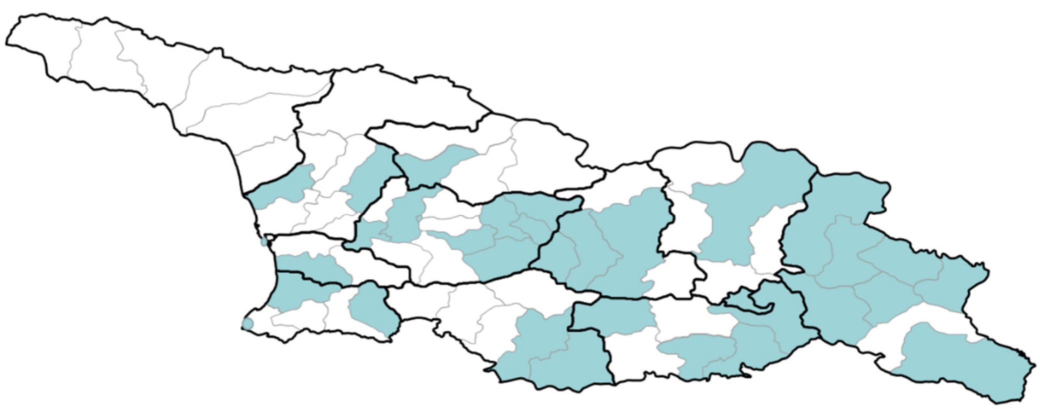
Immunization Coverage Survey in Georgia, 2015-2016

Final Report



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Contents

Executive Summary

- Although immunization services in Georgia have improved in the last decade, national estimates of coverage remain below the national target of 95% for most antigens and their accuracy is unclear due to difficulties with determining target populations. There has not been any independent validation of the administrative coverage data in Georgia since 2000. Therefore, we conducted nationwide immunization coverage survey during 2015-2016.
- We assessed coverage with all vaccines included in the routine immunization schedule through 5 years of age. Because of greater uncertainties with accuracy of reported coverage data in large cities, the survey was designed to allow separate estimates for three largest cities of Georgia – Tbilisi, Batumi, and Kutaisi, which together account for 38% of total population of the country, and the rest of Georgia. We included in the survey children who were eligible for routine immunizations in 2014: birth cohorts of 2014 (eligible to receive in 2014 vaccines recommended during the 1st year of life), 2013 (eligible to receive in 2014 vaccines recommended during the 2nd year of life), and 2009 (eligible to receive in 2014 vaccines recommended during the 6th year of life).
- The lists of children born in 2014, 2013, and 2009 from the Civil Registry data base which includes all children born in Georgia, whether they are registered with health care facility (HCFs) or not, and is linked to the Immunization Management Module of the e-Health system, was used as a survey sampling frame.
- A complex stratified multi-stage design was used for the survey. The country was divided into 4 survey domains - the 3 largest cities and the rest of the country. A sample size of 750 per birth cohort was allocated to Tbilisi, 600 - to Batumi and Kutaisi, and 800 - to the rest of Georgia, resulting in a total of 2750 children per birth cohort nationwide, and a total a sample size of 8250 children. Immunization information was obtained from HCF records. The children who could not be found were not substituted by selecting another child. To accommodate the timeframes of availability of staff and funding, the survey was implemented sequentially (in Batumi - in August 2015, in Kutaisi - in September 2015, in Tbilisi - in March 2016, and in the rest of Georgia – in August-October 2016).
- The statistical software Epi Info 7 was used for data entry. Analysis was conducted using SAS v9.4 and R v3.3. Analyses accounted for the complex survey design and sampling weights. Main outcome measures included per cent coverage (at the time of the survey and timely coverage at standard time points) and Wilson-Score 95% confidence intervals for proportions for each vaccine dose. Estimates of time to reach a specified proportion vaccinated with a given dose (50%, 80%, 90%, and 95%), and the proportion being vaccinated by a given point in time were captured from the Kaplan-Meier curves. The survey estimates were compared to the national target and to corresponding administratively reported coverage. Response rates for the survey were very high - in all birth cohorts and survey sites, >90% of eligible participants were enrolled (range, 90.4%-98.0%).
- Overall, the survey in Georgia revealed a well-developed, accessible and functioning routine immunization program in place throughout the country which has coped with challenges associated with changing landscape of health care system. The program provides adequate access to immunization services as judged

by very high proportion of children (>95%) who received at least one recommended vaccine dose by the time of the survey. However, not all children utilize the system to full extent and complete the recommended series.

- Immunization program performance, as judged by coverage, timeliness and dropout rates, has generally improving trend, but geographic variations are present. There are certain weaknesses with various aspects of immunization process – initiating vaccinations, completing the recommended series, and vaccinating on time. These weaknesses lead to suboptimal coverage for some vaccine doses, particularly the ones recommended after the 1st year of life, and prevent the country from consistently achieving the national immunization targets.
- Overall, immunization services appear strongest in Batumi, followed by the rest of Georgia and Tbilisi, and weakest – in Kutaisi, where the program is underperforming to a substantial extent.
- The overall national target of 95% coverage for all antigens was not met, but by the time of the survey, 95% coverage was achieved nationwide for Penta1/DTP1 and Pol1 in all cohorts. Batumi, with ≥95% coverage for most major vaccines, was closest to achieving the overall target, followed by the rest of Georgia and Tbilisi, which have achieved ≥95% coverage for some vaccine doses.
- Immunization coverage at the time of the survey was in the moderate to high range for most vaccinations recommended during the 1st year of life, but lower for vaccinations recommended after 12 months of age, particularly, for vaccine doses recommended at 5 years. Coverage and timeliness of vaccinations declined with the increase of recommended age for vaccine doses. Coverage and timeliness of vaccinations declined in the following order: Penta1/DTP1 ≥ Pol1 > Penta3 ≥ MMR1 > Pol3 > DTP4 ≥ MMR2 > Pol4 > DT5 > Pol5.
- Delayed vaccinations were common in all cohorts surveyed but timeliness showed certain improvement in 2014 and 2013 cohorts compared to 2009 cohort. Late initiation of routine vaccinations had negative impact on subsequent coverage (particularly for rotavirus vaccine) and on completion of recommended age-appropriate series of immunizations. Even when the coverage target was met, this usually happened long after the recommended age for the given dose.
- At the time of the survey, nationwide coverage for Penta/DTP was very high for the first dose, but lower for subsequent doses indicating that not all children complete recommended series. Of particular concern, coverage with DTP4 and DT5 throughout Georgia was suboptimal in most cases. Coverage with polio vaccines (OPV or IPV-containing combination vaccines) was close, but somewhat lower than for Penta/DTP/DT. The vast majority of children in Georgia received at least one dose of MMR vaccine, although often with substantial delays. Coverage for MMR2 was suboptimal.
- Survey coverage for BCG and HepB0 given at birth in maternity hospitals was substantially lower, than historically reported administrative coverage, which, particularly for BCG, has been traditionally high. Problems with transmitting information on immunizations from maternity hospitals to HCFs where children receive subsequent vaccinations, have likely contributed to this finding. There was a clear increase in HepB0 coverage over time.
- Georgia is well advanced towards meeting the 2020 targets for hepatitis B vaccine recently adopted by WHO European Region. Nationwide coverage with 3 doses of HepB reached the recently endorsed 90% interim WHO milestone in 2013 cohort and came close to it in 2014 cohort. Nationwide timely coverage with HepB0

in 2014 cohort was close to the 85% WHO interim milestone and this milestone was achieved in 2014 cohort in Batumi and Kutaisi.

- Immunization against Hib was introduced in Georgia in 2010, with Penta vaccine, therefore coverage with Penta largely reflects coverage with Hib.
- Relatively low overall coverage with 2 doses of rotavirus vaccine, introduced in 2013, in 2014 cohort was associated with delays in initiating vaccinations.
- Comparison of the survey estimates with corresponding administratively reported coverage demonstrated that the current administrative system of reporting overestimates coverage for most vaccine doses, in some cases, to a substantial extent.
- The full implementation of the Immunization Management Module should eventually solve the problem of denominator and lead to more accurate and real-time administrative assessment of coverage in Georgia. However, the implementation of the Immunization Module is still at early stage and many of its benefits cannot be yet fully utilized. Until the Immunization Module is fully developed and implemented, the current system for administrative reporting of coverage will have to be maintained, but coverage surveys will remain the optimal way to obtain reliable information on immunization coverage levels in Georgia.

1. Survey background

Immunization coverage in Georgia has been high until 1990[1], but declined in the 1990s, during the immediate period after the regaining of independence and subsequent armed conflicts and economic crisis. Although immunization services have improved in the last decade, major challenges remain, as demonstrated by continued occurrence of outbreaks of vaccine-preventable diseases (VPD), such as measles and rubella.

National coverage estimates for DTP3, Pol3, MMR1 and MMR2 reported by Georgia to WHO (Table 1) are mid-range when compared with national estimates of other Member States of the WHO European Region (Figure 1) but remain below the national target of 95% for most antigens. However, the accuracy of administrative coverage data is unclear due to difficulties with determining target populations, particularly in the cities where the continuous changes to health care system had greatest impact on primary health care facilities (HCFs). The abolition of geographic catchment areas for HCFs and intense population movement, and existence of uncertain number of children not registered with HCFs, resulted in greater difficulties with assessing coverage in large cities than in smaller towns and rural areas. Administrative coverage data have not been validated for over a decade as no independent nationwide coverage surveys have been conducted in Georgia since a Multiple Indicator Cluster Survey was implemented in Georgia in 1999[2].

In 2015, at the time of planning of the present survey, the national immunization schedule included vaccinations against 12 infections: tuberculosis, diphtheria, tetanus, pertussis, hepatitis B, *Haemophilus influenzae* type b (Hib), measles, mumps, rubella, poliomyelitis, rotavirus, and pneumococcal infection (Table 2). Nationwide routine infant immunizations against diphtheria, tetanus, pertussis, and tuberculosis have been in place in Georgia since late 1950s, against poliomyelitis (oral polio vaccine – OPV) and measles - since 1960s. Hepatitis B vaccine was introduced in 2000, rubella and mumps vaccines were added in 2004, Hib vaccine - in 2010, rotavirus vaccine - in 2013 and pneumococcal conjugate vaccine (PCV) was introduced in 2014. In the last decade, the national immunization schedule underwent changes to accommodate introduction of new vaccines (rotavirus, PCV) and new combination products, such as pentavalent vaccine against diphtheria, tetanus, whole cell pertussis, Hib and hepatitis B (Penta), and measles, mumps and rubella (MMR) vaccine. In addition to government-provided vaccines, vaccines are increasingly imported through the private sector, which offers some products not available through the national program, such as hexavalent vaccine containing diphtheria, tetanus, acellular pertussis, Hib, hepatitis B and inactivated polio vaccine (IPV) components (Hexa)[3].

Due to the lack of independent validation of the coverage data in Georgia and ongoing uncertainty with target populations, we conducted nationwide immunization coverage survey during 2015-2016 to assess coverage with vaccines included in the routine immunization schedule through 5 years of age.

2. Participating institutions and funding

The following institutions were responsible for planning and implementation of the survey:

[1] Direct comparisons of the pre-1990 coverage data are not possible due to the differences in methodologies for estimating coverage.

[2] State Department of Statistics, National Center for Disease Control, and UNICEF. Republic of Georgia Multiple Indicator Cluster Survey, 1999. Tbilisi, 2000. Available at https://mics-surveys-prod.s3.amazonaws.com/MICS2/Central%20and%20Eastern%20Europe%20and%20the%20Commonwealth%20of%20Independent%20States/Georgia/1999/Final/Georgia%201999%20MICS_English.pdf. Accessed March 14, 2017

[3] Beginning in 2015, Penta was replaced by Hexa for the first three doses given at 2, 3, and 4 months (primary series) in the national immunization schedule. However, children eligible for the present survey were not affected by this change.

- US Centers for Disease Control and Prevention (CDC), Center for Global Health (CGH)
    - Global Immunization Division
    - CDC South Caucasus office, Field Epidemiology and Laboratory Training Program (FELTP)
- National Center for Disease Control and Public Health (NCDC), MOLHSA, Tbilisi, Georgia

Funding for the survey was provided by US CDC and Gavi, the Vaccine Alliance. The World Health Organization Country Office in Georgia facilitated implementation of the survey part funded by Gavi, the Vaccine Alliance.

3. Objectives

- To obtain nationwide estimates of immunization coverage for vaccines included in the national immunization schedule through 5 years of age
- To obtain estimates of immunization coverage for vaccines included in the national immunization schedule through 5 years of age for major cities (Tbilisi, Batumi, and Kutaisi)
- To assess timeliness of immunization by vaccine dose in Georgia

4. Methods

4. 1. Survey design

4. 1. 1. Survey population and vaccine doses assessed

Most standard protocols for immunization coverage surveys (MICS, DHS, epi cluster survey) only include vaccines given during the first 12 months of life but this approach leaves out later doses, such as MMR2, DTP4, DT5 and Pol4-5. Ensuring high coverage with the vaccines given later in child's life is important as Georgia is committed to maintaining its polio-free status and has a goal to eliminate measles and rubella, along with the need to maintain adequate population immunity against other VPDs to prevent outbreaks such as diphtheria outbreak in the 1990s. The coverage with vaccine doses recommended after 12 months of age in Georgia has not been previously independently assessed. Therefore, we decided to assess coverage with all vaccines included in the immunization schedule before the age 6 years (with few exceptions noted below).

Per NCDC request, and because of greater uncertainties with accuracy of reported coverage data in cities, the survey was designed to allow obtaining separate estimates for three largest cities of Georgia. Therefore, the three largest cities of Georgia – Tbilisi (population in 2015 - 1,100,000), Batumi (154,000), and Kutaisi (148,000), which together account for 38% of total population of the country[4], and rest of Georgia were surveyed separately and nationwide estimates were obtained by pooling the data from these surveys. The areas currently not under Georgian Government control (South Ossetia and Autonomous Republic of Abkhazia) were excluded due to lack of population data, inaccessibility and security concerns.

We included in the survey children eligible for routine immunizations in 2014, the most recent year with available coverage data at the time of planning and initiation of the survey. These included three birth cohorts:

- Children born in 2014, eligible to receive in 2014 vaccines recommended during the 1st year of life
- Children born in 2013, eligible to receive in 2014 vaccines recommended during the 2nd year of life
- Children born in 2009, eligible to receive in 2014 vaccines recommended during the 6th year of life.

[4] National Statistics Office of Georgia (GEOSTAT). 2014 General Population Census -Main results, general information. Available at: http://census.ge/files/results/Census_release_ENG.pdf. Accessed March 14, 2017

We estimated immunization coverage with age-appropriate vaccines for each birth cohort based on the national immunization schedule applicable to each one (Appendix 1). The differences applicable between schedules are related to introduction of new vaccines during this period. As shown in Table 3, in the 2014 birth cohort, coverage was assessed for vaccine doses recommended before 12 months of age (corresponding to 2014 reported coverage). In the 2013 birth cohort, coverage was assessed for vaccines recommended before 12 months of age (corresponding to 2013 reported coverage for respective doses) and for vaccines recommended between 12-23 months of age (corresponding to 2014 reported coverage for these doses). In the 2009 birth cohort, coverage was assessed for vaccines recommended before 12 months of age (corresponding to 2009 reported coverage), between 12-23 months of age (corresponding to 2010 respective reported coverage) and between 60 and 71 months of age (corresponding to 2014 reported coverage for respective doses). Thus, the survey design allowed to assess coverage for vaccines recommended by 12 months of age for all three birth cohorts, for vaccines recommended between 12 and 23 months - for two birth cohorts (2013 and 2009) and for vaccines recommended between 60 and 71 months – for the birth cohort of 2009.

Due to the very recent introductions, we did not assess coverage for PCV for 2014 birth cohort and for Hib vaccine for 2009 birth cohort. Tetanus-diphtheria (Td) vaccine recommended at 14 years was not included in the survey.

Conducting a household survey for the purpose of coverage assessment in three age strata was not practicable because of the small average household size (3.3 persons; range, from 2.5 in Racha-Lechkhumi to 4.0 in Achara)[2] and small birth cohort in Georgia (approximately 60,000), which would require selecting a very large sample of households to identify sufficient number of households with children from targeted birth cohorts. The existence of the Civil Registry data base linked to the Immunization Management Module provided opportunity to conduct the survey targeting individual children rather than the households.

As very few families in Georgia keep their children's immunization cards at home[5] and parental recall is not considered a reliable source on child's immunization history, we obtained information on immunizations from HCFs where they receive immunization services, in accordance with recently revised WHO guidance on conducting immunization coverage surveys[6].

4. 1. 2. Sampling frame.

The lists of children born in 2014, 2013, and 2009 from the Civil Registry data base linked to the recently introduced electronic Immunization Management Module of the Health Information Management System, were used as a sampling frame for the survey. The availability of highly accurate sampling frame allowed to include in the survey all children, not only those registered with HCFs, on which officially reported administrative coverage data are based.

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[5] In the 2005 MICS in Georgia, it was not possible to assess immunization coverage because the survey was based on immunization cards kept at home, but the survey found that only 15% of children had immunization records at home (https://mics-surveys-prod.s3.amazonaws.com/MICS3/Central%20and%20Eastern%20Europe%20and%20the%20Commonwealth%20of%20Independent%20States/Georgia/2005/Final/Georgia%202005%20MICS_English.pdf; accessed March 14, 2017). The pilot for the present immunization survey conducted in 2014 in Kvemo Kartli region also confirmed that immunization cards are not generally available at home.

[6] WHO. 2015 Update of vaccination coverage survey manual. Available at: http://www.who.int/immunization/monitoring_surveillance/Briefing_note_CSManual.pdf. Accessed March 14, 2017.

The Civil Registry data base includes information on all children who are born and receive birth certificate in Georgia. Per UNICEF assessment in 2010, the rate of registration at the time of birth was very high (97%)[7], and has likely increased since then with further substantial improvement of Civil Registry services. The information available included child's name, date of birth, personal ID number, legal address, and, for a subset of children, the actual address and the name of HCF where the child receives health services. Children living outside Georgia where considered ineligible for the survey, therefore those with foreign address listed in the Civil Registry data base – 301 (0.5%) children in 2014 cohort, 326 (0.6%) in 2013 cohort, and 497 (0.8%) in 2009, as well as children who were initially sampled but were subsequently found to have moved overseas, were excluded from the survey.

4. 1. 3. Design and sample size.

A complex stratified multi-stage design was used for the survey (Table 4). The country was divided into 4 survey domains consisting of the 3 largest cities: Tbilisi, Kutaisi, Batumi, and the rest of the country. In the three large city domains, simple random sampling (SRS) was used to select children [primary sampling units (PSU)] from each of the 3 age groups.

The fourth domain, consisting of the populations not residing in one of the 3 largest cities, was divided into seven strata. The first stratum, which includes Rustavi and Poti, participants within each age group were selected by SRS because the sampling frame had no easily identifiable subdivisions to be used as sampling units for cluster survey. Rustavi is large enough to warrant being a certainty unit, but because Poti is not, for sampling purposes it was combined into one stratum with Rustavi.

Five strata required a two-stage cluster design. The first stage selected settlements (village/town) by probability proportionate to population size (PPS), followed by a SRS of children within each age group.

The last stratum, representing the remaining 54 districts of Georgia, required a 3-stage cluster design. The first stage selected districts by PPS, followed by selection of settlements by PPS, followed by a SRS of children within each of the 3 age groups. Very small settlements were pooled to create sampling unit with $\geq$10 children in it.

A sample size of 750 per birth cohort was allocated to Tbilisi (3.8% of all children), and 600 per birth cohort to Batumi and Kutaisi (20.0% and 22.1%, respectively), resulting in a total of 1950 children per birth cohort. Due to larger population, a sample size of 50 per birth cohort was allocated to Gori and combined Rustavi/Poti stratum. A sample size of 25 per birth cohort was allocated to 5 of the strata (five per PSU). In the 7th, a sample size of 5 children was allocated, resulting in 25 children per PSU. This resulted in 800 children per birth cohort in the fourth domain (2.4% of all children). A total of 2750 children per birth cohort were selected, resulted in a sample size of 8250 children for all three birth cohorts included in the survey. Selection of sampling units was performed using the population data for the 2014. Individual children were selected from the sampled units using line-lists for respective birth cohorts.

4. 1. 4. Survey procedures

The relevant population subsets were extracted from the Civil Registry birth registration data set via the Immunization Management Module link. The residence codes were assigned to each administrative unit based on child's address. If actual address was different from the child's legal address, the actual address was used to

[7] UNICEF Georgia. Birth registration. http://unicef.ge/10/Birth-registration/34. Accessed March 14, 2017

assign the child to sampling unit. This allowed to account for some population movement and reduce the proportion of children who could not be located.

Participant selection process was performed by survey coordinators. SRS was applied using an online random number generator (www.random.org). The survey field teams were given lists of selected children with their addresses and, if known, HCF indicated in the Immunization Management Module (the list and contact information of HCF is available through the Health Information Management System). For children with known HCFs, the teams visited HCFs to locate the immunization records of children selected for the survey.

If the child's immunization records could not be located at the listed HCF, or no HCF was listed, the teams visited the child's residence and, after providing information sheet about the survey (Appendix 2) asked parents/guardians if the child had received at least one vaccination. If the answer was positive, parents/guardians were asked to provide information about HCF where the child receives immunizations. If the immunization card was available at home, the data were obtained on-site. Otherwise, the team visited the HCF indicated by a parent/guardian to obtain immunization records. If the child was unvaccinated per parent/guardian report, this was noted the interview form (Appendix 3) and no further attempts to locate records for this child were undertaken (Appendix 4). The children who could not be found were not substituted by selecting another child.

The information collected on survey participants included date of birth, sex, residence district/city, HCF, vaccine doses received and dates of vaccination. The information was recorded on a survey data collection form (Appendix 5).

To accommodate the timeframes of availability of staff and funding the survey was implemented sequentially - in Batumi in August 2015, in Kutaisi - in September 2015, in Tbilisi - in March 2016, and in the rest of Georgia – in August-October 2016.   To reduce the impact of sequential timing of survey implementation, the immunization records for the children in Batumi and Kutaisi who had not reached full year of the cohort age at the time of initial field work (were born in the late months of year) and had not received all age-eligible vaccines, were reviewed again (at HCFs or via Immunization Management Module) in early 2016 and any additional doses received were noted.

The survey field teams consisted of the personnel from NCDC, CDC/GID, CDC South Caucasus Office, FELTP graduates and from local Public Health Centers of survey areas. Prior to beginning field work the survey personnel received comprehensive training on the survey objectives, methodology, and procedures for data collection.

4. 2. Data management and analysis

The statistical software Epi Info 7 was used for data entry. Analysis was conducted using SAS v9.4 and R v3.3. Analyses accounted for the complex survey design and sampling weights. We report Wilson-Score confidence intervals for proportions using survey procedures in SAS 9.4. Main outcome measures included per cent coverage for each vaccine dose or series assessed. The definitions for outcomes and the time points at which they were assessed are listed in Table 5. The proportion of children who have not received at least one dose of routine vaccines recommended at $\geq$2 months of age was calculated. The proportion of children who have received full series of age-appropriate "major vaccines" (against diphtheria, pertussis, tetanus, hepatitis B, measles, mumps, and rubella) and full series of all age-appropriate vaccines included in the national immunization schedule was also assessed.

The analysis included calculation of overall coverage at the time of the survey for each vaccine dose or series and assessment of timely coverage assessed at standard time points (Table 5). To account for differences in the time of observation, comparisons across cohorts were made based on the timely coverage. The drop-out between the first and third dose of Penta/DTP vaccines was calculated by subtracting coverage with the 3rd dose from coverage with the 1st dose. In addition, to remove the impact of the sequential implementation of the survey in different domains on the coverage levels, we calculated coverage for each dose by the time of the end of the initial field work in Batumi (the city surveyed first), by excluding any vaccine doses administered after September 1, 2015. Direct comparisons across survey sites were made based on the status as of September 1, 2015. The following definitions were used for coverage levels: high – ≥90% (very high - ≥95%), moderate – 80%-89%, and low –<80% (very low - <70%).

Timeliness of vaccinations was estimated by plotting (1 -estimated Kaplan-Meier curve) using the survey package in R v3.3. Estimates of time to reach a specified proportion vaccinated with a given antigen (50%, 80%, 90%, and 95%), and the proportion being vaccinated a given point in time were captured from the Kaplan-Meier curve. This analysis was focused on vaccine doses considered key program performance indicators – Penta1/DTP1, Pol1, Penta3/DTP3, Pol3, DTP4, DT5, Pol4, Pol5, MMR1, and MMR2.

The estimates of coverage were compared to the national target of ≥95% coverage for all doses[8]. The survey results were also compared to corresponding administrative coverage reported through GEOVAC system. GEOVAC, the existing system for administrative reporting of coverage in Georgia, is based on the data provided by HCFs to NCDC and only reflects children registered with HCFs.

5. Ethical issues

The coverage survey protocol was reviewed by Human Subject Research Coordinator, GID/CGH/CDC and Ethical Committee, NCDC, and determined to be an evaluation of public health program rather than human subject research.

6. Results

6. 1. Response rate

Response rates for the survey were very high. Of a total of 8,250 children selected in the three birth cohorts, 103 (1.2%) were found to have moved to other countries, resulting in 8,147 children eligible for the survey. We obtained immunization information for 7,723 (94.5%) of them, and 424 (5.2%) could not be found. In all birth cohorts and cities, >90% of eligible participants were enrolled (range, 90.4%-98.0%). Response rates were slightly lower for 2009 birth cohorts than for 2013 and 2014 cohorts, and were comparable across survey sites (Table 6).

6. 2. Coverage at the time of the survey

Estimates of national coverage at the time of the survey by birth cohort are presented in Table 7. In each birth cohort, the vast majority of children (96%-97%) have received at least one dose of routine vaccines recommended at ≥2 months of age. Of the remaining children who have not initiated routine vaccinations recommended at ≥2 months, 3% in 2014 cohort, 2% in 2014 cohort and <1% in 2009 cohort have received BCG

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[8] The target does not specifically refer to timely coverage, therefore, in the analysis we applied it to overall coverage by the time of the survey.

and/or HepB0 at birth, but no other doses, and 1% in 2014 and 2013 cohorts and 2% in 2009 cohort were completely unvaccinated.

Of the two vaccines given in Georgia at birth – BCG and HepB0 – BCG coverage was moderate in all cohorts (between 83% and 86%). Coverage with the birth dose of HepB vaccine has increased from 46% in 2009 cohort to 87% in 2014 cohort (Table 7).

Of the vaccine doses recommended during the first year of life, coverage with the first dose of Penta/DTP and polio vaccines (Penta1/DTP1 and Pol1) was uniformly high: $\geq$95% in 2013 and 2009 birth cohorts, and 94% in 2014 cohort. Coverage with the third dose (Penta3/DTP3 and Pol3) was high ($\geq$90% for all) in 2013 and 2009 cohorts, and moderate (88% and 87%, respectively) in 2014 birth cohort. Penta1/DTP1-Penta3/DTP3 dropout ranged between 5% in 2013 cohort and 7% in the other two cohorts. Coverage with HepB3 was very low (40%) in 2009 cohort, but much higher in 2013 (90%) and 2014 (87%) cohorts. Coverage with Hib3 was identical to Hep3 coverage in 2013 and 2014 cohorts (Table 7). In addition, 23% (95% CI, 21%-26%) of children in 2009 cohort have received at least three doses of Hib vaccine. These were the children who received commercially available combination vaccines or were vaccinated after the introduction of Penta in the national schedule in 2010. Coverage with newly introduced rotavirus vaccine was in the low range for both eligible cohort but had an increasing trend (Table 7). Rotavirus vaccine coverage varied substantially by the time of Penta1 receipt. Among children who received Penta 1 (i.e. initiated routine vaccinations) by the maximum recommended age for Rota1 – 16 weeks, Rota1 coverage was 77% in 2013 cohort, and 91% in 2014 cohort and coverage for Rota2 was 72% and 85%, respectively. Among children who received Penta1 after 16 weeks of age, Rota1 coverage was 12% in 2013 cohort and 13% for 2014 cohort (unweighted analysis. Children who did not receive Penta1 were unvaccinated for rotavirus as well.

Coverage with MMR1 recommended at 12 months exceeded 90% in 2009 birth cohort (93%) and was just below 90% in 2013 cohort. Coverage with the two vaccine doses recommended at 18 months (DTP4 and Pol4) was moderate in 2009 cohort - 85% for DTP4 and 83% for Pol4. Coverage for DTP4 and Pol4 in 2013 cohort was $\leq$80% (Table 7). Coverage with vaccine doses recommended at 5 years of age was uniformly low in 2009 birth cohort, the only eligible one in this survey, particularly for DT5 and Pol5 (Table 7).

The proportion of children who received age-appropriate recommended combined series with major vaccines as defined in Table 5, increased from 46% in 2009 birth cohort to 85% in 2014 cohort. The proportion of children who received combined series with all age-appropriate vaccines ranged between 34% in 2013 cohort and 54% in 2014 (Table 7). The status of completion of age-appropriate combined series of vaccines was associated with the age of initiation of routine vaccinations. In all cohorts, the median age of administration of Penta1/DTP1 was lower for children who received all age-appropriate vaccines than for children who did not complete the combined series: in 2014 cohort – 2.4 versus 3.6 months, in 2013 cohort – 2.3 versus 2.9 months, in 2009 cohort – 2.7 versus 3.2 months (unweighted analysis).

Generally, coverage was highest for doses schedules earlier in life and declined with subsequent doses, with lowest coverage observed for DT5 and Pol5. Also, for simultaneously recommended doses scheduled, coverage tended to be slightly higher for DTP containing vaccines, than for polio vaccines, and MMR coverage tended to be higher than for other vaccines scheduled in the same year of life. In each birth cohort, 3%-5% of children received at least one dose of commercially available vaccines (Table 7).

Subnational variations were analyzed by comparing coverage across survey sites based on the status as of September 1, 2015 which revealed substantial geographic differences in immunization coverage in Georgia. In all cohorts and for almost all vaccine doses the trend was highest coverage in Batumi, followed by the rest of Georgia, and lower coverage in two other large cities – Tbilisi, and, particularly, Kutaisi (Figure 2). The trends in differences in coverage at the time of the survey were identical (Table 8). The differences in coverage between Batumi and other survey sites were most prominent in 2009 cohort, when coverage levels in other sites were quite similar. In 2013 cohort, Batumi and the rest of Georgia had substantially higher coverage than the other two sites, among which Tbilisi had slightly higher coverage than Kutaisi. In 2014 cohort coverage in Tbilisi has improved, reaching the levels similar to Batumi and rest of Georgia for some antigens, while Kutaisi retained lowest coverage. Estimates of coverage at the time by survey site and birth cohort are presented in Table 8. Along with the estimates for the three urban centers, the table also includes the estimates of coverage for the rest of Georgia survey domain. However, it should be taken into consideration that the domain represents a combination of administrative units in all regions of Georgia outside the three major urban centers, pooled into one unit for statistical sampling purposes only. Therefore, these results provide general information on trends in coverage in other cities and rural areas of Georgia, but are not directly applicable to individual districts as substantial variations within the domain are likely.

6. 3. Timely coverage

Nationwide estimates of timely coverage (Table 9) tended to be substantially lower than overall coverage, reflecting delays in vaccinations. For BCG and HepB0, the difference was between 3% and 5% in all cohorts. For other vaccines, differences between overall and timely coverage were greater for older cohorts – 2013 and 2009, largely owing to more time for these children to catch-up with their vaccinations. Greatest differences were observed for DTP4 and Pol4 (>20% in both cohorts).

BCG coverage has slightly increased in 2014 compared to both 2013 and 2009. Coverage for HepB0 improved substantially from 2009 to 2014. For other vaccines, Penta1/DTP1, Penta3/DTP3, Pol3, DTP4, Pol4, and MMR1, the highest coverage was observed in 2013 cohort (Table 9). Timely coverage was particularly low for vaccine doses recommended after 12 months of age.

General trends in timely coverage observed across survey sites were similar to national trends (Table 10). For all vaccines in all cohorts surveyed, timely coverage was clearly highest in Batumi, followed by rest of Georgia, and lowest in Kutaisi. The differences between Batumi and other sites were most remarkable for 2009 cohort, and least prominent for 2014 cohort.

6. 4. Timing of vaccinations

In comparison of probability of being vaccinated at a given time after recommended age for vaccines performed for 2013 and 2009 cohorts which had sufficiently long observation period (Figure 3), there were differences between vaccines. Penta/DTP/DT doses had slightly higher proportion of vaccinated persons than corresponding polio vaccine doses[9]. The proportion of MMR recipients was close to the proportion of the previous Penta/DTP dose after similar time since recommended age – e.g. the curve for MMR1 closely followed the one for Penta3/DTP3 and the curve for MMR2 – the one for DTP4. Overall, Penta1/DTP1 and Pol1 had the best timeliness, followed by Penta3/DTP3 and MMR1, with Pol3 slightly behind them. Timeliness for DTP4 was lower than for the above, and very close to MMR2, but better than for Pol4. The worst timeliness was observed

[9] Pol1 and Pol3 are omitted in Figure 3 as their trends were very close to Penta1/DTP1 and Penta3/DTP3 and the curves were overlapping to a substantial extent.

for DT5, and particularly, Pol5. Timeliness of vaccination also varied by recommended age for the vaccine dose, generally declining with increasing age (similar to the trend observed for coverage) as shown on the examples of Penta/DTP/DT and polio vaccines (Figure 4).

Table 11 demonstrates the age and time since recommended age needed to achieve selected levels of coverage. For any given dose, there was a substantial period of time needed to achieve high coverage, and for a number of vaccine doses these high levels were not achieved by the survey time. However, there was a trend towards improvement over time – timeliness indicators for 2014 and 2013 cohorts were similar or close to each other and consistently better, than for 2009 cohort (Table 11, Figure 4).

The age of administration of Penta1/DTP1 reflects the actual timing of initiation of the primary series of vaccination with DTP-containing vaccines. Penta1/DTP1 in 2014 and 2013 cohorts had the best indicators of timeliness of all vaccine doses in all cohorts (Table 11, Figure 4) with 90% of children having received it within 6 months of recommended time. However, achieving 95% level took 17 months in 2013 cohort and 19 months – in 2014 cohort. The rate of increase over time in proportion of children vaccinated with DTP1 in 2009 cohort was substantially slower, with 80% level achieved 5 months, 90% - by 1 months, and 95% - by 65 months after recommended time respectively. The timeliness of Penta3/DTP3, which reflects the time of completion the three-dose primary series was initially similar to Penta1/DTP1, but slowed after 80% level (Table 11, Figure 4). Trends in timeliness the primary series of polio vaccine were close to those for Penta/DTP/DT doses recommended at the same time. However, delays in vaccinations were more common for polio vaccines (Table 11, Figure 4). The timing of MMR1 followed closely the trends for Penta3/DTP3 in 2013 cohort. Delays in vaccination were common for vaccine doses recommended at 18 months of age, particularly, for Pol4, and even more so, for vaccine doses recommended at 5 years of age (Table 11, Figure 4). The only vaccine recommended at 5 years, received by at least 80% of children was MMR2, but this did not happen until 34 months since recommended age (94 months of age) (Table 11).

With regard to vaccine doses recommended at birth, based on relatively small difference between timely and overall coverage (Table 9), most children who were vaccinated with BCG and HepB0, received them within recommended time frame. The improvement was observed for timeliness of BCG, recommended by day 6 since birth - in 2014 cohort 80% of children received BCG by age 4 days versus by 11 and 12 days in 2013 and 2009 cohort, respectively. Also, most children who received rotavirus vaccine, were vaccinated within the recommended time frame, but 2%-3% in both eligible cohorts received rotavirus vaccines after the recommended cut off age (16 weeks for Rota1 and 24 weeks for Rota2) (unweighted analysis).

Subnational trends in the timeliness of vaccination, presented in Table 10 and Figures 5-12, followed the same trends as coverage, with Batumi having the best performance, followed by the rest of Georgia, and Kutaisi underperforming. For Penta1/DTP1 (Table 10, Figure 5), the nationwide improvement in timeliness observed in 2013 and 2014 cohorts (Figure 4) was achieved due to improvements in Tbilisi and rest of Georgia, but there were no changes in Kutaisi. Subnational trends for Penta3/DTP3 timeliness were similar to Penta1/DTP1, but at a lower overall level and demonstrated worsening of timeliness in Kutaisi and improving in the rest of Georgia (Figure 6). There were considerable differences across sites in timeliness of MMR1 administration. The nationwide improvement in 2013 cohort was related to improvement in timeliness in the rest of Georgia, and to a lesser extent, in Tbilisi, with no changes in Batumi and Kutaisi (Table 10, Figure 7). The improvement at the national level in timeliness of DTP4 and, to a lesser extent, Pol4 was related to improvements in Tbilisi and rest of Georgia (Figures 8-9). For all three vaccine doses recommended at 5 years, Batumi had least delays, followed by rest of Georgia, and delays in vaccination were most common in Kutaisi (Table 10, Figures 10-12).

6. 5. Survey coverage versus administrative coverage

Comparison of timely coverage estimates from the survey to timely coverage reported through GEOVAC system (for selected doses where the information by age of vaccinated population was available in GEOVAC). The comparison revealed that in most cases administratively reported coverage overestimated coverage, in some cases to a substantial degree (by more than 15%-20%) (Tables 12-13).

6.6. Progress towards achieving the national coverage target

The status of achieving the national 95% target by vaccine dose is presented in Table 15. Nationwide, the target was consistently achieved for the first doses of Penta/DTP and polio vaccines, but not for other vaccine doses. However, substantial progress was made for Penta3/DTP3, Pol3 and MMR1 in 2013 and 2009 cohorts with $\geq$90%. Subnationally, Batumi was closest to achieving the overall target, followed by rest of Georgia and Tbilisi Batumi had achieved (or almost achieved[10]) $\geq$95% coverage for most major vaccine doses, including Penta1 and Pol1 in 2014 cohort, Penta1-3 and Pol1-3 in 2013 cohort, and DTP1-4, Pol1-4 and MMR1 in 2009 cohort. Tbilisi achieved $\geq$95% target for Penta1/DTP1 and Pol1 in all cohorts, and almost achieved it for MMR1 in 2009 cohort. In the rest of Georgia, the target was achieved for Penta1/DTP1 and Pol1 in all cohorts, and almost achieved for Penta3 and Pol3 in 2013 cohort. All these sites outperformed Kutaisi, where only DTP1 and Pol1 coverage in 2009 cohort met the $\geq$95% target by the time of the survey (Table 14).

7. Discussion

7. 1. Overall implications

Overall, the survey revealed a well-developed, functioning immunization program in Georgia. It appears that despite challenges associated with the ongoing reforms in primary health care, the system is successful in providing access to and delivering immunization services to children across the country. However, the survey also revealed geographic variations in immunization coverage and certain weaknesses with various aspects of immunization process – initiating vaccinations, completing the recommended series, and vaccinating on time. These weaknesses lead to suboptimal coverage for some vaccine doses, particularly the ones recommended after the 1st year of life, and prevent the country from consistently achieving the national immunization targets. Across major urban centers, immunization services appear strongest in Batumi, which consistently had highest immunization coverage, fewer dropouts and better timeliness, and weakest – in Kutaisi. Immunization services outside these major urban centers performed better, than in Tbilisi, and particularly, in Kutaisi, but mostly at a lower level than in Batumi. At the time of the survey, immunization coverage among the surveyed birth cohorts was in moderate to very high range for most vaccinations recommended during the 1st year of life, but much lower for vaccinations recommended during the 2nd year of life, and, particularly, at 5 years of age.

The 95% coverage target was met nationwide for Penta1/DTP1 and Pol1 and certain areas, e.g. Batumi, have made substantial progress towards achieving the target of $\geq$95% for all antigens. However, the overall national target of $\geq$95% for all vaccine doses is very high and difficult to achieve without well-defined strategy. Establishing interim milestones for coverage levels with clear timeframe for their achievement would help to better monitor the progress and help achieve the target. Setting coverage milestones r would be particularly helpful in underperforming areas and for later vaccine doses with coverage far below the target. The milestones

[10] Upper limit of 95% CI of an estimate is $\geq$95%

could be customized for geographic areas, setting appropriate levels and timeframe with higher milestones and shorter timeframe for better performing areas, and more time for gradual improvement in places requiring particular support, such as Kutaisi.

Generally, the highest coverage and best adherence to the recommended time of vaccination was observed for the first doses of routine vaccines recommended at 2 months of age, but both coverage and timeliness declined with each consecutive dose. This trend applied to all vaccines with multiple doses recommended. In each cohort and for every vaccine, lowest coverage was observed with the most recently scheduled doses: e. g., Penta3 and Pol3 in 2014, DTP4 and Pol4 in 2013, and DT5, Pol5 and MMR2 in 2009 cohorts. Suboptimal coverage for vaccine doses recommended after 12 months of age, particularly at 5 years, was a consistent problem. Of particular concern was very low coverage for vaccines recommended at 5 years of age in most survey sites (except in Batumi, which had moderate coverage with all three recommended vaccines).

The very high (>95%) proportion of children who received at least one vaccine dose recommended at ≥2 months of age in most groups demonstrates that the vast majority of children in Georgia access immunization system at some point in time. However, there was a considerable problem in Kutaisi where 13% or approximately 1 in 8 children in 2014 cohort had not begun routine immunizations by the time of the survey. This proportion remained substantial even in older cohorts – 8% or 1 in 12 children in 2013 cohort, and 4% or 1 in 25 children in 2009 cohort. Although some of these children received BCG and/or HepB0 at birth, they children remain susceptible to all major VPDs. Considering that not all children who initiate vaccination complete the full recommended series or do so with substantial delays, the immunity gap in Kutaisi is likely even greater.

Substantial dropout between the 1st and 3rd doses of Penta/DTP, particularly in Tbilisi and Kutaisi, confirms that many children in Georgia fail to complete the primary series. In addition, many children who completed the primary series, did not receive the 4th and 5th doses recommended at 18 months and 5 years. Similar trends were observed for MMR, polio, and rotavirus vaccines. The increase in the proportion of children who received applicable age-appropriate recommended series of vaccinations from 2009 to 2014 cohort, was a positive development. In 2014 cohort nationwide, 85% of children were age-appropriately vaccinated against major VPDs but only 54% had received all age-appropriate vaccines included in the national schedule.

Most children who initiated vaccinations received Penta1/DTP1 within few months of recommended age. A small proportion of children initiating vaccinations after 1-2 years of age suggests that if a child did not begin vaccinations by at least 2 years, he/she would likely remain unvaccinated, contributing to population susceptibility. Georgia has the immunization visit at 5 years (before school entry at 6 years) included in the current immunization schedule. Based on the slight increase in vaccinations with Penta1/DTP1 and MMR1 around 5 years of age, it appears that at least some of the previously unvaccinated children use this opportunity to begin vaccinations, even though Georgia at present has no legally mandated school entry immunization requirements. It is important that providers attempt to bring in previously unvaccinated, as well as under-vaccinated children for 5 year visit to initiate or complete their vaccinations utilizing catch-up schedules. The immunization visits at 12 month and 18 months could also be used as an opportunity to initiate or complete vaccination series.

There is a need for improvement in the timeliness of vaccination throughout the country, although the situation tends to be more favorable in Batumi. Timeliness showed certain improvement in 2014 and 2013 cohorts compared to 2009 cohort, but the timely coverage measured at standard age points rarely exceeded 80%-85% and was much less for later doses. The present survey was not designed to look into causes for not vaccinating but widespread use of false contraindications and parental refusals have been previously recognized in Georgia as a problem. Delays in vaccine administration without true medical causes prolong the period of susceptibility and put children at unnecessary risk of developing VPDs.

In the last decade, vaccines imported by private companies, have become increasingly available in Georgia, particularly Hexa. The survey found that Tbilisi was the only place where commercial vaccines were utilized to a substantial extent. In coming years the contribution of commercial market would likely decline as the Government began providing Hexa free of charge through the national program from 2015.

The very high response rate achieved in the survey ensured that the results are highly representative of surveyed population and demonstrated wide availability of immunization information which was of concern prior to the survey, considering challenges with record keeping with rapidly changing landscape of primary health care services in large cities.

7. 2. DTP-containing vaccines

At the time of the survey, nationwide coverage for Penta/DTP was very high for the first dose, but lower for subsequent doses indicating that not all children complete recommended series. One of the main indicators of performance of immunization system, nationwide coverage for Panta3/DTP3 at 12 months of age, needs improvement. Overall Penta3/DTPs coverage at the time of the survey, was considerably higher than timely coverage suggesting that delayed vaccinations account for low timely coverage to substantial extent. Reducing the dropout between the 1st and 3rd doses of Penta/DTP is important as minimum three doses of these vaccines are needed to complete primary series to ensure adequate protection from included VPDs. Because vaccine-induced immunity against diphtheria, tetanus, and pertussis wanes with time after immunization, particular attention should be paid to ensuring high coverage with booster doses at 18 months and 5 years. Of concern, coverage with DTP4 and DT5 throughout Georgia was suboptimal in most cases. Considering the history of a large-scale diphtheria outbreak in Georgia in the 1990s, it is important to ensure improvement of coverage with all recommended doses of diphtheria-containing vaccines to prevent recurrence of diphtheria. The increasing use of combination vaccines offers an obvious advantage of allowing immunization against several diseases simultaneously, however, it can be associated with additional risks, if high coverage with multi-component vaccines is not achieved and maintained, as the resulting immunity gap will affect all of these VPDs.

7. 3. Polio vaccines

Georgia has been certified free of wild polioviruses (WPV) in 2002, along with the rest of the European region. However, there is still an ongoing risk of reintroduction of wild polioviruses from the remaining endemic areas or emergence and spread of vaccine-derived polioviruses (VDPVs) in OPV-using areas with low coverage. The recent experiences in the European region, including outbreak in Tajikistan and three other countries in 2010[11] following importation of WPV1, circulation of imported WPV1 in Israel in 2013[12], as well as circulating VDPV1 outbreak in Ukraine in 2015[13], clearly demonstrates that this risk is real. The country is currently ranked by WHO at intermediate risk of poliovirus spread in case of WPV importation or VDPV emergence, primarily

[11] Khetsuriani N, Pallansch MA, Jabirov S, et al. Population immunity to polioviruses in the context of a large-scale wild poliovirus type 1 outbreak in Tajikistan, 2010. Vaccine 2013;31:4911–6.

[12] Anis E, Kopel E, Singer SR, et al. Insidious reintroduction of wild poliovirus into Israel, 2013. Eurosurveillance 2013;18:2–6. <http://www.eurosurveillance

[13] Khetsuriani N et al. Responding to a cVDPV1 outbreak in Ukraine: Implications, challenges and opportunities. Vaccine (2017), http://dx.doi.org/10.1016/j.vaccine.2017.04.036

because of suboptimal population immunity[14], and needs to maintain high level of preparedness for any polio-related event, including achieving and sustaining high population immunity.

In this survey, coverage with polio vaccines (OPV or IPV-containing combination vaccines) was close, but somewhat lower than for Penta/DTP/DT. As part of the polio "Endgame strategy", Georgia introduced IPV for the primary series by replacing Penta with Hexa beginning in 2015, and in April 2016, along with all other countries in the world, switched from the trivalent OPV to bivalent OPV, containing polioviruses 1 and 3[15]. Although these recent changes in Georgian immunization schedule did not affect the cohorts included in the current survey, they have substantial polio-related implications for subsequent cohorts. Beginning in 2015, Hexa is the only source of the immunity against poliovirus type 2, and coverage with Hexa determines coverage for polio. This transition could reduce the number of polio susceptible children in in the future, if the coverage with Hexa is maintained at least at the current level of Penta. Also, with this change, the OPV doses given at 18 months and 5 years have become the only source of live polio vaccine. Unless improved, the current problem with delivering vaccinations after 12 months of age in Georgia could have substantial impact on the state of population immunity against polioviruses, because IVP provides protection from clinical disease but only OPV induces mucosal immunity necessary to prevent infection and reduce shedding and further transmission of polioviruses. In addition, high coverage with OPV is critical for preventing emergence and spread of vaccine-derived polioviruses.

7. 4. MMR

Georgia has adopted the European Regional goal of achieving measles and rubella elimination. However, substantial population susceptibility exists as evidenced by recurring large-scale measles outbreaks. Due to extremely high contagiousness of measles, very high coverage ($\geq$95%) with two vaccine doses is needed for achieving herd immunity necessary to interrupt measles virus transmission. The survey data demonstrates that the vast majority of children in Georgia receive at least one dose of MMR vaccine, although often with substantial delays. As a result, high coverage with MMR1 is not achieved until around the time of school entry, much later than recommended. Due to the delays in vaccinations, suboptimal coverage for MMR2, and <100% effectiveness of MMR vaccine, many children in Georgia likely remain unprotected for these diseases, particularly for measles, unless they became ill and acquired natural immunity during the 2013-2014 measles outbreak. Notably, it appears that the immunization activities in response to this outbreak may have had a certain impact as judged by higher coverage for MMR than for DTP-containing and polio vaccines scheduled at the same time, but did not succeed in increasing MMR coverage sufficiently to reach the national target.

7. 5. BCG

BCG coverage in the survey was substantially lower, than historically reported administrative coverage. Considering the existence of well-accepted BCG vaccination program with traditionally high coverage since the

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[14] World Health Organization. Report of the 30th meeting of the European regional certification commission for poliomyelitis eradication. Sarajevo, Bosnia and Herzegovina, 31 May-2 June 2016. <http://www.euro.who.int/__data/assets/pdf_file/0006/318651/Meeting-report-30th-RCC.pdf?ua=1>[accessed 28 September 2016].

[15] Transmission of wild poliovirus type 2 has been interrupted in 1999, and its eradication was declared by the Global Certification Commission in 2016. After this, type 2 component was removed from OPV in a synchronized manner to reduce the risk of emergence and circulation of type 2 VDPVs. Global Polio Eradication Initiative. Polio eradication and endgame strategic plan 2013–2018. <http://www.polioeradication.org/Portals/0/Document/Resources/StrategyWork/EndGameStratPlan_20130329_ENG.pdf> [accessed 28 September 2016].

1950s, and the current system of transmitting the BCG immunization information, problems with documentation have likely contributed to this finding to a certain extent. BCG, along with HepB0, is given at birth by maternity hospitals[16] and the immunization information is provided to HCFs by parents as part of the transfer form issued at discharge from maternity hospital. It's the parent's responsibility to register the child with a HCF of their choice and provide the transfer form to the HCF, where the information should be entered in child's record and into the immunization card (Form 063). Problems at any stage of this process would result in missing information. In this survey, sometimes, BCG and HepB0 immunization from the transfer form was not included in immunization section of the chart and/or For 063. In some cases, checking the Immunization Management Module records allowed to locate missing information on BCG and HepB0 immunizations entered by maternity hospitals. Also, at in one PSU (Khulo district), where most children were born at a local maternity ward, we cross-checked the maternity hospital records and were able to obtain some missing immunization information. These findings indicate that HCF might not be the best place to obtain information on vaccines administered at maternity hospitals due to potential problems with transmitting this information and relying on only HFC records could underestimate coverage. Additional efforts are needed to determine the relative contribution of lack of vaccination and lack of documentation to apparent low BCG coverage in the survey. Improvement of the quality of transfer forms and widespread utilization of the Immunization Management Module by maternity hospitals could help with improving documentation of vaccinations given at birth. Also, primary health care providers should ensure that all the immunization information is accurately entered in child's record, irrespective of where the vaccine was given.

7. 6. Hepatitis B

WHO European Region has recently adopted the Action Plan for the health sector response to viral hepatitis in the WHO European Region[17], which envisions the 2020 target of 95% coverage with three doses of hepatitis B vaccine and 90% timely coverage with the birth dose by 2020, and interim milestones of 90% coverage with three doses and 85% timely coverage with the birth dose of hepatitis B vaccine by 2018[18].

In the survey, HepB0 coverage in Georgia was lower than coverage for BCG, another vaccine administered at maternity hospitals. And similar to BCG, the administrative coverage was 10%-15% higher than survey coverage. The very low coverage in 2009 cohort, also reflected in the administrative coverage data, is likely due to the shortage of hepatitis B monovalent vaccine in 2009 in Georgia. The negative impact of the adverse event associated with hepatitis B vaccine in 2002, at the early stage of hepatitis B vaccine introduction in Georgia felt for years, could also have contributed. Problems with documentation of vaccines administered at maternity hospitals in the child's records at HCF, as discussed under BCG section, represent another potential contributor to low HepB0 coverage found in the survey. Nevertheless, the clear increasing trend in HepB0 coverage over time is encouraging and suggests the increased trust in hepatitis B vaccine in Georgia.

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[16] The vast majority of births in Georgia occur at hospitals (98% in 2010). (Serbanescu F, Egnatashvili V, Ruiz A, Suchdev D, and Goodwin M. Reproductive Health Survey, Georgia, 2010. Summary report. CDC, Atlanta, 2011. Pp.1-278).

[17] Resolution EUR/RC66/R10 of the 66th session of the Regional Committee for Europe, Copenhagen, Denmark, 12–15 September 2016. Action plan for the health sector response to viral hepatitis in the WHO European Region. Available at: http://www.euro.who.int/__data/assets/pdf_file/0003/319206/66rs10e_Hepatitis_160771_R10.pdf?ua=1. Accessed March 7, 2017.

[18] WHO. Action plan for the health sector response to viral hepatitis in the WHO European Region. Adopted by 66th session of the Regional Committee for Europe (EUR/RC66/10), Copenhagen, Denmark, 12–15 September 2016. Available at: http://www.euro.who.int/__data/assets/pdf_file/0008/315917/66wd10e_HepatitisActionPlan_160555.pdf?ua=1. Accessed March 7, 2017.

Successful introduction of Penta led to substantial increase in coverage for hepatitis B. Nationwide coverage with 3 doses of HepB reached the recently endorsed the 90% interim WHO milestone in 2013 cohort and came close to it with 87% in 2014 cohort. In Batumi, 2013 cohort came close to achieving the 2020 WHO target, with 93% coverage and 95% level within the confidence limits of the estimate (95% CI, 90%-95%). For the birth dose of HepB nationwide timely coverage in 2014 cohort (84%) was close to the 85% WHO interim milestone. Of note, 2014 cohort achieved this milestone in Batumi and Kutaisi (87% and 85%, respectively) (Table 10).

Overall, the situation with hepatitis B vaccination is on improving track, making progress towards achieving the regional and national coverage targets. It is necessary to sustain increasing trend in HepB0 coverage. Further improvement in timeliness of vaccination can be a substantial contributor to the progress in this direction. Nevertheless, hepatitis B immunity gap in 2009 cohort is of concern. Additional assessments might be needed to decide on the need for any one-time catch-up immunization in this cohort.

7. 7. Hib

Immunization against Hib was introduced in Georgia in 2010, with Penta vaccine, therefore coverage with Penta largely reflects coverage with Hib as most children in 2013 and 2014 received combination vaccines containing Hib. In these cohorts, the proportion of children who received DTP/DT for primary series and thus remain unvaccinated for Hib was small (usually <2%, with the highest difference between coverage for Penta3 and Hib of 3.8% in Tbilisi in 2013 cohort) (Tables 7 and 8). Reducing to the maximum possible extent the proportion of children receiving DTP or DT for primary vaccination instead of combination vaccines would help to further increase population protection against *H. influenzae* type B.

7. 8. Rotavirus

Rotavirus vaccine was introduced in Georgia beginning in 2013 and achieved 66% 2-dose coverage in 2014 cohort. Although generally not high, this appears to be within expected reasonable range for a newly introduced vaccine, particularly the one with strict time limits for administration. The association of rotavirus vaccine coverage with the timing of Penta1 receipt indicates that the main reason for not getting vaccinated for rotavirus is the delay in beginning routine vaccinations. Therefore, improving timeliness of vaccinations in general will likely lead to improving coverage for rotavirus vaccine in Georgia. The survey also demonstrated that a small proportion of children in Georgia receive rotavirus vaccine later than recommended time frame which should be discouraged.

7. 9. Administrative versus survey coverage

The comparison of the survey estimates with corresponding administratively reported coverage confirmed weaknesses of the current administrative reporting system. With the present coverage survey sampling frame incorporating all children in Georgia, including those not registered with HCFs, discrepancies in coverage between administrative and survey coverage were expected.

One potential source for discrepancies could be migration to foreign countries. In the survey, only 0.7%, 0.8% and 1.7% of children in 2014, 2013 and 2009 cohorts, respectively, were residing outside Georgia at the time of the survey (Table 6). Even taking into account additional <1% of children with foreign address in each cohort in the Civil Registry data base, the contribution of foreign migration appears relatively minor.

Another, more significant source of discrepancy between the survey and GEOVAC estimates is the substantial difference between GEOVAC target populations for BCG (which is very close to birth cohort) and Penta1/DTP1 consistently observed in Georgia over the past decade (in the surveyed cohorts, between 9% and 12% of the cohort)[19], leading to underestimating the target used for assessing coverage for Penta1/DTP1 and other doses of the primary series.

However, for some vaccine doses the difference was far greater (e.g. for Pol5 in 2009 cohort – 64% in survey versus 87% in GEOVAC, Table 12), than could be explained by the existence of non-registered populations or migration to foreign countries. Likely additional contributors to the discrepancy in coverage between the survey and the administrative system could be inaccuracies in reporting numbers of vaccinated persons and target populations, or both, to GEOVAC.

Detailed review of immunization data quality at the HCF level would help in determining specific reasons for these inaccuracies. Of note, addressing the issue of data quality at the HCF level would improve accuracy of the estimates within the system, but would not solve the problem of unregistered children. This problem is related to current health care system in Georgia, where most of the HCF are private entities, immunizations are included in a package of services funded on a per capita basis and provided through primary health care providers and maternity hospitals (for BCG and HepB0). Notably, these private facilities do not have specified catchment areas and individuals can register with any provider of their choice independent of its location. The registration with a HCF is an individual's responsibility and is not mandatory. Under such circumstances, HCFs lack the motivation and the mechanisms to identify children not registered with their HCF.

The full implementation of the Immunization Management Module as part of the Health Management Information System should eventually solve the problem of denominator and lead to more accurate and real-time administrative assessment of coverage in Georgia. The Immunization Module is built around the citizen's national ID number assigned at birth that enables monitoring of migration of beneficiaries as well as tracking vaccinations administered to individuals. The module enables instant access to the person's vaccination history to any provider countrywide, using the child's national ID assigned at birth. However, the implementation of the Immunization Module is still at early stage and many of its benefits cannot be yet fully utilized. The quality of data populating the system has not been assessed and its analytical capacity needs strengthening. Until the Immunization Module is fully developed and implemented, the current system for administrative reporting of coverage will have to be maintained, but coverage surveys will remain the optimal way to obtain reliable information on immunization coverage levels in Georgia.

8. Conclusions

1. Georgia has a well-developed, accessible and functioning routine immunization program which has coped with challenges associated with changing landscape of health care system.

2. National immunization program in Georgia provides adequate access to immunization services as judged by very high proportion of children who received at least one recommended vaccine dose by the time of the survey. However, not all children utilize the system to full extent and complete the recommended series.

3. Immunization program performance, as judged by coverage, timeliness and dropout rates, has generally improving trend, but geographic variations are present.

[19] The difference between GEOVAC target populations for BCG and Penta1/DTP1 in 2014 was 7,100 children in 2013 –5,400 children, and in 2009 – 7,800 children, accounting for 11%, 9% and 12 % of BCG target population, respectively.

4. Overall, immunization services appear strongest in Batumi, followed by the rest of Georgia and Tbilisi, and weakest – in Kutaisi, where the program is underperforming to a substantial extent.

5. The overall national target of 95% coverage for all antigens was not met, but by the time of the survey, $\geq$95% coverage was achieved nationwide for Penta1/DTP1 and Pol1 in all cohorts. Batumi, with $\geq$95% coverage for most major vaccines, was closest to achieving the overall target, followed by rest of Georgia and Tbilisi, which have achieved $\geq$95% coverage for some vaccine doses.

6. Kutaisi has considerable problems in delivering immunization services, with substantial proportion of children who have not initiated routine vaccinations, widespread delays, high dropouts, and as a result, suboptimal levels of coverage achieved.

7. Immunization coverage at the time of the survey was in the moderate to high range for most vaccinations recommended during the 1st year of life. However, coverage was lower for vaccinations recommended after 12 months of age, particularly, for vaccine doses recommended at 5 years.

8. Delayed vaccinations are common in all cohorts surveyed. Even when the coverage target is met, this usually happens with substantial delay after the recommended age for the given dose. Late initiation of routine vaccinations has negative impact on subsequent coverage (particularly, for rotavirus vaccine) and on completion of recommended age-appropriate series of immunizations.

9. Coverage and timeliness of vaccinations decline with the increase of recommended age for vaccine doses in the following order: Penta1/DTP1 $\geq$ Pol1 > Penta3 $\geq$ MMR1 > Pol3 > DTP4 $\geq$ MMR2 > Pol4 > DT5 > Pol5.

10. Relatively low coverage for rotavirus vaccine is related to delays in initiating routine vaccinations.

11. Georgia is well advanced towards meeting the 2020 targets for hepatitis B vaccine recently adopted by WHO European Region.

12. Primary HCFs may not be the best place to assess coverage with the vaccine doses administered at maternity hospitals. Problems with transmitting immunization information from maternity hospitals to primary HCFs could have resulted in underestimating BCG and HepB0 coverage in the survey.

13. The current administrative system of reporting overestimates coverage for most vaccine doses, in some cases, to a substantial extent.

14. Not having interim milestones and defined time frame makes the national coverage target of $\geq$95% coverage for all antigens difficult to achieve, particularly in underperforming areas and for later vaccine doses for which current coverage is far below the target.

15. The Immunization Management Module has the potential to become extremely useful tool for monitoring immunization system performance. The linkage of the Module with the Civil Registry data set has been critical for having access to sampling frame needed for design and implementation of this survey.

9. Recommendations

1. To increase coverage and ensure better timeliness of immunizations in Georgia, a complex of measures aimed at strengthening information systems and decreasing parental and provider hesitancy should be implemented. National public health authorities should continue working with stakeholders among national and local government entities, legislative bodies, insurance companies, HCFs, professional organizations, etc., as well as international partners to ensure adequate regulatory framework, and technical and financial support for strengthening immunization program in Georgia.

2. National public health authorities should consider setting the interim milestones for coverage levels and develop the timeline for achievement of the national targets. This would allow to better monitor progress, particularly in underperforming areas and to increase usefulness of having national goals as a tool for the system strengthening.

3. To improve the situation with immunization services in Kutaisi, a special targeted intervention to strengthen immunization services should be developed and implemented.

4. With transition of Georgia's national immunization program from Penta to Hexa in late 2015, public health authorities and health care workers should pay particular attention to achieving and maintaining high coverage with 3 doses of Hexa, which currently is the only vaccine against type 2 poliovirus. In addition, high coverage with three doses of Hexa, which contains acellular pertussis vaccine, is critical for ensuring population protection against pertussis.

5. With transition of Georgia to IPV as part of Hexa for primary immunization series against polio, bOPV at 18 months and 5 years are the only doses given as live polio vaccine, which provides mucosal immunity, necessary for reducing poliovirus shedding and transmission. Therefore, it is extremely important to improve coverage with both doses of bOPV.

6. To prevent further outbreaks and achieve measles and rubella elimination in Georgia, targeted efforts to increase coverage and timeliness of both doses of MMR, particularly MMR2, should be implemented. The section aimed at increasing MMR coverage in all population groups should be included in the National Plan for Measles and Rubella Elimination currently under development.

7. Maternity hospitals and primary HCFs should be reminded of the need for accurate documentation of BCG and HepB0 doses in child's records, including entering BCG and HepB0 immunizations into the Immunization Management Module by maternity hospitals. The reasons for lower than expected coverage with BCG and HepB0 in the survey should be verified.

8. To meet WHO European Regional 2018 milestones and 2020 targets for hepatitis B vaccines, measures to ensure every newborn receives the birth dose of hepatitis B vaccine within the first 24 hours of life should be implemented, including increasing awareness about the need for the birth dose among both providers (maternity hospitals) and parents.

9. To further improve already good access to immunization services, measures to help reduce the number of children unregistered with primary HCFs, should be implemented. Parents should be provided, at maternity hospitals, or at the time of obtaining child's birth certificate, with information explaining importance and procedures for having children registered with a primary HCFs as early as possible.

10. A complex of measures should be implemented to improve timeliness of vaccinations and reduce the impact of delays on coverage:
    - Measures to reduce false contraindications should be implemented focusing on providers and opinion-makers in relevant clinical disciplines. This should include informing and training them, monitoring use of contraindications by providers, requiring written justification for delays or exemptions and documentation of the condition recognized as contraindication by the Ministerial Decree regulating immunizations in Georgia.

    - National public health authorities should recommend and assist HCFs in developing/strengthening systems for reminder and recall for vaccinations. Measures should be implemented to increase parental awareness and utilization of existing smartphone applications and SMS reminders to parents about vaccinations, and encourage their further development.

    - Involving child care institutions and schools in reviewing/monitoring children's immunization status and reminding parents of the need for immunizations should be considered. The possibility of immunization requirements for kindergarten/school entry for at least some VPDs (e.g. poliomyelitis, diphtheria, tetanus, measles, and rubella) could be considered. This is a very complex, multi-faceted issue and all aspects need to be carefully assessed before making the decision.

    - The potential for using of the Immunization Management Module for identification of children not registered with HCFs, as well as for identification and tracking of unvaccinated and under-vaccinated children registered with HCFs ("defaulter tracing"), should be explored.

    - The possibility of expanding the capacity of the Immunization Management Module to allow parental access to child's record to look up their child's immunization status and get information on vaccinations that are due, should be explored.

11. To mitigate the impact of vaccination delays, providers should be reminded and encouraged to utilize catch-up schedules defined in national guidelines for children who have fallen behind the immunization schedule.

12. To reduce missed opportunities for immunizations, any visit to primary HCF should be used to offer applicable vaccinations. As a minimum, child's immunization status should be reviewed and parents should be informed on vaccinations needed.

13. Interventions to decrease to maximum possible extent parental refusals, a common reason for children not getting vaccinated in Georgia, need to be implemented. Communication interventions directed toward parents are needed to counteract the various influences leading to the decision not to vaccinate. Georgian legislation allows parental refusal with written documentation but has no defined non-medical criteria for eligibility for exemptions from vaccinations. Therefore, the possibility for better defining regulatory criteria allowing parental refusal should be explored.

14. Monitoring of immunization coverage should be improved to ensure that the system capable of providing timely and accurate coverage estimates is in place.
    - The Immunization Management Module, particularly its analytical capacity should be strengthened to allow accurate, up-to-date reporting of coverage at HCF, district and national level, as well as provide flexibility for additional analyzes.

- Measures to increase acceptance and utilization of the Immunization Management Module by providers should be implemented, such as ensuring access to computers and Internet, additional training, technical support, monitoring of the extent of use of the system to help with identification of underperforming areas.
- Until the Immunization Management Module has become fully functional, it will be necessary to work with providers and district public health authorities on improving quality of data reported to the existing system (GEOVAC). Relevant public health authorities at district and national level should closely and systematically monitor the quality of coverage data (both denominator and numerator) reported through GEOVAC, and request reporting entities to correct any identified inconsistencies.

10. Tables

Table 1. Official country estimates of immunization coverage reported to WHO, Georgia, 1990-2014 (http://apps.who.int/immunization_monitoring/globalsummary/coverages?c=GEO Accessed Jan 28, 2017)

Vaccine	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
BCG	96	95	95	96	97	95	95	96	95	95	91	87	80	97	95	95	94	76	70	32	30	30	67	91	95
DTP3	91	98	92	95	91	88	92	98	87	84	78	76	85	86	98	98	89	92	92	54	58	54	58	45	69
HepB3	91	93	92	92	95	54	89	94	83	74	64	49	51	61	55										
HepB-BD	95	80	93	93	90	55	95	93	87	93	75	90		69											
Hib3	91	93	92	92	67																				
MCV1	92	97	93	94	94	83	96	97	95	92	86	80	99	100	97	97	90	95	88	61	63	61	16	81	99
MCV2	87	89	84	77	84	71	87	92	88	87	75	57	40	8											
Pol3	91	94	93	91	88	93	90	88	88	84	66	75	90	81	98	98	95	98	94	82	82	82	68	45	87
Rota1	77	74																							
Rota2	69	56																							
RCV1	92	97	93	94	94	83	97	97	95	92	31														

Table 2. Recommended national immunization schedule in Georgia (updated October 2014)

Age / Diseases	0-12 hrs	0-5 d	2 mos	3 mos	4 mos	12 mos	18 mos	5 yrs	14 yrs
Hepatitis B	**HepB0**								
Tuberculosis		**BCG**							
Diphtheria, tetanus, pertussis, Hib, hepatitis B			**Penta1**	**Penta2**	**Penta3**				
Diphtheria, tetanus,							**DTP4**		
Poliomyelitis			**OPV1**	**OPV2**	**OPV3**		**OPV4**	**OPV5**	
Rotavirus			**Rota1**	**Rota1**					
Pneumococcal infection*			**PCV1**	**PCV2**		**PCV3**			
Measles, mumps, rubella						**MMR1**		**MMR2**	
Diphtheria, tetanus								**DT5**	
Tetanus, diphtheria									**Td**

* 10-valent PCV introduced in late 2014

Table 3. Birth cohorts included in the survey and coverage assessed for each one by year and vaccine dose

Birth cohort	Birth dates	Coverage assessed for:	Years corresponding coverage reported
2014	1/1/-12/31/2014	Penta1, *, Pol1, 3**, BCG, HepB0, HepB3***, Rota1-2	2014
2013	1/1-12/31/2013	Penta1, 3*, Pol1-3**, BCG, HepB0, HepB3***,	2013
		DTP4*, Pol4**, MMR1	2014
2009	1/1-12/31/2009	DTP1, 3*, Pol1, 3**, BCG, HepB0, HepB3***,	2009
		DTP4*, Pol4**, MMR1	2010
		DT5*, MMR2, Pol5**	2014

* Other age-appropriate vaccines containing diphtheria-tetanus components (e.g. DTP, DT, Hexa) are also included in coverage calculations for Penta and DTP;

** Both types of polio vaccines - OPV and IPV are included in coverage calculations for Pol.

*** Both monovalent HepB vaccine and combination vaccines containing HepB component are included in coverage calculations for HepB3.

Table 4. The design of the coverage survey, Georgia

Domain	Stratum name	PSU definition	# of PSUs	SSU definition	# of SSU / PSU	# of TSU	Total children per birth cohort	Design	PSU size
1	Tbilisi (capital city)	Child	750	N/A	N/A	N/A	750	SRS	1
2	Kutaisi (city)	Child	600	N/A	N/A	N/A	600	SRS	1
3	Batumi (city)	Child	600	N/A	N/A	N/A	600	SRS	1
	Three large cities						*1950*		
4	Rustavi and Poti* (cities)	Child	50	N/A	N/A	N/A	50	SRS	1
	Kobuleti (district)	Village	5	Child	5	N/A	25	2-stage cluster	5
	Marneuli (district)	Village	5	Child	5	N/A	25	2-stage cluster	5
	Gardabani (district)	Village	5	Child	5	N/A	25	2-stage cluster	5
	Zugdidi (district)	Village	5	Child	5	N/A	25	2-stage cluster	5
	Gori (district)	Village	10	Child	5	N/A	50	2-stage cluster	5
	Remaining 54 districts	District	24	Village/town	5	5	600	3-stage cluster	25
	Rest of Georgia						*800*		
	Georgia						*2750*		

PSU, primary sampling unit; SSU, secondary sampling unit; TSU, tertiary sampling unit; SRS, simple random sampling; N/A, not applicable.

* Rustavi and Poti were combined in one unit for sampling purposes.

Table 5. Definitions of main outcome measures and time points for assessing coverage by birth cohort

Vaccine dose/series	Definition	Time point for assessing:	
	% of children who received:	**Overall coverage**	**Timely coverage**
BCG	BCG	Time of the survey	by day 6
HepB0	HepB vaccine (monovalent)	Time of the survey	by day 2
Penta1/DTP1	1st dose of Penta/DT/Hexa or other comb. vaccine	Time of the survey	by 12 months
Penta3/DTP3	3rd dose of Penta/DT/Hexa or other comb. vaccine	Time of the survey	by 12 months
DTP4	4th dose of Penta/DT/Hexa/or other comb. vaccine	Time of the survey	by 24 months
DT5	5th dose of DT vaccine	Time of the survey	by 72 months
Pol1	1st dose of polio vaccine (OPV or IPV)	Time of the survey	by 12 months
Pol3	3rd dose of polio vaccine (OPV or IPV)	Time of the survey	by 12 months
Pol4	4th dose of polio vaccine (OPV or IPV)	Time of the survey	by 24 months
Pol5	5th dose of polio vaccine (OPV or IPV)	Time of the survey	by 72 months
MMR1	1st dose of MMR vaccine	Time of the survey	by 24 months
MMR2	2nd dose of MMR vaccine	Time of the survey	by 72 months
HepB3	3 doses of HepB-containing vaccine (monovalent or combination)	Time of the survey	
Hib3	3 doses of Hib-containing vaccine	Time of the survey	
Rota1	1st dose of rotavirus vaccine	Time of the survey	by 16 weeks
Rota2	2nd dose of rotavirus vaccine	Time of the survey	by 24 weeks
Dropout DTP1-DTP3	Coverage with Penta1/DTP1 minus coverage with Penta3/DTP3	Time of the survey	by 12 months
Combined series - major vaccines - % of children who received at least:			
2014 cohort	3 doses of vaccines against diphtheria, tetanus, pertussis, HiB, HepB and polio	Time of the survey	by 12 months
2013 cohort	4 doses of vaccines against diphtheria, tetanus, pertussis, and polio, 3 doses against HiB and HepB, and 1 dose of MMR vaccine	Time of the survey	by 24 months
2009 cohort	5 doses of vaccines against diphtheria, tetanus, and polio, 4 doses against pertussis, 3 doses against HepB, and 2 dose of MMR vaccine	Time of the survey	by 72 months
Combined series - all vaccines - % of children who received at least:			
2014 cohort	3 doses of vaccines against diphtheria, tetanus, pertussis, HiB, and polio, 4 doses against HepB, 1 dose of BCG, and 2 doses of rotavirus vaccine	Time of the survey	by 12 months
2013 cohort	4 doses of vaccines against diphtheria, tetanus, pertussis, polio, and HepB, 3 doses against HiB, 1 dose of MMR vaccine, 1 dose of BCG, and 2 doses of rotavirus vaccine	Time of the survey	by 24 months
2009 cohort	5 doses of vaccines against diphtheria, tetanus, and polio, 4 doses against pertussis, 3 doses against HepB, 1 dose of BCG, and 2 dose of MMR vaccine.	Time of the survey	by 72 months

Table 6. Response rates by survey site and cohort

Survey Site/Cohort	Total children, No.	Total targeted, No. (% of total)	Moved overseas, No. (% of targeted)	Total in Georgia, eligible for survey, No. (% of targeted)	Found, data obtained, No. (% of eligible)	Not found, No. (% of eligible)
Tbilisi						
2014	20,121	750 (3.7)	5 (0.6)	745 (99.4)	703 (94.3)	42 (5.6)
2013	19,329	750 (3.9)	2 (0.3)	748 (99.7)	712 (95.2)	36 (4.8)
2009	19,706	750 (3.8)	17 (2.3)	733 (97.7)	677 (92.4)	56 (7.6)
Batumi						
2014	2,927	600 (20.5)	3 (0.5)	597 (99.5)	572 (95.8)	25 (4.2)
2013	2,978	600 (20.1)	8 (1.4)	592 (98.6)	572 (96.6)	20 (3.4)
2009	3,078	600 (19.5)	3 (0.5)	597 (99.5)	553 (92.6)	44 (7.4)
Kutaisi						
2014	2,636	600 (22.8)	5 (0.8)	595 (99.2)	581 (97.6)	14 (2.4)
2013	2,731	600 (22.0)	3 (0.5)	597 (99.5)	585 (98.0)	12 (2.0)
2009	2,783	600 (21.6)	5 (0.8)	595 (99.2)	548 (92.1)	47 (7.9)
Rest of Georgia						
2014	35,668	800 (2.2)	17 (2.1)	783 (97.9)	747 (95.4)	36 (4.6)
2013	33,536	800 (2.4)	13 (1.6)	787 (98.4)	750 (95.3)	37 (4.7)
2009	37,628	800 (2.1)	20 (2.5)	780 (97.5)	705 (90.4)	75 (9.6)
Georgia						
2014	61,352	2750	30 (1.1)	2720 (98.9)	2609 (95.9)	111 (4.1)
2013	58,574	2750	27 (1.0)	2723 (99.0)	2623 (96.3)	100 (3.7)
2009	63,204	2750	46 (1.7)	2704 (98.3)	2491 (92.1)	213 (7.9)

Table 7. Nationwide coverage in Georgia at the time of the survey - by birth cohort, survey site and vaccine dose

Vaccine dose	**2014 cohort** (N=2609)		**2013 cohort** (N=2623)		**2009 cohort** (N=2491)	
	No. vaccinated	**Coverage, % (95% CI)**	**No. vaccinated**	**Coverage, % (95% CI)**	**No. vaccinated**	**Coverage, % (95% CI)**
BCG	2301	86 (83-89)	2204	83 (80-86)	2151	83 (80-86)
HepB0	2249	84 (81-87)	1857	70 (66-73)	1239	46 (43-49)
Penta1/DTP1	2442	95 (94-96)	2517	97 (96-98)	2424	97 (96-97)
Penta3/DTP3	2221	88 (86-90)	2372	92 (90-93)	2279	90 (88-92)
DTP4			1981	80 (78-82)	2176	85 (83-87)
DT5					1808	72 (69-74)
Pol1	2423	94 (93-96)	2496	96 (95-97)	2414	96 (95-97)
Pol3	2195	87 (85-89)	2353	91 (90-92)	2279	90 (88-91)
Pol4			1920	76 (74-78)	2132	83 (81-85)
Pol5					1788	69 (67-72)
MMR1			2281	89 (88-91)	2343	93 (92-94)
MMR2					1911	76 (73-79)
HepB3	2191	87 (84-89)	2318	90 (88-91)	1017	40 (37-44)
Hib3	2193	87 (84-89)	2320	90 (88-91)		
Rota1	1821	72 (69-75)	1574	60 (57-62)		
Rota2	1690	66 (63-69)	1464	56 (53-59)		
Combined series with major vaccines[a]	2154	85 (83-87)	1793	71 (69-74)	1230	46 (42-49)
Combined series with all vaccines[b]	1436	54 (50-58)	893	34 (31-37)	1161	43 (39-46)
Received no vaccines recommended at $\geq$2 months	142	4 (3-5)	94	3 (2-4)	52	3 (2-4)
Received $\geq$1 dose with commercial vaccine	113	5 (4-6)	110	5 (4-6)	75	3 (3-4)

[a] Combined series with major vaccines includes at least: for 2014 birth cohort – 3 doses of vaccines against diphtheria, tetanus, pertussis, HiB, HepB and polio; for 2013 birth cohort - 4 doses of vaccines against diphtheria, tetanus, pertussis, and polio, 3 doses against HiB and HepB, and 1 dose of measles-mumps-rubella vaccine; for 2009 birth cohort - 5 doses of vaccines against diphtheria, tetanus, and polio, 4 doses against pertussis, 3 doses against HepB, and 2 dose of measles-mumps-rubella vaccine. Hib is not included in this series for 2009 birth cohort as this was the year of its introduction.

[b] Combined series with all vaccines includes at least: for 2014 birth cohort – 1 dose of BCG, 3 doses of vaccines against diphtheria, tetanus, pertussis, HiB, and polio, 4 doses against HepB, and 2 doses of rotavirus vaccine; for 2013 birth cohort – 1 dose of BCG, 4 doses of vaccines against diphtheria, tetanus, pertussis, polio, and HepB, 3 doses against HiB, 1 dose of measles-mumps-rubella vaccine and 2 doses of rotavirus vaccine; for 2009 birth cohort – 1 dose of BCG, 5 doses of vaccines against diphtheria, tetanus, and polio, 4 doses against pertussis, 3 doses against HepB, and 2 dose of measles-mumps-rubella vaccine. PCV and Hib are not included in this series for 2014 and 2009 birth cohorts, respectively, because for these vaccines these were the years of their introduction.

Table 8. Subnational coverage at the time of the survey - by site by birth cohort, survey site and vaccine dose

Vaccine dose	Tbilisi		Batumi		Kutaisi		Rest of Georgia	
	No. vaccinated	Coverage, % (95% CI)	No. vaccinated	Coverage, % (95% CI)	No. vaccinated	Coverage, % (95% CI)	No. vaccinated	Coverage, % (95% CI)
2014 cohort	(N=709)		(N=572)		(N=581)		(N=746)	
BCG	645	91 (89-93)	524	92 (89-94)	512	88 (85-90)	620	83 (77-88)
HepB0	602	85 (82-87)	521	91 (88-93	507	87 (84-90)	619	83 (77-87)
Penta1	682	96 (95-97)	544	95 (93-97)	502	86 (83-89)	714	95 (93-97)
Penta3	607	86 (83-88)	501	88 (85-90)	433	75 (71-78)	680	91 (87-94)
Pol1	674	95 (93-96)	538	94 (92-96)	504	87 (84-89)	707	95 (91-97)
Pol3	594	84 (81-86)	492	86 (83-89)	433	75 (71-78)	676	90 (86-93)
HepB3	592	83 (81-86)	499	87 (84-90)	432	74 (71-78)	668	89 (85-92)
Hib3	594	84 (81-86)	499	87 (84-90)	432	74 (71-78)	668	89 (85-92)
Rota1	473	67 (63-70)	441	77 (73-80)	341	59 (55-63)	566	75 (71-80)
Rota2	425	60 (56-63)	420	73 (70-77)	313	54 (50-58)	532	71 (66-75)
Combined series - major vaccines[a]	576	81 (78-84)	490	86 (83-88)	426	73 (70-77)	662	88 (84-91)
Combined series - all vaccines[b]	368	52 (48-56)	378	66 (62-70)	273	47 (43-51)	417	55 (49-62)
Received no vaccines recommended at ≥2 months	20	3 (2-4)	26	5 (3-7)	73	13 (10-15)	23	3 (2-5)
Received ≥1 dose with commercial vaccine	95	13 (11-16)	5	1 (0-2)	4	1 (0-2)	9	1 (1-2)
2013 cohort	(N=716)		(N=572)		(N=585)		(N=750)	
BCG	596	83 (80-86)	505	88 (85-91)	485	83 (80-86)	618	83 (77-87)
HepB0	486	68 (64-71)	456	80 (76-83)	389	67 (63-70)	526	71 (65-76)
Penta1	691	97 (95-98)	562	98 (97-99)	534	91 (89-93)	730	97 (95-98)
Penta3	647	90 (88-92)	540	94 (92-96)	486	83 (80-86)	699	93 (91-95)
DTP4	530	74 (71-77)	444	78 (74-81)	367	63 (59-67)	640	85 (82-88)
Pol1	678	95 (93-96)	560	98 (96-99)	530	91 (88-93)	728	97 (95-98)
Pol3	635	89 (86-91)	535	94 (91-95)	484	83 (79-86)	699	93 (91-95)
Pol4	500	70 (66-73)	437	76 (73-80)	370	63 (59-67)	613	81 (77-84)
MMR1	629	88 (85-90)	511	89 (87-92)	456	78 (74-81)	685	91 (88-94)
HepB3	619	86 (84-89)	531	93 (90-95)	479	82 (79-85)	689	92 (89-94)
Hib3	621	87 (84-89)	532	93 (91-95)	478	82 (78-85)	689	92 (89-94)
Rota1	377	53 (49-56)	418	73 (69-77)	293	50 (46-54)	486	63 (59-67)
Rota2	716	48 (44-52)	398	70 (66-73)	261	45 (41-49)	461	60 (56-64)
Combined series with major vaccines[a]	452	63 (60-67)	419	73 (70-77)	341	58 (54-62)	581	77 (73-81)
Combined series with all vaccines[b]	193	27 (24-30)	267	47 (43-51)	140	24 (21-28)	293	38 (33-43)
Received no vaccines recommended at ≥2 months	21	3 (2-4)	7	1 (1-3)	48	8 (6-11)	18	2 (1-4)

Received ≥1 dose with commercial vaccine	93	13 (11-16)	6	1 (0-2)	2	0 (0-1)	9	1 (1-2)
2009 cohort	(N=685)		(N=553)		(N=548)		(N=705)	
BCG	608	89 (86-91)	509	92 (89-94)	468	85 (82-88)	566	79 (74-84)
HepB0	279	41 (37-44)	390	71 (67-74)	234	43 (39-47)	336	47 (42-52)
Penta1/DTP1	673	98 (97-99)	550	99 (98-100)	523	95 (93-97)	678	96 (94-97)
Penta3/DTP3	616	90 (87-92)	540	98 (96-99)	489	89 (86-92)	634	89 (86-92)
DTP4	581	85 (82-87)	530	96 (94-97)	460	84 (81-87)	605	85 (81-88)
DT5	461	67 (64-71)	474	86 (83-88)	352	64 (60-68)	521	73 (69-77)
Pol1	667	97 (96-98)	550	99 (98-100)	524	96 (94-97)	673	95 (93-96)
Pol3	608	89 (86-91)	540	98 (96-99)	493	90 (87-92)	638	90 (87-92)
Pol4	560	82 (79-84)	521	94 (92-96)	459	84 (80-87)	592	83 (80-86)
Pol5	440	64 (61-68)	474	86 (83-88)	367	67 (63-71)	507	67 (63-71)
MMR1	646	94 (92-96)	539	97 (96-98)	503	92 (89-94)	655	92 (90-94)
MMR2	484	71 (67-74)	481	87 (84-90)	385	70 (66-74)	561	78 (74-82)
HepB3	323	47 (43-51)	194	35 (31-39)	232	42 (38-46)	268	37 (32-42)
Hib3	191	28 (25-31)	98	18 (15-21)	126	23 (20-27)	152	21 (18-25)
Combined series with major vaccines[a]	318	46 (43-50)	340	61 (57-65)	254	46 (42-51)	318	44 (38-49)
Combined series with all vaccines[b]	308	45 (41-49)	325	59 (55-63)	235	43 (39-47)	293	40 (35-46)
Received no vaccines recommended at ≥2 months	8	1 (1-2)	2	0 (0-1)	22	4 (3-6)	20	3 (2-5)
Received ≥1 dose with commercial vaccine	64	9 (7-12)	2	0 (0-1)	6	1 (1-2)	3	0 (0-1)

Table 9. Timely vs overall coverage at the time of the survey nationwide - by cohort and vaccine dose

Vaccine dose	Age assessed	% Timely coverage*	% Coverage at the time of survey	Difference
2014 cohort				
BCG	6 days	83	86	3
HepB0	1 day	81	84	3
Penta1	12 months	92	95	3
Penta3	12 months	81	88	7
Pol3	12 months	81	87	6
2013 cohort				
BCG	6 days	78	83	5
HepB0	1 day	66	70	4
Penta1	12 months	94	97	3
Penta3	12 months	84	92	8
DTP4	24 months	68	80	22
Pol3	12 months	83	91	8
Pol4	24 months	66	76	10
MMR1	24 months	86	89	3
2009 cohort				
BCG	6 days	78	83	5
HepB0	1 day	43	46	3
Penta1	12 months	88	97	9
Penta3	12 months	78	90	12
DTP4	24 months	64	85	21
DT5	72 months	66	72	8
Pol3	12 months	77	90	13
Pol4	24 months	62	83	21
Pol5	72 months	64	69	5
MMR1	24 months	80	93	13
MMR2	72 months	70	76	6

* Probability of being vaccinated by the reference time x 100%

Table 10. Timely versus overall overage at the time of the survey across survey sites - by cohort and vaccine dose

Vaccine dose	Age assessed	Tbilisi, % coverage			Batumi % coverage			Kutaisi, % coverage			Rest of Georgia, % coverage		
		Timely	At the time of survey	Difference	Timely	At the time of survey	Difference	Timely	At the time of survey	Difference	Timely	At the time of survey	Difference
2014 cohort													
BCG	6 days	88	91	3	88	92	4	86	88	2	78	83	5
HepB0	1 day	82	85	3	87	91	4	85	87	2	80	83	3
Penta1	12 mos	93	96	3	95	95	0	86	86	0	92	95	3
Penta3	12 mos	77	86	9	86	88	2	69	75	6	84	91	7
Pol3	12 mos	76	84	8	84	86	2	69	75	6	84	90	6
2013 cohort													
BCG	6 days	79	83	4	85	88	3	82	83	1	76	83	6
HepB0	1 day	64	68	4	75	80	5	65	67	2	67	71	5
Penta1	12 mos	93	97	4	97	98	1	89	91	2	94	97	3
Penta3	12 mos	80	90	10	89	94	5	74	83	9	87	93	6
DTP4	24 mos	60	74	14	77	78	1	57	63	7	73	85	12
Pol3	12 mos	78	89	11	88	94	6	74	83	9	86	93	7
Pol4	24 mos	57	70	13	75	76	1	57	63	7	71	81	10
MMR1	24 mos	83	88	5	89	89	0	75	78	3	88	91	3
2009 cohort													
BCG	6 days	86	89	3	87	92	5	79	85	6	74	79	5
HepB0	1 day	39	41	2	68	71	3	40	43	3	43	47	4
Penta1	12 mos	89	98	9	96	99	3	87	95	8	86	96	10
Penta3	12 mos	77	90	13	86	98	12	76	89	13	78	89	11
DTP4	24 mos	63	85	22	73	96	23	59	84	25	65	85	20
DT5	72 mos	61	67	6	85	86	1	61	64	3	68	73	5
Pol3	12 mos	76	89	13	86	98	10	75	90	15	77	90	13
Pol4	24 mos	58	82	24	71	94	23	56	84	28	64	83	19
Pol5	72 mos	58	64	6	85	86	1	64	67	3	66	67	4
MMR1	24 mos	79	94	15	88	97	9	76	92	16	80	92	12
MMR2	72 mos	63	71	8	86	87	1	67	70	3	72	78	6

Table 11. Age and time since recommended age by which selected proportions of children in (50%, 80%, 90% and 95%) receive a given vaccine dose, by cohort and vaccine dose

Vaccine dose	Recommended age	Age (time since recommended age) by which a given proportion of children are vaccinated, days - for BCG and HepB0, months - for all other vaccines			
		50%	80%	90%	95%
2014 cohort					
BCG	6 days	2 (0[a])	4 (0[a])	Not achieved	Not achieved
HepB0	1 day	0 (0[a])	1 (0[a])	Not achieved	Not achieved
Penta1	2 months	3 (1)	5 (3)	8 (6)	21 (19)
Penta3	4 months	6 (2)	11 (7)	29 (25)	Not achieved
OPV1	2 months	3 (1)	5 (3)	8 (6)	29 (27)
OPV3	4 months	6 (2)	11 (7)	Not achieved	Not achieved
2013 cohort					
BCG	6 days	2 (0[a])	17 (11)	Not achieved	Not achieved
HepB0	1 day	0 (0[a])	Not achieved	Not achieved	Not achieved
Penta1	2 months	3 (1)	5 (3)	8 (6)	19 (17)
Penta3	4 months	6 (2)	10 (6)	25 (21)	Not achieved
DTP4	18 months	21 (3)	34 (16)	Not achieved	Not achieved
OPV1	2 months	3 (1)	5 (3)	8 (6)	22 (20)
OPV3	4 months	6 (2)	11 (7)	27 (23)	Not achieved
Polio4	18 months	21 (3)	44 (26)	Not achieved	Not achieved
MMR1	12 months	13 (1)	18 (6)	38 (26)	Not achieved
2009 cohort					
BCG	6 days	3 (0[a])	18 (12)	Not achieved	Not achieved
HepB0	1 day	Not achieved	Not achieved	Not achieved	Not achieved
Penta1	2 months	3 (1)	7 (5)	21 (19)	67 (65)
Penta3	4 months	7 (3)	14 (10)	Not achieved	Not achieved
DTP4	18 months	21 (3)	60 (42)	Not achieved	Not achieved
DT5	60 months	64 (4)	Not achieved	Not achieved	Not achieved
OPV1	2 months	3 (1)	7 (5)	22 (20)	73 (71)
OPV3	4 months	7 (3)	14 (10)	Not achieved	Not achieved
Polio4	18 months	21 (3)	63 (45)	Not achieved	Not achieved
Polio5	60 months	65 (5)	Not achieved	Not achieved	Not achieved
MMR1	12 months	14 (2)	25 (13)	66 (54)	Not achieved
MMR2	60 months	64 (4)	94 (34)	Not achieved	Not achieved

[a] Within recommended age range

Table 12. Survey coverage versus administrative coverage nationwide - by cohort and vaccine dose

Vaccine dose	Age assessed	Survey coverage, timely, %	Admin. coverage, timely, %	Difference
2014 cohort				
BCG	6 days	83	95	12
HepB0	1 day	81	91	10
Penta3	12 mos	81	88	7
Pol3	12 mos	81	88	7
2013 cohort				
BCG	6 days	78	94	16
HepB0	1 day	66	80	14
Penta3	12 mos	84	93	9
DTP4	24 mos	68	93	25
Pol3	12 mos	83	94	11
Pol4	24 mos	66	86	20
MMR1	24 mos	86	90	4
2009 cohort				
BCG	6 days	78	93	15
HepB0	1 day	43	55	12
Penta3	12 mos	78	88	10
DTP4	24 mos	64	78	14
DT5	72 mos	66	87	21
Pol3	12 mos	77	93	16
Pol4	24 mos	62	77	15
Pol5	72 mos	64	87	23
MMR1	24 mos	80	94	14
MMR2	72 mos	70	86	16

Table 13. Survey coverage versus administrative coverage across survey sites by cohort and vaccine dose

Vaccine dose	Age assessed	Tbilisi, % coverage			Batumi, % coverage			Kutaisi, % coverage		
		Survey	Admin.	Difference	Survey	Admin.	Difference	Survey	Admin.	Difference
2014 cohort										
BCG	6 days	88	96	8	88	94	6	86	94	8
HepB0	1 day	82	84	2	87	98	11	85	96	11
Penta3	12 mos	78	82	4	86	98	12	69	90	21
Pol3	12 mos	76	82	6	84	97	13	69	90	21
2013 cohort										
BCG	6 days	79	96	17	85	97	12	82	98	16
HepB0	1 day	64	76	12	75	87	12	65	76	11
Penta3	12 mos	80	82	2	89	95	6	74	93	19
DTP4	24 mos	60	85	25	77	105	28	57	93	36
Pol3	12 mos	78	83	5	88	94	6	74	93	19
Pol4	24 mos	57	82	25	75	95	20	57	92	35
MMR1	24 mos	83	84	1	89	99	10	75	93	18
2009 cohort										
BCG	6 days	86	87	1	87	94	7	79	95	16
HepB0	1 day	39	52	13	68	80	12	40	48	8
Penta3	12 mos	77	90	13	86	84	-2	76	79	3
DTP4	24 mos	63	78	15	73	79	6	59	78	19
DT5	72 mos	61	85	24	85	100	15	61	85	24
Pol3	12 mos	76	99	23	86	90	4	75	86	11
Pol4	24 mos	58	77	19	71	76	5	56	69	13
Pol5	72 mos	58	87	29	85	94	9	64	91	27
MMR1	24 mos	79	94	15	88	99	11	76	87	11
MMR2	72 mos	64	83	19	86	97	11	67	91	24

Admin. – administrative; mos – months

Table 14. Coverage levels and progress towards achieving 95% national target by vaccine dose

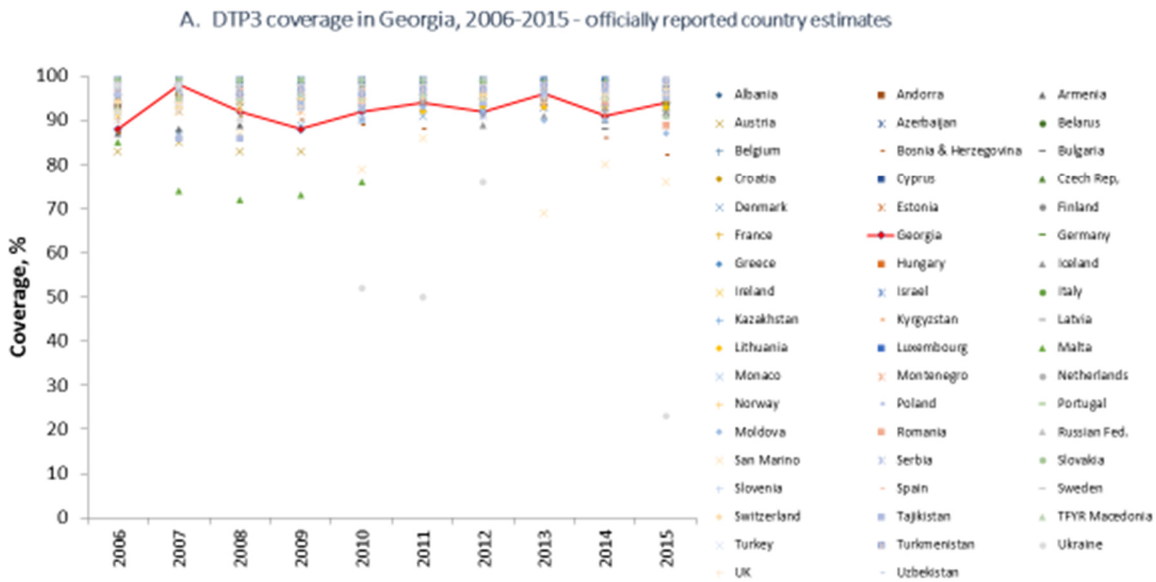
Vaccine dose	Georgia		Tbilisi		Batumi		Kutaisi		Rest of Georgia	
	Coverage level	**95% target achieved**	**Coverage level**	**95% target achieved**	**Coverage level**	**95% target achieved**	**Coverage level**	**95% target achieved**	**Coverage level**	**95% target achieved**
2014 cohort										
BCG	Moderate	No	High	No	High	No	Moderate	No	Moderate	No
HepB0	Moderate	No	Moderate	No	High	No	Moderate	No	Moderate	No
Penta1	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	Moderate	No	**High**	**Yes**
Penta3	Moderate	No	Moderate	No	Moderate	No	Low	No	High	No
Pol1	**High**	**Yes**	**High**	**Almost***	**High**	**Almost***	Moderate	No	**High**	**Yes**
Pol3	Moderate	No	Moderate	No	Moderate	No	Low	No	High	No
2013 cohort										
BCG	Moderate	No	Moderate	No	Moderate	No	Moderate	No	Moderate	No
HepB0	Low	No	Low	No	Low	No	Low	No	Low	No
Penta1	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	High	No	**High**	**Yes**
Penta3	High	No	High	No	**High**	**Almost***	Moderate	No	**High**	**Almost***
DTP4	Moderate	No	Low	No	Low	No	Low	No	Moderate	No
Pol1	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	High	No	**High**	**Yes**
Pol3	High	No	Moderate	No	**High**	**Almost***	Moderate	No	**High**	**Almost***
Pol4	Low	No	Low	No	Low	No	Low	No	Moderate	No
MMR1	Moderate	No	Moderate	No	Moderate	No	Low	No	High	No
2009 cohort										
BCG	Moderate	No	Moderate	No	High	No	Moderate	No	Low	No
HepB0	Low	No	Low	No	Low	No	Low	No	Low	No
DTP1	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**
DTP3	High	No	High	No	**High**	**Yes**	Moderate	No	Moderate	No
DTP4	Moderate	No	Moderate	No	**High**	**Yes**	Moderate	No	Moderate	No
DT5	Low	No	Low	No	Moderate	No	Low	No	Low	No
Pol1	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**	**High**	**Yes**
Pol3	High	No	Moderate	No	**High**	**Yes**	Moderate	No	High	No
Pol4	Moderate	No	Moderate	No	**High**	**Almost***	Moderate	No	Moderate	No
Pol5	Low	No	Low	No	Moderate	No	Low	No	Low	No
MMR1	High	No	**High**	**Almost***	**High**	**Yes**	High	No	High	No
MMR2	Low	No	Low	No	Moderate	No	Low	No	Low	No

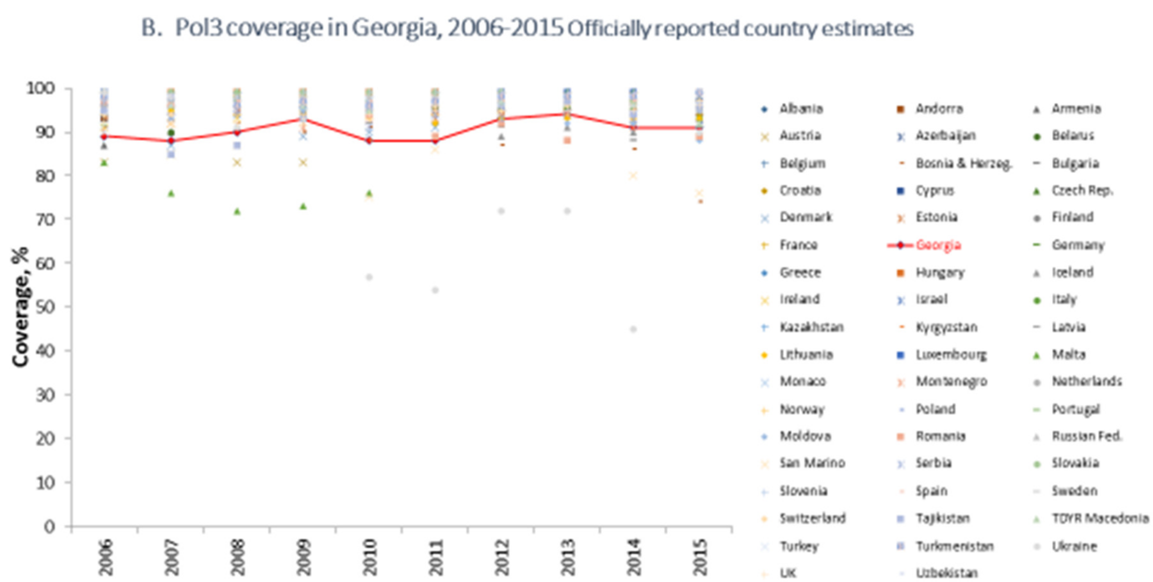
Note. High – ≥90%; Moderate – 80%-89%; Low – <80%.

* Upper 95% confidence interval of an estimate is ≥95.0%. Vaccine doses with national target achieved or almost achieved are shaded in blue.

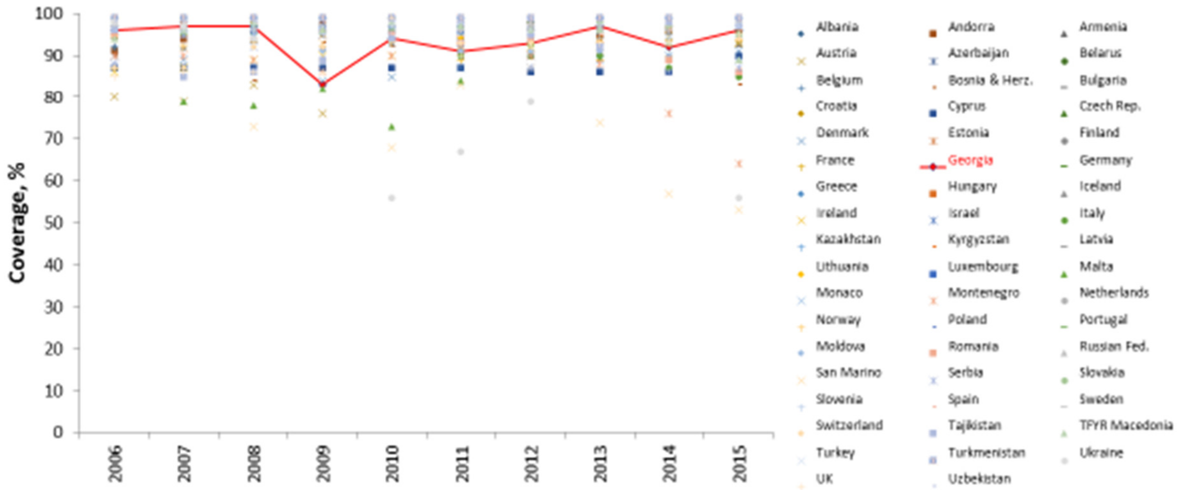
11. Figures

Figure 1. Official country estimates of immunization coverage with DTP3, Pol3, MMR1 and MMR2, reported to WHO, Georgia, 2006-2015 (http://apps.who.int/immunization_monitoring/globalsummary/coverages?c=GEO Accessed Jan 28, 2017)





C. MMR1 coverage in Georgia, 2006-2015 Officially reported country estimates



D. MMR2 coverage in Georgia, 2006-2015 Officially reported country estimates

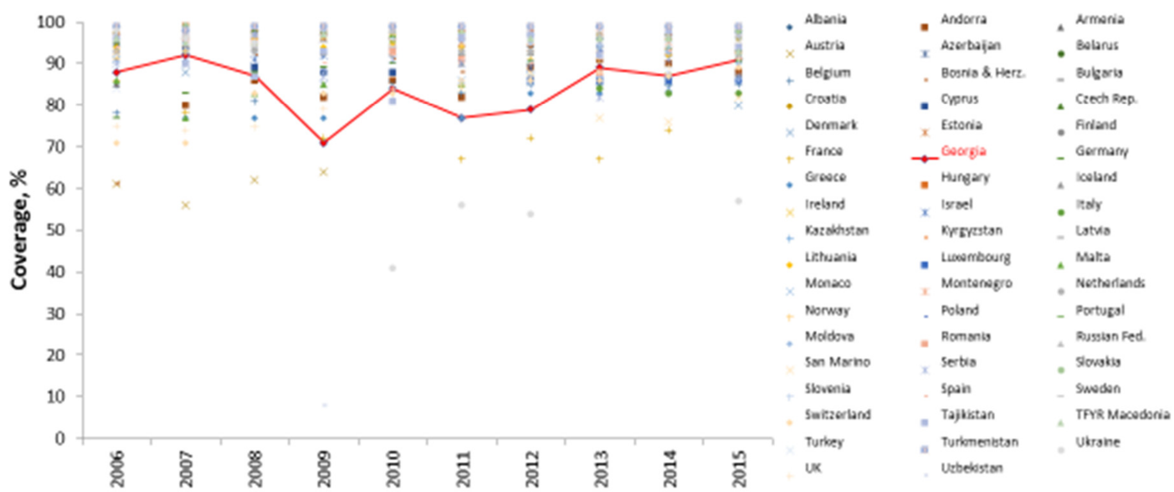
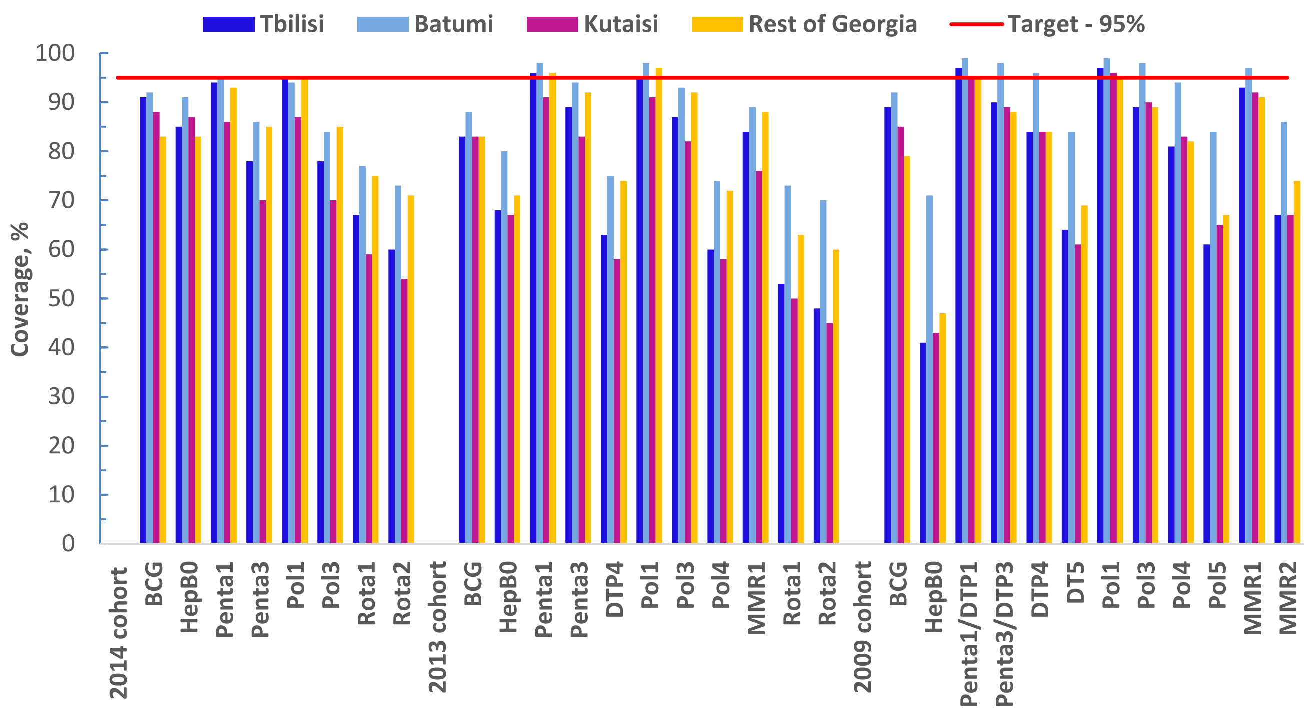
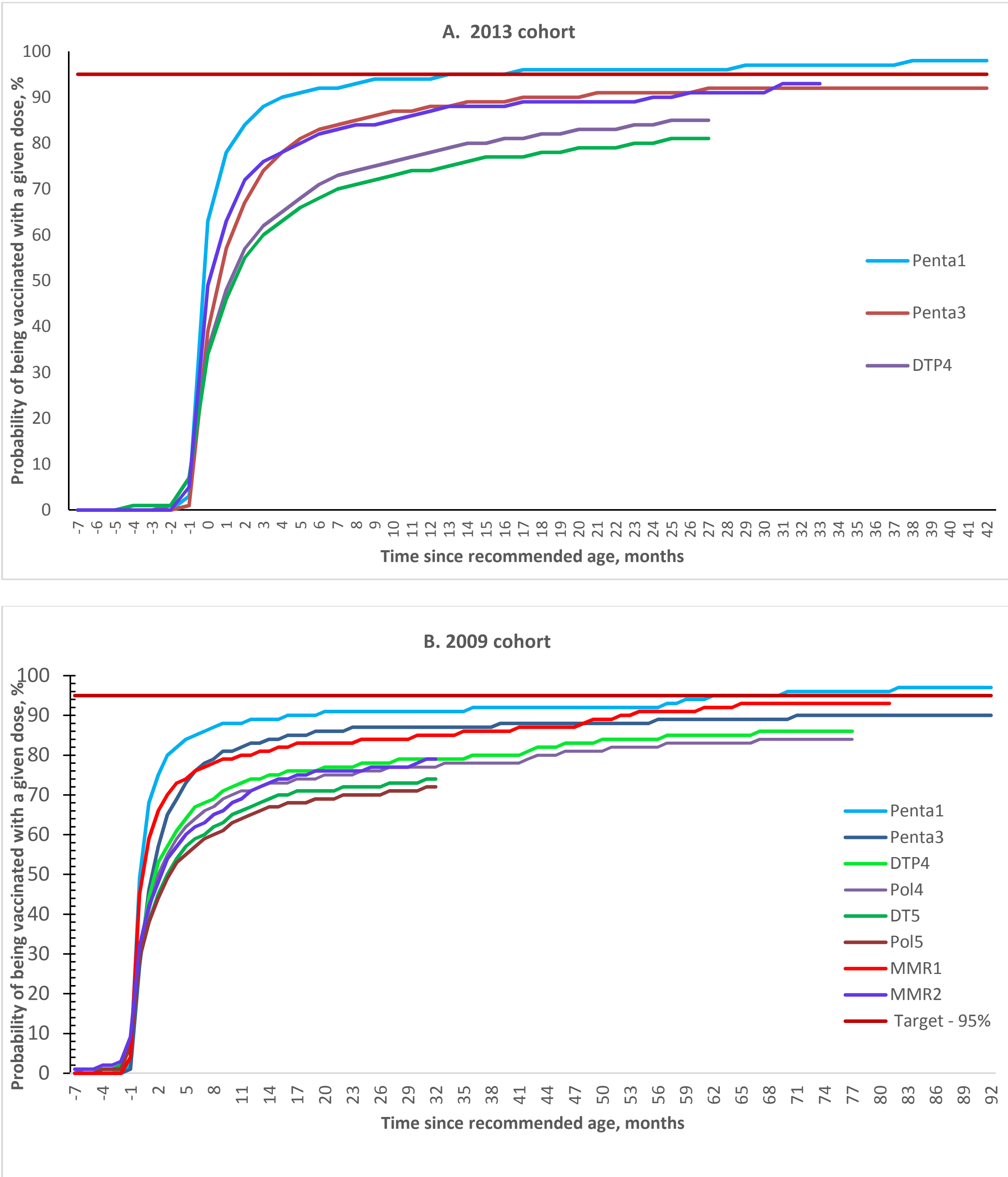


Figure 2. Immunization coverage by survey site and birth cohort - status as of September 1, 2015*.



* To account for sequential implementation of the survey , for the purpose of direct comparisons across survey sites the coverage estimates were adjusted to reflect situation as of September 1 2015, the time of the survey implementation in Batumi, the city surveyed first.

Figure 3. Probability of vaccination by time since recommended age for the given vaccine*



*The data for Pol1 and Pol3 are omitted in the chart because of substantial overlap of the curves with those for Penta1/DTP1 and Penta3/DTP3.

Figure 4. Timing of vaccination for DTP and polio-containing vaccines, nationwide, by birth cohort

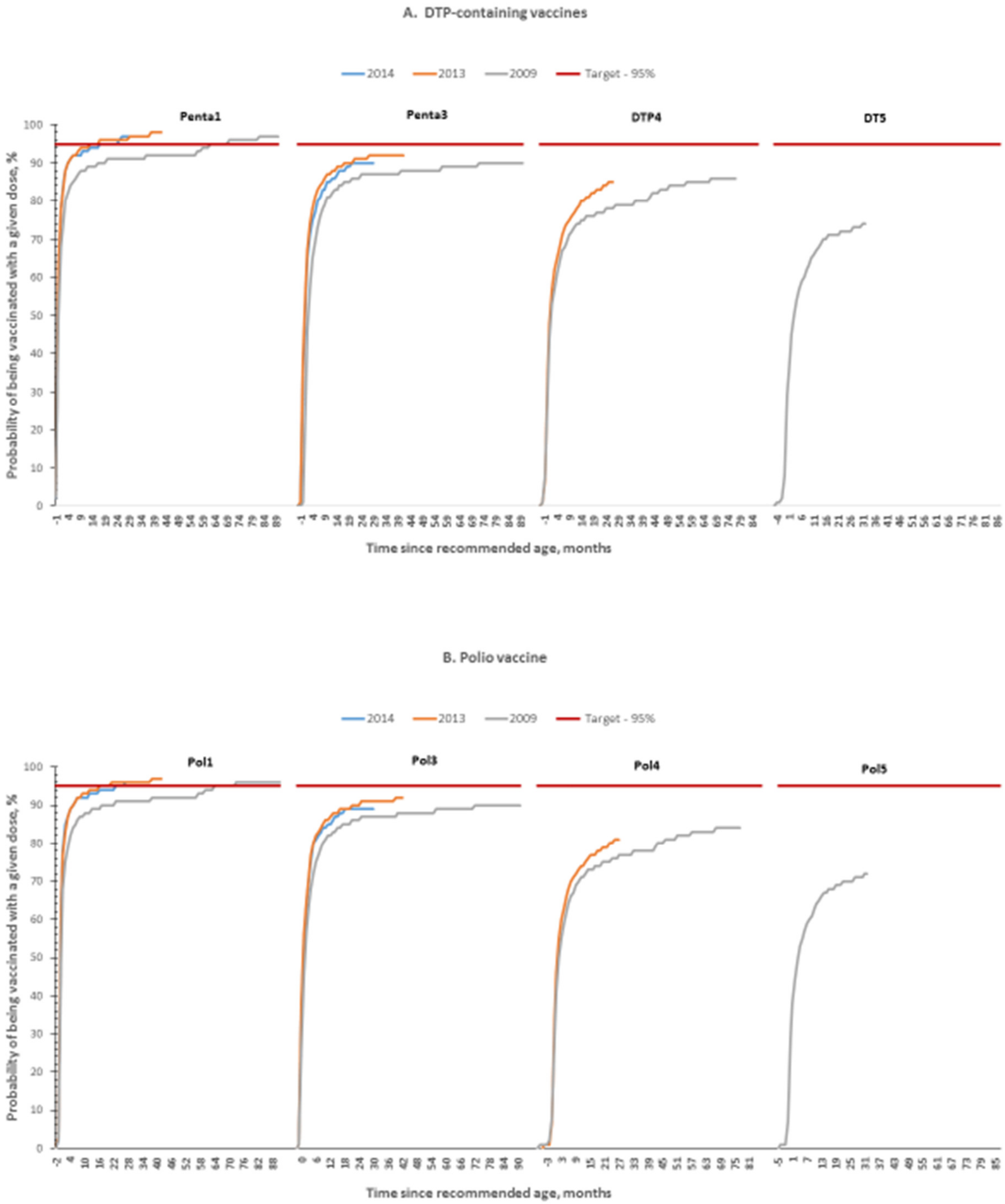
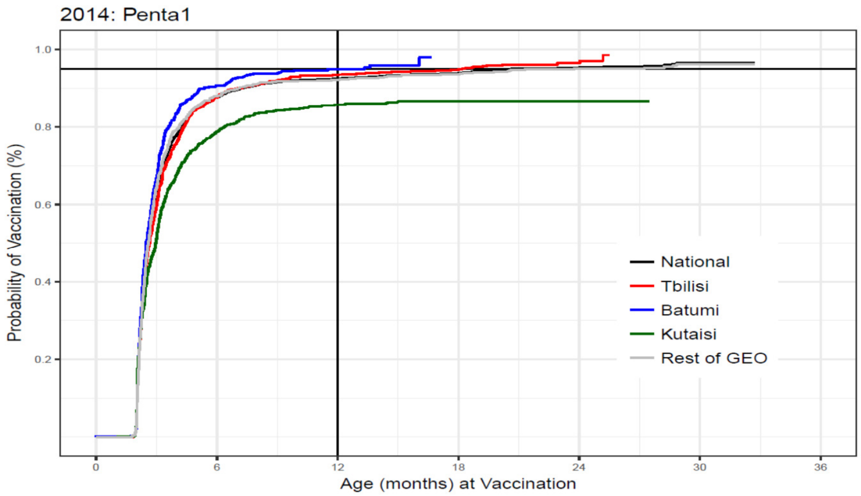
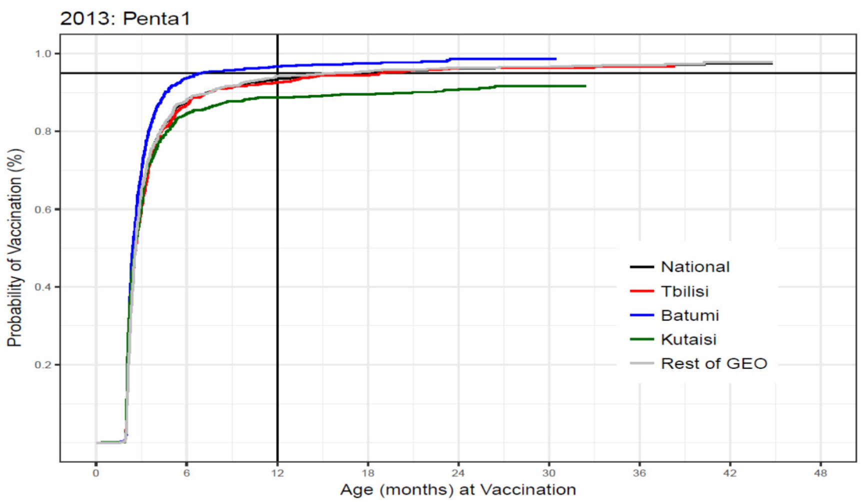


Figure 5. Timeliness of receipt of Penta1/DTP1 by birth cohort – nationwide and for survey sites





Note. Penta1 on the chart includes doses of any DTP-containing vaccine (Penta, DTP, DT, Hexa or other combination vaccines)

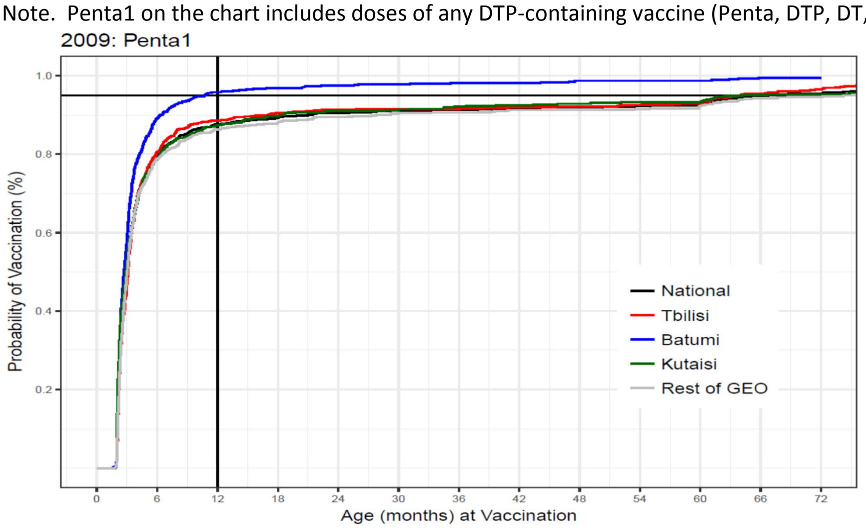
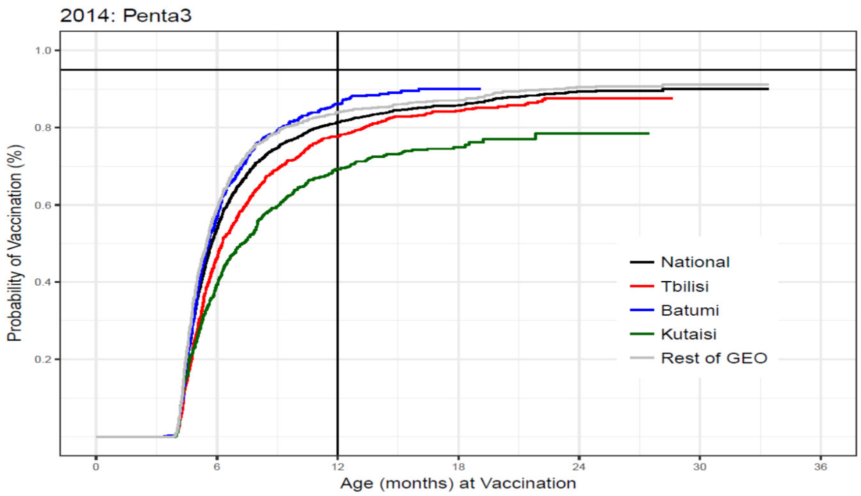
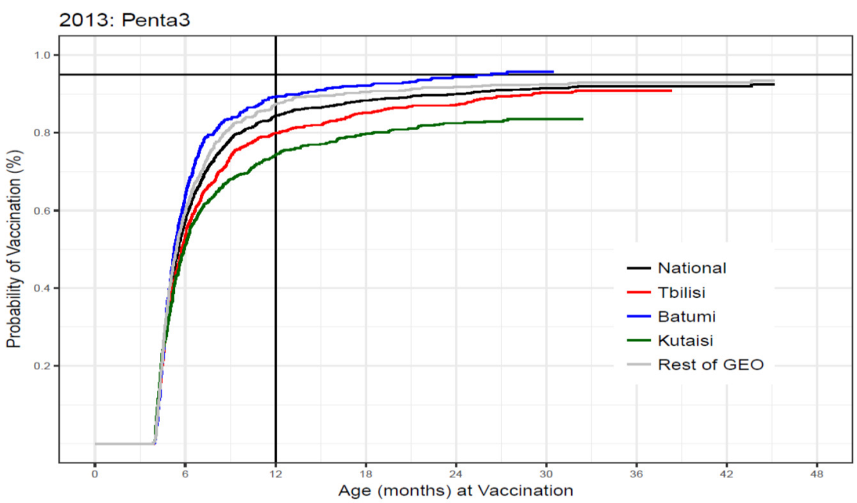


Figure 6. Timeliness of receipt of Penta3/DTP3 by birth cohort – nationwide and for survey sites





Note. Penta3 on the chart includes doses of any DTP-containing vaccine (Penta, DTP, DT, Hexa or other combination vaccines)

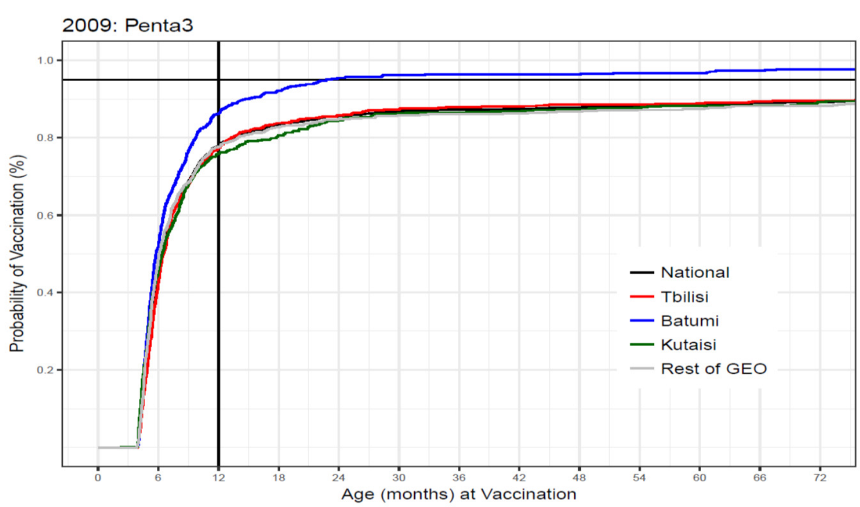
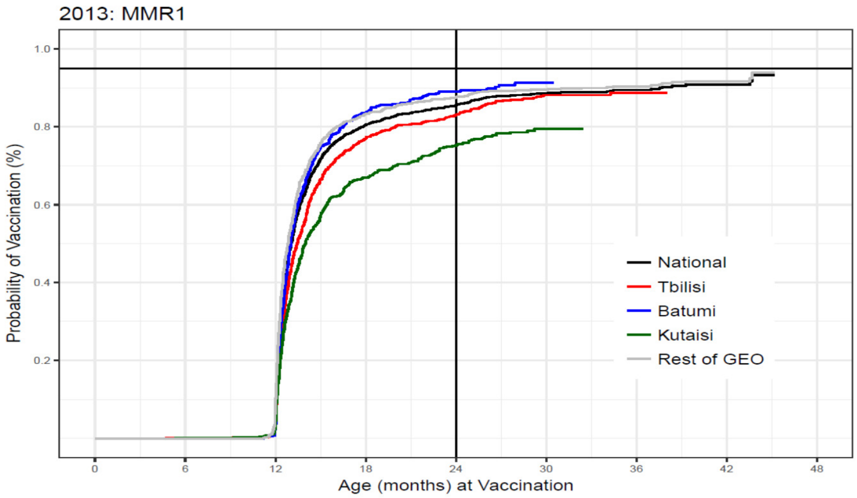


Figure 7. Timeliness of receipt of MMR1 by birth cohort – nationwide and for survey sites



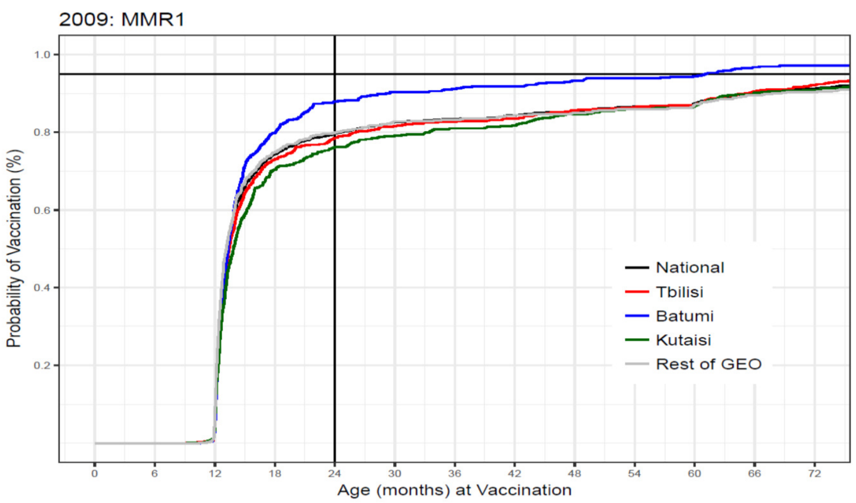
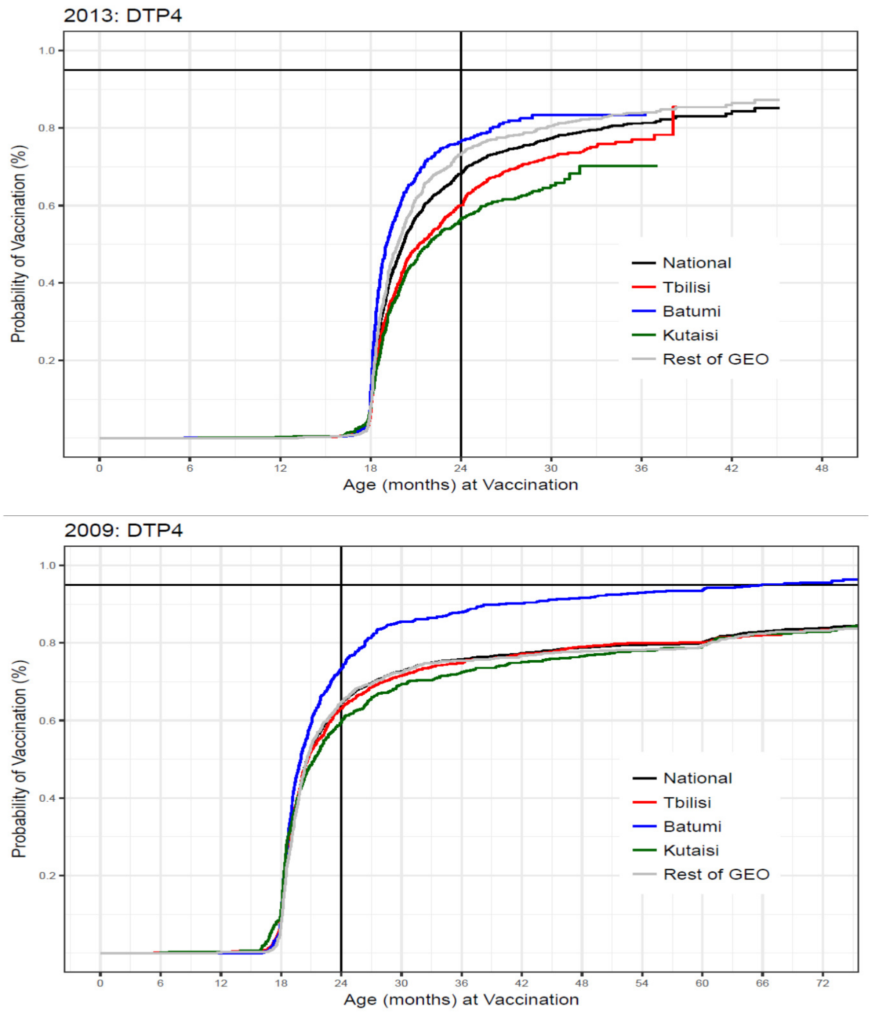
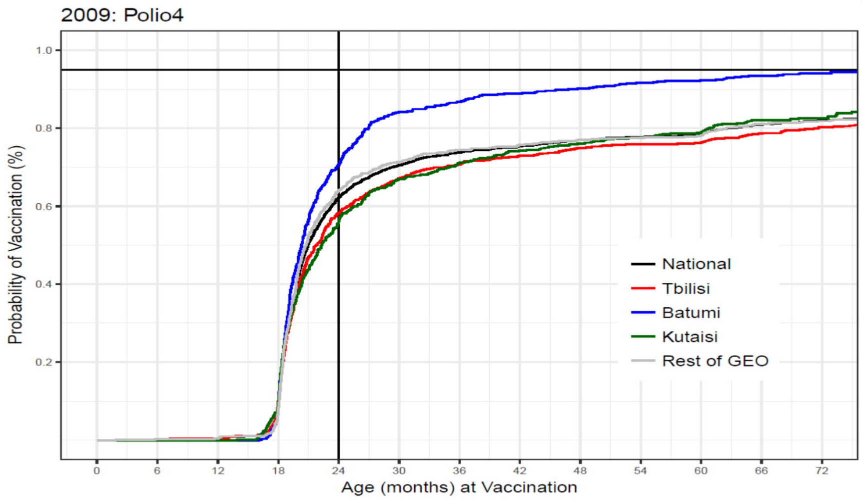


Figure 8. Timeliness of receipt of DTP4 by birth cohort – nationwide and for survey sites



Note. DTP4 on the chart includes doses of any DTP-containing vaccine (Penta, DTP, DT, Hexa or other combination vaccines)

Figure 9. Timeliness of receipt of Pol4 by birth cohort – nationwide and for survey sites



Note. Pol4 on the chart includes doses of any polio-containing vaccine (OPV or IPV as part of combination vaccines)

Figure 10. Timeliness of receipt of MMR2 in 2009 birth cohort – nationwide and for survey sites

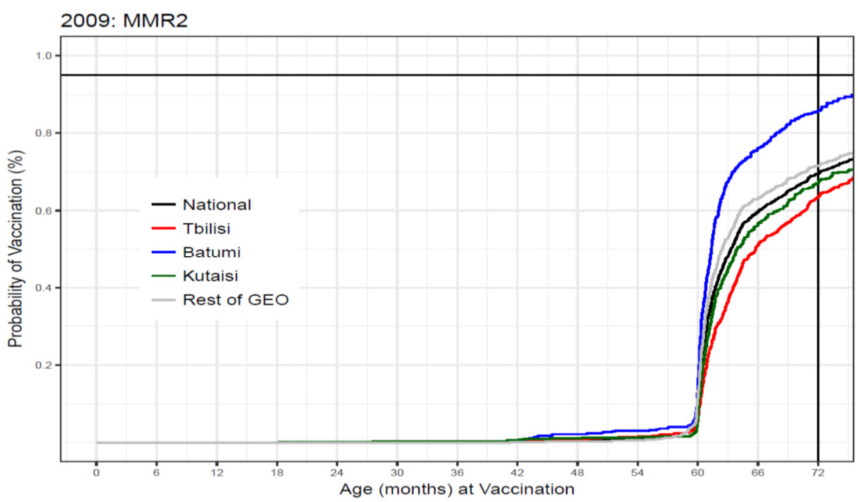


Figure 11. Timeliness of receipt of DT5 in 2009 birth cohort – nationwide and for survey sites

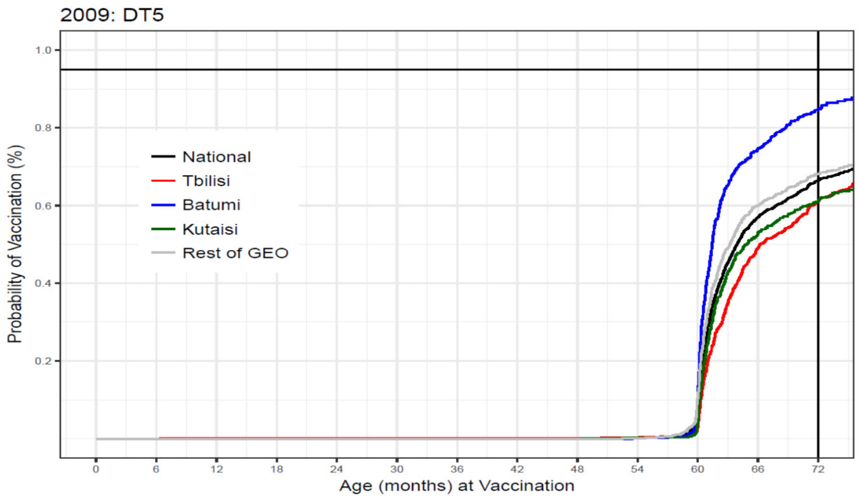
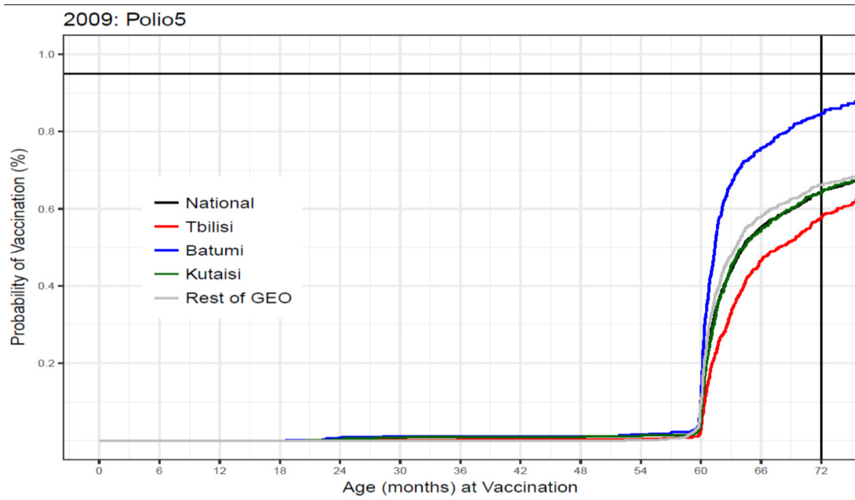


Figure 12. Timeliness of receipt of Pol5 in 2009 birth cohort – nationwide and for survey sites



Note. Pol5 on the chart includes doses of any polio-containing vaccine (OPV or IPV as part of combination vaccines)

12. Appendices

Appendix 1. Immunization schedules applicable to birth cohorts included in the coverage survey and vaccines used

Age	Vaccines - recommended /*also used*	0-12 hrs	0-5 days	2 mos	3 mos	4 mos	12 mos	18 mos	5 Yrs	14 yrs
Diseases										
For the 2014 birth cohort:										
Hepatitis B	**Hep B**	X								
Tuberculosis	**BCG**		X							
Diphtheria, tetanus, pertussis, Hib, hepatitis B	**Penta (DTwPHibHepB) /** DTwP, DT, Hexa (DTaPHibHepBIPV)			X	X	X				
Diphtheria, tetanus, pertussis	**DTwP /** DT, Hexa							X		
Poliomyelitis	**OPV /** Hexa (for doses 1-4)			X	X	X		X	X	
Rotavirus	**Rotarix**			X	X					
Pneumococcal infection	**10-valent PCV**			X	X		X			
Measles, mumps, rubella	**MMR**						X		X	
Diphtheria, tetanus	**DT**								X	
Tetanus, diphtheria	**Td**									X
For the 2013 birth cohort:										
Hepatitis B	**Hep B**	X								
Tuberculosis	**BCG**		X							
Diphtheria, tetanus, pertussis, Hib, hepatitis B	**Penta (DTwPHibHepB) /** DTwP, DT, Hexa (DTaPHibHepBIPV)			X	X	X				
Diphtheria, tetanus, pertussis	**DTwP /** DT, Hexa							X		
Poliomyelitis	**OPV /** Hexa (for doses 1-4)			X	X	X		X	X	
Rotavirus	**Rotarix**			X	X					
Measles, mumps, rubella	**MMR**						X		X	
Diphtheria, tetanus	**DT**								X	
Tetanus, diphtheria	**Td**									X
For the 2009 birth cohort:										
Hepatitis B	**Hep B**	X		X	X					
Tuberculosis	**BCG**		X							
Diphtheria, tetanus,	**DTwP /** DT, Hexa			X	X	X		X		
Poliomyelitis	**OPV /** Hexa (for doses 1-3)			X	X	X		X	X	
Measles, mumps, rubella	**MMR**						X		X	
Diphtheria, tetanus	**DT**								X	
Tetanus, diphtheria	**Td**									X

Appendix 2. Information sheet about the survey for parents/guardians of the children who did not have health care facility indicated

National Center for Disease Control and Public Health

Assessment of immunization coverage in Georgia

Information sheet

The National Center for Disease Control and Public Health of Georgia is conducting the assessment to find out how well children in Georgia are receiving vaccinations. The assessment is done in collaboration with the Georgia Office of the United States Centers for Disease Control and Prevention. To obtain the most accurate information, we need to review immunization records of randomly selected children.

Your child was selected for this assessment randomly. We would like to ask the child's mother or other closest caregiver, if the child has been vaccinated and which vaccines he or she has received.

If you have the immunization card at home, we will review it now. If you do not have it at home, we will ask you at which health care facility does your child receive vaccinations and obtain the records there. Only the information on children's immunizations to which public health officials have routine access for the purpose of program monitoring will be obtained for this assessment.

You are free to decline your child being part of this survey. There will be no direct benefits to you or your child from being part of this assessment, but having your child's immunization data will help us to more accurately assess the situation with immunization in Georgia and help us to better target our activities to reduce diseases that can be prevented by vaccines. To avoid potential minimal risk of the loss of confidentiality of the collected information, we will protect the data as much as possible: only investigators directly involved in the assessment will have access to your child's information, the files containing personal information will be password-protected and the your child's name and address will not be entered into the survey data base.

If you would like to have more information about this assessment, please contact ____________________ (name) - the Survey Coordinator at NCDC at __________________ (phone number).

Thank you for your help with this assessment.

დაავადებათა კონტროლის და საზოგადოებრივი ჯანმრთელობის ეროვნული ცენტრი

იმუნიზაციით მოცვის შეფასება საქართველოში

საინფორმაციო გვერდი

დაავადებათა კონტროლის და საზოგადოებრივი ჯანმრთელობის ეროვნული ცენტრი ატარებს შეფასებას, რომ დაადგინოს რამდენად კარგად ხდება საქართველოში ბავშვების აცრები. შეფასება ტარდება ამერიკის შეერთებული შტატების დაავადებათა კონტროლის და პრევენციის ცენტრების საქართველოს ოფისთან თანამშრომლობით. ზუსტი ინფორმაციის მოსაპოვებლად, ჩვენ გვჭირდება შემთხვევითი შერჩევის მეთოდით შერჩეული ბავშვების პროფილაქტიკური აცრების ბარათების შემოწმება.

თქვენი შვილი ამ შეფასებისთვის შეირჩა შემთხვევითი შერჩევის მეთოდით (რანდომულად). ჩვენ გვინდა ვკითხოთ ბავშვის აცრების შესახებ დედას ან სხვა მეურვეს რომელსაც ახლო კავშირი აქვს ბავშვთან.

გთხოვთ გვითხრათ რომელ სამედიცინო დაწესებულებაში იცრება ბავშვი, აცრების შესახებ ჩანაწერის მოსაძიებლად. თუ თქვენ სახლში გაქვთ პროფილაქტიკური აცრების ბარათი, ჩვენ მას აქვე ვნახავთ. ამ კვლევისთვის ავიღებთ მხოლოდ იმ ინფორმაციას ბავშვის აცრების შესახებ, რომელიც ჩვეულებრივ ხელმისაწვდომია საზოგადოებრივი ჯანმრთელობის ცენტრების წარმომადგენლებისთვის პროგრამის მონიტორინგის მიზნით.

თქვენ შეგიძლიათ უარი თქვათ აღნიშნულ შეფასებაში მონაწილეობაზე. შეფასებაში მონაწილეობა არ წარმოადგენს პირდაპირ სარგებელს თქვენთვის ან თქვენი შვილისთვის, მაგრამ ინფორმაცია თქვენი შვილის აცრების შესახებ დაგვეხმარება სწორად შევაფასოთ საქართველოში იმუნიზაციის მდგომარეობა და უკეთესად დავგეგმოთ ღონისძიებები ვაქცინებით მართვადი დაავადებების შესამცირებლად. შეგროვილი ინფორმაციის კონფიდენციალობის დარღვევის მინიმალური რისკის თავიდან ასაცილებლად, ჩვენ მაქსიმალურად დავიცავთ მონაცემებს: მხოლოდ კვლევაში უშუალოდ ჩართულ პირებს ექნებათ წვდომა თქვენი შვილის შესახებ ინფორმაციაზე, პერსონალური ინფორმაციის შემცველი ფაილები დაცული იქნება პაროლით და თქვენი შვილის სახელი და მისამართი არ იქნება შეტანილი კვლევის მონაცემთა ბაზაში.

თუ გსურთ აღნიშნული შეფასების შესახებ დამატებითი ინფორმაციის მიღება, გთხოვთ დაუკავშირდით თამთა კომახიძეს - კვლევის კოორდინატორს დაავადებათა კონტროლის და საზოგადოებრივი ჯანმრთელობის ეროვნული ცენტრიდან ტელ: 032 255 3939.

გმადლობთ კვლევის მხარდაჭერისთვის.

Appendix 3. The interview form for parents/guardians of the children who did not have health care facility indicated

National Center for Disease Control and Public Health

Assessment of immunization coverage in Georgia

Parent/Guardian interview form

Survey ID number ___________

Child's Name ______________________________________ Date of birth ___ / ___ /____ (dd /mm / yyyy)

Residence: City /district /village _________________________ Region ______________________

IF child not found, mark with "X" and stop: Not found [ ]

IF child found, provide the parent/guardian with the Survey Information Sheet and ask for their participation.

IF parent/guardian refused to provide information mark with "X" and stop: Refusal [ ]

1. Since birth, has this child received at least one vaccination? Yes [ ] [ ] Only in maternity hospital No [ ] Unknown [ ]

   IF "No", mark with "X" and go to Question 3: Unvaccinated child [ ]

   IF "Yes" or
   Only in maternity hospital", or "Unknown", **continue**.

2. Do you have this child's immunization records at home? Yes [ ] No [ ]

   IF" Yes", fill in the Survey Data Collection Form.

3. At which health care facility does this child receive health services?
   a. Facility name ____
   b. Address ____

IF the child is not registered with any health care facility, mark with "X": Not registered [ ]

IF the child's health care facility is unknown, mark with "X" Health care facility unknown [ ]

დაავადებათა კონტროლის და საზოგადოებრივი ჯანმრთელობის ეროვნული ცენტრი

იმუნიზაციით მოცვის შეფასება საქართველოში

მშობელთან/მეურვესთან გასაუბრების ფორმა

კვლევის ID ნომერი _____________

ბავშვის სახელი ______________________________ დაბადების თარიღი ___ / ___ /____ (დდ/თთ/წწწწ)

კვლევის ადგილი: ქალაქი_________________________ რაიონი/სოფელი ________________________

თუ ბავშვი ვერ მოიძებნა, აღნიშნეთ "X" -თ და დაასრულეთ: <u>სტატუსი</u>: ვერ მოიძებნა [ ]

თუ ბავშვი მოიძებნა, გააცანით მშობელს/მეურვეს საინფორმაციო გვერდი და სთხოვეთ თანხმობა მონაწილეობის შესახებ.

თუ მშობელი/მეურვე უარს აცხადებს ინფორმაციის გაზიარებაზე აღნიშნეთ "X"-ით და დაასრულეთ: <u>სტატუსი</u>: მშობლის/მეურვის უარი [ ]

1. ბავშვი ერთხელ მაინც არის აცრილი? [ ] დიახ [ ] მხოლოდ სამშობიაროში [ ] უცნობია [ ] არა

თუ "არა", მონიშნეთ "X"-თ და გადადით მე-3 კითხვაზე: აუცრელი ბავშვი [ ]

თუ "დიახ" ან „მხოლოდ სამშობიაროში" ანდ "უცნობია", გააგრძელეთ.

2. გაქვთ ბავშვის აცრების ბარათი სახლში? დიახ [ ] არა [ ]

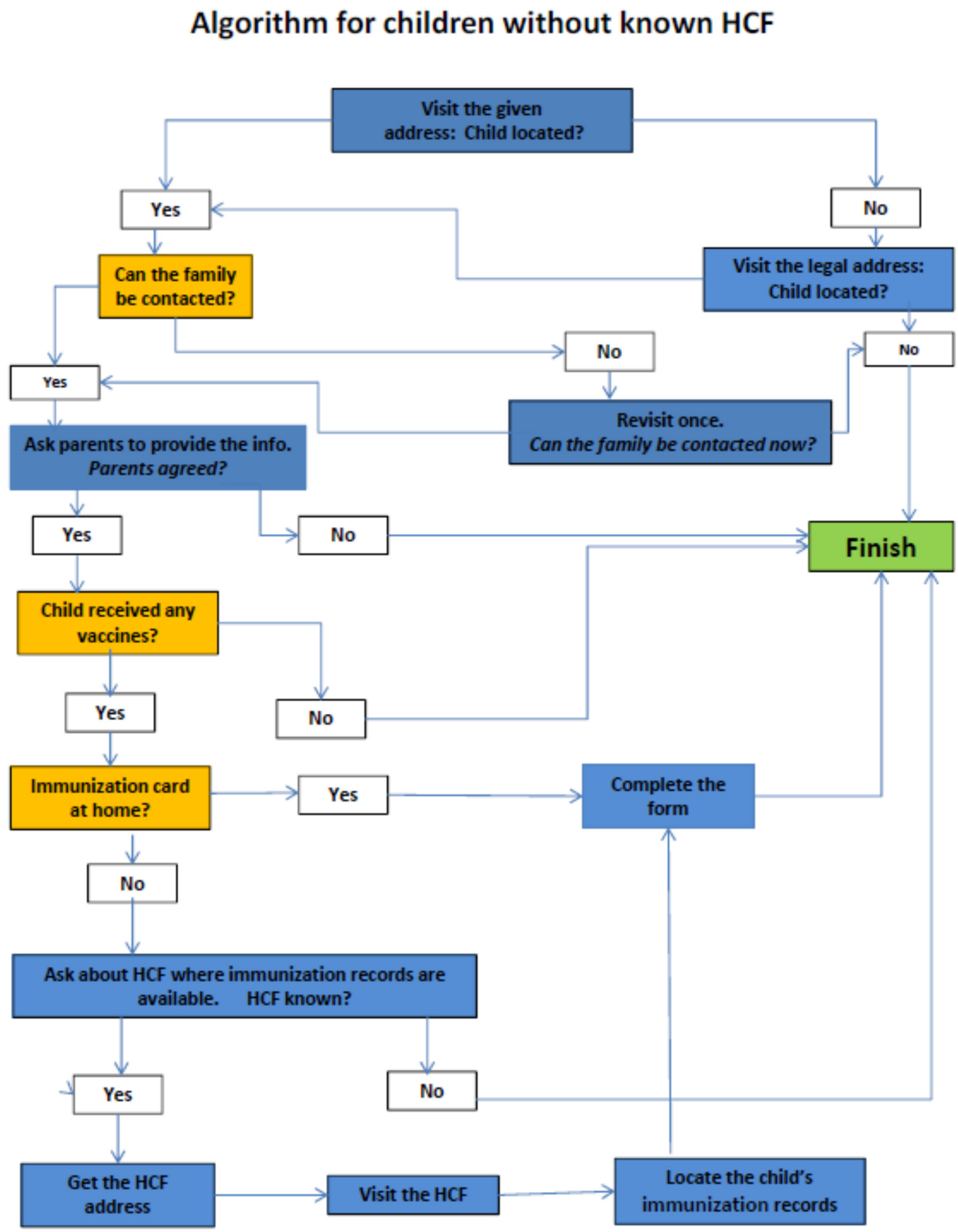
თუ "დიახ", შეავსეთ კვლევის მონაცემთა შეგროვების ფორმა.

3. რომელ სამედიცინო დაწესებულებაში იცრება ბავშვი?
   a. დაწესებულების დასახელება ____
   b. მისამართი ____
   c. ექიმი ____

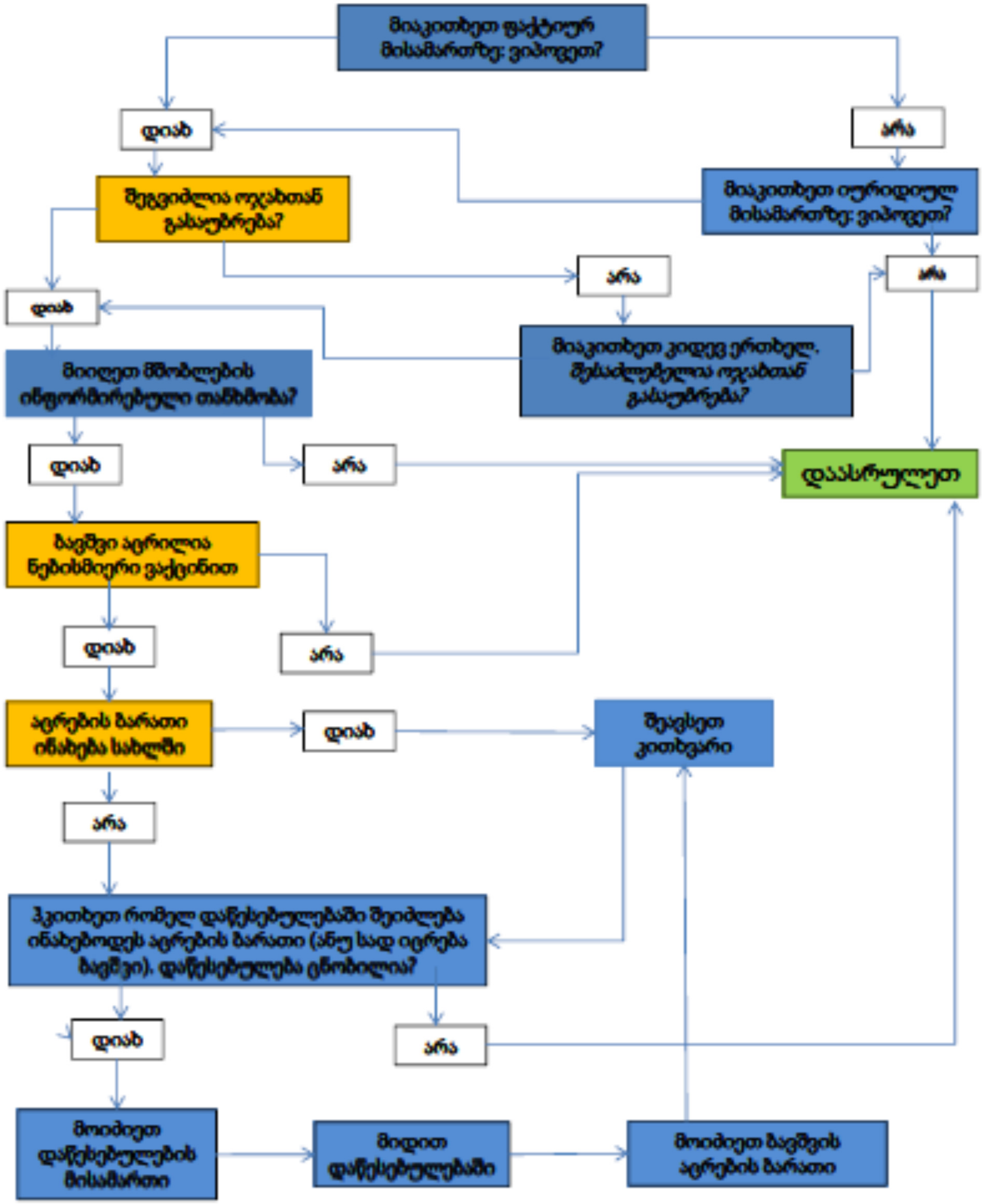
თუ ბავშვი არ არის რეგისტრირებული არცერთ სამედიცინო დაწესებულებაში, აღნიშნეთ "X"-ით: არ არის რეგისტრირებული [ ]

თუ სამედიცინო დაწესებულება უცნობია, აღნიშნეთ "X" -ით დაწესებულება უცნობია [ ]

Appendix 4. Survey algorithm for children who did not have HCF indicated



ალგორითმი ბავშვებისთვის, რომლებზეც არ გვაქვს ინფორმაცია დაწესებულების შესახებ



Appendix 5. Survey data collection form

Survey Data Collection Form

Assessment of immunization coverage in Georgia National Center for Disease Control and Public Health	
Location and Date	
1. Survey ID number *(# from the list of selected children)*	____________
2. Date completed	___ / ___ / ______ (dd / mm / yyyy)
3. Field team #	4. Birth cohort: a. 2014 [ ] b. 2013 [ ] **c.** 2009 [ ]
5. Survey site	a. Batumi [ ] c. Kutaisi [ ] b. Tbilisi [ ] d. Rest of Georgia [ ]
If the answer was "d. Rest of Georgia"	6. Cluster No. ____ / Sampling Unit No. _____
7. Location of health care facility (HCF)	a. City ______________ b. District/Village _________________ / ____________________
8. Name of HCF	
9. HCF address	

Demographic data	
10. Child's name	________________ ____________________________ *First name* *Last name*
11. Child's date of birth	___ / ___ / ______ (dd / mm / yyyy)
12. Sex	**a.** Male [ ] b. Female [ ]
Child's address (actual)	a. Region ____ b. City/District ____ c. Village ____ d. Address ____

Immunization data		
13. Immunization status	a. Unvaccinated	[ ]
	b. Received $\geq$1 vaccine dose (after vaccines given at maternity hospital)	[ ]
	c. Only at maternity hospital (BCG/HepB0)	[ ]
14. Source of immunization information *(mark all)*	HCF records	[ ]
	Immunization card at home	[ ]
	Immunization module	[ ]
15. Any "commercial" vaccine received	If a child received any "commercial" vaccine, mark **"X"**	[ ]

Immunizations received					
Diseases	Vaccine	**Sequential # of doses**	**Vaccination date** (dd / mm / yyyy)	Lot No.	Brand name *(if indicated)*
TB	**BCG**	[ ]			
Hepatitis B *(Monovaccine for Hepatitis B is used for birth dose and was in use for other doses before 2010)*					
	Hep B 0	**0** [ ]			
Only if monovaccine was given	**Hep B**	**1** [ ]			
Only if monovaccine was given	**Hep B**	**2** [ ]			
Only if monovaccine was given	**Hep B**	**3** [ ]			
Penta (DTwPHibHepB) / Hexa / DTP / DT *(Penta since 2010; DTP before 2010; DT may be used if pertussis component is contraindicated; Hexa – "commercial" only)*					
Mark one	**Penta** [ ] **Hexa** [ ] **DTP** [ ] **DT** [ ]	**1** [ ]			
Mark one	**Penta** [ ] **Hexa** [ ] **DTP** [ ] **DT** [ ]	**2** [ ]			
Mark one	**Penta** [ ] **Hexa** [ ] **DTP** [ ] **DT** [ ]	**3** [ ]			
DTP / DT *(DT may be used if pertussis component is contraindicated)*					
Mark one	**DTP** [ ] **DT** [ ]	**4** [ ]			
DT					
	DT [ ]	**5** [ ]			
Rotavirus *(since 2013)*					
	Rota	**1** [ ]			
	Rota	**2** [ ]			
Poliomyelitis					
	OPV	**1** [ ]			
	OPV	**2** [ ]			
	OPV	**3** [ ]			
	OPV	**4** [ ]			
	OPV	**5** [ ]			
MMR					
	MMR	**1** [ ]			
	MMR	**2** [ ]			
Other (Include if child is vaccinated with any other vaccine, e.g. PCV, chickenpox) *Please complete all fields*					
Comments:					

კვლევის მონაცემთა შეგროვების ფორმა

იმუნიზაციით მოცვის შეფასება საქართველოში დაავადებათა კონტროლის და საზოგადოებრივი ჯანმრთელობის ეროვნული ცენტრი	
ადგილი და თარიღი	
2. კვლევის ID ნომერი *(ნომერი გამოსაკვლევად შერჩეული ბავშვების სიიდან)*	______________
2. შევსების თარიღი	___ / ___ / ______ (დდ / თთ / წწწწ)
3. ჯგუფის #	4. ბავშვის დაბადების წელი — d. 2014 [ ] e. 2013 [ ] f. 2009 [ ]
5. კვლევის ადგილი	c. ბათუმი [ ] c. ქუთაისი [ ] d. თბილისი [ ] d. საქართველო (სხვა) [ ]
თუ წინა კითხვის პასუხია: "d. საქართველო (სხვა)"	6. ა. კლასტერის # __________ ბ. შერჩევის ერთეულის (დასახლების) # ___________
7. სამედიცინო დაწესებულების ადგილმდებარეობა	a. ქალაქი _________________ b. რაიონი/სოფელი ____________________ / _________________________
8. სამედიცინო დაწ. დასახელება	
9. დაწესებულების მისამართი	
დემოგრაფიული მონაცემები	
	პასუხი
10. ბავშვის სახელი	___________________ __________________________________ *სახელი* *გვარი*
11. ბავშვის დაბადების თარიღი	___ / ___ / ______ (დდ / თთ / წწწწ)
12. სქესი	**b.** მამრობითი [ ] b. მდედრობითი [ ]
13. ბავშვის მისამართი (ფაქტიური)	a. რეგიონი ____ b. ქალაქი/რაიონი ____ c. სოფელი ____ მისამართი ____

იმუნიზაციის სტატუსი		
	პასუხი	
13. იმუნიზაციის სტატუსი	d. ბავშვი აუცრელია [ ] e. გაკეთებული აქვს 1 ან მეტი აცრა (სამშობიაროში გაკეთებული აცრების შემდეგ) [ ] **f.** აცრები გაკეთებული აქვს მხოლოდ სამშობიაროში (BCG/HepB0 [ ]	
14. იმუნიზაციის შესახებ მიღებული ინფორმაციის წყარო *(აღნიშნეთ ყველა)*	აცრების დოკუმენტაცია დაწესებულებაში [ ]	
	აცრების ბარათი სახლში [ ]	
	იმუნიზაციის მოდული [ ]	
15. აცრილია „ფასიანი“ ვაქცინით	თუ ბავშვს მიღებული აქვს რომელიმე ფასიანი ვაქცინა, აღნიშნეთ **"X"**-ით [ ]	

ჩატარებული აცრები					
დაავადება	ვაქცინის დასახელ.	დოზის რიგითობა	აცრის თარიღი *დდ / თთ / წწწწ*	სერიის ნომერი	სავაჭრო დასახელება *(თუ მითითებულია)*
ტუბერკულოზი	**BCG**	**[ ]**			
ჰეპატიტი B *(Hep B გამოიყენება დაბადებისას და 2010 წლამდე გამოიყენებოდა მომდევნო დოზებისთვისაც)*					
	Hep B 0	**0 [ ]**			
თუ მხოლოდ მონოვაქცინაა	**Hep B**	**1 [ ]**			
თუ მხოლოდ მონოვაქცინაა	**Hep B**	**2 [ ]**			
თუ მხოლოდ მონოვაქცინაა	**Hep B**	**3 [ ]**			
პენტა (DTwPHibHepB) / ჰექსა / დყტ / დტ *(პენტა 2010 წ-დან; დყტ 2010 წ-მდე; დტ - თუ უკუჩვენებაა ყივანახველას კომპონენტზე; ჰექსა - მხოლოდ 'ფასიანი')*					
მონიშნეთ ერთი	**Penta [ ]** **Hexa [ ]** **DTP [ ]** **DT [ ]**	**1 [ ]**			
მონიშნეთ ერთი	**Penta [ ]** **Hexa [ ]** **DTP [ ]** **DT [ ]**	**2 [ ]**			
მონიშნეთ ერთი	**Penta [ ]** **Hexa [ ]** **DTP [ ]** **DT [ ]**	**3 [ ]**			
დყტ / დტ ***(დტ გამოიყენება, თუ უკუჩვენებაა ყივანახველას კომპონენტზე)***					
მონიშნეთ მხოლოდ ერთი	**DTP [ ]** **DT [ ]**	**4 [ ]**			
დტ					
	DT [ ]	**5 [ ]**			
როტავირუსი ***(2013 წლიდან)***					
	Rota	**1 [ ]**			
	Rota	**2 [ ]**			
პოლიომიელიტი					
	OPV	**1 [ ]**			
	OPV	**2 [ ]**			
	OPV	**3 [ ]**			
	OPV	**4 [ ]**			
	OPV	**5 [ ]**			
წწყ					
	MMR	**1 [ ]**			
	MMR	**2 [ ]**			
სხვა (თუ ბავშვი აცრილია სხვა ვაქცინებით, მაგ. ჩუტყვავილა, პკვ და ა.შ) *გთხოვთ შეავსოთ ყველა ველი*					
შენიშვნები:					