Prenatal Exposure to Mild Shock and Early Childhood Health:

Evidence from Nepal

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Motivation

Figure 1: *Janam Kundali* (Cosmic map of the solar system for a person born at 8 AM on October 11, 2018, in Madison-WI

Introduction

Fetal Origin Hypothesis - (Barker, 1992)

- Nutritional Deficiency in utero can lead to future diseases

Economist's Contribution

- Natural shocks (environmental pollution, extreme climatic events, natural disasters)
- Socio-cultural shocks (civil unrest, war, domestic violence, Ramadan)
- Economic shocks (income, agricultural output, prices)
- Health (Illness, Injury, maternal health stressors)

Wide range of outcomes - **test-scores**, **educational attainment**, **income** and **health**.

Does temperature shock in utero impacts early childhood health?

Literature Review & Research Gap

1: Focus on severe events like drought or heat-wave

- Kumar et al., 2016; Agero, 2014; Skoufias and Vinha, 2012; Groppo and Kraehnert, 2016

2: Focus on the outcomes at birth or in adulthood

- Nepal: Mulmi et al., 2016; Tiwari et al., 2016;
- Sub-Saharan Africa: Wang et al., 2014; Wilde et al., 2017
- South America: Molina and Saldarriaga, 2017

Research Gap

Impact of `mild shocks` in utero on `early childhood health`

Research Questions

Question 1

How does mild temperature shocks in utero impact early childhood health status?

Question 2

Is the impact, if any, transitory or persistent?

Question 3

What are the possible channels through which mild temperature shock in utero can impede child growth?

Methodological Framework

Questions 1 & 2

$$H_{imyr} = \alpha + \beta_2 T_{imyr} + \pi X_{imyr} + \lambda_m + \delta_y + \gamma_r + \epsilon_{imyr} \quad (1)$$

- H_{imyc} – is the outcome variable for child (i), born in the month (m), in the year (y) and in the ecological belt (r)
- T – Number of prenatal days exposed to high temperature (Daily mean temperature higher or equal to 32 C [89.6 F])

Identification Strategy

- The underlying assumption is that the extreme temperature is an **exogenous** and **random variable**, given the controls for the place-specific seasonality.

Data

Data Sources

- Multiple Indicator Survey (MICS) - Nepal 2014
  - Information on child, mother and household characteristics
- Department of Hydrology and Meteorology (DHM), Nepal
  - Ground-level daily temperature stations
- Ministry of Agriculture Development (MAD), Nepal
  - Food prices for major retail food market in Nepal

Data and Descriptive Statistics - 1

Table 1 – Panel A: Descriptive Statistics for Child, Mother and Household Characteristics

Variable	Variable Description	Mean (std. dev.)
Height-for-Age z-score	Height-for-age z-score of the children between ages 0 to 60 months. Calculated by MICS using 2006 WHO child growth standards.	-1.653
		(1.537)
Female	An indicator variable where 1 = female gender and 0 = male gender.	0.473
		(0.499)
Age of child	Age of the children in months.	30.79
		(17.28)
Birth order	Birth order of the children	2.878
		(1.728)
Mother's level of schooling	Mother's education level. Categorical Variable: None, Primary, Secondary and Higher.	2.150
		(1.161)
Age of Mother	Mothers age at birth (in years).	27.26
		(5.931)
Wealth index	Household Wealth index: Categorical variable: Poorest, Second, Middle, Fourth and Richest	2.481
		(1.434)
Household size	Head-count of the people living under the same roof and sharing kitchen.	6.210
		(3.068)
Rural	Indicator variable where 1 = child is a rural resident, and 0 = Urban resident	0.822
		(0.383)
Dalit	Indicator variable: where 1 = Dalit or lower caste as classified by Nepal Census 2011, 0 = otherwise.	0.175
		(0.380)
Mountain	Climate and agro-ecological zone of Nepal with elevation (from sea level) 2000 meters or above.	0.289
		(0.453)
Hill	Second climate and agro-ecological zone with elevation ranges from 300 to 2000 meters.	0.364
		(0.481)
Lowland	Also called Terai is the lowest climate and agro-ecological zone with elevation ranges from 60 to 300 meters.	0.347
		(0.476)
Observations		4704

Data and Descriptive Statistics - 2

Table 1: Panel B – Descriptive statistics for extreme temperature and matching distances

Variable	Variable Description	Mean (std. dev.)
Temperature	Number of days in gestation with daily mean temperature higher or equal to 32 degree Celsius (98.6 degree Celsius).	4.043
		(9.641)
Difference in elevation	Differences between household cluster elevation and matched station elevation. The elevation is measured in meters.	23.33
		(462.4)
Distance	The distance between household cluster and matched meteorological station. The distance is measured in kilometers.	17.47
		(11.52)
Observations		4704

Q1: How does mild temperature shocks in utero impact early childhood health status?

Table 2: Effect of Extreme Temperature in utero on the Height-for-Age z-score

	Height-for-Age z-score			
	(1)	(2)	(3)	(4)
Temperature	-0.0108***	-0.0107***	-0.00980***	-0.00804***
	(0.00303)	(0.00305)	(0.00291)	(0.00285)
Female		0.0400	0.0535	0.0595
		(0.0424)	(0.0423)	(0.0418)
Age of child		-0.0131	0.00615	0.0319
		(0.0256)	(0.0240)	(0.0235)
Mother's level of schooling			0.255***	0.116***
			(0.0238)	(0.0253)
Mother's age square			0.000256***	0.000254***
			(0.0000711)	(0.0000768)
Wealth index				0.192***
				(0.0246)
Household size				-0.0210**
				(0.00838)
Rural				-0.0275
				(0.0719)
Dalit				-0.155**
				(0.0721)
Elevation	-0.000229***	-0.000222***	-0.000202***	-0.000194***
	(0.0000794)	(0.0000796)	(0.0000738)	(0.0000700)
Region-month fixed effects	Yes	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes	Yes
R-squared	0.117	0.117	0.150	0.176
Observations	4704	4704	4704	4704

Notes: Robust standard errors in parentheses clustered by the household sampling cluster unit; * p < 0.10, ** p < 0.05, *** p < 0.01

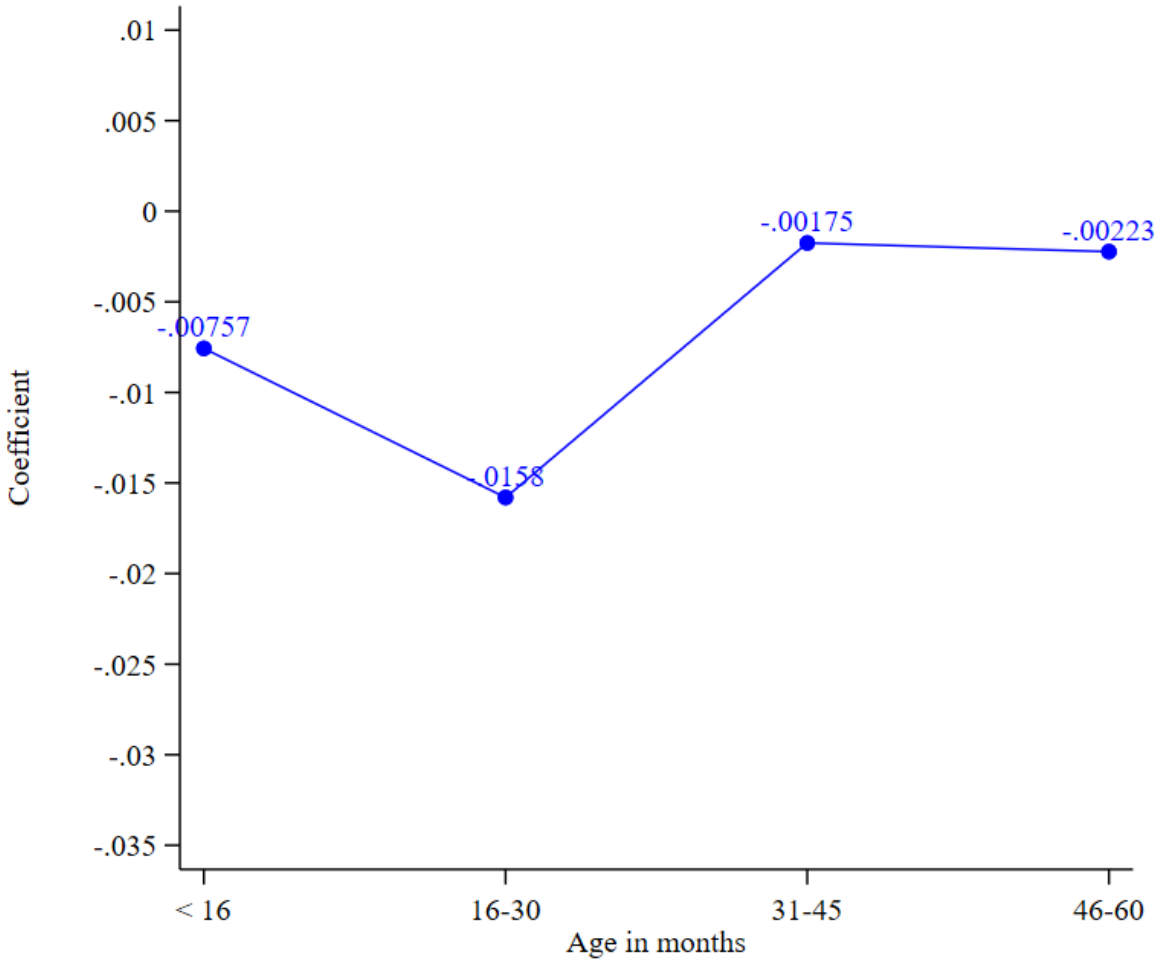
Q2: Is the impact, if any, transitory or persistent?

Table 6: Effect of Extreme Temperature in utero on the Height-for-Age z-score for Different Age Groups

	Height-for-Age z-score			
	Younger than 16 months	Between 16 to 30 months	Between 31 to 45 months	Between 46 to 60 months
Temperature	-0.00757*	-0.0158***	-0.00175	-0.00223
	(0.00589)	(0.00501)	(0.00649)	(0.00503)
Female	0.101	0.218**	0.00243	-0.0200
	(0.0919)	(0.0877)	(0.0785)	(0.0785)
Age of child	-0.0116	0.0584	-0.0172	0.0915***
	(0.0496)	(0.0397)	(0.0366)	(0.0339)
Mother's level of schooling	0.0717	0.0976**	0.141***	0.117***
	(0.0476)	(0.0490)	(0.0453)	(0.0420)
Mother's age square	0.0000181	0.000567***	0.000309**	0.000165
	(0.000179)	(0.000162)	(0.000138)	(0.000112)
Wealth index	0.107**	0.215***	0.213***	0.248***
	(0.0490)	(0.0456)	(0.0377)	(0.0395)
Household size	-0.00383	-0.0331**	-0.00482	-0.0396***
	(0.0156)	(0.0156)	(0.0163)	(0.0110)
Rural	0.0944	-0.190	-0.0129	0.0652
	(0.151)	(0.128)	(0.123)	(0.118)
Dalit	-0.347**	-0.148	-0.164	0.0383
	(0.142)	(0.134)	(0.114)	(0.122)
Elevation	-0.000160	-0.000151	-0.000103	-0.000307***
	(0.000145)	(0.000131)	(0.000107)	(0.000106)
Region-month fixed effects	Yes	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes	Yes
Observations	1148	1146	1220	1190
R-squared	0.107	0.150	0.127	0.173

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses clustered at the household sampling cluster unit. All model uses the specification in Table 2 Column 4.

Q2: Is the impact, if any, transitory or persistent?



Note: Plot of coefficients from Table 6.
Calculated using the specification in Table 2, Column 4.

Mechanism

Indirect mechanisms:

- Lack of food and safe drinking water
- Poor sanitation
- Changing disease pattern
- Health-care utilization

Child stunting (Height-for-age z-score $<$ -2) in Nepal:

From 2001 to 2011, child stunting decreased by 16 percentage points

- Health intervention
- Nutrition intervention
- Improved sanitation
- Mothers education

Q3: Channels: Income Shock

Table 8: Effect of extreme temperature on food prices

	(1) Rice	(2) Meat	(3) Milk	(4) Wheat	(5) Vegetables	(6) Lentil
Temperature	0.315**	1.642**	0.249**	-0.0684	0.235	0.234
	(0.123)	(0.724)	(0.121)	(0.0742)	(0.204)	(0.204)
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Geographical region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.168	0.081	0.013	0.359	0.052	0.052
Observation	1,043	1,021	1,029	1,040	995	994

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses clustered by the district level. Temperature is defined as the number of extreme temperature days (daily mean temperature equal or higher than 32 C). The wholesale prices are in constant 2016 Nepali Rupees. Except column 3 which is measured in Liters, the foods are measured in kilograms. Further definition of the food item can be found in Table 1 Panel C.

Assuming a person consumes half a kilogram of rice per day, rice consumption only would increase the monthly budget by Rs. 47.25 or (2%). Similarly, assuming a person consumes 1 kilogram meat per week, meat consumption would increase the monthly budget by 3 percent.

Q3: Channels: Avoidance Behavior

Table 9: Effect of extreme temperature on prenatal care utilization

	Prenatal Health Care Utilization	
	(1)	(2)
Temperature	-0.0163***	-0.0110**
	(0.00478)	(0.00472)
Birth order		-0.0698**
		(0.0295)
Age of Mother		0.0244
		(0.0602)
Mother's age square		0.0000901
		(0.00105)
Father absent		-0.0195
		(0.103)
Mother's level of schooling		0.221***
		(0.0396)
Wealth index		0.304***
		(0.0441)
Household size		-0.0354***
		(0.0126)
Rural		-0.383**
		(0.153)
Dalit		-0.00275
		(0.111)
Month fixed effects	Yes	Yes
Geographical region fixed effects	Yes	Yes
R-Squared	0.061	0.207
Observation	2091	2090

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses clustered at the sampling cluster unit.

Results Summary

Q1:How does mild temperature shocks in utero impact early childhood health status?

- Exposure to 10 additional high temperature days during gestation impedes child growth by 0.08-0.11 standard deviations

Q2:Is the impact, if any, transitory or persistent?

- The damage appears to be transitory as opposed to persistent and cumulative as the impact gradually decreases with age

Q3: What are the possible channels through which mild temperature shock in utero can impede child growth?

- The impact on food price is ambiguous - high commodity food (rice and meat) are stronger compared to low commodity staples (wheat or lentils)
- Pregnant women respond with reduced prenatal care suggesting avoidance behavior

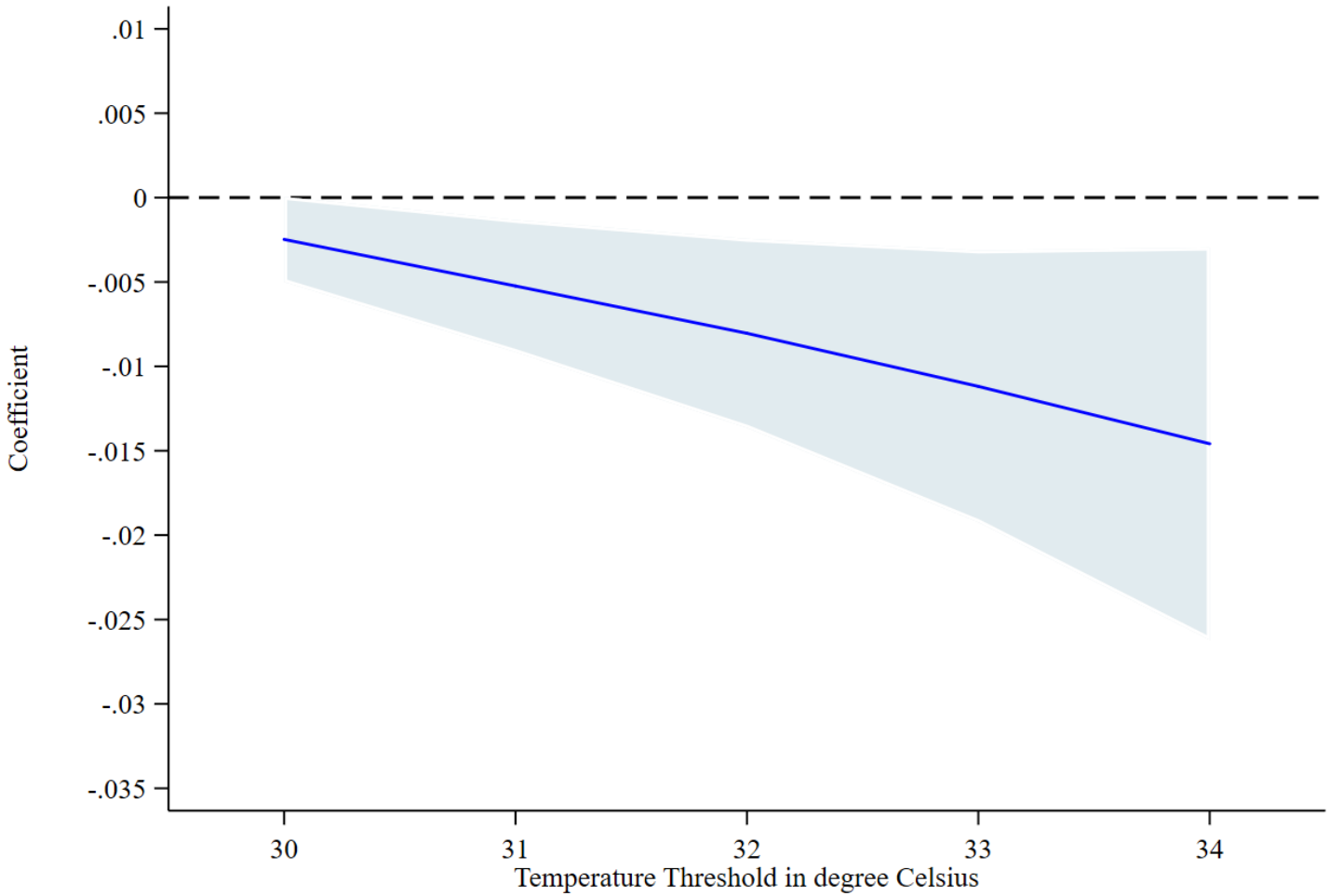
Conclusion

Consistent with the fetal origin hypothesis, prenatal exposure to `mild shocks` in utero negatively impact `early childhood health`.

However, the impact is transitory as opposed to persistent.

Questions

Robustness Check



Note: Coefficient estimated using Model 4 Table 2 for different threshold for extreme temepature.
The blue line represents the point estimate with 95% confidence Interval.

Figure 2: *Robustness Check 1: Different definition of High Temperature*

Temperature Distribution

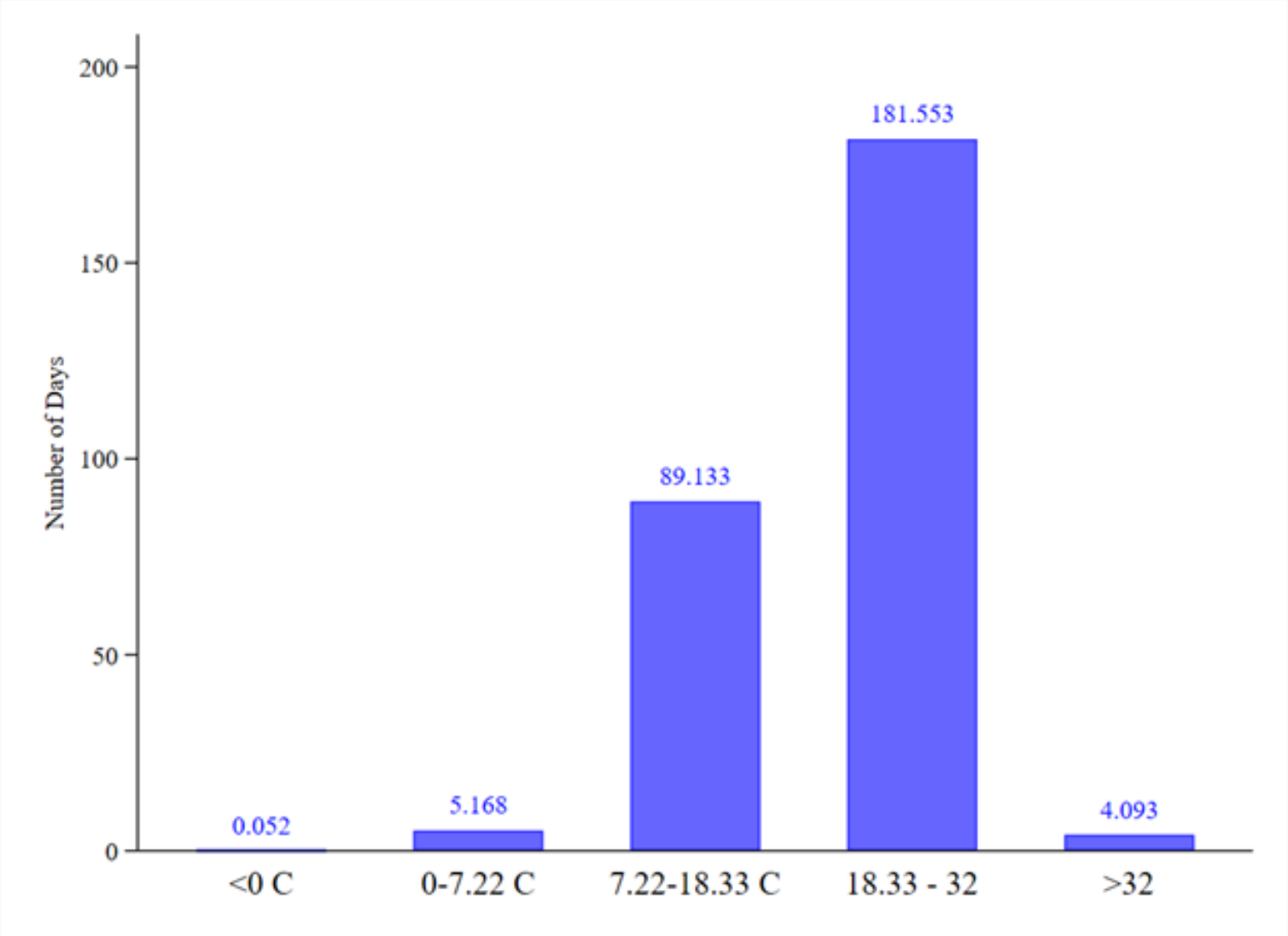


Figure 3: *Distribution of daily mean temperature exposure during the gestation*

Study Area

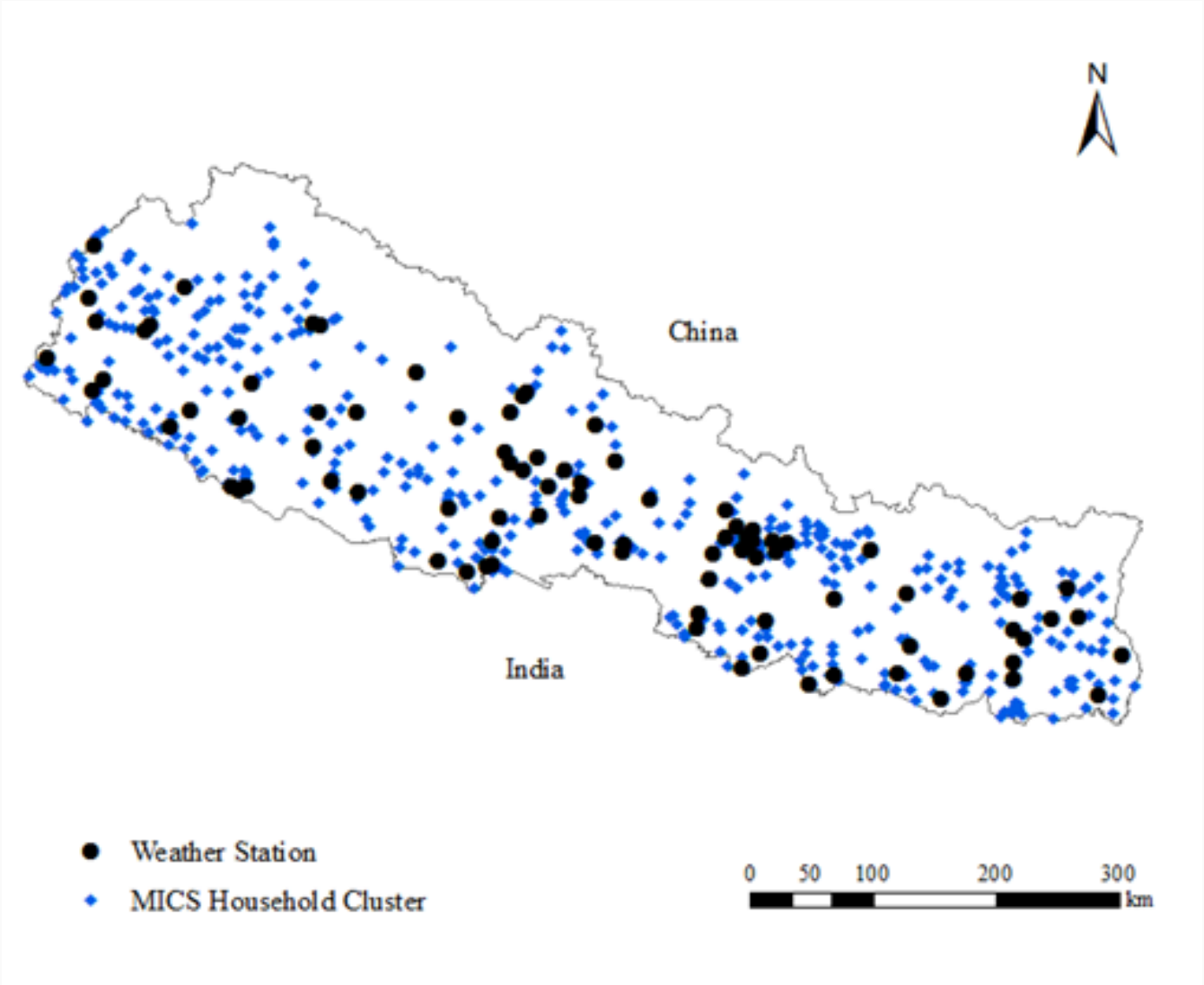


Figure 4: *MICS household cluster and weather station cluster distribution*

Birth month

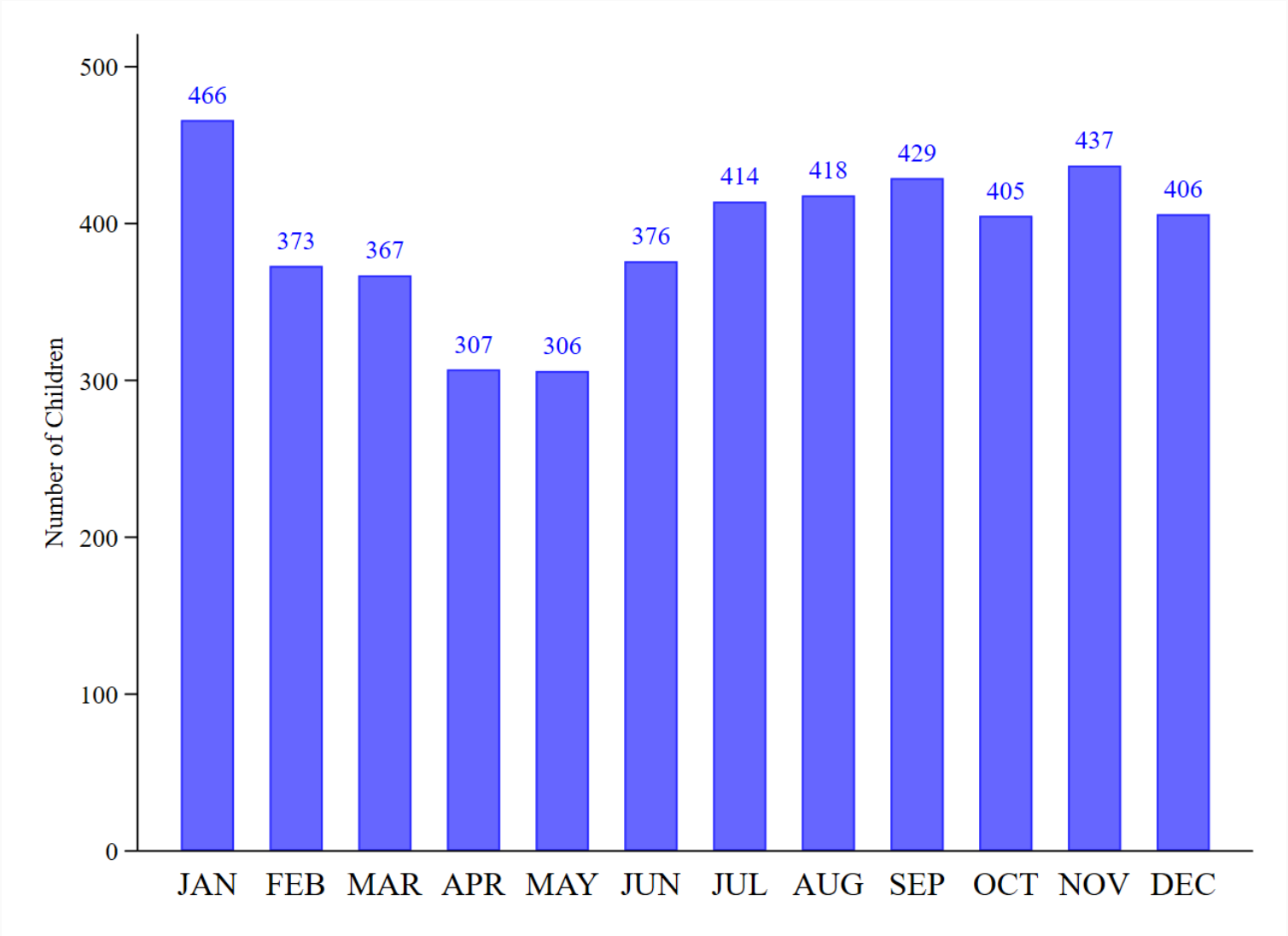


Figure 5: *Number of child birth by birth month*

Identification Strategy

Temperature can be correlated with:

- Fetal Loss
- Residential sorting
- Birth timing or conception
- Catch up growth

Theoretical Framework

A simple two-period model of child health production is represented as:

$$H_t = [\alpha H_{t-1} + (1-\alpha)H_t]$$

We can show how exposure to temperature shock in utero ($w_{(t-1)}$) affects health outcomes in early childhood

$$\frac{\partial H_t}{\partial w_{t-1}} = \underbrace{\frac{\partial H_t}{\partial E_{t-1}} \frac{\partial E_{t-1}}{\partial w_{t-1}}}_{\text{Health Effects}} + \underbrace{\frac{\partial H_t}{\partial I_{t-1}} \frac{\partial I_{t-1}}{\partial w_{t-1}}}_{\text{Investment Channel}} + \underbrace{\frac{\partial H_t}{\partial a_{t-1} w_{t-1}} \frac{\partial a_{t-1} w_{t-1}}{\partial w_{t-1}}}_{\text{Behavioral Channel}}$$

Fetal Loss

Table 4: Effect of Extreme Temperature on the Probability of Child Being Female

	Probability of being a female child		
	(1)	(2)	(3)
Temperature	-0.00444	-0.00467	-0.00443
	(0.00457)	(0.00459)	(0.00462)
Elevation	-0.0000181	-0.0000178	-0.0000180
	(0.0000182)	(0.0000182)	(0.0000182)
Mother characteristics	No	No	Yes
Pregnancy characteristics	No	Yes	Yes
Region-month fixed effects	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes
Observations	4704	4704	4704
R-squared	0.008	0.010	0.012

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses clustered at the sampling cluster unit. The results are using the linear probability model. Temperature is defined as the number of high temperature days 30 days before the conception days (281 to 311 days). Mother characteristics includes mother's level of education, indicator variable whether mother is a rural resident and lower caste. Pregnancy characteristics includes mothers' age at conception and pregnancy order (or birth order).

Non-Linear Effect

Table 3: Effect of Extreme Temperature in utero on the Height-for-Age z-score using Different Temperature Bins

	Height-for-Age z-score
Temperature Bin 1	-0.0564
	(0.0420)
Temperature Bin 2	-0.00426
	(0.00284)
Temperature Bin 3	0.00329**
	(0.00158)
Temperature Bin 4	0.00149
	(0.00128)
Observations	4704
R-squared	0.180

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses clustered by the sampling cluster unit. Estimates come from model using Table 2 Column (4) specification. The base category is Temperature Bin 5. Temperature Bin 1 = Less than 0 C; Temperature Bin 2 = greater than 0 or less than 7.22 C; Temperature Bin 3 = greater than 7.22 or less than 18.333 C; Temperature Bin 4 = greater than 18.333 or less than 32 C; Temperature Bin 5 = greater than 32 C.