EPIDEMIOLOGY

MORBIDITY STATUS FOR SELECTED VACCINE-PREVENTABLE INFECTIONS IN THE IRKUTSK REGION IN DIFFERENT PERIODS OF VACCINE PREVENTION

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RESUME

Background. *The success of vaccination prevention at the present stage is undeniable. However, the epidemiological features of individual infections dictate the need of optimizing this preventive measure. This study is devoted to the epidemiological analysis of measles and whooping cough morbidity as infections with proven epidemiological effectiveness of the conducted vaccination, but at the same time, characterized by an increase in the incidence rate over the past years. Chickenpox and meningococcal infection are nosological forms, despite the continuing epidemiological, social and economic significance, characterized by a selective approach to vaccination of the population.*
The aim. *Study intensity of the epidemic process of infections with different vaccination strategies using the example of whooping cough, measles, chickenpox, meningococcal infection to justify the optimization of vaccination prevention tactics in the region.*
Materials and methods. *A retrospective epidemiological analysis of the incidence of whooping cough, measles, chickenpox, and meningococcal infection was conducted using previously published data and reporting forms from the Office of Rospotrebnadzor for the period 1955–2023 in the Irkutsk region.*
Results. *The introduction of mass vaccination against whooping cough and measles in the National Immunization Schedule has contributed to a decrease in morbidity. The period 2014–2023 in the region was characterized by an uneven distribution of indicators with an upward trend for these infections (Tgrow. was 15.1 and 18.7 %, respectively). It has been shown that against the background of a selective vaccination strategy against meningococcal infection and chickenpox, a decrease in morbidity is observed until 2021. At the same time, direct correlations are observed between the number of vaccinated and morbidity levels ($\rho = 0.952$, $\rho = 0.842$ at $p < 0.05$, respectively).*
Conclusion. *The obtained results of the study are necessary for optimization of the existing vaccination prevention program in the region. The introduction of revaccination of children, adolescents and adults against whooping cough, cohort vaccination of children against chickenpox and meningococcal infection will reduce the burden of infections with different vaccination strategies at the level of the subject of the Russian Federation.*

Key words: *vaccine-preventable diseases, regional calendar of preventive vaccinations, epidemiological analysis, morbidity status, vaccination prevention, vaccination strategy*

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СОСТОЯНИЕ ЗАБОЛЕВАЕМОСТИ ПО ОТДЕДЬНЫМ ВАКЦИНОУПРАВЛЯЕМЫМ ИНФЕКЦИЯМ В ИРКУТСКОЙ ОБЛАСТИ В РАЗНЫЕ ПЕРИОДЫ ВАКЦИНОПРОФИЛАКТИКИ

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РЕЗЮМЕ

Обоснование. *Успехи вакцинопрофилактики на современном этапе неоспоримы. Однако эпидемиологические особенности отдельных инфекций диктуют необходимость оптимизации этого профилактического мероприятия. Данное исследование посвящено эпидемиологическому анализу заболеваемости корью и коклюшем, как инфекциям с доказанной эпидемиологической эффективностью проводимой вакцинопрофилактики, но при этом, характеризуется ростом уровня заболеваемости на протяжении последних лет. Ветряная оспа и менингококковая инфекция – нозологические формы, несмотря на сохраняющуюся эпидемиологическую, социальную и экономическую значимость, характеризуются селективным подходом к вакцинации населения.*

Цель исследования. *Изучение интенсивности эпидемического процесса инфекций с разными стратегиями вакцинации на примере коклюша, кори, ветряной оспы, менингококковой инфекции для обоснования оптимизации тактики вакцинопрофилактики в регионе.*

Материалы и методы. *Ретроспективный эпидемиологический анализ заболеваемости коклюшем, корью, ветряной оспой, менингококковой инфекцией проведен по ранее опубликованным данным и отчетным формам Управления Роспотребнадзора по Иркутской области за период 1955–2023 гг.*

Результаты. *Внедрение массовой вакцинации против коклюша и кори в Национальный календарь профилактических прививок способствовало снижению заболеваемости. Период 2014–2023 гг. в регионе характеризовался неравномерным распределением показателей с тенденцией к росту по данным инфекциям (Тпр. составил 15,1 и 18,7 % соответственно). Показано, что на фоне селективной стратегии вакцинации против менингококковой инфекции и ветряной оспы отмечается снижение заболеваемости до 2021 г. При этом между числом привитых и уровнями заболеваемости прослеживаются прямые корреляционные зависимости ($\rho = 0,952$, $\rho = 0,842$ при $p < 0,05$ соответственно).*

Заключение. *Полученные результаты исследования необходимы для оптимизации имеющейся программы вакцинопрофилактики в регионе. Внедрение ревакцинации детей, подростков и взрослых против коклюша, когортной вакцинации детей против ветряной оспы и менингококковой инфекции позволят снизить бремя инфекций с разными стратегиями вакцинации на уровне субъекта Российской Федерации.*

Ключевые слова: *вакциноуправляемые инфекции, региональный календарь профилактических прививок, эпидемиологический анализ, состояние заболеваемости, вакцинопрофилактика, стратегия вакцинации*

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INTRODUCTION

At the present stage, vaccinal prevention is a priority component of public health protection and ensuring the sanitary and epidemiological well-being of the population. For certain infections, it represents the only effective measure for preventing the occurrence of infectious diseases, reducing their incidence, and achieving elimination. Within the territory of the Russian Federation (RF), vaccinal prevention has evolved from the first domestic list of recommended inoculations, "On the timing of preventive inoculations for children", developed in 1958, to the immunization schedule granted "National" status in 2001, with its subsequent gradual expansion to include infections against which the state guarantees protection [1].

Thanks to the successful implementation of vaccinal prevention programs, sustainable epidemiological well-being has been achieved for a number of infections, including diphtheria, rubella, viral hepatitis B, and tetanus [2].

Currently, in accordance with Order of the Ministry of Health of Russia No. 1122n dated December 6, 2021 (as amended in 2023) "On the approval of the national calendar of preventive immunizations, preventive immunizations according to epidemic indications, and the procedure for conducting preventive immunizations", routine vaccination of children and adults is carried out. Furthermore, for certain categories of citizens, vaccination according to epidemic indications is provided for a fairly large number of infectious diseases. In addition, by Decree of the Government of the Russian Federation No. 2390-r dated September 18, 2020, the Strategy for the Development of Immunoprophylaxis of Infectious Diseases for the period up to 2035 was approved, which envisions a phased expansion of the National Calendar of Preventive Immunizations (NCPI).

A number of constituent entities, taking into account the specific features of the epidemiology of infectious diseases, are actively developing and implementing regional preventive immunization schedules into practice. This measure allows for additional vaccination of the population against infections for which vaccination is not currently included in the NCPI or is carried out according to epidemic indications [3-6]. The development of regional vaccination programs aligns with the key goals of the Strategy for the Development of Immunoprophylaxis in the Russian Federation [7].

In the territory of the Irkutsk Region, as in the Russian Federation as a whole, diphtheria, tetanus, mumps, and rubella have not been registered for a number of years, and the number of cases of acute hepatitis B is registered at a sporadic level [8]. Furthermore, the region has accumulated considerable successful experience with vaccination according to epidemic indications [9, 10].

Despite the fact that the epidemiological situation regarding vaccine-preventable infections in the region has been favorable for a number of years, there is an objective need for additional study of morbidity and optimization of vaccinal prevention for infections with universal and selective vaccination strategies.

THE AIM OF THE STUDY

To study the intensity of the epidemic process of infections with different vaccination strategies using the examples of pertussis, measles, varicella, and meningococcal infection, in order to substantiate the optimization of vaccinal prevention tactics in the region.

MATERIALS AND METHODS

The study was conducted with the approval of the Ethics Committee of the Irkutsk State Medical University (Protocol No. 1 dated March 7, 2022). A retrospective epidemiological analysis of morbidity covering more than 60 years was performed. The dynamics of measles and pertussis incidence in the total population of the region were reconstructed for the period 1955–2023; the dynamics of varicella and meningococcal infection incidence were reconstructed for the period 1980–2023, based on previously published data [11] and current data from official medical statistics. A more detailed analysis of morbidity for the studied infections was conducted for the total population and children in different age groups in 2014–2023, according to data from federal state statistical observation (Form 2 "Information on infectious and parasitic diseases"). Vaccination volumes against varicella and meningococcal infection from 2014 to 2023 are presented according to data from federal state statistical observation (Form 5 "Information on preventive immunizations").

Morbidity rates in different age groups were studied over the last 10 years (2014–2023), for which the following periods were identified: 2014–2019 (the period before the spread of COVID-19); 2020–2022 (the period of COVID-19 spread); and 2023 (the last year of analysis). For measles, this analysis was conducted for the period from 2011 to 2023 (10 years of observation), as no cases of measles were registered in the region in 2014, 2021, and 2022.

Descriptive epidemiological methods were applied to identify patterns in the long-term dynamics of morbidity for the studied infections and the distribution of morbidity by age group. Time series analysis (calculation of intensive and extensive rates, average annual growth/decline rates (Tgr./Tdecl.), Spearman correlation coefficients, regression equations), and graphical representation of data were performed using Microsoft Office Excel 2011. Confidence intervals with a significance level of 95% (95% CI) were calculated to assess the statistical significance of differences in relative indicators.

RESULTS

Following the introduction of mass pertussis vaccination in the Russian Federation in 1957, a widespread decline in incidence was noted [12]. In the Irkutsk Region, within 10 years of vaccine use, the incidence rate decreased 10-fold, from 450 per 100,000 to 41.5 per 100,000. Over the subsequent 50 years, the long-term average annual rate (LAAR) remained at 8.2 [6.0÷10.4] per 100,000 (Tdecl. = -2.2 %, regression coefficient = -3.5). However, the period 2014–2023 was characterized by an uneven distribution of incidence rates, with levels varying from 0.79 [0.49÷1.1] to 3.4 [1.8÷5.0] per 100,000, showing an upward trend (regression coefficient = 1.8, Tgr. = 15.1 %). In 2023, a record number of pertussis cases was registered – 834 cases, with a rate of 36.2 [33.5÷38.9] per 100,000 in the total population and 136.9 [129.5÷144.3] per 100,000 among children under 17 years of age (Fig. 1). These changes occurred against the backdrop of achieving regulated indicators of preventive immunization coverage among children — 97.0–98.0 % and higher [8].

In the age structure of the cases, children under 17 years predominated, with their proportion ranging from 90.2 % to 93.3 % in different years. The proportion of individuals aged 18 years and older varied slightly, from 6.7 % to 9.8 %. Among children of different age groups, those under 2 years and aged 7–14 years prevailed, accounting for 33.1 % [29.4÷36.8] and 37.1 % [29.8÷44.4] of cases, respectively.

The dynamics of measles incidence in the total population also showed a pronounced downward trend over the study period, with a regression coefficient of -19.0 (Fig. 2). The measles elimination period (since 2001) was characterized by the registration of sporadic cases in various years, with the maximum number of cases recorded in 2023 – 59 cases, corresponding to a rate of 2.5 [2.0÷3.0] per 100,000 population. The average annual growth rate for 2014–2023 was 18.7 %. Coverage rates for preventive immunization among children and adults were maintained at regulated levels of 98.0 % and above [8].

Children under 17 years of age predominated in the case structure, with their proportion ranging from 56.4 % to 62.7 %. An exception was the period 2020–2022, during which measles cases were registered only in 2020 and exclusively among adults (2 cases, with a rate of 0.1 per 100,000 population).

The incidence rate of meningococcal infection (MI) over the observation period showed a steady downward trend, with rates ranging from 7.6 [6.4÷8.8] to 0.42 [0.22÷0.62] per 100,000 population (Fig. 3). Since 2020, only generalized forms of MI (GFMI) have been subject to official registration in statistical reporting forms for infectious diseases; therefore, the dynamics of GFMI incidence for the period 2014–2023 are presented in more detail. The long-term average annual incidence rate of GFMI in the total population was 0.4 [0.25÷0.55] per 100,000, with annual rates varying from 0.13 [0.03÷0.23] to 0.87 [0.57÷1.17] per 100,000.

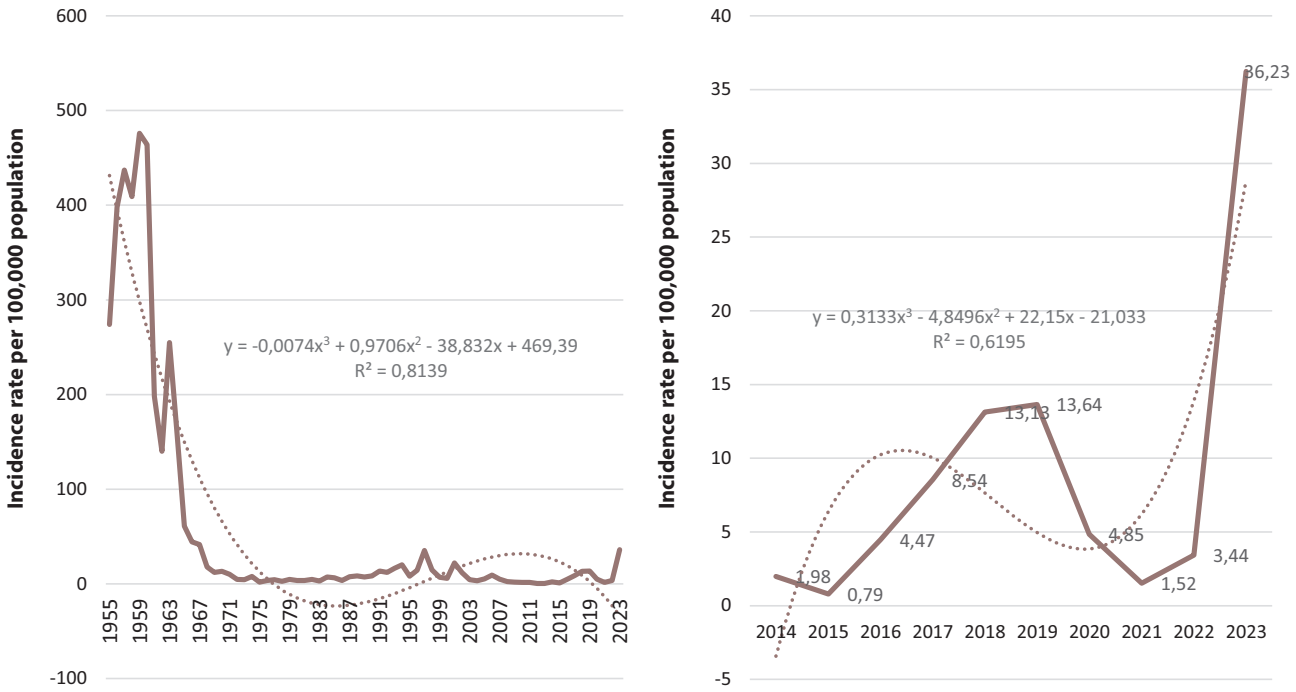

FIG. 1.
Long-term dynamics of whooping cough incidence in the total population of the Irkutsk region for the period from 1955 to 2023 (left) and for the period from 2014 to 2023 (right)

The period 2020–2022 was characterized by a marked decrease in rates, similar to most airborne infections; however, in 2023, the incidence rate increased by 2.3 times. In the age structure of cases, children under 17 years predominated, accounting for 79.0 %.

Despite the relatively low incidence rates of MI and GFMI, the case fatality rate remained quite high. The average case fatality rate over the observation period was 21.4 %, ranging annually from 10.0 % to 42.5 %.

These changes in morbidity and mortality occurred against the backdrop of selective vaccination of the population based on epidemic indications. The period 2014–2023 was characterized by a statistically significant 2.9-fold decrease in the incidence rate ($p < 0.05$). However, a direct correlation was observed between the number of vaccinated individuals and the incidence rate of MI and GFMI (0.952, $p < 0.05$).

The incidence rate of varicella over the observation period remained consistently high, with a long-term average annual rate of 573.2 [563.6–582.8] per 100,000 population. The long-term dynamics of incidence were characterized by alternating periods of increase

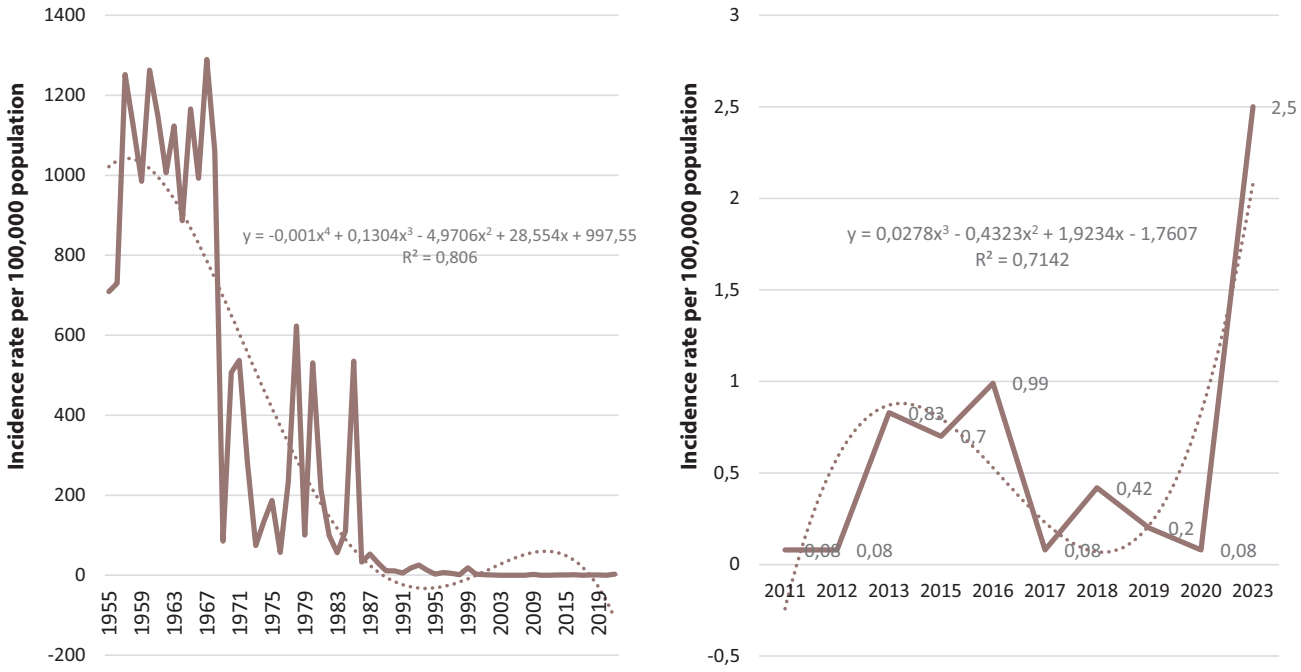

FIG. 2.
Long-term dynamics of measles incidence in the total population of the Irkutsk region for the period from 1955 to 2023 (left) and for the period from 2011 to 2023 (right)

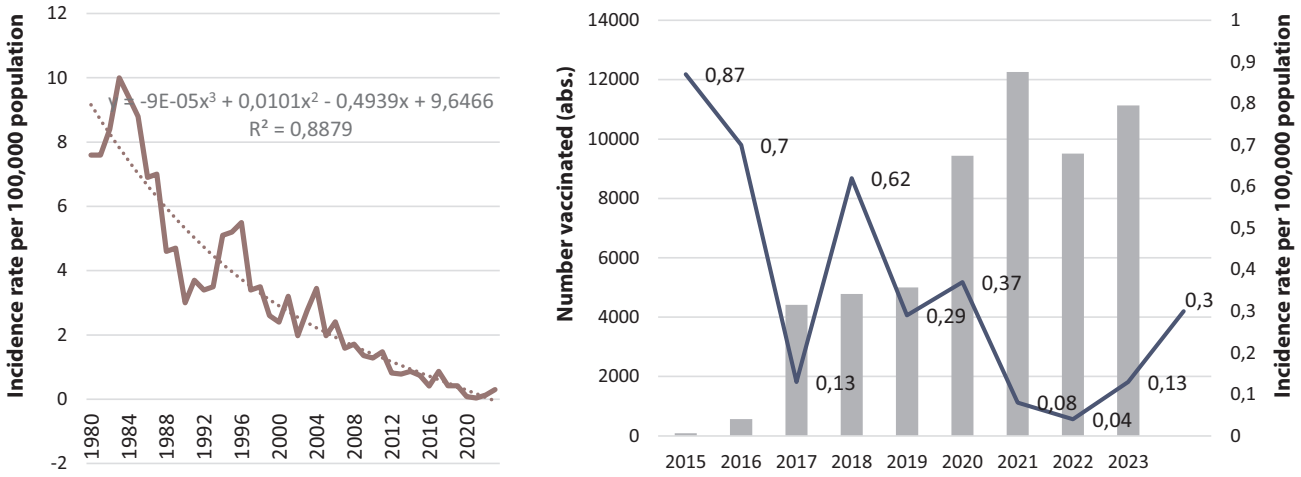

FIG. 3.
Long-term dynamics of meningococcal infection incidence in the total population of the Irkutsk region for the period from 1980 to 2019 (period 2020–2023 dynamics of GFMI incidence) on the left and dynamics of generalized meningococcal infection incidence and the number of vaccinated for the period from 2014 to 2023 (on the right)

and decrease. For instance, the period 1982–1998 was marked by a pronounced decline in incidence (regression coefficient = -40.8, Tdecl. = -2.8 %) (Fig. 4). Subsequently, an increase in rates was observed (regression coefficient = 21.9, Tgr. = 2.7 %). Starting from 2013, another decline in the incidence rate was recorded (regression coefficient = -44.3, Tdecl. = -2.8 %). This decline occurred alongside the implementation of selective vaccination of the population within the framework of the preventive immunization schedule for epidemic indications (primarily contacts in epidemic foci and military conscripts). Vaccination volumes in the region increased annually, with the total number of vaccinated individuals exceeding 22,000 people, including over 13,000 children. At the same time, a direct correlation was observed between the number of vaccinated individuals and the varicella incidence rate (0.842, $p < 0.05$).

The period 2020–2022 was characterized by a statistically significant decline in the incidence rates of the studied infections (Table 1). Thus, the incidence of pertussis among children under 17 years decreased by 2.3 times, and among adults, by 1.5 times. In 2023, an increase in incidence was registered, by 11.2 times and 10.7 times in the respective groups. During 2014–2019, measles incidence was recorded at levels of 0.9 and 0.2 per 100,000 in children and adults, respectively; in 2020–2022, only sporadic cases among adults were registered. In 2023, the incidence rates in the compared groups were 6.5 and 1.2 per 100,000, respectively. The incidence of GFMI in 2023 returned to the average annual level of 2014–2019. The epidemiological situation for varicella was similar to that of pertussis: a sharp decline in 2020–2022, followed by an increase in 2023, which was not statistically different from the levels observed in 2014–2019.

Analysis of morbidity across different observation periods and age groups of the population showed that the highest incidence rates for pertussis, measles, and GFMI were recorded among children, with the primary risk groups being children under 1 year and those aged 1–2 years. For varicella, the highest rates were observed in children aged 3–6 years. Notably, in 2023, the greatest increase in varicella incidence (a 1.7-fold rise) occurred among children aged 7–17 years (Table 1).

DISCUSSION

Infectious diseases remain one of the most significant challenges to public health worldwide. The history of combating "contagious diseases (plagues, pestilences)" spans several centuries [13]. At the present stage, the effective implementation of vaccinal prevention programs can preserve achieved successes and ensure the maintenance of the sanitary and epidemiological well-being of the population. Global practice has shown that a decline in population coverage with preventive immunizations is immediately followed by an increase in the incidence of vaccine-preventable infections, escalating into large outbreaks and epidemics [14-16].

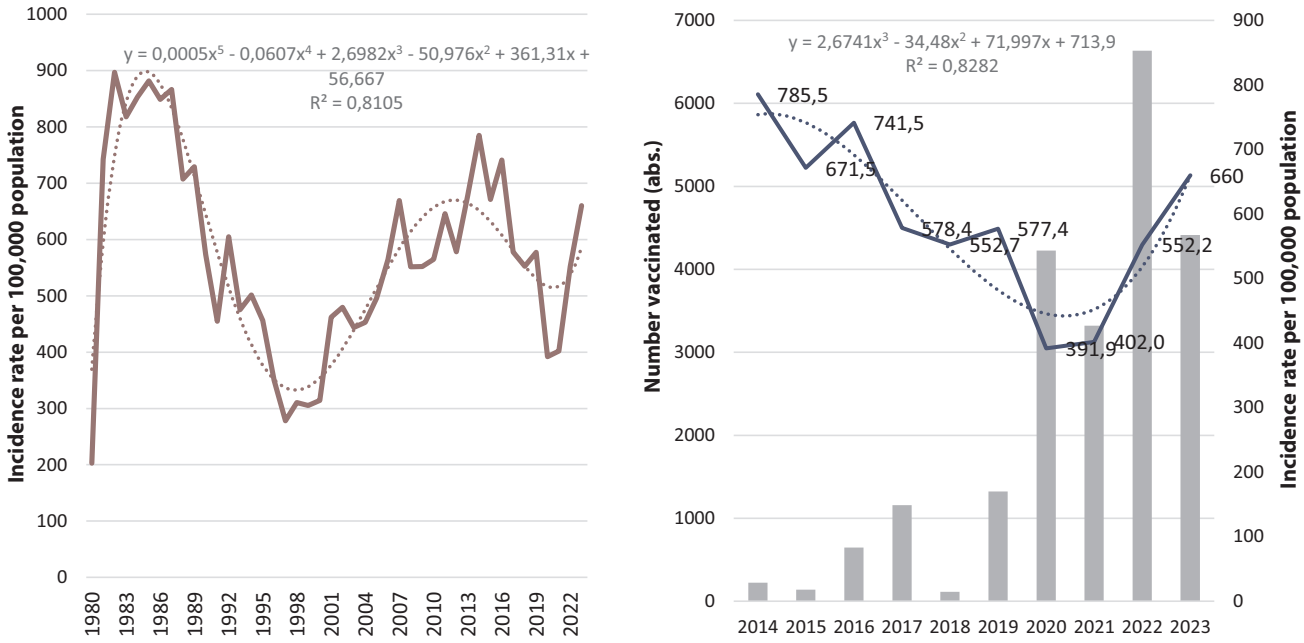

FIG. 4.
Long-term dynamics of chickenpox incidence in the total population of the Irkutsk region for the period from 1980 to 2023 (left); dynamics of chickenpox incidence and the number of vaccinated for the period from 2014 to 2023 (right)

TABLE 1

INCIDENCE OF WHOOPING COUGH, MEASLES, CHICKENPOX AND GENERALIZED FORMS OF MENINGOCOCCAL INFECTION AMONG DIFFERENT AGE GROUPS OF THE POPULATION (PER 100 THOUSAND OF THE CORRESPONDING GROUP)

Period	2014–2019				2020–2022				2023			
Age / Disease	Pertussis	Measles	GFMI	Varicella	Pertussis	Measles	GFMI	Varicella	Pertussis	Measles	GFMI	Varicella
Under 1 year	67.4 [63.7÷71.1]	8.5 [7.2÷9.8]	9.5 [8.1÷10.9]	1241.0 [1225.4÷1256.7]	31.5 [28.9÷34.0]	Not registered	3.8 [2.9÷4.7]	896.8 [888.5÷910.1]	596.4 [585.5÷607.3]	36.8 [34.1÷39.5]	12.5 [10.9÷14.1]	1397.1 [1380.5÷1413.7]
1–2 years	36.0 [33.3÷38.7]	2.0 [1.4÷2.6]	6.6 [5.5÷7.7]	2855.7 [2832.2÷2879.2]	26.0 [23.7÷28.3]	Not registered	Not registered	2217.0 [2196.2÷2237.8]	163.5 [157.8÷169.2]	13.3 [11.7÷14.9]	1.9 [1.3÷2.5]	3632.1 [3605.7÷3658.5]
3–6 years	23.4 [21.2÷25.6]	1.6 [1.0÷2.2]	1.2 [0.7÷1.7]	6315.0 [6280.6÷6349.4]	16.7 [14.9÷18.5]	Not registered	Not registered	4376.1 [4347.2÷4405.0]	66.6 [62.9÷70.3]	6.4 [5.3÷7.5]	0.8 [0.4÷1.2]	6256.5 [6222.3÷6290.7]
7–17 years	25.1 [22.9÷27.3]	0.3 [0.06÷0.5]	0.04 [0÷0.13]	1056.1 [1041.7÷1070.6]	6.4 [5.3÷7.5]	Not registered	0.03 [0÷0.1]	727.6 [715.6÷739.6]	126.4 [121.4÷131.4]	3.6 [2.8÷4.5]	Not registered	1255.9 [1240.2÷1271.6]
0–17 years	28.3 [25.9÷30.7]	0.9 [0.5÷1.3]	1.9 [1.3÷2.5]	2634.3 [2611.7÷2656.9]	12.2 [10.6÷13.8]	Not registered	0.2 [0÷0.4]	1758.1 [1739.5÷1776.7]	137.0 [131.8÷142.2]	6.5 [5.4÷7.6]	0.9 [0.5÷1.3]	2580.3 [2557.9÷2602.7]
18 years and older	0.6 [0.3÷1.0]	0.2 [0÷0.4]	0,1 [0÷0.24]	51.7 [48.5÷54.9]	0.4 [0.1÷0.7]	0.1 [0÷0.2]	0.1 [0÷0.2]	29.3 [26.9÷31.7]	4.3 [3.4÷5.2]	1.2 [0.7÷1.7]	0.1 [0÷0.2]	46.9 [43.8÷49.9]

In the Irkutsk Region, the incidence of infectious (contagious) diseases remained at a high level for a number of years [11, 17].

In the territory of the Russian Federation, against the background of implementing mass vaccination programs, epidemiological well-being has been achieved for infections controllable by specific preventive measures [2]. The results of this study also confirm this. A manifold decrease, by dozens of times, in diseases such as measles and pertussis over a period of more than 50 years testifies to the need to maintain high levels of vaccination coverage in the population [15, 18, 19]. However, the last 10–15 years are characterized by somewhat different trends and manifestations of the epidemic process for this group of infections: an uneven distribution of incidence rates over time and among different age groups of the population [12, 18-20]. Thus, in 2023, a record number of pertussis cases was registered both in the Russian Federation and in the Irkutsk Region. Objective reasons for this phenomenon included the introduction of new diagnostic methods, leading to the detection of mild, atypical forms [2, 8]. The incidence rate in the region exceeded that of the Russian Federation [8]. Despite routine vaccination among children, pertussis remains a relevant "under-controlled" infection [12], with fatal cases being registered [2]. This necessitates a change in approaches to the organization of vaccinal prevention, including among children aged 3–6 years, adolescents, and adults [19, 20].

The measles elimination period was characterized by sporadic cases registered everywhere [16, 18]. In the Irkutsk Region, the annual number of cases among children and adults varied from 2 to 24, with a maximum in 2023 (59 cases). In accordance with the execution of Decree No. 1 of the Chief State Sanitary Physician of the Russian Federation dated February 8, 2023, "On conducting catch-up immunization against measles in the territory of the Russian Federation", over 80 thousand people were vaccinated [8]. Thus, special attention must be directed towards timely vaccination of children and adults within the framework of the NCPI. To achieve the goals of the Immunization Agenda 2030 (IA2030), it is necessary to maintain population coverage with preventive immunizations and consider the results of serological monitoring assessing the level of population immunity.

Meningococcal infection occupies a special place among aerosol anthroponoses, retaining its status as a deadly and difficult-to-control infectious disease [21, 22]. In the region, despite sporadic cases, the case fatality rate remains high (21.4 %).

Varicella is a widespread infectious disease. In terms of the magnitude of economic damage, it has been leading for a number of years, second only to acute upper respiratory tract infections [2, 6]. The results of this study demonstrate a persistently high incidence rate in the population (573.2 and 2366.1 per 100,000 for the total population and children under 17 years, respectively).

Vaccination carried out according to epidemic indications is undoubtedly effective in epidemic foci and among certain categories of citizens. However, the practice of selective immunization does not significantly affect overall incidence rates. The results of this study regarding MI and varicella clearly confirm this: direct correlations are observed between the number of vaccinated individuals and incidence rates. The priority direction for the prevention of these infections remains routine vaccination of children. Studies by domestic and foreign researchers [6, 23-25] have demonstrated the effectiveness, including economic effectiveness, of this measure.

Against the background of the spread of the new coronavirus infection COVID-19, a decrease in the incidence of a number of nosological forms was registered, including for the group of airborne infections. This was primarily associated with the isolation of the population and the anti-epidemic measures implemented against COVID-19 [2]. Furthermore, according to temporary WHO recommendations dated March 26, 2020, it was recommended to temporarily suspend mass vaccination campaigns due to the increased risk of infection spread in the population [26]. These measures contributed to the accumulation of non-immune and thus highly susceptible individuals in the population, consequently leading to a registered increase in 2023 in the number of infections controllable by specific preventive measures among different population groups [2, 8, 14, 19, 21, 23].

CONCLUSION

The obtained results of the study can be used to optimize the existing vaccinal prevention program in the region. Thus, despite routine vaccination against pertussis and measles, there is an objective need to introduce booster vaccination against pertussis for children, adolescents, and adults, as well as for adult risk groups, in accordance with the methodological guidelines "Vaccination of the Adult Population". It is advisable to monitor documented vaccination coverage among the adult population, particularly vaccination and revaccination against measles among decreed groups and other contingents (students of higher and secondary educational institutions, migrants, etc.). The introduction of cohort vaccination of young children against varicella and meningococcal infection will significantly reduce the burden of these infections at the level of the constituent entity of the Russian Federation.

Conflicts of interest

The authors declare no conflicts of interest.

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