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CLINICAL RESEARCH:

Municipal Inequalities in the Prevalence of Caries-Free Children Aged 2, 4, and 6 Years in Santiago, Chile: An Ecological Study

Desigualdades comunales en la prevalencia de niños libres de caries de 2, 4 y 6 años en Santiago de Chile: Un estudio ecológico

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ABSTRACT: To analyze municipal inequalities in the prevalence of caries-free children among 2-, 4-, and 6-year-old children treated in the eastern sector of Santiago, Chile, during 2024, and to evaluate the presence of social inequalities according to municipal socioeconomic position. An ecological study based on monthly statistical records (REM) from the Chilean Ministry of Health. Data from 6,951 children aged 2, 4, and 6 years who entered dental care at primary health care centers in the eastern sector were analyzed. The prevalence of caries-free children was estimated as the proportion of children with a dmft index of 0, by municipality and age group. Territorial inequalities were assessed using absolute and relative differences, and the relative variation index. The social gradient was analyzed using the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII), considering the Social Priority Index as the socioeconomic position variable. A statistical significance level of $p<0.05$ was used. The analyses were performed using Stata 19.5. The overall prevalence of children with no caries experience was 62.9%. By age, prevalence was 87.6% at 2 years, 49.6% at 4 years, and 50.3% at 6 years. The absolute differences between communes reached 25.3 percentage points at 2 years and exceeded 50 percentage points at 4 and 6 years. The relative difference indicated that the commune with the highest prevalence had approximately twice the prevalence of the commune with the lowest (PR=2.02). Inequalities were more pronounced at older ages. No statistically significant socioeconomic gradient was observed according to SII and RII. The prevalence of children without caries experience decreases with age, and territorial gaps widen in later stages. The absence of a statistically significant social gradient should be interpreted with caution, considering the limitations of the study design and the context analyzed.

KEYWORDS: Dental caries; Health inequalities; Social determinants of health; Oral health; Primary teeth; Child; Risk factors; Ecological study.

RESUMEN: Analizar las desigualdades comunales en la prevalencia de niños de 2, 4 y 6 años sin experiencia de caries atendidos en el sector oriente de Santiago de Chile, durante el año 2024, y evaluar la presencia de desigualdades sociales según posición socioeconómica comunal. Estudio ecológico basado en registros estadísticos mensuales (REM) del Ministerio de Salud de Chile. Se analizaron registros de 6.951 niños de 2, 4 y 6 años que ingresaron a atención odontológica en Atención Primaria. La prevalencia de niños sin experiencia de caries se definió como índice ceo-d igual a cero y se estimó por comuna y grupo etario. Las desigualdades territoriales se evaluaron mediante diferencias absolutas y relativas, además del índice de variación relativa. El gradiente social se analizó utilizando el Índice de Desigualdad Absoluta (Slope Index of Inequality, SII) y el Índice de Desigualdad Relativa (Relative Index of Inequality, RII), empleando el Índice de Prioridad Social como variable de posición socioeconómica. Se consideró un nivel de significancia de $p<0,05$. Los análisis se realizaron en STATA 19.5 La prevalencia global de niños sin experiencia de caries fue 62,9% con una disminución marcada según edad. 87,6% a los 2 años, 49,6% a los 4 años y 50,3% a los 6 años. Se observaron importantes brechas comunales, con diferencias absolutas de hasta 25,3 puntos porcentuales a los 2 años y superiores a 50 puntos en edades mayores. La razón de prevalencias indicó que la comuna con mayor prevalencia duplicó a la de menor prevalencia (RP=2,02). Las desigualdades fueron más marcadas en edades mayores. No se evidenció un gradiente socioeconómico estadísticamente significativo según SII y RII. La prevalencia de niños sin experiencia de caries disminuye con la edad, mientras que las brechas territoriales se amplifican en etapas posteriores. La ausencia de un gradiente social significativo debe interpretarse con cautela, considerando posibles limitaciones del diseño y del contexto analizado.

PALABRAS CLAVE: Caries dental; Desigualdades en salud; Determinantes sociales de la salud; Salud bucal; Dentición primaria; Niño; Factores de riesgo; Estudio ecológico.

INTRODUCTION

Early childhood caries remains one of the most prevalent public health problems worldwide, disproportionately affecting children living in contexts of greater social vulnerability. According to estimates from the Global Burden of Disease Study, oral diseases affect more than 3.5 billion people, with caries in the primary dentition being one of the most frequent conditions among children under 5 years of age (1, 2). Although it is a preventable disease (3), its persistence reflects structural inequalities related to social determinants, access to health services, and territorial conditions (4).

National and international evidence has consistently shown that the distribution of caries follows a socially unequal pattern, with a higher burden concentrated in more socioeconomically disadvantaged groups (5-11). These inequalities are expressed not only at the individual or family level, but also across territories, where factors such as the availability of dental services, water fluoridation, health infrastructure, and municipal socioeconomic conditions influence oral health outcomes (12, 13). In this regard, territorial analysis makes it possible to understand how the context in which children live shapes differential opportunities for oral health.

In Latin America, the burden of childhood caries remains high and is marked by profound social gaps (8, 14). In Chile, although public policies aimed at preventing dental caries in the pedia-

tric population have been implemented, such as the Programa de Control con Enfoque de Riesgo Odontológico (CERO), Sembrando Sonrisas, and, within the framework of the Garantías Explícitas en Salud (GES), the Comprehensive Oral Health Program for 6-Year-Old Children (15-17), differences in health outcomes across municipalities and health services still persist. National studies have shown that caries experience in children is associated with socioeconomic status, maternal education, and access to preventive dental checkups, suggesting that equity in coverage does not necessarily translate into equity in outcomes (7, 8, 18).

The Metropolitan Region encompasses substantial socioeconomic heterogeneity, even within specific geographic sectors. The eastern sector of Santiago includes municipalities with different demographic profiles, income levels, and coverage of public services, which may be reflected in differences in caries experience. Assessing the prevalence of caries-free children aged 2, 4, and 6 years provides a positive oral health indicator and may offer insight into the impact of preventive strategies implemented during early childhood. From a social determinant of health perspective, territorial inequalities should not be interpreted solely as statistical variations, but rather as expressions of structural processes that generate unequal opportunities for well-being (4, 13).

Within this framework, identifying municipal gaps in the prevalence of caries-free children may provide relevant evidence to inform health planning, target preventive interventions, and strengthen intersectoral strategies. Therefore, this study aims to analyze municipal inequalities in the prevalence of caries-free 2-, 4-, and 6-year-old children receiving care in the eastern sector of the Metropolitan Region, thereby contributing to the understanding of territorial inequalities in child oral health from an epidemiological and social perspective.

METHODOLOGY

An ecological study was conducted using secondary data from the Monthly Statistical Registry (Registro Estadístico Mensual, REM), A-09 series, of the Chilean Ministry of Health, corresponding to the year 2024. The information was obtained from the official website of the Department of Health Statistics and Information (Departamento de Estadísticas e Información de Salud, DEIS), the agency responsible for consolidating and systematizing administrative records from the public healthcare network (19).

The study population consisted of records of children aged 2, 4, and 6 years who were beneficiaries of the public health system and entered dental care at Primary Health Care (PHC) facilities in municipalities of the eastern sector of the Metropolitan Region during 2024.

The eastern sector comprises the municipalities of Providencia, Las Condes, Vitacura, Lo Barnechea, Ñuñoa, La Reina, Macul, and Peñalolén, with an approximate population of 650,000 public health system beneficiaries, of whom nearly 15% are under 15 years of age. Since all available records for the study period were used, no sample size calculation was performed, which allowed a representative estimate of the prevalence of caries-free children in this population.

Records of children aged 2, 4, and 6 years were included if they: a) entered dental care for the first time through the Dental Risk-Based Care Program (Programa de Control con Enfoque de Riesgo Odontológico, CERO), b) had the dmft index recorded at the time of entry, and c) received care in public PHC facilities. The study included only children affiliated with the public health system who accessed dental care in PHC facilities, excluding those treated in the private sector or those who did not seek care. This may have introduced

selection bias and limited the representativeness of the findings.

The dependent variable was the prevalence of children without caries experience, defined as the percentage of children with a dmft index equal to 0 at entry into the dental program. The dmft index corresponds to the sum of decayed, missing due to caries, and filled primary teeth. This diagnosis was based on the clinical examination performed by dentists, following the Chilean Ministry of Health's technical guidelines for recording the dmft index within the dental program. Although formal inter-examiner calibration processes could not be verified in this study, the use of nationally standardized protocols contributes to the comparability of records. Nevertheless, information bias derived from differences in clinical practice and recording cannot be ruled out. The independent variables were age (2, 4, and 6 years), municipality of care, and the municipal Social Priority Index (Índice de Prioridad Social, IPS). The IPS was used as a measure of territorial socioeconomic position (20).

Statistical analysis was performed at the municipal level, considering as the unit of analysis the municipalities in the eastern sector of the Metropolitan Region that belong to the Eastern Metropolitan Health Service (Servicio de Salud Metropolitano Oriente, SSMO). The prevalence of caries-free children aged 2, 4, and 6 years was estimated based on the proportion of children with a dmft index equal to 0 at entry into the dental program and the examined population. Because this was an ecological study, no inferences can be made at the individual level.

Inequalities were assessed using both simple measures and gradient-based measures. Simple measures included the absolute difference in prevalence (absolute gap) between the municipalities with the highest and lowest levels of vulnerability, the prevalence ratio (relative gap) between these extremes, and the relative variation index (21).

Gradient-based measures included the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). For this purpose, the relative rank of socioeconomic position (Ri) was used as a continuous independent variable, constructed by ordering municipalities according to the Social Priority Index (IPS), from lowest to highest vulnerability (21).

The Ri was calculated using the ridit scoring method, taking into account the population distribution of each municipality. Specifically, municipalities were ranked according to IPS, the cumulative proportion weighted by population size was calculated, and each municipality was assigned the midpoint of its cumulative rank, ranging from 0 (lowest vulnerability) to 1 (highest vulnerability). This procedure incorporates the relative size of each territorial unit and avoids assuming equal intervals between categories. Given the limited number of territorial units included, the statistical power to detect socioeconomic gradients using SII and RII may have been reduced.

The SII was estimated using weighted linear regression and represents the estimated absolute difference in prevalence between the extremes of the socioeconomic gradient. The RII was estimated using generalized linear models with Poisson distribution, log link, and robust variance, expressing the relative ratio between these extremes. Estimates were reported with 95% confidence intervals. Analyses were performed using Stata software, version 19.5.

REM data are nationally consolidated administrative records that undergo institutional validation and supervision processes. However, it was not possible to independently assess the completeness or quality of the records in each

facility, so inconsistencies or underreporting may have affected the estimates.

The study used anonymized secondary data from the REM of the Ministry of Health, which are publicly available. No identifiable information was accessed and no interventions involving human participants were conducted; therefore, informed consent and ethics committee approval were not required, in accordance with current national regulations on research using public databases.

RESULTS

During 2024, a total of 6,951 children were examined in the eastern sector, of whom 4,373 had a dmft index of 0, corresponding to an estimated prevalence of 62.9% of children without caries experience.

Prevalence decreased markedly with age, from 87.6% at 2 years to 49.6% at 4 years and 50.3% at 6 years. Substantial territorial inequalities were also observed, with municipal values ranging from 43.3% in La Reina to 87.6% in Macul. These differences were more pronounced among 4- and 6-year-old children, whereas prevalence among 2-year-old children tended to be consistently higher across municipalities (Table 1).

When inequality indicators were analyzed, marked territorial heterogeneity was observed in the municipal prevalence of children without caries experience, with values ranging from 43.3% to 87.6%. The absolute difference reached 44.3 percentage points, while the relative difference indicated that the municipality with the highest prevalence had approximately twice the prevalence of the municipality with the lowest (PR=2.02). A relative variation index (RVI) of 0.70 suggests moderate to high inequality at the aggregate level.

In the age-specific analysis, inequalities were less pronounced among 2-year-old children, with an absolute difference of 25.3 percentage points, and the relative variation index (RVI) was 0.29, indicating low to moderate inequality and a relatively homogeneous distribution across municipalities. In contrast, variability was substantially greater among the 4- and 6-year-old groups. At 4 years of age, the absolute difference reached 54.0 percentage points and the RVI was 1.09. Similarly, at 6 years of age, the mean prevalence was 50.3%, with an absolute difference of 53.2 percentage points and an RVI of 1.06. In both age groups, an RVI greater than 1 indicates that the magnitude of the gap exceeded the group mean, reflecting marked territorial inequality.

The Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) were calculated using the relative rank of socioeconomic position (Ri), estimated through ridit scoring. The SII was obtained using weighted linear regression, whereas the RII was estimated using Poisson regression with robust variance.

As shown in Table 3, the analysis based on the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) did not reveal a significant socioeconomic gradient in the overall prevalence of children without caries experience. In the 2-year-old group, the SII and RII values indicated a minimal absolute and relative difference between the extremes of the social gradient, with no statistically significant evidence of inequality. Among 4-year-old children, although the results

did not reach statistical significance, the RII value suggests a possible trend toward a higher prevalence of children without caries experience in municipalities with a more favorable socioeconomic position. In the 6-year-old group, a small and non-significant difference was observed, with no consistent pattern of social gradient. When all age groups were considered together, the SII and RII values confirmed the absence of significant social inequalities in the prevalence of children without caries experience in the eastern sector during 2024.

Table 1. Estimated prevalence of caries-free children by municipality and age group, eastern sector of the Metropolitan Region, 2024.

Municipality	2 years (%)	4 years (%)	6 years (%)	Total (%)
Las Condes	86,5	64,2	59,6	69,9
La Reina	79,5	28,4	28,7	43,3
Peñalolén	85,0	40,6	43,6	55,7
Ñuñoa	92,8	69,9	61,2	75,0
Vitacura	100,0	82,4	61,0	77,6
Providencia	95,4	64,4	47,3	67,1
Lo Barnechea	74,7	56,7	37,8	54,2
Macul	95,8	67,9	81,9	87,6
Total	87,6	49,6	50,3	62,9

Note: %=percentage of examined children without caries experience.

Table 2. Inequality indicators for the prevalence of caries-free children by age group in the eastern sector of the Metropolitan Region, 2024.

Indicator	2 years	4 years	6 years	Sector
Mean prevalence, eastern sector (%)	87,6	49,6	50,3	62,9
Maximum prevalence (%)	100,0	82,4	81,9	87,6
Minimum prevalence (%)	74,7	28,4	28,7	43,3
Absolute difference (%)	25,3	54,0	53,2	44, 3
Relative difference (PR)	1,34	2,9	2,9	2,02
Relative variation index (RVI)	0,29	1,09	1,06	0,70

Note: The absolute difference corresponds to the subtraction of the minimum prevalence from the maximum prevalence observed across municipalities (max-min). The relative difference is expressed as a prevalence ratio (PR=maximum prevalence/minimum prevalence). The relative variation index (RVI) was calculated as the absolute difference divided by the mean prevalence of the sector. Higher PR and RVI values indicate greater territorial inequality.

Table 3. Social inequality indices (SII and RII) for the prevalence of caries-free children by age group in the eastern sector of the Metropolitan Region, 2024.

Age	SII	p-value	RII	p-value	Interpretation
2 years	+0,05	0,64	1,06	0,53	No gradient
4 years	+0,25	0,23	1,49	0,10	Trend
6 years	–0,07	0,76	0,88	0,73	No gradient
Total	+0,01	0,95	1,02	0,94	No gradient

Note: SII: Slope Index of Inequality; RII: Relative Index of Inequality. The SII measures absolute inequality and the RII measures relative inequality in the prevalence of caries-free children across the socioeconomic gradient. SII values > 0 or RII values > 1 indicate a higher prevalence in more advantaged groups; SII values < 0 or RII values < 1 indicate a higher prevalence in more disadvantaged groups. $p < 0.05$ indicates statistical significance.

DISCUSSION

The aim of this study was to analyze municipal inequalities in the prevalence of caries-free 2-, 4-, and 6-year-old children in the eastern sector of the Metropolitan Region during 2024. The results showed an estimated overall prevalence of 62.9% of caries-free children, with a declining pattern by age: 87.6% at 2 years, 49.6% at 4 years, and 50.3% at 6 years.

These findings are consistent with the literature, which indicates that dental caries begins early and increases progressively with age (9, 11, 22). In the present study, the prevalence of caries-free children at 2 years of age was 1.7 times higher than at 4 years, reflecting the rapid accumulation of cariogenic damage during the preschool period and reinforcing the importance of implementing preventive strategies from the earliest years of life.

Early childhood is a critical period for overall development. Maintaining adequate oral health not only contributes to tooth eruption and dental development but also influences craniofacial growth and the proper acquisition of functions such as mastication, breathing, swallowing, and speech. All these processes are directly related to the quality of life and well-being of preschool children (23, 24).

Territorial variability was more evident in the 4- and 6-year-old groups, whereas at 2 years of age prevalences tended to be consistently higher in most municipalities. This pattern suggests that, at 2 years of age, caries damage remains limited, which is epidemiologically plausible given that cumulative exposure to social, environmental, and behavioral determinants is lower than at later ages (4). As age increases, prolonged interaction with risk factors, such as sugar-rich dietary habits, inadequate oral hygiene practices, and unfavorable socioeconomic conditions, may contribute to greater territorial differentiation in oral health outcomes (25).

Several studies have shown that dental caries in childhood follows a cumulative pattern, increasing progressively with age and occurring more frequently in contexts of greater social vulnerability (11, 13, 14). In this regard, the greater dispersion observed in the 4- and 6-year-old groups may reflect the cumulative effect of these determinants over time.

Likewise, the universal coverage of preventive programs targeting early childhood may be contributing to a more homogeneous distribution of oral health at younger ages. In Chile, initiatives such as Sembrando Sonrisas, the CERO Program,

and the Explicit Health Guarantee (GES) for oral health at 6 years of age have expanded access to preventive interventions and dental check-ups in the pediatric population (7, 8, 26). Evidence suggests that this type of population-based strategy may help reduce inequalities during the early stages of life, particularly when implemented with high coverage in the public health system (2). Nevertheless, the greater heterogeneity observed at older ages suggests that the effects of the social determinants of health may emerge progressively as children grow and accumulate differential exposures within the family and community environment.

Regarding social inequalities, although relevant territorial differences were observed in the prevalence of caries-free children across municipalities, social gradient analyses did not show statistically significant associations according to municipal socioeconomic position as measured by the Social Priority Index (IPS). Both the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) showed low-magnitude and non-significant associations, suggesting the absence of a clearly defined social gradient in the distribution of this indicator at the aggregate level. However, these findings should be interpreted with caution. First, the analysis was conducted in municipalities from the eastern sector of the Metropolitan Region, an area characterized by relative socioeconomic homogeneity compared with other areas of the country, which may have reduced the variability needed to detect systematic differences in oral health. Second, the limited number of territorial units included in the analysis may have reduced the statistical power to detect gradients using indicators such as the SII and RII. Taken together, these factors may have contributed to an underestimation of existing inequalities. Therefore, the lack of statistical significance should not be interpreted as evidence of the absence of inequity, but rather as a limitation of the study design and the context analyzed.

In addition, broad coverage of preventive oral health programs in primary care directed at the pediatric population should also be considered. Previous studies have indicated that universal public policies focused on early childhood may help reduce social gaps in oral health, especially when they are implemented with high coverage and continuity in the public system (2, 13). However, the presence of relevant municipal differences in the observed prevalence suggests that other contextual factors, such as characteristics of the local environment, patterns of healthcare utilization, or behavioral and family-related determinants, may be influencing the territorial distribution of caries damage (27, 28).

Some limitations should be considered when interpreting the results of this study, including the use of secondary data derived from administrative records of the public health system. This information depends on the quality of clinical recording in primary care facilities. This may have introduced information bias and affected prevalence estimates, either through underreporting or variability in diagnostic criteria across professionals. The analysis was based on aggregated municipal-level data, which implies the possibility of ecological fallacy, since associations observed at the territorial level do not necessarily reflect relationships at the individual level. The population analyzed consisted exclusively of children covered by the public health system who entered dental care during the study period, which may have introduced selection bias by excluding those who received care in the private sector or who did not access dental care. The small number of territorial units analyzed limits the statistical power to detect social gradients in the inequality analyses. Taken together, these limitations suggest that the findings should be interpreted with caution, particularly with regard to the magnitude and statistical significance of the observed inequalities and reinforce the need for future studies incorporating

greater territorial heterogeneity, individual-level analyses, and complementary data sources.

This study suggests that, in the eastern sector of the Metropolitan Region, approximately six out of ten children aged 2, 4, and 6 years receiving care in the public health system had no caries experience, and that this proportion declines markedly between 2 and 4 years of age, highlighting the rapid progression of the disease during early childhood. Although relevant territorial differences were observed across municipalities, the social inequality indicators did not show statistically significant gradients according to the Social Priority Index.

From a public health perspective, these findings suggest that preventive strategies implemented within the public health system may be contributing to the attenuation of social inequalities at early ages. However, the municipal differences observed indicate the need to strengthen context-specific interventions and continue monitoring the territorial distribution of child oral health. In this sense, positive oral health indicators, such as the prevalence of caries-free children, may provide relevant evidence for health planning, efficient resource allocation, and the design of preventive strategies aimed at reducing oral health inequities during early childhood.

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