Journal of Epidemiology and Global Health (2025) 15:121
https://doi.org/10.1007/s44197-025-00460-4

RESEARCH

Diarrhea-Related Mortality in Latin American and Caribbean Countries from 2000 through 2019

Raquel Gutierrez Adrianzen[1] · Carlos Quispe-Vicuña[1] · Wagner Rios-Garcia[1] · Juan Ramon-Canepa[2] · Lita del Rio-Muñiz[3] · Jorge Ybaseta-Medina[2] · Julio A Poterico[4] · J. Smith Torres-Roman[5]

Received: 26 June 2025 / Accepted: 27 August 2025

Abstract

Background Diarrhea remains a major cause of preventable mortality in Latin American and Caribbean (LAC) countries, particularly among children and vulnerable populations. However, there are no studies showing the changes that have occurred in recent years in developing countries. Our objective was to determine the evolution of diarrhea mortality rates in LAC countries between 2000 and 2019.

Methods An ecological observational time series study was conducted using only countries with complete population-based data in the World Health Organization mortality database between 2000 and 2019 with diarrhea mortality. Analyses were performed using Joinpoint Regression software to calculate mortality trends and annual percentage change by sex and by country. A mortality rates analysis of the last 5 years of the study period was performed to assess the countries with the highest rates.

Results Between 2000 and 2019, most Latin American and Caribbean countries experienced a significant decline in diarrhea-related mortality across all age groups and sexes. The largest reductions were observed in Ecuador, Costa Rica, and El Salvador. In children aged 0–14 years, thirteen countries showed significant decreases, notably Ecuador, Venezuela, and Colombia. Moreover, in the most recent five-year period (2015–2019), the highest age-standardized mortality rates (ASMRs) were observed in Guatemala (11.14 per 100,000 in males; 5.97 in females) and Guyana (5.82 in males; 4.30 in females), while the lowest ASMRs were recorded in Chile (0.29 in males; 0.28 in females) and Argentina (0.36 in males; 0.33 in females).

Conclusion In the two decades from 2000 to 2019, diarrhea-related mortality rates declined in Latin American and Caribbean countries, largely due to public health interventions and policies.

Keywords Diarrhea · Gastroenteritis · Latin america · Mortality · Trends

1 Introduction

Diarrhea is a digestive disorder resulting, in most cases, from infectious processes that has a major impact on health worldwide, especially in developing countries [1]. It mainly affects children, and is a major cause of stunting, malnutrition and impaired cognitive development [2]. In 2019, diarrhea was the fifth leading cause of death globally, and the second leading cause of death in children under 5 years of age and in children aged 5–9 years [3, 4]. According to World Health Organization (WHO), diarrhea is responsible for approximately 525,000 deaths in children each year and is among the top ten leading causes of death worldwide [1, 5].

✉ J. Smith Torres-Roman
jstorresroman@gmail.com

1 Latin American Network for Cancer Research (LAN–CANCER), Lima, Peru

2 Universidad Nacional San Luis Gonzaga, Ica, Peru

3 Unidad de Epidemiología, Hospital San José de Chincha, Ica, Peru

4 Universidad de Huanuco, Huanuco, Peru

5 Universidad Cientifica del Sur, Lima, Peru

Published online: 20 October 2025

Although diarrhea is usually a temporary and self-limiting condition, it can lead to complications, especially in vulnerable populations such as infants, young children, the elderly and people with weakened immune systems. Its main complication is dehydration, which, if not treated promptly, can be life-threatening [6]. On the other hand, thanks to the implementation of oral rehydration schemes and universal vaccination against rotavirus, child mortality from diarrhea has significantly decreased over time [6]. Despite this progress, diarrhea remains an important cause of morbidity and mortality and remains an issue of concern in developing countries, where limited access to safe water, sanitation facilities and health services can exacerbate the impact of diarrheal diseases, accounting for 829 000 deaths annually worldwide [7].

Knowledge of the epidemiology of this disease is important; however, Latin America and Caribbean (LAC) countries have not reported updates on the evolution of mortality by diarrhea in recent years. Therefore, the objective of this study was to determine the evolution of diarrhea mortality rates in LAC countries between 2000 and 2019. Moreover, we also evaluated the changes that have occurred in recent years in children from 0 to 14 years of age.

2 Materials and Methods

2.1 Data Source

The WHO mortality database, which is available in open access through the following link: https://www.who.int/data/data-collection-tools/who-mortality-database was used. Mortality data for the period 2000 to 2019 were used in LAC countries, with prior preparation and quality analysis of the data. Deaths due to diarrheal diseases were identified with code A09 according to the International Classification of Diseases 10th revision (ICD-10) [8]. Given that in the original database the age variable is numerically determined, a categorization was made according to the previously established categories by age group and calendar year. In addition, an interval of 0 to 14 years was established to explore mortality in this group.

This study only included data from countries that reported data duly coded according to the ICD-10 and countries providing consistent information enough to be able to perform the analysis in the software. Data were available for the following LAC countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago. Uruguay and Venezuela. Of these 20 countries, only 15 were used in the analysis for the age range 0–14 years. Mortality rates were also analyzed by age group and calendar year. Population estimates for each country were obtained from World Population Prospects 2022 [9].

2.2 Statistical Analysis

Age-standardized mortality rates (ASMR) per 100,000 person-years were estimated by the direct method using the SEGI global standard population. We analyzed diarrhea mortality trends for all age groups and for the interval 0 to 14 years,15 to 29 years, 30 to 44 years, ≥45 years. Analysis was performed to calculate age-specific mortality trends using Joinpoint regression software version 5.0 (National Cancer Institute, Bethesda, Maryland, USA) [10]. In the tie point analysis, the program selects the best-standing points where the rate changes significantly. The process starts with the minimum number of tie points (zero, which is a straight line) and checks whether one or more tie points (up to three) are significant and should be included in the model. Each significant tie point that indicates a change in slope is retained in the final model.

Ten tie points with annual results were identified and the annual percentage change was estimated with the average annual percentage change and their corresponding 95% confidence intervals (95%CI) for each country. The annual percentage changes were considered statistically significant at a p value < 0.05. Each significant join point indicating a change in slope (if any) is retained in the final model. Mortality trend analyses could not be performed for countries with low death counts in a given year. The significance levels used are based on the Monte Carlo permutation method, using the logarithm of the ratio [11].

3 Results

In the 20 countries included in this analysis, men had higher ASMRs for diarrhea than women. To highlight a more current picture, ASMRs over the past 5 years (2015–2019) were described, finding that for males the highest ASMRs were in Guatemala (11.14), Guyana (5.82) and Nicaragua (2.66) while the lowest ASMRs were in Cuba (0.37), Argentina (0.36) and Chile (0.29). For females, the highest ASMRs were in Guatemala (5.97), Guyana (4.30) and Suriname (2.38) while the lowest mortality rates were in Ecuador (0.39), Argentina (0.33) and Chile (0.28) (Fig. 1).

For males of all ages between 2000 and 2019, 19 countries reported significant decreases in diarrhea mortality, the most notable countries being Ecuador (-15.8%), Costa Rica (-12.9%), El Salvador (-11.0%) and Colombia (-10.6%). There were also significant percentage changes between the study periods. Of these, Ecuador showed a decrease

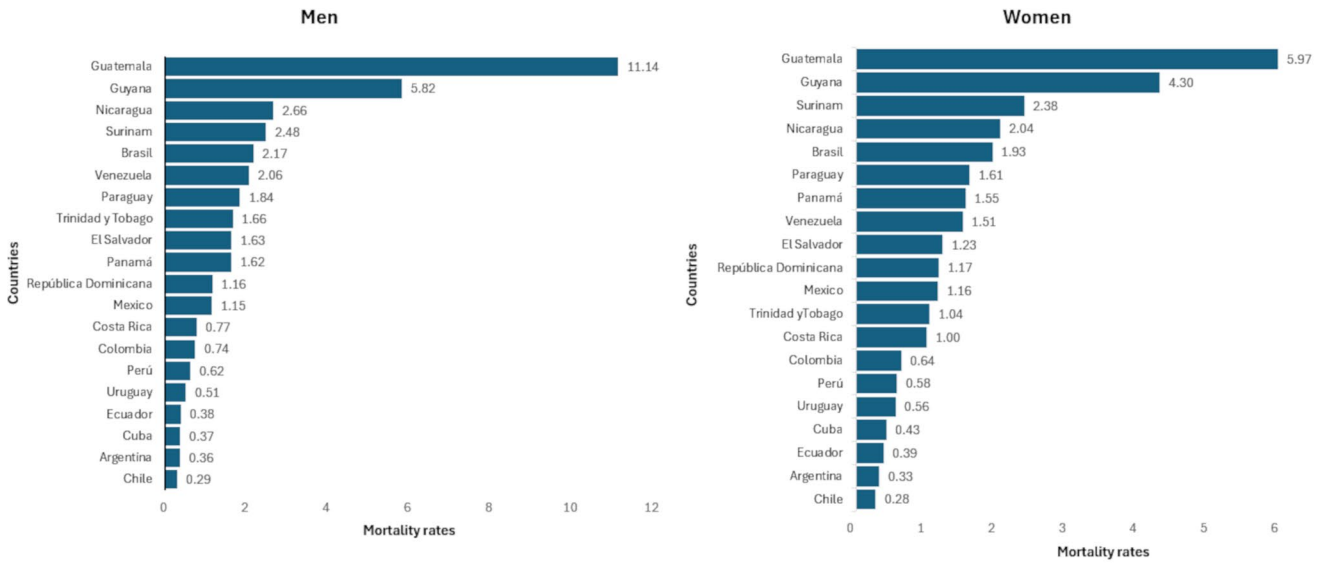

Fig. 1 Average standardized mortality rates due to diarrhea for the last 5 years (2015–2019) in men and women in Latin America and the Caribbean of all ages

*Data up to 2009 for Costa Rica and Trinidad and Tobago, up to 2016 for Brazil, Dominican Republic, Guyana, Nicaragua and Venezuela

Table 1 Average age-standardized diarrhea mortality rates (Segi world standard population) per 100 000 in men of all ages in Latin America and the caribbean, 2000–2019

Country	Age-standardized mortality rate per 100 000		Trend 1	APC 1	Trend 2	APC 2	AAPC (95% CI)
	2000[a]	2019[b]					
Argentina	1.16	0.22	2000–2019	-6.4*(-8.1,-4.8)			-6.4*(-8.1,-4.8)
Brasil	4.18	2.06	2000–2016	-5.0*(-5.8,-4.3)			-5.0*(-5.8, -4.3)
Chile	1.54	0.18	2000–2019	-7.1*(-9.6,-4.5)			-7.1*(-9.6, -4.5)
Colombia	5.05	0.86	2000–2019	-10.6*(-12.2,-9.1)			-10.6*(-12.2,-9.1)
Costa Rica	2.83	1.00	2000–2009	-12.9*(-17.9,-7.6)			-12.9*(-17.9,-7.6)
Cuba	1.42	0.42	2001–2019	-7.5*(-9.5,-5.4)			-7.5*(-9.5,-5.4)
Ecuador	5.82	0.28	2000–2011	-10.6*(-12.4,-8.7)	2011–2019	-22.5*(-28.2,-16.4)	-15.8*(-18.4,-13.1)
El Salvador	10.08	0.84	2000–2018	-11.0*(-12.6,-9.4)			-11.0*(-12.6,-9.4)
Guatemala	33.16	2.61	2005–2019	-8.8*(-14.1,-3.2)			-8.8*(-14.1,-3.2)
Guyana	19.15	3.65	2001–2016	-7.0*(-9.7,-4.3)			-7.0*(-9.7,-4.3)
Mexico	5.27	0.90	2000–2013	-6.2*(-7.2,-5.3)	2013–2019	-16.3*(-20.4,-11.9)	-9.5*(-11.0,-8.1)
Nicaragua	7.31	2.36	2000–2016	-7.5*(-9.2,-5.8)			-7.5*(-9.2,-5.8)
Panama	4.06	0.45	2000–2012	4.7(-0.4,9.9)	2012–2019	-23.9*(-35.2,-10.6)	-6.9*(-12.5,-1.0)
Paraguay	7.42	1.48	2000–2016	-8.8*(-10.5,-7.0)			-8.8*(-10.5,-7.0)
Perú	3.53	0.54	2000–2019	-6.5*(-9.8,-3.2)			-6.5*(-9.8,-3.2)
Dominican Republic	3.38	0.75	2000–2016	-7.4*(-10.2,-4.5)			-7.4*(-10.2,-4.5)
Surinam	13.00	0.96	2000–2014	-9.1*(-15.4,-2.3)			-9.1*(-15.4,-2.3)
Uruguay	1.94	0.09	2000–2019	-3.5(-6.9,0.0)			-3.5(-6.9,0.0)
Venezuela	9.07	4.03	2000–2016	-10.0*(-13.1,-6.7)			-10.0*(-13.1,-6.7)
Trinidad and Tobago	3.91	1.04	2000–2009	-9.7*(-17.5,-1.1)			-9.7*(-17.5,-1.1)

APC: Annual Percentage Change. AAPC: Average annual percentage change. CI: confidence interval

a: 2001 data for Cuba and Guyana, 2005 for Guatemala

b: 2016 data for Brazil, Nicaragua, Paraguay, Uruguay, Venezuela, Guyana and Dominican Republic, 2009 for Costa Rica and Trinidad and Tobago, 2018 for El Salvador, 2014 for Suriname

* Significantly different from 0 ($p<0.05$)

between 2000 and 2011 by 10.6% annually, after which between 2011 and 2019 it decreased by 22.5%. Between 2013 and 2019, Mexico decreased by 16.3% and between 2012 and 2019, Panama decreased by 23.9% (Table 1).

For women of all ages between 2000 and 2019, 18 countries reported significant decreases in diarrhea mortality. The most notable countries were Ecuador (-15.6%), Colombia (-10.7%) and El Salvador (-10.6%). There were also significant percentage changes in countries such as Ecuador, which during 2010 to 2019 decreased by 21.3%; Mexico during 2012 to 2019 decreased by 14.3%; and Panama during 2011 to 2019 decreased by 17.6% (Table 2).

For boys aged 0–14 years between 2000 and 2019, all 15 countries included for this analysis reported significant decreases in diarrhea mortality. The countries with the largest rates of decline were Costa Rica (-15.9%), Ecuador (-14.8%), Venezuela (-14.1%), and Colombia (-12.5%). Panama also showed a significant decrease between 2012 and 2019 (-26.3%) (Table 3).

For girls aged 0–14 years between 2000 and 2019, 13 countries reported significant decreases in diarrhea mortality. The most notable countries were Ecuador (-14.8%), Venezuela (-13.9%), Colombia (-13.4%), and Paraguay (-11.7%) (Table 4).

4 Discussion

We found that in 20 Latin American and Caribbean countries, diarrhea-related mortality declined overall from 2000 to 2019. The most notable reductions were observed in Ecuador, Costa Rica, and El Salvador, whereas countries such as Guatemala, Guyana, and Nicaragua recorded the highest mortality rates in the most recent five-year period. For instance, in Guatemala, approximately 11 out of every 100,000 males died due to diarrhea-related causes during 2015–2019, in contrast to less than 1 in 100,000 in Chile and Argentina.

Our findings on the decline in diarrhea-related mortality across all age groups, including children aged 0–14 years, align with trends observed in other middle- and low-income

Table 2 Average age-standardized diarrhea mortality rates (Segi world standard population) per 100 000 in women of all ages in Latin America and the caribbean, 2000–2019

Country	Age-standardized mortality rate per 100 000		Trend 1	APC 1	Trend 2	APC 2	Trend 3	APC 3	AAPC (95% CI)
	2000[a]	2019[b]							
Argentina	0.90	0.19	2000–2019	-5.0*(-7.1,-2.8)					-5.0*(-7.1,-2.8)
Brazil	3.64	1.86	2000–2016	-4.6*(-5.3,-4.0)					-4.6*(-5.3,-4.0)
Chile	1.28	0.18	2000–2019	-7.7*(-10.0,-5.3)					-7.7*(-10.0,-5.3)
Colombia	4.34	0.68	2000–2019	-10.7*(-12.2,-9.0)					-10.7*(-12.2,-9.0)
Costa Rica	2.59	1.22	2000–2009	-9.8*(-14.0,-5.3)					-9.8*(-14.0,-5.3)
Cuba	1.08	0.61	2001–2019	-5.9*(-8.4,-3.2)					-5.9*(-8.4,-3.2)
Ecuador	5.55	0.23	2000–2005	-16.3*(-19.7,-12.7)	2005–2010	-3.4(-10.3,4.0)	2010–2019	-21.3*(-24.4,-18.1)	-15.6*(-17.8,-13.3)
El Salvador	6.61	0.57	2000−2018	-10.6*(-11.8,-9.4)					-10.6*(-11.8,-9.4)
Guatemala	26.73	1.92	2005–2019	-9.5*(-13.4,-5.5)					-9.5*(-13.4,-5.5)
Guyana	11.95	2.14	2001–2016	-7.6*(-10.2,-4.8)					-7.6*(-10.2,-4.8)
Mexico	4.91	0.94	2000–2012	-5.4*(-6.9,-3.9)	2012–2019	-14.3*(-18.5,-9.9)			-8.8*(-10.5,-7.0)
Nicaragua	6.15	2.22	2000–2016	-8.0*(-9.2,-6.7)					-8.0*(-9.2,-6.7)
Panama	4.03	0.16	2000–2011	4.9(-1.7,12.0)	2011–2019	-17.6*(-29.2,-4.1)			-5.2(-11.5,1.5)
Paraguay	6.86	1.58	2000–2016	-8.5*(-10.4,-6.5)					-8.5*(-10.4,-6.5)
Peru	3.31	0.54	2000–2019	-7.1*(-10.1,-3.9)					-7.1*(-10.1,-3.9)
República Dominicana	2.84	0.96	2000–2016	-6.7*(-9.3,-4.1)					-6.7*(-9.3,-4.1)
Suriname	12.06	1.09	2000–2014	-9.8*(-15.6,-3.7)					-9.8*(-15.6,-3.7)
Uruguay	1.84	0.04	2000–2019	-1.0(-5.3,3.5)					-1.0(-5.3,3.5)
Venezuela	6.68	2.58	2000–2016	-10.5*(-13.5,-7.5)					-10.5*(-13.5,-7.5)
Trinidad	1.44	0.98	2000–2009	-7.9(-15.3,0.1)					-7.9(-15.3,0.1)

APC: Annual Percentage Change. AAPC: Average annual percentage change. CI: confidence interval

a: 2001 data for Cuba and Guyana, 2005 for Guatemala

b: 2016 data for Brazil, Nicaragua, Paraguay, Uruguay, Venezuela, Guyana and Dominican Republic, 2009 for Costa Rica and Trinidad and Tobago, 2018 for El Salvador, 2014 for Suriname

* Significantly different from 0 ($p<0.05$)

Table 3 Average age-standardized diarrhea mortality rates (Segi world standard population) per 100 000 in children aged 0–14 years in Latin America and the caribbean, 2000–2019

Country	Age-standardized mortality rate per 100 000		Trend 1	APC 1	Trend 2	APC 2	AAPC (95% CI)
	2000[a]	2019[b]					
Argentina	2.51	0.04	2000–2019	-10.9*(-12.2,-8.8)			-10.9*(-12.2,-8.8)
Brasil	7.99	1.87	2000–2016	-9.7*(-10.6,-8.8)			-9.7*(-10.6,-8.8)
Colombia	9.55	0.89	2000–2019	-12.5*(-14.3,-10.8)			-12.5*(-14.3,-10.8)
Costa Rica	3.17	0.78	2000–2009	-15.9*(-20.2,-11.4)			-15.9*(-20.2,-11.4)
Ecuador	12.57	0.20	2000–2019	-14.8*(-16.5,-13.2)			-14.8*(-16.5,-13.2)
El Salvador	14.56	0.42	2000–2018	-11.7*(-14.2,-9.2)			-11.7*(-14.2,-9.2)
Guatemala	48.61	3.32	2005–2019	-10.6*(-14.1, -6.9)			-10.6*(-14.1, -6.9)
Guyana	28.28	3.72	2001–2016	-7.3*(-10.5,-4.0)			-7.3*(-10.5,-4.0)
México	8.91	0.79	2000–2019	-10.0*(-11.4,-8.6)			-10.0*(-11.4,-8.6)
Nicaragua	15.00	5.51	2000–2016	-7.4*(-9.1,-5.7)			-7.4*(-9.1,-5.7)
Panamá	6.79	0.58	2000–2012	-4.1(-0.9,9.3)	2012–2019	-26.3*(-39.2,-10.8)	-8.4*(-14.6,-1.7)
Paraguay	13.95	1.38	2000–2016	-11.9*(-13.8,-9.9)			-11.9*(-13.8,-9.9)
Perú	5.05	0.75	2000–2019	-6.9*(-9.7,-3.9)			-6.9*(-9.7,-3.9)
República Dominicana	6.74	1.29	2000–2016	-8.2*(-11.6,-4.8)			-8.2*(-11.6,-4.8)
Venezuela	18.49	3.21	2000–2016	-14.1*(-17.2,-10.9)			-14.1*(-17.2,-10.9)

APC: Annual Percentage Change. AAPC: Average annual percentage change. CI: confidence interval

a: 2001 data for Guyana, 2005 for Guatemala

b: 2016 data for Brazil, Nicaragua, Paraguay, Venezuela, Guyana and Dominican Republic, 2009 for Costa Rica, 2018 for El Salvador

* Significantly different from 0 ($p<0.05$)

Table 4 Average age-standardized diarrhea mortality rates (Segi world standard population) per 100 000 in girls aged 0–14 years in Latin America and the caribbean, 2000–2019

Country	Age-standardized mortality rate per 100 000		Trend 1	APC 1	AAPC (95% CI)
	2000[a]	2019[b]			
Argentina	1.73	0.04	2000–2019	-7.5*(-9.9,-5.0)	-7.5*(-9.9,-5.0)
Brasil	6.80	1.52	2000–2016	-9.6*(-10.7,-8.5)	-9.6*(-10.7,-8.5)
Colombia	8.72	0.58	2000–2019	-13.4*(-15.2,-11.6)	-13.4*(-15.2,-11.6)
Costa Rica	1.96	1.01	2000–2009	-9.5(18.8, -0.8)	-9.5(18.8, -0.8)
Ecuador	12.92	0.54	2000–2019	-14.8*(-16.2,-13.4)	-14.8*(-16.2,-13.4)
El Salvador	11.54	0.44	2000–2019	-11.4*(-13.8,-9.0)	-11.4*(-13.8,-9.0)
Guatemala	43.47	2.48	2005–2019	-10.6*(-14.3,-6.8)	-10.6*(-14.3,-6.8)
Guyana	18.42	1.81	2001–2016	-9.6*(-14.4,-4.5)	-9.6*(-14.4,-4.5)
México	7.62	0.73	2000–2019	-9.9*(-11.3,-8.6)	-9.9*(-11.3,-8.6)
Nicaragua	14.25	4.36	2000–2016	-9.4*(-11.1,-7.6)	-9.4*(-11.1,-7.6)
Panamá	8.53	2.44	2000–2018	-1.8(-5.7,2.4)	-1.8(-5.7,2.4)
Paraguay	13.60	2.95	2000–2016	-11.7*(-13.2,-10.2)	-11.7*(-13.2,-10.2)
Perú	4.86	0.37	2000–2019	-8.2*(-10.9,-5.4)	-8.2*(-10.9,-5.4)
República Dominicana	5.85	1.80	2000–2016	-7.4*(-10.4,-4.3)	-7.4*(-10.4,-4.3)
Venezuela	14.12	2.74	2000–2016	-13.9*(-17.2,-10.4)	-13.9*(-17.2,-10.4)

APC: Annual Percentage Change. AAPC: Average annual percentage change. CI: confidence interval

a: 2001 data for Guyana, 2005 for Guatemala

b: 2016 data for Brazil, Nicaragua, Paraguay, Venezuela, Guyana and Dominican Republic, 2009 for Costa Rica, 2018 for El Salvador and Panama

* Significantly different from 0 ($p<0.05$)

countries. For example, in India, a consistent decrease in diarrhea mortality was reported across all age groups between 1990 and 2019 [12]. Compared to the Indian study, the mortality rates observed in our analysis were lower, with diarrhea-related mortality reaching approximately 45 deaths per 100,000 population across both sexes. Notably, the Indian study reported higher mortality among older adults and women [12]. In our study, while no substantial sex-specific differences in mortality rates were identified, the rate of decline was generally lower among females than males in most countries.

Similarly, between 2000 and 2015, Reiner et al. reported a decrease mortality rates among children under 5 years of age in most African countries [13]. These decreases are likely attributable to improvements in child nutrition and expanded use of oral rehydration therapy [13]. Nevertheless, despite downward trends in Asia and Africa, a study covering the years 2000 to 2017 found that these regions continued to exhibit the highest mortality rates from diarrhea among children under five—likely a result of persistent socioeconomic and cultural inequalities [14]. In contrast, high-income countries present a different scenario. For example, in 2017, regions such as Europe and North America showed mortality rates of less than 5 per 100 000, and less than 1 per 100,000 in Oceania [15]. The stark differences between countries in our study and those in more developed regions are likely attributable to disparities in socioeconomic conditions, access to healthcare services, infrastructure quality, and sanitation practices.

In LAC countries, access to health services and sanitation conditions may be unequal and diarrhea mortality rates tend to be higher compared to developed countries, which generally have stronger health systems and better sanitation practices. For example, according to data from the WHO, diarrhea mortality rates in Latin America vary significantly among countries, with some countries facing significant challenges in terms of access to safe water and basic sanitation [16]. In contrast, regions such as Europe and North America report considerably lower mortality rates from diarrhea, supported by advanced healthcare infrastructure and well-established public health policies related to water and sanitation.

Our study revealed significant decreases in diarrhea-related mortalityin Ecuador, Colombia, Costa Rica, El Salvador and Venezuela for all ages and both sexes from 2000 to 2019. Mexico also demonstrated a significant decline, though limited to males. Other countries such as Suriname and Venezuela also reported significant decreases in their mortality rates, but the available information was recorded for shorter periods, from 2000 to 2014 and from 2000 to 2016, respectively. These findings could largely be explained by the introduction of the rotavirus vaccine. In Ecuador, Guzman et al. reported a greater reduction in diarrhea mortality rates after the introduction of the rotavirus vaccine in 2008 [17]. In our study, we found that Ecuador showed a great reduction in mortality rates after 2008. Similarly, a study evaluating the impact of rotavirus vaccine on diarrhea mortality in four countries, including Ecuador and Colombia, reported that mortality rates significantly decreased from 4.3 per 100 000 in the pre-vaccination era to 2.2 per 100 000 in the post-vaccination era in children under 5 years of age [18]. In Panama, where the rotavirus vaccine was introduced in 2006, a significant decline in mortality among children aged 0–14 years was observed between 2012 and 2019 [19].

On the other hand, Brazil presented lowest rate of decrease in mortality, ranking fifth in the average mortality rates in the last 5 years of the study period. Previous studies, such as that by Lima et al., reported that, between 2000 and 2019, there was a decreasing trend in mortality in one Brazilian state, decreasing from 9.41 per 100 000 to 2.21 especially in children under 1 year of age [20]. However, there was an increase in the young adult population and stability among older adults [20]. A possible explanation for this trend may be the extreme environmental temperatures in recent years [21] which could contribute to contamination of water supplies and the proliferation of pathogenic microorganisms, such as bacteria, viruses, and parasites, which are responsible for waterborne diarrheal diseases. In addition, events such as floods and droughts can trigger the disrupt sanitation systems and limited access to safe drinking water, exacerbating the risk of diarrheal disease outbreaks [22].

In Peru, the findings are consistent with the results of a previous study that reported a decrease in the specific mortality rate for acute diarrheal disease in children under 5 years of age, showing a decreasing trend from 243.3 deaths per 100,000 in the period 1986–1990 to 15.3 in the period 2011–2015 [23]. However, this trend was not constant across all regions, with some showing stationary trends or deceleration, and two regions even showing an increase in their mortality rates [23]. In addition to rotavirus vaccination and oral rehydration therapy, this reduction was made possible by improved sanitation and hygiene services [24, 25]. It is likely that the regions that did not achieve significant reductions in mortality rates are affected by geographic, economic and cultural differences. Therefore, it is important to create intervention policies adapted to these social determinants to ensure prevention and timely management of diarrhea. In general, although children from poor sectors receive a lower percentage of adequate therapy for diarrheal disease than children from more affluent sectors, none of them achieve coverage of more than 50% [26].

The results of this study reflect the efforts made by LAC countries to combat the increase in mortality caused by diarrhea. Previous studies reported that the prevalence of this disease in LAC countries was due to several preventable factors, such as bacterial and viral infections [27]. In this context, our study offers a clear perspective on this problem using reliable data. However, it is crucial to intensify efforts in resource-limited and developing nations, especially for children, as the incidence of diarrhea is more common in these areas [28, 29]. Although public health policies vary by country or region, it is essential to universally ensure and expand interventions that prevent and protect against diarrhea. This way, the loss of thousands of lives each year due to this disease could be avoided [30].

This study has some limitations that should be mentioned. Firstly, the use of data from a secondary public database provides limited information at the population level and may have biases in the selection and quality of the death registry. Furthermore, the database used did not allow for the analysis of other variables that may be associated with mortality, such as socioeconomic level, etiological agent, nutritional status of the patients, among others. On the other hand, this study also has strengths. First, a meticulous and paired analysis of the databases provided by the WHO was carried out, ensuring the correct evaluation of each country and year. Additionally, it covers a broad period from 2000 to 2019, allowing for a detailed and extensive view of trends over time. Its geographic scope covers several LAC countries, providing a comprehensive regional perspective. It is also distinguished by its detailed focus on the analysis of mortality rates for all ages and in the most affected age group (0–14 years), which provides a more complete and specific understanding of the changes observed in the different segments of the population. Moreover, this is the first study that seeks to evaluate mortality trends in diarrhea in LAC, our results may serve as an epidemiological basis for improvements in public policies and future studies on this disease.

In conclusion, our findings demonstrate a substantial decline in diarrhea-related mortality across all ages and both sexes in Latin American and Caribbean (LAC) countries from 2000 to 2019. These reductions are likely the result of sustained public health interventions, including vaccination programs, improvements in sanitation, and expanded access to care. Strengthening national mortality registries remains crucial for generating high-quality data, enabling countries to monitor trends, share insights at the regional level, and implement coordinated, evidence-based strategies.

To further reduce the burden of diarrheal diseases, it is essential to enhance the quality of incidence and cause-specific mortality data. Continued research is needed to design and evaluate targeted interventions, particularly in vulnerable populations, and to inform the development of effective and equitable public health policies across the region.

Acknowledgements AcknowledgmentsWe thank the editing services of the Universidad Cientifica del Sur for reviewing our paper.

Author Contributions Authors' contributionsConceived and designed the idea: RGA, JSTR.Had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis: RGA, CQV, WRG, JSTR.Contributed to the writing of the manuscript: All authors.Contributed to the statistical analysis: RGA, CQV, JSTR.Critical revision of the manuscript: JRC, LRM, JYM, JAP.Approval of the submitted and final version: All authors.

Funding Not applicable.

Data Availability The datasets generated and/or analysed during the current study are available in the following link: [https://www.who.int/data/data-collection-tools/who-mortality-database](about: blank).

Declarations

Ethics Approval and Consent to Participate .

Consent for Publication Not applicable.

Competing Interests The authors declare no competing interests. Not applicable.

References

1. World Health Organization. Diarrhoeal disease. 2017. [February 07, 2024]. Available in https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease. 2017.
2. Farthing M, Salam MA, Lindberg G, Dite P, Khalif I, Salazar-Lindo E, Ramakrishna BS, Goh K-L, Thomson A, Khan AG. Acute diarrhea in adults and children: a global perspective. J Clin Gastroenterol. 2013;47(1):12–20.
3. Perin J, Mulick A, Yeung D, Villavicencio F, Lopez G, Strong KL, Prieto-Merino D, Cousens S, Black RE, Liu L. Global, regional, and National causes of under-5 mortality in 2000–19: an updated systematic analysis with implications for the sustainable development goals. Lancet Child Adolesc Health. 2022;6(2):106–15.

4. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, Lawn JE, Cousens S, Mathers C, Black RE. Global, regional, and National causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the sustainable development goals. Lancet. 2016;388(10063):3027–35.
5. World Health Organization. Global Health Estimates: Life expectancy and leading causes of death and disability. 2019. [February 07, 2024]. Available in: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates
6. Bellido-Blasco J, Arnedo-Pena A. Epidemiology of infectious diarrhea. Encyclopedia Environ Health 2011:659.
7. Nguyen TV, Le Van P, Le Huy C, Gia KN, Weintraub A. Etiology and epidemiology of diarrhea in children in hanoi, Vietnam. Int J Infect Dis. 2006;10(4):298–308.
8. World Health Organization. International Classification of Disease and Related Health Problems: 10th Revision. Geneva. 1992. Available in:https://www.who.int/standards/classifications/classification-of-diseases/list-of-official-icd-10-updates. 1.
9. World Population Prospects. The 2022 revision. New York: United Nations, Department of Economics and Social Affairs, Population Division,; 2022.
10. National Cancer Institute. Joinpoint regression program. [Accesed 1 March. 2024] Available in: https://surveillance.cancer.gov/help/joinpoint
11. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med. 2000;19(3):335–51.
12. Behera DK, Mishra S. The burden of diarrhea, etiologies, and risk factors in India from 1990 to 2019: evidence from the global burden of disease study. BMC Public Health. 2022;22:1–9.
13. Reiner RC Jr, Graetz N, Casey DC, Troeger C, Garcia GM, Mosser JF, Deshpande A, Swartz SJ, Ray SE, Blacker BF. Variation in childhood diarrheal morbidity and mortality in africa, 2000–2015. N Engl J Med. 2018;379(12):1128–38.
14. Almasi A, Zangeneh A, Ziapour A, Saeidi S, Teimouri R, Ahmadi T, Khezeli M, Moradi G, Soofi M, Salimi Y. Investigating global Spatial patterns of diarrhea-related mortality in children under five. Front Public Health. 2022;10:861629.
15. Troeger CE, Khalil IA, Blacker BF, Biehl MH, Albertson SB, Zimsen SR, Rao PC, Abate D, Ahmadi A, brahim Ahmed MLC. Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the global burden of disease study 2017. Lancet Infect Dis. 2020;20(1):37–59.
16. World Health Organization (WHO). (2020). Global Health Observatory (GHO) data. [March 26, 2024]. Available in https://www.who.int/data/gho
17. Juliao P, Guzman-Holst A, Gupta V, Velez C, Rosales T, Torres C. Incidence and mortality trends of acute gastroenteritis and Pneumococcal disease in children following universal rotavirus and Pneumococcal conjugate vaccination in Ecuador. Infect Dis Ther. 2021;10:2593–610.
18. Paternina-Caicedo A, Parashar U, Garcia-Calavaro C, de Oliveira LH, Alvis-Guzman N, la Hoz-Restrepo D. Diarrheal deaths after the introduction of rotavirus vaccination in 4 countries. Pediatrics 2021, 147(1).
19. Bayard V, DeAntonio R, Contreras R, Tinajero O, Castrejon MM, Ortega-Barría E, Colindres RE. Impact of rotavirus vaccination on childhood gastroenteritis-related mortality and hospital discharges in Panama. Int J Infect Dis. 2012;16(2):e94–8.
20. Lima DS, da Paz WS, Lopes de Sousa ÁF, de Andrade D, Conacci BJ, Damasceno FS, Bezerra-Santos M. Space–Time clustering and socioeconomic factors associated with mortality from diarrhea in alagoas, Northeastern brazil: A 20-Year Population-Based study. Trop Med Infect Dis. 2022;7(10):312.
21. Sanches FH, Martins FR, Conti WR, Christofoletti RA. The increase in intensity and frequency of surface air temperature extremes throughout the Western South Atlantic Coast. Sci Rep. 2023;13(1):6293.
22. Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature. 2005;438(7066):310–7.
23. Valdez Huarcaya W, Vidal Anzardo MH, Miranda Monzón JA. Análisis de La tendencia de La Mortalidad Por Enfermedad diarreica Aguda En El Perú y Sus regiones, 1986–2015. An fac med: 2021. UNMSM. Facultad de Medicina; 2021. pp. 211–9.
24. Huicho L, Tavera M, Huayanay-Espinoza CA, Béjar-Díaz M, Rivera-Ch M, Tam Y, Walker N, Black RE. Drivers of the progress achieved by Peru in reducing childhood diarrhoea mortality: a country case study. J Glob Health 2019, 9(2).
25. Juliao P, Guzman-Holst A, Gupta V, Velez C, Petrozzi V, Ochoa TJ. Acute gastroenteritis morbidity and mortality trends following universal rotavirus vaccination in children in peru: ecological database study with time-trend analysis. Infect Dis Therapy. 2021;10:2563–74.
26. UNICEF DATA, Diarrhoea UNICEF. 2018 [March 26, 2024]. Available in: https://data.unicef.org/topic/child-health/diarrhoeal-disease/
27. Torres AG, Amaral MM, Bentancor L, Galli L, Goldstein J, Krüger A, Rojas-Lopez M. Recent advances in Shiga toxin-producing Escherichia coli research in Latin America. Microorganisms. 2018;6(4):100.
28. Keddy KH, Saha S, Kariuki S, Kalule JB, Qamar FN, Haq Z, Okeke IN. Using big data and mobile health to manage diarrhoeal disease in children in low-income and middle-income countries: societal barriers and ethical implications. Lancet Infect Dis. 2022;22(5):e130–42.
29. Kotloff KL, Platts-Mills JA, Nasrin D, Roose A, Blackwelder WC, Levine MM. Global burden of diarrheal diseases among children in developing countries: incidence, etiology, and insights from new molecular diagnostic techniques. Vaccine. 2017;35(49):6783–9.
30. UNICEF. One is too many: Ending child deaths from pneumonia and diarrhea, UNICEF, New York. 2016. Available in: https://data.unicef.org/resources/one-many-ending-child-deaths-pneumonia-diarrhoea/