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BURNING RAGE: HOW HEAT SHAPES GENDER-BASED VIOLENCE

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Abstract

We investigate the impact of temperature on gender-based violence (GBV) in Italy, focusing on femicides and calls to the 1522 helpline, a public service for victims of GBV and stalking. Both femicides and helpline calls increase significantly with warmer temperatures, particularly during elevated nighttime temperatures, suggesting that extreme heat may contribute to GBV by disrupting sleep or influencing social interactions. To better understand the underlying mechanisms, we consider key contextual factors at the provincial level. We find that environmental, social, and institutional factors interact in shaping the response of GBV to heat.

JEL Class.: J12, J16, Q51, Q54.

Keywords: Climate change, temperatures, gender-based violence, domestic abuse.

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Burning Rage: How Heat Shapes Gender-Based Violence*

Carmen Aina, Lavinia Parisi and Matteo Picchio

1 Introduction

The promotion of gender equality and the elimination of gender-based violence (GBV) remain central global priorities, as emphasized by the United Nations Sustainable Development Goal 5 (SDG 5).[1] Despite advances in legislation and the expansion of support services, intimate partner violence (IPV) and femicide continue to occur at troubling levels in many countries, including Italy. The consequences of GBV extend beyond individual suffering, generating substantial social and economic costs through their impact on health, productivity, public services, and long-term well-being.

In the Italian context, GBV remains pervasive. Between 2017 and 2021, emergency room visits related to violence increased from 14.1 to 18.3 per 10,000 inhabitants (Istat, 2023a), while calls to the 1522 national helpline, dedicated to supporting victims of domestic abuse and stalking, have steadily increased (Istat, 2023b). Although legal reforms, such as Law No. 69/2019, have aimed to strengthen protections and improve judicial responses, persistent gaps in enforcement, access to services, and structural prevention raise concerns about the overall effectiveness of current interventions.

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[1]See https://www.un.org/sustainabledevelopment/gender-equality/ (last accessed August 5, 2025).

Alongside these structural challenges, a growing body of interdisciplinary research suggests that GBV may also respond to environmental stressors, particularly those linked to climate change. High temperatures are increasingly associated with elevated aggression, emotional dysregulation, and interpersonal violence through physiological and behavioral mechanisms such as sleep disruption, dehydration, and increased time spent indoors. In particular, sustained nighttime heat has been shown to impair rest and increase irritability, heightening the risk of domestic conflict. Empirical studies from the United States, India, and Latin America have documented temperature-induced increases in violent crime, including IPV and femicide, especially under conditions of low adaptive capacity (e.g., Anderson, 2001; Ranson, 2014; Sanz-Barbero et al., 2018; Behrer and Bolotnyy, 2022)

This paper contributes to this emerging literature by investigating whether short-term fluctuations in ambient temperature influence GBV in Italy. Using weekly data on femicides and calls to the 1522 helpline from 2013 to 2022, matched with high-resolution meteorological information, we estimate the causal effect of maximum and minimum weekly temperatures on GBV outcomes, exploiting within-province deviations from monthly temperature norms and controlling for air pollution, other weather conditions, and province-specific time trends. We find that higher temperatures, particularly high nighttime heat, are associated with a significant increase in both help-seeking behavior and lethal violence. These effects are robust to multiple specifications and persist when excluding the COVID-19 lockdown period. Heterogeneity analyses reveal that helpline calls respond more strongly to heat in provinces with lower levels of educational attainment, and stronger labor market conditions, suggesting a role for both vulnerability and empowerment in shaping help-seeking behavior. Conversely, femicides increase more markedly in areas with widespread air conditioning and conservative gender norms, highlighting the importance of household exposure and normative constraints in the escalation to fatal violence.

The remainder of the paper is organized as follows. Section 2 reviews the literature on temperature, aggression, and GBV. Section 3 describes the data and the empirical strategy. Section 4 presents the main results, including heterogeneity and robustness checks. Section 5 concludes and discusses policy implications.

2 Previous studies on temperature and violence

Climate and environmental conditions exert a significant influence on human behavior, crime rates, and public health outcomes. Variability in climate, particularly temperature extremes, rainfall patterns, and natural disasters, has been shown to affect various forms of violence, including GBV such as IPV.[2]

Researchers have examined a wide range of meteorological and environmental factors, as well as diverse categories of crime. With regard to climate conditions, numerous studies have analyzed the impact of temperature, consistently finding that higher temperatures are positively correlated with higher rates of violent crime (Anderson and Anderson, 1996; Ranson, 2014). The role of seasonality has also been explored, showing that violent crime tends to peak during the summer months, while property crimes may decline due to changes in routine activities (LeBeau and Corcoran, 1990; Cohn, 1993). In terms of precipitation and humidity, rainfall has been found to reduce opportunities for outdoor crimes, whereas high humidity may exacerbate heat-induced aggression (Rotton and Cohn, 2000). Extreme weather events, such as hurricanes and heatwaves, have been associated with increased social disorder (Miles-Novelo and Anderson, 2019), while growing evidence points to air pollution as a further driver of aggression and criminal behavior (Burkhardt et al., 2019; Herrnstadt et al., 2021; Baryshnikova et al., 2022). Taken together, this body of research underscores the environmental sensitivity of violence, a dimension that is often underappreciated despite its relevance.

In terms of types of crime, existing research includes analyses of the effects of climate conditions on violent crimes, property crimes, and, notably, GBV, which is the primary focus of our study. Numerous studies highlight a strong correlation between high temperatures and increased violent crime. For example, Michel et al. (2016) found that violent crime, particularly gun-related offenses, increased with rising temperatures in Baltimore (2007-2013), while rain and snow were associated with reduced criminal activity. Berman et al. (2020) analyzed 14 years of data in 436 US counties, revealing that a 10°C increase in temperature led to about 12% increase in violent crime, the effect being more pronounced in low-income communities. Behrer and Bolotnyy (2022) studied Texas (2010-2017) and found that violent crime increased by 15% on hot days, particularly gun-related offenses. Li et al. (2023), in their global analysis of 140 countries, found that hotter temperatures and extreme weather events exacerbated violence, especially in regions facing

[2]See Choi et al. (2024) and Corcoran and Zahnow (2022b) for comprehensive reviews.

economic instability, while wealthier nations were less affected due to climate resilience. Property crimes also appear to be influenced by weather conditions. Cohn and Rotton (2000) showed that temperature is a significant predictor of property offenses. Hu et al. (2024) demonstrated that short-term temperature spikes, particularly in cities with large seasonal variations, increased assaults and robberies. Additionally, Blakeslee and Fishman (2018) found that droughts and heatwaves in India significantly raised property crime rates, suggesting that economic stress driven by extreme weather can lead to theft and burglary.

Unlike street crime, which is influenced by routine activities and outdoor interactions, GBV primarily occurs in private settings, where most incidents of intimate partner violence take place, and it is likely shaped by psychological, economic and social stressors. Research indicates that rising temperatures, extreme weather events and climate variability can exacerbate GBV, particularly IPV, through key mechanisms that can be categorized into psychological, economic, social, and structural factors.

Psychologically, extreme heat increases stress, irritability, and aggression, all of which contribute to higher rates of IPV. Several studies highlight this mechanism, noting that heatwaves are linked to an increase in IPV (Sanz-Barbero et al., 2018), heightened domestic conflicts (Choi et al., 2024), and emotional abuse (Rai et al., 2021). Prolonged exposure to high temperatures, as observed by Ranson (2014) and Stevens et al. (2021), leads to frustration and irritability, which can escalate tensions within households and foster a conducive environment for IPV.

Economically, climate-induced financial strain, such as that caused by droughts, heatwaves, and climate shock, heightens stress and contributes to IPV. These environmental stressors can lead to crop failures, job losses, and financial hardship, exacerbating household tensions. For example, research shows that droughts increase IPV in agricultural households (Epstein et al., 2020), while extreme weather events that induce income loss have been linked to higher rates of physical and sexual violence (Díaz and Saldarriaga, 2023). Climate shocks may contribute to male unemployment, which increases power imbalances and control over women, reinforcing GBV (Le and Nguyen, 2024). Additionally, food insecurity, exacerbated by climate change, further escalates IPV, as economic strain increases male frustration (Agrawal et al., 2023), and dowry-related violence in India rises during droughts as families struggle with financial obligations (Sekhri and Storeygard, 2014). High temperatures also reduce productivity and income, particularly for low-income families reliant on outdoor work, which further amplifies economic stress and, consequently, IPV (Agnew, 2012).

Socially and behaviorally, extreme weather and temperature changes disrupt daily routines, affecting where people spend their time and how they interact, which in turn increases the risk of GBV. Studies indicate that extreme heat often forces women to remain indoors for longer periods, increasing their exposure to abusive partners (Schinasi and Hamra, 2017; Cools et al., 2020). Additionally, extreme weather events like hurricanes and floods lead to displacement, putting women at higher risk of sexual violence in temporary shelters (Rai et al., 2021).

Finally, structural and policy-related factors may play a significant role in amplifying IPV during climate-induced crises. In many climate-affected regions, the lack of strong legal protections, social safety nets, and crisis response systems makes it more difficult for women to escape abusive situations during extreme weather events. For example, climate-driven IPV is particularly severe in countries with weak women's rights protections (Díaz and Saldarriaga, 2023), and gender inequality worsens the effects of climate change, as women in lower-income households have fewer options to leave abusive relationships (Epstein et al., 2020). Disaster response systems often fail to address GBV, leaving women at greater risk in refugee camps and emergency shelters (Agrawal et al., 2023). Studies such as Zhu et al. (2023) show that a 1°C increase in annual mean temperature is associated with a 4.5% rise in IPV prevalence in low- and middle-income South Asian countries.

Although GBV is widely recognized as a severe manifestation of gender inequality and one of the most widespread human rights violations of our time (EIGE, 2014), the causal effect of temperature and its underlying mechanisms remain unclear. By studying the causal impact of temperature on GBV in Italy, we contribute to the literature from several perspectives. First, while existing evidence is largely correlational and concentrated in low- and middle-income countries, we focus on a high-income, institutionalized setting where climate resilience and legal protections differ significantly from previously studied contexts. Second, we explore heterogeneity across key contextual factors at the provincial level, such as geographical area, prevalence of air conditioning, socio-economic conditions, and indicators of societal gender norms and institutional support. This allows us to shed light on the role of environmental, social, and institutional factors in shaping the response of GBV to temperature variations. Third, by showing whether and how temperature-driven stressors translate into increased GBV even in the presence of formal support systems, we provide valuable insights for policy-making regarding the social and economic costs of a changing climate. Hence, our study helps bridge a critical gap in the literature by moving beyond correlational analysis to better understand the relevance and mechanisms of climate-induced GBV.

3 Method

3.1 Data and sample

To measure the intensity of GBV, we used two different data sources. First, we exploited data gathered by the Italian National Institute of Statistics (Istat), consisting of the count of the calls to the 1522 helpline from each province and each week from the beginning of 2013 until the end of 2022.[3] The 1522 helpline,[4] a public service initiated by the Presidency of the Council – Department for Equal Opportunities in 2006, operates around the clock and is available at no cost. This service provides specialized professionals offering assistance and support to victims of violence and stalking. The calls are distinguished between those made by victims – i.e. individuals who personally experienced some form of intra and extra-family GBV – and those made by non-victims – i.e., callers who witnessed GBV or sought information or support related to GBV or stalking. For our empirical analyses, we use exclusively calls made by victims to 1522. The dataset contains only calls classified as consistent with the nature of the service provided. Although 1522 operators collect socio-demographic information on the callers and information on the call (e.g., reason for the call, type of violence, and location), Istat does not release data at province-by-week level further disaggregated by these characteristics to protect the privacy of the individuals involved.[5]

Analyzing the impact of temperature only on calls to the 1522 helpline may provide a limited and potentially biased view of the causal relationship between temperature and GBV. In fact, extreme heat may have behavioral consequences that go beyond increased

[3]The 1522 helpline dataset can be downloaded from the Istat webpage: https://www.istat.it/notizia/il-numero-di-pubblica-utilita-1522-anni-2013-2024 (last accessed August 5, 2025). At the time of conducting the empirical analysis and writing the paper, the dataset covered the period 2013-2022. In late 2024, its coverage was extended to include data up to the third quarter of 2024.

[4]See https://www.1522.eu/?lang=en (last accessed August 5, 2025).

[5]In November 2023, we requested weekly counts of 1522 calls at the province level disaggregated by socio-demographic characteristics and type of violence but the Istat contact center denied our request due to a privacy protection issue concerning the individuals involved. In October 2024, we requested invalid 1522 calls; also this request was denied.

aggressiveness, emotional dysregulation, and interpersonal violence. For example, it may also affect the reporting behavior of victims in an ambiguous way. On the one hand, extreme heat may discourage victims from reporting due to fatigue and reduced mobility during heatwaves, leading to an under-reporting bias that masks the true effect on violence. On the other hand, heat may facilitate reporting if, for example, women spend more time online at home and become more aware of GBV campaigns and helpline services. Distinguishing between a genuine impact of heat on GBV and a change in reporting behavior using helpline calls alone is therefore a challenging identification issue.

The second data source aims to overcome this limitation. We extracted femicide data for Italy from the annual reports written and published by "Casa delle Donne",[6] an association that offers help and support to women who have been threatened or subjected to violence. Each annual report provides a comprehensive list of femicides that occurred in Italy during the respective year. For each victim, the report includes the date, municipality, and province of the incident, along with individual details such as the woman's age and the weapon used in the crime. Since the data on 1522 helpline calls are weekly and at the provincial level from 2013 until 2022, we aggregated the femicide data on the weekly and provincial level in the same time window. Unlike helpline calls, femicides are observable events that cannot easily go unreported, because a death is a verifiable, recorded event. Femicides are therefore largely independent of victim's reporting behavior.

We merged these datasets with meteorological data from the Copernicus Programme, the European Union's Earth Observation initiative. Specifically, we used the E-OBS dataset, which provides daily gridded land-only observational data for Europe.[7] We downloaded meteorological data, including precipitation, wind speed, relative humidity, and daily temperature (average, maximum, and minimum) measured at 2 meters above ground level, with a horizontal grid resolution of $0.25° \times 0.25°$ (about 28 square kilometers). This data covers the period from January 1, 2013, to December 31, 2022. Moreover, within the same time frame, we obtained daily data from the Copernicus Atmosphere Monitoring Service's global greenhouse gas reanalysis (EGG4) (Inness et al., 2019). This dataset comprises measurements of particulate matter with a diameter of less than 2.5 micrometers ($PM_{2.5}$) and ozone (O_3). The dataset features a horizontal resolution of $0.75° \times 0.75°$. These air pollution measures will be used as control variables, because they may be corre-

[6]These reports can be downloaded from https://femicidiocasadonne.wordpress.com/ricerche-pubblicazioni (last accessed August 5, 2025).

[7]For more details, see https://cds.climate.copernicus.eu/datasets/insitu-gridded-observations-europe?tab=overview (last accessed August 5, 2025).

lated with meteorological conditions, like temperatures (Liu et al., 2020), and with criminal or violent activities, because air pollution may impact the central nervous system through mechanisms involving ultrafine toxicants or by triggering an inflammatory response (Xu et al., 2013).

We matched the weekly data on 1522 helpline calls and on femicide with the daily meteorological and atmospheric data by first collapsing to weekly averages the daily meteorological and atmospheric variables and, second, by using the latitude and longitude of the provincial capital. Consequently, as in Filomena and Picchio (2024), we used the meteorological conditions within the 0.25°×0.25° latitude/longitude grid encompassing the provincial capital to approximate the conditions for the entire province.[8] This approach may introduce a measurement error, potentially biasing toward zero our estimated effects. However, this issue is mitigated by two factors. First, the distribution of the population within the provinces is uneven, with a higher concentration in the provincial capitals. Despite provincial capitals occupying only 6.8% of the Italian land area, they house approximately 30% of the population.[9] Second, our identification strategy is based on deviations of the weekly average temperature from the monthly average temperature for the same province. This short-term deviation is likely to be more evenly distributed throughout a province compared to weekly temperature variations because of the strong spatial correlation of climatic events. The final dataset includes 109 provinces, excluding Brindisi due to incomplete wind speed data.[10] Observations span a maximum of 522 weeks from 2013 to 2022, totaling 55,905 province-week observations. Meteorological data were missing for some weeks in the following provinces: Agrigento, Caltanissetta, Catania, Catanzaro, Enna, Messina, Palermo, Ragusa, Reggio Calabria, Siracusa, Trapani, and Vibo Valentia. These provinces have between 411 and 492 weekly observations instead of the full 522.

Table 1 displays the summary statistics of the outcome variables and the set of covariates, both meteorological and atmospheric variables, which are used in the empirical analysis. The average number of victims' weekly calls to the 1522 helpline is about 0.32 per 100,000 inhabitants. The average number of femicides in a province per week

[8] The average surface area of Italian provinces is approximately 2,800 square kilometers. This range includes provinces that exceed 7,000 square kilometers, such as Sassari and Bolzano, as well as those that are smaller than 400 square kilometers, such as Prato and Trieste.

[9] These figures pertain to 2015 and are sourced from the Atlante Statistico dei Comuni (Istat, https://asc.istat.it/ASC/asc.html, last accessed August 5, 2025).

[10] Italy had 110 provinces from 2005 until 2016, when the number was reduced to 107.

is 0.044. The number of femicides is a count variable, extremely skewed to the right, with a very large proportion of zeros (98.1%), 1.8% of the observations (991 cases) with one femicide and the remaining 1.1% (59 observations) with two of more femicides in a week.[11] The weekly average of the maximum temperature is 19.7°C, ranging from -8°C to almost 40°C. The weekly average of the minimum temperature is about 10°C lower. Figure 1 visualizes the differences between provinces in the calls of victims to the 1522 helpline, femicides, and the maximum temperature, after averaging across weeks from the beginning of 2013 to the end of 2022.

Table 1: Summary statistics

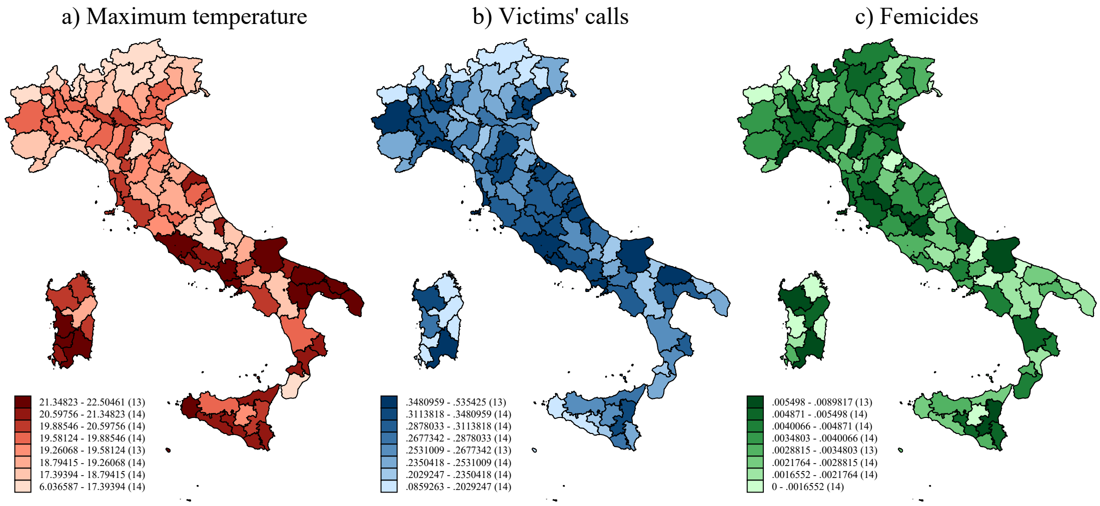
	Average	Std. Dev.	Min.	Max.
a) Outcome variables				
Weekly victims' calls per 100,000 inhabitants	0.324	0.295	0.000	4.625
Weekly femicides	0.044	0.223	0.000	4.000
b) Covariates (weekly averages)				
Maximum daily temperatures (°C)	19.724	7.732	-8.021	39.569
Minimum daily temperatures (°C)	10.561	6.762	-16.003	27.851
Average daily temperatures (°C)	14.979	7.158	-12.067	32.409
Wind speed (m/s)	2.431	0.754	0.404	12.640
Precipitation (mm/m^2)	2.185	3.055	0.000	47.986
$PM_{2.5}$ (mg/m^3)	0.013	0.006	0.001	0.208
Ozone (mg/kg)	0.071	0.025	0.002	0.148
# of observations				55,905
# of weeks				522[(a)]
# of provinces				109[(b)]

Notes: Summary statistics are weighed by provincial population retrieved from the Atlante Statistico dei Comuni of Istat.
[(a)] The meteorological data were not available on all the weeks of the observed time window for the following provinces: Agrigento, Caltanissetta, Catania, Catanzaro, Enna, Messina, Palermo, Ragusa, Reggio Calabria, Siracusa, Trapani, and Vibo Valentia. They had between 411 and 492 weekly observations instead of 522.
[(b)] We could not use data for the province of Brindisi because information about the wind speed was missing.

Figure 2 presents the unconditional relationship between maximum temperatures and 1522 helpline calls when callers are victims (panel a) or femicides (panel b). These graphs show the smoothed values of kernel-weighted local first-order polynomial regression of our GBV outcomes on the weekly average of the daily maximum temperatures. There is a marked increase in victim call rates as temperatures rise to approximately 10°C. Beyond this point, the relationship becomes negligible until 27°C, after which victims' calls begin to rise again, although at a modest rate. In the case of femicides (panel b of Figure 2), the upward trend is more pronounced, particularly above 30°C, where the increase becomes

[11] After weighting by provincial population, the proportion of zeros is 96%, the proportion of observations with one femicide is 3.7% and the one with two of more femicides is 0.3%.

Figure 1: Weekly averages of maximum temperatures (°C), weekly victims' 1522 calls (per 100,000 inhabitants) and weekly femicides (per 100,000 inhabitants) across Italian provinces (2013-2022 averages)

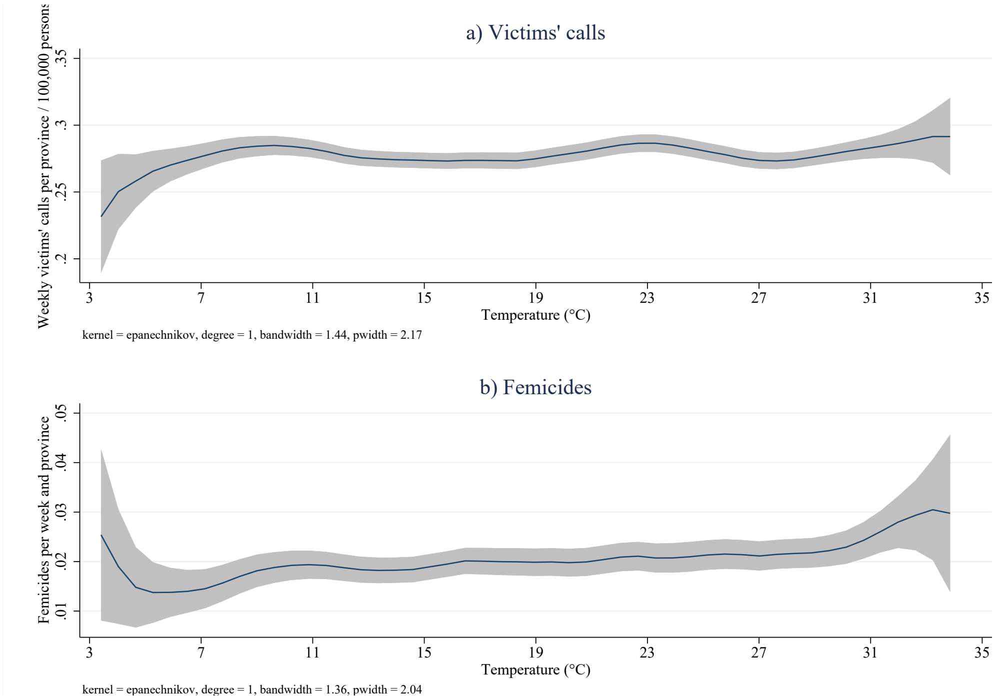


notably steep. To establish a credible identification of the causal impact of temperatures on GBV, as measured by either the number of calls to the 1522 helpline or incidents of femicide, we estimated regression models conditioned on the covariates listed in Table 1. Additionally, we incorporated fixed effects (FE) at the month-year-province level and at the sequential week level to mitigate potential omitted variable bias. Moreover, by including month-year-province FE, we exploit the deviation of the weekly average temperature from the monthly average in a given province as plausibly exogenous identifying information, conditional on a common time trend, captured by the sequential week FE, and the meteorological and air quality variables reported in Table 1.

3.2 Empirical strategy

Recent years have seen a rapid expansion in empirical research utilizing non-experimental data to examine the influence of weather conditions on economic outcomes (Dell et al., 2014). In this context, a robust method for identifying causal effects relies on longitudinal high-frequency data and the short-term temporal variation of weather conditions within a specific spatial unit. By exploiting this presumably exogenous short-term variation in weather variables, it becomes feasible to determine the impact of temperature on outcomes such as GBV.

Figure 2: Kernel-weighted local polynomial smoothing of the relation between GBV outcomes and weekly average of daily maximum temperatures



Notes: This figure is obtained using 54,786 observations: from the original 55,905 observations we excluded the first and last percentiles of the weekly maximum temperatures, which correspond to 3.4°C and 33.9°C, respectively. The gray area shows the 95% confidence interval.

When the outcome variable y_{it} is the weekly number of victims' calls to the 1522 helpline per 100,000 inhabitants, we estimate the following linear model:

$$y_{it} = f(temp_{it}; \boldsymbol{\beta}) + \boldsymbol{\alpha}\mathbf{x}_{it} + \delta_t + \gamma_{im} + \varepsilon_{it}, \tag{1}$$

where $i = 1, \dots, 109$ indexes the 109 provinces and $t = 1, \dots, 522$ refers to the different sequential weeks in our observed time window spanning from January 2013 until December 2022; δ_t is the sequential-week FE; γ_{im} is the month-year-province FE; $f(temp_{it}; \boldsymbol{\beta})$ is a step function of the weekly average temperature and $\boldsymbol{\beta}$ is the parameter vector associated with the linear combination of indicators of temperature intervals; $\mathbf{x}_{it}$ is a $1 \times K$ vector of other weather and air quality characteristics which are likely to be correlated with both temperatures and to aggressiveness and, therefore, GBV; finally, ε_{it} is the idiosyncratic error term. When the outcome variable y_{it} is the number of femicides in province i in week t, given the count nature of this variable, we took the exponential of the right-hand side of Equation (1), resulting in the Poisson regression model which is estimated by pseudo-maximum likelihood. We weighted each regression by the provincial population registered at the beginning of the year of the observation.

Sequential-week FE, denoted as δ_t, controls for weekly shocks common at the national level. Hence, it flexibly captures the national trend in GBV over time. It removes from estimates the fact that GBV may vary over particular weeks of the year, different months of the year, and different years. The scientific literature suggests that GBV exhibits seasonal patterns (Landau and Fridman, 1993). For example, the sequential-week FE accounts for the increase in domestic violence during major holidays (Cohn, 1993) or during big sporting events (Brimicombe and Cafe, 2012; Kirby et al., 2014; Forsdike et al., 2022), which occur at particular times of the year and, therefore, are correlated with particular weather conditions.

The month-year-province FE, denoted as γ_{im}, accounts for potential variations in GBV that could arise from changes in local labor market conditions and the business cycle. More specifically, it allows us to base our identification strategy on the exogeneity of weekly temperature deviations relative to the average temperature in the same month and province.

To avoid imposing stringent parametric constraints on $f(temp_{it}; \boldsymbol{\beta})$, we employed a step function to describe the relationship between weekly average maximum temperatures and 1522 helpline calls. We partitioned the range of weekly average maximum temperatures into bins of equal size, each spanning two degrees Celsius. The first bin captures maximum temperatures below 4°C, while the last bin includes maximum temperatures above 30°C. We selected the bin $(6, 8]$°C as a reference category and excluded its corresponding indicator variable from the regressors in Equation (1).[12]

Finally, the idiosyncratic error term may exhibit correlation within both sequential weeks t and province i. The correlation across sequential weeks may arise from anomalous weather events, such as heatwaves or cold spells, which tend to affect large areas and create spatial correlation among observations from different provinces during those weeks. Furthermore, since our climate-gridded dataset was derived using spatial interpolation from station data, it is very likely to be characterized by spatial correlation in temperature shocks (Hsiang, 2016). Concerning the correlation within provinces, each area has unique characteristics related to geography, climate, social norms, labor market conditions and business cycle. Consequently, we suspected that the observations might not be independent over time within a province. To address this, we made inference using the two-way cluster variance estimator proposed by Cameron et al. (2011), clustering at both the provincial and sequential month levels.[13] This estimator of the variance-covariance matrix is robust to heteroskedasticity, serial correlation within provinces, and cross-sectional spatial correlation.

4 Results

4.1 Main results

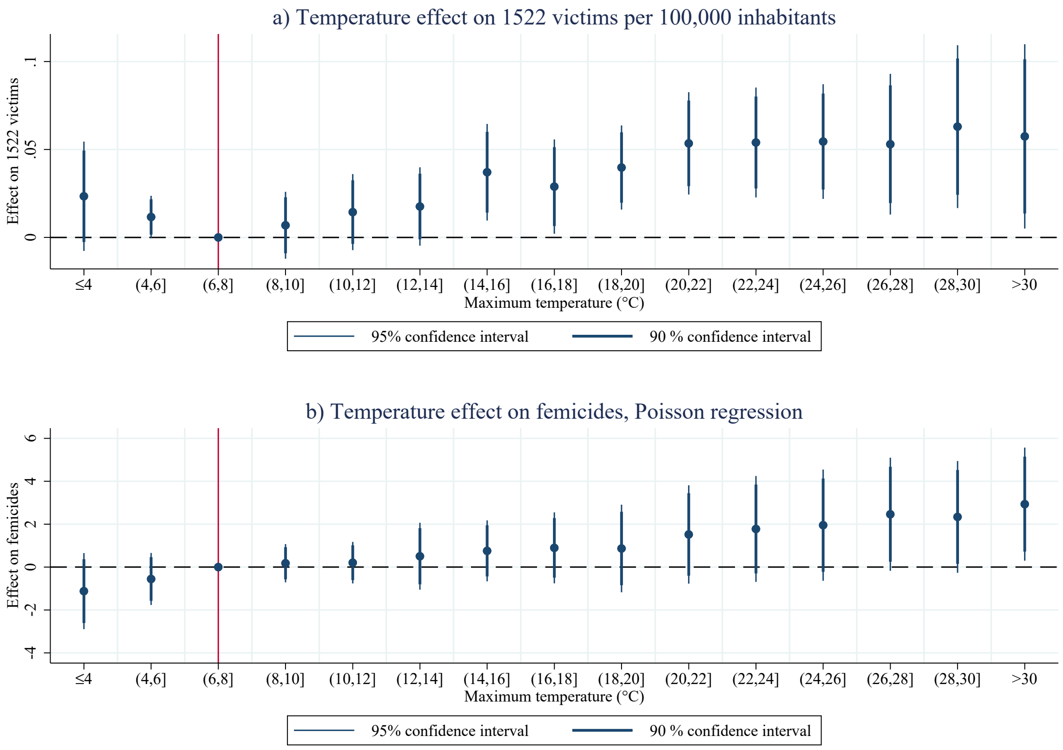
Figure 3 reports our main findings. It displays the estimated coefficients of each temperature bin, using the 6-8°C range as the reference category. The complete set of estimation results are reported in Table 2. Heat affects victims' calls and femicides in a similar way: as temperatures rise, both the victim call rate and the number of femicides exhibit an increasing pattern. When weekly maximum temperatures exceed 28°C, the victim call rate peaks, being 0.057-0.063 points higher than that at 6-8°C, which is approximately

[12]This normalization does not affect the generality of the results.

[13]We had 109 provinces and 120 sequential months, providing a sufficiently large number of clusters in both dimensions. We run a sensitivity analysis to check if inference would change by either clustering at the sequential week level or by not addressing the concern of spatial correlation at all, i.e. by not clustering observations at whatever time unit. This robustness check is discussed in Subsection 4.4.

19-21% larger than the victim call rate at the reference temperature of 6-8°C (0.307). [14] When average maximum temperatures exceed 30°C, the expected number of femicides is almost 300% higher than at 6-8°C.

Figure 3: Effect of weekly average maximum temperature on weekly calls to 1522 helpline by victims (panel a) and on femicides (panel b)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of victims' helpline calls per 100,000 inhabitants is 0.307 at 6-8°C. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

[14]Note that the victims' call rate becomes significantly higher than that at the reference temperature bin already at 14–16°C. Since these figures represent weekly averages of maximum temperatures, this result may reflect a few particularly hot days within the week and thus explain why an effect is already observed at temperatures that, on average, are not yet extremely high.

Table 2: Estimation of GBV equation

Outcome:	Victims' calls per 100,000 inhabitants	Femicides
Regression model:	Two-way FE	Poisson pseudo-likelihood
	(1)	(2)
Weekly average of maximum daily temperature - Reference: $(6, 8]°C$		
< 4°C	0.0234	-1.1220
	(0.0157)	(0.9045)
$(4, 6]$°C	0.0116*	-0.5559
	(0.0061)	(0.6192)
$(8, 10]$°C	0.0069	0.1796
	(0.0096)	(0.4550)
$(10, 12]$°C	0.0144	0.2047
	(0.0109)	(0.4939)
$(12, 14]$°C	0.0176	0.5056
	(0.0112)	(0.7957)
$(14, 16]$°C	0.0371***	0.7565
	(0.0139)	(0.7251)
$(16, 18]$°C	0.0289**	0.8973
	(0.0135)	(0.8442)
$(18, 20]$°C	0.0398***	0.8671
	(0.0121)	(1.0414)
$(20, 22]$°C	0.0535***	1.5214
	(0.0147)	(1.1694)
$(22, 24]$°C	0.0540***	1.7767
	(0.0158)	(1.2598)
$(24, 26]$°C	0.0545***	1.9542
	(0.0164)	(1.3227)
$(26, 28]$°C	0.0530***	2.4626*
	(0.0202)	(1.3455)
$(28, 30]$°C	0.0630***	2.3382*
	(0.0234)	(1.3301)
> 30°C	0.0574**	2.9346**
	(0.0264)	(1.3453)
Wind speed (m/s)	0.0040	-0.4428**
	(0.0032)	(0.2106)
Precipitation (mm/m^2)	0.0001	0.0239
	(0.0006)	(0.0346)
PM$_{2.5}$	0.8467	14.1095
	(0.5150)	(21.4562)
Ozone (mg/kg)	0.2062	-15.9467
	(0.3854)	(18.4229)
# of observations	55,896	3,825
# of months	120	120
# of provinces	109	105
Adj. R-Square / Pseudo R-Square	0.4828	0.1531
Joint significance test H_0: $\boldsymbol{\beta} = \mathbf{0}$, p-value	0.0050	0.0618

Notes: * p-value<0.10, ** p-value<0.05, *** p-value<0.01. Two-way clustered standard errors are in parenthesis; clusters are at the level of sequential months and of provinces. Each regression includes sequential week FE and month-year-province FE and is weighted by the provincial population during the year of the observation. The number of observations is lower than what shown in Table 1 because: in column (1) 9 observations were singleton observations; in column (2) 52,080 observations were singletons or separated by a fixed effect. Separated observations, e.g. perfectly predicted observations after conditioning on high dimensional fixed effects, do not offer information about the parameters with interior solutions and can be safely dropped when searching the maximum of the pseudo-likelihood function (Correia et al., 2020, 2021).

4.2 Can sleep quality trigger violence?

Exposure to excessive heat can alter cognitive performance and trigger physiological responses that promote intolerance and aggression (Corcoran and Zahnow, 2022a). However, this direct impact is not the sole concern. Indirect effects may also occur due to poor sleep quality, as elevated temperatures are known to disrupt sleep (Mullins and White, 2019), which can subsequently increase aggression (Anderson et al., 2000).

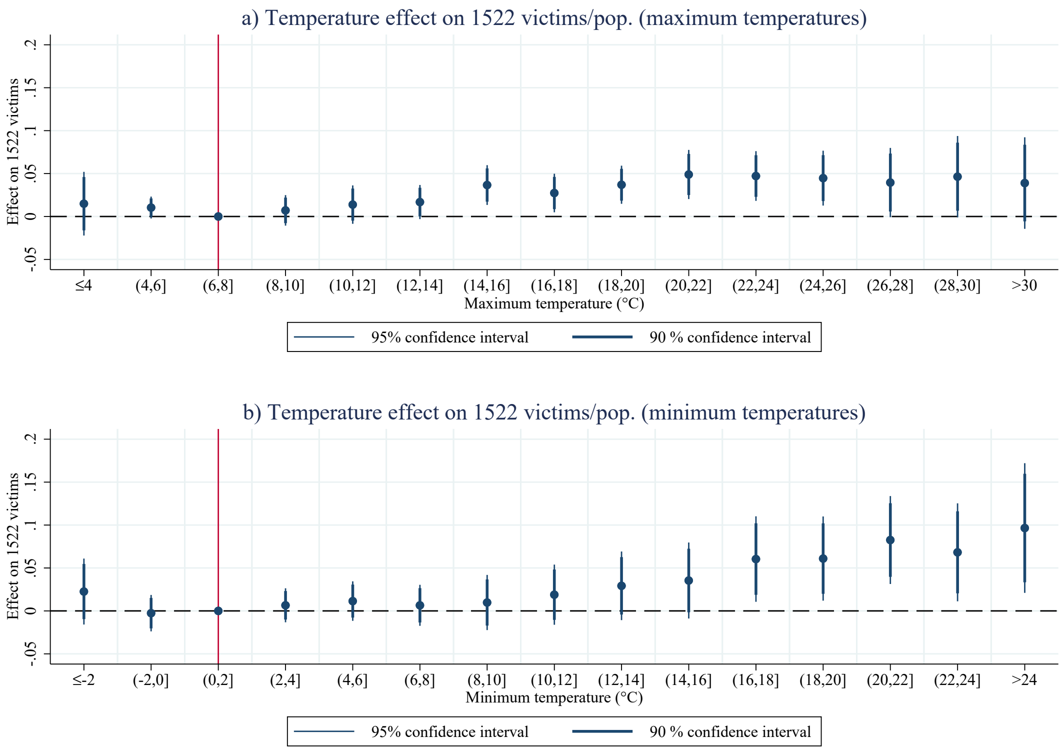
To isolate and provide evidence for the indirect effects of nighttime temperatures, distinct from those driven by daytime conditions, we modified the baseline model. Specifically, we included bins for weekly average *minimum* temperatures, in addition to bins for weekly average maximum temperatures.[15] Minimum temperatures serve as a proxy for overnight conditions, as they are typically recorded in the early morning hours, while maximum temperatures represent daytime conditions, because they are generally observed in the early afternoon. Figures 4 and 5 show the effect of minimum and maximum temperatures when they are jointly included in the model specification on the call rate of victims and femicides, respectively. Panels a display the effect of maximum temperatures, whilst panels b displays the effect of minimum temperatures. We find that minimum temperatures play a relevant role in affecting victims' call rate and femicides. When the weekly average of minimum temperatures is above 24°C, the victims' call rate is 0.096 points higher than that with a weekly average minimum temperature of 0-2°C, which is about 31% of the average at the reference (0.313), and the expected number of femicides is about 390% larger than that at the reference temperature of 0-2°C. These findings, along with evidence that the incorporation of minimum temperatures decreases the effect of warm maximum temperatures, suggest that elevated nighttime temperatures have a greater influence on GBV than hot daytime temperatures.

A possible explanation is that elevated nighttime temperatures negatively affect sleep quality, leading to increased irritability, frustration and aggression and, therefore, to an amplification of the likelihood of triggering violence against women. However, there are other possible explanations. For example, with warmer nighttime temperatures, women may stay out later for social and economic activities that extend into the night. This may increase the likelihood of being exposed to less secure areas, where the risk of violence

[15] The bins for minimum temperatures are defined differently, with all values shifted 6°C lower to ensure an adequate number of observations in each bin. Consequently, the lowest bin includes weekly average minimum temperatures below -2°C, while the highest bin captures those above 24°C (the reference category is 0-2°C).

and harassment is greater.

Figure 4: Effect of weekly average maximum and minimum temperature on victims' weekly calls to 1522 helpline

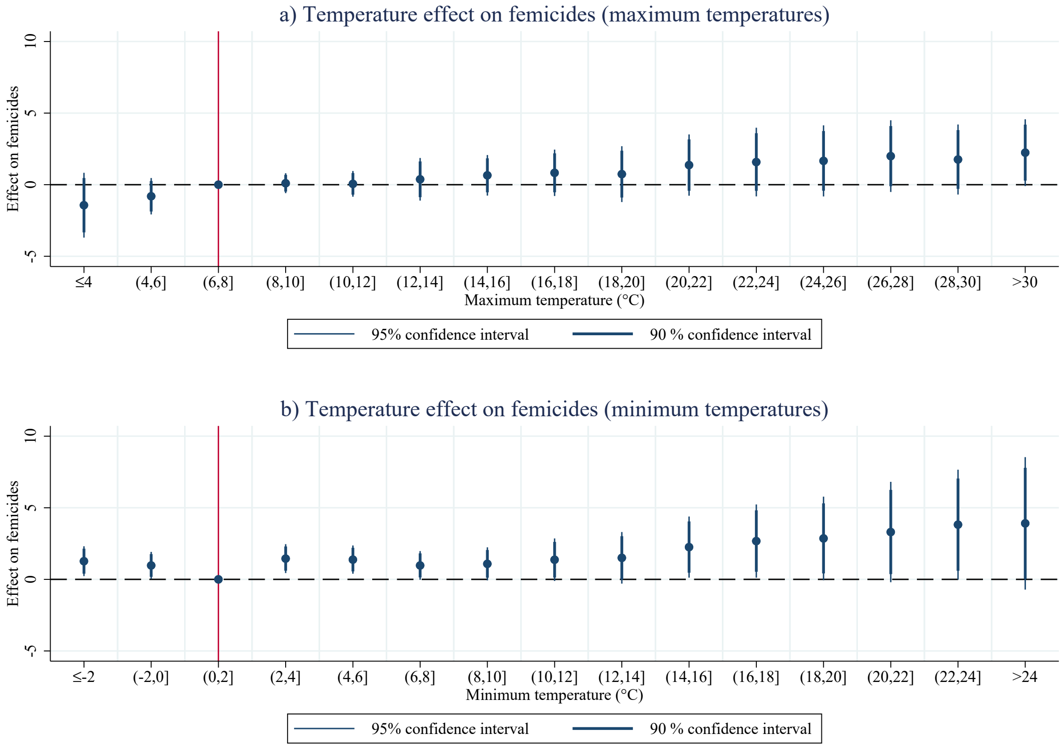


Notes: The vertical lines indicate the reference category, $(6, 8]$°C for maximum temperatures and $(0, 2]$°C for minimum temperatures, whose coefficient are normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.307; b) 0.313. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

4.3 Effect heterogeneity

We conduct a heterogeneity analysis to explore the potential mechanisms underlying our main findings, incorporating a range of contextual factors to provide a more nuanced understanding of the drivers of our outcomes. Specifically, we examine how temperature affects calls to the 1522 helpline and incidents of femicide by splitting provinces above or below the median along seven key dimensions: geographical location, air-conditioning

Figure 5: Effect of weekly average maximum and minimum temperature on femicides (Poisson regression)



Notes: The vertical lines indicate the reference category, $(6, 8]$°C for maximum temperatures and $(0, 2]$°C for minimum temperatures, whose coefficient are normalized to zero. Each regression is weighted by the provincial population of the year of the observation. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

prevalence, unemployment, tertiary education, immigration, and indicators related to both the prevalence of GBV and societal sensitivity to the issue.[16]

Table A.1 in the appendix reports the correlations among the seven variables used to divide provinces. When interpreting the results, it should be noted that the geographical split between the North and Center-South captures a broader socio-economic gradient – characterized by lower unemployment, a higher share of foreigners, and less traditional gender norms – and that high unemployment is strongly correlated with both a lower fraction of foreigners and more conservative gender norms.

4.3.1 Geographical area: Center-South and North

We divide Italian provinces into two macro-regions, North and Center-South, following conventional territorial distinctions in socio-economic and infrastructural development. The macro-regions also differ climatically: the North experiences more continental conditions, with colder winters and greater temperature fluctuations, while the Center-South is warmer and more climatically stable. As a result, extreme heat may be perceived differently, leading to heterogeneous behavioral responses. In the South, people may be more accustomed to high temperatures, whereas in the North, similar heat levels may induce greater stress and discomfort, potentially triggering higher aggression.

Moreover, the North and the Center-South exhibit different baseline levels of GBV, with the Center-South characterized by higher rates, possibly due to socioeconomic and cultural factors.[17] This suggests that the marginal effects of temperature may vary, with temperature spikes acting as a more salient trigger in the North, where GBV may be more latent.

Figures 6 and 7 report the estimated coefficients by temperature bin, using the 6-8°C interval as the reference category. Results are shown separately for calls to the 1522 helpline and for femicides, distinguishing between Center-South (panel a) and North (panel b). The estimated effects exhibit broadly similar qualitative patterns across regions, as none of the coefficients for Center-South provinces differ significantly from their Northern counterparts. However, some regional differences in magnitude and threshold

[16] The model is demanding in terms of observations, especially for identifying the impact on femicides, which are rare events from a statistical point of view. This limitation prevented us from adopting a more granular sample split.

[17] In our sample, the weekly number of victims' 1522 calls (per 100,000 inhabitants) was 0.304 in the North and 0.342 in the Center-South. The weekly number of femicides (per 100,000 inhabitants) was 0.040 in the North and 0.046 in the Center-South.

effects emerge, particularly in the case of femicides (Figure 7).

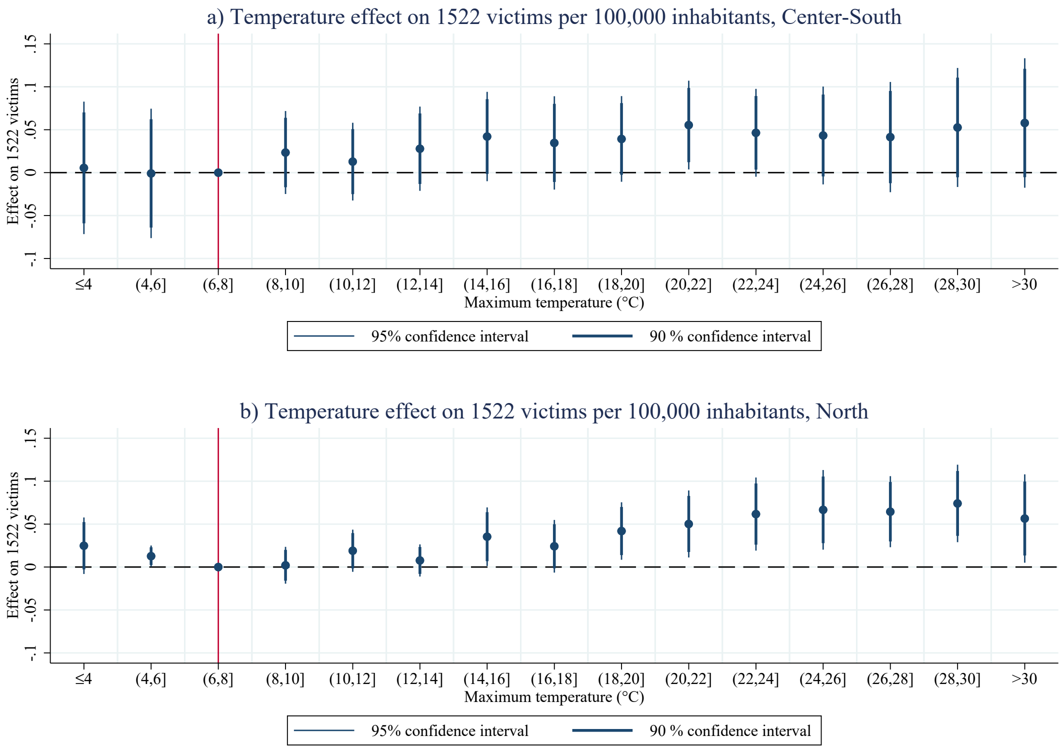
In the North, the impact of weekly average maximum temperature begins to rise from approximately 12°C and becomes significant at the 10% level when temperatures are above 20°C. In contrast, in the Center-South, the estimated effect, relative to the 6-8°C baseline, reaches the same magnitude and significance level when temperatures are above 30°C. This divergence suggests that what drives the relationship between temperature and GBV may not be the absolute level of heat, but rather its deviation from local climatic norms and baseline temperature conditions. Southern provinces are typically exposed to higher average temperatures and, therefore, people may exhibit greater physiological and behavioral adaptation to moderate heat. In these areas, a shift from 6-8°C to 20°C may be perceived as relatively mild and insufficient to generate significant discomfort or behavioral disruption. Conversely, in the North, where such temperatures are less frequent, the same increase represents a more substantial anomaly, potentially triggering greater psychological stress or changes in routine activities that could escalate into violent episodes. These findings align with the hypothesis that populations regularly exposed to warmer climates are partially adapted, for example through thermoregulation, air conditioning use, or behavioral strategies like adjusted daily routines, so that only large departures from climatological norms lead to significant consequences for interpersonal dynamics.

This pattern contrasts with previous empirical evidence on the temperature-violence relationship in other geographical contexts. For instance, US-based studies have documented that the effects of moderate and warm temperatures on crime are very similar across climate zones; thus, there are no clear differences in temperature effects that can be attributed to seasonal adaptation (Ranson, 2014). Similarly, the meta-analysis by Choi et al. (2024), which pools over 200 studies, finds that long-term temperature exposures are associated with higher risks of crime compared to short-term exposures, casting doubt on the relevance of habituation and adaptive capacity in modulating responses to thermal stress.

4.3.2 High and low air conditioning penetration index

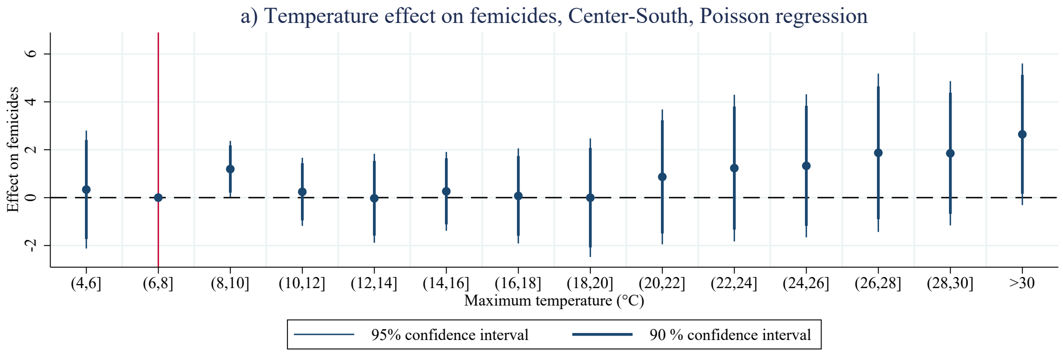
To account for differences in environmental comfort that may moderate the impact of high temperatures, we use regional data on air conditioning (AC) penetration in residential buildings, as reported by Istat (2022). The share of households with air conditioning varies significantly across regions, potentially influencing individual heat exposure and

Figure 6: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by geographical area



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. None of the displayed coefficients for provinces in the Center-South are significantly different from those for provinces in the North. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.343; b) 0.295. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 7: Effect of weekly average maximum temperature on femicides (Poisson regression) by geographical area



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. The results for the first temperature bin ($\leq$ 4°C) is not displayed because not identified for provinces in the Center-South, where rarely weekly average maximum temperatures are below 4°C. Each regression is weighted by the provincial population of the year of the observation. None of the displayed coefficients for provinces in the Center-South are significantly different from those for provinces in the North. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

behavioral responses.

Figures 8 and 9 report the estimated coefficients by temperature bin, using the 6-8°C range as the reference category. The two figures refer, respectively, to calls to the 1522 helpline and to femicides, and distinguish between provinces with high (panel a) and low (panel b) levels of AC penetration. The relationship between temperature and calls to the 1522 helpline appears qualitatively and quantitatively similar across groups, with no statistically significant differences between areas with high and low AC penetration when comparing the coefficients directly. However, statistically differences across groups emerge when we examine femicides. In provinces with high AC penetration, femicides increase steadily with temperature, peaking at around 30°C. Conversely, in provinces with low AC penetration, no clear temperature-femicide relationship is observed.

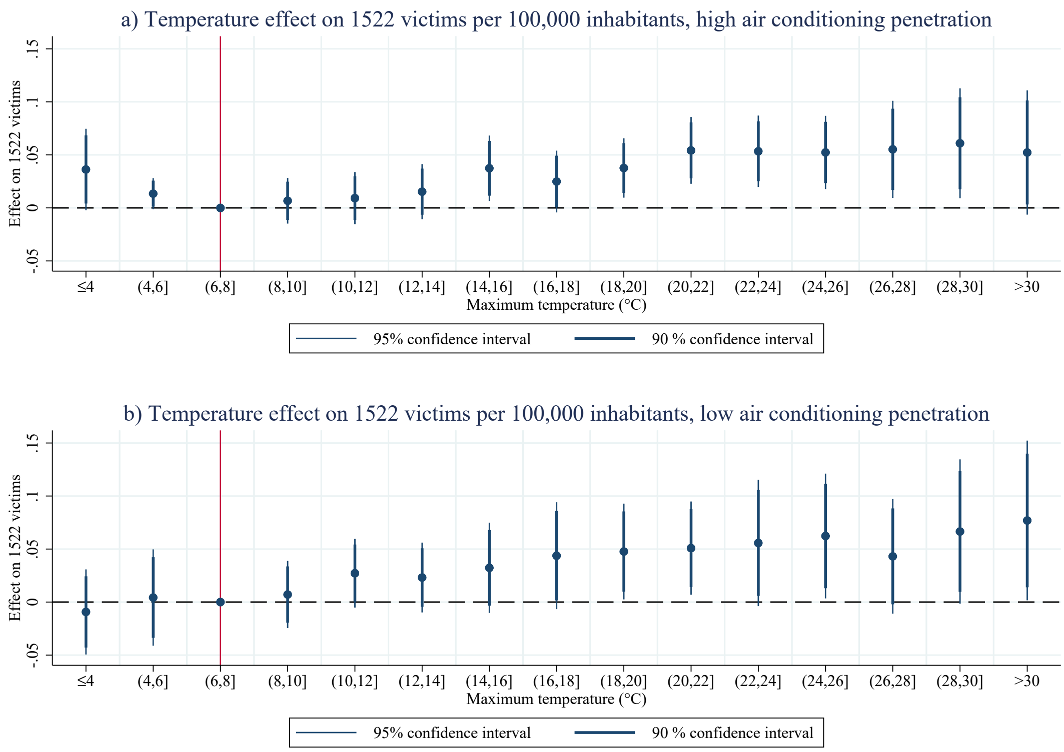
In areas with low AC availability, higher ambient temperatures may push individuals out of their homes, increasing visibility and the likelihood of third-party intervention, thereby limiting the escalation of violence to lethal outcomes. In contrast, in areas with widespread AC, people are more likely to remain indoors to avoid the heat. This increased proximity to potential aggressors, combined with reduced social oversight, may elevate the risk of fatal escalation.

This suggests that, while AC can buffer the psychological stress associated with heat, it may also increase the lethality of violent incidents by fostering prolonged, unsupervised cohabitation during hot periods. These offsetting behavioral effects imply that adaptation technologies, while beneficial in many respects, may not substitute for robust violence-prevention infrastructure. Complementary measures, such as the strengthening of support services and outreach efforts during extreme heat events, may be essential to mitigate the unintended social costs of climate adaptation.

4.3.3 Socio-economic conditions

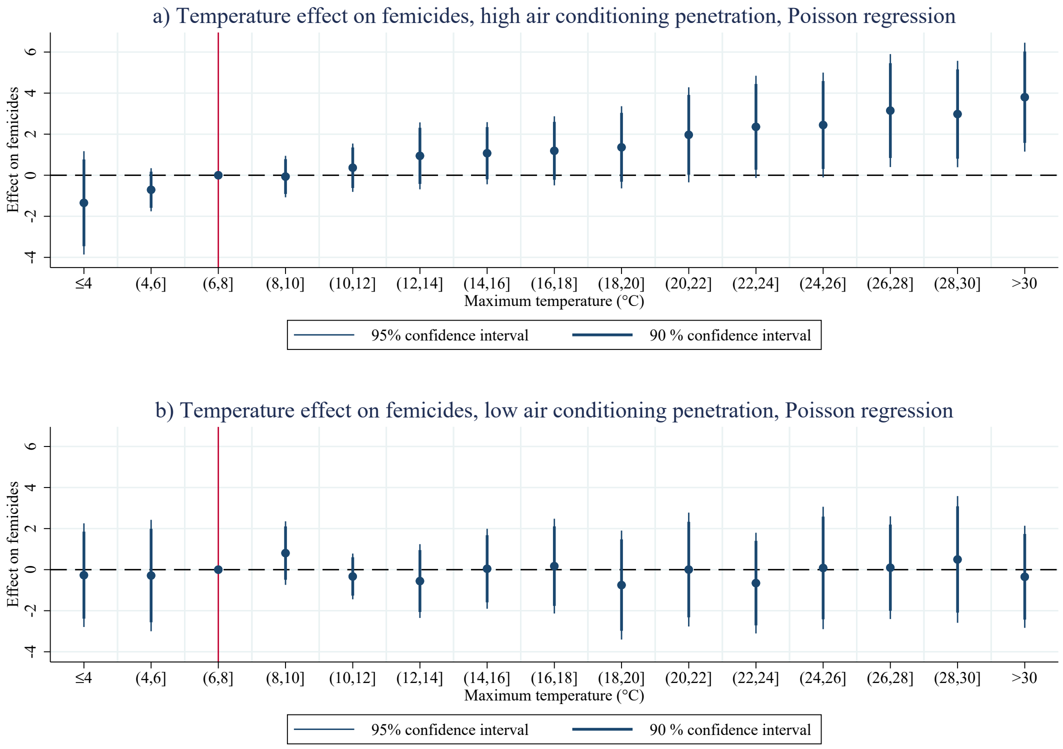
Drawing on data from the Istat Labour Force Survey (2013–2022), we classify provinces based on a set of socio-economic indicators that may affect both exposure to and vulnerability to violence. These include the unemployment rate, the share of the working-age population with tertiary education and the proportion of foreign-born residents.

Figure 8: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by air conditioning penetration index



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.331; b) 0.286. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 9: Effect of weekly average maximum temperature on femicides (Poisson regression) by air conditioning penetration index



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

High and low unemployment rate over the observed time period

Poor labor market conditions increase psychosocial distress,[18] financial strain and relationship conflict, all of which may amplify the effects of temperature stress and lead to more violent behavior during episodes of extreme heat. Moreover, in areas with higher unemployment, people, especially men, may spend more time at home. On the one hand, this increases the opportunities for domestic conflict; on the other hand, it reduces the possibility for victims to report a violent incident.

Figures 10 and 11 report the estimated coefficients for victims' calls to the 1522 helpline and femicides, respectively. In both figures, estimates are disaggregated by provinces with average unemployment rates above (panel a) and below (panel b) the median unemployment rate.

The influence of temperature on help-seeking behavior appears to vary substantially with local labor market conditions. In provinces with low unemployment rates, the causal effect of temperature on victims' calls to the 1522 helpline increases steadily, peaking at temperatures above 28°C. At that level, the number of calls is approximately 30% higher than at 6-8°C. This pattern is markedly attenuated in areas with high unemployment, suggesting that economic conditions may shape the capacity or willingness to report domestic violence during heat stress events.

Several mechanisms may account for this disparity. In areas with lower unemployment, individuals may benefit from greater economic independence, mobility, and access to information and services, which collectively reduce the opportunity cost-and perceived risk-of seeking help. Conversely, in high-unemployment contexts, victims may face heightened financial dependency, reduced privacy, and limited access to external support networks, which can suppress help-seeking even when conflict intensity is comparable or higher.

When turning to femicides, however, the results show no meaningful difference between high and low unemployment areas. This suggests that while economic context affects the visibility and reporting of domestic violence, it does not substantially alter the risk of its most severe outcomes. In both groups, extreme heat appears to raise the incidence of femicides to a similar extent.

This contrast aligns with prior research indicating that unemployment can influence

[18] See the meta-analysis in Picchio and Ubaldi (2024) for a survey on the impact of unemployment on psychological health, with men being particularly affected.

both the frequency and the escalation dynamics of IPV. For example, Anderberg et al. (2016) show that economic interdependence and relative bargaining power matter: when men face unemployment, they may restrain abusive behavior to maintain relationships; when women lose economic autonomy, they become more vulnerable and IPV increases, potentially offsetting temperature-induced triggers. Similarly, Schneider et al. (2016) find that unemployment and economic hardship at the household level are positively related to abusive behavior: macroeconomic downturns raise IPV primarily through non-lethal episodes, while the risk of femicide remains relatively stable across economic cycles.

Further supporting this interpretation, Tur-Prats (2021) emphasizes that the unemployment–IPV relationship is highly context-dependent. In regions with patriarchal gender norms, female unemployment shocks are associated with a stronger increase in IPV than male unemployment shocks. In Italy, provinces with structurally high unemployment also tend to exhibit more traditional gender roles and weaker social service networks-factors that may inhibit help-seeking without necessarily affecting escalation risk.

High and low fraction of the active population with tertiary education over the observed time period

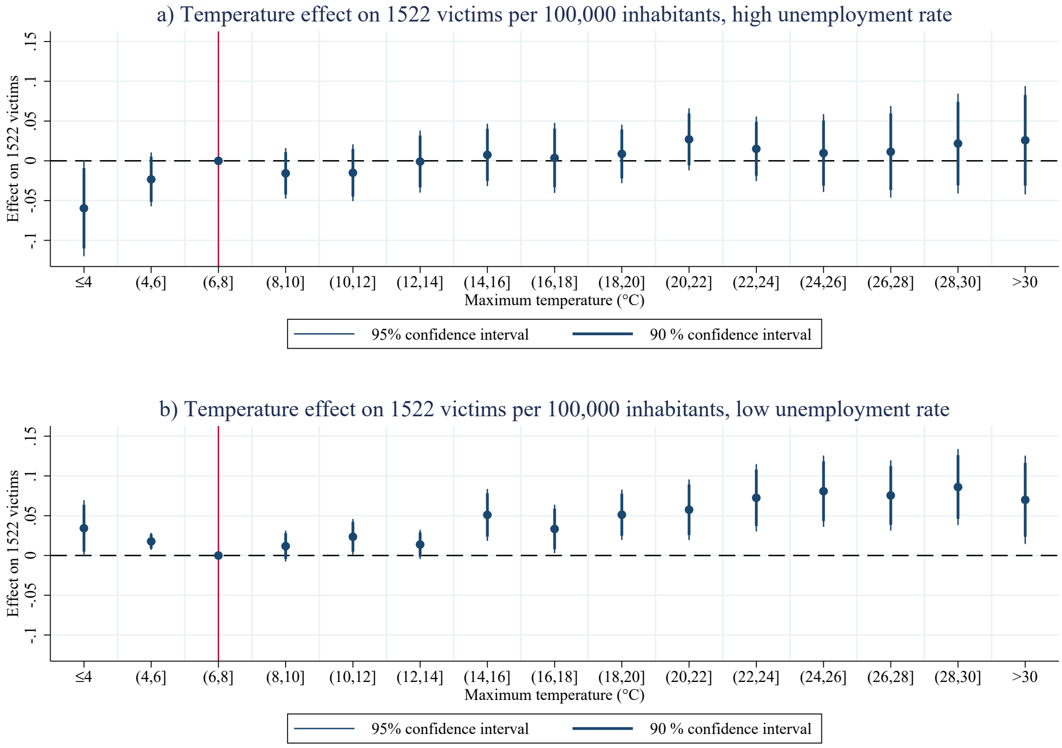
Figures 12 and 13 display estimated coefficients with the former focusing on the results for calls to the 1522 helpline and the latter dealing with femicides. In both cases, the estimates are disaggregated by provinces with a share of tertiary-educated individuals above (panel a) or below (panel b) the median over the observed period.

We find that provinces with lower levels of tertiary education exhibit a sharper increase in both helpline calls and femicides as temperatures rise. In contrast, provinces with higher educational attainment experience a markedly attenuated response to temperature increases. These patterns suggest that education may serve as a protective factor, moderating behavioral and social reactions to environmental stressors such as heat.

Several mechanisms could explain this differential vulnerability. Higher educational attainment is typically associated with more stable employment, improved housing conditions, better economic security, greater awareness of available support services and better conflict resolution skills. Together, these factors may reduce both the likelihood and severity of domestic tensions triggered by heat stress, and limit their escalation into violence.

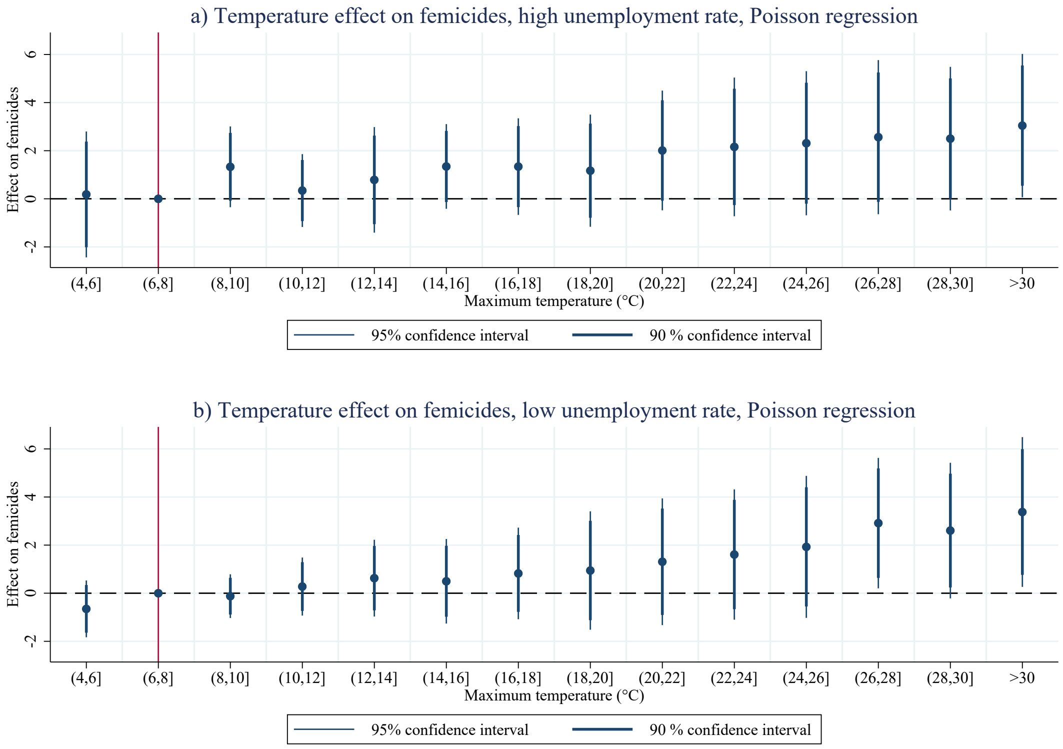
Moreover, the higher volume of helpline calls in low-education provinces may reflect not only a greater incidence of GBV, but also a heavier reliance on national services due to

Figure 10: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by unemployment rate (above and below the median unemployment rate)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.331; b) 0.286. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 11: Effect of weekly average maximum temperature on femicides (Poisson regression) by unemployment rate (above and below the median unemployment rate)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

underdeveloped local support systems. In these contexts, the 1522 helpline may represent a critical, sometimes sole, resource for victims seeking assistance. Thus, the increase in calls may simultaneously indicate heightened vulnerability and structural service gaps, reinforcing the notion that educational disadvantage operates through multiple, interrelated channels.

This interpretation aligns with a growing body of empirical research. Boyle et al. (2009), for instance, show that women with higher levels of education are significantly less likely to experience IPV, emphasizing the role of education as a key protective factor. Similarly, Heise and Kotsadam (2015) demonstrate that women's tertiary education consistently reduces IPV risk across countries, particularly in contexts marked by entrenched patriarchal norms and high gender inequality.

Taken together, these findings suggest that education strengthens both individual and community capacity to cope with climate-related stressors, reducing the risk that heat translates into GBV.

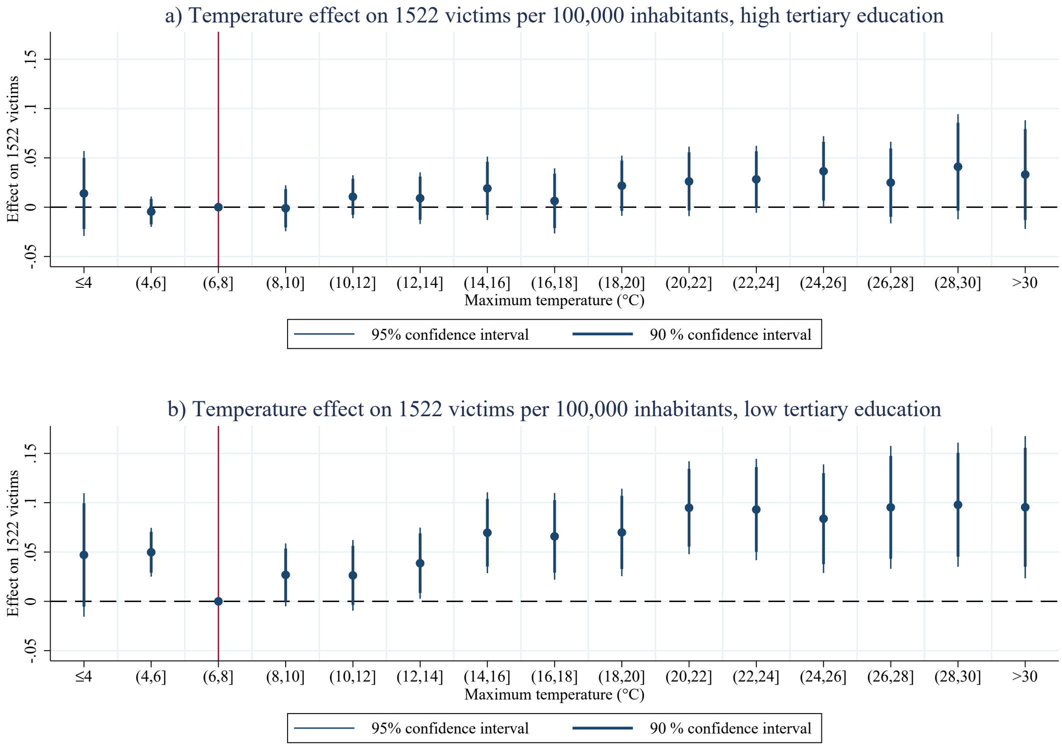
High and low fraction of foreigners (citizenship) over the observed time period

The proportion of foreign-born residents may also be relevant, as migrants often face poorer socio-economic conditions and may hold different cultural attitudes toward gender-based violence, including the reporting of both partner and non-partner violence.

Figures 14 and 15 display the estimated coefficients for victims' calls to the 1522 helpline and femicides, respectively. In both cases, the estimates are disaggregated by provinces with a share of foreign residents above (panel a) or below (panel b) the median over the observed period.

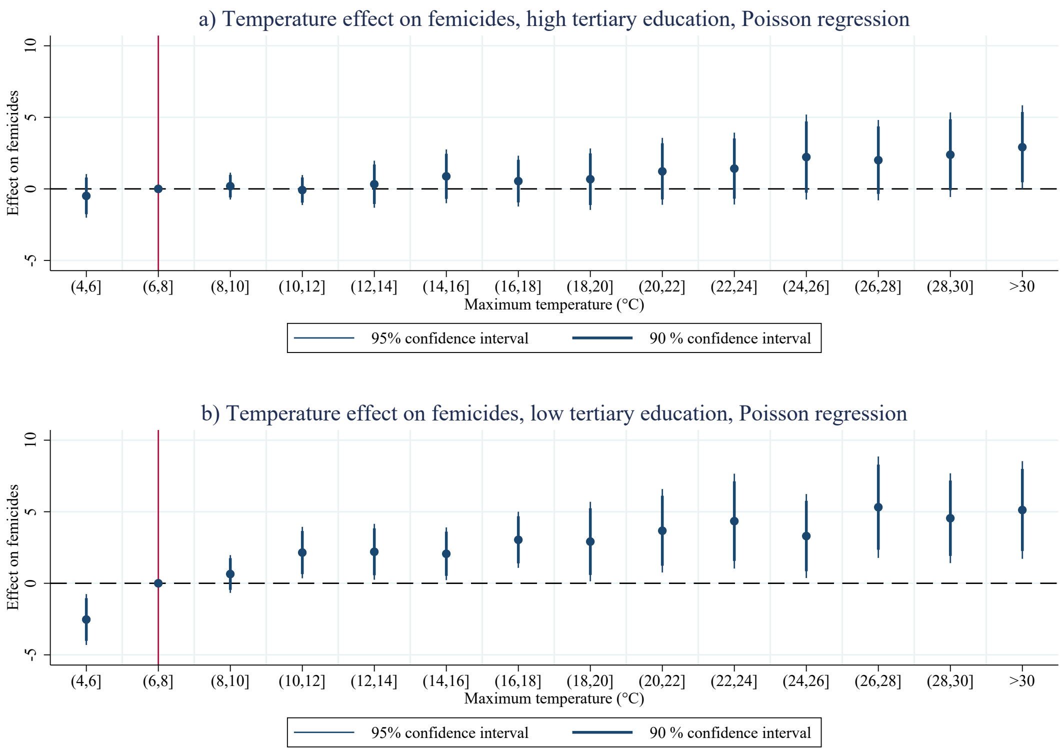
The results for help-seeking behavior reveal a broadly consistent response to temperature increases across both demographic contexts. In provinces with both high and low shares of foreign residents, helpline calls begin to rise noticeably once weekly average maximum temperatures exceed approximately 16-18°C. However, the similarity in call-rate slopes across provinces may mask underlying heterogeneity in reporting behavior. Prior evidence indicates that foreign-born women are significantly less likely to seek help from formal institutions, due to language barriers, fear of deportation, and distrust of authorities (Newberry et al., 2025). Population-based data from Sweden further confirm that foreign-born women face heightened threat and victimization risks while remaining institutionally invisible (Fernbrant et al., 2014). These findings suggest that observed sim-

Figure 12: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by tertiary education (above and below the median fraction of the active population with tertiary education)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.349; b) 0.287. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 13: Effect of weekly average maximum temperature on femicides (Poisson regression) by tertiary education (above and below the median fraction of the active population with tertiary education)

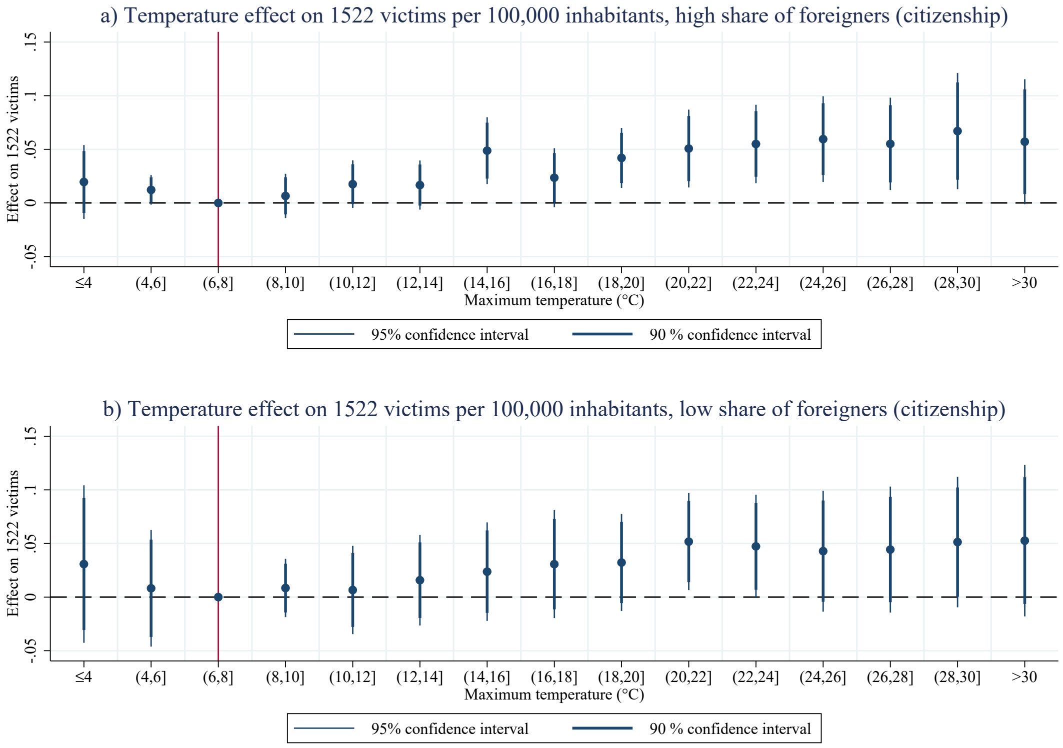


Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

ilarities in helpline activity may reflect a combination of stronger unreported victimization among migrants and greater institutional access among natives.

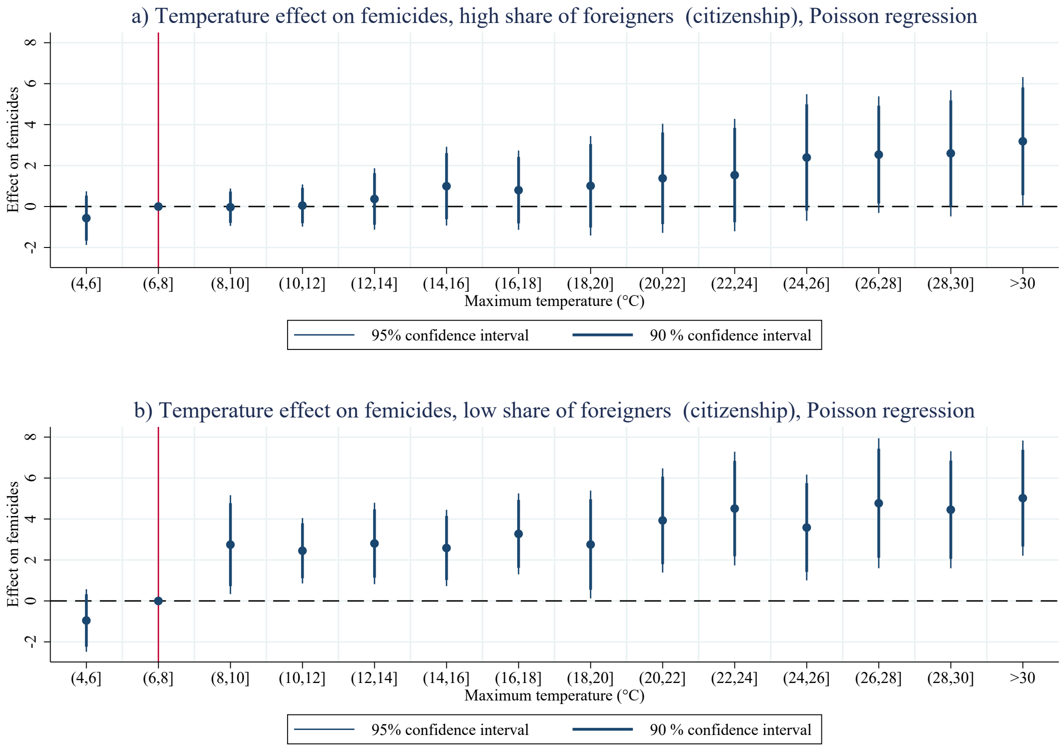
In contrast, the femicide estimates display a more nuanced divergence. Between 14°C and 24°C, the coefficients are consistently higher in provinces with lower shares of foreign residents, although not statistically significant. This suggests that moderate heat may be more strongly associated with lethal outcomes in native-dominated areas. While the mechanisms require further investigation, the result underscores the need to interpret aggregate femicide patterns in light of demographic composition and institutional responsiveness.

Figure 14: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by fraction of foreigners (above and below the median fraction of foreigners)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.330; b) 0.311. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 15: Effect of weekly average maximum temperature on femicides (Poisson regression) by fraction of foreigners (above and below the median fraction of foreigners)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

4.3.4 Sensitivity to GBV and its prevalence

To assess how social norms and institutional capacity relate to our outcomes, we use two complementary indicators. First, we employ the Gender Norms Index (GNI) developed by Carrer and De Masi (2024), which captures societal attitudes toward gender roles across multiple dimensions. Provinces are categorized as having high or low GNI, allowing us to explore the role of prevailing gender norms. Second, we use updated data on the presence of Anti-Violence Centers (CAVs), sourced from the official 1522 portal and aggregated at the provincial level by Cerqua et al. (2024). This mapping enables us to examine the territorial distribution and accessibility of specialized support services, shedding light on the institutional response to GBV across Italy.

Above and below the median of the Gender Norm Index

Figures 16 and 17 display the results for calls to the 1522 helpline and femicides, respectively, with estimates disaggregated by provinces above (panel a) and below (panel b) the median of the Gender Norm Index (GNI), which captures territorial variation in conservative gender attitudes across Italy (Carrer and De Masi, 2024).

The temperature-response profiles appear strikingly similar across the two groups. For helpline calls and femicides, both high-GNI (more conservative) and low-GNI (more egalitarian) provinces show a comparable increase in response to rising temperatures, particularly above 18°C. This symmetry suggests that the behavioral response to thermal stress may be relatively unaffected by prevailing gender norms.

While this might seem at odds with prior evidence linking conservative gender norms to higher baseline levels of IPV (González and Rodríguez-Planas, 2020), it aligns with the idea that acute stressors, such as extreme heat, may operate through universal channels, including physiological discomfort, reduced sleep quality, or prolonged co-presence within the home, triggering conflict independently of normative context. These mechanisms are consistent with routine activity and stress-aggression theories, which emphasize situational rather than structural triggers.

Moreover, the absence of a differential temperature effect by GNI is conceptually coherent with the nature of the index itself. As a proxy for deeply rooted normative beliefs, the GNI is better suited to capture long-run, structural determinants of GBV prevalence than short-term behavioral reactions. In this sense, the index may explain geographic variation in baseline risk levels or in reporting behavior, but not necessarily in the marginal sensitivity to climatic shocks. This interpretation aligns with recent evidence. For instance, González and Rodríguez-Planas (2020) show that gender norms imported from countries of origin significantly predict the risk of IPV among immigrant women in Spain, underscoring the role of cultural transmission in persistent vulnerabilities. However, this does not imply that short-run behavioral responses to temperature are norm-sensitive. Similarly, Gracia et al. (2025) demonstrate that contextual hostile sexism, distinct from broader gender norms, clusters spatially and is strongly associated with IPV risk. However, they do not find direct evidence that such attitudes moderate climate-related escalations into lethal violence.

In sum, while gender norms remain important for understanding long-term patterns of GBV, their role in moderating the short-term impact of environmental stress appears limited. The findings suggest that norm progressiveness should not be assumed to buffer against heat-related violence. Rather, even more egalitarian provinces require climate-aware prevention strategies, including strengthened support services, surge capacity during heatwaves, and early-warning systems tailored to anticipate spikes in domestic conflict.

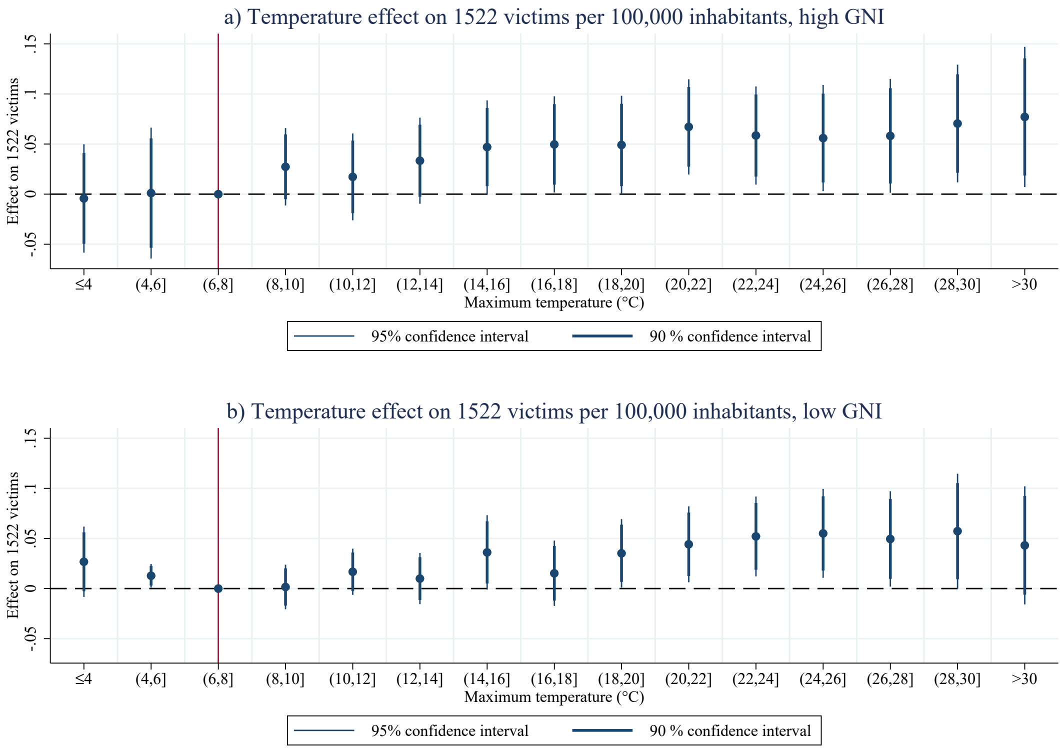
High and low presence of anti-violence centers over the observed time period

Figures 18 and 19 show the results for calls to the 1522 helpline and femicides, respectively, with estimates disaggregated by provinces with a density of anti-violence centers (AVCs) above (panel a) or below (panel b) the median, based on the mapping developed by Cerqua et al. (2024).

For helpline calls, the temperature-response profiles appear broadly similar across groups, with no statistically significant differences in most bins. However, above 28°C, a divergence emerges: provinces with fewer AVCs show a sharper increase in calls. Although the difference is not statistically significant, this pattern may signal a compensatory role played by the 1522 helpline in underserved areas. Where local, in-person services are sparse, victims may turn more readily to national hotlines during episodes of heat-induced stress and conflict. In this sense, the helpline may act as a substitute for physical support infrastructure in areas with limited territorial coverage.

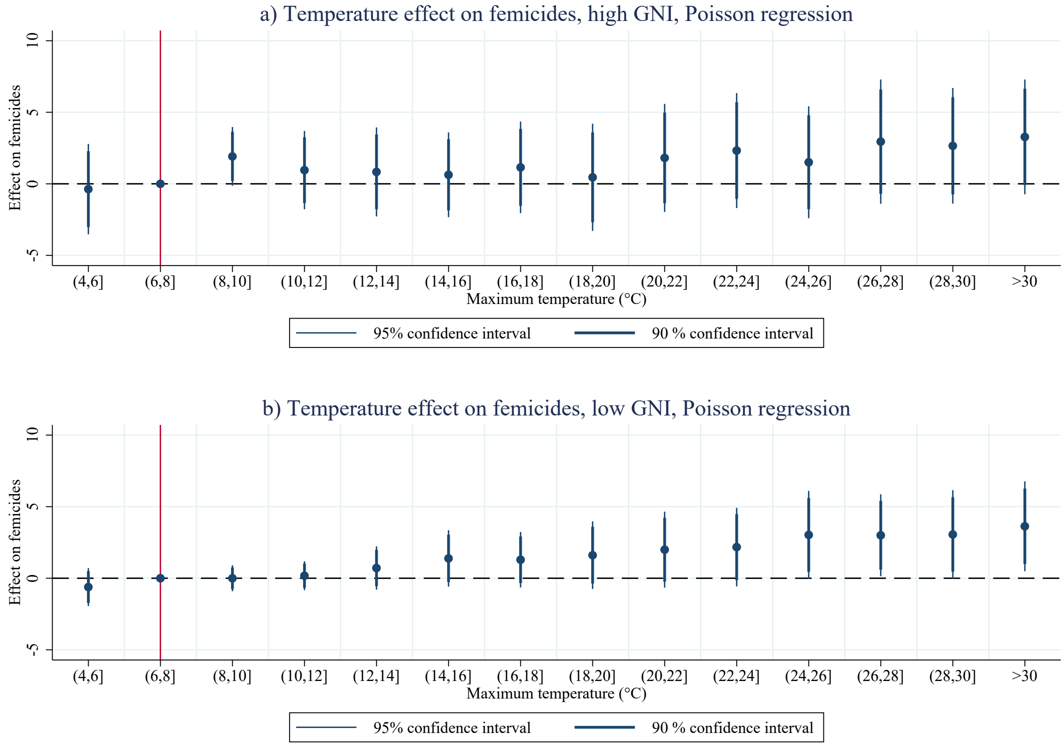
The femicide results paint a different picture. While overall differences between high- and low-AVC provinces remain statistically modest, coefficients tend to increase at high temperatures (above 26°C), particularly in areas with greater AVC presence. At first

Figure 16: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by GNI (above and below the median GNI)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. None of the displayed coefficients for high GNI provinces are significantly different from those for low GNI provinces. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.312; b) 0.330. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 17: Effect of weekly average maximum temperature on femicides (Poisson regression) by GNI (above and below the median GNI)



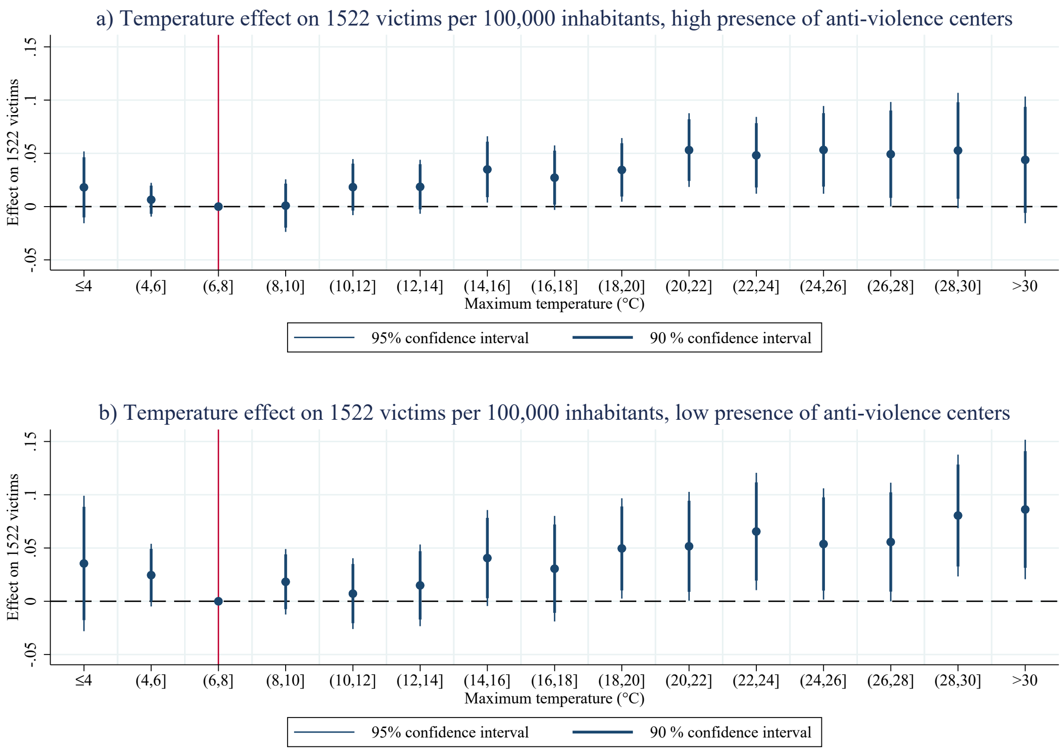
Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. The results for the first temperature bin ($\leq$ 4°C) is not displayed because not identified for provinces with high GNI. Most of these provinces are indeed from the South of Italy, where rarely weekly average maximum temperatures are below 4°C. Each regression is weighted by the provincial population of the year of the observation. None of the displayed coefficients for high GNI provinces are significantly different from those for low GNI provinces. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

glance, this may appear paradoxical: why would lethal outcomes rise more where services are stronger? One possibility is that the observed effect reflects better case detection in these provinces. Prior evaluations have shown that the expansion of domestic violence services often improves reporting and administrative classification, without necessarily indicating an increase in actual incidence (Aizer and Dal Bó, 2009; Wells et al., 2010). The upward shift in femicide coefficients in high-AVC areas may thus reflect institutional engagement and improved surveillance rather than more violence per se.

Importantly, these findings align with prior studies showing that the mere availability of shelters or hotlines may not be sufficient to reduce victimization or alter help-seeking behavior. Both Aizer and Dal Bó (2009) and Wells et al. (2010) find that while anti-violence centers contribute to increased visibility and formal documentation of abuse, they do not consistently lower IPV incidence or intimate partner homicide. This suggests that support services alone, without legal and behavioral commitment mechanisms, may have limited influence on the underlying dynamics of violence.

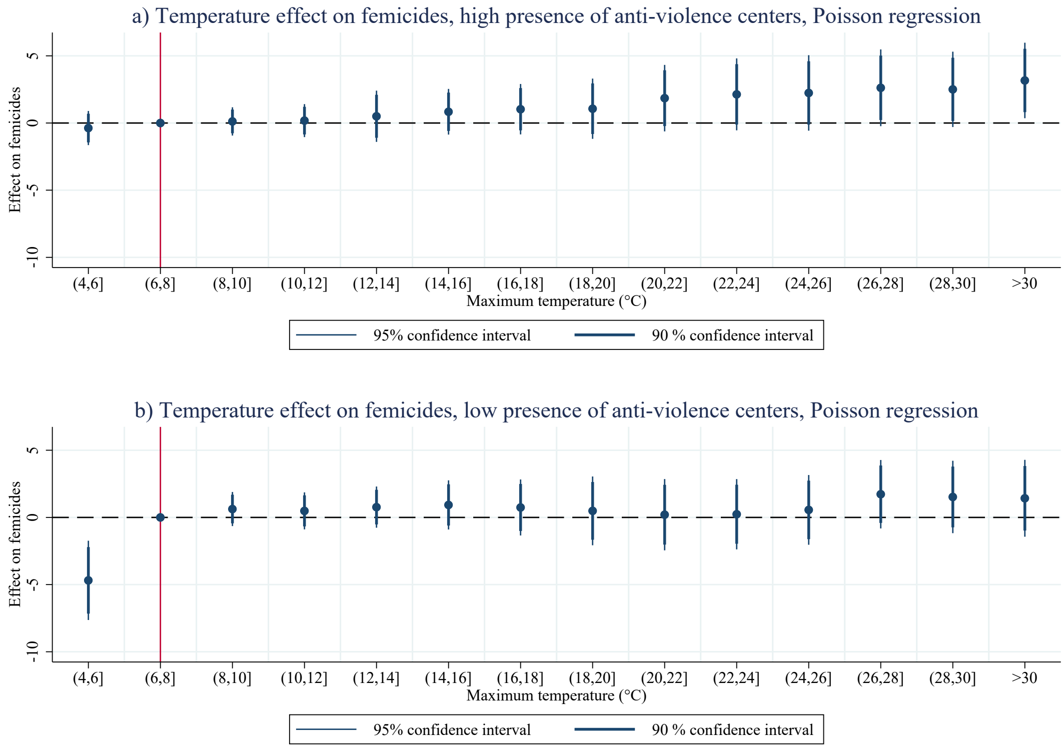
In sum, while the presence of AVCs does not seem to fundamentally alter the temperature-violence relationship, small differences in the magnitude of responses, particularly with extreme heat, highlight the importance of institutional context. In provinces where access to physical services is limited, the national helpline appears to serve as an essential outlet, especially during environmental shocks. In contrast, provinces with stronger service networks may report more cases due to enhanced detection mechanisms and institutional engagement, rather than higher true incidence.

Figure 18: Effect of weekly average maximum temperature on victims' weekly calls to 1522 helpline by presence of anti-violence centers (above and below the median presence of anti-violence centers)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of the dependent variable, weekly 1522 helpline calls by victims per 100,000 inhabitants, at the reference bin for each graph is as follows: a) 0.345; b) 0.265. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Figure 19: Effect of weekly average maximum temperature on femicides (Poisson regression) presence of anti-violence centers (above and below the median presence of anti-violence centers)



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

4.4 Sensitivity analysis

To assess the robustness of our findings, we first replicated the analysis excluding the COVID-19 lockdown period. Figure A.1 in the appendix shows the estimated effect of weekly average maximum temperature on 1522 helpline calls (panel a) and femicides (panel b) after removing weeks affected by the national lockdown and major restrictions. The results confirm the validity of the main patterns: both the direction and magnitude of the coefficients remain broadly consistent with those obtained using the full sample. This suggests that the relationship between temperature and domestic violence outcomes is not driven by pandemic-specific dynamics, and that the estimates are robust to the inclusion of this exceptional period.

Second, we conducted a sensitivity analysis to assess whether our inference would change when clustering at the sequential week level or when not addressing spatial correlation at all, that is, by not clustering observations at any time unit. In our benchmark model, the estimation of the variance–covariance matrix is robust to heteroskedasticity, within-province serial correlation, and cross-sectional spatial correlation, as we use the two-way cluster variance estimator proposed by Cameron et al. (2011), with clustering at the provincial and monthly levels. We found that, when the dependent variable is the number of victims' calls to the 1522 helpline, different clustering methods yielded very similar standard errors. However, when the outcome is the number of femicides, our standard errors were more conservative. In particular, clustering only at the local area level to account only for within-province serial correlation would have produced more precise standard errors, about 16% smaller for the estimated coefficients of the extreme heat temperature bins. This suggests that ignoring spatial correlation in temperature shocks, which is highly likely with granular data on climatic exposure, can more easily lead to a type I error.

Third, in Figure A.2 in the appendix, we report the estimates of the benchmark model without weighting provinces by their population. The estimates for victims' calls to the 1522 helpline are very similar to those displayed in Figure 3. In contrast, the estimated profile of the temperature-femicides relationship is flatter. However, the effect of extreme heat, while not significantly different from zero at the conventional 5% significance level, is still substantial, with femicides increasing by about 100% when temperatures exceed 26°C compared to 6-8°C.

Finally, we added the weekly average relative humidity as an additional control variable. Relative humidity typically co-moves with temperature, and if it independently affects aggression, stress, sleep, or time spent in risky settings, omitting it could introduce omitted-variable bias. Figure A.3 in the appendix shows that the results remain unaffected.

5 Conclusions

This study provides novel empirical evidence on the relationship between temperature extremes and GBV in Italy, contributing to a growing body of research at the intersection of environmental stressors and social outcomes. By leveraging high-frequency, province-level data over a ten-year period, we assess how both cold spells and heatwaves influence two distinct indicators of violence against women: help-seeking behavior, as proxied by weekly calls to the 1522 national helpline, and lethal violence, measured through femicide events.

The findings point to a non-linear and asymmetric impact of thermal stress. Exposure to extreme cold (weekly maximum temperatures below 2°C) is associated with a significant increase in helpline calls, suggesting heightened domestic tensions and potentially greater confinement-related risks. In contrast, extremely high maximum temperatures (above 30°C) are linked to a sharp increase in femicides, while elevated nighttime temperatures (minimums exceeding 24°C) amplify both forms of violence, with a particularly strong association with lethal outcomes. These effects—spanning from notable increases in help-seeking during cold spells to marked surges in lethal violence during hot nights—highlight the sensitivity of violent dynamics to environmental shocks.

Importantly, the differential effects across temperature dimensions suggest distinct underlying mechanisms. Cold-related increases in help-seeking may reflect greater indoor exposure and reduced external monitoring, while heat-induced lethality could stem from physiological stress, irritability, or disinhibition. The disproportionate effect of high minimum temperatures points to the cumulative burden of heat, particularly when recovery during nighttime hours is impaired.

From a broader perspective, these results call for a rethinking of GBV prevention frameworks in light of climate change. Rising temperatures and the increasing frequency of extreme weather events may exacerbate existing vulnerabilities, particularly in contexts already marked by gender inequality. While institutional and cultural drivers of violence remain central, our findings underscore the need to integrate climate-sensitive components into policy design-such as anticipatory interventions during heatwaves, enhanced emergency service capacity, and geographically targeted support in periods of environmental stress.

By establishing a robust empirical link between climatic conditions and violence against women, this research contributes to a more comprehensive understanding of the factors that shape gendered harm. Future work should continue to explore the interplay between environmental, institutional, and behavioral dimensions of violence, particularly in light of global warming and its uneven social consequences.

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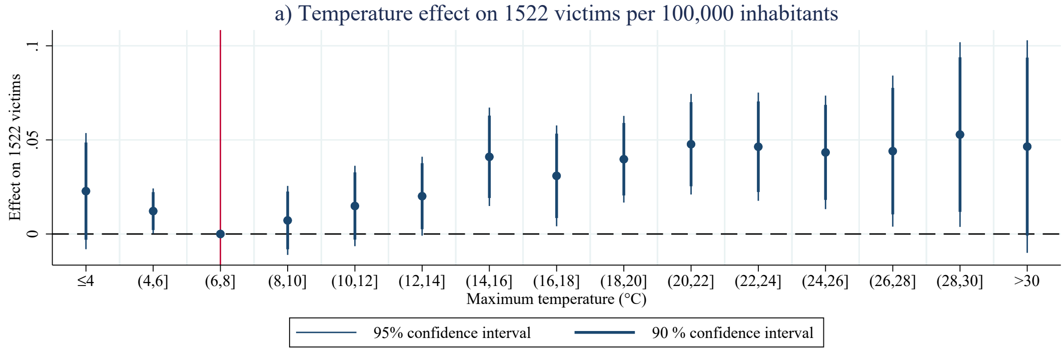
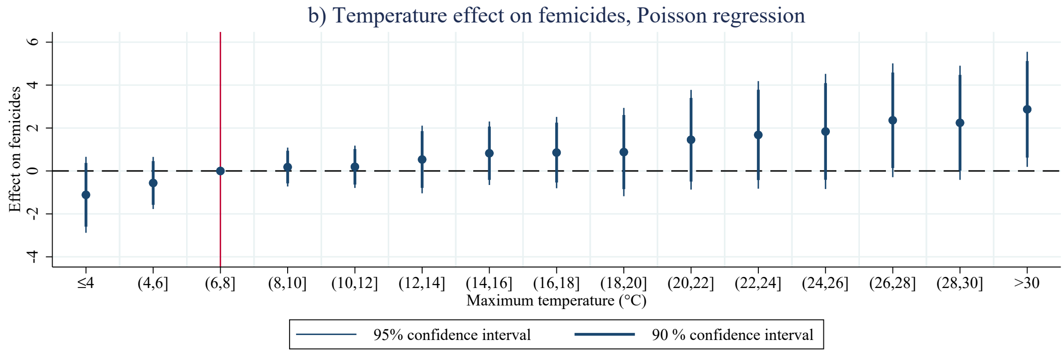
Appendix

A Further results

Figure A.1: Effect of weekly average maximum temperature on weekly calls to 1522 helpline by victims (panel a) and femicides (panel b) without COVID-19 lockdown period



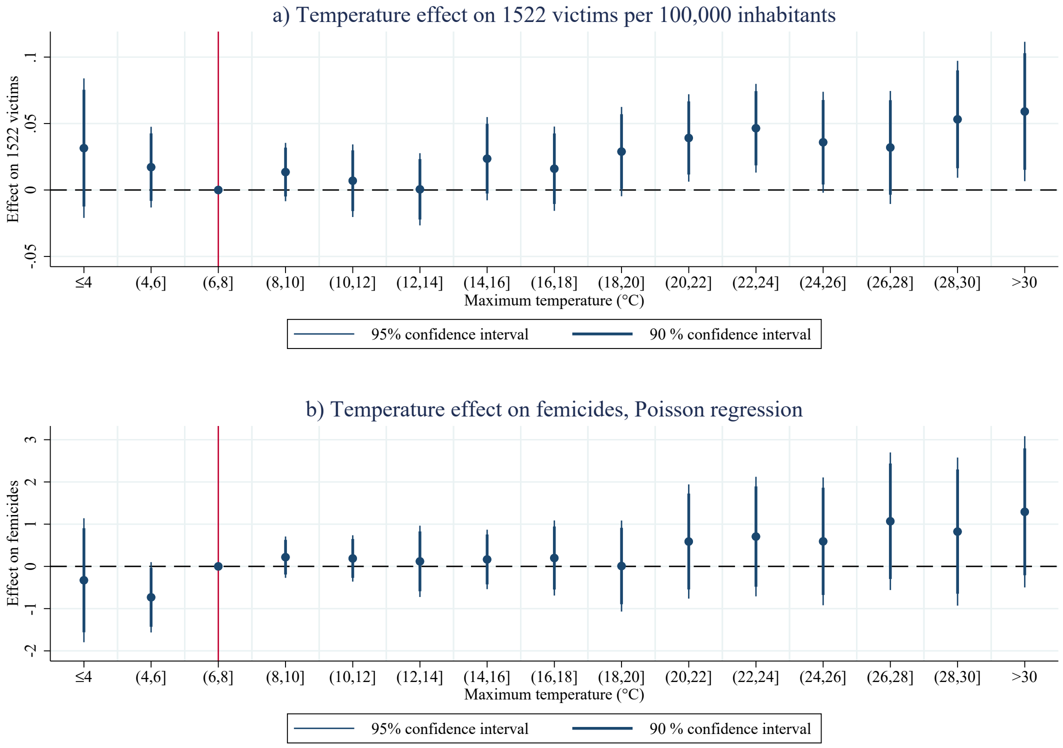


Notes: The vertical segments are 95% confidence intervals. The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation.

Table A.1: Correlation matrix of the different dimensions of effect heterogeneity

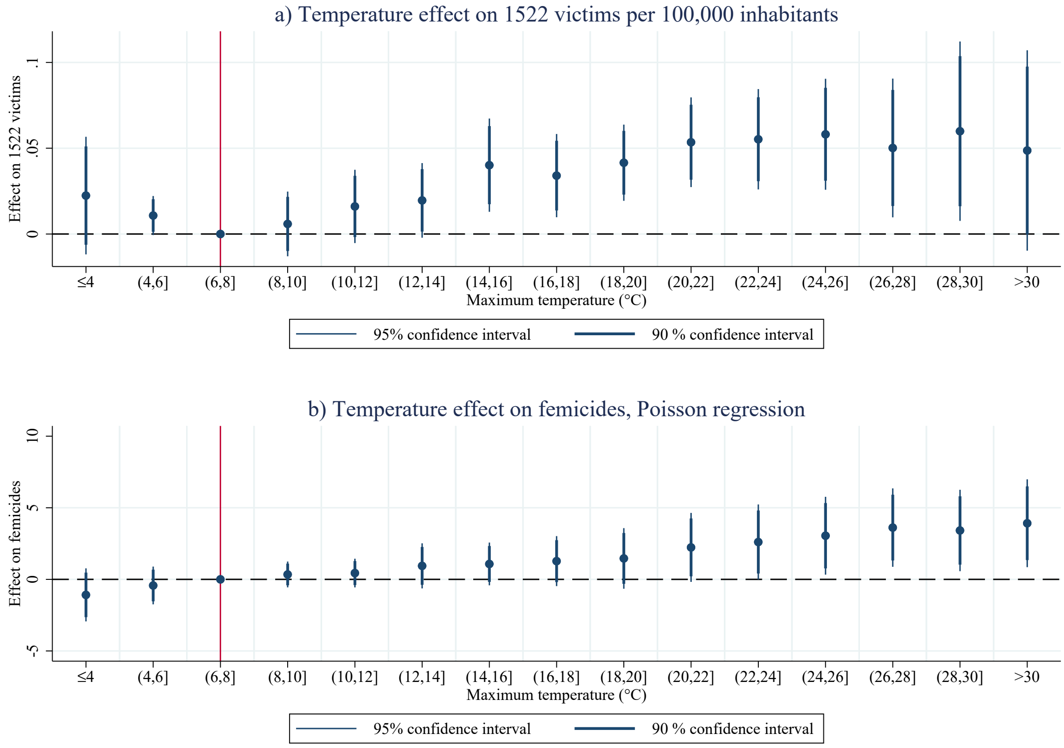
	North	High AC penetration	High unemployment	High tertiary eduction	High fraction of foreigners	High gender norm index	High presence of anti-violence centers
North	1.000						
High AC penetration	-0.077	1.000					
High unemployment	-0.705	0.006	1.000				
High tertiary eduction	0.200	-0.203	-0.235	1.000			
High fraction of foreigners	0.538	0.005	-0.645	0.290	1.000		
High gender norm index	-0.668	-0.077	0.552	-0.235	-0.384	1.000	
High presence of anti-violence centers	-0.028	0.339	0.029	-0.011	-0.085	-0.083	1.000

Figure A.2: Effect of weekly average maximum temperature on weekly calls to 1522 helpline by victims (panel a) and users (panel b), unweighted regressions



Notes: The vertical segments are 95% confidence intervals. The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero.

Figure A.3: Effect of weekly average maximum temperature on weekly calls to 1522 helpline by victims (panel a) and on femicides (panel b), controlling for relative humidity



Notes: The vertical lines indicate the reference category $(6, 8]$°C, whose coefficient is normalized to zero. Each regression is weighted by the provincial population of the year of the observation. The average of victims' helpline calls per 100,000 inhabitants is 0.307 at 6-8°C. Confidence intervals are derived from two-way clustered standard errors, with clusters at the level of sequential months and of provinces.

Table A.2: Estimations results of the main model using different approaches to estimate clustered standard errors

	Victims' calls per 100,000 inhabitants	Femicides per 100,000 inhabitants
Weekly average of maximum daily temperature - Reference: $(6, 8]°C$		
< 4°C	0.0234	-1.1220
	(0.0157)	(0.9045)
	[0.0181]	[0.8603]
	{0.0164}	{0.8994}
$(4, 6]$°C	0.0116*	-0.5559
	(0.0061)	(0.6192)
	[0.0082]	[0.4869]
	{0.0091}	{0.4675}
$(8, 10]$°C	0.0069	0.1796
	(0.0096)	(0.4550)
	[0.0101]	[0.4013]
	{0.0102}	{0.3450}
$(10, 12]$°C	0.0144	0.2047
	(0.0109)	(0.4939)
	[0.0102]	[0.4258]
	{0.0104}	{0.3496}
$(12, 14]$°C	0.0176	0.5056
	(0.0112)	(0.7957)
	[0.0102]	[0.7612]
	{0.0122}	{0.7023}
$(14, 16]$°C	0.0371***	0.7565
	(0.0139)	(0.7251)
	[0.0116]	[0.6777]
	{0.0140}	{0.6038}
$(16, 18]$°C	0.0289**	0.8973
	(0.0135)	(0.8442)
	[0.0137]	[0.7819]
	{0.0143}	{0.6991}
$(18, 20]$°C	0.0398***	0.8671
	(0.0121)	(1.0414)
	[0.0140]	[0.9880]
	{0.0150}	{0.9151}
$(20, 22]$°C	0.0535***	1.5214
	(0.0147)	(1.1694)
	[0.0158]	[1.0819]
	{0.0162}	{0.9971}
$(22, 24]$°C	0.0540***	1.7767
	(0.0158)	(1.2598)
	[0.0162]	[1.1642]
	{0.0169}	{1.0732}
$(24, 26]$°C	0.0545***	1.9542
	(0.0164)	(1.3227)
	[0.0187]	[1.2201]
	{0.0196}	{1.1219}
$(26, 28]$°C	0.0530***	2.4626*
	(0.0202)	(1.3455)
	[0.0216]	[1.2731]
	{0.0219}	{1.1756}
$(28, 30]$°C	0.0630***	2.3382*
	(0.0234)	(1.3301)
	[0.0241]	[1.2442]
	{0.0242}	{1.1221}
> 30°C	0.0574**	2.9346**
	(0.0264)	(1.3453)
	[0.0275]	[1.2601]
	{0.0279}	{1.1293}

Notes: * p-value$<$0.10, ** p-value$<$0.05, *** p-value$<$0.01. In parenthesis (brackets) we report two-way clustered standard errors with clusters at the level of sequential months (weeks) and of provinces. In curly braces, we report standard errors clustered only at the level of provinces. Each regression is weighted by the provincial population of the year of the observation. Each regression includes wind speed, precipitation, $PM_{2.5}$, ozone, sequential week FE and month-year-province FE, and is weighted by the provincial population during the year of the observation.