Seroprevalence of Antipolio Antibodies among Children <15 Years of Age in Border Provinces in China

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Despite remarkable progression toward polio eradication worldwide, wild poliovirus (WPV) importation has been a great challenge for China, as it shares borders with countries where WPV is endemic. The objective of this study was to estimate poliovirus antibody seroprevalence among children <15 years of age in 3 border provinces (Yunnan Province, Tibet Autonomous Region, and Xinjiang Uygur Autonomous Region) in China. A cross-sectional, hospital-based study was undertaken in 3 border provinces in 2010. Individuals <15 years old who visited hospitals at the prefecture level or above to have their blood drawn for any reason were invited to participate in our study. Neutralizing antibody titers to polio serotypes 1 (P1), P2, and P3 were assayed according to the World Health Organization manual for the virological investigation of polio. Antibody titers of ≥8 were considered positive. Among the 1,360 subjects enrolled, 1,220 (89.7%), 1,259 (92.6%), and 1,112 (81.8%) were seropositive to P1, P2, and P3, respectively, and 1,051 (77.3%) subjects were seropositive to all three serotypes. The highest seropositive rates were observed in Xinjiang Uygur Autonomous Region. By age, 3- to 5-year-old subjects had the highest rate of seropositivity, and seropositivity decreased significantly with increasing age. The risk of WPV importation will continue until WPV transmission has been interrupted worldwide. Consistent with the Global Polio Eradication Initiative’s polio endgame strategy, China must maintain its polio-free status by ensuring adequate population immunity against polio. Because immunity wanes with increasing age, a booster dose with bivalent type 1 and 2 oral poliovirus vaccine could be considered for teenagers in China.

Since the World Health Assembly launched the Global Polio Eradication Initiative in 1988, global polio eradication activities have resulted in near elimination of the disease from several regions, with the disease burden being reduced by more than 99%, from over 350,000 cases in 1988 to as few as 223 in 2012. The number of countries in which polio is endemic decreased from 125 to 4 during the same period (1). Indigenous transmission of type 2 wild poliovirus (WPV) had been interrupted globally since 1999 (2). Despite such progress toward global eradication of polio, many previously polio-free countries have been affected by WPV importations from the countries where polio remains endemic (3–6). During 2009, for example, outbreaks from the importation of WPV affected 19 previously polio-free African countries (5). In 2010, a WPV outbreak in the European Region, which had been declared polio-free in 2002, resulted in 476 polio cases: 458 in Tajikistan, 14 in Russia, three in Turkmenistan, and one in Kazakhstan (7, 8).

Live, attenuated oral poliovirus vaccine (OPV) was included in China’s Expanded Program on Immunization in 1978. Currently in China, children receive a 3-dose primary vaccination series at 2, 3, and 4 months of age, with one booster at 4 years of age. As a result of the high quality of routine immunization, and in conjunction with supplementary immunization activities, China made substantial progress on polio eradication. The last case of poliomyelitis caused by indigenous WPV occurred in September 1994. In October 2000, the Western Pacific Regional Commission for the Certification of the Eradication of Poliomyelitis certified that the entire Western Pacific Region was free of indigenous WPVs.

WPV importation has been a continuous threat to China’s polio-free status, as China shares borders with 3 of the 4 countries that had endemic WPV transmission in 2010. Between 1995 and 1999, there were 3 importations of WPV into China: in Yunnan Province in 1995 and 1996 (9) and in Qinghai Province in 1999 (10–12). Until WPV transmission is interrupted globally, the threat of WPV importation and outbreak will continue, especially for the countries sharing borders with countries where WPV is endemic.

Serological surveys are a useful tool for assessing population immunity and for identifying areas with low immunity. The study was designed to determine the prevalence of antibodies against poliovirus serotype 1 (P1), P2, and P3 in western border provinces (Yunnan Province, Tibet Autonomous Region, and Xinjiang
Uygur Autonomous Region) in China. This study was conducted immediately prior to the 2011 WPV importation into Xinjiang.

MATERIALS AND METHODS

**Study participants.** In 2010, we conducted a serologic survey in 2 prefectures (Xigaze and Lhasa) of Tibet Autonomous Region, 3 prefectures (Dehong, Baoshan, and Lincang) of Yunnan Province, and 4 prefectures (Urumqi, Kezilesukeer, Kashgar, and Yili) of Xinjiang Uygur Autonomous Region. Individuals <15 years old in selected prefectures who visited hospitals at the prefecture level or above for a blood draw because of reasons not related to the study were invited to participate. Willing participants were consecutively enrolled after written, informed consent was provided by the parents or guardians. Individuals were excluded if they had a known immunodeficiency or had been treated with immunosuppressant drugs during the previous 12 months. Upon enrollment, subjects were stratified into five age groups: 0 to 2 years, 3 to 5 years, 6 to 8 years, 9 to 11 years, and 12 to 14 years. In each prefecture, 150 subjects were enrolled, 30 in each age group. This study was approved by the Chinese Center for Disease Control and Prevention institutional review board.

**Measurement of antibody levels.** A 2-ml blood sample was collected from each child by venipuncture for the purpose of this study and kept in a labeled sterile serum tube. Samples were immediately placed in an ice box and transported to the laboratory. Serum was separated within 24 h after the collection of samples by low-speed centrifugation for 10 min and then stored at −20°C. Neutralization antibodies against P1, P2, and P3 were determined by a microneutralization assay with authentic Sabin strains in accordance with WHO guidelines (13). Serum samples were completely inactivated at 56°C for 30 min and diluted from 1:4 to 1:1,024 and then incubated in duplicate wells for 3 h at 36°C with 100% tissue culture infective doses (TCID50) of poliovirus antigen. After incubation for 7 days, the highest dilution of serum that protected 50% of the cultures was recorded. A serum sample was considered positive if the neutralization antibody level was present at a dilution of ≥1:8.

**Statistical analysis.** Statistical tests were performed using SAS 9.1 software (SAS Institute Inc., Cary, NC). Chi-square tests were used to determine the association between demographic characteristics and seropositivity. Analysis of variance was used to compare the difference of geometric mean titers (GMTs) after logarithm transformation among different demographics. A P value of <0.05 was considered statistically significant for all analyses.

**RESULTS**

**Study population.** A total of 1,360 subjects were enrolled in 2010: 450 in Yunnan Province, 310 in Tibet Autonomous Region, and 600 in Xinjiang Uygur Autonomous Region (Table 1). The demographic characteristics of the study population are summarized by province in Table 2. Of the 1,360 participants, 285 were ≤2 years of age, 275 were between 3 and 5 years of age, 267 were between 6 and 8 years of age, 270 were between 9 and 11 years of age, and 263 were between 12 and 14 years of age. A total of 808 (59.4%) were male, and the mean age of the study population was 6.8 ± 4.3 years. There was no statistically significant difference by gender among different provinces (P = 0.50).

**Polio antibody seroprevalence.** Seroprevalence of polio antibodies is summarized in Table 1. Among the 1,360 subjects enrolled, 1,220 (89.7%), 1,259 (92.6%), and 1,112 (81.8%) were seropositive to P1, P2, and P3, respectively, at titers of ≥1:8. There were differences in antibody seropositivity among P1, P2, and P3. With regard to seropositivity to more than one serotype, 1,184 (87.1%) subjects were seropositive to a combination of P1 and P2 serotypes, while 1,065 (78.3%) and 1,088 (80.0%) were seropositive to a combination of P1 and P3 and P2 and P3, respectively, at titers of ≥1:8. Overall, only 1,051 (77.3%) subjects were positive to all three serotypes. The highest seropositive rates were observed in Xinjiang Uygur Autonomous Region for P1, P2, and P3, and any combination of the three serotypes (including P1 and P2, P1 and P3, P2 and P3, P1 and P3, P1 or P2 or P3) was significantly higher than the seroprevalences observed in the other 2 provinces.

We observed a correlation between age groups and seropositivity. For P1 and P2, the antibody seroprevalence was highest in children 3 to 5 years old and was >85% in the majority of age groups (Fig. 1), except for P1 antibody seroprevalence (82.8%) in children 0 to 2 years old. For P3, we observed lower antibody seroprevalence in all age groups, and the highest P3 seropositivity was also in children 3 to 5 years old, subsequently decreasing with increasing age. Seropositivity was below 80% in children 12 to 14 years old. Seropositivity for P1 and P2 and P3 was less than 70% in children 12 to 14 years old.

The relationships between demographic characteristics and antibody GMTs by province are shown in Table 2. We did observe a correlation among age groups and seropositivity in each province. In Yunnan Province and Xinjiang Uygur Autonomous Region, a downward trend by age of all 3 serotypes was observed, again with the highest antibody seropositivity in children 3 to 5 years old. However, an ascending trend by age was observed in Tibet Autonomous Region. There were also

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**TABLE 1 Seropositive poliovirus antibodies of single serotype and combined serotypes by province**

| Polio serotype(s) | Yunnan Province (n = 450 subjects) | Tibet Autonomous Region (n = 310 subjects) | Xinjiang Uygur Autonomous Region (n = 600 subjects) | P value | Total no. of seropositive subjects (%) |
|-------------------|-----------------------------------|--------------------------------------------|---------------------------------------------------|---------|---------------------------------------|
| P1                | 394 (87.6)                        | 251 (81.0)                                 | 575 (95.8)                                        | <0.01   | 1,220 (89.7)                          |
| P2                | 400 (88.9)                        | 267 (86.1)                                 | 592 (98.7)                                        | <0.01   | 1,259 (92.6)                          |
| P3                | 341 (75.8)                        | 214 (69.0)                                 | 557 (92.8)                                        | <0.01   | 1,112 (81.8)                          |
| P1 and P2         | 368 (81.8)                        | 241 (77.7)                                 | 575 (95.8)                                        | <0.01   | 1,184 (87.1)                          |
| P1 and P3         | 317 (70.4)                        | 204 (65.8)                                 | 544 (90.7)                                        | <0.01   | 1,065 (78.3)                          |
| P2 and P3         | 324 (72.0)                        | 209 (67.4)                                 | 555 (92.5)                                        | <0.01   | 1,088 (80.0)                          |
| P1 or P2 or P3    | 306 (68.0)                        | 201 (64.8)                                 | 544 (90.7)                                        | <0.01   | 1,051 (77.3)                          |

*P1, poliovirus serotype 1; P2, poliovirus serotype 2; P3, poliovirus serotype 3. Chi-square tests were used to determine the difference of polio seropositivity among different provinces. P values indicate overall significance levels of difference between 3 provinces.*
significant differences of GMTs among age groups, with a downward trend in Yunnan Province and Xinjiang Uygur Autonomous Region (Table 3).

In Yunnan Province, for P1 and P2, there was no statistically significant difference in antibody seropositivity among districts, but P3 antibody seropositivity was significantly lower in Lincang City than in Baoshan and Dehong. In Tibet Autonomous Region, both P1 and P2 antibody seroprevalence were significantly lower in Xigaze City than in Lhasa City. There was no statistically significant difference of antibody seropositivity and GMTs among prefectures in Xinjiang Uygur Autonomous Region.

**DISCUSSION**

This survey was conducted immediately before the type 1 WPV outbreak in Xinjiang Uygur Autonomous Region in 2011 (14). Data from this study were very useful in the guidance of the emergency response to the WPV outbreak in Xinjiang Uygur Autonomous Region. This study showed that in these border provinces, 77.3% of subjects were seropositive to all three poliovirus serotypes, 4.0% had no antibodies at all to the three poliovirus serotypes, and 89.7%, 92.6%, and 81.8% were seropositive to P1, P2, and P3, respectively.

Over 90% of subjects were seropositive to all three poliovirus serotypes in Xinjiang Uygur Autonomous Region, while in Yunnan Province, the seropositivity was lower, especially in Lincang City. In Tibet Autonomous Region, the seropositivity was also lower in Xigaze City.

**TABLE 2 Antibody seropositivity of P1, P2, and P3 by demographic characteristics in 3 provinces**

| Region and characteristic | P1 | P2 | P3 |
|---------------------------|----|----|----|
|                           | No. (%) of seropositive subjects | P value | No. (%) of seropositive subjects | P value | No. (%) of seropositive subjects | P value |
| Yunnan Province           |    |    |    |
| Sex                       |    |    |    |
| Male                      | 224 (86.2) | 0.29 | 230 (88.5) | 0.74 | 191 (73.5) | 0.18 |
| Female                    | 170 (89.5) |    | 170 (89.5) |    | 150 (78.9) |    |
| Age group (yr)            |    |    |    |
| 0–2                       | 78 (86.7) | 0.04 | 83 (92.2) | 0.01 | 76 (84.4) | <0.01 |
| 3–5                       | 87 (95.6) |    | 87 (95.6) |    | 76 (83.5) |    |
| 6–8                       | 75 (84.3) |    | 79 (88.8) |    | 62 (69.7) |    |
| 9–11                      | 81 (90.0) |    | 79 (87.8) |    | 68 (75.6) |    |
| 12–14                     | 73 (81.1) |    | 72 (80.0) |    | 59 (65.6) |    |
| District                  |    |    |    |
| Lincang                   | 128 (85.3) | 0.13 | 127 (84.7) | 0.06 | 96 (64.0) | <0.01 |
| Baoshan                   | 138 (92.0) |    | 140 (93.3) |    | 21 (80.7) |    |
| Dehong                    | 128 (85.3) |    | 133 (88.7) |    | 124 (82.7) |    |
| Tibet Autonomous Region   |    |    |    |
| Sex                       |    |    |    |
| Male                      | 147 (81.2) | 0.90 | 157 (86.7) | 0.71 | 126 (69.6) | 0.79 |
| Female                    | 104 (80.6) |    | 110 (85.3) |    | 88 (68.2) |    |
| Age group (yr)            |    |    |    |
| 0–2                       | 52 (66.7) | <0.01 | 56 (71.8) | <0.01 | 50 (64.1) | 0.82 |
| 3–5                       | 52 (83.9) |    | 53 (85.5) |    | 44 (71.0) |    |
| 6–8                       | 47 (85.5) |    | 53 (96.4) |    | 40 (72.7) |    |
| 9–11                      | 48 (85.7) |    | 54 (96.4) |    | 38 (67.9) |    |
| 12–14                     | 52 (88.1) |    | 51 (86.4) |    | 42 (71.2) |    |
| District                  |    |    |    |
| Xigaze                    | 122 (76.3) | 0.03 | 127 (79.4) | <0.01 | 106 (66.3) | 0.27 |
| Lhasa                     | 129 (86.0) |    | 140 (93.3) |    | 108 (72.0) |    |
| Xinjiang Uygur Autonomous Region |    |    |    |
| Sex                       |    |    |    |
| Male                      | 348 (94.8) | 0.12 | 363 (98.9) | 0.51 | 340 (92.6) | 0.82 |
| Female                    | 227 (97.4) |    | 229 (98.3) |    | 217 (93.1) |    |
| Age group (yr)            |    |    |    |
| 0–2                       | 106 (90.6) | <0.01 | 113 (96.6) | 0.19 | 108 (92.3) | 0.13 |
| 3–5                       | 122 (100.0) |    | 122 (100.0) |    | 117 (95.9) |    |
| 6–8                       | 120 (97.6) |    | 122 (99.2) |    | 118 (95.9) |    |
| 9–11                      | 119 (96.0) |    | 123 (99.2) |    | 113 (91.1) |    |
| 12–14                     | 108 (94.7) |    | 112 (98.2) |    | 101 (88.6) |    |
| District                  |    |    |    |
| Kashgar                   | 147 (98.0) | 0.14 | 149 (99.3) | 0.39 | 144 (96.0) | 0.17 |
| Yili                      | 146 (97.3) |    | 149 (99.3) |    | 140 (93.3) |    |
| Urumqi                    | 140 (93.3) |    | 146 (97.3) |    | 134 (89.3) |    |
| Kezilesukeer              | 142 (94.7) |    | 148 (98.7) |    | 139 (92.7) |    |

a P1, poliovirus serotype 1; P2, poliovirus serotype 2; P3, poliovirus serotype 3. Chi-square tests were used to determine the association between demographic characteristics and seropositivity. P values indicate overall significance levels of difference by demographic characteristics.
serotypes in Xinjiang Uygur Autonomous Region, and 98.0%, 99.3%, and 96.0% were seropositive to P1, P2, and P3, respectively, in Kashgar, which was one of the 4 prefectures affected by WPV in the 2011 outbreak. Furthermore, the highest seroprevalences and GMTs for all three poliovirus serotypes were in Xinjiang Uygur Autonomous Region, where the WPV importation and outbreak occurred. A significantly lower rate of antibody seroprevalence was found among other districts not involved with the 2011 polio outbreak (antibody seroprevalence of <80% for all 3 serotypes in Xigaze, Tibet Autonomous Region). Therefore, there was a potentially higher risk of outbreak if WPV was imported into Yunnan Province or Tibet Autonomous Region.

That the highest prevalence of antibodies to P1 (98%) was seen in an area that experienced the spread of WPV type 1 less than 1 year later raises a critically important question: why did an imported WPV result in transmission in Xinjiang Uygur Autonomous Region? There are three plausible reasons for this. First, the subjects in our study may not be representative of the population in Xinjiang Uygur Autonomous Region, as children who are not reached by immunization activities may be less likely to be hospitalized in high-level hospitals. Second, the study subjects were children <15 years of age, and the immunity of adults was unknown. Adults were potential sources of WPV infection for children in their families, and WPV outbreaks have been characterized by a large proportion of adult cases in recent years (15–19). Finally, in addition to population immunity, other factors, including hygiene conditions, population density, and population mobility, etc., may affect WPV transmission. Another reason could be a decline in OPV coverage levels, but that is unlikely since there were no program changes between the study and the outbreak. The results proved the challenge of maintaining polio-free status in China, as widespread transmission of WPV may have been induced if WPV was also imported into the other 3 prefectures in Xinjiang Uygur Autonomous Region. However, based on the results from this study, the high prevalence of anti-polio antibodies in the population might have had an effect on limiting the extent and severity of WPV transmission compared to those of similar events in Africa and more recently in Europe (7, 8, 20). A total of 21 WPV cases were reported in a three-month span in 2011 following WPV importation (the first WPV case was in July 2011, and the last case was in October 2011) (14). In contrast, Tajikistan reported 458 laboratory-confirmed WPV cases from 35 of 61 administrative territories, with paralysis onset dates from 1 February to 4 July 2010 (7).

Our findings are consistent with the global polio literature. The highest antibody seroprevalence and GMTs in each age group were for P2 and the lowest was for P3. These results are similar to those of other countries, such as Brazil (21), Germany (22), the United States (23), Italy (24–27), Belgium (28), Greece (29), Netherlands (30), and South Africa (31). Nates and colleagues in Argentina found that humoral immunity to P3 declined significantly over time (32). Lower seroconversion rates have been observed for P3 following OPV immunization (33). Luchs and colleagues in Brazil demonstrated that seropositivity to P1 and P2 increased with increasing age and peaked in children 6 to 15 years old, while seropositivity to P3 declined with increasing age from 71.1% in children 0 to 5 years old to 51.8% in children older than 15 years (21). This is likely a result of low vaccine immunogenicity of P3 and/or low initial P3 antibody titers that eventually fell below the detection limits as time passed (34).

For all three polio serotypes, the highest seropositivity was in children 3 to 5 years old, and antibody seroprevalence decreased significantly with increasing age. A study in Uruguay found that antibody prevalence against all serotypes decreased with increasing age until at least 20 years of age, and seroprotection rates and GMTs were low in both adolescents and adults (35). The suboptimal antibody seroprevalence observed in elderly age groups was most likely due to waning immunity. Generally, the presence of antibody titers of ≥8 have been regarded as immunity to poliovirus. However, individuals with lower or undetectable antibody levels may be protected from poliomyelitis by immune memory that provides a rapid immune response to infection. But older age groups appear to be at a greater risk of infection in the case of WPV importation (36–38). Examples of importations in Albania and Namibia demonstrated the immunity gap among the elderly population (15, 19), and outbreaks reported in adults may be related to low levels of antibodies in these individuals (39).

Our study has several limitations, as indicated above. The study was based on convenience sampling, enrolling subjects hospitalized at the prefecture level or above. The seroprevalence of antibody against poliovirus may be overestimated, as the children who are not reached by immunization activities may be less likely to be hospitalized in high-level hospitals. Second, the immunity of adults was not measured in this study. Finally, immunization history and detailed demographics were not available in this study. We were therefore unable to estimate the actual waning effect of immunity induced by OPV with increasing age, as well as the factors associated with population immunity.

Two recommendations arise from the study findings. First, a more representative study targeting all age groups should be conducted in border provinces in the future. This could be accomplished through a sampling strategy that relies on a locally representative population rather than a hospital-based population. Second, given the waning immunity observed in this study, and given that the Xinjiang outbreak involved transmission among adults, consideration should be given for inclusion of a booster dose of OPV for teenagers (38); bivalent type 1 and 2 OPV (bOPV) may be a good choice, as type 2 WPV has been eradicated worldwide.

In conclusion, Xinjiang Uygur Autonomous Region had the highest seroprevalence and GMTs among the three border provinces in 2010, but WPV was imported into Xinjiang Uygur Auton-
omous Region and resulted in limited transmission in 2011. The risk of WPV importation will continue until WPV transmission has been interrupted worldwide. For China to maintain its polio-free status, adequate population immunity must be maintained. Program performance measures and representative serologic surveys can help ensure population protection. Because immunity waned with increasing age, a booster dose of bOPV should be considered for teenagers.

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### TABLE 3 GMTs of P1, P2 and P3 by demographical characteristics in 3 provinces

| Region and characteristic | P1 GMT | P value | P2 GMTs | P value | P3 GMT | P value |
|---------------------------|--------|---------|---------|---------|--------|---------|
| **Yunnan Province**       |        |         |         |         |        |         |
| Sex                       |        |         |         |         |        |         |
| Male                      | 30.1 (25.3–35.8) | 0.26   | 30.7 (26.3–36.0) | 0.83   | 16.8 (14.2–19.9) | 0.37   |
| Female                    | 35.1 (28.7–42.8) |       | 31.5 (26.4–37.6) |       | 18.9 (15.6–22.8) |       |
| Age group (yr)            |        |         |         |         |        |         |
| 0–2                       | 53.2 (38.1–74.3) | <0.01  | 52.8 (40.0–69.6) | <0.01  | 34.6 (24.6–48.5) | <0.01  |
| 3–5                       | 50.2 (38.6–65.2) |       | 45.1 (35.4–57.4) |       | 22.0 (17.0–28.5) |       |
| 6–8                       | 29.8 (22.0–40.4) |       | 30.3 (23.3–39.4) |       | 17.4 (12.6–24.2) |       |
| 9–11                      | 27.0 (21.0–34.8) |       | 23.3 (18.3–29.7) |       | 12.1 (9.9–14.8)  |       |
| 12–14                     | 15.8 (12.5–19.9) |       | 17.1 (13.7–21.4) |       | 10.6 (8.7–12.8)  |       |
| District                  |        |         |         |         |        |         |
| Lincang                   | 24.7 (20.0–30.6) | 0.02   | 20.1 (16.6–24.2) | <0.01  | 10.9 (9.1–13.0)  | <0.01  |
| Baoshan                   | 37.1 (29.8–46.1) |       | 38.3 (31.8–46.2) |       | 18.6 (15.4–22.5) |       |
| Dehong                    | 36.1 (28.3–46.1) |       | 39.0 (31.5–48.4) |       | 27.0 (20.9–34.9) |       |
| **Tibet Autonomous Region** |      |         |         |         |        |         |
| Sex                       |        |         |         |         |        |         |
| Male                      | 34.3 (26.5–44.4) | 0.94   | 33.9 (27.2–42.3) | 0.78   | 12.2 (9.9–15.0) | 0.86   |
| Female                    | 33.8 (25.1–45.5) |       | 35.6 (27.0–47.1) |       | 11.8 (9.3–15.1) |       |
| Age group (yr)            |        |         |         |         |        |         |
| 0–2                       | 24.3 (15.5–38.0) | 0.19   | 22.8 (15.3–34.2) | 0.04   | 11.9 (8.5–16.7) | 0.47   |
| 3–5                       | 44.8 (27.8–72.0) |       | 42.8 (27.7–66.1) |       | 15.6 (10.5–23.3) |       |
| 6–8                       | 45.5 (30.5–68.1) |       | 43.9 (31.5–61.1) |       | 12.6 (9.0–17.7) |       |
| 9–11                      | 32.4 (21.5–48.8) |       | 45.3 (32.9–62.3) |       | 10.0 (7.1–14.0) |       |
| 12–14                     | 32.0 (21.8–47.1) |       | 29.8 (20.8–42.8) |       | 10.6 (7.5–15.0) |       |
| District                  |        |         |         |         |        |         |
| Xigaze                    | 31.5 (23.4–42.2) | 0.41   | 32.0 (24.4–42.0) | 0.36   | 11.4 (9.0–14.4) | 0.49   |
| Lhasa                     | 37.1 (28.8–47.7) |       | 37.6 (30.5–46.4) |       | 12.8 (10.3–15.8) |       |
| **Xinjiang Uygur Autonomous Region** |      |         |         |         |        |         |
| Sex                       |        |         |         |         |        |         |
| Male                      | 126.6 (107.9–148.4) | 0.12  | 159.6 (139.6–182.4) | 0.66  | 45.4 (39.2–52.6) | 0.95  |
| Female                    | 153.9 (128.3–184.6) |       | 167.3 (142.0–197.1) |       | 45.7 (38.4–54.5) |       |
| Age group (yr)            |        |         |         |         |        |         |
| 0–2                       | 157.5 (114.4–216.9) | <0.01  | 241.3 (187.5–310.4) | <0.01  | 77.4 (58.3–102.6) | <0.01  |
| 3–5                       | 277.2 (226.9–338.6) |       | 223.1 (182.0–273.4) |       | 72.1 (57.2–91.0) |       |
| 6–8                       | 143.3 (115.8–177.3) |       | 142.5 (115.9–175.1) |       | 39.9 (32.2–49.3) |       |
| 9–11                      | 115.7 (89.9–149.1) |       | 125.9 (99.5–159.2) |       | 35.4 (28.2–44.4) |       |
| 12–14                     | 62.8 (47.1–83.8) |       | 117.6 (93.0–148.6) |       | 24.5 (19.1–31.4) |       |
| District                  |        |         |         |         |        |         |
| Kashgar                   | 148.4 (118.7–185.5) | 0.25  | 189.6 (154.7–232.3) | 0.07  | 45.5 (37.3–55.4) | 0.23  |
| Yili                      | 151.9 (119.9–192.4) |       | 164.3 (134.0–201.4) |       | 52.7 (41.7–66.6) |       |
| Urumqi                    | 159.1 (106.7–181.3) |       | 172.6 (137.9–216.1) |       | 47.4 (36.9–60.9) |       |
| Kezilesuiker              | 110.9 (87.5–140.6) |       | 129.8 (107.0–157.5) |       | 37.8 (30.5–46.9) |       |

P1, poliovirus serotype 1; P2, poliovirus serotype 2; P3, poliovirus serotype 3. Analysis of variance was used to compare the difference of geometric mean titers (GMTs) after logarithm transformation among different demographic characteristics. P values indicate overall significance levels of difference by demographic characteristics.
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