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ORIGINAL ARTICLE

Infant Mortality in the Metropolitan Region, Chile 2005-2014

Mortalidad Infantil en las comunas de la Región Metropolitana, período 2005-2014

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What do we know about the subject matter of this study?

In Chile, infant mortality has not experienced a significant decrease in the last decade, however, it is one of the lowest in Latin America. Furthermore, it has not been possible to reduce the gaps within the country, as is the case between local communities.

What does this study contribute to what is already known?

This study allows us to recognize the inequality gaps between municipalities with higher and lower infant mortality rates and their sub-components, deepening the importance of characterizing differences in the territory in order to develop public policies in line with local needs.

Abstract

Introduction: Infant mortality depends on the economic, social, and cultural level of development of the place of residence. **Objective:** To describe the infant mortality rates (IMR) and the late infant mortality rates (LIMR) of the Metropolitan Region (MR) communes and to evaluate their trend between 2005 and 2014. **Material and Method:** Ecological study that describes the rates of the 52 communes of the MR. For the analysis, the IMR and LIMR were elaborated for each year and commune and were compared using population attributable risk (PAR), attributable risk percent (AR%), and rate ratio (RR). Trends were analyzed through the Prais-Winsten model. A value $p < 0.05$ was considered a statistically significant trend. **Results:** The commune 'Independencia' presented the highest IMR and LIMR with 12.7 and 4.05 per 1000 live births respectively, 1.75 and 2.05 times more compared with the IMR and LIMR of the MR. The commune 'Las Condes' and 'Vitacura' presented the lowest IMR and LIMR respectively. The IMR trend regarding 2005 increased in Lo Barnechea, Lo Espejo, and Recoleta, and decreased in Las Condes, Macul, Pudahuel and San Bernardo. The LIMR decreased in Peñalolén, Puente Alto, Las Condes, Providencia, San Bernardo, Macul, Pudahuel, Talagante, Pedro Aguirre Cerda, and Quilicura, and increased in Peñaflor. **Conclusion:** The regional IMR and LIMR hide the slight increase in rates and the persistence of heterogeneity among communes. This forces us to explore the causes of these inequities through future analytical studies.

Keywords:
Infant Mortality;
Late Infant Mortality;
residence;
inequity;
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Introduction

The infant mortality rate (IMR) is an indicator that strongly represents the health level of a population[1-3]. A high rate reflects a significant percentage of avoidable and premature deaths that we can prevent through individual and collective actions aimed at influencing the social and economic determinants of health[4-9].

One of the first studies of social segregation, carried out in New York in 1948, describes the differences between the African-American and Caucasian populations[10]. Infant and fetal mortality rates were directly related to the proportion of the African-American population living in the neighborhood, which represents the first report of residential segregation.

Another study showed that social deprivation in a specific geographical area, measured through the Townsend deprivation index (unemployment, non-home ownership, and household overcrowding), is strongly associated with IMR. This factor shows a socioeconomic gradient where 20% of the population with the lowest socioeconomic level has an IMR ranging from 21% to 55% greater than the highest socioeconomic one[11].

Studies conducted in Latin American and Caribbean countries have shown that increased access to education for women and increased vaccination coverage, among other factors, have lowered the IMR of the region by reducing the social gradient[12-14].

In 2015, the IMR in Chile was 6.9:1,000 live births (LB), which reflexes a 0.1 decrease compared with 2014. Although it is one of the lowest rates in Latin America, it presents a heterogeneous distribution among the country's regions and communes and depends on socio-economic variables[15].

Hertel observed that the socioeconomically disadvantaged ones are at significantly higher risk of IMR due to infectious diseases and trauma during the first month of life[16]. The Late Infant Mortality Rate (LIMR) or post-neonatal is an interesting indicator since it represents with greater sensitivity the impact of the social determinants of health on population groups[16].

Another important determinant is the area of residence which defines the conditions in which people live, leading to a higher or lesser 'risk' of illness or death[17,18]. The objective of this study is to describe the IMR of the Metropolitan Region's (MR) municipalities and to evaluate its trend between 2005 and 2014.

Material and Method

Descriptive ecological study that explores the IMR and LIMR's geographical distribution in the 52 communes of the Metropolitan Region's (RM) provinces: Santiago, Cordillera, Chacabuco, Maipo, Melipilla, and Talagante. We analyzed the period between 2005 and 2014, using the commune as analysis unit.

On the one hand, the IMR is defined by the sum of total deaths of infants under 1 year of age in each commune per 1,000 LB within the 9-year study period. On the other hand, the LIMR is defined by the sum of total deaths of newborns over 28 days and under 1 year of age in each commune per 1,000 LB in the same period. These data were collected from the Department of Statistics and Health Information (DEIS) and the National Institute of Statistics (INE).

We compared the IMRs between communes with the regional standard and with the commune that has the lowest rate of the analyzed ones. We used three indicators for this end: Population Attributable Risk (PAR), Attributable Risk Percentage (AR%), and Rate Ratio (RR). The PAR was calculated through the formula PAR = (Communal IMR - Reference IMR); the AR% = (Communal PAR/IMR)*100; and the RR was calculated using the formula RR = (Communal IMR / Reference IMR). When the commune with the lowest rate was used as a reference, the PAR and AR% were expressed as RPAR and RAR%, respectively.

The trend of IMFs by commune and year were assessed using the Prais-Winsten regression represented as graphics generated using the STATA 14.0 software. An upward or downward trend was considered statistically significant with a $p < 0.05$ value. A map developed with the R software shows the IMR's geographical distribution in the MR.

Results

Comparing Commune with Regional Standards

Between January 1, 2005, and December 31, 2014, 989,173 children were born in the MR and 7,164 children under one year of age died, resulting in an IMR of 7.24:1,000 LB during the decade. When analyzing the MR's provinces, Maipo presented the highest IMR (9.01:1,000 LB) and Melipilla and Chacabuco presented the lowest one. In the Santiago province, 729,745 children were born and 3,674 died, resulting in an IMR of 7.10:1,000 LB during the studied decade.

The communes with the highest IMR were San Bernardo and Independencia. The last one presents a 12.7:1,000 LB rate. Its PAR compared with the MR is 5.46:1,000 LB, with 43% of AR%, and 1.75 of RR (Table 1).

Without considering the communes Alhué and San Pedro, which have extremely low birth rates and exceptional deaths, Lo Barnechea, Vitacura, Las Condes, Ñuñoa, and Pudahuel showed rates lower than 6:1,000 LB. The commune Las Condes presented the lowest

IMR, with a 4.88:1,000 LB rate over the decade, -48.4% of AR%, and 0.67 of RR (Table 1).

Inter-community comparison

The commune Las Condes, which has the lowest IMR, was selected as the commune of reference. When comparing such commune with the other ones, the RAR% vary widely, reaching a maximum of 61.6% in Independencia, with a 2.6 RR between both communes (Table 1).

Late Infant Mortality Analysis

In the specific commune-by-commune analysis of the LIMR, Vitacura presents the lowest rate (1.08:1,000 LB), while Independencia presents the highest one (4.38:1,000 LB). When compared with the regional standard, the PAR of Vitacura is -1.05, AR% -97.6, and RR 0.51, while the indicators of Independencia are PAR 2.25, AR% 51.31, and RR 2.05 (Table 2).

In the analysis with the commune Vitacura as reference, there was a higher variation than that observed in the IMR, reaching maximum values in the commune Independencia. This commune has a 3.3:1,000 LB RPAR, 75.3% RAR%, and 4.05 RR (Table 2).

Trend Evaluation

It was observed that the IMR of the MR follows a decreasing trend regarding 2005 (coefficient -0.075; 95%CI:-0.11 to -0.03), indicating that the IMR decreases 0.075:1,000 LB on average per year (Table 3). The communes that showed a significant increase in the period were Lo Barnechea (coefficient 0.33; 95%CI: 0.07 to 0.58), Lo Espejo (coefficient 0.27; 95%CI: 0.05 to 0.49), and Recoleta (coefficient 0.45; 95%CI: 0.18 to 0.73). The communes that showed a decrease with respect to 2005 were Las Condes (coefficient -0.24;

Table 1. Comparison of impact indicators of the Infant Mortality Rate in relation to regional IMR and referential commune, 2005 - 2014

Commune	Total births	Total infant deaths	IMR (per thousand LB)	PAR*	PAR%*	RR*	CPAR^	CAR%^	RR^
Santiago	44,574	288	6.46	-0.78	-12.05	0.89	1.58	24.46	1.32
Cerrillos	11,711	78	6.66	-0.58	-8.70	0.92	1.78	26.73	1.36
Cerro Navia	20,607	142	6.89	-0.35	-5.07	0.95	2.01	29.17	1.41
Conchalí	18,635	141	7.57	0.33	4.31	1.05	2.69	35.54	1.55
El Bosque	25,058	215	8.58	1.34	15.62	1.19	3.70	43.12	1.76
Estación Central	17,931	137	7.64	0.40	5.24	1.06	2.76	36.13	1.57
Huechuraba	15,808	117	7.40	0.16	2.18	1.02	2.52	34.05	1.52
Independencia***	11,657	148	12.70	5.46	42.98	1.75	7.82	61.57	2.60
La Cisterna	11,002	76	6.91	-0.33	-4.81	0.95	2.03	29.38	1.42
La Florida	48,214	319	6.62	-0.62	-9.43	0.91	1.74	26.28	1.36
La Granja	19,699	139	7.06	-0.18	-2.60	0.97	2.18	30.88	1.45
La Pintana	34,063	230	6.75	-0.49	-7.22	0.93	1.87	27.70	1.38
La Reina	9,885	60	6.07	-1.17	-19.28	0.84	1.19	19.60	1.24
Las Condes **	36,282	177	4.88	-2.36	-48.41	0.67	0.00	0.00	1.00
Lo Barnechea	12,826	75	5.85	-1.39	-23.81	0.81	0.97	16.58	1.20
Lo Espejo	15,934	138	8.66	1.42	16.40	1.20	3.78	43.65	1.77
Lo Prado	14,611	106	7.25	0.01	0.20	1.00	2.37	32.69	1.49
Macul	15,190	107	7.04	-0.20	-2.78	0.97	2.16	30.68	1.44
Maipú	70,809	511	7.22	-0.02	-0.32	1.00	2.34	32.41	1.48
Ñuñoa	24,106	143	5.93	-1.31	-22.05	0.82	1.05	17.71	1.22
Pedro Aguirre Cerda	14,564	111	7.62	0.38	5.01	1.05	2.74	35.96	1.56
Peñalolén	38,315	295	7.70	0.46	5.97	1.06	2.82	36.62	1.58
Providencia	17,984	109	6.06	-1.18	-19.45	0.84	1.18	19.47	1.24
Pudahuel	35,091	208	5.93	-1.31	-22.14	0.82	1.05	17.71	1.22
Quilicura	32,123	259	8.06	0.82	10.20	1.11	3.18	39.45	1.65
Quinta Normal	15,075	114	7.56	0.32	4.26	1.04	2.68	35.45	1.55
Recoleta	23,662	201	8.49	1.25	14.77	1.17	3.61	42.52	1.74
Renca	22,565	164	7.27	0.03	0.38	1.00	2.39	32.87	1.49
San Joaquín	12,100	98	8.10	0.86	10.61	1.12	3.22	39.75	1.66

Table 1. Comparison of impact indicators of the Infant Mortality Rate in relation to regional IMR and referential commune, 2005 - 2014 (continuation)

Commune	Total births	Total infant deaths	IMR (per thousand LB)	PAR*	PAR%*	RR*	CPAR^	CAR%^	RR^
San Miguel	12,493	104	8.32	1.08	13.03	1.15	3.44	41.35	1.70
San Ramón	15,107	100	6.62	-0.62	-9.37	0.91	1.74	26.28	1.36
Vitacura	12,064	69	5.72	-1.52	-26.58	0.79	0.84	14.69	1.17
Total Prov. Santiago	*729,745*	*5.179*	*7.10*	*-0.14*	*-2.01*	*0.98*	*2.22*	*31.27*	*1.45*
Puente Alto	83,953	623	7.42	0.18	2.44	1.02	2.54	34.23	1.52
Pirque	2,913	21	7.21	-0.03	-0.43	1.00	2.33	32.32	1.48
San José de Maipo	1,944	10	5.14	-2.10	-40.75	0.71	0.26	5.06	1.05
Total Prov. Cordillera	*88,810*	*654*	*7.36*	*0.12*	*1.68*	*1.02*	*2.48*	*33.70*	*1.51*
Colina	19,584	150	7.66	0.42	5.47	1.06	2.78	36.29	1.57
Lampa	12,573	63	5.01	-2.23	-44.49	0.69	0.13	2.59	1.03
Tiltil	2,351	24	10.21	2.97	29.08	1.41	5.33	52.20	2.09
Total Prov. Chacabuco	*34,508*	*237*	*6.87*	*-0.37*	*-5.42*	*0.95*	*1.99*	*28.97*	*1.41*
San Bernardo	48,344	436	9.02	1.78	19.72	1.25	4.14	45.90	1.85
Buin	12,678	119	9.39	2.15	22.87	1.30	4.51	48.03	1.92
Calera de Tango	3,235	29	8.96	1.72	19.24	1.24	4.08	45.54	1.84
Paine	9,022	76	8.42	1.18	14.05	1.16	3.54	42.04	1.73
Total Prov. Maipo	*73,279*	*660*	*9.01*	*1.77*	*19.62*	*1.24*	*4.13*	*45.84*	*1.85*
Melipilla	16,309	113	6.93	-0.31	-4.49	0.96	2.05	29.58	1.42
Alhué	1,095	3	2.74	-4.50	-164.26	0.38	-2.14	-78.10	0.56
Curacaví	3,851	26	6.75	-0.49	-7.24	0.93	1.87	27.70	1.38
María Pinto	1,577	15	9.51	2.27	23,88	1.31	4.63	48.69	1.95
San Pedro	1,006	4	3.98	-3.26	-82.09	0.55	-0,90	-22,61	0,82
Total Prov Melipilla	*23,838*	*161*	*6.75*	*-0.49*	*-7.20*	*0.93*	*1.87*	*27.70*	*1.38*
Talagante	10,101	67	6.63	-0.61	-9.15	0.92	1.75	26.40	1.36
El Monte	4,770	33	6.92	-0.32	-4.65	0.96	2.04	29.48	1.42
Isla de Maipo	4,654	37	7.95	0.71	8.93	1.10	3.07	38.62	1.63
Padre Hurtado	7,021	54	7.69	0.45	5.87	1.06	2.81	36.54	1.58
Peñaflor	12,447	82	6.59	-0.65	-9.90	0.91	1.71	25.95	1.35
Total Prov. Talagante	*38,993*	*273*	*7.00*	*-0.24*	*-3.41*	*0.97*	*2.12*	*30.29*	*1.43*

*reference value: Infant Mortality in the Metropolitan Region (7.24 x 1000 LB); ^reference value: Infant Mortality in the Vitacura Commune (4.88 x 1000 LB); **commune with lower rate of infant mortality (excluding Alhue and San Pedro due to its low birth rate); ***commune with a higher rate of infant mortality; IMR: infant mortality rate; LB: live (new)borns; Prov: province; PAR: Population attributable risk; PAR%: Population attributable percentage; RR: Rate ratio; CPAR: Communal population attributable risk; CAR%: Communal percentage attributable risk

95%CI:-0.41 to -0.07), Macul (coefficient -0.31; 95%CI:-0.57 to -0.05), Pudahuel (coefficient -0.39 (95%CI:-0.76 to -0.01), and San Bernardo (coefficient -0.23; 95%CI:-0.38 to -0.08) (Figure 1).

Regarding LIMR, the MR shows a significant negative trend of 0.08:1,000 LB over the studied decade (Table 3). Peñalolén, Puente Alto, Las Condes, Providencia, San Bernardo, Macul, Pudahuel, Talagante, Pedro Aguirre Cerda, and Quilicura all showed significant decreases over the decade under study, while only Peñaflor showed a significant increase in its LIMR (Figure 2).

The heat map shows the geographical distribution of the IMR among the MR's communes, the color of the commune represents the indicator magnitude. The darker the color, the highest the figure. (Figure 3).

Discussion

The study results show the heterogeneity persistence of the IMR among the provinces and communes of the MR, however, the inequalities remain despite the significant decrease due to the implementation of

Table 2. Comparison of impact indicators of the Late Infant Mortality Rate in relation to regional LIMR and referential commune, 2005 - 2014

Commune	Total Births	Total late infant deaths	LIMR (per thousand LB)	PAR*	PAR%*	RR*	CPAR^	CAR%^	RR^
Santiago	44,574	69	1.55	-0.58	-37.60	0.73	0.47	30.23	1.43
Cerrillos	11,711	25	2.13	0.00	0.22	1.00	1.05	49.41	1.98
Cerro Navia	20,607	42	2.04	-0.09	-4.51	0.96	0.96	47.01	1.89
Conchalí	18,635	49	2.63	0.50	18.99	1.23	1.55	58.93	2.43
El Bosque	25,058	61	2.43	0.30	12.50	1.14	1.35	55.64	2.25
Estación Central	17,931	41	2.29	0.16	6.85	1.07	1.21	52.77	2.12
Huechuraba	15,808	38	2.40	0.27	11.39	1.13	1.32	55.07	2.23
Independencia***	11,657	51	4.38	2.25	51.31	2.05	3.30	75.31	4.05
La Cisterna	11,002	22	2.00	-0.13	-6.52	0.94	0.92	45.99	1.85
La Florida	48,214	87	1.80	-0.33	-18,04	0.85	0.72	40.15	1.67
La Granja	19,699	41	2.08	-0.05	-2.34	0.98	1.00	48.11	1.93
La Pintana	34,063	71	2.08	-0.05	-2.19	0.98	1.00	48.19	1.93
La Reina	9,885	18	1.82	-0.31	-16.97	0.85	0.74	40.69	1.69
Las Condes	36,282	44	1.21	-0.92	-75.64	0.57	0.13	10.94	1.12
Lo Barnechea	12,826	22	1.72	-0.41	-24.18	0.81	0.64	37.04	1.59
Lo Espejo	15,934	36	2.26	0.13	5.72	1.06	1.18	52.20	2.09
Lo Prado	14,611	41	2.81	0.68	24.09	1.32	1.73	61.51	2.60
Macul	15,190	27	1.78	-0.35	-19.83	0.83	0.70	39.24	1.65
Maipú	70,809	132	1.86	-0.27	-14.26	0.88	0.78	42.07	1.73
Ñuñoa	24,106	35	1.45	-0.68	-46.70	0.68	0.37	25.62	1.34
Pedro Aguirre Cerda	14,564	34	2.33	0.20	8.76	1.10	1.25	53.74	2.16
Peñalolén	38,315	86	2.24	0.11	5.10	1.05	1.16	51.88	2.08
Providencia	17,984	42	2.34	0.21	8.80	1.10	1.26	53.76	2.16
Pudahuel	35,091	70	1.99	-0.14	-6.78	0.94	0.91	45.86	1.85
Quilicura	32,123	78	2.43	0.30	12.28	1.14	1.35	55.52	2.25
Quinta Normal	15,075	43	2.85	0.72	25.33	1.34	1.77	62.14	2.64
Recoleta	23,662	64	2.70	0.57	21.25	1.27	1.62	60.07	2.50
Renca	22,565	57	2.53	0.40	15.68	1.19	1.45	57.25	2.34
San Joaquín	12,100	23	1.90	-0.23	-12.06	0.89	0.82	43.18	1.76
San Miguel	12,493	20	1.60	-0.53	-33.05	0.75	0.52	32.54	1.48
San Ramón	15,107	23	1.52	-0.61	-39.90	0.71	0.44	29.06	1.41
Vitacura**	12,064	13	1.08	-1.05	-97.66	0.51	0.00	0.00	1.00
Total Prov. Santiago	*729,745*	*1505*	*2.06*	*-0.07*	*-3.40*	*0.97*	*0.98*	*47.57*	*1.91*
Puente Alto	83,953	189	2.25	0.12	5.39	1.06	1.17	52.03	2.08
Pirque	2,913	6	2.06	-0.07	-3.41	0.97	0,98	47.57	1.91
San José de Maipo	1,944	3	1.54	-0.59	-38.02	0.72	0.46	30.02	1.43
Total Prov. Cordillera	*88,810*	*198*	*2.23*	*0.10*	*4.48*	*1.05*	*1.15*	*51.57*	*2.06*
Colina	19,584	50	2.55	0.42	16.57	1.20	1.47	57.70	2.36
Lampa	12,573	22	1.75	-0.38	-21.73	0.82	0.67	38.28	1.62
Tiltil	2,351	10	4.25	2.12	49.92	2.00	3.17	74.61	3.94
Total Prov. Chacabuco	*34,508*	*82*	*2.38*	*0.25*	*10.50*	*1.12*	*1.30*	*54.62*	*2.20*
San Bernardo	48,344	118	2.44	0.31	12.73	1.15	1.36	55.75	2.26
Buin	12,678	39	3.08	0.95	30.76	1.44	2.00	64.89	2.85
Calera de Tango	3,235	11	3.40	1.27	37.36	1.60	2.32	68.24	3.15
Paine	9,022	29	3.21	1.08	33.73	1.51	2.13	66.40	2.98
Total Prov. Maipo	*73,279*	*197*	*2.69*	*0.56*	*20.82*	*1.26*	*1.61*	*59.85*	*2.49*

Table 2. Comparison of impact indicators of the Late Infant Mortality Rate in relation to regional LIMR and referential commune, 2005 - 2014 (continuation)

Commune	Total Births	Total late infant deaths	LIMR (per thousand LB)	PAR*	PAR%*	RR*	CPAR^	CAR%^	RR^
Melipilla	16,309	34	2.08	-0.05	-2.17	0.98	1.00	48.19	1.93
Alhué	1,095	0	.	.	.	.	.	.	.
Curacaví	3,851	8	2.08	0.00	0.00	0.98	0.00	0.00	1.92
María Pinto	1,577	6	3.80	1.67	44.02	1.79	2.72	71.61	3.52
San Pedro	1,006	2	1.99	-0.14	-7.14	0.93	0.91	45.68	1.84
Total Prov Melipilla	*23,838*	*50*	*2.10*	*-0.03*	*-1.43*	*0.99*	*1.02*	*48.57*	*1.94*
Talagante	10,101	14	1.39	-0.74	-53.68	0.65	0.31	22.08	1.28
El Monte	4,770	6	1.26	-0.87	-69.34	0.59	0.18	14.14	1.16
Isla de Maipo	4,654	11	2.36	0.23	9.88	1.11	1.28	54.31	2.19
Padre Hurtado	7,021	16	2.28	0.15	6.53	1.07	1.20	52.61	2.11
Peñaflor	12,447	28	2.25	0.12	5.31	1.06	1.17	51.99	2.08
Total Prov. Talagante	*38,993*	*75*	*1.92*	*-0.21*	*-10.94*	*0.90*	*0.84*	*43.75*	*1.78*

*reference value: Late Infant Mortality in the Metropolitan Region (2.13 x 1000 LB); ^reference value: Late Infant Mortality in the Vitacura Commune (1.08 x 1000 LB); **commune with lower rate of late infant mortality (excluding Alhué due to its low birth rate); ***commune with a higher rate of late infant mortality; LIMR: late infant mortality rate; LB: live (new)borns; PAR: Population attributable risk; PAR%: Population attributable percentage; RR: Rate ratio; CPAR: Communal population attributable risk; CAR%: Communal percentage attributable risk.

social policies, such as the Comprehensive Protection System for Early Childhood *Chile Crece Contigo* (Chile Grows with You), among others.

Our study shows differences that are unthinkable in an OECD country. For instance, 43% of deaths of children under one year of age in the commune Independencia could be avoided if it had the same IMR as the MR. Also, the risk of a child death is 75% higher in this commune than in the MR and, just by having born in Independencia, the risk of an infant dying in her/his first year of life during the decade studied was 2.6 times higher than the one of a child born in Las Condes. Specifically, when analyzing the LIMR, which mainly groups the preventable causes of death in early childhood, the difference is even greater. In the commune Independencia, one in two child deaths after the month of life could be avoided if it had the same indicators of the MR, while the risk of child death between the month and year of life in Independencia during the decade studied is four times higher than the risk of the commune Vitacura.

These differences could be explained by social determinants of health that show an impact on infant mortality, such as smoking in pregnancy[19], mother with lower education level[20], and the lack of adherence to medical follow-up visits and indications, which are more prevalent in socially deprived groups.

Differences among communes could reflect residential segregation that may be related to the inequity in health, economic, social, and environmental indicators between them[21]. The northern area, where Independencia is located, has a higher percentage of poor households, presenting greater overcrowding, a higher unemployment rate, and a lower average of years of schooling than the national and MR ones[22], and it is also one of the areas that have a significant percentage of immigrants (4.7%) from Peru, Haiti, Argentina, and Colombia[29].

This situation has influenced the birth rate increase, especially in recent years, due to the characteristics of the mainly female and young population, similar to what has been described in other regions of the globe, which has been called the 'feminization of migration'[23].

The rise in the IMR could be explained by the increase in the birth rate of immigrant mothers from countries with low rates of birth control or due to the barriers that hinder the access of this population to health services in our country, such as the lack of timely delivery of information, cultural aspects, language, geographic, and administrative barriers that worsen in undocumented migrants[24,25].

In Chile, there are studies that show that immigrant women, especially those of African descent, have little birth control and, therefore, late detection of maternal

Table 3. Trend for communes of the Metropolitan Region, 2005-2014

Commune	*IMR*		*LIMR*	
	Coef. (IC95%)*	p ≤ value	Coef. (IC95%)*	p ≤ value
RM	*-0.075 (-0.11 a -0.03)<*	*0.005&*	*-0.08 (-0.10 a -0.06)<*	*0.001&*
Santiago	-0.16 (-0.36 a 0.4)	0.107	-0.09 (-0.19 a 0.001)	0.053
Cerrillos	0.01 (-0.31 a 0.33)	0.967	-0.18 (-0.45 a 0.09)	0.168
Cerro Navia	-0.22 (-0.59 a 0.16)	0.223	-0.05 (-0.18 a 0.09)	0.420
Conchalí	-0.14 (-0.66 a 0.38)	0.556	0.004 (-0.34 a 0.34)	0.976
El Bosque	0.08 (-0.49 a 0.65)	0.753	-0.05 (-0.26 a 0.15)	0.550
Estación Central	0.01 (-0.50 a 0.51)	0.970	-0.07 (-0.45 a 0.32)	0.697
Huechuraba	0.05 (-0.24 a 0.35)	0.682	-0.03 (-0.31 a 0.25)	0.792
Independencia	-0.20 (-0.91 a 0.51)	0.529	-0.07 (-0.49 a 0.36)	0.726
La Cisterna	0.09 (-0.28 a 0.45)	0.599	0.16 (-0.01 a 0.33)	0.063
La Florida	0.08 (-0.20 a 0.37)	0.515	0.07 (-0.04 a 0.19)	0.182
La Granja	-0.11 (-0.67 a 0.45)	0.658	-0.18 (-0.48 a 0.12)	0.209
La Pintana	-0.17 (-0.37 a 0.02)	0.077	-0.01 (-0.13 a 0.12)	0.890
La Reina	0.17 (-0.24 a 0.57)	0.365	0.09 (-0.03- a 0.22)	0.121
Las Condes	*-0.24 (-0.41 a -0.07)<*	*0.011&*	*-0.21 (-0.36 a -0.07)<*	*0.010&*
Lo Barnechea	*0.33 (0.07 a 0.58)>*	*0.019&*	*-0.29 (-0.15 a 0.74)*	*0.168*
Lo Espejo	*0.27 (0.05 a 0.49)>*	*0.022&*	*-0.6 (-0.17 a 0.05)*	*0.247*
Lo Prado	-0.17 (-0.42 a 0.09)	0.170	-0.27 (-0.55 a 0.03)	0.052
Macul	*-0.31 (-0.57 a -0.05)<*	*0.025&*	*-0.34 (-0.55 a -0.14)<*	*0.005&*
Maipu	-0.13 (-0.31 a 0.04)	0.109	-0.07 (-.021 a 0.07)	0.290
Ñuñoa	0.17 (-0.13 a 0.46)	0.226	0.04 (-0.09 a 0.17)	0.542
Pedro Aguirre Cerda	*-0.16 (-0.72 a 0.39)*	*0.520*	*-0.32 (-0.58 a -0.06)<*	*0.022&*
Peñalolén	*-0.07 (-0.24 a 0.09)*	*0.342*	*-0.16 (-0.31 a -0.02)<*	*0.029&*
Providencia	*-0.43 (-0.99 a 0.13)*	*0.118*	*-0.22 (-0.43 a -0.01)<*	*0.039&*
Pudahuel	*-0.39 (-0.76 a -0.01)<*	*0.044&*	*-0.13 (-0.21 a -0.05)<*	*0.006&*
Quilicura	*0.15 (-0.37 a 0.68)*	*0.523*	*-0.14 (-0.19 a -0.09)<*	*0.001&*
Quinta Normal	0.13 (-0.14 a 0.40)	0.293	0.05 (-0.21 a 0.30)	0.691
Recoleta	*0.45 (0.18 a 0.73)>*	*0.005&*	*0.06 (-0.14 a 0.26)*	*0.536*
Renca	-0.01 (-0.50 a 0.47)	0.948	-0.16 (-0.44 a 0.12)	0.217
San Joaquín	0.04 (-0.44 a 0.51)	0.866	-0.028 (-0.28 a 0.22)	0.802
San Miguel	0.24 (-0.14 a 0.63)	0.184	0.10 (-0.11 a 0.31)	0.304
San Ramón	0.46 (-0.02 a 0.93)	0.057	-0.003 (-0.16- a 0.16)	0.958
Vitacura	-0.46 (-1.01 a 0.10)	0.095	-0.14 (-0.31 a 0.03)	0.098
Puente Alto	*-0.22 (-0.49 a 0.05)*	*0.100*	*-0.17 (-0.30 a -0.04)<*	*0.015&*
Pirque	*-0.55 (-2.02 a 0.92)*	*0.411*	*-0.76 (-1.38 a -0.14)*	*0.023*
San José del Maipo	-0.02 (-1.73 a 1.70)	0.984	0.22 (-0.39 a 0.95)	0.373
Colina	0.20 (-0.23 a 0.64)	0.316	-0.03 (-0.19 a 0.12)	0.661
Lampa	-0.02 (-0.40 a 0.36)	0.902	-0.06 (-0.26 a 0.12)	0.418
Tiltil	-0.72 (-2.05 a 0.60)	0.246	-0.46 (-1.37 a 0.44)	0.269
San Bernardo	*-0.23 (-0.38 a -0.08)<*	*0.007&*	*-0.22 (-0.34 a -0.10)<*	*0.003&*
Buin	0.17 (-0.95 a 1.29)	0.736	0.14 (-0.38 a 0.67)	0.545
Calera de Tango	-0.10 (-1.38 a 1.19)	0.863	-0.43 (-0.12 a 0.33)	0.230
Paine	-0.27 (-0.78 a 0.23)	0.252	-0.22 (-0.75 a 0.30)	0.367
Melipilla	-0.20 (-0.65 a 0.25)	0.341	0.09 (-0.22 a 0.39)	0.528
Alhué	-0.15 (-1.51 a 1.21)	0.806	-	-
Curacaví	-0.21 (-1.88 a 1.47)	0.785	0.31 (-0.03 a 0.64)	0.068
María Pinto	-0.22 (-0.91 a 0.48)	0.495	0.50 (-0.25 a 1.26)	0.162
San Pedro	-0.66 (-1.96 a 0.64)	0.276	-0.29 (-0.1.16 a 0.56)	0.445
Talagante	*-0.06 (-0.56 a 0.44)*	*0.785*	*-0.13 (-0.23 a -0.03)<*	*0.016&*
El Monte	-0.24 (-0.98 a 0.50)	0.477	-0.19 (-0.41 a 0.031)	0.084
Isla Maipo	-0.45 (-0.94 a 0.05)	0.070	-0.33 (-0.66-0.002)	0.051
Padre Hurtado	0.10 (-1.02 a 1.21)	0.844	0.17 (-0.65- a 0.98)	0.643
Peñaflor	*0.21 (-0.02 a 0.44)*	*0.072*	*0.18 (0.06 a 0.31)>*	*0.009&*

* 95% confidence interval; & Statistically significant; > Increase; < Decrease.

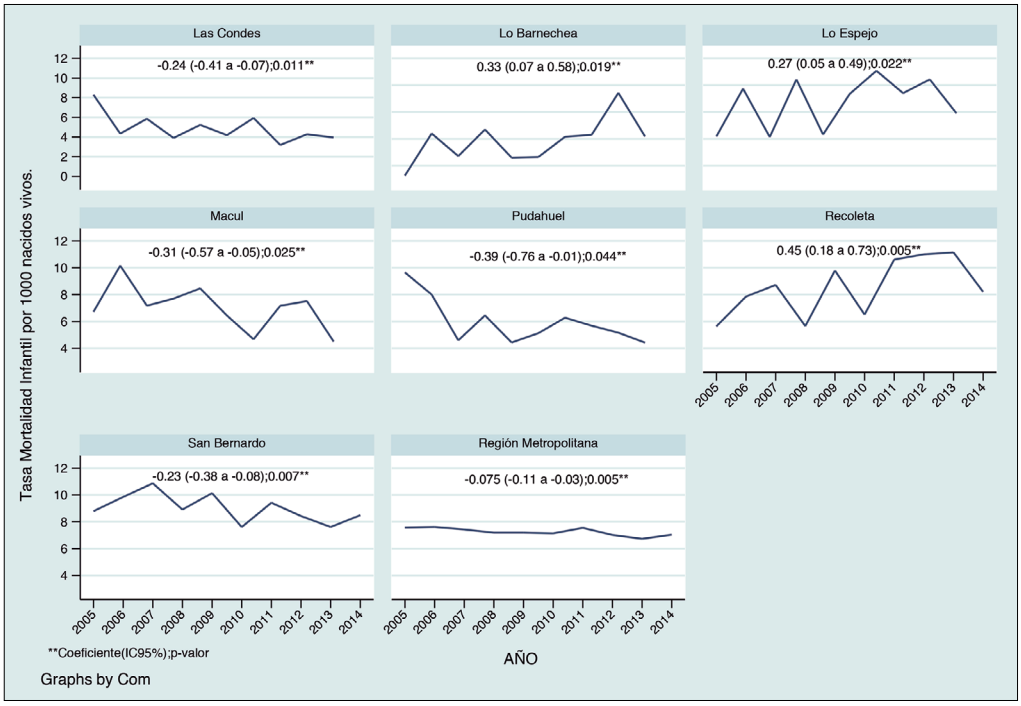

Figure 1. Communes with significative variations in the trends of the infant mortality rate, Metropolitan Region, 2005-2014.

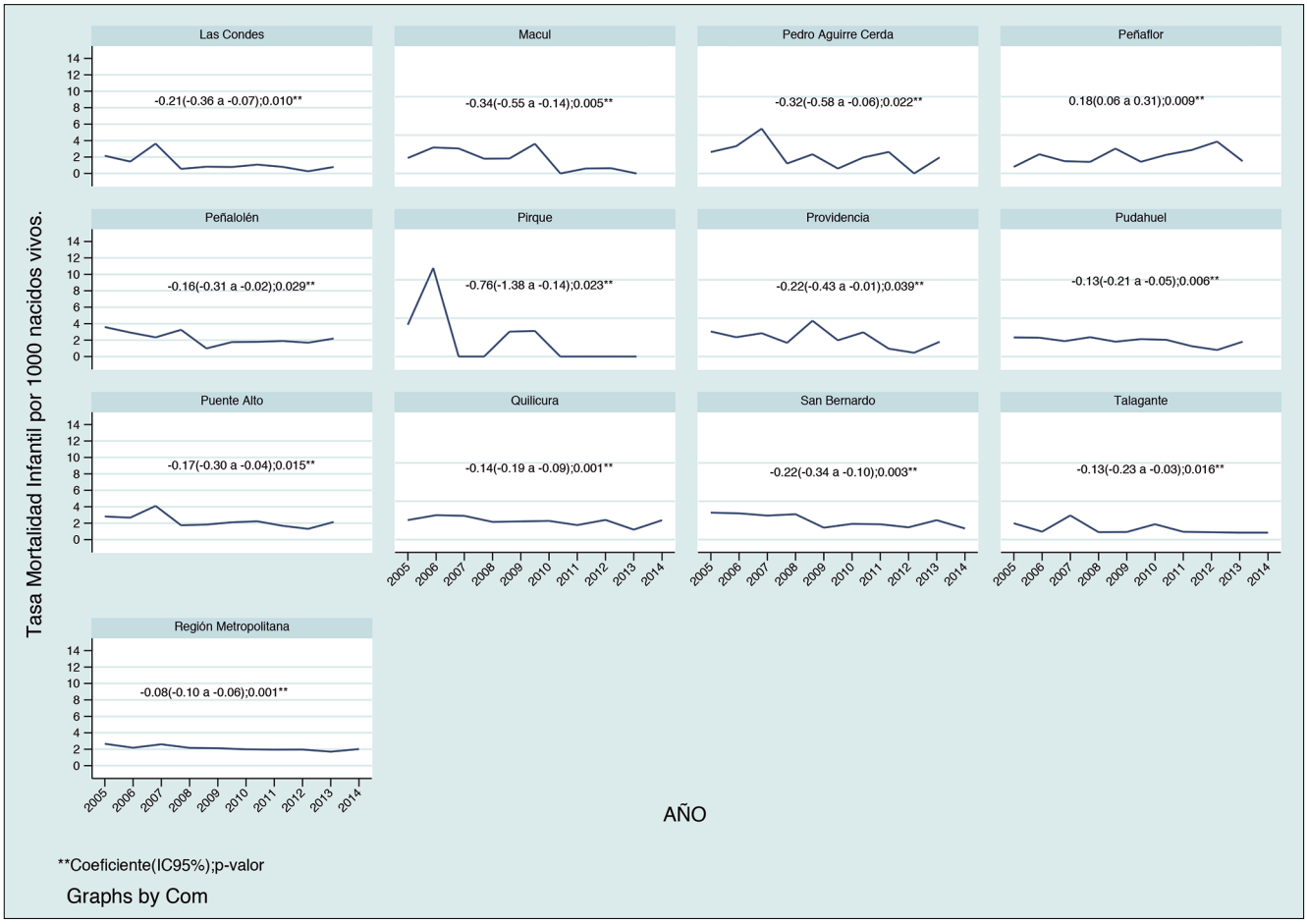

Figure 2. Communes with significative variations in the trends of the late infant mortality rate, Metropolitan Region, 2005-2014

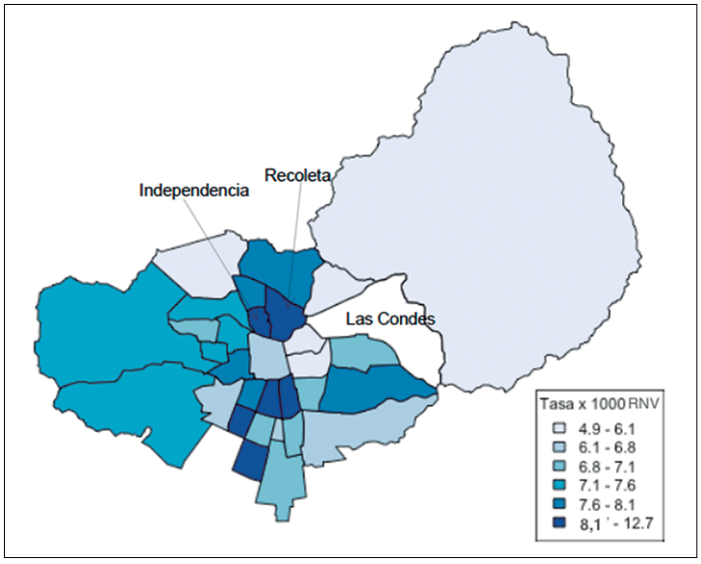

Figure 3: Heatmap of infant mortality rate in communes of the Metropolitan Region, periodz 2005-2014

and fetal diseases[26].

In recent years, the Chilean Ministry of Health has modified the regulatory framework in order to improve access to health care for immigrants, especially for certain priority groups, such as protection of pregnant women, childcare, emergency care and care for undocumented immigrants. Thus, Circular A 15 No. 6 states that all facilities in the public health system must provide both health care and services regardless of their legal status in the country[24]. However, the beneficiary population is not always aware of these regulations. Even in this scenario of increasing immigration, the gaps in IMR between communes in our country are still longstanding[27], therefore, migration is only one factor that would accentuate these differences.

In Chile, the decrease in IMR occurred due to public health interventions[20], however, quality education without differences in socioeconomic status is still a challenge[28]. Thus, in Chile, municipalities with high IMRs such as Independencia and San Bernardo have poverty percentages of 9.8% and 9.2%, respectively, while in Las Condes and Vitacura these percentages are 0.6% and 0%[29].

The differences recorded in overall IMR are also confirmed in the assessment of IMR trends by commune, where Lo Barnechea, Lo Espejo and Recoleta have increased their rates. In the case of Lo Barnechea and Lo Espejo, it could be explained by the growth in the number of inhabitants in recent years, generally because of the young population.

Recoleta, on the one hand, has a significant number of immigrants which, as already mentioned, influences the birth and mortality rate. On the other hand, the communes that decreased the IMR in the period were Las Condes, Macul, Pudahuel, and San Bernardo. The decrease in the IMR in Las Condes is in line with the high socio-economic and quality of life indicators and the high number of people aged over 60 in the commune (20.34%). In contrast, Macul, Pudahuel, and San Bernardo maintain higher levels of poverty (5.3%, 7.8%, and 9.2%, respectively)[29].

The strategy of focusing on individual interventions to improve health and reduce inequities has not proven to be effective by itself, unlike community interventions[30]. Therefore, strategies must have a universal and cross-sectoral approach, beyond the healthcare sector.

One example of a successful universal policy that has narrowed the gap of unequal conditions for child development, has been increased paid parental leave to attend prenatal follow-up visits and care the child in the first months of life, for both mother and father[31]. In Chile, this policy has been implemented with the extension of postnatal parental leave.

The largest reductions in the IMR in our country were related to improvements in living conditions of housing and education, to the increase in the health budget, and the implementation and improvement of maternal and child health programs, such as complementary feeding programs, prenatal and well-child care[32,33].

Nowadays, the existence of specific programs that educate and achieve a change in risk behavior in less-favored social groups[34] such as the Acute Respiratory Infections (IRA) program, a universal policy that has specific strategies for patients with chronic obstructive pulmonary disease or asthma[35], will allow maintaining the reductions in IMR achieved today. However, the difficulty in further reducing the already low levels of IMR remains, since prematurity and congenital malformations are the main contributors to IMR, which are not easy to prevent due to their multi-causal nature.

Increased chronic comorbidities during pregnancy, increased gestational age, and fertility treatments that present a higher probability of multiple pregnancy are, among others, proven risk factors in the Chilean population, which contribute to increasing the premature births rate. However, there are real strategies identified to reduce the mortality associated with prematurity where access to fair and quality healthcare is essential[36].

In Chile, this context contributes to *'the tyranny of averages'* that hides the phenomena still present, represented in the unresolved inequalities between communes as those presented in this work and adding future challenges, such as those arising from migration, cross-culturalism, and the country's development that could help to increase the premature birth rate. This

means that those strategies that were effective in reducing IMR in groups of people with higher levels of poverty and lower schooling levels must be added to those of the epidemiological transition in our country.

In the 1960s, the problem of IMR was addressed from a much broader perspective than the healthcare sector, considering the mother-child dyad and the social determinants where it developed. Today, when we have better records and more precise and affordable methodological tools, we must resume the IMR analysis and, with a preventive view, propose concrete measures for sustaining the achievements made, reduce inequities within our country, and avoid increases in IMR in groups at risk due to access barriers that people who enter the healthcare system may face.

Strategies to reduce risk factors for non-communicable diseases will also improve the health of future pregnant women and their children. In this light, it is essential to concentrate cross-sectoral efforts on education by improving its quality, as well as on health care. These measures could be implemented by strengthening the training of the health team in subjects related to the populations at greatest risk, such as migration, transculturality, and adolescent pregnancy from the first years of professional training and/or training continuously the health teams in these matters, as well as in the health problems that prevail today in our population.

Likewise, it is essential greater participation of vulnerable populations in health decision-making. This will allow us to understand why policies aimed at reducing inequities in Chile have not been effective enough, which leads us to rethink what changes in our society are currently not being adequately addressed to contribute to the reduction of such inequities, represented by the inequality in the IMR.

Limitations

Although in Chile the scope of vital event statistics since 1990 is considered solid, a possible limitation of our study is related to the potential inter-communal variability in the quality of the statistics, as occur interregionally, where ill-defined deaths vary between 1.5% and 13.7%[37]. However, in Chile, the current legislation safeguards the quality of vital statistics through child mortality audits according to the regulation in force revised in 2012[38]. Since 1885, our country has also the legal obligation to register births and deaths, in couple with the estimation and correction of late birth registrations carried out by the INE[39].

Finally, this study shows that observing the regional average indicator hides the differences between the current IMR and LIMR in the territory. Therefore, public policies must be addressed from different levels and under the slogan *'health in all policies'*, considering social determinants expressed as marginalization, poverty, rurality, and lack of access, and crucial factors such as education and health. These determinants have shown in several studies a close relationship with IMR and LIMR, and even more in the current demographic and epidemiological context, where identifying characteristics of the social and physical environment is a challenge that can explain inequities such as migration, pregnancy at extreme ages, and high-risk pregnancies, which could change the infant mortality profile of the country.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors state that the information has been obtained anonymously from previous data, therefore, Research Ethics Committee, in its discretion, has exempted from obtaining an informed consent, which is recorded in the

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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