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Relationship between Climate Variables and Dengue Incidence in Argentina

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BACKGROUND: Climate change is an important driver of the increased spread of dengue from tropical and subtropical regions to temperate areas around the world. Climate variables such as temperature and precipitation influence the dengue vector's biology, physiology, abundance, and life cycle. Thus, an analysis is needed of changes in climate change and their possible relationships with dengue incidence and the growing occurrence of epidemics recorded in recent decades.

OBJECTIVES: This study aimed to assess the increasing incidence of dengue driven by climate change at the southern limits of dengue virus transmission in South America.

METHODS: We analyzed the evolution of climatological, epidemiological, and biological variables by comparing a period of time without the presence of dengue cases (1976–1997) to a more recent period of time in which dengue cases and important outbreaks occurred (1998–2020). In our analysis, we consider climate variables associated with temperature and precipitation, epidemiological variables such as the number of reported dengue cases and incidence of dengue, and biological variables such as the optimal temperature ranges for transmission of dengue vector.

RESULTS: The presence of dengue cases and epidemic outbreaks are observed to be consistent with positive trends in temperature and anomalies from long-term means. Dengue cases do not seem to be associated with precipitation trends and anomalies. The number of days with optimal temperatures for dengue transmission increased from the period without dengue cases to the period with occurrences of dengue cases. The number of months with optimal transmission temperatures also increased between periods but to a lesser extent.

CONCLUSIONS: The higher incidence of dengue virus and its expansion to different regions of Argentina seem to be associated with temperature increases in the country during the past two decades. The active surveillance of both the vector and associated arboviruses, together with continued meteorological data collection, will facilitate the assessment and prediction of future epidemics that use trends in the accelerated changes in climate. Such surveillance should go hand in hand with efforts to improve the understanding of the mechanisms driving the geographic expansion of dengue and other arboviruses beyond the current limits. https://doi.org/10.1289/EHP11616

Introduction

Climate plays an influential role in the geographic spread, transmission dynamics, and emergence and reemergence of vector-borne diseases.[1] In the past few decades, many mosquito-borne diseases have expanded their distributions from tropical and subtropical regions to temperate areas around the world.[2–7] The factors that contribute to the global expansion and intensification of dengue virus (DENV) and other arboviruses include global-scale travel,[8] rapid and unplanned urbanization,[8,9] and changes in climate leading to increased temperatures and erratic precipitation patterns.[10–12] Dengue fever is considered one of the most important emerging and reemerging arboviral diseases at present.[8,13] Dengue is a mosquito-borne viral infection caused by four closely related virus serotypes that can cause a wide spectrum of symptoms, from extremely mild symptoms such as fatigue to those that may require medical intervention and hospitalization. Occasionally the disease can cause complications that can be fatal. Currently about half of the world's population is at risk of contracting dengue.[13] Severe effects on health due to increasing dengue epidemics are predicted for the next several decades as a consequence of projected climate changes.[14] The Americas is one of the most severely affected regions,[13] with the southern limit of DENV transmission in Argentina, South America.

The first records of DENV transmission in Argentina date back to 1916 and include an outbreak in the northeast of the country. Dengue transmission was reconfirmed some 70 y later at the end of the 1990s when an epidemic occurred in the northern subtropical provinces.[15,16] Since then, autochthonous DENV transmission has been reported in the northernmost provinces almost every year.[17] In 2009, autochthonous DENV transmission was detected for the first time in temperate central Argentina, and after that, dengue incidence has increased considerably in most of the country's provinces.[5,7] The expansion of dengue beyond tropical and subtropical latitudes where dengue is endemic emphasizes the need for haste in addressing this problem.[18–21] Large-scale global dengue epidemics are associated mainly with the presence of *Aedes aegypti* mosquitoes, which are also responsible for transmitting other emerging and reemerging arboviruses such as yellow fever, Zika, and chikungunya.[22,23]

In Argentina, the geographical distribution of *Ae. aegypti* is expanding. Records show that in 1986 the vector was found in only two provinces in the north of the country above 28° S latitude.[24] Currently, there are records of the species as far as the 40° S latitude[25] in 20 of the country's 24 provinces. Climate conditions, especially temperature, influence the global spread of the vector, the species' life history characteristics, and the acceleration of

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the virus transmission capacity.[26–30] In addition, the extrinsic incubation period (the time between ingestion of the pathogen by the vector and the vector becoming infectious) for DENV is inversely associated with ambient temperature.[1] According to the "Sixth Assessment Report of the Intergovernmental Panel on Climate Change,"[31] temperatures have been increasingly warmer—and warmer than any decade prior to 1850—in each of the past four decades. Global surface temperatures in the past two decades (2001–2020) are 0.99°C higher than in the period 1850–1900. Without significant reductions in CO_2 and other greenhouse gases, global surface temperatures will continue to rise until at least the middle of the century.[31] In addition, increases in precipitation and flooding events will become more likely and more intense in some regions of South America.[32,33] These projected changes in climate are predicted to impact the distribution and vector competence of vectors like *Ae. aegypti* and will likely have a significant impact on the future epidemiology of dengue (and other vectorborne diseases) globally.[34] The expected impacts of climate change on vectorborne diseases are a major threat as the incidence, transmission season duration, and spread of these diseases will likely change drastically.[1]

As global temperatures continue to rise, the concerns are that the mosquito and virus will spread to higher latitudes and DENV incidence will increase.[1] The intensification of dengue epidemics over the past decade in regions at the southern limit of distribution of *Ae. aegyti* is indicative of increasing dengue emergence, and it is extremely necessary to better understand the drivers that contribute to its increase. This work aims to analyze the evolution of the incidence of DENV in Argentina from its reintroduction in 1998 until the largest epidemic to date in 2020 and its relationship to climate change. Herein, we describe the trends and anomalies of temperature and precipitation across the country and analyze the number of months and days with suitable temperature conditions for DENV transmission in representative cities.

Methods

Health Data

The Ministerio de Salud de Argentina (MSA) groups 24 provinces or federal states (https://www.argentina.gob.ar/pais/provincias) into

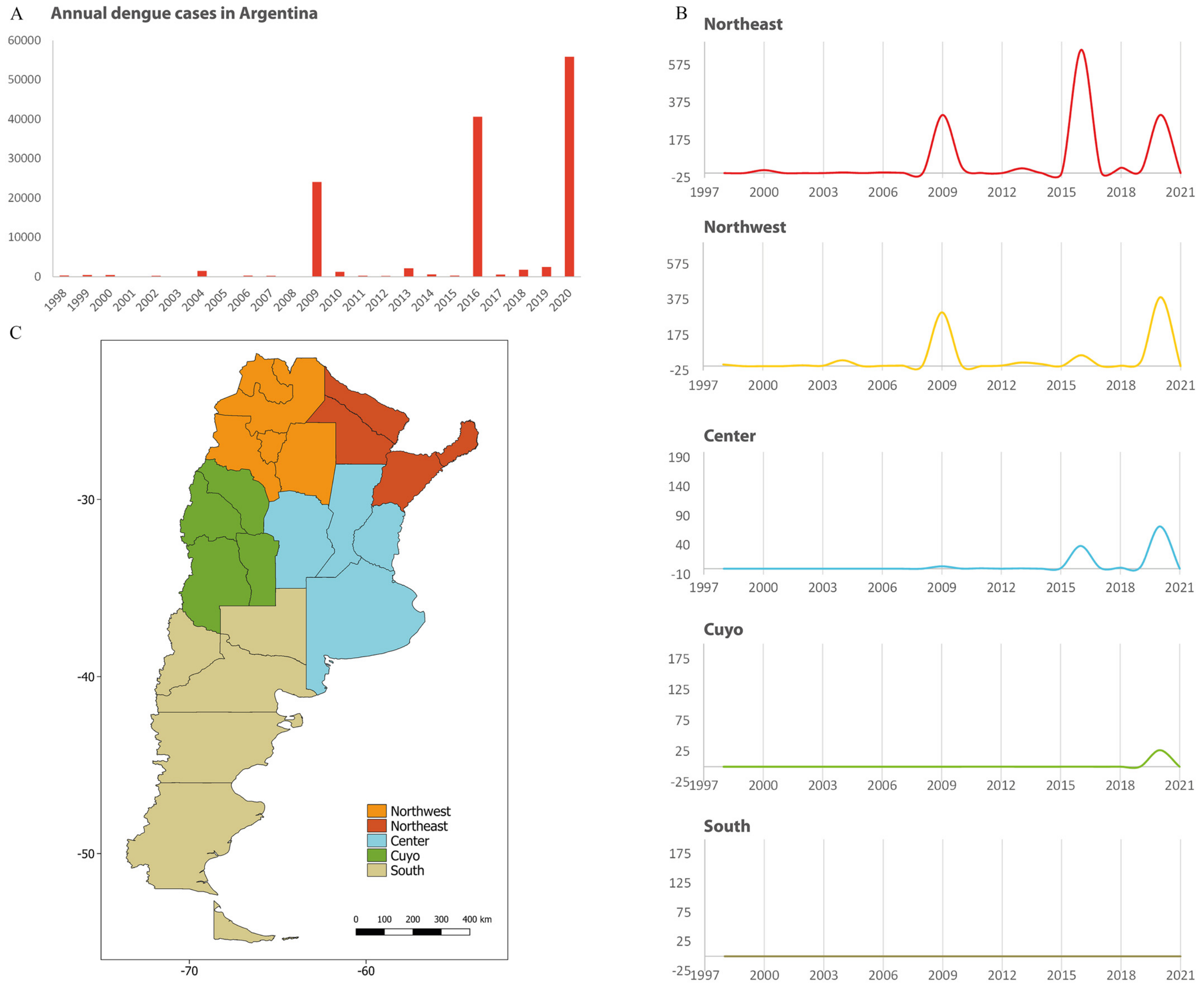

Figure 1. (A) Cases of dengue in Argentina in the period 1998–2020. (B) Incidence of DENV by geographic region (cases per 100,000 inhabitants). (C) Geographic regions of Argentina. Supplemental material Table S1.

five regions (Figure 1C). Confirmed and probable autochthonous cases of dengue in all regions in the period 1998–2020 were compiled from 551 MSA periodic National Epidemiological Bulletins (report number 1642 IX of 2009 to report SE 53 of 2020; https://bancos.salud.gob.ar/bancos/materiales-para-equipos-de-salud/soporte/boletines-epidemiologicos). We identified key data, including the cumulative number of probable dengue cases (i.e., with at least one positive laboratory diagnosis) as well as confirmed cases (with two positive laboratory tests), and autochthonous cases (i.e., locally transmitted) per year and province. This study did not include imported cases (i.e., illness in individuals with a travel history to regions with arbovirus activity), or suspected and unconfirmed cases (suspected cases have infection symptoms but lack laboratory diagnosis). The provinces belonging to five regions with autochthonous DENV cases were Chaco, Corrientes, Formosa, Misiones (Northeast region); Catamarca, Jujuy, Salta, Santiago del Estero, Tucumán (Northwest region); Autonomous City of Buenos Aires, Buenos Aires, Córdoba, Entre Ríos, Santa Fe (Center region); La Rioja, Mendoza, San Juan, San Luis (Cuyo region) and La Pampa, Neuquén (South region) (Figure 1C).

We constructed a time-series data set built with the number of cases per year to detect the epidemics that occurred in the study period. The incidence of DENV (number of cases per 100,000 inhabitants) was determined for each Argentinean region, and maps were plotted to show the trends in registered epidemics. The incidence was also used to determine the most affected regions of Argentina. The maps were made with the QGis 3.14 software. The shape files were obtained from https://www.ign.gob.ar/NuestrasActividades/InformacionGeoespacial/CapasSIG.

Climate Data

According to Beck et al.,[35] Argentina presents different climates primarily determined by a gradient of temperature and precipitation that decreases along latitudes from north to south. Precipitation can also follow a longitudinal gradient decreasing from east to west [Servicio Meteorológico Nacional (SMN); https://www.smn.gob.ar/clima/vigilancia-mapas].[36] Characteristics of the climate of each of the five regions of Argentina were described by Beck et al.,[35] and they are shown in Table 1.

Table 1. Types of climates in Argentina by region according to Beck et al.[35]

Argentine region	Climate	Symbols	Description
Northeast	Tropical	Am	Monsoon
	Temperate	Cfa	Without dry season
Northwest	Tropical	Am	Monsoon
	Arid	Bsh	Steppe, hot
		Bsk	Steppe, cold
	Temperate	Cwa	Dry winter, hot summer
Center	Temperate	Cfa	Without dry season, hot summer
Cuyo	Arid	Bsh	Steppe, hot
		Bwh	Desert, hot
		Bwk	Desert, cold
South	Temperate	Cfa	Without dry season, hot summer
	Arid	Bsk	Steppe, cold
		Bwk	Desert, cold

The climate variables analyzed were mean temperature, minimum temperature, maximum temperature, and precipitation from 1961 to 2020. Data for these variables were collected from weather stations throughout the country and provided by the SMN.[36] Data were collected from 71 meteorological stations distributed in the 20 provinces in which autochthonous DENV cases have been reported. The climate indicators calculated for these variables were trends (changes in long-term behavior) and anomalies (differences from long-term mean behavior), both of which were analyzed at a regional scale.

The climate trends were calculated as the slope of a linear regression of the precipitation and temperature time series during the 1961–2020 period. A positive slope indicates an average increase of the mean values during that period, whereas a negative slope indicates an average decrease. The trend maps were constructed with the results obtained for all the meteorological stations in the region. The maps were made with Surfer (version 13.6.618; Golden Software LLC). The shape files were obtained from https://www.ign.gob.ar/NuestrasActividades/InformacionGeoespacial/CapasSIG.

The anomalies are defined as the difference between temperature (mean, maximum, minimum) and precipitation (total) and the mean values of those variables in the reference period 1981–2010, established by the World Meteorological Organization.[37] Anomalies data, provided by SMN, consist of the value of the annual anomaly at each meteorological station for each year of the period 1961–2020. Standardized anomalies were calculated by dividing anomalies data by the corresponding standard deviation for the temporal series of each meteorological station. Mean anomalies were calculated for each province by averaging the standardized anomaly values of each meteorological station in the province. A mean annual standardized anomaly was then calculated using the standardized mean values of all provinces with reported autochthonous DENV cases. To evaluate the changes in the climate variables, the standardized anomalies of annual mean temperature, annual mean maximum temperature, annual mean minimum temperature, and precipitation in two periods were compared: 1976–1997 (without DENV cases) and 1998–2020 (with DENV cases). These anomalies were analyzed using the Kruskal Wallis test with a statistical significance <0.05 using the software InfoStat (version 2008).

Finally, we investigated changes in the duration of time in which temperatures were suitable for dengue transmission by considering the amount of time each year in which temperatures were in the optimal range for dengue transmission. According to Mordecai et al.,[38] the temperature range of DENV transmission has a lower thermal limit of 17.8°C and upper thermal limit of 34.5°C, with the optimal range for transmission being 28.4–29.8°C. For each provincial capital and the autonomous city of Buenos Aires, we calculated the mean number of months per year in which mean temperatures were within this optimal range. We compared the means from the period 1976–1997 (without DENV cases) with the period 1998–2020 (with DENV cases) to analyze changes in the mean number of months with temperature between the optimal thermal limits of DENV transmission. To investigate these changes at a finer resolution, we also analyzed the mean number of days per year with mean temperatures within the optimal range for transmission.

Results

Dengue cases in Argentina increased from the reintroduction of DENV in 1998 until the largest epidemic to date in 2020 (Figure 1A). During the 1998–2008 period, only five provinces (Corrientes, Formosa, Jujuy, Misiones, and Salta) reported autochthonous cases in the northeastern (NE) and northwestern (NW) regions of the country. In the period 2009–2020, the number of provinces with autochthonous cases rose to 20, with provinces in the Center, Cuyo, and southern regions to the former regions identified. Three large epidemics occurred in the country between 1998 and 2020. The first occurred in 2009 with 24,080 cases, the second in 2016 with 40,649 cases, and the last in 2020 with 55,854 cases. The NE and NW regions had the largest incidence in 2020, with an incidence of 1,344.14 and 790.92 cases (per 100,000 people), respectively; the central region had a total incidence of 123.33 cases (per 100,000 people), and Cuyo and southern Argentina had the lowest incidences, with 27.27 and 0.3,057 cases (per 100,000 people; Figure 1B), respectively. In

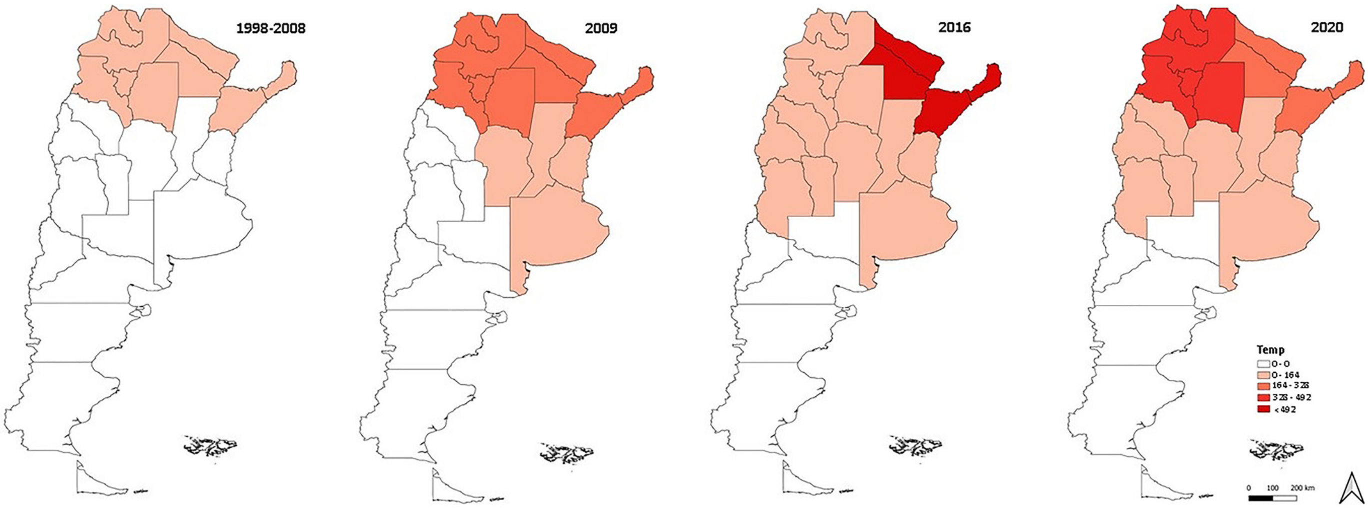

Figure 2. Incidence of DENV by region in the period 1998–2008 and in the three epidemics registered in 2009, 2016, and 2020. Supplemental material Table S2.

four provinces (Río Negro, Chubut, Santa Cruz, and Tierra del Fuego) of the southern region, no DENV cases were registered. Figure 2 shows the increasing DENV incidence in the regions of Argentina since the reintroduction of the virus to the country until the last and most important epidemic of the year 2020.

The climate in Argentina underwent considerable changes in the last six decades, with substantial increases in temperature observed between 1961 and 2020 (60 y). A positive trend (increase) in the mean annual temperature was observed in most of the country, reaching 1.9 (°C/60 y) in the northwestern region (Figure 3A). The trends of maximum and minimum annual temperature were also positive, with increases up 1.7 (°C/60 y) and to 2.3 (°C/60 y) respectively (Figure 3B,C). Trends in precipitation were more erratic, with decreases in northwestern, central-western, and southern provinces and increases in the central-eastern and northeastern provinces (Figure 3D).

We performed an analysis comparing anomalies in mean annual climatic variables between the period without DENV transmission (1976–1997) and the period with DENV transmission and epidemics (1998–2020) (Table 2). Significant differences were observed in the mean ($p = 0.0049$), minimum ($p = 0.0139$), and maximum ($p = 0.0115$) temperature values between both periods. However, no significant differences were observed in the precipitation ($p = 0.2202$) of both periods. Consequently, the period of time with DENV transmission and epidemics (1998–2020) was characterized by a greater number of years with mean (16 of 23 y), minimum (18 of 23 y) and maximum (15 of 23 y) temperature anomalies (°C) with values higher than the mean values of the entire period (1976–2020), in comparison with the period without DENV transmission (1976–1997). Figure 4 shows the temperature anomalies and autochthonous dengue cases from 1976 to 2020. The reintroduction of DENV into Argentina and its expansion to higher latitudes (central and Cuyo regions) coincide with the period of the greatest positive temperature anomalies in the country. Figure 5 shows the anomalies of temperature and precipitation in the different regions of Argentina in the period without DENV transmission and with DENV transmission. In the period with DENV transmission, only positive temperature anomalies were observed in all regions of the country. The northwestern and central regions presented the highest positive anomaly values. For the precipitation anomalies, the majority of provinces in the central and Cuyo regions, where DENV transmission is currently expanding, presented positive anomalies in the most recent period.

We examined the number of months with an optimal temperature range for the transmission of DENV in the capital cities of each province for both the periods without and with DENV transmission (see Table 3). Five of 20 cities (25%) experienced increases in the number of months with optimal temperatures for DENV transmission in the latter period in comparison with the

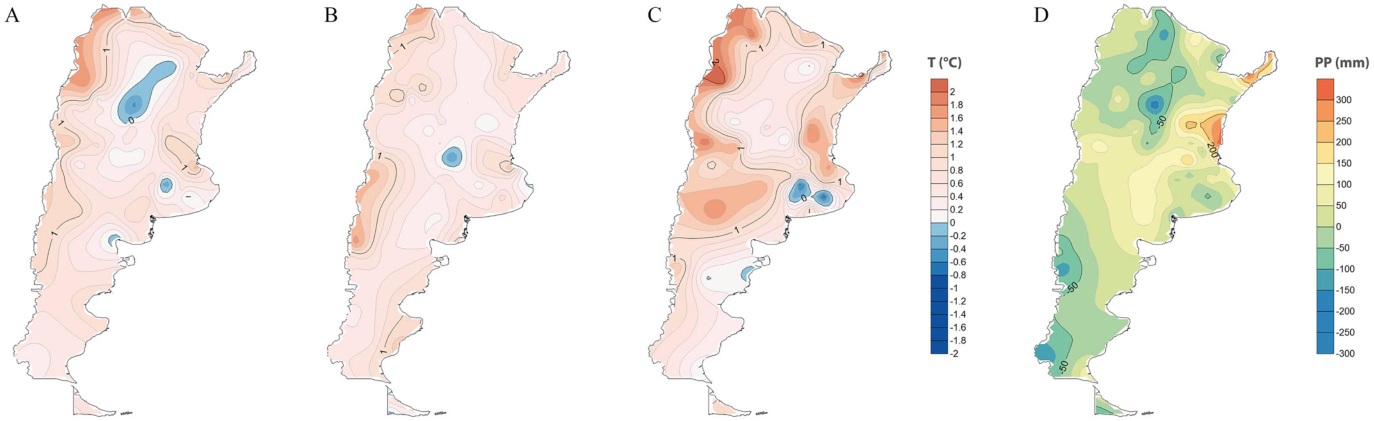

Figure 3. Trends of (A) annual mean temperature, (B) maximum temperature, (C) minimum temperature, and (D) precipitation in the period 1961–2020 in Argentina. Supplemental material Table S3.

Table 2. Comparison of mean annual climatic anomalies in the periods 1976–1997 (without DENV cases, 22 y) and 1998–2020 (with DENV cases, 23 y).

	1976–2020		1976–1997			1998–2020			Comparison 1976–1997/1998–2020	
Variables	Mean	SD	Mean	SD	N° years	Mean	SD	N° years	Statistic	Significance
Precipitation	−0.01	0.46	1.45	11.28	16/22	−1.63	11.94	16/23	$H = 1.50$	$p = 0.2202$
Mean temperature	0.46	0.78	0.08	0.38	8/22	0.43	0.38	16/23	$H = 7.86$	$p = 0.0049$[a]
Minimum temperature	0.1	0.67	−0.10	0.41	7/22	0.23	0.39	18/23	$H = 6.01$	$p = 0.0139$[a]
Maximum temperature	0.18	0.8	−0.09	0.44	7/22	0.33	0.55	15/23	$H = 6.35$	$p = 0.0115$[a]

Note: N° y: Number of years with anomalies above the mean for the period 1976–2020 (45 y). H, statistical value; SD, standard deviation.

[a] Statistical significance at the $\alpha = 0.05$.

former. The city with highest increase was Neuquén, located in the southern region (0.69 months/45 y). We also examined these relationships at a finer resolution by considering changes in the mean number of days in which temperatures were in the optimal range for DENV transmission between the two time periods. Table 4 shows the variation in the number of days with optimal temperatures for DENV transmission. Twelve of 20 cities (60%) showed increases in the number of days, mainly in the cities located within the central region (e.g., Santa Fe with an increase of 4.94 d/45 y, Paraná with an increase of 3.5 d/45 y, and Córdoba with an increase of 2.69 d/45 y) and the Cuyo region (e.g., La Rioja with an increase of 4.35 d/45 y), all in which DENV cases have increased in the past decade. In summary, there was an increase in the number of days with an optimal temperature range that could be favoring the transmission in most of the cities analyzed between the periods of 1976–1997 and 1998–2020; also, there was an increase in the mean number of months with an optimal DENV transmission temperature range in some cities.

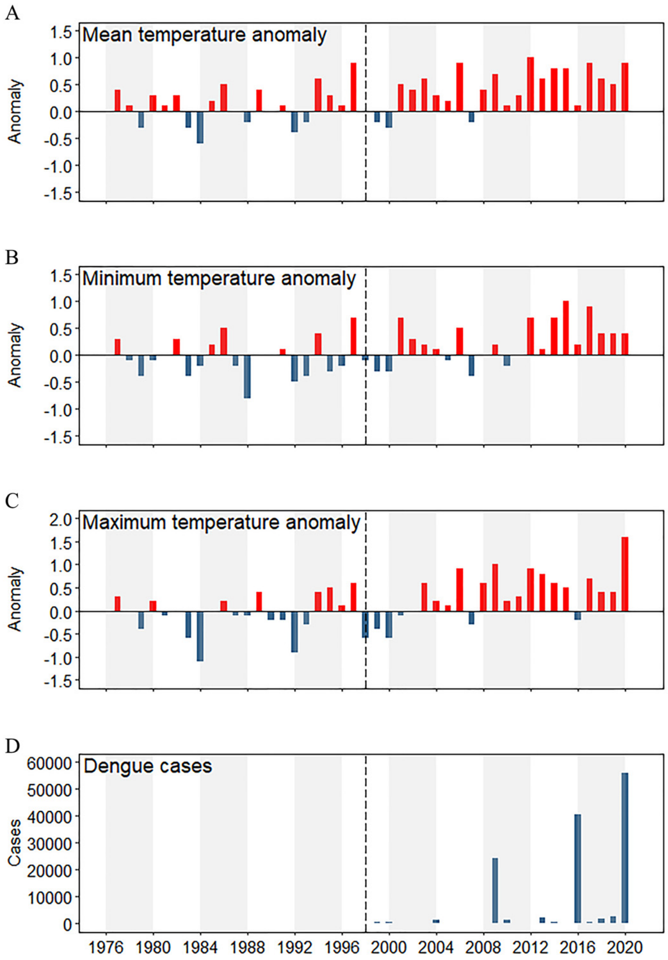

Figure 4. Temperature anomalies (°C) and autochthonous dengue cases (number of cases per year) in Argentina for the period 1976–2020. The dotted lines divide the two periods compared the periods 1976–1997 and 1998–2020. Supplemental material Table S4.

Discussion

The impacts of climate on the dynamics, distribution, and spread of infectious diseases have received significant attention in recent years, because changes in climate can alter seasonality and intensity of transmission.[5,6,12,34,39] These impacts are of particular concern to regions of Central and South America, which are highly vulnerable to and will likely be strongly impacted by climate change.[14] As a consequence of climate change, the incidence of climate-sensitive infectious diseases, particularly mosquito-borne diseases, is on the rise.[40] 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. This evaluation does not deny other factors involved in the expansion of DENV, such as greater connectivity and increased travel among countries, the rise in global population, changes in socioeconomics and population demographics, or even improvement of public health systems.[1,41,42] However, climate conditions and changes therein can facilitate the presence, abundance, and expansion of vectors, as well as higher virus transmission and the emergence of epidemics in areas where DENV is not endemic.

Many recent studies have focused on the relationships between climate and mosquito populations and dengue transmission. One study determined the optimal temperature ranges for the transmission of DENV by *Ae. aegypti* mosquitoes.[38] Minimum temperatures were found to function as barriers, which prevent DENV's spread into new regions.[11,43] In addition, Díaz-Nieto et al.[24] and Rubio et al.[25] described the new distribution records for *Ae. aegypti* in southern South America. Our results show that the temperature trends of the past six decades are positive (increasing) in most parts of the country, which is more remarkable for minimum temperatures, which is in agreement with other studies.[32,44] This positive trend is consistent with an increase in the incidence and expansion of DENV in the different regions of Argentina.[6,7,45,46] That is, the increase in temperature throughout the country has likely led to greater circulation of the virus and the consequent increase in the frequency and magnitude of epidemics. Moreover, warmer temperatures may have triggered epidemics in areas without viral circulation until the past decade.[5–7,46] According to Messina et al.,[47] who examined DENV case occurrence related to climate, population, and socioeconomic projections, dengue risk is predicted to extend not only latitudinally but also to higher altitudes in northern Argentina between 2015 and 2080. We showed that temperature (mean, minimum, and maximum) anomalies increased between the analyzed periods, with anomalies being higher in the period with

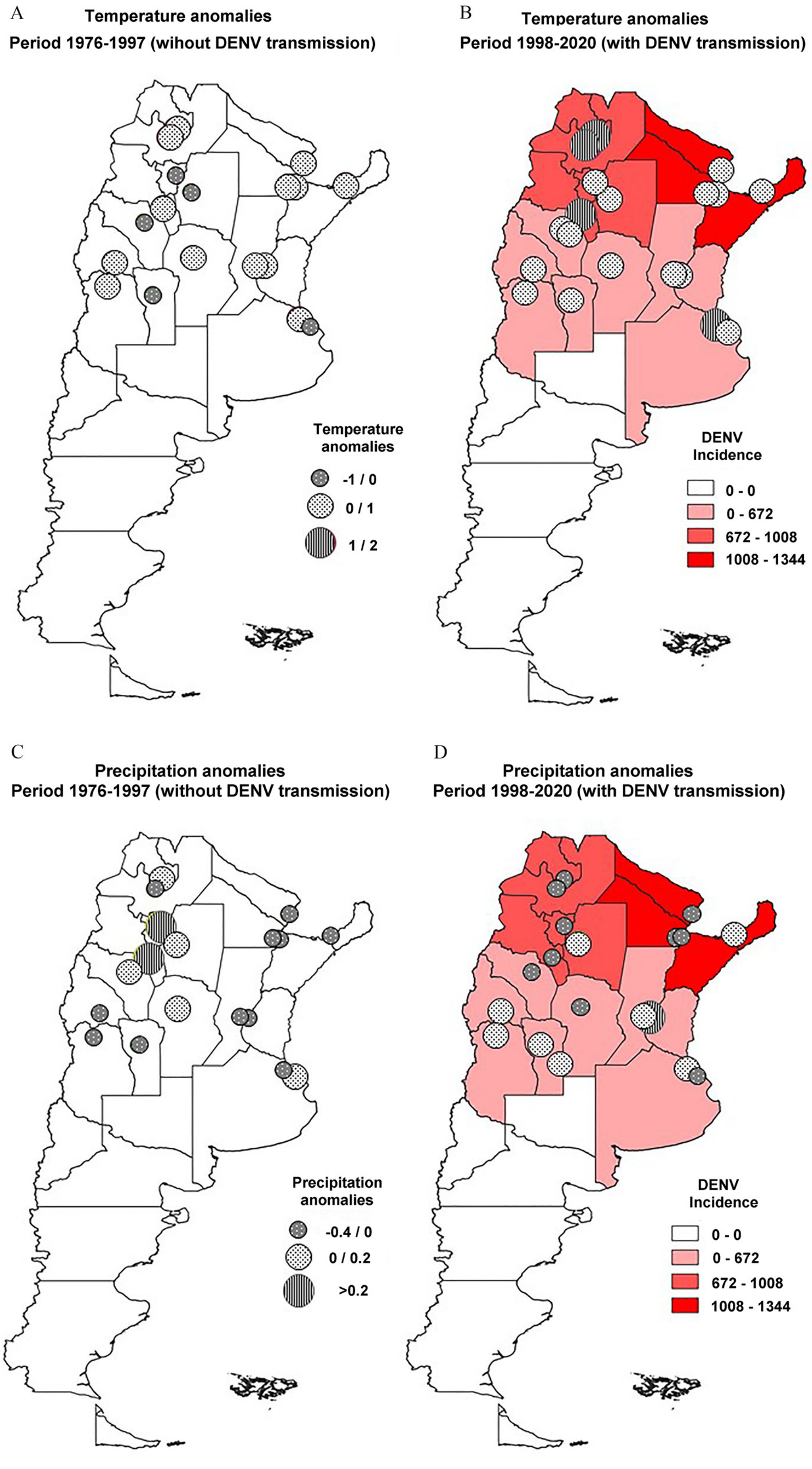

Figure 5. Anomalies of mean temperature (above) and total precipitation (below) in the different regions of Argentina in the period without DENV transmission (left) and with DENV transmission (right). (A) Temperature anomalies, period 1976–1997 (without DENV transmission), (B) Temperature anomalies, period 1998–2020 (with DENV transmission), (C) Precipitation anomalies, period 1976–1997 (without DENV transmission), and (D) Precipitation anomalies, period 1998–2020 (with DENV transmission). Supplemental material Table S5.

Table 3. Difference in the mean number of months per year with optimal DENV transmission temperature ranges between periods 1976–1997 (without DENV cases) and 1998–2020 (with DENV cases). Trend: "+" indicates increase in months, and "−" indicates decrease in the mean number of months in which temperatures were in the optimal range for DENV transmission between 1976–1997 and 1998–2020.

			Mean number of months within thermal limits ranges per year			
Region	City	Coordinates	Period 1976–1997	Period 1998–2020	Trend	Variation between periods (months/45 y)
Northwest	Catamarca	−28.6, −65.77	8	8	−	0
	Jujuy	−24.38, −65.08	8.82	8.82	−	0
	Salta	−24.85, −65.48	9.45	8.78	−	−0.67
	Santiago del Estero	−27.77, −64.3	6.73	6.22	−	−0.51
	Tucuman	−26.85, −65.1	10.33	9.52	−	−0.81
Northeast	Corrientes	−27.45, −58.77	10.64	10.83	+	0.19
	Formosa	−26.2, −58.23	10.86	9.65	−	−1.21
	Resistencia	−27.45, −59.05	9.75	8.41	−	−1.34
	Posadas	−27.37, −55.97	11.18	11.61	+	0.43
Central	CABA	−34.58, −58.48	8	8	−	0
	Cordoba	−31.3, −64.2	10.32	9.17	−	−1.15
	La Plata	−34.97, −57.9	11.86	11.79	−	−0.07
	Parana	−31.78, −60.48	11.82	11.7	−	−0.12
	Santa Fe	−31.7, −60.82	11.41	10.78	−	−0.63
Cuyo	La Rioja	−29.38, −66.82	8.57	8.4	−	−0.17
	Mendoza	−32.83, −68.78	8.15	7.76	−	−0.39
	San Juan	−31.57, −68.42	5.73	6.13	+	0.4
	San Luis	−33.27, −66.35	9.77	10	+	0.23
South	Santa Rosa	−36.57, −64.27	9	8.78	−	−0.22
	Neuquén	−38.95, −68.13	6.09	6.78	+	0.69

DENV cases in Argentina. Monthly positive anomalies in minimum temperature have already been recorded in central Argentina, indicating that the period of dengue emergence in the city of Cordoba was characterized by warmer-than-average temperatures.[6] These results show that the areas of Argentina prone to infectious diseases transmitted by mosquitoes could continue to expand, and epidemics could consolidate in regions where outbreaks have already occurred.

The higher incidence of DENV in the different regions of Argentina does not show a relationship with precipitation trends and anomalies. This finding may be because the habits of people during droughts could be influencing the formation of mosquito breeding sites that generate epidemics, as mentioned in literature.[46,48] For example, in 2020, the largest DENV epidemic was registered in Argentina while most of the country was under a strong precipitation deficit (negative anomalies) according to a report by the SMN.[49] In addition, the DENV epidemic coincided with the beginning of the COVID-19 pandemic and mandatory preventive social isolation. Consequently, vector control measures were reduced, and people remained in their homes and were likely exposed to *Ae. aegypti* much longer than usual, which, according to Robert et al.,[6] could explain the greater magnitude of the DENV epidemic. Another explanation for the lack of relationship between precipitation and the increasing incidence of DENV in our results may be the regional scale of our analysis. The heavy precipitation episodes with which DENV outbreaks are associated[6,39] generally occur over relatively small areas (local scale). In this sense, evaluating the cases based on precipitation on a smaller scale could show a better relationship between precipitation and the formation of outbreaks in the different regions of the country.

Table 4. Difference in the mean number of days per year with optimal DENV transmission temperature ranges between periods 1976–1997 (without DENV cases) and 1998–2020 (with DENV cases). Trend: "+" indicates increase in days, and "−" indicates decrease in the mean number of days between 1976–1997 and 1998–2020 in which temperatures were in the optimal range for DENV transmission.

			Mean number of days with optimal temperatures			
Region	City	Coordinates	Period 1976–1997	Period 1998–2020	Trend	Variation between periods (days/45 y)
Northwest	Catamarca	−28.6, −65.77	30.52	27.19	−	−3.33
	Jujuy	−24.38, −65.08	37.32	33.64	−	−3.68
	Salta	−24.85, −65.48	34.14	35.65	+	1.51
	Santiago del Estero	−27.77, −64.3	30.05	28.87	−	−1.18
	Tucuman	−26.85, −65.1	30.16	29.96	−	−0.2
Northeast	Corrientes	−27.45, −58.77	36.68	35.05	−	−1.63
	Formosa	−26.2, −58.23	35.19	33.35	−	−1.84
	Resistencia	−27.45, −59.05	35.3	35.91	+	0.61
	Posadas	−27.37, −55.97	34.82	35.04	+	0.22
Central	CABA	−34.58, −58.48	23.23	25.3	+	2.07
	Cordoba	−31.3, −64.2	28.86	31.55	+	2.69
	La Plata	−34.97, −57.9	20.95	22.27	+	1.32
	Parana	−31.78, −60.48	27.59	31.09	+	3.5
	Santa Fe	−31.7, −60.82	27.33	32.27	+	4.94
Cuyo	La Rioja	−29.38, −66.82	27.76	32.1	+	4.35
	Mendoza	−32.83, −68.78	26.4	24.81	−	−1.59
	San Juan	−31.57, −68.42	22.64	21.78	−	−0.86
	San Luis	−33.27, −66.35	27.32	28.64	+	1.32
South	Santa Rosa	−36.57, −64.27	21.05	21.39	+	0.34
	Neuquén	−38.95, −68.13	24.05	24.09	+	0.04

In the present work, cities across the country were evaluated to determine whether there had been an increase in the number of months and days with optimal mean temperatures for DENV transmission. Our results show no significant increase in the number of months. However, the number of days with temperatures that contribute to maximizing transmission increased in most of the cities analyzed and in particular in the central region of the country. Given the important role that temperature plays in the timing of the extrinsic incubation period, having more days with optimal temperatures could reduce the time necessary between infection and infectiousness in mosquitoes, thereby increasing the rates of spread of DENV.[50]

In agreement with other studies, we show that changes in climate increasingly favor the transmission of DENV, its expansion, and establishment in new regions.[7,11,46,51] In the past two decades, incidence of DENV and other viruses transmitted by *Ae. aegypti* mosquitoes has risen dramatically and consistently with the combined effects of climate, urbanization, and declining vector control.[38] Since the reintroduction of DENV in Argentina in 1998, policies recommended by the Pan American Health Organization (PAHO) for control have been implemented in the country[16,52]; however, based on the decentralization criterion, the national government transferred the responsibility for surveillance and control of *Ae. aegypti* to the municipalities,[53] which often have limited economic and human resources to conduct control activities. Given the rate of movement of people between municipalities, control activities could be more effective if each provincial government developed a robust surveillance network and coordinated closely with each municipality. These actions could be conducted in coordination with regional research groups.

The rapid warming of the Earth caused by anthropogenic greenhouse gas emissions has profound long-term implications for the prevention and control of vectorborne diseases.[1] In this context, long-term monitoring and control programs are needed for *Ae. aegypti* and the detection of flaviviruses such as the ones recently described by Cardozo et al.[54] and Selvarajoo et al.[55] These programs would make it possible to analyze the evolution of the vector and the circulation of flaviviruses. The early detection of arbovirus activity in new areas or increased viral activity in vector populations coupled with prompt medical attention is key to successfully controlling the associated diseases and reducing their case–fatality rates.[56] Climate warming may increase the geographic and seasonal ranges of mosquito-borne diseases relative to their current distribution by increasing periods of time in which temperatures are within optimum ranges for transmission. Climate monitoring of each region of Argentina together with biological (vector monitoring) and epidemiological (DENV surveillance) information are essential for the implementation of early warning systems. It is necessary to better understand the relationship between accelerated climate change, the adaptation of *Ae. aegypti* to these conditions, and the susceptibility of the population in each region of the country. Current and future geographic range limits to transmission may depend primarily on the capacity of *Ae. aegypti* to tolerate heat and cold stress,[57–59] 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.

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