# Congenital syphilis in Argentina: temporal trends and association with income inequality, 2006–2021

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## ABSTRACT

***Introduction.*** Congenital syphilis (CS) is a persistent public health problem, and Argentina has been experiencing an increase in its incidence in recent years. Various social factors influence the distribution of CS. The objective of this study is to describe the temporal trends in CS rates and evaluate their association with income inequality in Argentina in the period 2006-2021.

***Methods.*** An ecological study was conducted, considering the 24 Argentine jurisdictions (23 provinces plus the Autonomous City of Buenos Aires [CABA, by its Spanish acronym]) as units of analysis. CS rates were estimated by jurisdiction for each year of the study, and their temporal distribution was analyzed for the national total and by region. An exploratory analysis of the distribution of CS rates and the Gini coefficient was performed at the national level and by region. Next, mixed linear models were estimated to assess the association between the Gini coefficient and CS rates.

***Results.*** The CS rate showed an oscillating and upward trend at the national level and in most regions, with a sustained increase in the Northwest region (NOA) and recent marked increases in Cuyo. As the Gini coefficient increases, the CS rate in the provinces increases (95% CI: 0.11-0.42).

***Conclusion.*** CS rates generally showed an upward trend, with variations across different regions. Income inequality was associated with higher CS rates, highlighting the influence of structural social factors on this disease in Argentina. Income inequality was associated with higher CS rates at the provincial level, demonstrating the impact of structural factors on disparities in this disease in Argentina.

***Keywords:*** *congenital syphilis; socioeconomic factors; Argentina; linear models; Gini coefficient.*

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## INTRODUCTION

Congenital syphilis (CS) is a significant public health issue that remains an unresolved challenge.[1] Mother-to-child transmission of syphilis is caused by syphilis infection during pregnancy, which subsequently affects the newborn.[2] The consequences are severe, with a perinatal mortality rate of nearly 40% due to miscarriages and neonatal death, as well as an increased risk of premature birth and low birth weight.[3]

According to the World Health Organization (WHO), there was a significant increase in CS cases, reaching 700,000 worldwide in 2022.[4] In the Americas, the incidence of syphilis increased by 30% between 2020 and 2022, and the CS rate reached 4.98 cases per 1,000 live births, which is 10 times higher than the target set for 2030.[4]

Timely diagnosis and treatment of syphilis in pregnant women are crucial to preventing CS. Inadequate prenatal care and delayed or incomplete treatment of maternal syphilis are factors associated with CS.[5,6] In addition, social determinants have been identified that contribute to the unequal incidence of CS in different populations. These structural and social vulnerability determinants influence behavioral and clinical risk factors.[6,7]

Since the 1940s, with the discovery of penicillin, a milestone was reached in the treatment of syphilis; however, evidence suggests that its control and eradication depend primarily on understanding complex processes that involve social, cultural, environmental, biological, and economic factors. In particular, the relationship between the health of the mother, the unborn child, and living conditions is crucial in the context of CS.[1] Indeed, the scientific literature indicates that CS has a higher incidence in children of socially vulnerable women, including young, single mothers with lower levels of education and belonging to ethnic minority groups.[8] In addition, previous studies show that various indicators of social inequality are related to the occurrence of CS.[9-13] However, research on this subject in Argentina remains limited. Given this scenario, the objective of this study is to describe the temporal trends in CS rates and evaluate their association with income inequality in Argentina in the period 2006-2021.

## METHODS

### Study design and data sources

An ecological study was conducted,[14] which included the 24 jurisdictions of Argentina (23 provinces plus the Autonomous City of Buenos Aires [CABA, by its Spanish acronym]) as units of analysis during the period 2006-2021.

Data on CS cases and live births by jurisdiction for this period were obtained from the National Ministry of Health's Basic Indicators series, which comes from the National Health Surveillance System (SNVS, by its Spanish acronym).[15] The SNVS network of establishments is made up of 67% publicly funded institutions.

Based on data on stillbirths and live births, stillbirth rates were estimated by jurisdiction for each year of the study. Information on the Gini index was obtained from the Permanent Household Survey (EPH, by its Spanish acronym), based on databases publicly available from the National Institute of Statistics and Censuses (INDEC, by its Spanish acronym).[16] It should be noted that the Gini index is a measure of inequality in income distribution within a population. Its range varies from 0 to 1, with 0 representing complete equality and 1 representing maximum inequality.[17]

All data used in this study come from secondary sources, are publicly available, and are anonymized. This work, developed within the framework of a project accredited by the Secretariat of Science and Technology of the Universidad Nacional de Córdoba, was submitted for evaluation by the CIEIS HNC-UNC, according to note NO-2023-00566264-UNC-CE#HNC, which resolves that, in accordance with current regulations in the province of Córdoba (Provision 40, art. 5), it does not require approval by an ethics committee.

### Statistical analysis

Initially, the temporal distribution of CS rates for the national total and by region during the period studied (2006-2021) was analyzed using trend graphs. Next, descriptive statistics of the CS rate and the Gini coefficient were calculated for the national total and by region for the periods 2006-2010, 2011-2015, and 2016-2021. Subsequently, the distribution of CS rates by Gini coefficient tertiles was analyzed, using box plots. Finally, linear mixed models were estimated, including years as random intercepts, regions and population size of jurisdictions as covariates, the Gini coefficient (standardized to its mean) as the exposure variable, and CS rates as the response variable. The multilevel approach applied, in which observations are nested within years,

allows for capturing variation between years and partially considering temporal correlation throughout the period analyzed. Although it does not explicitly model temporal dependence within each jurisdiction, it helps control for some of the unobserved heterogeneity linked to the temporal context. All analyses were performed using Stata™ software.[18]

## RESULTS

The CS rate shows an oscillating and upward trend at the national level and in most regions, with a sustained increase in the Northwest (NOA, by its Spanish acronym). Particularly in the last five years, there has been a marked increase in Cuyo and heterogeneous behavior in Patagonia (*Figure 1, Table 1*).

*Table 1* presents descriptive statistics of CS rates and the Gini coefficient at the national level and by region. Nationwide, CS rates are highest on average (1.42 CS cases per 1,000 live births) for the final five-year period (2016-2021). At the regional level, the Northeast (NEA, by its Spanish acronym) region has the highest CS rates for the entire study period (1.97 CS cases per 1,000 live births). In comparison, the Patagonia region has the lowest values (0.61 CS cases per 1,000 live births). There is considerable heterogeneity in CS rates both between regions and between periods.

Regarding the Gini coefficient, the country has a value of 0.44 for the entire period studied, with the first five years of the study (2006-2010) showing the highest values (0.46). At the regional level, the first period (2006-2010) shows coefficients slightly higher than those of subsequent periods. In general, there is not much variability in the Gini coefficient, either between regions or between periods.

*Figure 2* shows that, although in all periods there is a higher concentration of CS in jurisdictions with greater income inequality (tertile III), the most remarkable heterogeneity is observed in the last years (2016-2021). Results from ANOVA tests indicate that the mean CS rates differed significantly between Gini tertiles in the periods 2011–2015 and 2016–2021 ($p < 0.05$).

The results of the model estimation indicate that as the Gini coefficient increases, the CS rate in Argentine jurisdictions increases. Specifically, for each one standard deviation increase in the Gini coefficient (0.035), the provincial CS rate rises by 0.26 (95% CI: 0.11-0.42). Furthermore, compared to the Patagonia region, all regions have higher CS rates (*Table 2*).

## DISCUSSION

The study results showed a fluctuating and upward trend in the CS rate at the national level

**Figure 1. Temporal distribution of the congenital syphilis rate at the national level and by region. Argentina, 2006-2021**

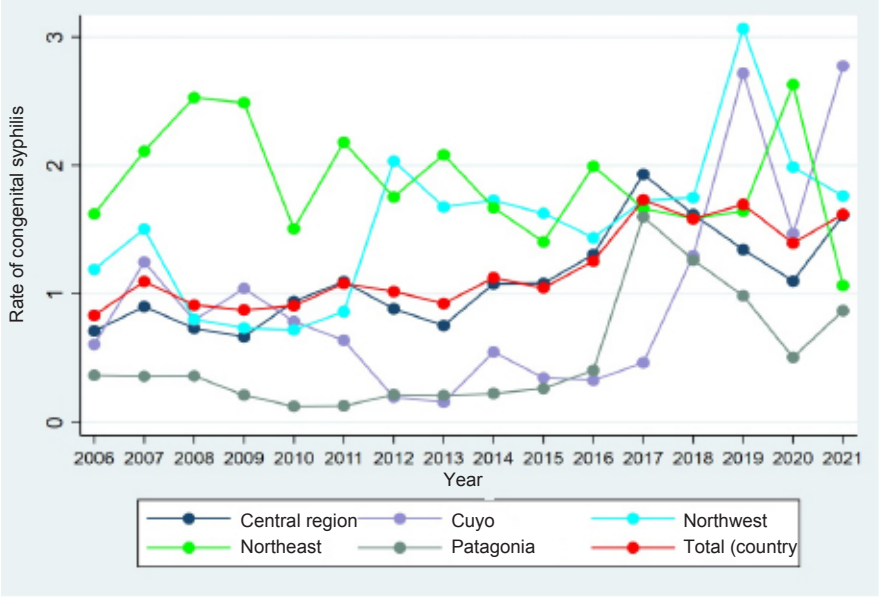

**Table 1. Descriptive statistiscs of congenital syphilis rates and the Gini coefficient at the national and regional level, and by period, 2006-2021**

| | Congenital syphilis rate | | | | Gini coefficient | | | |
|---|---|---|---|---|---|---|---|---|
| **Region/period** | **Mean** | **Standard deviation** | **Median** | **p25-p75** | **Mean** | **Standard deviation** | **Median** | **p25-p75** |
| Central region | | | | | | | | |
| 2006-2010 | 1.02 | 0.62 | 1.01 | 0.49-1.34 | 0.43 | 0.01 | 0.43 | 0.42-0.43 |
| 2011-2015 | 1.04 | 0.42 | 0.91 | 0.85-1.49 | 0.39 | 0.01 | 0.39 | 0.39-0.40 |
| 2016-2021 | 1.29 | 0.84 | 1.6 | 0.36-1.80 | 0.41 | 0.02 | 0.41 | 0.40-0.43 |
| Total period (2006-2021) | 1.1 | 0.78 | 1 | 0.46-1.57 | 0.41 | 0.02 | 0.41 | 0.39-0.42 |
| Cuyo | | | | | | | | |
| 2006-2010 | 1.56 | 1.74 | 0.91 | 0.28-2.85 | 0.42 | 0.03 | 0.42 | 0.41-0.43 |
| 2011-2015 | 0.43 | 0.15 | 0.4 | 0.30-0.55 | 0.38 | 0.01 | 0.38 | 0.37-0.39 |
| 2016-2021 | 1.36 | 1.4 | 0.84 | 0.44-2.28 | 0.38 | 0.03 | 0.38 | 0.35-0.40 |
| Total period (2006-2021) | 1.18 | 1.87 | 0.71 | 0.13-1.22 | 0.39 | 0.03 | 0.39 | 0.37-0.41 |
| Northwest | | | | | | | | |
| 2006-2010 | 0.96 | 0.82 | 0.88 | 0.55-0.93 | 0.46 | 0.05 | 0.44 | 0.44-0.46 |
| 2011-2015 | 1.27 | 0.89 | 1.38 | 0.36-1.64 | 0.41 | 0.02 | 0.4 | 0.39-0.42 |
| 2016-2021 | 1.67 | 1.48 | 1.2 | 0.59-1.62 | 0.41 | 0.04 | 0.41 | 0.39-0.43 |
| Total period (2006-2021) | 1.31 | 1.44 | 0.89 | 0.35-1.82 | 0.42 | 0.04 | 0.41 | 0.39-0.44 |
| Northeast | | | | | | | | |
| 2006-2010 | 1.92 | 0.73 | 1.74 | 1.37-2.48 | 0.46 | 0.03 | 0.46 | 0.44-0.47 |
| 2011-2015 | 1.66 | 0.91 | 1.26 | 1.09-2.22 | 0.4 | 0.03 | 0.4 | 0.38-0.41 |
| 2016-2021 | 1.82 | 0.66 | 1.78 | 1.34-2.30 | 0.41 | 0.03 | 0.41 | 0.39-0.43 |
| Total period (2006-2021) | 1.97 | 1.87 | 1.48 | 0.86-2.37 | 0.42 | 0.04 | 0.41 | 0.39-0.44 |
| Patagonia | | | | | | | | |
| 2006-2010 | 0.31 | 0.26 | 0.22 | 0.28-0.37 | 0.43 | 0.03 | 0.43 | 0.41-0.44 |
| 2011-2015 | 0.18 | 0.13 | 0.15 | 0.14-0.20 | 0.4 | 0.02 | 0.4 | 0.38-0.41 |
| 2016-2021 | 1.11 | 1.24 | 0.67 | 0.39-0.83 | 0.42 | 0.03 | 0.42 | 0.4-0.44 |
| Total (2006-2021) | 0.61 | 1.12 | 0.33 | 0.10-0.62 | 0.41 | 0.03 | 0.41 | 0.39-0.43 |
| Total (country) | | | | | | | | |
| 2006-2010 | 1.07 | 1.05 | 0.85 | 0.26-1.46 | 0.46 | 0.02 | 0.46 | 0.45-0.47 |
| 2011-2015 | 0.87 | 0.8 | 0.55 | 0.28-1.32 | 0.42 | 0.01 | 0.42 | 0.42-0.42 |
| 2016-2021 | 1.42 | 1.19 | 0.92 | 0.53-1.81 | 0.44 | 0.01 | 0.43 | 0.43-0.44 |
| Total period (2006-2021) | 1.17 | 0.3 | 1.08 | 0.91-1.39 | 0.44 | 0.02 | 0.43 | 0.42-0.44 |

and in most regions, with a sustained increase in the NOA and recent marked increases in Cuyo. In addition, the results of the model estimation indicated that as income inequality increases, the CS rate in the provinces increases, and that the Patagonia region has the lowest CS rate.

Similar to these findings, a study conducted in Porto Velho (Brazil) reported an increase in the incidence of CS during the period 2009-2014,[19] and a survey conducted in Bahia (Brazil) also showed an increase in incidence in the period 2007-2017.[9] In contrast, in Mexico, after the implementation of the regional strategy *Elimination of mother-to-child transmission of HIV and CS in the Americas* in 2009, there was a decrease in the CS rate, reaching values below the target set by the Pan American Health Organization (PAHO); however, significant regional variations were observed.[20]

This study found a positive association between CS and the Gini coefficient. Fajardo and Schmalbach[10] analyzed inequalities in the

**Figure 2. Distribution of the congenital syphilis rate by Gini coefficient tertiles. Argentina, periods 2006-2010, 2011-2015, and 2016-2021**

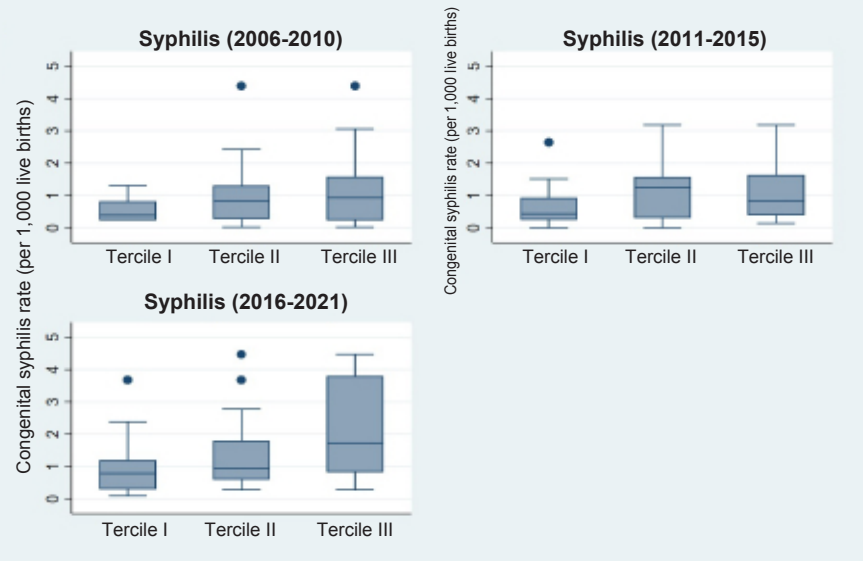


**Table 2. Measures of association between the congenital syphilis rate and the Gini coefficient. Argentina, 2006-2021**

| | β | 95%CI | *p-value* |
|---|---|---|---|
| Gini coefficient (Z score) | 0.264 | 0.109-0.419 | 0.001 |
| Region* | | | |
| Central | 0.518 | 0.016-1.020 | 0.043 |
| Cuyo | 0.779 | 0.316-1.243 | 0.001 |
| Northwest | 0.689 | 0.267-1.111 | 0.001 |
| Northeast | 1.103 | 0.656-1.550 | <0.001 |

*Linear mixed model adjusted for the population size of the jurisdictions, with random intercept for the years.*
*95%CI: 95% confidence interval.*
**Patagonia region as reference.*

incidence of CS related to living conditions in neighborhoods in the city of Bogotá (Colombia). They found that the incidence was much higher than the target proposed by PAHO, with the highest incidence concentrated in places with the worst living conditions. Ramos et al.[11]analyzed the variation in CS incidence rates according to the spatial distribution of the living conditions index among neighborhoods in the city of Recife (Brazil) from 2007 to 2016, finding a higher incidence in strata with poorer living conditions, as well as in districts with poor sanitary conditions and low educational levels among heads of households. In addition, Da Costa Dantas et al.[12] observed a spatial correlation between poorer socioeconomic conditions (specifically, inadequate sanitation and water supply) and an increase in CS in the northern regions of Brazil.

Contrary to the results of our study, Soares and Aquino,[9] when analyzing the incidence of CS in Bahia (Brazil) during the period 2007-2017, identified a significant positive association between the CS rate and the human development index (HDI), but a negative association with the Gini index. In addition, Costa et al.[13] showed that a higher Gini coefficient was associated with a lower incidence of CS. They suggest that one of the mechanisms could be that income inequalities exacerbate health inequalities in more vulnerable populations, but not in the total population.

Multiple factors may explain the observed association between income inequality and increased CS rates. In contexts of greater inequality, socially disadvantaged pregnant women often face various barriers to accessing health services, including geographical, economic, organizational, and cultural obstacles, which create conditions that increase the likelihood

of vertical transmission of this infection. The discontinuity and late start of prenatal controls, plus the limitations of the health system in detecting and treating sexually transmitted diseases promptly in contexts of high inequality, are also critical factors in this process.

In addition, in some areas of the country –such as the NOA and NEA– additional factors may contribute to income inequality, amplifying the risk of CS. Previous evidence from Latin American countries suggests that other social factors, such as migration processes, can affect the monitoring of pregnant women and hinder adherence to treatment regimens.[23] Furthermore, in contexts of high inequality, the health system tends to be highly fragmented, with subsystems that have disparate capacities in terms of adequate coverage and continuity of care.[24]

It is worth noting that Argentina is a country with a high degree of social inequality, which translates into significant disparities in various health indicators,[25,26] including those related to maternal and child health.[27] In this regard, the results of this study, which show marked heterogeneities in the temporal and regional distribution of CS, also show similarities with the results of previous studies.

In the recent Argentine context, various public policies have been promoted aimed at strengthening sexual and reproductive health, with potential impact on reducing CS. Both changes to the information system and changes to case definitions influenced the casuistry of CS cases. Thus, as of epidemiological week 18 of 2018, SNVS 2.0 allows for the unambiguous identification of individuals, as it takes information from the national identity document of the National Registry of Persons. As for changes in the case definition, starting in 2021 and with the update of the standards manual in 2022, the notification of newborns exposed to *Treponema pallidum* infection was incorporated in cases where the treatment status of the pregnant person is unknown. These changes aim to enhance the sensitivity and specificity of the surveillance system. *Figure S1* in the supplementary material summarizes these temporary changes in CS reporting in Argentina.

Particularly during the last year, there has been a reorientation of national policies in this area, with a growing transfer of responsibilities to provincial governments. This decentralization has been accompanied by a significant reduction in the resources allocated to strategic programs, such as sexual health and responsible procreation, which affects the provision of key supplies—including benzathine penicillin—and limits the operational capacity to sustain prenatal screening actions in several jurisdictions.

This study has several limitations that are worth mentioning. First, changes in the surveillance system and case definition could have introduced fluctuations in CS reporting, which may have affected the interpretation of the temporal trend. Second, other potentially confounding variables, such as prenatal care, were not included in the analysis. Third, although the study considered regional differences, the analysis was not disaggregated by age groups or specific subpopulations (such as adolescents or migrants), nor were patterns within jurisdictions explored, which could conceal significant internal heterogeneities. Additionally, the period analyzed ends in 2021, which is a response to data availability constraints. However, this limitation also affects the validity of the results, considering recent changes in public health. Finally, to avoid ecological fallacies typical of this type of design, it is essential to note that the results observed at the jurisdictional level cannot be directly inferred at the individual level. Among its strengths, this study is the first to analyze the trend of CS in a recent period and its association with an indicator of income inequality in Argentina.

The findings of this study show the need to implement effective actions to prevent CS from an equity perspective. To this end, it is essential to strengthen public health programs with comprehensive interventions that ensure access to affordable and accessible health services, taking into account the social determinants of health.

## CONCLUSION

This study shows that overall CS rates presented an upward trend, although with heterogeneous pattern in different regions. Additionally, it identifies that income inequality is associated with higher CS rates at the provincial level, reflecting the influence of structural social factors on this condition in our country. ■

The supplementary material provided with this article is presented as submitted by the authors. It is available at: https://www.sap.org.ar/docs/publicaciones/archivosarg/2025/10710_AO_Tumas_Anexo.pdf

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