

RESEARCH PAPER



One single-center serological survey on measles, rubella and mumps antibody levels of people in Youyang, China

Qing Wang^{a,*}, Xiaoping Cheng^{b,*}, Dandan Liu^a, Changhui Chen^c, and Kaihu Yao^a 

^aKey Laboratory of Major Diseases in Children, Ministry of Education, National Key Discipline of Pediatrics (Capital Medical University), Beijing Pediatric Research Institute, Beijing Children's Hospital, Capital Medical University, National Center for Children's Health, Beijing, China; ^bClinical Laboratory, Youyang County People's Hospital, Chongqing, China; ^cDepartment of Pediatrics, Youyang County People's Hospital, Chongqing, China

ABSTRACT

Although measles, rubella and mumps elimination had achieved great progress in recent years, outbreaks were still reported worldwide. Serological surveillance on the remaining susceptibility in the population is essential to evaluate the preventive policy, estimate the current risk of infection, and predict evolutions in the future. In this study, we aimed to investigate the prevalence of seropositivity of antibodies against measles, rubella and mumps in a population of all ages in Youyang, southwest China. A cross-sectional hospital-based study was conducted among 657 cases who attended to Youyang Hospital from Sep 2018 to Aug 2019. Sero IgG antibodies were measured by ELISA. No difference in the seropositivity of antibodies against measles, rubella and mumps was found between neither urban vs. rural, nor male vs. female. The overall seropositivity of anti-measles, rubella, mumps IgG antibodies was 81.1% (95% CI: 78.0–83.9), 65.9% (95% CI: 62.2–69.4) and 63.2% (95% CI: 59.4–66.8), respectively. The IgG seropositivity varied with age significantly. In this study, the seropositivity of antibodies against measles, rubella and mumps among the participants was insufficient in the population, especially among infants, teenagers and productive women, who were suggested to booster the immunity. To better control and eliminate measles, mumps and rubella-related diseases, nation-wide active laboratory-supported surveillance, outbreak investigation and revaccination for vulnerable population are needed.

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Introduction

Vaccinations are used to prevent targeted diseases, by changing the disease susceptibility among the population and thus slowing down their epidemic cycles.¹ Among these vaccine preventable diseases, measles, rubella and mumps are supposed to be at the top list of the most contagious diseases, which contribute significantly to the global mortality and morbidity.^{2,3}

In 2013, the World Health Organization (WHO) announced the Global Vaccine Action Plan (GVAP) for 2011–2020, calling for the elimination of measles and rubella in at least five of six WHO regions by 2020.⁴ However, despite the success of the global measles vaccine program, including a declaration of measles elimination in America in 2000,⁵ millions of people are still at risk of this disease. A resurgence of measles, which was believed to be the most severe over the past 25 years, just happened in America in 2019.⁶ Also, outbreak of measles has been reported in mainland of China,⁷ Hongkong,⁸ Taiwan,⁹ Japan¹⁰ and Brazil¹¹ et al. According to the latest data of WHO, 353,236 measles cases were reported in 2018.¹² The situation of measles is still worthy of attention.

Atypical measles can not be distinguished with rubella, which is also a public health concern. Rubella usually affected susceptible children and young adults. While much progress has occurred, rubella remains an important pathogen and public health concern around the world.¹³ It was reported

that the numbers of rubella cases all around the world were still at high levels in recent 5 years.¹² In China, 32,539 persons suffered from this disease in 2019.¹⁴ The infection occurring just before conception and during early pregnancy often results in miscarriage, fetal or early infant death, or multi-organ congenital defects known as congenital rubella syndrome (CRS),¹⁵ which poses a serious health risk to people. We conducted a serological study on rubella antibody level in Beijing, China, and the result indicated that the virus was quite common in the environment considering their vaccination experience.¹⁶ For the importance of measles and rubella, clinical manifestations overlap of both diseases and the available combined vaccines, the future aim is to eliminate these diseases at the same time, although there's still a long way to go.

Mumps usually occur in childhood, most often affecting children between 5–9 years old with symptoms as headache, fever, body aches. However, the virus can also infect adults, possibly with serious complications, such as orchitis and accompanying low fertility, meningitis, deafness as well as encephalitis and permanent neurological damage.¹⁷ Though it declined slightly in 2014 and 2015, the number of mumps cases still maintained at a level of 550,438 per year in recent 10 years.¹² Mumps became a notifiable disease in China since 1989.¹⁸ In 2007, it was incorporated into Expanded Programme of Immunization (EPI). However, it was reported

that the incidence of mumps as well as the seasonal epidemiologic feature, episode ages had no obvious changes in the first few years after the policy.¹⁹ Now mumps incidence is still remaining at a high level (12.7655/100000 in 2016, 18.3166/100000 in 2017, 18.6503/100000 in 2018) in recent years in China.

According to the National Immunization Program (NIP), Chinese Center for Disease Control and Prevention (CCDC),²⁰ the measles vaccine was first introduced in China in 1965, and one dose measles vaccination was not implemented nationwide until 1978. Two doses of measles vaccine were introduced in 1986 (8 ms, 7 ys) and the age of administration of the second dose was lowered in 2005 (8 ms, 18 ms). In 2007, the Expanded Programme of Immunization (EPI) was conducted with a measles-rubella vaccine (MRV) at 8 months, followed by a measles-rubella-mumps vaccine (MMR) at 18–24 months. At the beginning of 2020, two doses of MMR vaccine were suggested at 8 months and 18 months, respectively.²¹ Although a lot work has been done in preventing and controlling the three diseases, the incidence is still considerable. National Notifiable Disease Reporting System (NNDRS) had posted a report that in 2018, the number of measles, rubella and mumps cases in China was 3,940, 3,930 and 259,071, respectively.¹⁴

It seems that the present situation is still tough, and sustained efforts are needed to eliminate measles, rubella and mumps related diseases thoroughly.

To evaluate the serological epidemiology on these diseases, which is an important step to estimate the susceptibility in the population, and to better improve the immunization policy, we conducted the study and analyzed the susceptibility to measles, rubella and mumps in the population of southwest China.

Materials and methods

Study population

The study lasted for 1 year from Sep 2018 to Aug 2019. Serum samples were collected randomly and continuously from patients willing to attend this study and provide samples after the clinical testing finished among people who admitted to Youyang County People's Hospital. Subjects included young children who visited the hospital for medical examination, and adults and olds who visited the hospital for medical examination, antenatal care, fracture, or chronic diseases. The cases with skin rash and fever, chronic infectious diseases, immunosuppressed condition, as well as multiple transfusions experiences were excluded. Overall 657 samples were collected. The samples were divided into eight groups according to the ages of the subjects: <8 months, 8–18 months, 18 months–3 years, 3–6 years, 6–18 years, 18–40 years, 40–60 years and ≥60 years. Information of the subjects' age or birth date, gender, residence area, was also collected. The patients' name, ID number, residential address and contact information were not collected for this study.

Serology testing

The samples of plasma were stored frozen (−20°C) until testing. The samples were analyzed with commercially available

ELISA kits (SERION ELISA classic anti-Measles/Rubella/Mumps virus IgG Kit, Institut Virion/Serion GmbH, Würzburg, Germany) following the manufacturer's instructions. Quantitative titers were obtained from the optical density (OD) values as specified by the manufacturer in terms of mIU/mL for measles, IU/mL for rubella and U/mL for mumps. Samples were categorized as seropositive, equivocal or seronegative for each antibody according to the cutoff values proposed by the manufacturer and adopted in previous studies.^{22–25} For measles IgG, values <150 and >200 mIU/mL were considered seronegative and seropositive respectively, while 150–200 equivocal. For rubella IgG, values <10 and >20 IU/mL were considered seronegative and seropositive, respectively, while 10–20 equivocal. For mumps IgG, the lower and upper cutoffs were <70 and >100 U/mL, respectively. The IgG positive means past infection, successful vaccination, or immunoglobulin recipient.

Statistical analysis

Antibody levels were expressed with 25%, 50% and 75% percentile, respectively. Antibody seropositivity were calculated with 95% confidence interval (CI). The seroprevalence among different groups was compared with the chi-square test. Data were analyzed by JMP 13. $P < .05$ was statistically significant.

Results

Sample collection

A total of 657 samples were collected, which included 379 (57.7%) from males and 278 (42.3%) from females; 273 (41.6%) from urban and 384 (58.4%) from rural area.

The 25%, 50% and 75% percentiles for measles, rubella, mumps-specific IgG in the population and those of each age groups are summarized in Table 1. The distribution of seroprevalences of antibodies against measles, rubella, mumps is shown in Table 2. No significant differences in seropositivity of measles, rubella, mumps vaccine-specific IgG were observed between urban vs. rural, male vs. female.

Characterizations of IgG antibodies against measles

A total of 533 individuals were positive for measles IgG antibodies, giving a seropositivity of 81.1% (95% CI: 78.0–83.9); 23 were equivocal (3.5%, 95% CI: 2.3–5.2), and 101 were negative (15.4%, 95% CI: 12.8–18.3). The prevalence (%) of seropositivity against measles per age group is shown in Figure 1(a). Seroprevalences differed among the age groups ($\chi^2 = 127.16$, $P < .0001$). The seropositivity of infants aged <8 months and 8–18 months were 59.6% (95% CI: 50.0–68.5) and 44.8% (95% CI: 33.5–56.6) respectively, both significantly lower than 98.4% in children aged 18 months–3 years (95% CI: 91.7–99.7) ($P < .0001$). Then it declined with age. Compared with children aged 18 months–3 years, the seropositivity of people aged 6–18 years and 18–40 years, significantly decreased to 88.4% (95% CI: 79.9–93.6) and 83.8% (95% CI: 73.8–90.5) respectively, and maintained at a level of 87.1% (95% CI: 79.8–92.0) among people aged 40–60 years (with all P value < .05). It finally

Table 1. Titers of antibodies against measles, rubella, mumps in the general population.

Anti-body	25% percentiles	50% percentiles	75% percentiles
Anti-Measles (mIU/mL)	309.93	689.57	1100.53
<8 ms ^a	53.30	309.93	731.36
8–18 ms	25	53.11	931.35
18 ms–3 ys ^b	926.20	1758.51	3746.20
3–6 ys	1054.32	1865.78	3232.77
6–18 ys	345.49	677.67	847.69
18–40 ys	270.49	600.26	780.95
40–60 ys	369.08	648.77	912.43
≥60 ys	586.88	840.86	1091.48
Anti-Rubella (IU/mL)	14.17	30.23	43.93
<8 ms	3.68	19.44	41.07
8–18 ms	1.34	6.50	47.94
18 ms–3 ys	42.26	62.62	95.86
3–6 ys	31.68	50.28	80.18
6–18 ys	14.46	25.60	36.41
18–40 ys	19.11	33.30	38.34
40–60 ys	15.30	26.04	34.30
≥60 ys	20.38	30.05	41.50
Anti-Mumps (U/mL)	15	200.97	440.47
<8 ms	15	30.58	197.28
8–18 ms	15	15	15
18 ms–3 ys	15	87.91	315.05
3–6 ys	54.43	323.20	796.63
6–18 ys	211.68	452.11	738.48
18–40 ys	56.05	194.18	377.25
40–60 ys	197.02	284.28	513.83
≥60 ys	176.52	306.86	455.19

^ams: months; ^bys: years.**Table 2.** Seropositivity of antibodies against measles, rubella, mumps in different groups (95% CI).

Variable	N ^c	Seropositivity % (95% CI) ^d		
		Anti-Measles	Anti-Rubella	Anti-Mumps
Total	657	81.1 (78.0–83.9)	65.9 (62.2–69.4)	63.2 (59.4–66.8)
<8 ms ^a	104	59.6 (50.0–68.5)	48.1 (38.7–57.6)	37.5 (28.8–47.1)
8–18 ms	67	44.8 (33.5–56.6)	37.3 (26.7–49.3)	6.0 (2.3–14.4)
18 ms–3 ys ^b	64	98.4 (91.7–99.7)	87.5 (77.2–93.5)	48.4 (36.6–60.4)
3–6 ys	69	92.8 (84.1–96.9)	88.4 (78.8–94.0)	66.7 (54.9–76.6)
6–18 ys	86	88.4 (79.9–93.6)	61.6 (51.1–71.2)	83.8 (74.5–90.0)
18–40 ys	74	83.8 (73.8–90.5)	74.3 (63.3–82.9)	66.2 (54.9–76.0)
40–60 ys	116	87.1 (79.8–92.0)	64.7 (55.6–72.8)	89.7 (82.8–94.0)
≥60 ys	77	97.4 (91.0–99.3)	75.3 (64.6–83.6)	90.9 (82.4–95.5)
P	-	<.0001	<.0001	<.0001
Gender				
Male	379	81.8 (77.6–85.4)	67.0 (62.1–71.6)	61.5 (55.6–67.1)
Female	278	79.5 (74.4–83.8)	63.7 (57.9–69.1)	64.7 (59.0–70.1)
P	-	.460	.372	.560
Residence place				
Urban	273	80.2 (75.1–84.5)	66.3 (60.5–71.6)	61.5 (55.6–67.1)
Rural	384	81.3 (77.0–84.8)	65.1 (60.2–69.7)	64.8 (60.0–69.5)
P	-	.741	.750	.386

^ams: months; ^bys: years; ^cN: Total number of samples; ^dCI: confidence interval.

increased to a high level in people aged ≥60 years (97.4%, 95% CI: 91.0–99.3), which was significantly higher than 6–18 years, 18–40 years and 40–60 years ($P < .05$), while with no significant difference among children aged 18 months–3 years.

The seropositivity of anti-measles IgG antibodies among women of child-bearing age (15–49 years) was 81.5% (95% CI: 70.4–89.1).

Characterization of IgG antibodies against rubella

In total, 433 individuals were positive for rubella IgG antibodies, with a seropositivity of 65.9% (95% CI: 62.2–69.4); 86 were equivocal (13.1%, 95% CI: 10.7–15.9), and 138 were negative (21.0%, 95% CI: 18.1–24.3). The prevalence (%) of seropositivity against rubella per age group is shown in Figure 1(b). The seropositivity of infants aged <8 months was at a low level of 48.1% (95% CI: 38.7–57.6), and further decreased to 37.3% (95% CI: 26.7–49.3) among infants aged 8–18 months. Then it increased sharply in age group of 18 months–3 years and 3–6 years, with a seropositivity of 87.5% (95% CI: 77.2–93.5) and 88.4% (95% CI: 78.8–94.0) respectively, both significantly higher than previous two groups. It significantly decreased to 61.6% (95% CI: 51.1–71.2) in the population aged 6–18 years vs. children aged 18 months–3 years and 3–6 years, with both $P < .05$.

The seropositivity of people aged 18–40 years, 40–60 years, as well as ≥60 years fluctuated with age, maintained at a moderate level of 74.3% (95% CI: 63.3–82.9), 64.7% (95% CI: 55.6–72.8) and 75.3% (95% CI: 64.6–83.6), respectively, which were all significantly lower than the peak value of children aged 3–6 years ($P < .05$).

For productive women (15–49 years), the seropositivity of anti-rubella IgG antibodies was 64.6% (95% CI: 52.5–75.1).

Characterization of IgG antibodies against mumps

Altogether 415 individuals were positive for mumps antibodies, with a seropositivity of 63.2% (95% CI: 59.4–66.8); 29 were equivocal (4.4%, 95% CI: 3.1–6.3), and 213 were negative (32.4%, 95% CI: 29.0–36.1). The prevalence (%) of seropositivity against mumps per age group was shown in Figure 1(c). The seropositivity of infants aged <8 months was 37.5% (95% CI: 28.8–47.1), and decreased sharply to 6.0% (95% CI: 2.3–14.4) among infants aged 8–18 months ($P < .0001$). Then the prevalence of seropositivity increased with age and was

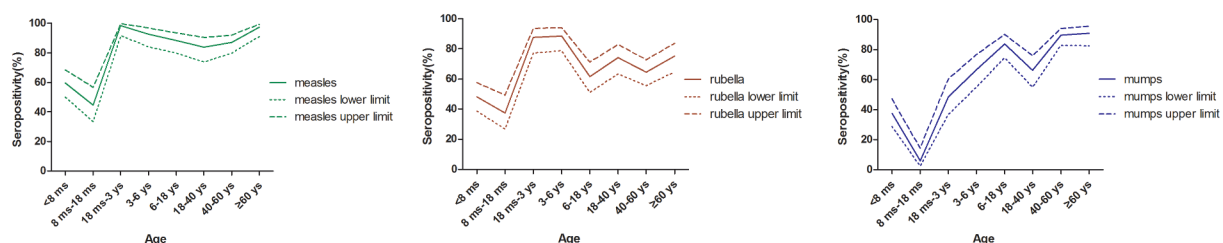


Figure 1. Seropositivity (%) of anti-measles, rubella, mumps IgG antibodies of different age groups. Panel A for anti-measles, Panel B for anti-rubella, Panel C for anti-mumps. Solid lines represents prevalence of seropositivity for measles antibodies (>200 mIU/mL), rubella antibodies (>20 IU/mL), mumps antibodies (>100 U/mL). Dashed lines represent upper and lower limits of the exact binomial 95% confidence interval.

significantly higher than children aged 8–18 months among the population aged 18 months–3 years, 3–6 years and 6–18 years, with a level of 48.4% (95% CI: 36.6–60.4), 66.7% (95% CI: 54.9–76.6) and 83.8% (95% CI: 74.5–90.0), respectively, with $P < .0001$. The seropositivity of antibodies among people aged 18–40 years decreased to 66.2% (95% CI: 54.9–76.0), and it increased significantly among the population aged 40–60 years and ≥ 60 years, with the seropositivity of 89.7% (95% CI: 82.8–94.0) and 90.9% (95% CI: 82.4–95.5), respectively ($P < .05$).

The seroprevalence of anti-mumps IgG antibodies among women of child-bearing age (15–49 years) was 76.9% (95% CI: 65.4–85.5).

Discussion

Herd immunity can block the transmission of measles in the population when the positive serological result is higher than the herd immunity threshold.^{26,27} To eliminate measles, Plans-Rubió suggested that the measles immunity levels should be at least 95%, either in children aged 1–9 years old or people aged >9 years old.²⁸ In this study, the general prevalence of antibody seropositivity for measles was 81.1%, indicating a susceptibility to measles-related diseases in the population. Infants <1 year are the most vulnerable population for measles related diseases. However, in China, the seropositivity among infants was low. For infants aged <8 months, the seropositivity of antibody against measles was 16.67% in Hubei province²⁹ and 35.80% in Shanghai.³⁰ In this study, the seropositivity of antibody among infants aged <8 months increased to a level of 59.6% (95% CI: 50.0–68.5), which was close to the antibody level in previous study conducted in Beijing.¹⁶ The low-level seropositivity was probably due to the infants' mother, as they were among the population who began to be vaccinated with measles and acquired immunity from vaccination in their childhood. As antibodies against measles would wane with age,³¹ and nowadays the women have children more late than before, protective antibody titer attenuated, passed on to their offspring less protective effect against measles virus in the first 8 months of life. Also, with the tapering off of feeding, the maternal antibody of the infants decreased. It was reported that 84.1% of infants aged 0–1 months were measles positive, and declined to less than half among infants aged 5–7 months.³²

It was worthy of attention that the seropositivity of measles in productive women was generally insufficient. In Taiwan, the seropositivity of measles antibodies among people aged 16–25 years and 20–29 years, stages with a high fertility, waned to 75% and 78.1% respectively.^{33,34} In this study, the prevalence of seropositivity of child-bearing women (15–49 years) was 81.5% (95% CI: 70.4–89.1), similar with previous study conducted in mainland of China (86.7%),³⁵ still insufficient. As newborn infants get immunity as a result of active placental transfer of IgG class antibodies during late pregnancy, the antibody levels of infants were highly correlated to their mothers.³⁶ To enhance their antibody levels, child-bearing women are suggested to booster the immunity against measles, to keep their babies away from measles infection. In previous studies, Wang showed that inoculation of measles vaccine 3–12 months before pregnancy was the best time to enhance the immune response, with the highest seropositivity

and antibody levels.³⁷ So strengthen publicity and even conduct strict implementation among the child-bearing women to booster immunization are meaningful to protect pregnant women and their offspring from measles infections. Seroprevalence of anti-measles antibody declined with age during 3–40 years old (Figure 1(a)). This was perhaps due to attenuated antibody titer. The result was in accordance with previous study that a shift emerged in age distribution of measles cases toward older children.³⁸ According to a nationwide study on the epidemiologic characteristics of measles cases reported in China from 2013–2019, conducted by NIP, CCDC, among the measles cases from 2013 to 2019, the proportion of children aged <8 months declined from 30.6% to 5.9%, while people aged ≥ 15 years increased from 26.9% to 41.6%; proportion of infants who received no dose of measles vaccine declined from 64.9% to 14.6%, while people with 2 doses of measles vaccine increased from 6.1% to 39.2%.²⁰ It is worthy of attention, as individuals in this age groups are highly mobile and have more social contacts in school and offices than younger children. To solve this problem, American Centers for Disease Control and Prevention recommended that a visit at age of 11–12 years can serve as a catch-up opportunity to verify vaccination status and administer vaccine to those susceptible children.³⁹ Besides, two doses for adults at high risk of measles exposure and transmission, and one dose for other adults aged ≥ 18 years were suggested.⁴⁰

Notably, people aged ≥ 60 years, who had no access to measles vaccine and acquired immunity from exposure to wild virus, had a high seropositivity of antibodies, indicating that infection induced immunity appeared to be lifelong and persisted at a high level, agreed with previous study.³³

Incorporating rubella into China EPI system in 2007 was an important step to control and eliminate rubella and prevent CRS. The incidence of rubella had decreased from 91.0 per million in 2008 to 2.83 per million in 2018,¹⁴ while still at a high level.

According to this study, the seropositivity of anti-rubella antibody among infants aged <8 months who had not received vaccine was quite low (48.1%, 95% CI: 38.7–57.6), similar with previous study.⁴¹ Actually, according to studies carried out in several other regions of China, Ma⁴² and Ge⁴³ proved that the seropositivity of anti-rubella IgG antibodies of 8-months infants was only 4.6% and 3.33%, respectively. This implies the insufficient protection from maternal transferred antibody as well as an urgent necessity to increase mothers' antibody.

According to data of Chinese NNDRS during 2014–2017, the age group with highest incidence of rubella was 10–19 years old.⁴⁴ Our result was in accordance with this study that the seropositive rate of teenagers aged 6–18 years (61.6%, 95% CI: 51.1–71.2) declined drastically, significantly lower than children aged 3–6 years (88.4%, 95% CI: 78.8–94.0), with $P < .001$. Besides, the seropositivity of anti-rubella IgG antibodies among child-bearing women (15–49 years) was low (64.6%, 95% CI: 52.5–75.1). Considering the nationwide rubella immunization of infants was initiated in Nov 2007, women of reproductive age will continue to be susceptible to rubella for about 2–3 decades under the current program policies and practices. In view of this, rubella vaccines are suggested here to promote rubella immunity, especially for young teenagers and child-bearing women.

China still has the highest incidence of mumps in the world.⁴⁵ According to WHO, the number of mumps in China ranks the first between 2014 and 2018, accounting for nearly half of the total number of cases worldwide.¹² In this study, the prevalence of seropositivity against mumps among the population aged 18–40 years (66.2%, 95% CI: 54.9–76.0) decreased sharply, may be due to that the population had received neither programmed immunization for mumps, nor efficient natural exposure to the virus. With no doubt, this embarrassing situation existed in productive women as the age groups were similar. The seropositivity of anti-mumps IgG antibodies among the child-bearing women (15–49 years) was 76.9% (95% CI: 65.4–85.5), not efficient for the infants aged <18 months who mainly gained immunity from their mothers to protect from mumps, resulting in the low seroprevalence of antibodies among infants in this age.

The seropositivity of anti-mumps antibodies among infants aged 8–18 months decreased to a dangerously low level of 6.0% (95% CI: 2.4–14.4), which was a little higher than Liu's study in Sichuan province,⁴⁶ while lower than Yin's study in Hubei province.⁴⁷ This low-level seropositivity may be due to the protection in this stage was still from their mothers. As the maternal antibodies in infants was metabolized, and the lactation gradually ended in this age, the titers dropped, and the protection from their mothers faded away, while they had not been immunized with mumps vaccines. Based on the current immunization situation of the population, it seemed that one dose mumps-containing vaccine at 18 months was insufficient to prevent and control mumps. Ma¹⁸ proved that among the mumps cases, people with two doses of mumps-containing vaccines were very rare, and the vaccine effectiveness against mumps complications for two dose mumps containing vaccine was higher than for one dose. So the National Immunization Program was updated since Jan 2020, that 1st dose of mumps-containing vaccine at 8 months and the 2nd dose at 18 months has been scheduled.²¹

It was notable that the seropositivity of measles and rubella among infants aged 8–18 months (immunized with one dose of measles and rubella vaccine), was still lower than the result of infants aged <8 months (not vaccinated), not in accordance with previous study.⁴⁸ It was supposed to be due to the actual age of the former group in this study gathered ≤ 12 months, still had not been vaccinated with 1st dose of measles and rubella vaccine timely and qualifiedly.

The study was subjected to several limitations. Firstly, this was a hospital-based study. All subjects were collected from people who went to Youyang County People's Hospital during Sep 2018 and Aug 2019. It might not represent the real level of people in the whole region. This was because the representative studies were costly and difficult to realize. In spite of this, the data in this study still can indicate the problem of insufficient immune protection among people in this region under the background that relevant studies were rare. In future studies, sample sources should be expanded. And multi-center studies in the whole country should be performed in the future to provide evidence for national

improvement of immunization strategies as well as disease control and prevention. Secondly, as the medical system and immune system are two separate systems in China, the information of the vaccination status of the cases could not be obtained, and consultation with the subjects could not help in getting an accurate reply. We estimated the immunization status according to their age and the immunization strategies carried out in China of recent decades. Whether the antibodies of the study subjects were due to infection or immunization can not be explicitly illustrated. So the finding in this study can only suggest causation, but can not prove it.

Conclusion

In the present study we tested the seropositivity of IgG antibodies against measles, rubella and mumps among the population from neonates to 89-year-old people. We found that the seropositivity of antibodies in the population changed with age and exhibited different characterizations for measles, rubella and mumps, respectively. Teenagers as well as child-bearing women were susceptible to measles, rubella and mumps, and the vaccination on them need to be strengthened. In general, to eliminate measles, rubella and mumps thoroughly, persistent efforts still need be taken to conduct nationwide active surveillance on seroprevalence of IgG antibodies against measles, rubella and mumps, vaccinating and re-vaccinating the susceptible population, and ensure the efficient immunity of the population.

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Author contributions

CCH and YKH were involved in conceptualization for the study and its design. WQ and CXP collected the data, analyzed and wrote the draft of the manuscript. LDD oversaw data analysis planning and execution, and helped analyse the data. CCH and YKH reviewed and revised the manuscript, and approved the final manuscript as submitted. All authors reviewed and approved the final manuscript.

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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ORCID

Kaihu Yao  <http://orcid.org/0000-0003-1548-8670>

Data availability statement

The datasets used during the current study are available from the corresponding author upon reasonable request.

Ethics approval

This study was reviewed and approved by the Ethics Committee of Youyang County People's Hospital. Written informed consent was obtained from the patients as well as the participants' parent or legal guardian for children under 16 years old.

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