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Behavior of influenza in the state of Mexico and its climatic correlation: analysis of 2009-2018

Comportamiento de la influenza en el Estado de México y su correlación climática: análisis del 2009-2018

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ABSTRACT

The abrupt changes of the climate and its diversity, as well as the direction of the winds in a certain region, are known to be a favorable factor for the appearance of acute respiratory illnesses like cold, laryngitis, pneumonia and influenza between others, the same that are related more with some seasonal period as the one that predominates over the dry-cold climate and/or climate with few moisture. Therefore, it is important to know if the climatic factors or environmental and geographic influence or were influential in the distribution of cases of influenza in the 125 municipalities of the state of Mexico. We reviewed the annual concentrations of databases in Excel with a positive result for some type of influenza from the pandemic (2009) until the end of the 2018 season (epidemiological week 20). We analyze the circulation of the virus according to the cardinal points, climatic and geographic conditions, municipalities and jurisdictions and its proximity to the CDMX (Mexico City). Our results were: of one total 19,444 suspected cases analyzed, 4,594 positive cases were found, of which the majority (3,561 [77.51%]) focused only in 19 municipalities and the rest (1,033 [21.8%]) were presented in the different towns. The circulation of the virus was mainly in those places located to the north of the city of Mexico, regardless if it is registered as a municipality or jurisdiction. The municipalities with the largest registry of cases of influenza were: Nezahualcoyotl, Ecatepec, and Naucalpan. **Conclusions:** This behavior in the State of Mexico could be first; The municipalities with the highest

RESUMEN

*Se sabe que los cambios abruptos del clima y su diversidad, así como la dirección de los vientos en una determinada región son un factor favorable para la aparición de enfermedades respiratorias agudas como catarro, laringitis, neumonía y gripe, entre otras; las mismas que se relacionan más con algún periodo estacional como el que predomina sobre el clima seco y frío y/o el clima con poca humedad. Por lo tanto, es importante saber si los factores climáticos o ambientales y geográficos influyen o fueron influyentes en la distribución de los casos de gripe en los 125 municipios del Estado de México. Revisamos las concentraciones anuales de las bases de datos en Excel con un resultado positivo para algún tipo de gripe desde la pandemia (2009) hasta el final de la temporada de 2018 (semana epidemiológica 20). Analizamos la circulación del virus según los puntos cardinales, las condiciones climáticas y geográficas, los municipios y jurisdicciones y su proximidad a la CDMX. Nuestros resultados fueron: de un total de 19,444 casos sospechosos analizados, se encontraron 4,594 casos positivos, de los cuales la mayoría (3,561 [77.51%]) se concentraron sólo en 19 municipios y el resto (1,033 [21.8%]) se presentaron en los diferentes pueblos. La circulación del virus se produjo principalmente en los lugares situados al norte de la Ciudad de México, independientemente de que esté registrada como municipio o jurisdicción. Los municipios con el mayor registro de casos de gripe fueron: Nezahualcóyotl, Ecatepec y Naucalpan. **Conclusiones:** Este comportamiento en el Estado de México podría ser el primero; los municipios con mayor*

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number of cases of influenza are within the defined areas with dry steppe and semidry. And in addition to the correlation of the following geographical factors helping for the spread of the virus of influenza, such as the formation of microclimates, latitude, and circulation of winds (predominantly north to south, east to west), topography, solar radiation, environmental pollution, and human activity. That in combination makes atmospheric basins, which favorises the virus to find ideal conditions for its spread.

Keywords: Influenza virus, climate, winds, topography, environment, State of Mexico, Mexico City (CDMX).

número de casos de influenza se encuentran dentro de las áreas definidas con estepa seca y semiseca. Además de la correlación de los siguientes factores geográficos que contribuyen a la propagación del virus de la gripe, como la formación de microclimas, la latitud y la circulación de los vientos (predominantemente de norte a sur, de este a oeste), la topografía, la radiación solar, la contaminación ambiental y la actividad humana. Eso en combinación hace que las cuencas atmosféricas favorezcan que el virus encuentre las condiciones ideales para su propagación.

Palabras clave: *Virus de la influenza, clima, vientos, topografía, medio ambiente, Estado de México, Ciudad de México (CDMX).*

INTRODUCTION

A. economic impact: The direct and indirect prices for the public health, only associated to influenza (without including the interruptions in the trade and other costs for the business and the industry) have been estimated in $181 thousand million dollars for the perspective of a moderated pandemic, with no interventions (similar to the ones in 1957 and 1968). The next possible threat is foreseen to be H5N1 or even worse H9N2, therefore before such a threat, the United States of North America and their international associates like the WHO-GIRS (World Health Organization - Global Influenza Surveillance and Response System) have combined efforts to be able to answer quickly and effectively to reduce the scope and the magnitude of the potentially catastrophic consequences in money expenses.[1,2]

Currently, influenza is considered within diseases epidemiological surveillance for its impact on public health, and costs that represent both the State (Government); for companies by labor absenteeism by disease at any given time (loss of day's/work/-day's/production); for schools in terms of student achievement (learning) and at last for the same patient who in our environment, the vast majority have to pay his health care and its medications.

B. The seasonal flirtation of the prevention vs the illness: Every year influenza or flu comes touching doors, but, not only in the countries (Canada, The United States) is also comes in ours, México, and some others of Center America; in general in the north countries it starts at the beginning of Autumn, in México, the period of influenza begins in the 40th epidemiologic week and end in the 20th week of the following year. In the USA and equally in Mexico the means of diffusion are replete with allusive signs to the period. The experts on the topic, appear in the programs of news of the television or radio, quoting during the interview, the past statistics and the waiting for the following period, speculating whether the patient's more vulnerable, and cheering each of those up from the hearing to vaccinate against influenza. Every nation is apparently mobilized for this period, since we know that the immunization by means of the vaccination is the best method to prevent the infection, the illness and its complications, that is the motive for which from the period of the flu 2010-2011, the Advisory Committee of Practices of the Immunization (ACIP) has recommended that the persons of 6 months and the elders (> 60 years) receive annual vaccinations with the most updated strains of the influenza, or with the ones that are foreseen to be circulating in a certain year. Based in studies and information of awareness of viral circulating strains, the WHO across GISRS (WHO-GISRS Organization-global World Health Influenza Surveillance And response System) determines the composition of the vaccines of influenza of every following year, monitoring circulating viruses in the human being during the course of every period, and by means of the analysis of the changes and antigenic mutations, is how it expresses the recommendations of which strains or lineages must be included in the following annual or seasonal vaccine.[3-5]

Everything seems fine, right? ... Yes and No. *Yes:* if the sensitization or awareness of the importance of vaccinating has been shown to be higher than in past years. *No:* because despite the availability of more than a dozen influenza vaccines in various preparations, it continues to cause significant morbidity and mortality.

The severity of the flu changes the period a period, depending this on the circulation of the viral-specific strains; of that so well the new vaccines combine to the circulating viruses, and of all the people one manages to vaccinate. In general, all the vaccines against the flu work better between healthy adults and major children. The prices of the infection of the flu are the highest between children younger than 5 years, pregnant

women and aged adults. The incidence of influenza is major between children < 5 years (with a major risk of dying in the persons younger than 2 years), who truly develop serious complications, but less common than the biggest adults for which the mortality is lower. Serious complications, hospital management, and related deaths are higher in particular in person's ≥ 65 years, pregnant women and persons of any age with comorbidities that increase the risk for it (asthmatic, hyper tenses, diabetic, obese, immunocompromised, between others).[6]

And this is what makes that not everything goes well, coupled with that according to the goal, flu vaccination rates have fallen as far as the aims or goals of healthy people in 2020. An example, during the flu season 2011-2012, the vaccination coverage in the United States (USA) at the national level among children 6 months to 17 years was 56.7% (compared with 70% healthy people 2020 goal) and among adults ≥ 18 years was the 38.3% (compared with the objective of the healthy people 2020 90%). In Mexico according to the Specific Program of Action – about Universal Vaccination (Program of health), the universal coverage of vaccination in children < 5 years (included it vaccinates against influenza) in 2012 was 85.50% and in adults > 60 years the coverage was closely 56.53%, for which the considered goal in this Government (2013-2018/President period) is claimed to be for the whole population including vaccines of children and adults of > 95%. As such Mexico is known as one of the countries with better coverage's of vaccination, from what it seems it had no problems with the goal of the healthy people.[7]

As such influenza in our country (Mexico) according to the guidelines of the DGE (General direction of epidemiology) of the SS (Ministry of Health) began its surveillance week 40 and ends at the 20 of the following year, but the greatest number of cases or flirting this, It occurs from the 52 weeks to week 12 of next year. That is where prevention interventions must be 100% to avoid falling into their networks or to be a catch or avoid flirting with infection vs disease.[8]

Demography, geography, and climate of the State of Mexico

Mexico, normally called the Mexico State to distinguish it from the country, is one of the thirty-one States that, together with the city of Mexico, form the Mexican United States, and its population is referred to as a state. Its capital is Toluca de Lerdo, and its most populous city is that of Ecatepec de Morelos. It is located in the central region South of the country, bordering other States; to the North with Queretaro, to the Northeast with Hidalgo, to the East by Tlaxcala, to the Southeast with Puebla, to the South by Morelos and virtually surrounds the Mexico City (CDMX), Guerrero Southwest and to the West by Michoacán. With 22 357 km², it is the seventh less extensive, but the most densely populated. It was founded on March 2, 1824.

Most mexiquense territory is located in the central part of the Neovolcanic axis. Which includes the valleys of Mexico, Toluca, part of the Puebla-Tlaxcala Valley, as well as the mountain ranges of the Sierra Nevada, Monte de Las Cruces, Monte Alto, and Western summits. On this same plateau significant elevations as the volcano Popocatepetl (5500 m), Iztaccíhuatl (5220 m), Nevado de Toluca (4680 m) and hills (4120 m), Telapón (4060 m) Tlaloc, and Jocotitlán (3910 m) are located.[9]

Certainly, the state of Oaxaca is the state of the Mexican Republic with the highest number of municipalities (570), but it is also the one with the greatest number of these with smaller populations. The State of Mexico occupies the first place at the national level by its number of inhabitants (17,118.524 habits [2015]), and is a region with a significant number of municipalities (125 in total), of which the of Ecatepec de Morelos which is the largest of the entity; it represents the second most populated of the country (extension of 155 km², and with a million 688 thousand 258 people), and Nezahualcoyotl is the other municipality that while it is very large (63.74 km²) if it is the 10th most populous country with 1 million 140 thousand 528 people (17 thousand for each 1,000 Mts2). The State of Mexico contributes 9.8 of GDP (Gross Domestic Product) and is one of the most industrialized of all the entities of Mexico and Latin America.

When we evaluate the climate in the state of Mexico, we find that the existing climates in the Mexiquense entity according to the classification of Köpen modified by Enriqueta García adapted to the conditions of the Mexican Republic are the following: Temperate, semi-cold and cold in the mountainous areas, dry steppe and semi-dry in the northeastern region of the state, semi-warm and warm in the South and Southwest *(Figure 1)*.[10,11]

73% of the sub-humid temperate climate presents state, located in the high valleys of the north, center, and east; the 21% is warm sub-humid and is located toward the southwest, the 6% dry and semi-dry,

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present in the northeast, and 0.16% cold weather, located in the upper parts of the volcanoes.[12,13]

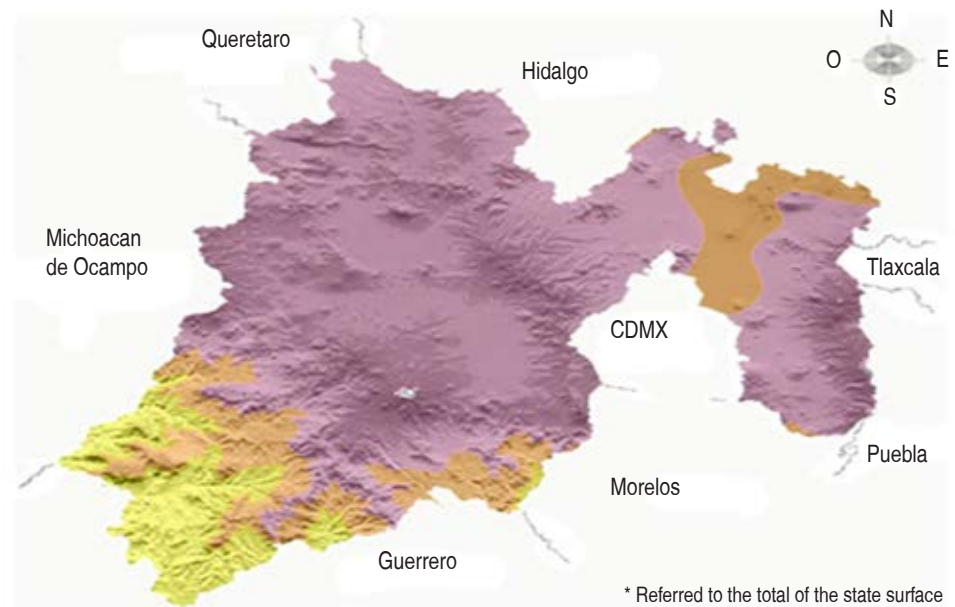
In terms of the pattern of circulation of winds in the State, the ministry of the environment of the GEM (Government of the State of Mexico) (2007), through the General Directory of Prevention and Control of Pollution Air, highlights that the general circulation of the atmosphere is regulated above the 1,000 m (meters above the sea level).[9] The winds circulation within the State of Mexico is from East to West, but certain natural factors such as mountainous or Rocky elevations and location, which define the limits of the atmospheric basin, give rise to the concentration of heat in the neighboring municipalities of the Valley of Mexico *(Figure 2)*.

The orographic factors affect the wind direction due to the variation in height in the main elevations and their location, however the difference of the winds are slightly different from the general circulation of the same, but both become important when the degree of solar radiation is concentrated in a particular area, the mountain barriers, atmospheric pressure and the behavior of the masses of air that contain lead to define units of geographic space that by these natural features make it different to other surrounding areas delimiting atmospheric basins and different microclimates.[14,15]

Given its geography and demography conducted a study through the Office of Epidemiology of the State of Mexico to assess the impact of influenza in this state, as it has two towns with the highest population of our country, which are also within the 10 most populated municipalities of our republic.[16] Having two main objectives: 1. To know what has been the movement of the different types of influenza virus from the pandemic until the end of the 2016 season, in the different municipalities and/or Jurisdictions of the State of Mexico and 2. To know if some climatic, environmental and geographic factors influenced the distribution of cases of influenza in the different municipalities of the state of Mexico.

MATERIAL AND METHODS

To assess this, we reviewed the annual concentrates all the cases reported as positive for some kind of virus (cases collected by the surveillance of Health Units [USMIs monitors Influenza]), which were confirmed by the state laboratory, and that are stored in Excel from the pandemic event of 2009 until the end



* Referred to the total of the state surface
SOURCE: Prepared based on the INEGI.
Climate chart: 1:1 1 000 000.

Note the predominance of the cold climate temperate (humid), in the central part, but semi-dry and dry steppe in the regions that are North of the Federal District (Today CDMX).

Figure 1:

Climates in the State of Mexico.

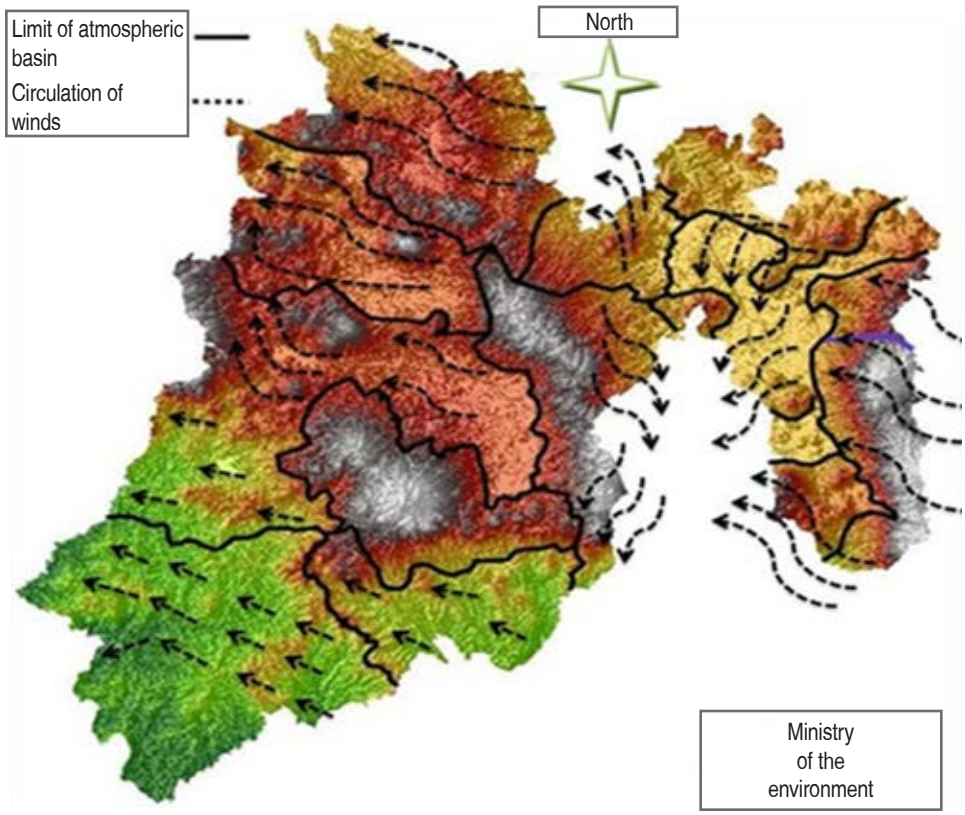


Figure 2:

Circulation of winds in the State of Mexico.

of the 2018 season (covering them from week 40 to the epidemiological week 20), such documents are in the Department of Mycobacterium and Communicable Diseases Epidemiology Branch of the ISEM (Institute of Health of the State of Mexico). All reports or records were based on the platform which was designed by the DGE (General Directorate of Epidemiology) as part of the strategy of sentinel surveillance of pandemic influenza in Mexico.[17]

The behavior or distribution of the influenza virus was carried out using the analysis of each of the seasons, to determine first simple frequencies and accumulated by each season analyzed. In the comparison between these periods of time observed, we analyzed by equal percentages, measures of central tendency and dispersion of the distribution of each virus in importance identified by each season observed. Similarly, in relation to the cases presented by the municipality and jurisdiction, we analyzed its incidence rate per 100 000 inhabitants in terms of number of population per entity, which was obtained from the data reported from two population censuses, from 2010 and the 2015; analyzing the incidence rate with the first census from the pandemic to the 2013-2014 season and the other four seasons with the 2015 census.

Distribution of influenza in the State of Mexico

From this evaluation will be recorded a total of 19,444 suspected cases, of which 4,594 (23.62%) were positive for some type of influenza virus. In the global predominance of AH1N1pdm-09 with 2,493 cases (54.30%) in the nine seasons, followed by AH3 (1,044 cases), influenza B with 556 cases, and influenza A endemic (501 cases). Independently and outside of the pandemic strain of influenza virus, the «A» prevailed in the 2010-2011 and 2011-2012 seasons with 138 (27.54%) and 171 (34.13%) cases, respectively, with respect to the strain of Influenza «B», was the rise in the season 2015-2016 follow for the season 2016-2017, unlike the other seven seasons with 201 (36.15%) and 129 (23.20%) cases respectively, however prevailing «H3» with 289 cases (27.68%) was in season 2015-2016. Just in three of the last four seasons (2014-2015, 2015-2016 and 2017-2018), there was a greater number in cases of the virus «H3»: 153, 289 and 223 per season,

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in contrast to the smaller number of cases observed in the pandemic influenza seasons 2012-2013 and 2014-2015 (only 2 and 1 case respectively). Regardlessly of this, it highlights that the pandemic virus AH1N1 after the pandemic showed an increase in the number of cases, in general, every two years, cutting its biannual cycle in the 2016-2017 season where we register another increase with 238 cases. And it is striking that in the global of the identified strains; in the post-pandemic event was observed a similar increase every two years, as shown in *Tables 1 and 2*. We note that the seasons 2009-2010 and 2015-2016 recorded the highest number of confirmed cases of influenza, corresponding in its majority, to this last season (903 vs 871). Followed by the 2013-2014, 2011-2012 and 2016-2017 seasons with 733 and 664 and 471 confirmed cases respectively. The seasons 2017-2018, 2014-2015, 2012-2013 and 2010-2011 with many fewer cases; being of 294 - 224 - 220 and 214 respectively. The behavior of the distribution of the prevalence of the different viral strains identified in the epidemiological season (week 40 to 20) in the State of Mexico is shown in *Figures 3 a 5*, according to the largest number of cases submitted for each strain identified. In *Figure 3* shows the distribution of the pandemic and the H3 and in the *Figure 4* the distribution of Influenza A and B. In the global distribution of suspected cases of influenza, we observed that at the end of the 2018 season the seasons that recorded the most events were the first four after the pandemic, in the following order: 2009-2010 - 2010-2011 - 2013-2014 - 2015 -2016 and 2011-2012; whit 5,138, 1,536, 3,851, 2,236 and 2,141 respectively. *Figure 5* shows the global distribution.

In terms of distribution by municipalities, of the 125 that has the State of Mexico if it is true that in some there was no case and in others there was a minimal of events, it should be noted that only 19 of them we detected the greatest number of confirmed cases of

Table 1: Ratio of the total number of cases confirmed influenza types per annual season and high season (SEM: 40-20): N = 4,594.

Virus type	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	Total
AH1N1-pdm	801	10	468	2	560	1	385	238	28	2,493
INF-A	68	138	171	17	41	12	28	20	9	504
INF-B	1	11	5	88	29	58	201	129	34	556
AH3	1	55	20	113	103	153	289	87	223	1,044
Total	871	214	664	220	733	224	903	474	294	4,597

Note that cases of pandemic influenza showed a biannual course.

Table 2: Relationship of frequency of type of virus identified by season and their corresponding percentages in relation to the number total of each identified virus.

	Virus type and percentage								
Season	AH1N1-pdm	%	INF-A	%	AH3	%	INF-B	%	Total
2009-2010	801*	32.12*	68	13.57	1	0.09	1	0.17	871
2010-2011	10	0.41	138[ll]	27.54[ll]	55	5.26	11	1.97	214
2011-2012	468*	18.77*	171[ll]	34.13[ll]	20	1.91	5	0.89	664
2012-2013	2	0.08	17	3.39	113‡	10.82‡	88§	15.82§	220
2013-2014	560*	22.46*	41	8.18	103‡	9.86‡	29	5.21	733
2014-2015	1	0.04	12	2.39	153‡	14.65‡	58§	10.43§	224
2015-2016	385*	15.44*	28	5.58	289‡	27.68‡	201§	36.15§	903
2016-2017	238*	9.54*	17	3.39	87	8.33	129§	23.20§	471
2017-2018	28*	1.12*	9	1.79	228‡	21.83‡	34	6.11	299
Total	2,493	100.00	501	100.00	1,044	100.00	556	100.00	4,599

We note that H1N1 flu has shown a biannual course practically from the pandemic.
* = 1. ‡ = 2. § = 3. ll = 4.

Table 3: Cases of influenza by municipality and season and its rate of incidence.

Municipality	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	Total
Municipality at north of CDMX (rate of incidence for 100,000 inhabitants)										2,080
Atizapán de Zaragoza	50 (10)	21 (4)	79 (16)	21 (4)	33 (6)	21 (4)	49 (9)	11 (2)	17 (3)	302 (57)
Cuautitlán	14 (10)	1 (0.7)	13 (9)	3 (2)	21 (14)	9 (6)	18 (12)	12 (8)	5 (3)	96 (64)
C. Izcalli	7 (1.4)	3 (0.6)	7 (1)	1 (0.2)	9 (1)	3 (0.5)	11 (2)	4 (0.7)	5 (0.9)	50 (9)
Coacalco	8 (2)	2 (0.7)	10 (3)	3 (1)	16 (5)	4 (1)	6 (2)	5 (1)	5 (1)	59 (20)
Ecatepec	129 (7)	20 (1)	53 (3)	14 (0.8)	91 (5)	8 (0.4)	100 (5)	65 (3)	17 (1)	497 (29)
Naucalpan	102 (12)	53 (6)	109 (13)	40 (4)	56 (6)	9 (1)	121 (14)	54 (6)	23 (2)	567 (67)
Tecámac	11 (3)	1 (0.2)	7 (1)	1 (0.2)	24 (6)	2 (0.4)	21 (4)	12 (2)	8 (1)	87 (19)
Tepotzotlán	1 (1)	0 (0)	2 (2)	0 (0)	4 (4)	0 (0)	2 (2)	1 (1)	0 (0)	10 (10)
Tlalnepantla	111 (16)	18 (2)	47 (7)	15 (3)	41 (6)	18 (2)	54 (7)	22 (3)	14 (1)	340 (48)
Tultitlán	13 (2)	2 (0.3)	8 (1)	2 (0.3)	20 (3)	4 (0.7)	13 (2)	9 (1)	1 (0.1)	72 (13)
Municipality at southwest of CDMX (rate of incidence for 100,000 inhabitants)										120
Malinalco	2 (7)	0 (0)	1 (3)	1 (3)	1 (3)	2 (0.7)	2 (7)	1 (3)	1 (3)	11 (40)
Tejupilco	6 (8)	1 (1)	12 (16)	1 (1)	4 (5)	8 (10)	13 (16)	0 (0)	7 (8)	52 (2)
Tenancingo	1 (1)	0 (0)	0 (0)	1 (1)	7 (7)	8 (8)	34 (34)	1 (1)	5 (5)	57 (58)
Municipality at east of CDMX (rate of incidence for 100,000 inhabitants)										874
Chimalhuacán	20 (3)	1 (0.1)	15 (2)	3 (0.4)	25 (4)	4 (0.5)	31 (4)	17 (2)	6 (0.8)	122 (17)
Nezahualcóyotl	145 (13)	27 (2)	66 (5)	18 (1)	119 (19)	54 (5)	120 (11)	91 (8)	50 (4)	690 (66)
Texcoco	15 (6)	0 (0)	4 (1)	5 (2)	9 (3)	0 (0)	7 (2)	18 (7)	4 (1)	62 (25)
Municipality at southeast of CDMX (rate of incidence for 100,000 inhabitants)										108
Chalco	4 (1)	5 (1)	1 (0.3)	6 (2)	24 (7)	5 (1)	32 (9)	23 (6)	8 (2)	108 (31)
Municipality at west of CDMX (rate of incidence for 100,000 inhabitants)										359
Toluca	47 (5)	17 (2)	76 (9)	29 (3)	68 (8)	13 (1)	65 (7)	13 (1)	31 (3)	359 (41)
Municipality at northwest of CDMX (rate of incidence for 100,000 inhabitants)										20
Atlacomulco	2 (2)	0 (0)	1 (1)	0 (0)	4 (4)	2 (1)	9 (8)	1 (0.9)	1 (0.9)	20 (19)
Global	688 (7)	172 (1)	511 (5)	164 (1)	576 (6)	174 (2)	708 (7)	360 (3)	208 (2)	3561 (38)

influenza throughout the time of the seven influenza seasons. To prevail in the first place: Nezahualcoyotl city with 690 cases, followed by Naucalpan with 567, Ecatepec with 497 and Toluca with 359 cases, respectively, out of a total of 3,561 cases in 19 municipalities. The municipalities that fewer cases recorded were Atlacomulco, Malinalco, and Tepotzotlán with 20-11 and 10 cases respectively, as referred to in *Table 3*. The rest of confirmed cases (1,033) were presented in the rest of the remaining 106 municipalities of our state.

Epidemiological surveillance of influenza in the state of Mexico is evaluated by jurisdictions, which represent 19 in total and 11 of them have the same name as your municipality. However, the assessing the number of cases of influenza by jurisdiction we observe a smaller number of events (190 cases), this distribution of cases in relation to the jurisdiction it was reported, are shown in *Table 4*.

Variability of influenza in the State of Mexico

The variability of the virus was present both by season and by isolated strain and with much more in terms of the number of identified cases. This is

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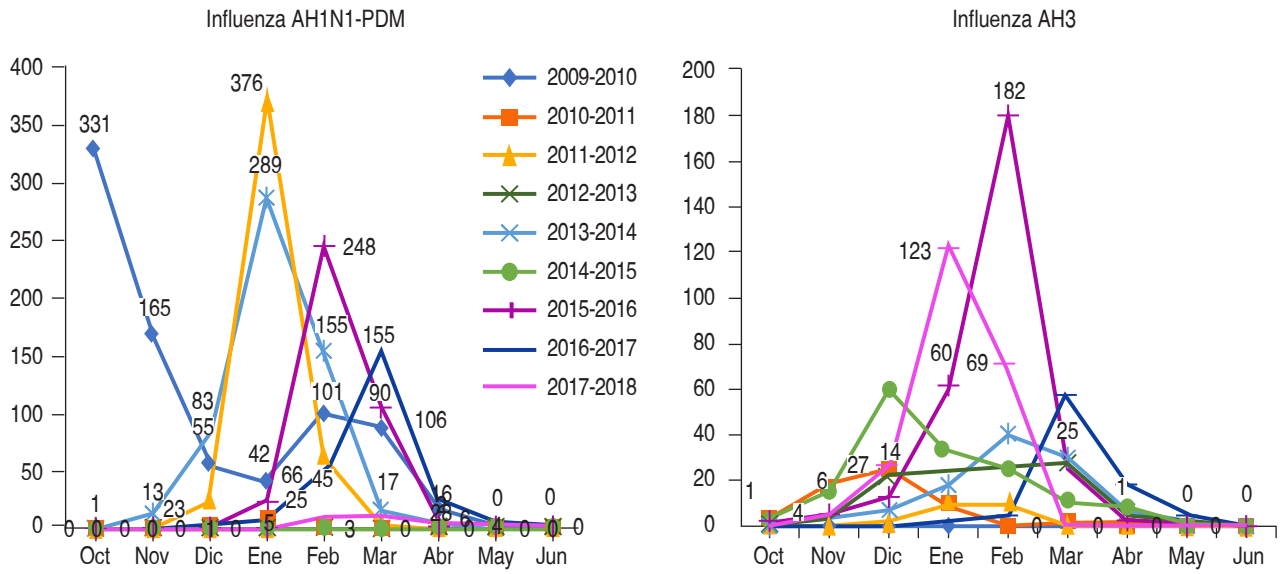
reflected in that, for example, influenza «A» would occupy the fourth place in terms of the total number of cases (501) in the nine seasons, which is in terms of the number of seasons in which each strain showed its higher prevalence This is observed in *Table 2*, wherein gray, from highest to lowest intensity are identified by the number 1 to the pandemic influenza that prevailed in 5 seasons, with the number 2 to influenza «H3» that prevailed equal in 5 seasons, with the number 3 to the influenza «B» that prevailed in four seasons and finally with the number 4 to the influenza «A», which I highlight in only two seasons. Although it is true that unlike the other strains in the 2010-201 season, influenza «A» had the highest number of cases (138-27.54%), as indicated in *Table 2*.

A pandemic event occurs when a new influenza virus, which can infect and be efficiently and

Table 4: Cases of influenza by jurisdiction and by season and its rate of incidence.

Jurisdiction	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	Total
Jurisdiction at north of CDMX (rate of incidence for 100,000 inhabitants)										1,898
Atizapán de Zaragoza	50 (10)	21 (4)	79 (16)	21 (4)	33 (6)	21 (4)	49 (9)	11 (2)	17 (3)	302 (57)
Cuautitlán	21 (3)	4 (0.06)	20 (3)	4 (0.06)	30 (4)	12 (1)	29 (4)	16 (2)	10 (1)	146 (21)
Zumpango	2 (1)	0 (0)	3 (1)	0 (0)	8 (5)	0 (0)	19 (9)	12 (6)	2 (1)	46 (23)
Ecatepec	129 (7)	20 (1)	53 (3)	14 (0.8)	91 (5)	8 (0.4)	100 (5)	65 (3)	17 (1)	497 (29)
Naucalpan	102 (12)	53 (6)	109 (13)	40 (4)	56 (6)	9 (1)	121 (14)	54 (6)	23 (2)	567 (67)
Tlalnepantla	111 (16)	18 (2)	47 (7)	15 (3)	41 (6)	18 (2)	54 (7)	22 (3)	14 (1)	340 (48)
Jurisdiction at northeast of CDMX (rate of incidence for 100,000 inhabitants)										10
Teotihuacán	0 (0)	1 (1)	1 (1)	0 (0)	1 (1)	1 (1)	4 (7)	2 (3)	0 (0)	10 (17)
Jurisdiction at southwest of CDMX (rate of incidence for 100,000 inhabitants)										209
Tenango del Valle	0 (0)	0 (0)	6 (7)	5 (7)	41 (52)	9 (10)	37 (42)	0 (0)	2 (2)	100 (128)
Tejupilco	6 (8)	1 (1)	12 (16)	1 (1)	4 (5)	8 (10)	13 (16)	0 (0)	7 (8)	52 (2)
Tenancingo	1 (1)	0 (0)	0 (0)	1 (1)	7 (7)	8 (8)	34 (34)	1 (1)	5 (5)	57 (58)
Jurisdiction at east of CDMX (rate of incidence for 100,000 inhabitants)										752
Nezahualcóyotl	145 (13)	27 (2)	66 (5)	18 (1)	119 (19)	54 (5)	120 (11)	91 (8)	50 (4)	690 (66)
Texcoco	15 (6)	0 (0)	4 (1)	5 (2)	9 (3)	0 (0)	7 (2)	18 (7)	4 (1)	62 (25)
Jurisdiction at southeast of CDMX (rate of incidence for 100,000 inhabitants)										37
Amecameca	1 (2)	0 (0)	0 (0)	0 (0)	3 (6)	2 (3)	27 (53)	3 (5)	1 (1)	37 (72)
Jurisdiction at west of CDMX (rate of incidence for 100 000 inhabitants)										415
Xonacatlán	2 (4)	0 (0)	2 (4)	0 (0)	1 (2)	0 (0)	9 (17)	0 (0)	1 (1)	15 (29)
Toluca	47 (5)	17 (2)	76 (9)	29 (3)	68 (8)	13 (1)	65 (7)	13 (1)	31 (3)	359 (41)
Valle de Bravo	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	2 (3)	36 (54)	1 (1)	1 (1)	41 (62)
Jurisdiction at northwest of CDMX (rate of incidence for 100 000 inhabitants)										50
Atlacomulco	2 (2)	0 (0)	1 (1)	0 (0)	4 (4)	2 (1)	9 (8)	1 (1)	1 (1)	20 (19)
Jilotepec	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	9 (10)	0 (0)	1 (1)	12 (13)
Ixtlahuaca	3 (2)	0 (0)	0 (0)	0 (0)	4 (2)	0 (0)	9 (10)	1 (0.6)	1 (0.6)	18 (11)
Global	637 (8)	163 (2)	479 (6)	153 (2)	522 (7)	167 (2)	751 (9)	311 (4)	189 (2)	3,371 (44)



Note the course of presentation of each 2 years of pandemic Influenza, the greatest number of cases of AH3 was recorded in the season 2015-2016. Emphasizes that in all seasons with the highest number of cases was between December - March vs January - April.

Figure 3: Distribution by season of influenza pandemic and AH3.

effectively transmitted between individuals (person to person), due to the loss of pre-existing immunity in the population, such as occurred in our country and our state as an example where pandemic influenza season in the 801 cases were reported of which 688 in the municipalities most affected.

It should be noted that the State of Mexico has five municipalities with the largest population according to the censuses of 2010 and 2015 which are: Ecatepec with 1,656,107 vs 1,677,678 inhabitants respectively and which is the second largest municipality in the state, followed by Nezahualcoyotl with 1'110,565 vs 1'039,867; Naucalpan with 833,779 vs 844,219; Toluca with 819,561 vs 873,536 and Tlalnepantla with 664,225 vs 700,734. Note that Nezahualcoyotl is the 10th most populated in the country and does not have such a large territorial extension, for example, if we compare it with Naucalpan whose territorial extension is little more than double that of Nezahualcóyotl (155.70 km^2).[9] Regardless of the distribution of cases both by municipalities or by jurisdictions highlights that the distribution of events post-pandemic showed equal an increase in the number of cases, in general, every two years, until the 2015-2016 season, since in the following two (2016-2017 and 2017-2018) the number of cases was lower than in the last seven seasons, including the pandemic. So surely the 2018-2019 seasons will be expected to have a considerable number of events *(Tables 3 and 4)*.

However, when analyzing the incidence rate by municipality and jurisdiction, we observed that the incidence rate per 100,000 inhabitants during the pandemic was not greater than 16 cases, and that it showed an increasing pattern every 2 years in relation to the number of cases per 100,000 inhabitants until the 2015-2016 season since for the next one (2016-2017) the number of cases was also increased, which decreased in the recent season (2017-2018). According to the number of cases by the municipality in the global Naucalpan and Nezahualcoyotl occupied the first places with 67 and 66 cases respectively. However, when analyzing the global incidence of cases per 100 000 inhabitants per jurisdiction, it was elevated in those such as Tenango del Valle with 128 cases followed by Amecameca with 72 cases, Naucalpan with 67 cases, Nezahualcoyotl with 66 cases and Tenancingo with 58 cases, denoting that three are jurisdictions with fewer inhabitants.

Due to the fact that the State of Mexico is located in the center of the country, the analysis of the circulation of the viruses that cause influenza was made on the basis of the cardinal points (north, south, east and west) being able to observe that regardless if analyzed its circulation by municipalities or by jurisdictions; when he was

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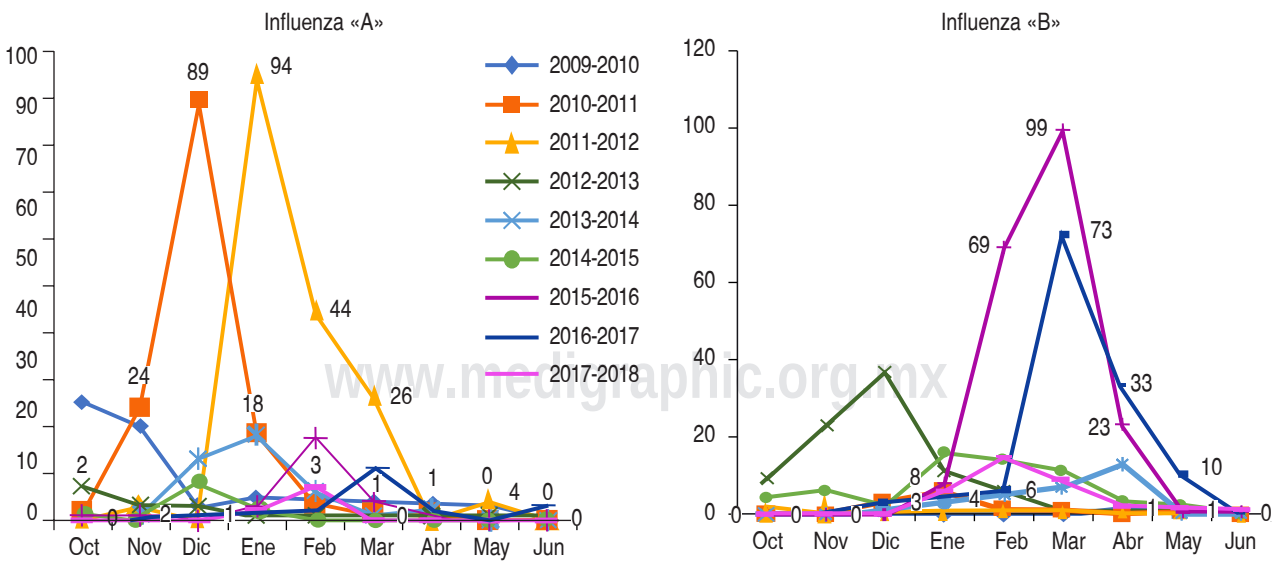
by municipalities, the highest number of cases was observed in those located in the north of the CDMX (Mexico City Federal District [before]); corresponding to 2080 by municipalities vs 1898 that when was by jurisdiction.

Followed by the cases identified in the municipalities (874) vs jurisdictions (752) located in the East side of the CDMX; also note that both the municipalities and jurisdictions to the west of the CDMX occupied the third place of events with 359 and 415 cases respectively *(Tables 3 and 4)*. It is striking that the lower number of cases identified both by municipality or jurisdiction are polarized to the North, being 20 in the municipalities in the North-West of the CDMX and 10 cases in the jurisdictions to the northeast of the CDMX. As such the State of Mexico has no municipalities adjacent to the South of Mexico City. It should also be noted that in assessing jurisdiction, Tenango of Valle's not reported any case of the influenza pandemic and cycle back to the pandemic; this because it was not initially a USMI unit, and cases were reported by other municipalities that are integrated into this jurisdiction of Tenango of Valle's. But from 2011 the confirmed cases could register, as shown in *Table 4*.

Considering the circulation of influenza according to cardinal points it can be presumed that, as has already been shown for example, that in cities whose degree of contamination is quite high, and in other areas where climate variations are changing (rain, soil moisture, transition between heat - cool climate - lowering of temperature) or the thermal inversion, and including the circulation of winds, the respiratory infections such as flu, common cold, bronchitis and asthma are the most commonly observed. And added to that it's worsening during winter, autumn, and spring rarely. In winter there are sudden changes in temperature with cold winds; in autumn winds favor the pollination and in spring, are favored infections by dry air; it is perhaps one reason to understand that the municipalities as Nezahualcoyotl, Naucalpan, and Ecatepec were the most affected to have these characteristics.[18,19] Something similar has been reported with other diseases such as Kawasaki, in where it has suggested that participation climate and winds play an important role in the epidemiology of the disease, similar happen with avian influenza.[20-22]

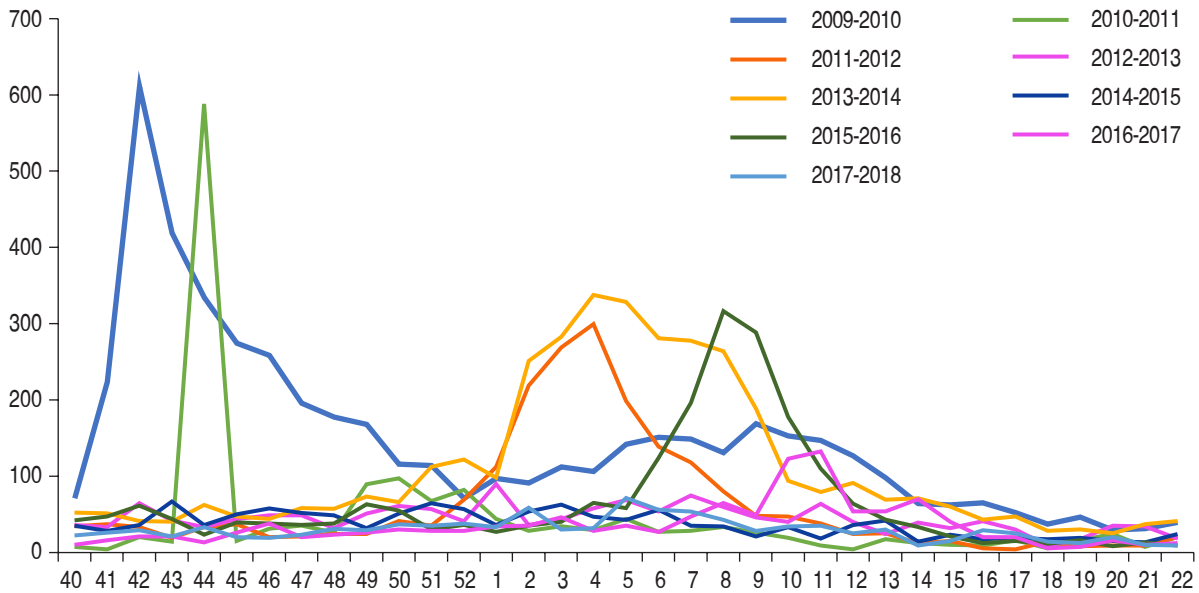
Climate relationship

As it as can be seen in the figure of the climates of the State of Mexico and in *Tables 1 and 2* of total cases of Influenza during the 2009-2018 seasons, municipalities with a greater number of cases of influenza are located in North, Northeast, and Northwest which are within the defined areas with climates: dry, semi-dry steppe, semi-cold, temperate-sub-humid, where the



Influenza A only two high periods, but followed: 2010-2011-2011-2012, like Influenza B, that had equal two followed season. However, none of them exceeded the range of 100 cases.

Figure 4: Seasonal distribution of influenza «A» and «B».



The seasons that recorded the most events were the first four after the pandemic, in the order of: 2009-2010 - 2010-2011 - 2013-2014 - 2015-2016 and 2011-2012.

Figure 5: Global Seasonal distribution of influenza: 2009-2018.

virus is the ideal conditions for its spread *(Figure 3)*. The State of Mexico as it's shown in the map, is made up of a variety of microclimates, which are reinforced by the human factor that contributes to the change of these micro-climates, this factor in these areas is the development of the geographical space, giving rise to the concentration of solar radiation in certain areas.

Examples of these micro-climates are the municipalities of greater registration of cases such as Nezahualcoyotl, Ecatepec, Tlalnepantla, Naucalpan, Nicolas Romero, Coacalco and Cuautitlan, which also concentrates the largest number of population density in the country, an example of this is the case of Ecatepec with 10857.66/km²) which has the third place of cases of influenza in the state. As such, in the municipalities with cases of Influenza with semi-cold climate (Toluca and Atlacomulco) this may be another factor because the virus remains infectious in this type of environment, in other regions with tropical rainy climate and semi, it's not identified a possible relationship with geographic factors which lead to the spread of the virus, we believe that it is probable that the identified cases is due to the transfer of population by work activities and trade to the places where the influenza virus is common, and in fact in municipalities of the state of Mexico with this climate, are not recorded cases of influenza.

The latter supports the fact that in communities with low population density but high state influx to the CDMX and from this to the state of Mexico, the number of population at risk to get influenza, its incidence rate per 100,000 inhabitants has been increased.

Analysis

Some authors have considered that the migration of diseases is the result of global climate change, by which, based on the observed behavior of the influenza virus in the state of Mexico, with the above we can say that we identify the correlation of the following geographical factors for the spread of the virus of Influenza: Climate, latitude, movement of the winds, topography, solar radiation, environmental pollution, and human activity. In the State of Mexico the diversity of climates, with predominantly temperate humid, dry and semi-dry of the municipalities adjacent to the CDMX (where you can observe some degree of pollution and important environmental pollution), as well as its topography and currents or predominant circulation of the winds is what has favored that the majority of cases observed are concentrated in the municipalities and/or jurisdictions located to the north, northeast, and southwest in relation to the

CDMX. It is possible but we can't ensure that the migration of people from the state of Mexico, CDMX and vice versa as well as the population density of the municipalities of Ecatepec or Cd. Nezahualcoyotl is an extra factor of the greater number of cases found in the closest towns to the CDMX. Indirectly we could infer or consider that these directions of the winds may explain why the CDMX) DF (for example in 2018, it was the first place in cases DIT/AIR [Disease type Influenza/Acute Infections Respiratory] (4.086) and also the first place of positive cases of influenza (696 cases).[23,24]

CONCLUSIONS

Indirectly we could infer or consider that these directions of the winds may explain why the CDMX) DF (for example in 2018, it was the first place in cases DIT/AIR [Disease type Influenza/Acute Infections Respiratory] (4.086) and also the first place of positive cases of influenza (696 cases).[23] It is well known that the extent and severity of a pandemic depends on the specific characteristics of the virus, and although a new influenza virus may emerge somewhere in the world at any time, fortunately: a) The 2009 pandemic (H1N1pdm-09), after its submission, spread, and control, step to be like all the other viruses that have been reported throughout history, an endemic virus and b) Governments, communities and other stakeholders in the public and private sectors must anticipate and prepare for a future and new pandemic defining roles and responsibilities to develop the Continuity of Operations Plans, according to the recommendations issued by the WHO-GISRS, since 2014 to 2018.[25,26]

It seems that with everything already described, we can say, that the climate variables and the geography of our state influenced that despite having the second largest number of people within our country, the majority of events were recorded in those towns to the north of the CDMX.

Future perspectives

It is important to continue monitoring the epidemiological impact of influenza in our country and in our State, taking into account its topography and distribution of climates. In addition to this, the next step will be to see what happens within the CDMX, which practically is surrounded by the State of Mexico and see if the circulation of winds played a role in cases of influenza. Although it is important to considerate and investigate if there is a relationship between vaccinated and non-vaccinated who get sick from influenza.

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