Abstract
Adverse conditions in utero can have lasting effects on health outcomes at birth or many years after birth. Rather than focusing either on adverse events or health outcomes at birth and in adulthood, we progress by examining the impact of prenatal exposure to mild and persistent early life events on childhood health in a developing country context. Evidence from Nepal shows that prenatal exposure to high-temperature days impedes child growth; however, the damage appears to be transitory as opposed to persistent – as the effect gradually decreases with age and becomes almost undetectable by age five. While exploring potential indirect mechanisms, the impacts of high-temperature days on food prices are ambiguous, although effects on the high commodity food (rice and meat) are stronger compared to low commodity staples (wheat or lentils). In addition, we explore how pregnant women respond to heat stress when the market does not provide climate amenities, focusing on the impact of heat stress on healthcare-seeking behavior. Our finding suggests that women react with reduced antenatal care utilization.

KEYWORDS: Early childhood events, anthropometric outcomes, climate change, Nepal

JEL Codes: D10, J13, I12, I15, O13
1 Introduction
Research shows that adverse events during pregnancy can have wide-ranging and persistent effects, including health outcomes at birth and in adulthood (Almond & Currie, 2011; Almond et al., 2017; Currie & Vogl, 2012). Early attempts to understand these effects (e.g., Barker, 1995) exploited exogenous variations in the prenatal environment using uncommon and adverse incidents such as famine, armed conflicts, natural disasters, pandemics and extreme weather (for the review of literature, see Almond & Currie, 2011; Almond et al., 2017). However, such adverse conditions may either take many years to unfold (e.g., war) or are infrequent in occurrence (e.g., drought). On the other hand, mild stressors occur frequently and are experienced commonly. Hence, a burgeoning literature uses mild uterine stressors (e.g., weather events, mild nutritional deprivation, pollution) to capture exogenous variations in utero environment (Almond et al., 2017; Rosales-Rueda, 2018). In particular, as global climate change models predict increasing average temperatures and the frequency of high-temperature days, incidence of high-temperature events/days during pregnancy, as a mild uterine stressor, presents a not so uncommon yet relevant shock during pregnancy.

Moreover, studies on the health impacts of prenatal shock, including weather shock, primarily focus either on health outcomes at birth or in adulthood. The impact of weather shock on birth outcomes is well documented in the literature. As health damages can remain latent for

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1 Referred to as the fetal origin hypothesis, it postulates that *in utero* condition influences outcomes later in life. Since the outset of the seminal fetal programming hypothesis (Baker, 1995), studies on uterine stressor show a wide range of impacts on later-life outcomes, including test-scores, educational attainment, income, risky behavior, crime and health (for an excellent review of the literature, see Almond and Currie, 2011; Almond et al., 2017).

2 Mild shocks include: mild nutrition deprivation (e.g., daytime fasting during Ramadan), maternal stress, seasonal diseases, pollution, weather shocks, alcohol and tobacco consumptions (for an excellent review, see Almond et al., 2017).

3 Recent studies from developing countries show negative effects of weather shock (extreme temperature and/or rainfall, drought and flood) during pregnancy on birth outcomes and infant mortality: in Nepal (Mulmi et al., 2016; Regmi et al., 2008; Tiwari et al., 2016) in Sub-Saharan Africa (Wang, et al., 2014; Wilde et al., 2017); in Mexico
many years (e.g., heart disease) only to appear in adulthood (Almond & Currie, 2011), the outcomes in adulthood, however, can suffer from self-productivity and investment due to the dynamic nature of health. Therefore, the impact of mild prenatal shock on later-life health outcomes can be indiscernible as the effect can fade out if further removed in time (Heckman, 2007). One approach to understand the impact of mild uterine stressors on long-term health outcomes is by focusing on the cumulative measure of health at early or middle childhood.

The objective of this analysis is to econometrically investigate the impact of a mild but persistent event during pregnancy on early childhood health status for in a developing country context. The analysis uses climate data on the frequency of high-temperature days (ambient daily mean temperature greater or equal to 32 degree Celsius) during pregnancy as a mild and persistent uterine stressor. We then combine the climate data with a national household survey based data from Nepal that contains information on children born in between 2009 and 2014. A variety of possible explanations are explored.

Consistent with the fetal origin hypothesis, results from econometric analysis indicate that exposure to an additional high-temperature days in gestation impedes child growth (measured in-terms of height-for-age z-score) by 0.008-0.011 standard deviations. The impact is stronger in the third trimester when the fetus dramatically grows in mass and size. Unlike the persistent effects observed for adverse shocks, the damage appears to be transitory, i.e., the effect gradually decreases with age and becomes almost undetectable by age five.

As the total impact of high-temperature days in utero is not entirely a biological phenomenon, we hypothesize that some of this impact is mediated through indirect economic

(Agüero, 2014; Skoufias and Vinha, 2012); in Nigeria (Rabassa et al., 2014); in Mongolia (Groppo and Kraehnert, 2016); in India (Banerjee and Maharaj, 2019); and in China (Mueller and Gray, 2018).
mechanisms. We explore the impact of high-temperature days on food prices and antenatal care utilization. The results show a statistically significant and positive impact of high-temperature days on selected food prices. We find that the effects on high commodity food (e.g., rice and meat) are stronger compared to low commodity staples (e.g., wheat or lentils). In addition, we explore how pregnant women respond to heat stress when the market only provides inadequate climate amenities. We do so by focusing on the impact of high-temperature days on healthcare-seeking behavior during pregnancy. Our findings suggest that the mothers react with reduced utilization of antenatal care.

These findings add to the fetal programming literature in the following ways. First, existing research focuses overwhelmingly on adverse events like drought or heat-wave when exploring the impact of high-temperature during pregnancy on health outcomes (e.g., Kumar et al., 2016). Our focus on high-temperature days, a mild and persistent shock in utero, and complements the current literature and calls for a renewed attention on the role of moderate shocks in fetal development. Second, previous studies look at either birth outcomes (e.g., child mortality or birthweight) or health outcomes many years after birth or in adulthood (Almond et al., 2017). Our focus on the cumulative measure of early childhood health partially addresses the research gap for “middle years” – between infancy to adulthood (Almond et al., 2017). Third, our analysis improves previous studies on the assignment of temperature exposure from weather stations to the individual. We use ground-level station data within 50 kilometers radius of the household cluster – providing a more accurate exposure to ambient temperature due to fine level of geographic disaggregation (mostly at the village level). Finally, when assigning temperature, previous studies use birth month or data covering larger geographical area (e.g., Agüero, 2014; Kumar et al., 2016;
Skoufias & Vinha, 2012). A detailed birth date allows us to assign temperature more accurately at a daily level.

The paper is organized as follows. Sections 2 and 3 discuss the conceptual framework and background. In Section 4, we outline data sources and discuss how the survey data is linked with meteorology data. Sections 5 and 6 offer an empirical model and results, respectively. In section 7, we present robustness checks and address selection issues. Section 8 discusses economic mechanisms. Finally, we conclude in Section 9.

2 Conceptual Framework
Using the dynamic health production function approach (e.g., Cunha & Heckman, 2007; Currie & Almond, 2011; Grossman, 1972; Heckman, 2007; Rosales-Rueda, 2018), we illustrate the role of high-temperature days on early childhood health. The central proposition is that health, as a dynamic stock, is a durable commodity, which can be augmented by investment and is subject to depreciation. A simple two-period model of health production is represented as:

\[ H_{t+1} = f(P_t, H_t, I_t, T_t, X_t) \]  \hspace{1cm} (1)

Health stocks, \( H_{t+1} \) and \( H_t \), represents health at time \( t + 1 \) (in early childhood) and \( t \) (in utero). Heath in early childhood is influenced by fetus health at time \( t \) (also known as self-productivity). Genetic or parental endowment at conception is represented by \( P_t \). Health investment in utero (\( I_t \)) such as nutritional food, healthcare utilization, etc., is a twice continuously differentiable and concave function (Cunha & Heckman, 2007). A vector of unobserved inputs (\( X_t \)) also influences health capital accumulation (e.g., quality of healthcare utilization). Finally, number of high-temperature days during pregnancy (\( T_t \)) is the mild but persistent uterine stressor. We assume that the high-temperature in \( t + 1 \) does impact health at \( t + 1 \).
The temperature shock in utero, $T_t$, impacts health directly through physiological damages and indirectly through investment. Shocks during pregnancy directly impacts fetus development by causing fetal loss, shorten gestation period, and low birth-weight (Rashid et al., 2017). It also can transmit through stress caused to maternal physiology (Lundgren et al., 2013). To capture the direct physiological damages caused by high-temperature days in gestation, fetal health ($H_t$) can be expressed as:

$$H_t = q(P_t, T_t)$$

(2)

High-temperature days indirectly impacts later-life health through economic channels. The economic channels influence later life outcomes through health capital investment. Investment behavior is endogenous and interacts with the parental endowment at conception ($P$), temperature shock ($T$), and other unobserved factors that influence investment decisions ($Z$). For example, when exposed to extreme heat, families may choose to invest more (or less) on the pregnant women (e.g., reduce their work and mobility). Thus, parents indulge in compensatory (or reinforcing) behavior. The investment behavior can be written as:

$$I_t = h(P_t, T_t, Z_t)$$

(3)

Replacing Equations 2 and 3 into 1, the partial derivatives can be presented as follows:

$$\frac{\partial H_{t+1}}{\partial T_t} = \frac{\partial H_{t+1}}{\partial H_t} \frac{\partial H_t}{\partial T_t} + \frac{\partial H_{t+1}}{\partial I_t} \frac{\partial I_t}{\partial T_t}$$

(4)

In Equation 4, the total effect ($\partial H_{t+1} / \partial T_t$) is decomposed into two channels; namely, biological and economical. The first-term on the right-hand side is the biological effects due to exposure to
temperature shock in utero, which is expected to be negative. The second-term is the economic channel. High-temperature days can influence fetus development through various indirect channels: lack of food and safe drinking water, poor sanitation, population migration or changing disease pattern (Rylander et al., 2013). The net impact of the economic channels is unknown. For example, high-temperature can increase or decrease food prices either by increasing or decreasing agricultural yields or by reducing shelf-life of certain food items. If high-temperature days increases food prices, it shifts the household budget curve downwards, i.e., families have fewer resources for human capital investment. In such a scenario, the economic channel negatively impacts the future outcomes.

Both channels - biological and economic – cannot be discerned without comprehensive information on maternal and family responses to high-temperature during pregnancy. Due to data limitation, the first part of our analysis estimates the total effect. Using secondary data, the second part investigates the economic channels.

3 Background
Growing scientific evidence documents three stylized facts regarding the global climate change, and its impact. First, the incidence of extreme temperature is rising with increasing frequency, intensity and duration (IPCC, 2014). Second, the physiological and psychological discomfort

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4 Extreme heat exposure uses water and salt in the body, which creates sweat in order to dissipate heat. If exposure to extreme heat is prolonged, and water and salt are not adequately replenished, then the maternal body experiences physical discomfort like dizziness, muscles cramps and fever. Although the effect of pregnancy on woman’s heat tolerance is unclear, altered hormone levels, added weight, reduced adaptive capacity and the increased circulatory demands may effect fetus development (Lundgren et al., 2013). Similarly, woman’s body is sensitive to temperature affecting chemistry, electrical properties, and function of vital organ which can be detrimental for a fetus to reach one’s full capacity (Seltenrich, 2015; Wang et al., 2014). Medical literature shows that exposure to heat stress in utero is associated with multiple birth defects; for example, hypospadias (Kilinc et al., 2016), atrial septal (Auger et al., 2017), etc.

5 Health production function strategy has several key assumptions. The model does not account for substantial geographic variation in health inputs, seasonal variability on exposure and the cost of health investment. We address these issues empirically with various fixed effects. We also assume that the contemporaneous investment does not impact health outcomes.
caused by high-temperature days is elevated among children and pregnant women (Rylander et al., 2013). Third, developing countries experience stronger impact as climate change channels through various indirect pathways (IPCC, 2014; Rylander et al., 2013). Ranked 24th in the Global Climate Risk Index (Kreft et al., 2017), Nepal is experiencing the direct and indirect consequences of global climate change. Below we discuss why Nepal provides an ideal scenario to study the impact of high-temperature days during pregnancy on early childhood health.

In Nepal, the incidence of extreme temperature is rising with increasing frequency, intensity and duration. Since 1975 to 2005, the annual mean temperature has increased by 0.06 degree Celsius (C) per year and is predicted to grow by 1.3C to 3.8C by 2060, which is higher than the corresponding global estimation (Government of Nepal, 2017). In addition, Nepal’s topographical setting provides a wide range of micro-climates, creating a considerable variation in exposure, and on the effect of extreme temperature.

Similarly, climate change disproportionately affects Nepalese women as they are susceptible to injuries and death caused by environmental insults. For example, combined with casual household labor (e.g., cleaning, cooking), women work more than men, on average – especially among agricultural, pastoral and wage laborer households (Goodrich et al., 2017). Consequently, women are more likely to be exposed to high-temperatures. Similarly, women are more vulnerable to environmental insults because they have little say in the decision-making process (e.g., outdoor labor time during hot days or technology adoption) even though they play a central role in agricultural and resource management (Goodrich et al., 2017). Moreover, women are less informed about the impact of climate change. A national survey on climate change finds 61 percent of women have not heard the term “climate change” or “global warming” compared to the overall rate at 50 percent (Government of Nepal, 2017).
Moreover, Nepal is experiencing increased incidences of climate-related disasters, heightened disease burden, and reduced agricultural production - all attributed to rising temperature (Ministry of Health and Population, 2012). In Nepal, poor infrastructure and resource constraints (to use climate amenities when the market allows), combined with the weak formal market (to provide climate amenities), limit the ex-ante or ex-post mitigations strategies to cope with extreme weather. Thus, the lack of mitigation strategies makes it easier to establish a causal link between heat stress during pregnancy and health outcome in early childhood.

4 Data
Children data
We use the Multiple Indicator Survey (MICS) 2014 for children, mother and household characteristics. This nationally representative survey, MICS 2014, uses multi-stage, stratified cluster sample selection technique, and provides comprehensive information on the children and women, including information on early childhood development and complete birth history of the women ages 15 to 49. It collects information on 5,349 children under five from 519 household clusters.

Table 1 provides the definitions and descriptive statistics for the children, mother, and household characteristics. The final estimating sample consists of 4,704 children from 3,725 households in 506 sampling clusters. The height for age z-score (HAZ) is calculated using the 2006 World Health Organization standard for the children age 0-59 months. The mean HAZ is -

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6 We lost 12 percent of the sample size due to following reasons: missing or biologically impractical height-for-age z-score (i.e., greater than 6 or less than -6 standard deviations); missing date of birth; and unable to match with a weather station within 50 kilometers of the household cluster.

7 Negative HAZ reflects long-term, cumulative deficiencies in health and/or nutrition resulting in a child failing to reach his or her growth potential (World Health Organization, 1995). It is linked with increased morbidity, mortality, and reduced long-term health. It is also widely associated with a wide range of socio-economic outcomes such as education, cognitive ability, and adult economic productivity (e.g., Vogl, 2017; Strauss and Thomas, 2008; Victora et al., 2008). In addition, HAZ is correlated with socio-economic factors (e.g., maternal education, migration
1.65 – meaning, on average, children experience growth retardation (40.5% of the children in our sample are stunted, i.e., HAZ less than -2.).\(^8\) Our sample consists of a lower percentage of females (47%). The mean birth order is 2.8 and the average maternal age is 27 years old. Finally, most households are rural (82%), non-Dalit (82.5%) and live in Hills or Terai plains (71.1%).

[Insert Table 1]

**Temperature data**
The Department of Hydrology and Meteorology (DHM), Nepal, provides the daily maximum and minimum temperature data from 112 ground-level weather stations across Nepal. The weather stations with missing daily maximum or minimum temperature for more than 30 consecutive days are dropped. We also drop weather stations without any temperature data for the study period (2009-2014). This leaves us with 89 weather stations that are fairly expansive throughout Nepal (see Figure 1).

[Insert Figure 1]

**Exposure to high temperature**
The daily mean temperature is the average of the daily maximum and daily minimum temperatures. Daily mean temperature greater or equal to 32°C (89.6F) is defined as the high-temperature days, which is a mild and persistent uterine stressor. As the thermal comfort zone is 18 to 22°C, temperature greater than or equal to 32°C can physically impact human body (e.g., sunstroke, muscle cramps, heat exhaustion). However, this definition of high-temperature is somewhat

\(^8\) In developing countries, HAZ decreases with increasing age as we observe similar trend in Nepal (Appendix, Figure A1). Similarly, children born during the hot months have lower HAZ than the children born during the winter season (Appendix, Figure A2)
arbitrary as there is no unanimous consensus on the threshold of high-temperature. In the literature, the threshold ranges from 25 to 32°C (e.g., Deschenes & Greenstone, 2011; Hu & Li, 2016; Barreca et al., 2018; Banerjee & Maharaj, 2019). Throughout this paper, extreme temperature and high-temperature days are interchangeably used.

The total number of high-temperature days in gestation is a mild and persistent uterine stressor. MICS-2014, however, does not provide information on conception day to calculate accurate gestation length. So, we use the standard length of 40 weeks for gestation period. The conception day is determined by backward counting from birthday.

**Linking weather stations with household clusters**

Mountainous terrain and sparsely located weather stations challenge temperature assignment in Nepal. To link weather stations to the household clusters, we matched the nearest weather station within 50 kilometers of the household cluster. This technique can produce unlikely matches as there are sharp rises in the elevation within a narrow geographical area. For example, in the northern mountainous and hilly part of Nepal, a village may lie in the lowlands of a valley while the weather station is positioned at the hilltop, which is within the 50 kilometers radius. A large difference in altitude causes discrepancy between the assigned versus actual temperature exposure as a thousand meters increase in altitude decreases ambient temperature by 6.5°C.

The concern on the linking weather stations to a household cluster can be omitted because of the following reasons. First, we observe that the mean distance between matched sample cluster and weather station is 17.4 kilometers and the mean difference in altitude is 23.33 meters (see Table A1). Second, the weather stations and the household clusters are sparsely located on the mountainous northern part of the country (see Figure 1) – as the habitation is lower in the region.
After the linking the data, the final the estimating sample consists of 506 households linked with 85 weather stations.

To provide a better outlook of temperature exposure during pregnancy, Figure 2 provides the distribution of daily mean temperature during gestation period across five temperature bins (less than 0C; between 0-7.22C, 7.22-18.33C, 18.33-32C, and higher or equal to 32C). The vertical axis represents the average gestation length in each temperature bin. On average, women experience four high-temperature days during gestation. On the other hand, women experience few days when the weather is extremely cold (0.05 days when the temperature falls below 0C).

[Insert Figure 2]

**Food price data**
To examine the economic mechanism through investment in utero, we explore the impact of high-temperature days on food prices. The food price information is extracted from the annual reports published by the Agriculture Business Promotion and Marketing Development Directorate, Ministry of Agriculture Development (MAD), Nepal. These reports provide monthly mean prices for major food items sold in the selected districts across Nepal. The data is available from 2011 to 2014, when the surveyed women were pregnant. Although the data covers 46 districts (10 Mountain districts, 21 Hill districts, and 15 Terai districts), the districts are well-balanced throughout Nepal with fewer districts from sparsely populated mountain region of the country (see Figure A3).  

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9 MAD provides either the exact address of the food retail market or the name of the district where a market is located. Instead of the retail market, if the district name is provided, we compute the geo-coordinates the centroid of the municipality or village development committee in which the District Agriculture Office (DAO), Government of Nepal, is located. We use the geo-coordinates of the centroid to match the nearest weather station with 50 kilometers. We use the centroid because DAOs are located in the district headquarters and collect the food price data. This study uses Nepali district units as defined by pre-2015 boundaries. Finally, as discussed earlier, sharp rise
Table 2 provides definitions and summary statistics for the six food categories. Rice, meat, and milk are high commodity food items, whereas wheat, vegetables, and lentils are low commodity food items. The mean price of rice is Nepalese Rupees (Rs.) 41.83 per kilogram. Similarly, the mean price of meat is Rs. 265.4 per kilogram and that of milk is Rs. 49.44 per liter. All prices are in constant 2016 Nepalese Rupees.

[Insert Table 2]

5 Empirical model
The effect of high-temperature days during pregnancy on early childhood health status is estimated using the following linear fixed-effects model.

$$H_{imyr} = \alpha + \beta T_{imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr}$$ (5)

where $H_{imyr}$ is the outcome variable (height-for-age z-score) for a child ($i$) born in the month ($m$) and year ($y$) in the agro-climatic region ($r$). $X$ controls for the child, mother, and household characteristics. The child characteristics include gender, age, and birth order, whereas mother characteristics include mother’s education and mother’s age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether the household dwells in a rural or urban areas, and an indicator variable whether a household is the member of a lower caste as defined by the National Planning Commission, Government of Nepal in 2011 census. $\delta_m$ controls for the birth-month fixed effect. Similarly, $\lambda_y$ controls for the birth-year fixed effect and $\eta_r$ is the agro-climatic region fixed effect. Finally, to account for the spatial correlation, $\epsilon$ is the robust standard error clustered at the household

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in altitude makes it difficult to assign the weather station to geo-codes of the retail food market. Again, the mean distance between weather station and market centroid is 11.78 kilometers.
sampling cluster. The main variable of interest, $T$, is the number of high-temperature days in gestation.

Our estimation technique uses agro-climatic region, birth-year, and birth-month fixed effects to control for the permanent geographical and seasonal characteristics that may affect height-for-age $z$-score directly. This allows us to identify the impacts using only the random variation in temperature. We use the agro-climatic region fixed effects because each region is characterized by different sets of weather, economic activities, social norms, and population dispersion. For example, the mountainous northern region is dry with little or no rainfall, whereas the southern lowland (Terai) is fertile with hotter and wetter climate. Similarly, we observe an inverse relation between altitude and household poverty in Nepal. The Terai region is comparatively developed on availability of market and road (Gallup et al., 1999). Without agro-climatic region fixed effects, regional differences may bias the effects toward zero.

We use birth month fixed effect to control for the seasonality. First, the season of birth is associated with nutrition availability and likelihood of infection. Not only is temperature correlated with season, the season of birth (even birth month) is also associated with later life outcomes as documented in the literature (e.g., Buckles & Hungerman, 2012). Second, harvesting and wedding seasons can also influence birth rates.\(^{10}\) For example, we observe higher number of children born nine months after the wedding season (see Figure A4). To account for the heterogeneity due to seasonality, we rely on the birth-month fixed effect.

\(^{10}\) Accounting 95 percent of our sample, Hindu, Buddhist and many indigenous religions (e.g., Kirat) perform marriage ceremony only in certain dates. Traditional marriage can only occur in three distinct period: mid-January to mid-March; mid-April to mid-June; and mid-November to mid-December.
Moreover, children born in later years tend to be taller in low-income countries, mainly due to economic growth, improved access to health care and availability of nutritious food (Strauss & Thomas, 2008). Our sample consists of the children born from 2009 to 2014, which was marked by economic and political volatility following the decade-long armed conflict. So, we use the birth-year fixed effect to control for cohort-specific heterogeneity.

Finally, temperature bundles with other environmental agents to affect human health. For example, the effect of temperature amplifies or alleviates with the oxygen level, humidity, ozone, and air pollutions. Higher elevation reduces air quality and decreases humidity (Jans et al., 2018). This bundling weakens the causal link between temperature and health as it is difficult to isolate the effects of high-temperature. To control for these confounders, we use the elevation of the household cluster, which minimizes any biases due to confounding environmental factors.11

6 Results

Effect of extreme temperature on early childhood health

Table 3 presents the aggregate impact of the high-temperature days during pregnancy on early childhood health. Columns (1) through (4) incrementally add controls for the child, mother and household characteristics, including the controls for birth-month, birth-year, and agro-climatic region fixed-effects. All four specifications show statistically significant and negative association between number of high-temperature days during pregnancy and height-for-age z-score. When exposed to an additional high-temperature day during pregnancy, children’s height-for-age z-score decreases by 0.008 to 0.011 standard deviations, on average.

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11 Although agro-climatic fixed effects can capture these confounders, the altitude variation is strikingly different within each agro-climatic region. For example, the elevation ranges from 300 meters to 2000 meters in the Hilly region, whereas the Mountain region has the difference of almost 2000 meters (the settlement above 4000 meters is non-existent).
Timing of exposure
A typical, full-term pregnancy is equally divided into three trimesters, and each period is characterized with a specific role in fetus development. Medical literature characterizes the first trimester or embryonic stage as the period of a baby’s body development. The second trimester is characterized by the development of vital organs. The third trimester is important because the fetus grows dramatically in size and mass.

To investigate whether the effect of heat stress varies by trimesters, we modify Equation 5 by including high-temperature days in each trimester.

\[ H_{imyr} = \alpha + \beta_1 T_{1_imyr} + \beta_2 T_{2_imyr} + \beta_3 T_{3_imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr} \] (6)

where \( T_1, T_2, \) and \( T_3 \) are the total number of high-temperature days in the first, second and third trimesters, respectively. Counting backward from the birth date, we designate 280 to 171 days before birth as the first trimester, 170 to 91 days before birth as the second trimester, and 90 to the day of birth as the third trimester.

Results in Table 4 suggest that the negative effect on height-for-age z-score is largest in the third trimester, which is also statistically significant in all four specifications. In the third trimester, an increase by one high-temperature day during pregnancy leads to 0.0136 to 0.0163 standard deviations shorter in stature. This is consistent with the medical literature (Kramer, 1987). Therefore, the third trimester is most sensitive to high-temperature days as the fetus grows in mass and length.
Declining effects by age
When exposed to adverse events in utero, the impact can last for many years (Almond & Currie, 2011; Almond et al., 2017). We examine whether the impacts of high-temperature days in utero is persistent. For this analysis, we divide the estimating sample into four subgroups so that the sample size remains relatively large in each group: (1) children younger than 16 months old (<16 months); (2) children between 16 to 30 months old (16-30 months); (3) children between 31 to 45 months old (31-45 months); and (4) children older than 45 months (45< months). Using the baseline model (Table 2, Model 4), we estimate the impacts of high-temperature days in utero on height-for-age z-score for each subsample. The coefficients are plotted in the Figure 3. The coefficient estimates are statistically significant for the younger two subsamples (<16 months and 16-30 months); but the coefficients are smaller in magnitude and are statistically insignificant for the older two groups (31-45 months and 45< months). A joint test rejects the null hypothesis that the coefficients are equal at the 5 percent significance level. As the coefficients for the younger two groups are larger and statistically significant compared to older two groups, we infer that impact of mild shock during pregnancy is temporal. Unlike the persistent effect of adverse condition, the impact of high-temperature days – as a mild and persistent uterine stressor – gradually decreases with age and becomes almost undetectable by age five.

7 Robustness checks and selection Bias
Allowing different definitions of high-temperature days and gestation length
As discussed earlier, we assume 32°C as a threshold for the high-temperature days and 280 days for the gestation length. We allow some flexibility by using alternative definition of the high-temperature days and gestation length.
Figures 4 and 5 plots the coefficient using alternate definition of the high-temperature days and gestation length. Figure 4 plots the coefficient for different thresholds (30–34C) of high-temperature using our baseline model. As expected, assigning a higher threshold for extreme temperature has a stronger impact (the coefficient is larger) and statistically significant. These results are consistent with our baseline finding in Table 3 i.e., high-temperature days during pregnancy has negative impact on early childhood. Furthermore, figure 5 plots the effects of high-temperature days (i.e., baseline threshold of 32C) on HAZ, while allowing the gestation length to vary (266-294 days). As expected, a longer gestation length is associated with better health status in early childhood.

Selection issue: 
To estimate the causal link between high-temperature days in utero and early childhood health, the underlying assumption is that the exposure to temperature is exogenous and random, given individual, temporal and spatial controls. There are number of ways that undermines our assumptions. This section discusses some potential threat to the identification assumptions.

Fetal loss
Selection bias occurs if we exclude the lost-fetus due to high-temperature. If weaker fetuses are lost, then the remaining fetuses are inherently stronger and healthier, which means our sample is biased towards healthier fetus. This downward biases the coefficient estimate. In addition, medical literature postulates that the male fetus requires higher maternal resources; thus, adverse conditions in utero lead to higher survival probability for the female fetus (Almond & Currie, 2011; Trivers
& Willard, 1973). If high-temperature days in gestation eliminates fragile fetuses, then a higher number of girls are conceived and born.

To test whether mild shock leads to fetal loss, we run a linear probability model to estimate the effects of high-temperature days during conception on the probability of a child being female. The dichotomous variable for the gender of a child is regressed on the number of high-temperature days along with other covariates. As mentioned earlier, conception day is determined by backward counting from the birthday. Since the conception day is somewhat arbitrary, we count the total number high-temperature days 7 days prior and after the assigned conception date.

We find that the impact of high-temperature days on the probability of the child being female is small and statistically insignificant (Table 5). From columns (1) to (3), we incrementally add mother and household characteristics. In all three models, the coefficient estimates are small and statistically insignificant, (i.e., the impact of high-temperature days on the probability of being a female child is non-existent). In addition, having a lower percentage of girls in our sample (47%) reinforces the results in Table 5. Although previous studies find that the adverse condition during pregnancy decreases the survival probability of the male fetus (Almond & Currie, 2011; Trivers & Willard, 1973), our finding that high-temperature days in gestation does not influence the probability of being a female child may be due to the fact that high-temperature days during pregnancy is a mild uterine stressor. Therefore, it is not as detrimental compared to more severe adversities (e.g., drought, natural disaster).

[Insert Table 5]

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12 Other covariates includes: mother’s characteristics (mother’s level of schooling, mother’s age squared, and number of pregnancies); household characteristics (wealth index, household size, elevation). We also use birth-month, birth-year and agro-climatic region fixed effects.
**Additional issues: migration, abortion, and under-five mortality**

Additional concern on the identification strategy arises from migration during pregnancy, sex-selective abortion, and under-five mortality. Due to data limitation, we are unable to test empirically if these consideration impacts our results. Nonetheless, below we discuss how these issues do not influence our estimates.

As a pregnancy lasts for nine months, temporary and permanent migration can occur during this period. If indeed temperature-induced permanent migration (e.g., residential sorting) has occurred in Nepal, we expect increased internal migration to cooler areas or vice versa. However, internal migration in Nepal is age and sex-specific, where women migrate largely due to marriage and men migrate seeking better economic opportunities (Suwal, 2014). According to 2001 and 2011 Nepalese Census, on average, four persons (male or female) per 1000 migrate crossing agro-climatic boundaries and six persons per 1000 cross district boundary (Suwal, 2014). Therefore, if residential sorting due to extreme temperatures exist, we deem that its impacts are negligible.

Similarly, women may travel temporarily during gestation. This contaminates the actual versus assigned temperature exposure, which can impact our estimation. In Nepal, we anticipate women traveling to the fraternal house for major festivals due to the patrilocal system. Such travels may be frequent and can occur during pregnancy.\(^\text{13}\) However, our data does not provide information on maternal travel during pregnancy. Controlling for socio-cultural characteristics partly addresses this problem.

\(^{13}\) In the following festivals, women are expected to travel to their father’s or male sibling’s house: Teej (in September), Janai Purnima (in August), Dashain/Tihar (in October/November), Maghe Sankranti (in January) etc. Such festivals occur throughout the year. These festivals are celebrated by Hindus, Buddhist, and many indigenous religions (e.g., Kirat), which constitutes 95 percent of our sample.
Finally, sex-selective abortion and under-five mortality also can bias our coefficient estimates. Nepal is characterized by strong son-preference because of patrilineal system. This can lead to sex-selective abortion against female fetus, and the higher under-five mortality for female child due to low human capital investment. Although sex-selective abortion is against the law, abortion in general is increasing due to accessible ultrasound technology in recent years (Frost, 2013). Compared to other South Asian countries (e.g., India and Pakistan), Nepal, however, has a low abortion rate (Singh et al. 2018). Using a 2014 nationally representative sample of 386 facilities data from legal abortion clinics and post-abortion care facilities, Puri et al. (2016) estimate the abortion rate to be 42 per 1000. This argument – the sex-selective abortion is low in Nepal – is further supported by the fact that the male to female ratio at birth is 1.04 in Nepal, which is very close to natural sex ratio of 1.05 (Lamichhane et al., 2011). Similarly, due to strong son-preference, female child may be subject to lower human capital investment in early childhood. This may lead to a higher female under-five mortality even though the female child has higher survival chances. On the contrary, under-five mortality for the male is higher than the female (35.8 versus 31.3 per 1000 live births) according to the World Bank (2018). Hence, we argue that neither under-five mortality nor sex-selective abortion contaminates our estimation.

8 Mechanisms
Theory tells us that the impacts of high-temperature days during pregnancy on early childhood health channel through two pathways, namely biological and economic channels. We estimated the aggregate impacts in the previous section. This section explores the economic channels.

To explore economic channels, we focus on the major drivers that rapidly reduced child stunting and undernutrition in recent years. Stunting reduction is attributed to four factors: health and nutritional intervention; improved sanitation; maternal education; and assets accumulation
(Headey & Hoddinott, 2015). We focus on the health and nutritional interventions to explore the economic pathways through which high-temperature days lead to shorter stature among children. Health interventions include antenatal care utilization, and nutritional interventions include improved maternal nutrition during pregnancy. First, we explore how high–temperature days influence food prices. Second, we explore health intervention by focusing on the impact of high-temperature days on antenatal care utilization.

**Effect of high-temperature days on food prices**

High-temperature days can directly affect nutritional intervention through food availability and security. First, it may increase or decrease agricultural yield depending on the crop type and location. If extreme temperature reduces crop yields, the food prices increase (or decrease) depending on the crop type. Second, high temperature reduces the shelf-life of certain agricultural products (e.g., meat and vegetables) in absence of food storage technologies. Both, crop yield and product shelf-life, influence the food prices, which directly affect food availability and security.

Using the following linear fixed-effects model, we estimate the impact of frequency of high-temperature days on major food prices:

\[ P_{imr} = \alpha + \beta T_{imr} + \lambda_m + \phi_r + \epsilon_{imr} \]  

(7)

where \( P_{imr} \) is the price of a food item \((i)\), in the month \((m)\), and sold in the agro-climatic zone \((r)\). \( T \) is the number of high-temperature days in a month. Vector of month fixed effects, \( \lambda_m \), captures all unobserved seasonal characteristics (e.g., the supply of certain locally grown food items). Similarly, agro-climatic region fixed effect, \( \phi_r \), controls for time-invariant characteristics.

---

14 Due to warmer winters, some hilly parts of Nepal can grow certain crop (e.g., millet) in winter that was not cultivated previously. Similarly, warmer winters have reduced livestock death during the cold season (Machhi et al., 2015).
of each market in the geographic regions (e.g., transportation costs, labor costs, and production costs). Finally, robust standard error, $\epsilon$, is clustered at the district level.

Table 6 presents how high-temperature days impact the retail price of major food items. We estimate statistically significant and positive impact on rice, meat, and milk. One additional high-temperature day in a month increases the per kilogram retail price of rice and meat by Rs. 0.32 and Rs. 1.64 respectively. On the other hand, we do not find statistically significant impact of high-temperature days on wheat, vegetables, and lentils.\footnote{To put this into perspective, average per capita food consumption is Rs. 2,527 per month, in 2016 constant Nepali Rupees (Government of Nepal, 2016). Assuming a person consumes half a kilogram of rice per day, an additional high-temperature day in a month increases rice consumption budget by Rs. 4.80 or 0.2 percent. Similarly, assuming the same person also consumes one kilogram of meat per week, meat consumption increases the monthly budget by 0.3 percent. Together, they increase the monthly budget by 0.5 percent per person when there is an additional high-temperature days in a month. This can impact household welfare when the largest share of food expenditure is spent on the rice and meat, and an average household spends 57 percent of household expenditure in food (Government of Nepal, 2016).} High-temperature days have stronger negative effects on high commodity food (rice and meat) compared to low commodity staples (wheat and lentils).

\[ \text{[Insert Table 6]} \]

Increase in food prices, particularly in developing countries, reduces household welfare (Tiberti & Tiberti, 2018). The inward shift in budget curve limits opportunities for families to invest in human capital, including nutrition and health. This has long-term negative consequences on health capital accumulation. Evidence from Nepal shows that the increase in food prices reduces household welfare (Shrestha & Chaudhary, 2012).\footnote{Given that the 80 percent of our sample household own agricultural land, it should be noted that net food-selling and net food-buying households are likely to experience an opposite effects if the food price fluctuates due to high temperature.} Therefore, increase in high-temperature days negatively impacts food availability and security, which in turn affects health capital investment during pregnancy.
**Effect of high-temperature days on antenatal care utilization**

High-temperature days can directly affect health intervention through antenatal care utilization (Wilde et al., 2017) or by altering the disease environment (Rylander et al., 2013). For antenatal care utilization in Nepal, distance to health post is a major hindrance as it requires considerable geographical mobility (Maleku & Pillai, 2016). About 23.4 percent of the women reported problems in accessing health care due to distance to health facility (World Bank, 2018). With 82 percent of the household being rural, it requires 1-4 hours for a rural resident to travel to a local health post (Garha, 2017). During hot days, women may reduce antenatal care visitation in order to avoid heat and heat related discomforts. Thus, we expect that the high-temperature days during pregnancy decreases antenatal care utilization.

To explore how high-temperature days impacts antenatal care utilization, the following linear fixed-effects model is used:

$$C_{imyr} = \alpha + \beta T_{imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr}$$  \hspace{1cm} (9)

where $C_{imyr}$ is the number of prenatal care visits for a woman ($i$) who gave birth in the month ($m$),year ($y$) and from the agro-climatic region ($r$). $T$ is the number of high-temperature days in gestation. $\delta_m$ controls for the birth-month fixed effect. Similarly, $\lambda_y$ controls for the birth-year fixed effect, and $\eta_r$ is the agro-climatic region fixed effect. We also include controls for pregnancy characteristics ($X$).\(^{17}\) Finally, to account for spatial correlation, $\epsilon$, is the robust standard error cluster at the household sampling cluster.

---

\(^{17}\)Mother and household characteristics include age of the mother and its square, mother’s level of schooling, wealth index, household size, and the indicator variable for the rural and Dalit households. Pregnancy characteristic includes the number of pregnancies a woman had (as proxied by birth order). We include pregnancy characteristics because mothers are likely to engage in risky behavior in earlier birth but frequently visit doctors or peruse pregnancy-related knowledge (Lehmann et al., 2014).
As expected, Table 7 shows an inverse relationship between number of high-temperature days in gestation and number of antenatal care. When adding maternal, household and pregnancy characteristics (column 2), we also observe that educated mothers utilize more care, while women utilize less antenatal care in later pregnancy. To avoid additional heat related discomfort, women respond by decreasing the antenatal care utilization.

9 Conclusion
We examined the impact of high-temperature days during pregnancy – as a mild exogenous variation in utero environment – on the cumulative measure of early childhood health. Consistent with the fetal programming hypothesis, our findings show that mild shock negatively affects early childhood health. Additional high-temperature day in utero (days with daily mean temperature equal or higher than 32 degree Celsius) reduces height-for-age $z$-score by 0.008 to 0.011 standard deviations for the children younger five. Unlike the persistent effects observed for adverse shocks, the damage appears to be transitory as opposed to persistent, i.e., the impact gradually decreases with age and becomes almost undetectable by age five. We also find that the timing of exposure is important. Compared to first or second trimester, the third trimester has the strongest impacts as the fetus grows dramatically in size and mass.

Besides the aggregate impact of high-temperature days during pregnancy on early childhood health, we use secondary data to investigate the economic channels. We explore the impacts of high-temperature days on food prices and antenatal care utilization. Our findings suggest that high-temperature days has a stronger and statistically significant impact on high commodity food (rice and meat). In addition, high-temperature days during pregnancy reduces
antenatal care utilization as it requires considerable geographical mobility. Both channels, nutritional and health, can lead to negative health outcome in early childhood.

As climate change can fundamentally alter the earth’s climate system threatening child wellbeing, our findings have important implication for policies that aim at increasing childhood health and mitigating damages from climate change. In the case of Nepal, the Sustainable Development Goal, 2016-2030, targets under-five stunting reduction to 1 percent by 2030, a bold target given the current stunting rate at 40 percent (Devkota, et al., 2016). High-temperature days not only slows progress in reducing child stunting and under nutrition, but it also has the potential to reverse the recent gain. Beside policies to tackle climate change, the child wellbeing policies should treat high-temperature days as an uterine stressor. When 61 percent of women are unaware of the climate change or global warming, such policies may include increasing awareness of climate change and its impact on pregnant women. More importantly, focus should be given to the fact that the impact of increasing high-temperature days can channel through various aspects of life and livelihood.
References


Rylander, C., Odland, J. Ø., & Sandanger, T. M. (2013). Climate change and the potential effects on maternal and pregnancy outcomes: an assessment of the most vulnerable – the mother, fetus, and newborn child. *Global Health Action, 6*. https://doi.org/10.3402/gha.v6i0.19538


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Figures

Figure 1: MICS household cluster and weather station distribution
Figure 2: Distribution of daily mean temperature during gestation

Note: Temperature reported in degree Celsius (C).
Figure 3: Effect of high-temperature days in utero on the height-for-age z-score for different sub-samples

Note: Coefficient estimated using Model 4 Table 2 for different subsample. The dot represents the point estimate with 95% confidence interval.
Figure 4: Effect of high-temperature days in utero on the height-for-age z-score: Using different threshold for high-temperature day

Note: Coefficient estimated using Model 4 Table 2 for different threshold for high-temperature days. The line represents the point estimate with 95% confidence interval.
Figure 5: Effect of high-temperature days in utero on the height-for-age z-score: Using different definition of gestation length.

Note: Coefficient estimated using Model 4 Table 2 for different definitions of gestation length. The line represents the point estimate with 95% confidence interval.
### Tables:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Description</th>
<th>Mean (std. dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height-for-Age z-score</td>
<td>Height-for-age z-score of the children between ages 0 to 60 months. Calculated by MICS using 2006 WHO child growth standards.</td>
<td>-1.653 (1.537)</td>
</tr>
<tr>
<td>Female</td>
<td>An indicator variable where 1 = female child and 0 = male child.</td>
<td>0.473 (0.499)</td>
</tr>
<tr>
<td>Age of child</td>
<td>Age of the children in months.</td>
<td>30.79 (17.28)</td>
</tr>
<tr>
<td>Birth order</td>
<td>Birth order of the children</td>
<td>2.878 (1.728)</td>
</tr>
<tr>
<td>Antenatal Care</td>
<td>Number of antenatal care received from skilled health professionals in the last pregnancy.</td>
<td>4.11 (1.71)</td>
</tr>
<tr>
<td>Mother's level of schooling</td>
<td>Mother's education level. Categorical Variable: None, Primary, Secondary and Higher.</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>No formal schooling</td>
<td>0.43 (0.495)</td>
</tr>
<tr>
<td>Primary</td>
<td>One to eight years of schooling</td>
<td>0.18 (0.381)</td>
</tr>
<tr>
<td>Secondary</td>
<td>Nine to twelve years of schooling</td>
<td>0.21 (0.410)</td>
</tr>
<tr>
<td>Higher</td>
<td>More than twelve years of schooling</td>
<td>0.18 (0.386)</td>
</tr>
<tr>
<td>Age of Mother</td>
<td>Mothers age at birth (in years).</td>
<td>27.26 (5.931)</td>
</tr>
<tr>
<td>Wealth index</td>
<td>Composite indicator of wealth. Constructed by principal component analysis using the information on the ownership of consumer goods, dwelling characteristics, water and sanitation, and other characteristics that are related to the household’s wealth.</td>
<td>0.37 (0.481)</td>
</tr>
<tr>
<td>Poorest</td>
<td></td>
<td>0.20 (0.402)</td>
</tr>
<tr>
<td>Second</td>
<td></td>
<td>0.15 (0.357)</td>
</tr>
<tr>
<td>Middle</td>
<td></td>
<td>0.16 (0.362)</td>
</tr>
<tr>
<td>Fourth</td>
<td></td>
<td>0.13 (0.334)</td>
</tr>
<tr>
<td>Richest</td>
<td></td>
<td>6.210 (3.068)</td>
</tr>
<tr>
<td>Household size</td>
<td>Head-count of the people living under the same roof and sharing kitchen.</td>
<td>0.822</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicator variable where 1 = rural household, and 0 = Urban household.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.383)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dalit Indicator variable: where 1 = Dalit or lower caste as defined by Nepal Census 2011, 0 = otherwise.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.175 (0.380)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agro-climatic region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Climate and agro-ecological zone of Nepal with elevation (from sea level) 2000 meters or above.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.289 (0.453)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hill Second climate and agro-ecological zone with an elevation ranging from 300 to 2000 meters.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.364 (0.481)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terai Third climate and agro-ecological zone with elevation ranging from 60 to 300 meters.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.347 (0.476)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Observations</strong> 4704</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Definitions and descriptive statistics for major food items

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Description</th>
<th>Mean (std. dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Mean wholesale price per kilogram of various rice quality – coarse, medium, fine and flattened local rice.</td>
<td>41.83 (10.26) [1043]</td>
</tr>
<tr>
<td>Meat</td>
<td>Mean wholesale price per kilogram of chicken, mutton, and buffalo meat.</td>
<td>265.4 (56.99) [1021]</td>
</tr>
<tr>
<td>Milk</td>
<td>Mean wholesale price per liter of milk (could be cow or buffalo milk).</td>
<td>49.44 (12.15) [1029]</td>
</tr>
<tr>
<td>Wheat</td>
<td>Wheat flour wholesale price per kilogram.</td>
<td>40.19 (9.720) [1040]</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Wholesale price of a vegetable basket consisting of one kilogram of each of the vegetables – potato, tomato, cauliflower, and cabbage.</td>
<td>134.5 (25.61) [995]</td>
</tr>
<tr>
<td>Lentil</td>
<td>Mean wholesale price of lentil, per kilogram.</td>
<td>105.8 (16.56) [994]</td>
</tr>
</tbody>
</table>

Note: All price are in 2016 constant Nepali Rupees, calculated using the Consumer Price Index from the World Bank.
Table 3: Effect of high-temperature days in utero on the height-for-age z-score

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-temperature</strong></td>
<td>-0.0108***</td>
<td>-0.0107***</td>
<td>-0.00980***</td>
<td>-0.00804***</td>
</tr>
<tr>
<td></td>
<td>(0.00303)</td>
<td>(0.00305)</td>
<td>(0.00291)</td>
<td>(0.00285)</td>
</tr>
<tr>
<td><strong>Child Characteristics</strong></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mother Characteristics</strong></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Birth-month fixed effects</strong></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Birth-year fixed effects</strong></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agro-climatic region fixed effects</strong></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R-squared</strong></td>
<td>0.117</td>
<td>0.117</td>
<td>0.150</td>
<td>0.176</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>4704</td>
<td>4704</td>
<td>4704</td>
<td>4704</td>
</tr>
</tbody>
</table>

*Notes: The child characteristics include gender, age, and birth order, whereas mother characteristics include mother’s education and mother’s age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether a household is a rural or urban residence, and an indicator variable whether the household is a member of a lower caste. Robust standard errors in parentheses clustered at the household sampling cluster unit.

* p < 0.10, ** p < 0.05, *** p < 0.01
Table 4: Effect of high-temperature days in utero on the height-for-age z-score by trimester

<table>
<thead>
<tr>
<th></th>
<th>Height-for-Age z-score</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>First Trimester</td>
<td>-0.0117**</td>
<td>-0.0118**</td>
<td>-0.00957*</td>
<td>-0.00747</td>
</tr>
<tr>
<td></td>
<td>(0.00578)</td>
<td>(0.00579)</td>
<td>(0.00541)</td>
<td>(0.00532)</td>
</tr>
<tr>
<td>Second Trimester</td>
<td>-0.00540</td>
<td>-0.00523</td>
<td>-0.00584</td>
<td>-0.00376</td>
</tr>
<tr>
<td></td>
<td>(0.00451)</td>
<td>(0.00452)</td>
<td>(0.00450)</td>
<td>(0.00443)</td>
</tr>
<tr>
<td>Third Trimester</td>
<td>-0.0163***</td>
<td>-0.0161***</td>
<td>-0.0147***</td>
<td>-0.0136***</td>
</tr>
<tr>
<td></td>
<td>(0.00519)</td>
<td>(0.00519)</td>
<td>(0.00504)</td>
<td>(0.00498)</td>
</tr>
</tbody>
</table>

Child Characteristics  
Mother Characteristics  
Household Characteristics  

Birth-month fixed effects  
Birth-year fixed effects  
Agro-climatic region fixed effects  

Observations | 4704 | 4704 | 4704 | 4704  
R-squared     | 0.118 | 0.118 | 0.150 | 0.176  

P-value (3rd = 2nd) | 0.05 | 0.055 | 0.10 | 0.07  
P-value (1st = 2nd) | 0.37 | 0.58 | 0.058 | 0.08  

Notes: The child characteristics include gender, age, and birth order, whereas mother characteristics include mother’s education and mother’s age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether household is a rural or urban residence, and an indicator variable whether the household is a member of a lower caste. Robust standard errors in parentheses clustered at the household sampling cluster unit.  
* p < 0.10, ** p < 0.05, *** p < 0.01
Table 5: Effect of high-temperature days on the probability of child being female

<table>
<thead>
<tr>
<th></th>
<th>Probability of being a female child</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>High-temperature</td>
<td>0.0000619</td>
</tr>
<tr>
<td></td>
<td>(0.000822)</td>
</tr>
<tr>
<td>Mother &amp; pregnancy characteristics</td>
<td>√</td>
</tr>
<tr>
<td>Household characteristics</td>
<td></td>
</tr>
<tr>
<td>Birth-month fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>Birth-year fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>Agro-climatic region fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>Observations</td>
<td>4704</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Notes: The results are using the linear probability model. Mother characteristics include mother’s level of education, indicator variable whether mother is a rural resident and indicator variable for the caste. Pregnancy characteristics include mothers’ age at conception and pregnancy order (or birth order). Household characteristics include wealth index, household size, and elevation. Robust standard errors in parentheses clustered at the sampling cluster unit.

* p < 0.10, ** p < 0.05, *** p < 0.01
Table 6: Effects of high-temperature days on food prices

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
<td>Meat</td>
<td>Milk</td>
<td>Wheat</td>
<td>Vegetables</td>
<td>Lentil</td>
</tr>
<tr>
<td>High-temperature days</td>
<td>0.315**</td>
<td>1.642**</td>
<td>0.249**</td>
<td>-0.0684</td>
<td>0.235</td>
<td>0.234</td>
</tr>
<tr>
<td></td>
<td>(0.123)</td>
<td>(0.724)</td>
<td>(0.121)</td>
<td>(0.0742)</td>
<td>(0.204)</td>
<td>(0.204)</td>
</tr>
<tr>
<td>Month fixed effects</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Agro-climatic region fixed effects</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.168</td>
<td>0.081</td>
<td>0.013</td>
<td>0.359</td>
<td>0.052</td>
<td>0.052</td>
</tr>
<tr>
<td>Observation</td>
<td>1,043</td>
<td>1,021</td>
<td>1,029</td>
<td>1,040</td>
<td>995</td>
<td>994</td>
</tr>
</tbody>
</table>

Notes: High-temperature days in month is defined as the number of days with daily mean temperature equal to 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 items can be found in Table 2. Robust standard errors in parentheses clustered at the district level.

* p < 0.10, ** p < 0.05, *** p < 0.01.
### Table 7: Effect high-temperature days on antenatal care utilization

<table>
<thead>
<tr>
<th></th>
<th>Antenatal Care Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>High-temperature days</td>
<td>-0.0163*** (&lt;0.01)</td>
</tr>
<tr>
<td></td>
<td>(0.00478)</td>
</tr>
<tr>
<td>Mother, pregnancy and household characteristics</td>
<td>√</td>
</tr>
<tr>
<td>Birth-month fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>Birth-year fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>Agro-climatic region fixed effects</td>
<td>√</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.061</td>
</tr>
<tr>
<td>Observation</td>
<td>2091</td>
</tr>
</tbody>
</table>

**Notes:** Mother and household characteristics include age of the mother and its square, mother’s level of schooling, wealth index, household size, and the indicator variable for the rural and Dalit households. Pregnancy characteristic includes the number of pregnancies a woman had (as proxied by birth order). Robust standard errors in parentheses clustered at the sampling cluster unit.

* p < 0.10, ** p < 0.05, *** p < 0.01.
### Table A1: Descriptive statistics for high-temperature days and matching distances

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Description</th>
<th>Mean (std. dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Number of days in gestation with daily mean temperature higher or equal to 32 degree Celsius (98.6 Fahrenheit).</td>
<td>4.043 (9.641)</td>
</tr>
<tr>
<td>Difference in elevation</td>
<td>Differences between household cluster elevation and matched station elevation. The elevation is measured in meters.</td>
<td>23.33 (262.4)</td>
</tr>
<tr>
<td>Distance</td>
<td>The distance between household cluster and matched meteorological station. The distance is measured in kilometers.</td>
<td>17.47 (11.52)</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>4704</td>
</tr>
</tbody>
</table>
Figures

Figure A1: Height-for-age z-score by age in month
Figure A2: Height-for-age z-score by birth month

Note: MAR, APR and MAY is the Spring Season; JUN, JUL, and AUG is the Monsoon Season; SEP, OCT and NOV is the Autumn Season; and DEC, JAN and FEB is the Winter Season.
Figure A3: Districts with available food prices (administrative boundary before 2015)
Figure A4: Frequency of birth by birth month