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Seroepidemiology of diphtheria and tetanus among children and young adults in Tajikistan: Nationwide population based survey, 2010*

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Abstract

Background: Tajikistan had a major diphtheria outbreak (~10,000 cases) in the 1990s, which was controlled after nationwide immunization campaigns with diphtheria-tetanus toxoid in 1995 and 1996. Since 2000, only 52 diphtheria cases have been reported. However, in coverage surveys conducted in 2000 and 2005, diphtheria-tetanus-pertussis vaccine coverage was lower than administratively reported estimates raising concerns about potential immunity gaps. To further assess population immunity to diphtheria in Tajikistan, diphtheria antibody testing was included in a large-scale nationwide serosurvey for vaccine-preventable diseases conducted in connection with a poliomyelitis outbreak in 2010. In addition, the serosurvey provided an opportunity to assess population immunity to tetanus.

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Disclaimer: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of CDC. Some of the co-authors are staff members of the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions, policy or views of the World Health Organization. The findings of this study were presented in part at the 30th Meeting of the European Society for Paediatrics Infectious Diseases (ESPID 2012), May 8-12, 2012, Thessaloniki, Greece. Abstract: N. Khetsuriani, K. Zakikhany, A. Efstratiou, S. Jabirov, N. Saparova, N. Sinavbarova, K. Broughton, J. Glumac, K. Wannemuehler, R. Martin. Diphtheria and tetanus seroepidemiology among children and young adults in Tajikistan, 2010.

Conflicts of interest: None declared by any co-author.

Methods: Residents of all regions of Tajikistan aged 1–24 years were included in the serosurvey implemented during September–October 2010. Participants were selected through stratified cluster sampling. Specimens were tested for diphtheria antibodies using a Vero cell neutralization assay and for tetanus antibodies using an anti-tetanus IgG ELISA. Antibody concentrations ≥0.1 IU/mL were considered seropositive.

Results: Overall, 51.4% (95% CI, 47.1%–55.6%) of participants were seropositive for diphtheria and 78.9% (95% CI, 74.7%–82.5%) were seropositive for tetanus. The lowest percentages of seropositivity for both diseases were observed among persons aged 10–19 years: diphtheria seropositivity was 37.1% (95% CI, 31.0%–43.7%) among 10–14 year olds, and 35.3% (95% CI, 29.9%–41.1%) among 15–19 year olds; tetanus seropositivity in respective age groups was 65.3% (95% CI, 58.4%–71.6%) and 70.1% (95% CI, 64.5%–75.2%).

Conclusions: Population immunity for diphtheria in Tajikistan is low, particularly among 10–19 year-olds. Population immunity to tetanus is generally higher than for diphtheria, but is suboptimal among 10–19 year-olds. These findings highlight the need to improve routine immunization service delivery, and support a one-time supplementary immunization campaign with diphtheria-tetanus toxoid among birth cohorts aged 1–19 years in 2010 (3–21 years in 2012) to close immunity gaps and prevent diphtheria outbreaks.

Keywords

Diphtheria; Tetanus; Population immunity; Susceptibility; Seroprevalence; Tajikistan

1. Introduction

Tajikistan, along with other republics in Central Asia had high incidence of diphtheria in the pre vaccine era. Following successful implementation of routine childhood immunization since late 1950s, diphtheria incidence declined from >70 per 100,000 in 1959 to 0.2–0.3 per 100,000 during the 1970s, and remained low during the 1980s despite localized outbreaks. However, during 1993–1998, Tajikistan had a major diphtheria outbreak; approximately 10,000 diphtheria cases and 800 deaths were reported, with peak incidence of 76.2 per 100,000 in 1995 [1,2]. This outbreak was part of a large-scale resurgence in epidemic diphtheria in former Soviet Union countries in the 1990s [3]. The true burden of the outbreak in Tajikistan was likely much higher as surveillance was severely disrupted by the civil war during 1992 to 1997. To control the outbreak, nationwide supplementary immunization activities (SIAs) with diphtheria-tetanus toxoid were implemented in 1995 (targeting persons aged 3–50 years) and in 1996 (targeting persons aged 15–50 years) [2]. Overall, 52 diphtheria cases were reported in Tajikistan since 2000 [1]. However, the quality of surveillance is uncertain and the laboratory capacity for diphtheria case confirmation is very limited, resulting in the potential for missing cases and difficulties of timely outbreak detection.

Presently, the routine childhood immunization schedule in Tajikistan follows World Health Organization recommendations [4] and includes three doses of pentavalent vaccine containing diphtheria, tetanus, whole cell pertussis, *Haemophilus influenzae* type B, and hepatitis B (DTwP-HiB-HepB) components at 2, 4, and 6 months, followed by one dose

of diphtheria, tetanus, whole cell pertussis (DTwP) vaccine at 16–23 months, and one dose of diphtheria-tetanus (DT) toxoid at 6 years of age. Administratively reported routine immunization coverage for Tajikistan during 2000–2011 ranged from 88% to 99% for DTP1 (first dose of diphtheria-tetanus-pertussis vaccine) and from 86% to 97% for DTP3 (three doses of DTP), with the lowest reported coverage in 2007 (88% for DTP1 and 86% for DTP3); DTP1 DTP3 dropout during 2000–2011 was 2% to 6% [5]. National coverage estimated by the World Health Organization (WHO) and UNICEF during 2000–2011 ranged from 88% to 96% for DTP1 and 83% to 93% for DTP3, with DTP1-DTP3 dropout of 2% to 8%. In Multiple Indicator Cluster Surveys, DPT3 coverage was 76% with 8% DTP1-DTP3 dropout in 2000 and DTP3 coverage was 82% with 9% DTP1-DTP3 dropout in 2005 [6,7].

The present study was part of a nationwide population-based serosurvey conducted after a large scale importation-related poliomyelitis outbreak was reported in Tajikistan in 2010 [8]. The scale and explosive nature of the poliomyelitis outbreak highlighted problems with the performance of immunization service delivery and surveillance systems, and indicated the potential for outbreaks of other vaccine-preventable diseases (VPDs). The history of previous diphtheria outbreaks during the early 1990s and uncertainties about immunization coverage raised concerns about potential immunity gaps and the risk of future diphtheria outbreaks. The serosurvey provided an opportunity to also explore population immunity against tetanus. The serosurvey was a collaborative effort between the Ministry of Health (MOH) of Tajikistan, the United States Centers for Disease Control and Prevention (CDC), the WHO Regional Office for Europe, the WHO Country Office in Tajikistan, and the United Kingdom's Health Protection Agency (HPA). The diphtheria-tetanus-related objectives of the serosurvey were to assess population immunity among children and young adults aged 1–24 years), detect potential immunity gaps, and develop strategies to address identified problems.

2. Methods

2.1 Survey design

Residents of all regions of Tajikistan aged 1–24 years (age groups 1–4, 5–9, 10–14, 15–19, 20–24 years), were included in the serosurvey implemented during September–October 2010. The age groups sampled and sample sizes were determined to allow achieving the primary objective of the serosurvey–assessment of population immunity against polioviruses by age group. However, for the analysis of diphtheria and tetanus seroprevalence, the age groups under 10 years were modified to 1–2, 3–6, 7–9 to correspond to the diphtheria-tetanus immunization schedule in Tajikistan. The details of sampling and participant selection procedures are reported elsewhere in a separate manuscript describing the polio component of the serosurvey [9]. Participants were selected through stratified multi-stage cluster sampling. Potential participants were identified from registries maintained at government health care facilities. The vast majority of the residents of Tajikistan receive health care services, including immunizations, at government health facilities. The health facility registries include persons living in the respective catchment area and provide information on their age and residence. The registries for children were updated during preparation for the SIAs in response to the poliomyelitis outbreak to include previously

unregistered persons. After obtaining verbal consent from participants or their guardians, and providing them with the survey information sheet, a brief questionnaire including demographic information was completed and 3–5 mL of venous blood was obtained.

The serosurvey protocol was reviewed by the Human Subjects Research Coordinator at the National Center for Immunization and Respiratory Diseases, CDC and determined to be a program evaluation, and therefore exempt from institutional review board approval. The protocol was also approved by the Ministry of Health of Tajikistan.

2.2 Laboratory testing

Blood (3–5 ml, without anticoagulants, in serum separation tubes) was obtained by venipuncture. Specimens were centrifuged at district level and stored refrigerated until delivered to the National Measles and Rubella Laboratory (NMRL) in Dushanbe. At the NMRL, serum was split into three aliquots (for poliovirus, measles-rubella and diphtheria-tetanus antibody testing) and stored at −20 °C until shipped by air on dry ice for testing to the WHO Diphtheria Reference Laboratory, HPA, London, UK. If the specimen amount was insufficient for all three aliquots, the highest priority was given to poliomyelitis, followed by diphtheria and tetanus.

Specimens were tested for antibodies against diphtheria and tetanus at the HPA. For diphtheria antibody testing, the in-house Vero cell neutralization assay was used. An antibody concentration of 0.01 IU/mL is the lowest level giving some degree of protection and 0.1 IU/mL is considered a protective level of circulating antibodies; antibody concentrations of ≥1.0 IU/mL are associated with long term protection [10]. For this study, persons having diphtheria antibody concentrations <0.1 IU/mL were considered seronegative and persons with antibody concentrations ≥0.1 IU/mL were considered seropositive [10]. Tetanus IgG antibody con centrations were determined by enzyme-linked immunosorbent assay (ELISA). Persons with tetanus antibody concentrations <0.1 IU/mL were considered seronegative and those with antibody concentrations ≥0.1 IU/mL were considered seropositive [11].

2.3 Data analysis

Statistical analysis of the data was conducted using SAS v9.3 (Cary, NC, USA) and SUDAAN v10 (Research Triangle PARK, NC, USA). Seroprevalence was analyzed by age group (modified to correspond to the diphtheria-tetanus routine immunization schedule) and by region. Seroprevalence estimates and 95% confidence intervals (CI) were calculated taking into account the stratified cluster sampling design and weights scaled to approximate the population of each region by age group. A descriptive summary of paired diphtheria-tetanus seroprevalence results is provided to help assess potential factors contributing to seronegativity in Tajikistan (e.g., lack of immunization, incomplete immunization, or waning immunity).

3. Results

In total, 2582 participants were enrolled; 123 were excluded for the following reasons: inferior specimen quality ($n = 100$), insufficient specimen quantity for testing ($n = 10$),

no questionnaire provided (n = 9), and age >24 years (n = 4), resulting in 2459 eligible participants. Of these, specimens from 2325 participants were available for testing for diphtheria antibodies and 2319 samples were available for testing for tetanus antibodies. Demographic characteristics of the participants are described in the polio report of the present serosurvey [9].

Overall, 51.4% (95% CI, 47.1%–55.6%) of participants were seropositive for diphtheria (Table 1); of these, diphtheria antibody concentrations were 0.1–0.99 IU/mL for 34.7% (95% CI, 31.1%–38.5%) and ≥1.0 IU/mL for 16.7% (95% CI, 14.4%–19.3%) (Table 2). Of seronegative participants, 22.4% (95% CI, 19.1%–26.0%) had no detectable antibodies and 26.2% (95% CI, 24.3%–28.2%) had antibody concentrations 0.01–0.09 IU/mL (Table 2). Diphtheria seropositivity was highest among 20–24 year-olds (67.8%; 95% CI, 63.0%–72.2%) and 1–2 year-olds (65.0%; 95% CI, 57.6%–71.7%), and lowest among persons aged 15–19 years (35.3%; 95% CI, 29.9%–41.1%) and 10–14 years (37.1%; 95% CI, 31.0%–43.7%) (Table 1). The highest proportion of persons with no detectable antibodies was found among persons aged 10–14 years (35.5%; 95% CI, 29.9%–41.4%) and 15–19 years (29.3%; 95% CI, 24.2%–35.1%). Seropositivity was lowest among participants in Kulyab (38.8%; 95% CI, 35.2%–42.4%), Rayons of Republican Subordination (RRS) (44.8%; 95% CI, 31.5%–59.0%), and Kurgan-Tube (51.8%; 95% CI, 44.2%–59.4%) regions (Table 1).

Overall, 78.9% (95% CI, 74.7%–82.5%) of participants were seropositive for tetanus (Table 1). Across age groups, the estimated proportion of seropositive persons was >90% among 1–2 year-olds and 20–24 year-olds; seropositivity was lowest among persons aged 10–14 years (65.3%; 95% CI, 58.4%–71.6%) and 15–19 years (70.1%; 95% CI, 64.5%–75.2%). Across regions, tetanus seropos itivity was >90% only in Gorno-Badakhshan Autonomous Oblast (GBAO) and was lowest in Kulyab (67.2%; 95% CI, 61.0%–72.8%), RRS (70.9%, 95% CI, 59.1%–80.4%), and Kurgan-Tube (78.9%, 95% CI, 73.0%–83.5%) (Table 1).

Among persons tested for both diphtheria and tetanus antibodies, 51.7% were seropositive for both, 27.4% were seropositive for tetanus and seronegative for diphtheria, and 19.9% were seronegative for both (Table 3). Overall, 23 (1.0%) participants were seronegative for tetanus but seropositive for diphtheria; of these, 13 (56.5%) were born during 1992–1999.

4. Discussion

The findings of the serosurvey revealed serious diphtheria immunity gaps among children and young adults in Tajikistan. In 2010, almost half of the general population aged 1–24 years did not have a protective level of circulating diphtheria antibodies including >20% without detectable antibodies. This high level of susceptibility is comparable to the levels found in the countries of ex-USSR during large-scale diphtheria outbreak of the 1990s [12–15]. Consistent with the diphtheria disease and immunization history in Tajikistan, diphtheria immunity was highest among 20–24 year-olds, the age group exposed to the outbreak of the 1990s, and targeted by a diphtheria-tetanus SIA in 1995. The lowest level of protection was found among persons aged 10–19 years. Most of the birth cohorts in this age group were too young to be included in the 1995 SIA and relied for diphtheria immunity exclusively on routine immunization services, which experienced serious disruptions during

and after the 1992–1997 civil war. In addition, those born after the major outbreak has ended in 1998, had very limited opportunities for acquiring immunity through natural exposure. The higher seroprevalence among 1–9 year old children reflects improved routine immunization services in Tajikistan in the last decade, but overall immunity is low in this age group too. The high proportion of individuals with no detectable antibodies, particularly among 10–19 year-olds, indicates that in these age groups, there are large numbers of persons who have not been primed and for whom at least two doses of diphtheria-containing toxoid will be needed for seroprotection [10].

The diphtheria immunity gap among children in Tajikistan is especially worrying, as it indicates the lack of population protection by herd immunity among children and suggests high risk of outbreaks. Low diphtheria seropervalence among adults has been observed in other countries [16–20]. However, herd immunity among children has been suggested as protective factor preventing diphtheria outbreaks in these populations. For example, in a large pan European diphtheria serosurvey conducted across seven countries in Western Europe (England and Wales, Finland, France, Italy, Sweden, The Netherlands, and West Germany) in the 1990s [16], and in recent studies conducted in Turkey, France, Belgium, and Luxembourg [17–20], 40%–80% of adults aged >40 years were seronegative, but 75%–99% of toddlers and schoolchildren were seropositive; none of these countries had diphtheria outbreaks in recent past. In contrast, low diphtheria seropositivity among adults together with suboptimal population immunity among children in countries of former Soviet Union led to large scale outbreaks with wide age range in the 1990s [2,3,12–15,21–25]. The findings of this serosurvey raise concerns that substantial immunity gaps for diphtheria might potentially be present among children and young adults in other countries of former Soviet Union with comparable history of diphtheria epidemiology and immunization programs. In general, any country with underperforming immunization system could potentially face similar problems, underscoring the importance of ensuring high quality of immunization service delivery globally. Comprehensive assessments of diphtheria situation, including surveillance review, validation of immunization coverage, and serosurveys, as needed, would be helpful for assessing the risk of potential future diphtheria outbreaks in individual countries.

Population immunity to tetanus in Tajikistan was higher than to diphtheria, likely due to higher immunogenicity of tetanus toxoid [10], but age specific seroprevalence for tetanus and diphtheria generally followed the same trends, consistent with the use of combination vaccines containing diphtheria-tetanus toxoids. Comparison of immunity to tetanus and diphtheria among persons tested for both seromarkers revealed that both lack of immunization and incomplete immunization may have contributed to diphtheria susceptibility. Approximately 20% of participants were seronegative for both diphtheria and tetanus, suggesting that they were likely never vaccinated. In addition, more than 25% were seropositive for tetanus but seronegative for diphtheria, suggesting incomplete immunization. Waning of diphtheria antibodies over time in the absence of natural or vaccine-induced boosting could have contributed to low seroprevalence [10]. Among children 1–2 years of age in this survey who are not likely to have waning immunity, ~90% were seropositive for tetanus antibody indicating they received at least one DPT dose, but ~35%% were seronegative for diphtheria antibody, indicating they might not have

completed the immunization schedule. These findings suggest that previous assessments of dropout between DTP1 and DTP3 doses in Tajikistan (<10%) [5–7] have underestimated the true extent of incomplete immunization.

There were consistent geographic trends in seroprevalence across regions of Tajikistan. Generally, RRS, Kurgan-Tube and Kulyab had lower proportion of protected individuals than Dushanbe, Sogd and GBAO. These findings are consistent with geographic trends observed for polio and measles vaccine coverage in the 2005 Tajikistan Living Standards Measurement Survey [26] and suggest particular problems with delivery of routine immunizations in these regions. In the polio component of the present serosurvey, the same three regions (RRS, Kurgan-Tube and Kulyab) had the lowest seropevalence for poliovirus type 3 (PV3) among children aged 1–4 years [9].

The low diphtheria antibody seroprevalence in this serosurvey, particularly for age groups immunized only through routine services, is in line with lower seroprevalence for PV3 in the birth cohorts who received immunizations through routine program only, versus birth cohorts targeted by polio SIAs during 1995–2002 [9]. There results highlight long-standing weaknesses of the routine immunization program in Tajikistan and support the need for a diphtheria-tetanus SIA as a one-time measure to close immunity gaps and prevent future outbreaks. Large-scale nationwide SIAs targeting children and adults up to age 59 years with diphtheria-tetanus toxoids were widely implemented in the countries of former Soviet Union to control diphtheria outbreaks during the 1990s and have proven to be both effective and safe [21–25]. Based on the serosurvey results and taking into account historic data on diphtheria incidence, past SIAs, and WHO/UNICEF estimates of DTP3 coverage [5–7,10,26], the target for the SIA should be persons who were aged 1–19 years during the 2010 serosurvey (birth years, 1991–2009). Persons targeted for the SIA should receive age-appropriate diphtheria-tetanus toxoid i.e., DT for 3–6 year olds and a Td (adult formulation tetanus-diphtheria toxoid) for persons aged ≥7 years.

One dose of toxoid given in SIA would not be able to induce high seroprevalence of protective levels of immunity in the 10–19 year old age group, which has 29.3%–35.5% of persons without detectable diphtheria antibodies. For unvaccinated persons aged ≥1 year, three doses of toxoid (two doses given at least one month apart followed by the third dose after ≥6 months) are recommended for achieving protection [4]. However, tetanus seroprevalence data from this serosurvey show that substantial proportion of persons (at least 65%–70%) in the 10–19 year-old age group have likely received at least one dose of diphtheria-tetanus toxoid. Therefore, we considered that two additional toxoid doses given in SIA would be sufficient for achieving substantial increase in the prevalence of protective levels of anti-diphtheria antibodies in these birth cohorts. The epidemiologic data from a diphtheria outbreak in the 1990s in Georgia demonstrated that the receipt of at least 2 doses of diphtheria toxoid significantly reduced the risk of severe illness and death [23]. Therefore, in the proposed SIA, we recommended one dose of age-appropriate vaccine for the 2001–2009 birth cohorts and two doses of Td toxoid at least one month apart for the 1991–2000 birth cohorts (Table 4). Including children aged <3 years in the SIA would not be advisable, as they should receive combination vaccines also containing pertussis, HiB and hepatitis B

antigens and experience of large-scale mass campaigns using these combination vaccines is lacking.

Tajikistan has a history of successful implementation of nationwide SIAs in the 1990s, such as diphtheria-tetanus SIAs [2], a measles SIA in 2004, a measles-rubella SIA in 2009 [27] and multiple polio SIAs as part of Operation MECACAR [28] and in response to the 2010 outbreak [8]. However, SIAs should not be viewed as a "replacement" for routine immunization services and, due to very high resource requirements, should be reserved for special situations only. There is clearly an urgent need to strengthen routine immunization services in Tajikistan, particularly in RRS, Kurgan-Tube and Kulyab regions.

By the time of this report, the SIA targeting over 700,000 children aged 3–6 years with one dose of DT has been implemented by the MOH of Tajikistan (23–28 April, 2012) with very high (98.8%) administratively reported coverage, and the SIAs with Td among 7–21 year age group were underway. Successful implementation of these SIAs should close the immunity gap detected by the serosurvey and reduce the risk of large-scale outbreak, thereby allowing focusing on strengthening the routine immunization program in Tajikistan.

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Table 1

Seropositivity (antibody concentration ≥0.1 IU/mL) for diphtheria and tetanus by age group and region, Tajikistan, 2010.

Variables	Diphtheria				Tetanus			
	Tested, No.	Seropositive (≥0.1 IU/mL)			Tested, No.	Seropositive (≥0.1 IU/mL)		
		No.	%	95% CI		No.	%	95% CI
Overall	2325	1225	51.4	47.1–55.6	2319	1835	78.9	74.7–82.5
By age group								
1–2 years	208	136	65.0	57.6–71.7	206	186	90.7	86.0–94.0
3–6 years	422	248	58.2	52.9–63.4	420	356	85.1	79.6–89.3
7–9 years	272	174	62.6	54.5–70.1	271	221	81.4	71.8–88.3
10–14 years	514	201	37.1	31.0–43.7	513	341	65.3	58.4–71.6
15–19 years	475	174	35.3	29.9–41.1	475	332	70.1	64.5–75.2
20–24 years	434	292	67.8	63.0–72.2	434	399	92.3	88.3–95.0
By region								
Dushanbe	396	266	66.7	59.7–73.1	393	335	85.0	82.4–87.3
RRS	457	201	44.9	31.5–59.0	456	320	70.9	59.1–80.4
Kurgan Tube	427	224	51.8	44.2–59.4	426	336	78.7	73.0–83.5
Kulyab	392	153	38.8	35.2–42.4	392	266	67.2	61.0–72.8
Sogd	497	283	55.7	50.3–61.0	496	435	87.0	82.7–90.4
GBAO	156	98	62.4	59.7–65.1	156	143	91.5	76.9–97.2

RRS, Rayons of Republican Subordination; GBAO, Gorno Badakhshan Autonomous Oblast.

Table 2

Population immunity by diphtheria antibody concentration[a] and age group, Tajikistan, 2010.

Variables	Tested, No.	Seronegative (<0.1 IU/mL)						Seropositive (≥0.1 IU/mL)					
		<0.01 IU/mL			0.01–0.09 IU/mL			0.1–0.99 IU/mL			≥1.0 IU/mL		
		No.	%	95% CI	No.	%	95% CI	No.	%	95% CI	No.	%	95% CI
Overall	2325	502	22.4	19.1–26.0	598	26.2	24.3–28.2	808	34.7	31.1–38.5	417	16.7	14.4–19.3
By age group													
1–2 years	208	26	12.9	8.8–18.4	46	22.1	15.7–30.1	75	38.1	32.9–43.5	61	26.9	20.1–35.1
3–6 years	422	75	17.8	13.1–23.6	99	24.0	20.1–28.5	149	34.9	30.0–40.1	99	23.3	19.7–27.4
7–9 years	272	56	21.7	14.9–30.4	42	15.7	11.2–21.6	73	26.8	21.1–33.4	101	35.8	28.9–43.4
10–14 years	514	173	35.5	29.9–41.4	140	27.4	23.4–31.9	134	25.0	20.4–30.2	67	12.1	7.7–18.7
15–19 years	475	136	29.3	24.1–35.1	165	35.4	32.1–39.0	145	29.5	24.3–35.3	29	5.8	3.8– 8.7
20–24 years	434	36	8.1	5.4–12.0	106	24.1	20.7–27.9	232	54.4	49.1–59.6	60	13.4	10.1–17.4

[a] An antibody concentration of 0.01 IU/mL is the lowest level giving some degree of protection for diphtheria, concentrations ≥0.1 IU/mL are considered a fully protective level of circulating antibodies; antibody concentrations of ≥1.0 IU/mL are associated with long term protection [10].

Table 3

Tetanus and diphtheria seroprevalence among participants tested for both antibodies.

Age groups	Total tested for both antibodies, No.	Seropositive for both		Tetanus-seropositive, Diphtheria-seronegative		Tetanus seronegative, diphtheria seropositive		Seronegative for both	
		No.	%	No.	%	No.	%	No.	%
1–2 years	206	133	64.6	53	25.7	2	1.0	18	8.7
3–6 years	420	244	58.1	112	26.7	2	0.5	62	14.8
7–9 years	271	171	63.1	50	18.5	3	1.1	47	17.3
10–14 years	513	198	38.6	143	27.9	2	0.4	170	33.1
15–19 years	475	162	34.1	170	35.8	12	2.5	131	27.6
20–24 years	434	290	66.8	109	25.1	2	0.5	33	7.6
Total	2319	1198	51.7	637	27.4	23	1.0	461	19.9

Table 4

Target age groups, vaccine type and number of doses for the diphtheria-tetanus supplemental immunization activity in Tajikistan, 2012.

Birth years	Target groups, age in 2012	Vaccine type	Number of doses
2006–2009	3–6 years	DT	1
2001–2005	7–11 years	Td	1
1991–2000	12–21 years	Td	2

DT, diphtheria-tetanus toxoid

Td–adult formulation tetanus diphtheria toxoid.