EPIDEMIOLOGY

EFFECT OF VACCINATION ON MORBIDITY AND MORTALITY FROM COMMUNITY-ACQUIRED PNEUMONIA

Bayanova T.A.[1],
Stukova E.S.[2],
Kravchenko N.A.[1]

[1] Irkutsk State Medical University (Krasnogo Vosstaniya str. 1, Irkutsk 664003, Russian Federation)
[2] Center of Hygiene and Epidemiology in the Irkutsk Region (Trilissera str. 51, Irkutsk 664047, Russian Federation)

Corresponding author:
Tatyana A. Bayanova,
e-mail: bayanova_tanya@mail.ru

ABSTRACT

Background. *Community-acquired pneumonia (CAP) remains one of the most common and life-threatening forms of pathology among respiratory diseases.*
The aim of the study. *To identify the features of the epidemiology of community-acquired pneumonia in the conditions of mass immunization against pneumococcal infection in the Irkutsk region.*
Materials and methods. *We conducted a descriptive epidemiological retrospective study. We studied the incidence of community-acquired pneumonia (including community-acquired pneumonia of bacterial and viral etiology) and mortality from this disease in the Irkutsk region for 2011–2022 according to statistical reporting forms No. 2, No. 5, No. 6, C51.*
Results. *The incidence of community-acquired pneumonia during the observation period remained at a high level: the long-term annual average rate among the total population was 627.3 [467.8÷786.8]. At the same time, there was a persistent decrease in the incidence of community-acquired pneumonia of bacterial etiology (Tdecrease = 6.8 %). Incidence rates of community-acquired pneumonia of bacterial etiology were distributed unevenly over the years and the compared population groups. The highest levels were recorded in children in 2018–2019 – 12.3 [10.8÷13.8] and 19.3 [17.8÷20.8], respectively. A decrease in the mortality rate from community-acquired pneumonia among children, adults and in the general population in 2020 was shown, with a subsequent increase in the rate among adults and the general population by 2.5 times. Against the background of ongoing immunization of the population against pneumococcal infection, there is a statistically significant decrease in the incidence of community-acquired pneumonia, including community-acquired bacterial pneumonia, and mortality from community-acquired pneumonia among different population groups.*
Conclusion. *Despite the high incidence of community-acquired pneumonia, a statistically significant decrease in the incidence of community-acquired pneumonia of bacterial etiology has been shown among children and adults. The decrease in mortality from community-acquired pneumonia has continued since the introduction of immunization against pneumococcal infection. The results of the study can be used to optimize epidemiological surveillance and epidemiological control of community-acquired pneumonia at the regional level.*

Key words: *community-acquired pneumonia, bacterial pneumonia, pneumococcal pneumonia, viral pneumonia, morbidity, mortality, vaccination*

Received: 06.06.2023
Accepted: 05.02.2024
Published: 26.03.2024

For citation: Bayanova T.A., Stukova E.S., Kravchenko N.A. Effect of vaccination on morbidity and mortality from community-acquired pneumonia. *Acta biomedica scientifica*. 2024; 9(1): 241-250. doi: 10.29413/ABS.2024-9.1.24

ВЛИЯНИЕ ВАКЦИНАЦИИ НА ЗАБОЛЕВАЕМОСТЬ И СМЕРТНОСТЬ ОТ ВНЕБОЛЬНИЧНЫХ ПНЕВМОНИЙ

Баянова Т.А.[1],
Стукова Е.С.[2],
Кравченко Н.А.[1]

[1] ФГБОУ ВО «Иркутский государственный медицинский университет» Минздрава России (664003, г. Иркутск, ул. Красного Восстания, 1, Россия)

[2] ФБУЗ «Центр гигиены и эпидемиологии в Иркутской области» (664047, г. Иркутск, ул. Трилиссера, 51, Россия)

Автор, ответственный за переписку:
Татьяна Александровна Баянова,
e-mail: bayanova_tanya@mail.ru

РЕЗЮМЕ

Обоснование. *Внебольничные пневмонии (ВП) остаются самой распространённой и угрожающей жизни формой патологии среди болезней органов дыхания.*

Цель исследования. *Выявить особенности эпидемиологии внебольничных пневмоний в условиях массовой вакцинации против пневмококковой инфекции в Иркутской области.*

Материалы и методы. *Проведено описательное эпидемиологическое ретроспективное исследование. Изучены заболеваемость ВП (в том числе бактериальной и вирусной этиологии) и смертность от них в Иркутской области за 2011–2022 гг. по данным статистических отчётных форм № 2, № 5, № 6, С51.*

Результаты. *Заболеваемость ВП за период наблюдения сохранялась на высоком уровне: среднемноголетний показатель среди совокупного населения составил 627,3 [467,8÷786,8]. При этом отмечалось стойкое снижение уровня заболеваемости ВП бактериальной этиологии (Тсниж. = 6,8 %). Показатели заболеваемости внебольничными пневмококковыми пневмониями были распределены неравномерно по годам и сравниваемым группам населения. Наибольшие уровни регистрировались у детей в 2018–2019 гг. – 12,3 [10,8÷13,8] и 19,3 [17,8÷20,8] соответственно. Показано снижение уровня смертности от ВП среди детей, взрослых и совокупного населения в 2020 г. с последующим ростом показателя среди взрослых и совокупного населения в 2,5 раза. На фоне проводимой вакцинации населения против пневмококковой инфекции (ПИ) отмечается статистически значимое снижение уровня заболеваемости ВП, в том числе внебольничными бактериальными пневмониями и смертности от ВП среди разных групп населения.*

Заключение. *Несмотря на высокие уровни заболеваемости ВП, показано статистически значимое снижение заболеваемости ВП бактериальной этиологии среди детей и взрослых. Снижение смертности от ВП продолжилось с начала введения вакцинации против пневмококковой инфекции. Полученные результаты исследования могут быть применены для оптимизации эпидемиологического надзора и эпидемиологического контроля за ВП на региональном уровне.*

Ключевые слова: *внебольничные пневмонии, бактериальные пневмонии, пневмококковые пневмонии, вирусные пневмонии, заболеваемость, смертность, вакцинация*

Статья поступила: 06.06.2023
Статья принята: 05.02.2024
Статья опубликована: 26.03.2024

Для цитирования: Баянова Т.А., Стукова Е.С., Кравченко Н.А. Влияние вакцинации на заболеваемость и смертность от внебольничных пневмоний. *Acta biomedica scientifica*. 2024; 9(1): 241-250. doi: 10.29413/ABS.2024-9.1.24

INTRODUCTION

Community-acquired pneumonia (CAP) is one of the most common infectious diseases [1, 2]. High levels of morbidity and mortality, polyetiology, and difficulties in laboratory diagnosis necessitate optimisation of epidemiological surveillance and approaches to the prevention of this pathology [3, 4]. *Streptococcus rpeimopiae* (*S. rpeimopiae*) is the dominant agent in respiratory tract lesions [5]. The World Health Organisation estimates that pneumococcal disease (PD) is responsible for more than 1.5 million deaths each year, and almost half of these are in children. An unfavourable factor hindering the effectiveness of treatment is the progressive antibiotic resistance of strains of this pathogen [3, 6]. The diversity of clinical forms, high prevalence of PD determines the relevance of the problem of their prevention [5]. With the epidemic spread of viral infections (influenza, COVID-19), the relevance of CAP, including bacterial etiology, remains [7]. Viral infections have been confirmed to be the trigger mechanism for colonisation of the respiratory tract by pathogenic bacterial flora [8].

Vaccine prophylaxis is recognised as an effective strategy for the prevention of CAP [5]. Vaccination against influenza, Haemophilus influenzae type B, measles, pertussis, PD, COVID-19, implemented within the framework of Immunization Schedule (IS) of different countries, is aimed at reducing CAP morbidity and mortality among different population groups. Scheduled vaccine prophylaxis of pneumococcal infection on the territory of the Russian Federation was included in the IS one of the last, in 2014. The accumulated experience of the scheduled vaccination demonstrates the epidemiological and prophylactic efficacy of this measure in some regions [9-11].

In the Irkutsk region, the incidence rate of CAP in the period 2011–2019 exceeded that of the Russian Federation (RF) by 1.5 times [12]. Specific PD prophylaxis is carried out within the framework of Order No. 1122н (Annexes 1, 2). It is extremely relevant to study changes in the level of morbidity and mortality caused by CAP at the level of the constituent entity of the Russian Federation in the conditions of scheduled vaccine prophylaxis against pneumococcal infection.

THE AIM OF THE STUDY

To identify the features of the epidemiology of community-acquired pneumonia in the conditions of mass immunization against pneumococcal infection in the Irkutsk region.

MATERIALS AND METHODS

We conducted a descriptive epidemiological retrospective study. We studied the incidence of CAP (viral and bacterial, including pneumococcal, etiology) and mortality from their occurrence in the Irkutsk region for 2011–2022 by continuous samples of reporting forms № 2 "Information about infectious and parasitic diseases", C51 "Distribution of the dead by sex, age and causes of death". The volumes of vaccination against pneumococcal infection among the population are presented according to the data of forms No. 5 "Information on preventive vaccinations" for 2013–2022; No. 6 "Information on contingents vaccinated against infectious diseases" for 2016–2022.

CAP incidence and mortality of different population groups (child, adult, aggregate) are presented by periods: 2011–2019 – period before the spread of COVID-19; 2020 – COVID-19 pandemic onset year; 2021–2022 – years of COVID-19 spread.

To assess the extent to which immunisation against PD influences the incidence of CAP, community-acquired bacterial pneumonia (CABP) and community-acquired pneumococcal pneumonia (CAPP) and CAP mortality, age stratified analyses were performed in children (under 17 years), adults (18 years and older) and the general population.

Descriptive epidemiological methods were used to study long-term dynamics of CAP morbidity, including bacterial etiology, CAPP and CAP mortality, distribution of morbidity by age groups of the population. Calculation of relative indices, average annual growth/decline rates ($T_{growth}/T_{decrease}$), regression equations, Spearman correlation coefficients, data analysis and their graphical representation were performed using MS Office Excel 2010 (Microsoft Corp., USA).

Statistical significance of differences in relative values was calculated using confidence intervals with a significance level of $p \leq 0.05$ (95% CI).

RESULTS

The CAP incidence among different age groups of the population in the Irkutsk region remained at a high level. For the period 2011–2019, the incidence rate for children (0-17 years) exceeded that of adults and the general population by a factor of 2.3 and 1.7, respectively. In 2020, a significant increase in the CAP incidence rate among adults was registered. In the subsequent period (2021–2022), the incidence rate among adults decreased but exceeded that among children (Table 1).

In analysing the CAP structure among laboratory-confirmed cases within follow-up, the predominance of CAP cases of bacterial etiology was observed – 78.4 %; the exceptions were 2020 and 2022, where the share of pneumonias of viral etiology was 84.2 % and 73.5 %, respectively.

The dynamics of CAP morbidity incidence of bacterial etiology during the observation period was characterised by a decreasing trend among children and adults. The incidence rate in children was

higher and declined at a higher rate than in adults; the average annual rates of decline were 9.3 per cent and 5.8 per cent, respectively. In the multi-year follow-up of child morbidity, the period 2018–2019 was characterised by a significant increase in indicators: the average level was 179.7 [125.6÷233.8] per 100,000 population, in 2018 the incidence increased by 14.0 % compared to the previous period, in 2019 – by 35.0 %. In 2021, there was a significant decrease in the incidence rate, the indicator was 21.4 [12.4÷30.4] per 100 thousand population (the lowest level for the observation period); in 2022, a statistically insignificant increase in the incidence rate was registered – 30.1 [25.4÷34.8] per 100 thousand population. Similar trends were observed in the follow-up of adult morbidity. CAP incidence of viral aetiology differed significantly between the compared groups. Specifically, among the adult population, the period 2011–2018 was characterised by a consistently low incidence rate, with a long-term average annual indicator (LTAAI) of 9.4 [0÷18.4] per 100,000 population. An increase in the rate to 18.8 [16.9÷20.7] per 100 thousand population was observed from 2019, which continued in 2020 – to 721.9 [709.7÷734.1] per 100 thousand population. In 2021, the incidence rate was observed at the 2019 level with a further increase in 2022. In the long-term follow-up of the CAP incidence of viral aetiology in children, the levels and periods of incidence were distributed similarly to those of bacterial CAP: periods of decrease and growth alternated with each other. In 2020, the CAP incidence of bacterial and viral etiology was recorded at 80.2 [72.6÷87.8] and 86.5 [78.3÷94.7] per 100,000 population, respectively. The lowest incidence rate for the observation period was recorded in 2021 – 3.2 [1.6÷4.8] per 100 thousand population; in 2022 there was another rise in the incidence rate (statistically significant), the rate was 54.0 [47.6÷61.6] per 100 thousand population (Fig. 1).

The share of CAPP in the structure of bacterial CAP was insignificant. In particular, the minimum level was observed in 2013 and amounted to 0.4 %, the maximum in 2021 (11.0 %). According to the long-term average annual values for the analysed period, the CAPP share was 3.1 %, with a lower average for the period 2013–2019 than for the period 2020–2022: 2.5 % and 4.6 % respectively.

Since 2013, laboratory-confirmed cases of pneumococcal pneumonia have been registered in the Irkutsk region in reporting form No. 2. For the period 2013–2022 LTAAI in the general population was 3.2 [1.9÷4.5] per 100,000 population, in children and adults 5.5 [2.0÷9.0] and 2.6 [1.4÷3.8] per 100,000, respectively (differences were not statistically significant). Analysis of the comparison of CAPP long-term incidence rates in adults and children showed an uneven distribution of indicators over the years with multidirectional trends. The following periods can be distinguished in the follow-up of the CAPP incidence rate among children: 2013–2017 – decrease in the incidence rate (the average annual rate of decrease was 5.8 %, regression coefficient -0.6); 2018–2019 – significant growth of indicators (growth rate (T_{growth}) = 21.5 %; incidence rate – 12.3 [10.8÷13.8] and 19.3 [17.8÷20.8], respectively); 2020–2022 – sharp decrease in the incidence rate (decrease rate – 27.8 %). Over the period 2013–2022, the CAPP adult incidence trends show an excess of 1.3 times the LTAAI in 2015 and 2018 and 3.7 times the LTAAI in 2021. In 2022, the incidence of pneumococcal pneumonia in the comparison groups was 0.5 per 100,000 (Fig. 2).

Among children of different age groups, the highest incidence rates of CAPP were registered in the age groups under 1 year and 1–2 years, LTAAI was 12.1 [0÷31.8] and 17.1 [4.1÷30.1] per 100,000 population, respectively. It is worth noting that in 2018–2019, an increase in incidence rates was observed among children of all age groups. The maximum incidence rate was observed in 2019 in children under 1 year old and was 103.7 per 100,000 population (Table 2).

One of the important areas that characterise the epidemic process manifestations of an infectious disease

TABLE 1

COMMUNITY-ACQUIRED PNEUMONIA INCIDENCE AMONG DIFFERENT POPULATION GROUPS COMPARED BY PERIODS (PER 100,000 POPULATION)

Population groups	2011-2019 (LTAAI)	2020	2021-2022 (LTAAI)
Total population	528.4* [437.3÷619.5]	1400.5* [1385.8÷1415.2]	685.7* [454.8÷916.6]
Children under 17 years old	928.5* [786.8÷1070.2]	732.4 [710.6÷754.2]	569.6* [488.3÷704.7]
Adult population (persons over 18 years of age)	411.3* [325.5÷497.1]	1613.1* [1595.1÷1631.1]	711.9* [350.7÷1073.1]

Note. LTAAI – long-term average annual indicator; * – statistically significant differences by observation periods.

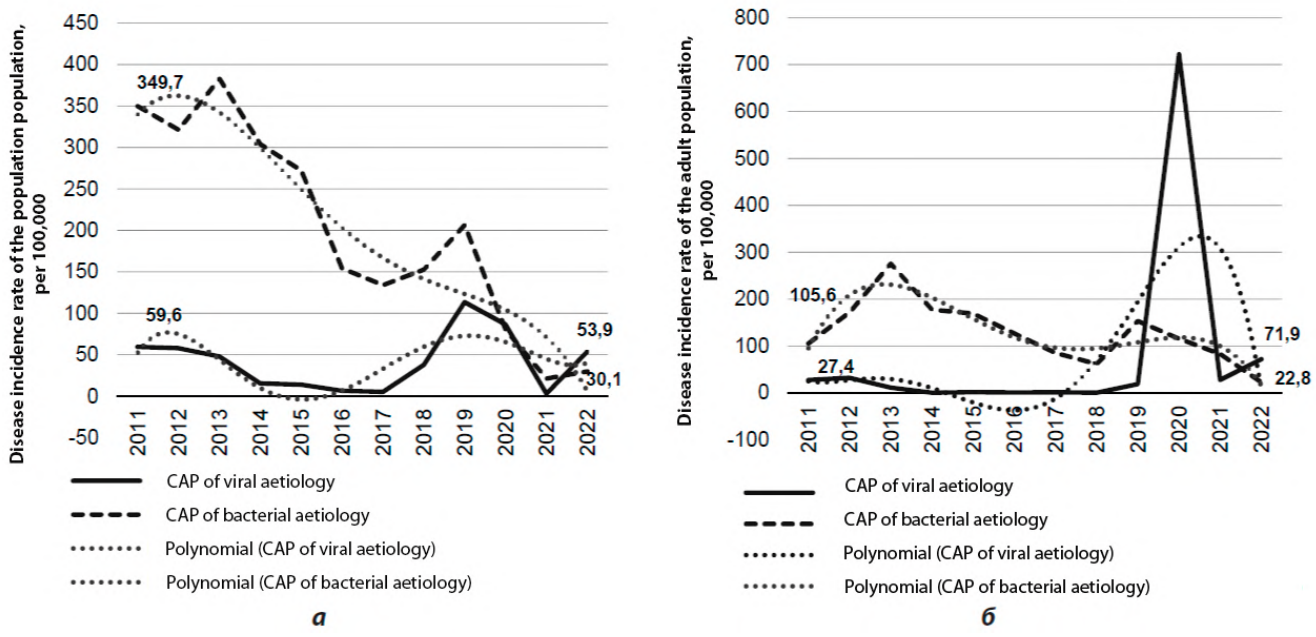

FIG. 1.
Long-term follow-up of the incidence of community-acquired bacterial and viral pneumonia in children (a) and adults (б) in the Irkutsk region for the period 2011-2022 (per 100,000 population)

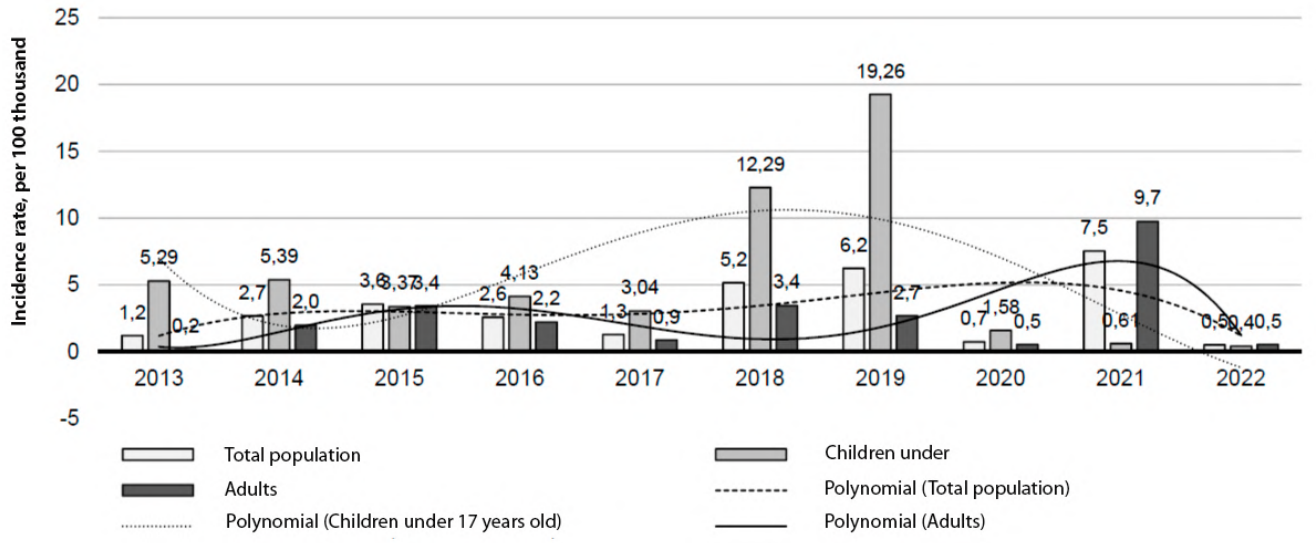

FIG. 2.
Long-term incidence rate of community-acquired pneumococcal pneumonia in children, adults and the total population of the Irkutsk region for the period 2013-2022 (per 100,000 population)

is the assessment of the mortality rate of the population. In 2020, CAP mortality rates were lower than 2011–2019 levels in the general population, children, and adults by a factor of 1.7, 7.8, and 1.7, respectively. In contrast, in 2021 among adults and the total population, the rate was 2.5 and 2.4 times higher than the 2020 level, respectively; and the 2011–2019 level was 1.4 times higher than the 2020 level. The specific volume of bacterial CAP in the structure of CAP mortality during the observation period varied from 7.4 to 18.1 %, with the minimum level being observed in 2020–2021. CABP mortality rates among the compared groups ranged from 0.5–4.8 per 100,000 population. Among children for different periods

the rate did not exceed 1.0 per 100 thousand population, among adults – a decrease in the mortality rate in 2020–2021 was observed (Table 3).

The coverage of the Irkutsk region total population with preventive vaccinations during the analysed period was at the level of 4.0–8.0 %. Vaccination rates among children increased annually from 14.0 % to 22.0 %. The total number of people vaccinated against PD in the total population for 2013–2022 was 401,812 (17.0 % of the 2022 population), among them 262,733 children (53.4 % of the 2022 child population).

The number of people vaccinated against pneumococcal infection was unevenly distributed by year. The CAP incidence rate among children from the onset of vaccination till 2022 decreased 1.7-fold from 1266.6 [1254.9÷1278.3] to 715.3 [692.0÷738.6] ($p < 0.05$; Fig. 3). During the period analysed, there was an inverse correlation between the number of children vaccinated and the number of children sickened with CAP, CABP and CAPP ($\rho = -0.555$; $\rho = -0.139$; $\rho = -0.382$, respectively); the differences were not statistically significant ($p > 0.05$). Unlike children, among the adult population, the incidence of VP increased 1.2 times over the same period – from 436.7 [427.5-445.9] to 527.6 [517.3-537.9] ($p < 0.05$). A statistically non-significant direct correlation was revealed between the number of vaccinated persons and the number of CAP, CABP and CAPP cases ($\rho = 0.636$; $\rho = 0.345$; $\rho = 0.227$, respectively; $p > 0.05$).

TABLE 2

FOLLOW-UP INCIDENCE RATE OF COMMUNITY-ACQUIRED PNEUMOCOCCAL PNEUMONIA IN CHILDREN OF DIFFERENT AGE GROUPS IN 2013–2022 (PER 100,000 ELIGIBLE CHILDREN; 95% CI)

Age groups	Periods			LTAAI
	2013-2017	2018-2019	2020-2022	
Up to 1 year	2.7 [1.1÷4.3]	51.8 [0÷153.3]	1.8 [0÷4.1]	12.1 [0÷31.8]
1-2 years	8.7* [5.0÷12.4]	57.2* [54.5÷59.9]	0.9 [0÷7.7]	17.1 [3.8÷30.4]
3-6 years old	3.2 [2.5÷4.9]	8.2 [1.6÷14.8]	0	3.2 [1.2÷4.3]
7-14 years old	3.7 [0.8÷6.6]	5.1 [0÷11.7]	0.5 [0.2÷0.8]	3.0 [0.9÷5.1]
15-17 years old	3.2 [0.5÷5.9]	2.9 [0÷8.5]	0.6 [0÷1.3]	2.3 [0.8÷3.8]

Note. * – statistically significant differences by observation periods.

TABLE 3

MORTALITY CAUSED BY COMMUNITY-ACQUIRED PNEUMONIA, INCLUDING BACTERIAL PNEUMONIA, AMONG DIFFERENT POPULATION GROUPS COMPARED BY PERIODS (PER 100,000 POPULATION)

Population groups	2011-2019 (LTAAI)		2020		2021	
	CAP	CABP	CAP	CABP	CAP	CABP
Total population	37.8* [35.4÷40.2]	3.8* [3.0÷4.6]	21.4* [19.6÷23.2]	1.7* [1.1÷2.3]	51.8* [48.9÷54.7]	2.2 [1.6÷2.8]
Children under 17 years old	3.9* [2.3÷5.5]	0.4 [0÷0.8]	0.5* [0÷1.1]	0	1.2 [0.4÷2.0]	0.5 [0÷1.1]
Adult population (persons over 18 years of age)	47.8* [44.7÷50.9]	4.8* [3.8÷5.8]	27.2* [24.8÷29.6]	2.2* [1.6÷2.8]	67.7* [64.0÷71.4]	3.2 [2.2÷4.2]

Note. * – statistically significant differences by observation periods.

One of the objectives of vaccine prophylaxis at the present stage is to reduce mortality caused by infections. Over the period 2011–2019 in the total population, CAP mortality decreased from 56.1 [53.2÷59.0] to 15.2 [13.6÷16.8] per 100 thousand (differences are statistically significant). An inverse correlation of medium strength between the number of vaccinations and mortality rate was observed for each year (ρ = -0.614; $p > 0.05$). In 2020–2021, an increase in the indicator is observed with the maximum value in 2021 – 51.8 [48.9÷54.7] per 100 thousand population. Among children, there was a pronounced downward trend in this indicator: the average annual rate of decline was 8.4 %, regression coefficient -0.82. In 2020, the indicator was 7.6 times lower than in 2011. There was a weak inverse correlation between the number of vaccinated and CAP deaths (ρ = -0.214; $p > 0.05$) (Fig. 4).

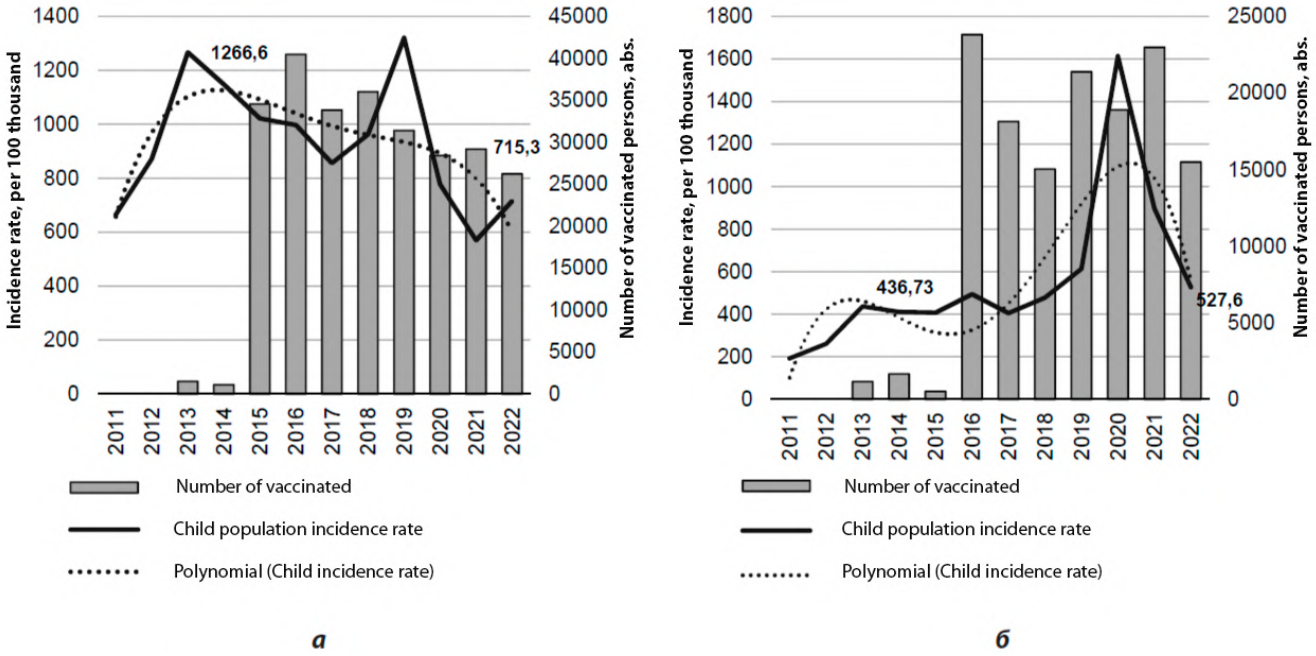

FIG. 3.
Long-term incidence followed-up of community-acquired pneumonia and the number of children (a) and adults (б) vaccinated against pneumococcal infection in the Irkutsk region for the period 2013-2022 (per 100,000 population)

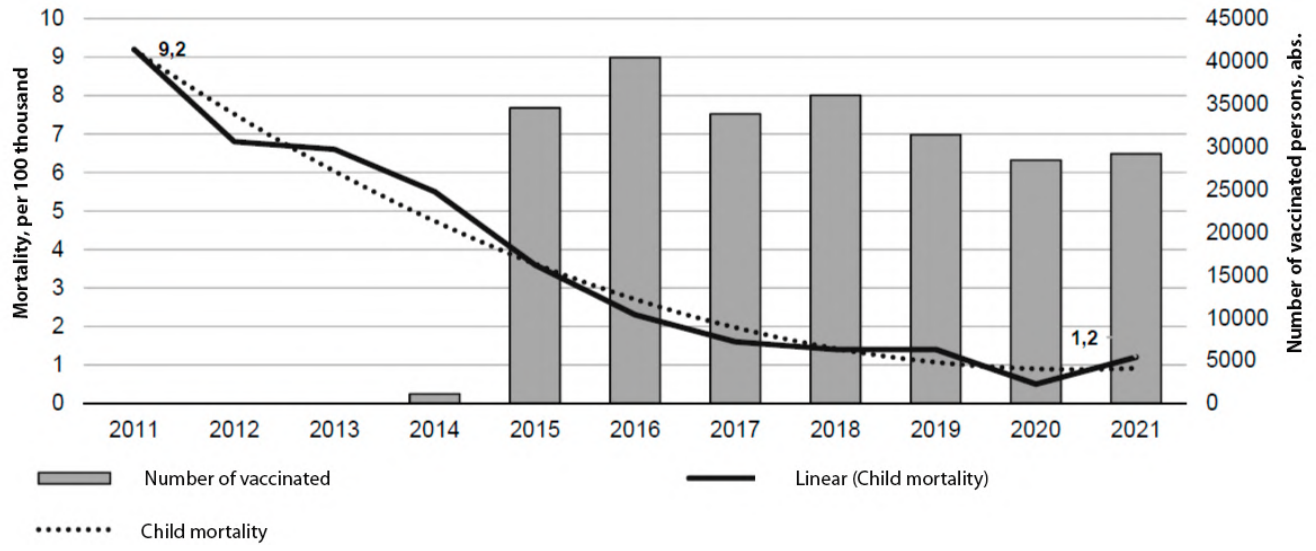

FIG. 4.
Long-term dynamics of mortality caused by community-acquired pneumonia and the number of children vaccinated against pneumococcal infection in the Irkutsk region for the period 2011-2021 (per 100,000 population)

DISCUSSION

The incidence of community-acquired pneumonia in Irkutsk region was observed at a high level in different periods of observation. Against the background of the COVID-19 pandemic, the incidence rate has increased and the age groups at risk have changed, which has also been observed in studies [3, 7, 12]. In the Irkutsk region, as well as in the Russian Federation as a whole, in 2020 the maximum CAP incidence rate among adults was observed, which is associated not only with the selective effect of the SARS-CoV-2 virus, but also with the approaches to statistical recording and registration of COVID-19 infection: this disease was not registered as an independent nosological form, and all manifestations of the new coronavirus infection were counted either as community-acquired pneumonia or in the group of acute respiratory infections of the upper respiratory tract [12]. The CABP incidence was higher compared to viral among different populations. Accordingly, the long-term average annual indicator for CAP of bacterial etiology exceeded that for CAP of viral etiology among children and adults by 4.8 and 1.7 times, respectively; the periods of growth and decline in the multi-year follow-up coincided. This distribution of CAP by etiological agent is explained by a wide range of typical and «atypical» bacteria and their associations (*pneumococci, Klebsiella, chlamydia, mycoplasmas, Staphylococcus aureus, Pseudomonas bacillus*, etc.) [1, 3].

The proportion of laboratory-confirmed pneumococcal pneumonia and pneumococcal infection, according to different authors, varies between 4–45 % [3, 6, 13]. The results of this study reveal a very low proportion of laboratory-confirmed CAPP cases (0.4–6.4 %) among the reported cases, with a significant increase (11.0 %) during the period of COVID-19 infection, which may be associated with an increase in the number of laboratory tests performed [12].

An increase in the incidence rate of CAPP in children was revealed in 2018–2019; the average annual rate of increase was 21.5 %. In the region, this period was characterised by an increase in the incidence of influenza and respiratory tract infections among the population [12]. The increased incidence of CAPP in adults in 2021 is also likely to be associated with the adherence of bacterial infections in the spread of COVID-19 [7].

Against the background of increased incidence rate, a high level of mortality from CAP persisted. Among adults, the rates were significantly higher at different periods and ranged from 27.2 to 67.7. No data is available to study the dynamics of mortality from pneumococcal pneumonia according to statistical reporting forms due to the lack of information in them. According to the results of sample studies conducted earlier in the Irkutsk region [14], the proportion of laboratory-confirmed cases of fatal pneumococcal pneumonia was 30 %.

According to the Order of the Ministry of Health of the Russian Federation No. 1122н, children aged 2 and 4.5 months should be vaccinated twice against PD, followed by revaccination at 15 months of age. For epidemic reasons, vaccination is indicated for children 2–5 years of age and adults at risk (persons over 60 years of age suffering from chronic lung diseases, persons over working age living in social service organisations and persons subject to military conscription). Pneumococcal conjugate vaccines (PCV) have been recommended for routine immunisation of children, and their use helps to reduce the incidence and carriage of PD in the general population. A single administration of polysaccharide pneumococcal vaccine (PPV) or sequential administration of PCV and PPV at 1-year intervals is recommended for immunisation of adults at risk, depending on the presence or absence of immunocompromising conditions and comorbidities [3, 5, 15, 16].

In the region, prophylactic vaccination coverage against PD has increased among the general population and children to 8.0 % and 22.0 %, respectively, since the introduction of vaccination. The effect of vaccination on the incidence of CAP and CAPP has been shown in studies [5, 9, 15]. The results of the study revealed a statistically significant reduction in bacterial CAP in different population groups (105.7 [101.2÷110.2] and 30.1 [27.6÷32.6] among adults; 349.8 [332.4÷367.2] and 22.8 [18.7÷26.9] among children). CAPP incidence rates were recorded an order of magnitude lower and were unevenly distributed in follow-up. There was an inverse correlation with the number inoculated ($\rho = -0.382$; $p > 0.05$). One of the reasons for the increased incidence of adult CAP against the background of vaccination against PD and other infectious diseases (influenza, COVID-19) may be the difficulty in organising vaccination work among these populations, including an increase in preventive vaccination coverage rates as a consequence of low vaccination adherence [17].

The decrease in mortality from pneumonia against the background of vaccination is clearly traceable and consistent with the data of other researchers [1, 3, 16]. An inverse significant correlation was observed between the number of vaccinated persons and the number of CAP deaths in the general population and among children by year (differences were not statistically significant; $p > 0.05$), which is probably associated with the short period of observation. No doubt, other therapeutic, diagnostic and preventive measures also have an impact on the reduction of CAP mortality. However, vaccination of the population against PD should not be ruled out.

CONCLUSION

Despite high levels of CAP morbidity, a statistically significant decrease in the incidence for CAP

of bacterial aetiology among different age groups of the population was revealed. The decline in CAP mortality has continued since the introduction of PD vaccination. However, the insignificant share of pneumococcal pneumonias in the structure of CAP, uneven distribution of morbidity rates by population groups, and lack of registration of CAPP as a cause of death in statistical forms of Rosstat (Russian Federal State Statistics Service) make it difficult to assess the objective epidemiological situation and the effectiveness of vaccination.

The results of the study can be used at the regional level to optimize epidemiological surveillance, primarily in terms of microbiological monitoring of cases of illness and death from CAP, CABP, CAPP; as well as epidemiological control of PD, aimed at increasing the coverage of preventive vaccination against PD in different population groups, timeliness of immunization and formation of adherence to vaccination.

Conflict of interest

The authors of this article declare no conflicts of interest.

REFERENCES

1. Bilichenko TN, Chuchalin AG. Morbidity and mortality of the Russian population from acute respiratory viral infections, pneumonia and vaccination. *Terapevticheskii arkhiv*. 2018; (1): 22-26. (In Russ.).

2. Tsai D, Chiong F, Secombe P, Hnin KM, Stewart P, Goud R, et al. Epidemiology and microbiology of severe community-acquired pneumonia in Central Australia: A retrospective study. *Intern Med J*. 2022; 52(6): 1048-1056. doi: 10.1111/imj.15171

3. Briko NI, Korshunov VA, Lomonosov KS. Pneumococcal infection in Russia: State of the issue. *Annals of the Russian Academy of Medical Sciences*. 2021; 1(76): 28-42. (In Russ.).

4. Theilacker C, Sprenger R, Leverkus F, Walker J, Häckl D, von Eiff C, et al. Population-based incidence and mortality of community-acquired pneumonia in Germany. *PLoS One*. 2021; 16(6): e0253118. doi: 10.1371/journal.pone.0253118

5. Capabilities of atopic dermatitis systemic therapy with selective immunosuppressors: Resolution of the experts workshop of dermatology profile. *Pediatric Pharmacology*. 2022; 19(2): 209-211. (In Russ.). doi: 10.15690/pf.v19i2.2424

6. Protasova IN, Ilyenkova NA, Sokolovskaya ES. Epidemiology of pneumococcal serotypes in children with outpatient pneumonia and carriers in Krasnoyarsk. *Pacific Medical Journal*. 2019; (4): 78-82. (In Russ.). doi: 10.34215/1609-1175-2019-4-78-82

7. Kostinov AM, Kostinov MP, Mashilov CV. Antagonism between pneumococcal vaccines and COVID-19. *Medical Council*. 2020; (17): 66-73. (In Russ.). doi: 10.21518/2079-701X-2020-17-66-73

8. Egorov AYu. The problem of bacterial complications post respiratory viral infections. *Microbiology Independent Research Journal (MIR Journal)*. 2018; 5(1): 1-11. (In Russ.). doi: 10.18527/2500-2236-2018-5-1-1-11

9. Semerikov VV, Zubova ES, Sofronova LV. The effect of selective and mass immunization against pneumococcal infection on the morbidity and mortality due to community-acquired pneumonia in children under 5 years of age. *Pediatric Pharmacology*. 2019; 16(4): 216-228. (In Russ.). doi: 10.15690/pf.v16i4.2051

10. Demko IV, Korchagin EE, Gordeeva NV, Kraposhina AYu, Solov'eva IA. An experience of vaccination against pneumococcal infection of adults at Krasnoyarsk krai. *Pulmonologiya*. 2017; 27(1): 21-28. (In Russ.). doi: 10.18093/0869-0189-2017-27-1-21-28

11. Lawrence H, Pick H, Baskaran V, Daniel P, Rodrigo C, Ashton D, et al. Effectiveness of the 23-valent pneumococcal polysaccharide vaccine against vaccine serotype pneumococcal pneumonia in adults: A case-control test-negative design study. *PLoS Med*. 2020; 17(10): e1003326. doi: 10.1371/journal.pmed.1003326

12. Kravchenko NA, Kazanova VB, Khakimova MI, Gavrilova TA, Zaikova ZA, Botvinkin AD. Dynamics of morbidity and etiological structure of acute respiratory infections on the eve and in the first year of COVID-19 in the Irkutsk region. *Epidemiology and Vaccinal Prevention*. 2022; 21(3): 50-62. (In Russ.). doi: 10.31631/2073-3046-2022-21-3-50-62

13. Desmet S, Lagrou K, Wyndham-Thomas C, Braeye T, Verhaegen J, Maes P, et al. Dynamic changes in paediatric invasive pneumococcal disease after sequential switches of conjugate vaccine in Belgium: A national retrospective observational study. *Lancet Infect Dis*. 2021; 21(1): 127-136. doi: 10.1016/S1473-3099(20)30173-0

14. Kravchenko NA, Yakovenko ON, Svistunov VV, Belinskaya EI, Kogan GYu, Karnoukhova OG, et al. Etiology of lethal pneumonia by results of microbiological and molecular and genetic researches of sectional material. *Infectious diseases: News, Opinions, Training*. 2016; (4): 93-99. (In Russ.).

15. Elkina TN, Pirozhkova NI, Gribanova OA, Gribanova AS. Efficiency of the specific prevention of pneumococcal infection in children attending preschool institutions. *Mother and Baby in Kuzbass*. 2021; 3(86): 63-70. (In Russ.).

16. Fedoseenko MV. Prophylaxis of pneumococcal infection in children has positive effect on all population. *Current Pediatrics*. 2008; 7(6): 66-71. (In Russ.).

17. Briko NI, Mindlina AYa, Galina NP, Korshunov VA, Polibin RV. Adherence to immunoprevention: How to change the situation? *Fundamental and Clinical Medicine*. 2019; 4(4): 8-18. (In Russ.). doi: 10.23946/2500-0764-2019-4-4-8-18

Information about the authors

Tatyana A. Bayanova – Cand. Sc. (Med.), Associate Professor at the Department of Epidemiology, Irkutsk State Medical University, e-mail: bayanova_tanya@mail.ru, https://orcid.org/0000-0003-4289-3460

Ekaterina S. Stukova – Epidemiologist, Center of Hygiene and Epidemiology in the Irkutsk Region, e-mail: katya.stu.med@mail.ru, https://orcid.org/0000-0003-0279-5831

Natalya A. Kravchenko – Teaching Assistant at the Department of Epidemiology, Irkutsk State Medical University, e-mail: tasha_v_gorode@mail.ru, https://orcid.org/0000-0001-9839-6629