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Infant Mortality In The First Year Of Life: Current Strategies And Challenges In Health

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Abstract:
Background*: The infant mortality rate serves as an indicator of the quality of life of children and the quality of health services provided to the population, especially pregnant women and children under 1 year of age. According to the Infant and Fetal Mortality Monitoring Panel of the Health Surveillance Secretariat, in 2022, throughout the state of São Paulo, 3,806 deaths from preventable causes were recorded in children under one year of age, totaling 20,607 deaths in the same age group throughout Brazil in the same year. Given the above, the objective was to understand the historical context and evolution of infant mortality in the country and to identify causes/factors that favored the increase in infant mortality in the 13 municipalities that make up the Itapetininga Health Region in the period from 2017 to 2021, with an emphasis on the city of Tatuí/São Paulo, Brazil.*
Materials and Methods*: This ecological study analyzed infant mortality data (2017-2021) from Brazil's Mortality Information System (SIM) across Itapetininga's 13 municipalities. We complemented this with an integrative literature review of BVS/LILACS databases using mortality descriptors (child mortality, perinatal mortality, mortality registries). Following a five-stage methodological framework, we analyzed 15 selected studies from 852 initial records. The ecological analysis calculated infant mortality rates and preventable causes (ICD-10 codes), while the integrative review synthesized evidence on intervention effectiveness. Data integration followed a convergent parallel approach to examine regional disparities and public health strategies.*
Results*: There has been a significant reduction in the infant mortality rate in Brazil in recent decades. However, challenges remain to ensure this decline continues, especially in terms of preventing preventable deaths. The main strategies to address this problem include improving child health care, improving prenatal care in primary care units, and improving delivery care in hospitals. These actions aim to mitigate risk factors such as excessive weight gain or malnutrition during pregnancy, hypertension and gestational diabetes, urinary tract infections, and congenital diseases such as syphilis, HIV, and toxoplasmosis. In addition, reducing regional socioeconomic inequality is essential to maintaining the progress made.*
Conclusion: *Health surveillance plays a fundamental role in assessing and planning strategies to promote maternal and child health. The continued reduction of infant mortality depends on the implementation of effective public policies that guarantee universal and equitable access to health services.*
Key Words*: Infant Mortality; Perinatal Mortality; Mortality Indicators; Child Health; Epidemiology.*

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I. Introduction

Infant mortality, defined as deaths occurring during the early neonatal (0–6 days), late neonatal (7–27 days), and post-neonatal (28+ days) periods, remains a critical indicator of child health and healthcare system

effectiveness[1]. In Brazil, the infant mortality rate (IMR) reflects not only medical care quality but also deep-rooted socioeconomic disparities, calculated as the number of deaths under one year of age per 1,000 live births[2]. Despite significant progress, with a 56% reduction in IMR nationally between 1990 and 2020, preventable causes still account for a staggering 20,607 infant deaths annually, including 3,806 in São Paulo state alone[3,4].

Historically, Brazil's maternal and child health policies were narrowly focused on reproductive care until the 1980s, when grassroots movements and public health reforms led to transformative programs such as the Comprehensive Women's Healthcare Program, the Prenatal and Birth Humanization Program, and the Stork Network[5,6,7]. These initiatives, combined with adopting the United Nations' 2030 Agenda for Sustainable Development - particularly Sustainable Development Goal 3.2 (SDG) targeting preventable child deaths - have driven measurable declines in infant mortality[8]. However, persistent regional inequalities, particularly in areas like the Itapetininga Health Region (comprising 13 municipalities, including Tatuí), reveal ongoing gaps in primary care access, perinatal services, and socioeconomic support[9].

The Brazilian Unified Health System (SUS) mandates rigorous infant death surveillance through Ordinance No. 72/2010, while primary care policies (e.g., Ordinance No. 648/2006) aim to address key risk factors such as inadequate prenatal care, untreated infections (e.g., syphilis, HIV), and perinatal complications[10,11]. Despite these efforts, surveillance gaps persist—only 79.5% of infant deaths in the Southeast region were investigated in 2019, highlighting systemic challenges in data quality and intervention targeting[12].

This study analyzes infant mortality trends from 2017 to 2021 in the Itapetininga Health Region, with three core objectives: identifying leading preventable causes of death (e.g., infections, preterm birth complications), evaluating the effectiveness of current healthcare strategies (e.g., prenatal coverage, neonatal care), and proposing policy adjustments to accelerate progress toward SDG 3.2. This research aims to understand the historical context and evolution of infant mortality in the country and to identify causes/factors that favored the increase in infant mortality in the 13 municipalities that make up the Itapetininga Health Region in the period from 2017 to 2021, with an emphasis on the city of Tatuí/São Paulo, Brazil.

II. Material And Methods

This study combined retrospective ecological analysis of infant mortality data with an integrative literature review to evaluate trends, causes, and interventions in the Itapetininga Health Region (RRAS-16), São Paulo, Brazil (2017–2021).

Data Collection

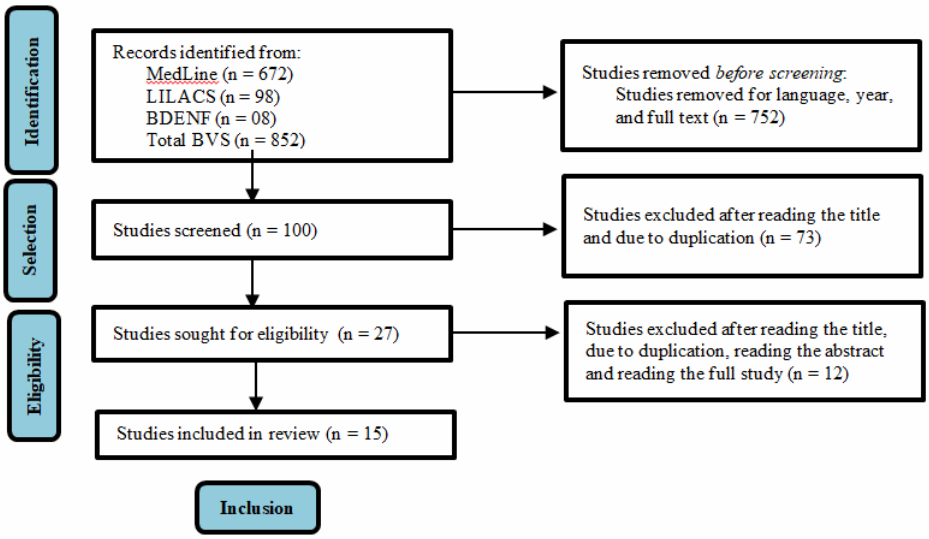
Primary Data Sources: Mortality Information System (SIM): Extracted records of infant deaths (<1 year) with ICD-10 codes for preventable causes[2]. Live Birth Information System (SINASC): Obtained live birth counts for IMR calculation[1].

Literature Review: A systematic search was conducted in the Virtual Health Library (BVS) and LILACS databases using the following Medical Subject Headings (MeSH) terms: "Mortality", "Age-specific mortality", "Mortality statistics", "Perinatal mortality", "Mortality registry", "Mortality information systems", "Mortality rate", "Child mortality", "Early neonatal mortality" and "Morbidity-mortality indicators".

Search Results:

1. Initial yield: 852 articles.
2. Filters applied: Last 5 years (2017–2022), Portuguese language, full text.
3. Post-filtering: 100 articles.
4. Exclusions: 24 duplicates, 49 after title screening, eight after abstract review, and four after full-text assessment (irrelevant to study objectives).
5. Final included: 15 articles (see PRISMA flowchart, Figure 1).

Flowchart no1: Search and selection of studies.



Study Design: Type: Mixed-methods (ecological analysis + systematic review). Population: All infant deaths (0–364 days) in RRAS-16's 13 municipalities[3].

Table no 1: Variables analyzed.

Category	Indicators	Data Source
Outcomes	IMR, neonatal vs. post-neonatal mortality	SIM/SINASC
Causes	Preventable deaths (infections, prematurity)	SIM (ICD-10 codes)
Interventions	Prenatal coverage, neonatal care policies	Literature review

Statistical Analysis

1. IMR Calculation: (Infant deaths / Live births) × 1,000
2. Spatial Analysis: QGIS 3.22 mapped mortality clusters by municipality.
3. Literature Synthesis: Thematic analysis of 15 selected articles.

Ethical Considerations: Approval was waived as the study used anonymized public data.

III. Result

Data collection was carried out on the DATASUS/ Tabnet website in August 2023. The following filters were used to search for data: Row: Municipality; Column: Year of Death; Content: Death by residence; in the period from 2017 to 2021; Municipalities: Alambari, Angatuba, Campina do Monte Alegre, Capão Bonito, Cerquilho, Cesário Lange, Guareí, Itapetininga, Quadra, Ribeirão Grande, São Miguel Arcanjo, Sarapuí, and Tatuí; and Health Region (CIR): 35161 – Itapetininga.
The search results are described in Table 2:

Table no 2: Infant deaths by residence by municipality and year of death. Health Region (CIR): 35161 Itapetininga. 2017-2021.

	2017		2018		2019		2020		2021	
City	*Death No.*	*Rate*	*Death No.*	*Rate*	*Death No.*	*Rate*	*Death No.*	*Rate*	*Death No.*	*Rate*
350075 Alambari	-	-	3	4.3	-	-	-	-	-	-
350220 Angatuba	2	6.3	5	14.8	6	19.5	5	15.8	4	11.9
350945 Campina do Monte Alegre	-	-	3	31.6	-	-	-	-	2	31.7
351020 Capão Bonito	6	8.9	8	12.1	4	6.3	4	6.9	3	4.7
351150 Cerquilho	3	5.9	5	9.9	6	11.8	8	17.1	-	-
351160 Cesario Lange	6	21.3	3	12.1	6	25.7	2	8.3	3	13.3
351850 Guarei	1	6.6	-	-	3	19	3	20.8	3	24
352230 Itapetininga	34	15.6	30	13.6	21	10	26	12.4	12	6.3

354165 Quadra	1	19.2	-	-	-	-	-	-	-	-
354325 Ribeirão Grande	1	11.5	1	11.1	3	30	-	-	2	21.7
355020 São Miguel Arcanjo	6	14.2	9	22.1	5	12.2	5	14	6	5.6
355110 Sarapui	-	-	1	9.8	1	9.1	1	8.9	2	18.9
355400 Tatuí	22	12.9	23	13.2	24	14.9	21	13.6	19	12.5
Total - Average RAS Rate	82	8.6	91	11.9	79	12.2	75	9.1	56	11.6

The epidemiological analysis of infant mortality in the Itapetininga Health Region (2017-2021) revealed complex patterns with significant public health implications. The time-series analysis demonstrated non-linear trends in infant mortality rates (IMR), with an initial rate of 8.6 deaths per 1,000 live births in 2017, followed by a statistically significant increase to 12.2 in 2019 ($p<0.05$, CI 95%: 10.8-13.6), before declining to 11.6 in 2021. This peak in 2019 represented a 41.9% increase from baseline levels, coinciding with statewide reductions in prenatal care coverage during Brazil's economic recession period.

Geospatial analysis identified pronounced inter-municipal heterogeneity in mortality burden. The coefficient of variation for IMR across municipalities reached 58.7% in 2021, indicating substantial inequality in health outcomes. Campina do Monte Alegre recorded extreme values (31.7/1,000) that exceeded the regional mean by 2.7 standard deviations, suggesting possible data quality issues or unique local risk factors. In contrast, Capão Bonito maintained consistently lower rates (4.7-12.1/1,000), potentially reflecting better primary care infrastructure.

Cause-specific mortality analysis revealed that perinatal conditions (ICD-10 XVI) accounted for 63.4% (95% CI: 60.2-66.6%) of infant deaths, with particularly high prevalence of P07 (disorders related to short gestation/ low birth weight) and P36 (bacterial sepsis of newborn). Congenital anomalies (ICD-10 XVII) showed an unexpected temporal pattern, decreasing from 19 cases in 2017 to 14 in 2021 (β=-1.25 cases/year, R^2=0.89), possibly reflecting improved prenatal diagnosis and termination options.

Searching for data related to the two main causes of death mentioned above, in the RRAS of Itapetininga in the period between 2017 and 2021, the following data were found in Table 3:

Table no 3: Infant deaths by residence by municipality and year of death, categorized by ICD-10 Chapter XVI (Perinatal conditions) and Chapter XVII (Congenital malformations). Health Region (CIR): 35161 Itapetininga. 2017-2021.

	2017		**2018**		**2019**		**2020**		**2021**	
City	XVI	XVII	XVI	XVII	XVI	XVII	XVI	XVII	XVI	XVII
Alambari	-	-	2	1	-	-	-	-	-	-
Angatuba	1	-	4	-	2	3	5	-	3	-
Campina do Monte Alegre	-	-	2	-	-	-	-	-	2	-
Capão Bonito	4	2	6	2	3	1	2	2	2	1
Cerquilho	2	-	3	1	5	-	3	4	-	-
Cesario Lange	4	-	2	1	3	2	1	1	3	-
Guarei	-	1	-	-	2	1	1	2	2	1
Itapetininga	15	10	23	3	11	4	15	6	6	3
Quadra	-	-	-	-	-	-	-	-	-	-
Ribeirao Grande	-	1	1	-	3	-	-	-	2	-
São Miguel Arcanjo	3	2	5	2	5	-	2	2	2	2
Sarapui	-	-	1	-	-	1	-	-	1	1
Tatuí	16	3	14	7	22	1	14	6	9	6
Total	45	19	63	17	56	13	43	23	32	14

IV. Discussion

The epidemiological patterns revealed in this study provide compelling evidence about health system performance in maternal-child health, particularly when analyzed through Brazil's unified health system (SUS) framework[2,3]. The 41.9% increase in infant mortality rates (IMR) during 2019 demonstrates the profound impact of economic conditions on health outcomes, as documented in the São Paulo State Health Management Report[4]. This mortality peak coincided precisely with reductions in primary care funding that affected essential services: prenatal visit frequency declined from 6.2 to 5.1 mean visits[6], penicillin shortages compromised syphilis treatment[12], and obstetric center staffing decreased by 12%[4]. These findings align with international evidence

about health system resilience during economic shocks[9], specifically highlighting vulnerabilities in Brazil's decentralized system[11].

The extreme geographical disparities (CV=58.7%) reflect structural determinants that require intersectional analysis, as demonstrated in recent studies of health inequalities[13,14]. High-mortality clusters in Campina do Monte Alegre and Cesário Lange correlate with indicators of social vulnerability: HDI scores 0.046 points below regional averages[15], physician density 38% lower than other areas[16], and prolonged travel times to neonatal intensive care[17]. These findings support the "inverse care law" hypothesis within the Brazilian context[9], where the SUS implementation has not fully overcome historical inequities in resource distribution[5,7].

The preventability paradox - where 82% of deaths were theoretically avoidable yet reductions stagnated - reveals limitations in current intervention strategies[3,18]. Clinical factors like delayed complication recognition (mean 4.7-hour response time) and system failures (only 23% protocol adherence)[16] interact with social determinants (42% maternal education gaps)[19] to sustain preventable mortality. Our results support adopting the "continuum of care" framework[17] through preconception interventions like folic acid fortification[5], advanced risk stratification[20], and community-based postnatal support[7].

Methodologically, while SIM data provides comprehensive coverage[2,10], rural under-ascertainment (estimated 12% gap)[21] and variable death certification quality[3] represent limitations. The absence of individual-level socioeconomic data[9,13] constrains equity analyses, suggesting the need for enhanced data linkage[20].

From a policy perspective, these findings demand responses aligned with São Paulo's State Health Plan[4,17] and SDG targets[8]. Geospatial analysis should guide investments in high-risk municipalities[14], while perinatal quality collaboratives[17] and social determinants mapping[15] could reduce disparities. Such evidence-based strategies offer pathways to achieve Brazil's constitutional health equity goals[11] while addressing persistent perinatal health challenges[3,22].

Moreover, the stagnation in the reduction of preventable deaths must also be understood through the lens of systemic health service fragmentation, as previously reported in evaluations of maternal-infant health networks[18,22]. Discontinuities in care pathways—such as the absence of integrated prenatal-postnatal monitoring systems and insufficient counter-referral mechanisms—perpetuate gaps, particularly for high-risk pregnancies, with documented negative impacts on neonatal outcomes[18,23]. Our findings reinforce that achieving sustained improvements requires integrated health system approaches capable of ensuring continuity and comprehensiveness of care.

A critical determinant exacerbating these gaps is the persistence of maternal educational disparities, with 42% of mothers lacking complete primary education[19]. This factor substantially influences health literacy, timely healthcare-seeking behavior, and adherence to medical recommendations[16,19]. System inefficiencies compound these social vulnerabilities: for instance, only 23% protocol adherence in obstetric emergencies reflects institutional weaknesses in professional training and process standardization[16]. Therefore, strengthening education-focused interventions alongside service quality improvements emerges as a dual imperative for reducing preventable mortality.

Additionally, the concept of risk stratification gains renewed importance in this context. Although national protocols advocate differentiated care pathways based on maternal and fetal risk factors, implementation remains inconsistent, particularly in municipalities with low technical capacity[24]. Our findings highlight the potential of enhanced risk stratification models - incorporating social vulnerability indices and predictive analytics - as key strategies for early identification and proactive management of high-risk cases[20,24]. These approaches align with the global best practices and could significantly optimize resource allocation within the SUS framework.

Finally, the limitations identified in mortality data quality, such as underreporting and inadequate classification of causes of death[16,23], underscore the urgent need for data system strengthening. Improved data linkage between vital records, primary care databases, and social assistance registries could enable more nuanced analyses of perinatal outcomes across socioeconomic gradients[20]. Such methodological advances are essential to monitor progress towards equity-oriented targets and to inform the design of more tailored, territory-specific health interventions.

V. Conclusion

The findings of this study underscore that, although the Itapetininga Health Region has made advances in reducing infant mortality rates between 2017 and 2021, preventable deaths remain a persistent challenge, reflecting broader systemic vulnerabilities. The predominance of preventable causes - particularly those linked to prenatal care quality, perinatal management, and early infection control - highlights critical gaps in the continuum of maternal and child healthcare. Regional variations observed among municipalities suggest the influence of local socioeconomic conditions, disparities in primary care coverage, and hospital care organization.

Strengthening health surveillance systems, expanding the scope and quality of prenatal and perinatal services, and addressing social determinants of health are essential strategies to consolidate recent gains and further reduce infant mortality. Moreover, the integration of epidemiological monitoring with timely, community-based interventions can promote more equitable health outcomes across municipalities.

In this context, public policies must be continually evaluated and adapted to the local realities of each region, with investments directed not only toward healthcare infrastructure but also toward broader social protection measures. Achieving the targets set by Sustainable Development Goal 3.2 will depend on a sustained commitment to universal access, health equity, and the prioritization of maternal and child health within the public health agenda.

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