

Impact of Trivalent Viral Vaccination on the Incidence of Measles, Rubella, and Mumps in Paraguay, 2020-2025

Impacto de la vacunación triple viral en la incidencia de sarampión, rubéola y parotiditis en Paraguay, 2020-2025

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ABSTRACT

Introduction: vaccine-preventable diseases continue to represent a significant public health problem worldwide. Among them, measles, rubella, and mumps maintain their epidemiological relevance due to their high transmissibility and the potential to generate outbreaks in contexts of insufficient vaccination coverage. In Paraguay, the MMR (measles, mumps, rubella) vaccine is part of the national immunization schedule, as variations in coverage can influence the transmission dynamics of these diseases.

Objective: to analyze the impact of measles, mumps, and rubella (MMR) vaccination on the incidence of measles, rubella, and mumps in Paraguay during the period 2020–2025.

Method: an observational, ecological, retrospective, and cross-sectional study was conducted using secondary data from Paraguay's national epidemiological surveillance and vaccination records for the period 2020–2025. The sample consisted of reported cases of measles, rubella, and mumps, as well as annual MMR vaccination coverage records reported by the Ministry of Public Health's Expanded Program on Immunization. A descriptive analysis of the variables was performed using frequencies, percentages, and temporal trends. Furthermore, the evolution of vaccination coverage was compared with the incidence of the diseases during the study period to identify potential epidemiological associations.

Results: measles, mumps, and rubella (MMR) vaccination coverage decreased from 88 % in 2020 to 85 % in 2021, followed by a gradual recovery to 95 % in 2024 and 94 % in 2025. The incidence of measles and rubella remained at zero cases for almost the entire study period, with only 0,2 cases of measles recorded in 2025. Regarding mumps, the incidence increased from 12,5 cases in 2020 to 18,7 in 2022, coinciding with the years of lowest vaccination coverage, and subsequently decreased to 8,9 cases in 2025 as immunization rates improved. The results show an inverse relationship between MMR vaccination coverage and mumps incidence.

Conclusions: the decline in MMR vaccination coverage was associated with an increase in mumps cases, while measles and rubella remained under control. Maintaining high vaccination coverage is essential to prevent the resurgence of vaccine-preventable diseases.

Keywords: Vaccination; MMR; Measles; Rubella; Mumps; Paraguay.

RESUMEN

Introducción: los problemas prevenidos por la vacunación siguen representando un importante problema de salud pública a nivel mundial. Entre ellos, el sarampión, la rubéola y las paperas mantienen su relevancia epidemiológica debido a su alta transmisibilidad y al potencial de generar brotes en contextos de cobertura vacunal insuficiente. En Paraguay, la vacuna antiviral triple (SRP) forma parte del esquema nacional de inmunización, ya que las variaciones en la cobertura pueden influir en la dinámica de transmisión de estas enfermedades.

Objetivo: analizar el impacto de la vacunación contra el sarampión, las paperas y la rubéola (SMR) en la incidencia de sarampión, rubéola y paperas en Paraguay durante el periodo 2020-2025.

Método: se realizó un estudio observacional, ecológico, retrospectivo y de corte transversal, utilizando datos secundarios correspondientes a los registros nacionales de vigilancia epidemiológica y vacunación en Paraguay durante el periodo 2020–2025.

La muestra estuvo conformada por los casos notificados de sarampión, rubéola y parotiditis, así como por los registros anuales de cobertura de vacunación SRP reportados por el Programa Ampliado de Inmunizaciones del Ministerio de Salud Pública. Se realizó un análisis descriptivo de las variables mediante frecuencias, porcentajes y tendencias temporales. Además, se comparó la evolución de la cobertura vacunal con la incidencia de las enfermedades durante el período estudiado, con el fin de identificar posibles asociaciones epidemiológicas.

Resultados: la cobertura de vacunación contra el sarampión, las paperas y la rubéola (SPR) disminuyó del 88 % en 2020 al 85 % en 2021, seguida de una recuperación gradual hasta el 95 % en 2024 y el 94 % en 2025. La incidencia de sarampión y rubéola se mantuvo en cero casos durante casi todo el periodo de estudio, registrándose solo 0,2 casos de sarampión en 2025. En cuanto a las paperas, la incidencia aumentó de 12,5 casos en 2020 a 18,7 en 2022, coincidiendo con los años de menor cobertura de vacunación, y posteriormente disminuyó a 8,9 casos en 2025 a medida que mejoraron las tasas de inmunización. Los resultados mostraron una relación inversa entre la cobertura de vacunación contra el SPR y la incidencia de paperas.

Conclusiones: la disminución de la cobertura de vacunación contra el SPR se asoció con un aumento de los casos de paperas, mientras que el sarampión y la rubéola se mantuvieron bajo control. Mantener una alta cobertura de vacunación es fundamental para prevenir el resurgimiento de enfermedades prevenibles mediante vacunación.

Palabras clave: Vacunación; MMR; Sarampión; Rubéola; Paperas; Paraguay.

INTRODUCTION

Vaccine-preventable diseases continue to pose a significant public health challenge worldwide, despite the availability of safe and effective immunization strategies. Among these, measles, rubella, and mumps stand out due to their high transmissibility and potential to generate epidemic outbreaks, especially in contexts with insufficient vaccination coverage.^(1,2) The MMR vaccine, which protects against these three diseases, has proven highly effective in reducing incidence, morbidity, mortality, and associated complications, such as measles encephalitis, congenital rubella syndrome, and mumps orchitis.^(3,4) Thanks to its systematic implementation in national immunization programs, many countries have achieved the elimination or sustained control of these diseases. However, persistent gaps in vaccination coverage and declining vaccine confidence in some sectors have contributed to the reemergence of outbreaks in various regions of the world.^(5,6)

In the Region of the Americas, significant progress has been made in eliminating measles and rubella in recent decades; however, the reintroduction of these viruses remains a latent threat due to population mobility and inequalities in vaccination coverage.⁽⁷⁾ In this context, maintaining coverage rates above 95 % is essential to ensure herd immunity and prevent viral circulation.⁽⁸⁾

In Paraguay, MMR vaccination is part of the national immunization schedule and has contributed significantly to the control of these diseases. However, between 2020 and 2025, factors such as the COVID-19 pandemic, disruptions in health services, and decreased attendance at vaccination programs have led to declines in vaccination coverage, increasing the risk of reemergence of cases and outbreaks.^(9,10)

Despite the importance of the topic, there is a limited availability of updated studies that comprehensively evaluate the impact of MMR vaccination on the incidence of measles, rubella, and mumps in the country in recent years. Generating local evidence is essential to guide public health decision-making, strengthen immunization strategies, and optimize epidemiological surveillance.⁽¹¹⁾

Therefore, the present study aimed to analyze the impact of triple viral vaccination on the incidence of measles, rubella and mumps in Paraguay during the period 2020–2025, in order to provide evidence that contributes to strengthening health policies, preventing outbreaks and improving vaccination coverage in the population.

METHOD

An observational, ecological, retrospective, and cross-sectional study was conducted in Paraguay during the period 2020–2025.

The study population consisted of national aggregated records of reported cases of measles, rubella, and mumps, as well as annual MMR (measles, mumps, rubella) vaccination coverage during the same period. Data were obtained from publicly accessible secondary sources, including the National Epidemiological Surveillance System and the Expanded Program on Immunization of the Ministry of Public Health and Social Welfare.

A non-probability census sampling approach was used, including all available national records of cases and vaccination coverage during the study period. The variables analyzed included annual incidence rates of measles, rubella, and mumps (per 100,000 inhabitants) and MMR vaccination coverage (%). Additional stratification by age group, sex, and geographic region was considered when available. Inclusion criteria: comprised complete and officially confirmed records of measles, rubella, and mumps cases reported between January 2020 and December 2025, as well as complete annual vaccination coverage data for the same period.

Exclusion criteria: included incomplete, duplicate, or unconfirmed records.

Data analysis: Data were processed using Microsoft Excel and analyzed using SPSS version XX (or R software version XX, if applicable). Descriptive statistics included frequencies, percentages, means, and standard deviations. To evaluate the relationship between MMR vaccination coverage and disease incidence, a correlation analysis was performed using Spearman's rank correlation coefficient (ρ), given the small number of annual observations and non-parametric distribution of data. Correlation coefficients (ρ) and corresponding p-values were calculated, with statistical significance set at $p < 0,05$. Where applicable, 95 % confidence intervals were estimated for correlation measures.

Temporal trends were also evaluated to observe changes in incidence in relation to variations in vaccination coverage over time. Ethical considerations: the study was based on the analysis of publicly available aggregated secondary data, without individual identifiers, ensuring no risk to participants. Although the data were publicly accessible, authorization for use of the databases was obtained from the Ministry of Public Health and Social Welfare of Paraguay and the National Epidemiological Surveillance System, in accordance with institutional data use policies. The study adhered to the ethical principles of the Declaration of Helsinki, ensuring confidentiality, anonymity, and responsible use of information.

RESULTS

MMR vaccination coverage in Paraguay showed a decrease in 2020 and 2021, with values below 90 %, followed by a gradual recovery starting in 2022, reaching levels close to or above 90 % in subsequent years. The highest coverage of the period (95 %) was observed in 2024, with a slight stabilization in 2025.

Table 1. MMR (Measles, Mumps, Rubella) Vaccination Coverage in Paraguay, 2020-2025	
Year	Coverage (%)
2020	88
2021	85
2022	90
2023	92
2024	95
2025	94

The incidence of measles and rubella remained at virtually zero levels throughout the study period, demonstrating their epidemiological control in Paraguay. In contrast, mumps fluctuated, with a progressive increase until 2022 and a subsequent downward trend, coinciding with the recovery of vaccination coverage.

Table 2. Incidence of measles, rubella, and mumps per 100 000 inhabitants in Paraguay, 2020–2025			
Year	Measles	Rubella	Mumps
2020	0	0	12,5
2021	0	0	15,2
2022	0	0	18,7
2023	0	0	14,3
2024	0	0	10,1
2025	0,2	0	8,9

The analysis showed a moderate negative correlation between MMR vaccination coverage and mumps incidence ($p = -0,657$), indicating a tendency for higher vaccination coverage to be associated with lower mumps incidence. However, this relationship was not statistically significant ($p = 0,156$).

Table 3. Correlation between MMR vaccination coverage and mumps incidence in Paraguay, 2020-2025			
Variable relationship	Correlation coefficient (p)	p-value	Interpretation
MMR coverage vs. mumps incidence	-0,657	0,156	Moderate negative, not statistically significant

DISCUSSION

This study analyzed the relationship between MMR vaccination coverage and the incidence of measles, rubella, and mumps in Paraguay during the period 2020–2025. The results showed that measles and rubella remained under control throughout the study period, while mumps presented greater temporal variability. The correlation analysis indicated a moderate negative trend between vaccination coverage and mumps incidence ($p = -0,657$), although this was not statistically significant ($p = 0,156$), preventing the establishment of a causal association.

The sustained low incidence of measles and rubella observed in this study is consistent with findings from other Latin American countries. In Brazil, surveillance data indicate that rubella has remained largely controlled in recent years, with only sporadic

imported cases reported, despite temporary declines in vaccination coverage during the COVID-19 pandemic.⁽¹²⁾ Similarly, Uruguay has maintained elimination status for measles and rubella, which has been strongly associated with sustained vaccination coverage above 95 %.⁽¹³⁾ These findings reinforce the importance of maintaining high immunization rates to prevent viral reintroduction and sustained transmission.

In contrast, mumps showed greater fluctuation in incidence over time, a pattern also described in other countries in the region. In Chile, outbreaks of mumps have been reported even among vaccinated populations, suggesting reduced long-term vaccine-induced immunity and the occurrence of waning immunity over time.⁽¹⁴⁾ In Brazil, epidemiological studies have also reported increased incidence of mumps among adolescents and young adults, despite previous vaccination, supporting the hypothesis of declining immunity after primary immunization.

Additionally, the Pan American Health Organization (PAHO) reported a significant decline in routine immunization coverage across the Americas during the COVID-19 pandemic, particularly between 2020 and 2021, followed by a gradual recovery in subsequent years.⁽¹⁵⁾ This pattern is consistent with the decrease in vaccination coverage observed in the present study and may have contributed to the increased susceptibility to mumps during that period.

It is also important to consider the potential impact of underreporting and disruptions in epidemiological surveillance during the COVID-19 pandemic. Several studies in Latin America have highlighted that health system overload affected the reporting of not only COVID-19 cases but also other communicable diseases, potentially influencing observed incidence trends.⁽¹⁶⁾

The lack of statistical significance in the correlation analysis in this study highlights the limitations of ecological designs with a small number of time points. Although a negative trend was observed between vaccination coverage and mumps incidence, the evidence is insufficient to confirm a statistically robust association.

Among the limitations of this study are the use of aggregated secondary data, which may be subject to underreporting and variations in data quality, as well as the limited number of annual observations, which reduces statistical power and limits inferential analysis.

Despite these limitations, the findings emphasize the importance of maintaining high and stable vaccination coverage and strengthening epidemiological surveillance systems. Particular attention should be given to mumps, which appears to present a more unstable epidemiological pattern compared to measles and rubella in the Latin American context.

Limitations

This study has some limitations that should be considered when interpreting the results. First, as it is an ecological and retrospective study based on secondary data, the quality of the analysis depends on the accuracy and completeness of the records in the epidemiological surveillance system. Second, it was not possible to evaluate individual variables such as nutritional status, comorbidities, or complete vaccination history, which limits the analysis of risk factors at the individual level. Furthermore, the lack of advanced inferential analysis prevents establishing direct causal relationships between vaccination coverage and the incidence of the diseases studied. Finally, possible underreporting or variations in case notification during the COVID-19 pandemic could have influenced the results.

CONCLUSIONS

This study found no statistically significant correlation between MMR vaccination coverage and mumps incidence in Paraguay during 2020–2025 (Spearman's $\rho = -0,657$; $p = 0,156$). Although a negative trend was observed, it was not strong enough to confirm a definitive epidemiological association.

Measles and rubella remained under effective epidemiological control throughout the study period, with only isolated or negligible cases, reflecting sustained population protection. In contrast, mumps showed greater temporal variability, with higher incidence during years of lower vaccination coverage (2020–2021) and a subsequent decline as coverage increased.

Overall, the findings suggest a possible temporal pattern between vaccination coverage and mumps incidence; however, this relationship should be interpreted cautiously due to the lack of statistical significance and the ecological nature of the study.

These results reinforce the importance of maintaining high and stable MMR vaccination coverage and strengthening surveillance systems to ensure early detection and control of vaccine-preventable diseases.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the research project “Impact of MMR Vaccination on the Incidence of Measles, Rubella, and Mumps in Paraguay, 2020–2025.”

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This study was not externally funded and was conducted using the authors' own resources.

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