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**Dynamics of Timely Vaccination Among Tender-Age Infants in two Subjects of Russian Federation with the Lowest Immunization Coverage in 2020: Serial Cross-Sectional Study**

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***Background.*** *It was revealed in 2020 that immunization of children in decreed times in several subjects of Russian Federation was below the standard level. Therefore, monitoring of timely vaccination in children of these regions was relevant.* ***Objective. The aim of the study is to*** *evaluate changes in the timeliness of vaccination in children of two subjects of Russian Federation with low immunization rates according to 2020 data.* ***Methods.*** *Immunization of children born in 2015-2017 and 2020-2022 were studied according to the form of federal statistical monitoring (FFSM) №6 and vaccination record cards (form №063/y) obtained from children's polyclinics of the Republic of Bashkortostan (two in 2020 and three in 2023) and the Republic of Sakha (Yakutia) (two in 2020 and four in 2023). The vaccination timeliness among children against infections from the national immunization schedule (NIS) list was determined. The timeliness of vaccination was evaluated by the proportion of children who received the required number of vaccine doses against each of the infection from the NIS list by the decreed age among all persons of the decreed age.* ***Results.*** *Data from 998 records was analyzed. The increase in timely vaccination against all vaccine-controlled infections in children was revealed. The proportion of children vaccinated according to the NIS has increased by 1.5-4 times. Timely vaccination of ≥95% children in the decreed age (by FFSM №6) was achieved in the Republic of Sakha (Yakutia) against tuberculosis, hepatitis B, measles, rubella, and mumps, and in the Republic of Bashkortostan against measles, rubella, and mumps. The increase in the multivalent vaccines’ usage and simultaneous administration of several vaccines has been discovered.* ***Conclusion.*** *Monitoring the level of documented immunization and timely vaccination in children allows effectively control routine immunization quality. Implementation of multivalent vaccines and simultaneous administration of several vaccines in routine immunization provides radical change in the vaccination rate in pediatric population.*

***Keywords:*** *preventive vaccination, immunization, immunization coverage, timely vaccination, immunization schedule, multivalent vaccines, children*

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**Table 1.** Decreed age according to FFSM №6 and NIS considered for determining the timely vaccination among children

|  |  |  |
| --- | --- | --- |
| **Infection (according to NIS [12])** | **Decreed age of vaccination** | |
| **according to FFSM №6** | **according to NIS** |
| Tuberculosis | 30 d | 3–7 d |
| Hepatitis B | 12 m (V3) | V1 — 1 d V3 — 6 m |
| Diphtheria/tetanus | 12 m (V3) | V1 — 3 m V3 — 6 m |
| Pertussis | 12 m (V3) | V1 — 3 m V3 — 6 m |
| Pneumococcal disease | 12 m (V2) | V1 — 2 m V2 — 4,5 m |
| Poliomyelitis | 12 m (V3) | V1 — 3 m V3 — 6 m |
| Diphtheria/tetanus RV1 | 24 m | 18 m |
| Pertussis RV1 | 24 m | 18 m |
| Measles | 24 m | 12 m |
| Rubella | 24 m | 12 m |
| Parotitis | 24 m | 12 m |
| Pneumococcal disease RV | 24 m | 15 m |
| Poliomyelitis RV1 | 24 m | 18 m |

*Note.* FFSM (ФСН) — form of federal statistical monitoring №6 "Data on children and adults population vaccinated against infectious diseases" [2]; NIS (НКПП) — national immunization schedule approved by order of the Ministry of Health of Russian Federation №1122n [13]; RV — revaccination (RV1 — first revaccination), V1–3 — first, second, third vaccination.

**Table 2.** The timeliness of vaccination in children according to FFSM №6

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Infection** | **Decreed age** | **Cohort, birth year** | **Republic of Bashkortostan \*** | | | **Republic of Sakha (Yakutia)\*** | | |
| **Abs.** | **% (95% CI)** | ***р*** | **Abs.** | **% (95% CI)** | ***р*** |
| Tuberculosis | 30 d | 2015–2017 | 195/227 | 85,9 (81,4–90,4) | 0,621 | 268/295 | 90,8 (87,0–93,6) | 0,093 |
| 2020–2022 | 189/216 | 87,5 (82,4–91,3) | 245/259 | 94,6 (91,1–96,8) |
| Hepatitis B | 12 m | 2015–2017 | 91/226 | 40,3 (33,9–46,7) | < 0,001 | 226/294 | 76,9 (72,1–81,7) | < 0,001 |
| 2020–2022 | 167/213 | 78,4 (72,9–83,9) | 242/249 | 97,2 (95,1–99,2) |
| DPT\*\* | 12 m | 2015–2017 | 111/227 | 48,9 (42,5–55,4) | < 0,001 | 189/295 | 64,1 (58,4–69,3) | < 0,001 |
| 2020–2022 | 187/213 | 87,8 (83,4–92,2) | 225/249 | 90,4 (86,7–94,0) |
| DPT RV1\*\* | 24 m | 2015–2017 | 83/224 | 37,1 (30,7–43,4) | < 0,001 | 92/294 | 31,3 (26,0–36,6) | < 0,001 |
| 2020–2022 | 94/118 | 79,7 (71,5–85,9) | 103/153 | 67,3 (59,5–74,2) |
| Poliomyelitis | 12 m | 2015–2017 | 148/227 | 65,2 (58,8–71,1) | < 0,001 | 179/294 | 60,9 (55,3–66,5) | < 0,001 |
| 2020–2022 | 194/212 | 91,5 (87,8–95,3) | 228/249 | 91,6 (88,1–95,0) |
| Poliomyelitis RV1 | 24 m | 2015–2017 | 159/226 | 70,4 (64,4–76,3) | < 0,001 | 121/292 | 41,4 (35,8–47,1) | < 0,001 |
| 2020–2022 | 103/118 | 87,3 (80,1–92,1) | 109/152 | 71,7 (64,6–78,9) |
| Pneumococcal disease | 12 m | 2015–2017 | 107/227 | 47,1 (40,7–53,6) | < 0,001 | 110/295 | 37,3 (32,0–42,9) | < 0,001 |
| 2020–2022 | 176/213 | 82,6 (77,0–87,1) | 168/249 | 67,5 (61,4–73,0) |
| Pneumococcal disease RV | 24 m | 2015–2017 | 77/227 | 33,9 (27,8–40,1) | < 0,001 | 55/295 | 18,6 (14,6–23,5) | < 0,001 |
| 2020–2022 | 90/118 | 76,3 (67,8–83,0) | 83/153 | 54,2 (46,3–61,9) |
| Rubella V1 | 24 m | 2015–2017 | 216/227 | 95,2 (91,5–97,3) | 0,145 | 239/292 | 81,8 (77,4–86,3) | < 0,001 |
| 2020–2022 | 116/118 | 98,3 (94,0–99,5) | 145/153 | 94,8 (90,0–97,3) |
| Measles, parotitis V1\*\* | 24 m | 2015–2017 | 216/226 | 95,6 (92,9–98,3) | 0,075 | 244/291 | 83,8 (79,6–88,1) | < 0,001 |
| 2020–2022 | 116/118 | 98,3 (94,0–99,5) | 146/153 | 95,4 (90,9–97,8) |

*Note*. <\*> — here and in Table 3: some preventive vaccination records have shown incorrect dates of birth or vaccine administration (one year or months before the possible date of birth/vaccination) or the corresponding dates could not be determined due to the poor quality of photocopies; such data was not considered when calculating the vaccination timelines, therefore, total number of analyzed cards differed (was less) from the number of cards included in the study. <\*\*> — the vaccination timeliness (against these infections) was the same, therefore, they were presented in one line. RV — revaccination (RV1 — first revaccination); DPT (КДС) – diphtheria, pertussis, tetanus.

**Table 3.** The timeliness of vaccination in children according to NIS (version of 2021)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Infection** | **Decreed age** | **Cohort, birth year** | **Republic of Bashkortostan \*** | | | **Republic of Sakha (Yakutia)\*** | | |
| **Abs.** | **% (95% CI)** | ***р*** | **Абс.** | **% (95% CI)** | **Abs.** |
| Tuberculosis | 7 d | 2015–2017 | 189/227 | 83,3 (78,4–88,1) | 0,913 | 259/295 | 87,8 (84,1–91,5) | 0,420 |
| 2020–2022 | 179/216 | 82,9 (77,8–87,9) | 233/259 | 90,0 (86,3–93,6) |
| Hepatitis B V1 | 1 d | 2015–2017 | 47/227 | 20,7 (15,4–26,0) | < 0,001 | 273/294 | 92,9 (89,9–95,8) | 0,059 |
| 2020–2022 | 136/217 | 62,7 (56,2–69,1) | 249/258 | 96,5 (94,3–98,80 |
| Hepatitis B V3 | 6 m | 2015–2017 | 28/226 | 12,4 (8,1–16,7) | < 0,001 | 86/294 | 29,3 (24,1–34,5) | < 0,001 |
| 2020–2022 | 57/217 | 26,3 (20,4–32,1) | 133/259 | 51,4 (45,3–57,4) |
| DPT V1 | 3 m | 2015–2017 | 39/227 | 17,2 (12,3–22,1) | < 0,001 | 131/292 | 44,9 (39,2–50,6) | < 0,001 |
| 2020–2022 | 117/215 | 54,4 (57,8–61,1) | 151/256 | 59,0 (53,0–65,0) |
| DPT V3 | 6 m | 2015–2017 | 18/227 | 7,9 (4,4–11,4) | < 0,001 | 27/295 | 9,2 (5,9–12,4) | < 0,001 |
| 2020–2022 | 46/216 | 21,3 (15,8–26,8) | 76/259 | 29,3 (23,8–34,9) |
| DPT RV | 18 m | 2015–2017 | 6/224 | 2,7 (0,6–4,8) | 0,004 | 11/294 | 3,7 (1,6–5,9) | < 0,001 |
| 2020–2022 | 14/146 | 9,6 (4,8–14,4) | 23/181 | 12,7 (7,9–17,6) |
| Poliomyelitis V1 | 3 m | 2015–2017 | 56/227 | 24,7 (19,1–30,3) | < 0,001 | 130/291 | 44,7 (39,0–50,4) | 0,001 |
| 2020–2022 | 118/215 | 54,9 (48,2–61,5) | 151/256 | 59,0 (53,0–65,0) |
| Poliomyelitis V3 | 6 m | 2015–2017 | 19/227 | 8,4 (4,8–12,0) | < 0,001 | 30/294 | 10,2 (6,7–13,7) | < 0,001 |
| 2020–2022 | 46/216 | 21,3 (15,8–26,8) | 76/259 | 29,3 (23,8–34,9) |
| Poliomyelitis RV1 | 18 m | 2015–2017 | 58/226 | 25,7 (20,0–31,4) | 0,072 | 30/292 | 10,3 (6,8–13,80 | 0,002 |
| 2020–2022 | 26/147 | 17,7 (11,5–23,9) | 37/180 | 20,6 (14,7–26,5) |
| Measles, parotitis V1 | 12 m | 2015–2017 | 65/226 | 28,8 (22,9–34,7) | < 0,001 | 80/291 | 27,5 (22,4–32,6) | < 0,001 |
| 2020–2022 | 122/212 | 57,5 (50,9–64,2) | 126/247 | 51,0 (44,8–57,2) |
| Rubella V1 | 12 m | 2015–2017 | 68/227 | 30,0 (24,0–35,9) | < 0,001 | 75/292 | 25,7 (20,7–30,7) | < 0,001 |
| 2020–2022 | 122/212 | 57,5 (50,9–64,2) | 126/247 | 51,0 (44,8–57,2) |
| Pneumococcal disease V1 | 2 мес | 2015–2017 | 35/226 | 15,5 (10,8–20,2) | < 0,001 | 92/293 | 31,4 (26,1–36,7) | < 0,001 |
| 2020–2022 | 94/216 | 43,5 (36,9–50,1) | 135/257 | 52,5 (46,4–58,6) |
| Pneumococcal disease V2 | 4,5 m | 2015–2017 | 25/227 | 11 (6,9–15,1) | < 0,001 | 32/292 | 11,0 (7,4–14,5) | < 0,001 |
| 2020–2022 | 71/215 | 33 (26,7–39,3) | 71/257 | 27,6 (22,2–33,1) |
| Pneumococcal disease RV | 15 m | 2015–2017 | 18/227 | 7,9 (4,4–11,4) | < 0,001 | 20/295 | 6,8 (3,9–9,6) | < 0,001 |
| 2020–2022 | 64/185 | 34,6 (27,7–41,4) | 45/216 | 20,8 (15,4–26,2) |

*Note.* RV — revaccination (RV1 — first revaccination), V1–3 — first, second, third vaccination, DPT (КДС) – diphtheria, pertussis, tetanus.

**Table 4.** Age of 95% immunization coverage

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Infection** | **Age of 95% immunization coverage, months (95% CI)** | | | | | | | | | |
| **Republic of Bashkortostan** | | | | | **Republic of Sakha (Yakutia)** | | | | |
| **2015–2017 birth year** | ***n*** | **2020–2022 birth year** | ***n*** | ***p*** | **2015–2017 birth year** | ***n*** | **2020–2022 birth year** | ***n*** | ***p*** |
| Tuberculosis | 6,0 (4,0; 14,9) | 227 | 4,6 (2,4; н.о.) | 216 | 0,672 | 12,1 (3,4; н.о.) | 295 | 1,4 (0,3; 12,1) | 259 | 0,048 |
| Hepatitis B V3 | 42,5 (38,4; н.о.) | 226 | 23,0 (20,4; н.о.) | 217 | < 0,001 | > 67 (54,7; н.о.) | 294 | 10,4 (9,8; 13,2) | 259 | < 0,001 |
| DPT V3 | 30,9 (29,8; 38,5) | 227 | 14,7 (12,9; 18,2) | 216 | < 0,001 | 37,7 (32,2; н.о.) | 295 | 14,8 (13,5; 17,5) | 259 | < 0,001 |
| DPT RV | 61,8 (47,3; но) | 224 | 30,8 (29,1; н.о.) | 146 | < 0,001 | > 67\* | 294 | 31,1 (30,5; н.о.) | 181 | < 0,001 |
| Poliomyelitis V3 | 28,6 (23,6; 33,9) | 227 | 15,5 (13,3; 18,7) | 216 | < 0,001 | 35,9 (29,3; н.о.) | 294 | 14,8 (13,5; 17,5) | 259 | < 0,001 |
| Poliomyelitis RV1 | 39,1 (37,2; но) | 226 | 29,0 (26,1; н.о.) | 147 | < 0,001 | > 67\* | 292 | 31,1 (30,4; н.о.) | 180 | < 0,001 |
| Pneumococcal disease V2 | > 68\* | 227 | 23,0 (17,9; н.о.) | 215 | < 0,001 | > 67\* | 292 | > 41\* | 257 | < 0,001 |
| Pneumococcal disease RV | > 68\* | 227 | > 41\* | 185 | < 0,001 | > 67\* | 295 | > 41\* | 216 | < 0,001 |
| Rubella V1 | 24,3 (21,0; 29,1) | 227 | 17,3 (16,3; 19,7) | 212 | < 0,001 | > 67 (57,8; н.о.) | 292 | 22,6 (18,1; 26,4) | 247 | < 0,001 |
| Measles, parotitis V1 | 24,3 (21,0; 26,7) | 226 | 17,3 (16,3; 19,7) | 212 | < 0,001 | 57,8 (39,6; н.о.) | 291 | 22,6 (18,1; 26,4) | 247 | < 0,001 |

*Note.* <\*> — 95% CI values were not calculated as the 95% immunization coverage among children by maximum age in the cohort (67 and 68 months in the 2015-2017 cohort and 41 months in the 2020-2022 cohort) was not achieved. DPT (КДС) – diphtheria, pertussis, tetanus; N/a (н.о.) — not avaliable.

**Table 5.** Frequency of multivalent vaccines usage or simultaneous administration of several vaccines

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Subject of Russian Federation** | **Cohort, birth year** | **DPT** **+ Poliomyelitis V1–3, abs. (%)** | **At least one case of vaccination** | | |
| **Hepatitis B + DPT, abs. (%)** | **DPT + poliomyelitis**  **+ pneumococcal disease, abs. (%)** | **Hepatitis B + DPT**  **+ poliomyelitis + pneumococcal disease, abs. (%)** |
| **Republic of Sakha (Yakutia)** | 2015–2017 | 140/295 (47,5) | 208/295 (70,5) | 94/295 (31,9) | 70/295 (23,7) |
| 2020–2022 | 259/259 (100) | 203/259 (78,4) | 160/259 (61,6) | 132/259 (51,0) |
| **Republic of Bashkortostan** | 2015–2017 | 107/227 (47,1) | 191/226 (84,5)\* | 49/227 (21,6) | 41/226 (18,1)\* |
| 2020–2022 | 214/227 (98,6) | 171/217 (78,8) | 142/227 (65,4) | 119/217 (54,8) |

*Note.* <\*> — calculated for a smaller number of children as copy of one child record, born in 2016, could not be read out on hepatitis B V3 due to the poor quality of the photocopy. V1–3 — first, second, third vaccination, DPT (КДС) – diphtheria, pertussis, tetanus.

|  |  |
| --- | --- |
| **Republic of Bashkortostan** | **Republic of Sakha (Yakutia)** |
|  |  |
|  |  |
| **Fig.** Timely vaccination for children according to use of combined pentavalent vaccine or simultaneous administration of pneumococcal vaccine | |
| **Birth year**  **vaccination against DPT at 12 months**  **vaccination against poliomyelitis at 12 months**  **DPT + poliomyelitis V1, V2 and V3**  **vaccination against DPT at 12 months**  **vaccination against poliomyelitis at 12 months**  **vaccination against pneumococcal disease at 12 months**  **proportion of children vaccinated at least once simultaneously against DPT, poliomyelitis and pneumococcal disease** | |

**RESEARCH LIMITATIONS**

Samples representativeness (cohorts with different birth years) cannot be evaluated. Thereby, extrapolation of the obtained results to the pediatric populations in the studied subjects of Russian Federation should be implemented carefully. Moreover, it is not possible to estimate the data comparability between cohorts formed at different periods (children born in 2015-2017 and 2020-2022). Thus, the results of comparing the timeliness of vaccination in these cohorts and any conclusions made about the immunization dynamics at the decreed times should not be considered final.

The data reliability in provided copies of medical records cannot be evaluated. It is impossible to exclude possible distortions in preventive vaccination records of children. It is crucial to conduct the study of immunity level via serological studies alongside with the study of documented vaccination to objectivate estimates.

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**DISCLOSURE OF INTERESTS**

Not declared.

**AUTHORS CONTRIBUTION**

**Radima A. Mukozheva** — data collection and statistical processing, analysis of the research results, manuscript writing.

**Tatyana V. Kulichenko** — study planning, data collection, analysis of the obtained results, manuscript editing.

**Liudmila Yu. Semavina** — study planning, data collection, analysis of the obtained results.

**Vera I. Bosikova** — study planning, data collection, analysis of the obtained results.

**Alexandra V. Uarova** — study planning, data collection, analysis of the obtained results.