

# Trends in infant mortality in Venezuela between 1985 and 2016: a systematic analysis of demographic data

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## Summary

**Background** Between the 1950s and 2000, Venezuela showed one of the most substantial improvements in infant mortality rates in Latin America. However, the recent economic crisis alongside an increase in infectious and parasitic diseases might be reversing previous patterns. Because no official updated mortality statistics have been published since 2013, the effect of these recent events has been difficult to assess accurately. We therefore aimed to estimate infant mortality rate trends and report the effect of the crisis.

**Methods** We estimated infant mortality rates using direct methods (ie, death counts from Venezuelan Ministry of Health via yearbooks and notifiable diseases bulletins, and birth records published by the UN Economic Commission for Latin America and the Caribbean and the Venezuelan National Institute of Statistics) and indirect methods (using census data and a Living Conditions Survey ENCOVI 2016). We shaped yearly estimations using a semiparametric regression model, specifically a P-Spline model with a cubic thin plate base. The primary objective was to estimate infant mortality rate trends from 1985 to 2016.

**Findings** Around 2009, the long-term decline in infant mortality rate stopped, and a new pattern of increase was observed. The infant mortality rate reached 21·1 deaths per 1000 livebirths (90% CI –17·8 to 24·3) in 2016, almost 1·4 times the rate of 2008 (15·0, –14·0 to 16·1). This increase represents a huge setback on previous achievements in reducing infant mortality.

**Interpretation** Our conservative estimation indicates that Venezuela is in the throes of a humanitarian crisis. The increase in infant mortality rate in 2016 compared with 2008 takes the country back to the level observed at the end of the 1990s, wiping out 18 years of expected progress, and leaves the Venezuelan Government far from achieving the target of nine deaths per 1000 livebirths stated in the UN Millennium Development Goals.

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## Introduction

Accelerated economic and social transformations led to improved living standards in Venezuela during the second half of the 20th century.<sup>1</sup> An increase in life expectancy mostly driven by a reduction of infant mortality—from 108·0 per 1000 livebirths in 1950 to 18·2 in 2000—was observed during this period.<sup>2</sup> As in most Latin American countries, this progress was linked to macroeconomic development, notably sanitary controls, mass vaccination campaigns, elimination of disease vectors, and antibiotic distribution.<sup>3</sup> Initial improvements were attributable to a reduction of infectious and parasitic diseases such as gastroenteritis, malaria, and tuberculosis.<sup>1</sup>

Recent socioeconomic and political events have led to a collapse in living standards, along with a breakdown of the health system.<sup>4</sup> Gross domestic product per capita decreased by almost 30% in 2016 and 14% in 2017.<sup>5</sup> Cumulative inflation reached 254·4% in 2016 and 1087·5% in 2017, and the national budget deficit was more than 13%.<sup>5</sup> At the individual level, the 2014 consumer survey report signalled declining consumption of foods providing essential micronutrients, such as

milk (–45%) and beef (–12%), compared with previous years.<sup>6</sup> In 2017, 61·2% of the population was in extreme poverty;<sup>7</sup> 89·4% of households reported not having enough money to buy food and 61·9% of the adult population had gone to bed hungry at least once during the past 3 months.<sup>8</sup>

In parallel, funding for the Venezuelan health system has been substantially reduced since 2007.<sup>9</sup> Patient-to-doctor ratios have decreased from 1·7 to 1·2 per 1000,<sup>10</sup> and hospital bed ratios (hospital bed per population) have fallen from 1·3 to 0·73 per 1000.<sup>11</sup> Vaccination campaigns have ceased in many parts of the country. Between 2007 and 2009, for example, the Venezuelan Ministry of Health did not provide vaccines against polio; diphtheria, tetanus, pertussis, hepatitis B, and *Haemophilus influenzae* type b; to children younger than 5 years, and did not vaccinate nearly 20% of children in 2010.<sup>12</sup> In addition, shortages of basic medicines, surgical supplies, and infant formula have increased health-care costs,<sup>13</sup> making it unaffordable for most of the population. Contrary to official governmental rhetoric, public health spending has never exceeded individual spending since 1990, and household

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### Research in context

#### Evidence before this study

Since 2013, no official mortality estimates have been published in Venezuela. Consequently, academic studies attempting to quantify infant mortality trends for the most recent years are likely to be inaccurate. We used the data released from the 2014–16 Notifiable Diseases Bulletins and the 2016 National Survey of Living Conditions of the Venezuelan Population (known as ENCOVI 2016) to produce more realistic infant mortality rate estimations.

#### Added value of this study

This study might be the only attempt to robustly estimate annual infant mortality rates for the most recent years in Venezuela. In this sense, two pieces of added value can be

identified: the estimation of long-term updated infant mortality rate trends and determination of infant mortality rates during times of crisis and absent data.

#### Implications of all the available evidence

International infant mortality rate estimates for Venezuela do not reflect the progressive deterioration in socioeconomic conditions. On the contrary, they involuntarily conceal the humanitarian crisis when modelling a continuous decreasing trend in infant mortality. Venezuela's case could be an obvious exception because of a relatively unexpected shift in mortality and fertility patterns. However, monitoring in countries should be guided when possible by sound empirical data adjusted for known biases, rather than by modelling assumptions.

spending accounted for 64% of total health expenditures in 2014—one of the highest percentages in Latin America.<sup>11</sup>

Medical and humanitarian non-governmental organisations have been reporting increasing morbidity and mortality due to infectious and parasitic diseases. Diseases that have been controlled or eradicated in the past decades are reappearing. Most of them are associated with inadequate access to basic sanitation, malnutrition, and insufficient vaccination campaigns. In the past 2 years, the Pan-American Health Organization has issued several epidemiological alerts reporting malaria,<sup>14</sup> measles,<sup>15</sup> and diphtheria<sup>16</sup> outbreaks. Critical warnings are given out not just to the Venezuelan Government but also to neighbouring countries affected by the spread of these diseases.<sup>17</sup>

A strict secrecy policy has ruled public institutions, especially since 2013. Data sources are no longer updated nor publicly available.<sup>4</sup> The government's constant denial of the crisis has made it even more difficult to properly assess its extent. At the international level, the UN Economic Commission for Latin America and the Caribbean (ECLAC) collected, systematised, and published statistical information including infant mortality estimations.<sup>18</sup> Their estimations were built on the basis of life tables implicit in the population projections. Likewise, WHO produces infant mortality estimations for all countries through the Global Health Observatory.<sup>19</sup> In Venezuela's case, the latest available estimates are based on official data reported by the Venezuelan Ministry of Health in 2013. WHO's updated 2018 estimations as well as ECLAC's updated 2016 estimations rely on the projection of a continuous decrease in infant mortality (appendix p 9). As a consequence, they cannot reflect the effect of the recent socioeconomic deterioration.

The UN Inter-Agency Group for Child Mortality Estimation (IGME)<sup>20</sup> produces an annual report on trends in neonatal, infant, and under-5 mortality for all UN member states. 2017 IGME estimations did not

consider any change in mortality trends, reporting an infant mortality rate of 14.1 per 1000 livebirths for the year 2016. The IGME estimations update of infant mortality rate released on Sept 18, 2018, incorporated new estimation solely for the years 2014 and 2016, without indicating the official Venezuelan data source (appendix pp 9–11).

To overcome the information gap, we took up the challenge of producing the most accurate yearly infant mortality rate estimation possible. We decided to focus on infant mortality rate because its trends are very sensitive to malnutrition, environmental risks, and dysfunctional health services,<sup>21</sup> all of which are combined in the current Venezuelan context. Our hypothesis is that the historical downward trend in infant mortality has been reversed and that the economic breakdown has led to a humanitarian crisis in the country. We therefore aimed to estimate infant mortality rate trends, reveal the current situation of infant mortality in the absence of official estimations, and report the humanitarian emergency underway through analysis of infant mortality rates.

### Methods

#### Data sources

Infant mortality analysis requires calculation of death counts in the population who are younger than 1 year, as well as livebirths during the same period. Information about both events is covered and published by a vital statistics system. Quality evaluations of the Venezuelan vital statistics system estimated under-coverage of about 2.4%,<sup>22</sup> which is better than most Latin American countries.<sup>23</sup> For our analysis, we took death counts published by the Venezuelan Ministry of Health in its mortality yearbooks from 1985 to 2013,<sup>24</sup> and reported by WHO. These yearbooks include all deaths for which a medical certification was issued, regardless of its civil or legal registration (appendix p 2). To complete the infant mortality rates, we took long-term birth series estimated by ECLAC<sup>18</sup> and those held as reference by the Venezuelan

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Ministry of Health for its official infant mortality rate estimations.

As indicated previously, neither mortality yearbooks nor any other official mortality estimates have been published since 2013. However, weekly Notifiable Diseases Bulletins<sup>25</sup> from 2013 to 2016 were briefly available during the year 2017 on the Venezuelan Ministry of Health's official website.<sup>4</sup> Although the main aim of these bulletins is not to report death counts, they do dedicate a section to report weekly hospital deaths of the population who are younger than 1 year since 2003. The Notifiable Diseases Bulletins annual deaths summary has historically underestimated mortality yearbook counts (appendix p 4). This underestimation was readily summarised into a linear model (appendix pp 2, 3). We created adjusted death counts for the years 2013–16, corrected with a linear extrapolated underestimation ratio. Birth counts for the years 2003–16 came from summaries of registered births corrected by the National Institute of Statistics (appendix pp 3, 4).<sup>26</sup> To estimate this set of infant mortality rates, we assumed births of late-registration patterns and proportion of hospital deaths kept the same historical pattern, meaning data quality and coverage remained unchanged despite the crises.

Another important source of information in the country is census and survey data. During the period of our analysis, the National Institute of Statistics had undertaken three population and household censuses in 1990, 2001, and 2011. Census data remain available and allow information to be collected about the numbers of children ever born and children dead by women's age. More recently, a National Survey of Living Conditions of the Venezuelan Population (ENCOVI) has been done annually by three of the most important universities in the country. In 2016, the ENCOVI survey included questions regarding the number of children ever born and still alive. This information is known as a summary birth history and is commonly used by demographers to apply model-based methods to estimate infant mortality rates. Here, we use Brass's method on Trussell's variant (appendix pp 4, 5). This variant calculates multipliers to transform proportions of children who have died into cohort-specific probabilities of dying through a regression approach.

### Data analysis

In short, we used estimations based on direct and indirect methods to produce three sets of data. The first dataset comprised infant mortality rates from 1985 to 2013, using a direct method on death counts from the mortality yearbooks and birth records published by ECLAC and the Venezuelan Ministry of Health. The second dataset included infant mortality rates from 2003 to 2016, using direct methods on adjusted deaths and births. The third dataset consisted of a group of infant mortality rate estimations, obtained through indirect methods based on census data and a recent living

conditions survey (ie, ENCOVI 2016). In this sense, we covered all data sources publicly available in the country regarding mortality data from 1985 to 2016.

All previous infant mortality rate estimations were synthesised and smoothed in a P-spline model. This model allows us to eliminate irregularities in the data produce by combining several data sources and methods of adjustment, each affected by different types of error,<sup>27</sup> without losing possible changes in the pattern. The P-spline method of this research has a cubic thin plate base and the smoothing parameter  $\lambda$  is estimated using maximum restricted likelihood (appendix pp 6, 7).<sup>28</sup> We used maximum restricted likelihood to set probable historical patterns. The assumptions of this model are the same as those that underlie the mixed linear models. We present the most probable infant mortality rate estimations rather than the most exact ones, because of the available estimations in the country.

We used the R package SemiPar developed by Matt Wand (2003) for the data analyses.

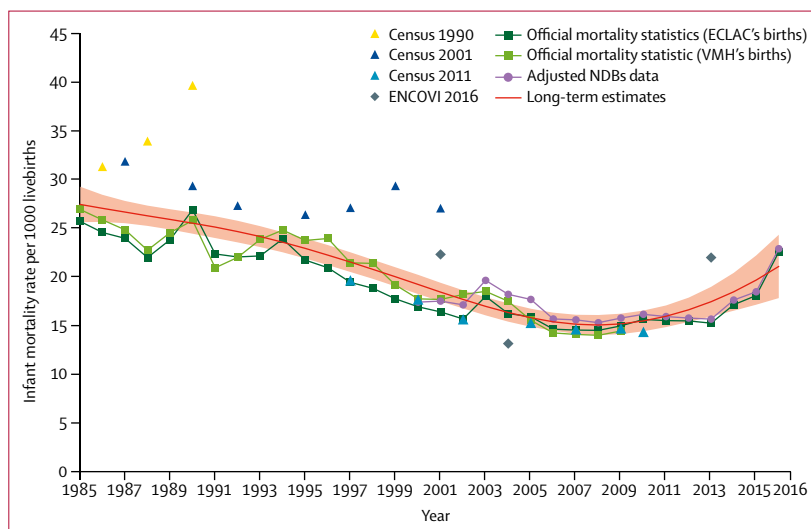
For more on the SemiPar package see <https://cran.r-project.org/web/packages/SemiPar/SemiPar.pdf>

### Role of the funding source

There was no funding for this study. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

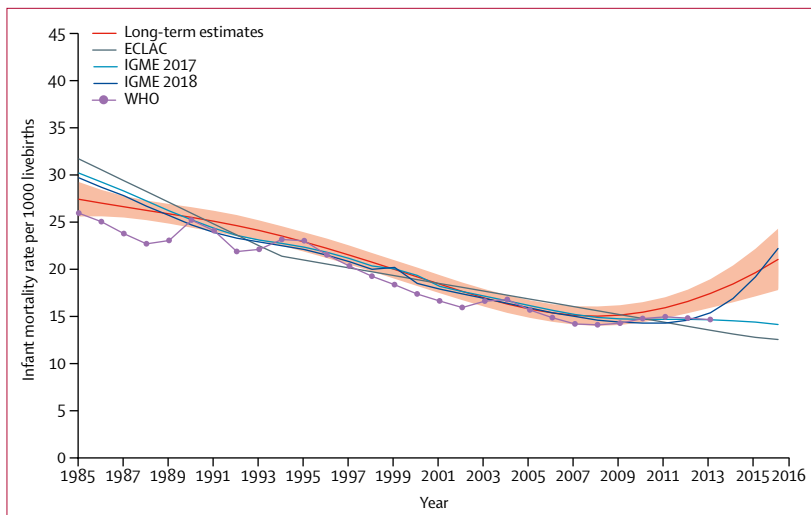
### Results

Trends in infant mortality rates started changing from 2009 onwards (figure 1). Rates stopped declining and began increasing, with the steepest increase seen after 2011. In 2016, the infant mortality rate (21.1 deaths per 1000 livebirths, 90% CI –17.8 to 24.3) had returned to the level observed at the end of the 1990s.



**Figure 1: Venezuelan infant mortality rate estimations between 1985 and 2016**

Orange shading is the 90% CIs of long-term estimates. ECLAC=Economic Commission for Latin America and the Caribbean. VMH=Venezuelan Ministry of Health. NDBs=Notifiable Diseases Bulletins. ENCOVI=National Survey of Living Conditions of the Venezuelan Population.



**Figure 2: Comparison with international Venezuelan infant mortality estimations between 1985 and 2016**  
Orange shading is the 90% CIs of long-term estimates. ECLAC=Economic Commission for Latin America and the Caribbean. IGME=Inter-Agency Group for Child Mortality Estimation.

According to Reed and colleagues,<sup>29</sup> several stages of alerts based on mortality rates can be used as thresholds to formally declare a humanitarian emergency. These thresholds can be either fixed or assigned according to a baseline.<sup>30</sup> One way to see it is to link stages to specific proportional increases. Thus, an initial phase of a crisis is determined by the time in which the rate doubles its value, whereas the height of the crisis is the phase between the doubling and its maximum increase. In Venezuela, the infant mortality rate during the year 2016 was 1.4 times the rate of 2008 (15.0, –14.0 to 16.1). By Reed and colleagues' measure, then, the country is on the way to entering the second stage of a humanitarian crisis.

Although we were unable to determine the causes of death from the data gathered, the 2017–18 WHO reports<sup>14</sup> indicate that in Venezuela, during the first decade of the 21st century, malaria prevalence stabilised at around 1.5 per 1000 inhabitants, with lethality at less than 0.05% of the reported cases (appendix pp 12, 13). By 2016, incidence had increased five times to 7.5 per 1000 inhabitants and continued increasing up to 10.1 per 1000 during the year 2017.<sup>14</sup> Until now, malaria outbreaks have been mostly concentrated in the southern region of Venezuela, where uncontrolled mining activity has been increasing. However, WHO's most recent reports have been identifying cases all over the country.

Likewise, cases of measles have tripled since 2013. 727 cases were reported in 2017 and 4605 cases between January and August, 2018, whereas in the past there were rarely more than 300 cases per year. The age group most affected among the confirmed cases is children younger than 5 years.<sup>15</sup> Diphtheria, a disease eradicated in Venezuela in the 1990s, has reappeared. Diphtheria outbreaks have continued spreading. 2024 cases in total have been reported since 2016 (324 cases in 2016,

1040 cases in 2017, and 660 cases between January and August, 2018). So far, cumulative diphtheria lethality exceeds 16.5% of reported cases<sup>16</sup> when it does not usually exceed 10%.<sup>31</sup> Medicine shortages, elevated costs of antibiotics, and a deficit of tetanus–diphtheria booster shots impair the situation.

In addition to the alarming malaria, measles, and diphtheria outbreaks, reported diseases in the 2014–16 Notifiable Diseases Bulletins<sup>25</sup> showed constant increases in cases of diarrhoea (34.6%) and acute bronchitis (almost 40%), as well as an increase in already high maternal mortality. In 2016, 65.8% more deaths were associated with complications during childbirth than in previous years. Deterioration of the health system and less access to monthly antenatal care programmes might have contributed to this increase.

## Discussion

Progress achieved in Venezuela during the first decade of the 21st century has been completely cancelled out by the increase in infant mortality rate over the past 7 years, confirming our hypothesis. Different methods have been used to produce accurate infant mortality estimations, from simple linear regression adjustment to more sophisticated techniques such as splines. We have provided robust estimations and filled the gap in national statistics for the most recent years. The main assumption behind these estimates is that, despite the deep crisis, registration patterns for both birth and death counts remained stable. We acknowledge that this assumption might not be realistic because of the deep socioeconomic crisis affecting public institution performance. Although we were unable to prove and measure possible changes, we take the risk of producing conservative estimations. This factor constitutes the main limitation of our analysis (appendix p 8).

Comparing our results with IGME's 2017 revision, we noticed that the infant mortality rate figures before 2009 were very similar (figure 2). IGME's most recent data for estimating infant mortality rate come from the 2013 vital registration system. These data certainly cannot account for the effects of the recent deterioration in living conditions in Venezuela. It should, however, give clues about increasing mortality rates before 2013. We found the same discrepancy with WHO estimations.<sup>19</sup> Even bigger differences are found with respect to IGME's 2018 revision, for the period before 2013 (appendix pp 9–11). The inclusion of new infant mortality rate estimation for the latest year gives the appearance of a sudden crisis shock, which reversed the declining trend after the year 2013, and our estimations show a progressive deterioration. Digging deeper into the data, it is possible to see differences that might come from changes in fertility pattern. WHO's birth figures are considerably higher when comparing with our estimations and ECLAC's latest ones (appendix p 11). Following adjusted births in vital registration for the most recent years allows us to see

not just declining fertility rates but also important changes in the fertility age structure (appendix pp 11, 12). Since 2006, fertility has been declining for all age groups of women, except the 10–19 year age group (appendix p 12). Teenage pregnancy represents higher risks of infant mortality than in any other group of women.

More generally, the increasing infant mortality rate is likely to derive from the progressively deteriorating nutrition status, the collapse in living standards, and a breakdown of the health system. This breakdown of the health system is reflected in the systematic undercutting of vaccination campaigns, and shortage of medicines and medical treatment. The UN Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) consider child mortality as a key indicator of health, social, and environmental conditions. In this framework, and as a member of the UN, Venezuela assumed the legal commitment to reduce infant mortality to nine or less per 1000 livebirths by the year 2015. This commitment has not been kept.<sup>32</sup> During the 2000s, Venezuela had created policies, such as health missions, aimed at the most vulnerable populations. But these efforts are not reflected in the avoidable death rates of Venezuelan children seen today. In the concluding year of the MDGs, Venezuela committed via the SDGs to eradicate preventable infant deaths. Regrettably, far from succeeding, the country is showing a deterioration of child survival for the first time. Venezuela is the only country in South America that has risen back to the infant mortality rate levels of the 1990s.

During important crises, the most common causes of death are the same as those reported in countries with the highest child mortality rates: diarrhoeal diseases, acute respiratory infections, measles, malaria, and severe malnutrition.<sup>21</sup> All these elements are present in Venezuela and will certainly adversely affect future infant mortality rate trends. Organisations such as the Venezuelan Health Observatory,<sup>33</sup> International Amnesty,<sup>34</sup> and the UN Refugee Agency<sup>35</sup> have acknowledged the state of the humanitarian crisis in Venezuela. In 2016, the Venezuelan National Assembly declared a humanitarian crisis in the country and requested international humanitarian aid to facilitate the importation of medical supplies and medicines into the country.<sup>4</sup> This attempt and all others have been vetoed by the government. This study provides a strong evidence base for action to be taken to alleviate and aid the humanitarian crisis under way in Venezuela.

#### Contributors

JG and GC conceptualised this paper and analysed the data. JG wrote the first draft. BR contributed to the interpretation and literature review. All authors agreed with the final version of the paper.

#### Declaration of interests

We declare no competing interests.

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