# CLIMATE CHANGE AND THE RISING INCIDENCE OF DENGUE IN ARGENTINA

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## 1) INTRODUCTION

Climate can affect the transmission dynamics, geographic spread, and re-emergence of vector-borne diseases (Rocklöv and Dubrow 2020). In the past few decades, many mosquito-borne diseases have expanded their distributions from tropical and subtropical regions to temperate areas around the world (Tomasello et al. 2013; Rey 2014; Robert et al. 2019; Robert et al. 2020; López et al. 2021). The factors that contribute to the global expansion and intensification of dengue virus (DENV) and other arboviruses include global-scale travel, rapid and unplanned urbanization, and changes in climate leading to increased temperatures and erratic precipitation patterns (Gubler 2002, 2011; Hii et al. 2009; Butterworth et al. 2017; Huber et al. 2018). The Americas is one of the most severely affected regions, with the southern limit of DENV transmission located in Argentina, South America (WHO 2020).

Large-scale global dengue epidemics are associated mainly with the presence of *Aedes aegypti* mosquitoes, which are also responsible for transmitting other emerging and re-emerging arboviruses such as yellow fever, Zika, and chikungunya (Lambrechts et al. 2010). In Argentina, the geographical distribution of *Ae. aegypti* is expanding. Climate conditions, especially temperature, influence the global spread of the vector, the species' life history characteristics, and the acceleration of the virus transmission capacity (Boggs et al. 2012; Bhatt et al. 2013; Carrington et al. 2013; Kraemer et al. 2015; Caldwell et al. 2021). In addition, heavy precipitation and associated flooding events are projected to become more intense and frequent in some regions of South America (e.g., Lovino et al. 2018a, 2018b). These projected changes in climate conditions are predicted to affect the distribution and competence of *Ae. aegypti* and other vectors and have a potentially significant impact on the epidemiology of dengue globally (Rocklöv and Tozan 2019).

This work aims to analyze the evolution of the incidence of DENV in Argentina from its re-introduction in 1998 until the most recent and largest epidemic in 2020, and its relation to climate change. We described the trend and anomalies of temperature and precipitation across the country. Finally, we analyzed the number of months and days with suitable temperature conditions for DENV transmission in representative cities.

## 2) METODOLOGY

We analyze the evolution of climate, epidemiological, and biological variables, comparing a period without the presence of dengue cases (1976-1997) to a more recent period with the occurrence of cases and epidemics (1998-2020). A time series was built with the number of cases and incidence (number of cases per 100,000 inhabitants) for each Argentinean region and maps were plotted to show the trends in registered epidemics. The climate variables analyzed were mean temperature, minimum temperature, maximum temperature, and precipitation from weather stations throughout the country. Data were provided by the National Meteorological Service (https://www.smn.gob.ar). Data were collected from 71 meteorological stations distributed in 20 provinces that presented autochthonous DENV cases. The climate indicators calculated for these variables were trends and anomalies, which were analyzed at the regional scale. The anomalies of annual mean temperature, annual mean maximum temperature, and annual mean minimum temperature in 1976–1997 (without DENV cases) and 1998–2020 (with DENV cases) were compared (Kruskal Wallis test, Infostat 2008). According to Mordecai et al. (2019), the temperature range of DENV transmission is between 17.8 °C and 34.5 °C. The number of months per year in 1976–2020 with that temperature range was counted at the meteorological stations closest to the provincial capitals and the autonomous city of Buenos Aires. Likewise, we analyzed the number of days per year with the optimal range of mean temperatures for transmission (28.4 – 29.8 °C, Mordecai et al. 2019). Subsequently, the means of the number of months and days were calculated for each meteorological station in the periods 1976–1997 (without DENV cases) and 1998–2020 (with DENV cases) to analyze changes in the number of months and days with optimal temperatures between periods.

## 3) RESULTS

Dengue cases in Argentina increased from the re-introduction of DENV in 1998 until the last and largest epidemic in 2020 (Figure 1). During the 1998–2008 period, only five provinces reported autochthonous cases in the northeastern (NE) and northwestern (NW) country regions. In the period 2009–2020, the number of provinces with autochthonous cases rose to 20, adding the center, Cuyo, and south regions to the former regions identified. The climate in Argentina underwent considerable changes in the past six decades. The annual mean, minimum, and maximum temperature trends show that there was a neutral (no increase) or positive variation (0–1.5°C) in the country between 1961 and 2020 (Figure 2). The precipitation trend showed a more erratic pattern, with decreases in northwestern, central-western, and southern provinces and increases in the central-eastern and northeastern provinces (Figure 2). When analyzing climate anomalies, temperature variables were significantly different between the periods under study. No significant differences were observed in the precipitation of both periods. The period of DENV transmission and epidemics (1998–2020) was characterized by warmer temperatures, with 82.60 % of the years (19 of 23) warmer mean temperatures, 73.91 % (17 of 23) warmer minimum, and 73.91 % (17 of 23) warmer maximum temperatures than the period without DENV transmission (1976–1997). The number of months with optimal temperatures for DENV transmission was similar in the 1976–1997 and 1998–2020 periods but there was an increase in the number of days with an optimal temperature range that could be favoring the transmission in the cities analyzed.

## 4) CONCLUSIONS

This study shows how the temperature changes that occurred in Argentina during the past decades are associated with higher incidence and expansion of DENV in different regions of the country. The increase in temperature throughout the country has probably led to the circulation of the virus and the consequent increase in the frequency and magnitude of epidemics. The higher incidence of DENV in the different regions of Argentina does not show a relationship with precipitation trends and anomalies. This may be because the habits of people during droughts could be influencing the formation of mosquito breeding sites that generate epidemics. Climate warming may increase the geographic and seasonal ranges of mosquito-borne diseases with high thermal optima and upper limits relative to their current distribution. Current and future geographic range limits to transmission may depend primarily on the capacity of organisms to tolerate heat and cold stress, as well as factors like water availability, land use, and vector control. Understanding the drivers of dengue expansion at the distribution boundaries is important for predicting whether dengue will continue to expand.

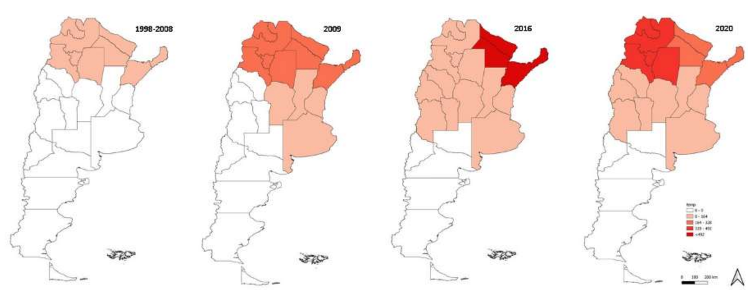
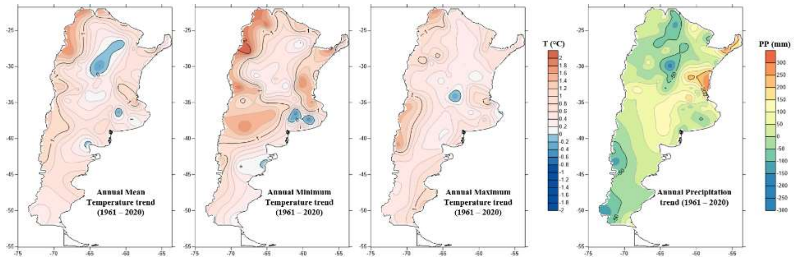



*Figure 1: Incidence of DENV by region in the period 1998-2008 and in the three epidemics registered in 2009, 2016, and 2020.*

*Figure 2. Trends of annual mean, maximum and minimum temperature and precipitation in the period 1961-2020.*

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