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

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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-Faijer 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(¤)	>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. (¤) PAHO (2005). (ù) Palloni et al. (2015). ($) PAHO. (2014). (#) Bay, G. (2015). (/) United Nations Statictis Division (2021).

3. Mortality estimations

3.1Mortality 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($)	11671($)	655508	7044
2018	527518(%)	11095(#)	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.

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

and,

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

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

$$\widehat{IMR_{(c,y)}} = \frac{{}_1d_0(c,y)}{b(c,y)} * CF_{(c,y)} \tag{6}$$

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.

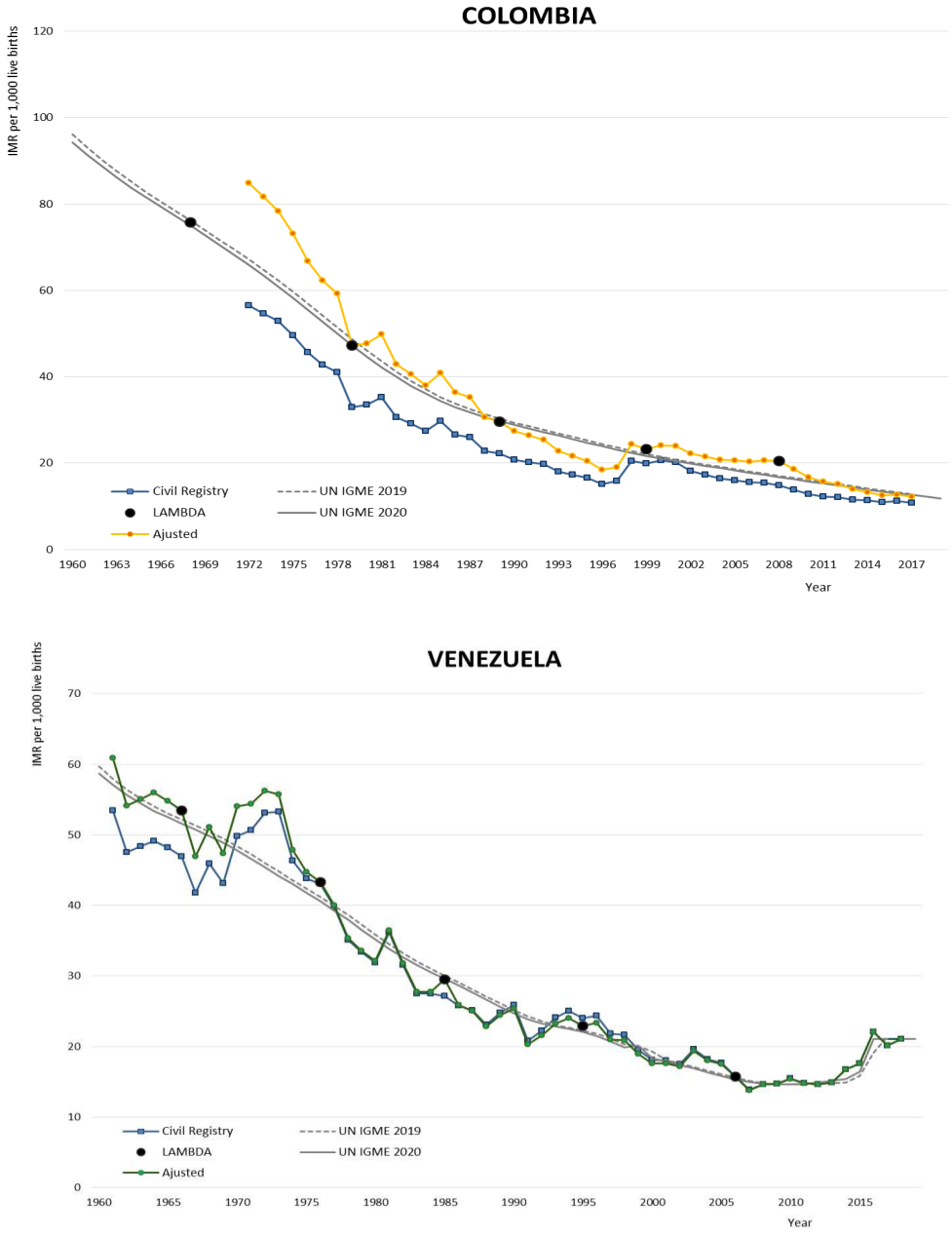
Table 4. Infant mortality estimates from LAMBdA inter-census life tables

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
	2005–208	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*:

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

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):

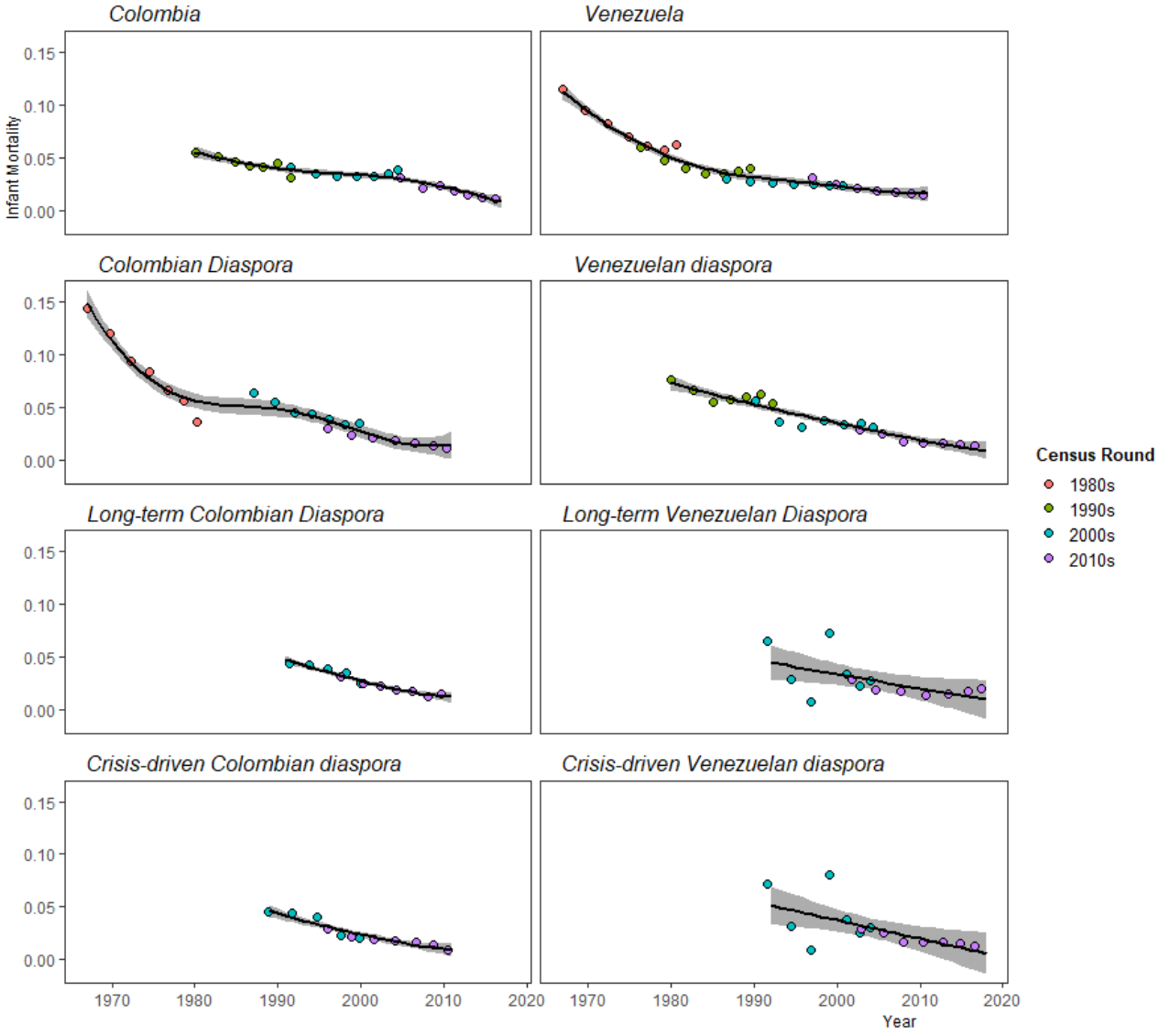
$$P_{(x\ to\ x+5)} / P_{(x+5\ to\ x+10)} = \left(\frac{CEB\ (x\ to\ x+5)}{women\ (x\ to\ x+5)} / \frac{CEB\ (x+5\ to\ x+10)}{women\ (x+5\ to\ x+10)}\right) \tag{8}$$

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).

$${}_n\hat{q}_{1\ (Di,y)} = f(y_i) + \varepsilon_i, \qquad \varepsilon_i \sim N(0, \sigma_\varepsilon^2) \tag{9}$$

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.

$$Gap_{(Di,y)} = \frac{{}_n\hat{q}_{1\,(Di,y)}}{{}_n\hat{q}_{1\,(c,y)}} \tag{10}$$

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	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					
			Diaspora gap (Di. C)			Diaspora IMR		
	Colombia	Venezuela	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.

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