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Unveiling Rubella Antibody Trends of Healthy Populations in Guangzhou and Heyuan, Guangdong Province, China, 2021-2023

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Abstract

Background

Serological surveillance of rubella antibodies is favorable for disease risk assessment and evaluation of vaccination effectiveness, and understanding the immunity status of healthy individuals.

Methods

From 2021 to 2023, serum samples were collected from healthy residents in Guangzhou and Heyuan of Guangdong Province, China. Rubella IgG antibody levels were determined by enzyme-linked immunosorbent assay (ELISA) and analyzed in combination with vaccination history.

Results

In this study, a total of 5,092 participants were enrolled, and the positivity rate of rubella IgG antibodies is 84.58% (95% CI: 83.56%-85.56%). The geometric mean concentration (GMC) was 37.45 IU/mL (95% CI: 36.34–38.57). The seropositivity rate and concentration of rubella antibody exhibited a U-shaped curve across age groups. The highest rates were observed in the 8 months − 3 years group (98.21%) and the > 60 years group (92.57%), while the lowest seropositivity rate was found in the 17–25 years group (67.17%). The seropositivity rate in the 2 doses vaccinated group (93.78%) was significantly higher than both the unvaccinated group (82.50%) and the 1 dose vaccinated group (78.67%). Based on the Generalized Additive Model (GAM) prediction, the antibody of 2 doses vaccination group showed an annual decline rate of 5.6%, with predicted persistence for 32.6 years.

Conclusions

The rubella IgG antibody among healthy populations in Guangdong Province during 2021–2023 remained at a high level. The 2 doses Measles-mumps-rubella combined vaccine (MMR) vaccination could stimulate long-lasting antibody protection. However, lower antibody levels in populations born before China’s NIP implementation, particularly among 17–40 years, suggest an booster vaccination.

1.Introduction

Rubella is an acute respiratory infectious disease caused by the rubella virus, which was described in 1752 by German physician De Bergen. Rubella was initially misclassified as a variant of measles, hence its colloquial designation as "German measles". The rubella virus belongs to the genus *Rubivirus* within the family Matonaviridae. It is a single-stranded positive-sense RNA virus with only one known serotype. Rubella can be classified into congenital rubella syndrome (CRS) and acquired rubella. CRS occurs when pregnant women infected with rubella virus during early pregnancy, and the virus transmit across the

placenta to the fetus, resulting in severe medical and public health consequences that may include spontaneous abortion, fetal death, or congenital abnormalities (particularly ocular, auditory, cardiac, and craniofacial defects) [1]. In contrast, acquired rubella typically presents as a milder clinical condition, with infected individuals being either asymptomatic or exhibiting self-limiting symptoms characterized by fever, generalized maculopapular rash, and lymphadenopathy[2]. Rubella is primarily transmitted between individuals via respiratory droplets. The average age of rubella infection was 5–9 years, with seasonal outbreaks typically occurring annually in spring and epidemics recurring every 3–8 years [3].

As a vaccine prevented disease, the World Health Organization (WHO) established the *Global Measles and Rubella Strategic Plan: 2012–2020* [4]. Although the elimination target was not ultimately achieved, significant progress was made by the end of 2020. To maintain the achieved efforts on rubella elimination, WHO subsequently developed the *Measles and Rubella Strategic Framework (MRSF) 2021–2030*[5], which provides comprehensive guidance to support global, regional and national initiatives on rubella elimination. As of January 2024, rubella vaccines had been introduced in 175 out of 194 countries, with an estimated global coverage rate of 69%. Reported rubella cases declined by 97%, dropping from 670,894 cases across 102 countries in 2000 to 17,865 cases in 78 countries by 2022 [6]. As of 2023, 99 countries (51%) have reported the elimination of rubella. In recent years, low-level rubella transmission has existed in China, with an occasional outbreak in 2019 (32,520 cases, incidence rate of 2.33 per 100,000 individuals), and followed by sustained minimal levels since 2020 (2,505 cases, 0.18 per 100,000 individuals). To strengthen rubella prevention and control, China launched the *Measles and Rubella Prevention and Control Plan (2024 Edition)* in December 2024, marking a significant step toward achieving the goal of national rubella elimination [7].

Within the last five decades, the rubella vaccine has been updated and combined with the measles or mumps vaccine as well[8, 9]. Currently, four types of rubella-containing vaccines (RCVs) are available worldwide, Rubella vaccine (R), Measles-rubella combined vaccine (MR), Measles-mumps-rubella combined vaccine (MMR), Measles-mumps-rubella-varicella combined live attenuated vaccine (MMRV). RCVs were included in China's Expanded Program on Immunization (EPI) system in 2008, with a program to administer one dose of MR at 8 months and one dose of MMR at 18–24 months [10]. Since 2020, China's National Immunization Program (NIP) has been updated to administer 2 doses of MMR vaccine with the same program [11, 12]. A global systematic review of rubella seroprevalence studies reported a median serum positivity rate of 90.5% with a median mean antibody titer of 51 IU/mL[13]. A meta-analysis revealed that the rubella IgG antibody seropositivity rate among healthy Chinese populations was 77.29% (95% CI: 75.26–79.33)[14]. A separate seroepidemiological study reported a similar trend in eastern China, the IgG seropositivity rate was 79.91% (95% CI: 77.83%-82%) with a geometric mean concentration (GMC) of 43.53 IU/mL[15]. Current data indicate that the rubella IgG antibody seropositivity rate and GMC in China's healthy population are lower than global levels and fail to meet the herd immunity threshold of 85% [16]. Therefore, it is imperative to strengthen population immunity surveillance to provide evidence-based support for current immunization programs. This study aims to determine rubella IgG antibody among healthy populations in Guangdong Province, China, and assess

vaccination effectiveness through immunization record linkage and quantifying the temporal decline in antibody titers.

2.Methods

2.1 Sampling Design

This study employed a multistage stratified random sampling approach, categorizing Guangdong Province's 21 cities into two economic strata. Guangzhou was randomly selected from the high-economic stratum, while Heyuan was chosen from the low-economic stratum. Within each sampled city, one district/county was randomly selected, Panyu District in Guangzhou and Heping County in Heyuan. A single hospital was then designated as the surveillance site in each selected locality.The required sample size was calculated using the cross-sectional study formula: $n = \frac{Z^2_{\alpha/2}(1-P)}{\delta^2 P}$, where n represents the sample size, the error probability α was set at 0.05 (with $Z_{\alpha/2}$=1.96), the permissible error δ was set at 0.05, and P denotes the rubella seroprevalence rate - taken as 75% based on the rubella IgG antibody positivity rate among healthy Chinese populations[14, 15], the sample size was calculated to be 512. Considering potential non-response and other influencing factors, we randomly selected at least 800 participants annually from each hospital during the 2021–2023 study period. The final dataset included 5,152 initially recruited participants, from which 60 were excluded due to incomplete or erroneous information, resulting in 5,092 valid study subjects for analysis.

2.2 Information collection

Basic demographic information, including name, age, gender, address, and ID number, was collected through questionnaires, with children's data provided by their guardians. For children without ID numbers, their guardians' ID information and the children's names were recorded to facilitate subsequent vaccination record matching. Trained technicians retrieved RCV immunization records, including vaccination dates, doses, and vaccine types, from the Immunization Planning Information System (IPIS) of the Guangdong Provincial Center for Disease Control and Prevention.

2.3 Serum samples collection

For each participant, 3–5 mL of peripheral venous blood was collected (umbilical cord blood for neonates). All blood samples were left at room temperature for approximately 30 minutes, then centrifuged at 2,000 rpm for 10 minutes to separate serum. The serum was transferred to new cryotubes, labeled with sample ID and collection time, and stored at -20°C until testing.

2.4 Rubella IgG antibody measurement

All serum samples were tested for rubella IgG antibody concentrations using the Rubella Virus IgG ELISA kit (IBL International GmbH, Germany) strictly following the manufacturer's instructions. According to the kit specifications, samples with IgG concentrations > 15 IU/mL were considered Positive, those with 10–

15 IU/mL as Equivocal, and those < 10 IU/mL as Negative. Therefore, this study adopted 15 IU/mL as the cut-off value for determining positive/negative results.

2.5 Data analysis

This study primarily utilized Excel for data organization, with SPSS Statistics 27 and R 4.4.3 employed for data analysis. A two-tailed significance level was set at α = 0.05, where $P < 0.05$ indicated statistically significant differences. In descriptive statistical analyses, qualitative data were expressed as ratios with between-group differences assessed using Pearson's chi-square test, while quantitative data were presented as geometric mean concentrations (GMC) with between-group comparisons conducted via t-tests or analysis of variance (ANOVA). A generalized additive model (GAM) was applied to establish the declining trend curve of rubella IgG antibody levels over time, with the threshold set at 15 IU/mL to ensure testing sensitivity and reliability.

3 Results

3.1 Demographic information

We recruited a total of 5,092 participants with sample collection spanning three years, including 1,497 (29.4%) in 2021, 1,904 (37.4%) in 2022, and 1,691 (33.2%) in 2023, comprising 2,706 males (53.1%) and 2,386 females (46.9%). The study population was stratified into seven age groups: <8 months (n = 417, 8.2%), 8 months-3 years (n = 392, 7.7%), 4–16 years (n = 586, 11.5%), 17–25 years (n = 1,115, 21.9%), 26–40 years (n = 853, 16.8%), 41–60 years (n = 827, 16.2%), and > 60 years (n = 902, 17.7%). The participants were distributed across two cities, with 2,474 (48.6%) from Guangzhou and 2,618 (51.4%) from Heyuan. (Table 1) The study period was stratified based on China's NIP implementation starting in 2008. Participants aged 8 months – 16 years were classified as the post-NIP group, those over 17 years as the pre-NIP group, and infants under 8 months (predominantly newborns) as the neonate group. A total of 416 participants (8.2%) were assigned into the neonate group, followed with 958 (18.8%) into the post-NIP group and 3,718 (73.0%) into the pre-NIP group. Vaccination history analysis revealed that 818 (85.4%) participants had documented vaccination in the post-NIP group, 28 (2.9%) had no vaccination records, and 112 (11.7%) were uncertain. For the pre-NIP group, only 45 (1.2%) showed documented vaccination, while 3,110 (83.6%) had no records and 563 (15.1%) were uncertain (Table 1).

Table 1
Number of different characteristics of participants.

Characteristics	Participants (%)	Characteristics	Participants (%)
Year		City	
2021	1497 (29.4)	Guangzhou	2474 (48.6)
2022	1904 (37.4)	Heyuan	2618 (51.4)
2023	1691 (33.2)	Period&Vaccine history	
Sex		Neonate	416 (8.2)
Male	2706 (53.1)	post-NIP	958 (18.8)
Female	2386 (46.9)	Yes	818 (85.4)
Age		No	28 (2.9)
<8 months	417 (8.2)	Unknown	112 (11.7)
8 months-3years	392 (7.7)	pre-NIP	3718 (73.0)
4–16 years	586 (11.5)	Yes	45 (1.2)
17–25 years	1115 (21.9)	No	3110 (83.6)
26–40 years	853 (16.8)	Unknown	563 (15.1)
41–60 years	827 (16.2)		
> 60 years	902 (17.7)	Total	5092

3.2 seropositivity of Rubella IgG antibody

Among the 5,092 participants, 4,307 tested positive for rubella IgG antibodies, yielding a positivity rate of 84.58% (95% CI: 83.56%-85.56%). Refer to year group, the positivity rates for 2021–2023 were 82.83%, 85.03%, and 85.63% respectively ($P = 0.073$), showing a slight increasing trend that did not reach statistical significance. The positivity rate was slightly lower in males (83.37%) than in females (85.96%) ($P = 0.011$). Refer to age group, the positive rate was 79.86% in the < 8 months group. Remaining age groups revealed a U-shaped distribution of rubella IgG antibody positivity rates, The highest rate was observed in the 8 months − 3 years group (98.21%), followed by older age groups: 41–60 years (92.14%) and > 60 years (92.57%). Intermediate rates were found in the 4–16 years (86.18%) and 26–40 years (86.52%) groups, while the lowest positivity rate occurred in the 17–25 years group (67.17%) ($P < 0.001$) (Table 2). When all the individuals with vaccination records were removed, the age group positivity rates starting from the 4–16 year old group showed a gradual increase of 51.1%, 65.4%, 86.2%, 92.3%, and 91.8%, probably due to the increase in the probability of natural infection associated with increasing age. Refer to geography, the positivity rates in Guangzhou (84.84%) and Heyuan (84.34%) were close to each other ($P = 0.619$). Guangzhou exhibited consistently higher rubella IgG antibody positivity rates in males

compared to females across 2021–2023, while Heyuan showed the reverse pattern with slightly elevated rates in females (Fig. 1). Significant differences in rubella IgG antibody positivity rates were observed across the time-period groups ($P < 0.001$), with the neonate group showing 79.81% seropositivity rate, the post-NIP group demonstrating 92.07%, and the pre-NIP group at 83.19%.

Table 2
Rubella IgG seropositivity and GMC in different characteristics

Characteristics	Participants (%)	Seropositivity (%)	*χ2*	*P*	GMC (IU/mL)	*t/F*	*P*
Year			5.233	0.073		8.129	< 0.001
2021	1497 (29.4)	1240 (82.83)			34.67		
2022	1904 (37.4)	1619 (85.03)			37.15		
2023	1691 (33.2)	1448 (85.63)			40.44		
Sex			6.520	0.011		-1.514	0.130
Male	2706 (53.1)	2256 (83.37)			36.67		
Female	2386 (46.9)	2051 (85.96)			38.36		
Age			406.094	< 0.001		89.579	< 0.001
<8 months	417 (8.2)	333 (79.86)			32.14		
8 months-3years	392 (7.7)	385 (98.21)			66.29		
4–16 years	586 (11.5)	505 (86.18)			38.55		
17–25 years	1115 (21.9)	749 (67.17)			21.46		
26–40 years	853 (16.8)	738 (86.52)			41.80		
41–60 years	827 (16.2)	762 (92.14)			43.64		
> 60 years	902 (17.7)	835 (92.57)			47.94		
City			0.247	0.619		2.058	0.040
Guangzhou	2474 (48.6)	2099 (84.84)			38.67		
Heyuan	2618 (51.4)	2208 (84.34)			36.34		
Period			53.956	< 0.001		42.030	< 0.001
Neonate	416 (8.2)	332 (79.81)			32.04		
Post-NIP	958 (18.8)	882 (92.07)			49.55		
Pre-NIP	3718 (73.0)	3093 (83.19)			35.45		
Total	5092	4307 (84.58)			37.45		

3.3 GMC of Rubella IgG antibody

The GMC of rubella IgG antibodies among the 5,092 healthy participants was 37.45 IU/mL (95% CI: 36.34–38.57). Refer to year group, the GMC of rubella IgG antibodies demonstrated statistically significant differences across 2021–2023 ($P < 0.001$), with values of 34.67 IU/mL in 2021, 37.15 IU/mL in 2022, and 40.44 IU/mL in 2023. In the sex subgroup, there was almost no difference between male GMC (36.67 IU/mL) and female (38.36 IU/mL) ($P = 0.130$). The age group analysis revealed the highest GMC of rubella IgG antibodies in the 8 months − 3 years group (66.29 IU/mL) and the lowest in the 17–25 years group (21.46 IU/mL), consistent with the positivity rate patterns, while other age groups showed relatively similar GMC levels ($P < 0.001$). The GMC of rubella IgG antibody in Guangzhou city (38.67 IU/mL) was slightly higher than that in Heyuan city (36.34 IU/mL) ($P = 0.040$). The GMC of rubella IgG antibodies varied significantly across period groups ($P < 0.001$), with the neonate group measuring 32.04 IU/mL, the post-NIP group showing the highest level at 49.55 IU/mL, and the pre-NIP group at 35.45 IU/mL. The post-NIP group demonstrated statistically significant differences in GMC when compared separately with both the neonate group and the pre-NIP group (Fig. 2A). The trends in positivity rates and antibody concentrations showed near-identical patterns in the graphical representation, exhibiting an initial increase followed by a decline and subsequent rebound (Fig. 2B). The post-NIP group consistently demonstrated the highest GMC across year, sex and city (Fig. 2C). Based on matched vaccination records, the post-NIP group included 778 recipients (92.0%) who had completed 2 doses of RCV, with minimal representation of unvaccinated or 1 dose recipients, vaccination rate of 96.69% among those who should be vaccinated. In contrast, the post-NIP group comprised 3,110 unvaccinated individuals (77.7%), with only limited numbers having received 1 or 2 doses RCV (Fig. 2D).

3.4 RCV vaccination and rubella IgG antibodies

The vaccination history of the healthy population was collected through the IPIS of the Guangdong Provincial Center for Disease Control and Prevention, in which the rubella IgG antibodies in the neonatal group were maternally transmitted antibodies, which could represent maternally derived antibodies to some extent, and will be analyzed in the later discussion section. To clarify the relationship between RCV immunization and rubella IgG antibody GMC, we excluded 1,091 participants with uncertain vaccination histories, retaining 4,001 individuals for analysis. In the 0 dose group, which is also known as the unvaccinated group, a total of 3138 individuals were found to have a seropositivity rate of 82.50%, with a GMC of 34.61 IU/mL. This group predominantly consisted of individuals aged over 16 years, reflecting RCV vaccine uptake was minimal before NIP in 2008. The 1 dose vaccinated group(n = 75) exhibited a rubella IgG antibody seropositivity rate of 78.67% with a GMC of 31.46 IU/mL. Age stratification showed 7 persons in the 8 months − 3 years group, 37 in the 4–16 years group, and 31 in the 17–25 years group. The 2 doses vaccinated group(n = 788) exhibited a rubella IgG antibody seropositivity rate of 93.78% with a GMC of 51.73 IU/mL. This group was overwhelmingly composed (98.7%, n = 778) of children aged 8 months − 16 years, reflecting successful implementation of NIP. (Table 3, Fig. 3A) Statistically significant differences were observed in both seropositivity rate and antibody concentrations across vaccination dose groups ($P < 0.001$), with the 2 doses regimen demonstrating significantly higher values compared to both 0 dose group and 1 dose group (Fig. 3B). Considering that the age composition of different dose groups varied greatly, we chose the same age group of 4–16 years old to compare the antibody

seropositivity rate and GMC differences between different doses, and found that there was a significant difference ($P < 0.001$), with seropositivity rate of 51.51%, 86.49%, and 90.76% for dose 0, 1, and 2, respectively, and the GMC of 15.27 IU/mL, 31.63 IU/mL, and 43.48 IU/mL, the differences exceed 10 IU/mL. This also proved the effect of different inoculation doses on the serum antibody level of the population (Table 3).

Depending on the type of RCV given to the participants, the different doses can be further categorized into different vaccination procedures.The 1 dose group can be categorized into R, MR, and MMR. Most of the 2 doses group is MR + MMR since 2008 and MMR + MMR since 2020.The other vaccination procedures in the 2 doses are uniformly categorized as other groups. Among the 1 dose group, an increasing trend in seropositivity rate and GMC were observed in the R, MR, and MMR groups. Among the 2 doses group, the highest seropositivity rate and GMC were found in the MMR + MMR group, indicating that the MMR vaccine induced a stronger antibody response (Table 4, Fig. 3C). The current international and Chinese recommendations for vaccination with RCV vaccines are 2 doses, and according to the GAM model, rubella IgG antibodies following 2 doses RCV vaccination are predicted to decline below the protective threshold of 15 IU/mL after 390.8 months (32.6 years). The decay curve demonstrates a consistent downward trend, with an overall annual decline rate of 5.6%, with 9.1% in the first 8 years and then decaying at 2.0%. (Fig. 3D).

Table 3
Seropositivity and GMC of rubella IgG antibodies in different vaccination dose groups in the general population and in the population aged 4–16 years (excluding neonates and individuals with unknown vaccination history).

RCV vaccination	Number (%)	Seropositivity(%)	χ2	*P*	GMC (IU/mL)	F	*P*
General			63.764	< 0.001		46.210	< 0.001
0 dose	3138 (78.4)	2589 (82.50)			34.61		
1 dose	75 (1.9)	59 (78.67)			31.46		
2 doses*	788 (19.7)	739 (93.78)			51.73		
Total	4001	3387 (84.65)			37.37		
4–16 years			43.376	< 0.001		25.724	< 0.001
0 dose	33 (6.5)	17 (51.51)			15.27		
1 dose	37 (7.3)	32 (86.49)			31.63		
2 doses	433 (86.1)	393 (90.76)			43.48		
Total	504	442 (87.70)			39.65		
* 3 doses incorporated into 2 doses							

Table 4
Seropositivity and GMC of rubella IgG antibodies in different vaccination procedures

Type of Vaccine	Number (%)	Seropositivity(%)	GMC(IU/mL)
0 dose	3138 (78.4)		
1 dose	75 (1.9)		
R	7 (9.3)	5 (71.43)	45.11
MR	26 (34.7)	20 (76.92)	46.43
MMR	42 (56.0)	34 (80.95)	53.06
2 dose	788 (19.7)		
MR + MMR	520 (66.0)	475 (91.35)	51.78
MMR + MMR	240 (30.5)	238 (99.17)	76.98
Other	28 (3.5)	26(92.86)	46.57
Total	4001		

4 Discussion

The low incidence of rubella encourage various countries and regions are actively promoting actions to eliminate rubella. By 2023, there are 35,743 reported cases of rubella globally, of which 556 cases were in China [17, 18]. Rubella is classified as a Category C infectious disease and became a mandatory reporting infectious disease under the National Normalized Disease Reporting System (NNDRS) in China since 2004, and was incorporated into China's measles surveillance system in 2014 [10]. According to official data released by the National Disease Control and Prevention Administration and Guangdong Provincial Disease Control and Prevention Administration, China reported 891 rubella cases between January 2024 and March 2025, of which Guangdong Province accounted for 122 cases (13.7% of the national total), maintaining a relatively low incidence level. However, achieving rubella elimination requires continued efforts to strengthen immunization programs and maintain protective antibody levels in the population. This study evaluated rubella IgG antibody seroprevalence and concentrations among healthy individuals in Guangdong Province from 2021–2023, through reporting of positivity rates, levels and modeling the antibody decay tendency.

The rubella IgG antibody seropositivity rate in Guangdong was 84.58%, with a GMC of 37.45 IU/mL. Compared with domestic studies, these results were higher than those from Hebei Province during 2015–2021(75.29%, GMC 32.66 IU/mL) [19] and Zhejiang Province in 2022(70.9%, GMC 35.30 IU/mL) [20], but comparable with Hubei Province in 2020(92.63%) [21] and Liaoning Province in 2020(87.15%, GMC 40.90 IU/mL) [22]. Nevertheless, it is higher than the national average (meta-analysis 77.29%) [15], which indicate approaching to the 85% herd immunity threshold. The neonate group samples consisted

of umbilical cord blood, showing a rubella antibody seropositivity rate of 79.81% and a GMC of 32.04 IU/mL, which indicate that neonates receive substantial protective immunity through maternal transfer.Additionally, research shows that maternally derived antibodies decline rapidly, with a protection period of approximately 2–4 months[23, 24]. Therefore, it is recommended to introduce rubella vaccination before 8 months of age to provide essential protection for infants. Rubella antibody levels showed a U shaped distribution across age groups. China's current NIP administers two doses of MMR vaccine at 8 months and 18–24 months, resulting in the highest antibody seropositivity rates and GMC in the 8 months – 3 years group, followed by a gradual decline. Most Pre-NIP group populations were unvaccinated with RCV, leaving the 17–25 years group with the lowest levels. However, antibody levels increased after age 26 due to higher rates of natural rubella infection. This distribution pattern is consistent with national trends [15]. However, it should be noted that a significant proportion of individuals aged 17–25 and 26–40 years remain unvaccinated and uninfected, representing a susceptible population that may potentially drive future rubella transmission. Therefore, we recommend implementing vaccination programs for these susceptible individuals aged 17–40 years from the pre-NIP group.

In the vaccination dose subgroup, no significant difference in seropositivity rates was observed between the unvaccinated group and the 1 dose vaccinated group. This phenomenon may be attributed to the substantial proportion of older individuals in the unvaccinated group who acquired immunity through natural infection, resulting in comparable seropositivity rates to the 1 dose vaccinated group. The 2 doses vaccinated group demonstrated significantly higher rubella IgG antibody levels compared to both the unvaccinated and 1 dose vaccinated groups. These findings are consistent with other relevant studies [25, 26], which similarly report substantially improved antibody seropositivity rates and titers following 2 doses vaccination. Furthermore, we found that regardless of 1 or 2 doses, recipients of combined vaccines exhibited higher rubella antibody levels. Similarly, archived studies comparing post-vaccination rubella antibody titers between domestic MMR vaccine and rubella vaccine showed significantly increased geometric mean titers with the combined vaccine [27, 28], while other studies reported no significant difference [29, 30], warranting further investigation. In 2 doses, the present study showed that MMR + MMR had a higher seropositivity rate and GMC than MR + MMR. Meanwhile, one study of vaccination groups (MR + MMR versus MMR + MMR) consistently found that the MMR + MMR group had a higher seroprevalence rate but a lower GMC [31]. In addition, we employed a GAM model to simulate the rubella antibody decay curve within 2 does RCV vaccination population, and found IgG antibodies persist for 32.6 years with an annual average decline rate of 5.6% in concentration, with 9.1% in the first 8 years and then decaying at 2.0%. Multiple long-term follow-up studies (including 7, 10, and 20 years tracking data) consistently confirmed maintained high seropositivity rates of rubella IgG antibodies in subjects receiving 2 doses MMR vaccination [32–34], robustly evidencing that rubella vaccination induces durable and effective immune protection. For comparison, other related studies found an annual average antibody decline rate of 5.9% after 2 MMR doses vaccination [35]. A 20 years longitudinal study revealed an initial annual decline rate of 8.2% during the first 8 years, decreasing thereafter to 3.1% [33], observed antibody decay rates in these studies are similar to our current findings.

This study has several limitations. First, the samples were collected from limit geographical areas of Guangdong. Although stratified by economic level, potential representative bias is likely exist. Second, the personal information of the participants is not comprehensive. When collecting samples, information on pertussis cases should be gathered for further exploration. Thirdly, the ELISA method used in this study can detect rubella IgG antibody, whereas vaccine-induced immunity may not be distinguished with natural infection.

5 Conclusions

In this study, a cross-sectional serological study of rubella IgG antibodies was performed on a healthy population in Guangdong Province from 2021 to 2023 and analyzed in relation to the history of RCV vaccination. The data showing high RCV vaccine coverage and high levels of rubella IgG antibodies in populations after NIP implementation. Furthermore, the antibody decay curve constructed by the GAM indicates that the current 2 doses vaccination regimen under NIP can sustain long-term protection for 32.6 years. However, in the pre-NIP population, particularly among those aged 17–40 years with low rubella IgG levels. Nevertheless, under the steady implementation of China's NIP, the country is progressing toward, thereby achieving the goal of rubella elimination.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Guangdong Provincial Center for Disease Control and Prevention (Approval No.: W96-027E-202018). All procedures were performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all adult participants (aged 16 years or older) prior to sample collection and data collection. For participants under the age of 16, written informed consent was obtained from their parents or legal guardians.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due [REASON WHY DATA ARE NOT PUBLIC] but are available from the corresponding author on reasonable request.

Competing interests

The authors have declared that no competing interests exist.

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Figures

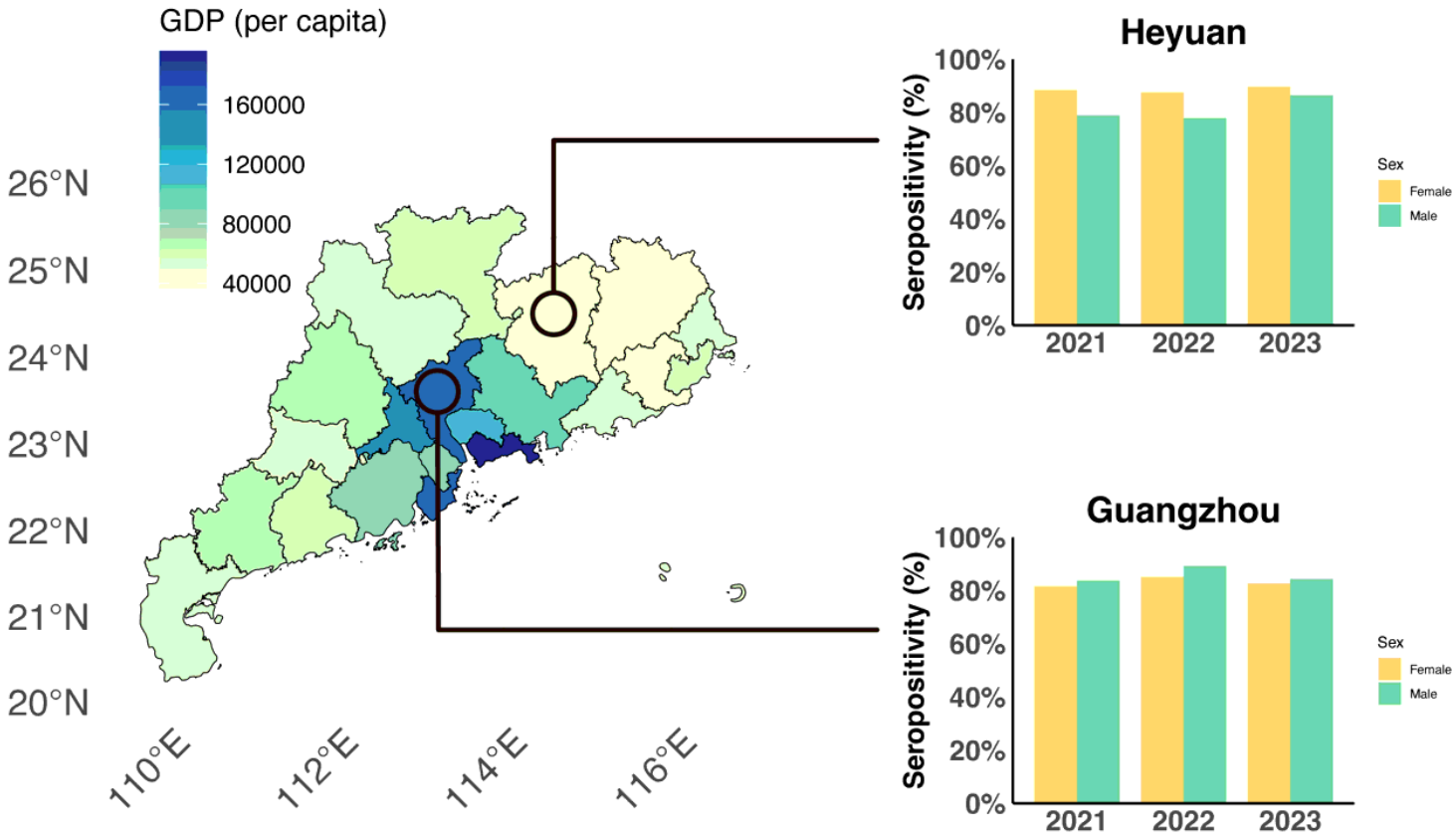


Figure 1

Seroprevalence IgG rates of rubella in Guangzhou and Heyuan by year, sex in Guangdong Province.

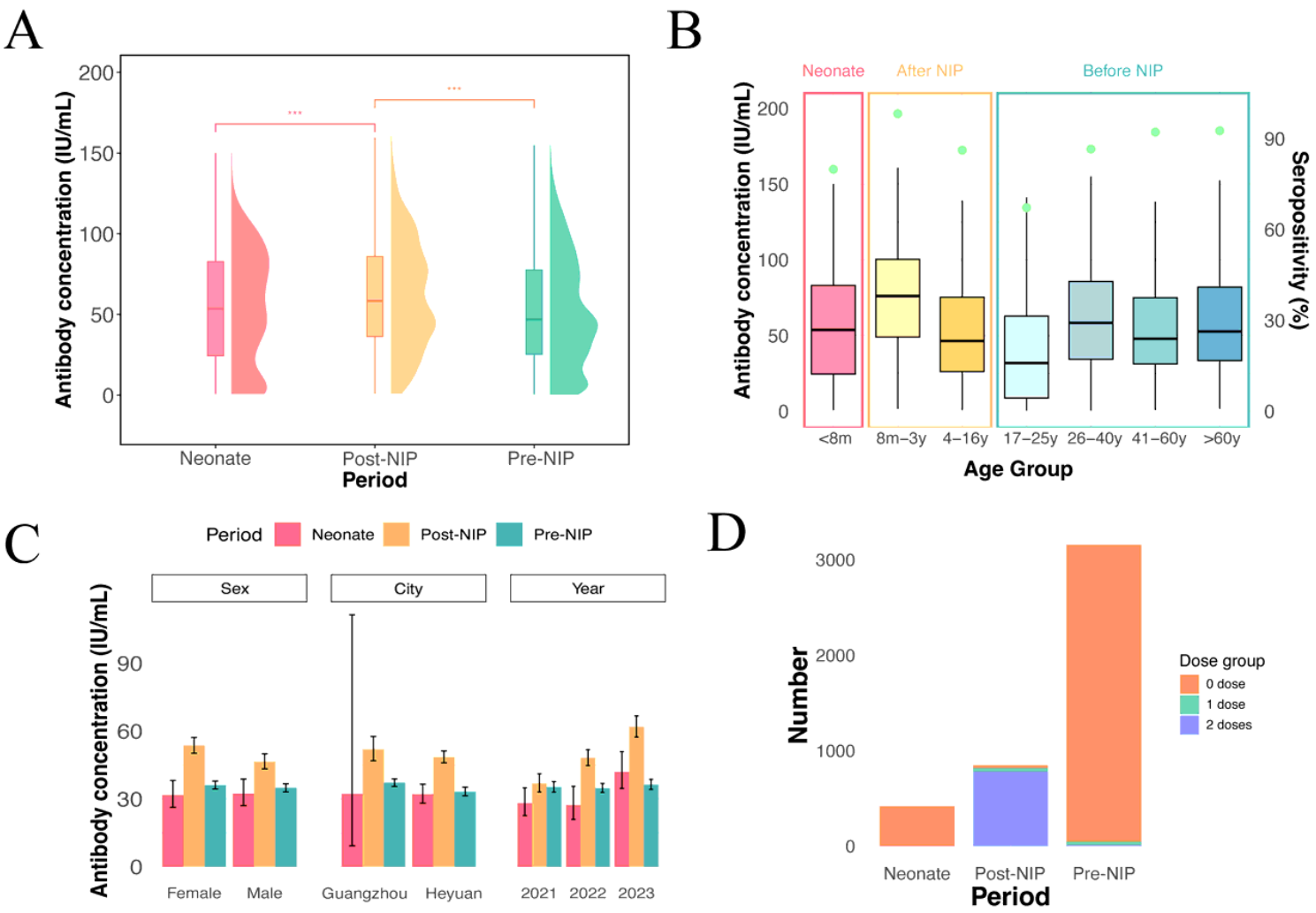


Figure 2

(A)Rubella IgG antibody concentration by different periods (***P<0.001). (B) Rubella IgG antibody concentration and seropositivity rate by age group, with the antibody concentration on the left y-axis and the seropositivity rate on the right y-axis. (C) Rubella IgG antibody concentration across different periods stratified by gender, region, and year The height of the bar chart represents GMC. (D) Vaccination doses administered across periods.

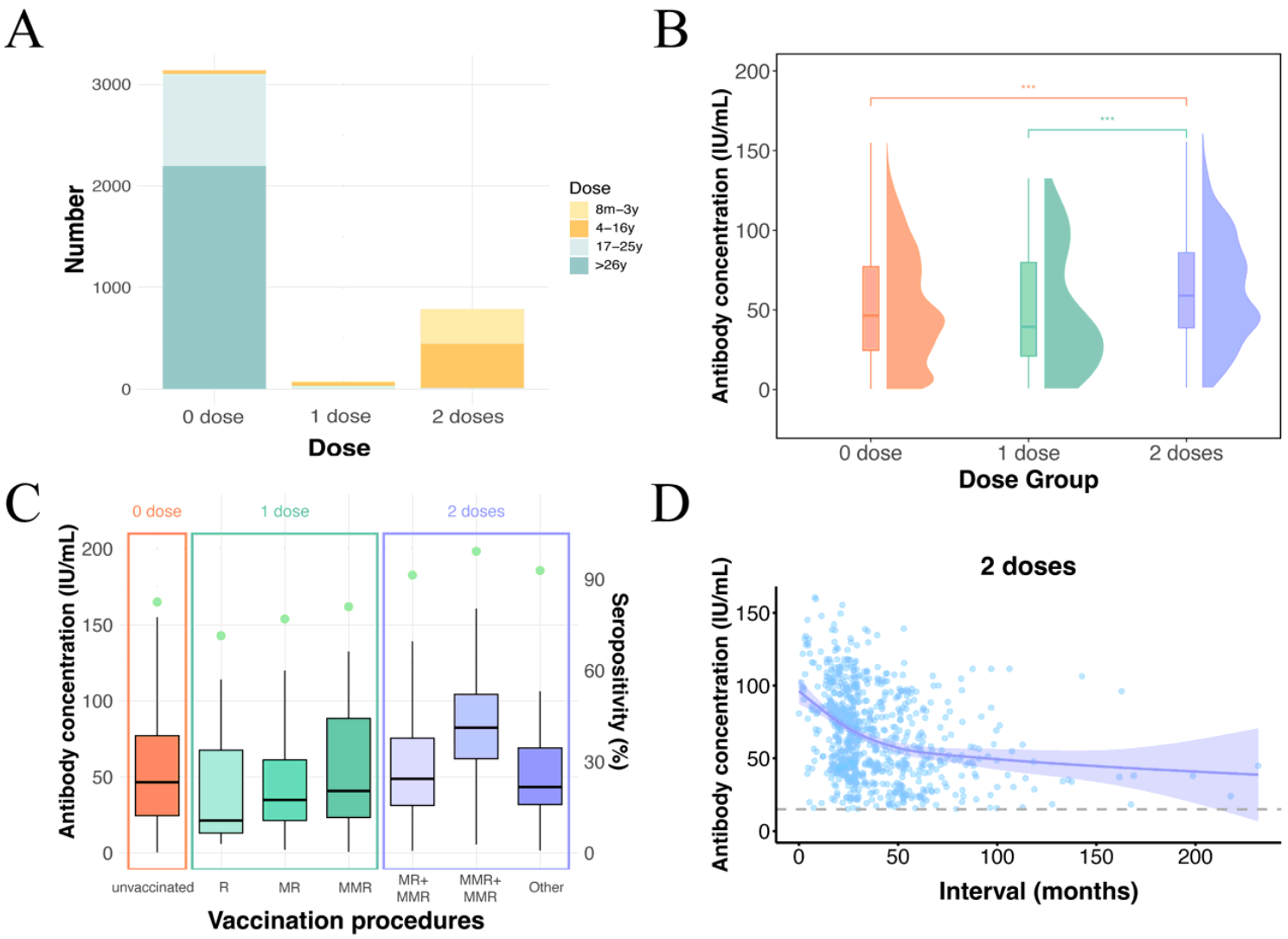


Figure 3

(A) Age groups administered across vaccine doses. (B)Rubella IgG antibody concentration by different vaccination dose groups(***P<0.001). (C) Rubella IgG antibody concentration and seropositivity rate by vaccination procedures, with the antibody concentration on the left y-axis and the seropositivity rate on the right y-axis. (D) The decay tendency of rubella IgG antibody concentration for 2 doses (Solid lines indicate the fitted declining trend of rubella IgG antibodies, shading indicates 95% confidence intervals, the dashed line represents a threshold of 15 IU/mL).