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Artigo Original

HPV vaccination coverage among adolescents in the Federal District compared with the Central-West region and Brazil (2014–2024)

Cobertura vacinal contra o HPV em adolescentes no Distrito Federal em comparação ao Centro-Oeste e Brasil (2014–2024)

Cobertura de vacunación contra el VPH en adolescentes del Distrito Federal en comparación con la región Centro-Oeste y Brasil (2014–2024)

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Abstract

This study aimed to analyze the temporal evolution of Human Papillomavirus (HPV) vaccination coverage among adolescents aged 10 to 14 years in the Federal District from 2014 to 2024, compared with the Central-West region and Brazil. An ecological time-series study was conducted using secondary data from the Brazilian Ministry of Health vaccination coverage database, considering sex, age group, dose type (first dose, second dose, and single dose), and temporal trends. A marked decline in vaccination coverage was observed during the COVID-19 pandemic, followed by a gradual recovery from 2022 onward. The Federal District showed higher coverage levels than the Central-West region and Brazil, although without statistically significant differences. Persistent inequalities by sex and age were identified, with higher coverage among girls and older adolescents. The introduction of the single-dose schedule in 2024 appears to be a promising strategy to increase vaccination uptake. These findings highlight the need for sustained immunization strategies, particularly school-based campaigns, targeted communication, and continuous monitoring of demographic and regional disparities.

Keywords: human papillomavirus; vaccination; vaccination coverage; adolescent; public health.

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Resumo

Este estudo teve como objetivo analisar a evolução da cobertura vacinal contra o Papilomavírus Humano (HPV) em adolescentes de 10 a 14 anos no Distrito Federal, no período de 2014 a 2024, em comparação com a região Centro-Oeste e o Brasil. Trata-se de um estudo ecológico de série temporal, baseado em dados secundários do Painel de Cobertura Vacinal do Ministério da Saúde, considerando sexo, faixa etária, tipo de dose (D1, D2 e dose única) e tendência temporal. Observou-se queda acentuada da cobertura vacinal durante a pandemia de COVID-19, seguida de recuperação gradual a partir de 2022. O Distrito Federal apresentou desempenho superior ao da região Centro-Oeste e do país, embora sem diferença estatisticamente significativa. Persistiram desigualdades por sexo e idade, com maior cobertura entre meninas e adolescentes mais velhos. A introdução do esquema de dose única em 2024 mostrou-se uma estratégia promissora para ampliar a adesão vacinal. Os achados reforçam a necessidade de estratégias contínuas de imunização, com foco em campanhas escolares, comunicação direcionada e monitoramento das desigualdades regionais e demográficas.

Palavras-chave: papilomavírus humano; vacinação; cobertura vacinal; adolescente; saúde pública.

Resumen

Este estudio tuvo como objetivo analizar la evolución de la cobertura de vacunación contra el Virus del Papiloma Humano (VPH) en adolescentes de 10 a 14 años en el Distrito Federal, durante el período de 2014 a 2024, en comparación con la región Centro-Oeste y Brasil. Se trata de un estudio ecológico de serie temporal, basado en datos secundarios del Panel de Cobertura Vacunal del Ministerio de Salud, considerando sexo, grupo etario, tipo de dosis (D1, D2 y dosis única) y tendencia temporal. Se observó un descenso pronunciado de la cobertura vacunal durante la pandemia de COVID-19, seguido de una recuperación gradual a partir de 2022. El Distrito Federal presentó un desempeño superior al de la región Centro-Oeste y del país, aunque sin diferencias estadísticamente significativas. Persistieron desigualdades por sexo y edad, con mayor cobertura entre las niñas y los/las adolescentes de mayor edad. La introducción del esquema de dosis única en 2024 se mostró como una estrategia prometedora para ampliar la adhesión a la vacunación. Los hallazgos refuerzan la necesidad de estrategias continuas de inmunización, con énfasis en campañas escolares, comunicación dirigida y monitoreo de las desigualdades regionales y demográficas.

Palabras-clave: virus del papiloma humano; vacunación; cobertura vacunal; adolescente; salud pública.

INTRODUCTION

Human Papillomavirus (HPV) is the causative agent of the most prevalent sexually transmitted infection worldwide, associated with a broad spectrum of diseases ranging from genital warts to malignant neoplasms of the cervix, anus, penis, vagina, and oropharynx [1,2]. It is estimated that more than 80% of the sexually active population will meet the virus during their lifetime, making preventive vaccination a fundamental public health strategy [3,6].

In Brazil, the HPV vaccine was incorporated into the National Immunization Program (PNI) in 2014, initially targeting girls aged 11 to 13, with a subsequent expansion to include boys and adolescents aged 9 to 14 in 2017 [1,3]. Since then, vaccination has been offered free of charge at Basic Health Units and, primarily, through school-based campaigns. Despite these efforts, the country has faced a progressive decline in vaccination coverage, particularly following the COVID-19 pandemic, which disrupted campaigns and reduced attendance at health facilities[3,4].

The Federal District (DF) and the Center-West region exhibit distinct patterns regarding vaccine uptake. The DF, which traditionally maintains higher coverage, shows marked fluctuations related to logistical factors and periods of campaign interruption[8]. Conversely, the states in the Center-West demonstrate a trend toward more stable coverage, albeit at lower levels. This regional disparity reflects structural inequalities, differences in access, and varying levels of engagement among primary care teams[2,3].

In 2024, the PNI adopted a single-dose schedule for boys and girls aged 9 to 14, following the recommendation of the World Health Organization (WHO), representing a significant shift in national immunization policy[7]. This change directly impacts the assessment of coverage and

reinforces the need for continuous monitoring to ensure the 90% vaccination target advocated by the program[6,7].

Given this scenario, this study aims to analyze the evolution of HPV vaccination coverage among adolescents aged 10 to 14 in the Federal District from 2014 to 2024, in comparison with the Center-West region and Brazil. The analysis considers variations by sex and dose type, while discussing the primary factors influencing vaccine adherence.

MATERIALS AND METHODS

Study Design

This is an ecological time-series study with a quantitative, descriptive-analytical approach, based on the analysis of secondary data regarding Human Papillomavirus (HPV) vaccination coverage among adolescents residing in the Federal District from 2014 to 2024. For comparative purposes, aggregate data for Brazil and the Center-West region were also analyzed.

The ecological design was adopted to allow for the evaluation of collective vaccination coverage behavior over time, enabling the identification of temporal trends and population disparities associated with public immunization policies. This design is suitable for monitoring and evaluating public health programs, as it does not aim to establish causal relationships at the individual level.

Data Sources

Vaccination coverage data were obtained from official public databases of the Ministry of Health. The primary source was the Vaccination Coverage Dashboard (SAGE/MS), which centralizes consolidated and standardized historical data from the National Immunization Program (PNI), ensuring greater consistency and comparability across the time series. Population estimates used as denominators were obtained from the Brazilian Institute of Geography and Statistics (IBGE). Information from the National Immunization Program Information System (SI-PNI) was utilized for data verification and contextualization.

Data extraction took place between August and September 2025. It should be noted that information regarding the year 2024 is preliminary and subject to updates.

Study Population and Variables

The study population consisted of adolescents aged 10 to 14 years, with data aggregated by year and location. The analyzed variables included:

- Reference year (2014 to 2024);
- Sex (female and male);

- Age group (10 to 14 years);
- Dose type (first dose – D1; second dose – D2; and single dose, implemented in 2024);
- Geographic scope (Brazil, Center-West region, and Federal District);
- Vaccination coverage (%).

Calculation of Vaccination Coverage

Vaccination coverage was calculated as the ratio between the number of vaccinated adolescents and the estimated population in the corresponding age group, multiplied by 100. The numerator accounted for the vaccination schedule in effect during each period: a three-dose schedule between 2014 and 2016 (D1 + D2 + D3), a two-dose schedule between 2017 and 2023 (D1 + D2), and a single-dose schedule in 2024. The denominator corresponded to the estimated population of adolescents aged 10 to 14 years, by sex and year, according to IBGE data.

Data Processing and Analysis

Data were initially organized in electronic spreadsheets and subsequently processed in a computational environment using the Python programming language, which ensured greater reproducibility, traceability, and consistency of the analyses. Data processing included steps for cleaning, variable standardization, verification of inconsistencies, and temporal and spatial aggregation.

Statistical analyses were performed using the *pandas* (data manipulation and organization), *numpy* (numerical operations), *statsmodels* (statistical modeling and linear regression), and *scipy.stats* (non-parametric statistical tests) libraries. Graphical visualization was conducted using the *matplotlib* library, through the construction of line and bar charts to support the interpretation of results and the analysis of temporal trends.

Considering the aggregate nature of the data and the absence of normality assumptions, non-parametric statistical tests were employed. The Wilcoxon test was used to compare vaccination coverage between girls and boys. The Friedman test was applied to evaluate differences between age groups and among the analyzed geographic scopes. Simple linear regression was used to estimate temporal trends in vaccination coverage, evaluating the slope coefficient and the coefficient of determination (R^2), allowing for a comparison of temporal behavior across different locations.

CONTEXTUAL CONSIDERATIONS

In interpreting the results, relevant events influencing the dynamics of vaccination coverage throughout the analyzed period were considered, including the inclusion of boys in the National

Immunization Program starting in 2017, the impact of the COVID-19 pandemic on immunization campaigns between 2020 and 2021, and the introduction of the single-dose schedule in 2024.

ETHICAL ASPECTS AND USE OF ARTIFICIAL INTELLIGENCE

This study exclusively used aggregate, publicly accessible secondary data, involving no individual identification of participants. Thus, in accordance with Resolution No. 510/2016 of the National Health Council, the research is exempt from review by a Research Ethics Committee.

Artificial intelligence tools were used as an assistive resource for textual organization, linguistic review, and support in structuring the scientific writing, without interference in the statistical analysis, data interpretation, or methodological decision-making. All final content, including analyses, interpretations, and conclusions, is the sole responsibility of the authors, in compliance with the principles of scientific integrity, transparency, and best editorial practices.

RESULTS AND DISCUSSION

Between 2014 and 2024, HPV vaccination coverage exhibited three distinct patterns: high initial uptake among girls, fluctuations following the inclusion of boys in 2017, and a significant decline during the COVID-19 pandemic, followed by a progressive recovery starting in 2022. Data from the Ministry of Health's Vaccination Coverage Dashboard[4] confirm that the Federal District (DF) maintained superior performance compared to the Center-West region throughout the historical series. In some years, female coverage rates exceeded 100%, likely reflecting the vaccination of cohorts outside the target age range and potential variations in the population denominators used in the information systems[4,5].

Following the introduction of vaccination for boys in 2017, there was significant growth in male coverage, particularly in the DF, which rose from less than 5% in 2014 to approximately 75%–80% in 2023. As illustrated in Figure 1, both sexes experienced a sharp decline during 2020–2021 amidst the COVID-19 pandemic. This phenomenon was extensively documented by the Federal Government and Agência Brasil [1,6], which associate the decline with the disruption of school-based campaigns and reduced demand for routine health services, a finding corroborated by national studies[12].

The adoption of a single-dose schedule in 2024, in accordance with Pan American Health Organization recommendations[7], contributed to increased adherence by reducing dropout rates between doses and expanding overall coverage. Evidence indicates that improved delivery strategies—particularly school-based vaccination—enhance uptake and reduce dropout[17], while WHO recommendations support simplified HPV vaccine schedules[18].

Beyond the immediate impact on expanding vaccination coverage after the introduction of the single-dose schedule in 2024, international modeling studies suggest that comprehensive HPV vaccination programs, especially when combined with organized screening strategies, have the potential to substantially reduce cervical cancer incidence and mortality in the coming decades[9,20].

Moreover, evidence supports population-level benefits of HPV vaccination, including herd protection, with reductions in HPV infection prevalence and HPV-related outcomes even among unvaccinated individuals[20]. Taken together, these findings suggest that simplifying the HPV vaccination schedule may improve short-term adherence and contribute to achieving global targets for cervical cancer elimination as a public health problem[9,20].

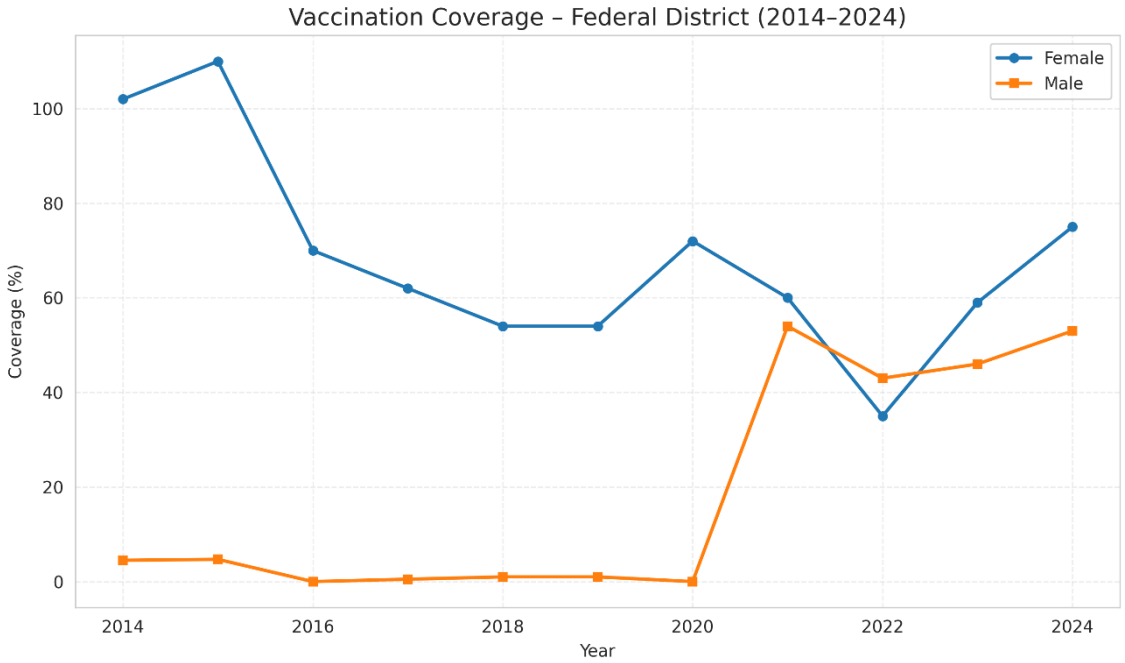

Figure 1 - HPV vaccination coverage among female and male adolescents in the Federal District (2014–2024), according to the National Immunization Program (PNI).

The regional comparison shows that the Federal District maintained vaccination coverage consistently higher than the Central-West average throughout the analyzed period, as demonstrated in Figure 2 and reported by the Ministry of Health and Reis et al.[2,8]. This performance may be attributed to a stronger primary health care infrastructure, higher urban density, and a well-established tradition of school-based campaigns—strategies that enhance adolescent outreach and reduce inequalities[15,19]. In contrast, the Central-West region showed a more stable trend, but with lower mean values, highlighting persistent challenges in mobilizing rural populations and ensuring regular access to primary care units, as noted by Reis et al.[8] and Federal Governamental data[6].

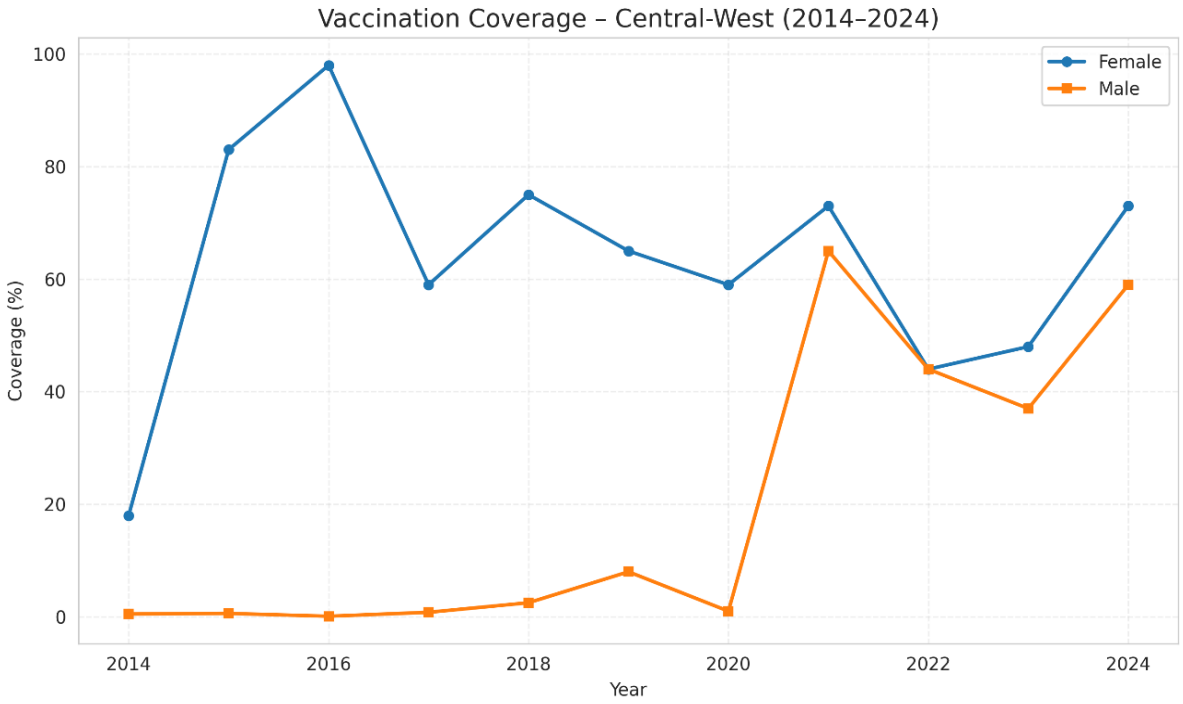

Figure 2 - HPV vaccination coverage among female and male adolescents in the Central-West region (2014–2024), according to the National Immunization Program (PNI).

The differences observed between girls and boys reflect relevant sociocultural and communication-related determinants. Female vaccination has been prioritized since 2014, with a focus on preventing cervical cancer, which contributed to higher initial uptake[3,8]. In contrast, male vaccination introduced into the immunization schedule only in 2017 still faces barriers related to lower risk perception, the limited availability of campaigns specifically targeting boys, and the persistence of misinformation. These challenges have been highlighted by Zanini et al.[10] and by studies assessing predictors of vaccine uptake[13,14].

As shown in Figure 3, a similar pattern is observed in Brazil, the Federal District, and the Central-West region, characterized by higher initial coverage among girls and a progressive increase in vaccination among boys in subsequent years. Statistical analysis using the paired-sample Wilcoxon test showed that, across all locations analyzed, vaccination coverage was significantly higher among girls ($p < 0.05$), indicating a consistent gender disparity, although with a decreasing trend over the analyzed period.

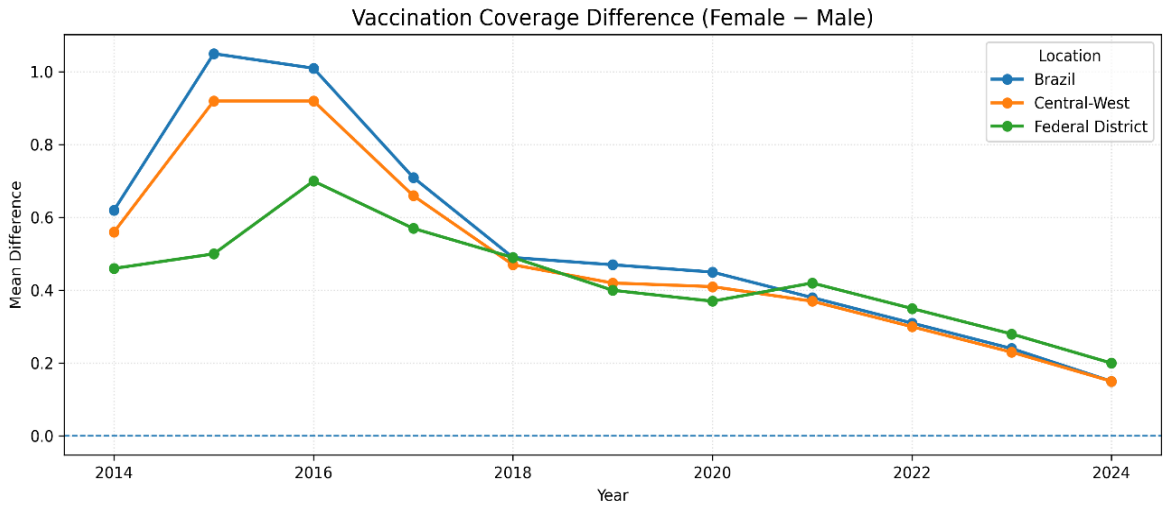

Figure 3 - HPV vaccination coverage among female and male adolescents in Brazil (2014–2024), according to the Vaccination Coverage Dashboard (SAGE/MoH).

Age-group differences were also statistically significant among ages 9 to 14 in all locations ($p < 0.05$), according to the Friedman test. As illustrated in Figure 4, coverage was generally higher among adolescents aged 11 to 13 and lower among those aged 9 and 10. This finding suggests that vaccination strategies anchored in school-based campaigns tend to be more effective in specific age groups, while also highlighting the need for targeted approaches to increase uptake among younger children.

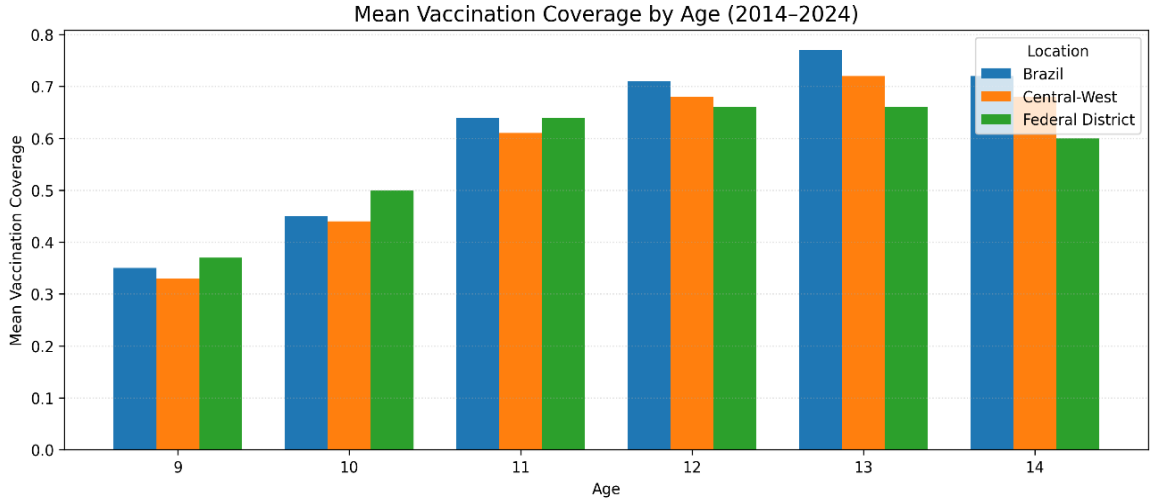

Figure 4 - Mean vaccination coverage by age (2014–2024), according to the Vaccination Coverage Dashboard (SAGE/MoH).

The analysis of the temporal trend in vaccination coverage, presented in Figure 6, did not indicate statistically significant differences in vaccination coverage among Brazil, the Central-West

region, and the Federal District (p = 0.0597). Nevertheless, the Federal District (FD) showed higher mean coverage throughout the years and, more importantly, demonstrated the steepest annual growth trend and the best fit for the linear regression model (R^2 = 0.81). The increasing trend observed across all locations suggests a gradual recovery in vaccination coverage, particularly after 2022, although it remains insufficient to reach the 90% target established by the National Immunization Program.

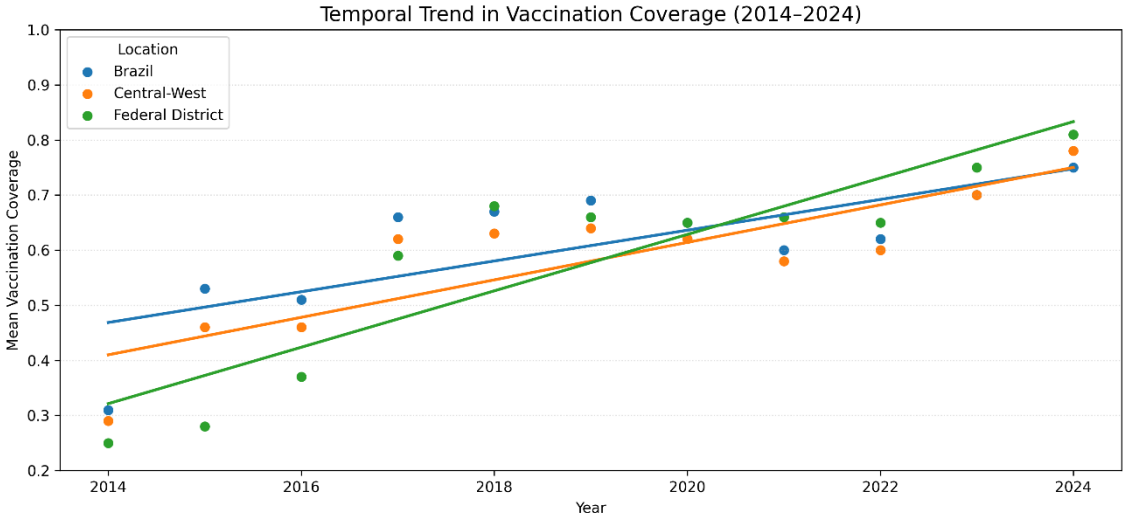

Figure 5 - Temporal trend in vaccination coverage (2014–2024), according to the Vaccination Coverage Dashboard (SAGE/MoH).

Figure 6 shows an overall and consistent increase in HPV vaccination coverage across all analyzed regions throughout the historical series. Despite fluctuations observed between 2017 and 2022, the mean coverage in 2024 is clearly higher than that recorded in 2014 for Brazil, the Central-West region, and the Federal District, suggesting recovery and progress in vaccine acceptance over the decade.

The COVID-19 pandemic (2020–2021) constituted a relevant external factor that negatively affected immunization programs, contributing to stagnation or a temporary decline in vaccination coverage, as indicated by Reis et al.[8] and Ministry of Health data. The introduction of the single-dose schedule in 2024, aimed at simplifying the regimen and increasing uptake, represents a recent event whose impacts should be monitored, but it may already be reflected in the improvement observed at the end of the time series, as discussed by Zanini et al.[10] and Reis et al.[8].

The Ministry of Health practical guide on HPV highlights school-based vaccination as one of the main strategies to increase coverage among adolescents[3]. Scientific evidence shows that school campaigns facilitate access to immunization and help reduce inequalities, especially in urban settings[15,19]. However, excessive reliance on this approach may limit vaccine reach among populations outside the school environment, as noted by Zanini et al.[10]. In addition, limited

engagement of health professionals and the lack of communication strategies targeting boys and younger children contribute to maintaining coverage below recommended levels, as discussed by Reis et al.[8].

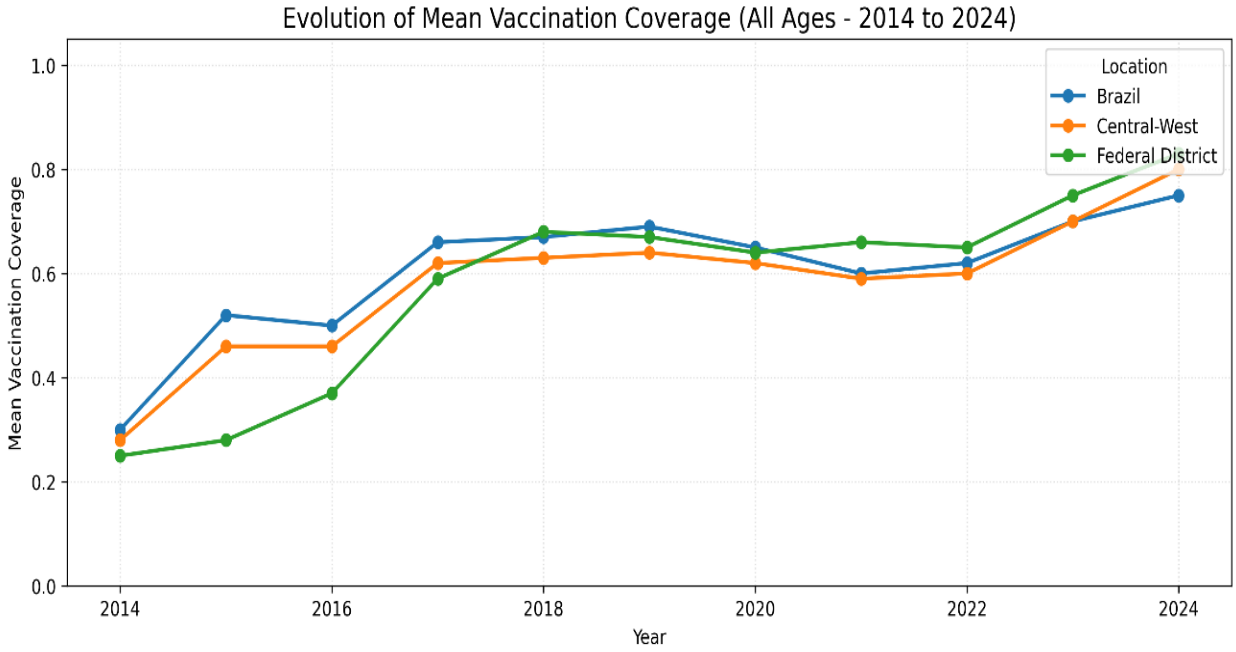

Figure 6 - Evolution of mean vaccination coverage (2014–2024), according to the Vaccination Coverage Dashboard (SAGE/MoH) and the National Immunization Program (PNI).

CONCLUSION

HPV vaccination coverage from 2014 to 2024 showed a gradual recovery after the decline observed during the COVID-19 pandemic, with the Federal District maintaining better performance compared to the Central-West region and Brazil, although without statistically significant differences. Important inequalities persist by sex and age group, with lower uptake among boys and younger adolescents, reinforcing longstanding challenges faced by the National Immunization Program in achieving established targets.

Among the study limitations are the use of aggregated secondary data, which may be subject to underreporting and operational inconsistencies, as well as the inability to assess individual determinants of vaccine uptake or establish causal relationships.

Nevertheless, the findings contribute to understanding the temporal dynamics of HPV vaccination and may support surveillance and health planning actions. Strengthening school-based campaigns, targeted communication strategies, and continuous monitoring of the impact of the single-dose vaccination schedule are recommended, particularly in regional contexts, to expand vaccination coverage equitably.

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