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Climate Change and Getting Pregnant: Weather Exposure and a Full Accounting of Conceptions in Armenia and Tajikistan

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Abstract

Research on how climate or weather affects conceptions is limited and often constrained by data limitations. We use finely detailed data on local weather conditions and all conceptions, including those not ending in a live birth. Additionally, scientific knowledge is typically based on research focused on very poor or wealthy settings and routinely excludes many middle-income settings. Here, we examine two such contexts: Armenia and Tajikistan. These countries are undergoing complex economic development transitions but have highly developed health and education infrastructure. Using fixed-effects linear probability modeling of the time until each conception event based on Demographic and Health Surveys, we find no relationship between rainfall and conceptions in either context and no relationship between heat and conceptions in Armenia. In contrast, higher temperatures than usual and more hot days suppress conception probabilities in rural Tajikistan. This finding does not depend on whether we examine all conceptions or only those resulting in a live birth. Further, this relationship does not vary by women's educational attainment, nor by being childless or not. Our findings do not, therefore, point to groups of women that may be specifically vulnerable to climate variability beyond those living in rural areas. This result suggests that how heat affects resources is potentially less important in the short-term than how individuals use their time and in what ways they engage with the environment.

Keywords: Climate, weather, conceptions, heat, rainfall, fertility, Armenia, Tajikistan

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Introduction

Climate and weather[1] conditions have long been considered factors underlying the seasonality of births (Dorélien 2016; Lam and Miron 1996). As climate change research has expanded, a small body of research has directly considered the impact of rainfall and temperature conditions on birth rates (Barreca et al. 2018), delivery timing (Barreca and Schaller 2020), fertility preferences or ideal family size (Eissler et al. 2019), a new household birth (Simon 2017), and parity-specific live births (Sellers and Gray 2019). In this study, we move beyond seasonal approaches to fertility and beyond a focus on live births by identifying how changes in climate and weather conditions are linked to conceptions, net of seasonality.

The conception data we use is unique in that it includes pregnancies ending in miscarriage, abortion, and stillbirth. As such, and differing from most related studies, our analysis of conceptions is not biased toward live birth outcomes (Davenport et al. 2020, Brooks et al. 2023, Grace et al. 2023). Our focus on conceptions instead of live births is important for understanding the ways that climate change and associated weather impacts reproductive health. Because research has shown the potential for climate or weather to influence pregnancy outcomes, particularly via an increase in the likelihood of miscarriage (Davenport et al. 2020; Sexton et al. 2021), considering conceptions irrespective of pregnancy outcome supports a more complete understanding of climate change and health.

Climate–health research has documented that countries, regions within countries, and communities within regions experience and respond quite differently to climate and weather

[1] A note on terminology: weather refers to short-term atmospheric conditions while climate refers to "average" conditions over a long-period of time (30-50 or more years). As such, increasing temperatures associated with climate change, for example, may result in frequent and intense heatwaves, or as gradual warming. In this paper we are exploring the associations between weather and conceptions as a way of gaining insight into the ways climate change may impact reproductive health.

events (Brown et al. 2014; Hondula et al. 2015; Phalkey et al. 2015). For example, the time it takes for a heat wave to induce electrical outages or tax local health systems varies depending on the level of development and the community's or country's experience with the weather event (Hondula et al. 2015). Further, individuals within communities face differential risks depending on individual-level factors (Bekkar et al. 2020; Isen et al. 2017) and consequently respond differently. Therefore, identifying human responses to climate and weather events depends on fine spatial scale detail – specifically at the community-level, the context within which people live and make decisions - and with attention to an individual's lived experience. Considering individuals' conditions within their environmental context is especially important for documenting the experiences of marginalized people, such as women and individuals experiencing poverty (see also Lau et al. 2021; Rao et al. 2019). Reflecting these ideas, we expect the relationship between climate change and conceptions to be place-specific. Our analytic strategy links individual-level data to relatively fine-scale climate and weather conditions (Grace 2017; Grace et al. 2020; Shively 2017). To avoid unobserved heterogeneity that may bias our results, we account for time-constant characteristics related to the individual and place, while additionally exploring how the relationship varies according to educational attainment or urban/rural place of residence.

We focus on the short-term linkages between weather and conceptions in two climate-sensitive yet severely understudied countries: **Armenia and Tajikistan**. Unlike most low- and middle-income countries, both have near-universal health care and high levels of female educational attainment. This comparatively higher level of development allows us to mitigate potential confounding effects of women's incomplete access to health care or education—factors that may be linked to adverse health outcomes. In contrast to climate–health research in high-income populations (e.g., the United States and Western/Northern Europe), our case studies offer contexts in which large portions of the population are agriculturally dependent and therefore potentially interact with environmental conditions in multiple ways (e.g., through agricultural field labor). In addition, as part of the former Soviet Union, Armenia and Tajikistan have long provided women with access to modern methods of contraception and induced abortion; during the Soviet era, induced abortion was the main means of fertility control (Popov 1991). Because of the Soviet legacy, prenatal care, contraception, and abortion are widespread, (relatively) culturally acceptable, and affordable in these countries, in contrast to many other low- and middle-income contexts. Therefore, these countries—where female literacy is high, contraception and abortion are widely available, but impoverished individuals may face climate risks with few mitigation options—provide unique cultural and development settings for documenting how climate change impacts reproductive health and women's[2] lives. Despite all that these two contexts share, their demographic and economic circumstances differ greatly: Tajikistan is much poorer than Armenia, fertility rates are significantly higher in Tajikistan, and the ethnic/religious composition is very different in the two cases.

Because Tajikistan and Armenia have relatively high induced abortion rates, investigating the variability in all conceptions will provide cleaner estimates of the biological linkages between climate conditions and pregnancy. The difference between conceptions ending in live births versus other birth outcomes is not negligible. In our study contexts, the proportion of conceptions not ending in live births is 35% for Armenia and 16% for Tajikistan. Thus, a main

[2] We recognize that pregnancy and reproductive health concerns are relevant for individuals who do not identify as women. However, because our data focus on individuals identifying as women at the time of survey, we refer to respondents as "women." Unfortunately, the data do not contain information on gender identity or assignment at birth or later years, preventing us from more fully exploring gender and health in this study.

research question we explore is how a fuller accounting of conceptions enhances our understanding of the conception and climate relationship.

Specifically, we focus on heat and rainfall conditions in each woman's place of residence and investigate how these weather conditions intersect with conception timing. Variation in weather conditions and human responses provides insight into the ways long-term climate change may impact health outcomes. We combine recently collected reproductive health survey data from the Demographic and Health Surveys (DHS) for both countries with high-frequency rainfall and temperature data from the Climate Hazards Center. Monthly rainfall and temperature statistics (averages, variation, and count of days above a universal threshold temperature indicating heat stress) are spatially merged with geocoded DHS data. We evaluate the relationship between time-varying community-level weather conditions and conception using time-conditioned linear probability fixed-effects models, adjusting for covariates with established links to pregnancy timing, including month, year, and place of conception.

The Linkages Between Climate/Weather Conditions and Conceptions

In climate–health research, describing the pathways that link weather conditions to health outcomes is an important aspect of the research design guiding the temporal aggregation and spatial linking of the climate/weather data sets to the health data (Eissler et al. 2019; Grace et al. 2020, Brooks et al. 2023). Here, we describe the linkages that guide our analyses, as shown in Figure 1. Although our data do not permit us to evaluate most of these linkages specifically, they reveal the key underlying processes mediating the relationship between climate and conception and are useful for situating our research.

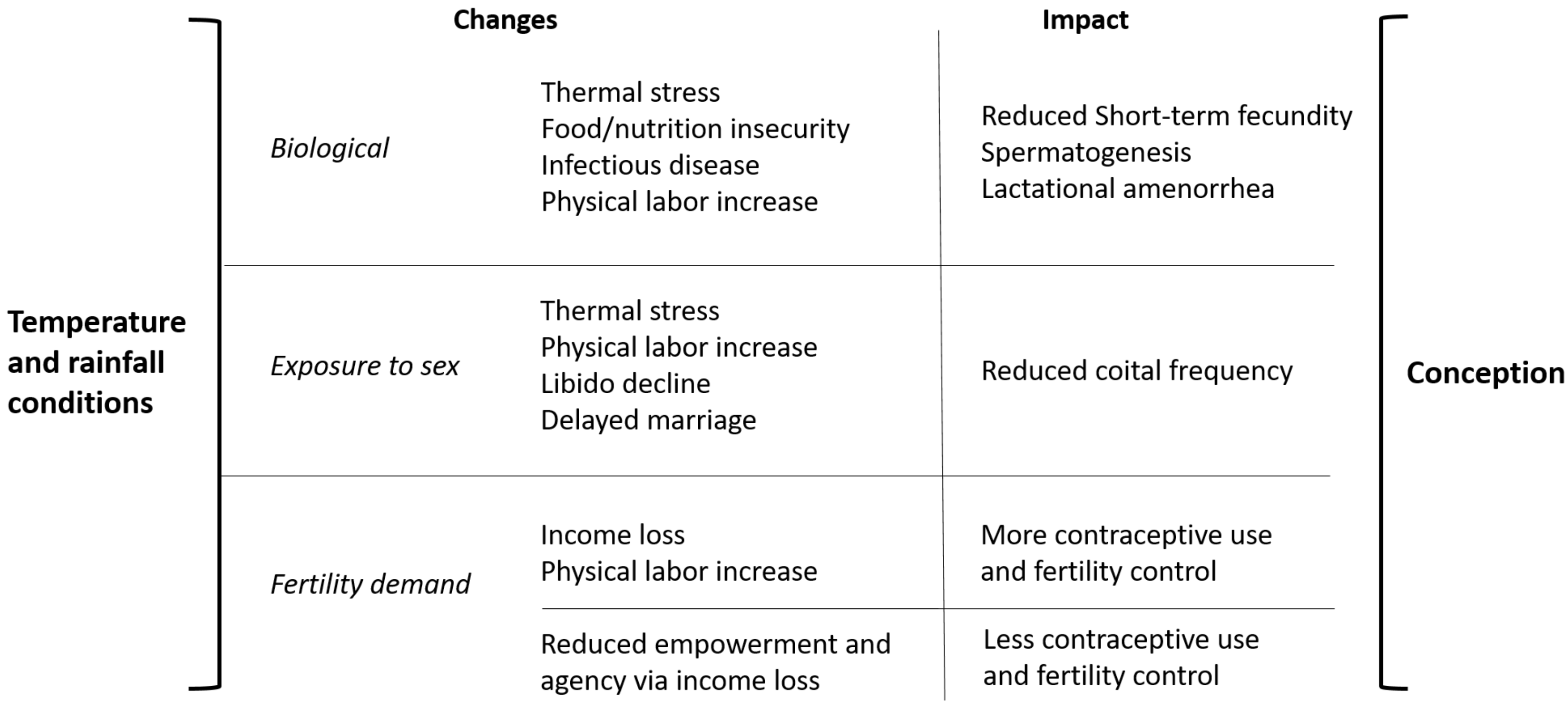

Fig. 1 Linkages between climate and conceptions

Biological Processes

Fecundity can be reduced by heat and rainfall, primarily through thermal stress (Barecca et al. 2018), nutritional variability and food insecurity (Davenport et al. 2020), and seasonal factors related to infectious disease (e.g., influenza; Dorélien 2015, 2019). In some settings, possibly including the more rural settings in Tajikistan, rainfall variability may increase food insecurity and increase physical labor demands (see also Jost et al. 2016; Rao et al. 2019). The limited social science and demographic research on the impacts of shifts in physical labor on reproduction suggests that physical labor can reduce short-term fecundity (Higgins and Alderman 1997; Panter-Brick 1996; Vartianien et al. 1994). Hotter temperatures may increase the risk of thermal stress, especially if people modify their physical labor to make up for potential agricultural losses as temperatures increase (Ebi et al. 2021).

Biological responses to heat may be sensitive to stages in women's reproductive life course. For example, women may change their breastfeeding behaviors, potentially affecting lactational amenorrhea and birth spacing depending on whether breastfeeding is intensified or reduced (Randell et al. 2021). Through their impact on spermatogenesis, exposure to elevated temperatures and heat stress may also reduce men's capacity to contribute to conceptions (Levine 1994; Mao et al. 2017).

Exposure to Sexual Activity

Thermal stress may modify a couple's sexual activity (Lam and Miron 1996). In addition, individuals may modify their short-term behaviors related to sexual activity based on environmental conditions. Couples or individuals may choose to avoid pregnancy or sexual activity during specific times of year—for example, because of the physical demands of harvest or weeding (Mosher 1979; Panter-Brick 1996; Pasternak 1978).

Further, evidence suggests that libido declines with higher temperatures. Wilde et al. (2017) found that sub-Saharan women's accounts of sexual activities in surveys were negatively related to temperature, as was online sex-related activity. Finally, in agricultural settings, marriages may be delayed during a particularly lean year, potentially lowering the proportion of women in cohabiting unions, decreasing coital frequency, and therefore first-conception probabilities in that period.

Fertility Demand

Climate- and weather-related changes in the ideal timing of children or ideal family sizes can influence contraception or fertility control (see Eissler et al. 2019; Sellers and Gray 2019). These factors may be particularly relevant for poor individuals in poor countries, where household resources are uniquely dynamic and are often strongly associated with climate- and weather-dependent factors: agricultural production and livestock or labor needs (Caldwell 2006). Lower income and lower access to household income may further reduce women's empowerment and agency in the household, which may generally lead to higher childbearing, shorter pregnancy intervals, lower contraceptive use, and higher family size goals (Hogan et al. 1999; Rao et al. 2019; Upadhyay et al. 2014).

Income levels can influence the resources available for children and the demand for children (Caldwell 2006; Montgomery et al. 2000). In wealthy countries, economic downturns are associated with reduced fertility goals and later fertility timing (Goldstein et al. 2013; Kreyenfeld et al. 2012; Sobotka et al. 2011). Likewise, households and communities that are dependent on rainfall for their livelihoods—for agricultural production, consumption, or income—are particularly vulnerable to climate change (Brown et al. 2014). These households may avoid pregnancy during lean years or seasons when they are less likely to meet the costs of childbearing and childrearing. The small body of recent research investigating how land use impacts the demand for children (Axinn and Ghimire 2011; Biddlecom et al. 2005; Brauner-Otto and Axinn 2017) has not routinely incorporated monthly changes in weather conditions, leaving many questions unanswered (Eissler et al. 2019; Grace 2017).

Differential Impact

The effect of exposure to variable climate conditions varies by the household's or individual's ability to modify their behaviors or mitigate against extreme events (Davenport et al. 2017; Ebi et al. 2021). For example, households and communities without adequate infrastructure to limit individual exposures to extreme heat (e.g., through air conditioning or fans) or reduce vulnerability to inconsistent rainfall may experience more significant impacts of exposure to weather variability. The unique ways that climate and weather factors affect individual women's lives are spatially and temporally diverse but also poorly understood (Jost et al. 2016; Lau et al. 2021; Rao et al. 2019). Couples and families living in disadvantaged households and communities face even greater challenges than their better-off counterparts because they have fewer resources to help mitigate the effects of heat stress and climate extremes.

Setting

Few sources provide information on latitude and longitude of the community of residence, length of time at the residence (migration history), and pregnancy histories that would allow us to pinpoint when conceptions occurred. All of these measures are available for Armenia and

Tajikistan, two contexts that represent a range of agriculturally-dependent post-Soviet countries. Comparing results from two countries with commonalities allows us to assess the consistency of a relationship across spaces. We have no a priori reason to believe that the relationship between weather and conceptions will differ across the two countries.

Armenia and Tajikistan have a history of state socialism and belonged to the former Soviet Union until the early 1990s. This shared history includes universal health care and education, as well as a command economy that extended to collectivized agricultural production (Lerman et al. 2004). Both experienced turbulent transitions from state socialism to independence, including armed conflict. After the fall of communism, the two countries maintained universal basic education and health care but underwent privatization reforms (Alcantara et al. 2013; Lerman et al. 2004; Müller and Munroe 2008). Most relevant to climate issues is the privatization of agricultural production, which essentially ended national-level collectivization and central planning of agricultural practices, putting the fate of agricultural production in the hands of individual farmers, laborers, and landowners (Gorton 2001; Kandiyoti 2002; Mathijs and Noev 2004).

Substantial variation exists in the living conditions across the two countries. Economically and developmentally, Tajikistan fares worse. According to the 2020 Human Development Index (United Nations Development Program [UNDP 2016]), of 189 countries, Armenia ranks 81st and Tajikistan ranks 125th. Specifically relevant to heat, both countries have near-universal access to electricity (own calculations from DHS data), but no information exists on the presence of air conditioning in homes.

The countries have unique demographic and cultural profiles, as well as geographical, climate, and agricultural characteristics. The two case studies allow us to observe women and children across varied weather and land-use patterns. We aim to identify whether climate influences conceptions consistently across different demographic conditions and whether such effects may be context specific.

Natality in Context

Both contexts have a generally low level of modern contraceptive use and a relatively high abortion rate. They are also similar in that sex and childbearing generally occur within marriage. However, Tajikistan is at an earlier stage of fertility transition and has markedly higher fertility than Armenia.

Armenia

Armenia became independent from the Soviet Union at the end of 1991. In 1992, it entered an armed conflict in a territorial dispute with Azerbaijan over the Nagorno-Karabakh region. By 1994, an estimated 30,000 people had died, and more than a million Armenians and Azeri had been displaced.

Compared with other former Soviet republics with a similar GDP in 1990, Armenia's GDP grew relatively well throughout the 1990s. That success was partly due to strong remittances from the large Armenian diaspora (Danielyan 2006). Women's persistently high unemployment rates (16% in 2000 and 12% in 2005) plagued Armenia after independence (Laborsta database 2010).

According to the latest Demographic and Health Survey (DHS) report of the 2015/2016 DHS survey (National Statistical Service et al. 2017), the total fertility rate was 1.7, which showed no change since the 2000 DHS estimate. The median age at first marriage was 20.9, similar to the reported age at first intercourse. The median age at first birth for women who had reached age 25–49 by the time of the survey was 22.8, and only 3% of women younger than 20 had had a first birth. In 2015/2016, 28% of women used modern contraceptive methods, and 13% of women had "unmet need" for family planning services. The total abortion rate was 0.8 and 0.4 per woman in rural and urban areas, respectively. Of these reported induced abortions, 8% were reported by women surveyed in DHS to be related to fetal sex selection. This estimate is likely low: Jilozian and Agadjanian (2016) found evidence of underreporting of sex-selective abortions, in particular, in rural Armenia due to public backlash against the high sex ratio imbalance at birth.

Fertility and reproductive issues have been relatively little explored in Armenia. In a comparative analysis, Billingsley and Duntava (2017) found that the decline in the total fertility rate after the transition from communism began resulted from a dramatic decline in higher order births and virtually no increase in childlessness. Billingsley (2011) found that better economic conditions, measured through women's employment and household wealth, were linked to women's desire for family expansion (having second and third children). Minasyan et al. (2007) reported that labor migration occurs in 8% to 9% of households and almost exclusively involves men. The summer months are the most important for labor migration, but it generally begins in March and can last as late as December. Women with husbands participating in seasonal labor migration are less likely to use contraception (Sevoyan and Agadjanian 2013).

Tajikistan

Tajikistan was the poorest of the Soviet republics, and it experienced the most severe decline in economic conditions after the end of the Soviet Union. In 1992, shortly following Tajikistan's independence from the Soviet Union, armed conflict erupted in the country. The heaviest fighting ended in early 1993, but ceasefire agreements were continually broken until 1998. The conflict is estimated to have resulted in 100,000 deaths, the displacement of 10% of the 6.4 million residents (Shemyakina 2013), and approximately 20,000 women losing their husbands (Falkingham 2000). The transition from Soviet collectivized agriculture, subsidies, and trade toward a private agriculture market was slow and difficult, resulting in a major food crisis in the mid-1990s. This food crisis led households to grow more wheat than vegetables in their private plots for subsistence (Harris 1998). By the end of the 1990s, 95% of the population lived under the official minimum subsistence level (Falkingham 2003).

Rainfall declined in 2000 and 2001, bringing about the worst drought in 70 years. The key grain-growing months of March and April saw less than half of the long-term rainfall average (Economist Intelligence Unit 2001:40), causing another serious food crisis.

Research on the impact of conflict and food crises on fertility in the post-socialist region is scant (for a rare study on Azerbaijan, see Torrisi 2020). However, this limited research offers some clues. First, the armed conflict in Tajikistan spurred migration and delayed first marriages (Shemyakina 2013). Second, broader uncertainty related to conflict in Tajikistan has been linked to increased abortions (O'Brien 2021). Finally, Clifford et al. (2010) found that unexpected increases in bread prices during the food shortage of the mid-1990s delayed marriages. Although fertility and marital rates recovered, they again declined in the second year of the drought that began in 2001. Clifford et al. interpreted the swift responses to food availability as evidence that behavioral rather than biological factors led to fertility decline, particularly because the marriage rate decline contributed significantly to lower fertility.

Family norms in Tajikistan have been described as gendered, with women expected to care for the family and men expected to provide for the family (United Nations Committee on the Elimination of Discrimination Against Women 2005). Traditional marital practices have revived somewhat, albeit unevenly across the regions. Such practices include bride prices, arranged marriages, polygamy, and Muslim religious marriage ceremonies (Shemyakina 2013). How widespread these practices are, however, remains difficult to estimate.

According to the latest Demographic and Health Survey (DHS) report of the 2017 DHS survey (Statistical Agency et al. 2018), the total fertility rate in Tajikistan was 3.8 in 2014–2016—the same as estimated in 2009–2011. The median age at first birth among women aged 25–49 remains low, at 21.9. This low first-birth median age is due to high marital fertility following early marriage rather than adolescent childbearing (only 3% of women aged 14–19 had given birth). Women in Tajikistan have had access to contraception and abortion relatively free of social stigma since Tajikistan was a republic in the Soviet Union. Among married women, 27% use modern contraceptive methods, mostly relying on the IUD and male condoms, and unmet need for family planning is estimated to be 23%. Unwanted pregnancies sometimes result in induced abortions, and the total abortion rate has held steady at 0.5 per woman over recent DHS collection rounds (i.e, since 2009). Abortions are primarily used to limit family size: only 1% of first pregnancies end in abortion, compared with 32% of fifth or sixth pregnancies.

In both Armenia and Tajikistan, fertility behavior may be sensitive to contextual change. Tajikistan, in particular, has demonstrated links between climate- and weather-related events and fertility (Clifford et al. 2010). No research has explored similar questions in Armenia, and no research has specifically examined conceptions in either country.

Climate Change and Land Use

To illustrate how mechanisms related to biological factors, fertility demand, and exposure to sex may operate in the two contexts we study, we outline important factors related to climate, weather, and land use. Armenia and Tajikistan are climate-sensitive countries whose economies rely heavily on the agricultural sector, with large shares of the population (36% in Armenia and 43% in Tajikistan) engaged in agricultural labor (World Factbook 2019).

The UNDP (2009) detailed the costs of climate change for Armenia, reporting that 30% of the country's GDP comes from agriculture and that 98% of its crops and livestock come from very small farms. The agricultural sector supports 47% of the Armenian population (UNDP 2013). A sizable share (40%) of agricultural production in Armenia is for self-consumption, and both rural and urban populations depend on the family farm's agricultural production. A stable climate is essential for food security in Armenia. The UNDP predicted that heat waves and high temperatures would increase mortality and poor health outcomes and that water shortages would occur. It further predicted that farms will increasingly rely on irrigation from rivers, which will be diminished as a result of the predicted climate changes. Forest damage and natural disasters have also been found in relation to Armenia's climate sensitivity. The UNDP (2013) reported a 50% reduction in grain production, a 35% reduction in potato production, and a 65% reduction in vegetable production due to major droughts in 2000, 2006, and 2010 and such weather events as spring floods, early frosts, and hail storms. The 2009 global recession exacerbated the situation, such that the poverty rate reached 35% in 2010.

For Tajikistan, a recent review of climate sensitivity reported that in 2018, the agricultural sector made up 17% of the GDP and provided 51% of all employment (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2020). Remittances made up another 31% of the GDP, leaving Tajikistan vulnerable to external factors and global fluctuations. Seven percent of Tajikistan's land is considered arable, and 30% is considered agricultural. The vast majority is rainfed pastureland, and the land dedicated to crops relies on irrigation. Cotton is an important crop and is water intensive. These factors make Tajikistan highly dependent on seasonal rainfall conditions. Climate change and instability have already led to soil erosion, reduced water quality, and biodiversity loss. Higher temperatures and floods are predicted to increase infectious diseases. Therefore, in the Tajik context, health is vulnerable to food and nutrition security as well as illness.

Expectations

The majority of the pathways we identified link weather variability to conceptions based on how it influences resources and physical activities. We expect these pathways to be particularly strong for the rural poor, as they are the individuals whose livelihoods, nutritional stability, and physical labor are most affected by weather. In contrast, thermal stress and spermatogenesis brought about by heat are not based on interaction with agriculture. Heat could, therefore, affect even the urban non-poor through these biological mechanisms. We also expect to see a relationship between weather variation and conception for childless women in particular, if exposure to regular sexual intercourse is an active mechanism; delayed marriages due to poor growing seasons would be reflected in delayed entrance into parenthood. Our research questions therefore incorporate difference based on residential location (specifically urban or rural residence), socioeconomic status (women's educational attainment), and childlessness status. Beyond these potential differences, disentangling the mechanisms is more difficult.

Data

We analyze two types of data: population/health survey data and climate data based on remote sensing.

Population Data

The Demographic and Health Surveys (DHS) are the world's primary source of information on fertility, contraceptive use, and infant and maternal health. Although the DHS are generally considered cross-sectional data, some of the surveys contain detailed information on pregnancy timing for each surveyed woman. We maximize the longitudinal potential of the DHS by using these retrospective recall pregnancy data to investigate conception timing relative to individual and climate characteristics. The DHS also collects Global Positioning System (GPS) coordinates for the DHS clusters—that is, the villages and towns where they collect data. Each cluster contains approximately 20 households. To maintain respondent confidentiality, the DHS shifts each rural cluster up to 5 kilometers, shifting 1% of them up to 10 kilometers. We accommodate this random displacement by assuming that the cluster can be located anywhere within a 10-kilometer radius of the provided latitude and longitude. The Armenia 2015/2016 and Tajikistan 2017 DHS contain pregnancy histories, GPS information, and information on the duration at the current residence. This last item allows us to match individuals to the climate and weather conditions throughout their pregnancy histories beginning in January after the year they moved to the current location. Residency is vital for ensuring proper exposure linking, although it is rarely considered in analyses set in wealthier countries, where information on the place of conception is generally missing.

DHS designate the residence as being in an urban or rural area. In addition, the highest level of education attained and the number of years of education provide information to estimate a woman's highest level of education at any given age.

Climate Data

To estimate agricultural production at the level of the rural DHS cluster, we use two recently developed data sets providing high-quality, fine-temporal scale, remotely sensed estimates of temperature and precipitation. For precipitation, we use the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data set (Funk et al. 2014). The CHIRPS data set, which U.S. Geological Survey scientists recently developed in collaboration with the Climate Hazards Group at the University of California at Santa Barbara, combines high-resolution (at 0.05 degrees) climatology (Funk et al. 2015) with time-varying station data and observations from geostationary weather satellites. In other words, CHIRPS relies on station data and high-resolution, remotely sensed data. USAID-supported projects use CHIRPS for monitoring and forecasting drought conditions in Africa and Central Asia (Funk et al. 2014).

The temperature data are from the Climate Hazards Center Infrared Temperature with Stations ($CHIRTS_{max}$[31]). The Climate Hazard Center (CHC) recently developed a quasi-global (60°S–60°N) mean monthly maximum temperature product at a spatial resolution of 0.05 degrees (~5 kilometers). The primary data set is available at a monthly resolution because it combines monthly Berkeley Earth station observations (http://berkeleyearth.org/) with very high-resolution, cloud-screened geostationary infrared radiation measurements. However, the CHC recently developed a daily maximum temperature data set by downscaling and bias correcting the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) daily maximum temperature values using the $CHIRTS_{max}$ as reference (Verdin et al. 2020). The $CHIRTS_{max}$ daily data are available for 1983–2016, which aligns well with the retrospective DHS data.

The $CHIRTS_{max}$ data product—along with many of the gridded temperature data products—leverages the fidelity of ground-based observations. What sets $CHIRTS_{max}$ apart from other data sources is its inclusion of remotely sensed temperatures and a dense set of weather stations. Hence, $CHIRTS_{max}$ is much less vulnerable to the so-called reporting crisis—referring to a decay of observation networks, increased data privacy, and restrictive access to data—which resulted in approximately a 600% decline in CRU stations from 1983 to 2016.

CHIRPS and CHIRTS are both widely used for health, development, and humanitarian research in low and middle income countries because the data contain relatively highly detailed information on the spatial and temporal dimensions of rainfall and temperature. In validation studies, CHIRPS performs well in mountainous areas, including Central Asia and especially in terms of modeling monthly conditions (Pena-Guerrero et al. 2022, Pyarali et al. 2022). CHIRTS has been more recently developed than CHIRPS, but because of the high quality of the data and the high spatial frequency, it is also widely used to capture temperature conditions both globally and in data poor regions (Verdin et al. 2019, Tuholske et al. 2022).

Analysis

We match climate data to the place of residency using GPS data designated at the time of the DHS survey. Because we do not have detailed migration histories, we observe women only as far back as January after the year they moved to their current residence. Thus, some conceptions may be unobserved because women enter the sample for either a first or later conception, depending on whether they were pregnant before they moved to their current residence. That is, some women's conceptions are left-censored and therefore unobserved. For example, 19% of our Tajik sample and 23% of our Armenian sample moved to a new city, town, or village between age 16 and their first pregnancy. We capture 94% and 75% of all first pregnancies in the Tajik and Armenian histories, respectively.

Observations are censored at women's age 45 or the time of the survey. We include conceptions occurring between 1985 and 2015/2016 in Armenia and between 1987 and 2017 in Tajikistan. We follow pregnancy histories up to the fourth conception, after which there are few conceptions in our two samples.

DHS full pregnancy histories do not offer conception dates, but they provide dates of pregnancy outcomes. Because most women give birth approximately nine months after conception, conception is almost always approximated by backdating all live births by nine months. The timing is less clear for miscarriages, induced abortions, and stillbirths. In this study, we use country-specific information derived from DHS calendar data (which provides recall information about reproductive status for every month of the last five years, giving the exact month of conception) to establish gestation statistics for live births and non–live birth outcomes. Table 1 details the mean, median, and standard deviation, as well as the minimum and maximum months women reported for pregnancies in the calendar data covering the last five years. We impute conception month by backdating pregnancy outcomes according to the gestation length summarized from the calendar data. Specifically, we impute the number of months based on the observed distribution in the specific country context. If 95% of the values fall within two months of the standard deviation around the mean, we generate a random value within that range for 95% of the observations and a random value outside that range (but bounded by the observed range) for the remaining 5%. Almost all imputations, for example, result in backdating conceptions ending in stillbirth seven months earlier, conceptions ending in miscarriages three months earlier, and conceptions ending in abortions two months earlier. However, the imputations also reflect the variance observed in the specific context.

Table 1 Gestation by pregnancy outcome

	Live Birth	Stillbirth	Miscarriage	Abortion
Armenia, 2015–2016				
Mean	8.56	6.77	2.57	2.24
Median	9	7	2	2
SD	1.35	1.89	0.88	0.8
Min.	2	2	1	1
Max.	10	9	7	9
Number of pregnancies	2,084	17	305	783
Tajikistan, 2017				
Mean	8.63	6.61	2.22	1.9
Median	9	7	2	2
SD	1.28	1.93	1.18	1.02
Min.	1	2	1	1
Max.	10	9	9	9
Number of pregnancies	6,890	70	538	715

Method

To analyze the transition to first and later conceptions, we approximate a piecewise-constant event-history model paired with monthly climate data by following a discrete-time hazard analysis setup (Allison 2009; Barber et al. 2000), where the unit of analysis is person/month. Instead of using a logit specification, however, we use linear probability modeling (LPM). LPM has important advantages: it outperforms maximum likelihood estimations when the event is rare (Timoneda 2021), allows comparisons of coefficient sizes across samples (Mood 2010), and is more accommodating of multilevel data structures. Our analysis uses a time-conditioned LPM that estimates the probability of having a conception at a given time versus a later time, conditional on the event not having occurred yet. Our approach therefore allows us to include women who may not yet have experienced the event of interest by properly censoring these observations. It also allows us to consider the relevance of time-varying factors to the timing of conception.

Our modeling approach also aims to estimate the conception–climate relationship as accurately as possible by removing the influence of potential confounders. First, we adjust the estimates for monthly and yearly fixed effects to account for the seasonality of births and period effects, allowing us to capture the effect of random variation in temperature and rainfall. To address sources of heterogeneity across communities and women that may be correlated with living in an area with certain climate characteristics, we nest pregnancies within women using respondent-level fixed effects. In a cross-sectional analysis, this would mean that only women who have two or more pregnancies could contribute to our sample. Nesting months until a first or later conception provides us with multiple observations from which a fixed-effects model can derive its baseline mean and include women who have not yet had a child. We explore the robustness of our results to this choice in the sensitivity analyses section. The fixed-effects approach neutralizes differences based on time-constant biological, social, or cultural factors and is therefore a rigorous test of whether temperature and rainfall are linked to conception probability. In addition, our approach resolves issues of spatial autocorrelation because estimates are derived solely from within-woman variation in outcomes and no differences between women or places factor into the results. We do not, however, gain knowledge about spatial heterogeneity or within-group variability from this approach.

A third important benefit of the fixed effects approach is that the model transforms all covariates into the difference from their mean. Coupled with the inclusion of monthly fixed effects, this means that the effects of heat and rainfall do not reflect seasonality or general weather conditions, but rather a change in weather conditions. This rigorous test of climate change effects may give us only a low estimate of how weather conditions influence conceptions; e.g., if women are usually less fecund in a specific time of the year due to heat, we will not pick this up in our results. In this way, we are able to identify how variation in weather, as a snapshot of climate change, relates to conception probabilities.

We use robust standard errors clustered on the woman to account for the non-independence of observations. The model notation is as follows:

$$\Pr(y_{it} = 1 | y_{t-1,i} = 0) = \beta x_{it} + \mu_i + \varepsilon_{it},$$

where the probability that individual i has an event during interval t, given that no event has occurred before the start of t, is denoted on the left side of the equation and reflects the discrete-time approximation to a continuous-time hazard function (Steele and Washbrook 2013). An individual-specific intercept, μ_i, represents the combined effect of all time-constant unobserved variables on *y*. An idiosyncratic error term, ε_{it}, represents random variation at each time point (Allison 2009). X represents the matrix of variables.

We pool all women's conceptions and nest pregnancies within a respondent. Because the climate–conception relationship may vary across parity, particularly for the first versus higher order conceptions, we include an interaction between the time scale and parity to allow the baseline hazard to vary. Therefore, we set the time scale a) according to age (time since turning age 16) for spells leading to a first conception and, b) according to time since the previous birth for spells leading to higher parity conceptions. We also interact age at the starting point of observation (age 16 or previous birth) with time since the starting point to allow differences in the effect of age on conception probability according to conception timing. As in any time-to-event setup, coefficients reflect the combined influence of how quickly the event of interest occurred and whether it ever occurred.

Measures

Because we use fixed-effects modeling, we do not include controls for variables that do not vary substantially over time, such as educational attainment and urban/rural residence. We do, however, use these variables to stratify samples in some models. Educational levels include "in education" (imputed on the basis of the variable that tells us education in single years), "less than completed secondary", "completed secondary" and "incomplete or complete higher education".

Further, we do not use the rich information available at the time of the survey because we are observing women's histories, over which individual and household characteristics may have changed. The two variables with substantial variation over time, and that are therefore suitable for inclusion in a fixed-effects model, are parity and the sex composition of previous children.

Parity reflects pregnancies that ended in a live birth. Parity is important because we would expect a different timing structure for women's first pregnancy because it is likely tied to the event of marriage, and marriage timing itself may be determined by climate developments (to the extent that growing seasons affect resources). Controlling for the sex composition of previous children is important because of the demonstrated son preference in the region (Billingsley 2011; Bongaarts 2013; Duthé et al. 2012; Meslé et al. 2007) and the link between temperature and the culling of male fetuses (Wilde et al. 2017).

The values of several independent variables change monthly, including climate variables: monthly rainfall total, monthly rainfall variability (standard deviation), daily maximum temperatures averaged monthly, and monthly counts of the number of days above both 95°F and 100°F (biologically relevant thresholds used to capture heatwaves). We use monthly measures of weather conditions because this temporal scale aligns with the monthly conception data. Rainfall total and standard deviation of rainfall capture general rainfall conditions that may be relevant for growing season quality and also to capture conditions that may impact field-labor or time-use (e.g., Randell et al. 2021). Monthly temperature averages capture general trends in heat while temperature thresholds are more useful for capturing heatwaves. Each of these dimensions of temperature have been related to health in different settings (e.g., Grace et al. 2015, Isen et al. 2017, Barecca et al. 2020). Using Akaike's information criterion and Bayesian Information Criterion (Little 2004), we assess the model fit when using lagged and non-lagged climate data.

Descriptive statistics for the individual-level, rainfall, and temperature data are presented in the online appendix (Tables A1 and A2).

Results

Main results

Figure 2 displays the coefficients and confidence intervals from fixed-effects, time-adjusted models based on all conceptions and on only those resulting in a live birth. The estimates can be interpreted as the average increase or decrease in the probability of a conception in a given month, conditional on not having a conception before that month. Extended model results are displayed in the Appendix.[3] On average, conception probability declined over parity, was lowest during the summer months, and was highest at ages 22-25, when no sons have yet been born, and after a 2-3 year birth interval. Model fit comparisons for both countries clearly show that lagging the rainfall and temperature variables by one month improved model fit over a non-lagged measure. All models therefore apply the lagged measure.

First, none of the climate measures used in this analysis were relevant to conceptions in Armenia. In Tajikistan, however, heat was linked to a lower probability of conception, regardless of whether we measure it with the mean daily maximum temperatures in a month or a count of days with the temperature exceeding 95°F or 100°F. Comparing the two count measures, we see that the effect of temperature on conceptions was greater with the more extreme threshold of hot days. Neither changes in precipitation total nor the precipitation standard deviation is linked to conception probabilities.

[3] Table A3 shows the full model results for the measure of number of days above 95°F. The coefficients of other variables did not change substantially when we considered other climate measures.

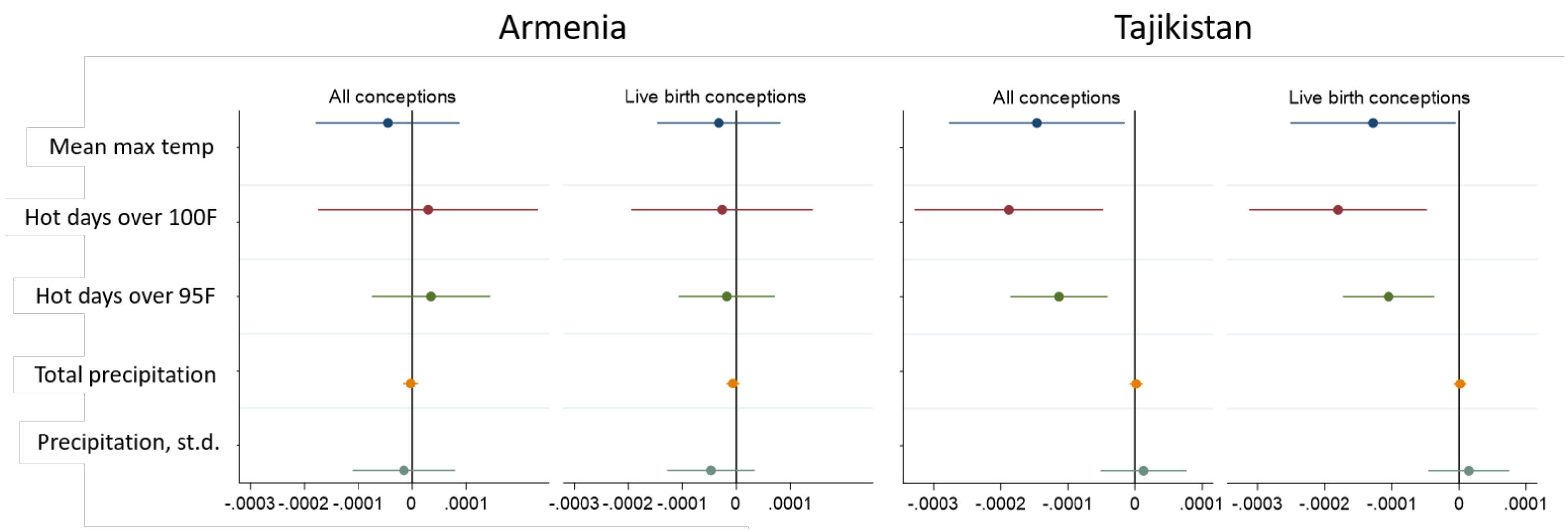

Fig. 2 Coefficients and confidence intervals from fixed-effects time-conditioned models of conception, by all conceptions and only those resulting in a live birth. Models adjust for year and month fixed effects, the interaction of time since start of observation and age at start, the interaction of time since start and parity, and whether a son was born.

Second, the figure shows that a full accounting of conceptions, including those that do not result in a live birth, does not conclusively influence the estimates. For Armenia, the direction of effects varied according to whether we observe all conceptions or only those resulting in a live birth, but the proximity to zero and the wide confidence intervals suggest that these estimates are unreliable. In Tajikistan, the relationship between the mean maximum temperature and conceptions is slightly attenuated when we observe only live births, but the confidence interval does not quite overlap with zero. In sum, it appears that the results are consistent across conception measures.

Figure 3 displays predictive margins of all conceptions across specific counts of days above 95°F, averaging over all other covariates. We display variation in the heat–conception relationship across samples that are stratified (estimated separately) by urban or rural residence, using the threshold of 95 degrees because it is less extreme than 100 degrees and more concrete than the mean maximum. Results are robust across all three temperature measures. The *x*-axis reflects the true range of values in our data. In Tajikistan, the number of hot days mattered more for conceptions in rural areas than for those in urban areas. Whereas the predictive margins were lower for urban women than for rural women across most of the temperature spectrum, the predicted decline for rural women led to convergence at the highest number of hot days observed.

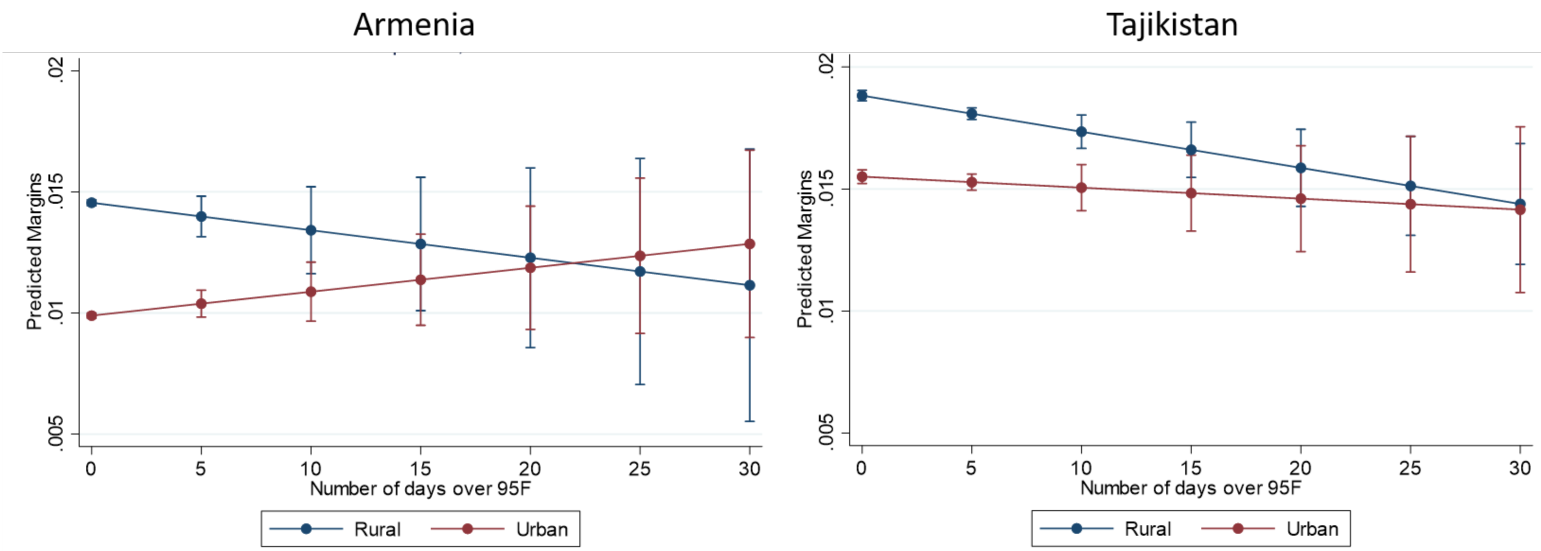

Fig. 3 Predictive margins of conception according to the count of days above 95°F, from models stratified by women's residence in urban or rural areas

A similar pattern is evident for Armenia. However, the confidence intervals around the points on each respective line overlap with other point estimates, rendering any difference in conception probability across the count of days inconclusive.

Similarly, Figure 4 presents predictive margins of all conceptions across specific counts of days above 95 degrees from models stratified by women's educational level. A woman may contribute observations to the educational level of "in education" and later contribute observations with another educational attainment level after they have completed their education. These samples may therefore be considered "synthetic". Because fixed-effects modeling relies on shared observations, splitting women's periods of life may weaken the effectiveness of the fixed-effects approach. On the other hand, most women delay childbearing until finishing their education, so the loss of meaningful observations is minimal.

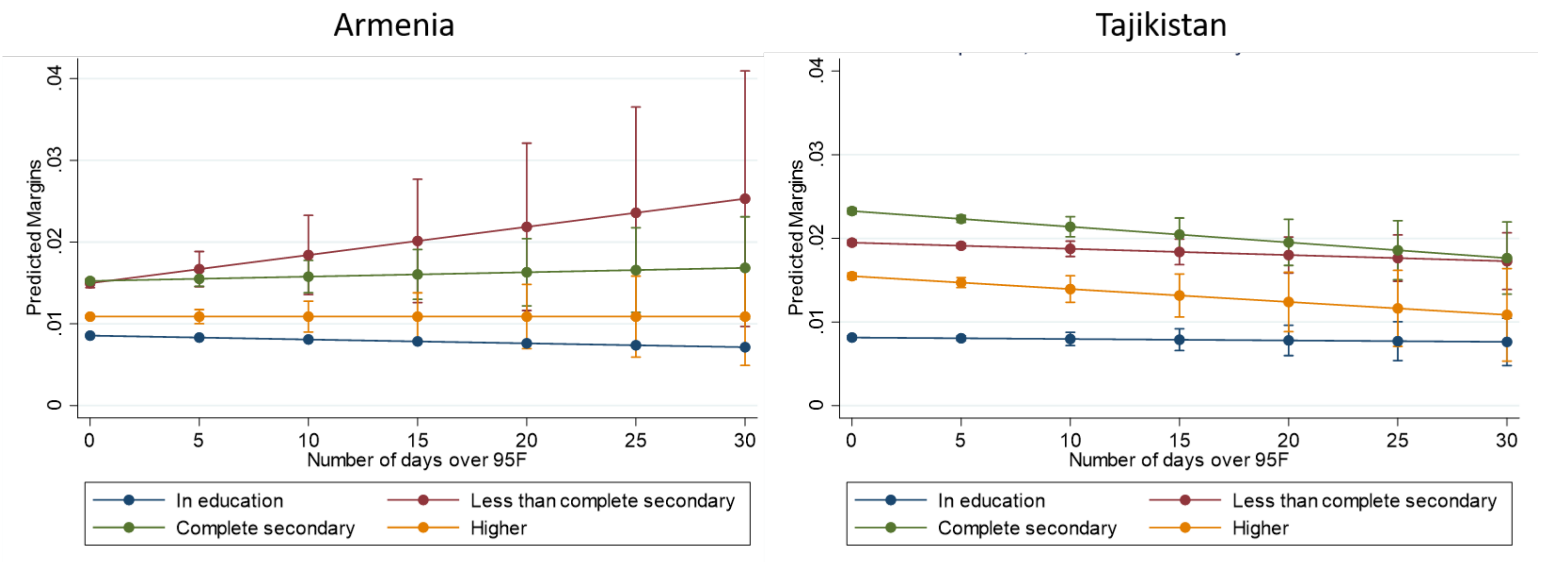

Fig. 4 Predictive margins of conception according to the count of days above 95°F, from models stratified by women's educational level

Overlapping confidence intervals, similar slopes, and model fit tests indicate that more hot days had no discernibly different effect on women across either educational levels or childlessness. Thus, the observed difference between urban and rural areas was not related to compositional differences in these areas by educational level. In addition, we explored interactions between educational attainment or childlessness and above average number of hot days only in rural areas, in order to assess whether some groups were more vulnerable in areas where weather variability would likely have the strongest effect. Again, the model fit did not improve with these interactions and the slopes were similar.

Robustness Checks

We conducted sensitivity analyses to assess the robustness of our findings to other specifications. First, we considered the possibility that the fixed-effects models were not picking up relevant unobserved heterogeneity because LPM allows all individuals to be retained in the data, including those who end up not having a conception (in contrast to fixed-effects logistic models). This feature allowed us to retain spells in which women had not yet had a first conception, increasing the information we could use in the model. In the robustness check, we follow a more traditional setup, comparing only women with two or more events instead and estimating the relationship between temperature and conceptions for this sample only. For Tajikistan, even with losing 35% of the original sample with this restriction, the negative relationships between the heat measures and conceptions persisted. The lack of a relationship in Armenia also persisted.

Second, we explored an alternative approach to fixed-effects modeling because using a discrete-time setup—in which the event is considered time dependent and the covariates change over time—with LPM and including fixed effects is not standard in the literature. Following Allison's (2009) suggestion of modeling fixed effects in event-history analysis, we used a stratified Cox regression. In a stratified Cox model, the baseline hazard is estimated for each individual in the data, which accounts for unobserved heterogeneity in the model. We did not use this method for our main model in the analysis because Cox models are not commonly used in fertility research. Although a stratified, piecewise-constant event-history model is more suitable—particularly when working with varying baseline hazards, as in our case—such a model was not estimable with the stratification addition. Using a stratified Cox model, we found a negative relationship between temperature and conceptions in Tajikistan and no relationship in Armenia. This model, however, was more sensitive to the loss of observations because of sample selection on the number of conceptions.

A final sensitivity analysis excluded the years before 2000 to ensure that the inclusion of the turbulent 1990s—involving conflict and massive social, political, and economic changes in both settings—was not affecting the results. Our results were robust to an examination of this more limited period.

Discussion

In this analysis, we examined how climate change–related environmental exposures, as measured by rainfall and temperature, affected conceptions. Our analysis used highly detailed climate data (daily measures at relatively fine spatial scales) and detailed calendars for all conceptions, regardless of birth outcome (induced abortion, spontaneous miscarriage, stillbirth, and live birth).

The research design allows us to consider multiple conceptions for each woman in our study. The country settings we examine provide an opportunity to investigate these important relationships. In these settings, education and health care access are widespread, the fertility impacts of climate change have been less studied than in richer Global North and poorer Global South countries, and climate change in the form of increasing temperatures and weather variability has been occurring. Our approach, to focus on differences only within a woman's environmental exposure and to use detailed conception data, ultimately provides a unique opportunity to investigate the impacts of rainfall and temperature conditions without the usual challenges of poor data quality and unmeasured biological or local characteristics that might confound the climate–conception relationship. Additionally, unlike in other related studies, studying conception timing regardless of the birth outcome allows us to focus on the climate influences specifically at this stage of the reproductive process.

Our statistical analyses reveals multiple findings. Methodologically, we found that the relationship between weather variability and conceptions is best measured with a one-month lag. A second methodological issue for research on climate and reproductive health relates to the conception measurement. Conceptions measured retrospectively are usually subject to bias based on the final pregnancy outcome because histories are based on live births only or pregnancies that do not end in a live birth are not recorded. In our study, some of the main concerns about data quality are abated by the structure of our data set (providing a full pregnancy history), as well as the relatively high level of education and literacy, health care accessibility, and legal and cultural acceptability of induced abortion in the countries we examine. Our analysis thus provides an important insight into measurement in terms of the robustness of the climate–conception relationship. We find that the relationship does not vary significantly depending on the precision of the conception measurement. Therefore, our analysis suggests that even studies using data biased toward live births may be successful in advancing research on conception and climate.

Despite the increased precision of our conception measure in including birth outcomes that were not live, only women who were aware of a pregnancy could report it. Half of all conceptions are estimated to end before women know they are pregnant (Wang et al. 2003; Wilcox et al. 1988). Thus, some part of the negative effect of temperature on conceptions may be occurring through the mechanism of early and unknown miscarriage. This biological process is naturally embedded in our analytical design because the lack of a recorded conception includes these early miscarriages.

A second notable finding is that variation in rainfall was not statistically related to conceptions, suggesting that short-term changes in rainfall conditions are not related to conceptions in these settings. The impact of rainfall on conceptions and prenatal health is complicated: rainfall variability is associated with shifts in agricultural labor, food availability, and disease (Grace et al. 2021; Randell et al. 2021); the appropriate temporal and spatial scale is difficult to identify correctly because the mechanism linking rainfall and reproductive health is indirect and varied. An approach considering livelihood zones and the seasonality of the specific agricultural production in a locality may be more useful for understanding the influence of rainfall. Drought, as a specific event culminating from accumulated lack of rainfall, has already been shown to suppress fertility and marriage in Tajikistan (Clifford et al. 2010). Whether the droughts that occurred in Armenia in 2000, 2006, and 2010 and the related decline in agricultural production influenced fertility in Armenia has yet to be assessed.

Temperature is hypothesized to have more direct effects on pregnancy and our analytical approach likely captures these direct impacts of temperature better than the indirect effects of rainfall. We find that hotter temperatures lower the risk of conception among women residing in Tajikistan on average, but this effect is concentrated in rural communities. Although studies set in rich and poor countries have also observed this result (Barecca et al. 2018; Davenport et al. 2020; Grace et al. 2021; Wilde et al. 2017), their data typically have not included all conceptions (owing to data collection challenges in collecting full pregnancy histories, particularly where induced abortion is illegal or stigmatized) and have rarely accounted for the place of residence at conception. Because these limitations do not apply to our study, and because we use only variation within a woman's weather exposure, our analysis provides strong evidence of conceptions being impacted by temperatures that are unusually high for a local area.

However, we observe no relationship between temperature and conception in Armenia, regardless of urban or rural place of residence. Compared to Armenia, Tajikistan has higher average temperatures and, according to the data used in this study, is more prone to extreme weather. At the same time, households in Tajikistan are poorer than Armenia, which may limit communities' and individuals' capacity to respond to temperature extremes. Another important difference is that women have more children in Tajikistan than Armenia; if contraception or fertility control is more usual in Armenia, fluctuations in conception probability are likely not as noticeable.

We expected that vulnerability to weather variation would be represented by livelihood differences (rural vs. urban), socioeconomic resources (educational attainment), and childlessness. Although we might expect heat to be more intense in urban areas (Heaviside et al. 2017), the effect is instead limited to rural areas. That our findings are not more universal, even within the same country context, suggests that behavioral factors may amplify the adverse impacts of heat. These factors could be related to time use, use of air conditioning, or cultural norms around pregnancy and rest during hot times. We also do not find differences in conception risks by women's educational attainment, which implies that resource differences are not a strong determinant of whether weather variability influences conceptions. Our data do not allow us to investigate adaptation strategies. However, our findings suggest that exploring variability in behaviors, including those developed intentionally or unintentionally to manage climate-related risks, is vital for mitigation and adaptation (e.g., Hondula et al. 2015). Likewise, childless women were not more impacted through heat than women with children, which would have been the case if heat interfered with marriage timing and exposure to sexual intercourse due to the effects on rural subsistence strategies.

Our results instead point to universality within a place, specifically rural areas. It is, therefore, not just the rural poor who are at risk. If urban infrastructure provides more relief from heat in Tajikistan through greater use of air-conditioning and shade, thermal stress and spermatogenesis brought about by heat may be likely mechanisms for the rural heat effect. Because highly educated women are likely less at risk of nutritional instability and increased physical labor than women with incomplete secondary education, these mechanisms appear less convincing. Livelihoods, through heat-related loss of agricultural production, might affect all households in rural areas, leading women to hold off on getting pregnant.

It is important to comment on our ability to disentangle the mechanisms linking temperature and conceptions. Deciphering processes to identify distal and proximate determinants of key reproductive health outcomes has a long history in demography (e.g., Bongaarts 1978; Panter-Brick 1996). Earlier in this article, we outlined several potential mechanisms linking environmental conditions to conceptions and pregnancy health. Although our findings suggest that behavioral factors may reduce adverse risks, our data prevent us from identifying those processes. In reality, behavior and biology are deeply enmeshed in people's lived experiences. In terms of climate change, this enmeshment means that individuals and communities are adapting to changing environmental conditions constrained and enabled by biological, behavioral, and structural features (Hondula et al. 2015). No mechanism acts in isolation from the others. Thus, although identifying distinct mechanisms is foundational to this discipline, the artificial nature of a mechanism-based approach and the lack of climate–health data facilitating this kind of analysis may require us to consider human–environment interactions from an ecological lens. This lens suggests that human and environmental systems are constantly interacting and responding to new processes of adaptation and marginalization potentially emerging (see Bai et al. 2016; Crenshaw et al. 2000; Peng et al. 2021). This perspective requires new ways of considering the impact of demographic research on climate change policy, but it may be a required shift given the realities of data and the complexities of people's lives.

An important limitation of our data is that we do not have migration histories to be able to assess how weather-related moves might influence our relationship. For example, unusual or inconsistent weather may interrupt agricultural production and encourage urbanization. Our results can only be generalized to those women who are not mobile, presumably making the rural sample more selected. If those who stayed were the ones who managed weather variation better due to having more resources, and women wait until after relocating to proceed with family formation or expansion, our estimates would likely be biased downwards and we might only be capturing the low end of an estimated relationship. On the other hand, because the loss of data on first conceptions was more severe in Armenia than Tajikistan due to migration (25% vs. 6%), we may be missing a vital link in Armenia due to this data limitation if climate variability leads to delayed marriages and migration simultaneously.

A limitation of our methodological approach is that we cannot assess spatial heterogeneity in human responses to climate variability. Individual-level fixed effects models sweep away this heterogeneity and an approach more focused on specific spatial aspects are needed to address this important question.

Women in Tajikistan's rural areas face lower conception risk with more extreme heat in the region, which has implications for other rural and agricultural contexts even when we are seeing investment in healthcare and gains in women's education. The finding that reproductive health is affected by unusually high temperatures demonstrates an important facet of the societal challenges that climate change entails. Whether lower conception probabilities contribute to lower overall fertility or a shift in the timing of childbearing for these women is a next step in understanding the nature of this relationship. Differences between rural and urban women in their time-use patterns or protection from weather are key to understanding rural women's lived experience of heat and getting pregnant.

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Online Appendix

Table A1 Monthly climate data descriptive statistics for the observation sample: Means, with maximum values shown in parentheses

	Armenia		Tajikistan	
	Rural	Urban	Rural	Urban
Temperature Max. Mean	14 (38)	15 (38)	17 (40)	19 (40)
Number of Days Over 95°F	0.6 (27)	0.8 (27)	2 (31)	2 (31)
Number of Days Over 100°F	0.2 (17)	0.2 (17)	0.8 (26)	0.7 (24)
Precipitation Total	42 (213)	39 (211)	32 (410)	39 (291)
Precipitation SD	4 (31)	4 (31)	4 (59)	5 (47)

Table A2 Descriptive statistics of sample

	Armenia	Tajikistan
Number of Women	5,685	9,451
Number of Observations	685,378	1,014,763
Number of Conceptions	7,976	17,504
Conception (%)		
1st	57	55
2nd	18	16
3rd	20	17
4th	5	12
Parity (%)		
0	54	53
1	16	15
2	24	18
3	7	14
Rural (%)	37	60
Has a Son (%)	34 (74)	36 (76)
Education (%)		
In education	35	23
Incomplete secondary	4	34
Completed secondary	31	87
Higher	30	13
Age at Start of Observation (1st conc:16; other conc: most recent)		
<18	54	53
18–21	15	12
22–25	19	19
26–29	9	10
30–34	3	4
35+	1	1
Time Since Start of Observation (%)		

≤1 year	33	43
2–3 years	21	23
4–6 years	19	17
7–10 years	13	10
11+ years	14	8

Table A3 Extended results from linear probability fixed-effects models, including the effect of the number of days above 95°F

	Armenia		Tajikistan	
	B	SE	B	SE
Parity				
0	Omitted		-0.000	0.004
1	1		1	
2	-0.042***	0.002	-0.038***	0.001
3	-0.078***	0.005	-0.077***	0.004
Has a Son	-0.003***	0.001	-0.005***	0.001
Age at Start of Observation (1st conc:16; other conc: most recent)				
<18	-0.018***	0.003	-0.024***	0.004
18–21	1		1	
22–25	0.004**	0.001	0.006***	0.001
26–29	0.002	0.002	-0.006**	0.002
30–34	-0.004	0.003	-0.020***	0.003
35+	-0.006	0.006	-0.037***	0.004
Time Since Start				
≤1 year	1		1	
2–3 years	0.021***	0.001	0.015***	0.002
4–6 years	0.012***	0.002	-0.005**	0.002
7–10 years	-0.003*	0.001	-0.018***	0.002
11+ years	-0.011***	0.002	-0.036***	0.002
Month				
January	1		1	
February	0.000	0.001	0.000	0.001
March	0.000	0.001	0.000	0.001
April	-0.001*	0.001	-0.001	0.001
May	-0.002**	0.001	0.001	0.001
June	-0.002**	0.001	0.000	0.001

July	-0.002*	0.001	0.002*	0.001
August	-0.002**	0.001	0.003***	0.001
September	-0.002**	0.001	0.001	0.001
October	0.000	0.001	0.004***	0.001
November	0.000	0.001	0.004***	0.001
December	-0.001	0.001	0.003***	0.001
Days Above 95°F	0.00003	0.00006	-0.0001**	0.000
Constant	0.030***	0.001	1.049***	0.002
N	685,378		1,014,763	
AIC	-1,136,208		-1,284,115	
BIC	-1,135,316		-1,283,205	

Notes: Standard errors are robust. The model is also adjusted for year fixed effects and two interactions: (1) time since start of observation × parity and (2) time since start of observation × age at start. AIC = Akaike's information criterion. BIC = Bayesian information criterion.

**p* < .05; ***p* < .01; ****p* < .001

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