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CAUSAL AGENTS OF DIARRHEA IN THE CHILD POPULATION DURING CLIMATE CHANGE

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Abstract: Introduction: IntroductionClimate change represents a problem in the health and well-being of human beings, it is established that the effects of climate change on health "threaten to undermine the advances made in public health", this is attributed to waterborne diseases, Since high temperatures can alter the survival, replication and virulence of pathogens, heavy rains can mobilize pathogens and compromise the water and sanitation infrastructure, resulting in acute diarrhea. Objective: Determine the causal agent of diarrhea in the child population during winter periods, by reviewing updated scientific articles that allow us to choose the best treatment for this type of patient. Methodology: Descriptive-narrative bibliographic review study; based on the analysis and interpretation of high-impact scientific articles such as: PubMed, The lancet, Elsevier, Google Scholar. Conclusion: Rotavirus is the most frequent causative agent of diarrhea in children during the winter season.

Keywords: Diarrhea, rain, climate change, microorganism.

INTRODUCTION

Climate change represents a problem in the health and well-being of human beings; and it can even be established that the effects of climate change on health "threaten to undermine the advances achieved in public health and development during the last half century"[1]. This is attributed to waterborne diseases, as high temperatures can disrupt pathogen survival, replication, and virulence, drought can concentrate pathogens in limited water supplies, and heavy rains can mobilize pathogens and compromise water infrastructure. and sanitation resulting in diarrhea [2].

The World Health Organization (WHO) defines diarrhea as bowel movements greater

than 3 times a day with soft or liquid stools, each year resulting in the death of 1.5 million children and 80 to 90% of these cases are related to the environment; diarrhea is more common in underdeveloped countries[2]. During the period 1980-2015, despite the fact that there has been a decrease of approximately 80% in deaths, this left 1.3 million deaths, which positioned it in this year as the 4th cause of death in children under 5 years of age. and the 9th cause of death in all ages, which is why it continues to be a topic of interest for the medical population[3].

Diarrhea is a disease that has several causative agents, so worldwide there has been a need to identify those that predominate in children, taking into consideration that there are enteropathogens that are easy to grow and reproduce in humid temperatures, that is why That is why studies have been carried out where it is established that diarrhea is a consequence of climatic changes[4].

In this article, a systematic review of the literature on the relationship between climate change and diarrhea in children will be carried out, in order to keep us updated on this issue, which is part of the health problem and compromises a high number of children. of pediatric patients in Primary Care[5].

DEVELOPMENT

DIARRHEA: DEFINITION AND EPIDEMIOLOGY

The World Health Organization (WHO) defines diarrhea as bowel movements greater than 3 times a day with soft or liquid stools, classified as acute, persistent, and chronic; Acute diarrhea lasts from seven to fourteen days, persistent diarrhea lasts more than fourteen days but less than twenty-eight days, and finally chronic diarrhea is one that lasts twenty-eight days [2,6,7].

This pathology is responsible for 1.5 million deaths in children worldwide, it is considered the fourth cause of death in children under 5 years of age and the ninth cause of death in all ages, and it is predominant in developing countries[2,3,8,9]. Climate change is a factor that can increase its incidence by altering the epidemiology of the causative agents, which is why the WHO projected that by the year 2050 there will be an annual increase of approximately 50,000 deaths from childhood diarrhea worldwide[10,11].

In 2017, Dr. Ali H Mokdad published a systematic analysis regarding "estimates of morbidity, mortality, and etiologies of diarrheal diseases at the global, regional, and national levels" where he was able to determine that the mortality rate from diarrheal diseases globally was 74,000 per 100,000 in children under 5 years of age and 17,000 per 100,000 inhabitants at all ages. In Ecuador it was 14,000 per 100,000 children under 5 years of age and 3,000 per 100,000 inhabitants of all ages[8,9].

ETIOLOGY AND ROUTES OF TRANSMISIÓN

The etiology of diarrhea is given by microorganisms that can be of bacterial, viral, or parasitic origin, with rotavirus, Cryptosporidium, Shigella, and enterotoxigenic Escherichia being the four most common pathogens in Mexico and Singapore[2,12].

Ecuador is a tropical country in which cases of diarrhea increase in the rainy season. In 2006 and 2014, studies were carried out regarding climate change and the incidence of diarrhea in the province of Esmeraldas, Eloy Alfaro canton, where it is established that the causal agents that prevail in this population are: Escherichia coli, rotavirus and Giardia, each with a different epidemiology. Both pathogenic E. coli and rotavirus are responsible for high mortality and morbidity

in developing countries, while Giardia is more widespread and causes higher infection rates. These microorganisms have in common some routes of transmission which occur through food, water and from person to person[5,13]. This pathology for its development is influenced by biological and environmental factors, that is, by the ability of the pathogen to remain viable in the environment, the capacity of the infectious inoculum, transmission routes, and ineffectiveness of the microorganism, among others. All these factors help us to identify which are the most infectious, Giardia has an ineffective inoculum which only infects 50% of exposed people, while Rotavirus has high dissemination rates, has a long duration of dissemination and is more infectious than E. coli[5,14].

Characteristic	Number of cases of diarrhea(n [%])
Total	33.927 (100,0)
Year old)	
< 5	20.818 (61,4)
≥ 5	13.109 (38,6)
Sex	
Male	16.927 (49,9)
Female	17.000 (50,1)
The race	
Black	10.425 (30,7)
Indigenous	1.726 (5,1)
Mixed race	21.140 (62,3)
White/gold	636 (1.9)

Table 1. Distribution of diarrhea cases by demographic characteristics, Esmeraldas Province, Ecuador, January 8, 2013 to December 31, 2014

Author: Eisenberg et al. 2006

Source: Eisenberg JNS, Cevallos W, Ponce K, et al. Environmental change and infectious disease: How new roads affect the transmission of diarrheal pathogens in rural Ecuador [Homepage on the Internet]. California: 2006; Available from: www.pnas.orgcgi-doi10.1073pnas.0609431104

According to this article, the population most affected by diarrhea are mestizos, females, under 5 years of age, and those least affected are whites, males older than or equal to 5 years of age.

RISK FACTOR'S

During the years 2005-2015, the risk factors for presenting diarrhea did not change, among them we have[8]:

- Climate change
- Non-potable water
- Sanitation

Among children under 5 years of age:

- Emaciation
- Suboptimal breastfeeding
- Vitamin A deficiency
- Zinc deficiency

INFLUENCE OF CLIMATIC CHANGES ON DIARRHEA

One of the risk factors for diarrhea is climate change. The global environment suffers from constant climate change that results in gastrointestinal and tropical diseases (malaria), which are considered the pathologies with the highest mortality worldwide. The WHO establishes more than 3.3 million decreases among the previously mentioned pathologies since their morbidity and mortality are influenced by environmental factors, it also determined that the most affected countries are those in developing countries such as Africa and India[15,16].

Climate change alters the epidemiology, transport and dissemination of pathogens, for example: drought allows the concentration and multiplication of pathogens on all types of surfaces and their dissemination route is by person-to-person contact by not maintaining good hygiene ; while, rain mobilizes microorganisms that live in periods of humidity, causing them to contaminate waterways and food in those communities

with poor water facilities, inadequate sanitation and poor hygiene, generating more cases of diarrhea[11,13,17,18].

In Ecuador, to evaluate the potential impacts on rainfall patterns, during 2013 to 2014 an analysis was carried out of all the medical facilities of the Ministry of Public Health (MSP) in the province of Esmeraldas - Ecuador, in this study it was taken a sample of 33,927 cases of diarrhea in children under 5 years of age, in which it was possible to study the association that exists between diarrhea and heavy rain events after dry periods in urban areas, the result of which was positive, evidencing an increase in 1.35 cases of diarrhea in this population (95%CI)[11].

ROTAVIRUS AS A CAUSATIVE AGENT OF DIARRHEA AFTER THE RAINY SEASON

Rotavirus is the main causative agent of acute-severe diarrhea in children worldwide, to which more than 400,000 deaths per year are attributed, mainly affecting developing countries. It is responsible for 40% of hospitalizations for childhood gastroenteritis and 37% of deaths related to diarrhea in children under 5 years of age[7,15,19].

It is a round virus belonging to the Reoviridae family, which has eleven double-stranded RNA segments, and a viral genome covered by three concentric layers of proteins, classified into seven groups ranging from A to G, where the group A is the one that generates an increase in the number of cases of diarrhea [2,15,19].

The duration time as an acute disease is between 7 to 14 days, its route of transmission is mainly fecal-oral; however, it is also transmitted through food, water and from person to person, the infection mechanism is carried out by the entry of the pathogen into the villous mature enterocytes of the upper small intestine that will result in diarrhea[2,15,19].

It constitutes one of the main causes of greater flow of patients in PHC. In 2019, Spain reports an annual incidence between 15.4 and 19.5 cases per thousand children under five years of age, and 20 cases per thousand children under three years of age[2,7].

This table shows the increase in cases of diarrhea from 1998 to 2014, which varies depending on the geographical area, with the last incidence rate from April to October 2014 being 2.01. cases per 100 children.

According to Levy K, Woster A, Goldstein R et al. In 2016, he conducted a retrospective study in the city of Dhaka - Bangladesh, where he described the two main seasonal patterns of rotavirus[16,19]. ELISA-confirmed rotavirus case records, through the continuous surveillance program at Dhaka Hospital and long-term surveillance of the International Center for Diarrheal Disease Research, Bangladesh (ICDDR,B). 1 sample was taken for every 25 patients who visited the hospital between 1990 and 1995, and for every 50 patients between 1996 and 2011[16,19]. These samples were extrapolated to correct the sampling frequency and produce a consistent time series over time[16,19]. In temperate regions, the incidence tends to peak during the winter months. In the tropics, the incidence shows a less pronounced seasonal variation, with incidence throughout the year and peaks during the summer or autumn after the monsoon rains, so that the infection of the virus can be verified due to climatic changes[16,19].

Chua PNg C Tobias A et al. In 2022, he conducted a systematic review and meta-analysis by searching PubMed, Web of Science, and Scopus for articles published from January 1, 2000 to December 31, 2019, which included studies that quantified the effects of increases in ambient temperature in specific enteric infections of common human pathogens[10,20,21]. Studies that expressed room temperature as a categorical or diurnal

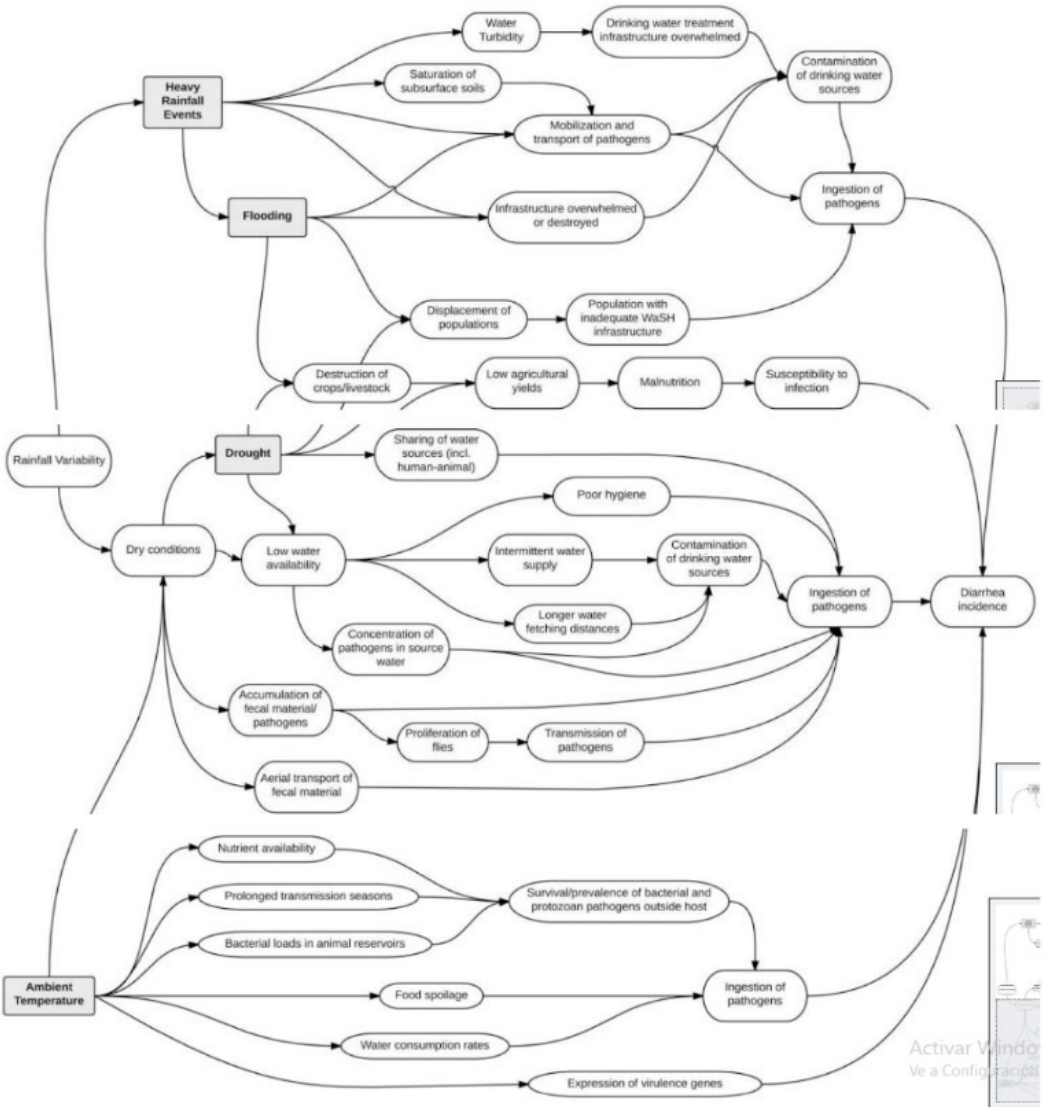

Table 2. Mechanisms of climate change as a risk factor for diarrhea.

Author: Levy et al. 2016

Source: Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the Impacts of Climate Change on Waterborne Diseases: A Systematic Review of Relationships between Diarrheal Diseases and Temperature, Rainfall, Flooding, and Drought [Homepage on the Internet]. Environ Sci Technol. 2016;50(10):4905–4922. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5468171/

Urban/rural situation	Canton (administrative unit)	Number of cases of diarrhea (n[% of total])	Number of parishes(n)	Number of days with 0 cases (n[%])
Urban	-	13.638 (40,2)	-	-
	Atacames	482 (1.4)	1	443 (61,3)
	Eloy Alfaro	822 (2.4)	1	371 (51,3)
	Esmeraldas	6.964 (20,5)	1	162 (22,4)
	Muisne	286 (0,8)	1	570 (78,8)
	Quinindé	2.833 (8,4)	1	114 (15,8)
	Rioverde	1.138 (3,4)	1	270 (37,3)
	San Lorenzo	1.113 (3,3)	1	365 (50,5)
Rural	-	20.289 (59,8)	-	-
	Atacames	1.574 (4,6)	4	271 (37,5)
	Eloy Alfaro	3.981 (11,7)	14	46 (6,4)
	Esmeraldas	3.034 (8,9)	8	172 (23,8)
	Muisne	2.612 (7,7)	8	135 (18,7)
	Quinindé	5.484 (16,2)	5	72 (10,0)
	Rioverde	1.957 (5,8)	5	195 (27,0)
	San Lorenzo	1.647 (4,9)	12	224 (31,0)

Table 3. Cases of diarrhea in urban vs. rural population in Esmeraldas / Ecuador 2013-2014

Author: Deshpande A et al.2020.

Source: Deshpande A, Chang HH, Levy K. Heavy Rainfall Events and Diarrheal Diseases: The Role of Urban–Rural Geography. American Journal of Tropical Medicine and Hygiene [homepage on the Internet] 2020;103(3):1043–1049. Available from: https://pubmed.ncbi.nlm.nih.gov/32700663/

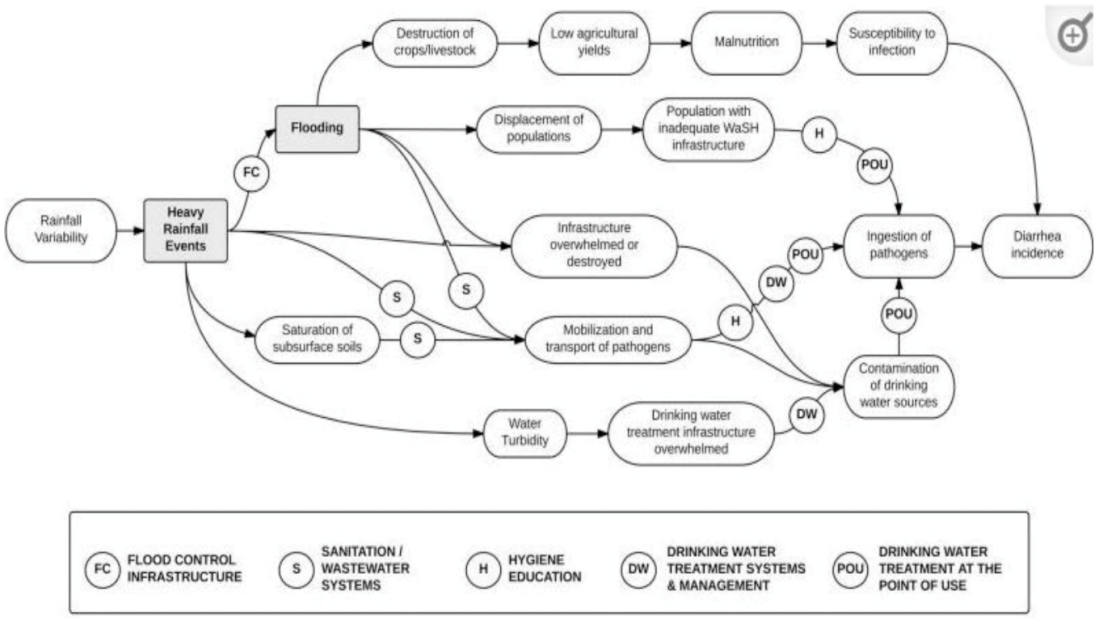

Table 5. Solution of predisposing factors for diarrhea due to rain.

Author: Levy et al. 2016

Source: Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the Impacts of Climate Change on Waterborne Diseases: A Systematic Review of Relationships between Diarrheal Diseases and Temperature, Rainfall, Flooding, and Drought [Homepage on the Internet]. Environ Sci Technol. 2016 50(10):4905–4922. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5468171/

Study	Geographical area (evaluated period)	Study population	Methodology	Results
Gerstel, 2009[3]	Aragón(1998-2006	General population N = 1,044,888 cases of diarrhea; 89% in <5 years	Retrospective, passive surveillance of diarrhea notifications to the Aragon syndromic surveillance system and notifications to microbiology laboratories	RV+: 17.1% (90.2% of positive diagnoses due to viruses). Increase in the average number of samples positive for RV from 22 to 47/100,000
Díez-Domingo, 2006[4]	Valencia (December 2003-November 2004)	Children <5 years. N= 553 AGE cases	Prospective in 13 pediatric consultations. Active search for VR cases among children who attend GEA consultations. Detection of RV in feces by EIA (rotaclone) and genotyping by PCR	inhabitants-year RV+: 15.0%. Annual incidence: 15.4% cases/1000 children <5 years) (31 per 1000 children <1 year) 80% of cases between January and March
Díez-Domingo, 2011[5]	Six European countries, including Spain (Valencia) November 2005-May 2007	Children <5 years. N= 2,088 cases of AGE in Spain	Prospective in pediatric consultations of 9 health centers. Active identification of VR cases among the AGE cases that come to the consultations. Detection of RV in feces by immunochromatography (RotaStrip), and confirmation and genotyping by PCR	VR+: 12.8% Confirmed with PCR: 11.5%. Annual incidence with PCR+: 19.5% cases/1000 children-year (38.0 per 1000 person-years in children <1 year)
Arístegui, 2016[6]	Catalonia, the Basque Country and Andalusia (October-April 2014)	Children <3 years. N= 1,087 AGE cases	Prospective study in 64 pediatric consultations and 2 hospital emergency departments. Active identification of VR cases among the AGE cases that come to the consultations. Direction of RV in feces by immunochromatography (Vikia Rota-"Adeno	**VR+: 33.9%. Incidence rate during the 5 months: 2.01 cases/100 children (73% of the cases in children 6-324 months of age)**

EIA: enzyme immunoassay; PCR: polymerase chain reaction; RV+: proportion of AGE cases with a positive result to the rotavirus detection test.

Table 4. Burden of rotavirus disease in Primary Care in Spain.

Author: Díez-Domingo J et al. 2019

Source: Díez-Domingo J, Garcés-Sánchez M, Giménez-Sánchez F, Colomina-Rodríguez J, Martinón-Torres F. What have we learned about rotavirus in Spain in the last 10 years? Pediatry (Engl Ed) [homepage on the Internet] 2019;91(3):166–179. Available from: https://reader.elsevier.com/reader/sd/pii/S1695403319300761?-token=3E55108E9F7192B852ECD04D45FDFD681D878CFF9F622250A50B2B1CD181AA8739F661B3B-1506D71ABE6280CFD842F85&originRegion=us-east-1&originCreation=20220923171042

range, or in a standardized format were excluded[10,20,21]. This study established that the sensitivity to temperature of enteric infections can vary depending on the pathogen that causes the infection. In this case, rotavirus is considered the main microorganism that develops diarrhea in children under 5 years of age during periods of humidity and rain, even if determined its presence after 30 days in river and tap water, in soils, vegetables, porous and non-porous inanimate surfaces, surviving both at room temperature and at low temperatures, that is, those above 4°C, especially in above 20°C, while it becomes ineffective at temperatures below 4°C[10,20,21]. In addition, human rotavirus particles in feces have been found to remain infectious at temperatures around 30°C for more than 2 months[10,20,21].

For this reason, to reduce cases of rotavirus diarrhea, action must be taken on the predisposing factors for the development of the disease. Thanks to the creation of the vaccine in 1998 and technological advances to

reduce the side effects of its use, it was possible to create a safe vaccine, which is why the WHO implemented it in the vaccination scheme in 2009, managing to reduce the rate. mortality by 50%[7]. In 2016, around 28,000 deaths in young children were prevented. Other studies have shown that rotavirus vaccination changes or decreases the seasonality of rotavirus infections and that the association between weather factors and rotavirus infections varies between settings with and without ongoing rotavirus vaccination[7,11,12].

Thus, understanding the mechanisms involved in exposure-response relationships to disease can provide information on where to intervene to prevent the transmission of waterborne pathogens, both under current conditions and under future climate scenarios[16].

In these cases the effects of these events can be diminished by preventing the contamination of water systems, controlling the occurrence of floods ("Flood Control Infrastructure"), or by reducing the presence of pathogens in the environment available for development. transport via proper fecal disposal ("Sanitation/Wastewater Systems"). Should contamination of the environment and/or drinking water sources occur, prevention of human ingestion of pathogens may occur through from efforts to improve hygiene ("Hygiene Education") and/or by treating drinking water in the home ("Point-of-Use Drinking Water Treatment")[1,13,16,20].

In 2014, Eisenberg J conducted a study in which water treatment through filtration, boiling, or chlorination modified the relationship between heavy rain events and the incidence of diarrhea (P = 0.0036)[13].

- When rainfall during the previous 8 weeks was low and community water treatment was high, the association between heavy rain events and diarrhea incidence decreased[13].
- Similarly, when rainfall during the previous 8 weeks was moderate or high and community water treatment was high, heavy rain events were associated with a lower incidence of diarrhea[13].

Sanitation, hygiene, and social cohesion did not change the relationship between heavy rain events and diarrhea incidence (P=0.1216, P=0.0848, and P=0.3607, respectively)[13].

CONCLUSION

Climate change is considered a risk factor that triggers diarrhea, especially in developing countries, since during rainy periods (winter), contagion and contamination of the individual by microorganisms is favored, mainly rotavirus because this It develops in periods of humidity and can remain after 30 days in river water as well as in tap water, in soils, vegetables, inanimate porous and non-porous surfaces, the population not having a good wastewater sanitation system, good hygiene or a good flood control infrastructure ingests it and begins its replication process in the mature villous enterocytes of the upper small intestine.

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