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Evaluating Rubella Immunity in Women of Reproductive Age in Mysuru: A Cross-Sectional Serosurvey

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ABSTRACT

Introduction: This study aimed to determine the seroprevalence of rubella IgG antibodies among women of reproductive age in Mysuru, India. Estimating the rubella seroprevalence in this populationis crucial for informing public health interventions aimed at preventing congenital rubella syndrome (CRS), a severe birth defect caused by rubella infection during pregnancy. **Methods:** A cross-sectional serosurvey was conducted among women of reproductive age (18–38 years) in Mysuru city from January 15, 2019, to December 31, 2019. A total of 311 participants were recruited using a convenience sampling technique. Rubella IgG antibody levels were measured using ELISA with the CALBIOTECH Rubella IgG ELISA kit. **Results:** The mean age of the 311 women of reproductive age included in the study was 25.8 ± 5.2 years. Age was not significantly associated with rubella IgG antibody status (P=0.123). Overall, 95.5% (n = 297) of participants were seropositive for rubella IgG antibodies, indicating immunity against rubella. The lowest seroprevalence (92.1%, n = 51) was observed in the 21–25 years age group. Although not statistically significant (P=0.872), a slightly higher proportion of urban residents (95.68%, n = 267) were seropositive compared to rural residents. Furthermore**,** participants with a history of normal pregnancy (98.59%, n = 166) and those who reported being vaccinated (100%) had a significantly higher seroprevalence of rubella IgG antibodies. **Conclusion:** This study found a high seroprevalence of rubella IgG antibodies (95.5%) among women of reproductive age in Mysuru, indicating a potentially low risk of rubella infection and a high level of population immunity. This high seroprevalence is likely attributable to the successful implementation of the national Measles-Rubella vaccination campaign in India, as evidenced by the high seroprevalence observed self-reported vaccinated participants. Further research is warranted to investigate the duration of rubella immunity conferred by vaccination and to assess the need for booster doses in this population.

INTRODUCTION

Rubella, a highly contagious viral infection, poses a significant threat to pregnant women due to the risk of congenital rubella syndrome (CRS) in their developing fetuses. Transmitted primarily through respiratory droplets, rubella infection during pregnancy can result in CRS, characterized by severe birth defects such as cataracts, sensorineural deafness, intellectual disabilities, and congenital heart defects. The prevention of CRS represents a critical global public health priority. A key strategy for achieving this objective is ensuring high levels of rubella immunity among women of childbearing age [1, 2].

As part of its commitment to eliminating measles and rubella, India launched one of the world's largest measles-rubella (MR) vaccination campaigns in February 2017, targeting children aged 9 months to less than 15 years [3]. Between 2017 and 2021, India witnessed a substantial decline (48%) in the incidence of rubella, dropping to 1.2 cases per million population [2]. Despite this progress, achieving the goal of eliminating measles and rubella by 2023 requires ensuring high rubella immunity levels among women of childbearing age, a population often missed by routine vaccination programs. Notably, national routine coverage for both the second dose of measles-containing vaccine (MCV2)

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and the first dose of measles-rubella containing vaccine (MRCV1) between 2019 and 2021 (from 84% to 82% and 95% to 89%, respectively), coinciding with the COVID-19 pandemic. Similarly, coverage for the first dose of measles-rubella containing vaccine (MRCV1) also decreased, from 95% in 2019 to 89% in 2021, coinciding with the COVID-19 pandemic. The observed decline in vaccination coverage underscore the importance of sustained efforts to improve and maintain high rubella vaccination coverage, particularly among women of childbearing age, to achieve measles and rubella elimination goals and prevent CRS [4].

While rubella infection can affect individuals of all sexes and ages, it poses a particular risk to pregnant women due to the potential for CRS in the developing fetus. CRS can have devastating consequences, including pregnancy loss (spontaneous abortion, miscarriage, or stillbirth) and congenital anomalies affecting hearing (sensorineural hearing loss), vision (cataracts), and the heart. Achieving and maintaining high levels of rubella immunity among women of childbearing age is therefore crucial for preventing CRS and its devastating consequences, thereby reducing the substantial societal and economic burden of this preventable condition. The risk of CRS is highest (approaching 90%) during the first trimester, particularly within the first 8–10 weeks of gestation, when rubella infection often results in multiple congenital anomalies [4, 5]. Studies conducted in India have reported a wide range of rubella seroprevalence rates among pregnant women, with estimates as low as 6.5% in asymptomatic pregnancies and as high as 26.8% in women experiencing adverse pregnancy outcomes, such as preterm birth, low birth weight, or stillbirth. These findings suggest that rubella infection, even if asymptomatic, may contribute to adverse pregnancy outcomes [6].

Rubella remains a significant public health threat in regions with suboptimal vaccination coverage, particularly for women of childbearing age, who face an elevated risk of infection and adverse pregnancy outcomes, including CRS. Recognizing this risk, the World Health Organization (WHO) recommends regular assessments of rubella epidemiology and population immunity, along with targeted interventions like supplementary immunization activities (SIAs) and enhanced surveillance, to achieve and sustain rubella elimination [7].

Infection with the rubella virus triggers the production of two key antibody isotypes: immunoglobulin M (IgM), which provides an initial rapid response to infection, and immunoglobulin G (IgG), which confers long-lasting immunity. IgM antibodies are produced rapidly after infection, peaking within 7–10 days before declining, while IgG antibodies develop more slowly but provide the long-lasting immunity crucial for protecting women of childbearing age from rubella infection and the risk of CRS during pregnancy. Specifically, the detection of rubella virus-specific IgG antibodies in serum is a reliable marker of immunity, indicating either past infection or successful vaccination. However, it is important to acknowledge that serological assays, particularly IgM tests, may yield false-positive results due to cross-reactivity with other antibodies or the presence of rheumatoid factor. These factors should be considered when interpreting serological test results [8].

Accurate interpretation of rubella antibody serological test results requires careful consideration of clinical context, including vaccination history and potential exposure, to ensure a comprehensive assessment of immunity, particularly in women of childbearing age. Accurate assessment of rubella immunity is particularly crucial for informing clinical decisions and guiding appropriate management, especially in pregnant women with suspected rubella infection [8]. Previous seroprevalence studies conducted in India, while limited in number, have provided valuable insights into rubella immunity levels within specific populations. These data are crucial for understanding rubella epidemiology, informing public health strategies, and guiding interventions aimed at achieving and sustaining rubella elimination and preventing CRS, as seroprevalence studies provide essential information on disease prevalence and transmission patterns [9].

Given India's high measles incidence, which often coincides with rubella due to their similar transmission routes, conducting localized seroprevalence studies is crucial for informing and refining national rubella and measles control and elimination strategies. Mysuru, with its diverse population encompassing both urban and rural settings, offers a valuable opportunity to assess rubella immunity levels and vaccination program effectiveness across different demographic and geographic contexts [10]. Assessing rubella antibody levels in the Mysuru region can help identify susceptible subgroups of women of childbearing age, particularly in the context of potential outbreaks due to suboptimal vaccination coverage or waning immunity. Therefore, this cross-sectional serosurvey aimed to estimate the seroprevalence of rubella IgG antibodies among women of childbearing age in Mysuru, Karnataka, India, providing valuable data for informing rubella control and elimination strategies in the region.

MATERIAL AND METHODS

Study design and setting. This cross-sectional serosurvey was conducted from January 2019 to December 2019 at the Department of Microbiology, Mysore Medical College and Research Institute (MMCRI), Mysuru, Karnataka, India.

Participants and sampling. Women aged 18 to 35 years residing in Mysuru and surrounding areas were recruited using a convenience sampling method. Individuals were excluded if they had a known history of recent rubella infection, a history of giving birth

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to a child diagnosed with CRS, or if they reported experiencing symptoms consistent with rubella infection (*e.g*., fever, rash, joint pain). A total of 311 participants who met the inclusion criteria and provided informed consent were included in the study.

Sample size calculation and recruitment. The sample size was calculated to achieve a 95% confidence interval (CI) and a 5.22% margin of error for the estimated rubella IgG seroprevalence. To ensure a conservative estimate of the required sample size, the calculation assumed a 30% seronegativity rate among women of childbearing age in India, based on findings from a previous study [11]. The minimum required sample size of 311 participants was calculated using the formula for estimating a single population proportion, as described by Daniel *et al*. (1999) [12]. Participant recruitment was conducted using a convenience sampling approach. Women of reproductive age (18-35 years) attending the outpatient clinics or seeking laboratory services at the Department of Microbiology, Mysore Medical College and Research Institute (MMCRI), Mysuru, were screened for eligibility and approached for potential enrollment until the target sample size was reached.

Ethical considerations. Ethical approval for the study was obtained from the Institutional Ethics Committee of MMCRI, Mysuru (as provided in the Supplementary Information). All participants received a detailed explanation of the study's purpose, procedures, and potential risks and benefits. Written informed consent was obtained from each participant before enrollment.

Data collection. A structured questionnaire was used to collect data on participants' demographics, medical history (including rubella vaccination and infection history), personal and menstrual history, and obstetric history (including pregnancy outcomes and history of congenital anomalies in offspring). All data were recorded on a standardized case report form (CRF) that had been previously validated and pilot-tested by the research team.

Laboratory procedures. Peripheral venous blood samples (5 mL) were collected from each participant using standard aseptic venipuncture techniques. After allowing the blood samples to clot for 20 min at room temperature (20–25°C), serum was separated by centrifugation at f 1500 × g for 10 min using a refrigerated centrifuge. The separated serum samples were immediately transported to the Microbiology laboratory at 2–8°C in a cold box and stored at -20°C until further analysis.

Serological analysis. Serum samples were tested for rubella IgG antibodies using a commercially available enzyme-linked immunosorbent assay (ELISA) kit (CALBIOTECH Rubella IgG ELISA, catalog number RB025G) according to the manufacturer's instructions [13]. The assay was performed as follows:

1. Calibrator verification: The optical density (OD) of the calibrator was measured to ensure adequate assay sensitivity. The assay was considered valid only if the calibrator OD exceeded 0.250.

2. Negative control validation: The sample index (ratio of negative control OD to calibrator OD) was calculated to assess non-specific background signal. The assay was considered valid only if the negative control index was below 0.9, indicating minimal background signal.

3. Positive control validation: The sample index (ratio of positive control OD to calibrator OD) was calculated to confirm adequate assay reactivity. The assay was considered valid only if the positive control index exceeded 1.2, ensuring the ability to detect positive samples.

The cut-off value for distinguishing between positive and negative results was determined by multiplying the calibrator's optical density (OD) by the kit-provided calibrator factor, which converts OD to international units per milliliter (IU/mL).

The sample index for each serum sample was calculated using the following formula:

Sample Index = Sample OD / Cut-off value.

Rubella IgG antibody results, based on the calculated sample index, were interpreted as follows:

- Sample Index < 0.9: Negative for rubella IgG antibodies, suggesting a lack of immunity to rubella infection.

- Sample Index 0.9–1.1: Equivocal, indicating an uncertain immune status. In such cases, repeat testing is recommended. Further investigation, including assessment of rubella-specific IgM antibodies, may be warranted based on clinical presentation and risk factors.

- Sample Index > 1.1: Positive for rubella IgG antibodies, indicating presumptive immunity to rubella infection.

Statistical analysis. Descriptive statistics were used to summarize the characteristics of the study participants. Continuous variables were presented as means ± standard deviations (SD), and categorical variables as frequencies and percentages. The association between rubella IgG seropositivity and potential risk factors, including age, self-reported history of rubella vaccination, education level, parity, and socioeconomic status, was assessed using the chi-square test. A two-sided *P*-value of < 0.05 was considered statistically significant. All statistical analyses were performed using coGuide Statistics software, Version 2.0 [14].

RESULTS

Participant characteristics. The mean age of the 311 participants was 25.88 ± 5.20 years (range: 15–49 years) (Table 1). The most common age group was 21–25 years (36.98%, n = 115), followed by 26–30 years (25.08%, n = 78), 15–20 years (17.68%, n = 55), and 31–49 years

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(20.26%, n = 63). Regarding place of residence, 162 participants (52.09%) resided in urban areas, while 149 (47.91%) resided in rural areas within the Mysuru region. The majority of participants (82.32%, n = 256) reported being unaware of their rubella vaccination history. Of those who knew their vaccination history, 9.65% (n = 30) reported receiving at least one dose of a rubella-containing vaccine, while 8.04% (n = 25) reported not receiving any rubella-containing vaccine. Of the 311 participants, 71 (22.83%) reported one or more pregnancies without any adverse obstetric outcomes, such as miscarriage, stillbirth, or congenital rubella syndrome. Additionally, 30 (9.65%) reported experiencing at least one adverse obstetric outcome. Among those with adverse outcomes, the most frequently reported event was miscarriage (22 participants, 73.33%). Stillbirth was reported by 2 participants (6.67%), and preterm delivery by 1 participant (3.33%). One participant (3.33%) reported having an infant with intellectual disability and a congenital heart defect. Overall, 297 participants (95.50%) tested positive for rubella IgG antibodies, indicating presumptive immunity.

Table 1. Sociodemographic and clinical characteristics of participants

Parameters	Summary
Age (in years)	25.88 ± 5.20
Residence	
Urban	162 (52.09%)
Rural	149 (47.91%)
Vaccination status	
Vaccinated	30 (9.65%)
Not vaccinated	25 (8.04%)
Unknown	256 (82.32%)
Previous pregnancy outcomes	
Normal	71 (20.82%)
Bad obstetric history	30 (8.80%)
Miscarriage	22 (6.45%)
Stillbirth	3 (0.88%)
Preterm delivery	3 (0.88%)
Intellectual disability	1 (0.29%)
Congenital heart defect	1 (0.29%)
Nulliparous	210 (61.58%)
Serum rubella IgG antibody	
Positive	297 (95.5%)
Negative	14 (4.5%)

Factors associated with rubella IgG seropositivity. A chi-square test of independence revealed no statistically significant association between age group and rubella IgG seropositivity (P = 0.123). Although not statistically significant, the highest seroprevalence of rubella IgG antibodies was observed in the 21–25 years age group (92.17%, n = 115). Rubella IgG seroprevalence did not differ significantly between participants residing in urban (95.68%, n = 162) and rural (95.30%, n = 149) areas (P = 0.872).

A statistically significant association was observed between a history of adverse pregnancy outcomes and rubella IgG seropositivity (P = 0.004). Among women with a history of term pregnancies without complications, 70 (98.59%) tested positive for rubella IgG antibodies. However, among women with a history of miscarriage, rubella IgG seroprevalence was significantly lower at 77.27% (n=17/22) (Table 2).

No statistically significant association was observed between rubella IgG seropositivity and self-reported vaccination status (P = 0.095) (Table 2).

Table 2. Association between Rubella IgG serostatus and sociodemographic and clinical characteristics

Parameters	Serum Rubella IgG antibody		*P*-value
	Positive	Negative	
Age			
≤20 (N = 55)	54 (98.18%)	1 (1.82%)	0.123
21-25 (N = 115)	106 (92.17%)	9 (7.83%)	
26-30 (N = 78)	77 (98.72%)	1 (1.28%)	
≥31 (N = 63)	60 (95.24%)	3 (4.76%)	
Residence			
Urban (N = 162)	155 (95.68%)	7 (4.32%)	0.872
Rural (N = 149)	142 (95.30%)	7 (4.70%)	
Previous pregnancy outcomes			
Normal (N = 71)	70 (98.59%)	1 (1.41%)	**0.004***
Bad obstetric history	-	-	
Miscarriage (N = 22)	17 (77.27%)	5 (22.73%)	
Stillbirth (N = 3)	3 (100.00%)	0 (0.00%)	
Preterm delivery (N = 3)	3 (100.00%)	0 (0.00%)	
Mental retardation (N = 1)	1 (100.00%)	0 (0.00%)	
Congenital heart defect (N = 1)	1 (100.00%)	0 (0.00%)	
Nulliparous (N = 210)	202 (96.19%)	8 (3.81%)	
Vaccination status			
Vaccinated (N = 30)	30 (100.00%)	0 (0.00%)	0.095
Not vaccinated (N = 25)	22 (88.00%)	3 (12.00%)	
Unknown (N = 256)	245 (95.70%)	11 (4.30%)	

Note: *Statistically significant

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DISCUSSION

This cross-sectional serosurvey revealed a high seroprevalence of rubella IgG antibodies (95.5%) among women of reproductive age in Mysuru. This finding suggests widespread past exposure to rubella virus or successful vaccination within this population. Consequently, a high level of protective immunity can be inferred. This finding is considerably higher than the 73.3% seroprevalence reported by Karunakaran *et al*. (2022) in a study of women of reproductive age in Govt TD Medical College, Alappuzha, Kerala from June 2016 to June 2017 [15]. Notably, the seroprevalence of rubella IgG antibodies in developing countries exhibits substantial variability, ranging from 32% to 95.3% across various geographical regions and populations [16]. This wide range highlights the critical need for continued surveillance efforts and the implementation of tailored vaccination strategies to achieve and maintain high levels of rubella immunity.

The study found no significant difference in rubella IgG seroprevalence between urban and rural residents, suggesting that geographic location within Mysuru may not be a major determinant of rubella immunity in this population. However, this study has limitations. We did not collect data on socioeconomic, cultural, or logistical factors that could influence access to healthcare and, consequently, rubella vaccination coverage. Future research should explore these factors to better understand the complex interplay between geographic, socioeconomic, and other relevant determinants of rubella immunity.

A study by Taku *et al*. (2019) in the Centre and South-West regions of Cameroon involving 522 women of reproductive age found that 5.5% (29/522) tested negative for both rubella IgG and IgM antibodies, suggesting susceptibility to rubella infection [17].

The high rubella IgG antibody seroprevalence observed in many high-income countries can be attributed, at least partially, to the success of comprehensive rubella vaccination programs implemented as part of their national immunization strategies [18]. While these programs have undoubtedly contributed to reducing rubella susceptibility, it is important to acknowledge that other factors, such as naturally acquired immunity and herd immunity effects, also play a role in reducing rubella incidence. Therefore, attributing specific reductions in incidence solely to vaccination efforts requires careful consideration of these factors. Accurate interpretation of rubella seroprevalence data requires careful analysis of local vaccination coverage data and consideration of potential variations in rubella epidemiology, such as circulating strains and transmission patterns [18-20].

This study identified a statistically significant association between a history of adverse pregnancy outcomes and lower rubella IgG seropositivity. This finding aligns with previous research in India, which has reported that 10–20% of women with a history of adverse pregnancy outcomes, such as recurrent miscarriage, stillbirth, and congenital anomalies, had serological evidence of past rubella infection [21]. These outcomes are consistent with the potential consequences of rubella infection during pregnancy.

Among women reporting term pregnancies without complications, 98.59% (n = 70) tested positive for rubella IgG antibodies in the present study. Although not statistically significant, a trend toward a higher proportion of seronegativity (22.73%) was observed among women reporting miscarriages, compared to the overall seronegativity rate of 4.5%. The small sample size of women with a history of miscarriage (n=22) may have limited the statistical power to detect a significant difference, highlighting the need for future studies with larger sample sizes to confirm these findings.

Global rubella seronegativity rates in women of reproductive age exhibit substantial variability, with reported rates ranging from less than 1% in some European countries with high vaccination coverage to over 50% in certain African regions with limited access to vaccination [22]. This wide range underscores the significant impact of regional differences in rubella epidemiology, vaccination program effectiveness, and broader public health infrastructure on population immunity levels. Despite the high overall seroprevalence of rubella IgG antibodies in our study population, the identification of a substantial proportion of susceptible individuals (4.5% seronegativity) remains a concern. This finding underscores the importance of sustained efforts to achieve and maintain high rubella vaccination coverage, coupled with robust surveillance systems, to effectively prevent CRS. A comprehensive assessment of the potential risk for rubella transmission and CRS requires considering a broader range of factors beyond seroprevalence data alone. These factors include rubella vaccination coverage rates, the local incidence of rubella infection, and relevant population demographics, such as age, socioeconomic status, and access to healthcare.

A substantial proportion of participants (82.32%, n=245) reported being unaware of their rubella vaccination status, which could hinder accurate assessment of population immunity levels and the effectiveness of vaccination programs. This finding highlights the critical need for implementing targeted health communication strategies to raise awareness about the importance of rubella vaccination and for strengthening record-keeping practices to ensure accurate documentation of vaccination status. While a lack of knowledge regarding rubella and its potential adverse effects, particularly during pregnancy, may contribute to the low awareness of vaccination status observed in this study, other potential factors warrant consideration. These factors include limited access to healthcare services, socioeconomic disparities, cultural

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beliefs and practices, and individual experiences with healthcare providers. Future research should explore these factors in greater detail to inform the design and implementation of tailored interventions aimed at enhancing both vaccination awareness and the accessibility of reliable vaccination records, particularly among vulnerable populations.

This study has several limitations. First**,** the single-center design and recruitment of participants primarily from a tertiary care hospital in Mysuru may limit the generalizability of our findings to the broader population of women of reproductive age in India. Women attending tertiary care hospitals may differ from the general population in terms of socioeconomic status, access to healthcare, and health-seeking behaviors, potentially introducing selection bias. Second, the cross-sectional nature of our study design limits our ability to establish causality or determine the temporal relationship between rubella vaccination, infection, and seroprevalence. Because cross-sectional studies collect data at a single point in time, they cannot determine whether exposure (*e.g*., vaccination or infection) preceded the outcome (*e.g*., seropositivity). Prospective cohort studies, which follow participants over time and assess exposure and outcome status at multiple time points, are better suited to investigate the causal relationships between rubella vaccination, infection, and the development of immunity. Third, although our sample size was sufficient to estimate overall rubella seroprevalence with adequate precision, the study may have been underpowered to detect statistically significant associations between rubella IgG serostatus and specific sociodemographic or reproductive characteristics, such as education level, income, parity, or history of adverse pregnancy outcomes. This limitation could have led to type II errors, where true associations were not detected due to insufficient statistical power. Future studies with larger and more diverse sample sizes are warranted to explore these potential associations comprehensively and to determine their magnitude and clinical significance. These studies should also consider the use of advanced statistical techniques, such as multivariable regression analysis, to control potential confounding factors and to identify independent predictors of rubella IgG serostatus. Finally, the potential for waning rubella IgG antibody levels over time raises the possibility of underestimating past exposure to the rubella virus. However, the high overall seroprevalence observed in our study (95.5%) suggests that this potential underestimation is unlikely to be a major limitation in this specific context. To gain a more comprehensive understanding of the long-term dynamics of rubella immunity, including the potential impact of waning antibody levels and the need for booster vaccinations, future research should incorporate longitudinal serological studies that follow individuals over an extended period.

The high rubella IgG seroprevalence (95.5%) observed in this study among women of reproductive age in Mysuru is an encouraging finding and suggests positive progress towards the goal of rubella elimination in India. However, it is crucial to recognize that seroprevalence data alone are not sufficient to confirm rubella elimination. Achieving and verifying elimination requires a comprehensive approach that includes high documented vaccination coverage, robust disease surveillance systems to detect and respond to outbreaks, and ongoing monitoring of rubella incidence and congenital rubella syndrome cases. The findings of this study, in conjunction with existing evidence on the importance of rubella immunity in women of childbearing age, suggest that healthcare providers should consider incorporating rubella susceptibility screening into routine preconception counselling. A validated rapid serological test could be used to assess rubella IgG antibody levels during the initial preconception visit. Women identified as susceptible should be vaccinated against rubella, following national immunization guidelines. Decisions regarding rubella susceptibility screening during pregnancy should be guided by a comprehensive assessment that considers local epidemiological factors, resource availability, and individual risk factors. Maintaining high vaccination coverage with the MMR vaccine among all children through the national immunization program is essential for achieving and sustaining rubella elimination. Furthermore, targeted rubella vaccination programs should be implemented for susceptible women of childbearing age. These programs should particularly focus on geographic areas or populations with documented low rubella immunity. This approach can help reduce the incidence of congenital rubella syndrome and its associated morbidity and mortality. To achieve and sustain rubella elimination, policymakers and public health authorities should prioritize robust MMR vaccination programs. These programs should include strategies to increase and maintain high vaccination coverage, improve equitable access to MMR vaccines, and effectively address vaccine hesitancy. Furthermore, robust surveillance systems are crucial for: (1) monitoring rubella cases and CRS incidence; (2) rapidly identifying and responding to outbreaks; and (3) evaluating the effectiveness of vaccination programs. Strategies for strengthening vaccination programs and surveillance systems should be aligned with the WHO's Strategic Framework for Rubella Elimination and the Global Measles and Rubella Strategic Plan.

This cross-sectional serosurvey conducted in Mysuru, India, revealed a high prevalence of rubella IgG antibodies among women of reproductive age, suggesting a potentially low risk of rubella infection and subsequent CRS compared to populations with lower seroprevalence. However, these findings should be interpreted with caution, acknowledging the limitations inherent in a single-center study design. The results may

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not be generalizable to other regions or populations within India, as rubella immunity can vary considerably based on geographic location, socioeconomic status, and access to healthcare. Despite these limitations, the findings of this study offer valuable insights for ongoing efforts to eliminate rubella and CRS in India. Continuous monitoring of rubella seroprevalence is essential for evaluating the effectiveness of vaccination programs and informing public health interventions, particularly among vulnerable populations such as pregnant women, where infection can have devastating consequences, and women of childbearing age. Achieving and sustaining rubella elimination goals in India, and contributing to global eradication efforts, requires a multifaceted approach that includes maintaining high and equitable MMR vaccination coverage, establishing robust surveillance systems, and implementing targeted public awareness campaigns.

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CONFLICT OF INTEREST

The authors seclare that there are no conflicts of intretsts associated with this manuscript.

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