ORIGINAL ARTICLE

Distribution of cases of congenital heart disease in a hospital in Oeste Paulista

Bruna Maria Casachi Bernardes de Melo Carapeba, Sérgio Marques Costa, Rogério Giuffrida, Ana Paula Alves Favareto, Ana Paula Marques Ramos, Fabíola de Azevedo Mello, Marcus Vinicius Pimenta Rodrigues, Renata Calciolari Rossi

ABSTRACT

The aim of this research was to conduct a comprehensive spatial-temporal analysis of the population affected by congenital heart anomalies assisted at the Pediatric Cardiology Outpatient Department at the distinguished Western Paulista reference hospital. We conducted a retrospective study involving the analysis of electronic database records and patient medical charts for individuals diagnosed with congenital heart disease during the period from July 2013 to July 2018. A total of 298 medical records were selected for the analysis of variables encompassing the ICD-10 codes, gender, spatial distribution, and temporal trends. It was possible to observe that septal defects were the most prevalent congenital heart abnormalities, and there was no gender-based difference. An increase in diagnoses was noted from 2014, coinciding with the implementation of the "heart test," and 51% of the cases were from Presidente Prudente, with a higher concentration of cases in the industrial park area. There is an association between cardiac congenital malformations and an adverse environmental context. The findings can inform public health policies aimed at reducing the exposure of the most vulnerable population in pursuit of improving health indicators.

Keywords: Heart diseases, Environment and public health, Spatio-temporal analysis.

INTRODUCTION

Congenital heart diseases (CHD) represent one of the primary congenital malformations in live-born infants, with approximately 40%, being the leading cause of death due to congenital malformations[1,2] and, the majority of cardiac anomalies having an unknown etiology[3,2,4].

The advancement in etiological assessments in recent decades aligns with the progress in embryology knowledge and the development of genetic and molecular techniques to identify genes responsible for genetic diseases, this advancement has contributed to the identification of hereditary causes linked to CHD[3]. Non-inherited causes account for approximately 2% of cardiac anomalies. In recent years, greater importance has been given to the association between environmental factors or modifiable factors as potential risks for the development of congenital anomalies[3,5].

The city of Presidente Prudente (PP), where the study was conducted, is situated in the Western São Paulo region, belonging to the mesoregion and microregion with the same name[6]. The region has several aspects of vulnerability, such as correctional facilities. Additionally, the region has a strong agricultural activity, with sugarcane being a prominent feature. It is known that, for the proper management of these crops, the use of agricultural pesticides is indispensable. However, the correct application methods have been discussed in studies, as well as the adverse effects related to human health[7,8].

Due to the large number of patients treated in the Regional Health Care Networks with congenital heart diseases (CHD), a regional study was deemed necessary to assess the occurrence and prevalence of CHDs and their relationship with the region. Thus, the study aimed to analyze the spatiotemporal distribution of patients with congenital heart diseases treated at the Pediatric

Universidade do Oeste Paulista, Presidente Prudente, (SP), Brasil.

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Cardiology Outpatient Clinic of the reference hospital in Western São Paulo.

METHODS

This is a retrospective ecological study involving the analysis of data obtained from medical records of patients with congenital heart disease at the Pediatric Cardiology Outpatient Clinic of the Regional Hospital of Presidente Prudente.

Sample composition

The initial database consisted of 462 records of cardiac conditions, with 144 physiological cases excluded, along with 12 individuals with inconsistent data, and 8 originating from different regions. Thus, a total of 298 records were analyzed, with all patients having their diagnoses confirmed through echocardiography performed at the study hospital from July 2013 to July 2018. For the statistical analyses, the records were grouped into seven categories according to the international classification of diseases code adopted in Brazil[9]: Q20, Q21, Q22, Q23, Q24, Q25, and Q26.

Data collection and processing

Data collection was conducted through analyses of individual patient records and the electronic database of the Regional Hospital of Presidente Prudente to ascertain the prevalence of congenital heart disease in the respective most prevalent types described in the sample composition. Data relating to patient origin, age, ethnicity, and gender were collected.

Spatial distribution of congenital heart disease cases

Thematic maps depicting the spatial distribution of congenital heart diseases (CHD) between 2013 and 2018 in the 45 municipalities corresponding to Regional Health Care Networks (RHCN) 11 were created following the recommendations of Dent et al.[10] (2009). The maps were produced using Geographic Information System (GIS) software, utilizing a vector cartographic base provided by IBGE. The municipalities located in the regions of Alta Paulista, Alta Sorocabana, Alto Capivari, Extremo Oeste Paulista, and Pontal do Paranapanema are part of RHCN 11.

Following this stage, the most populous municipality, which refers to Presidente Prudente, was mapped to identify the most prevalent locations of congenital heart diseases (CHD). Subsequently, a regional analysis was conducted to examine potential environmental factors that could be associated with these incidences.

Comparison between sexes and congenital heart diseases

All analyses were conducted using the statistical software R[11], with a significance level of $p < 0.05$ adopted for all comparisons. The G-test was employed to compare equal proportions and determine whether congenital heart diseases, regardless of the type, predominated in one of the sexes. To assess whether a significant association occurred between sex and the category of congenital heart disease, or the outcomes “surgical treatment” and “clinical treatment,” the chi-square test or Fisher’s exact test was employed, along with odds ratio estimates along with the respective 95% confidence intervals. The frequencies of the pathologies recognized as most significant, specifically Q21.0, Q21.1, Q21.3, Q25.0, and Q25.8, were subjected to comparison using Cochran’s Q test. Contrast analysis was then conducted employing the Wilcoxon method, and the resulting p-values were adjusted through the False Discovery Rate (FDR) method.

Time series

Monthly birth rates of individuals with congenital heart diseases were calculated per 10,000 live births for the years 2000 to 2019, using data from the 2010 censuses[12]. Using these data, box-plot graphs were constructed to examine the behavior of these rates within each month. To assess the temporal evolution of congenital heart disease birth registrations, a generalized linear regression Poisson method was fitted. This model utilized the monthly cases rate per 10,000 live births within the scope of RHCN 11, based on the census data from 2000 and 2010[13]. This model was chosen due to the data being dispersed, as the variance and mean of monthly recorded cases exhibited significant asymmetry[14].

RESULTS

In our study, it was possible to observe an increase in the diagnosis of congenital heart diseases starting from the year 2014, as demonstrated in the Poisson regression model (Figure 1). This increase coincides with the period of implementation of the "heart screening test," which was widely disseminated in the neonatology service.

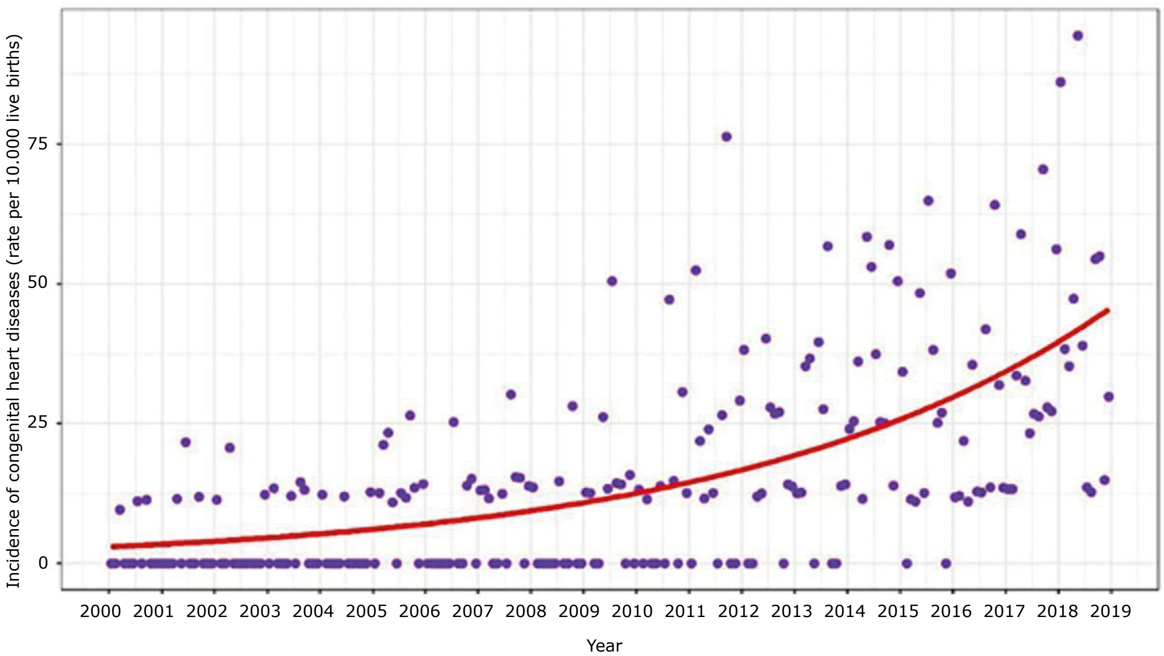

Figure 1: Monthly cases of births with congenital heart diseases (rate per 10,000 live births) within the coverage area of RHCN 11. The purple points represent the observed case rates recorded each month, and the red curved line represents the values predicted by the Poisson regression model. Source: Authors.

Table 1
Comparisons between sexes.

Variable	Sex			p	OR	CI 95%
	Male (n = 131) (%)	Female (n = 167) (%)	Total (n = 298) (%)			
Q20	10 (3.36)	8 (2.68)	18 (6.04)	0.44	0.60	0.23-1.59
Q21	77 (25.84)	99 (33.22)	176 (59.06)	1	1.02	0.64-1.62
Q22	12 (4.03)	14 (4.70)	26 (8.72)	0.99	0.91	0.40-2.03
Q23	5 (1.68)	3 (1.01)	8 (2.68)	0.48	0.46	0.10-1.96
Q24	1 (0.34)	6 (2.01)	7 (2.35)	0.14	4.84	0.57-40.75
Q25	27 (9.06)	37 (12.42)	64 (21.48)	0.78	1.10	0.63-1.92
Q26	1 (0.34)	2 (0.67)	3 (1.01)	1	1.57	0.14-17.57

p = statistical significance of Pearson's chi-square test; OR = odds ratio; 95% CI = 95% confidence interval for OR estimation. Source: Authors.

Although we observed a higher number of congenital heart disease diagnoses in females, there was no statistical significance between the sexes (Table 1).

Sex did not influence the indication of the type of treatment for the heart condition (Table 2).

The distribution of diagnosed cases in RHCN 11 – (Figure 2) showed higher prevalence in the municipality of PP, followed by the municipalities of Dracena, Presidente Venceslau, Presidente Epitácio, Santo Anastácio, Estrela do Norte, Álvares Machado, and Martinópolis. This higher percentage found in the municipality of Presidente Prudente can be justified

Table 2

Bivariate analysis for the association between indicated treatment and sex.

Variable	Sex			p	OR	CI 95%
	Male (%)	Female (%)	Total (%)			
Clinical treatment						
Yes	66 (22.1)	82 (27.5)	148 (49.7)	0.918	1.05	0.66-1.66
No	65 (21.8)	85 (28.5)	150 (50.3)			
Total	131 (44)	167 (56)	298 (100)			
Clinical treatment						
Yes	79 (26.5)	113 (37.9)	192 (64.4)	0.232	0.72	0.45-1.17
No	52 (17.4)	54 (18.1)	106 (35.6)			
Total	131 (44)	167 (56)	298 (100)			

p = statistical significance of Pearson's chi-square test; OR = odds ratio; 95% CI = 95% confidence interval for OR estimation. Source: Authors.

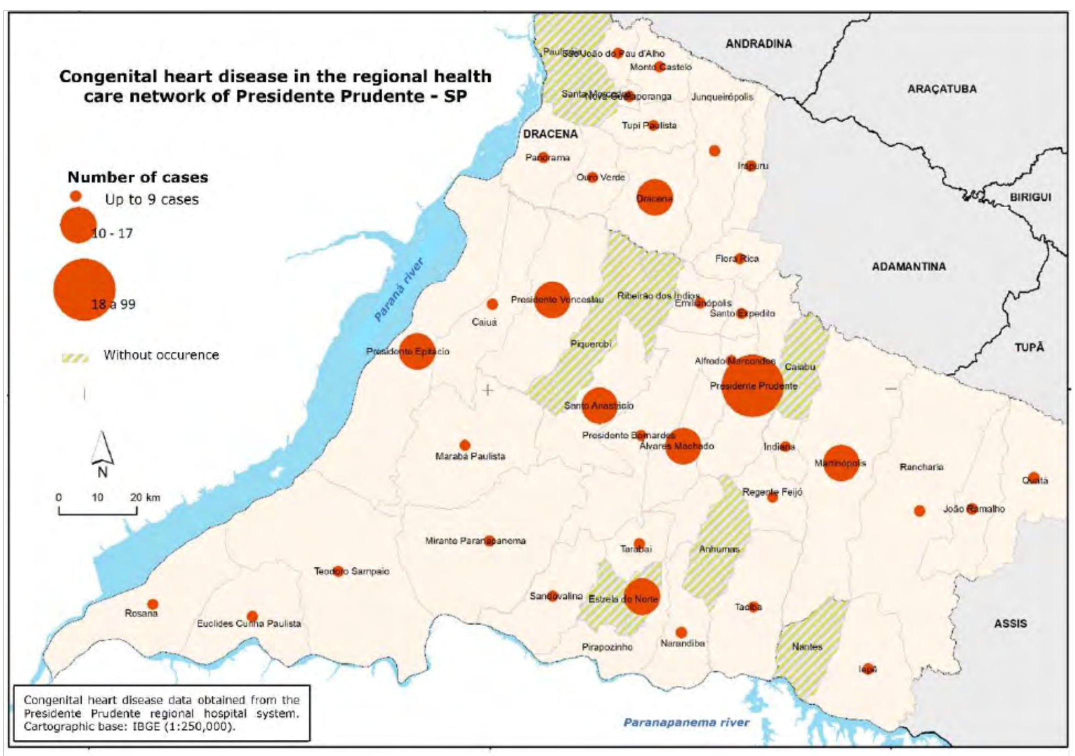

Figure 2: Prevalence of congenital heart disease cases treated at a hospital belonging to RHCN 11.

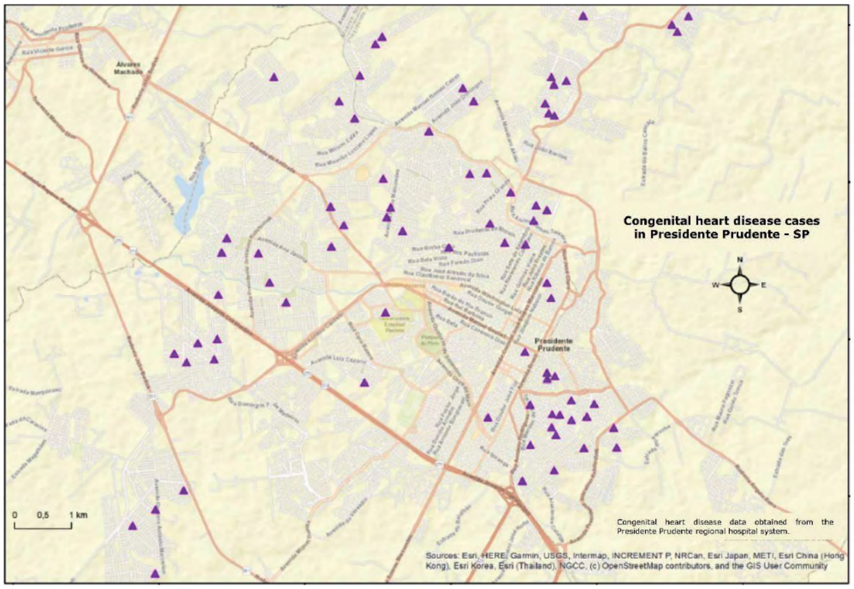

Figure 3: Land use and land cover zoning, Presidente Prudente, 2018.

by the higher demographic index of the region and the fact that it's the city where the Regional Hospital is located, where the study was conducted. It's also the only hospital in RHCN 11 with a specialist in congenital heart diseases during the study period.

In Presidente Prudente, we found the highest number of cases concentrated in the Eastern zone, which is close to the industrial park where the municipal landfill is also located (Figure 3). This region is classified as potentially pollutive, with a maximum land occupancy rate of 60%[6].

DISCUSSION

A total of 298 congenital heart disease records treated at the reference hospital in Western São Paulo were analyzed. The prevalence of congenital heart disease is significant due to its impact on infant morbidity and mortality. It is the second leading cause of death in children under 1 year of age and the primary cause of death due to malformations in children[15,16]. Early diagnosis of cyanotic heart disease prevents complications that can lead to irreversible sequelae and even mortality[17,18].

The ideal diagnostic method for early identification of congenital heart diseases is fetal or postnatal echocardiography with color flow mapping. However, using this examination as mandatory screening is impractical in our context due to the required investment in infrastructure and qualified personnel[17].

In 2014, a significant milestone was achieved in pediatric cardiology with the mandatory implementation of the heel prick test by the Ministry of Health (MS). The test involves performing pulse oximetry on newborns before hospital discharge (between 24 and 48 hours of life), enabling early identification of critical heart conditions, the majority of which are accompanied by cyanosis. If the test yields abnormal results, an echocardiogram should be performed before hospital discharge[16,17,18].

Similar findings have been found in other studies, such as the one conducted by Amorin et al.[19] (2013), which evaluated the profile of 300 children undergoing cardiac surgery at the Hospital das Clínicas in Aracaju, Sergipe and, by Belo et al.[20] (2016) who evaluated the profile of 77 children diagnosed with congenital heart disease. These studies demonstrated that the majority of cases were also recorded in females but without statistical significance.

Septal defects (ASD and VSD) and PDA were the most prevalent acyanotic congenital heart diseases in our study. These findings differ from what is described in the literature, where VSD is the most common diagnosed[5,20,21,22]. Our study demonstrated ASD as the most prevalent at 38.19%, followed by VSD as the second at 19.65%. The high number of atrial septal communications in our service may be related to the classification of atrial septal defects and the challenge of distinguishing between physiological defects (patent foramen ovale) and pathological ones (atrial septal defects), as described in the classification of congenital heart diseases in the ICD-10.

The most commonly diagnosed cyanotic congenital heart disease in our study was T4F, followed by transposition of the great vessels. These results are in line with the findings of reference studies[20,21], indicating that in our study area, congenital heart diseases have a similar incidence.

In the quest to identify the primary risk factors for the development of cardiac anomalies, many studies in recent years have sought to correlate maternal exposure to environmental agents as potential causes of congenital heart diseases. It is known that the earlier the exposure, especially during the first trimester of pregnancy, the higher the risk of developing anomalies[3,4]. Air pollution exerts adverse effects as pro-oxidant, leading to oxidative stress and free radical production, triggering a series of congenital defects. Recent studies also demonstrate evidence of atmospheric pollution causing epigenetic alterations, resulting in changes to DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid)[23].

The results of our study align with the findings of recent studies that confirm associations between congenital alterations and maternal exposure to environmental agents. Nicoll et al.[2] (2018), demonstrated in their review that recent studies confirm this association. In this study, a small but significant association of congenital anomalies was also found in the vicinity of residential areas near incinerators. Studies also indicate a relationship between congenital anomalies and air pollution, water pollution, and agrochemical exposure[2,3,22].

In addition to pollution characteristics, the eastern zone of the city of Presidente Prudente is home to a concentration of sectors with higher population vulnerability[24], this takes into consideration the assessment of aspects such as family income, life cycles, education, and marital status[25]. Social vulnerability, characterized by precarious living conditions that lead to fragility or insecurity, is also more concentrated in this region[24]. Thus, the environmental and social conditions of the region may be related to health issues within the local population, such as the higher prevalence of congenital heart diseases identified in the present study.

FINAL CONSIDERATIONS

Early diagnosis of cyanotic congenital heart diseases is essential to prevent complications and irreversible sequelae, including mortality. While the ideal diagnostic method is fetal or postnatal echocardiography with color flow mapping, its mandatory implementation as a screening tool faces challenges due to the required investment in infrastructure and qualified personnel.

An important milestone in pediatric cardiology was the mandatory implementation of the newborn screening test (commonly known as "teste do pezinho" or heel prick test) by the Ministry of Health in 2014. This test involves performing pulse oximetry on newborns before they are discharged from the hospital, allowing for the early identification of critical heart conditions, especially those accompanied by cyanosis. If the test yields abnormal results, an echocardiogram should be performed before the infant is discharged.

Similar studies have also reported similar findings, such as the predominance of cases in females, although without significant statistical significance. Septal defects like ASD and VSD, as well as PDA, were the most prevalent acyanotic congenital heart diseases in your study, contradicting the literature where VSD is more commonly diagnosed. The high frequency of atrial communication may be related to the classification of the atrial septal defect and the difficulty in distinguishing between physiological (patent foramen ovale) and pathological (atrial septal defect) conditions in the classification of congenital heart diseases in the ICD-10.

Regarding the risk factors for the development of cardiac anomalies, recent studies have been investigating the correlation between maternal exposure to environmental agents and the emergence of congenital heart diseases. Early exposure, particularly during the first trimester of pregnancy, poses a higher risk for the development of these anomalies. Air pollution, for instance, can induce oxidative stress and free radical production, triggering congenital defects, including evidence of epigenetic alterations in DNA and RNA.

The findings of our study align with the most recent research confirming the association between congenital alterations and maternal exposure to environmental agents. Furthermore, the concentration of congenital heart disease cases in the eastern zone of Presidente Prudente may be linked to the environmental and social conditions of the region.

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Corresponding Author:
Sérgio Marques Costa
sergiocosta@unoeste.br

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