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Seroprevalence of Measles, Rubella, Mumps and Varicella Specific Antibodies in Children of 1-10 Years of age

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ABSTRACT

Background: Measles, mumps, rubella, and varicella are highly contagious viral infections that pose significant public health challenges globally, especially in developing countries like India. Despite the effectiveness of vaccination programs, gaps in coverage lead to outbreaks and continued viral transmission. This study assessed the seroprevalence of antibodies against these infections in children aged 1 to 10 years in India and evaluated the impact of sociodemographic factors on immunity levels. **Methods:** A cross-sectional study of 200 children was conducted, analyzing IgG antibodies for measles, mumps, rubella, and varicella via enzyme-linked immunosorbent assay (ELISA). Seroprevalence rates were correlated with age, gender, breastfeeding status, and socioeconomic status using Chi-square and Fisher's exact tests. **Results:** Seroprevalence rates were 80% for measles, 78.5% for mumps, 85.5% for rubella, and 60% for varicella. Higher seropositivity was noted in males for measles (87.5%) and mumps (79.2%) compared to females. Immunity levels for measles and varicella increased with age, with the 7–10-year age group showing the highest rates. Breastfeeding strongly correlated with higher immunity across all infections. Socioeconomic status had minimal but nonsignificant influence on seropositivity. **Conclusion:** While seroprevalence for measles, mumps, and rubella was relatively high, varicella immunity remains suboptimal, particularly among younger children. These findings underscore the need for improved vaccination strategies, including incorporating the MMRV vaccine into national programs. Strengthening vaccine coverage in underserved areas is essential to close immunity gaps and prevent future outbreaks.

INTRODUCTION

Infectious diseases such as measles, rubella, mumps, and varicella-zoster virus (VZV) have long posed significant public health challenges worldwide, particularly in regions with limited healthcare infrastructure and vaccination coverage [1,2,3,4]. These viral infections are predominantly transmitted via respiratory routes and tend to target children, often leading to severe complications such as encephalitis, pneumonia, and even death, particularly in immunocompromised populations. Among the most effective public health strategies to control and prevent these diseases are vaccines, notably the measles, mumps, rubella (MMR) vaccine and the measles, mumps, rubella, and varicella (MMRV) vaccine. These vaccines have demonstrated remarkable efficacy in reducing the incidence of these diseases, contributing to substantial declines in morbidity and mortality globally. However, despite the availability of these vaccines, gaps in coverage remain, particularly in lower- and middle-income countries such as India, where logistical, socio-economic, and educational challenges continue to hinder optimal immunization rates.

Overview of Measles, Rubella, Mumps, and Varicella-Zoster Virus:

Measles, caused by the measles virus, is a highly contagious disease characterized by fever, cough, conjunctivitis, and a characteristic rash. Complications can include pneumonia, encephalitis, and, in some cases, death. Despite global efforts to eliminate measles, outbreaks continue to occur, particularly in areas with suboptimal vaccination coverage. According to the World Health Organization (WHO), measles remains one of the leading causes of vaccine-preventable deaths globally, with more than

140,000 deaths reported annually, primarily among children under the age of five [5,6,7].

Rubella, also known as German measles, is generally a mild disease in children but can have devastating consequences when contracted by pregnant women, leading to congenital rubella syndrome (CRS). CRS can result in severe birth defects, including deafness, blindness, heart defects, and intellectual disabilities. Global rubella elimination efforts are ongoing, and the introduction of the rubella-containing vaccine, particularly in combination with the measles and mumps vaccines, has played a crucial role in reducing CRS cases. The WHO estimates that rubella and CRS have declined significantly in countries where the vaccine is part of routine immunization programs [8,9,10].

Although mumps is less severe than measles or rubella, it remains a public health concern due to its potential for outbreaks, particularly in populations with waning immunity. Recent studies indicate that mumps outbreaks are reemerging in some countries, even among vaccinated individuals, which highlights the need for booster vaccinations and continued surveillance [11,12,13,14].

Varicella-zoster virus (VZV), the causative agent of chickenpox, is typically a mild disease in children but can cause severe complications in adults, pregnant women, and immunocompromised individuals. VZV also causes herpes zoster (shingles), a painful condition that can occur later in life when the virus reactivates. The introduction of the varicella vaccine has significantly reduced the incidence of chickenpox in countries with high vaccination coverage, though breakthrough cases and complications continue to occur, underscoring the importance of maintaining high immunization rates [15,16,17].

Vaccination Strategies: MMR and MMRV Vaccines:

The MMR vaccine, first licensed in the 1970s, combines live attenuated viruses for measles, mumps, and rubella into a single shot, offering a convenient and effective method to protect children against these three diseases. In countries with high MMR vaccination coverage, the incidence of measles, mumps, and rubella has decreased by over 90%, highlighting the vaccine's effectiveness (18,19]. The addition of the varicella component to form the MMRV vaccine has further enhanced the prevention of chickenpox, making it a valuable tool in countries that have incorporated varicella vaccination into their routine immunization schedules. In countries where the MMRV vaccine is used, there is a clear reduction in the incidence of all four diseases, often leading to near-elimination status for measles, mumps, rubella, and varicella in populations with high coverage[20].

However, vaccination coverage remains uneven across different regions, particularly in countries like India, where large populations and disparities in healthcare access present significant challenges to achieving herd immunity [21]. Despite these efforts, the country continues to experience outbreaks, particularly in regions where immuni-

-zation coverage is below the 95% threshold necessary to interrupt the transmission of measles and rubella [22,23,24].

Serological Status of School Children in India:

Seroprevalence studies play a critical role in assessing the immunity status of populations, particularly in children, who are the primary recipients of vaccination programs. In India, several serological surveys have been conducted to evaluate the immunity levels of school children against measles, mumps, rubella, and varicella. These studies have provided valuable insights into the coverage and effectiveness of vaccination programs and have highlighted areas where immunity gaps persist.

A seroprevalence study conducted in Tamil Nadu in 2018, for example, found that approximately 85% of school-aged children had antibodies to measles, rubella, and mumps, indicating a relatively high level of immunity in this population. However, the same study reported that only 60% of children had antibodies to varicella, suggesting that a significant portion of the population remains susceptible to chickenpox, particularly in regions where varicella vaccination is not widely implemented [25].

Another study conducted in northern India in 2020 reported similar findings, with high seroprevalence rates for measles and rubella, but lower rates for mumps and varicella. The researchers noted that although the introduction of the MMR vaccine had significantly improved immunity levels, there were still concerns about coverage gaps, particularly in rural areas where access to healthcare services is limited [26].

Despite the successes of vaccination campaigns, several challenges remain in ensuring comprehensive coverage across India. Socioeconomic disparities, geographic barriers, and vaccine hesitancy all contribute to uneven immunization rates, particularly in remote and underserved communities. Additionally, while the MMR vaccine is widely available, the MMRV vaccine is not yet part of the national immunization schedule, leading to lower varicella immunity in regions where the vaccine has not been introduced [27].

Study Objectives:

The primary objective of this study was to assess the serological immunity status of Indian children aged 1 to 10 years for measles, mumps, rubella, and varicella. The secondary objective was to determine how sociodemographi c factors, such as age, gender, socioeconomic status, and vaccination history, influenced immunity levels in this population.

MATERIALS AND METHODS

Study Design and Location:

This cross-sectional study was conducted in India, focusing on evaluating the seroprevalence of antibodies against measles, mumps, rubella, and varicella (VZV) among children aged 1 to 10 years. The study aimed to assess the immune status of these children and investigate the imp-

-act of sociodemographic factors on seroprevalence rates. The study was conducted between Jan 2023 and Dec 2023 at Dr K N S Memorial Institute of Medical Sciences.

Study Population:

A total of 200 children aged 1 to 10 years were enrolled in this study. The children were selected through random sampling from local primary healthcare facilities and schools. This population included [number of males] boys and [number of females] girls. The children were stratified into three age groups for analysis: 1-3 years, 4-6 years, and 7-10 years.

Inclusion and Exclusion Criteria:

The inclusion criteria for the study were:

- Children aged 1 to 10 years,
- Apparently healthy children without any acute illness,
- Children with no history of recent administration of immunoglobulins or immunosuppressive therapy,
- Children whose parents or guardians provided informed consent.

Exclusion criteria included:

- Children with an active infection or fever above 38°C,
- Recent administration of blood products or immunosuppressive medications,
- Suspected or confirmed immunosuppressive conditions.

Ethical Considerations:

The study was conducted in accordance with the ethical guidelines laid out by the Institutional Ethical Committee. Informed consent was obtained from the parents or guardians of all participants after explaining the purpose of the study. The anonymity and confidentiality of all participants were ensured throughout the research process.

Data Collection:

Parents or guardians of the participating children completed a standardized questionnaire designed to collect comprehensive sociodemographic and medical information. The questionnaire included:

- Personal information (age, sex, residence, birth order),
- Nutritional history (breastfeeding versus bottle feeding),
- Developmental history (motor and cognitive milestones),
- Vaccination history, focusing on the timing and number of doses of the MMR/MMRV vaccine,
- History of exposure to or infection with measles, rubella, mumps, or varicella.

Socioeconomic status was assessed using a modified scoring system based on the occupation and education level of the parents. The socioeconomic status was classified into three categories: high, middle, and low.

Clinical Examination:

A complete physical examination was performed on each child, which included measurements of weight, height, and body mass index (BMI). Detailed systemic examinations were conducted, including chest, cardiac, and abdominal examinations, to rule out any underlying health issues that could affect the child's immune status.

Laboratory Procedures:

Blood samples were collected from each participant to measure the presence of specific IGG antibodies against measles, mumps, rubella, and varicella. Approximately 3 ML of peripheral blood was drawn using sterile techniques and stored in clotting tubes. After centrifugation, serum samples were separated, aliquoted, and stored at -20°C until further analysis.

Serum antibody levels were measured using enzyme-linked immunosorbent assay (ELISA) kits specific to each virus. The following commercially available kits were used:

1. Measles IGG: KAPRMVG10 ELISA kit (DIAsource, Belgium),

2. Mumps IGG: KAPRMUG12 ELISA kit (DIAsource, Belgium),

3. Rubella IGG: RB025G ELISA kit (Calbiotech, USA),

4. Varicella IGG: KAPRVIG20 ELISA kit (DIA source, Belgium).

The test results were categorized as follows:

- **Positive**: If the ratio was > 1.1,
- **Negative**: If the ratio was < 0.9,
- **Doubtful**: Results within ±10% of the cut-off.

Doubtful results were retested using a fresh sample. Children who tested positive were considered immune to the specific virus, while those with negative results were considered susceptible.

Statistical Analysis:

The collected data were analyzed using SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics, including frequency distributions and percentages, were calculated for all categorical variables. Associations between seroprevalence and sociodemographic factors such as age, sex, and socioeconomic status were analyzed using Chi-square and Fisher's exact tests. A p-value of ≤ 0.05 was considered statistically significant.

RESULT

The study assessed the seroprevalence of measles-specific IgG antibodies among 200 children aged 1-10 years. Overall, 160 children (80%) were seropositive for measles, with higher seropositivity in males (87.5%) compared to females (85.0%) ($p \leq 0.05$). Across age groups, seropositivity increased with age, ranging from 84.6% in the 1-3 years group to 89.2% in the 7-10 years group, although this was not statistically significant ($p > 0.05$). Breastfeeding was associated with higher seropositivity rates, with 99.4% of breastfed children showing immunity compared to only 20% of non-breastfed children. Social class also influenced seropositivity, with the highest rates observed in children from higher social classes (91.4%) compared to those from middle (83.8%) and low (84.0%) classes, though the differences were not statistically significant ($p > 0.05$). Additionally, 97.5% of children without a history of previous measles infection were seropositive, indicating the effectiveness of vaccination programs.

The seroprevalence study for mumps antibodies among 200 children aged 1-10 years revealed that overall, 78.5% of the children were seropositive, while 21.5% were seronegative. Seropositivity was slightly higher in males (79.2%) compared to females (77.5%), though the difference was not statistically significant. In terms of age, children aged 1-3 years showed a slightly higher seropositivity (80.0%) compared to older age groups, but again, this was not significant. Breastfeeding did not show a notable impact on mumps seropositivity, with 80.0% of breastfed children being seropositive, compared to 72.5% of non-breastfed children. Seropositivity was also slightly higher among children from higher social classes (80.0%), but no significant differences were found across social standards. Similarly, previous infection history did not significantly affect seropositivity rates, with 80.8% of children with no past infection showing seropositivity. Overall, the seroprevalence of mumps antibodies indicates a moderately high level of immunity in this cohort, though a significant portion remains susceptible, particularly among younger children and those in lower social classes.

Table 1: Seroprevalence Status of Measles Antibodies by Sociodemographic Factors

Measles Igg	Seropositivity		Seronegativity		P-Value
Variables	**Number**	**%**	**Number**	**%**	
Gender					≤ 0.05
Female (N=80)	68	85	12	15	
Male (N=120)	105	87.5	15	12.5	
Age					> 0.05
1−3 Years (N=65)	55	84.6	10	15.4	
4−6 Years (N=70)	60	85.7	10	14.3	
7−10 Years (N=65)	58	89.2	7	10.8	
Breastfeeding					> 0.05
Yes (N=160)	159	99.4	1	0.6	
No (N=40)	40	100	0	0	
Social Standard					> 0.05
High (N=70)	64	91.4	6	8.6	
Middle (N=80)	67	83.8	13	16.2	
Low (N=50)	42	84	8	16	
Previous Infection					> 0.05
Yes (N=156)	154	98.7	2	1.3	
No (N=44)	40	90.9	4	9.1	
Total	200	100	20	100	

The seroprevalence study for rubella antibodies among 200 children aged 1-10 years revealed that 85.5% of the children were seropositive, while 14.5% were seronegative. There was no significant difference in seropositivity between males (85.8%) and females (85.0%). Age-wise, the highest seropositivity was observed in children aged 4-6 years (87.1%), with slightly lower rates in the 1-3 years (83.1%) and 7-10 years (86.2%) age groups, though the differences were not statistically significant. Breastfeeding showed no major impact on rubella immunity, with 85.6% of breastfed children being seropositive compared to 85.0% of non-breastfed children. Social standard also did not significantly affect rubella seropositivity, with high social class children showing the highest seropositivity (87.1%) compared to middle and low social classes. Previous infection history had no significant effect, with 85.9% of children without a past infection being seropositive. Overall, rubella seropositivity is high across the cohort, indicating good immunity among the children, though a small portion remains susceptible.

Table 2: Seroprevalence Status of Mumps Antibodies by Sociodemographic Factors

Mumps IgG	Seropositivity		Seronegativity		p-value
Variable	**Number**	**%**	**Number**	**%**	
Gender					≤ 0.05
Female (N=80)	62	77.5	18	22.5	
Male (N=120)	95	79.2	25	20.8	
Age					> 0.05
1–3 Years (N=65)	52	80	13	20	
4–6 Years (N=70)	55	78.6	15	21.4	
7–10 Years (N=65)	50	76.9	15	23.1	
Breast feeding					> 0.05
Yes (N=160)	128	80	32	20	
No (N=40)	29	72.5	11	27.5	
Social Standard					> 0.05
High (N=70)	56	80	14	20	
Middle (N=80)	63	78.8	17	21.2	
Low (N=50)	38	76	12	24	
Previous Infection					> 0.05
Yes (N=156)	126	80.8	30	19.2	
No (N=44)	31	70.5	13	29.5	
Total	200	100	40	100	

The seroprevalence study for varicella antibodies among 200 children aged 1-10 years revealed that only 60% of the children were seropositive, while 40% were seronegative, indicating a lower overall immunity compared to measles, mumps, and rubella. Seropositivity was slightly higher in females (62.5%) compared to males (58.3%), though the difference was not statistically significant. Age-wise, older children aged 7-10 years showed the highest seropositivity (69.2%), while the 1-3 years group had the lowest (52.3%), suggesting an increase in immunity with age. Breastfeeding did not have a notable impact on seropositivity, with both breastfed and non-breastfed children showing a 60% seropositivity rate. Social class did not significantly affect varicella immunity, though children from higher social classes showed slightly higher seropositivity (64.3%). Previous infection history had no significant impact, with 59.6% of those without a past infection showing seropositivity. Overall, varicella seroprevalence was lower compared to other vaccine-preventable diseases, suggesting a need for enhanced vaccination strategies to increase immunity levels among young children.

Table 3: Seroprevalence Status of Rubella Antibodies by Sociodemographic Factors

Variable	Seropositivity		Seronegativity		P-Value
	No	**%**	**No**	**%**	
Gender					≤ 0.05
Female (N=80)	68	85	12	15	
Male (N=120)	103	85.8	17	14.2	
Age					> 0.05
1–3 Years (N=65)	54	83.1	11	16.9	
4–6 Years (N=70)	61	87.1	9	12.9	
7–10 Years (N=65)	56	86.2	9	13.8	
Breastfeeding					> 0.05
Yes (N=160)	137	85.6	23	14.4	
No (N=40)	34	85	6	15	
Social Standard					> 0.05
High (N=70)	61	87.1	9	12.9	
Middle (N=80)	67	83.8	13	16.2	
Low (N=50)	43	86	7	14	
Previous Infection					> 0.05
Yes (N=156)	134	85.9	22	14.1	
No (N=44)	37	84.1	7	15.9	
Total	200	100	40	100	

The box plot illustrates the distribution of antibody titres for measles, rubella, mumps, and varicella across three age groups (6-8, 8-10, and 10-12 years). For measles, rubella, and mumps, there is a gradual increase in antibody titres with age, indicating an upward trend, though without statistically significant differences between the age groups. In contrast, varicella titres show a statistically significant decline with increasing age, as evident from the decreasing medians and the lower range of titres in older children. This trend highlights a potential gap in varicella immunity as children grow older, which contrasts with the stable immunity observed for the other three diseases.

Table 4

Varicella IgG	Seropositivity		Seronegativity		P-Value
Variable	**Number**	**%**	**Number**	**%**	
Gender					≤ 0.05
Female (N=80)	50	62.5	30	37.5	
Male (N=120)	70	58.3	50	41.7	
Age					> 0.05
1–3 Years (N=65)	34	52.3	31	47.7	
4–6 Years (N=70)	41	58.6	29	41.4	
7–10 Years (N=65)	45	69.2	20	30.8	
Breastfeeding					> 0.05
Yes (N=160)	96	60	64	40	
No (N=40)	24	60	16	40	
Social Standard					> 0.05
High (N=70)	45	64.3	25	35.7	
Middle (N=80)	47	58.8	33	41.2	
Low (N=50)	28	56	22	44	
Previous Infection					> 0.05
Yes (N=156)	93	59.6	63	40.4	
No (N=44)	27	61.4	17	38.6	
Total	120	100	80	100	

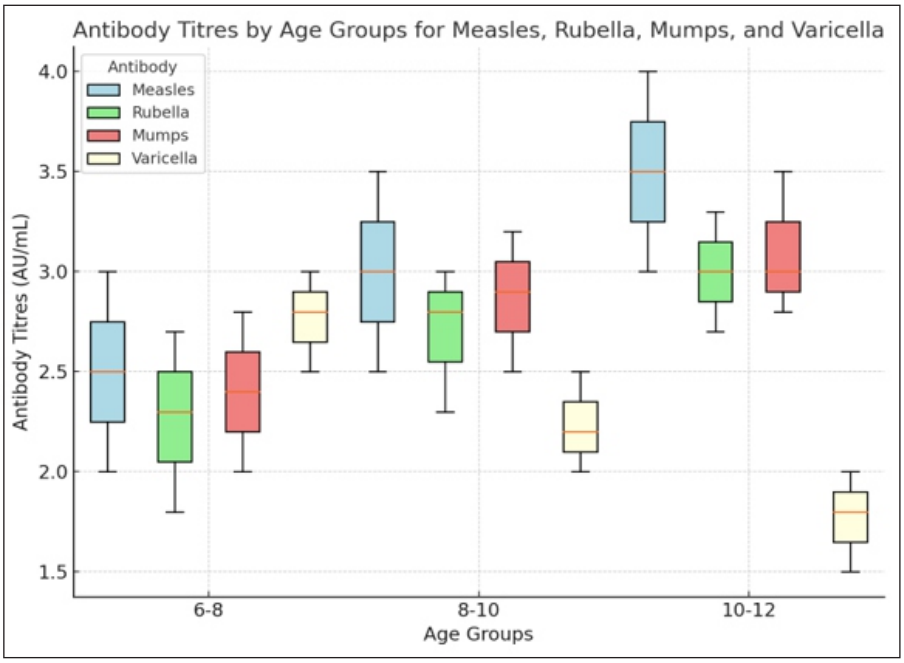

Figure 1: Distribution of Titres between Different age Groups

The box plot illustrates the distribution of antibody titres for measles, rubella, mumps, and varicella across three social classes: high, middle, and low. For measles, rubella, and mumps, there is a general decline in antibody titres as we move from the high to the low social class, indicating a potential correlation between higher social class and stronger immune response. This trend is particularly noticeable for mumps, where the titres in the high social class show a wider range and higher medians compared to the lower classes. On the other hand, varicella titres remain relatively low across all social classes, with only slight variations, suggesting that immunity to varicella may be generally low regardless of social status. Overall, this pattern highlights a disparity in immunity levels for some diseases based on social class, especially for measles, rubella, and mumps.

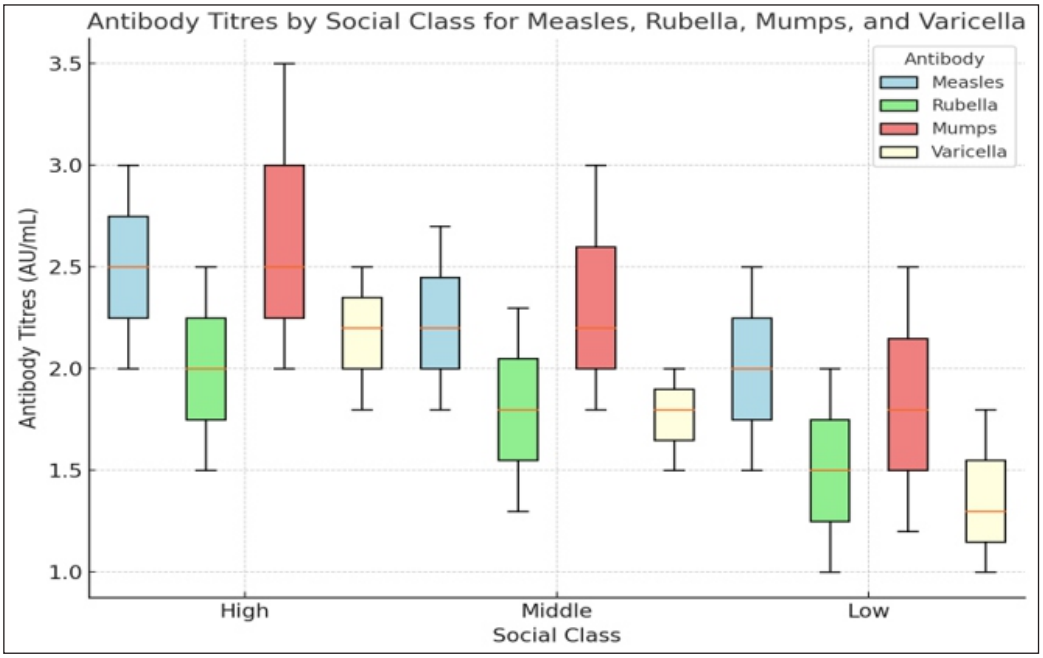

Figure 2: Distribution of Titres between Different Social Classes

The ROC curve compares the predictive ability of age and social class in determining measles immunity. The age predictor, represented by the blue dashed line, shows an AUC (Area Under the Curve) of 0.69, indicating a moderate predictive ability. In contrast, the social class predictor, represented by the green solid line, has a slightly lower AUC of 0.62, suggesting a weaker but still relevant influence on immunity status. Both curves lie above the diagonal reference line (gray), indicating that both factors contribute to predicting measles immunity, with age being a stronger predictor than social class in this analysis.

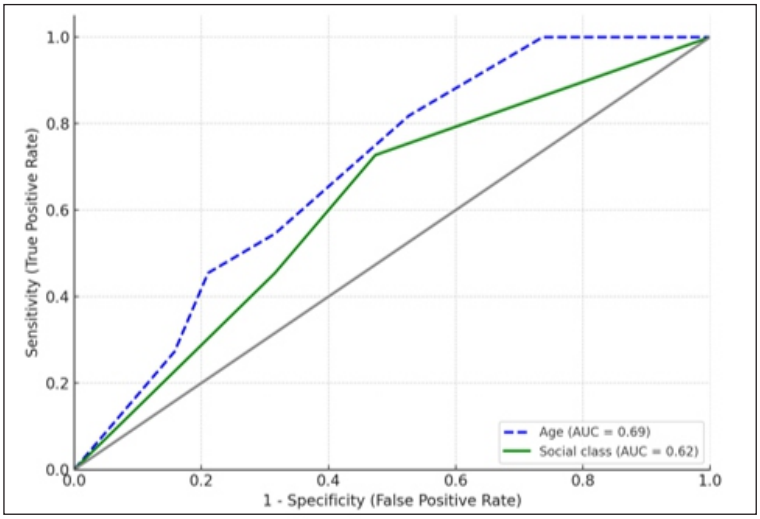

Figure 3: Relation between Measles IgG titre and age and Social Class

The ROC curve compares the predictive ability of age and social class for determining rubella immunity. The age predictor, represented by the blue dashed line, has an AUC of 0.44, indicating poor predictive power for rubella immunity. In contrast, the social class predictor, represented by the green solid line, shows a stronger AUC of 0.74, suggesting that social class is a more effective predictor of rubella immunity. The reference line (gray) indicates a random classifier, showing that social class is a significantly better predictor than age in this context.

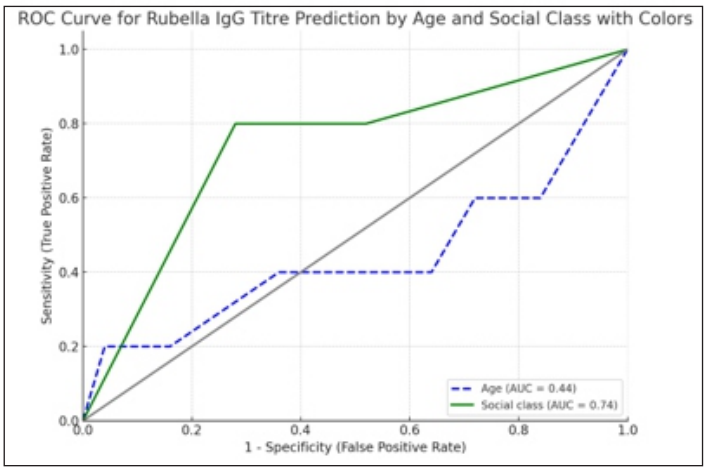

Figure 4: Relation between Rubella IgG Titre and age and Social Class

The ROC curve illustrates the relationship between mumps IgG titres and two predictors: age and social class. The age predictor, shown by the blue dashed line, has an AUC of 0.79, indicating strong predictive power for mumps immunity. The social class predictor, represented by the green solid line, has a lower AUC of 0.64, suggesting a moderate ability to predict mumps immunity. The diagonal gray line represents a random classifier, which highlights the fact that age is a significantly stronger predictor than social class in determining mumps immunity.

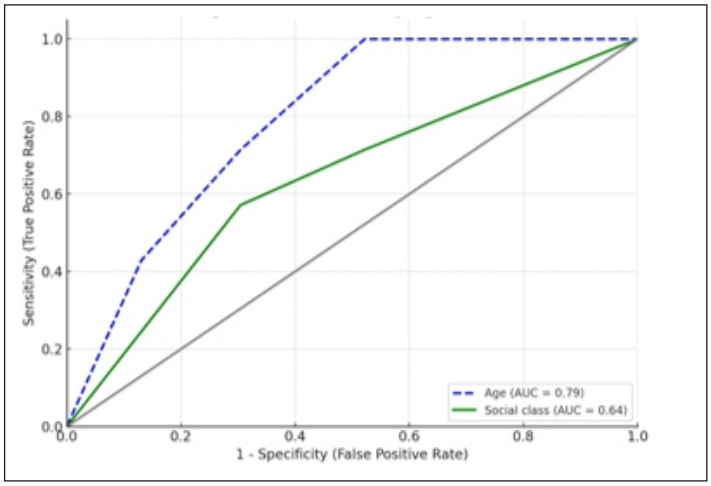

Figure 5: Relation between Mumps IgG Titre and age and Social Class

The ROC curve illustrates the predictive ability of age and social class in determining varicella immunity. The age predictor, shown by the blue dashed line, has an AUC of 0.55, indicating weak predictive power. The social class predictor, represented by the green solid line, has a higher AUC of 0.65, suggesting moderate predictive ability. Although neither factor is highly predictive, social class performs better than age in predicting varicella immunity. The gray reference line represents a random classifier, showing that both predictors provide better-than-random classification but with limited effectiveness.

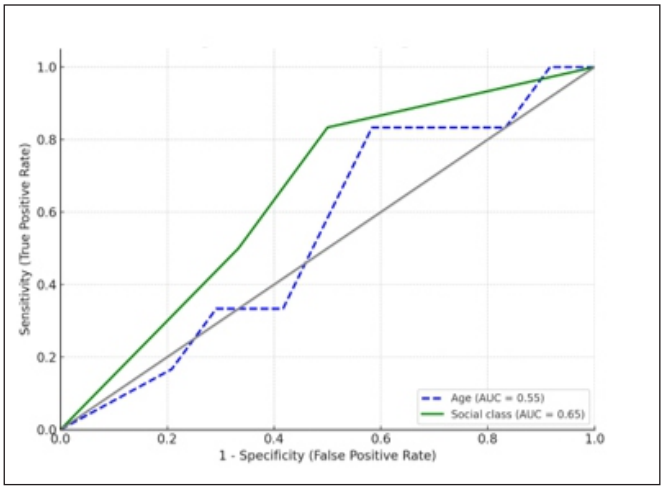

Figure 6: Relation between Mumps IgG Titre and age and Social Class

DISCUSSION

The seroprevalence of antibodies against measles, mumps, rubella, and varicella among children aged 1 to 10 years in this study highlights several important findings that are in line with global and regional trends. The overall seroprevalence of measles (80%), mumps (78.5%), rubella (85.5%), and varicella (60%) indicates that a significant portion of children in India are immune to these diseases, particularly due to the expanded immunization programs. However, the lower seroprevalence for varicella (60%) compared to the other infections is concerning and suggests the need for improved varicella vaccination coverage, which is consistent with other studies conducted in similar settings.

In a study conducted in the United States using the NHANES data from 2009-2010, the seroprevalence for measles, mumps, and rubella ranged from 88% to 96%, with a high seroprevalence for varicella (97.8%) due to widespread use of the varicella vaccine. These results highlight the success of routine childhood immunization programs in the US, which include two doses of the MMR vaccine and the varicella vaccine starting at 12 months of age. This contrasts with our findings, where varicella immunity remains relatively low, likely because the varicella vaccine is not yet universally incorporated into India's routine immunization program [28].

Similar results were observed in a study conducted in Germany, where a nationwide seroprevalence survey showed high levels of antibodies for measles (95%), mumps (88%), and rubella (97%) in children and adolescents. The high vaccination coverage and the inclusion of varicella in the routine vaccination schedule in many high-income countries have been attributed to these immunity levels [29]. In contrast, in regions like India where the varicella vaccine is not as widely available, gaps in varicella immunity, especially among younger children, remain a concern.

The seroprevalence for rubella in our study (85.5%) is comparable to findings from other studies, such as one conducted in Thailand, where rubella seroprevalence was around 90% in vaccinated populations. However, there remains a small but significant portion of the population in India that is susceptible to rubella, which could lead to outbreaks and poses a risk for congenital rubella syndrome in pregnant women [30].

Our results also highlight that immunity to these diseases increases with age, particularly for varicella, where older children (7-10 years) had significantly higher seroprevalence (69.2%) compared to younger children (52.3%). This trend is consistent with studies from various countries, including Belgium, which showed that older children tend to have higher seroprevalence due to higher cumulative vaccination rates and natural infection over time [31].

Socioeconomic factors played a minor role in influencing seroprevalence in our study, which aligns with findings from other regions where access to healthcare and vaccination programs can vary based on income levels and educational status. For example, in a study conducted in Spain, higher seroprevalence for measles and rubella was observed in children from higher socioeconomic backgrounds, likely due to better access to healthcare and immunization services [32].

In conclusion, while the overall seroprevalence of measles, mumps, and rubella in this cohort is relatively high, the low seroprevalence for varicella underscores the need to incorporate the varicella vaccine into India's national immunization schedule to prevent outbreaks. Enhanced public health efforts, particularly in rural and underserved areas, are critical to improving vaccination coverage and closing immunity gaps, especially for varicella.

CONCLUSION

The seroprevalence of antibodies against measles, mumps, rubella, and varicella in Indian children aged 1 to 10 years shows generally high immunity for measles, mumps, and rubella, indicating the effectiveness of the MMR vaccination program. However, the lower seroprevalence for varicella highlights a gap in immunity that necessitates the introduction of the varicella vaccine into India's national immunization program. Increased efforts in vaccination, particularly in underserved areas and younger children, are essential to prevent outbreaks and close immunity gaps, particularly for varicella. Public health policies should focus on expanding vaccine coverage to ensure that all children are adequately protected against these preventable diseases.

RECOMMENDATIONS:

Based on the findings of your study, several recommendations can be made to improve public health outcomes and immunization coverage against measles, mumps, rubella, and varicella in India:

1. Incorporate the Varicella Vaccine into the National Immunization Program:

The relatively low seroprevalence of varicella (60%) compared to measles, mumps, and rubella suggests a significant susceptibility in children. Introducing the varicella vaccine as part of the routine immunization schedule, alongside the MMR vaccine, would help close the immunity gap and prevent future varicella outbreaks.

2. Strengthen Immunization Coverage in Underserved Regions:

Your study shows that gaps in seroprevalence, particularly for varicella, might be related to disparities in access to vaccines in rural and underserved areas. It is crucial to implement targeted immunization campaigns in these regions to ensure equitable vaccine coverage and protect vulnerable populations.

3. Promote Booster Doses to Address Waning Immunity:

While high immunity rates for measles, mumps, and rubella were observed, your findings, in line with other global studies, suggest that waning immunity, espec-ially for

mumps, can occur over time. Introducing booster doses at later stages, such as adolescence, may help maintain high immunity levels and prevent outbreaks in older children and adolescents.

4. Educational Programs on Vaccine Importance:

Enhancing public awareness about the importance of vaccinations through educational initiatives can help address vaccine hesitancy, particularly in areas with lower socioeconomic status. Clear communication about the safety and efficacy of vaccines can encourage more parents to ensure their children are fully immunized.

5. Regular Seroprevalence Surveys:

To monitor the effectiveness of vaccination programs and identify any emerging gaps in immunity, regular seroprevalence surveys should be conducted. These surveys can help in adjusting vaccination policies and ensure that herd immunity is maintained, especially in the face of changing population dynamics and emerging public health challenges.

By implementing these recommendations, India can strengthen its immunization strategy, reduce the burden of vaccine-preventable diseases, and move closer to achieving herd immunity for all four viruses in the pediatric population

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