Extreme Weather and Health Outcomes in Women

Evidence from Colombia and Perú

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Abstract

This paper investigates the relationship between health outcomes during delivery and extreme temperatures in Colombia and Perú. Using geo-coded household survey data from the DHS, we construct an index accounting for the incidence of pregnancy complications for women during labor. Matching this dataset with monthly-temperature data, we identify that experiencing extreme temperatures during pregnancy, particularly cold temperatures, increases the probability of suffering pregnancy complications in Colombia. Contrary to majority of the literature on health outcomes and temperature, we find no effect of experiencing extreme high temperatures. Interestingly, we find no significant effects in Perú.

JEL classification: J16, Q54
Keywords: Climate change, Health, Gender

1 Introduction

Anthropogenic climate change will affect the frequency and severity of extreme weather events, which include heat waves, cold waves, floods, droughts, hurricanes, etc.(Hashim and Hashim, 2016). These extreme weather events have a direct effect on the health of human populations due to health sensitivity to shifts in weather patterns. Indirectly, the ecological damage brought on by climate change can adversely impact human health through crop failures, higher incidence of disease and population displacement due to prolonged droughts (Smith et al., 2014).

The direct effects of climate change on human health can occur in a number of ways. More frequent, severe and prolonged heat events will lead to an increase in heat-related deaths and illnesses. Rising temperatures and wildfires increase ozone and particulate concentration in the atmosphere, which elevates the risk of cardiovascular diseases. J. Balbus and Sarofim (2016) detail the possible influence of climate change on various health outcomes, from increased incidence of diseases such as asthma to worsening outcomes for individuals with certain illnesses such as Alzheimer's and Chronic Obstructive Pulmonary Disease (COPD).

Though climate change is a global problem, the adverse effects are not distributed uniformly across countries and populations, with developing and poorer countries suffering the brunt of the damages (Mendelsohn et al., 2006). Low-income countries and areas where malnutrition is widespread, education is poor, and infrastructures are weak will have the most difficulty adapting to climate change and related health hazards. Even within a country, the socio-economic conditions also cause substantial variation in the adverse effects experienced. For example, when considering the psychological effects of extreme weather events in Australia, Berry et al. (2010) find a substantial link to psychological distress—but only for those residing in rural and remote areas.

The effects of climate change are also heterogeneous across genders due to the differences in vulnerability and the ability to cope with such effects. Women are disadvantaged due to both physiological and sociological differences. From a sociological standpoint, gendered differences in access to resources and information cause differences in adaptation capabilities. For example, women are less flexible in working off-farm in response to crop losses compared to men (Eriksen et al., 2005).The differences due to physiology depend on the type of health impact being measured. For temperature-related effects, there appears to be no significant difference across genders. But for mental health, women appear to be more susceptible to stress-related disorders such as Post Traumatic Stress Disorder (PTSD), depression and anxiety following extreme weather events. (Liu et al., 2006; Ehrlich et al., 2010; Kim et al., 2010). Women face additional and unique challenges associated with their reproductive role as mothers, since the effects of climate change have adverse impacts on maternal health and pregnancy outcomes (Rylander et al., 2013). Exposure to natural disasters and extreme weather events increases the probability of poor pregnancy outcomes. Research has linked in-utero exposure to extreme temperatures and low birth-weight (Grace et al., 2015; Deschênes et al., 2009) .

In this paper, we focus on the effects of extreme temperatures on health outcomes. Specifically, we investigate the impact of experiencing extreme temperature while pregnant on complications

during delivery for women in Colombia and Perú. Maternal health is an important policy outcome variable due to the welfare implications on the household. The death or illness of the mother has negative implications on the child, increasing the probability of its death and poor development (WHO, 2005). We use geo-coded household survey data with detailed information on pregnancy-related health outcomes at an individual female level from the Demographic and Health Surveys (DHS). Using gridded monthly temperature data from Willmott and Matsuura (2012), we are able to identify the temperature during pregnancy to analyse the effect of extreme temperature during gestation.

Few papers investigate the effects on maternal health, with most of the focus on the health outcomes of newborns. In a study in the U.S, Kim et al. (2019a) find that prenatal exposure to extreme heat increases the risk of hospitalization, with a higher effect for black women compared to white. This re-enforces the notion of the heterogeneous effects across gender and socio-economic groups. Our paper belongs to the same strand of literature. The rest of the paper proceeds as follows; Section 2 summarizes the relevant literature in the field. Section 3 provides information on the data sources used and the consolidation process. The empirical methodology is detailed in Section 4, and the results of our analysis are discussed in Section 5 followed by robustness checks. Section 6 Concludes.

2 Literature Review

Climate change, in addition to the heavy damages it causes to the environment, has highly negative consequences in terms of inequality. In this sense we observe that the literature identifies two types of inequality related to this phenomenon. On the one hand, considering economic inequality, developing countries are more exposed to climate change than developed countries. In addition to the reduced availability of resources to mitigate the impacts, the higher importance of agriculture in developing countries plays an important role in their increased vulnerability (Mendelsohn et al., 2006).

The literature also identifies the rural-urban contrast. As pointed out by Burgess et al. (2017), death rates during extreme heat events are higher for rural areas in India, when compared to urban. Therefore, there is an expansion of the literature from the beginning of this century, in which the impact of weather events on different health outcomes is studied. Deschênes and Moretti (2009) and Deschênes and Greenstone (2011) focus on the short term impact of extreme temperature on elderly mortality, whereas Green et al. (2009) and Ponjoan et al. (2017) study the impact on emergency department visits and hospitalizations. In addition, we can find in the literature studies that forecast the long-term impacts of climate change. Deschênes and Greenstone (2011) estimate, using Business As Usual (BAU) climate predictions, that the age adjusted mortality rate would increase by 3% by the end of this century.

The other inequality that is pronounced in this context is gender-related. Specifically, women in developing countries are disproportionately affected by the negative impacts of climate change, which is closely related to agrarian societies (Eastin, 2018). This deepens existing social inequalities

and threatens women and girl's health, safety and economic well-being. Larger gender inequalities and development gaps are associated with a higher impact of climate change on women, especially in the case of those that depend on natural resources for their livelihoods.

In this paper, we focus on the negative impacts on mothers during pregnancy, a branch of literature that has been developing in the last decade. Pregnancy complications is one of the main factors that increase the mortality risk among young women, especially in poor countries (WHO, 2019). It is therefore important to study how climate change can influence this policy-relevant outcome, taking into account that the consequences of this phenomenon are more suffered in the least developed countries.

Say et al. (2014) document that weather shocks affect pregnant mothers through 3 possible channels: stress, incidence of infectious diseases, harvests and income. A more recent study (Kim et al., 2019a) find that prenatal exposure to extreme heat increases the risk of maternal hospitalization during pregnancy, with the effect being larger for black than for white mothers. One of the channels mentioned, which is stress, is studied more in detail in Lin et al. (2017). They focus on the impact of extreme temperatures on maternal hospitalization, measured through the Global Severity Index (GSI), which is based on a questionnaire that solicits psychological and psycho-pathological aspects. When it comes to extreme temperatures, the literature makes a distinction between hot and cold shocks, usually defined as the 95th and 5th percentiles of the temperature distribution, respectively. The literature mostly focuses on the impact of hot shocks on different health outcomes, such as preterm birth or birth weight. However, when analyzing cold shocks, Hampel et al. (2011) find that cold shocks cause an increase in blood pressure, especially in pregnant mothers.

Another branch of the literature that is linked with our main question of interest, and for which we can find a higher number of publications, analyze this impact using infant and birth outcomes. This is the case of Hu and Li (2019) and Isen et al. (2017), that study the negative effects of in utero heat exposure on long-term cognitive ability and adult earnings, respectively. This impact is also analyzed using the birth weight as the outcome variable, considering extreme hot temperatures in the second and third trimesters of pregnancy (Deschênes et al., 2009). A number of papers have studied newborn health outcomes in the countries of analysis (Colombia and Perú), though not much work has been done on maternal health outcomes. In particular, Molina and Saldarriaga (2016) found that exposure to a temperature one standard deviation above the historical mean during pregnancy, reduces birth weight by approximately 20 grams.

3 Data

3.1 *Health Data*

To study the effect of temperature shocks on pregnancy complications, our study uses two sources of data. The health and socioeconomic measures are sourced from the Demographic Health Survey (DHS), a nationally-representative program which collects information on various health outcomes in developing countries. Households are interviewed and geo-referenced at a "cluster" level (with random noise for privacy), which is a collection of 25-30 households. The DHS contains 4 question-

naires: Household, Woman's, Man's and a Biomarker. We make use of a sub-sample of the woman's questionnaire (Children's Recode) which contains information on the children of each women. In particular, information on pregnancy complications is available for the latest pregnancy/delivery during the survey.

We focus our analysis on Colombia and Perú due to the availability of geo-referenced DHS data. Specifically, our study looks at the 2010 Standard Survey for Colombia and the 2009 Continuous Survey for Perú. The difference between the Standard and the Continuous types is only in the procedure used to collect the data, and does not affect our study.

3.2 *Temperature data*

The main purpose of this study is to identify the association between experiencing extreme temperatures during pregnancy and pregnancy complications at birth. We use temperature data collected from the monthly average air temperature data sets published by the University of Delaware (Willmott and Matsuura, 2012). This source is one of the most comprehensive in terms of temperature statistics, integrating measures from the Global Historical Climate Network (GHCN2) and the archive of Legates and Willmott (1990). Temperature and precipitation measures are recorded from 1900 and gathered from several terrestrial weather stations worldwide. The temperature data points are available at a 0.5^{o} by 0.5^{o} latitude/longitude grid.

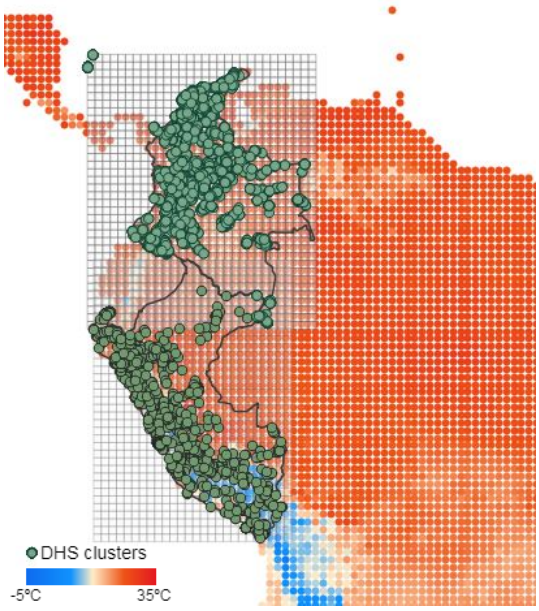
By merging the Geo-referenced DHS and the Delaware Temperature datasets by grids, we are able to associate households (grouped by cluster) to a grid containing a temperature data observation. To identify extreme temperatures, we look at the tail ends of the grid-month country temperature distributions. We use the distribution for 2004-2010 in Colombia and 2003-2009 in Perú, accounting for the entire duration of pregnancy for the women in both samples. Extreme temperatures are defined using the 5^{th} and 95^{th} percentiles. An extremely cold month is defined as having a monthly average temperature below the 5^{th} percentile and vice-versa for the 95^{th} percentile.

The merging process of the two datasets is shown in Figure 1. We project a grid layer onto the country and are able to locate the clusters from the DHS using geo-spatial data provided from the survey. The green dots represent the location of the DHS clusters. The dots on the color gradient from blue to red, represent the temperature data points. We consider the grid cells for which both temperature and survey data are present.

3.3 *Descriptive statistics*

Table 1 provides descriptive statistics on our sample composition. For Colombia we have 13,899 observations of women who gave birth within years 2005-2010, and for Perú we have 6,939 observations of women giving birth within years 2004-2009. In terms of age, the most represented group for both countries is between 20 and 29 years (52.03% for Colombia and 46.7% for Perú). In terms of education level, most of the individuals have completed secondary education (51.8% in Colombia and 40.9% in Perú). Furthermore, Colombia only has 16.5% respondents completed

Figure 1: Merging of DHS and Temperature Data



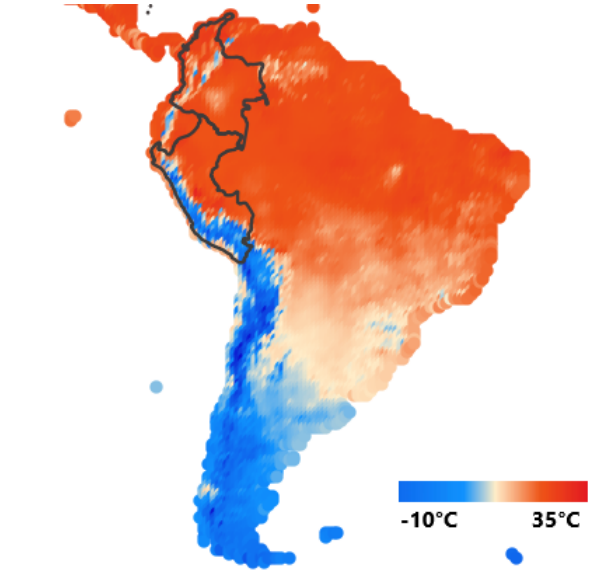
tertiary education. A majority of the Colombian sample (60%) are categorized as poor in terms of wealth, slightly lower proportion than in Perú (62.9%).

Concerning our main study variable, pregnancy complications were reported by 27.1% of the Colombian respondents, whereas 15.6% in Peruvians. The monthly temperature recorded in both countries has specific caveats that is worth to analyse. Colombia has a tropical weather, with little variation of temperature throughout the year. The main changes in weather conditions are more linked to precipitation with two distinguished periods, dry and rainy seasons. We observe that the temperature oscillations in Perú are higher, despite also being tropical country. The variety of features like mountains, deserts, and tropical rain forest contributes to a more heterogeneity in terms of weather. The temperature distribution within each country is shown in Figure 2. We observe Colombia mainly in hot temperatures, and the average monthly evolution of temperature is presented in Figure 3 across our study period.

The 5th percentile of Perú is 2.5°C and the 95th percentile at 28.2°C. Whereas in Colombia, which is more narrowly distributed, has the 5th and 95th percentiles at 12.7°C and 29.7°C respectively (Figure 5). We measure the proportion of women exposed to extreme hot months was lower (8.8%) with respect to those experienced extreme cold months (14.2%). Perú recorded a higher proportion of hot extremes (9.5%) compared to cold extremes (6.3%).

We exploit temperature variation at the grid-level, with 210 grids in Colombia and 4,283 clusters. On average, we have 66 observations per grid. There are 214 grids in Perú with 892 clusters and an average of 33 observations per grid.

Figure 2: Latin America:Temperature Map



Note: Temperatures correspond to May 2010.

Figure 3: Countries temperature fluctuation

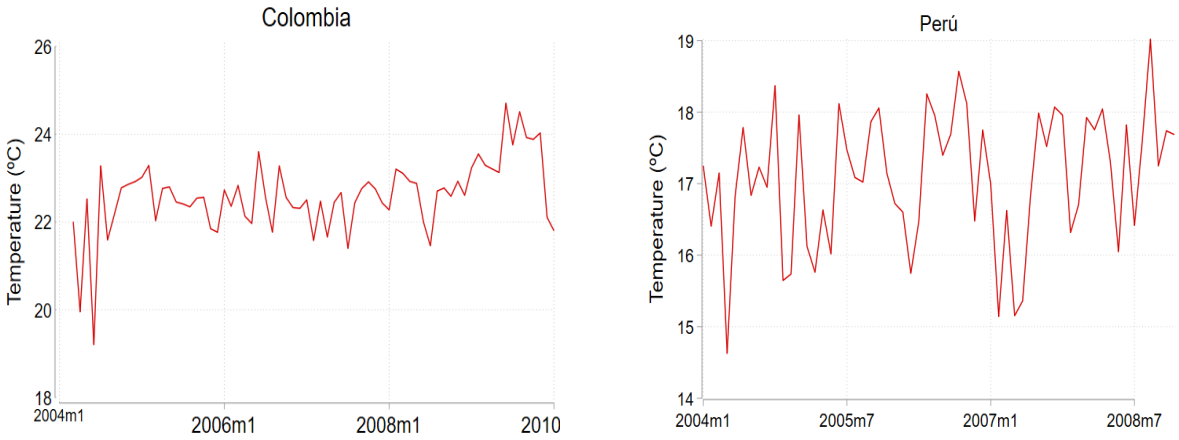


Figure 4: Countries temperature histograms

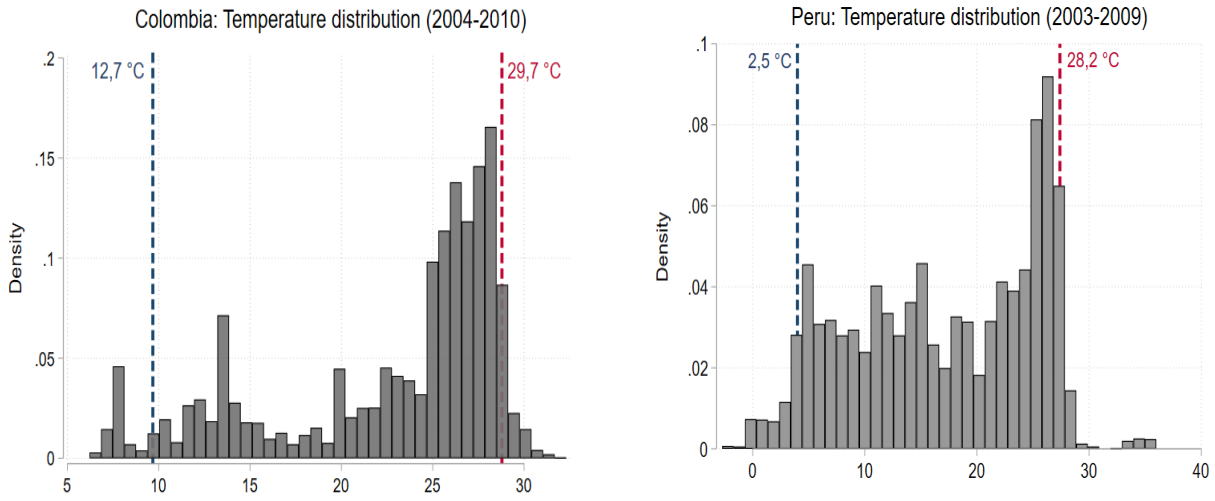


Table 1: Sample Demographic Characteristics

Age Groups	**% Colombia**	**% Peru**
13-19	11.6	7.7
20-29	52.03	46.7
30-39	29.41	35.3
40-49	6.96	10.4
Total	100.0	100.0
Education Level		
No education	2.6	4.8
Primary	29.2	37.7
Secondary	51.8	40.9
Higher	16.5	16.7
Total	100.0	100.0
Wealth Index		
Poor	60.0	62.9
Middle	19.6	21.8
Rich	20.4	15.3
Total	100.0	100.0
Pregnancy complications		
Yes	27.1	15.6
No	72.9	84.5
Total	100,0	100,0
Temperature exposure during	**pregnancy**	
Extreme cold	14.2	6.3
Extreme hot	8.8	9.5
Total	100.0	100.0
Sample size	13.899	6.939

Source: DHS Colombia 2010

4 Empirical Strategy

Based on findings from the literature, we hypothesize that expecting mothers who experience extreme temperatures during their pregnancy are more prone to pregnancy complications. For the health outcome variable, we use three indicators which have been identified in the literature (Souza et al., 2007) as possible complications at birth: excessive bleeding, convulsions and fever with vaginal discharge. These indicators are among the main causes of maternal death, especially for developing countries (Say et al., 2014). We construct a binary variable which takes the value one, if respondents reported having experienced any one of the three complications. We estimate the following model:

$$Y_{ig} = \alpha + \beta_H(Extreme\ Hot)_{ig} + \beta_C(Extreme\ Cold)_{ig} + \mathbf{X}_{ig} + \mu_g + \sigma_m + \epsilon_{ig} \tag{1}$$

where i denotes a woman belonging to a grid g. The dependent variable Y_{ig} takes a value of one, if the women reports having at least one of the previously mentioned complications (zero otherwise). The explanatory variables $Extreme\ Hot_{ig}$ ($Extreme\ Cold_{ig}$) is a measure of extremely hot (cold) temperature faced by woman i in grid g. $\mathbf{X}_{ig}$ is a vector of observable individual specific characteristics. We control for geographical location and temporal effects using grid fixed effects μ_g and month-of-conception fixed effects σ_m.

Extreme hot temperatures in grid g in month m are defined if the temperature is higher than the 95^{th} percentile of the country's temperature distribution at the grid-month level. Extreme cold temperature is defined in the similar way, if the temperature is below the 5^{th} percentile. The temperature thresholds are in Figure 3.

Our coefficients of interest are β_H and β_C, which measures the change in probability of experiencing a pregnancy complication in response to experiencing extreme hot and cold temperatures during pregnancy, respectively. Standard errors are clustered at the grid-level.

We use two measures for our independent variable:

1. $Extreme\ Hot_{ig}$ ($Extreme\ Cold_{ig}$) is a dummy variable that takes a value of one if woman i in grid g experienced at least one month with temperature above the 95^{th} (below 5^{th}) percentile during her pregnancy.

2. $t^{th}_Trimester_Extreme_J_{ig}$, where $t = 1^{st}, 2^{nd}$ *or* 3^{rd} and $J =$ *hot or cold* is a dummy variable that takes a value of one if woman i in grid g experienced at least one extreme temperature of type J in the t^{th} trimester. We redefine the variable in this way to analyse the effect by trimesters following the literature that documents differential susceptibilities during each of these stages of a pregnancy.

We run the following specification to account for the possible differential effects by trimester:

$$Y_{ig} = \alpha + \sum_{t=1-3, J=C,H} \beta_{tJ}(t^{th}_Trim_Extreme_J)_{ig} + \mathbf{X}_{ig} + \mu_g + \sigma_m + \epsilon_{ig} \tag{2}$$

where $\mathbf{X}_{ig}$, μ_g, σ_m are defined identically as in equation (1).

5 Results

5.1 *Main Findings*

The results of running Specifications (1) and (2) in Colombia are presented in the Tables below. Table 2 presents results from running specification (1). The independent variables of primary interest are dummy variables equal to one if a woman has experienced an extreme cold or hot temperature. Column (1) is the baseline OLS specification without controls or fixed-effects. At the cross-grid level, we find no effect of experiencing either extreme hot or cold temperatures. The results stay similar when adding individual-level controls such as age, ethnicity, wealth index etc, in column (2).

In column (3), we add grid fixed effects to explore the within variation at a grid-cell level by factoring out time-invariant grid-specific characteristics. We find that the effect of experiencing extreme cold temperature turns significant. The effect stays significant but decreases marginally when month-of-conception fixed effects are included in column (4). The effect of experiencing extreme cold temperatures is 2.5% increase in the probability of pregnancy complications, significant at the 5% level. A possible explanation for not finding an effect on extreme hot temperatures is the tropical climate of Colombia and the role of adaptation (Kim et al., 2019b). We further explore the role of wealth in the next subsection.

Table 2: Colombia: Regression Results for Extreme Temperatures

	(1)	(2)	(3)	(4)
Extreme Cold	-0.000	0.025	0.028**	0.025**
	(0.017)	(0.015)	(0.006)	(0.007)
Extreme Hot	0.016	0.004	-0.019	-0.017
	(0.018)	(0.018)	(0.019)	(0.019)
Constant	0.270**	0.499**	0.507**	0.505**
	(0.007)	(0.023)	(0.027)	(0.031)
Observations	13899	13899	13899	13899
Controls	NO	YES	YES	YES
Grid FE	NO	NO	YES	YES
Month-of-Conception FE	NO	NO	NO	YES

Standard errors in parentheses, clustered at the grid-level.
Columns (2), (3) & (4) include a vector of individual-level controls.
Column (4) includes grid and month of conception fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table (3) presents results of running specification (2). The results are presented similarly to Table (2) in terms of the inclusion of controls and fixed effects. Similar to our previous findings,

we only uncover significant effects for experiencing extreme cold temperatures. Interestingly, the direction of the effect changes depending on the trimester.

Experiencing extreme cold temperatures in trimesters one and three increases the probability of pregnancy complications, with the opposite trend in the second trimester. Experiencing extreme cold temperatures in the first trimester increases the probability of pregnancy complications by 2.5% and by 8.2% if in the third trimester, both significant at the 5% level. In contrast, there seems to be no detrimental effect of extreme cold temperature in the second trimester, with the sign being negative. These results are in-line with the literature, which documents that the first and third trimesters are the most critical for both the mother and newborn health outcomes.

Table 3: Colombia: Regression Results for Extreme Temperatures by Trimester

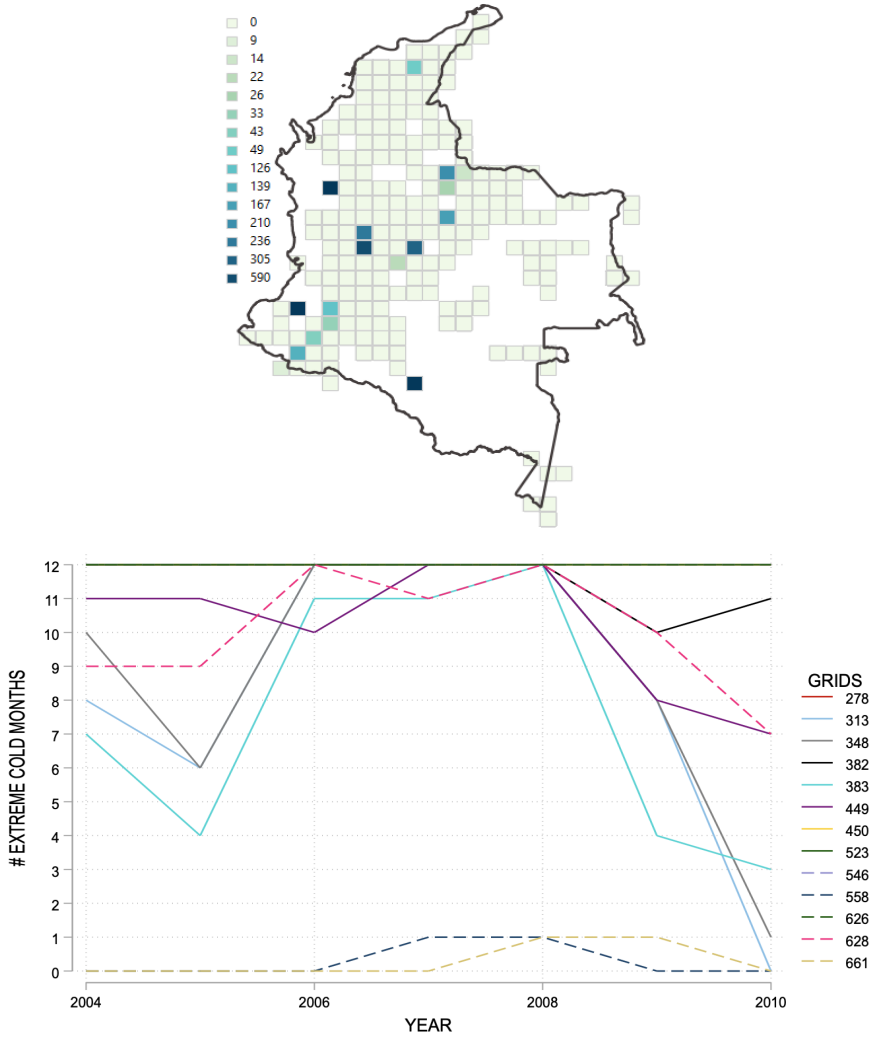
	(1)	(2)	(3)	(4)
1^{st} Trim. Extreme Cold	0.032	0.044*	0.058*	0.056*
	(0.020)	(0.019)	(0.023)	(0.024)
2^{nd} Trim. Extreme Cold	-0.098**	-0.086**	-0.085**	-0.093**
	(0.014)	(0.013)	(0.024)	(0.023)
3^{rd} Trim. Extreme Cold	0.068**	0.068**	0.076**	0.082**
	(0.023)	(0.022)	(0.022)	(0.023)
1^{st} Trim. Extreme Hot	0.000	-0.006	-0.012	-0.008
	(0.022)	(0.020)	(0.023)	(0.023)
2^{nd} Trim. Extreme Hot	-0.016	-0.015	-0.016	-0.017
	(0.025)	(0.024)	(0.025)	(0.025)
3^{rd} Trim. Extreme Hot	0.044*	0.037	0.023	0.024
	(0.026)	(0.025)	(0.027)	(0.028)
Constant	0.270**	0.498**	0.504**	0.502**
	(0.007)	(0.023)	(0.028)	(0.031)
Observations	13899	13899	13899	13899
Controls	NO	YES	YES	YES
Grid FE	NO	NO	YES	YES
Month-of-Conception FE	NO	NO	NO	YES

Standard errors in parentheses, clustered at the grid-level.
Columns (2), (3) & (4) include a vector of individual controls.
Column (4) includes grid and month of conception fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Following our results of finding an effect for only extreme cold temperatures, we investigate the location and occurrence of these events in Colombia. In the first panel of Figure 5, we plot the locations of the grids that experience extreme cold temperatures, with the darker grids experiencing the most number of extreme cold months. We observe that only a marginal number of grids experience extreme cold temperatures. Looking at the number of extreme cold months at the grid level, we find that five grids experience extreme cold temperatures all year during the years of our

study. As a robustness check, we exclude individuals who experienced extreme cold temperatures throughout their pregnancy, which is discussed in detail in section 5.3.

Figure 5: Colombia: Location & Incidence of Cold Extremes



The results of running specifications (1) for Perú are presented in Table (4). Interestingly, we find no significant effects of experiencing either extreme hot or cold temperatures. The results of specification (2), presented in the Appendix, similarly yield no significant results.

Table 4: Peru: Regression Results for Extreme Temperatures

	(1)	(2)	(3)	(4)
Extreme Cold	-0.010	-0.008	0.033	0.035
	(0.018)	(0.018)	(0.044)	(0.045)
Extreme Hot	0.021	0.022	-0.004	-0.005
	(0.015)	(0.015)	(0.022)	(0.022)
Constant	0.154***	0.169***	0.126***	0.132***
	(0.005)	(0.032)	(0.036)	(0.040)
Observations	6939	6939	6939	6939
Controls	NO	YES	YES	YES
Grid FE	NO	NO	YES	YES
Month-of-Conception FE	NO	NO	NO	YES

Standard errors in parentheses, clustered at the grid-level.
Columns (2), (3) & (4) include a vector of individual controls.
Column (4) includes grid and month of conception fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2 *Additional Effects by Wealth*

In this subsection, we explore if the effect of extreme temperatures differs by wealth status. The DHS classifies households into five categories according to their wealth status, from poorest to richest. We reclassify this variable generating a dummy variable (*poor*) that takes a value of one if the individual is classified as poor (zero otherwise). Using this new classification, we run specifications (1) and (2) interacting the regressor with the *poor* dummy.

We run the following specifications:

$$\begin{aligned} Y_{ig} = \alpha &+ \beta_C(Extreme\ Cold)_{ig} + \beta_H(Extreme\ Hot)_{ig} \\ &+ \beta_{C'}(Extreme\ Cold)_{ig}\ *\ poor_i + \beta_{H'}(Extreme\ Hot)_{ig}\ *\ poor_i \\ &+ \mathbf{X}_{ig} + \mu_g + \sigma_m + \epsilon_{ig} \end{aligned} \tag{3}$$

$$\begin{aligned} Y_{ig} = \alpha + &\sum_{t=1-3, J=C,H} \beta_{tJ}(t^{th}_Trim_Extreme_J)_{ig}\ *\ poor_i + \mathbf{X}_{ig} \\ &+ \mu_g + \sigma_m + \epsilon_{ig} \end{aligned} \tag{4}$$

The results of specification (3) and (4) are presented in Columns (1) and (2) of Table 7, respectively. We find that being poor has an additional effect on the probability of pregnancy complications. The coefficient of the interaction term is 5% i.e., an increase of 5% if an individual is poor.

5.3 *Robustness Checks & Sensitivity Analysis*

In this subsection, we run a robustness check to ensure that our findings are not a result of spurious associations. First, we observe that 7,9% of the Colombian sample experienced extreme cold

temperatures in all nine months of their pregnancy. To check that our results are not being driven by these individuals, we exclude them from our sample and run specifications (1) and (2) on the sub-sample. Our findings still hold with the 5% of significance. The regression results are presented in Table 5. As seen, the size and the coefficients are mostly equal.

Table 5: Robustness Check: Excluding individuals with extremes throughout pregnancy

	(1)	(2)
Extreme Cold	0.025***	
	(0.007)	
Extreme Hot	-0.016	
	(0.019)	
1^{st} Trim. Extreme Cold		0.057***
		(0.020)
2^{nd} Trim. Extreme Cold		-0.095***
		(0.024)
3^{rd} Trim. Extreme Cold		0.082***
		(0.026)
1^{st} Trim. Extreme Hot		-0.008
		(0.023)
2^{nd} Trim. Extreme Hot		-0.018
		(0.025)
3^{rd} Trim. Extreme Hot		0.025
		(0.028)
Constant	0.498***	0.497***
	(0.032)	(0.032)
Observations	12793	12793
Controls	YES	YES
Grid FE	YES	YES
Month-of-Conception FE	YES	YES

Clustered standard errors in parentheses.
(1) and (2) exclude individuals experiencing nine months of extreme cold temperatures.
All specifications include controls and grid & month-of-conception fixed effects.
* $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Next, we perform a sensitivity analysis to assess how sensitive our results are to the value defined by the temperature thresholds. For cold temperatures, we change the threshold to the 4th, 7th and 10th percentile of the temperature distribution. We then reclassify our explanatory variables using the new threshold to define extreme temperatures.

The results of running specifications (1) and (2) on the new definition of the explanatory variables are presented in Table 9 of the Appendix. Specifically, each column name indicates the percentiles used to define the threshold of extreme cold temperatures (4th, 7th and 10th). In gen-

eral, our results do not withhold the sensitivity checks. The exception is the 7th percentile for the case of extreme cold, obtaining a positive coefficient, significant at the 1% level. Therefore, the lack of significance of most of the coefficients in this inspection could be related with two main factors. On the one hand, the specific characteristics of the individuals who are not contributing to the pregnancy complication variation while re-defining the temperature thresholds. On the other hand, with the presence of confounding variables. There are in this case, many potential features related with both mothers' health complications at birth and the extreme weather conditions. For instance, the occurrence of rainfalls might have an incidence on health affecting the availability and supply of food mainly in poor and highlands, and also related with the air temperature. It might be interesting for further research to include other type of controls, to ensure the effect is being captured more accurately.

6 Conclusions

In this paper, we set out to find the effect of experiencing extreme temperatures during pregnancy on complications during delivery in Colombia and Perú. Using health outcomes data from the children's recode of the DHS, we are able to identify the average monthly temperature during pregnancy.

Our results from Colombia indicate that exposure to extreme cold temperatures during pregnancy increases the probability of experiencing pregnancy complications. We find a 2.5% increase in the probability of pregnancy complications, statistically significant at the 5% confidence level. When analysing the impacts by trimester, we find that extreme cold exposure during the first and third trimester increases the probability of experiencing complications at birth. The effect of exposure during the third trimester (8.2%) is higher than exposure during the first (5.6%). Analysing the impact by wealth status, we find that there is an additional increase in the probability of belonging to a lower wealth status.

Most of the work in this literature focuses on the health outcomes of infants and extreme hot temperatures. In this paper we address a emerging topic, which is the impact of extreme temperature on mothers health outcomes. Our results from Colombia show that extreme cold temperatures also pose a significant health risk to mothers.

The number of extreme weather events will rise with the alarming prospects of climate change. Hence, one could expect that the probability of deteriorating health outcomes would increase. Policies to increase adaptability to such weather outcomes are necessary, particularly for the poorer communities in developing countries.

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7 Appendix

The results of running specification (2) in Perú are presented in Table 6 below. As mentioned in the main paper, we find no significant results of experiencing either extreme temperatures.

Table 6: Peru: Regression Results for Extreme Temperatures by Trimesters

	(1)	(2)	(3)	(4)
1^{st} Trim. Extreme Cold	0.018	0.018	0.040	0.038
	(0.030)	(0.029)	(0.040)	(0.041)
2^{nd} Trim. Extreme Cold	-0.027	-0.023	-0.035	-0.031
	(0.022)	(0.023)	(0.036)	(0.035)
3^{rd} Trim. Extreme Cold	-0.023	-0.024	-0.019	-0.017
	(0.023)	(0.022)	(0.035)	(0.036)
1^{st} Trim. Extreme Hot	-0.009	-0.007	-0.023	-0.022
	(0.017)	(0.017)	(0.022)	(0.023)
2^{nd} Trim. Extreme Hot	0.016	0.016	0.004	0.005
	(0.020)	(0.018)	(0.020)	(0.021)
3^{rd} Trim. Extreme Hot	0.020	0.019	0.007	0.003
	(0.024)	(0.023)	(0.026)	(0.025)
Constant	0.155***	0.170***	0.130***	0.136***
	(0.008)	(0.039)	(0.036)	(0.040)
Observations	6939	6939	6939	6939
Controls	NO	YES	YES	YES
Grid FE	NO	NO	YES	YES
Month-of-Conception FE	NO	NO	NO	YES

Standard errors in parentheses, clustered at the grid-level.

Columns (2), (3) & (4) include a vector of individual controls.

Column (4) includes grid and month of conception fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

7.1 *Effects by Wealth in Perú*

The results of specifications (3) and (4) on Perú are presented in Table 8. We find no significant effects on being poor in this case.

7.2 *Sensitivity Analysis*

The sensitivity analysis for running specifications (1) and (2) on the other thresholds of the extreme temperature variable are presented in the Table 9.

Table 7: Colombia: Regression Results With Wealth Interactions

	(1)	(2)
Extreme Cold	0.017**	
	(0.007)	
Extreme Hot	-0.004	
	(0.026)	
Extreme Cold*Poor	0.050**	
	(0.024)	
Extreme Hot*Poor	-0.018	
	(0.022)	
Poor	0.013	0.014
	(0.011)	(0.011)
1^{st} Trim. Extreme Cold		0.044**
		(0.018)
2^{nd} Trim. Extreme Cold		-0.081***
		(0.020)
3^{rd} Trim. Extreme Cold		0.060*
		(0.033)
1^{st} Trim. Extreme Cold*Poor		0.034
		(0.056)
2^{nd} Trim. Extreme Cold*Poor		-0.066
		(0.062)
3^{rd} Trim. Extreme Cold*Poor		0.078
		(0.106)
1^{st} Trim. Extreme Hot		0.048
		(0.040)
2^{nd} Trim. Extreme Hot		-0.070*
		(0.037)
3^{rd} Trim. Extreme Hot		0.043
		(0.056)
1^{st} Trim. Extreme Hot*Poor		-0.074*
		(0.039)
2^{nd} Trim. Extreme Hot*Poor		0.072*
		(0.042)
3^{rd} Trim. Extreme Hot*Poor		-0.027
		(0.066)
Constant	0.489***	0.488***
	(0.033)	(0.034)
Observations	13899	13899
Controls	YES	YES
Grid FE	YES	YES
Month-of-Conception FE	YES	YES

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Peru: Regression Results With Wealth Interactions

	(1)	(2)
Extreme Cold	-0.005	
	(0.053)	
Extreme Hot	-0.019	
	(0.020)	
Extreme Cold*Poor	0.064*	
	(0.035)	
Extreme Hot*Poor	0.023	
	(0.046)	
poor	-0.012	-0.011
	(0.017)	(0.016)
1^{st} Trim. Extreme Cold		-0.030
		(0.047)
2^{nd} Trim. Extreme Cold		0.029
		(0.059)
3^{rd} Trim. Extreme Cold		-0.070
		(0.057)
1^{st} Trim. Extreme Cold*Poor		0.101*
		(0.052)
2^{nd} Trim. Extreme Cold*Poor		-0.087
		(0.068)
3^{rd} Trim. Extreme Cold*Poor		0.078
		(0.064)
1^{st} Trim. Extreme Hot		-0.003
		(0.043)
2^{nd} Trim. Extreme Hot		-0.008
		(0.043)
3^{rd} Trim. Extreme Hot		-0.025
		(0.023)
1^{st} Trim. Extreme Hot*Poor		-0.043
		(0.075)
2^{nd} Trim. Extreme Hot*Poor		0.024
		(0.052)
3^{rd} Trim. Extreme Hot*Poor		0.055**
		(0.025)
Constant	0.131***	0.137***
	(0.041)	(0.041)
Observations	6939	6939
Controls	YES	YES
Grid FE	YES	YES
Month-of-Conception FE	YES	YES

Standard errors in parentheses, clustered at the grid-level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Sensitivity Checks for Extreme Cold Temperatures

	(4^{th} Pctile)	(7^{th} Pctile)	(10^{th}h Pctile)
Extreme Cold_p_i	0.033	0.202***	-0.110**
	(0.057)	(0.024)	(0.045)
Extreme Hot	-0.017	-0.016	-0.016
	(0.019)	(0.019)	(0.019)
1^{st} Trim.Extreme Cold_p_i	-0.010	0.083	-0.085
	(0.026)	(0.067)	(0.059)
2^{nd} Trim.Extreme Cold_p_i	0.035	0.070	0.074
	(0.069)	(0.052)	(0.073)
3^{rd} Trim.Extreme Cold_p_i	0.034	0.043	-0.029
	(0.022)	(0.047)	(0.045)
1^{st} Trim.Extreme Hot	-0.008	-0.008	-0.008
	(0.023)	(0.023)	(0.023)
2^{nd} Trim.Extreme Hot	-0.017	-0.018	-0.018
	(0.025)	(0.025)	(0.025)
3^{rd} Trim.Extreme Hot	0.024	0.025	0.025
	(0.028)	(0.028)	(0.028)
Observations	13899	13899	13899
Controls	YES	YES	YES
Grid FE	YES	YES	YES
Month-of-Conception FE	YES	YES	YES

Standard errors in parentheses

The first two rows corresponds to the specification (1)

The last 6 rows corresponds to the specification (2).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$