Association between extreme temperature and work-related accidents in Chile: a case time series by communes' design - Supplementary material

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This supplementary material provides a detailed account of the exploratory and descriptive analyses carried out to support the main paper. It is organized as follows: first, we describe the preparation of the dataset, including cleaning, merging and restructuring into a time series format required for the models. We then present general tables summarizing occupational accidents by economic sector and sex, followed by more granular tables that explore age and sex distributions within sectors. The next section reports on regional patterns, showing the distribution of accidents across Chile's macro-zones, and includes cross-tabulations to highlight female participation by sector and region. We also include additional distributed lag non-linear models (DLNMs) using daily mean temperature (Tmean) instead of daily maximum temperature (Tmax), to assess the robustness of the findings under alternative temperature metrics. Finally, we discuss exploratory conclusions that emerge from these descriptive and supplementary models, which may guide future focused research and policy adaptation strategies.

0. Structure of the Rmd

1. Data preparation
2. General table: Accidents by economic sector and sex.
3. Tables by sector: age distribution and sex
4. Regional tables: distribution by macro-zone
5. Cross-tabulations: sector by region (female participation)
6. Models with T Mean
7. Exploratory conclusions

0.1 Setup

0.1.1 Functions

This section defines auxiliary functions used throughout the script. It includes functions to prepare data in the format required by the DLNM models, generate prediction matrices, and compute summary measures such as cumulative relative risks. For more details see the .Rmd file associated with this PDF file (it has the same name).

0.2 Preparation of Time Series

Accidents data is loaded, some filters are made and it is restructured so every commune has a data point for each day, including days with and without accidents. This is not very efficient in space use, but is the way the data is needed for dlnm package.

0.3 Short Description of data

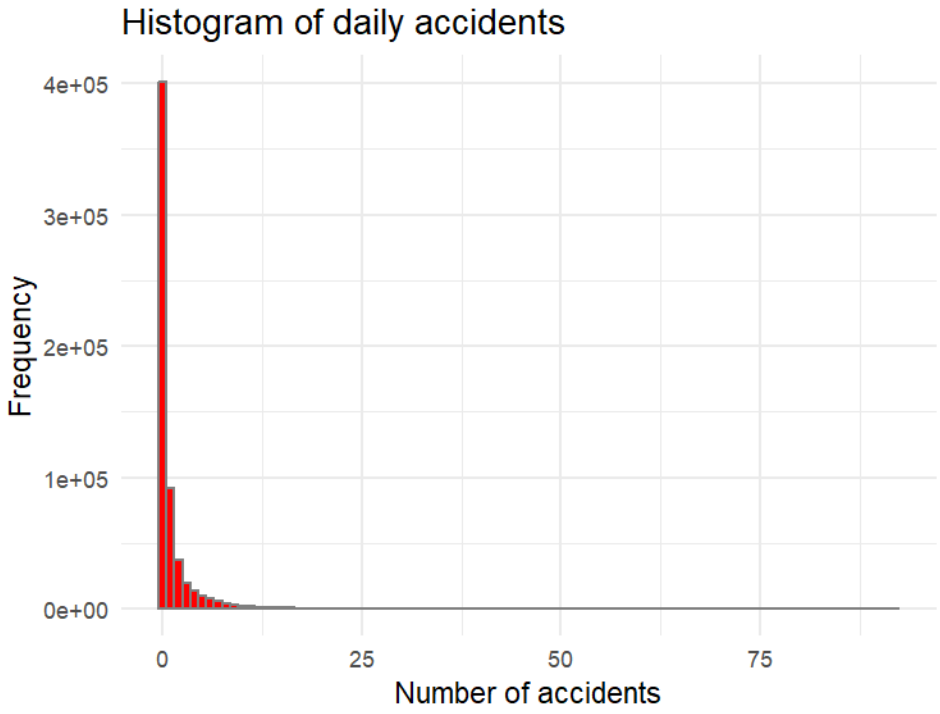


Figure 1: own elaboration

The figure 1 shows a high concentration of days with a low number of daily accidents (fewer than 5), and frequency rapidly decreases as the number of accidents increases. This indicates that most days exhibit a moderate burden of incidents, with fewer extreme events.

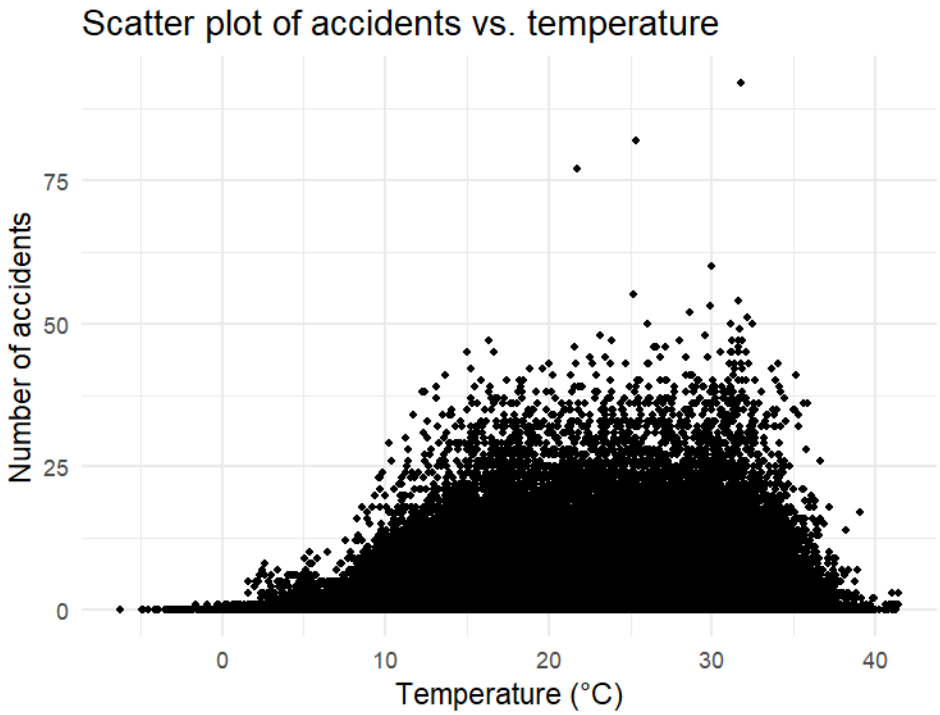


Figure 2: own elaboration

This scatter plot (Figure 2) reveals an approximately normal distribution, with most points concentrated in an intermediate range of temperatures and accident counts. This suggests a robust data volume for the analysis, adequately distributed across the observed temperature range.

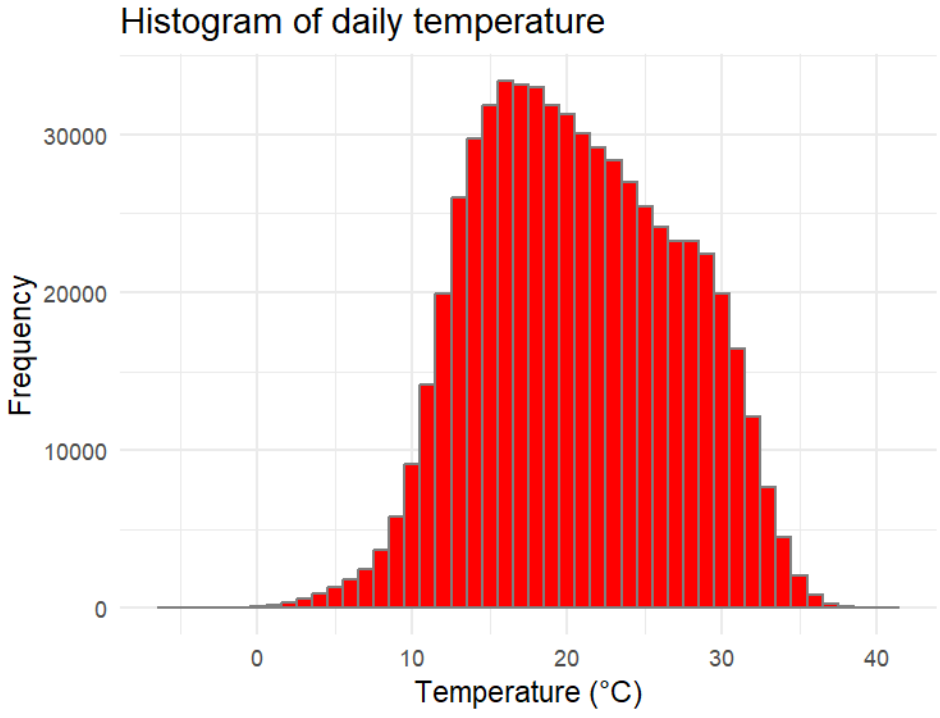


Figure 3: own elaboration

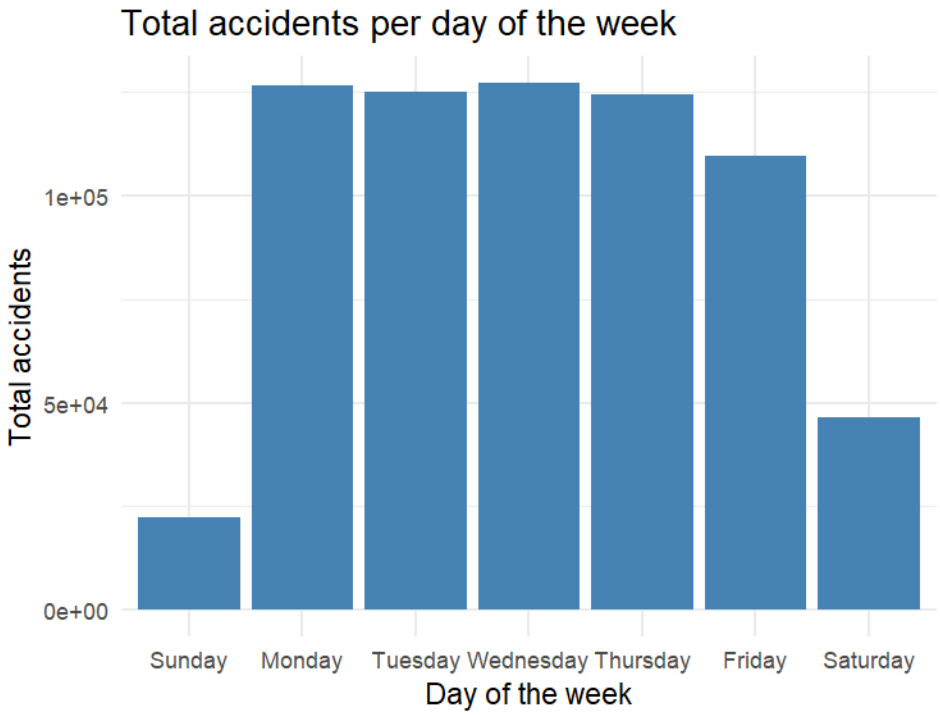


Figure 4: own elaboration

Throughout the week (Figure 4), occupational accidents are relatively evenly distributed, except for Fridays where a decrease is observed, likely influenced by work schedules such as 4x3 shifts used in mining or forestry that concentrate labor from Monday to Thursday. Saturdays and Sundays show lower incidence, consistent with reduced productive activity over weekends. It is important to note that these are interpretative hypotheses.

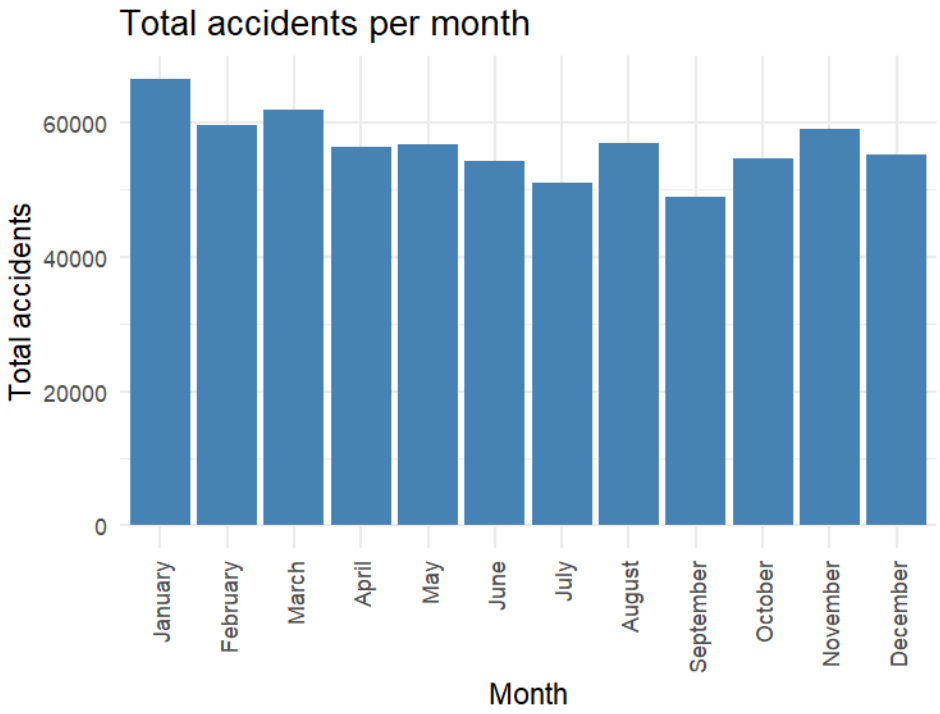


Figure 5: own elaboration

Although a slight increase in accidents can be observed during the summer months, the relative difference across months is not pronounced. This suggests that while there may be a seasonal influence, other factors such as the type of economic activity or labor organization likely play a more decisive role.

0.4 Difference between communes

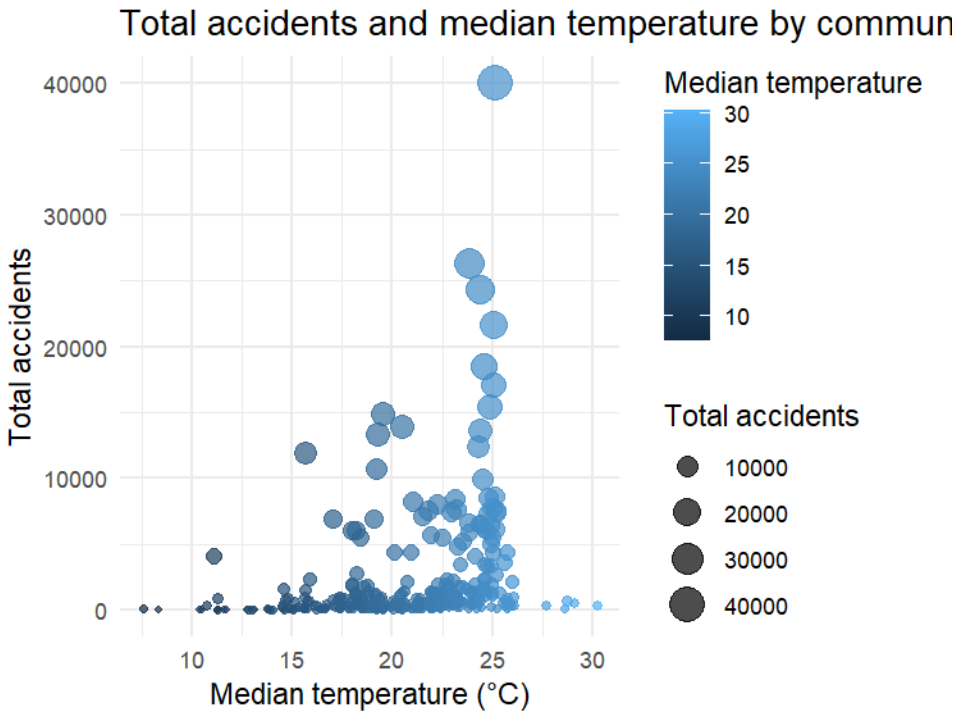


Figure 7: own elaboration

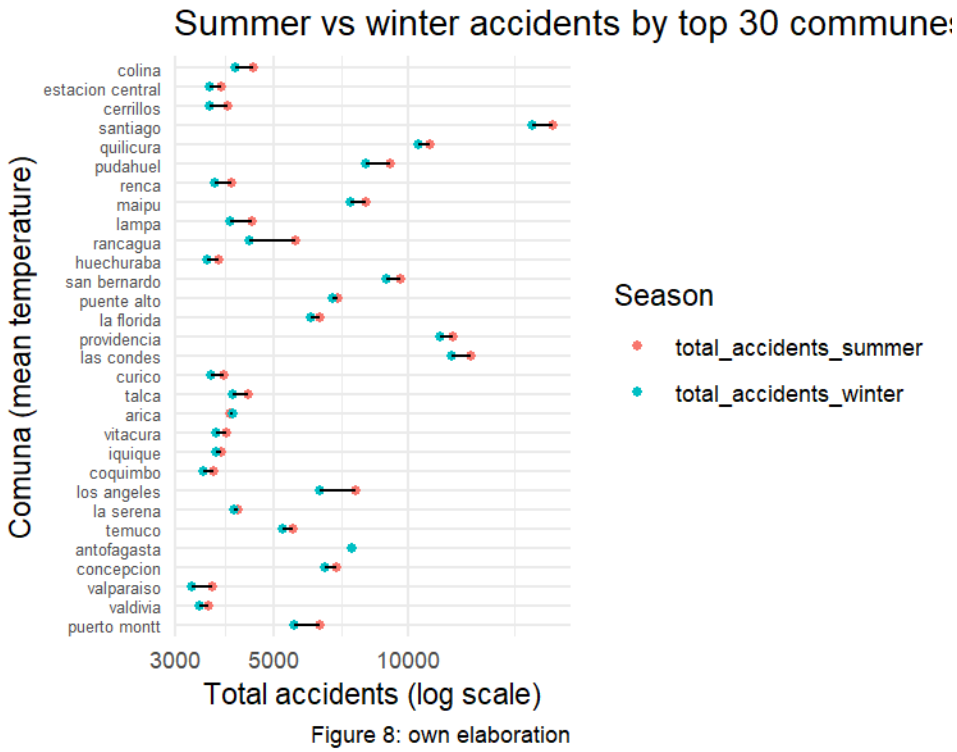


Figure 8: own elaboration

This figure displays the total number of accidents in summer and winter for the 30 communes with the highest accident counts, ordered by their mean temperature. It is noticeable that in a considerable number

of communes, accidents predominantly occur during the summer, although the magnitude of this difference varies across locations. This pattern suggests a possible seasonal influence that warrants further exploration, potentially analyzing whether specific economic activities or climatic characteristics amplify this effect. It is important to emphasize that this finding is preliminary and requires additional modeling to confirm its significance.

1. Tables: Count of accidents by sex, sector and age group

The tables are given by:

tableA{n} = if for paper

tableB{n} = if for supplementary material

1.1 Accidents by sector sex

This table summarizes the number and percentage of occupational accidents by economic sector and sex, providing a quick view of the distribution of cases across sectors and highlighting gender differences.

Table 1: (A1) Number and percentage of occupational accidents by economic sector and sex.

Macrosector	Sex	n	pct
Agroforestry and Fishing	Female	41,226	29.2
Agroforestry and Fishing	Male	99,809	70.8
Commerce	Female	64,140	36.2
Commerce	Male	112,875	63.8
Industry, Construction and Mining	Female	38,268	13.0
Industry, Construction and Mining	Male	257,025	87.0
Other Services	Female	18,666	20.6
Other Services	Male	72,098	79.4
Public Services	Female	198,516	70.8
Public Services	Male	81,957	29.2
Unassigned	Female	135,496	42.7
Unassigned	Male	181,959	57.3

Table 1 displays the number and percentage of occupational accidents by economic macrosector and sex. It is evident that males constitute the majority in nearly all cases, particularly in the Industry, Construction, and Mining sector, where they account for 87% of accidents. In contrast, females are the majority only within the Public Services sector. This may indicate a trend of gender-based occupational segregation in certain economic activities, although it is presented here as an exploratory hypothesis.

1.2 Accidents by sector age sex

This table breaks down accidents by economic sector, age group (18–39, 40–59, 60+), and sex. It shows how different age categories contribute to accident counts within each sector for both males and females.

Table 2: (B1) Breakdown of accidents by economic sector, age group, and sex.

Macrosector	Age_group	Sex	n	pct
Agroforestry and Fishing	18–39	Female	15,406	10.9
Agroforestry and Fishing	18–39	Male	35,579	25.2
Agroforestry and Fishing	40–59	Female	19,113	13.6
Agroforestry and Fishing	40–59	Male	39,636	28.1
Agroforestry and Fishing	60+	Female	6,707	4.8
Agroforestry and Fishing	60+	Male	24,594	17.4
Commerce	18–39	Female	26,237	14.8
Commerce	18–39	Male	55,749	31.5
Commerce	40–59	Female	28,858	16.3
Commerce	40–59	Male	41,626	23.5
Commerce	60+	Female	9,045	5.1
Commerce	60+	Male	15,500	8.8
Industry, Construction and Mining	18–39	Female	13,800	4.7
Industry, Construction and Mining	18–39	Male	104,799	35.5
Industry, Construction and Mining	40–59	Female	18,088	6.1
Industry, Construction and Mining	40–59	Male	107,278	36.3
Industry, Construction and Mining	60+	Female	6,380	2.2
Industry, Construction and Mining	60+	Male	44,948	15.2
Other Services	18–39	Female	7,120	7.8
Other Services	18–39	Male	27,523	30.3
Other Services	40–59	Female	8,711	9.6
Other Services	40–59	Male	31,071	34.2
Other Services	60+	Female	2,835	3.1
Other Services	60+	Male	13,504	14.9
Public Services	18–39	Female	71,722	25.6
Public Services	18–39	Male	25,418	9.1
Public Services	40–59	Female	90,996	32.4
Public Services	40–59	Male	35,592	12.7
Public Services	60+	Female	35,798	12.8
Public Services	60+	Male	20,947	7.5
Unassigned	18–39	Female	55,478	17.5
Unassigned	18–39	Male	90,293	28.4
Unassigned	40–59	Female	56,336	17.7
Unassigned	40–59	Male	64,626	20.4
Unassigned	60+	Female	23,682	7.5
Unassigned	60+	Male	27,040	8.5

1.3 Female share by sector

This table reports the female share of occupational accidents within each economic sector, detailing both absolute counts and relative proportions.

Table 3: (A2) Female share of occupational accidents within each economic sector.

Macrosector	Sex	n	pct
Agroforestry and Fishing	Female	41,226	29.2
Commerce	Female	64,140	36.2

Macrosector	Sex	n	pct
Industry, Construction and Mining	Female	38,268	13.0
Other Services	Female	18,666	20.6
Public Services	Female	198,516	70.8
Unassigned	Female	135,496	42.7

1.4 Female accidents by sector age

This table details the distribution of female accidents across economic sectors and age groups, indicating how age impacts female accident frequencies in different sectors.

Table 4: (B2) Distribution of female accidents across economic sectors and age groups.

Macrosector	Age_group	n	pct
Agroforestry and Fishing	18–39	15,406	37.4
Agroforestry and Fishing	40–59	19,113	46.4
Agroforestry and Fishing	60+	6,707	16.3
Commerce	18–39	26,237	40.9
Commerce	40–59	28,858	45.0
Commerce	60+	9,045	14.1
Industry, Construction and Mining	18–39	13,800	36.1
Industry, Construction and Mining	40–59	18,088	47.3
Industry, Construction and Mining	60+	6,380	16.7
Other Services	18–39	7,120	38.1
Other Services	40–59	8,711	46.7
Other Services	60+	2,835	15.2
Public Services	18–39	71,722	36.1
Public Services	40–59	90,996	45.8
Public Services	60+	35,798	18.0
Unassigned	18–39	55,478	40.9
Unassigned	40–59	56,336	41.6
Unassigned	60+	23,682	17.5

1.5 Female distribution by sector

This summary table presents the total number and percentage of women's occupational accidents by economic sector, offering an overall perspective of sectoral distribution among female workers.

Table 5: (A3) Total number and percentage of women's occupational accidents by economic sector.

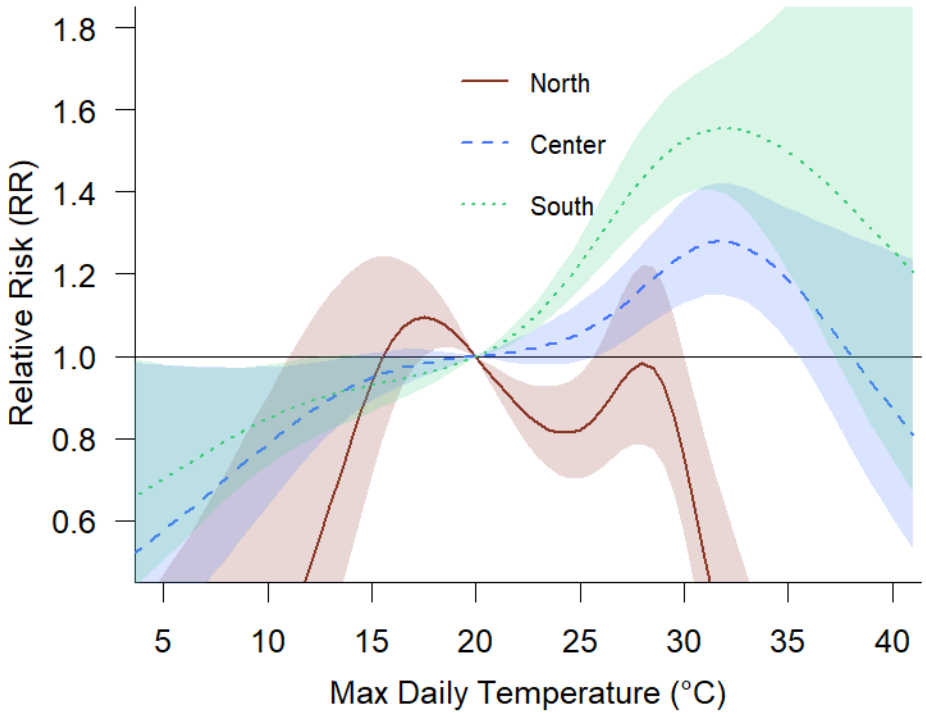
Macrosector	n	pct
Agroforestry and Fishing	41,226	8.3
Commerce	64,140	12.9
Industry, Construction and Mining	38,268	7.7
Other Services	18,666	3.8
Public Services	198,516	40.0
Unassigned	135,496	27.3

Table 5 shows the total number and percentage of women's occupational accidents by economic macrosector. Notably, the Public Services sector accounts for 40% of all female occupational accidents, suggesting a particularly substantial dataset for conducting focused analyses in this group. This is followed by Commerce at 12.9%, while other sectors exhibit lower proportions. These data facilitate the identification of gender- and sector-specific trends, providing context for subsequent analyses segmented by females. The remaining tables in this study, which detail distributions by age group and other characteristics, primarily serve a descriptive purpose to visualize the composition of the dataset.

2. Additional models of interest

2.1 Agroforestry by zone

This section estimates temperature-related risks for occupational accidents in the Agroforestry and Fishing sector across Chile's macro-zones (North, Center, South). It reveals how geographical context influences vulnerability to heat within this economic activity.



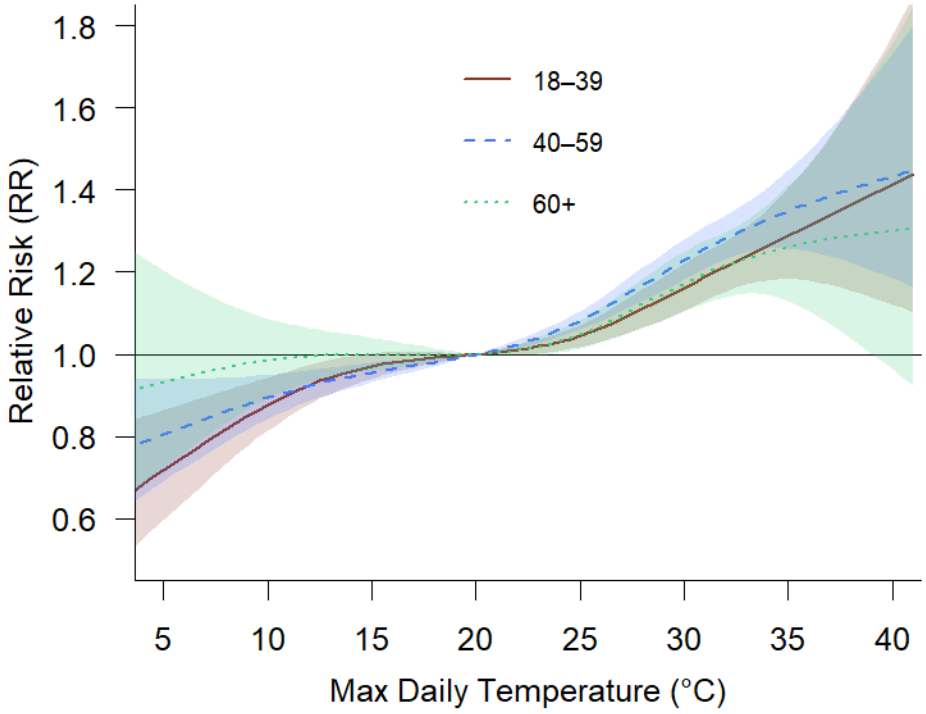
The stratified DLNM models reveal several relevant trends.
In the analysis of the agroforestry macrosector by geographic zone (Figure), the south shows a higher relative risk (RR) in response to increasing temperatures, which is consistent given that this region typically experiences lower average temperatures. Furthermore, since a large portion of the country's agroforestry activity is concentrated in the south, the larger sample size here may explain the stronger statistical significance. In contrast, in the north, confidence intervals are wide and the risk diverges rapidly, suggesting insufficient data for this group and supporting the notion that it might be excluded from the overall model.

2.2 Gender-Specific Risk Estimates by Subgroup (only female)

This section explores whether the increased relative risk observed in women persists across different subgroups. Specifically, we disaggregate the female subset into age groups, geographic macro-zones, and economic sectors. This analysis helps identify high-risk intersections of sex and exposure and can inform more targeted adaptation measures.

All models are run using the same case time series approach and parameters as the main model. For each subgroup within women, the RR is estimated across temperature values, with visual comparisons across categories.

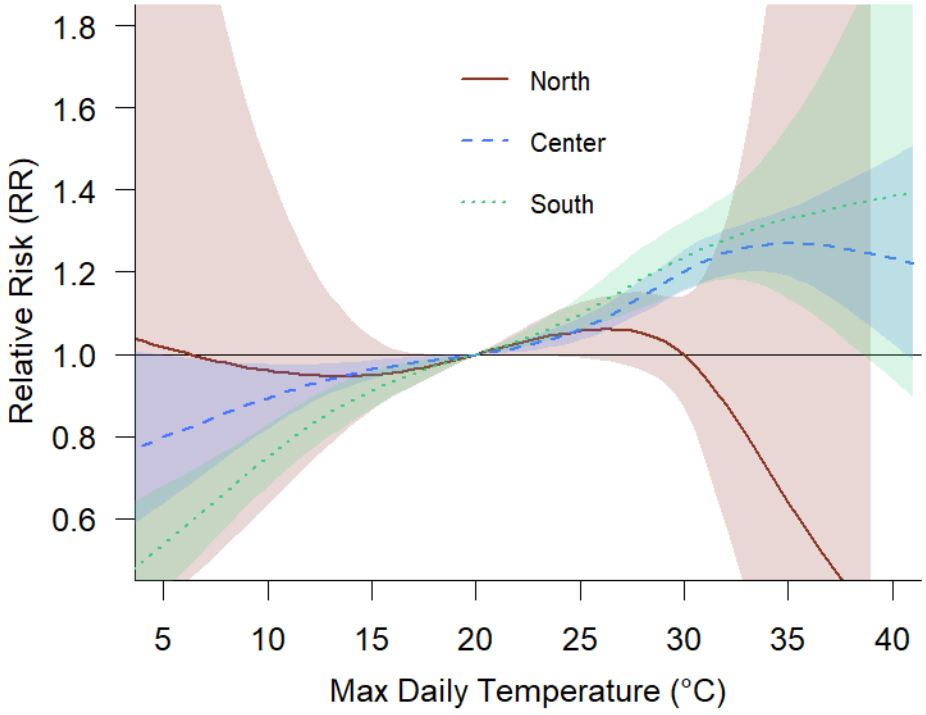
2.2.1 By age group



Result: no significance observed in the age group for females

2.2.2 By zone

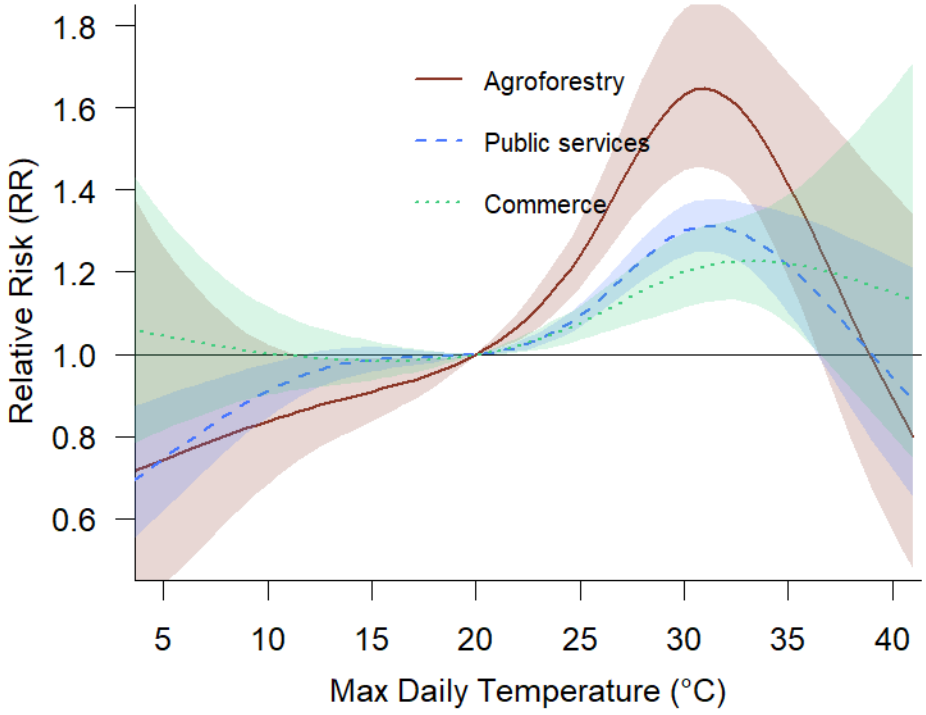
Here, the female dataset is stratified by macro-zone (North, Center, South) to examine how geographical differences shape women's occupational vulnerability to temperature extremes.



In the analysis restricted to women (Figure), a similar pattern emerges. When broken down by geographic zone, the north again lacks statistical significance, possibly due to the low representation of women in the main economic sector of that area (mining), directly impacting model robustness (exploratory hypothesis).

2.2.3 By economic sector

This model evaluates temperature risks in female workers across three major economic sectors—Agroforestry, Public Services, and Commerce—revealing sector-specific patterns of susceptibility.



When stratified by economic macrosector (Figure), agroforestry exhibits significantly higher relative risks compared to public services and commerce. This suggests a potentially higher inherent hazard or greater vulnerability in this sector to elevated temperatures. This finding prompted a more detailed examination of the agroforestry macrosector.

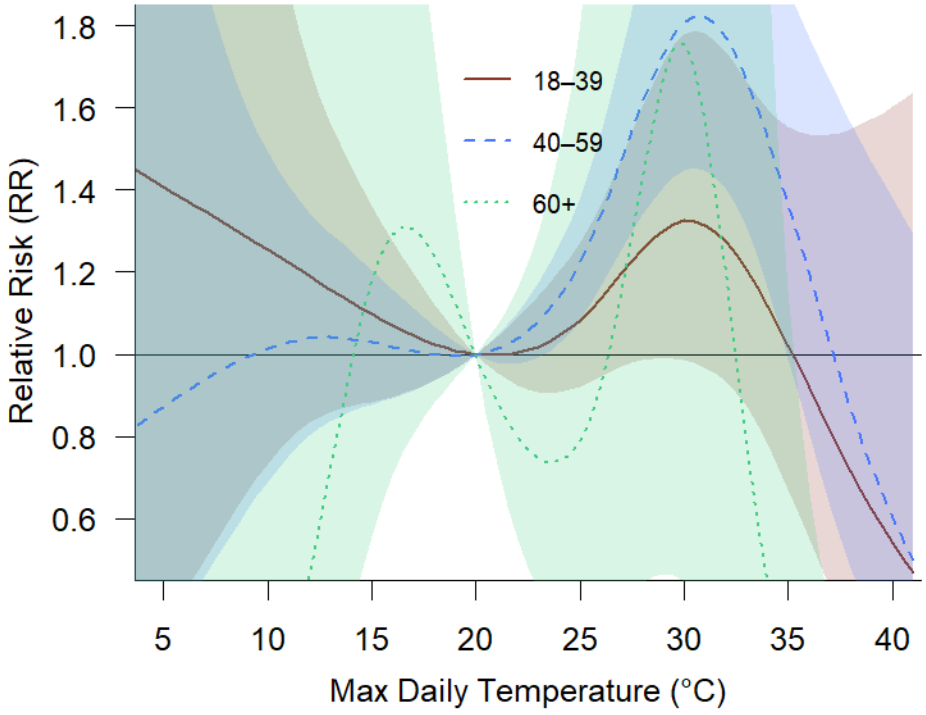
2.3 Disaggregation of female risk in high-risk sectors

This section analyzes in more detail the two economic sectors with the highest female burden and heat-related risk: Agroforestry and Fishing, and Public Services. For each sector, we stratify women's accidents by age group and macro-zone, to identify particularly vulnerable subpopulations.

2.3.1 Female workers in Agroforestry and Fishing

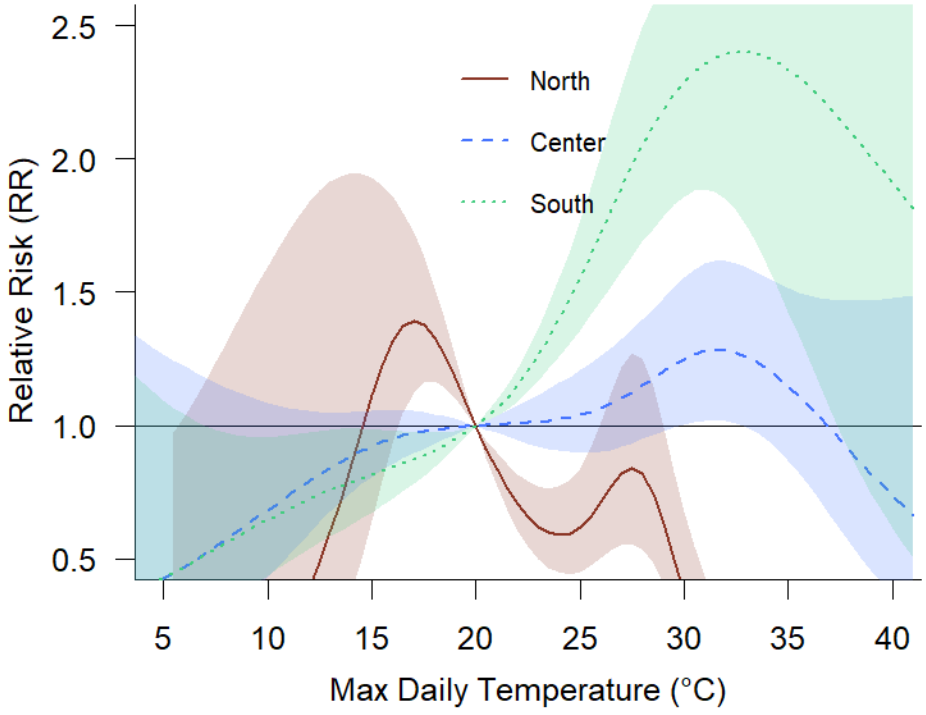
For women in Agroforestry, models are stratified by age group and macro-zone to pinpoint which combinations face the highest heat-related risks.

Age group stratification



Result: no significance observed in the age group for females

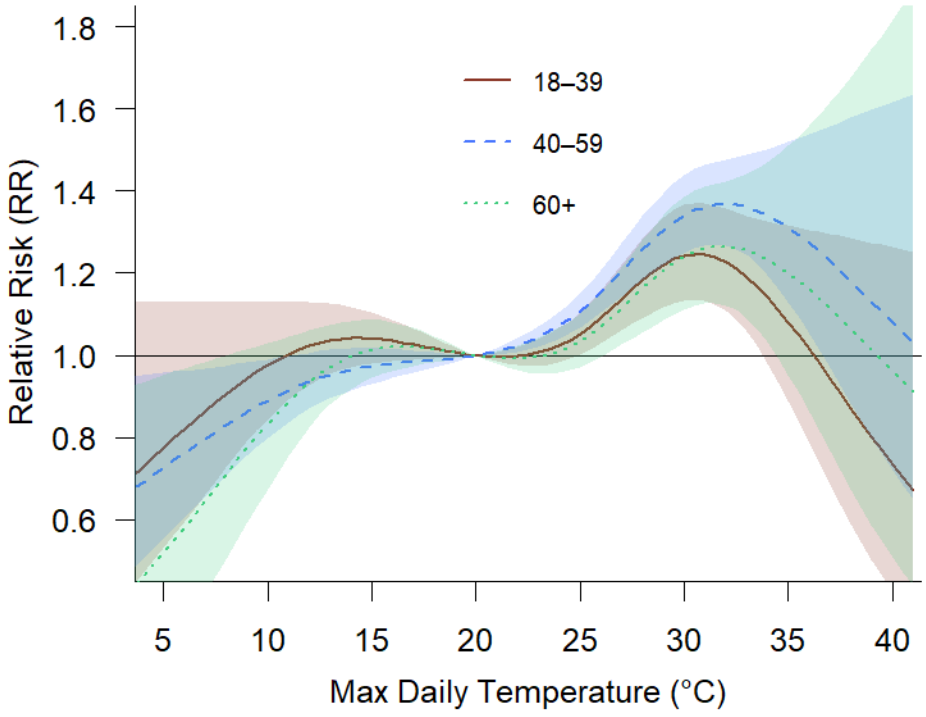
Macro-zone stratification



Lastly, analyzing the agroforestry sector by macrozone for women (Figure) reinforces the previously observed pattern: the north lacks significance, while the south appears as the main contributor to the overall identified risk. This suggests that women working in the agroforestry sector in the south may constitute a particularly vulnerable group during heat waves.

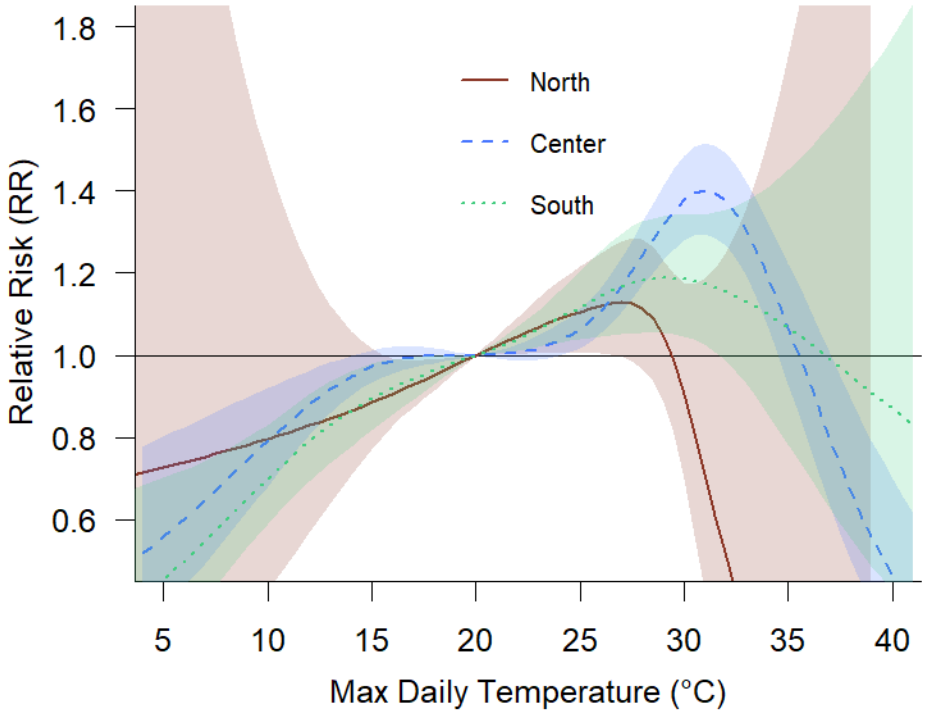
2.3.2 Female workers in Public services

Age group stratification



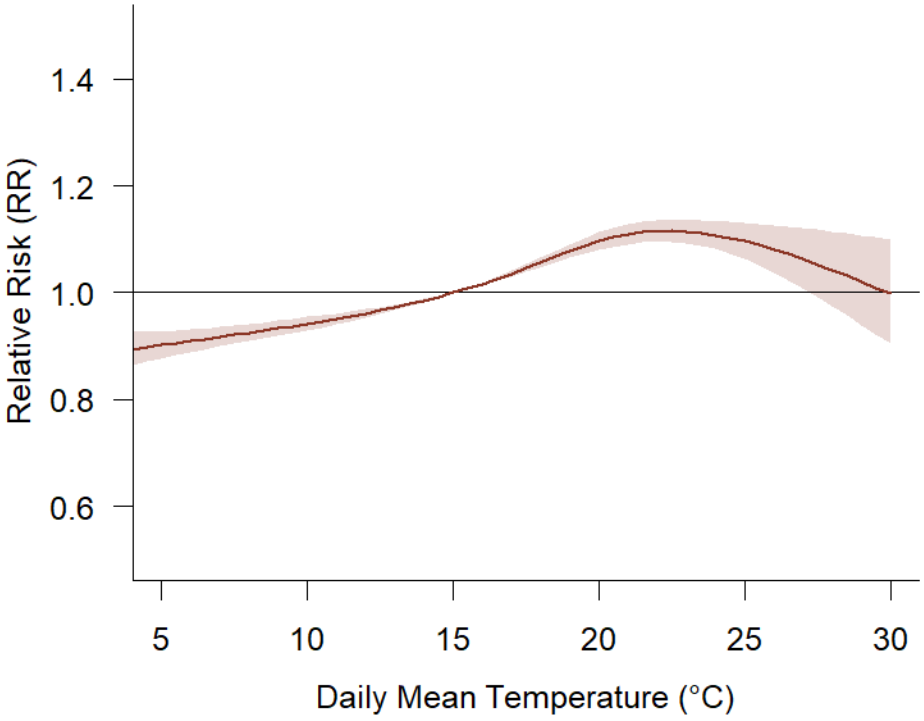
Result: no significance observed in the age group for females

Macro-zone stratification

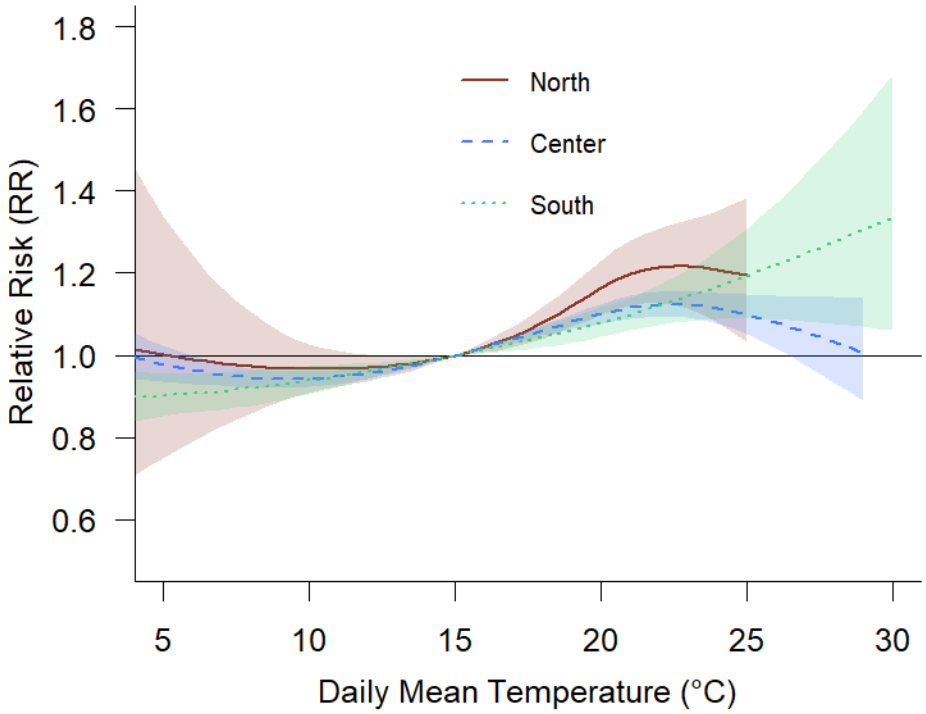


Result: no significance observed in the age group for females in public services.

3. Model with T° mean



3.1 T° mean by macro-zone



The observed decline in relative risk beyond 25°C in the mean temperature model may indicate heat adaptation in central and northern zones, as seen in the second figure, where the curves for these regions level off or even decline. Meanwhile, the continued rise in the South suggests less physiological or behavioral adaptation to heat, possibly due to historically cooler climates or differences in labor practices.

Conclusions

Taken together, the exploratory analyses and the non-linear risk models presented in this supplementary material help identify key patterns that complement and deepen the findings of the main manuscript. The initial descriptive analyses show a high concentration of accidents on certain days and in specific communes, with slight indications of seasonality. At the level of economic macrosectors, a marked sex difference emerges, with male predominance in industrial activities and a significant proportion of women in the public services sector.

The DLNM models reveal that relative risk associated with extreme temperatures is not uniform, highlighting the agroforestry sector in the south of the country as a potentially particularly vulnerable group, especially among women. Conversely, certain regions such as the north show high statistical uncertainty, indicating the need for cautious interpretation of these estimates and potentially warranting their exclusion from general analyses.

These findings underscore the importance of conducting differentiated assessments by economic sector, geographic zone, and sex to inform more targeted and effective climate change prevention and adaptation policies.