Extreme Temperature and Intimate Partner Violence: Evidence from Sub-Saharan Africa

Tarana Chauhan*

Brown University

Abstract

This paper tests the effect of extreme high and low temperatures on women's experience of intimate partner violence (IPV) through temperature-induced aggression in Sub-Saharan Africa. Related papers find that drought is likely to increase the incidence of IPV. I find a higher prevalence of physical forms of IPV for women who experienced higher maximum temperatures than the historical average. The prevalence of emotional and sexual violence is lower in this context. A test for the correspondence between the days of temperature-and-humidity-based discomfort and severity of violence reveals the same pattern for the three categories of violence. A woman experiencing extreme heat and cold is more likely to report physical, sexual and emotional violence if her partner drinks and if she is employed. These results highlight the distributional effects of climate change and the need for public policy measures, training of law enforcement agents and amendment of laws to reflect them.

Keywords: Temperature-induced Aggression, Temperature-Humidity Discomfort, Intra-household Dynamics, Gender-based Violence, Violence against Women, Climate Change, Climate and Violence

JEL codes: J12, O55, O57, Q54

*Postdoctoral Research Associate, Center for Philosophy, Politics, and Economics, Brown University, 25 George St., Providence, RI 02906, tarana_chauhan@brown.edu.

1 Introduction

In recent years, increasing global temperatures and changing weather patterns have severely affected countries with poor infrastructure, where agriculture is the largest employer and there is limited technology adoption to combat these weather fluctuations. Miles-Novelo and Anderson (2019) predict two pathways of violence from global warming. The first is a direct effect of heat on the individual's mood, with increased heat likely to cause irritability and aggressive behaviors. The second is an indirect effect through the reduction of agricultural output, economic instability, natural disasters and displacement of populations that increase the likelihood of violence-prone adults and inter-group conflict. Both channels are likely to affect outcomes of intimate partner violence (IPV) (Rotton and Frey, 1985; Henke and Hsu, 2020; Stevens, 2022). Other indirect effects of temperature highlighted in the literature include alcohol consumption (Cohen and Gonzalez, 2018), income and worker productivity.

In this paper, we analyze the relationship between IPV and extreme temperatures in Sub-Saharan Africa. We first summarize the relationship between annual average daily temperature and the prevalence of IPV. We then examine how deviations from the expected maximum and minimum temperature in a year correspond with the incidence of IPV. We leverage the weather fluctuations as an exogenous shock that helps understand the influence of temperature on IPV. All results are disaggregated by the type of violence - physical, emotional and sexual. We control for the indirect economic channel of temperature and violence through variables such as household insulation, nature of partner's economic activity (outdoor versus indoor), and household's ownership of agricultural land. Additional analysis using the discomfort index (DI) to help account for dry heat and humidity. Using a reduced form estimation, we explore trends in frequency of IPV by the number of days in ordered DI bins within the past year. The paper discusses the marginal effect of annual precipitation on IPV. It explores heterogeneity by risk and protective factors of IPV such as partner's alcohol consumption and women's empowerment (age, education and employment), respectively.

We combine survey-based self reports of IPV from the Demographic Health Surveys (DHS) of women aged 15- 49 with Earth observation data on temperature and precipitation of survey locations. We analyze outcomes for 22 countries in Sub-Saharan Africa between years 2005 and 2018. We find a positive correspondence between unanticipated heat and prevalence of physical IPV however, the prevalence of emotional and sexual violence are lower when heat was higher than the historical average in the year prior to survey. The same pattern emerged when testing the correspondence between days of discomfort from humidity and heat and frequency of each category of IPV. Heterogeneity tests of partner's alcohol consumption shows a higher prevalence of physical, sexual and emotional IPV among women whose partners drink in years of unexpected heat or cold weather.

There exists a vast body of literature that documents the effect of temperature on crime (Anderson and Anderson (1984), Anderson (1987), Ranson (2014), O'Loughlin et al. (2014), Michel et al. (2016), Blakeslee and Fishman (2018), Prudkov and Rodina (2019), Blakeslee et al. (2021), Heilmann et al. (2021), Mukherjee and Sanders (2021), Cruz et al. (2020)), group-based conflicts (Burke et al. (2009), Hsiang et al. (2013), von Uexkull et al. (2016), Baysan et al. (2018), Cruz et al. (2020)), aggressive behaviors (Boyanowsky et al. (1981), Yasayko (2010), Reifman et al. (1991), Kenrick and MacFarlane (1986), Anderson (1987)) and family disturbances (Rotton and Frey (1985), Stevens (2022)). In addition, there are several studies that demonstrate the impact of rising temperatures on economic outcomes such as agricultural output (Schlenker and Lobell (2010), Zhu and Troy (2018)) and agricultural productivity (Colmer, 2021; Ortiz-Bobea et al., 2021), the cognitive activity of an individual (Melo and Suzuki (2019), Park (2022), Graff Zivin et al. (2018), Schmit et al. (2017), Seppänen et al. (2005), Hancock and Vasmatzidis (2003)) and worker productivity (Adhvaryu et al. (2019), LoPalo (2023), Graff Zivin and Neidell (2014)). This paper adds to the literature that focuses exclusively on domestic violence outcomes and aligns closely with two multi-country studies: Zhu et al. (2023) that uses the same datasets but for the South Asian region and find a positive effect of annual mean temperature on IPV; and Cools et al. (2020) that find no significant effects of rainfall shocks on IPV in Sub-Saharan Africa.

Building on these results, in this paper we make two main contributions. First, we are the first to empirically test whether both extreme heat and cold correspond to higher aggression and prevalence of IPV. While Bollman et al. (2024) examine the effect of extreme cold on IPV in Peru, most of the literature has focused on extreme heat (Zhu and Troy, 2018; Stevens, 2022; Henke and Hsu, 2020; Rotton and Frey, 1985; Bhalotra et al., 2020) or the effect of floods and droughts (Munala et al., 2023; Abiona and Koppensteiner, 2018; Díaz and Saldarriaga, 2023; Cools et al., 2020; Epstein et al., 2020; Sekhri and Storeygard, 2014). Second, there is a disagreement in the literature on the relationship between temperature and aggression. Most of the literature finds that extreme heat is associated with higher IPV except for Cohn (1993) in the USA who finds a decrease in IPV with higher temperatures. Further, there is are theoretical disagreements. Temperature could have contradictory effects on arousal. On the one hand, it could increase physiological arousal which could lead individuals to engage in more activities, but it could alternatively increase lethargy (psychological arousal) which would lead them to stay indoors. This additional time indoors could lead to increased opportunities for conflict and IPV. Additionally, increase temperatures could influence aggressive behavior directly through affecting the cognitive and affective states. Third, we conduct the analysis in Sub-Saharan Africa, a region with less infrastructure and most at risk to suffer the effects of climate change. Finally, we explore the effects on both prevalence and frequency of IPV which has been only done by Nguyen (2024).

Section 2 of the paper theorizes how extreme heat/ cold causes physiological and psychological changes that can lead to IPV, reviews the current literature, and hypothesizes how different risk/ mitigating factors of IPV may interact with temperature. Section 3 describes the data and relationship between temperature and IPV as well as household characteristics by incidence of IPV. Section 4 outlines the empirical specifications, and Section 5 summarizes the results. Section 6 discusses the effect of precipitation and heterogeneity by risk and mitigating factors of IPV. Section 7 concludes with the findings of this paper and policy recommendations.

2 Conceptual framework

Physiological and psychological effects of temperature

Several theories explain the physiological and psychological effects of temperature. The General Affective Aggression Model (Anderson et al., 2000) is a useful overarching framework that outlines how situational factors such as heat can potentially affect a person's internal state through three routes: cognitive state (aggressive thoughts), affective state (feelings of hostility and anger) and arousal state (increasing heart rate). A person may respond in an automatic appraisal (e.g. fight/ flight response) and/or controlled reappraisal (a slower and more thought-out response such as revenge). It is worth noting that temperature may have contradictory effects on arousal: increasing heart rate, blood circulation rate and sweating (physiological arousal) while increasing lethargy (psychological arousal). Therefore, the aggressive behavior emitted would be a function of an individual's aggressive personality and changes in internal state. It is unclear which of the two effects (psychological or physiological arousal) dominates during extreme high and low temperatures. This fosters a disagreement in the literature about the shape of the relationship between temperature and aggression.

Anderson et al. (2000) predict an inverted U shaped function to explain the relationship between temperature and aggression. The Negative Affect Model suggests that at comfortable temperatures, we can expect more crimes outdoors instigated by more outside activity and an increase in sexual desires. When the heat increases to uncomfortable levels, there is more lethargy and higher likelihood that an individual will stay indoors. This can be extended to an M-shaped curve by accounting for similar patterns during extreme cold. In the absence of insulation and air conditioning, however, the uncomfortable temperatures outside match the temperature inside, providing no escape from the situation. Cohn (1993) predicts this will bring victims in contact with offenders. Jacobs (1961) and Straus et al. (1980) discuss the decrease in guardians such as police and "natural surveillance" by the community that increases the likelihood of IPV. The Excitation Transfer/ Misattribution of Arousal theory predicts that temperature-induced aggression can be mis-attributed to another person if temperature is not salient as a cause of arousal and negative feelings dissipate slowly (Zillman, 1983). This implies a U-shaped relationship: aggression would be higher as temperature rises or falls. Berkowitz (1983) also describes a model (uncomfortable weather primes aggressive thoughts) with a similar functional relationship.

Literature review of weather shocks and IPV

The current body of empirical evidence on weather shocks and IPV supports the Misattribution theory as maximum temperatures and droughts are positively associated with prevalence of IPV, in particular physical acts of violence. This effect persists in low- and high-income countries (Table 13). The literature is restricted to studying effects of either daily maximum temperature or precipitation. Rainfall shocks associated with floods have a positive effect on IPV in some countries in Sub-Saharan Africa and null effect in others. There is no consolidated analysis that examines the effects of both high and low temperatures as well as precipitation. The two sources of data used in the literature to test impacts on IPV are: administrative records of the police department (phone call or in person) and survey-based measures of women's self-reports of IPV (from the Demographic Health Surveys). The weather variables are extracted from a variety of projects processing data from remote-sensing satellites or ground-level monitoring stations.

Effects of precipitation, risk and mitigating factors on IPV

The literature finds a negative relationship between rainfall and crime outdoors (Horrocks and Menclova (2011), Michel et al. (2016)). While the Excitation theory predicts higher IPV in response to heavy rainfall, the papers on floods and IPV find contrasting evidence. Alcohol consumption is more common on hot days, linked with "mood disturbances" and anger, and expected to compound the effects of extreme temperature on IPV (Cohen and Gonzalez, 2018; Munala et al., 2023). Women's empowerment estimated using relative wages, inheritance rights, age and education can mitigate the effects of temperature-based violence (Abiona and Koppensteiner (2018), Epstein et al. (2020), Henke and Hsu (2020)).

Economic effects of temperature on threshold for violence

Baysan et al. (2018) assume that violence increases with temperature and provide an analytical model to determine the threshold of temperature at which an agent chooses to exercise violence against another agent. This is determined by the present discounted value of an agent's consumption of their initial assets, the value of consumption of initial and captured assets, cost of violence, and labor productivity and the level of violence at every temperature. Using their model, if consumption is as a function of temperature, the estimated threshold of temperature for choosing violence would be different from the case where consumption is independent of temperature (see Appendix). This result implies that households which own agricultural land or earn income from agricultural harvest or farm labor would be affected by temperature differently from households which do not.

3 Data and Descriptive Statistics

3.1 Variables and sources

Prevalence and frequency of IPV

The outcome variables and controls are extracted from the Demographic Health Surveys (DHS) conducted in Sub-Saharan Africa between 2005 and 2019. The survey adopts a stratified two-stage cluster sampling design in which the enumeration areas are generally selected from the country's census and a sample of households is drawn from each enumeration area. The sample is representative at the national level, residence level (rural/ urban) and a regional level (state/ province).

These repeated cross-sectional surveys ask questions about violence from intimate partner to women ages 15-49. Respondents can define who is an intimate partner but it is typically the current/ most recent husband or a partner she is living with as if married or has intimate relations with. Only one woman in the selected household is interviewed about her experience of violence to safeguard the respondent's safety. All DHS rounds that included questions on domestic violence and geolocation data are included in the analysis. Table 1 lists the year of survey rounds and number of observations per round.

This paper examines IPV outcomes for all surveyed women who are currently (ever) married or cohabiting, widowed, divorced or separated. The total number of women included in the sample is 209,123. We define the prevalence of IPV as binary indicators based on respondents' report of any type of physical, sexual or emotional violence from an intimate partner in the last 12 months. The acts of violence under "physical" include pushed, shook or had something thrown by intimate partner, slapped, punched with fist/ hit by something harmful, kicked/ dragged, strangled/ burnt, threatened with knife/gun or other weapon, or had arm twisted/ hair pulled. "Sexual" acts of violence include physically forced into unwanted sex, forced into other unwanted sexual acts or physically forced to perform sexual acts against the respondent's will. Lastly, threat or humiliation by partner, being threatened with harm or insulted and made to feel bad are types of "emotional" violence covered in the survey. Severity of violence is measured as categorical variables of the frequency of physical, sexual and emotional violence - "often", "sometimes" or "not in the last 12 months". Severity of violence is marked as "often in the last 12 months" if at least one activity under the category is reported as often.

Temperature and precipitation estimates

The weather variables are extracted from the European Centre for Medium-Range Weather Forecasts Reanalysis V5 (ERA5) that combines meteorological data with its models to forecast hourly estimates of weather variables for grids of size 30*30 kms at the equator since 1979. The variables include daily maximum, minimum and mean air temperature, dewpoint temperature and total daily precipitation at 2m height from surface. These weather variables are linked to respondents interviewed in the DHS by a unique coordinate for the cluster of households within an enumeration area. The DHS randomly displaces the latitude/longitude by upto 10 kms to preserve the anonymity of respondents. Therefore, we aggregate temperature and precipitation variables within a 10 km radius around the survey coordinates provided for each enumeration area. This can generate a classical measurement error in the estimates.

For each DHS respondent, we estimate the trends in temperature and precipitation upto a year before the date of interview using ERA5 variables. Figure 1 reports the "past year" annual and historical averages of maximum, minimum and mean daily temperatures by country-survey-year. The past year annual variable for each respondent is estimated over the 365 (/366) days prior to interview. The historical average is a long term average from 1979 until a year prior to DHS survey round. The past year average maximum and minimum temperature was higher than the historical average in several survey rounds and figure 5 in Appendix A shows the distribution of normalized deviation of annual maximum and minimum temperatures from the historical average. The dry and dewpoint averages available in the dataset are used to estimate relative humidity and the discomfort index (calculation provided in Appendix B3). Figure 6 plots the distribution of the index which is expressed in Fahrenheit by construction (Thom, 1959).

3.2 Environmental and demographic characteristics correlated with IPV

Relationship between temperature and IPV

Figure 2 plots the average of mean daily temperature in the past year for every country included in the sample against the percentage of respondents that reported IPV in the country. These crude country-wise estimates depict a downward sloping trend between physical and sexual IPV and mean temperature. There was lower prevalence of physical and sexual violence from intimate partner in countries where the mean temperature was between 25 to 30°C. The relationship between annual estimates of mean temperature and emotional violence is inverse U-shaped. Figure 3 plots the country-wise annual average of the discomfort index (DI) against prevalence of IPV. There is a clear negative relationship between temperature-and-humidity-based-discomfort and prevalence of sexual IPV. The negative correspondence between DI and prevalence of physical IPV is subtle and there is no relationship between DI and emotional IPV.

Demographic characteristics by incidence of IPV

Violence against women can be understood through a combination of risk factors that increase the likelihood of violence, protective factors that lower the incidence, and situational triggers that precipitate violence (The Prevention Collective, 2020). The literature describes the following as “risk factors": the time of first marriage, age gap with spouse Angelucci (2008), difference in years of education with the spouse (Ackerson et al. (2008), Hornung et al. (1981)), woman and spouse's working status, women's perceived acceptability of spousal violence in the community, spouse's controlling behaviours and consumption of alcohol, her personal history (Heise, 1998) such as witnessing marital violence as a child (Pollak, 2004). While age at the time of survey, years of completed education (Eswaran and Malhotra (2011), Farmer and Tiefenthaler (1997)) and having a female head of household may constitute “protective factors" implying they correspond with lower incidence of IPV.

Table 2 reports summary statistics of key demographic characteristics and some risk and protective factors by respondent women's experience of IPV : yes but not in the past year, in the last twelve months, and never experienced IPV. We use the individual weights provided by DHS to generate population relevant estimates. There is no evidence of the relationship predicted in the literature between women and spouse's age gap and IPV, or women's education and employment. However, partner's outdoor employment corresponds with the incidence of violence. Among women that experienced IPV in the past year, 65% had partners working in agriculture, construction or other outdoor occupations. For women who experienced violence but not in the last year, 62% had partners working in outdoor jobs and 58% for women who never experienced IPV. Physical acts of IPV were the most prevalent amongst women having experienced IPV ever or in the past year.

4 Analysis

4.1 Temperature anomalies and IPV prevalence

We explore the unanticipated effects of extreme temperature using discrete and continuous measures of deviation of the annual average of maximum (minimum). The annual average is calculated as the mean over 365 or 366 days before the interview of each respondent i. These are estimates for the 10 km circular region around the coordinates of each DHS enumeration area e. In the discrete variables estimation, we examine the linear correspondence between unanticipated temperature trends and prevalence of IPV by comparing respondents who experienced 1 standard deviation greater than historical average of annual maximum temperature with the other respondents, and or an annual minimum temperature less than 1 standard deviation of the historical average. The binary indicator $NormDevMax_{ect}$ ($NormDevMin_{ect}$) is equal to 1 when the normalized score of maximum (minimum) temperature is greater (lesser) than 1 (-1), and 0 otherwise. The binary variable $PositiveDev_{ect}$ identifies all observations where $NormDevMax_{ect} > 0$ and $NegativeDev_{ect}$ identifies the observations of $NormDevMin_{ect} < 0$). The outcome variables are the respondent woman i's experience of IPV in category k (physical, emotional and sexual). The model controls for the average $RelativeHumidity_{iect}$ in the past year (calculation in Appendix) as well as various individual-and-household-specific characteristics (X_{iect}) such as rural/urban location, religion, perceptions on the acceptability of spousal violence, partner's controlling behaviors, partner's education, her witnessing violence between mother and father as a child, sex of the head of the household and sex ratio of all household members. The equation controls for differences between countries and survey years through fixed effects, γ_c and τ_t, respectively. Standard errors are clustered at the enumeration area level.

$$\begin{aligned} IPV_{k,iect} =& \alpha_0 + \alpha_1 \mathbb{1}\{NormDevMax_{ect} > 1\} + \alpha_2 PositiveDev_{ect} \\ &+ \alpha_3 \mathbb{1}\{NormDevMax_{ect} > 1\} \times PositiveDev_{ect} \\ &+ \alpha_4 \mathbb{1}\{NormDevMin_{ect} < -1\} + \alpha_5 NegativeDev_{ect} \\ &+ \alpha_6 \mathbb{1}\{NormDevMin_{ect} < -1\} \times NegativeDev_{ect} \\ &+ \alpha_7 \overline{RelativeHumidity}_{iect} + \alpha_8' \mathbf{X}_{iect} + \gamma_c + \tau_t + \epsilon_{k,iect} \end{aligned} \tag{1}$$

where

$$NormDevMax_{ect} = \frac{AnnualMax_{ect} - \overline{HistMax}_{ec}}{SD_{ec}}$$

and $NormDevMin$ is defined similarly. The following equation uses a continuous indicator to measure the linear correspondence between gap in annual and historical averages and the prevalence of IPV in category k (physical, emotional and sexual) for respondent woman i during that year. Panels A and B of Tables 3, 4 and 5 report results of equations 1 and 2, respectively.

$$\begin{aligned} IPV_{k,iect} =& \alpha'_0 + \alpha'_1 (\frac{AnnualMaxTemp}{HistMaxTemp})_{ect} + \alpha'_2 (\frac{AnnualMinTemp}{HistMinTemp})_{ect} \\ &+ \alpha'_3 \overline{RelativeHumidity}_{iect} + \alpha''_4 \mathbf{X}_{iect} + \gamma'_c + \tau'_t + \epsilon'_{k,iect} \end{aligned} \tag{2}$$

While column 1 reports estimates of models described above, columns 2-6 include additional controls which may affect how temperature corresponds with IPV. Column 2 tests the hypothesis that households where the male partner's economic activity is outdoors (such as agriculture and construction) would have a significantly different correspondence between temperature and IPV than households where the partner's economic activity is indoors. Column 3 controls for agriculture as a source of income using a binary variable of whether household owns agricultural land. Following the extension of Baysan et al. (2018) in Section 2 where the threshold of temperature at which an agent chooses to exercise violence varies when temperature affects consumption, households dependent on agriculture are expected to have a different effect of extreme heat/cold on IPV than others. Their income and consumption are more directly affected by temperature shocks in the past year. Column 4 controls for differences between households by insulation for well-insulated households are likely to be less affected by extreme heat or cold than others. It includes binary variables for insulated roof (eg. thatch, bamboo, wood, sod) and floor (earth, mud, dung, wood, palm/bamboo, ceramic tiles, carpet). Column 5 controls for woman's empowerment which can help mitigate the effect of temperature on IPV. This includes her age, years of completed education, employment status and age at the time of first marriage. Lastly, column 6 controls for survey month to partial out effects from seasons experienced by respondent in past year recall.

4.2 Linear correspondence between discomfort index and IPV

The Discomfort Index defined in Thom (1959) helps account for discomfort from both temperature and humidity. An index value greater than 75 is uncomfortable while above 80 is discomfort. Equation 3 tests the correspondence between the annual average DI and prevalence of IPV in category k. It includes the same fixed effects and controls as equation 1. We use the equation to explore the difference between respondents that experienced “uncomfortable" weather in the past year and the rest.

$$IPV_{k,iect} = \beta_0 + \beta_1 DI_{ect} + \beta_3' \mathbf{X}_{iect} + \gamma_c + \tau_t + \epsilon_{k,iect} \quad (3)$$

We next explore the severity of discomfort and frequency of IPV in Table 8 by examining a non-linear estimation between the number of days in the following DI bins and frequency of IPV in each category k: 60 or below, 61-65, 66-70, 71-75, 76-80, 81-85, 86-90, above 90. Equation 4 below describes an ordered logistic regression where for each category k, the dependent variable is 0 in case of "no incidence of violence in last 12 months", 1 in case of experience "sometimes" and 2 for "often in the last 12 months".

$$FreqIPV_{k,iect} = \sum_{b=1}^{B} \delta_{kb} DIbin_{b,ect} + \theta_k' \mathbf{X}_{iect} + \gamma_c + \tau_t + \epsilon_{k,iect} \quad (4)$$

The coefficient δ_{kb} for each equation k (physical/ sexual/ emotional) would estimate the expected increase in the log odds of the severity of violence k in past year from an additional day in DI bin b in the past year t for respondent i. The model includes fixed effects for country and survey round, and the standard errors are clustered at the enumeration area level.

5 Results

5.1 Deviations in extreme temperatures and IPV

Panel A of Table 3 shows that women who experienced higher than the expected maximum temperatures were more likely to report experiencing some form of physical violence from their intimate partner. There is no significant difference in (physical) IPV prevalence between observations where the annual minimum was below the expected average. Panel B reports estimates of the continuous measure of the ratio of annual to historical averages. The ratio of annual to historical maximum temperature has a statistically insignificant relationship with the prevalence of physical acts of IPV. However, an increasing ratio of annual to historical minimum temperatures, suggesting more ambient temperatures in the last year, corresponded with lower prevalence of physical IPV. This pattern is reversed for emotional acts of violence where deviations from the historical maximum (discrete and continuous measures) correspond with lower prevalence of emotional acts of IPV (Table 4). There was lower prevalence of sexual IPV in places where the maximum temperature was above the anticipated average (panel A, Table 5). Instead, a declining maximum temperature relative to the historical average corresponds with more prevalence of sexual violence (panel B). There are no signficant trends by deviation from the minimum temperature.

5.2 Robustness checks for extreme weather and IPV prevalence

While these estimations control for relative humidity in the past year, it is difficult to interpret how uncomfortable the rising ratio of annual maximum (minimum) to historical maximum (minimum) are for the surveyed households. Therefore, we estimate the correspondence between IPV prevalence and discomfort from both rising temperature and humidity (Table 6). The continuous indicator of weather based discomfort has a negative correspondence with the prevalence of emotional and sexual acts of IPV. This is consistent with the negative correspondence between IPV and deviation from historical maximum temperatures suggesting that as discomfort from rising heat and humidity increases, women are less likely to report having experienced humiliation, threats, forced to have sex/ perform unwanted sexual acts. In case of physical IPV, there is higher prevalence among respondents that experienced DI at uncomfortable levels (≥ 75) in the last year relative to others.

Table 7 shows that results are consistent when the model controls for mean temperature or discomfort index on the day of the survey to account for reporting bias from the weather conditions when respondents were interviewed.

5.3 Days of discomfort and frequency of violence

Examining the intensity of temperature based discomfort on the frequency of reported IPV using the ordered logit in equation 4 shows that as the number of days in the higher intervals of the DI increase for a respondent, she reports a higher frequency of physical IPV while the frequency of reported sexual and emotional violence reduces with increased days of uncomfortable weather (DI above 75). Further decomposing the frequency of IPV as binary variables of extreme severity (often versus sometimes or not in the last 12 months) and moderate severity (sometimes versus not in the last 12 months) reveals that these patterns are largely driven by the moderate levels. While there is higher likelihood of severe acts of physical and sexual violence with more days of weather-based discomfort in the past year, the correspondence between severe emotional violence and days of discomfort is insignificant. The coefficients in the following tables are reported as odds ratio.

5.4 Rainfall shocks and IPV

The literature examining rainfall shocks and IPV finds contrasting evidence on the correspondence between excessive rainfall (or floods) on self-reported IPV. Díaz and Saldarriaga (2023) and Cools et al. (2020) find null effect of floods while Munala et al. (2023)

finds a positive correspondence with IPV. Estimating the marginal effect of annual mean precipitation on IPV in the past year for each country-survey wave using an ordinary least squares regression suggests that as the average annual precipitation increases, the marginal effect of rainfall on physical and emotional IPV declines (Figure 4). For emotional acts of violence, at higher levels of annual rainfall, there is a decline in emotional violence with a unit increase in rain in mm. For physical acts of violence, the effect of rainfall on violence is smaller at higher levels of annual rainfall but positive. In case of sexual IPV, higher levels of annual rainfall correspond with an increase in the marginal effect of rain on IPV (negative to positive).

5.5 Risk and mitigating factors of IPV

It is well established in the literature that partner's alcohol consumption exacerbates the likelihood of IPV (Kwagala et al. 2013; Devries et al. 2014; Kaufman et al. 2014; Adjah and Agbemafle 2016; Curtis et al. 2019). A heterogeneity test of IPV prevalence by partner's alcohol consumption is consistent with the hypothesis that alcohol consumption would exacerbate temperature-induced violence. Table 11 shows that alcohol consumption exacerbates IPV in extreme cold weather: respondents experiencing minimum temperatures lower than the historical average by at least 1 standard deviation were more likely to report experience of IPV than respondents that either did not experience this weather extremity or whose partner does not drink. For temperatures higher than the historical average by 1 standard deviation, partner's alcohol consumption corresponded with higher likelihood of emotional violence. Prevalence of sexual violence was lower with increasing discomfort from head and humidity for women whose partners consume alcohol.

Heterogeneity tests show there is higher prevalence of physical and emotional IPV for older women (Table 12). There exists conflicting evidence on the relationship between women's employment and experience of IPV in the literature. Evidence from developed countries finds that an increase in employment and access to resources reduces the likelihood of IPV for women((Bowlus and Seitz, 2006; Aizer, 2010; Anderberg et al., 2016). Studies in low-income countries find the opposite effect (Bloch and Rao, 2002; Eswaran and Malhotra, 2011; Bobonis et al., 2013; Heath, 2014), implying that this relationship may be context specific (Bhalotra et al., 2020). Respondent's employment has neither exacerbating or mitigating correspondence with outcomes of violence in extreme heat. However, in years of extreme cold weather, women's age and employment correspond with lower prevalence of physical and sexual violence.

6 Conclusion

With increasing weather extremes caused by global warming and climate change, there has been a concerted push towards studying outcomes on the economy and society as well as public policy measures to help mitigate these effects. What is overlooked are the distributional effects of these weather changes on women. The negative spillover effects of extreme hot or cold days on women include the displacement of weather-induced aggression of the partner on her. Extreme weather is also likely to force individuals to retreat indoors and increase exposure to their intimate partner. The reduced mobility and limited social interactions can result in perverse outcomes of domestic violence. Evidence from the pandemic shows an increased severity of violence such as physical assault during lockdown (Gibbens et al. 2021; Nesset et al. 2021; Olufunmilayo et al. 2021; Glowacz et al. 2022). Therefore, it is critical to examine the effects of such weather shocks on women's experience of IPV.

In this paper, we use self-reported data on the incidence and frequency of IPV in the last year and combine it with weather information during the recall period to test if there is any correspondence between unexpected weather fluctuations and the prevalence of IPV. While extreme heat is correlated with more women reporting physical acts of violence from their intimate partner, there is a decline in the prevalence of emotional and sexual acts of violence. This result is consistent when I examine the severity of weather-based discomfort and frequency of IPV. Interaction with risk and mitigating factors of IPV shows that women whose partners consume alcohol are more likely to report physical, sexual and emotional IPV when faced with extreme weather. Women's age and years of completed education interacted with unanticipated heat correspond with higher reports of physical, emotional and sexual violence. On the other hand, the interaction of age and employment with uncharacteristic lower temperatures in a year correspond with lower prevalence of physical violence. Sexual violence increases with age and falls with respondent's employment during these cold years.

Given the data constraints of an annual recall of violence and absence of longitudinal data, this paper is unable to test for causal effects of extreme temperature on violence. Partialling out the indirect effect of temperature on IPV through economic channels is also an important analysis outside the scope of this paper. This manuscript provides useful descriptive evidence of how temperature and precipitation correlate with IPV and is a useful starting point to motivate the study of gender dynamics in the context of climate change.

7 Figures and Tables

7.1 Figures

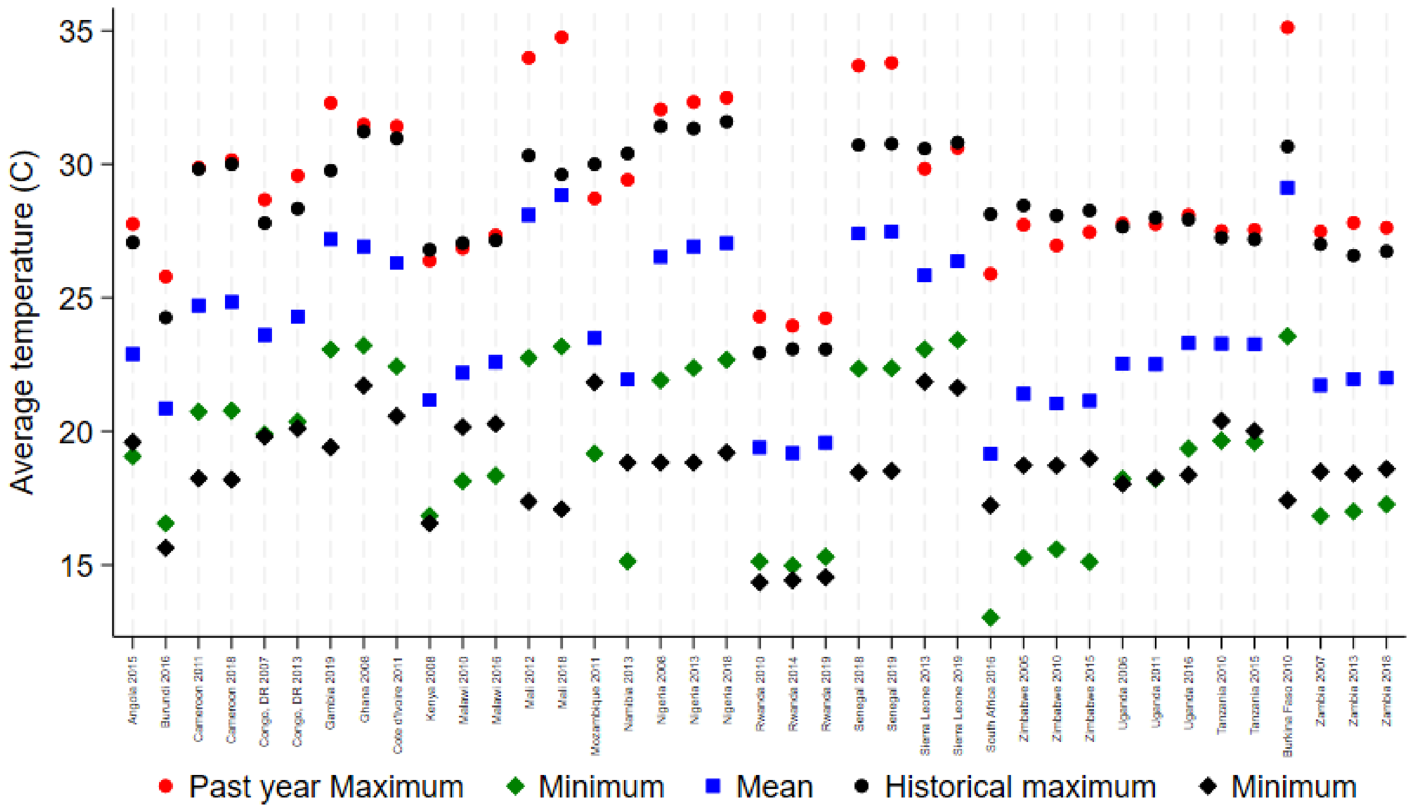

Fig. 1: Annual and historical averages of maximum, mean and minimum temperature (°C) of DHS countries included in analysis

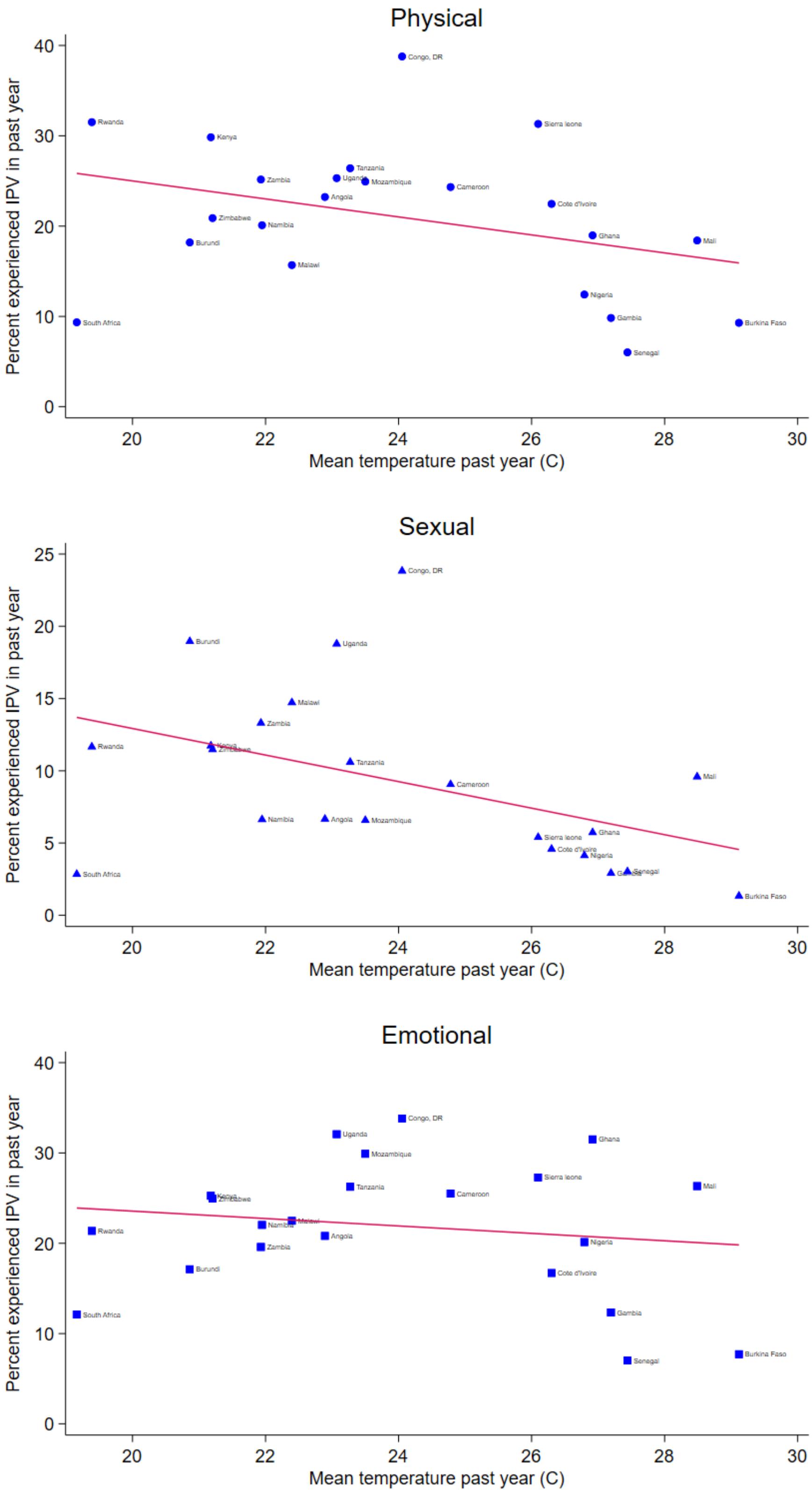

Fig. 2: Country-wise relationship between annual mean temperature and IPV prevalence

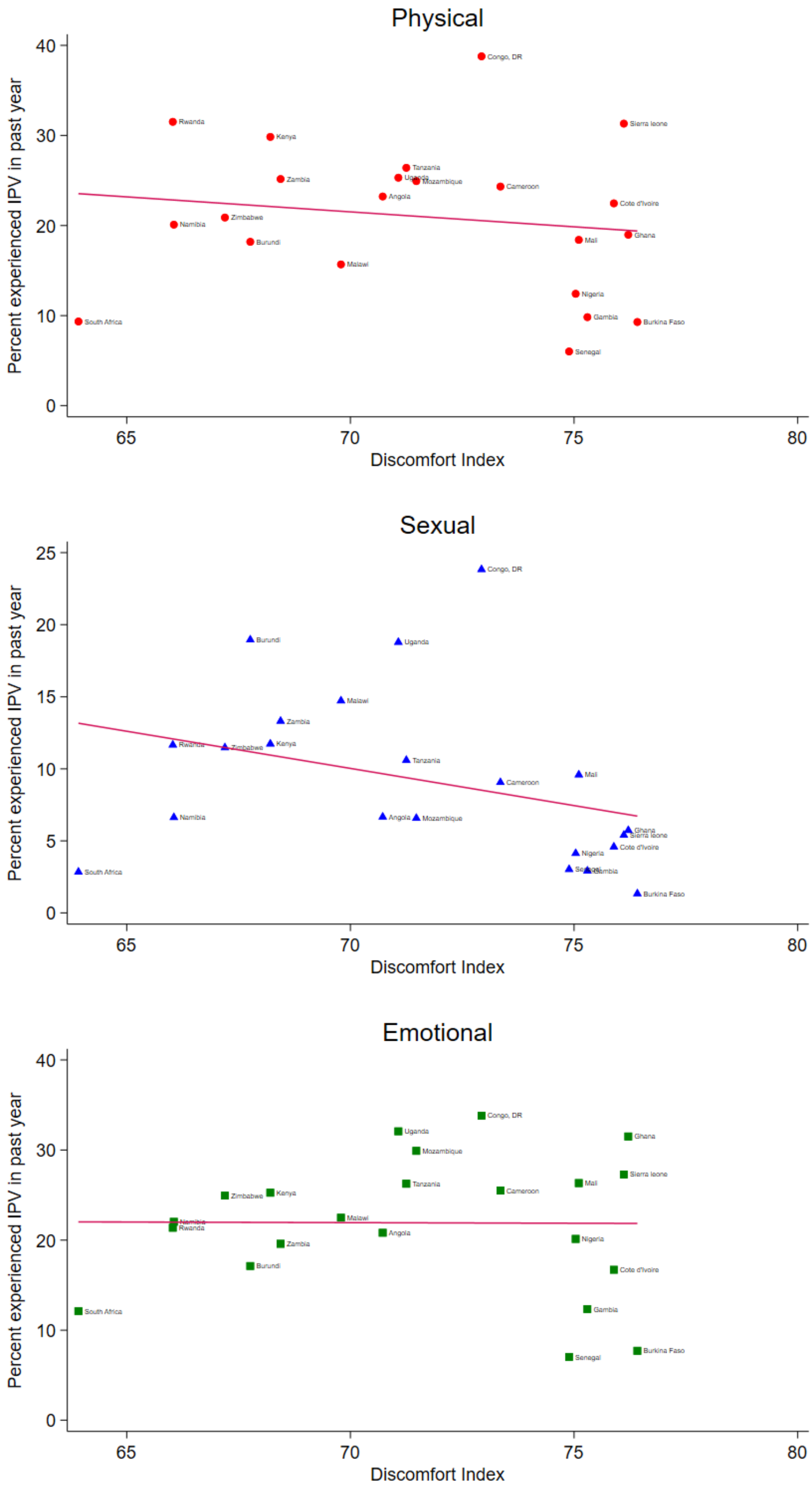

Fig. 3: Country-wise relationship between Discomfort Index and annual IPV prevalence

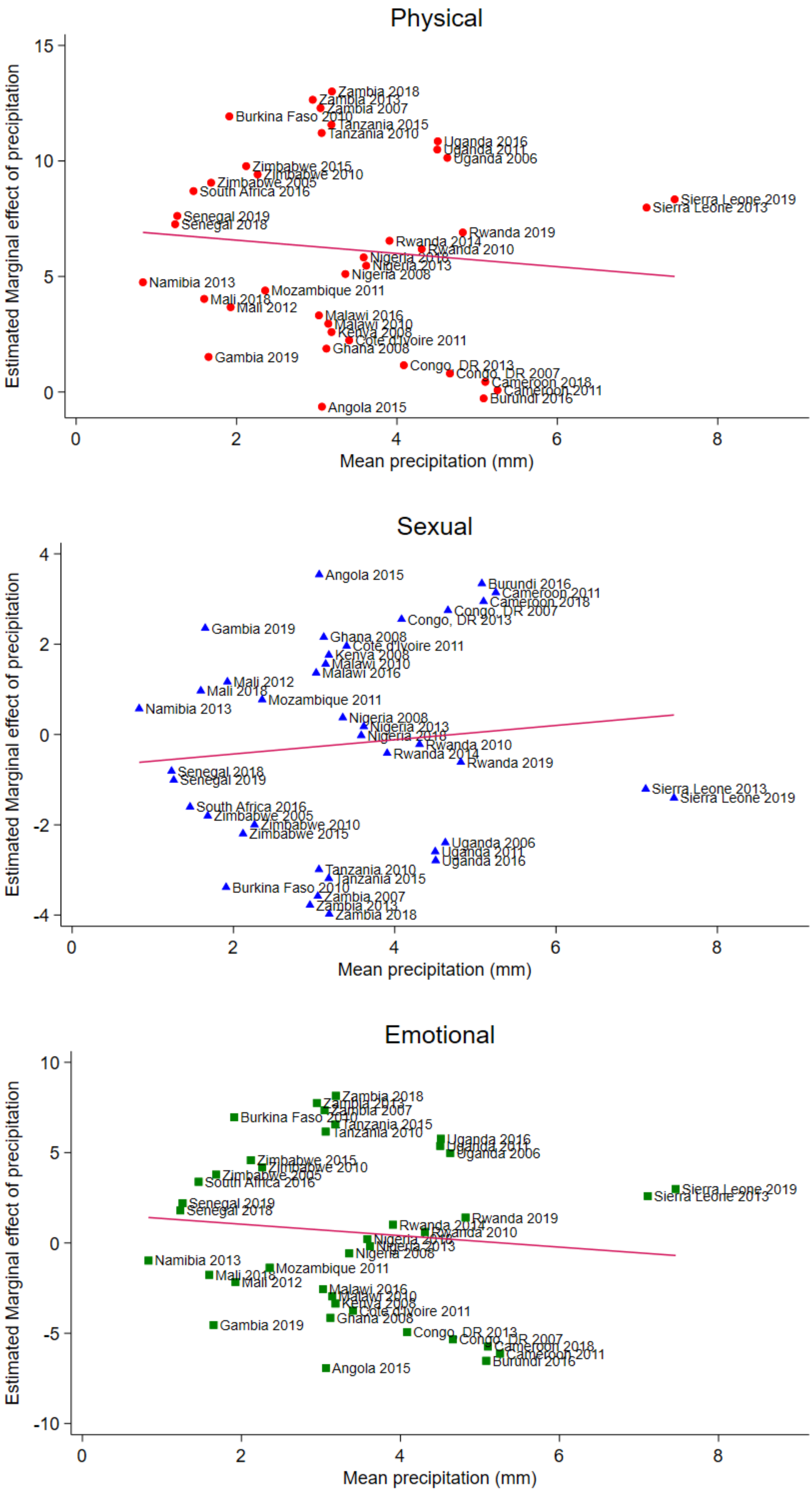

Fig. 4: Marginal effect of precipitation on IPV by annual mean precipitation

7.2 Tables

Table 1: DHS survey rounds included in analysis

Country	Survey Years	Sample
Angola	2015	7,669
Burkina Faso	2010	9,340
Burundi	2016	7,338
Cameroon	2011 // 2018	4,003 // 4,690
Côte d'Ivoire	2011	4,874
Congo, Dem. Rep.	2007 // 2013	2,795 // 5,211
Gambia	2019	1,953
Ghana	2008	1,798
Kenya	2008 // 2014	4,888 //4,519
Malawi	2010 // 2016	5,254 // 5,406
Mali	2012 // 2018	3,120 // 3,356
Mozambique	2011	5,824
Namibia	2013	1,449
Nigeria	2008 // 2013 // 2018	19,389 // 22,101 // 8,835
Rwanda	2010 // 2014 // 2019	3,476 // 1,908 // 1,852
Senegal	2018 // 2019	1,506 // 1,468
Sierra Leone	2013 // 2019	4,315 // 3,917
South Africa	2016	2,354
Tanzania	2010 // 2015	5,490 // 7,597
Uganda	2006 // 2011 // 2016	1,600 // 1,686 // 7,416
Zambia	2007 // 2013 // 2018	4,246 // 9,383 // 7,224
Zimbabwe	2005 // 2010 // 2015	4,963 // 5,096 // 4,333

Notes: The sample includes women aged 15 to 49 who have been married, cohabiting (currently or ever), divorced, separated or widowed at least once and were interviewed about experience of IPV in the DHS survey.

Table 2: Pooled statistics of households by experience of IPV

	Last 12 months		Yes but not last year		Never	
	Mean	SD	Mean	SD	Mean	SD
Household size	7.280	4.467	8.335	5.634	8.269	5.655
Household sex ratio	1.446	1.129	1.439	1.081	1.449	1.110
Household head female	0.212	0.409	0.300	0.458	0.246	0.431
Religion: Christian	0.384	0.486	0.349	0.477	0.310	0.463
Religion: Muslim	0.609	0.488	0.646	0.478	0.684	0.465
Religion: Other	0.005	0.074	0.007	0.081	0.007	0.083
Respondent: Age	31.515	7.981	34.828	8.239	32.359	8.692
Respondent: Education	3.959	4.405	3.700	4.374	3.831	4.749
Respondent: Employed	0.805	0.396	0.840	0.366	0.741	0.438
Spouse: Age	40.364	11.437	43.922	11.437	42.031	12.308
Spouse: Education	4.939	5.291	4.537	5.296	4.574	5.462
Spouse: Indoor employment	0.274	0.446	0.300	0.458	0.334	0.471
Spouse: Outdoor employment	0.651	0.477	0.622	0.485	0.580	0.494
Rural	0.608	0.488	0.609	0.488	0.581	0.493
Physical violence	0.218	0.413	0.356	0.479	0.644	0.479
Sexual violence	0.057	0.233	0.083	0.275	0.917	0.275
Emotional violence	0.210	0.407	0.083	0.275	0.720	0.449
N	66,895		18,277		122,143	

Notes: First two columns report summary statistics for households where interviewed woman report having experienced IPV but not in the past year. The next two columns summarize households where the respondent woman experienced IPV in past year and the last two columns are for households where the woman never experienced IPV. The sample includes women between ages 15 and 49 that have been married or in a union at least once. These are pooled estimates of all DHS survey waves included in the analysis (see Table 1). They use survey weights provided by the DHS for representativeness of the interviewed woman to the country population.

Table 3: Unanticipated temperature trends in past year and physical IPV prevalence

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Normalized deviation from historical average						
Normalized deviation of max temperature > 1 SD	0.015**	0.015**	0.015**	0.015**	0.015**	0.016**
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Normalized deviation of min temperature < −1 SD	-0.001	-0.003	-0.001	0.000	-0.002	-0.002
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Constant	0.029*	0.019	0.034**	0.018	0.085***	0.084***
	[0.015]	[0.015]	[0.015]	[0.015]	[0.016]	[0.016]
Panel B: Ratio of annual temperature to historical average						
Max temp past year/Historical max	-0.051	-0.031	-0.051	-0.055	-0.030	-0.030
	[0.040]	[0.041]	[0.041]	[0.040]	[0.042]	[0.042]
Min temp past year/Historical min	-0.192***	-0.198***	-0.204***	-0.195***	-0.222***	-0.222***
	[0.021]	[0.022]	[0.021]	[0.021]	[0.022]	[0.022]
Constant	0.422***	0.398***	0.449***	0.419***	0.501***	0.500***
	[0.038]	[0.039]	[0.040]	[0.038]	[0.040]	[0.040]
Observations	161693	153714	159937	161693	151300	151300

Notes: The dependent variable is a binary variable for whether respondent experienced physical violence in the last 12 months at least once. Panel A reports estimates from equation 1 and Panel B from 2. Standard errors clustered at the survey enumeration area level are reported in brackets.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Unanticipated temperature trends in past year and emotional IPV prevalence

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Normalized deviation from historical average						
Normalized deviation of max temperature > 1 SD	-0.028***	-0.029***	-0.029***	-0.028***	-0.031***	-0.030***
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Normalized deviation of min temperature < -1 SD	-0.009	-0.011*	-0.009	-0.009	-0.014**	-0.014**
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Constant	0.111***	0.114***	0.111***	0.106***	0.126***	0.115***
	[0.017]	[0.018]	[0.018]	[0.017]	[0.018]	[0.019]
Panel B: Ratio of annual temperature to historical average						
Max temp past year/Historical max	-0.259***	-0.252***	-0.263***	-0.263***	-0.244***	-0.243***
	[0.050]	[0.051]	[0.050]	[0.050]	[0.051]	[0.051]
Min temp past year/Historical min	-0.033	-0.040	-0.045	-0.035	-0.053*	-0.056**
	[0.028]	[0.028]	[0.028]	[0.028]	[0.028]	[0.028]
Constant	0.495***	0.496***	0.520***	0.497***	0.517***	0.509***
	[0.048]	[0.050]	[0.050]	[0.048]	[0.051]	[0.051]
Observations	161692	153712	159936	161692	151298	151298

Notes: The dependent variable is a binary variable for whether respondent experienced emotional violence in the last 12 months at least once. Panel A reports estimates from equation 1 and Panel B from 2. Standard errors clustered at the survey enumeration area level are reported in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Unanticipated temperature trends in past year and sexual IPV prevalence

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Normalized deviation from historical average						
Normalized deviation of max temperature > 1 SD	-0.010**	-0.012***	-0.011**	-0.010**	-0.012***	-0.012**
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]
Normalized deviation of min temperature < -1 SD	0.007	0.007	0.007	0.007	0.005	0.005
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]
Constant	-0.008	-0.009	-0.011	-0.014	0.013	0.009
	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.012]
Panel B: Ratio of annual temperature to historical average						
Max temp past year/Historical max	0.065**	0.081***	0.070**	0.060**	0.095***	0.095***
	[0.030]	[0.030]	[0.030]	[0.030]	[0.030]	[0.030]
Min temp past year/Historical min	0.004	0.002	0.005	0.002	-0.010	-0.011
	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]
Constant	-0.081***	-0.100***	-0.093***	-0.079***	-0.079***	-0.082***
	[0.028]	[0.029]	[0.029]	[0.028]	[0.029]	[0.029]
Observations	161666	153689	159910	161666	151276	151276

Notes: The dependent variable is a binary variable for whether respondent experienced sexual violence in the last 12 months at least once. Panel A reports estimates from equation 1 and Panel B from 2. Standard errors are clustered at the survey enumeration area level are reported in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Uncomfortable weather and prevalence of IPV

	Physical		Emotional		Sexual	
	(1)	(2)	(3)	(4)	(5)	(6)
Discomfort Index	0.001		-0.003***		-0.002***	
	[0.001]		[0.001]		[0.000]	
Uncomfortable (DI>=75)		0.009**		-0.011**		-0.009***
		[0.004]		[0.005]		[0.002]
Constant	0.098**	0.149***	0.328***	0.081***	0.162***	0.028***
	[0.040]	[0.011]	[0.046]	[0.011]	[0.029]	[0.008]
Sharpened q values	0.03	0.009	0.001	0.01	0.001	0.001
Observations	150099	150099	150097	150097	150075	150075

Notes: The dependent variable is a binary variable of experiencing violence in the past 12 months at least once. Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Standard errors are clustered at survey enumeration area level are reported in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Temperature on survey date and prevalence of IPV

	Physical			Emotional			Sexual		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Normalized	0.019***			-0.026***			-0.016***		
deviation of	[0.006]			[0.008]			[0.005]		
max > 1 SD	(0.003)			(0.003)			(0.003)		
Normalized	-0.007			-0.021***			0.009*		
deviation of min	[0.006]			[0.007]			[0.005]		
< −1 SD	(0.108)			(0.004)			(0.046)		
Max temp past		-0.035			-0.246***			0.095***	
year/Historical		[0.042]			[0.052]			[0.030]	
max		(0.143)			(0.001)			(0.003)	
Min temp past		-0.219***			-0.056*			-0.009	
year/Historical		[0.022]			[0.029]			[0.015]	
min		(0.001)			(0.001)			(0.196)	
Discomfort Index			0.000			-0.001*			-0.002***
			[0.001]			[0.001]			[0.000]
			(0.32)			(0.046)			(0.001)
Constant	0.107***	0.509***	0.163***	0.179***	0.584***	0.179***	-0.036**	-0.084***	0.141***
	[0.022]	[0.043]	[0.034]	[0.027]	[0.053]	[0.040]	[0.016]	[0.030]	[0.025]
Observations	150099	150099	150099	150097	150097	150097	150075	150075	150075

Notes: The dependent variable is a binary variable of experiencing violence in the past 12 months at least once. Columns 1-9 replicate results in Tables 3, 4, 5 and 6 with the addition of a control for mean temperature or DI on the day of interview. Other controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Standard errors are clustered at survey enumeration area level and reported in square brackets. Sharpened q values in round brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Days of discomfort and frequency of IPV

	Physical (1)	Emotional (2)	Sexual (3)
Num of days DI=60 and below	1.000	1.000	0.999
	[0.001]	[0.001]	[0.001]
Num of days DI between 66 & 70	1.001***	1.001***	1.000*
	[0.000]	[0.000]	[0.000]
Num of days DI between 71 & 75	1.001***	1.000	1.000
	[0.000]	[0.000]	[0.000]
Num of days DI between 76 & 80	1.001**	0.999***	0.999***
	[0.000]	[0.000]	[0.000]
Num of days DI above 80	0.998***	1.001	0.998*
	[0.001]	[0.001]	[0.001]
Observations	150214	150078	150120

Notes: The dependent variable is a categorical variable of frequency of violence (not in past 12 months, sometimes or often). Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Exponentiated coefficients; Standard errors are clustered at survey enumeration area level are reported in brackets; Reference category omitted: Days between 61 and 65. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Days of discomfort and IPV often in past 12 months

	Physical	Emotional	Sexual
	(1)	(2)	(3)
Num of days DI=60 and below	1.002*	1.001	1.002*
	[0.001]	[0.001]	[0.001]
Num of days DI between 66 & 70	1.000	1.001*	1.002***
	[0.001]	[0.000]	[0.000]
Num of days DI between 71 & 75	1.001	1.000	1.001***
	[0.001]	[0.000]	[0.000]
Num of days DI between 76 & 80	1.000	1.000	1.000
	[0.001]	[0.000]	[0.001]
Num of days DI above 80	0.999	0.999	1.000
	[0.002]	[0.001]	[0.002]
Observations	150214	150078	150120

Notes: The dependent variable is a binary variable of experiencing violence often in the last 12 months relative to sometimes or not at all. Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Exponentiated coefficients; Standard errors are clustered at survey enumeration area level are reported in brackets; Reference category omitted: Days between 61 and 65. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Days of discomfort and IPV sometimes in past 12 months

	Physical	Emotional	Sexual
	(1)	(2)	(3)
Num of days DI=60 and below	1.000	1.000	0.998**
	[0.001]	[0.001]	[0.001]
Num of days DI between 66 & 70	1.001***	1.001***	1.000
	[0.000]	[0.000]	[0.000]
Num of days DI between 71 & 75	1.001***	1.000	1.000*
	[0.000]	[0.000]	[0.000]
Num of days DI between 76 & 80	1.001***	0.999***	0.999***
	[0.000]	[0.000]	[0.000]
Num of days DI above 80	0.998***	1.001	0.997**
	[0.001]	[0.001]	[0.001]
Observations	147248	144837	147142

Notes: The dependent variable is a binary variable of experiencing violence sometimes in last 12 months relative to not at all. Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Exponentiated coefficients; Standard errors are clustered at survey enumeration area level are reported in brackets; Reference category omitted: Days between 61 and 65. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Spouse's alcohol consumption and discomfort on prevalence of IPV

	Physical		Emotional		Sexual	
	(1)	(2)	(3)	(4)	(5)	(6)
Normalized deviation	-0.006		0.010**		-0.006	
of max > 1 SD *	[0.005]		[0.004]		[0.005]	
partner drinks	(0.161)		(0.075)		(0.161)	
Normalized deviation	0.010**		0.010*		0.010**	
of min < -1 SD *	[0.005]		[0.006]		[0.005]	
partner drinks	(0.075)		(0.098)		(0.075)	
DI*partner drinks		0.000		0.001		-0.002***
		[0.000]		[0.001]		[0.000]
	(0.307)		(0.123)		(0.001)	
Partner drinks	0.043***	0.114***	0.004	0.054	0.043***	0.167***
	[0.003]	[0.035]	[0.003]	[0.037]	[0.003]	[0.027]
Constant	-0.012	0.137***	-0.020	0.168***	-0.012	0.020
	[0.012]	[0.029]	[0.024]	[0.035]	[0.012]	[0.021]
Observations	147722	147745	147812	147742	147722	147722

Notes: The dependent variable is a binary variable of experiencing violence in the past 12 months at least once. The table reports heterogeneity in outcome variables by whether the spouse drinks. Only interaction terms and partner's drinking habit are reported in the table but estimation includes binary variable of each normalized deviation. Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Standard errors are clustered at survey enumeration area level and reported in square brackets. Sharpened q values in round brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Women's empowerment and discomfort on prevalence of IPV

	Physical		Emotional		Sexual	
	(1)	(2)	(3)	(4)	(5)	(6)
Normalized deviation of	0.00119***		0.00060**		-0.00012	
max > 1 SD *	[0.000]		[0.000]		[0.000]	
Respondent's age	(0.001)		(0.041)		(0.461)	
Normalized deviation of	0.00041		0.00198***		0.00083**	
max > 1 SD *	[0.001]		[0.001]		[0.000]	
Respondent's education	(0.397)		(0.003)		(0.048)	
Normalized deviation of	-0.00159		-0.00109		0.00136	
max > 1 SD *	[0.005]		[0.006]		[0.004]	
Respondent works	(0.643)		(0.7)		(0.641)	
Normalized deviation of	-0.00073**		-0.00022		-0.00058**	
min < -1 SD *	[0.000]		[0.000]		[0.000]	
Respondent's age	(0.036)		(0.461)		(0.029)	
Normalized deviation of	-0.00038		0.00073		-0.00052	
min < -1 SD *	[0.001]		[0.001]		[0.001]	
Respondent's education	(0.478)		(0.349)		(0.353)	
Normalized deviation of	-0.02149***		-0.00173		0.00819*	
min < -1 SD *	[0.006]		[0.006]		[0.004]	
Respondent works	(0.001)		(0.643)		(0.078)	
DI * Respondent's age		0.00012***		0.00000		0.00001
		[0.000]		[0.000]		[0.000]
		(0.001)		(0.39)7		(0.478)
DI * Respondent's education		0.00028***		-0.00002***		0.00008**
		[0.000]		[0.000]		[0.000]
		(0.001)		(0.001)		(0.03)
DI * Respondent works		0.00048		0.00049***		-0.00184***
		[0.000]		[0.000]		[0.000]
		(0.301)		(0.001)		(0.001)
Respondent: Age	-0.00198***	-0.01038***	0.00001		-0.00065***	-0.00154
	[0.000]	[0.002]	[0.000]		[0.000]	[0.001]
Respondent: Education	-0.00211***	-0.02298***	-0.00197***		-0.00074***	-0.00653***
	[0.000]	[0.003]	[0.000]		[0.000]	[0.002]
Respondent: Employed	0.02704***	-0.01471	0.03699***		0.01386***	0.15062***
	[0.004]	[0.032]	[0.004]		[0.003]	[0.024]
Constant	0.12899***	0.60655***	0.05692***	0.22380***	0.01570**	0.04932
	[0.011]	[0.063]	[0.012]	[0.033]	[0.008]	[0.049]
Observations	150099	150099	150097	150097	150075	150075

Notes: The dependent variable is a binary variable of experiencing violence in the past 12 months at least once. The table reports heterogeneity in outcome variables by whether the woman is empowered. Only interaction terms and the continuous indicators of empowerment are reported in the table but estimation includes binary variable of each normalized deviation. Controls include - household size, sex ratio of household members, household head is female, household is christian, household located in rural area, household owns agricultural land for rent/ cultivation, household has insulated floor and walls, years of completed education of partner, partner has controlling behaviors, partner's employment activity is outdoors, respondent witnessed father beating mother as a child, respondent's views of the acceptability of IPV, her current age, age at the time of first marriage, years of completed education and whether she works. Standard errors are clustered at survey enumeration area level and reported in square brackets. Sharpened q values in round brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

References

Abiona, O. and Koppensteiner, M. F. (2018). The impact of household shocks on domestic violence: Evidence from Tanzania. *IZA Discussion Paper Series*, 11992. 3, 5

Ackerson, L. K., Kawachi, I., Barbeau, E. M., and Subramanian, S. V. (2008). Effects of individual and proximate educational context on intimate partner violence: a population-based study of women in india. *American journal of public health*, 98(3):507–514. 8

Adhvaryu, A., Kalaz, N., and Nyshadham, N. (2019). The light and the heat: Productivity co-benefits of energy-saving technology. *The Review of Economics and Statistics*, 102:1–36. 3, 42

Aizer, A. (2010). The gender wage gap and domestic violence. *American Economic Review*, 100(4):1847–59. 13

Anderberg, D., Rainer, H., Wadsworth, J., and Wilson, T. (2016). Unemployment and domestic violence: Theory and evidence. *The Economic Journal*, 126(597):1947–1979. 13

Anderson, C. A. (1987). Temperature and aggression: Effects on quarterly, yearly, and city rates of violent and nonviolent crime. *Journal of Personality and Social Psychology*, 52(6):1161–1173. 3

Anderson, C. A. and Anderson, D. C. (1984). Ambient temperature and violent crime: Tests of the linear and curvilinear hypotheses. *Journal of Personality and Social Psychology*, 46(1):91–97. 3

Anderson, C. A., Anderson, K. B., Dorr, N., DeNeve, K. M., and Flanagan, M. (2000). Temperature and aggression. *Advances in Experimental Social Psychology*, 32:63–133. 4

Angelucci, M. (2008). Love on the rocks: Domestic violence and alcohol abuse in rural mexico. *The B.E. Journal of Economic Analysis & Policy*, 8(1). 8

Baysan, C., Burke, M., González, F., Hsiang, S., and Miguel, E. (2018). Economic and non-economic factors in violence: Evidence from organized crime, suicides and climate in Mexico. *NBER Working Paper*, 24897. 3, 6, 10, 42

Berkowitz, L. (1983). Aversively stimulated aggression: Some parallels and differences in research with animals and humans. *American Psychologist*, 38:1135–1144. 5

Bhalotra, S., Kambhampati, U., Rawlings, S., and Siddique, Z. (2020). Intimate partner violence: The influence of job opportunities for men and women. *The World Bank Economic Review*. 3, 13

Blakeslee, D., Chaurey, R., Fishman, R., Malghan, D., and Malik, S. (2021). In the heat of the moment: Economic and non-economic drivers of the weather-crime relationship. *Journal of Economic Behavior & Organization*, 192:832–856. 3

Blakeslee, D. and Fishman, R. (2018). Weather shocks, agriculture, and crime: Evidence from india. *Journal of Human Resources*, 53:750–782. 3

Bloch, F. and Rao, V. (2002). Terror as a bargaining instrument: A case study of dowry violence in rural india. *American Economic Review*, 92. 13

Bobonis, G. J., Gonzalez-Brenes, M., and Castro, R. (2013). Public transfers and domestic violence: The roles of private information and spousal control. *American Economic Journal: Economic Policy*, 5(1). 13

Bollman, K., Chakraborty, J., Lakdawala, L., and Nakasone, E. (2024). Frosty Climate, Icy Relationships: Frosts and Intimate Partner Violence in Rural Peru. *Working Paper*. 3

Bowlus, A. J. and Seitz, S. (2006). Domestic violence, employment and divorce. *International Economic Review*, 47(4). 13

Boyanowsky, E. O., Calvert, J., Young, J., and Brideau, L. (1981). The effect of maximum daily temperature on outdoor violence. *Journal of Environmental Systems*, 11:81–87. 3

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., and Lobell, D. B. (2009). Warming increases the risk of civil war in africa. *Proceedings of the National Academy of Sciences*, 106(49):20670–20674. 3

Cohen, F. and Gonzalez, F. (2018). Understanding interpersonal violence: The impact of temperatures in Mexico. *Centre for Climate Change Economics and POlicy Working Paper*, 326. 2, 5

Cohn, E. G. (1993). The prediction of police calls for service: The influence of weather and temporal variables on rape and domestic violence. *Journal of Environmental Psychology*, 13(1):71–83. 3, 5

Colmer, J. (2021). Temperature, labor reallocation, and industrial production: Evidence from india. *American Economic Journal: Applied Economics*, 13(4):101–24. 3, 42

Cools, S., Flatø, M., and Kotsadam, A. (2020). Rainfall shocks and intimate partner violence in sub-saharan africa. *Journal of Peace Research*, 57(3):377–390. 3, 12

Cruz, E., D'Alessio, S. J., and Stolzenberg, L. (2020). The effect of maximum daily temperature on outdoor violence. *Crime & Delinquency*, 69:1161–1182. 3

Díaz, J.-J. and Saldarriaga, V. (2023). A drop of love? rainfall shocks and spousal abuse: Evidence from rural Peru. *Journal of Health Economics*, 89:102739. 3, 12

Epstein, A., Bendavid, E., Nash, D., Charlebois, E. D., and Weiser, S. D. (2020). Drought and intimate partner violence towards women in 19 countries in sub-saharan africa during 2011-2018: A population-based study. *PLOS Medicine*. 3, 5

Eswaran, M. and Malhotra, N. (2011). Domestic violence and women's autonomy in developing countries: Theory and evidence. *Canadian Journal of Economics*, 44(4). 8, 13

Farmer, A. and Tiefenthaler, J. (1997). An economic analysis of domestic violence. *Review of Social Economy*, 55(3). 8

Graff Zivin, J., Hsiang, S. M., and Neidell, M. (2018). Temperature and human capital in the short and long run. *Journal of the Association of Environmental and Resource Economists*, 5(1):77–105. 3

Graff Zivin, J. and Neidell, M. (2014). Temperature and the allocation of time: Implications for climate change. *Journal of Labor Economics*, 32(1):1–26. 3

Hancock, P. A. and Vasmatzidis, I. (2003). Effects of heat stress on cognitive performance: the current state of knowledge. *International Journal of Hyperthermia*, 19(3):355–372. 3

Heath, R. M. (2014). Women's access to labor market opportunities, control of household resources, and domestic violence. *World Development*, 57:32–46. 13

Heilmann, K., Kahn, M. E., and Tang, C. K. (2021). The urban crime and heat gradient in high and low poverty areas. *Journal of Public Economics*, 197:104408. 3

Heise, L. (1998). Violence against women: An integrated, ecological framework. *Violence against Women*, 4(3):262–290. 8

Henke, A. and Hsu, L. (2020). The gender wage gap, weather, and intimate partner violence. *Review of Economics of the Household*, 18:pages413–429. 2, 3, 5

Hornung, C. A., McCullough, B. C., and Sugimoto, T. (1981). Status relationships in marriage: Risk factors in spouse abuse. *Journal of Marriage and Family*, 43(3):675–692. 8

Horrocks, J. and Menclova, A. (2011). The effects of weather on crime. *New Zealand Economic Papers*, 45(3):231–254. 5

Hsiang, S. M., Burke, M., and Miguel, E. (2013). Quantifying the influence of climate on human conflict. *Science*, 341(6151):1235367. 3

Jacobs, J. (1961). *The death and life of great American cities*. Random House, New York, USA. 5

Kenrick, D. T. and MacFarlane, S. W. (1986). Ambient temperature and horn honking: A field study of the heat/aggression relationship. *Environment and Behavior*, 18(2):179–191. 3

LoPalo, M. (2023). Temperature, worker productivity, and adaptation: Evidence from survey data production. *American Economic Journal: Applied Economics*, 15(1):192–229. 3

Melo, A. P. and Suzuki, M. (2019). The effects of heat on cognitive performance: Evidence from a high-stakes exam in brazil. *Working Paper*. 3

Michel, S. J., Wang, H., Selvarajah, S., Canner, J. K., Murrill, M., Chi, A., Efron, D. T., and Schneider, E. B. (2016). Investigating the relationship between weather and violence in Baltimore, Maryland, USA. *International Journal of the Care of the Injured*, 47:272–276. 3, 5

Miles-Novelo, A. and Anderson, C. (2019). Climate change and psychology: Effects of rapid global warming on violence and aggression. *Current Climate Change Reports*, 5. 2

Mukherjee, A. and Sanders, N. (2021). The causal effect of heat on violence: Social implications of unmitigated heat among the incarcerated. *NBER Working Paper*. 3

Munala, L., Allen, E. M., Frederick, A. J., and Ngũnjiri, A. (2023). Climate change, extreme weather, and intimate partner violence in east african agrarian-based economies. *International Journal of Environmental Research and Public Health*, 20(23). 3, 5, 12

Nguyen, M. (2024). Temperature and Intimate Partner Violence. *Scottish Journal of Political Economy*, 71(2):197–218. 4

Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., and Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change*, 11:306–312. 3

O'Loughlin, J., Linke, A. M., and Witmer, F. D. W. (2014). Effects of temperature and precipitation variability on the risk of violence in sub-Saharan Africa, 1980–2012. *Proceedings of the National Academy of Sciences*, 111:16712–16717. 3

Park, R. J. (2022). Hot temperature and high-stakes performance. *Journal of Human Resources*, 57(2):400–434. 3

Pollak, R. A. (2004). An intergenerational model of domestic violence. *Journal of Population Economics*, 17(2):311–329. 8

Prudkov, P. N. and Rodina, O. N. (2019). Cold temperatures, stress, and violence. *Heliyon 5*, 5. 3

Ranson, M. (2014). Crime, weather, and climate change. *Journal of Environmental Economics and Management*, 67(3):274–302. 3

Reifman, A., Larrick, R., and Fein, S. (1991). Temper and temperature on the diamond: The heat-aggression relationship in major league baseball. *Personality and Social Psychology Bulletin*, 17. 3

Rotton, J. and Frey, J. (1985). Air pollution, weather, and violent crimes: Concomitant time-series analysis of archival data. *Journal of Personality and Social Psychology*, 49(5):1207–1220. 2, 3

Schlenker, W. and Lobell, D. B. (2010). Robust negative impacts of climate change on african agriculture. *Environmental Research Letters*, 5(1):014010. 3, 42

Schmit, C., Hausswirth, C., Le Meur, Y., and Duffield, R. (2017). Cognitive functioning and heat strain: Performance responses and protective strategies. *Sports Medicine*, 47(7):1289–1302. 3

Sekhri, S. and Storeygard, A. (2014). Dowry deaths: Response to weather variability in India. *Journal of Development Economics*, 111:212–223. 3

Seppänen, O., Fisk, W., and Lei, Q. (2005). Effect of temperature on task performance in office environment. *Lawrence Berkeley National Laboratory*. 3

Stevens, H. R. (2022). *The Association Between Temperature and Interpersonal Violence*. PhD dissertation, Macquari University. 2, 3

Straus, M. M. A., Gelles, R. J., and Steinmetz, S. K. (1980). *Behind closed doors: Violence in the American family*. Doubleday Press, New York, USA. 5

The Prevention Collective, . (2020). *Brief 2: Understanding the causes of violence against women*. The Prevention Collective. 8

Thom, E. (1959). The discomfort index. *Weatherwise*, 12(2):57–61. 7, 10, 35

von Uexkull, N., Croicu, M., Fjelde, H., and Buhaug, H. (2016). Civil conflict sensitivity to growing-season drought. *Proceedings of the National Academy of Sciences*, 113(44):12391–12396. 3

Yasayko, J. L. (2010). *Attacks on transit drivers as a function of ambient temperature*. PhD thesis, Simon Fraser University. 3

Zhu, X. and Troy, T. J. (2018). Agriculturally relevant climate extremes and their trends in the world's major growing regions. *Earth's future*, 6:656–672. 3, 42

Zhu, Y., He, C., Bell, M., Zhang, Y., Fatmi, Z., Zhang, Y., Zaid, M., Bachwenkizi, J., Liu, C., Zhou, L., Chen, R., and Kan, H. (2023). Association of ambient temperature with the prevalence of intimate partner violence among partnered women in Low- and Middle-Income South Asian countries. *JAMA Psychiatry*, 80(9):952–961. 3

Zillman, D. (1983). *Transfer of excitation in emotional behavior*. Guilford Press. 5

Appendices

Appendix A Figures and Table

A.1 Figure

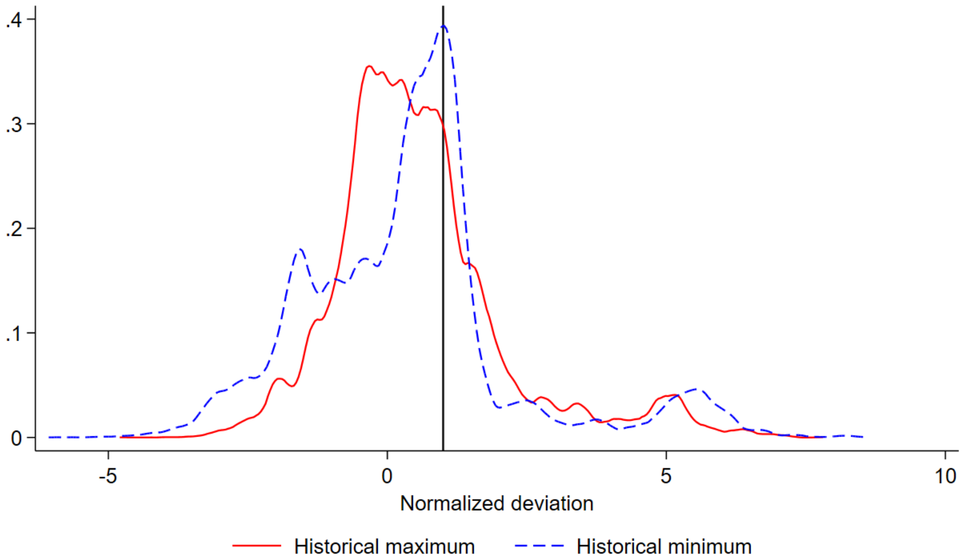

Fig. 5: Distribution of normalized deviation of annual maximum and minimum temperature of country-survey from historical mean

Notes: The normalized deviation is measured against the historical average of maximum (minimum) temperature up until a calendar year prior to recall months for a DHS interview. The vertical black line identifies the share of country-survey rounds where the deviation is greater than 1 standard deviation.

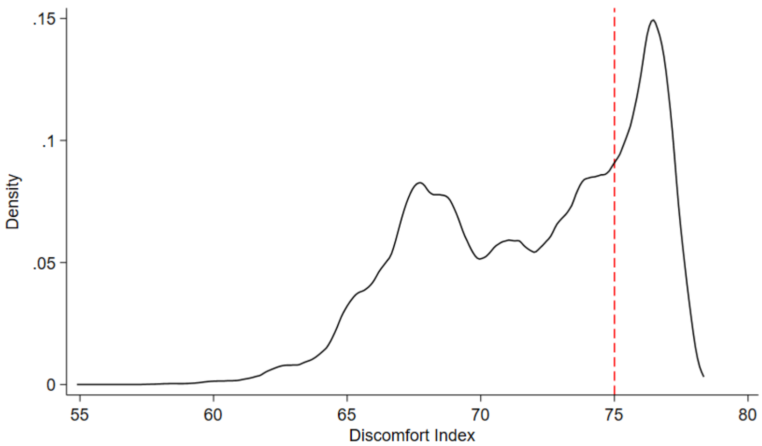

Fig. 6: Distribution of the Discomfort Index

Notes: The vertical red dashed line identifies the threshold beyond which values of the discomfort index are assigned as "uncomfortable" (Thom, 1959).

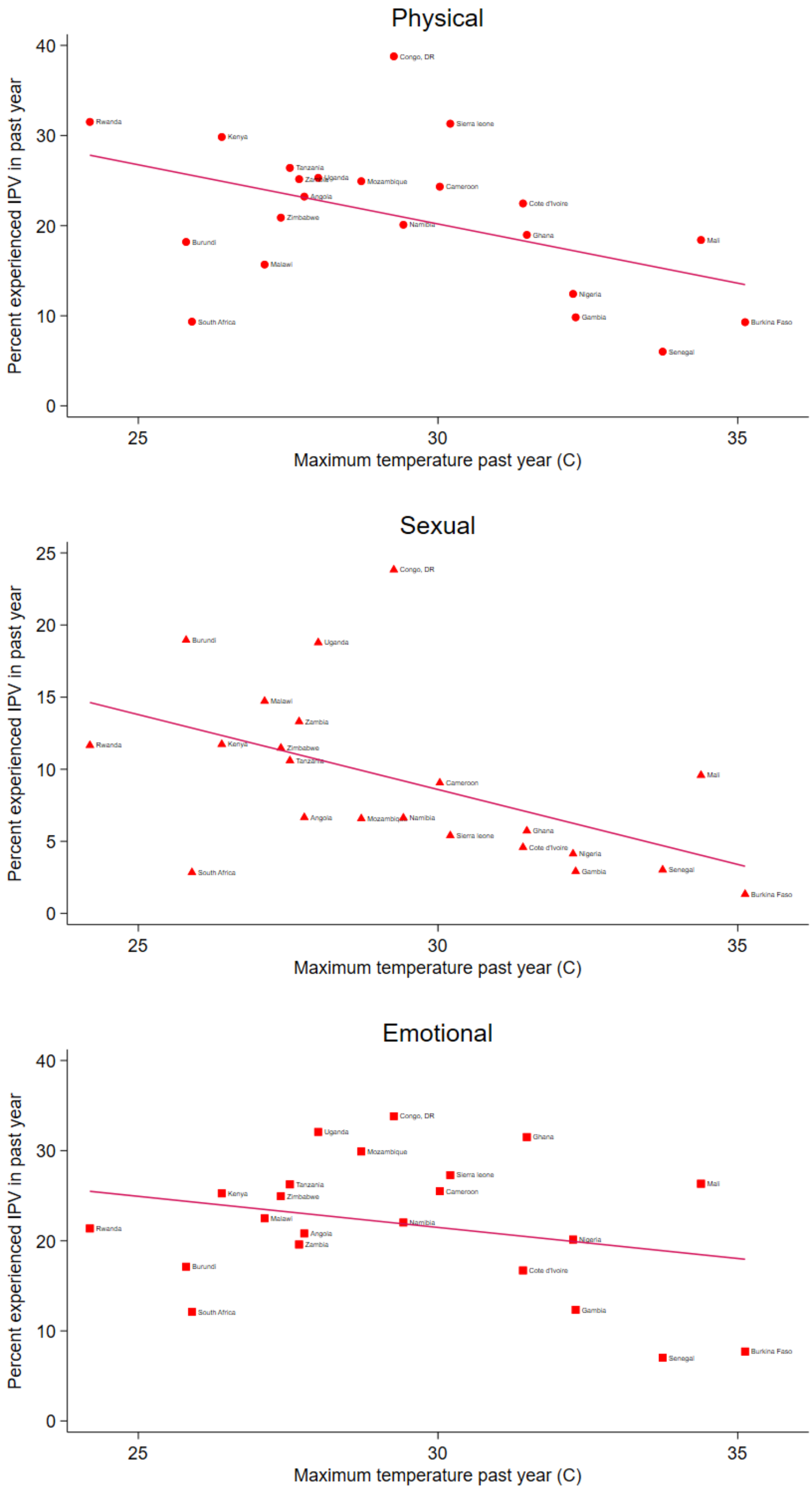

Fig. 7: Country-wise relationship between annual maximum temperature and IPV prevalence

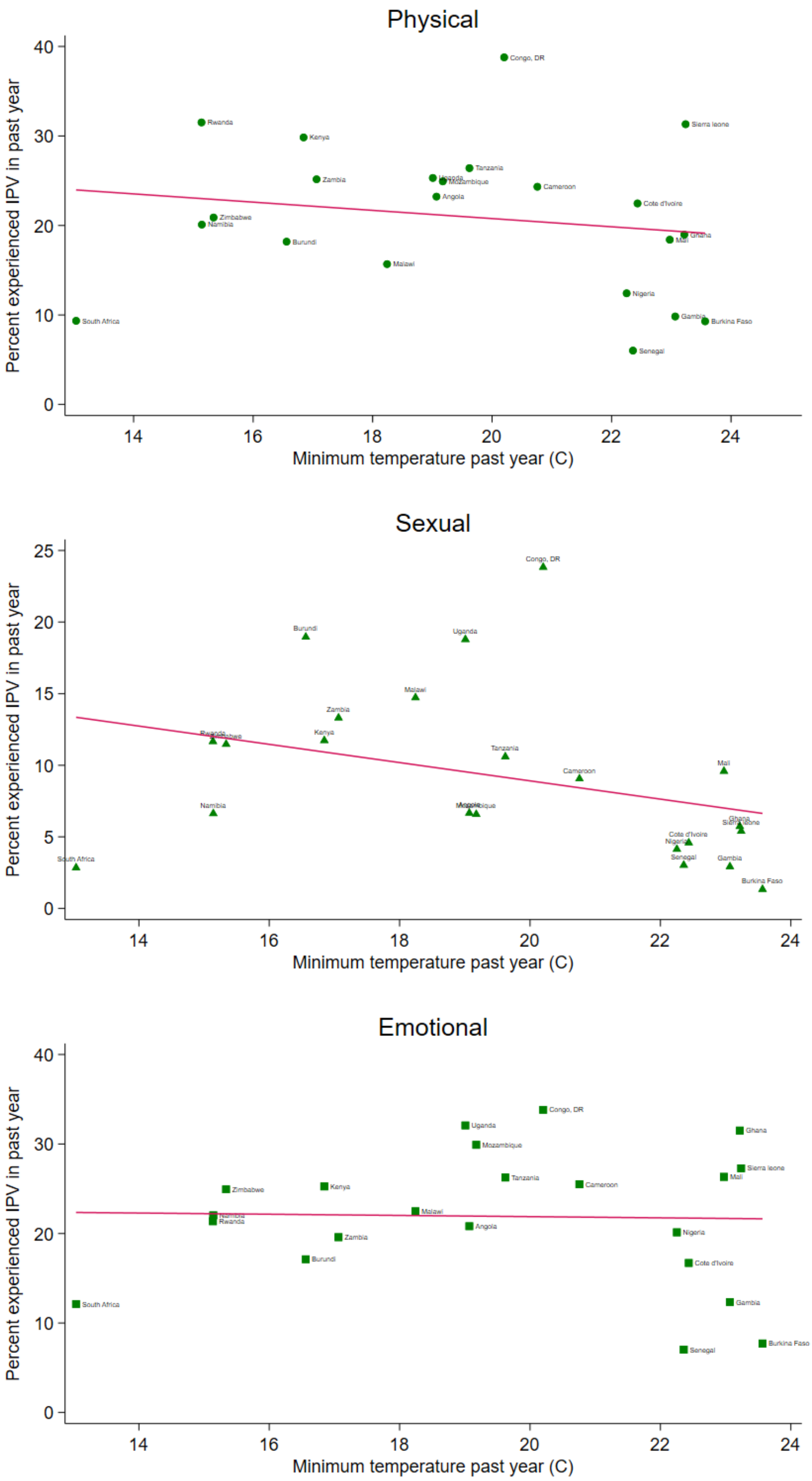

Fig. 8: Country-wise relationship between annual minimum temperature and IPV prevalence

A.2 Table

Table 13: Literature examining weather effects on IPV

Paper	Setting	Dataset/ Source	Method	Explanatory (Weather) variables	Outcome variables	Sign of effect
Rotton and Frey (1985)	Dayton, USA 1976-76	Calls to police department, monthly estimates by National Oceanic and Atmospheric Administration	Distributed lag analysis	Daily temperature, wind speed, humidity levels	Family and household disturbances	+ (hot and dry weather)
Cohn (1993)	Minneapolis, Minnesota	Calls to Minneapolis Police Department (1985, 87-88), National Weather Service	linear regression	Temperature, wind speed, precipitation	Domestic violence, rape	-
Sekhri and Storeygard (2014)	India (2002-07)	National Crime Records Bureau, Xie et al. (2002) data, Climate Research Unit University of East Anglia	Quasi-Maximum Likelihood	Negative rainfall shocks from long term annual district mean	Annual dowry deaths, domestic violence	+
Sanz-Barbero et al. (2018)	Madrid (2009-16)	Integral Monitoring System for Cases of Gender Violence (VioGen), State Meteorological Agency	Negative binomial and Poisson regressions	Daily max. temperature $> 34C$	Helpline calls, police reports on IP feminicide	+

Paper	Setting	Dataset/ Source	Method	Explanatory (Weather) variables	Outcome variables	Sign of effect
Abiona and Foureaux-Koppensteiner (2018)	Tanzania	Living Standards Measurement Study-Integrated Surveys on Agriculture	linear regression	Annual and seasonal Droughts; Floods	Self-reported IPV	+ (Droughts); Null (floods, mitigated by inheritance rights)
Diaz and Saldarriaga (2020)	Peruvian Andes (2005-14)	DHS, University of Delaware's Terrestrial Precipitation Gridded Monthly Time Series V 5.01, National Center for Atmospheric Research's Representative Concentration Pathways	Linear and conditional logistic regression	Floods (> 95th pct), Drought (< 5th pct)	Self-reported physical IPV	Null (Floods), + (Droughts)
Cools et al. (2020)	Sub-Saharan Africa (2003-13)	DHS, ERA-Interim Project	Linear regressions	Flood/drought last season and next-to-last season	Self-reported IPV	Null
Epstein et al. (2020)	Sub-Saharan Africa (2011-18)	DHS, Climate Hazards Group InfraRed Precipitation with Station	Logistic regression	Drought (in rainfall < 10th percentile)	Self-reported IPV	+ (Heterogeneity by age, employment)

Paper	Setting	Dataset/ Source	Method	Explanatory (Weather) variables	Outcome variables	Sign of effect
Henke and Hsu (2020)	USA	National Incident-Based Reporting System (FBI), Global Summary of the Day (NOAA), North America Land Data Assimilation System	Negative binomial	Daily maximum temperature by county	Daily count of physical assaults by county	+ (Women's bargaining has mitigating effect)
Stevens (2022)	New South Wales, Australia	Violent crime reports to police (Bureau of Crime Statistics and Research), Australian Water Availability Project	Negative binomial model	Daily mean maximum ambient temperature and humidity	Daily count of domestic violence	+ Heterogeneity (indoors vs outdoors, day of week, month)
Munala et al. (2023)	Uganda 2006, Zimbabwe 2010, Mozambique 2011	Integrated Public Use Microdata Series Demographic and Health Survey, Emergency Events Database	Logistic regression, multivariate model	Flood> five days, 10,000 people and droughts >= 1month	Self-reported IPV	+ Spouse controls (inc alcohol)
Zhu et al. (2023)	India, Nepal, Pakistan (2010-18)	DHS, ERA5	Multi-variable mixed-effects logistics regression	Annual mean temperature	Self-reported IPV	+ Annual cumulative precipitation (control)

Notes: The last column summarizes the sign of effect of the explanatory variables on outcome. - implies negative and + implies positive.

Appendix B Economic effects of temperature

Baysan et al. (2018) assume there are two agents $i \in I = 1, 2$ where each i can choose a violent or peaceful action $a \in A = V, P$. Labor input l is a numeraire and productivity is defined by θ. The cost of attacking for either agent is $c \in (o, 1]$ and the probability of i acquiring the other agent's resources when he/she attacks first is $p > 0.5$. The probability of acquiring resources when both agents attack simultaneously is $p = 0.5$. While the Baysan et al. (2018) model assumes that violence in time t is increasing with increasing temperature (τ), in this paper, I hypothesize a U-shaped relationship between temperature and violence.

$$\gamma_t = (\tau - \underline{\tau})^2 \tag{5}$$

Agents are indifferent between acting violent or peaceful when the returns from both actions (including the present discounted value of resources) are equal.

$$\theta_t + \delta V^P = p(2\theta_t(1-c) + \delta V^V) + \gamma_t \tag{6}$$

where δ is the discount factor, V^P is per-capita utility of consumption from the player's initial assets and V^V is per-capita expected utility from consumption of both their initial assets and the assets that they capture from their opponent.

The literature shows that temperature affects economic activity in the form of agricultural productivity and crop prices (Colmer, 2021), agricultural yield (Schlenker and Lobell (2010), Zhu and Troy (2018)) and manufacturing output (Adhvaryu et al., 2019). Following these findings, I assume that consumption is a function of temperature.

$$V^P = g(\tau) \quad \text{where} \quad g'(\tau) > 0 \text{ if } \tau < \underline{\tau} \tag{7}$$
$$g'(\tau) < 0 \text{ if } \tau > \underline{\tau}$$
$$V^V = f(\tau) \quad \text{where} \quad f'(\tau) > 0 \text{ if } \tau < \underline{\tau} \tag{8}$$
$$f'(\tau) < 0 \text{ if } \tau > \underline{\tau}$$

Substituting (1), (3) and (4) in (2):

$$\theta_t + \delta g(\tau) = p(2\theta_t(1-c) + \delta f(\tau)) + (\tau - \underline{\tau})^2$$

Differentiate with respect to τ:

$$\delta g'(\tau) = p\delta f'(\tau) + 2\tau - 2\underline{\tau}$$
$$\tau^* = \frac{\delta}{2}[pf'(\tau) - g'(\tau)] - \underline{\tau}$$

The optimal temperature threshold may differ based on whether there are economic effects of temperature. If consumption is not affected by temperature: $f'(\tau) = g'(\tau) = 0$ and $\tau^* = \underline{\tau}$. When consumption is affected by temperature: $\tau^* \lesseqgtr \underline{\tau}$. Therefore, at a given temperature the effect size on IPV may vary.

Appendix C Discomfort Index

The ERA5 reports daily dry bulb temperature and dewpoint temperature (in K). I estimate the discomfort index proposed by Thom (1959) using the following steps:

1. Convert dry bulb and dew point temperature in Celsius

2. Estimate Relative Humidity (%) using Bolton (1980)

$$RH = 100 * (e/e_s) \tag{A.1}$$

   where

$$e_s = 6.11 * exp((17.67T_{dry})/(T_{dry} + 243.5))$$
$$e = 6.11 * exp((17.67T_{dew})/(T_{dew} + 243.5))$$

3. Estimate wet bulb temperature (T_w) using equation 1 in Stull (2011)

$$\begin{aligned} T_{wet} =& T_{dry} * \arctan[0.151977(RH\% + 8.313659)^{1/2}] + \arctan(T + RH\%) \\ &- \arctan(RH\% - 1.676331) \\ &+ 0.00391838(RH\%)^{3/2} \arctan(0.023101 RH\%) - 4.686035 \end{aligned} \tag{A.2}$$

4. Discomfort Index (expressed in Fahrenheit):

$$DI = 0.4(t_d + t_w) + 15 \quad \text{where } t_d, t_w \text{ are expressed in F} \tag{A.3}$$