Too Hot to Handle: The Effects of High Temperatures during Pregnancy on Adult Welfare Outcomes

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Research Question

- Is there any long-term effects of high temperatures during pregnancy on later outcomes for Chinese adults?
- What's the possible channels behind the effects of high temperatures?

Motivation

- Underemphasized cost of global warming
- Especially important for developing countries, such as China
- Providing 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 et al. (2015) and Isen et al. (2017)

Data

- **Individual Data:** 2010 China Family Panel Studies (CFPS)
  - 141 counties across 25 provinces; Standarised test score
  - Restricting to rural born adult individuals in main results
  - 9022 observations in main regressions
- **Weather Data:** China Meterological Administration and NOAA
  - 1509 weather stations across China
  - Taking average of all the weather stations within 80km and that do not vary in elevation by more than 200 meters
  - High temperature: daily maximum temperature higher than 85 ˚F (30 ˚C)

Identification Strategy

- We exploit the random deviation in high temperatures during pregnancy for a given county from it's year-month average level.

$$Y_{icmy} = \beta HighTemp_{icmy} + W'_{icmy}\gamma + X'_i\delta$$

$$+ county_c \times year_y + county_c \times month_m + month_m \times year_y + \epsilon_{icmy}$$

- Include three sets of two-way fixed effects
- Include low temperature days and precipitation as weather control (W_{icmy})
- Include basic demographic variables (X_i) such as gender, parents' education, parental age at delivery, birth order, and number of siblings

Main Results

- A one standard deviation increase in high-temperature days (35.94 days) in utero （Table 1）
  - Lowers the average years of schooling by 0.56 years (13.46% s.d.)
  - Shifts up the probability of being illiterate by 6.47 percentage points
  - Decreases the average word-test score by 17.25% standard deviation
  - Lowers the average height by 0.85 cm (11.07% s.d.)
  - Increases the risk of growing into a lower tail height (bottom decile) by 5.75 percentage points
- The impacts are concentrated in the first and second trimesters.
- No effects for urban-born individuals

Dependent Variable:	(1) Eduy	(2) Illiteracy	(3) Word Test	(4) Height	(5) Bottom 10%
High Temp Days	-0.0155*	0.0018**	-0.0048**	-0.0236*	0.0016**
	(0.0093)	(0.0009)	(0.0022)	(0.0140)	(0.0008)
Low Temp Days	-0.0007	-0.0012	0.0023	0.0158	-0.0007
	(0.0156)	(0.0017)	(0.0038)	(0.0241)	(0.0015)
Precipitation (log)	0.0309	0.0038	-0.0358	-0.0192	-0.0200
	(0.1842)	(0.0218)	(0.0488)	(0.3448)	(0.0172)
Demographics Controls	Yes	Yes	Yes	Yes	Yes
County-Year FE	Yes	Yes	Yes	Yes	Yes
County-Month FE	Yes	Yes	Yes	Yes	Yes
Year-Month FE	Yes	Yes	Yes	Yes	Yes
Observations	9041	9041	9041	9041	9041
R-Squared	0.715	0.657	0.705	0.795	0.620

Note: 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 30°C (85°F) and with daily minimum temperatures lower than 0°C (32°F). Demographic controls include gender, race, birth order, number of siblings, and parents' education years and age at delivery. Ordinary least squares estimates for all columns. Bottom 10% is a dummy indicating that an adults height falls in the bottom 10% of the sample distribution. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Mechanism

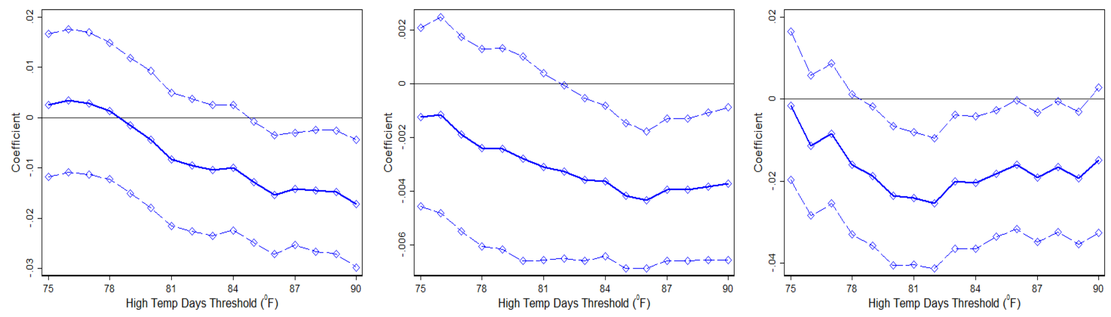
- **Income Effects:** high temperatures may cause damage to crop yields which determine family resources in rural areas
  - The higher the proportion of heat-tolerant crops (C4) , the less adverse effects of high temperatures (Table 2)
  - When the proportion reaches about 30%, the adverse effects of hot weather during pregnancy are muted

Dependent Variable:	(1) Eduy	(2) Illiteracy	(3) Word Test	(4) Height	(5) Bottom 10%
High Temp Days	-0.0313***	0.0034**	-0.0094***	-0.0520**	0.0035***
	(0.0118)	(0.0013)	(0.0033)	(0.0211)	(0.0013)
High Temp Days X C4	0.0011*	-0.0001*	0.0003	0.0018*	-0.0001*
	(0.0006)	(0.0001)	(0.0002)	(0.0010)	(0.0001)
Demographic & Weather Controls	Yes	Yes	Yes	Yes	Yes
County-Year FE	Yes	Yes	Yes	Yes	Yes
County-Month FE	Yes	Yes	Yes	Yes	Yes
Year-Month FE	Yes	Yes	Yes	Yes	Yes
Observations	9022	9022	9022	9022	9022
R-Squared	0.715	0.657	0.705	0.795	0.620

Note: 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-temperature days are defined as those with daily maximum temperatures higher than 85°F. 19 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. Weather controls include low-temperature days and total precipitation during pregnancy. Ordinary least squares estimates. Standard errors in parentheses, clustered by county. ***Significant at 1%, **significant at 5%, *significant at 10%.

Robustness Checks

- **Different thresholds** for high temperature day definitions (Figure 1)
  - The coefficients become larger with increasing thresholds
  - The results are robust for different thresholds
- **Placebo test**: high temperatures during nine months before conception have no effects
- **S.E. calculation:** the results are robust to various level of clustering for standard errors: 1) county clusters 2) province clusters (bootstrap) 3) Two-way clusters (county and year) 4) Spatial Clusters (Hsiang 2010)
- **Balance Check:** high-temperature days are not associated with the observable characteristics conditional on the sets of fixed effect. All coefficients of high-temperature days are neither economically nor statistically significant



(a) Schooling Years (b) Word-test Scores (c) Height

Note: 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.

Discussions

- **Temperatures after birth:**
  - High-temperature days during nine months after birth are negatively but not statistically significantly associated with any adult outcomes
  - Cold weather in nine months after birth statistically significantly affects educational attainment (consistent with Deschenes and Moretti (2009))
- **Heterogeneity:** No significant heterogeneous effects across parents with different education levels

Conclusions

- Hot weather during pregnancy not only triggers adverse birth outcomes, but has persistent and profound effects in later life
- The impacts are concentrated in the first and second trimesters
- The income effects are one important channel through which high temperatures during pregnancy affect birth weight and further adult outcomes

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