Time series analysis: climate and respiratory events in Cundinamarca, Colombia, 2009 to 2018

Fabian Camilo Salgado Escobar[1], Claudia Marcela Muñoz Lozada[1], Luis Carlos Gómez Ortega[1], Paola Elena León Velasco[1], Luis Reinaldo Barreto[2], Isabel Cristina Hoyos[3], Milcíades Romero[4], Sonia Diaz[1], María Natalia Muñoz[1], Jorge Alberto Gamarra Cuellar[5], Claudia Marcella Huguett Aragón[1], Milena Edith Borbón[5], Oscar Alberto Rojas[1], Oscar Eduardo Pacheco Garcia[1]

Authors affiliations: [1] Research Group in Applied Epidemiology, National Institute of Health of Colombia; [2]Climatology and Agrometeorology Group. Hydrology, Meteorology and Environmental Studies Institute of Colombia; [3]Quindío University, Colombia; [4]University of Salzburg – Austria UNIGIS; [5]Environmental Risk Factors Group, National Institute of Health of Colombia

Corresponding author**:** Claudia Marcela Muñoz Lozada, National Institute of Health, Calle 26 # 51-20, Bogotá, Colombia, postal address 111321, cmunoz@ins.gov.co, PBX 2207700 extension 16102.

Abstract

Introduction. Reported cases of respiratory diseases significantly increase each year during cold seasons, and environmental factors might increase the risk of complications. The objective of the study was to identify the relation between reported respiratory events and meteorological variables in study municipalities of Cundinamarca, Colombia. **Population and methods.** an ecological study of time series for Chronic Obstructive Disease (COPD) and Acute Respiratory Infection (ARI), integrating information from the national surveillance system, national health records and meteorological data of minimum and maximum temperatures and, precipitation from 2009 to 2018 of 14 municipalities of Cundinamarca. The analysis includes studying secularity through least squares, cyclical fluctuation using the residuals method, and seasonal and irregular variation using moving average method. **Results.** Seasonal analysis showed that when precipitation is higher than the median (χ^2 of 4.1 with a

P-value = 0.04), there was an increase in ARI, as well as when the minimum temperature is below its median (χ^2=29.6; *P*<0.001). There was a clear cyclical pattern in ARI occurrence, every six months and two years and COPD in 2 municipalities with a cycle every one and three years, with an increasing trend. **Discussion.** The time series allowed us to establish a relation between climatic variables and the diseases of interest in public health, the increase in precipitation levels and the temperature decrease are considered risk factors for the rise in ARI cases.

Keywords: time-series, acute respiratory infections, chronic obstructive pulmonary disease, epidemiology, climate, temperature, precipitation, Colombia

Introduction

Climate change causes direct impacts on human health, and how these vary by location depends on several factors, including regional climate impacts, demographic and human vulnerabilities, and local adaptive capacity [1]. Populations in regions such as an insular, coastal, high mountain, and densely populated desert areas are considered vulnerable [2].

In Colombia, although climate change efforts are focused on mitigation and clean development projects, the government´s National Plan for Adaptation to Climate Change (PNACC) aims to formulate priority programs and projects and strengthen actions undertaken. Achieving such aims would require considering climate variables into consideration when planning and executing actions to reduce negative long-term consequences of climate change for populations, the productive sector and ecosystems, as well as to monitor changes in the country [3].

In Colombia´s Andean and Caribbean regions, increases in temperature between 2°C and 4°C, as well as important changes in hydrological regime, and a reduction in rainfall of up to 30%, mainly in the Andean region, have been observed [4]. Such changes could be mitigated by strengthening the critical functions of the health system and better climate risk management. It is necessary to comprehend how

climate variability, understood as "the climate parameters variation concerning the climate average through observation over a long time in a specific region" [5] should be considered as part of the surveillance systems for events of interest in public health in Colombia.

Chronic obstructive pulmonary disease (COPD) is an important and growing cause of morbidity and mortality in the world, according to the 2019 classification of the 10 leading death causes in the world [6], ranked third with an equivalent of 6% deaths. In Colombia, it presents a higher prevalence in men than in women, with a crude prevalence in Cundinamarca of 1.1% [7].

Acute respiratory infections (ARI) are a group of diseases of the respiratory system caused by infectious agents, mostly viruses and bacteria; with a sudden onset and lasting less than two weeks. It is a significant cause of morbidity and mortality worldwide, especially in developing countries [8]. It is a leading cause of mortality from communicable diseases, ranking fourth cause of death The ARI notification in the outpatient and emergency service presented a high level of activity in the Cundinamarca department in the general population and the hospitalization service [9].

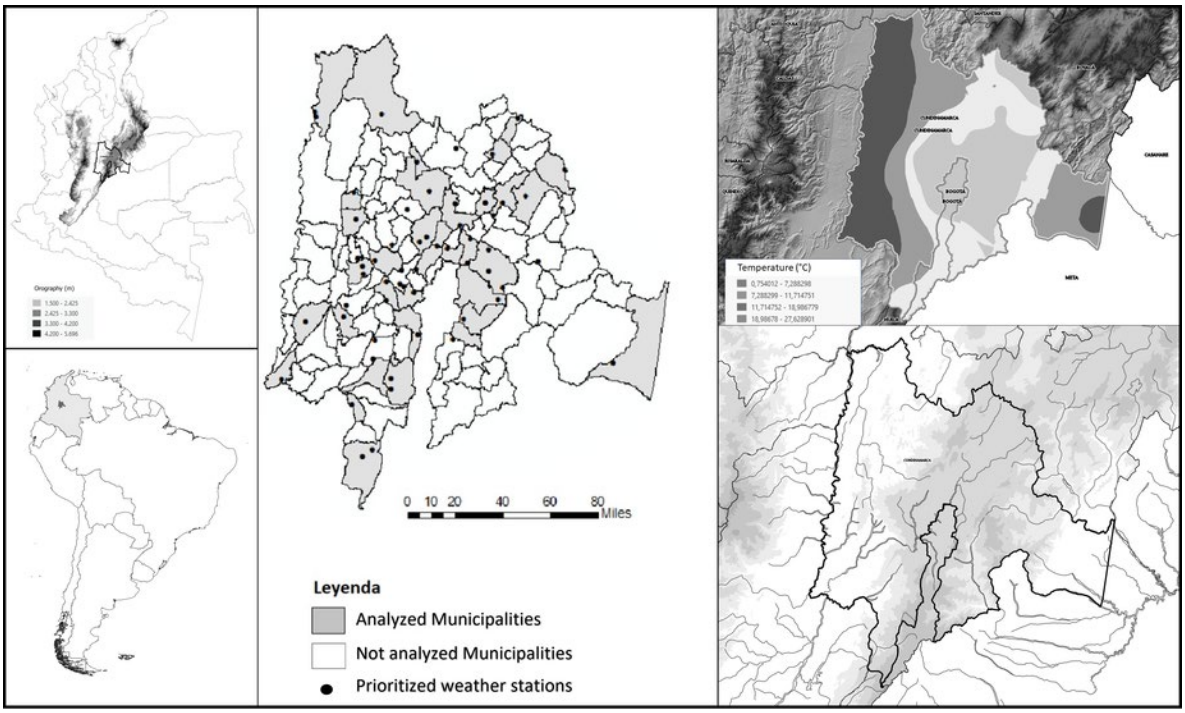
A time series is a set of numerical data obtained in regular periods, measured in hours, days, months, quarters, years, or that considered of interest [10]. Time series analysis allows identifying patterns in the data gathered over time and managing the uncertainty associated with future events [11].

Time series analysis has been used mainly in describing disease patterns in morbidity and mortality statistics, forecasting trends, detection of epidemics and evaluation of interventions. It is a powerful tool for understanding different biomedical events. It provides advantages because it integrates longitudinal data of repeated occurrence in specific periods and identifies trends before and after an intervention [12].

Cundinamarca is a department of 24,210 Km^2 of territorial extension, surrounding Bogotá Capital District, and occupying the fourteenth position among Colombia's departmental administrative divisions

with an equivalent of 2.1% of the country's area. It is located on the eastern mountain Andes range, along the Magdalena River's eastern margin up to the Llanos foothills. Its extension begins to the south in the eastern mountain range, forming the complex of the Sumapaz and Cruz Verde moorland (or *páramos*), followed in its middle part by the plateau of the Sabana de Bogotá; and further north, the Ubaté and Simijaca valley. The Magdalena Valley and the part of the Eastern Llanos correspond to the flat and warm sectors of the department. Cundinamarca is formed by 116 municipalities, grouped into 15 provinces and Bogotá Capital District. The provinces' structure allows municipalities to integrate according to their homogeneous characteristics at a social, spatial and proximity level to strengthen regional development [13]. For this study, 36 municipalities were set as study population, because they met the requirement of available data for the time series analysis (see Figure 1).

Figure 1. Map of the studied municipalities of Cundinamarca according to surveillance information and climate stations, Colombia 2009-2018



A year-to-year climate variability with increases in temperature of up to 0.5°C and decrease in precipitation up to 60% during El Niño, temperature decreases of 0.5°C and increases in precipitation

of 60% during La Niña has occurred. It is expected to identify the possible relation between the climatic variables of minimum temperature, maximum temperature, and precipitation, compared to the events behavior of ARI and COPD in the department of Cundinamarca through the analysis of time series. The study's objective was to identify the relationship between respiratory diseases and meteorological variables in the study municipalities of Cundinamarca.

Population and methods

This was a time series ecological study, having as study population the series of data recorded on municipalities of the Cundinamarca department, Colombia, collected in meteorological stations on minimum and maximum temperature, and precipitation, as well as reported visits from ARI and COPD between 2009 and 2018.

Meteorologic stations

The information from the meteorological stations was provided by the Hydrology, Meteorology and Environmental Studies Institute -IDEAM-, the operation stations recorded data automatically, or an observer registered data [14]. As an inclusion criterion for the analysis of the stations, it was considered a data series integrity greater than 75% for the study period.

Data was gathered from 58 stations corresponding to 44 municipalities of the department of Cundinamarca; 36 that met the inclusion criteria were selected as study population. The station categories were four agrometeorological stations, 22 ordinary climate stations, 17 principal climate stations, 14 special meteorological stations and one principal synoptic station.

ARI reported cases and COPD visits.

For ARI event, a time series was developed for each municipality, with data corresponding to the number of cases notified to the Public Health Surveillance System (SIVIGILA) of the National Institute of Health between 2014 and 2018. In contrast, for COPD, the time series were arranged from the

Individual Records of Provision of Services (RIPS) available in the Integrated Information System for Social Protection (SISPRO) of the Ministry of Health and Social Protection of Colombia between 2009 and 2018.

Data Analysis

To define the minimum number of reported ARI cases or the minimum number of registered consultations with diagnoses associated with COPD for each of the municipalities, department data were grouped and distributed in percentiles, including those above the 90th percentile only. Based on the time series, a descriptive analysis of health events behavior over time was conducted, using histograms where the following components were evaluated:

Secular trend: identifies the variable variation, evaluating whether it tends to increase or decrease over time [11]. It can be increasing, decreasing, constant, linear, curvilinear [12]. It is used to signal the behavior of respiratory events over time. Least squares regression methods were used, minimizing the error between the number of cases or consultations to estimate a line that fit the actual observed cases or consultations over time.

Cyclical fluctuation: indicates the variations occurring to the increase or decrease in more extended periods of the secular trend line. When the metric is in years, they are variations greater than one year, between 2 and 10 years [12]. to identify repetitive health events behaviors, given that unusual periodic increases could be observed. To measure it we use the method of residuals [11]., starting from the secular trend of each event previously achieved as a trend line and using the time series to find a fraction indicating a cyclical variation.

Seasonal variation: is a repetitive and predictable departure around the trend line in a year. To identify the seasonal variation, intervals are measured in small units and fixed periods such as days, weeks, months, quarters, or years (León-Álvarez et al. 2017b). This component identified when ARI and COPD

presented increases and decreases in reported cases or consultations to predict the behavior in a season and recognize the climatic variables that would explain changes. The measurement was made with the ratio to moving average method [11], obtaining the index describing each event's seasonal variation degree and each climatic variable.

Irregular variation: these are the oscillations of a short-term time series that show an unpredictable or random factor [12] to detect irregular behaviors due to an increase or decrease in the reporting of cases or consultations.

For the bivariate analysis, the values of the median, first and third quartile of the climatic variables of precipitation, average temperature and maximum temperature were defined. It was established in four intervals analyzing comparatively with the seasonal variation index of ARI and COPD behavior, the latter defined as less than or greater than one according to whether the average trend of the behavior of the event was exceeded. Contingency tables were prepared using the Epi Info Version 7.2.4 software. As an exposure factor, the different temperature and precipitation intervals (quartiles) were used and, as an outcome, the measurement number of the seasonal variation index. With the contingency tables, it was calculated the χ^2 and *P*-values.

The municipalities were categorized according to their location according to the height above sea level [15]. The contingency tables analysis was performed for municipalities categorized as cold, cool, and warm climates with different precipitation intervals and temperature intervals and the seasonal variation index.

Ethical considerations

The confidentiality and privacy of personal health records as required by law (Law 1581 of 2012 and Decree 1377 of 2013) were ensured by using de-identified health records. Open de-identified data

available in national information systems were used. Based on the Ministry of Health resolution 8430 of 1993, this research is considered of no risk.

Results

Trend

The first component evaluated in the study municipalities corresponds to the secular trend. It was observed that 28 municipalities (87.5%) of the 32 evaluated for COPD show an increasing trend. For ARI, the trend was also increasing in 18 municipalities (56.3%) and a decreasing trend was observed in 13 municipalities (40.6%) (see table 1).

Table 1. ARI and COPD Trend evaluation. Cundinamarca, Colombia, 2009-2018

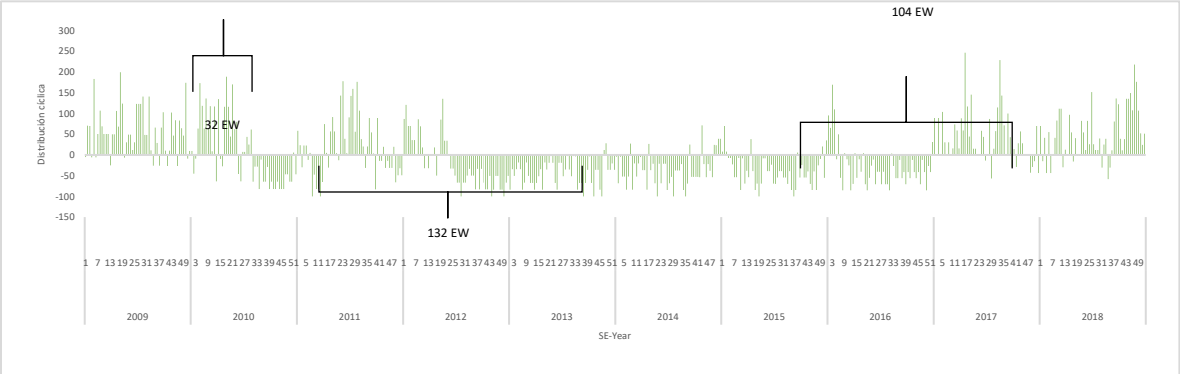
Health Event	Increase (%)	Decrease (%)	Stable (%)	Time Series
COPD	28 (87.5)	1 (3.2)	3 (9.4)	2009 - 2018
ARI	18 (56.3)	13 (40.6)	1 (3.2)	2014 - 2018

Source: IDEAM, SIVIGILA, RIPS-SISPRO

Cyclicity

In cyclicity evaluation, it is observed that COPD presents a cyclical behavior in two municipalities with cycles between one and three years. In Villeta municipality, increased consultations cycles ranging from 32 epidemiological weeks, as happened in 2011, or up to 104 weeks, observed from 2017 to 2018. It presents longer decrease cycles, as happened between 2012 and 2014, when it reached 132 weeks (see figure 2).

Figure *2*. EPOC cyclical residues distribution, Villeta municipality, Cundinamarca, 2009 – 2018



Source: IDEAM, SIVIGILA, RIPS-SISPRO

In the municipality of Facatativá, increasing cycles were observed ranging from 24 weeks being the shortest. And 49 weeks the longest. There were decreasing cycles between 24- and 72-weeks duration.

Regarding acute respiratory infection, cyclicity was identified in 14 municipalities with cycles from six months to two years. Intervals range from 5 to 86 epidemiological weeks when case notification increases and between 5 to 109 weeks when notification decreases; however, intervals change in each municipality (see table 2).

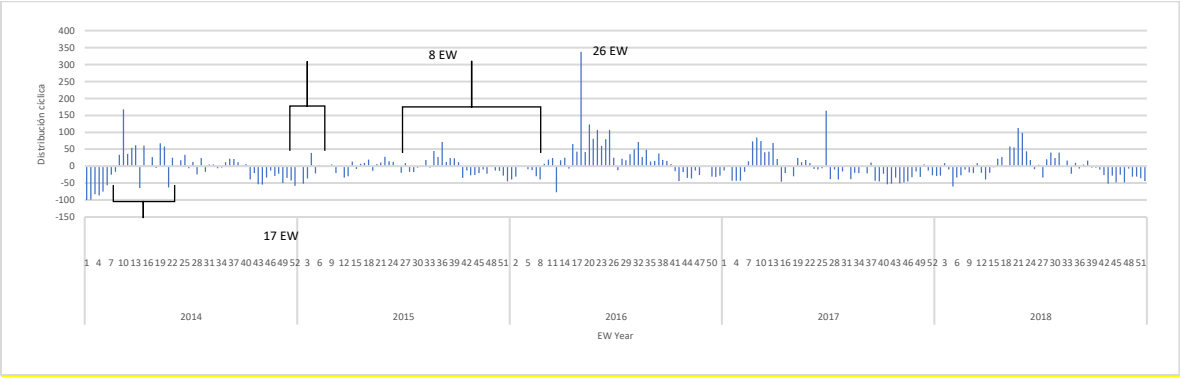
Table 2. Municipalities with cyclical ARI behavior according to case notification by weeks. Cundinamarca, Colombia, 2014-2018

Municipality	Increase		Decrease	
	Shortest Cycle	Longest Cycle	Shortest Cycle	Longest Cycle
Chía	12	46	33	41
Chocontá	8	26	17	36
Facatativá	17	23	12	23
Fusagasugá	17	27	20	43
Girardot	25	51	11	109
Guasca	5	15	5	21
Jerusalén	7	86	8	84
Paratebueno	12	33	22	83
Soacha	10	16	6	40
Suesca	8	29	10	34
Tabio	8	25	10	20
Ubaté	10	17	10	21
Villapinzón	11	31	19	42
Zipaquirá	9	23	9	26
Min	**5**	15	**5**	20
Max	25	**86**	33	**109**

Source: IDEAM, SIVIGILA, RIPS-SISPRO

We describe as an example the ARI cyclicality in Chocontá municipality, in which cycles between 8 and 25 weeks are observed when the cases notification increases, as happened in the periods 2015 and 2016, and cycles of 17 weeks, as happened during 2014 when the notification decreases (see figure 3).

Figure 3. Cyclical residues distribution of ARI in the Chocontá municipality. Cundinamarca, 2014 – 2018



Source: IDEAM, SIVIGILA, RIPS-SISPRO

Seasonal Variation

Chronic Obstructive Pulmonary Disease: when evaluating the seasonal disease behavior and the meteorological variables, it was found in Anolaima municipality that there is a possible relationship between the lowest levels of minimum temperature and the increase in consultations between weeks 25 and 37. During these weeks, the municipality registered temperatures below 14°C, and the consultations number increased by more than 50% according to the expected seasonal threshold.

The maximum temperature presented a possible relationship in the municipalities of Mosquera and Pandi with an increase in consultations when the maximum temperature levels are low. Regarding precipitation, Fusagasugá municipality shows a possible relationship between epidemiological weeks 21 and 39, when precipitation decreases and the number of consultations increases, which matches the period with the higher levels of maximum temperature.

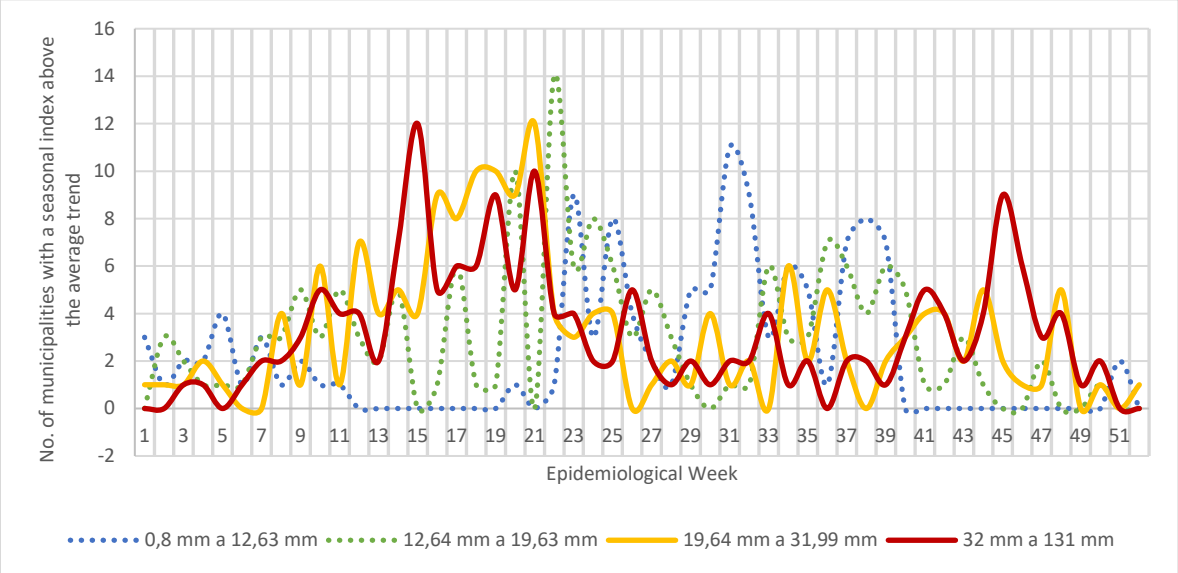
Acute Respiratory Infection: In 16 municipalities we found a clear relation between the minimum temperature and the occurrence of ARI, indicating a direct relation with the temperature levels and the frequency of reported cases of ARI in 11 municipalities with minimum temperature between 4 and 8 °C.

In Fúquene, Girardot, Villapinzón, Fusagasugá and Zipaquirá municipalities, there was an inverse relation: as the minimum temperature decreased, the cases increased and vice versa.

Regarding precipitations, a relation was observed in Choachí, Chocontá, Sopó and Supatá municipalities, where rainfalls and the reported number of cases increased concomitantly; also, as rain precipitation levels decreased, we observed that the number of reported cases of ARI decreased as well.

The median of minimum temperature was 7.9 °C, and the precipitation median was 19.6 mm of rain. The climatic variables grouped from ranges distributed in percentiles showed that when the precipitation is above the median, there is a risk related to the increase in case notification of acute respiratory infection (χ^2 =4.1; P = 0.04) (see figure 4).

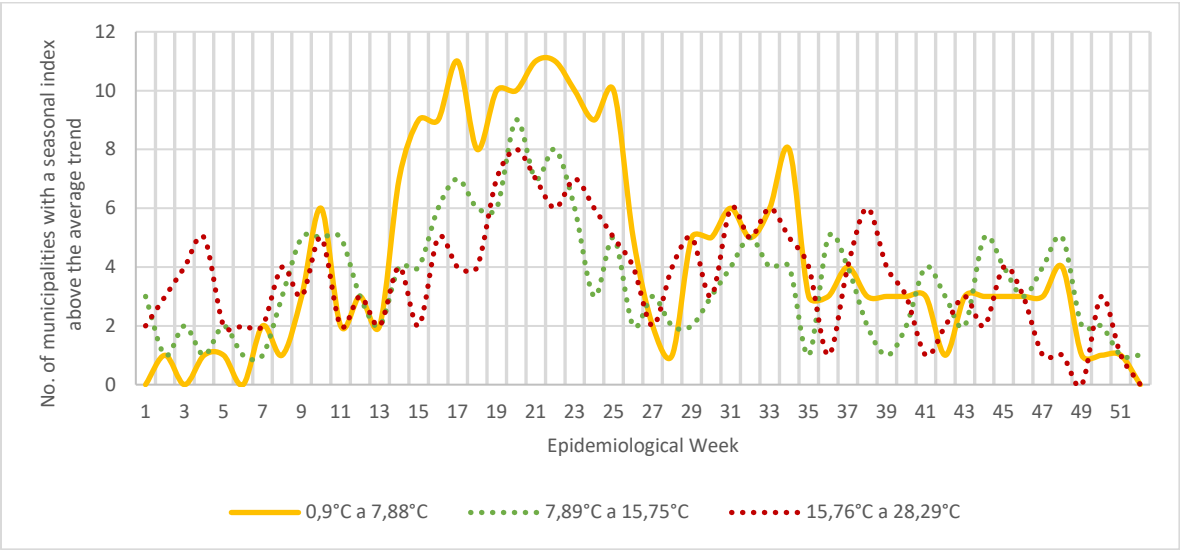
Figure 4. ARI Seasonal Variation Index for Municipalities of Cundinamarca by Precipitation Intervals, 2014-2018



Source: IDEAM, SIVIGILA, RIPS-SISPRO

It was observed that when minimum temperature values are below the median, there is a risk relationship (χ^2 =20.2; P < 0.001) (see figure 5).

Figure 5. ARI Seasonal variation index for municipalities of Cundinamarca by minimum temperature intervals, 2014-2018



Source: IDEAM, SIVIGILA, RIPS-SISPRO

It was found that, in cold weather municipalities, an increase in the occurrence of ARI cases was sustained when precipitation levels were higher than the median values of precipitation (χ^2 = 6.9; P=0.004). We also observed a relation between the occurrence of ARI with minimum temperature, that is it was lower than the median value of temperature (χ^2 =29.6; P<0.001). In cool climate municipalities, the relation between rain precipitation and ARI occurrence was found only for values greater than 32 mm of rain (χ^2=4.112; P= 0.02). For the municipalities with a warm climate, there was no statistically significant relation between the occurrence of ARI and the climate variables (see table 3). The number of COPD visits was related to precipitation and temperature only in cold municipalities, where we observed an increase in consultations for COPD, when precipitation registered values above 32 mm of rain (χ^2= 3.3; P= 0.03) and when the minimum temperature was below the median (χ^2 = 6.9 P=0.004) (see table 3).

Table 3. Seasonal index of respiratory events by precipitation and temperature, Cundinamarca, ARI 2014 – 2018 and COPD 2009-2018

Event	Climate	Precipitation Volume mm	Median mm	Index > 1	index < 1	χ2	*P*-value
ARI	Cold	19.6 – 32.0	19.6	231	293	6.9	0,004
		≠19.6 a 32.0		343	385		
ARI	Cool	32 - 131	19,3	112	104	4.1	0,02
		≠32 - 131		107	145		
COPD	Cold	32 a 131	19,6	27	18	3.3	0,03
		≠32 a 131		290	341		
Event	**Climate**	**Minimum Temperature °C**	**Median °C**	**Index > 1**	**Index < 1**	χ^2	***P*-Value**
ARI	Cold	0.9 – 7.9	7.9	183	128	29.6	<0.001
		≠0.9 – 7.9		250	375		
COPD	Cold	0.9- 7.9	7.9	182	166	6.9	0.004
		≠0.9 – 7.9		279	366		

Source: IDEAM, SIVIGILA, RIPS-SISPRO

Discussion

In this study, an increasing trend was observed in both ARI and COPD events. Similarly, a cyclical behavior was identified for both the reported number of cases of ARI and the number of consultations for COPD, although the length of the cycle varied by municipalities.

Regarding ARI behavior in Cundinamarca, Colombia, cycles of six months to two years were identified, like in other studies in Colombia, which describe an increase in cases of respiratory syncytial virus disease in March, with peaks between April and June corresponding to the Andean region rainy season [16]. ARI impacts health services because of the increase in outpatient consultations and hospitalization

in the winters, mainly during the epidemic peaks every four years as a cyclical behavior of the syncytial respiratory virus [17].

Concerning seasonal variation, we found a statistically significant inverse relation between temperature and the number of reported cases of ARI, and direct relation with the level of precipitation and the number of reported cases of ARI. The relation between these variables and the number of cases of ARI and outpatient and emergency visits for COPD contributes to establish a link between climate variables and events of interest in public health, although not directly with global warming. In one study, the environmental temperature was linked to an increase in acute lower respiratory infections; in cold seasons, viral infections increased, mainly due to respiratory syncytial virus [18]. In another study, a significant association was found between temperature decreases below 10°C and the increase in patients' admissions to hospitals with respiratory disease [19]. In Bogotá, the meteorological variables: humidity and temperature, were related to increased cases of acute respiratory disease [20].

Our findings of an upward trend in COPD in most of the municipalities evaluated is consistent with a nationwide increase reported between 2013 and 2016. The same report showed that the highest number of premature deaths from COPD and asthma occurred in Quindío, Risaralda, Caldas, Tolima, Cundinamarca, Antioquia, Norte de Santander, and Huila [21].

Evidence on the climatic variables' influence on COPD exacerbation is limited; nevertheless, we found a significant increase in consultations for this cause has been identified in cold municipalities and with high precipitation in Cundinamarca. It has been predicted given its association with smoking an increase in the prevalence of COPD in the coming years and its corresponding burden on public health [22].

The data from our study are consistent with studies that establish that cold periods of the year are related to the highest incidence of ARI, concluding possible indications of meteorotropism [23]. The scientific literature supports the notion that climate behavior has effects on health that are predictable,

and hence one can biometeorological forecasts can be of interest to prepare a response of public health services and healthcare services. Alerts would allow timely actions to reduce the impact of extreme weather on morbidity, and mortality. A decrease in ARI morbidity has been observed, mainly in children, with city weather and health alert programs [24, 25]. Forecasts based on climate behavior allow strengthening public health surveillance actions to reduce meteorotropisms at the local level [24]. Studies recommend that preventive measures be reinforced during rainy periods and throughout the year in areas with low temperatures [26].

The main limitations of this research were related to the completeness of the information at its sources, the lack of harmonization of the health data with climate data, especially as they relate to the time intervals. Although we achieved the goal of measurement we aimed, it still opened to debate how to improve the quality of the data and improve the analysis using other sources.

Conclusion

The analysis of this time series of several years made it possible to establish that a strong relation exists between temperature and rainfall precipitation and these two conditions, ARI, and COPD of great public health importance. An upward trend and a cyclical behavior were identified for ARI and COPD in Colombia.

Acknowledgments

We are very thankful to the public health surveillance teams of the municipalities of Cundinamarca for their continuous work in reporting events of interest in public health. To the National Institute of Health for their support in the development of this work, especially to Dr. Franklyn Edwin Prieto Alvarado for reviewing and adjusting the article. We received financial support from the Ministry of Science, Technology and Innovation of Colombia funded this project through open call No. 777-2017 for Science, Technology, and Innovation projects in health 201; in the category of Applied Scientific Research and

Environmental Health thematic line. Project number 210477758410 and National Institute of Health of Colombia, Directorate of Surveillance and Risk Analysis in Public Health.

Declaration of potential conflicts of interests

All authors declare that they have no conflict of interest for the development of the study, nor for the analysis of results nor writing this manuscript.

References

1. Schramm P, Ahmed M, Siegel H,. Donatuto J, Campbell L, Rabb K, *et al.* Climate Change and Health: Local Solutions to Local Challenges, Curr Envir Health Rpt 2020; 7(4): 363–370. http://dx.doi.org/10.1007/s40572-020-00294-1
2. Malagón J, Garrote C, Castilla P. Cambio climático y salud humana: una revisión desde la perspectiva colombiana. Salud Uninorte 2017; 33:224-41. http://dx.doi.org/10.14482/sun.33.2.10551
3. Plan Nacional de Adaptación al Cambio Climático (PNACC), [página de inicio en Internet]. Bogotá. Ministerio de Ambiente 2020. [Citado el 2 de febrero de 2021]. Disponible en: https://www.minambiente.gov.co/index.php/plan-nacional-de-adaptacion-al-cambio-climatico-pnacc/plan-nacional-de-adaptacion-al-cambio-climatico-pnacc
4. Organización Panamericana de la Salud. Lineamientos para evaluar la vulnerabilidad de la salud frente al cambio climático en Colombia. 2011. Disponible en: https://www.paho.org/col/dmdocuments/Lineamientos_vulnerabilidad_climatico.pdf Citado el 5 de mayo de 2021.
5. Cuartas DE, Méndez F. Climate changue and health : challengues for Colombia. Rev Univ Ind Santander, 2016; 48:428–35. http://dx.doi.org/10.18273/revsal.v48n4-2016001
6. Organización Mundial de la Salud. Las 10 principales causas de defunción, en el 2020.

Disponible en: https://www.paho.org/es/noticias/9-12-2020-oms-revela-principales-causas-muerte-discapacidad-mundo-2000-2019 Citado el 5 de mayo de 2021

7. Gil Y, Torres C, Figueredo M, Hernández F, Castañeda Lasalvia P, *et al.* Estimación de la prevalencia de EPOC en Colombia a partir del Registro Individual de Prestaciones de Servicios de Salud (RIPS), Rev Colomb Neumología 2019; 31:5–15. http://dx.doi.org/10.30789/rcneumologia.v31.n1.2019.325
8. Ministerio de Salud y Pretección Social Infecciones respiratorias agudas. https://www.minsalud.gov.co/salud/publica/PET/Paginas/infecciones-respiratorias-agudas-ira.aspx Citado el 15 de marzo de 2021
9. Instituto Nacional de Salud. Informe de evento Infección Respiratoria Aguda 2019. Bogotá. Disponible en: https://www.ins.gov.co/buscador-eventos/Informesdeevento/INFECCIÓN RESPIRATORIA AGUDA_2019.pdf
   Citado el 12 de marzo de 2021
10. Bello D, Martínez S. Una metodología de series de tiempo para el área de la salud; caso práctico, Rev. Fac. Nac. Salud Pública, 2007; 25:117-22.
11. Levin R, Rubin D. Estadística para administración y economía. 7ª. ed. Pearson Educación de México. México.2004.
12. León-Álvarez, A. Betancur J. Jaimes, F. and Grisales H. (2017) 'Ronda clínica y epidemiológica: Series de tiempo interrumpidas', Iatreia, 30: 344–51. http://dx.doi.org/10.17533/udea.iatreia.v30n3a11.
13. Cundinamarca.Gobernacion de Cundinamarca. Análisis de Situación de Salud con el Modelo de los Determinantes Sociales de Salud. 2015 Disponible en: http://www.cundinamarca.gov.co/wcm/connect/07f0fd4e-9af4-4dc6-921a-28bed95a7c17/ASIS+Cundinamarca+2015+WEB.pdf?MOD=AJPERES&CVID=llg82jv Citado el 5 de febrero de 2021

14. IDEAM. Definiciones del Catálogo Nacional de Estaciones 2019. Bogotá]. Disponible en: http://ideam.gov.co/documents/10182/557765/Definiciones+CNE.pdf/25e1cca5-ee47-4eaf-86c0-c4f5192a9937 Citado el 12 de marzo de 2021
15. Ministerio de vivienda. Clasificación del clima en Colombia según la temperatura y la humedad relativa y listado de municipios. 2017. Bogotá. Disponible en: http://ismd.com.co/wp-content/uploads/2017/03/Anexo-No-2-Mapa-de-Clasificaci%C3%B3n-del-Clima-en-Colombia.pdf Citado el 15 de marzo de 2021.
16. Barbosa J, Parra B, Alarcón L, Quiñonez F, Lopez E Franco M. Prevalencia y periodicidad del virus sincitial respiratorio en Colombia. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 2017; 41:435–46. http://dx.doi.org/10.18257/raccefyn.511
17. Grad E, Basso V, Jaquenod M. Programa de infecciones respiratorias agudas en la provincia de Buenos Aires resultados 2019, Rev Argen Salud Pública 2020; 12:7–17.
18. Avendaño L, Cespedes A, Stecher X, Palomino M. Influencia de virus respiratorios, frío y contaminación aérea en la infección respiratoria aguda baja del lactante. Rev. Méd. Chile 1999; 127:1–9. http://dx.doi.org/10.4067/S0034-98871999000900006
19. Makie T, Harada M, Kinukawa N, Toyoshiba H, Yamanaka T, Nakamura T, *et al.*Association of meteorological and day-of-the-week factors with emergency hospital admissions in Fukuoka, Japan', Int J Biometeorol 2002; 46: 38–41. http://dx.doi.org/10.1007/s00484-001-0110-2
20. Correal M, Marthá JE, Sarmiento R. Influencia de la variabilidad climática en las enfermedades respiratorias agudas en Bogotá. Biomedica 2015; 35:130–38. http://dx.doi.org/10.7705/biomedica.v35i0.2456
21. Ministerio de Salud y Protección Social. Ficha técnica para referentes territoriales EPOC. Bogotá.2018.. Disponible en: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/PP/documento-tecnico-dm-epoc-2018.pdf Citado el 15 de marzo de 2021.

22. Salabert Tortoló I, Alfonso Prínce JC, Alfonso Guerra D, Alfonso Salabert I, Toledo Martínez TE, Celestrin Montoro M. La enfermedad pulmonar obstructiva crónica es un problema de salud. Rev.Med.Electrón. 2019; 41(6): 1471-1486. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1684-18242019000601471&lng=es
23. Zeña S, Barceló C. Clima e incidencia de infecciones respiratorias agudas en Ancash, Perú (2005-2013), Rev Cubana Hig Epidemiol. 2014;, 53: 301–13.
24. Bartolome L, Ciomina E, Estrada A, Gomez E. Pronósticos biometeorológicos: vía para reducir la ocurrencia de crisis de salud. Caso Sagua La Grande. Rev Cubana Salud Pública 2008; 34:1. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1684-18242019000601471&lng=es
25. Mason T, Schooling M, Chan K, Tian L .An evaluation of the air quality health index program on respiratory diseases in Hong Kong: An interrupted time series analysis. Atmospheric Environment.2019; 211:151–58. https://doi.org/10.1016/j.atmosenv.2019.05.013
26. Correal ME, Marthá JE, Sarmiento R. Influencia de la variabilidad climática en las enfermedades respiratorias agudas en Bogotá. Biomedica 2015;35(Sup2):130-8. https://revistabiomedica.org/index.php/biomedica/article/view/2456