

# A binational analysis of infant mortality among crisis-driven diasporas and those who remain: a population-based study in Colombia and Venezuela

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## ABSTRACT

**Objective** To assess the health cost (or benefit) of crisis-driven migration by focusing on the infant mortality rate (IMR) of the Colombian diaspora in Venezuela and the Venezuelan diaspora in Colombia.

**Methods** We compare national to diaspora IMRs over the period 1980–2018. National IMRs are death-to-birth ratios reported by the official vital statistics, whereas diaspora IMRs are calculated by using a semiparametric regression model on the summary birth histories collected in the population censuses. We analyse the diaspora IMRs according to whether their arrival corresponds to precrisis or crisis-driven migration.

**Results** During crises, diaspora IMRs show better health outcomes than those of non-migrants. The Colombian diaspora had an average annual IMR of  $-1.8$  (95% CI  $-3.3$  to  $0.28$ ) per year and the Venezuelan diaspora had  $-4.5$  (95% CI  $-5.8$  to  $-3.3$ ). However, the protective role of migration is neither guaranteed nor consistent, as a crisis in the country of destination exposes immigrants to worse health outcomes than the non-migrant population.

**Conclusion** Migration is a survival strategy that allows people to reduce the negative effects they face during a crisis in their country of origin. The distinction between crisis-driven and precrisis migration provides a framework for assessing the cross-border effects on health outcomes due to diaspora composition, particularly when populations face adverse conditions.

## INTRODUCTION

Colombia and Venezuela share a 1378-mile border along seven Colombian *Departamentos* and five Venezuelan *Estados* (states herein). These two countries have historically maintained active cross-border populations and economic exchanges<sup>1 2</sup> nurtured by large numbers of binational families in circular mobility.<sup>3 4</sup> Mass migration from Colombia to Venezuela occurred from the 1970s until the early 2010s, with around one million Colombians going to Venezuela throughout the 70-year undeclared civil war known as the Colombian armed conflict. This migratory

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Previous studies have documented higher infant mortality among children of immigrants compared with native-born in South-to-North migration. Newborns' health outcomes in South-to-South migration contexts have been relatively neglected.
- ⇒ Mortality differences across migration status groups depend on immigrants' socioeconomic status and the context of reception.

## WHAT THIS STUDY ADDS

- ⇒ Comparing crisis-driven diaspora infant mortality rates with those of their non-migrant counterparts at the moment that migration occurred is key in the understanding of the effect of migration in health outcomes.
- ⇒ The protective role played by the stability of the long-term diaspora in crisis-driven migration health outcomes may be underestimated in academic studies due to the lack of data.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Given that migrants' survival (dis)advantages relative to the native-born are concentrated in the neonatal period, reliable access to prenatal and postpartum care in the destination country is the key to reducing a crises' harmful effects on newborns and their mothers.

flow has become reversed since 2014, when Venezuela began to undergo a profound social and economic crisis that drove Venezuelan families to pursue emigration as a crucial survival strategy. From 2014 to 2021, the main destination for Venezuelans was Colombia, which received approximately 1.8 million Venezuelans in that period.<sup>5</sup> According to the figures cited here, the Venezuelan population fled their country at a much faster rate than Colombians migrating to Venezuela, and the process is still ongoing.

We measure the health cost (or benefit) of migration by examining the infant mortality

rate (IMR) of the Colombian diaspora in Venezuela (the Colombian diaspora herein) and the Venezuelan diaspora in Colombia (the Venezuelan diaspora herein), particularly during crises. We focus on IMR because, in addition to being part of international developmental agendas such as the Developmental Millennium Goals, IMR is a very sensitive measure of population health. Social, economic and violence-related crises can negatively affect healthcare systems by reducing coverage and diminishing the availability of resources and personnel while simultaneously raising barriers for vulnerable groups (eg, forcibly displaced populations). All of these are likely to translate into lower quality care and attention, particularly for even more vulnerable populations (eg, pregnant women and newborns). By measuring the IMR among diasporas (at destination), we are capturing the potential role played by migration in one important aspect of population health.

From a theoretical perspective, migration can improve or worsen infant mortality. On the one hand, migration can reduce infant mortality because it allows families to escape violence, hunger and extreme deprivation, all of which negatively affect infant health.<sup>6,7</sup> On the other hand, migration may be associated with worse health outcomes for infants because migrant women may face barriers to accessing healthcare services and prenatal care at the destination, which could in turn translate into higher mortality risk for newborns. Likewise, migration-related and violence-related stress as well as other adverse conditions during migration may affect foetal health, which could worsen birth outcomes.<sup>8,9</sup>

Using census data and civil registration vital statistics (CRVS), we reconstruct the IMR time series for non-migrant populations and diasporas from 1980 to 2018. We define the diaspora population as those residing in a country that is different from their country of birth. Next, we analyse IMR trends during crises by zooming into two critical periods: the bloodiest years of the Colombian armed conflict (1998–2003) and the most severe years of Venezuela's socioeconomic crisis (2013–2018). Our main hypothesis is that IMR differences between diasporas and non-migrants are influenced by the socioeconomic background of those in the diaspora, their composition in terms of time since arrival (eg, recent, crisis-driven vs long-term or precrisis migration) and the host country's capacity to respond to the specific health needs of recent arrivals. Hence, higher socioeconomic background and long-term migration correlate with better mortality conditions, whereas recent migration and low socioeconomic status are associated with higher IMR, although all these associations are contingent on pre-existing conditions at destination.

## DATA

We combine CRVS and census data to estimate infant mortality rates (IMR) for diasporas and non-migrant populations in each country. Specifically, CRVS provides

us with the annual birth and death counts for the periods 1980–2019 for Colombia and 1980–2014 for Venezuela. The census data give us the summary birth histories (SBH), which include information on: (1) the number of children ever born; (2) the number of children still alive; (3) children born and still alive during the year previous to the census and (4) the date of birth for the last child ever born to all women aged 15–49. We use the 1981, 1990, 2001 and 2011 Venezuelan censuses and, for Colombia, the 1993, 2005 and 2018 censuses (online supplemental appendix 1).

## METHODS

### National infant mortality

We calculate national IMR as the death-to-birth ratios using the official CRVS data for both countries. We assess CRVS data quality and completeness for the entire period of analysis (online supplemental appendix 2), and we adjust the undercounts of births and deaths by inter/extrapolating their differences to the IMRs provided by the LAMBdA inter-census life tables<sup>10</sup> (online supplemental appendix 3.1).

### Diaspora infant mortality

We apply the Trussell variant of the Brass method to the SBHs to estimate diaspora IMRs.<sup>11</sup> This method allows us to overcome challenges in estimating diaspora IMRs due to data availability (online supplemental appendix 3.3). The Brass method produces estimates for up to 15 years prior to each census round. Infant mortality estimates are modelled into annual figures via independent p-spline models<sup>11</sup> in order to obtain a yearly diaspora proportional factor for each country, that is, a diaspora-to-national ratio for infant mortality. These ratios capture whether and how much infant mortality is higher or lower among the diaspora population with respect to non-migrants in the country of destination. We apply these ratios to the adjusted estimates using CRVS data (online supplemental appendix 3.4).

Our analytical sample comprises women who migrated before age 20, a selection criterion that allows us to include only women whose entire reproductive years were likely spent in the destination country. Additionally, we consider women with up to one child whose date of birth was posterior to the mother's declared year of arrival. We address women with one child because censuses only include the date of birth for the last child born. These sample selection strategies let us focus on births and child deaths occurring at destination (ie, the IMR of diasporas).

Since migration influxes are considerably high, especially during crises, we have reasonable sample sizes (online supplemental appendix 3.5) for reconstructing the time series of the diasporas' infant mortality. However, the selectivity of our analytical sample (first and unique births and women who migrated before age 20) may imply some biases in our estimates. Due to the positive

correlation between higher risk of dying through life and birth order,<sup>12 13</sup> we expect our IMR estimates to underestimate the actual IMR. Moreover, since our selection concerns only the diasporas, the diaspora/non-migrant IMR ratios are likely to be underestimated, thus making our results conservative.

### Crisis-driven and pre-crisis diaspora infant mortality

Analogously, we analyse the diaspora infant mortality differential according to their arrival at the destination, that is, whether they represent precrises (long-term migration) or crisis-driven (recent) migration. We create annual ratios of precrises and crisis-driven migrations to the whole diaspora, which are also applied to the adjusted IMR calculated from CRVS data (online supplemental appendix 3.5). In addition, we use linear regression models to contrast the conditional means of the subpopulations' IMRs during crises and according to the time since arrival. We consider the non-migrant population's IMR as reference. The statistical analysis allows us to determine differences in the rate of change of the conditional means among the subpopulations, which we measure as changes in IMR per 1000 live births during the period (online supplemental appendix 3.5). We

assess and interpret the magnitude and statistical significance of the regression coefficient as a way to summarise our findings. Admittedly, these associations do not measure causal effects.

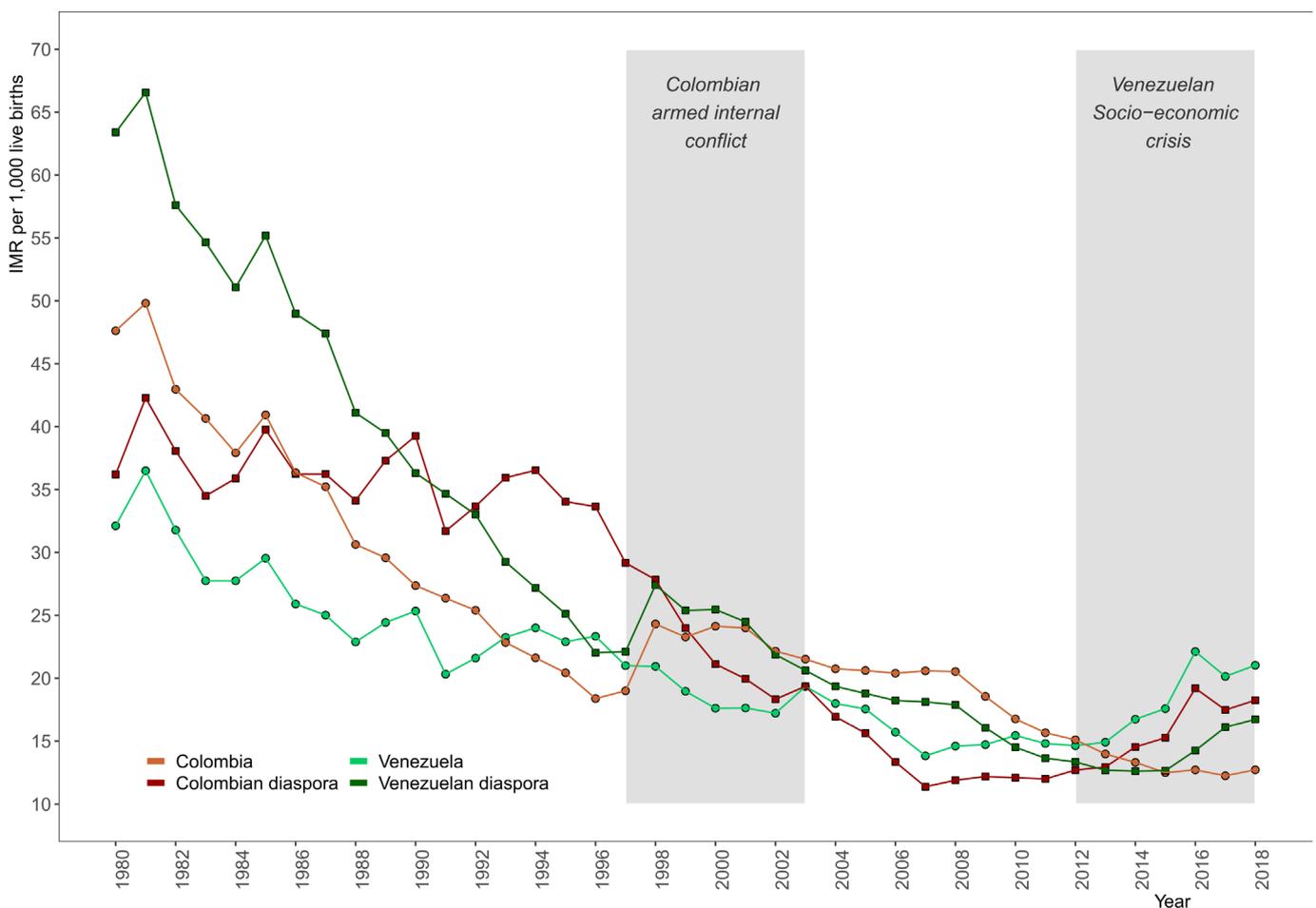
### Patient and public involvement statement

Neither the study participants nor the public were involved in designing, planning, conducting, reporting or disseminating our research.

## RESULTS

### National and diaspora infant mortality trends

Figure 1 captures the broad historical patterns (1980–2019) and mortality shocks during the two periods of crisis-driven migrations in each country. Whereas overarching historical patterns are consistent with those reported in the cited literature, short-term changes (eg, peaks, declines and crossovers within a 5-year period) need to be considered cautiously, as some of them may be affected by random fluctuations. However, considering the strong consistency with country-specific events such as peaks of violence and the onset of crises, this indicates that our correction approaches work as expected and



**Figure 1** IMR in Colombia and Venezuela, 1980–2018. Source: Author's own estimates based on civil registrations; vital statistics; Venezuelan population and household censuses from 1981, 1990, 2001 and 2011; Colombian population censuses from 1993, 2005 and 2018 and the LAMBdA. IMR, infant mortality rate; LAMBdA, Latin American Mortality Database.

short-term patterns are unlikely to be spurious or simply driven by random variations.

Hence, though the initial levels and relative paces differ, the IMR has been decreasing in both countries since the 1980s, with Venezuela beginning at a much lower level and Colombia catching up to them in the 1990s. [Figure 1](#) shows that, around 1993, the national IMRs converged to 23 deaths per thousand live births.

In Colombia, this convergence point was followed by 6 years of improving IMR up to 1998, which is the starting point of when the armed conflict intensified. The IMR trends after 1998 suggest that the conflict contributed to wiping out the 6 years of progress and restored the country's IMR to levels observed at the beginning of the decade. Consistent with previous research, the increased IMR overlapped the bloodiest years of the Colombian armed conflict.<sup>14 15</sup> With the 2010 peace agreement, conflict-related violence declined along with the IMR, which returned to its preconflict trend.

Overall, the national IMR for Venezuela has decreased continuously since the seventies—with a few brief exceptions. Sudden increases in the IMR potentially reflect the upsurges in economic shocks that hit the country, including the popular uprising against price increases known as *El Caracazo* (1989); the political and economic instability incurred by two attempted coups (1992 and 1993);<sup>16</sup> the 1994 banking crisis; another failed coup d'état (2002) and the 2002–2003 national oil strike that led to food and fuel shortages, impacted most of the population and fuelled an increase in violence. The overall declining trend stalled around 2009, potentially due to the ongoing economic and social crises. In 2018, the official figures set IMR at 21 per thousand live births, setting the country back to levels observed at the end of the 1990s.<sup>17</sup>

The diaspora IMRs also show declining trends, although they responded differently to the crises compared with their countries of origin and the local populations. In Venezuelan territory, the Colombian diaspora's IMR showed a slow decrease up to the mid-1990s, then culminated in its steepest decrease during the most acute years of Colombia's crisis (1998–2003) and up until 2007, when it became more similar to Venezuela's national IMR levels and finished, from the perspective of a point estimate, better off than any other subpopulation's IMR. When the Venezuelan crisis started hitting the country, the Colombian diaspora's IMR continued to maintain lower levels than that of Venezuelans, but was not better than the non-migrant Colombians back home.

In sharp contrast, among Venezuelans on the other side of the border (ie, in Colombian territory), this diaspora's IMR saw a constant and accelerated decrease from the 1980s up to 1997, when the armed conflict intensified. This intensification negatively influenced the IMRs of both the Colombian and Venezuelan diasporas, as evidenced by the post-1998 patterns. These descriptive patterns could be related to the fact that some of the highest rates of armed conflict and highest numbers of

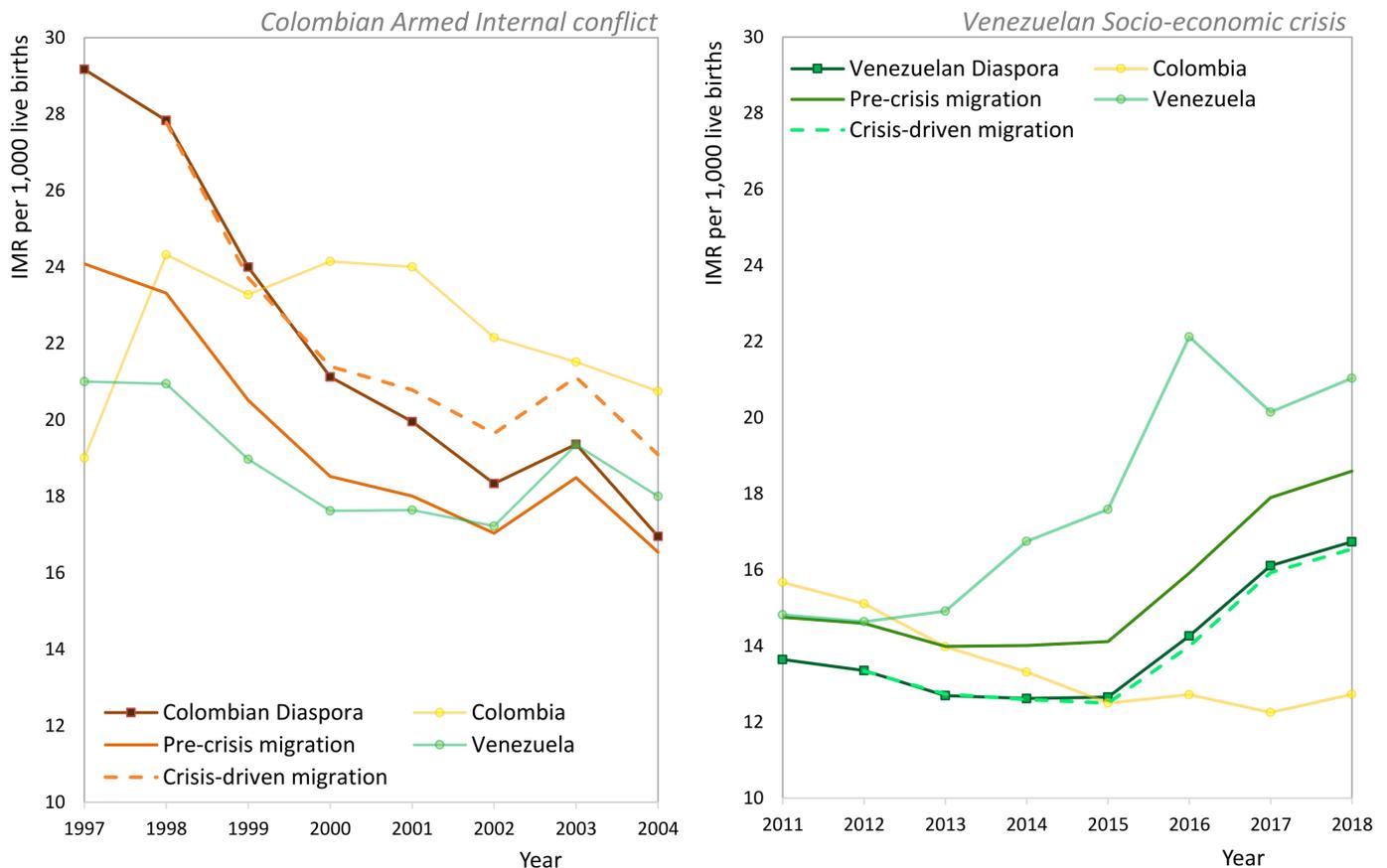
armed actors are found in Colombian border states, which also have the highest concentrations of Venezuelan-born migrants. For more than a 10-year period (2003–2014), the trend continued to decrease for the Venezuelan diaspora's IMR until a positive trend is again observed after 2015. The reappearance of an increasing trend coincides with the period of massive migration flows, which makes the trend more like that of the non-migrant Venezuelans.

### Infant mortality during crisis-driven migration periods

To better understand the potential mechanisms behind the heterogeneous influence of crises on diaspora IMRs, we zoom into the two periods of crises and divide the diasporas into crisis-driven migration and precrisis migration. During the period of intensified conflict in Colombia (left panel in [figure 2](#)), the IMR increased and stalled at high levels among Colombian non-migrants while the IMRs of all Colombian diasporas declined and show lower levels. These declines and overall lower diaspora IMRs may be due to the positive selection of Colombian migrants, who have the lowest IMRs, particularly among precrisis migrants. The precrisis migrants show even lower levels than Venezuelans who did not migrate after the year 2002. For the crisis-driven migrants, the results suggest that migration also acts as a protective factor. However, these groups of migrants may be facing depressing health outcomes due to the intensification of the conflict, which precrisis migrants have avoided; thus, they display higher IMRs during the entire period.

On the Venezuelan side (right panel in [figure 2](#)) until 2012, the IMRs of non-migrant Venezuelans were lower than those of their Colombian counterparts, an advantage that the precrisis Venezuelan diaspora potentially benefited from until 2013, when the Venezuelan-born flows began arriving in the Colombian border states. Throughout the most acute period of the Venezuelan socioeconomic crisis (2017–2018), the Venezuelan diaspora's IMR rose and remained above that of Colombians who did not migrate, regardless of the time of migration. In contrast to the Colombian diaspora in Venezuela, the IMRs of the precrisis Venezuelan diaspora are higher than those for the crisis-driven diaspora during the entire period under analysis.

Despite the higher IMRs of Venezuelan diasporas relative to non-migrant Colombians, a positive association still exists between migration and newborn health when considering the IMRs of non-migrant Venezuelans during their national crisis. Two important roles in modelling the rise of the Venezuelan diaspora's IMR may be played by, on the one hand, the socioeconomic characteristics of the migrants (who are probably more negatively selected during this time of crisis and travelling under precarious conditions) and, on the other hand, the limited access to health services at destination. Compared with other countries in the region, Colombian health systems rank poorly in terms of per capita investments, availability and access to health services.<sup>18</sup>



**Figure 2** Diaspora IMRs, 1997–2004 and 2012–2018. Source: Author’s own estimates based on population census, civil registrations, vital statistics and the LAMBdA. IMR, infant mortality rate; LAMBdA, Latin American Mortality Database.

Figure 3 summarises the annual average rate of changes in all subpopulations’ IMRs during the crisis periods: 1998–2003 for Colombia (top panel) and 2013–2018 for Venezuela (bottom panel). The black vertical line indicates the reference category (IMR among non-migrants in the country of origin). All coefficients of diaspora subgroups are negative, meaning that the average diaspora IMRs are lower compared with those of non-migrants during the crises in the country of origin. The Colombian diaspora IMR was, on average, 1.8 (95% CI –3.3 to 0.28) units lower than the annual average rate of changes in the IMR of Colombian non-migrants. Likewise, the Venezuelan diaspora’s IMR was 4.5 (95% CI –5.8 to –3.3) units lower than that of its non-migrant counterpart.

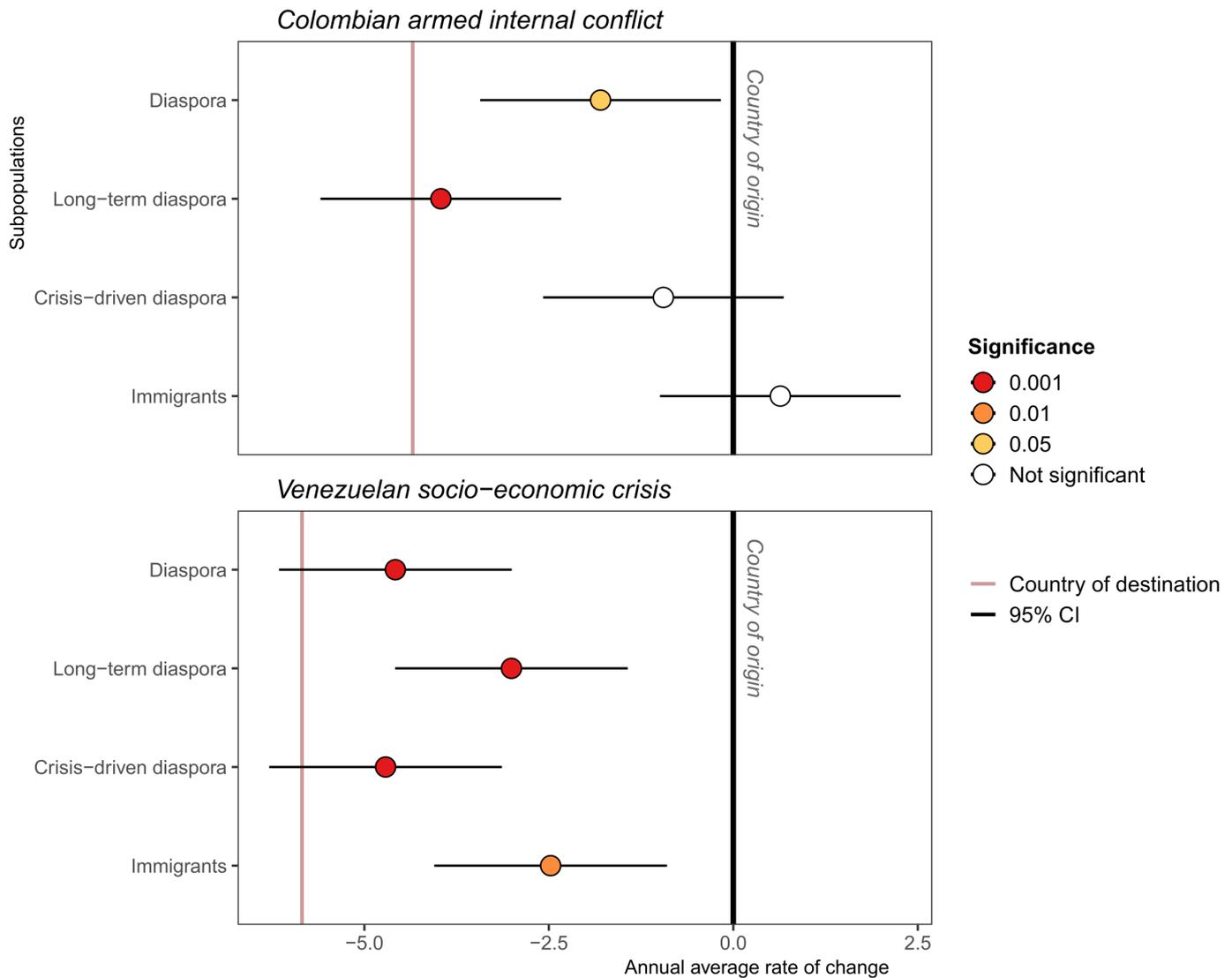
Figure 3 also shows evidence of the difference between the average rate of change in the IMRs of immigrants and the non-migrant populations. We use the term ‘immigrants’ to refer to Venezuelan-born migrants living in Colombia between 1998 and 2003 as well as to Colombian-born migrants living in Venezuela from 2013 to 2018. According to these results, the immigrant populations on both sides of the border are those who benefited the least from migration when crises occurred in their countries of destination. Despite the advantageous position that all diaspora IMRs have relative to their

non-migrant counterparts, their levels are higher than the non-migrants in the country of destination.

## DISCUSSION

In the contexts of the violence and socioeconomic crises in Colombia and Venezuela, the interdependence of societal and demographic processes yielded a heterogeneous spectrum of relationships between migration and newborn survival opportunities. By reconstructing the long-term time series of the diaspora IMRs in Colombia and Venezuela, this study sheds light on two important aspects: first, how populations react to the societal pressures stemming from violent conflicts and acute economic crises; and, second, how infants’ health outcomes evolve during periods of stability. The historical migration flows between Colombia and Venezuela are particularly interesting due to the changing conditions at origin and destination.

Our analysis reveals that migration served as a protective factor for the diasporas, which had lower IMRs than their respective national counterparts during their native countries’ periods of intense crises. At the same time, it also suggests that the protective role of migration is neither guaranteed nor constant. The Venezuelan diaspora had worse health outcomes than non-migrant Venezuelans until their country’s current socioeconomic



**Figure 3** Diasporas IMR conditional means to non-migrants IMR (reference) during crises. Source: Author’s own estimates based on a regression model on IMR during the period of crisis in each country. Colombia 1998–2003 and Venezuela 2013–2018. The annual average rate of changes comes from the regression  $\beta_1$  coefficients. IMR, infant mortality rate.

crisis began. In contrast, the Colombian diaspora did better than its non-migrant counterparts from the late nineties onward. Focusing on the destination reveals that the increasing flow of Venezuelans worsens the conditions of that country’s long-term diaspora, whose IMR had successfully coped with the non-migrant Colombian population’s increased IMR resulting from the Colombian-armed conflict.

The changing cause of binational migration flows and the consequent heterogeneity in the socioeconomic composition of the migrant populations could be the underlying reason why infant mortality is influenced by the interaction of: time since migration; the socioeconomic backgrounds of diaspora members and the social and economic crises occurring at origin and destination. As we hypothesise, the direction of IMR differences between diasporas and non-migrants depends on the diaspora’s composition in terms of socioeconomic background and time since arrival. Positive selection in terms

of socioeconomic status was a feature of the Colombian diaspora during the 1970s and 1980s, when migration was driven by the economic boom in Venezuela.<sup>19</sup> Middle-class Colombian families were more likely than their lower-class counterparts to have enough resources to benefit from economic conditions in their neighbouring country. They were also more likely to relocate beyond the bordering cities and settle in the interior, where living conditions and access to services are generally better in comparison to the border.<sup>20</sup> By the time, the Colombian-armed conflict intensified, these middle-class families represented 77% of the Colombian diaspora. In contrast, lower-class families and rural populations were greatly affected by the armed conflict and pushed out of the country mostly towards bordering cities in Venezuela, thereby increasing the share of recent Colombian diaspora migrants. This different socioeconomic composition and spatial scope of the migrations also appears in the Venezuelan exodus to Colombia. Whereas it is

mostly middle-class families that comprise flows to cities such as Bogota or Medellin, the crisis-driven migration flow that rapidly spread across the border involved mostly poor families.<sup>21</sup> In the case of the Venezuelan diaspora, the precrisis migration represented only 7% of the total diaspora.

Beyond the composition effect, another factor is the protective role played by the stability of the long-term diaspora in crisis-driven migration health outcomes. When large numbers of binational families in circular mobility are able to nurture stable networks and mobility patterns, they can expand their survival strategies beyond national borders. Although the lack of data in Venezuela renders these mobility patterns invisible in the context of the Colombian armed conflict, the official Colombian figures provide us with some information on the increasing number of non-migrant Venezuelans seeking medical assistance and prenatal care.<sup>22</sup>

When comparing diaspora IMRs with those of their non-migrant counterparts, migrations correlate to better health outcomes during times of crisis, as migration results in a successful survival strategy. However, these gains do not necessarily persist in the context of a crisis at the destination because immigrant IMR can be highly sensitive to a local crisis, as seen for both diasporas under study in this analysis.

The patterns and trends documented here speak to the complexity of interrelated social and demographic processes such as armed conflicts, social unrest/upheavals, migration and mortality. Contrary to the classic assimilation model of immigrant adjustment, which suggests that the health outcomes of immigrant groups improve the longer they reside in the country of destination,<sup>23 24</sup> our results show that migration's positive effect on reducing diaspora IMR relative to the native-born and their countries of origin is not straightforward. The contradiction may arise from the fact that assimilation models are used to explain south-to-north migration flows. Our results are similar to those of other studies reporting excess mortality among diaspora IMRs relative to the native-born, which highlight that two of the leading non-demographic predictors of the differential are failure to detect complications and poor prenatal care.<sup>25</sup>

### Limitations

We have focused on IMR and strategically combined a meticulously selected sample from the SBH (women who migrated before age 20 and women with up to one child born after their year of arrival), from census data and from the CRVS services in both countries. The migrant and non-migrant populations in these two countries can plausibly be compared due to their similar fertility trends. The main limitation of our study is the existence of birth order differentials in infant mortality, which makes our diaspora IMR estimates conservative. However, more detailed studies point to a neonatal mortality disadvantage for firstborns compared with later-born siblings,

which later reverses during the postnatal period and throughout the life course.<sup>26</sup> Because our data correspond to a retrospective collection, we believe our estimations somewhat smooth the differentials.

Although the IMR is internationally recognised as a fundamental measure of a population's health, it does not cover all dimensions of this concept. In a context such as binational migration between Colombia and Venezuela, other equally important and relevant aspects are reproductive health, overall mortality and violence-related mortality, just to mention a few. We acknowledge the importance of these other measures and hope to see more research on these outcomes in the future.

### Policy implications

The different diaspora IMR outcomes found in our study may be strongly related to healthcare access. Given that migrants' survival (dis)advantages relative to the native-born are concentrated in the neonatal period,<sup>27</sup> access to prenatal and postpartum care in the destination country is the key to reducing a crisis' negative effects on newborns and their mothers. If health systems are overwhelmed and institutional barriers prevent migrants from accessing them, migration can be associated with worse mortality outcomes.

Health outcomes are better among the Colombian diaspora than for non-migrant Colombians, and even better than those of non-migrant Venezuelans during the crises. Since 1961, Venezuela has maintained a parallel contributory and unremarkable welfare system for assisting and protecting all persons in the national territory, regardless of whether or not they are native-born Venezuelans or otherwise citizens of the Venezuelan state.<sup>28</sup> Likewise, the Colombian diaspora might benefit from having access to the health systems in both countries. In contrast, access to healthcare in Colombia is determined by the migrant's legal immigration status. According to the Constitutional Court of Colombia's 15 November 2017 unanimous sentence on SU677/17, access to the health system is limited to emergency services if a migrant has irregular residence status, which is the case for 56.4% of the Venezuelan diaspora in 2020.<sup>29</sup>

The Colombian government has undertaken many initiatives for regularising Venezuelan-born residency, from the Special Permanence Permit in 2017 to the implementation of a Temporary Protection Statute for Venezuelan Migrants in 2021. All these initiatives demand national ID documents, which represent a challenge for the Venezuelan diaspora. Therefore, their success in enlarging access to healthcare is limited. The most impactful initiative undertaken by the Colombian government may be the naturalisation of about 45 000 Venezuelan-born children in 2020.<sup>30</sup> This measure avoided the risk of statelessness faced by the children and allowed better healthcare for these newborns. Further initiatives must be undertaken to provide prenatal care for the Venezuelan and other diasporas living in Colombia.

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**Contributors** All authors contributed equally. JA acts as guarantor author.

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**Patient consent for publication** Not applicable.

**Ethics approval** Not applicable.

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**Data availability statement** All data relevant to the study are included in the article or uploaded as supplementary information.

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**Author note** The reflexivity statement for this paper is linked as an online supplemental file 1.

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## REFERENCES

- Mejía W. Panorama del Retorno Reciente de Migrantes Internacionales a Colombia. *Proceedings of VI Jornada Fundación Carolina*; March 19 2010, Barranquilla: Universidad del Norte, 2010:1–22.
- Cardenas M, Mejía C. Migraciones Internacionales en Colombia? ¿Que sabemos? working papers series, 2006. Available: <http://hdl.handle.net/11445/810>
- Ibáñez AM. Forced displacement in Colombia: magnitude and causes. *EPSJ* 2009;4(4):48–54. Vol. <https://www.epsjournal.org.uk/index.php/EPSJ/article/download/89/83>
- Urdinola BP. Forced migration: the case of internally displaced population in Colombia. *Les Cahiers Alhim* 2001;3.
- Observatorio Proyecto Migración Venezuela. Characterization of Venezuelans living in Colombia based on DANE - the large integrated household survey (GEIH). *Bogota: Observatorio Proyecto Migración Venezuela and DANE - GEIH* 2021. [Epub ahead of print: Available from] <https://migravenezuela.com/web/articulo/cuantos-son-y-donde-estan-los-venezolanos-en-colombia-1636>
- Brunborg H, Urdal H. The demography of conflict and violence: an introduction. *J Peace Res* 2005;42:371–4.
- Urdal H, Che CP. War and gender inequalities in health: the impact of armed conflict on fertility and maternal mortality. *International Interactions* 2013;39:489–510.
- Torche F. The effect of maternal stress on birth outcomes: exploiting a natural experiment. *Demography* 2011;48:1473–91.
- Torche F, Villarreal A. Prenatal exposure to violence and birth weight in Mexico. *Am Social Rev* 2014;79:966–92 <https://doi.org/10.1177/0003122414544733>
- University of Wisconsin. Latin America mortality database. Available: <https://www.ssc.wisc.edu/cdha/latinmortality/> [Accessed 25 Mar 2019].
- Wand M. Package 'SemiPar': Functions for semiparametric regression analysis. In: Ruppert D, Wand MP, Carroll RJ, eds. *Semiparametric regression*. Cambridge University Press, 2003. <https://cran.r-project.org/web/packages/SemiPar/index.html>
- Donrovich R, Puschmann P, Matthijs K. Rivalry, solidarity, and longevity among siblings: a life course approach to the impact of sibship composition and birth order on later life mortality risk, Antwerp (1846–1920). *Demographic Research* 2014;31:1167–98 <http://www.jstor.org/stable/26350092>
- Modin B. Birth order and mortality: a life-long follow-up of 14,200 boys and girls born in early 20th century Sweden. *Soc Sci Med* 2002;54:1051–64.
- Urdinola BP. Could political violence affect infant mortality? the Colombian case. In: *Rev. de Salud Pública*. 20, 2018.
- Salas LG. Corredores y Territorios Estratégicos del Conflicto Armado Colombiano: Una Prioridad POR Territorializar en La Geopolítica de Los Actores Armados. *Perspectiva Geografica* 2010;15:9–36.
- Avilan JH. Situation in Venezuela according to mortality statistics 1940–1995. *Gaceta Medica de Caracas* 1998; p 1998;106:27.
- García J, Correa G, Rousset B. Trends in infant mortality in Venezuela between 1985 and 2016: a systematic analysis of demographic data. *The Lancet Global Health* 2019;7:e331–6.
- Kanavos P, Colville G, Kamphuis B. “Latin America Healthcare System Overview. A comparative analysis of fiscal space in healthcare”, 2019. The London School of Economics and Political Science. London. Available: <https://www.lse.ac.uk/business/consulting/assets/documents/latin-america-healthcare-system-overview-report-english.pdf> [Accessed 21 Mar 2022].
- Rousset B, García J. Le pull and push de la migration vénézuélienne. In: Garzon OS, Sallerin M, Uribe Carreño E, eds. *Venezuela: La révolution bolivarienne, 20 ans après*, Strasbourg : L'Harmattan, 2021: 299–310.
- Mejía W. “Colombia y Las Migraciones Internacionales. Evolución Reciente y Panorama Actual a Partir de Las Cifras.”. *Revista Interdisciplinaria Da Mobilidade Humana* 2012;39:185–210.
- Rodríguez R, Stiven Y. *La Emigración Colombiana: Entre La Precariedad Y El Desplazamiento Forzado*. Universidad Santo Tomas, 2021.
- Ministerio de Salud de Colombia Bogotá DC, ed. *Plan de Respuesta del sector Salud al Fenomeno Migratorio*. MINSAL, 2019.
- Park RE. Race and Culture. In: *Glencoe, III*. Free Press, 1950.
- Kinge J, Kornstad T. Assimilation effects on infant mortality among immigrants in Norway: does maternal source country matter? *Demogr Res* 2014;31:779–812.
- Alderliesten ME, Vrijkotte TGM, van der Wal MF, et al. Late start of antenatal care among ethnic minorities in a large cohort of pregnant women. *BJOG* 2007;114:1232–9.
- Björkegren E, Svaleryd H. Birth order and child health. Working paper, no. 2017:16, Institute for evaluation of labour market and education policy (IFAU): 2011. Uppsala. Available: <https://www.diva-portal.org/smash/get/diva2:1179038/FULLTEXT01.pdf>
- Vang ZM. Infant mortality among the Canadian-born offspring of immigrants and non-immigrants in Canada: a population-based study. *Popul Health Metr* 2016;14:32.
- Delgado A. Concepción institucional del derecho a la salud en Venezuela. *Revista latinoamericana de derecho social* 2018;26:89–115.
- Colombia M. *Distribución de venezolanos en Colombia 31 de enero de 2021 Colombia*. Bogota: Migración Colombia, 2021. <https://www.migracioncolombia.gov.co/infografias/distribucion-de-venezolanos-en-colombia-corte-31-de-enero-de-2021>
- Colombia Pde la Rde. Acoger, integrar y crecer. Las políticas de Colombia frente a la migración proveniente de Venezuela. In: *Primera edición diciembre de*. Bogotá-Colombia: Presidencia de Colombia, 2020. <http://hdl.handle.net/20.500.11788/2315>

## Appendix S1 – Author Reflexivity Statement

### *A bi-national analysis of infant mortality among crisis-driven diasporas and those who remain: A population based study in Colombia and Venezuela*

#### 1. How does this study address local research and policy priorities?

This research may be the first academic attempt to estimate the Venezuelan and Colombian diasporas long-term IMR in these countries. The results contribute to the discussion on the impact of migration in population's health and mortality, from a south-south flow perspective, and considering diasporas' IMR trends during both periods of crisis and stability.

#### 2. How were local researchers involved in study design?

Dr. Castro and Dr Garcia are Colombian and Venezuelan nationals respectively. We got BAs in our respective countries. We are active members of the Latin America Population Association, and the Venezuelan and Colombian Population Studies Associations. Dr. Garcia is currently associate researcher at the Universidad Andres Bello in Caracas. The article submitted was presented at the Latin American Population Association (2020) and Colombian Population Association (2021).

#### 3. How has funding been used to support the local research team?

There was no specific fund dedicated to this study. However, Dr Garcia is funded by the H2020 European funding for Research, Marie Curie Action, Individual Global Fellowship, DEMOcrises (Grant Agreement: 892134).

#### 4. How are research staff who conducted data collection acknowledged?

We used official CRVS and censuses data to develop this research. Data came from publicly and anonymized databases. We accessed to the data via Web server. The Information on population and co-variables were collected by the official statistics office in Venezuela and Colombia.

#### 5. Do all members of the research partnership have access to study data?

Yes.

#### 6. How was data used to develop analytical skills within the partnership?

All authors were involved in the analytical interpretation of the data.

#### 7. How have research partners collaborated in interpreting study data?

We held regular meetings to discuss the data analysis process, findings, and interpretation.

#### 8. How were research partners supported to develop writing skills?

The English style of final manuscript was edited by a professional editor at the Institut National D'Etudes Demographiques INED.

#### 9. How will research products be shared to address local needs?

The paper will be published in an open-access journal, making it accessible for local researchers interested in similar areas. In the supplementary material is included all the estimations and data in-use, which makes the study replicable and the estimates re-usable for other researchers.

**10. How is the leadership, contribution and ownership of this work by LMIC researchers recognized within the authorship?**

Both authors are nationals of the countries under study and keep an academic and professional link with institutions in their country of origin.

**11. How have early career researchers across the partnership been included within the authorship team?**

Both authors are early career researchers.

**12. How has gender balance been addressed within the authorship?**

Authors are one female and one male.

**13. How has the project contributed to training of LMIC researchers?**

There is none contribution to training third parties. Both authors are early careers (post-doc) and nationals of the country under study.

**14. How has the project contributed to improvements in local infrastructure?**

This project has not directly contributed to improvements in local infrastructure; however, the findings contribute to the discussion of enlarging the access that Venezuelan migrants currently have to health care in Colombia, by estimating the gaps in IMR between migrants and Colombian nationals.

**15. What safeguarding procedures were used to protect local study participants and researchers?**

We used secondary data for this study. Hence, this question is not directly applicable in the current context.

## A bi-national analysis of infant mortality among crisis-driven diasporas and those who remain

**García, Jenny**

**Castro, Andrés**

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## 1. Census availability and quality

The censuses in Colombia and Venezuela enumerate individuals according to where they usually live (*de jure* censuses), and their unit of reference is the household. A household unit is defined as one or more people who live in the same dwelling and share meals or living accommodations regardless of their kinship relations (Tacla Chamy 2006). The completeness of census enumerations and their quality varies across countries in over time (Palloni and Pinto-Aguirre 2011). Table 1 shows omission rates for basic demographic information in censuses for Colombia and Venezuela from 1970s to 2010s. Omission rates are relatively low for both countries, between 4.6% and 10.6%, without indication of age or sex preference (ECLAC 2012). Last row indicates the mode of access to the census data: REDATAM (UN ECLAC) and IPUMS-I (Integrated Public Use Microdata Series).

Table 1 Population censuses and official omission, 1970–2020

Country	Indicators	1970s	1980s	1990	2000s	2010s
Colombia	Year	1973	1985	1993	2005	2018
	Collection	Sample	Sample	Sample	Census	Census
	% Omission*	10.6	8.2	6.7	4.9	8.5
	Availability	IPUMS	IPUMS	IPUMS	Redatam	Redatam
Venezuela	Year	1971	1981	1990	2001	2011
	Type	Sample	Census	Sample	Census	Census
	% Omission*	4.6	7.5	9.1	7.8	6.5
	Availability	Redatam	Redatam	Redatam	Redatam	Redatam

Note: IPUMS (Integrated Public Use Microdata Series), available online at <https://international.ipums.org/international/>; REDATAM (REtrieval of DATA for small Areas by Microcomputer), online census and CRVS at <https://redatam.org/redbin/RpWebEngine.exe/Portal?lang=esp>

Source: Economic Commission for Latin America and the Caribbean, Population Division, 2012 Revision — Principales cambios en las boletas de los censos latinoamericanos de las décadas de 1990, 2000 y 2010.

## 2. Civil registration and vital statistics quality

Venezuela has complete and good quality civil registration and vital statistics (CRVS) since the seventies, with 90% coverage and more than 90% of all deaths having medical certification (Bay and Orellana 2007; Jaspers-Faijfer and Orellana 1994; PAHO 2018). In contrast, Colombia had one of the highest proportions of under-registration of births and deaths in the region. It is only in recent years that the quality of Colombian registration systems has improved. Completeness of birth certification improved from around 77% in the early 2000s to 95% in 2015. Still, the completeness of death certification was about 86% in 2015 (CRVS 2018). Table 2 summarizes the historical incompleteness of the official reported death count estimates by several institutions and authors.

Table 2. Incompleteness of official reported death counts

Country	Colombia*	Venezuela
1944–1945(ù)	6.6	14.5
1950–1960(ù)	3.9	13.4
1960–1965**	10.1	24.8
1975–1980***	26.5	9.4
1980–1985	11.5	8
1990–1995(#)	24,4	9,9
2001(α)	>24.8	2.4 -12.2
2010–2012(\$)	>20	4 - 9
2021(/)	18.1	10

Source: Jasper & Orellana (1994). \* Own country reported information. \*\* Chackiel, j (1996). \*\*\* Demographic yearbook estimates. (α) PAHO (2005). (ù) Palloni et al. (2015). (\$) PAHO. (2014). (#) Bay, G. (2015). (/) United Nations Statistic Division (2021).

### 3. Mortality estimations

#### 3.1 Mortality data in use

We take the official births and deaths in the under one-year-old population reported by each country's vital statistics. Since 2014, there has been no official publication of Venezuelan birth and death counts; therefore, we take the counts reported in official international reports by the Venezuelan national government to international organizations. Table 3 show all the official figures considered for this research.

Table 3. Birth and death counts used for the infant mortality estimations

Year	Venezuela		Colombia**	
	Births(^)	Deaths*	Births	Deaths
1970	388622	19356		
1971	401531	20360		
1972	401727	21343	706485	39875
1973	401312	21387		
1974	430572	19956	707287	37378
1975	444787	19503	698052	34632
1976	459001	19761		
1977	461840	18347		
1978	471289	16541		
1979	477545	15941		21986
1980	489044	15598		22189
1981	493148	17866		23252
1982	505597			20125
1983	509604			19134
1984	498744	13731	620182	16985
1985	497732	13517	612050	18227
1986	504182	13028	617279	16438
1987	510945	12823	622551	16187
1988	514165	11867	627870	14302
1989	523436	12976	633234	14028
1990	571525	14776	638643	13258
1991	594560	12394	644099	13049
1992	553157	12327	649601	12844
1993	517845	12494	655167	11801
1994	541851	13577	669971	11575
1995	513976	12352	685110	11338
1996	488517	11913	700592	10576
1997	506487	11069	716424	11330
1998	494037	10721	720746	14794
1999	516558	10108	746013	14865
2000	533039	9649	752663	15556
2001	518320	9353	724184	14584
2002	510084	8949	700323	12758
2003	523627	10276	710577	12331
2004	509979	9272	722954	11869
2005	514784	9093	719812	11523
2006	531760	8371	714280	11107
2007	600701	8323	708998	10929
2008	567568	8307	715180	10614
2009	581576	8577	699514	9627
2010	579223	8965	654371	8355
2011	599711	8900	665281	8152
2012	605763	8881	676572	8220
2013	586137	8757	658636	7618
2014	587201	9852	668919	7589
2015	589955	10377	660825	7244
2016	581573	12866	647174	7220
2017	579349 <sup>(§)</sup>	11671 <sup>(§)</sup>	655508	7044
2018	527518 <sup>(%)</sup>	11095 <sup>(#)</sup>	645256	7203

Source: (^) INE-Venezuelan Civil registration report (2012). \*Office of Health Situation Analysis (OASIS). 2009. \*\*DANE-Vital Statistics. (\$) United Nations Statistic Division-CRVS (2021). (%) United Nations Department of Economic and Social Affairs, WPP2019. (#) United Nations Child Mortality Estimations (2020)

### 3.2 Infant mortality estimation at the national level

To estimate infant mortality rates, we adjust data incompleteness using the national inter-census life tables calculated by the Latin American Mortality Database (LAMBdA) for both countries (see Table 5). LAMBdA produces adjusted inter-census life tables of all Latin American countries based on deaths reported by the vital statistics systems and population censuses (University of Wisconsin 2018). LAMBdA adjusts specific mortality rates by eliminating incompleteness and age mis-declaration errors. These adjusted estimates create a yearly correction factor ( $\widehat{CF}_{(c,y)}$ ) according to each inter-census period (i). The  $\widehat{CF}_{(c,y)}$  comes from the linear inter/extrapolation of the inter-census ratio ( $CF_{(c,i)}$ ), which is obtained by dividing LAMBdA's rates into our rates at the national level.

$$CF_{(c,i)} = \frac{IMR_{(c,i)}}{IMR} \quad (4)$$

and,

$$\widehat{CF}_{(c,y)} = \beta_0 + \beta_1 * y_i \quad (5)$$

Then,  $\widehat{CF}$  is applied to estimate the adjusted long-term infant mortality rate in each country:

$$\widehat{IMR}_{(c,y)} = \frac{{}_1d_0(c,y)}{b(c,y)} * CF_{(c,y)} \quad (6)$$

Where  ${}_1d_0(c,y)$  refers to the under one year old population deaths in a specific country (c) and year (y), and  $b(c,y)$  to births in the same country and year.

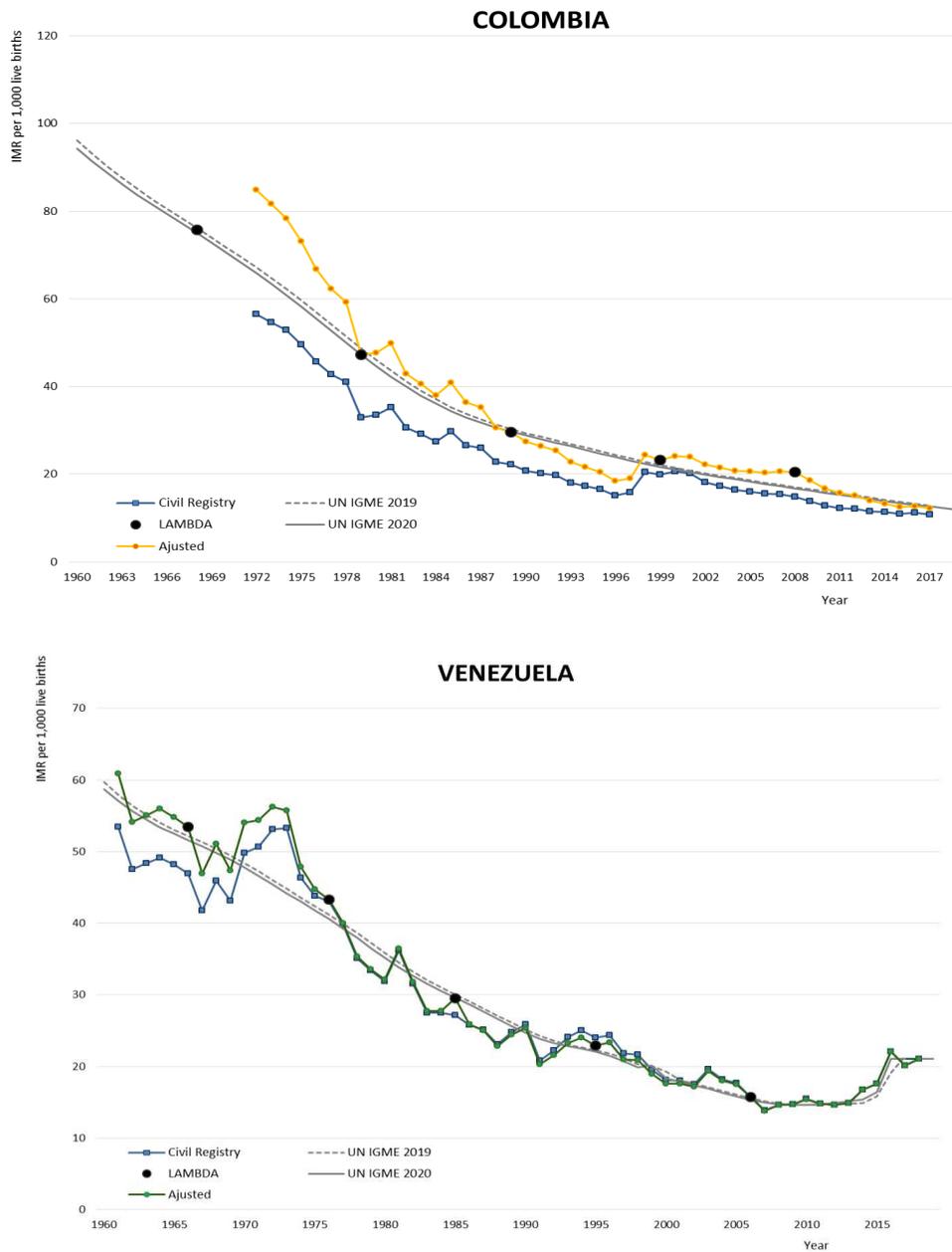
Table 4. Infant mortality estimates from LAMBdA inter-census life tables

Country	Inter-census Period	Estimated infant mortality
Venezuela	1950–1960	84.4
	1960–1971	53.5
	1971–1981	43.3
	1981–1990	29.5
	1990–2001	22.9
	2001–2011	15.7
Colombia	1964–1973	75.8
	1973–1985	47.2
	1985–1993	29.6
	1993–2005	23.3
	2005–2008	20.5

Source: University of Wisconsin, 2018

Figure 1 shows the results obtained by adjusting the officially reported national figures in both countries. We also compare our adjusted estimates to those published by the United Nations Inter-Agency Group for Child Mortality Estimations in the years 2019 and 2020.

Figure 1. Infant mortality rates in Colombia and Venezuela



Source: Own estimations, LAMBdA, UN IGME 2019 & 2020.

### 3.3 Diaspora infant mortality data availability

We estimate Colombian and Venezuelan diaspora infant mortality by using indirect methods. Indirect methods are traditionally used for countries with deficient vital registration systems. In our case, we are compelled to apply this method due to data availability and the national legal frameworks for acquiring citizenship (see Box 1) in both countries

#### **Box 1: Information on migrant events in civil registration and vital statistics**

In Venezuela, where citizenship is acquired by birth (*jus soli*), birth and death certificates include questions on nationality, the deceased's place of birth, and the mother's country of birth. Unfortunately, the information on mother's country of birth is available only for some years in official publications (2002 and 2011). The information on the deceased's place of birth and nationality remains incomplete for our aims, due to: 1) all children born in Venezuela are considered Venezuelan regardless of the mother's nationality; and 2) the information on deaths in Venezuela indicates only Colombian diaspora births that occurred before migration.

In contrast, citizenship in Colombia depends on the parents' legal status (*jus sanguinis*), and there is thus no question regarding parents' place of birth or nationality in the Colombian CRVS data. Birth and death certificates include questions on the parents' legal identity document in use and mother's usual place of residency. The collected information on the identity document is confidential and it is therefore not possible to determine the parents' country of birth or legal status. On the other hand, information on the mother's usual place of residence provides the annual birth and death statistics of populations in circular migration or families that move back and forth between the two countries.

### 3.4 Diaspora infant mortality rate estimations

Table 5 shows the number of women included in our analysis of summary birth histories by country and census years. These sample sizes warrant statistically robust analysis.

Table 5 Numbers of women migrating before age 20 and of one-child mothers giving birth after their migration date.

Country	Census	Number of women considered (% total)	Total women of reproductive age in diaspora
Venezuela	1990	83392 (39%)	213934
	2001	135197 (65%)	207259
	2011	147254 (77%)	190250
Colombia	1993		3000
	2005	9898 (81%)	12228
	2018	114097 (69%)	165806

Source: Population censuses in Colombia and Venezuela

The SBHs do not provide information on the timing of births and deaths, which we compensate for by modelling fertility and mortality age patterns. Likewise, the proportions of children ever born to women and are currently dead have been converted into a standard life table function (Moultrie, Dorrington, et al., 2013). The proportion of dead children is the ratio of children ever born (CEB) and still alive (CSA) from women in age group  $x$  to  $x+5$ :

$$D_{(x \text{ to } x+5)} = \frac{CEB(x \text{ to } x+5) - CSA(x \text{ to } x+5)}{CEB(x \text{ to } x+5)} \quad (7)$$

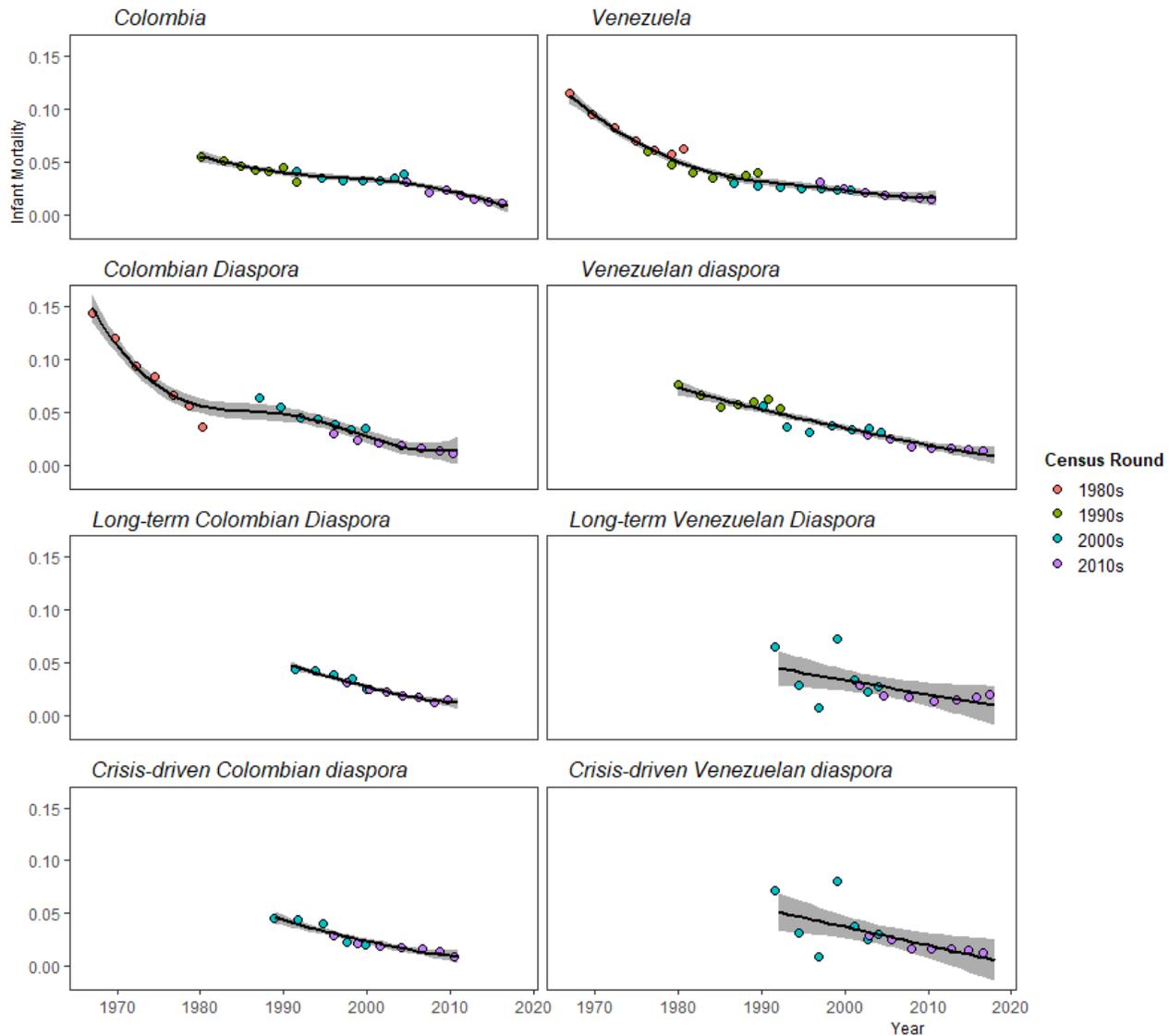
The underlying logic is that the oldest child has more years of exposure than younger ones, and the difference in the number of CEBs between groups of women indicates an above-average date of birth. Thus, parity ratios  $P$  are estimated by contrasting the proportion of women age  $x$  to  $x+5$  and age  $x+5$  to  $x+10$  with children ever born (CEB):

$$P_{(x \text{ to } x+5)} / P_{(x+5 \text{ to } x+10)} = \left( \frac{CEB(x \text{ to } x+5)}{\text{women}(x \text{ to } x+5)} / \frac{CEB(x+5 \text{ to } x+10)}{\text{women}(x+5 \text{ to } x+10)} \right) \quad (8)$$

Thus, it is possible to use the SBH data to estimate infant mortality levels for about 15 years before data collection. For all estimations, Coale-Demeny West model life tables were used because they allow making better adjustments to the latest demographic (mortality and fertility) trends in both countries. It has been established that this method overestimates infant mortality and produces declining trends once assumptions are violated (Verhulst 2016), which is the reason why we use these indirect estimates for obtaining a proportional factor of the gaps between diasporas and the total population.

We approximate annual figures for diaspora infant mortality ( ${}_n\hat{q}_{1(Di,y)}$ ) via independent p-spline models applied to the estimates obtained from the SBH. This model allows disregarding irregularities in the series introduced by the combination of several censuses, without losing possible changes in the pattern (Ahmad et al., 2000). To apply the model, we used the R package SemiPar and chose to calculate the smoothing parameter using the maximum likelihood method. This package contained functions for semi-parametric regression analysis (Wand 2003). Equation 9 shows model's specification and the normality assumption regarding the error term ( $\epsilon$ ).

$${}_n\hat{q}_{1(Di,y)} = f(y_i) + \epsilon_i, \quad \epsilon_i \sim N(0, \sigma_\epsilon^2) \quad (9)$$

Figure 2. Infant mortality estimations ( $n\hat{q}_1(Di,y)$ ) from census data

Yearly diaspora proportional factors ( $Gap_{(Di,y)}$ ) for each country, ( $c$ ), are calculated as the ratio of each diaspora subgroup ( $i$ ) and the national infant mortality. The proportional factors are later applied to the adjusted estimates using CRVS data.

$$Gap_{(Di,y)} = \frac{n\hat{q}_1(Di,y)}{n\hat{q}_1(c,y)} \quad (10)$$

We assume that under-coverage in diaspora registered births and deaths, as well as census omissions, follow the same patterns as national populations. Likewise, adjusting diaspora rates by these ratios allows us to: 1) maintain annual variations in the rates, which is crucial due to infant mortality being highly sensitive to socio-economic crises (Romero 1999); and 2) adjust the changing levels of incompleteness due to improvements in the data sources.

The sample of women described above for estimating total diaspora infant mortality allows splitting events occurring before and after migration from the declared SBH. However, this has its limitations. We assume that fertility and child survival experienced by all women is the same as for those whose entire reproductive lives were spent in the country of destination, or as those with only one child born after the year of arrival to the country of destination. (see Table 6).

Table 6. Adjusted infant mortality, diaspora gap, and diaspora IMR

Year	Adjusted IMR		Colombian diaspora		Venezuelan diaspora	
	Colombia	Venezuela <sup>a</sup>	Gap	IMR	Gap	IMR
1980	47.6	32.1	1.127	36.2	1.33	63.4
1981	49.8	36.5	1.159	42.3	1.34	66.6
1982	43.0	31.8	1.198	38.1	1.34	57.6
1983	40.7	27.7	1.243	34.5	1.34	54.7
1984	37.9	27.7	1.293	35.9	1.35	51.1
1985	40.9	29.5	1.346	39.8	1.35	55.2
1986	36.3	25.9	1.399	36.2	1.35	49.0
1987	35.2	25.0	1.448	36.2	1.35	47.4
1988	30.6	22.9	1.491	34.1	1.34	41.1
1989	29.6	24.4	1.526	37.3	1.34	39.5
1990	27.4	25.3	1.549	39.3	1.33	36.3
1991	26.4	20.3	1.560	31.7	1.31	34.7
1992	25.4	21.6	1.559	33.7	1.30	33.0
1993	22.8	23.3	1.545	35.9	1.28	29.3
1994	21.6	24.0	1.521	36.5	1.26	27.2
1995	20.4	22.9	1.487	34.0	1.23	25.1
1996	18.4	23.3	1.442	33.7	1.20	22.0
1997	19.0	21.0	1.389	29.2	1.16	22.1
1998	24.3	20.9	1.329	27.8	1.13	27.4
1999	23.3	19.0	1.265	24.0	1.09	25.4
2000	24.1	17.6	1.199	21.1	1.05	25.5
2001	24.0	17.6	1.131	20.0	1.02	24.5
2002	22.2	17.2	1.065	18.3	0.99	21.9
2003	21.5	19.3	1.001	19.4	0.96	20.6
2004	20.7	18.0	0.942	17.0	0.93	19.4
2005	20.6	17.6	0.890	15.6	0.91	18.8
2006	20.4	15.7	0.849	13.3	0.89	18.2
2007	20.6	13.8	0.823	11.4	0.88	18.1
2008	20.5	14.6	0.814	11.9	0.87	17.9
2009	18.6	14.7	0.828	12.2	0.87	16.1
2010	16.8	15.5	0.868	12.1	0.87	14.5
2011	15.7	14.8	0.868	12.0	0.87	13.6
2012	15.1	14.6	0.868	12.7	0.88	13.4
2013	14.0	14.9	0.868	12.9	0.91	12.7
2014	13.3	16.7	0.868	14.5	0.95	12.6
2015	12.5	17.6	0.868	15.3	1.01	12.7
2016	12.7	22.1	0.868	19.2	1.12	14.3
2017	12.3	20.1	0.868	17.5	1.32	16.1
2018	12.7	21.0	0.868	18.3	1.32	16.7

Source: Own estimations

### 3.4 Long-term and recent diaspora infant mortality

We analyse the diaspora infant mortality differential according to time of migration and whether it is long-term or recent during the crisis-driven migration periods. The crises periods we focus on are 1998–2004 for the Colombian diaspora and 2013–2018 for the Venezuelan diaspora. The idea of long-term migration refers to the migration flow occurring during a pre-conflict period. In this sense, we calculate the infant mortality of the Colombian diaspora

that arrived in Venezuela before 1998. and that of the Venezuelan diaspora living in Colombia and whose year of arrival is previous to 2013. We follow the same steps implemented for estimating the total diaspora infant mortality. Furthermore, we analyse the SBH of: 1) women whose maximum age upon arrival in the destination country was 20 years; and 2) women who declared having ever given birth to only one child and only after the year of arrival in the destination country (see Table 7).

Table 7 Numbers of women who migrated before age 20 and of one-child mothers who gave birth after the migration date, by recent or long-term migration

Country	Census	Number of women considered		
		Total diaspora	Long-term	Recent
Venezuela	2001	161029	123700 (77%)	37329 (33%)
	2011	147254	76104 (52%)	71149 (48%)
Colombia	2018	115109	6993 (7%)	108116 (93%)

Source: Population censuses in Venezuela and Colombia

We create a ratio of the long-term migration and recent or crisis-driven migration relative to the total infant mortality in the Venezuelan 2001 and 2011 censuses and the Colombian 2018 census. These annual ratios are applied to the adjusted IMR calculated with CRVS data (see Table 8).

Table 8. Long term and crisis-driven diaspora gap and IMR

Year	Adjusted IMR		Diasporas adjusted IMR					
	Colombia	Venezuela	Diaspora gap (Di. C)			Diaspora IMR		
			Total	Long-term	Crisis-driven	Total	Long-term	Crisis-driven
Colombian diaspora								
1997	19.0	21.0	1.39	1.15	1.42	29.2	24.1	29.9
1998	24.3	20.9	1.32	1.11	1.33	27.8	23.3	27.8
1999	23.3	19.0	1.26	1.08	1.25	24.0	20.5	23.7
2000	24.1	17.6	1.19	1.05	1.21	21.1	18.5	21.4
2001	24.0	17.6	1.13	1.02	1.18	20.0	18.0	20.8
2002	22.2	17.2	1.06	0.99	1.14	18.3	17.0	19.6
2003	21.5	19.3	1.00	0.96	1.09	19.4	18.5	21.1
Venezuelan diaspora								
2011	15.7	14.8	0.87	0.94	0.87	13.6	14.8	13.6
2012	15.1	14.6	0.88	0.97	0.88	13.4	14.6	13.3
2013	14.0	14.9	0.91	1.00	0.91	12.7	14.0	12.7
2014	13.3	16.7	0.95	1.05	0.95	12.6	14.0	12.6
2015	12.5	17.6	1.01	1.13	1.00	12.7	14.1	12.5
2016	12.7	22.1	1.12	1.25	1.10	14.3	15.9	14.0
2017	12.3	20.1	1.32	1.46	1.30	16.1	17.9	15.9
2018	12.7	21.0	1.32	1.46	1.30	16.7	18.6	16.5

Source: Own estimations.

## Reference

- Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. *New York: Bulletin of the World Health Organization* 78. 2000. 1175-1191.
- Bay. Guiomar and Hernán Orellana. 2007. “La Calidad de Las Estadísticas Vitales En América Latina.” in *Taller de expertos en el uso de estadísticas vitales: alcances y limitaciones*. Santiago de Chile.
- Bay. 2015. *América Latina: diferencia relativa de las defunciones totales (por cien) implícitas en las estimaciones y proyecciones de población y las defunciones registradas y disponibles según quinquenio. 1950-2005*.
- Chackiel. j (1996). "La investigación sobre causas de muerte en América Latina". *Notas de Población*. n° 44: pp 9-30. CELADE. Santiago. Chile.
- Civil Registration and Vital Statistics. 2018. “Colombia: A Strategy to Improve the Registration and Certification of Vital Events in Rural and Ethnic Communities”. *Bloomberg Philanthropies Data* (September) <https://crvsgateway.info/file/16987/2020>
- DANE- National Administrative Department of Statistics. 2019. *Resultados Censo Nacional de Población y Vivienda. 2018*. Bogotá D.C.
- Vital Statistics: Geovisor de estadísticas vitales (REDATAM) [Extracted in February 2020] <http://systema74.dane.gov.co/bincol/rpwebengine.exe/portal?lang=esp>
- European Commission. 2019. “Latin America and Caribbean.” *European Civil Protection and Humanitarian Aid Operations*. Retrieved ([https://ec.europa.eu/echo/where/latin-america-caribbean\\_en](https://ec.europa.eu/echo/where/latin-america-caribbean_en)).
- Human Rights Watch. 2019. *Venezuela’s Humanitarian Emergency*.
- Jaspers-Faijer. Dirk and Hernan Orellana. 1994. “Evaluación Del Uso de Las Estadísticas Vitales Para Estudios de Causas de Muerte En América Latina.” *Notas de Población* 60:47–77.
- INE-Venezuelan National Institute of Statistics. Vital Statistics Query System. . Birth counts. [Online] 2000-2012. [Cited: 03 12. 2018.] <http://www.ine.gov.ve/evitalesjsp/evitales.html>.
- 2001 Household and population census. REDATAM micro-data. [Online] [Cited: 01 03. 2020.] <http://www.redatam.ine.gov.ve/Censo2001/index.html>.
  - 2011 Household and population census. REDATAM micro-data. [Online] [Cited: 01 03. 2020.] <http://www.redatam.ine.gov.ve/Censo2001/index.html>.
- Minnesota Population Center. *Integrated Public Use Microdata Series. International: Version 7.3 [dataset]*. Minneapolis. MN: IPUMS. 2020. <https://doi.org/10.18128/D020.V7.2>
- Ministry of Health in Venezuelan -Office of Health Situation Analysis (OASIS). *Maternal and Infant Mortality. Bolivarian Republic of Venezuela. 1990-2009*. Caracas: Office of Health Situation Analysis. 2012.
- *Morbidity Yearbook*. Caracas: Epidemiology Division. 2003-2009.

- Notifiable Diseases Bulletin ("Boletín epidemiológico"). Caracas: s.n.. 2002-2016.
- Pan-American Health Organization "Atlas de indicadores básicos de salud en las Américas. 2001". Washington: PAHO. 2005.
- Basic indicators. Washington: PAHO. 2014.
- Palloni. A. and G. Pinto-Aguirre (2011). Adult Mortality in Latin America and the Caribbean. International Handbook of Adult Mortality. R. G. Rogers and E. M. Crimmins. Dordrecht. Springer Netherlands: 101-132.
- Palloni et al. (2015) "Two centuries of mortality decline in Latin America. from hunger to longevity"
- Romero. D. 1999. "Relación Entre Los Cambios de La Mortalidad Infantil y Deterioro Socioeconómico En Venezuela Durante La Década de Los Ochenta: Un Análisis Socio-Espacial."
- Tacla Chamy. O. (2006). La omisión censal en América Latina. 1950-2000. Proyecto Banco Interamericano de Desarrollo (BID-CELADE/CEPAL). P. Division. Santiago de Chile. United Nations Economic Commission for Latin America and the Caribbean
- United Nations High Commissioner for Refugees (UNHCR). 2021. Global trends forced displacement in 2020 <https://www.unhcr.org/60b638e37/unhcr-global-trends-2020>
- United Nations Statistics Division (2021) Demographic and Social Statistics. Civil Registration and Vital Statistics. <https://unstats.un.org/unsd/demographic-social/crvs/>
- United Nations Child Mortality Estimations (2020). Levels & Trends in child Mortality Estimates developed by the UN Inter-agency Group for Child Mortality Estimation Report 2020 <https://childmortality.org/wp-content/uploads/2020/09/UNICEF-2020-Child-Mortality-Report.pdf>
- UCAB-UCV-USB. Survey on living conditions in Venezuela ENCOVI-2016. Bengoa Foundation. [Online] [Cited: 04 10. 2018.] <https://www.fundacionbengoa.org/noticias/2017/encovi-2016.asp>.
- University of Wisconsin. 2018. "Latin America Mortality Database." Retrieved (<https://www.ssc.wisc.edu/cdha/latinmortality/>).