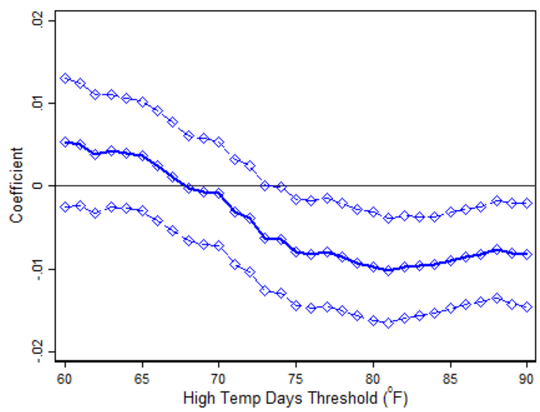
(e) Birth weight



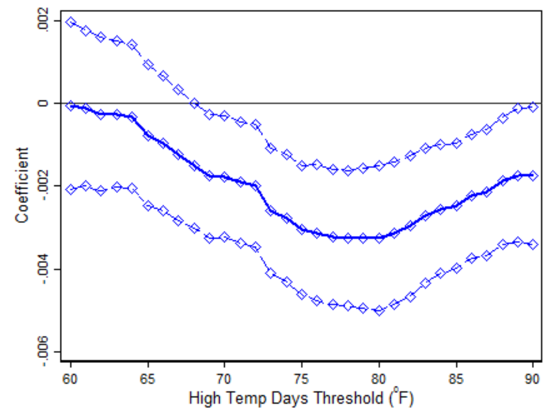
(f) LBW

Figure 2: Adult outcomes and birth weight against number of high-temperature days (>85°F) for typical gestational period by province.

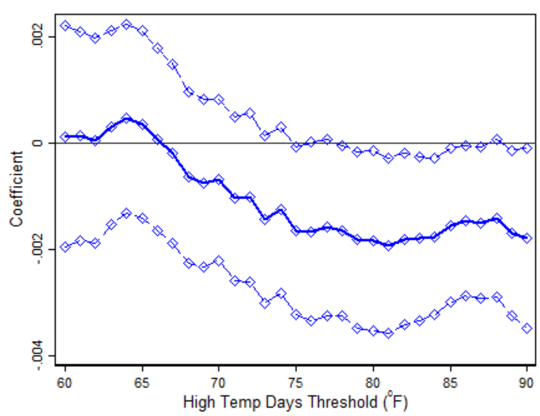
Notes: Red square and blue circle markers represent provinces in the north and south, respectively. The solid line is fitted using OLS.



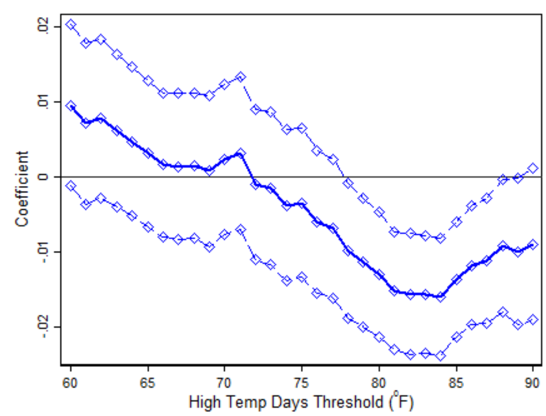
(a) Schooling years



(b) Word-test score



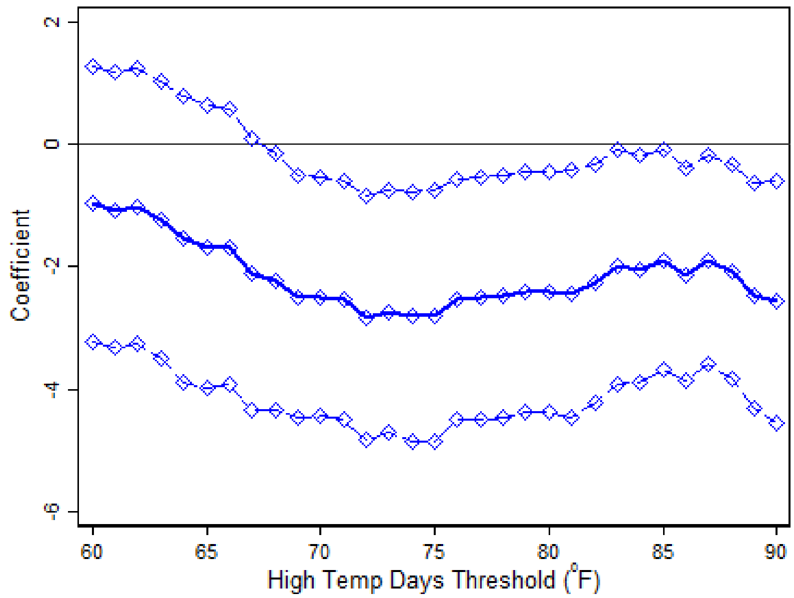
(c) Math-test score



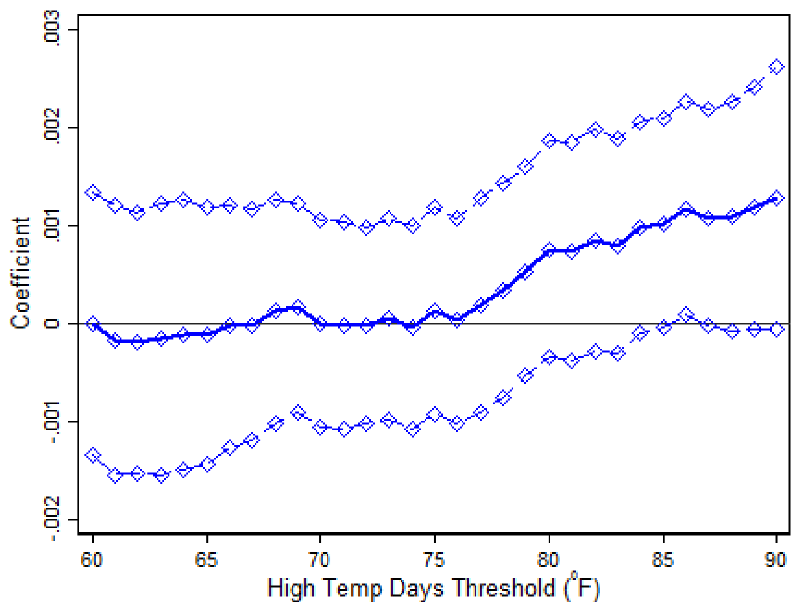
(d) Height

Figure 3: Coefficients of high-temperature days (>85°F) on adult outcomes from regressions using different definitions of high-temperature day.

Notes: The solid line denotes the estimated coefficients on each high-temperature-day definition. Dash lines represent the upper and lower bounds for the 90% confidence interval.



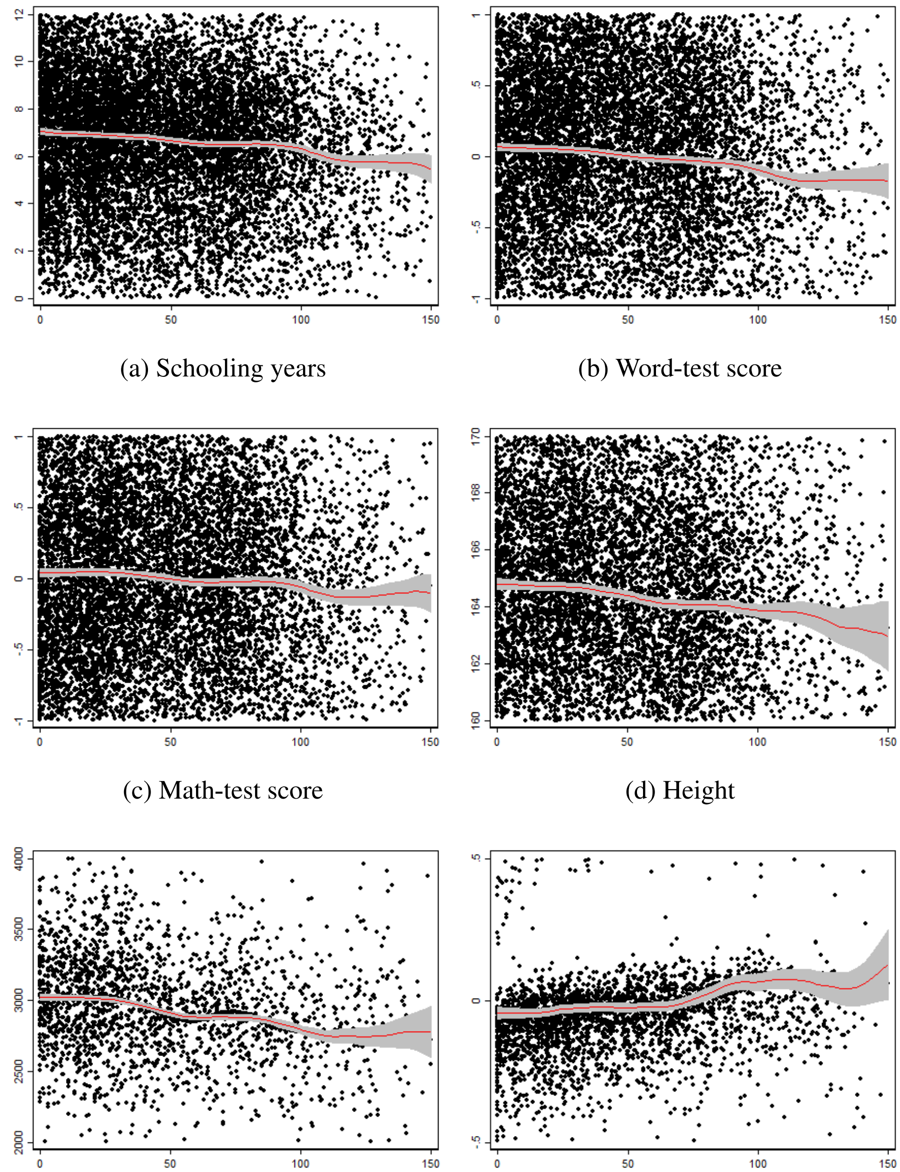
(a) Birth Weight



(b) LBW

Figure 4: Coefficients of high temperature days (>85°F) on birth weight (500 grams) and LBW incidence from regressions using different definitions of high-temperature day.

Notes: The solid line denotes the estimated coefficients on each high-temperature-day definition. Dash lines represent the upper and lower bounds for the 90% confidence interval.



(a) Schooling years

(b) Word-test score

(c) Math-test score

(d) Height

(e) Birth weight

(f) LBW

Figure 5: High-temperature days (>85°F) during pregnancy against adult outcomes and birth weight.

Notes: The solid line shows the fitted partially linear model, and the gray area denotes the 95% confidence interval.

A Appendix

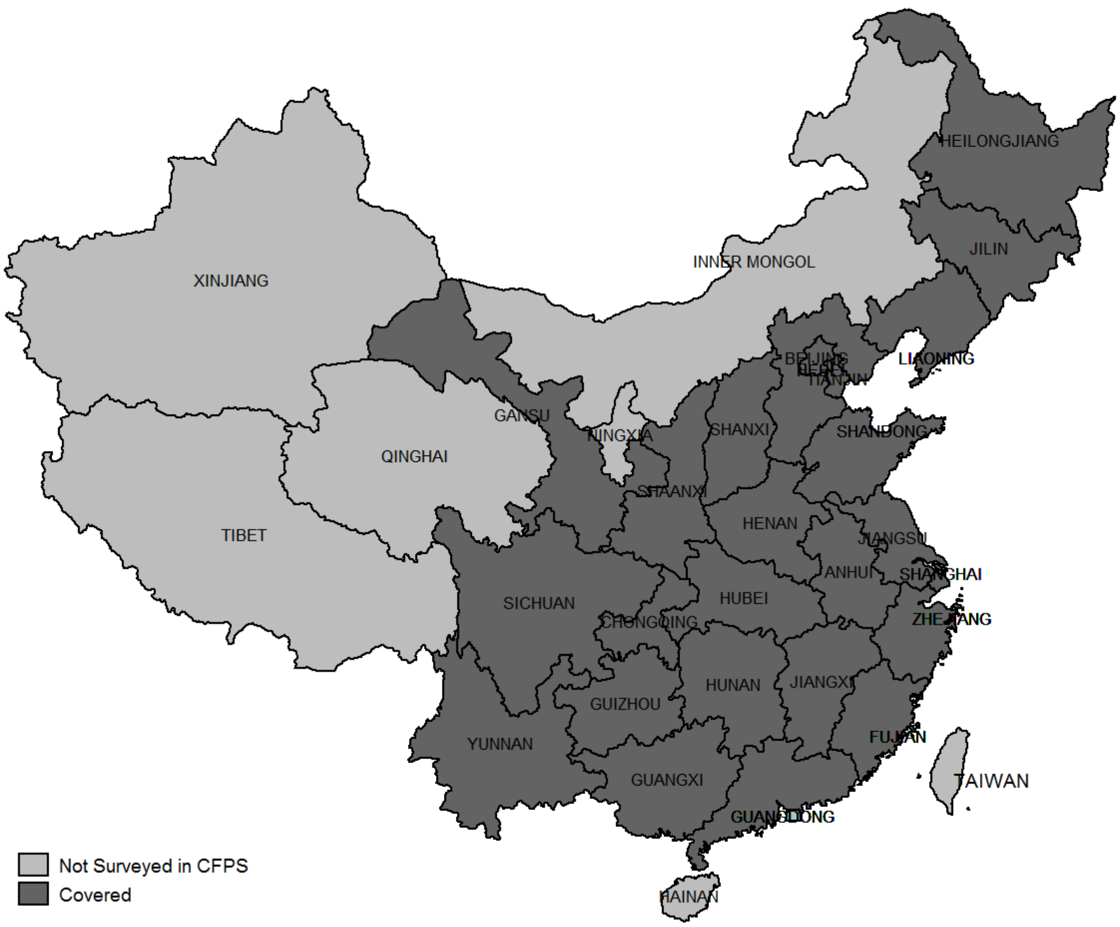
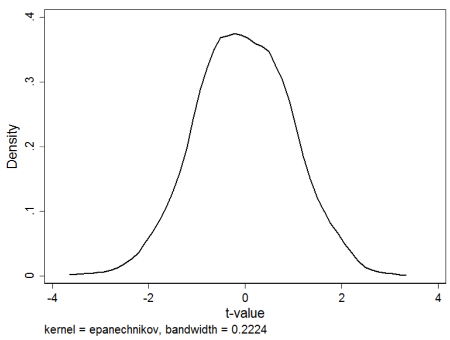
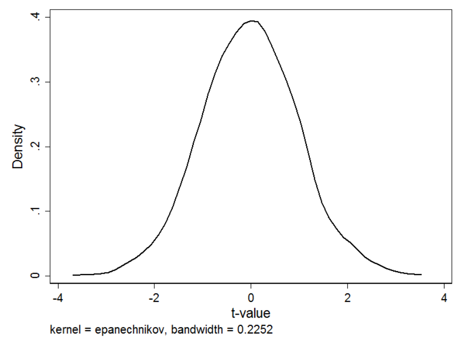


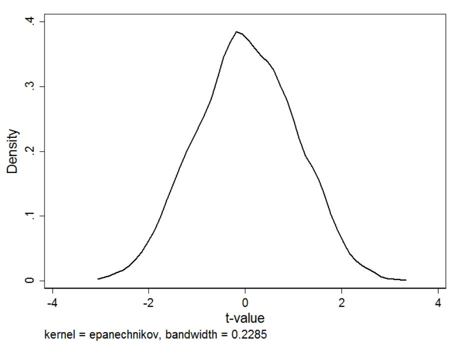
Figure A.1: Provinces covered in the CFPS sample.



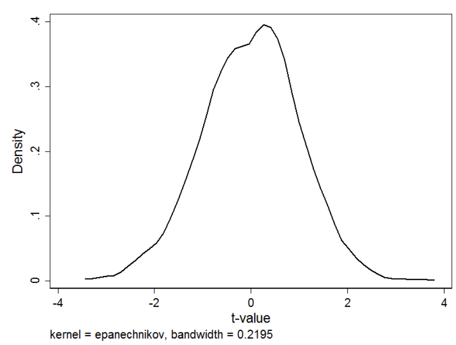
(a) Schooling years



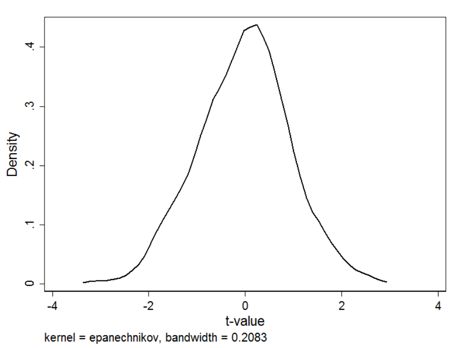
(b) Word-test score



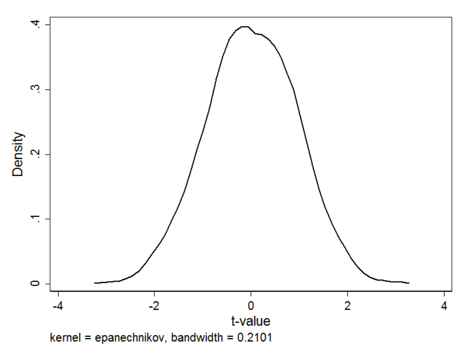
(c) Math-test score



(d) Height



(e) Birth weight



(f) LBW

Figure A.2: Distribution of t-statistic for high-temperature days of 1,000 estimates for Equation (1) with placebo birth time and place.

Table A.1: The effects of high temperature during the eight months before birth on all outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days (8 Mon)	-0.0091**	-0.0022**	-0.0015*	-0.0086*	-0.0033*	0.0009
	(0.0035)	(0.0010)	(0.0008)	(0.0049)	(0.0019)	(0.0006)
Low Temp Days (8 Mon)	0.0053**	0.0009	0.0010*	0.0041	0.0000	-0.0001
	(0.0023)	(0.0006)	(0.0006)	(0.0039)	(0.0014)	(0.0004)
Precipitation (8 Mon)	-0.0002	-0.0000	-0.0000	-0.0001	-0.0002*	0.0000
	(0.0002)	(0.0001)	(0.0000)	(0.0004)	(0.0001)	(0.0000)
Female	-1.3377***	-0.2982***	-0.3243***	-10.1616***	-0.2865***	0.0232*
	(0.1207)	(0.0332)	(0.0326)	(0.1374)	(0.0467)	(0.0140)
Han	0.0907	0.0844	0.0363	0.8566**	0.0732	0.0125
	(0.4289)	(0.1207)	(0.1164)	(0.3411)	(0.2118)	(0.0295)
Mother's Education Years	0.1097***	0.0193***	0.0262***	0.0650***	0.0034	-0.0015
	(0.0112)	(0.0027)	(0.0030)	(0.0204)	(0.0074)	(0.0019)
Mother's Age at Birth	0.0347***	0.0020	0.0079***	0.0216	-0.0101	0.0022
	(0.0108)	(0.0029)	(0.0026)	(0.0176)	(0.0064)	(0.0020)
Father's Education Years	0.1561***	0.0314***	0.0371***	0.0332*	0.0129*	-0.0040**
	(0.0118)	(0.0031)	(0.0032)	(0.0185)	(0.0071)	(0.0018)
Father's Age at Birth	-0.0197**	-0.0008	-0.0046*	-0.0187	0.0011	-0.0008
	(0.0094)	(0.0022)	(0.0023)	(0.0169)	(0.0064)	(0.0019)
Birth Order	0.0277	0.0035	0.0021	0.0464	0.0393	-0.0009
	(0.0434)	(0.0107)	(0.0100)	(0.0733)	(0.0318)	(0.0103)
Number of Siblings	-0.0515	0.0059	-0.0018	-0.0670	-0.0460*	0.0024
	(0.0373)	(0.0103)	(0.0093)	(0.0605)	(0.0255)	(0.0061)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	3223	3223
R-Squared	0.404	0.416	0.396	0.576	0.413	0.321

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.2: Robustness checks of effects of high temperatures during pregnancy for the two group individuals—with and without birth weight data.

	(1)	(2)	(3)	(4)
Dependent Variable:	Eduy	Word Test	Math Test	Height
High Temp Days X Birth Weight Missing	-0.0032	-0.0007	-0.0001	0.0027
	(0.0029)	(0.0007)	(0.0007)	(0.0044)
High Temp Days	-0.0062	-0.0017*	-0.0014	-0.0135**
	(0.0042)	(0.0010)	(0.0009)	(0.0061)
Birth Weight Missing	-0.0409	0.0166	-0.0533	-0.2377
	(0.1750)	(0.0397)	(0.0428)	(0.2685)
Low Temp Days	0.0051**	0.0008	0.0011*	0.0045
	(0.0025)	(0.0007)	(0.0006)	(0.0043)
Precipitation	0.0704	-0.0032	0.0038	-0.1897*
	(0.0708)	(0.0153)	(0.0144)	(0.0993)
Female	-1.3337***	-0.2980***	-0.3232***	-10.1620***
	(0.1201)	(0.0332)	(0.0325)	(0.1375)
Han	0.1025	0.0861	0.0390	0.8601**
	(0.4325)	(0.1213)	(0.1172)	(0.3394)
Mother's Education Years	0.1088***	0.0192***	0.0260***	0.0649***
	(0.0111)	(0.0027)	(0.0030)	(0.0204)
Mother's Age at Birth	0.0345***	0.0019	0.0078***	0.0213
	(0.0108)	(0.0029)	(0.0026)	(0.0177)
Father's Education Years	0.1558***	0.0314***	0.0369***	0.0327*
	(0.0119)	(0.0031)	(0.0032)	(0.0184)
Father's Age at Birth	-0.0197**	-0.0008	-0.0045*	-0.0181
	(0.0095)	(0.0022)	(0.0023)	(0.0169)
Birth Order	0.0281	0.0035	0.0020	0.0452
	(0.0437)	(0.0107)	(0.0101)	(0.0734)
Number of Siblings	-0.0499	0.0060	-0.0013	-0.0668
	(0.0374)	(0.0103)	(0.0093)	(0.0606)
County FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685
R-Squared	0.404	0.416	0.396	0.576

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.3: Robustness checks of the impacts of high temperatures on all outcomes using weather stations within 60 km radius

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0068*	-0.0014	-0.0005	-0.0105**	-2.8805***	0.0015**
	(0.0037)	(0.0010)	(0.0009)	(0.0048)	(1.0729)	(0.0007)
Low Temp Days	0.0038	0.0002	0.0004	0.0046	0.0613	0.0000
	(0.0027)	(0.0007)	(0.0007)	(0.0046)	(0.9020)	(0.0005)
Precipitation	0.0150	-0.0043	-0.0056	-0.1290	-64.3984***	0.0404***
	(0.0689)	(0.0121)	(0.0149)	(0.1081)	(22.0220)	(0.0130)
Female	-1.2850***	-0.2938***	-0.3225***	-10.1945***	-144.3006***	0.0261*
	(0.1229)	(0.0346)	(0.0339)	(0.1336)	(23.9008)	(0.0153)
Han	-0.3129	-0.0357	-0.0845	0.8252**	-25.9950	0.0347
	(0.2513)	(0.0568)	(0.0563)	(0.3301)	(110.4508)	(0.0257)
Mother's Education Years	0.1040***	0.0189***	0.0247***	0.0723***	1.8326	-0.0013
	(0.0115)	(0.0028)	(0.0029)	(0.0212)	(3.8675)	(0.0020)
Mother's Age at Birth	0.0396***	0.0021	0.0080***	0.0222	-4.4476	0.0021
	(0.0117)	(0.0033)	(0.0028)	(0.0198)	(3.6931)	(0.0023)
Father's Education Years	0.1545***	0.0303***	0.0367***	0.0323	6.0786	-0.0040**
	(0.0117)	(0.0031)	(0.0031)	(0.0196)	(3.7875)	(0.0019)
Father's Age at Birth	-0.0227**	-0.0011	-0.0047*	-0.0202	0.1367	-0.0004
	(0.0097)	(0.0024)	(0.0025)	(0.0175)	(3.5920)	(0.0021)
Birth Order	0.0295	0.0039	0.0001	0.0336	22.2157	-0.0012
	(0.0465)	(0.0117)	(0.0111)	(0.0799)	(16.6576)	(0.0104)
Number of Siblings	-0.0549	0.0072	-0.0003	-0.0496	-23.7325*	0.0002
	(0.0399)	(0.0110)	(0.0101)	(0.0628)	(13.4339)	(0.0068)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9850	9850	9850	9850	2977	2977
R-Squared	0.399	0.397	0.389	0.582	0.423	0.346

Notes: An observation is an individual born in a rural area. Each county is matched to all weather stations within 60 km. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.4: Robustness checks of the impacts of high temperatures on all outcomes using weather stations within 100 km radius

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0050	-0.0017*	-0.0006	-0.0122**	-1.8773*	0.0010
	(0.0036)	(0.0009)	(0.0008)	(0.0048)	(1.0650)	(0.0007)
Low Temp Days	0.0044*	0.0008	0.0009	0.0042	-0.6361	0.0001
	(0.0025)	(0.0007)	(0.0006)	(0.0042)	(0.8535)	(0.0004)
Precipitation	0.1504**	0.0223	0.0280	-0.2713***	-71.4837**	0.0283
	(0.0731)	(0.0203)	(0.0170)	(0.0874)	(32.6139)	(0.0230)
Female	-1.3769***	-0.3096***	-0.3340***	-10.1539***	-143.0207***	0.0222
	(0.1201)	(0.0325)	(0.0322)	(0.1344)	(22.9468)	(0.0134)
Han	0.0869	0.0826	0.0365	0.9068***	38.6816	0.0128
	(0.4238)	(0.1177)	(0.1136)	(0.3284)	(103.7749)	(0.0295)
Mother's Education Years	0.1083***	0.0193***	0.0261***	0.0633***	1.5907	-0.0015
	(0.0111)	(0.0027)	(0.0029)	(0.0204)	(3.7864)	(0.0019)
Mother's Age at Birth	0.0307***	0.0009	0.0072***	0.0173	-4.6842	0.0022
	(0.0107)	(0.0029)	(0.0025)	(0.0176)	(3.1381)	(0.0020)
Father's Education Years	0.1577***	0.0313***	0.0371***	0.0342*	6.3906*	-0.0038**
	(0.0114)	(0.0031)	(0.0031)	(0.0180)	(3.4893)	(0.0017)
Father's Age at Birth	-0.0170*	-0.0003	-0.0041*	-0.0186	0.6112	-0.0008
	(0.0091)	(0.0021)	(0.0022)	(0.0167)	(3.1877)	(0.0019)
Birth Order	0.0284	0.0018	0.0012	0.0521	15.9240	-0.0008
	(0.0426)	(0.0105)	(0.0099)	(0.0729)	(15.5404)	(0.0101)
Number of Siblings	-0.0585	0.0080	-0.0021	-0.0636	-20.0410	0.0021
	(0.0369)	(0.0100)	(0.0092)	(0.0580)	(12.4215)	(0.0059)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10932	10932	10932	10932	3268	3268
R-Squared	0.404	0.421	0.398	0.574	0.410	0.321

Notes: An observation is an individual born in a rural area. Each county is matched to all weather stations within 100 km. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.5: The impacts of high temperatures on all outcomes (three two-way fixed effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0079	-0.0024*	-0.0022*	-0.0126*	-2.4396	0.0013
	(0.0050)	(0.0013)	(0.0012)	(0.0073)	(1.8310)	(0.0011)
Low Temp Days	0.0113	0.0020	0.0027	0.0169*	-0.3866	0.0004
	(0.0071)	(0.0020)	(0.0020)	(0.0090)	(2.1706)	(0.0015)
Precipitation	0.1397*	0.0025	0.0167	-0.2104**	-89.0660**	0.0494**
	(0.0773)	(0.0167)	(0.0149)	(0.1058)	(39.0170)	(0.0223)
Demographics Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Province - Birth Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Province - Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year - Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	3223	3223
R-Squared	0.452	0.460	0.445	0.611	0.589	0.511

Notes: An observation is an individual born in an rural area. High-temperature days are defined as those with daily maximum temperature higher than 85°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.6: The impacts of high temperatures on all outcomes clustered at the province level

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0085***	-0.0022***	-0.0014**	-0.0115***	-2.1416*	0.0012**
	(0.0027)	(0.0007)	(0.0007)	(0.0041)	(1.0401)	(0.0005)
Low Temp Days	0.0052**	0.0008	0.0011*	0.0043	-0.4953	0.0001
	(0.0023)	(0.0005)	(0.0006)	(0.0026)	(0.6331)	(0.0003)
Precipitation	0.0733	-0.0028	0.0047	-0.1883*	-64.7445**	0.0320**
	(0.0540)	(0.0129)	(0.0128)	(0.1086)	(28.1537)	(0.0115)
Female	-1.3376***	-0.2948***	-0.3291***	-10.1642***	-144.6298***	0.0237
	(0.1832)	(0.0487)	(0.0544)	(0.1879)	(20.7447)	(0.0147)
Han	0.0945	0.0842	0.0375	0.8575*	37.6086	0.0119
	(0.5081)	(0.1259)	(0.1315)	(0.4661)	(115.8172)	(0.0204)
Mother's Education Years	0.1096***	0.0190***	0.0266***	0.0654***	1.8764	-0.0016
	(0.0138)	(0.0030)	(0.0035)	(0.0159)	(3.5041)	(0.0013)
Mother's Age at Birth	0.0346***	0.0019	0.0080***	0.0214	-5.0695*	0.0022
	(0.0108)	(0.0029)	(0.0028)	(0.0138)	(2.5107)	(0.0021)
Father's Education Years	0.1562***	0.0310***	0.0376***	0.0333	6.4526*	-0.0041**
	(0.0123)	(0.0033)	(0.0033)	(0.0234)	(3.5322)	(0.0017)
Father's Age at Birth	-0.0198**	-0.0008	-0.0047*	-0.0183	0.6383	-0.0009
	(0.0091)	(0.0025)	(0.0024)	(0.0141)	(3.1692)	(0.0014)
Birth Order	0.0284	0.0035	0.0022	0.0457	19.4080	-0.0007
	(0.0267)	(0.0077)	(0.0067)	(0.0593)	(13.5698)	(0.0093)
Number of Siblings	-0.0516	0.0058	-0.0019	-0.0677	-23.4000**	0.0025
	(0.0327)	(0.0070)	(0.0077)	(0.0463)	(10.5435)	(0.0047)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	3223	3223
R-Squared	0.404	0.416	0.396	0.576	0.414	0.322

Notes: An observation is an individual born in a rural area. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. Ordinary least squares estimates. Standard errors in parentheses, clustered by province. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.7: The impact of high temperatures during pregnancy on cognitive ability including county specific survey month fixed effects

	(1)	(2)
Dependent Variable:	Word Test	Math Test
High Temp Days	-0.0019**	-0.0010
	(0.0009)	(0.0009)
Low Temp Days	0.0005	0.0007
	(0.0007)	(0.0006)
Precipitation	-0.0037	0.0074
	(0.0160)	(0.0151)
Female	-0.2971***	-0.3292***
	(0.0332)	(0.0331)
Han	0.0560	0.0080
	(0.1155)	(0.1109)
Mother's Education Years	0.0176***	0.0244***
	(0.0027)	(0.0032)
Mother's Age at Birth	0.0025	0.0084***
	(0.0030)	(0.0027)
Father's Education Years	0.0292***	0.0353***
	(0.0029)	(0.0031)
Father's Age at Birth	-0.0011	-0.0054**
	(0.0023)	(0.0025)
Birth Order	0.0017	0.0006
	(0.0108)	(0.0101)
Number of Siblings	0.0055	-0.0014
	(0.0097)	(0.0093)
County-Survey Month FE	Yes	Yes
Birth Month FE	Yes	Yes
Province-Year FE	Yes	Yes
Observations	10685	10685
R-Squared	0.451	0.430

Notes: An observation is an individual born in a rural area. The dependent variable are standardised word-test and math-test scores. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.8: The impact of high temperatures during pregnancy on personal annual income (Log 2010 CNY)

	(1)	(2)	(3)	(4)
Dependent Variable:	Income(ln)	Income(ln)	Income(ln)	Income(ln)
High Temp Days	-0.0006	-0.0008	-0.0009	-0.0013
	(0.0013)	(0.0013)	(0.0012)	(0.0015)
Low Temp Days	-0.0009	-0.0002	-0.0002	0.0006
	(0.0010)	(0.0009)	(0.0009)	(0.0011)
Precipitation	0.0221	0.0100	0.0114	0.0381
	(0.0173)	(0.0170)	(0.0153)	(0.0241)
County FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes
County Specific Linear Trend	No	No	Yes	No
County Specific Quadratic Trend	No	No	Yes	No
Province-Year FE	No	No	No	Yes
Observations	8077	8077	8077	8077
R-Squared	0.202	0.280	0.317	0.379

Notes: An observation is an individual born in a rural area. The dependent variable is the logarithm of personal annual income. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.9: The impacts of high temperatures on all outcomes (county-year fixed effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0104***	-0.0025**	-0.0015	-0.0082	-2.5492**	0.0015**
	(0.0039)	(0.0010)	(0.0010)	(0.0054)	(1.0849)	(0.0007)
Low Temp Days	0.0057*	0.0006	0.0009	0.0043	-1.4540	0.0002
	(0.0033)	(0.0008)	(0.0008)	(0.0052)	(0.9054)	(0.0006)
Precipitation	-0.0454	-0.0257	-0.0183	-0.1111	-158.2645***	0.0687**
	(0.1286)	(0.0356)	(0.0328)	(0.2059)	(53.2945)	(0.0344)
Demographics Controls	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
County-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10685	10685	10685	10685	3223	3223
R-Squared	0.591	0.590	0.581	0.703	0.685	0.634

Notes: An observation is an individual born in an rural area. High-temperature days are defined as those with daily maximum temperature higher than 85°F. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.10: Does a high proportion of heat-tolerant crops mitigate the adverse effects of high temperatures during pregnancy on all outcomes? (using crop proportion in 1950)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Eduy	Word Test	Math Test	Height	Birth Weight	LBW
High Temp Days	-0.0095***	-0.0028***	-0.0016*	-0.0110*	-2.1387*	0.0015*
	(0.0036)	(0.0009)	(0.0009)	(0.0062)	(1.2196)	(0.0007)
High Temp Days X C4	0.0165	0.0085	0.0027	-0.0045	0.3136	-0.0048
	(0.0161)	(0.0052)	(0.0047)	(0.0490)	(10.5904)	(0.0065)
Low Temp Days	0.0051**	0.0008	0.0011*	0.0043	-0.4672	0.0000
	(0.0024)	(0.0006)	(0.0006)	(0.0043)	(0.8768)	(0.0004)
Precipitation	0.0743	-0.0033	0.0044	-0.1839*	-62.9296*	0.0322*
	(0.0703)	(0.0150)	(0.0145)	(0.0996)	(33.2612)	(0.0192)
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10628	10628	10628	10628	3207	3207
R-Squared	0.402	0.415	0.394	0.574	0.410	0.320

Notes: An observation is an individual born in a rural area. C4 Plant Area represents corn and sugarcane proportion of crop acreage within the province in 1950. High- and low-temperature days are defined as those with daily maximum temperatures higher than 85°F and with daily minimum temperatures lower than 32°F during the eight months before birth. 57 observations are missing from the main regression sample, because crop-area information is missing for Shanghai in 1993. Demographic controls include gender, race, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.