Temperature Shocks and Contraceptive Use in Low- and Middle-Income Countries: Disparities by Region, Method Type and Individual-Level Characteristics.

By Katherine Del Salto Calderón[1] and Joshua Wilde[1 2 3 4]

Abstract

Despite growing interest in the relationship between environmental change and population dynamics, few studies have explored climate change's potential impact on contraceptive use as either a fertility determinant or from a public health perspective. We estimate this effect by linking Demographic and Health Surveys' (DHS) contraceptive calendar data with subnational daily temperature data from 52 low- and middle-income countries. We use fixed effects models to remove seasonality, and use the random year-to-year temperature variation within subnational regions, lending our estimates a causal interpretation. Our results suggest that temperature increases have varied effects in different world regions. We show that Latin America and Sub-Saharan Africa experience reduced contraceptive use due to high temperatures, while South Asia sees a slight increase in contraceptive use with higher temperatures. Additionally, we explore how this effect differs by method type and women's individual characteristics. In terms of method type, we find that the use of Natural Family Planning (NFP) methods—like abstinence or the rhythm—rises as temperature rise, while the use of Short Acting Reversible Contraceptives (SARC) declines. Based on the women's wealth, place of residence, and level of education, we anticipate varying effects of temperature on contraception. We aim to add to the body of knowledge on climate change and population dynamics. In this work we aim to provide evidence on the its effect on reproductive health behavior, which is a critical component of overall health and fertility.

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INTRODUCTION

The effects of environmental shocks on demographic processes are complex and variable within and across geographic and individual contexts. Despite the growing interest on the relationship between environmental change and health, few studies have explored the possible effects of climate change on contraceptive use. It is widely accepted that there is a link between temperature and birth rates (Barreca et al., 2018; Barreca & Schaller, 2020; Chen et al., 2003; Cho, 2020; Conte Keivabu et al., 2023; Grace, 2017; Hajdu & Hajdu, 2021, 2021; Levitas et al., 2013; Mao et al., 2017; Segal & Giudice, 2022). Several mechanisms may explain this link, including both bio-physiological and behavioral pathways. This paper aims to explore the latter, by estimating the effect of ambient temperatures on contraceptive use.

Numerous studies have investigated how age, marital status, education, targeted information campaigns, geographical region and income influence the use of contraceptives (Ali et al., 2014; Ontiri et al., 2020; Sato et al., 2020; Fruhauf et al., 2021; D'Souza et al., 2022; Das et al., 2022). However, to the best of our knowledge few studies have investigated the effect of environmental factors on contraceptive use (Brauner-Otto, 2014; Abiona, 2017; Alam & Pörtner, 2018; Sellers & Gray, 2019; Mahapatra et al., 2023). These studies rely on country specific analyses and their operationalization of climate factors vary widely, from rainfall (Abiona, 2017) to composite indexes of climate vulnerability (Mahapatra et al., 2023). The different analytical approaches limit the generalizability and comparability of the results. These results find positive (Brauner-Otto, 2014; Mahapatra et al., 2023) and negative (Abiona, 2017; Alam & Pörtner, 2018) relationship between poor environmental conditions and contraceptive use.

Our study expands earlier research on the effects of environmental shocks on health behaviors and fertility by presenting the first multi-country study containing estimates for contraceptive use responses to temperature shocks. We analyze this effect across 52 countries of the Global South by pooling data on 1.8 million women from all available Demographic Health Surveys (DHS) conducted between 2000 and 2022. There are two main reasons why it is important to examine the link between temperature shocks and contraceptive use. Firstly, understanding if and how contraceptive use, as a determinant of fertility, is affected by temperature shocks can shed light on the behavioral pathways through which temperature affects fertility outcomes. Secondly, the increased likelihood of extreme temperature events and its disproportionate effect on countries of the Global South and poorer populations within those regions calls for an analysis of the full breath of these effects on people's fertility intentions and decisions. In addition, it could inform appropriate reproductive health policy responses to climate change.

To harness exogenous variation in temperature, we link contraceptive use data over 28 years to high resolution sub-national daily temperature data from the National Oceanic and Atmospheric Administration (NOAA). The structure of the data allows us to use panel methods to investigate the effects of temperature shocks over time within each subnational geographical entity. We use country-year and region-month fixed effects models to capture geographically specific time trends and capture fixed national and subnational characteristics. Furthermore, our model adjusts for time-invariant individual characteristics by using woman fixed effects. Finally, by using a discrete measure of the frequency at which a given maximum temperature happens in a given month, our operationalization of the temperature measure accounts for nonlinear effects on contraceptive use. The chosen specification allows us to interpret our results casually and evaluate heterogeneous effects across different population subgroups.

Our findings reveal that temperature increases have diverse impacts across global regions. When maximum daily temperatures exceed 30°C, Latin America and Sub-Saharan Africa witness a decrease in contraceptive use. Conversely, our research suggests that in other parts of the world, extreme temperatures do not significantly influence contraceptive use. Nevertheless, South Asia experiences a small increase in contraceptive use when daily temperatures rise above 35°C. It's important to note that our study did not detect significant effects of temperature shocks on contraceptive discontinuation. However, the direction of these contrasts with the direction of the effect observed in contraceptive use in the cases of Latin America and Sub-Saharan Africa. Regarding method type, we observe an upward trend in use of Natural Family Planning (NFP) methods, such as abstinence or the rhythm, while Short Acting Reversible Contraceptives (SARC) see a decrease. Given these results, we expect to see different impact of temperature on contraceptive based on women's educational attainment, wealth and place of residence.

Our findings contribute to the existing literature on the relationship between human fertility and climate change. In this study, we emphasize the impact of temperature shocks on a key factor in health behavior and fertility, namely, contraceptive use. We illustrate that these effects vary significantly across different regions of the world. It is probable that this association will become more pronounced with the onset of future climate change and the occurrence of longer heatwaves, potentially amplifying disparities in global access to sexual and reproductive healthcare.

LITERATURE REVIEW

Existing literature has explored different mechanisms to explain the relationship between climate change and fertility. Sellers and Gray (2019) and Sellers (2022) conceptualize the environment-fertility relation as a function of "*proximate*" and "*intermediate*" determinants within two distinct mechanisms. First a bio-physiological one, affecting general health and reproductive health. Second, influences affecting individual behavior and preferences, including resource allocation, desired family size, sexual activity, and contraceptive use (Sellers, 2022, p. 422). Despite increased interest in the relationship between climate change and fertility, less scholarship has evaluated the effects of climate change on the proximate behavioral determinants of fertility. Contraceptive use is among this group and is associated with lower fertility rates, longer intervals between births, and better health outcomes for women (Sully et al., 2019). Understanding the relationships between environmental shocks and contraceptive use adds to the understanding of the fertility decision-making processes (Sellers & Gray, 2019). The following paragraphs discuss prior evidence on the links between temperature and fertility more generally, and temperature and contraceptive use specifically.

Far less attention has been placed on evaluating temperature's effects on the behavioral determinants of fertility. From a behavioral perspective, couples or individuals might adjust their fertility intentions and ideals of family size due to the uncertainty levied by climate related stressors. Casey et al. (2019) argue that climate change may affect fertility behavior by altering the relative costs and benefits of having and raising children. The direction of such association however is ambiguous, with some households reducing fertility due to reduced income and support, while others may view children as a means of strengthening long-term income security. Evidence regarding desired family size is limited. Sellers and Gray (2019) using data from Indonesia, find that women facing above average temperatures were significantly less likely to want a child, this was particularly true for women in farm households. Eissler, Thiede and Strube (2019) using DHS data find hot temperatures to negatively impact women's fertility intentions in Sub-Sharan Africa. Additionally, income and the ability to generate income can impact women's empowerment and influence in the decision-making related to the use of contraceptives, and their ability to satisfy their contraceptive need.

In the immediate term couples might reduce sexual activity as a response to higher than usual temperatures due to the physical exertion associated with it. This in turn could adjust contraceptive use, especially if relaying in natural family planning methods. Empirical evidence evaluating the relationship between temperature and sexual activity is inconclusive. Earlier studies suggest seasonal variation of sexual activity (Macdowall et al., 2008; Markey & Markey, 2013), albeit not testing for temperature induced behavioral change. Evidence from a multi-country study in Sub-Saharan Africa suggests a negative effect of increased temperature on sexual activity (Wilde et al., 2017). Similarly, a study evaluating broader measures of climate shocks, such as agricultural losses, suggests an increase in sexual abstinence (Alam & Pörtner, 2018). However, recent evidence from Hungary finds no association between temperature and sexual activity (Hajdu & Hajdu, 2022).

Turning to our outcome of interest, the linkages between temperature shocks and contraceptive use havebeen rarely studied in the literature. To provide a more comprehensive review of the available literature, we summarize the evidence looking at broader measures of environmental factors. Research in this area has primarily focused on the effect of natural disasters on contraceptive access (Behrman & Weitzman, 2016; Ellington et al., 2013; Hapsari et al., 2009; Kissinger et al., 2007; Leyser-Whalen et al., 2011). In general, these studies found significant negative effects on contraceptive prevalence following a climatic shock. These studies rely mostly on acute events, small sample sizes and short time periods, thus limiting the generalizability of the results.

More recent studies have evaluated the relationship between climate change and contraceptive use in geographically specific areas. Brauner-Otto (2014) using data from Nepal and operationalizing environmental quality through plant density, diversity, and species richness, finds that poor environmental quality is associated with lower contraceptive use. These results are consistent with recent evidence from India, where climate vulnerability – measured by a composite index – is associated with lower use of modern contraceptives (Mahapatra et al., 2023). By contrast, evidence from Uganda, Tanzania and Indonesia suggest contraceptive use increases following periods of adverse environmental conditions. Abiona (2017) investigates the effect of unexpected rainfall shocks on contraceptive use and finds that periods of drought increase contraceptive demand. Similarly, using panel data from Tanzania, Alam and Pörtner (2018) find that unexpected crop loss due to environmental factors is associated with an increase in contraceptive use driven by traditional methods. Sellers and Gray (2019) investigate the correlation between deviations in temperature and precipitation patterns and fertility intentions, contraceptive use and births. Using Indonesian data, the authors find that a delayed onset of the monsoon season one year before is significantly linked to lower likelihood of current contraceptive use, and that an increase in community temperatures results in a reduction of over 50% in the odds of desiring another child (Sellers & Gray, 2019).

Data and methodological limitations have been pointed out in many of the studies referenced above. Firstly, some of the studies demonstrate associations, not causation, between climate indicators and contraceptive use. Secondly, all studies are country specific, which impedes the generalizability of the results. Our study pools data on 52 low- and middle-income countries, as such we contribute to the field by filling this gap. Furthermore, our fixed effects model specification – that account for annual fluctuations at the subnational level and women's individual characteristics – we aim to standardize temperature differences between countries and reduce potential estimation bias caused by annual trends. Finally, this specification allows us to interpret the results causally.

DATA & METHODS

CONTRACEPTIVE USE DATA

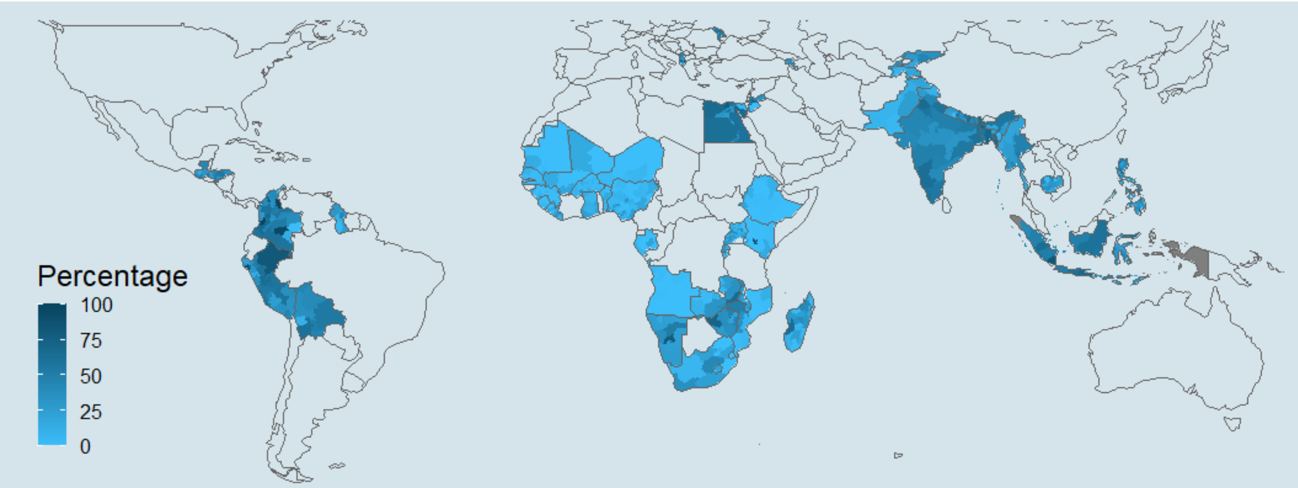
To investigate the relationship between temperature and contraceptive use, we use the contraceptive calendar and individual woman's characteristics data from 109 Demographic and Health Surveys (DHS) conducted between 2000 to 2022 in 52 low- and middle-income countries in Africa, Asia, Central Europe, and Latin America (See Table 1). The contraceptive calendar data of the DHS collects a complete history of women's reproduction and contraceptive use for a period of 5 years prior to the survey (ICF, 2018). That means our period of analysis spans 28 years, covering contraceptive histories of women between 1994 and 2022.

Table 1. World Regions and Countries

World Region	Countries	Number of Women (1,823,532)
Eastern Europe and Central Asia (ECA)	Albania, Armenia, Kyrgyzstan, Moldova, Tajikistan	47,847 (2.6%)
Sub-Saharan Africa (SSA)	Angola, Benin, Burkina Faso, Burundi, Comoros, Swaziland, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Uganda, Zambia, Zimbabwe	659,782 (36%)
South Asia (SA)	Bangladesh, Cambodia, India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, East Timor	842,716 (46%)
Latin America (LA)	Bolivia, Colombia, Guatemala, Guyana, Honduras, Peru	165,698 (9.1%)
West Asia and North Africa (MENA)	Egypt, Jordan	107,489 (5.9%)

Additional to the contraceptive calendar variable, we extract information on women's age, socioeconomic status, place of residence, marital status, and fertility preferences. The information relating to place of residence in the DHS is spatially referenced by coordinates of geographical clusters at the subnational level. We extract this information and match the temperature data for each latitude-longitude unit. This examines contemporaneous effects of temperature on contraceptive use during the five-year contraceptive history.

Figure 1 Spatial Distribution of Probability of Contraceptive Use



One outcome of interests is contraceptive use, for which an indicator variable is used where 1 specifies if the woman is using any contraceptive method in a given month (see Figure 1 and Table 2). We also evaluate the contemporaneous effect of temperature shocks on contraceptive discontinuation, using an indicator variable that takes the value of 1 if a woman used contraception in the previous month and no longer uses it in the current month.

Table 2. Contraceptive Use and Discontinuation and Contraceptive Method Summary Statistics

Characteristic N (%)[1]	ECA 3,123,737	SSA 39,905,939	SA 52,621,001	LA 9,575,340	MENA 6,288,880
Contraceptive use					
Non-use	2,222,439 (71%)	33,303,696 (83%)	30,517,659 (58%)	5,446,766 (57%)	2,965,552 (47%)
Use	901,298 (29%)	6,602,243 (17%)	22,103,342 (42%)	4,128,574 (43%)	3,323,328 (53%)
Discontinuation					
Discontinuation	5,915 (0.2%)	113,503 (0.3%)	174,769 (0.3%)	44,041 (0.5%)	43,436 (0.7%)
Method Type					
Permanent	30,594 (1.0%)	402,313 (1.0%)	10,972,324 (21%)	1,091,718 (11%)	100,842 (1.6%)
Long-acting reversible	302,892 (9.7%)	962,600 (2.4%)	1,073,325 (2.0%)	420,253 (4.4%)	1,723,569 (27%)
Short-acting reversible	170,105 (5.4%)	4,369,048 (11%)	6,517,687 (12%)	1,679,050 (18%)	1,071,811 (17%)
Natural Family Planning	392,223 (13%)	739,187 (1.9%)	3,442,380 (6.5%)	854,490 (8.9%)	415,276 (6.6%)
Other modern methods	507 (<0.1%)	23,802 (<0.1%)	63,892 (0.1%)	37,719 (0.4%)	786 (<0.1%)
Other traditional methods	4,977 (0.2%)	105,293 (0.3%)	33,734 (<0.1%)	45,344 (0.5%)	11,044 (0.2%)
Hormonal type					
Hormonal contraception	49,985 (1.6%)	4,487,673 (11%)	4,786,873 (9.1%)	1,356,739 (14%)	985,950 (16%)

[1]N represents woman-year-month observations.

We evaluate if the relationship between temperature and contraceptive use and discontinuation differs across world regions and subgroups of the population, we estimate the effects of temperature on contraceptive use by educational attainment, wealth index and marital status. We also investigate differential effects among women residing in rural and urban areas. Table 3 presents summary statistics of contraceptive use and discontinuation by population subgroup in our data. Finally, we will explore the impact of temperature on different contraceptive methods, such as modern and traditional methods and long-acting vs short-acting contraceptive methods. This will allow us to evaluate the mechanisms through which temperature influences contraceptive use.

Table 3 Contraceptive Use and Discontinuation by Population Subgroup

Characteristic N (%)[1]	Contraceptive Use 37,058,785	Contraceptive Discontinuation 381,664
Place of residence		
Rural	23,606,852 (63.70%)	245,990 (64.45%)
Urban	13,451,933 (36.30%)	135,674 (35.55%)

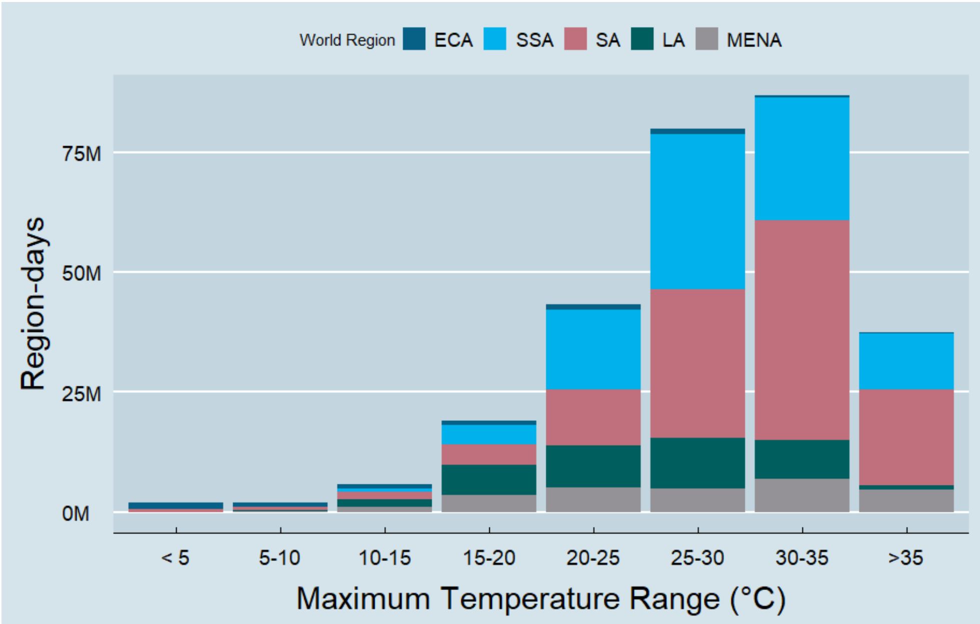
Characteristic N (%)[1]	Contraceptive Use 37,058,785	Contraceptive Discontinuation 381,664
Educational attainment		
No education	9,380,840 (25.31%)	79,803 (20.91%)
Incomplete primary	7,035,588 (18.98%)	74,651 (19.56%)
Complete primary	2,644,386 (7.14%)	31,305 (8.20%)
Incomplete secondary	10,997,888 (29.68%)	112,543 (29.49%)
Complete secondary	3,227,912 (8.71%)	38,111 (9.99%)
Higher	3,622,440 (9.77%)	42,944 (11.25%)
Missing	149,731 (0.40%)	2,307 (0.60%)
Wealth index		
Poorest	6,411,927 (17.30%)	75,054 (19.66%)
Poorer	7,273,396 (19.63%)	75,260 (19.72%)
Middle	7,429,446 (20.05%)	73,113 (19.16%)
Richer	7,209,082 (19.45%)	69,444 (18.20%)
Richest	7,106,774 (19.18%)	69,149 (18.12%)
Missing	1,628,160 (4.39%)	19,644 (5.15%)
Marital status		
Cohabiting	2,384,110 (6.43%)	30,316 (7.94%)
Divorced/separated	976,555 (2.64%)	16,945 (4.44%)
Married	31,698,499 (85.54%)	306,785 (80.38%)
Never married/cohabited	1,084,621 (2.93%)	20,514 (5.37%)
Widowed	914,832 (2.47%)	7,101 (1.86%)
Missing	168 (<0.1%)	3 (<0.1%)

[1]N represents woman-year-month observations.

TEMPERATURE DATA

Temperature data from the CPC Global Unified Temperature data from the National Oceanic and atmospheric Administration's (NOAA) is used in this analysis. The dataset provides daily global temperature on a 0.50-degree latitude x 0.50-degree longitude grid, since 1979. We operationalize the temperature variable with monthly temperature "bins." The variables represent the number of days within each month where the daily maximum temperature is recorded within a given temperature range. The temperature ranges are specified using 5°C bins from 10°C to 35°C, with additional bins for temperatures below 10°C and above 35°C. This operationalization of the temperature variable follows best-practice as laid out in Dell et al. (2014). Most importantly, it allows for non-linear relationships between temperature and contraceptive use. Figure 2 presents the distribution of daily maximum temperature across subnational region among the defined temperature bins by world region.

Figure 2 Temperature Distribution



ANALYTICAL STRATEGY

Simple unconditional associations between abnormal temperatures and contraceptive use alone cannot be interpreted as causal effects. Many other factors -- such as poverty rates and seasonality -- also correlate with climate and contraceptive use (Dell et al., 2014). Furthermore, weather variation across different geographical regions is largely fixed, which makes it difficult to isolate the impact of temperature solely through cross-country comparisons. To address this, we use panel methodologies and temporal within-region variation in temperature (Dell et al., 2014). By eliminating systematic differences in temperature across space and season, this method isolates the random component of temperature, which allows us to interpret our result causally.

Specifically, we estimate OLS fixed effects models of the following form:

$$C_{irt} = \sum_{j}^{J} \beta \boldsymbol{TEMP}_{r,t}^{j} + \delta_{cy} + \alpha_{rm} + \lambda_i + e_{rm}$$

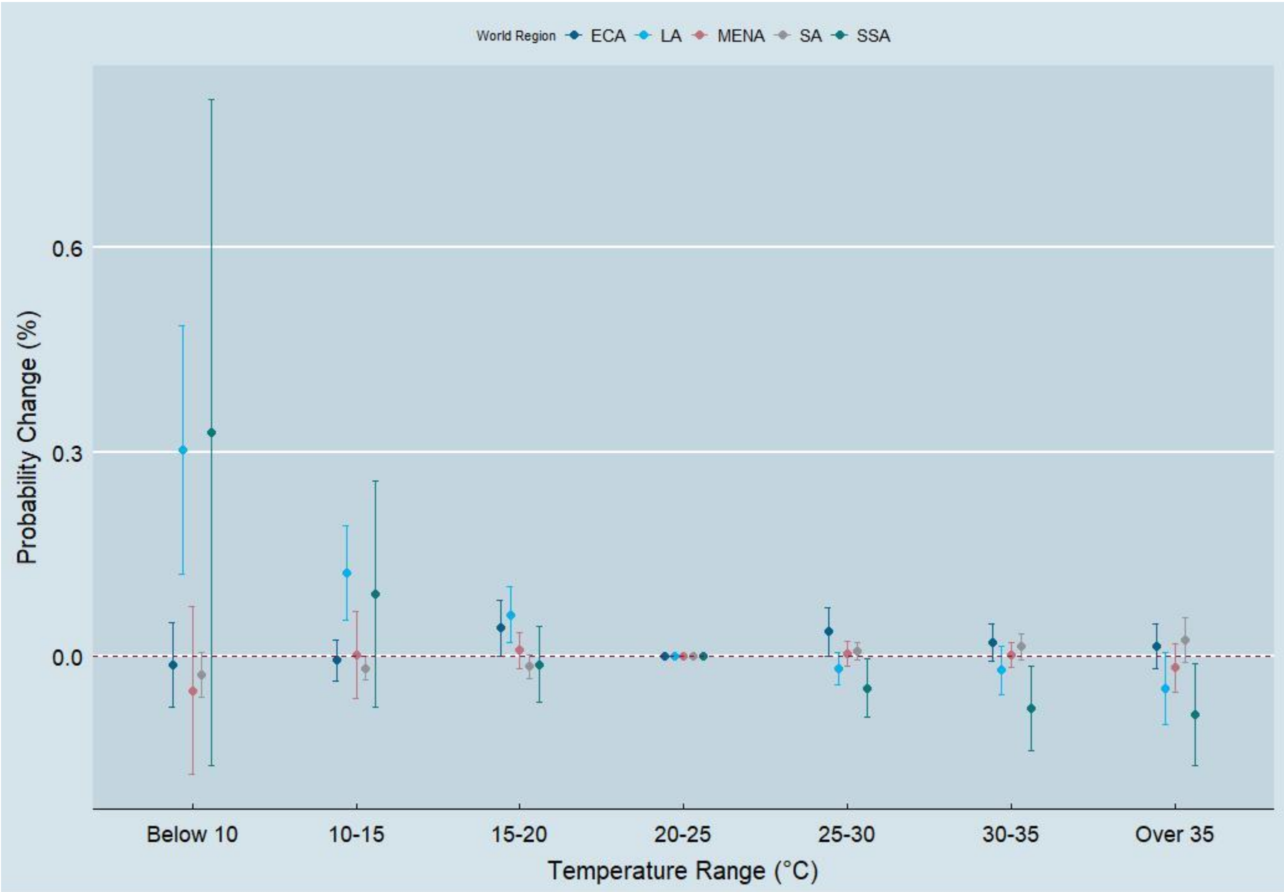
where C_{irt} indicates different contraceptive outcomes, as specified in the Data section, for woman *i* in subnational region *r,* at year-month *t*. TEMP is a vector of *J* count variables corresponding to the temperature bins in region *r,* at year-month *t*. Critical to the analytical strategy, we include country-year and region-month fixed effects captured by δ_{cy} and α_{rm} respectively. These fixed effects control for temperature seasonality at the subnational and unobserved heterogeneity across countries and over time. It also allows us to interpret our results as causal since we limit the effect of temperature on contraceptive use to the random year-to-year variation within each region, independent of seasonality. Moreover, we include woman fixed effects λ_i controlling for time-invariant unobserved factors at the individual level. Finally, we cluster standard errors e_{rm} at the region-month level to allow for serial correlation in the errors over time.

RESULTS

In Figure 3 we present the results of our main analysis, the varying impact of temperature across different world regions. We report the effect of temperature change on the probability of contraceptive use and corresponding 95% confidence interval. Our results suggest indicate that both Latin America (LA) and Sub-Saharan Africa (SSA) experience a negative effect of rising temperatures on the likelihood of contraceptive use. These coefficients represent the change in the proportion of women using any contraception method for each additional day of maximum daily temperature within a specific range. For SSA, an additional day with temperatures between 30°C and 35°C leads to a 0.076% decrease in the probability of contraceptive use compared to the reference category. These effects in SSA are statistically significant at the 0.05 level for temperatures above 25°C. In the case of Latin America, the effects are somewhat smaller. Nevertheless, each extra day with temperatures exceeding 35°C results in a 0.047% decrease in the likelihood of contraceptive use, reaching statistical significance at the 0.1 level.

These results suggest that the combination of contraceptive methods and the broader regional context could be influential factors. In Latin America and Sub-Saharan Africa, where short-acting reversible contraceptives (SARC) are most commonly used (see Appendix, Figure A1), abrupt temperature changes might disrupt access, usage, and even the effectiveness of these methods. Conversely, in South Asia, where permanent contraceptive methods are predominant, daily temperatures exceeding 35°C lead to a significant 0.024% increase in contraceptive use.

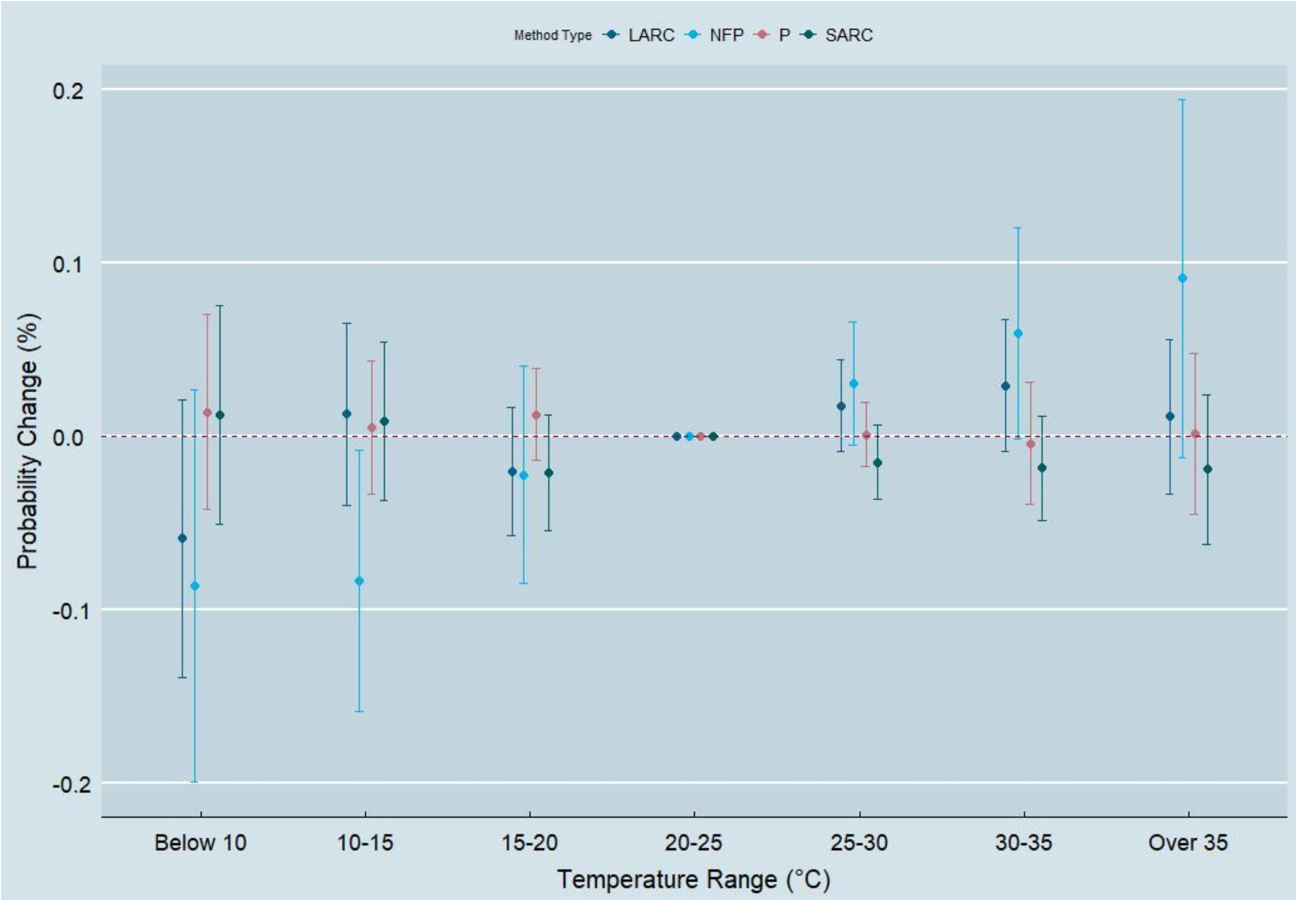
Figure 3 Maximum Temperature on Contraceptive Use by World Region



To delve deeper into this potential mechanism, we performed an analysis by the type of contraceptive method. Our preliminary results suggest that there is a trend in which higher temperature are associated with higher use of LARC and Natural Family Planning Methods, like abstinence, the rhythm and the symptothermal method. On the contrary, SARC seem to decrease slightly as contemporary temperatures increase (see Figure 4).

Furthermore, we examined the impact of temperature on contraceptive discontinuation. Our findings indicate that temperature does not have a significant effect on contraceptive discontinuation. Lastly, to continue exploring the potential mechanisms, we will examine how temperature affects different population subgroups, we conducted preliminary analyses based on place of residence and educational attainment. The results of these analyses can be found in the Appendix (Figures A.2 and A.3). We will also explore the differential effect based on women's age, wealth index and marital status.

Figure 4 Maximum Temperature on Type of Contraceptive Use



CONCLUSION

Our study expands upon previous research regarding the influence of environmental shocks on fertility. It distinguishes itself by presenting the first multi-country investigation, offering estimates for contraceptive use responses to temperature shocks. We employed panel methods to asses causally the impact of temperature shocks on contraceptive use. This study shows that variations in temperature can be causally linked to changes in contraceptive use. For Latin America and Sub-Saharan Africa, extreme temperatures above 35 °C and 25 °C respectively, decreases the probability of contraceptive use, while in South Asia temperatures above 35 °C increases the probability of contraceptive use. Notably, our study did not detect significant effects of temperature shocks on contraceptive discontinuation.

Current evidence suggest that there is profound and disproportionate consequences of climate change and weather shocks in the Global South (Ngcamu, 2023). Our results are in line with this evidence and suggest that as temperatures continues to increase, these regions could be disproportionally affected by it. We highlight the influence of temperature shocks on a pivotal factor in fertility, contraceptive use. Our analysis has important implications in the study of climate change and fertility and the on the reproductive rights of populations in the Global South.

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APPENDIX

Figure A.1 Share of Contraceptive Method by World Region

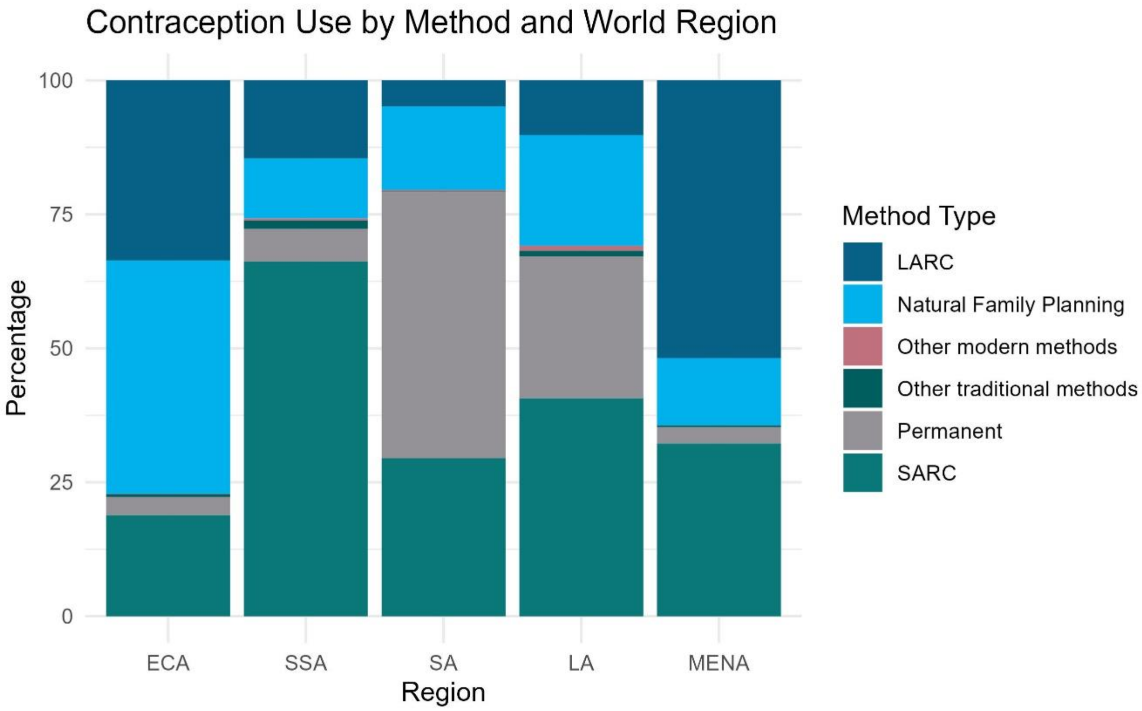

Figure A.2 Maximum Temperature on Contraceptive Use by Place of Residence

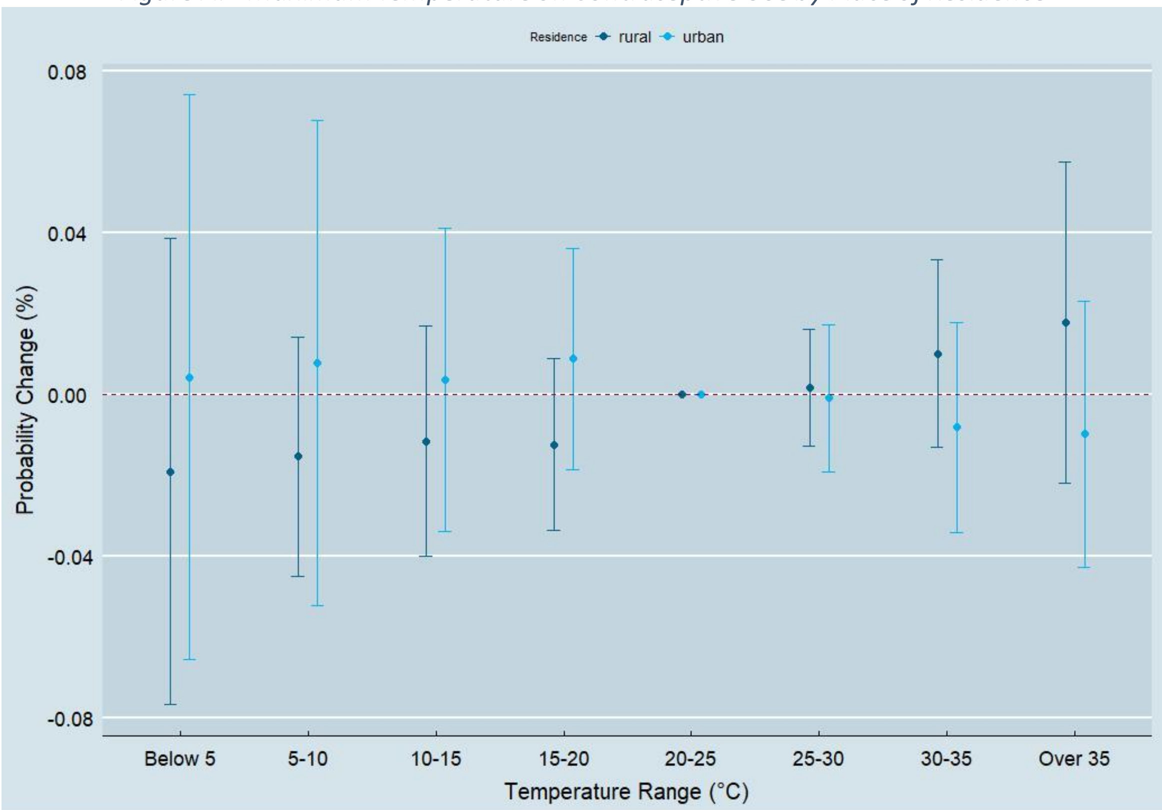

Figure A.3 Maximum Temperature on Contraceptive Use by Educational Attainment