Beatrice Meo 1516456
Climate Change Module
SAES Master UAB

Climate Change and Infectious Diseases:
A risk assessment of the Chikungunya transmission in Europe

1. Introduction

The Earth climate system has always been subject to natural fluctuations of climatic phenomena, but scientists observed a more drastic variation during the post-industrial revolution era, mostly due to a high amount of carbon dioxide released in the atmosphere. An increase of 40% of atmospheric CO_2 drove unprecedented level of global warming[1]: a surface temperature 0.87 °C higher than the average was recorded during the last century[2].
Many are the effects of climate change on the Earth systems and human lives, and an interdisciplinary approach is necessary to understand the impacts at different levels.

There is an increasing focus among the current literature on the impacts of climate change on human health and, in particular, on how it influences epidemic diseases' patterns. Climatic conditions affect the behaviour of infectious agents and today's temperature increases and extreme weather events are proven to have a big influence on the transmission of vector-borne diseases. Several studies highlight the growing climatic suitability of higher-altitudes regions for infectious agents which are related typically to tropical areas. An example is represented by the establishment of the *Aedes albopictus* mosquitos in Europe because of the increasing temperatures, precipitations and humidity in the Mediterranean basin. The Aedes albopictus, also known as tiger mosquito, is considered one of the most important distribution vectors of the Chikungunya virus (CHIKV), a mosquito-borne alphavirus from the *Togaviridae* family.

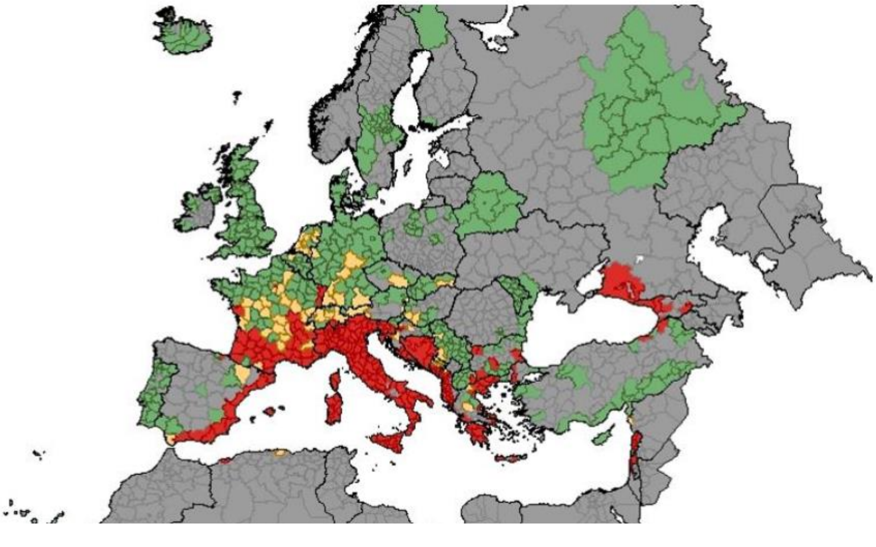

Figure 1. *Aedes Albopictus* diffusion in Europe.
In red, the areas with the establishment of the mosquito. The yellow zones represent those areas where the mosquito has been introduced but without endemic cases registered. The green regions are mosquito free.
Source: https://www.zerozanzare.it/970/zanzara-tigre-quali-malattie-trasmette-eliminarla/

---

[1] *www.metoffice.gov.uk*

[2] IPCC, 2018: Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

2. The Chikungunya case in Europe: a comparing experiment

In the past, manifestations of CHIKV have been observed restrictedly in Asia and South and Central America, mainly in areas characterised by a tropical climate. Indeed, higher temperatures and humidity represent a favourable condition for the survival of the mosquito *Aedes* and for an easier transmission of the virus[3].
However, during the last decade several cases of CHIKV have been registered in Europe, some of which with autochthonous transmission. Transcontinental connectivity through shipping and flight routes can be considered the main channel of the *Ae. Albopictus* in Europe, and many outbreaks have been imported by travellers coming from CHIKV-affected-areas[4].
Between 2007 and 2017, three occurrences of CHIKV have been registered in France and two in Italy, due to the establishment of the mosquito in such regions.
Heitmann et al., 2018 argue that the transmission of the CHIVK can occur also at lower temperature, but the change in climate conditions must be contemplated when considering the incubation of the virus. In order to examine the factors driving the potential transmission of Chikungunya in Europe, an assessment of the mosquito saliva experimentally infected has been conducted in Italy and Germany. These two regions have been chosen due to the different climatic conditions that usually characterise them.

The table below (Table 1) shows the infection rates, transmission rates and virus titres of the mosquito, exposed to three different temperature (18 °C, 21 °C or 24 °C) and to 80% humidity for 14 days during the experiment.

TABLE

Infection rates, transmission rates and virus titres of *Aedes albopictus* specimens from two different European populations experimentally infected with chikungunya virus and kept at three different temperatures, November 2017–March 2018 (n = 163 mosquitoes)

Aedes albopictus population origin	T in °C	Infection rate[a]		Transmission rate[b]		Titre	
		Number of CHIKV-positive specimens/number of analysed specimens	%	Number of specimens with CHIKV-positive saliva/ number of specimens with CHIKV-positive body	%	Mean log10 CHIKV RNA copies/ specimen	SD
Germany	18	32/32	100.0	16/32	50.0	11.3	0.6
Germany	21	23/23	100.0	9/23	39.1	8.4	0.8
Germany	24	24/24	100.0	9/24	37.5	8.5	0.2
Italy	18	30/30	100.0	19/30	63.3	10.8	1.8
Italy	21	30/30	100.0	19/30	63.3	10.4	1.6
Italy	24	24/24	100.0	9/24	37.5	8.6	0.2

CHIKV: chikungunya virus; SD: standard deviation; T: temperature.
[a] Infection rate: number of CHIKV-positive mosquito bodies per number of fed females.
[b] Transmission rate: number of mosquitoes with CHIKV-positive saliva per number of mosquitoes with CHIKV-positive bodies.

Table 1. Analysis of IR, TR and T of *Aedes albopictus*
Source: Heitmann Anna et al., Experimental risk assessment for chikungunya virus transmission based on vector competence, distribution and temperature suitability in Europe, 2018. EuroSurveill. 2018;23(29).

As exposed by Heitmann et al., 2018*,* the central European areas recently invaded by *Ae. albopictus* only reach mean daily temperatures of ≥ 18 °C or ≥ 21 °C for 2 weeks per year. Areas with long-standing populations around the Mediterranean Sea can also have 14 days with temperatures ≥ 24 °C.[5]
Highest TRs of 50% for the mosquito population from Germany were detected at 18 °C, while the Italian population had highest TRs of 63% at 18 °C and 21 °C, respectively. This shows how the current risk of CHIKV transmission in Europe is not primarily restricted by temperature (see the high

[3] https://ecdc.europa.eu/

[4] Heitmann Anna, Jansen Stephanie, Lühken Renke, Helms Michelle, Pluskota Björn, Becker Norbert, Kuhn Carola, Schmidt-Chanasit Jonas, Tannich Egbert. Experimental risk assessment for chikungunya virus transmission based on vector competence, distribution and temperature suitability in Europe, 2018. Euro Surveill. 2018;23(29):pii=1800033. https://doi.org/10.2807/1560-7917.ES.2018.23.29.1800033. Pp 7

[5] P10

percentage of transmission registered at lower temperature in Germany) but, in this case, rather by the vector distribution.
Nevertheless, the few autochthonous manifestations of CHIKV occurred in Europe still represent an important case, in order to analyse whether they represent one-time outbreaks or the beginning of a trend.
As defined in the above-mentioned research, the transmission of the chikungunya depends mainly on the distribution vector, but the incubation and the establishment of both mosquito and virus vectors in Europe depend on the suitable climatic conditions typical from tropical areas[6].
A wide accepted literature demonstrates how the current increase in temperatures, precipitations and humidity and the prolongation of the warmer periods currently characterising the climate in Europe are favouring the diffusion of autochthonous occurrences of Chikungunya.

3. Numbers and predictions

3.1 Data Analysis

Taking the results of the study carried out by Heitmann et al. as a starting point, historical data of yearly temperatures and precipitations trends have been collected for two European countries from different climatic zones: Italy and Germany. The graphs below (Fig.1 and 2) consider the 1901-2015 timeframe and shows data collected from the Data Portal of the World Bank website[7].
A similar trend in temperature fluctuations is visible for both countries, with slightly more pronounced picks in temperature decreases experienced in Germany. Overall, the temperature pattern shows an increase starting from the end of last century.

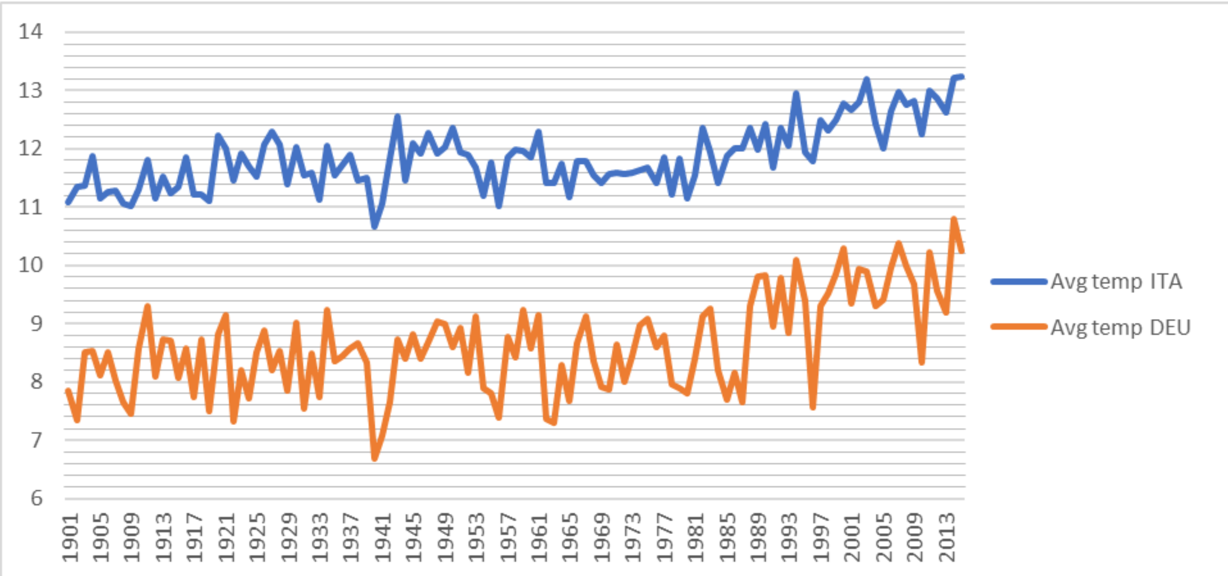

Figure 1. Yearly Temperature Average in Italy and Germany (1901-2015 timeframe)
Source: Climate Portal – World Bank

In terms of precipitations (Fig.2), the Italian peninsula has always experienced a higher amount of it, but the German regions registered more abrupt changes in precipitation quantity until few years ago, when such trend started to characterise instead the Italian region.

---

[6] European Centre for Disease Prevention and Control. Clusters of autochthonous chikungunya cases in Italy, 14 September 2017. Stockholm: ECDC; 2017.
[7] http://sdwebx.worldbank.org/climateportal/index.cfm

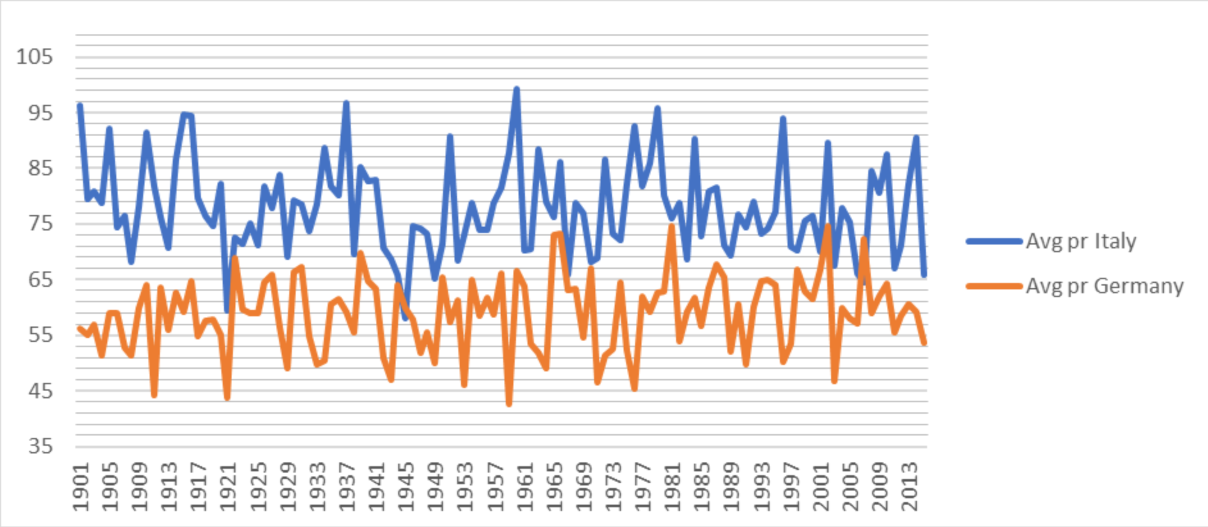

Figure 2. Yearly Precipitation Average in Italy and Germany (1901-2015 timeframe)
Source: Climate Portal – World Bank

3.2 Climate and disease transmission predictions

Based on the temperature conditions from endemic Chikungunya areas and given the historical data on temperature and precipitations collected for this research, an increase in the risk of CHIKV transmission could be expected in Northern and Central Europe areas (e.g. Germany), where the outbreaks of such virus have been so far detected only in very few cases and as merely through travel-transmission. Nevertheless, many Mediterranean regions (e.g. Italy and France) are currently, and will persist to be, climatically suitable for transmission, due to the vicinity of the increasingly warming Mediterranean Sea. Indeed, as claimed as well by Tilston et al. (2009), the highest risk of transmission by the end of the 21st century was projected for France, Northern Italy and the Pannonian Basin (East-Central Europe).

Other studies on spatio-temporal trends for risk exposure and season of transmission in Europe present projections of climate change impacts and possible climate scenarios discussed from the IPCCC[8].

According with a previous study[9], "higher temperatures will likely increase the risk of transmission as they lead to shorter Extrinsic Incubation Periods (EIP), defined as the time interval between acquisition of an infectious agent by a vector and the vector's ability to transmit the agent to other susceptible vertebrate hosts" (Fischer D., 2013, p. 3).

The following table (Table 2) indicates the projections of possible future temperatures scenarios pictured by the IPCCC. Therefore, the temperature rises across the whole European continent allowed recent occurrences of Chikungunya outbreaks in central and northern areas, typically characterised by a continental climate, but limited to one-off events. Instead, the CHIKV autochthonous cases experienced in the Italian peninsula can be explained by climatic trends that are increasingly shifting towards a tropical-simile climate, facilitating the incubation of the virus and the establishment of the mosquito.

---

[8] *Fischer, D., 2013, Climate change effects on Chikungunya transmission in Europe: geospatial analysis of vector's climatic suitability and virus' temperature requirements*

[9] Pan-European Chikungunya surveillance: designing risk stratified surveillance zones. Tilston N, Skelly C, Weinstein PInt J Health Geogr. 2009 Oct 31; 8():61.

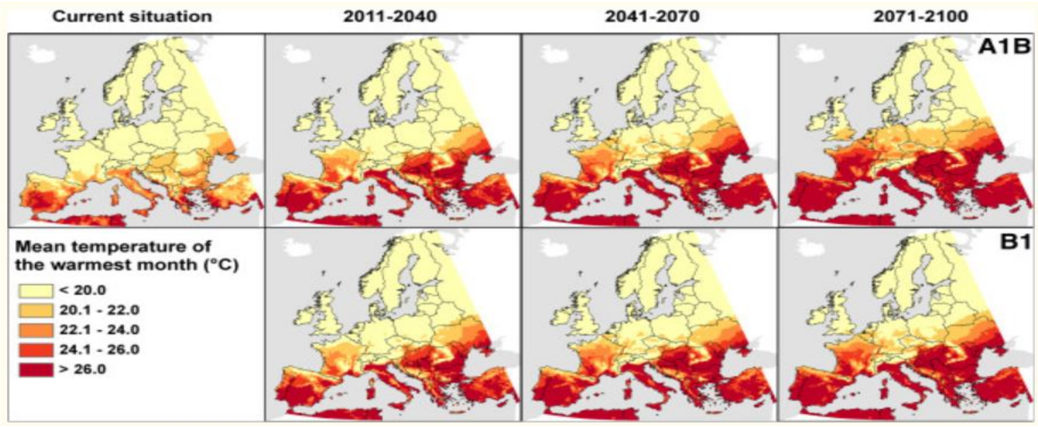

Table 2. *Projections for different time-frames are based on two emission scenarios (A1B and B1) from the Intergovernmental Panel on Climate Change, implemented in the regional climate model COSMO-CLM.*
Source: Pan-European Chikungunya surveillance: designing risk stratified surveillance zones. Tilston N, Skelly C, Weinstein PInt J Health Geogr. 2009 Oct 31; 8():61.

Conclusions

Among the numerous impacts of climate change, the ones related to human health are subject of a growing body of literature. The recent global warming and the shifting of weather conditions resulted in a change in climate in many parts of the world, moving tropical-climate related trends at higher altitudes. An example is represented by the Mediterranean basin countries, where higher temperature, more dense moisture and stronger precipitations are transforming the typical mild climate into a tropical one. Such conditions represent a favourable setting for the transmission of tropical diseases, such as Dengue and Chikungunya. This article focuses on the analysis of CHIKV outbreaks occurred in Europe and it demonstrate, through the collection of climatic historical data and a limited literature review, the connection between climate change and the growing CHIKV transmission. The temperatures increase in Germany allowed one-off cases of Chikungunya, while the stabilization of a tropical-simile climate in the southern part of Europe (e.g. Italy and France) can facilitate this one-time infectious diseases' cases to become a trend. Based on this, the article reports some general predictions of possible future scenarios in Europe, mentioning as well the IPCCC projections.