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CLINICAL AND EPIDEMIOLOGICAL ASPECTS OF POLIO AT THE PRESENT STAGE (LITERATURE REVIEW)

© Sergey V. Buymistrov, Vladimir N. Timchenko, Tatyana A. Kaplina, Vera F. Sukhovetskaya, Elena V. Barakina, Anna N. Nazarova, Oksana V. Bulina, Anna I. Petrakova

Saint Petersburg State Pediatric Medical University. 2 Lithuania, Saint Petersburg 194100 Russian Federation

Contact information:
Tatyana A. Kaplina — Candidate of Medical Sciences, Associate Professor, Professor M.G. Danilevich Department of Infectious Diseases in Children. E-mail: k.kta@yandex.ru ORCID: https://orcid.org/0000-0003-1659-2058 SPIN: 1381-9580

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ABSTRACT. ***Introduction.*** According to the World Health Organization (WHO), in a number of regions endemic for poliomyelitis there are cases of various forms of poliomyelitis associated with the continued circulation of vaccine-derived polioviruses and an unfavorable social and epidemiological situation. In the Russian Federation (RF), the situation is assessed as favorable, but there is a high risk of poliomyelitis cases occurring in neighboring countries (Tajikistan, Ukraine), which raises serious concerns due to the growing possibility of importation of wild strains and circulating vaccine-derived polioviruses (cVDPV). It is impossible to exclude the emergence of local cVDPV in the territory of the Russian Federation and the occurrence of new cases of vaccine-associated paralytic poliomyelitis (VAPP) if sanitary rules and regulations are not observed. ***Purposes and tasks*** — to study the clinical and epidemiological aspects of polio at the present stage. ***Materials and methods.*** Russian-language and foreign literary sources, processing, analysis and visualization of information. ***Results.*** To date, two states — Afghanistan, Pakistan — are endemic for wild poliovirus type 1. In 2021–2022, cases of importation of wild poliovirus type 1 to Malawi and Mozambique were reported. In 2024, 6 confirmed cases of polio caused by the wild strain were identified in these States. The problem of circulating vaccine strains of type 2 also remains relevant. In 2022, these viruses were detected in wastewater from London, New York and Jerusalem. According to WHO, for 2023 there are 308 cases of polio caused by mutated type 2 vaccine poliovirus worldwide. Since 2021, a new stable monovalent oral polio vaccine (nOPV2) containing a more. genetically stable type 2 vaccine poliovirus has been certified.

KEYWORDS: *epidemiology, vaccine-associated paralytic poliomyelitis, type 1 wild poliovirus, circulating vaccine-derived poliovirus 2 type, immunoprophylaxis*

КЛИНИКО-ЭПИДЕМИОЛОГИЧЕСКИЕ АСПЕКТЫ ПОЛИОМИЕЛИТА НА СОВРЕМЕННОМ ЭТАПЕ (ОБЗОР ЛИТЕРАТУРЫ)

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Санкт-Петербургский государственный педиатрический медицинский университет. 194100, г. Санкт-Петербург, ул. Литовская, д. 2

Контактная информация:
Татьяна Анатольевна Каплина — к.м.н., доцент, кафедра инфекционных заболеваний у детей им. проф. М.Г. Данилевича.
E-mail: k.kta@yandex.ru ORCID: https://orcid.org/0000-0003-1659-2058 SPIN: 1381-9580

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РЕЗЮМЕ. ***Введение.*** По данным Всемирной организации здравоохранения (ВОЗ), в ряде эндемичных по полиомиелиту регионах встречаются случаи заболевания различными формами полиомиелита, связанные с сохранением циркуляции полиовирусов вакцинального происхождения и с неблагоприятной социальной и эпидемиологической обстановкой. В Российской Федерации (РФ) ситуация оценивается как благополучная, но имеют место высокие риски возникновения случаев полиомиелита на территории близлежащих государств (Таджикистан, Украина), что вызывает серьезные опасения в связи с растущей возможностью завоза диких штаммов и циркулирующих полиовирусов вакцинного происхождения (цПВВП). Невозможно исключить появление локальных цПВВП на территории РФ и возникновение новых случаев вакцин-ассоциированного паралитического полиомиелита (ВАПП) при несоблюдении санитарных правил и норм. ***Цель*** — изучить клинико-эпидемиологические аспекты полиомиелита на современном этапе. ***Материалы и методы.*** Русскоязычные и иностранные литературные источники, обработка, анализ и визуализация информации. ***Результаты.*** В настоящее время эндемичными по дикому полиовирусу 1-го типа являются два государства — Афганистан и Пакистан. В 2021–2022 гг. зарегистрированы случаи завоза дикого полиовируса 1-го типа в Малави и Мозамбик. В 2024 г. выявлено 6 подтвержденных случаев полиомиелита, вызванных диким штаммом в этих государствах. Актуальность сохраняет также проблема циркулирующих вакцинных штаммов 2-го типа. В 2022 г. эти вирусы обнаруживались в сточных водах Лондона, Нью-Йорка и Иерусалима. По данным ВОЗ, за 2023 г. в мире зарегистрировано 308 случаев полиомиелита, вызванного мутировавшим вакцинным полиовирусом 2-го типа. С 2021 г. сертифицирована новая стабильная моновалентная оральная полиомиелитная вакцина (nOPV2), содержащая более генетически стабильный вакцинный полиовирус 2-го типа.

КЛЮЧЕВЫЕ СЛОВА: *эпидемиология, вакцин-ассоциированный паралитический полиомиелит, дикий полиовирус 1-го типа, циркулирующий полиовирус вакцинного происхождения 2-го типа, иммунопрофилактика*

INTRODUCTION

According to the World Health Organization (WHO), against the backdrop of the pandemic of a new coronavirus infection, military conflicts, unfavorable epidemiological situation in regions endemic for poliomyelitis, unjustified vaccine refusals, non-compliance with vaccination schedules in Third World countries, and the continued circulation of vaccine-derived polioviruses, the incidence of various forms of polio remains [1–4].

In the Russian Federation (RF), the polio situation is assessed as favorable, but there is a high risk of cases of the disease occurring in neighboring countries (Tajikistan, Ukraine). This raises serious concerns due to the growing possibility of importation of wild strains and circulating vaccine-derived polioviruses (cVDPV). It is impossible to exclude the emergence of local cVDPV in the RF and the occurrence of new cases of vaccine-associated paralytic poliomyelitis (VAPP) if sanitary vaccination standards are not observed [5, 6].

In 2022, new cases of wild poliovirus (WPV) type 1 were documented in countries declared polio-free. cVDPV types 2 and 3 were reported in waste waters in New York City and Jerusalem. Environmental surveillance sequencing showed that cVDPV type 2 strains from New York and Jerusalem were related not only to each other but also to environmental isolates found in London [7]. In the United States, a case of paralytic poliomyelitis caused by cVDPV type 2 was reported on 18 July 2022 in an unvaccinated patient with immunodeficiency [8].

The Global Polio Eradication Initiative has made significant progress. According to WHO, two out of three strains of wild poliovirus have now been eradicated worldwide. The WHO regions: Africa, Americas, Europe, Eastern Mediterranean and Western Pacific are certified polio-free. Endemic transmission of wild poliovirus type 1 persists in Afghanistan and Pakistan, where 12 cases of polio caused by WPV type 1 were reported in 2023. Additional surveillance in 2023, such as wastewater monitoring, shows widespread circulation of wild poliovirus type 1 among the population in endemic countries. This poses risks of international spread due to population migration [5].

According to the WHO, the new polio eradication strategy is planned to allocate from 4.5 to 6.2 billion dollars annually [9].

The causative agent of polio is *Poliovirus hominis*, which belongs to the family *Picornaviriadae*, the genus *Enterovirus*. It is an RNA + virus, the genome of which is about 7500 nucleotides long, size is 7.4 kb. The virus has an icosahedral capsid measuring 30 nm, consisting of 60 copies of 4 structural proteins (VP1, VP2, VP3, VP4). The genome contains a large open reading frame, framed by a highly structured 5'-untranslated region, ending with a poly(A) tail. The open reading frame encodes a polyprotein that is cleaved into four capsid proteins and seven non-structural proteins (2A, 2B, 2C, 3A, 3B, 3C, and 3D) involved in viral replication. The second, shorter reading frame encodes the ORF2p protein, which plays a significant role in viral replication [10–12].

There are three serotypes of wild poliovirus: type 1 — Brunhilde, it is characterized by epidemic outbreaks with the development of paralysis; type 2 — Lansing, the causative agent of sporadic cases; type 3 — Leon, causes VAPP. Since 1999, no case of wild poliovirus type 2 has been registered in the RF, and since 2012 — type 3 [13].

The pathogenesis of poliomyelitis is characterized by four phases: enteric, lymphogenous, viremic, and neural. The enteric phase is characterized by the entry of wild poliovirus into the gastrointestinal tract [14], after which the virus attaches to the CD155 receptors of epithelial cells. This causes conformational changes in the viral capsid necessary for the release of viral RNA into the cell cytoplasm [11]. During the lymphogenous phase, WPV replicates in the lymph nodes of the small intestine and Peyer's patches. Then, in the viremic phase, the virus enters the bloodstream. This leads to dissemination and replication in organs and tissues: spleen, liver, lungs, myocardium. The development of latent and abortive forms of the disease is associated with this stage of pathogenesis. Virus replication is also possible in muscle tissue, which causes myalgia before paralysis. In the neural phase, poliovirus enters the central nervous system through the blood-brain barrier. There is another variant of virus spreading — perineural. It consists of the entry of the infectious agent through the autonomic fibers of

the nerves innervating the gastrointestinal tract into the segments of the spinal cord. Poliovirus affects the gray matter of the spinal cord and brainstem, mainly the motor neurons of the anterior horns of the spinal cord, the motor nuclei of the cranial nerves (glossopharyngeal, vagus, facial, etc.). It is characterized by mosaic pattern and asymmetry of damage to individual muscle groups. In some cases, neurons of the posterior horns, cells of the spinal ganglia can be affected. The midbrain, cerebellar nuclei and cerebral cortex (neurons of the moto region of the frontal lobe of the cerebral cortex) can be affected in the brain. The posterior roots of the spinal cord are rarely involved in the inflammatory process, so there are no sensory disturbances in polio patients. Sometimes the reticular formation is affected. The presence of pain syndrome and neural tension symptoms is associated with damage to the spinal meninges [14]. It is worth noting that poliovirus does not replicate in muscles in vivo. All changes occurring in peripheral nerves and skeletal muscles are secondary to the neuronal cell death [15].

Strains included in the oral poliovirus vaccine (OPV) can mutate and become cVDPV, causing polio cases in regions with low immunization rates [12]. This is due to the lack of proofreading ability in RNA-dependent RNA polymerase, which leads to point mutations in the viral genome. This results in the formation of cVDPV types 1, 2, and 3 [10]. In addition to mutations, vaccine strains of polioviruses are capable of recombination with other enteroviruses C in coinfections and the return pathogenic properties [2]. One nucleotide site that is critical for attenuation lies in the 5' non-coding region of the genome of each of the three OPV strains, at nucleotide 480 in type 1, 481 in type 2 and 472 in type 3. Two mechanisms can lead to the formation of chimeric genes. The first is “break-and-join” mechanism, in which the genetic sequence of one parental genome is cleaved by a nuclease and re-ligated with a sequence derived from the other parental genome. The second is “copy-choice” mechanism, in which a nascent RNA strand switches the template strand during genome replication. It is these processes at the nucleotide sites of attenuation that lead to the adaptation of vaccine strains of polioviruses and the acquisition of pathogenic properties [16].

Currently, the WHO strategy has introduced novel oral polio vaccine type 2 (nOPV2) [9] as of 2021. Since March 2021, approximately 450 million doses of this vaccine have been distributed for local use to control cVDPV type 2 cases in 21 countries [17]. Modifications to the poliovirus genome in this vaccine stabilize mutations in the 5’-untranslated region, suppress replication with other enterovirus types in coinfections, and limit the adaptability of the virus [18].

EPIDEMIOLOGICAL SITUATION IN REGIONS OF THE WORLD ENDEMIC FOR WILD POLIOVIRUS TYPE 1

Currently, Pakistan and Afghanistan remain endemic countries for poliomyelitis (according to WHO data). The dynamics of polio cases caused by wild poliovirus type 1 are presented in Figure 1. The maximum rates were observed in 2019–2020, a decrease was noted in 2021 and an increase in 2022. In 2024, after the data update on 28.05.2024, 6 confirmed polio cases caused by WPV type 1 were detected in endemic countries. The last cases were detected in April 2024 [19].

The dynamics of the number of isolated WPV type 1 strains from the environment in endemic regions is shown in Figure 2. The maximum values were observed in 2019–2020, a decrease was noted by 2021 and an increase in 2023. In 2024, after updating WHO data on 05.28.2024, 173 isolated WPV type 1 strains were detected from the environment. In 2021–2022, importation into countries declared polio-free was registered — Malawi and Mozambique [19].

In Afghanistan, the unfavorable epidemiological situation has developed due to the ban on house-to-house polio vaccinations. This has led to the fact that since May 2018, more than 1 million children in the southern regions of the country have been systematically not covered by immunization against polio. As a result, in 2019–2020, 90% and 75% of polio cases caused by WPV type 1 in Afghanistan, respectively, occurred in areas currently inaccessible for vaccination. In areas accessible for vaccination, there are personnel problems, and there are no accounting and reporting mechanisms [9].

Fig. 1. The dynamics of the incidence of polio caused by type 1 wild poliovirus in endemic regions

Рис. 1. Динамика заболеваемости полиомиелитом, вызванным диким полиовирусом 1-го типа, в эндемичных регионах мира

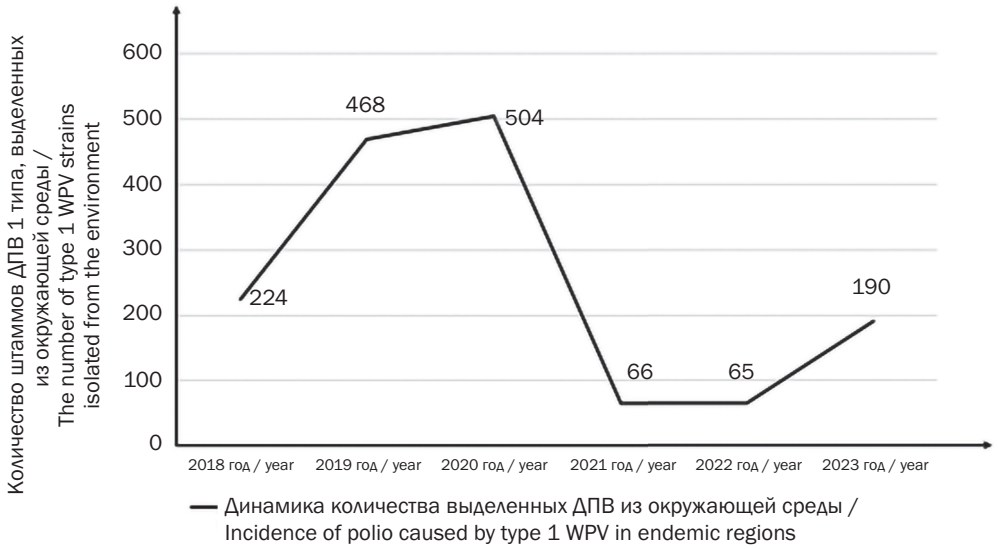

Fig. 2. Dynamics of the number of isolated wild poliovirus (WPV) type 1 strains from the environment in endemic regions

Рис. 2. Динамика количества выделенных штаммов диких полиовирусов (ДПВ) 1-го типа из окружающей среды в эндемичных регионах мира

In Pakistan, progress has been hampered by a combination of factors: decreased vigilance against a declining incidence from 2015 to mid-2018; no new cases were reported for several months; a change in national leadership; increasing public distrust of vaccines; discrepancy between emerging issues and traditional vaccine approaches. The growing amount of information on social networks from supporters of the anti-vaccination movement contributes to an increase in the frequency of unjustified refusals of parents to vaccinate. Immunization coverage has been impacted by a lack of effective engagement with special populations at high risk of polio, particularly the Pashtuns, who make up 15% of the country's population. Despite

the small size of this social group, it accounts for 81% of polio cases caused by WPV type 1 in Pakistan over the past 10 years [9].

In these countries, the previously mentioned problems have been exacerbated by the COVID-19 pandemic. In early 2020, the first wave of COVID-19 led to restrictions on movement and the temporary suspension of polio activities between March and July. During this pause, surveillance quality deteriorated and immunization campaigns were postponed. In 2021 and beyond, the introduction of COVID-19 vaccines has presented an opportunity to conduct public health education work among the population on immunoprophylaxis, including against polio [9].

EPIDEMIOLOGICAL SITUATION IN REGIONS OF THE WORLD WITH CIRCULATING VACCINE-DERIVED POLIOVIRUS

According to WHO, in addition to WPV type 1, cVDPV type 2 mainly continues to circulate in Africa and endemic countries. Elimination of WPV type 2 was declared in 2015. Following this, in April 2016, a global switch from trivalent to bivalent OPV containing poliovirus types 1 and 3 was implemented to completely eliminate the use of live attenuated vaccine type 2 and its associated risks. Outbreaks associated with cVDPV type 2 have emerged, despite the fact that this was preceded by the introduction of one dose of inactivated polio vaccine (IPV) in national immunization schedules and enhanced measures to increase herd immunity to vaccine-derived poliovirus type 2. Delay in measures taken in a number of African countries led to the emergence of a non-immune layer of the population group to poliovirus type 2 [20]. From 2016 to 2020, 64 cVDPV type 2 outbreaks have been reported, affecting 33 countries and causing a total of 1,572 cases of paralytic polio. In 2020, 1,082 cases of cVDPV type 2 infection were detected in 29 countries, 14 of which affected for the first time. The increase in cases is due to large outbreaks in countries such as Afghanistan, Pakistan, Chad, and Côte d'Ivoire, which together accounted for 59% of the total cases reported in 2020. The COVID-19-related pause in polio control activities from March to July 2020, in combination with disruptions basic immunization and IPV vaccination, also led to increased transmission of viruses. In early 2021, the risks associated with the spread of ongoing cVDPV type 2 outbreaks increased as these outbreaks threatened large population groups that lack immunity to cVDPV type 2 [9]. The dynamics of the number of polio cases worldwide

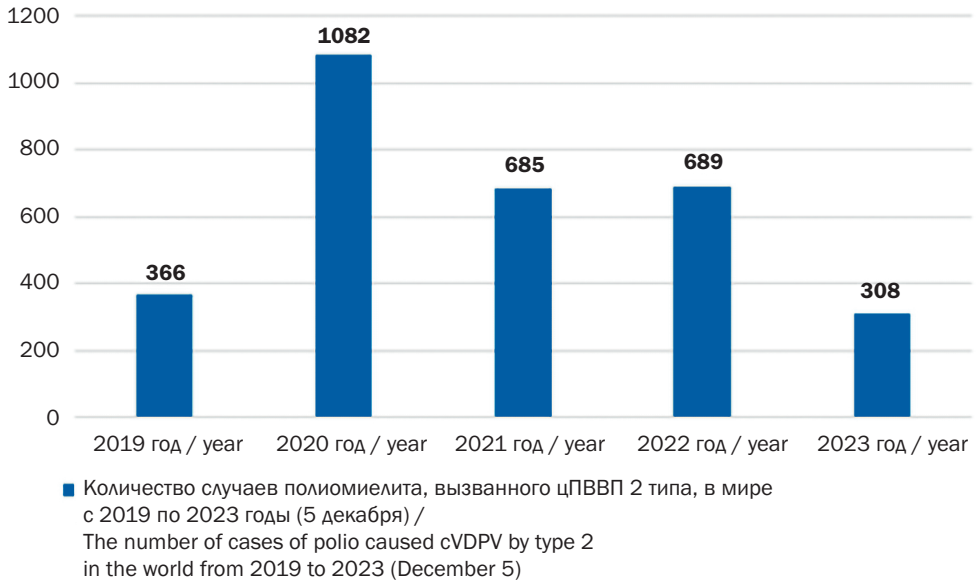

Fig. 3. Dynamics of the number of polio cases caused by type 2 circulating vaccine-derived polioviruses (cVDPV) in world (2019–2023 years)

Рис. 3. Динамика количества случаев полиомиелита в мире, вызванных циркулирующими полиовирусами вакцинного происхождения (цПВВП) 2-го типа (2019–2023 гг.)

caused by cVDPV type 2 from 2019 to 5 December 2023 is shown in Figure 3 [20].

The spread and continuation of cVDPV type 2 outbreaks are due to several factors: decreased mucosal immunity to cVDPV type 2 among young children born after the switch from trivalent to bivalent OPV; low coverage of basic IPV immunization; population migration, which allows the virus to be transmitted from one population to another; late detection of cVDPV type 2 outbreaks; delayed response to outbreaks; insufficient coverage of supplementary immunization measures [9].

IMMUNIZATION ACTIVITIES IN ENDEMIC REGIONS OF THE WORLD

WHO and UNICEF (an international organization operating under the auspices of the United Nations) estimate that national childhood coverage in Pakistan with three doses of OPV and one dose of IPV at 12 months of age was 83% for each vaccine in 2021. A 2021 study by C. Mbaeyi et al., supported by Gavi, the Vaccine Alliance, indicated that the proportion of children aged 12–23 months who had received 3 routine immunization OPV doses ranged by province from 45.1% in Balochistan to 94.9% in Punjab. None of the districts in the provinces of Balochistan, Khyber Pakhtunkhwa, and Sindh had coverage greater than 80%, compared with 31 (86%) of 36 districts in Punjab province [21].

Pakistan has also implemented supplementary immunization activities in response to cVDPV2 outbreaks using trivalent and nOPV2. In 2022, two national immunization days were conducted, targeting 44 million children under 5 years of age and five subnational immunization days for smaller populations. In 2023, one national immunization event and four subnational immunization events (February, March, May, and June) were held from January 2022 to June 2023, according to C. Mbaeyi et al. There are approximately 1.1 million children under 5 years of age eligible for vaccination in seven southern districts of Khyber Pakhtunkhwa. About 50,000 children in the region regularly miss out on OPV immunization, including 19,500 children in South Waziristan. In that district, militants have intimidated local health workers and prevented them from vaccinating children since August 2022, resulting in 19,500 children not receiving the vaccine. In January 2023, 505,750 children eligible for immunization were not vaccinated in the country, including 22,466 (4%) refusals [21, 22].

According to the WHO and UNICEF estimates, national coverage with three doses of OPV among children aged 12–23 months in Afghanistan was 71% in 2021 and 76% in 2022. Coverage with one dose of IPV in Afghanistan was 67% in 2021 and 71% in 2022. During 2023, routine immunization coverage with three doses or less of OPV increased to 73%, and the proportion of children who did not receive OPV decreased to 13%. The proportion of infants and children who never received OPV decreased from 1.4% in 2022 to 0.8% in 2023. In addition to routine immunization, Afghanistan offers vaccination to children under 10 years of age on major travel routes throughout the country and to persons of all ages at two border crossing points with Pakistan. During January 2022–June 2023, a total of 14,106,879 doses of bivalent OPV were administered at transit points and 1,690,497 at border crossings. Afghanistan also conducts regular surveillance for cases of acute flaccid paralysis, as one of the causes may be poliovirus [23].

CLINICAL AND EPIDEMIOLOGICAL SITUATION OF POLIO IN THE RUSSIAN FEDERATION

The Russian Federation has maintained its status as a polio-free country since 2002. The polio situation is assessed as favorable, but there remains a high risk of cases occurring in neighboring countries (Tajikistan, Ukraine). This raises serious concerns due to the growing possibility of importation of wild strains and circulating vaccine-derived polioviruses (cVDPVs). It is impossible to exclude the risk of the emergence of local cVDPVs in the RF and occurrence of new cases of vaccine-associated paralytic poliomyelitis if sanitary vaccination standards are not observed [5, 6, 24].

VAPP remains relevant in the RF. The dynamics of cases of vaccine-associated paralytic poliomyelitis in the Russian Federation from 2017 to 2022, according to the State Reports of Rospotrebnadzor, is shown in

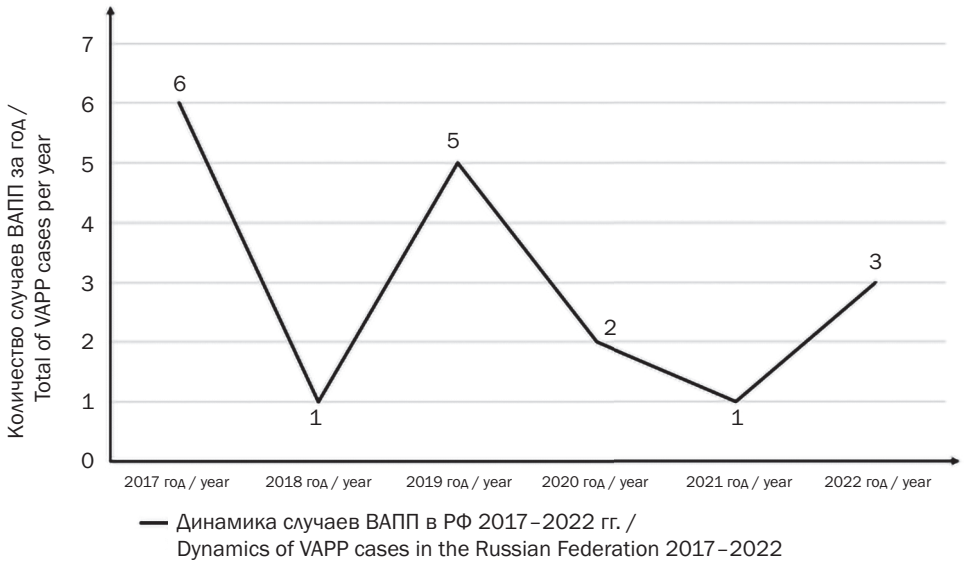

Fig. 4. Dynamics of vaccine-associated paralytic poliomyelitis (VAPP) cases in the Russian Federation (2017–2022 years)

Рис. 4. Динамика случаев вакцин-ассоциированного паралитического полиомиелита (ВАПП) в Российской Федерации (2017–2022 гг.)

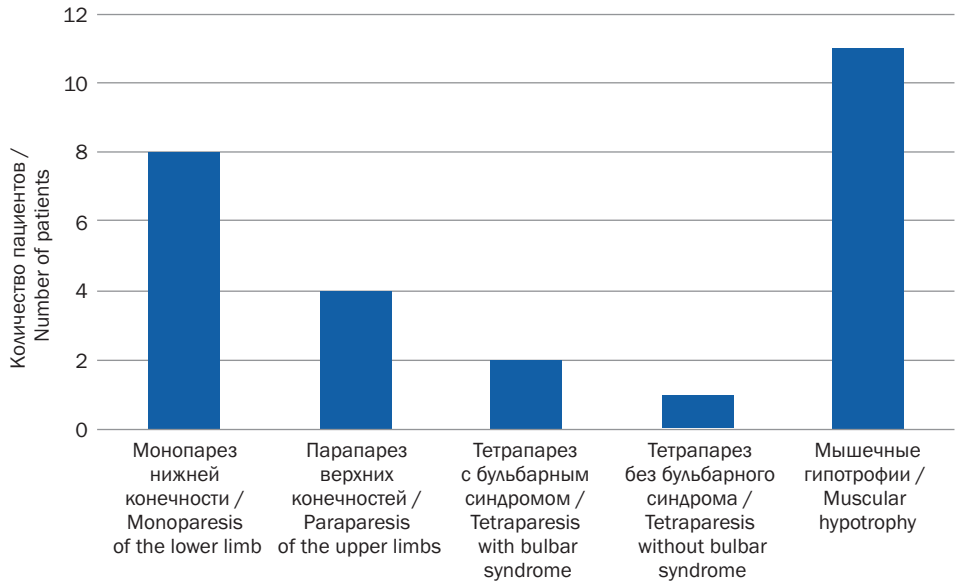

Fig. 5. Neurological manifestations of vaccine-associated paralytic poliomyelitis in oral polio vaccine recipients

Рис. 5. Неврологические проявления вакцин-ассоциированного паралитического полиомиелита у реципиентов оральной полиомиелитной вакцины

Figure 4. The largest number of detected cases was observed in 2017 and 2019 [26–30].

In the study by A.K. Shakaryan et al. (2019), an analysis of VAPP cases from 2006 to 2016 was conducted on individuals who received OPV as part of the vaccination – recipients of OPV and individuals in contact with the recipients of OPV who developed vaccine-associated paralytic poliomyelitis. Muscle hypotrophy, para- and monoparesis of the lower limbs predominated in persons in contact with recipients. In recipients of OPV muscle hypotrophy, para- and monoparesis of the lower limbs predominated, and tetraparesis with bulbar palsy was also encountered, which was not found in persons in contacts with recipients of OPV (Fig. 5, 6) [31].

In 2023, 1 case of VAPP was registered. Vaccine-derived polioviruses type 2 were isolated in two regions

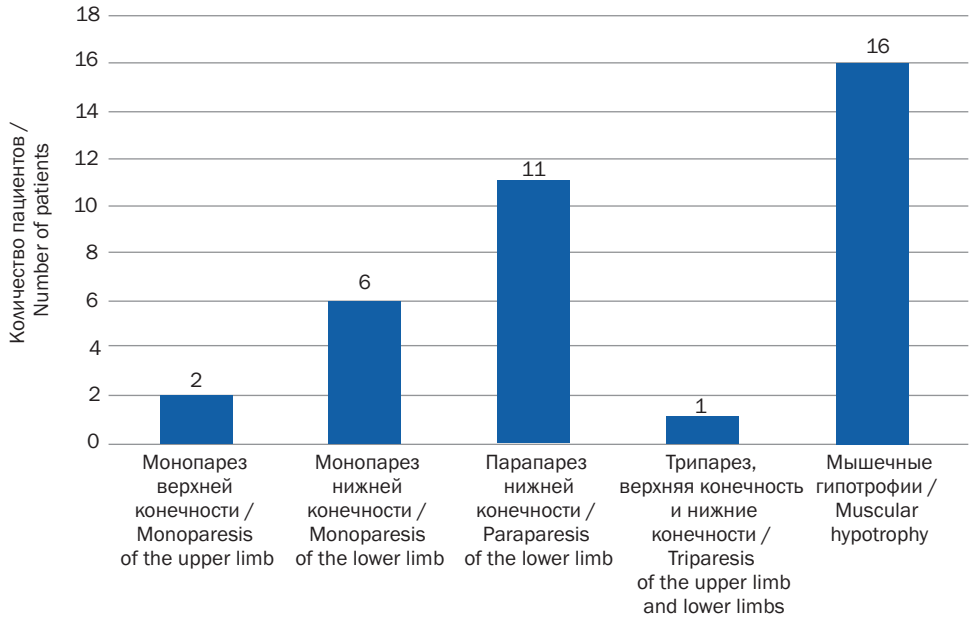

Fig. 6. Neurological manifestations of vaccine-associated paralytic poliomyelitis in contact persons

Рис. 6. Неврологические проявления вакцин-ассоциированного паралитического полиомиелита у контактных лиц

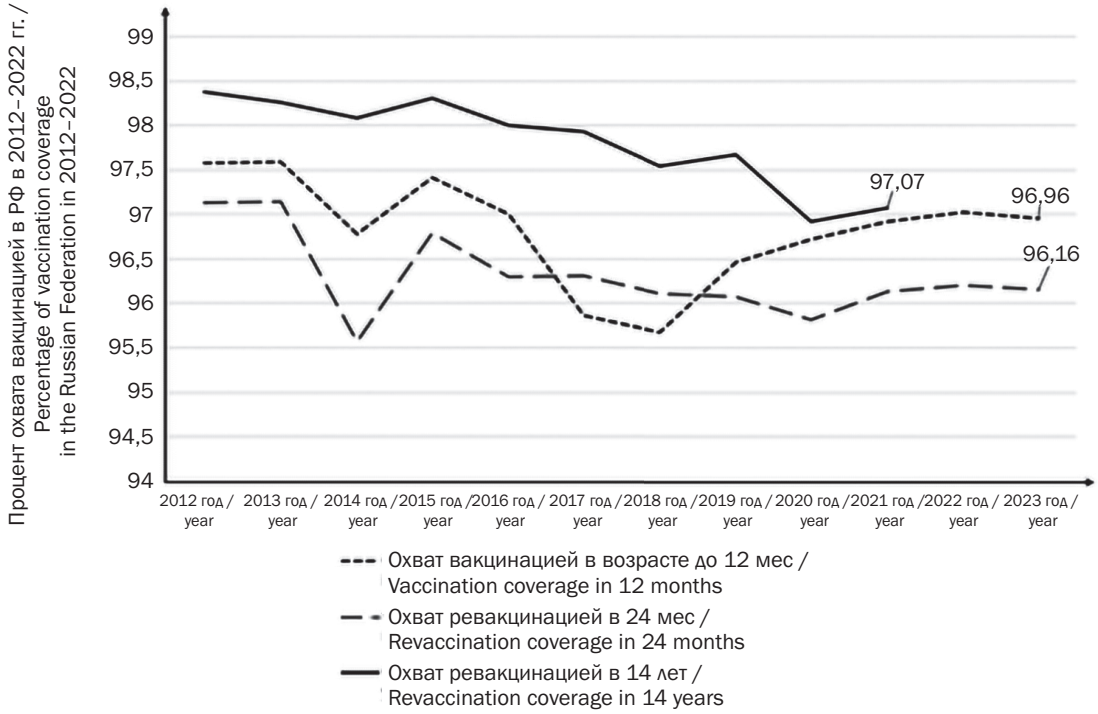

Fig. 7. Dynamics of polio vaccination coverage in the Russian Federation (2012–2023 years)

Рис. 7. Динамика показателей охвата вакцинацией против полиомиелита в Российской Федерации (2012–2023 гг.)

of the country. According to genome sequencing, the viruses are not related to each other and could have been isolated by individuals with immunodeficiency disorders. Rospotrebnadzor conducted an epidemiological investigation into this incident, organized a set of anti-epidemic and preventive measures, including immunization of the child population, in accordance with sanitary legislation and taking into account the WHO recommendations. As a result of the measures taken, the situation was localized, no new cases of isolation

of vaccine-derived poliovirus were recorded. The global situation and isolated findings of epidemiologically significant polioviruses, including as a result of importation, emphasize the relevance of the risks for the Russian Federation [5].

The dynamics of polio vaccination coverage rates in the RF in 2012–2023 are shown in Figure 7. Since 2022, according to the National Immunization Calendar of the Russian Federation, revaccination of children at 14 years of age has been replaced by revaccination at 6 years of age. Its rates were 88.1% in 2022 and 94.35% in 2023 [5].

Despite the high levels of vaccination coverage in the country as a whole, problems in the organization of immunoprophylaxis remain in a number of regions. In 2023, the coverage rate of children with timely immunization against polio at the age of 12 months was not achieved in 2 regions of the country (in 2022 — in 4), at the age of 24 months — in 4 (in 2022 — in 5), the coverage rate of the third revaccination at 6 years — in 20 (in 2022 — in 37) [5].

In 2023, in four federal subjects of the North Caucasus Federal District, catch-up supplementary immunization was held among all children aged 3 months to 9 years inclusive using inactivated and oral polio vaccines to increase the level of herd immunity to polioviruses. It was due to the isolation of vaccine-derived poliovirus type 1 in 2022 During the supplementary immunization program, high rates of poliomyelitis vaccination coverage were achieved, and measures to prevent VAPP were implemented [5].

In connection with the population migration from border states, immunization against polio was organized for unvaccinated or children under 14 years who have no data on preventive vaccinations that arrived during the year from Ukraine, the Donetsk and Lugansk People's Republics, and the Zaporizhye and Kherson regions. A total of 14,260 people were vaccinated [25].

Over the past 10 years (2014–2023), studies of material from 3,218 cases of acute flaccid paralysis and more than 70,000 healthy children from risk groups were conducted as part of polio surveillance. This made it possible to identify VAPP cases, as well as mutated vaccine-derived polioviruses of three types, including the import of cVDPV type 2 from the Republic of Tajikistan in 2021. A study of more than 140,000 wastewater samples showed the absence of circulation of WPV and cVDPV among the population of the Russian Federation [5].

CONCLUSION

Despite the activities carried out by the WHO, regions of Afghanistan and Pakistan currently remain endemic for wild poliovirus type 1. There are risks of the spread of WPV type 1 beyond the endemic regions due to military conflicts, unjustified refusals to vaccinate, non-compliance with vaccination schedules, the preservation of a non-immune layer of the population group in these countries and the incomplete scope of measures taken to fight against polio.

The prevalence of polio caused by cVDPV type 2 is much wider: it covers Africa and endemic countries. This is due to both the properties of the vaccine strains of polioviruses and the emergence of a non-immune layer of the population group in these regions along with the use of a live bivalent oral polio vaccine containing only poliovirus types 1 and 3. The new monovalent oral polio vaccine has reduced the incidence of poliomyelitis caused by cVDPV type 2.

In the Russian Federation, there remains a risk of importation of both wild and circulating vaccine strains of polio from other countries due to population migration from countries with low polio vaccine coverage. In the RF, there are isolated VAPP-cases caused by non-compliance with sanitary standards for general immunization.

Thus, the problem of polio remains relevant not only in endemic wild poliovirus regions, regions with circulation of cVDPV type 2, but also in the Russian Federation.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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