Infant mortality evolution in the metropolitan region of São Paulo (Brazil), 1980-2000

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Keywords
Infant mortality, trends. Mortality rate. Death certificates. Cause of death. Neonatal mortality (public health). Residence characteristics.

Abstract

Objective
To analyze IMR evolution in the São Paulo Metropolitan Area (SPMA) between 1980 and 2000, in terms of spatial, age and, causal differences.

Methods
SPMA municipalities were divided into 5 groups, based on their 1980 IMRs: ≥90‰ lb (Group 1); 70-89‰ lb (Group 2); 50-69‰ lb (Group 3); <50‰ lb (Group 4). Group 5 comprised the municipality of São Paulo itself (IMR=51‰ lb). The analysis of trends was carried out using exponential regression models.

Results
IMR and its components showed a statistically significant decrease ($p<0.05$), with coefficients of determination between 66 and 98%, indicating goodness of fit of the exponential model to all the time series analyzed. SPMA IMR fell 69.4%, from 55.2 to 16.9‰ lb, and Groups 1-5 showed reductions of 83.9%, 76.2%, 71.3%, 58.7%, and 68.8%, indicating that the groups with highest IMRs also showed the greatest reductions during the studied period.

Conclusions
IMRs were homogenized at around 18‰ lb in all municipality groups in the SPMA. One-half of all deaths were concentrated within the first week of life, and were due primarily to conditions originating in the perinatal period, indicating that greater care during the pre- and post-delivery periods will be required if the IMR in the SPMA is to descend to levels compatible with those of developed countries.

INTRODUCTION

The Infant Mortality Rate (IMR) has been used as an indicator not only of the quality of child health, but also of the level of development of a society. The IMR estimates the risk of a child dying during infancy (before reaching age 1 year), and can express the ability a community has to fulfill the nutritional, housing, and healthcare needs of its newborn.

IMRs in Brazil have decreased greatly in the last twenty years, falling from 69‰ live births in 1980 to 30‰ live births (lb) in 2000, a 57% decrease. Despite these numbers, infant mortality rates in Brazil are still high if compared to those of developed countries, in which IMRs were already below 15‰ lb in the 1980's. There are differences in the rates of infant mortality between the five Brazilian Regions: whereas the South and Southeast Regions have rates close to 20‰ lb, the rates in the Northeast Region are above 40‰ lb.[4]

Located in the Southeast Region, the São Paulo Metropolitan Area (SPMA), currently spanning 39 municipalities, is the largest urban center in Brazil,

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and one of the largest in the world. From 1950 to 1970, a large contingent of immigrants, especially from the Northeastern states, established themselves in the SPMA. This phenomenon promoted an increase in the demand for urban infrastructure and healthcare services, generating heterogeneous living standards and patent social exclusion. The aim of the present study is to analyze the evolution of infant mortality rates within the São Paulo Metropolitan Area – between 1980 and 2000 – with emphasis on spatial differences.

METHODS

Mortality rates were calculated for the early neonatal (0-6 days after delivery), late neonatal (7-27 days after delivery), and post neonatal (28-364 days after delivery) periods, as well as for the entire period (0-364 days after delivery) for all municipalities in the SPMA, between 1980 and 2000. The number of deaths according to age group was taken from data provided by the Ministry of Health's *Sistema de Informações sobre Mortalidade* (Mortality Information System – SIM/MS). The number of live births was taken from the *Sistema Estadual de Análise de Dados* (State Data Analysis System – SEADE) Foundation.

Specific mortality rates were calculated for the 5 major causes of death in the 1980-2000 period, based on International Classification of Diseases – 9th review (ICD-9) chapters I (Infectious and Parasitic Diseases), III (Endocrine, nutritional, and metabolic diseases and immune disorders), VIII (Diseases of the respiratory system), XIV (Congenital malfor-

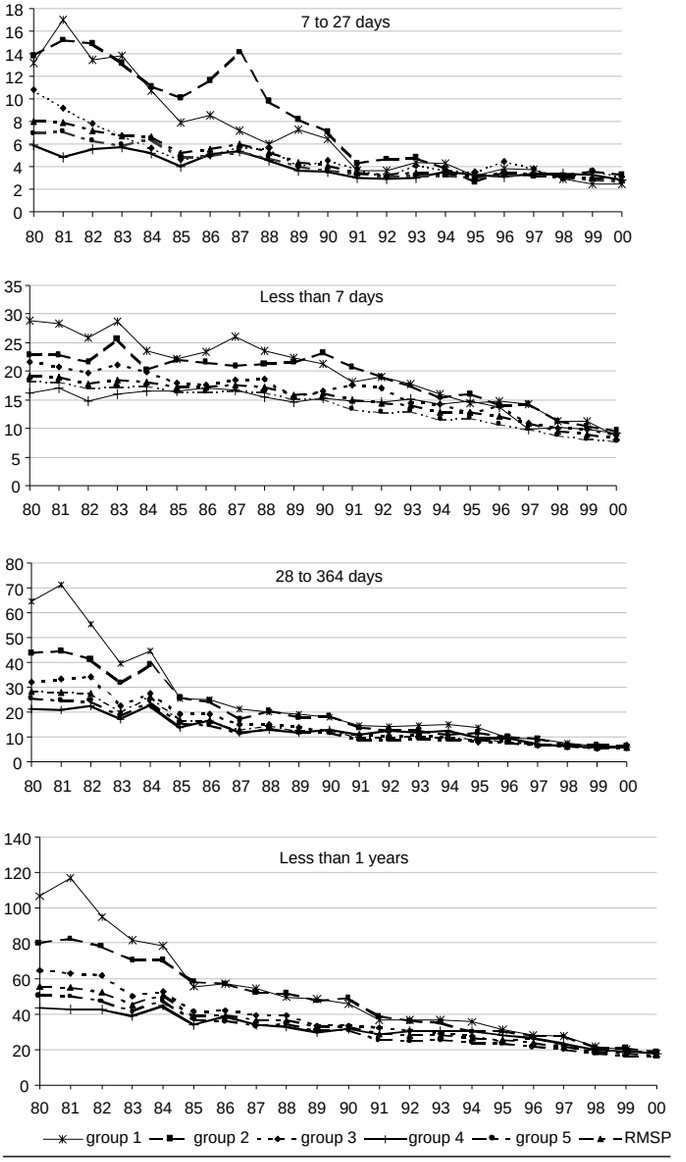

Figure 1 - Infant Mortality Rate and its components, according to municipality groups. São Paulo Metropolitan Area, 1980-2000.

Table 1 - Description of the Municipalities in the São Paulo Metropolitan Area.

Group	Infant mortality rate	Municipalities	Mean IMR of the group
1	≤90	Pirapora do Bom Jesus, Ferraz de Vasconcelos, Itapevi, Santana de Parnaíba, Poá, Carapicuiba e Itaquaquecetuba.	106.5
2	70 l— 90	Arujá, Suzano, Diadema, Itapecerica da Serra, Biritiba Mirim, Santa Isabel, Franco da Rocha, Francisco Morato, Salezópolis e Embu.	79.9
3	50 l— 70	Osasco, Embu Guaçu, Jandira, Rio Grande da Serra, São Bernardo do Campo, Mauá, Juquitiba, Caieiras, Cajamar, Mogi das Cruzes e Cotia.	64.5
4	<50	Mairiporã, Guararema, Ribeirão Pires, Guarulhos, Santo André, Barueri, Taboão da Serra, São Caetano do Sul e Vargem Grande Paulista.	43.6
5	50.6	São Paulo	50.6
Total		RMSP	55.2

Source: Crude data: Seade Foundation and Ministry of Health - SIM/MS.

mations), and XV (Certain conditions originating in the perinatal period).

SPMA municipalities were divided into 5 groups (Table 1), based on their 1980 IMRs: =90‰ lb (Group 1); 70-89‰ lb (Group 2); 50-69‰ lb (Group 3); <50‰ lb (Group 4). Group 5 comprised the municipality of São Paulo itself (IMR=51‰ lb).

The socioeconomic variables analyzed in each group included: percentage of households connected to the water supply and sewage networks, percentage literacy above age 5 years, and percentage households according to head of family's mean monthly income class (in number of minimum wages), collected in the 1980 and 2000 censuses.[3,4]

Trends in IMR and its components, according to municipality group and cause of death, were analyzed using exponential regression models[5] ($Y= \beta_0 e^{b_1 x}$) in which dependent variable (Y) is the infant mortality rate (dependent variable), X is the corresponding year (independent variable), and β_1 is the mean of the yearly increment during the studied period. In order to avoid auto-correlation between the points,[6] the independent variable was centralized (X-1990 and X-1988). X-1990 corresponds to the middle point of the time series for IMR and its components by age from 1980 to 2000, and X-1988 to the middle point of the time series for cause-specific rates, from 1980 to 1995. A trend was considered as significant when $p<0.05$. The determination coefficient (r^2) was used to evaluate the model's explanatory power (the closer this value is to 1, the better the model).[6]

RESULTS

Infant mortality and its components decreased in all municipality groups (Figure 1). The SPMA showed a 69.4% decrease in IMR between 1980 and 2000 (55.2 to 16.9‰ lb). Percent decreases in IMR in the five municipality groups were 83.9%, 76.2%, 71.3%, 58.7%, and 68.8%, respectively (Table 2). Therefore, the groups with highest IMRs were also those that registered the greatest decrease, which brought all IMRs in 2000 to somewhere around 18‰ lb.

Groups 1 and 2, which in 1980 had the highest IMRs, had also the worst socioeconomic conditions, with lower percentage of households connected to the water supply and sewage networks, lower literacy, and greater number of low-income households (Table 2). The great increase in the SPMA water supply network accounted for the 90% coverage registered in all groups at the end of the period. Likewise, illiteracy rates in all groups had also fallen below 10% by 2000. Sewage system coverage, however, is still not universal. Furthermore, the proportion of families included in the lowest income categories increased in all groups.

IMR and its components showed a statistically significant decrease ($p<0.05$), with determination coefficients between 66 and 98%, indicating the goodness of fit of the exponential model to all the time series analyzed (Table 3). Among the components of infant mortality, the post-neonatal period showed the greatest rate of decrease in all groups, followed by the late neonatal period. The early

Table 2 – Description of the indicators according to Groups. São Paulo Metropolitan Area, 1980 and 2000.

Indicator	Group 1		Group 2		Group 3		Group 4		Group 5		RMSP	
	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
Households connected to water supply network (%)	59.9	94.8	48.9	90.3	74.4	93.8	76.9	94.5	86.0	98.6	81.7	96.6
Households connected to sewage network (%)	3.1	67.7	20.2	60.8	39.5	73.4	50.7	80.9	52.0	87.4	47.4	81.6
Literacy rate (% individuals above age 5 years)	77.1	93.1	74.9	92.4	81.6	94.4	83.2	94.8	86.0	95.4	84.1	94.8
Households by mean monthly income of head of family (%)												
<1 minimum wage	4.7	11.0	4.9	12.8	3.9	8.2	3.3	7.7	2.6	6.7	3.0	7.7
1-2 minimum wages	16.7	19.1	16.2	21.1	11.4	14.8	10.5	14.2	9.3	12.8	10.2	14.2
2-5 minimum wages	49.5	43.7	47.0	41.8	39.6	36.8	38.0	36.7	34.9	33.2	36.8	36.6
5-10 minimum wages	22.7	19.2	23.4	17.8	27.8	25.1	29.8	25.6	28.0	23.4	27.8	23.3
>10 minimum wages	6.4	7.0	8.5	6.5	17.3	15.1	18.4	15.8	25.3	23.6	22.2	19.2
Mortality rate (‰ live births)	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
Early neonatal	28.8	8.7	22.8	9.6	21.6	8.8	16.3	9.1	18.3	7.7	19.1	8.3
Late neonatal	13.2	2.5	13.8	3.3	10.8	3.1	5.9	2.9	7.0	2.6	8.0	2.8
Post-neonatal	64.5	5.9	43.3	6.1	32.1	6.6	21.4	6.0	25.3	5.5	28.1	5.8
Infant mortality	106.5	17.1	79.9	19.0	64.5	18.5	43.6	18.0	50.6	15.8	55.2	16.9
Cause-specific mortality rate (‰ live births)	1980	1995	1980	1995	1980	1995	1980	1995	1980	1995	1980	1995
Infectious (1)	34.6	1.8	23.6	1.1	17.6	1.2	9.4	1.5	11.5	1.2	13.5	1.3
Endocrinal (2)	7.9	0.7	5.8	0.3	3.1	0.5	1.8	0.4	2.3	0.3	2.8	0.3
Respiratory system (3)	23.9	2.6	14.6	2.2	12.7	2.1	10.2	2.2	11.8	2.1	12.3	2.2
Congenital (4)	2.8	2.6	3.3	3.1	3.3	2.3	2.9	2.4	2.9	2.8	3.0	2.7
Perinatal (5)	30.7	11.9	25.2	12.0	23.3	11.5	16.2	12.2	19.2	10.3	20.1	11.0

Source: Crude data: Seade Foundation, IBGE Foundation, and Ministry of Health - SIM/MS
(1) infectious and parasitic diseases (2) endocrinal, metabolic, and nutritional diseases and immune disorders (3) diseases of the respiratory system (4) congenital malformations (5) conditions originating in the perinatal period.

Table 3 – Exponential regression models for infant mortality rate and its components in Groups 1-5 and SPMA, 1980-2000.

Group	Mortality rate (‰ live births)	β_0	β_1	IC 95% β_1		r^2
Group 1	Early neonatal	19.02	-0.051	-0.0589	-0.0431	0.91
	Late neonatal	5.78	-0.096	-0.1086	-0.0834	0.93
	Post-neonatal	18.91	-0.114	-0.1265	-0.1015	0.95
	Infant	44.78	-0.085	-0.0919	-0.0781	0.97
Group 2	Early neonatal	18.04	-0.040	-0.0500	-0.0300	0.75
	Late neonatal	6.56	-0.097	-0.1127	-0.0813	0.90
	Post-neonatal	16.70	-0.101	-0.1096	-0.0924	0.98
	Infant	42.35	-0.075	-0.0797	-0.0703	0.98
Group 3	Early neonatal	15.58	-0.040	-0.0472	-0.0328	0.88
	Late neonatal	4.73	-0.051	-0.0641	-0.0379	0.78
	Post-neonatal	13.36	-0.089	-0.0977	-0.0803	0.96
	Infant	34.13	-0.063	-0.0676	-0.0584	0.98
Group 4	Early neonatal	14.17	-0.026	-0.0349	-0.0171	0.66
	Late neonatal	3.93	-0.034	-0.0430	-0.0250	0.73
	Post-neonatal	12.12	-0.063	-0.0741	-0.0519	0.68
	Infant	30.70	-0.041	-0.0475	-0.0345	0.90
Group 5	Early neonatal	13.37	-0.043	-0.0500	-0.0360	0.90
	Late neonatal	4.13	-0.049	-0.0571	-0.0409	0.89
	Post-neonatal	11.34	-0.080	-0.0884	-0.0716	0.95
	Infant	29.19	-0.058	-0.0622	-0.0538	0.98
São Paulo Metropolitam Area						
	Early neonatal	14.44	-0.039	-0.0459	-0.0321	0.88
	Late neonatal	4.46	-0.054	-0.0621	-0.0459	0.91
	Post-neonatal	12.53	-0.081	-0.0892	-0.0728	0.96
	Infant	31.76	-0.059	-0.0630	-0.0550	0.98

Source: Crude data: Seade Foundation and Ministry of Health - SIM/MS
β_0: Intercept; β_1: Mean Exponential Increase; IC β_1: 95% Confidence Interval for β_1; r^2: determination coefficient.

neonatal period had the lowest rate of decrease.

In all analyses, the lowest rates of decrease were registered in Group 4, which consists of the municipalities with IMRs below 50‰ lb in 1980.

Infectious and parasitic diseases showed the highest rate of decrease in all municipality groups and in SPMA as a whole (Table 4). Congenital malformations showed the lowest rate of decrease as well as the lowest determination coefficients. In Group 4, IMRs due to endocrinal and nutritional diseases and congenital malformations remained stable throughout the period. This was also the case with congenital malformations in Group 5.

DISCUSSION

The infant mortality rate is one of the *Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute for Geography and Statistics – IBGE) Foundation's Minimal Social Indicators, which are part of the minimal national databases recommended by several international conferences promoted by the United Nations.

The state of São Paulo has one of the lowest rates of under-reporting in the country (2% for the number of live births and 10% for the number of deaths).[12] This allows for direct calculation of infant mortality rates, and for reliable time series to be built for the last two decades.

Despite the marked decrease observed in the period , the IMR in the São Paulo Metropolitan Area is still high when compared to developed countries, such as France (6‰ lb), Portugal (9‰ lb), Japan (4‰ lb), and United States (7‰ lb); even though, all municipality groups showed values below 30‰ lb (Brazil, 2000) and the 34‰ lb mean rate of all WHO member countries[15] (1999).

In 1980, at least 50% of deaths occurred within the post-neonatal period. With the decrease observed in this component, there is a relative shift in the proportion deaths towards the neonatal period, especially to the early neonatal period, corresponding to the first 7 days of life. Likewise, there was a marked decrease in the proportion of deaths due to infections and parasitic diseases; endocrinal, metabolic, and nutritional diseases; and diseases of the respiratory system, which in together accounted for almost 70% of all infant deaths in 1980.

In 2000, with the reductions in the number of deaths due to these diseases, the proportion of deaths caused by conditions originating in the perinatal period rose to 60% of all infant deaths, across all groups. Szwarcwald et al[13] compared the reductions in early neonatal and post neonatal mortality rates registered several Brazil-

ian states, including São Paulo, to results obtained in Japan, Chile, United States, and certain European countries, concluding that the reductions achieved in these states were compatible with those of other countries only in terms of the post-neonatal component. The authors add that the countries listed only achieved such low levels of infant mortality (below 10‰ lb) after reducing the early neonatal component. As in developed countries, an important reduction in infant mortality in the SPMA will only occur when a reduction in the early neonatal component is achieved.

In all SPMA municipality groups, the greatest reduction in mortality levels was observed in the post-neonatal component. In Guarulhos, the greatest trend towards reduction in the 1971-1998 period was registered in the post-neonatal component.[14] The implementation of a healthcare network and the improvements in supply which took place in that municipality from the 1970's on were pointed out as potential causes for this decrease.

In Botucatu (São Paulo state), inadequate water supply and low maternal schooling were associated to an increased risk of infant mortality.[8] In the present study, infants living in municipalities included in Groups 1 and 2 – which at the beginning of the period presented the worst sanitary conditions and the highest illiteracy rates – were also at the highest risk of dying. At the end of the period, with the improvements observed in these indicators, IMR levels were similar across the 5 groups.

An analysis of the trends observed in cause-specific mortality rates in the SPMA showed a greater reduction in the number of deaths due to infectious diseases in all groups, probably due to the increase in water supply and sewage network coverage. Monteiro and Nazário[11] (1995), in a study of infant mortality in the city of São Paulo between 1973 and 1993 (which divided the city into 3 income-based regions) also concluded that differences in mortality distribution were less marked at the end of the period, especially due to increases in water supply in poor regions and the consequent decreases in the number of deaths by infectious diseases.

In Rio de Janeiro state, mortality rates decreased un-

Table 4 – Exponential regression models for infant mortality rates specific for the 5 main causes of death (IDC-9) in Groups 1-5 and SPMA, 1980-1995.

Group	Mortality rate (‰ live births)	β_0	β_1	IC 95% β_1		r^2
Group 1	Infectious (1)	8.24	-0.1770	-0.2038	-0.1502	0.94
	Endocrinal (2)	2.11	-0.1435	-0.1735	-0.1135	0.88
	Resp. sys. (3)	10.62	-0.1071	-0.1325	-0.0817	0.85
	Congenital (4)	2.77	-0.0230	-0.0383	-0.0077	0.42
	Perinatal (5)	23.00	-0.0442	-0.0541	-0.0343	0.87
Group 2	Infectious (1)	7.46	-0.1616	-0.1786	-0.1446	0.97
	Endocrinal (2)	1.89	-0.1468	-0.1724	-0.1212	0.92
	Resp. sys. (3)	8.23	-0.0941	-0.1115	-0.0767	0.91
	Congenital (4)	3.05	-0.0226	-0.0383	-0.0069	0.41
	Perinatal (5)	22.26	-0.0301	-0.0428	-0.0174	0.65
Group 3	Infectious (1)	5.25	-0.1608	-0.1744	-0.1472	0.98
	Endocrinal (2)	1.48	-0.1019	-0.1231	-0.0807	0.88
	Resp. sys. (3)	7.42	-0.0873	-0.1023	-0.0723	0.92
	Congenital (4)	2.88	-0.0121	-0.0200	-0.0042	0.44
	Perinatal (5)	17.67	-0.0303	-0.0373	-0.0233	0.86
Group 4	Infectious (1)	4.62	-0.0855	-0.1077	-0.0633	0.83
	Endocrinal (2)	1.21	-0.0290	-0.0654	0.0074*	0.17
	Resp. sys. (3)	6.49	-0.0605	-0.0754	-0.0456	0.84
	Congenital (4)	2.79	-0.0049	-0.0174	0.0076*	0.05
	Perinatal (5)	15.47	-0.0079	-0.0143	-0.0015	0.34
Group 5	Infectious (1)	4.14	-0.1323	-0.1492	-0.1154	0.95
	Endocrinal (2)	1.21	-0.1038	-0.1319	-0.0757	0.82
	Resp. sys. (3)	6.62	-0.0783	-0.0910	-0.0656	0.93
	Congenital (4)	2.92	-0.0007	-0.0052	0.0038*	0.01
	Perinatal (5)	15.24	-0.0333	-0.0393	-0.0273	0.91
São Paulo Metropolitan Area						
	Infectious (1)	4.81	-0.1338	-0.1494	-0.1182	0.96
	Endocrinal (2)	1.36	-0.0980	-0.1203	-0.0757	0.86
	Resp. sys. (3)	7.03	-0.0790	-0.0919	-0.0661	0.93
	Congenital (4)	2.90	-0.0052	-0.0090	-0.0014	0.39
	Perinatal (5)	16.49	-0.0284	-0.0339	-0.0229	0.90

Source: Crude data: Seade Foundation and Ministry of Health - SIM/MS.
β_0: Intercept; β_1: Mean Exponential Increase; IC β_1: 95% Confidence Interval for β_1; r^2: determination coefficient.
(1) infectious and parasitic diseases (2) endocrinal, metabolic, and nutritional diseases and immune disorders (3) diseases of the respiratory system (4) congenital malformations (5) conditions originating in the perinatal period.
*p>0.05

equally between 1979 and 1993.[7] The reductions reached in the regions with highest IMRs were related to the post-neonatal component, which, according to the authors, was greatly influenced by the amplification of the public water supply network and of healthcare service coverage. Likewise, the decrease in IMR in the SPMA was more marked in regions where sanitation conditions were most deficient, due to the increase in the number of water supply connections registered during the study period. This happened in spite of the reduction in purchasing power observed in the SPMA population. Other improvements in infant health indicators, such as increases in the duration of breastfeeding and in the percentage of children receiving immunization and improvements in antenatal care, are likely to have contributed towards the advancement of infant health as a whole.[2,10] Reductions in fecundity – and consequent reductions in the number of births – may also have contributed towards the decrease in IMR.[9]

Generally speaking, the analysis of IMRs in the São Paulo Metropolitan Area showed that public policies aimed at improving basic sanitary conditions have been effective in reducing post-neonatal mortality, which is due mainly to diseases related to the environment in which the child lives.

Almeida et al[1] (2002), in an analysis of neonatal mortality in the city of São Paulo, highlighted the association between socioeconomic conditions and the type of service used by pregnant mothers. These factors – combined with the relative increase in the proportion of deaths occurred in the early neonatal period and with the reduction of population-wide income levels, registered in the present study – indicate the need for a healthcare policy that prioritizes the improvement of services and personnel related to newborn and maternal care in the pre- and post-delivery periods, thus ensuring a more systematical surveillance of high-risk newborns. Access to these services, regardless of socioeconomic level, is likely to reduce the IMRs of all SPMA municipalities to levels compatible with those of developed countries.

In conclusion, IMRs were homogenized at around 18‰ lb in all municipality groups in the SPMA. One-half of all deaths were concentrated within the first week of life, and were due primarily to conditions originating in the perinatal period. This indicates the need for improvements in care during the pre- and post-delivery periods in order to promote further reductions in IMR.

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