Original Research Article

INFLUENZA MORBIDITY IN THE STATE OF HIDALGO, IS THERE CORRELATION WITH CLIMATE CHANGE?

Abstract. Influenza is a contagious infection of viral origin; every year, it causes a high disease burden, due to the epidemics it instigates throughout the world. In Mexico, pneumonia and influenza are one of the major causes of morbidity and mortality. From the time of the Greek philosophers, diseases were attributed to the climatic changes. The WHO Early Warning System notes the influence of climatic that variation for influenza epidemic risk is moderate for. **Objective**. Determine if there is correlation between the minimum temperatures recorded in the state of Hidalgo, and the influenza cases reported during 2014, 2015 and 2016. **Material and methods.** A retrospective observational study was done, which was of transversal and correlational character which conducted a review of data Automated Unified System for Epidemiological Surveillance (SUAVE 2014-2016) and in Mexico Weather Report National Weather Service performed (2014-2016). **Results and conclusions**. According to the statistical analysis, it was concluded that in 2014 (Sig = 0.001) and 2015 (Sig. = 0.00) there is a correlation between the minimum temperatures recorded and the number of reported cases of influenza.

Keywords: climate change, minimum temperatures, morbidity of influenza, H1N1 influenza virus.

Introduction

It has been observed that the emission of greenhouse gases and pollution are changing the planet's climatic conditions, generating more frequent and intense weather phenomena. It is considered that the growth of industrial activities, urban expansion and the use of fossil fuels has increased the amount of these pollutants (Borg F, et al, 2021). According to the World Health Organization, these meteorological phenomena constitute a very serious risk to human health, as they increase the appearance and spread of infectious diseases (OMS, 2021).

Global warming favors the geographical expansion of some infectious diseases, since extreme weather events affect the survival, reproduction and distribution of pathogens, as well as alter the availability and means of their environment for their transmission. Climate change, on the other hand, can help create opportunities for outbreaks to appear in non-traditional places and times (Xiaoxu Wu, et al, 2016).

Climate variability such as increased temperatures and changes in rainfall patterns affect the transmission of infectious diseases; as in diseases transmitted by vectors, food and water. (Wei J, et al, 2014)

Climate change affects the behavior of infectious diseases by modifying three aspects: generating changes in human behavior (work, recreation and mobility) secondary to variations in temperatures and seasons of the year. The second produces changes in pathogens, by generating conditions conducive to their survival. Finally, the geographical distribution and population dynamics of vector diseases are especially related to changes in temperature, rainfall and humidity. Higher temperatures accelerate metabolism, increase egg production and the food needs of vectors. Rainfall influences the longevity of the vector, by creating a favorable habitat for its development. (Berberian & Rosanova, 2012)

Influenza Overview. Influenza is a contagious viral infection considered one of the most important causes of respiratory tract infections. The name given to this disease originated in the fifteenth century in Italy by an epidemic of respiratory disease that at that time was attributed according to the position of the stars. Subsequently, it was determined that this epidemic, among others that ensued were caused by the influenza virus, which can affect the nasal mucosa, pharynx, bronchi and often to the alveoli (Franco-Paredes, 2006).
Symptoms are similar to the common cold or flu, however, they are more severe and its onset is usually abrupt. It is therefore essential to differentiate influenza from the common cold or even the flu. While influenza is caused by three viruses (influenza A, B, and C), the common cold or flu can be caused by more than 100 different types of viruses. Although most symptomatic influenza infections are self-limited, acute disease can vary from mild to severe acute febrile illness and sometimes debilitating tables associated with secondary complications. Among these secondary bacterial pneumonias, it is the most relevant and which occur mostly on individuals who are younger than 2 years old and those that are over 65 years old. Other clinically important complications are pulmonary exacerbations of chronic conditions such as asthma or chronic and cardiovascular diseases such as congestive heart failure (Bonilla, 2014) bronchitis. Tissue damage of the attacked lung is also due to the exaggerated magnitude of the immune response mediated by the sudden release of cytokines (cytokine storm); however, the swine virus 2009 had

a very virulent behavior in patients affected by chronic lymphopenia and pregnant women, but it turned out to be of a low virulence in older hosts and previously immunized prior exposure to antigen H1 before 1957 (Bravo, 2011).

Viruses associated with human influenza are members of the Orthomyxoviridae family, having a helical morphology and its genome consists of a segmented RNA strand viruses Influenza A and B cause respiratory infections in humans and animals, the virus causes pandemics. C influenza virus moderate form affects children and occasionally adults. These viruses are distinguished by antigenic variations in two structural proteins (nucleoprotein and matrix protein). RNA is associated with the nucleoprotein and three viral polymerase proteins (PBI, PB2 and PA). The influenza A virus subtypes are classified according to two surface antigens: hemagglutinin (H) and neuraminidase (N). The hemagglutinin is considered the major antigen which oversees the production of neutralizing antibodies and whose function is the attachment of the virus by sialic acid residues on the surface of the human respiratory epithelium. The expression of neuraminidase is less abundant on the viral surface and its role is to facilitate the release of virions from infected host cells. Birds are a potential for genetic exchange for influenza virus reservoir, which represents a latent risk of pandemics. Influenza viruses also infect chickens, pigs, horses, and occasionally marine mammals (Solorzano-Santos, 2009). The expression of neuraminidase is less abundant on the viral surface and its role is to facilitate the release of virions from infected host cells. Birds are a potential for genetic exchange for influenza virus reservoir, which represents a latent risk of pandemics.

At unpredictable intervals, novel influenza viruses emerge with influenza antigen corresponding to a different subtype from strains circulating the previous year, a phenomenon known as antigenic shift surface. Surface antigens are of a particular interest in immunity and epidemiology; these antigens residing on different protein subunits of the viral envelope are hemagglutinin (H) and neuraminidase (N). Variations of the H and N antigens cause changes in epidemiology of influenza; if these viruses have the potential to be transmitted easily from person to person, it can produce a wide spread and a serious epidemic (Kuri Morales & Galvan, 2006).

Influenza epidemiology

It has been observed that pandemics have appeared at regular intervals of 10 to 20 years; this is due to the emergence of new subtypes generated by recombination of entire regions of genes and gene rearrangements inducing major antigenic changes. Influenza pandemics, defined as global outbreaks due to viruses with new antigenic subtypes have caused high mortality in humans. Since the sixteenth century several influenza pandemics have been documented, around three in every century. There are notable differences between them, but their common feature is rapid diffusion throughout the twentieth century there were three influenza pandemics, all of them, corresponding to the appearance of H1N1 subtype (1918, 1919, Spain Type A), H2N2 (1957-1958,

Seasonal influenza is an infectious disease that produces each year a high burden of disease, under epidemics caused worldwide. The influenza surveillance dates back to 1947, when the World Epidemiological Surveillance Network was established. This network, currently made up of 125 institutions from 96 countries, recommend annually to the World Health Organization (WHO) the content of the vaccine against seasonal influenza and acts as a mechanism to monitor the existence of new influenza viruses with pandemic potential (WHO, 2009).

Almost at the end of the century, in 1997, cases of human influenza virus began to be detected in Southeast Asian countries produced by the virus A (H5N1) which has an avian origin, with very high lethality (Mounts, 1999). Since then, the threat of an influenza pandemic caused by this virus has been dormant, although it has been reported low capacity, so far, to spread from person to person. In Mexico, pneumonia and influenza are a major cause of morbidity and mortality (Franco-Paredes, 2005).

Mexico has a National Preparedness and Response Plan against pandemic influenza, in which Chapter III provides that, as a rule, influenza is a disease subject to epidemiological surveillance and immediate notification. Given the large genetic lability of influenza virus, the plan also lays epidemiological surveillance in three possible scenarios, one of which is related to the emergence of a new strain of virus with pandemic potential (Fajardo-Dolci, 2009).

In Mexico, from late February to early April, two things happened which were out of the ordinary; on one hand, the number of hospitalizations and deaths from severe pneumonia increased and, on the other, an increased number of probable cases of influenza that health officials interpreted as "a shift in the seasonal peak at the beginning of the spring period, due to an extension in time of transmission. " The increase in the number of influenza cases also appeared in the United States and Canada, countries with which Mexico shares the same "ecological niche" of the disease. Because in the United States the number of cases began to decline in late February and reached on April 11th, its lowest level,

In April 2009, it was recognized that in Mexico a new variant of influenza circulated A. The genomic analysis of this strain of virus (human influenza A H1N1 2009) indicates that it is closely related to a common virus of swine influenza isolated in North America, Europe, and Asia (Kuri-Morales & Galvan, 2006). Up to April 11th had been a recording of 14 outbreaks of influenza in the country, the cumulative number of cases was three times higher than the same period in 2008 and three influenza patients had died, two confirmed and one laboratory only clinical diagnosis. This situation alerted the health authorities of the country and in order to typify the virus samples from suspected flu patients were sent to the National Microbiology Laboratory of the Office of Public of Health Canada and, on the other hand, the days of April 18th and 19th an active search for cases in 23 hospitals in the Federal District, in which 120 people hospitalized with pneumonia were found, 61% of whom were men whose predominant symptoms was a high fever above 38 ° C, cough, headache, malaise,

Currently, vaccination is the best way to prevent influenza and its complications. Although it is impossible to pinpoint the times, epidemiological data suggest a future occurrence of another pandemic with all its consequences. For that reason, it is vitally important to know that an influenza pandemic could compromise the effectiveness of the three levels of health care and therefore it is necessary to have an adequate response capacity (Jofre ML et al, 2005).

Climate change

Climate change is inherent to human activity, since the introduction of fossil fuels in the seventeenth century, has been increasing, being more noticeable in recent decades. (González Sánchez, Díaz & Fernández Gutiérrez Soto, 2013)

It is defined as the perception of temperature rise, retrospectively comparing records in the same location and timing, but also includes variations of precipitation and wind, resulting in global warming or climate instability. (González Sánchez et. Al., 2013) (Ize Lema, 2002) (Evia, 2016).

There is record that since the time of the Greek philosophers, diseases attributed climate change, a fact that currently the WHO (World Health Organization) confirms, in calculating 150,000 deaths annually from anthropogenic climate change (Avila- Agüero, 2009).

These deaths can be explained by the difference in the incidence and distribution of diseases traditionally it has been presented as a product of climate instability; additionally, there are contaminants present in the air, resulting in an increase on the surrounding environment's temperature, exposure to heat or cold, and health consequences, such as increased allergic reactions and asthma exacerbation of respiratory problems or cardiovascular previous, and it is believed that it weakens the immune system. (Ize Lema, 2002) (Berberian & Rosanova, 2012) (González Sánchez et. Al., 2013) (Evia, 2016)

According to the World Congress of the International Union for Conservation of Nature that took place in 2009, among the diseases that are most affected in incidence and distribution due to climate change, bird flu and its relationship to human influenza it is, seated in the report "Deadly Dozen" (Avila-Aguero, 2009). In addition to this report, the Early Warning System of the WHO points out that the influence of climatic variation for influenza, epidemic risk is moderate for (Berberiana & Rosanova, 2012).

Because as described above, it is that the objective of this study is to determine whether there is a correlation between minimum temperatures recorded in the state of Hidalgo and influenza cases reported during the years 2014, 2015 and 2016.

Material and methods

A retrospective observational study was done, which was of transversal and correlational character which conducted a review of data Automated Unified System for Epidemiological Surveillance (SUAVE 2014-2016) and in Mexico Weather Report National Weather Service performed (2014-2016).

For descriptive analysis of morbidity rates, they were formulated by sex, age and municipality plus the minimum temperatures and morbidity rates per month three years under study were graphed.

Finally, the data to SPSS (Statistical Package for Social Sciences) program, which first identified the behavior of the data did not show a normal distribution, reason in which it was proceeded to perform nonparametric correlations between cases of influenza and minimum temperatures reported and determine through the tests of Kendall and tau_b Spearman rho.

Results

There was a total of 115.1 influenza morbidity cases per every 100 000 inhabitants in 2014 and 91.52 in 2016. 55.0% of the cases were in the female population, the age groups most affected were reported less than one-year old; 65 and over (Figure 1).

Figure 1. Influenza cases and minimum temperatures reported in Hidalgo 2015-2016.1

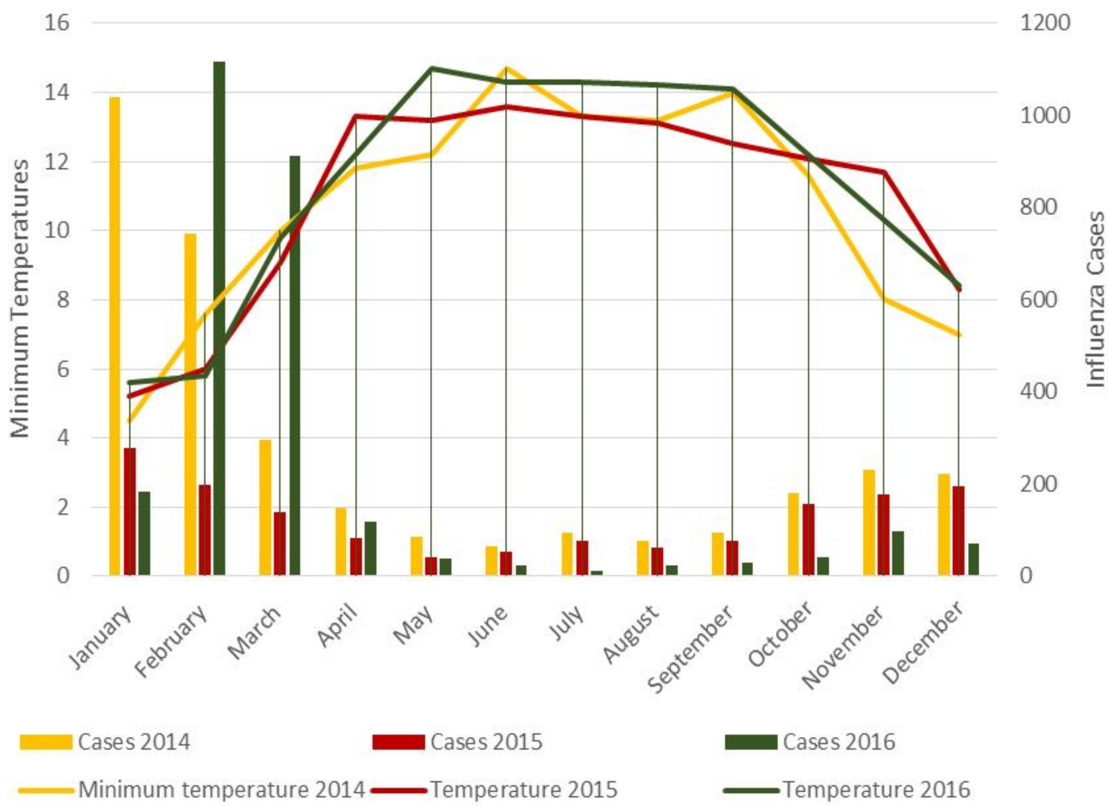
	Morbidity		
Age group	Female	Male	General
Less than 1	134.7	137.6	137.64
1 to 4	113.0	112.1	112.05
5-9	67.9	70.0	69.99
10 to 14	53.7	52.0	52.04
15 to 19	55.4	53.0	53.04
20 to 24	72.8	64.0	63.98
25 to 44	99.2	90.7	90.72
45 to 49	113.4	104.1	104.08
50 to 59	104.0	102.2	102.18
60 to 64	98.2	96.6	96.61
65 or more	139.9	129.5	129.52

Source: Single Automated System for Epidemiological Surveillance (SUAVE) 2014, 2015 and 2016 * / * Preliminary data, see April 2017.

By comparing the temperature with the incident of influenza, minimum temperature figures are similar in 3 years, however, the report morbidity January, February, and March 2014 and 2016 exceeds the figures reported in 2015.

Even though in 2015 and 2016 were years warmer than 2014, the minimum temperatures in January, February and March are much lower in the last 2 years, so it could be made possible regarding the increase in cases to late winter (Figure 2).

Figure 2. Influenza cases and minimum temperatures reported in Hidalgo 2014-2016



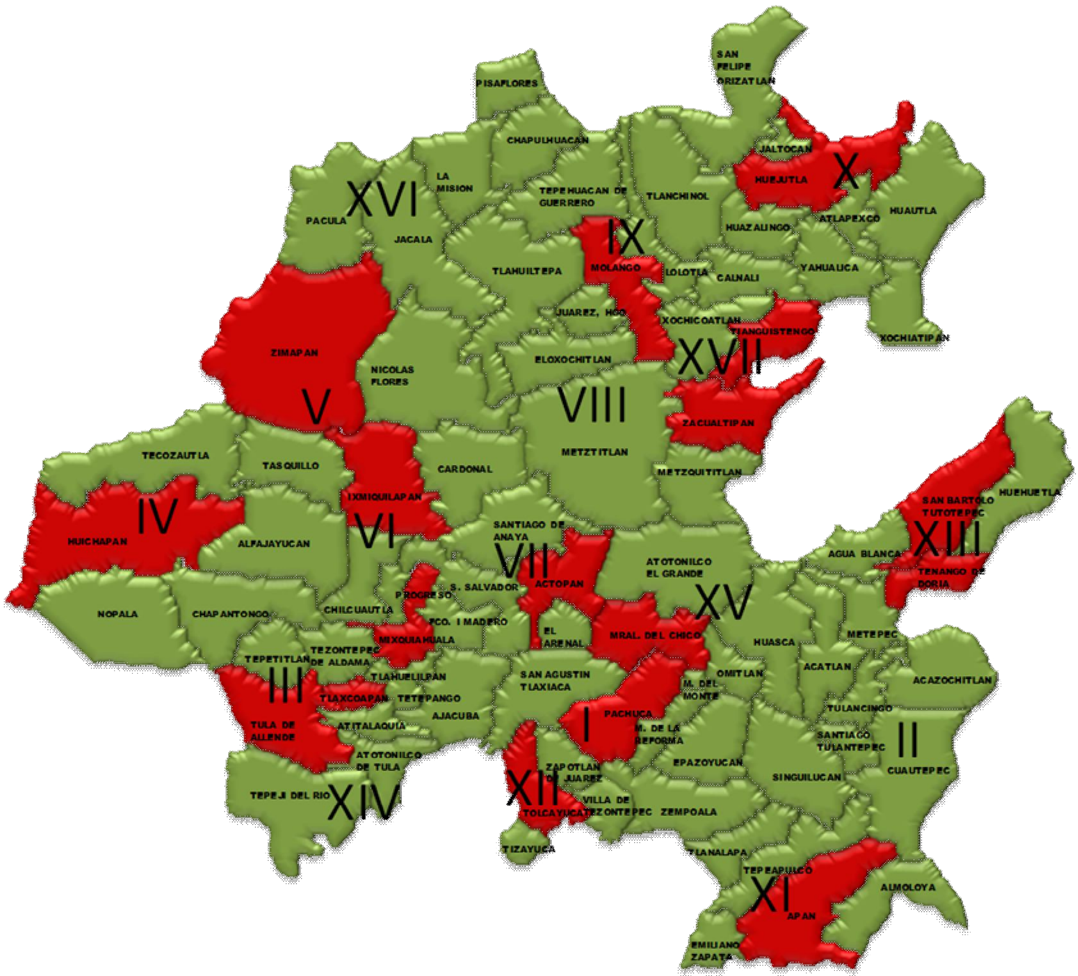
Source: Report average minimum temperature by state, 2014-2016, National Weather Service, Management meteorology and climatology, Subgerencia Forecast Medium and Long Term CONAGUA. Single Automated System for Epidemiological Surveillance (SUAVE) 2014, 2015 and 2016 *

* Preliminary data, see April 2017.

The ten municipalities with higher rates of morbidity from influenza in the state are: Apan (495.4), Molango de Escamilla (394.0), Pachuca de Soto (394.0), Tenango de Doria (202.1), Actopan (170.9), San Bartolo Tutotepec (167.2), Zacualtipán Angels (160.6), Tianguistengo, Mineral Del Chico (145.9) and Zimapán (141.5).

The ten municipalities that recorded the lowest rate of morbidity from influenza during 2014-2016 were: Huazalingo (0), Juárez Hidalgo (0), La Mission, Nicolás Flores (0), Alfajayucan (1.7), Tlahuelilpan (1.8), Singuilucan (2.1), Epazoyucan (2.2) Mineral Reformation (2.6) and Progress (2.8) (Figure 3).

Figure 3. Morbidity by influenza according to municipality, Hidalgo 2015.



Source: Single Automated System for Epidemiological Surveillance (SUAVE) 2014, 2015 and 2016 (preliminary data), see April 2017.

For statistical analysis of the data a statistics software package SPSS (Statistical Package for Social Sciences) was used, the NPar test was used to identify the temperature data and since influenza cases are nonparametric they were given a significant value of $p < 0.05$, considering the previous, it was proceeded to do nonparametric correlations for years, using the coefficient Tau_b Kendall, Spearman's rho, where the significance is the value of P (Tables 1, 2 and 3).

Table 1. Nonparametric correlations between cases of influenza and minimum temperatures recorded in 2014.

	CASE 2014	TEMPERATURE 2014

Kendall tau_b	CASE 2014	Correlation coefficient	1000	-.758 **
		Sig. (Bilateral)	.	.001
		N	12	12
	TEMPERATURE 2014	Correlation coefficient	-.758 **	1000
		Sig. (Bilateral)	.001	.
		N	12	12
Spearman rho	CASE 2014	Correlation coefficient	1000	-.895 **
		Sig. (Bilateral)	.	.000
		N	12	12
	TEMPERATURE 2014	Correlation coefficient	-.895 **	1000
		Sig. (Bilateral)	.000	.
		N	12	12

Source: Based on data from the report average minimum temperature by state, 2014-2016, National Weather Service, Management meteorology and climatology, Subgerencia Forecast Medium and Long Term CONAGUA. Single Automated System for Epidemiological Surveillance (SUAVE) 2014. Consultation April 2017.

Table 2. Nonparametric correlations between cases of influenza and minimum temperatures recorded in 2015

	CASE 2015	TEMPERATURE 2015		
Kendall tau_b	CASE 2015	Correlation coefficient	1000	-.718 **
		Sig. (Bilateral)	.	.001
		N	12	12
	TEMPERATURE 2015	Correlation coefficient	-.718 **	1000
		Sig. (Bilateral)	.001	.
		N	12	12
Spearman rho	CASE 2015	Correlation coefficient	1000	-.851 **
		Sig. (Bilateral)	.	.000
		N	12	12
	TEMPERATURE 2015	Correlation coefficient	-.851 **	1000
		Sig. (Bilateral)	.000	.
		N	12	12

Source: Prepared with data reporting average minimum temperature by state, 2014-2016, National Weather Service, Management meteorology and climatology, Subgerencia Forecast Medium and Long Term CONAGUA. Single Automated System for Epidemiological Surveillance (SUAVE) 2015 Consultation April 2017.

Table 3. Nonparametric correlations between cases of influenza and minimum temperatures recorded in 2016.

		CASE 2016	TEMPERATURE 2016
CASE 2016	Pearson correlation	1	-.186
	Sig. (Bilateral)		.562
	N	12	12
TEMPERATURE 2016	Pearson correlation	-.186	1
	Sig. (Bilateral)	.562	
	N	12	12

Source: Prepared with data reporting average minimum temperature by state, 2014-2016, National Weather Service, Management meteorology and climatology, Subgerencia Forecast Medium and Long Term CONAGUA. Single Automated System for Epidemiological Surveillance (SUAVE) 2016 *. Consultation April 2017 / * Preliminary data.

Discussion

The epidemiological profile of influenza in the state of Hidalgo in age of presentation, and its relationship to the winter season (a lower environmental temperature, the greater number of cases), are consistent with the literature, which also explains mortality groups at risk.

Cases of influenza were present throughout the year, however, there is a marked increase in the incident of cases during the winter season, mainly during the months of January, February, and March.

According to data National Weather Service, 2016 was the warmest record they recorded However, according to Ruiz-Corral et al. (2016), it is necessary regionalization of climate change, as there may be specific climatic differences.

Within this regionalization, Hidalgo can be found in the groups:

- *Group 1: moderate to severe heating shallow drying continentalization rudimentarily to the surface,* which is characterized by "an increased average temperature PV and OI 2 to 3 ° C; an increased thermal oscillation (OT) PV of 0 to 0.5 ° C and 0.5 to 1 OI ° C; a loss of 10 to 50 mm of rain during the period of PV as well as OI ".
- *Group 2: moderate heating to moderate-severe, very shallow to shallow drying very flat continentalization,* which is characterized by "an increased average PV temperature 2 to 3 ° C, while the increase in OI is 1 to 2 ° C. An increase in OT as well as in PV and RO which is from 0 to 0.5 ° C and, it includes a decrease of 10 to 50 mm for precipitation PV,

and 0 to 10 mm for precipitation OI "in small areas only.

- *Group 10: brief cooling, rudimentarily drying topicalization,* which is characterized by "being the only one with a temperature decrease in both PV and OI (-1 to 0 ° C) and a decrease in OT as well as PV and RO (-0.5 0 ° C). The reduction levels of precipitation are also the lowest in all groups identified ", but only in small areas.

Therefore, to make a finer analysis it would be requirement to have a registration of the areas or municipalities that make up these groups, and analyse whether there is variation regarding the incident of influenza.

However, with the existing information, it could be suspected that an overexposure to heat and cold as well as the incubation period of the influenza virus and exacerbation of previous respiratory pathology could explain the increase of influenza morbidity 2014 and 2015.

The analysis in this paper, could be a model for monitoring where environmental surveillance is conducted in terms of climate change and infectious diseases, it would be useful to perform the analysis for a decade at least to glimpse a bit more clearly on the effect of climate change on the diseases' behavior, and thus provide transcendent insights on the case of influenza, although their applications could be done individually or the whole assortment of infectious diseases according to geographical and social context prove to be incidents.

The patterns detected in this analysis regarding the correlation confirm that it is indeed necessary to perform emerging changes in the utility of fuel within the establishment of standards and their implementation with consistency in the search to reduce the emission of pollutants to the environment, the use of clean energy sources, changes range from in-school education received in educational institutions to become aware of the importance of taking care of environmental surroundings in the design of public policies in the field of environmental legislation locally and globally, as climate rafter affects not only state-wide or country wise, but globally, This indicates that from the meetings between the leaders of each country decisions will have to integrate thoughts and work alike to be executed for the same purpose, i.e., with environmental concerns globally and in line with actions at the local level.

Conclusions

When entering data to the statistical package, a significant correlation was identified within variables in the cases of influenza and temperature for the years 2014 (Sig = 0.001) and 2015 (Sig. = 0.00). A situation in which 2016, Pearson's correlation was not significant (Sig = .562).

The outlook for influenza in Hidalgo State, is similar to the literature reports.

Because of the ease of adaptation and mutation of the virus, it cannot be ensured that cases will continue to decline, but if the importance of addressing the factors that can facilitate their rise can be indicated, such as the exposure to heat and cold due to climate change.

It is necessary to achieve intersectoral combat various government programs, public policies on environmental legislation, society and private enterprises, intentional education with the constructivist approach, to become aware regarding the local environment and the global one, therefore, put an end to climate change, and thus reducing the impact on health.

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