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Trends in maternal mortality in Latin America and the caribbean: a joinpoint analysis

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Abstract

Background Maternal mortality remains a significant public health issue in low- and middle-income countries (LMICs), with high incidence rates in Latin America and the Caribbean (LAC). While maternal mortality decreased by nearly 45% between 1990 and 2015, regional inequalities persist. This study assesses maternal mortality trends in LAC women from 1997 to 2019, providing key insights to address this issue.

Methods An ecological observational time-series study was conducted using data from the WHO Mortality Database for 18 countries in Latin America and the Caribbean between 1997 and 2019, focusing on women aged 15–49 years. Age-standardized maternal mortality rates (ASMR) per 100,000 person-years were estimated using the direct method, based on the SEGI world standard population. The MMR, defined as maternal deaths per 100,000 live births, was calculated using data from the Pan American Health Organization (PAHO). Trends were analyzed using Joinpoint regression to estimate the Annual Percentage Change (APC) and Average Annual Percentage Change (AAPC), with $p < 0.05$ indicating statistical significance.

Results The highest maternal mortality rates in 1997 were reported in Guatemala, Nicaragua, and Paraguay, while by 2019, Venezuela, the Dominican Republic, and Paraguay had the highest rates. Similarly, the highest maternal mortality ratios (MMRs) in 2019 were observed in Venezuela, the Dominican Republic, and Paraguay. Joinpoint regression identified significant annual reductions in maternal mortality rates in seven countries—particularly Nicaragua (AAPC: −6.7%) and Guatemala (AAPC: −4.2%)—while Venezuela exhibited a significant increase (AAPC: +5.3%). Regarding MMR trends, the most notable improvements were seen in Nicaragua (AAPC: −4.5%) and Costa Rica (AAPC: −2.0%), whereas Brazil, Puerto Rico, and Venezuela experienced significant upward trends.

Conclusions Despite overall progress, regional differences in maternal mortality persist across Latin America and the Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care. Future studies should explore underlying contextual and structural factors driving these trends and promote the use of disaggregated data to inform equitable health policies.

Keywords Maternal mortality, Latin america, Mortality registries, Joinpoint regression

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Introduction

Maternal mortality is commonly measured using the Maternal Mortality Ratio (MMR), defined by the World Health Organization (WHO)as the number of female deaths per 100,000 live births occurring during pregnancy or within 42 days of termination, irrespective of the cause [1, 2]. Maternal mortality remains a major public health challenge, particularly in low- and middle-income countries (LMICs) [3, 4]. In 2017, a total of 295,000 maternal deaths were recorded worldwide, with an overall maternal mortality ratio (MMR) of 211 per 100,000 live births, representing a 35% reduction compared to the year 2000 [5]. Additionally, more than 300,000 women die annually due to complications related to pregnancy and childbirth [6].

Between 1990 and 2015, maternal deaths declined by 43%, from 532,000 to 303,000, with the MMR decreasing from 385 to 216 per 100,000 live births, equating to a 44% reduction or 2.3% annually [7, 8]. However, maternal mortality in Latin America and the Caribbean (LAC) remains a pressing concern, as significant health disparities persist due to unequal access to medical resource [9, 10]. In response, the WHO established strategies aiming to reduce maternal mortality to fewer than 70 deaths per 100,000 live births by 2030 [11]. Evidence suggests that maternal mortality is largely preventable through strategic interventions, including high-quality preconception, prenatal, intrapartum, and postpartum care [12–14].

Despite previous efforts, maternal mortality in LAC remains a critical issue, primarily due to persistent barriers limiting access to quality reproductive, maternal, and neonatal healthcare services [9, 15]. Moreover, although previous global assessments have reported maternal mortality patterns, few studies have focused specifically on long-term trends within the Latin American and Caribbean region. This study addresses that gap by providing a detailed analysis of changes in both age-standardized mortality rates and maternal mortality ratios across 18 countries over a 23-year period. The selected timeframe includes critical health policy transitions, such as the shift from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs), as well as significant political and economic instability in some countries, making a regional analysis both timely and necessary.

Materials and methods

Data source

This study employed an ecological observational time-series design to examine maternal mortality trends across Latin America and the Caribbean (LAC). Mortality data were retrieved from the WHO Mortality Database (https://www.who.int/data/data-collection-tools/who-mortality-database). The mortality data extracted from the WHO Mortality Database were based on each country's official reporting systems and were not adjusted for potential underreporting or misclassification of maternal deaths. These figures are typically derived using a mixed methodology, combining passive surveillance through national vital registration systems with active case finding strategies such as maternal death reviews, facility-based audits, and surveillance committees. While the degree of implementation and completeness of these methods may vary by country and year, the WHO dataset reflects the data formally submitted by national health authorities. Therefore, the estimates used in this study are intended to align closely with each country's official maternal mortality statistics, as reported through their health information systems. This study included 18 countries from Latin America and the Caribbean. Countries were selected based on the availability of maternal mortality data in the WHO Mortality Database, specifically those with at least 10 consecutive years of data between 1997 and 2019. Maternal mortality cases were classified under ICD-10 codes O00-O99, as per the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) [16].

Age adjusted mortality rates

Age-standardized mortality rates (ASMR) per 100,000 person-years were estimated using the direct method, based on the SEGI world standard population [17]. The analysis was restricted to women aged 15–49 years and stratified into seven five-year age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49 years). Standardization was performed to adjust for differences in the age distribution of women of reproductive age across countries and over time. Additionally, the study assessed the Maternal Mortality Ratio (MMR), defined as the number of maternal deaths per 100,000 live births in each country and year. Maternal mortality indicators (ASMR and MMR) were not extracted as pre-calculated rates but were independently computed by the authors. ASMRs were calculated using raw mortality counts from the WHO database and standardized via the direct method, while MMRs were calculated from maternal deaths and live birth data obtained from PAHO, where values expressed in thousands were converted to absolute numbers by multiplying by 1,000.

Maternal mortality trends were analyzed over the study period using Joinpoint Regression Program version 4.7.0 [18, 19]. Joinpoint regression analysis was used to identify statistically significant changes in maternal mortality trends over time. This method fits a series of joined straight lines on a logarithmic scale and estimates the Annual Percentage Change (APC) for each trend segment, with joinpoints indicating statistically significant changes. The Average Annual Percentage

Change (AAPC) summarizes the overall trend across the study period. The optimal number of joinpoints (APC1, APC2,….) was determined using the permutation test (Monte Carlo method), ensuring that identified changes were statistically significant ($p < 0.05$. The model selection algorithm balances model fit with parsimony to avoid overfitting, particularly in countries with unstable or sparse data. Additionally, APC and AAPC were estimated for the Maternal Mortality Ratio (MMR) to evaluate the evolution of maternal mortality risk in relation to the number of live births.

Ethical considerations

This study is based exclusively on secondary, publicly available data from the WHO Mortality Database. As the dataset contains no personal identifiers or individual-level information, no ethical approval was required for its use.

Results

In 1997, the countries with the highest maternal mortality rates were Guatemala (11.1 per 100,000 women), Nicaragua (10.1), and Paraguay (7.5). By 2019, the highest maternal mortality rates were reported in Venezuela (12.0), the Dominican Republic (7.9), and Paraguay (5.8) (Fig. 1). Regarding the MMR, the highest values in 1997 were observed in Nicaragua (88.0 per 100,000 live births), Guatemala (87.6 per 100,000 live births), and Paraguay (62.1 per 100,000 live births). However, by 2019, the countries with the highest MMR were Venezuela (174.1 per 100,000 live births), the Dominican Republic (109.3 per 100,000 live births), and Paraguay (73.8 per 100,000 live births), highlighting a significant increase in some countries within the region(Fig. 1).

Venezuela, the Dominican Republic, and Puerto Rico exhibited the largest increases in both the maternal mortality rates and the MMR. Regarding the maternal mortality rate, the Dominican Republic experienced a 147.5% increase (from3.2 per 100,000 women aged 15–49 years in 1997 to 7.9 in 2019), while Venezuela showed a 144.1% increase (from 4.9 in 1997 to 12.0 in 2016). Puerto Rico also reported a 46% increase, rising from 1.0 in 1999 to 1.5 in 2017. Conversely, fourteen out of eighteen countries (14/18) showed an overall decline in maternal mortality rates, with the most significant reductions observed in Nicaragua (– 80.7%), Uruguay (-70%), and Costa Rica (– 63.6%). Regarding the MMR, Venezuela exhibited the highest increase, with a 229.7% rise (from 52.8 per 100,000 live births in 1997 to 174.1 in 2016), followed by the Dominican Republic with a 229.5% increase

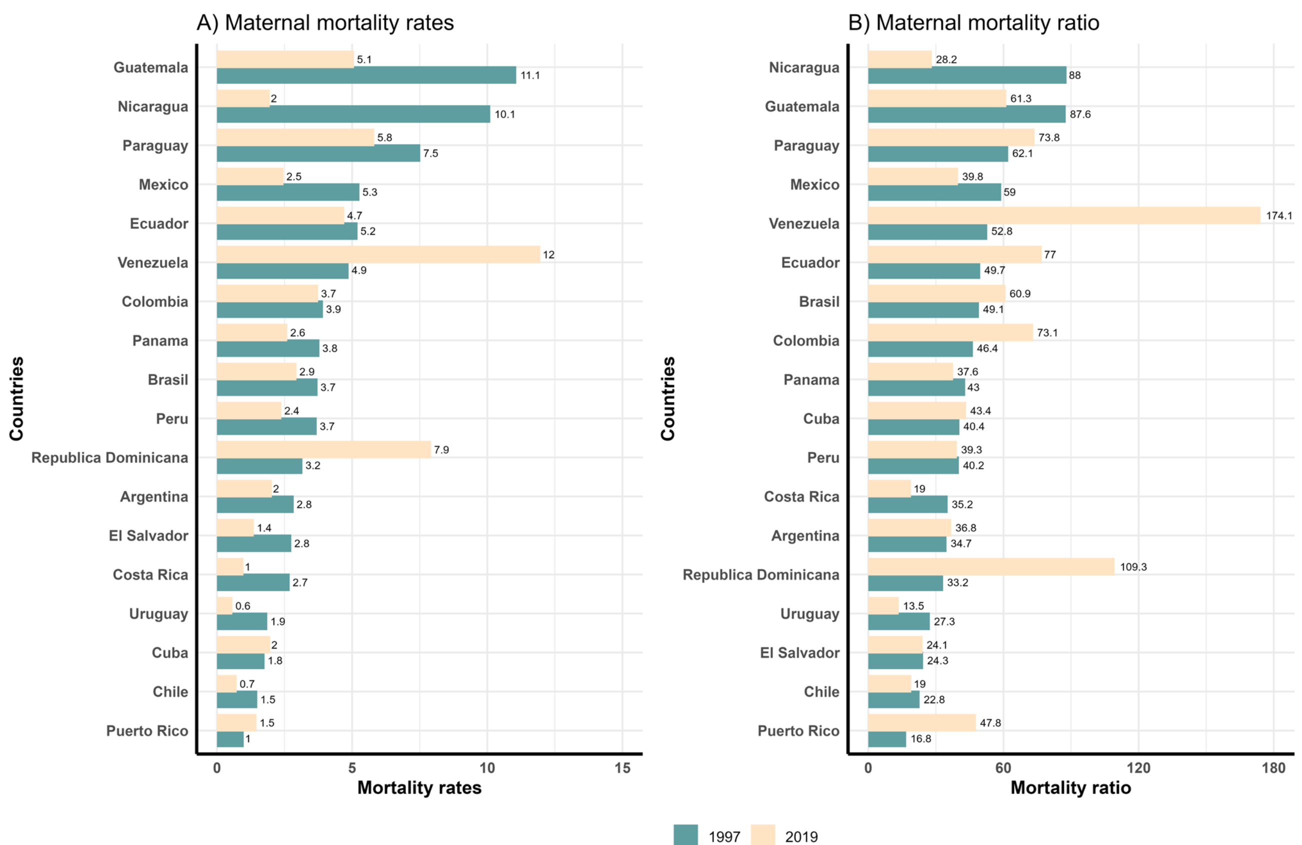

Fig. 1 Age-standardized mortality rates and maternal mortality ratio in Latin America and the Caribbean, 1997–2020

(from 33.2 in 1997 to 109.4 in 2019) and Puerto Rico with a 185.4% rise (from 16.8 in 1999 to 47.8 in 2017). In contrast, eight countries showed an overall decline in MMR, with the largest reductions observed in Nicaragua (– 80.7%), Uruguay (– 50.5%), and Costa Rica (– 46.2%) (Table 1).

Seven out of the eighteen countries (7/18) evaluated showed significant declines in maternal mortality rates over the study period, with the most notable reductions observed in Nicaragua (AAPC: −6.7%), Guatemala (AAPC: −4.2%), and Costa Rica (AAPC: −3.7%) (Table 2; Fig. 2, Supplementary 1). Conversely, Venezuela reported a significant increase in maternal mortality (AAPC: +5.3%). Regarding the Maternal Mortality Ratio (MMR), notable reductions were observed in Costa Rica (AAPC: −2.0%), Guatemala (AAPC: −1.6%), Mexico (AAPC: −1.9%), and Nicaragua (AAPC: −4.5%). In contrast, Brazil (AAPC: +1.4%), Puerto Rico (AAPC: +4.8%), and Venezuela (AAPC: +7.0%) experienced significant increases in MMR throughout the study period (Table 3; Fig. 2, Supplementary 2).

A sensitivity analysis employing Poisson regression was conducted to assess trends in maternal mortality across 18 countries. For maternal mortality rates, four countries exhibited statistically significant annual decreases in their age-standardized maternal mortality rates: Guatemala (-4.2%), Mexico (-3.5%), Nicaragua (-6.6%), and Paraguay (-2.8%). Conversely, two countries demonstrated significant annual increases: the Dominican Republic (+ 7.6%) and Venezuela (+ 3.4%) (Supplementary 3). Whereas for MMR, six countries showed significant annual reductions in their MMR, with the most notable declines observed in Costa Rica (-1.9%), Mexico (-1.9%), and Uruguay (-2.2%). In contrast, five countries experienced significant annual increases, particularly Puerto Rico (+ 3.4%), the Dominican Republic (+ 9.1%), and Venezuela (+ 5.2%) (Supplementary 4).

Discussion

This study provides a comprehensive analysis of maternal mortality trends in Latin America and the Caribbean (LAC) over a 23-year period, highlighting the divergent maternal mortality trends observed across countries in the region, with some showing substantial progress and others experiencing setbacks. While several countries, such as Costa Rica, Guatemala, Mexico and Nicaragua demonstrated significant reductions in maternal mortality, others, particularly Venezuela experienced alarming increases. These trends underscore the ongoing challenges in healthcare access, economic stability, and policy implementation across the region.

This study helps contextualize the importance of maternal health policy by illustrating contrasting trends in countries. For example, Costa Rica, Guatemala, Mexico and Nicaragua—which demonstrated significant reductions in ASMR and MMR—have implemented

Table 1 Number of deaths, maternal mortality ratio (MMR), and age-adjusted rates per 100,000, 1997 to 2019

Country	1997[a]			2019[b]			% change in Mortality rates (2019 vs. 1997)	% change in MMR (2019 vs. 1997)	Absolute Change ASMR	Absolute Change MMR
	Number of deaths	Mortality rates	MMR	Number of deaths	Mortality rates	MMR				
Argentina	249	2.84	34.71	257	2.03	36.79	-28.5	6.0	0.81	2.08
Brazil	1767	3.72	49.12	2138	2.94	60.91	-21.0	24.0	0.78	11.79
Chile	61	1.49	22.77	61	0.73	19.05	-51.0	-16.3	0.76	-3.72
Colombia	413	3.92	46.43	641	3.74	73.14	-4.6	57.5	0.18	26.71
CostaRica	28	2.69	35.22	17	0.98	18.96	-63.6	-46.2	1.71	-16.26
Cuba	56	1.8	40.43	44	1.97	43.40	9.4	7.3	-0.17	2.97
Ecuador	162	5.2	49.68	215	4.71	77.0	-9.4	55.0	0.49	27.32
El Salvador	42	2.8	24.31	25	1.36	24.08	-51.4	-0.9	1.44	-0.23
Guatemala	353	11.1	87.64	254	5.07	61.28	-54.3	-30.1	6.03	-26.36
Mexico	1416	5.3	58.99	1157	2.46	39.81	-53.6	-32.5	2.84	-19.18
Nicaragua	127	10.1	87.95	45	1.95	28.17	-80.7	-68.0	8.15	-59.78
Panama	30	3.8	42.98	28	2.60	37.63	-31.6	-12.4	1.2	-5.35
Paraguay	88	7.5	62.10	108	5.82	73.78	-22.4	18.8	1.68	11.68
Peru	256	3.7	40.18	225	2.38	39.31	-35.7	-2.2	1.32	-0.87
Puerto Rico	10	1	16.75	12	1.46	47.81	46.0	185.4	-0.46	31.06
Republica Dominicana	71	3.2	33.19	234	7.92	109.35	147.5	229.5	-4.72	76.16
Uruguay	15	1.9	27.32	10	0.57	13.51	-70.0	-50.5	1.33	-13.81
Venezuela	306	4.9	52.80	978	11.96	174.08	144.1	229.7	-7.06	121.28

[a] Data from 1997 or from the first year available. Cuba from 2001, Guatemala from 2005, Peru and Puerto Rico from 1999

[b] Data until 2019 or until the last year available. El Salvador until 2018, Puerto Rico until 2017, Venezuela until 2016

Table 2 Joinpoint analysis in the maternal mortality rates in Latin America and the caribbean, 1997–2019

	Years	APC 1	Years	APC2	Years	APC3	Years	APC4	AAPC
Argentina	1997–2009	1.1(− 0.5,2.8)	2009–2019	−4.3*(− 6.3,−2.1)					−1.0*(− 1.7,−0.2)
Brasil	1997–2002	−4.8*(− 7.7,−1.7)	2002–2019	0.1(− 0.3,0.6)					−0.8(− 1.5,0)
Chile	1997–2003	−8.1*(− 12.5,−3.6)	2017–2020	1.9*(0.4,3.5)	2017–2019	−20.0(− 41.0,8.4)			−3.0* (− 5.8,0.1)
Colombia	1997–1999	22.6(− 2.3,54.1)	1999–2008	−6.8*(− 9.0,−4.7)	2008–2019	0.3(-1.2,1.9)			−0.9(− 3.0,1.3)
Costa Rica	1997–2019	−3.7*(− 5.5,−1.9)							−3.7*(− 5.5,−1.9)
Cuba	2001–2019	0.7(− 0.1,1.7)							0.7(− 0.1,1.7)
Ecuador	1997–2000	15.4(− 13.6,54.5)	2000–2005	−29.8*(− 45.7,−9.4)	2005–2009	41.1(− 5.8,112.5)	2009–2019	−1.6(− 5.6,2.5)	−0.5(− 9.4,9.1)
El Salvador	1997–2011	−7.7*(− 10.2,−5.1)	2011–2014	53.2(− 15.3,177.2)	2014–2018	−21.1*(− 32.7,−7.4)			−3.7(− 11.4,4.7)
Guatemala	2005–2019	−4.2*(− 5.1,−3.4)							−4.2*(− 5.1,−3.4)
Mexico	1998–2019	−3.5*(− 3.8,−3.2)							−3.5*(− 3.8,−3.2)
Nicaragua	1997–2019	−6.7*(− 7.3,−6.0)							−6.7*(− 7.3,−6.0)
Panamá	1997–2019	−0.4(− 2.0,1.1)							−0.4(− 2.0,1.1)
Paraguay	1997–2002	11.0*(3.3,19.2)	2002–2012	−7.1*(− 9.7,−4.6)	2012–2019	1.0(− 3.3,5.6)			−0.6(− 2.9,1.6)
Peru	1999–2014	−6.4*(− 9.4,−3.4)	2014–2019	17.4(− 2.6,40.9)					−1.0(− 5.7,3.8)
Puerto Rico	1999–2017	0.9(− 3.1,5.2)							0.9(− 3.1,5.2)
Republica Dominicana	1997–2009	−3.7*(− 7.1,−0.1)	2009–2012	57.3(− 11.4,179.7)	2012–2018	−0.0(− 5.1,5.3)			4.4(− 3.4,12.9)
Uruguay	1997–2019	−3.4*(− 5.9,−0.8)							−3.4*(− 5.9,−0.8)
Venezuela	1997–2014	1.1*(0.3,1.9)	2014–2016	48.5*(28.0,72.3)					5.3*(3.6,7.0)

[a] Data from 1997 or from the first year available. Cuba from 2001, Guatemala from 2005, Peru and Puerto Rico from 1999

[b] Data until 2019 or until the last year available. El Salvador until 2018, Puerto Rico until 2017, Venezuela until 2016

*p value < 0.05

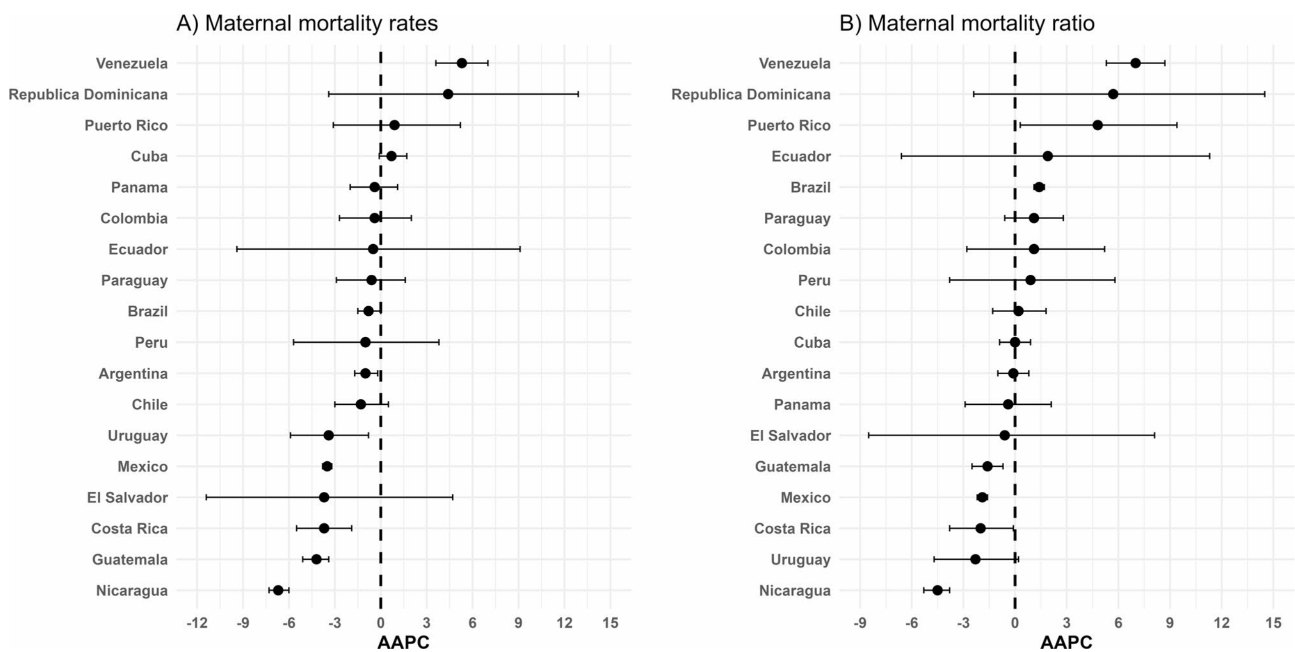

Fig. 2 Average annual percentage change for maternal mortality in Latin America and the Caribbean, 1997–2020

Table 3 Joinpoint analysis in the maternal mortality ratio (MMR) in Latin America and the caribbean, 1997–2019

Countries	Years	APC 1	Years	APC2	Years	APC3	Years	APC4	AAPC
Argentina	1997–2019	−0.1(− 1.0,0.8)							−0.1(− 1.0,0.8)
Brasil	1997–2019	1.4*(1.1,1.7)							1.4*(1.1,1.7)
Chile	1997–2003	−5.1*(− 9.9,−0.1)	2003–2019	2.3*(1.0,3.5)					0.2(− 1.3,1.8)
Colombia	1997–2000	19.4*(3.1,38.3)	2000–2003	−14.8(− 35.0,11.6)	2003–2019	1.2*(0.0,2.4)			1.1(− 2.8,5.2)
CostaRica	1997–2019	−2.0*(− 3.8,−0.1)							−2.0*(− 3.8,−0.1)
Cuba	2001–2019	−0.0(− 0.9,0.9)							−0.0(− 0.9,0.9)
Ecuador	1997–2000	17.6(− 10.4,54.4)	2000–2005	−28.0*(− 43.3,−8.5)	2005–2009	42.3(− 2.7,108.3)	2009 – 2019	1.6(− 2.3,5.7)	1.9(− 6.6,11.3)
El Salvador	1997–2011	−4.0*(− 6.6,−1.4)	2011–2014	50.5(− 16.5,171.3)	2014–2018	−17.6*(− 29.7,−3.4)			−0.6(− 8.5,8.1)
Guatemala	2005–2019	−1.6*(− 2.5,−0.7)							−1.6*(− 2.5,−0.7)
Mexico	1998–2019	−1.9*(− 2.2,−1.6)							−1.9*(− 2.2,−1.6)
Nicaragua	1997–2019	−4.5*(− 5.3,−3.8)							−4.5*(− 5.3,−3.8)
Panamá	1998–2012	2.8*(0.5,5.2)	2012–2019	−6.6*(− 12.6,−0.2)					−0.4(− 2.9,2.1)
Paraguay	1997–2002	14.3*(8.6,20.4)	2002–2014	−5.0*(− 6.4,−3.6)	2014–2019	3.9(− 1.3,9.3)			1.1(− 0.6,2.8)
Peru	1999–2014	−4.8*(− 7.7,−1.7)	2014–2019	20.1*(0.0,44.2)					0.9(− 3.8,5.8)
Puerto Rico	1999–2017	4.8*(0.3,9.4)							4.8*(0.3,9.4)
Republica Dominicana	1997–2009	−2.2(− 5.8,1.5)	2009–2012	57.7(− 12.2,183.3)	2012–2018	1.1(− 4.2,6.6)			5.7(− 2.4,14.5)
Uruguay	1997–2019	−2.3(− 4.7,0.2)							−2.3(− 4.7,0.2)
Venezuela	1997–2014	2.7*(1.9,3.5)	2014–2016	51.1*(30.0,75.8)					7.0*(5.3,8.7)

[a] Data from 1997 or from the first year available. Cuba from 2001, Guatemala from 2005, Peru and Puerto Rico from 1999

[b] Data until 2019 or until the last year available. El Salvador until 2018, Puerto Rico until 2017, Venezuela until 2016

*p value < 0.05

improvements in primary care coverage, midwifery, access to skilled birth attendance, and prenatal/postnatal care programs over the past two decades. However, these countries, with initially high rates, may demonstrate larger relative reductions simply due to their elevated starting points. In contrast, countries that had already achieved lower mortality levels may show smaller annual declines, not necessarily reflecting stagnation, but rather a plateauing trend typical of more advanced stages of maternal health improvement. In contrast, Brazil, Puerto Rico, Republica Dominicana, and Venezuela experienced stagnation or increases in maternal mortality, which may be associated with persistent structural barriers, socioeconomic instability, and health system disruptions.

Brazil has faced challenges in reducing maternal mortality rates, with some periods experiencing stagnation or increases [20]. Several factors are responsible for this situation, including structural barriers, socioeconomic instability and others factors. Inequalities in access to health services are significant contributors to maternal mortality [21, 22]. Women who use the public health system face a higher risk of maternal death compared to those who use private services. A study in Recife identified that women using the public health system had a higher risk of maternal death [23]. In addition, the quality of hospital care varies significantly, affecting maternal mortality outcomes. In Belo Horizonte, disparities in quality between hospitals contracted by SUS (Sistema Único de Saúde) and those not contracted by SUS contribute to high rates of perinatal mortality, with intrapartum asphyxia being one of the main causes of preventable death [24]. Likewise, socioeconomic factors such as low

levels of education and income are associated with higher maternal mortality. Women with less than four years of schooling had a higher risk of maternal death [23]. Racial disparities are evident, with black women experiencing almost double the maternal mortality rate compared to white women [25]. High cesarean section rates contribute to maternal mortality. In Campinas, São Paulo, cesarean delivery was associated with an increased risk of maternal death [26]. Addressing these problems requires comprehensive strategies to improve access and quality of care, reduce socioeconomic inequalities, and ensure robust responses from the Brazilian health system.

In the last years, Venezuela has experienced systemic disruptions and political instability. In fact, Venezuela reported the highest mortality rate among Latin American countries. This could be explained by the fact that Venezuela has reduced its investment in health by 58.6% (from 2.9 to 1.2% of GDP) and its per capita spending by 81.6% (from $418 to $77) [9], which has negatively impacted the capacity of the health system. This decrease in resources has limited the availability of supplies, infrastructure and trained personnel. Despite improvements in the coverage of births attended by professionals, critical inequalities persist. Moreover, economic crisis that threatens the public health of its population [27–29]. Shortages of medicines and health supplies, the interruption of basic services in health centers, and the emigration of health personnel have led to a progressive deterioration in the operational capacity of health care [27].

In Puerto Rico, maternal mortality ratios have shown a significant increase during the study period. Several contextual factors may help explain this trend. First, Puerto Rico experienced a sustained population decline due to large-scale migration to the United States, particularly among working-age individuals [30]. This demographic shift may have altered the profile of maternal health needs and potentially affected the accuracy of locally recorded data. Although the expansion of public health programs such as “Mi Salud” (implemented in 2011) improved access to primary care services during the early part of the century [31], these efforts may not have been sufficient to offset broader systemic vulnerabilities. Additionally, the aftermath of Hurricane Maria in late 2017 has been associated with significant underreporting of mortality—estimated at 62% below expected levels compared to 2016 [32]. Such disruptions may have affected the completeness and timeliness of maternal death surveillance, complicating accurate trend assessment. Taken together, these factors highlight the need for strengthened health system resilience and improved maternal death monitoring in contexts affected by demographic shifts and environmental crises.

Similarly, in the Dominican Republic, maternal mortality remains critically high despite near-universal institutional birth coverage. A population-based COM-Poisson regression analysis (2015–2019) found that although 98.2% of births occurred in health facilities and 97% of pregnant women received at least one prenatal visit, the provincial MMR averaged 9.26 per 100,000 live births, with rates as high as 20.4 in the province of Independencia. Notably, higher rates of vaginal deliveries and infant mortality were positively associated with increased MMR, whereas higher rates of births to single mothers appeared to be protective [33]. These findings suggest that access to care alone is insufficient to guarantee safe maternal outcomes. Systemic factors—such as overcrowding, clinical mismanagement, and obstetric violence—emerge as critical drivers of maternal risk. Complementing these findings, a separate program evaluation of the “Helping Mothers Survive” (HMS) training conducted between 2016 and 2020 in the DR showed that simulation-based education significantly improved provider knowledge: by 21.24% for postpartum hemorrhage and by 30.25% for preeclampsia/eclampsia. Despite these encouraging educational gains, persistently high MMRs indicate that deeper structural deficiencies in clinical practice and health system functioning remain unresolved. Collectively, these studies highlight the urgent need to bridge the gap between healthcare access and quality, underscoring that reducing preventable maternal deaths in the region requires not only coverage, but systemic transformation [34, 35].

Our study reported a decrease in maternal mortality in the LAC region, highlighting countries such as Costa Rica, Guatemala, Mexico and Nicaragua. This scenario has been reported previously, as between 1990 and 2019 there was a reduction of 30.9% (1.1% per year) in the maternal mortality rate in the region [10]. The possible cause may be due to the fact that, in recent decades, the LAC region has seen an increase in the coverage of skilled birth attendance, exceeding 90% since the 2000s [10], especially in Guatemala, where it was over 95%, which could also explain the greater reduction in mortality rates in this country in our results. However, in comparison with other regions such as Europe or Asia [36], the LAC region is still far from achieving the Millennium Development Goal 5 (MDG 5) target of reducing maternal mortality to <70 deaths per 100,000 live births by 2030 [37], and challenges persist that require attention. Maternal mortality is of special interest in LAC because it is a crucial indicator for assessing inequality, social inequities and the performance of health systems [38]. In this sense, its development in LAC is closely related to various factors such as poverty and educational level [39], which makes it a social phenomenon with determinants that transcend health systems.

Another possible explanation for the reduction in several LAC countries is that from 1990 to 2021, the number of human resources for health (physicians, nurses and midwives) grew by 145%, at a rate of 2.8% per year, reaching 2.4 physicians and 4.8 nurses and midwives in 2021 [10]. This may also explain the greater reduction in Guatemala, as although fewer human resources are reported [12], in recent years, the country's Ministry of Health has carried out programs to train and encourage the participation of physicians and midwives [40] to ensure a more accurate reduction in maternal mortality, focusing on early detection of complications and timely referral to specialized care centers. On the other hand, in Venezuela we found a situation contrary to the rest of the LAC region, with an increase of 5.3%. The reason for this marked difference may be the economic crisis in that country, which has spread, depleting the country's health infrastructure and increasing maternal morbidity and mortality [28].

The findings of this study offer valuable insights into maternal mortality trends in Latin America and the Caribbean. However, it is important to interpret these results in the context of potential limitations related to data quality. As described, issues such as underregistration and misclassification of deaths—particularly in countries with less robust health information systems—may lead to underestimation of maternal mortality rates [41, 42]. This could have attenuated the magnitude of declines observed in some countries or masked more severe maternal health challenges in others. Conversely, in countries where maternal death surveillance has improved over time, observed increases may partially reflect enhanced detection and reporting, rather than true worsening of outcomes. Understanding the direction of these biases is essential: underregistration typically biases mortality rates downward, while improved registration over time may bias trends upward. Although our analysis does not adjust for these potential biases, we believe the trends observed remain informative and relevant for policymaking and future research.

The results of this study are essential to guide the formulation and implementation of health policies in Latin America and the Caribbean. The persistence of high maternal mortality rates in countries such as Venezuela highlights important deficiencies in access to quality prenatal care and health infrastructure in several regions. These findings underscore the urgent need to strengthen health systems, particularly in rural and hard-to-reach areas, by implementing prevention and health education strategies to reduce the risk factors associated with maternal deaths. Furthermore, the improvements observed in countries such as Argentina and Costa Rica, with significantly lower mortality rates, highlight the effectiveness of public policies focused on guaranteeing universal access to quality medical services and promoting equity in health. These examples can serve as models for other countries in the region to follow, adapting them to their social and economic contexts. Overall, the results reinforce the importance of strengthening the monitoring of health indicators, evaluating the impact of current policies and designing new interventions to achieve greater health coverage and reduce regional disparities [43].

Notably, countries such as Costa Rica, Nicaragua, and Guatemala demonstrated the most significant improvements in maternal mortality indicators. In Costa Rica, the consolidation of the primary healthcare system through the implementation of the EBAIS model, combined with expanded coverage and coordinated referral networks, has been linked to sustained reductions in maternal deaths [44]. In contrast, countries like Venezuela and the Dominican Republic showed worsening trends, potentially attributable to political instability, underinvestment in healthcare systems, and shortages of skilled professionals and essential medicines [28]. Moreover, while our study is based on national averages, it is important to emphasize that these figures may mask profound subnational inequalities. Prior research in Latin America has highlighted stark disparities in maternal outcomes by geographic region, ethnicity, and socioeconomic status, underscoring the need for disaggregated data to inform targeted policy responses and address maternal health inequities effectively.

Limitations

The study has several limitations inherent to the use of secondary data from the WHO Mortality Database, including the lack of individual-level information and variation in the completeness and quality of mortality registries among countries and over time. One important limitation is the potential underreporting and misclassification of maternal deaths, which may differ significantly across settings and could bias results. For example, incorrect or incomplete application of ICD-10 codes could lead to misclassification of maternal causes, while weak civil registration systems could result in undercounting. These biases could potentially underestimate the true burden of maternal mortality, especially in low-resource settings. Conversely, countries with improved surveillance over time might show increases in maternal mortality simply due to better detection and reporting. While we did not perform a formal sensitivity analysis in this study, we acknowledge that such an approach—incorporating modeled or adjusted data—could further assess the robustness of our findings. We encourage future studies to build on our work by comparing WHO-based trends with modeled estimates such as those from the Global Burden of Disease (GBD) study, which incorporate

correction algorithms for incomplete registration. Moreover, while we calculated maternal mortality indicators directly from raw data, the study did not incorporate contextual variables (e.g., health expenditure, skilled birth attendance, poverty) due to heterogeneity and gaps in data availability across countries and years. Including these variables was not within the primary objective or analytical design of this study. However, future research should consider multivariable ecological models that integrate such indicators to better understand their influence on maternal mortality trends. In addition, 2020 was excluded from the analysis to avoid potential confounding effects related to the COVID-19 pandemic, which may have disrupted health services and reporting systems. Despite these limitations, we conducted a thorough and transparent analysis to provide the most accurate results possible using available data. We also recommend that future studies explore adjusted estimates from initiatives such as the Global Burden of Disease (GBD) project and promote efforts to improve the completeness and quality of national mortality data systems in the region.

Conclusion

In conclusion, despite overall progress, significant regional disparities persist, emphasizing the urgency of policy reforms and targeted healthcare investments to align with global maternal health goals. While our analysis did not directly evaluate the influence of contextual or structural determinants on maternal mortality trends, the observed differences between countries suggest that factors such as healthcare access, the availability of skilled birth attendants, and national health system capacity may play a critical role. Future research should incorporate multivariable ecological analyses to assess the influence of such factors in greater depth and to evaluate the effectiveness of national maternal health policies across diverse country settings in Latin America and the Caribbean.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Author contributions

Conceived and designed the idea: LQA, 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: LQA, CQV, JSTRContributed to the writing of the manuscript: All authors.Contributed to the statistical analysis: LQA, WRG, CQV, JMFM, JSTR.Critical revision of the manuscript: JYM, JSTR.Approval of the submitted and final version: All authors.

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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.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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