

# Climate-driven Patterns of West Nile Virus in Lombardy: A Spatio-Temporal Analysis (2013-2022)

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## INTRODUCTION

Climate change is one of the most pressing global health threats of the 21<sup>st</sup> century, driving shifts in infectious disease patterns and facilitating the spread of mosquito-borne viruses like West Nile Virus (WNV). Lombardy, in northern Italy, is a high-risk area for WNV circulation and now represents an endemic zone in the Po River Valley. Despite the well-established impact of temperature and precipitation on mosquito population dynamics and WNV transmission, current surveillance does not incorporate climatic parameters to monitor WNV epidemiology.

## OBJECTIVE

This study aims to describe the epidemiology of WNV in Lombardy Po Valley from 2013 to 2022 and to evaluate the association between climatic factors – specifically temperature and precipitations – and the occurrence and distribution of WNV cases, in order to determine whether climate data can support more effective surveillance and warning systems.

## METHODS

A retrospective observational study using human WNV case data collected through the national surveillance system in Lombardy from 2013 to 2022 was conducted. Weekly provincial case counts were matched with meteorological data from ARPA Lombardy, including weekly average temperature and total precipitation. In the descriptive phase, we created choropleth maps showing the geographical distribution of WNV cases across across the period in Lombardy provinces.

Moreover we plotted weekly time series of case prevalence per 10000 inhabitants, temperature, and precipitation to assess their temporal co-occurrence and seasonal patterns. For inferential analysis, we fitted a hurdle model with two components: (1) a logistic regression modeling the probability of WNV case occurrence, and (2) a zero-truncated Poisson regression for the count of cases, conditional on occurrence. Models included a two-week lag for temperature and a one-week lag for precipitation and fixed effects for province and year, and offset terms for population size.

## RESULTS

Between 2013 and 2022, 311 WNV cases were recorded in six Lombardy provinces, with a prevalence in males (74%) and individuals over 65 years (58%). Among the 164 cases with clinical classification (available from 2019 onward), 53% were neuroinvasive (WNND), while 25% were identified through blood/tissue donation. The majority of cases occurred between July and October, peaking in August (52.4%). The most affected years were 2018, 2020 and 2022. Spatially, the highest prevalence was observed in southern provinces (Cremona, Mantua, Pavia, Lodi), forming a south-north gradient. Time-series plots highlighted a recurrent seasonal alignment between rising temperatures and WNV prevalence, while precipitation showed less consistent patterns. The hurdle model confirmed a significant role of temperature: a 1°C increase (lagged two weeks) raised the odds of case occurrence by 27% (OR=1.27) and the number of cases by 11% (IRR=1.11). Precipitation (lagged one week) had no effect on outbreak onset but increased case counts by 13% (IRR=1.13) once circulation began. Provincial and in-

ter-annual differences were significant in predicting virus occurrence but not outbreak intensity.

## CONCLUSIONS

Temperature is the most influential factor for both triggering and amplifying WNV transmission, while precipitation acts as a secondary amplifier. This study demonstrates the critical role of short-term climatic variables, particularly temperature, in shaping WNV dynamics in Lombardy. Rising temperatures significantly increase both the probability of outbreak initiation and the intensity of transmission. While precipitation alone does not appear to initiate outbreaks, it contributes to amplifying transmission once WNV is circulating. These findings reinforce the importance of integrating climate indicators into surveillance systems to enhance early warning capacity and timely public health responses. The identification of provincial-level risk differentials and temperature thresholds can inform geographically tailored interventions. In the context of ongoing climate change, such predictive models could become essential tools to mitigate the impact of future arboviral epidemics.

## REFERENCES

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