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The Increasing Occurrence of Infectious Diseases in Childhood: Is It Linked with Declining Vaccination Rates Across Society?

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Abstract

Introduction. Childhood infectious diseases have been a significant medical problem, with a global increase in recent years. Modern diagnostic methods and new vaccinations are available. Poland is part of the WHO-coordinated global measles and rubella elimination program. Controversy surrounds mandatory and recommended vaccinations in Poland. There has been a concerning increase in the abandonment of vaccinating children, leading to a resurgence of infectious diseases. In 2024, the WHO reported a significant increase in measles cases in the European region, including in Poland. It's crucial to remind people of these diseases and warn them about the complications they bring.

Aim of study. The aim of this study is to investigate the increasing occurrence of infectious diseases in childhood and examine the correlation with declining vaccination rates across society.

Materials and methods. An unsystematic review of scientific literature was conducted, employing specific keywords such as „measles,” „pertussis,” „rubella,” „infectious diseases,” „vaccination,” and „hib.” The review was executed on the PubMed database, analyzing a total of 59 sources published until the conclusion of 2024.

Conclusions. To control and eliminate infectious diseases, it is vital to maintain and improve vaccination rates. Policymakers and healthcare providers should prioritize immunization programs and address barriers to vaccine access. Further research is crucial to develop comprehensive strategies for increasing vaccination coverage and understanding vaccine-preventable diseases in modern public health challenges.

KEY WORDS: measles, pertussis, rubella, vaccination, hib, infectious diseases

INTRODUCTION

Infectious diseases of childhood have been a major medical problem for years. Recently, a global increase in the incidence of infectious diseases has been observed. However, it should be noted that modern diagnostic methods are now available that improve diagnosis, and new vaccinations for many of these diseases are also emerging.

With regard to infectious diseases that do not have an animal reservoir and for which vaccines with a high degree of effectiveness are available, it is possible to achieve the goal of eliminating the disease in a given area (understood as the absence of infections in the country with possible infections from abroad), and then eradication of the disease, i.e. its complete elimination in the world. Currently, Poland participates in the WHO-coordinated global measles and rubella elimination program.

The topic of mandatory and recommended vaccinations in Poland causes much controversy and concern among parents. Due to the increasing abandonment of vaccination of children, scientists warn of the recurrence of infectious diseases that seemed to be under control.

In 2014, more than 10000 people evaded mandatory immunization, while in 2022 the number of evasions increased almost sevenfold. A decrease in the level of immunization status with most mandatory vaccinations has been noted, the largest decrease relates to the MMR measles-mumps-rubella vaccine. According to WHO data, in 2023 the vaccination level is 71%, where as recently as 2019 it exceeded the value of 92%.

In 2024, the WHO reported a more than 30-fold increase in measles cases in the European region. From January to mid-May 2024, 160 measles cases were recorded in Poland, while in the same period in 2023 there were only 12. The measles virus is very effective in finding populations insufficiently resistant to the disease. Its exceptionally high baseline replication rate results in highly dynamic epidemics that regularly occur in countries where population immunity is less than the cutoff value, set at around 95% for most populations. In view of the recurrence of infectious disease epidemics, we would like to remind people of the diseases and warn them of the complications they bring.

INFECTIOUS DISEASES OF CHILDHOOD IN POLAND - EPIDEMIOLOGY

The World Health Organization (WHO) has issued a warning regarding a significant increase in measles cases in the WHO European Region. Between January and October 2023, over 30,000 measles cases were reported, compared to 941 cases in 2022. Experts are concerned that the situation will deteriorate further if necessary preventive measures are not implemented. The increase in measles cases is concerning, with a high number of hospitalizations (20,198 in 2023) and 5 reported deaths in 2 countries. The main reason for the resurgence of measles is the decline in childhood vaccination rates from 2020 to 2022, which was exacerbated by the COVID-19 pandemic. In the WHO European Region, the percentage of children vaccinated with the first dose of measles vaccine dropped to 93% in 2022, and to 91% for the second dose. Vaccination rates vary between countries, but it is estimated that over 1.8 million children in Europe did not receive the recommended measles vaccine doses between 2020 and 2022 [1].

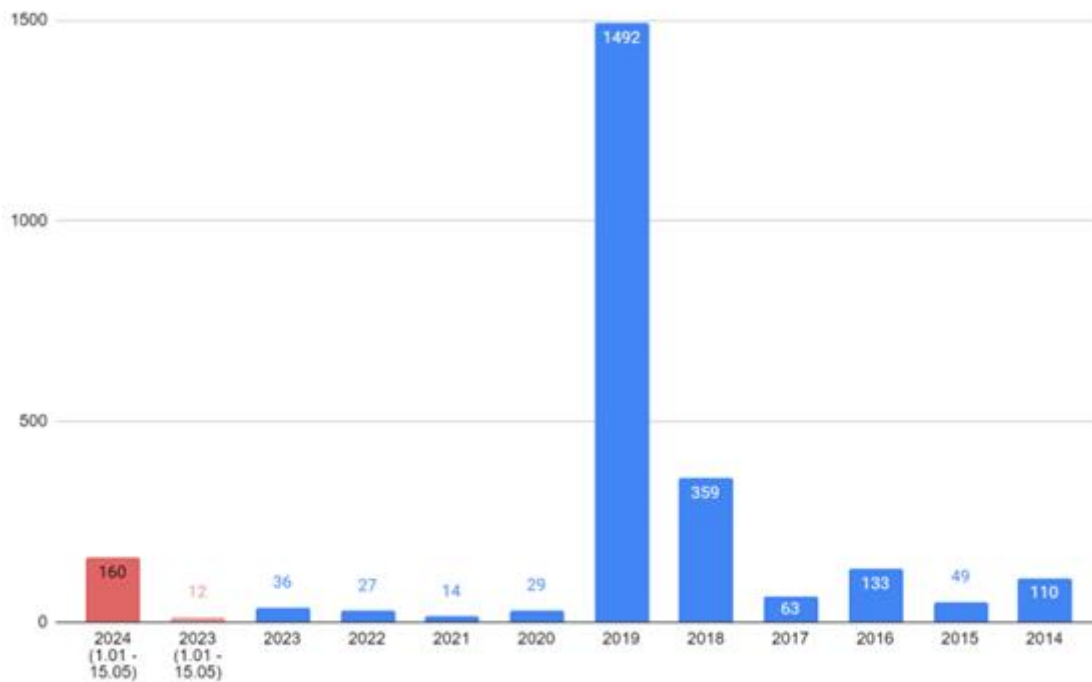


Fig. 1. The Number of Measles Cases in Poland (2014 - 2024) [3]

In 2022, 72736 people 9.9/1000 people aged 0-19 years evaded mandatory vaccinations in Poland. The increase in childhood infectious diseases and the rise in the number of hospitalizations related to the course of the disease is not surprising. In order to guarantee immunity against measles for the public, it is necessary to maintain a vaccination rate of 95% meanwhile, in Poland, the percentage of children vaccinated with a basic dose of MMR fell below this limit already in 2017 [2].

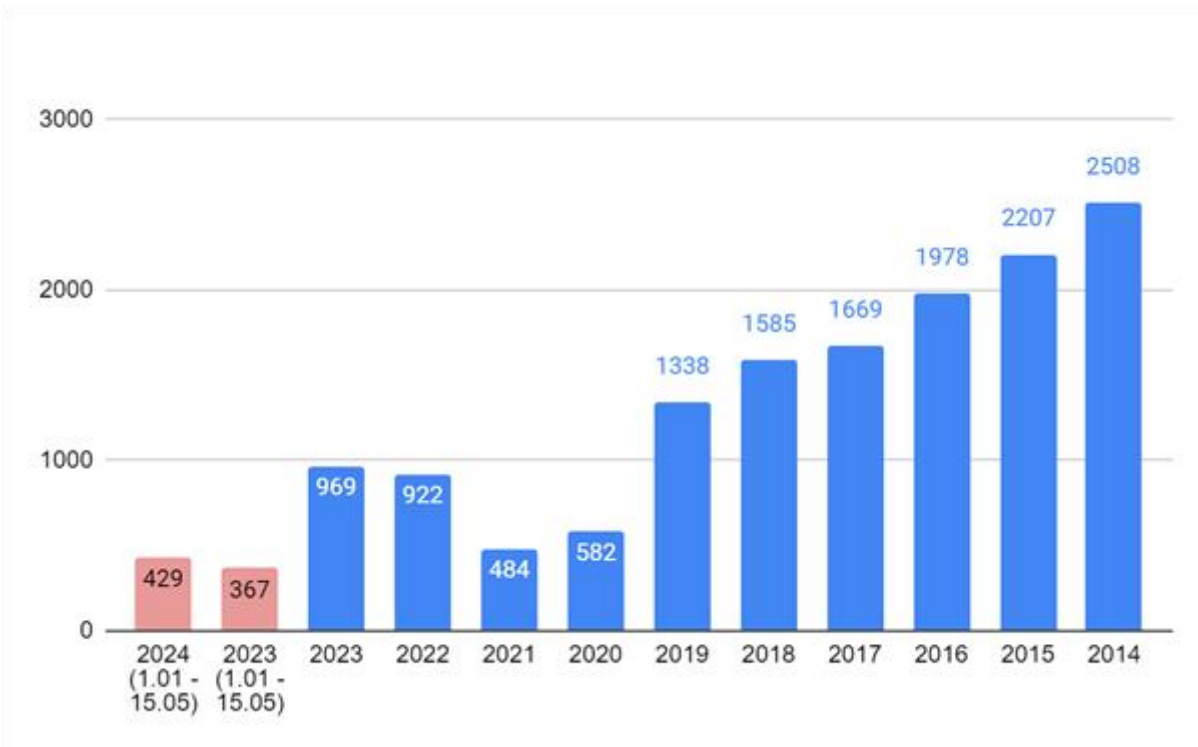


Fig. 2. The Number of Mumps Cases in Poland (2014 - 2024) [3]

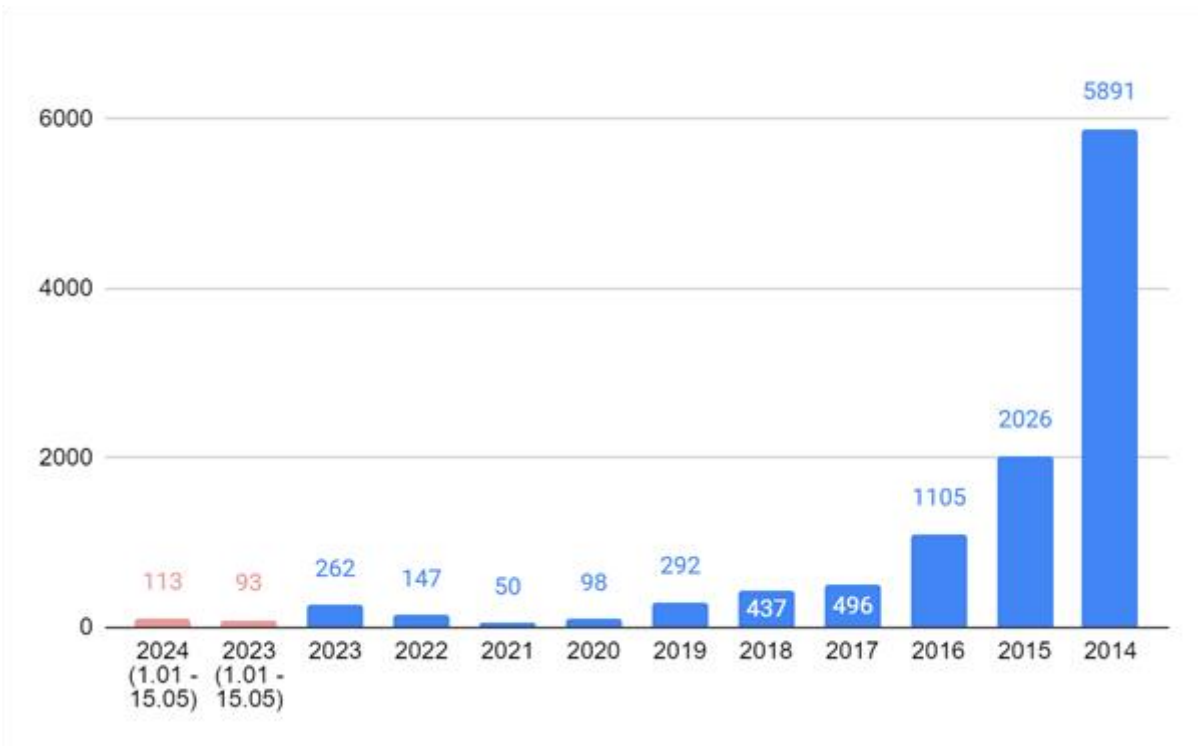


Fig. 3. The Number of Rubella Cases in Poland (2014 - 2024) [3]

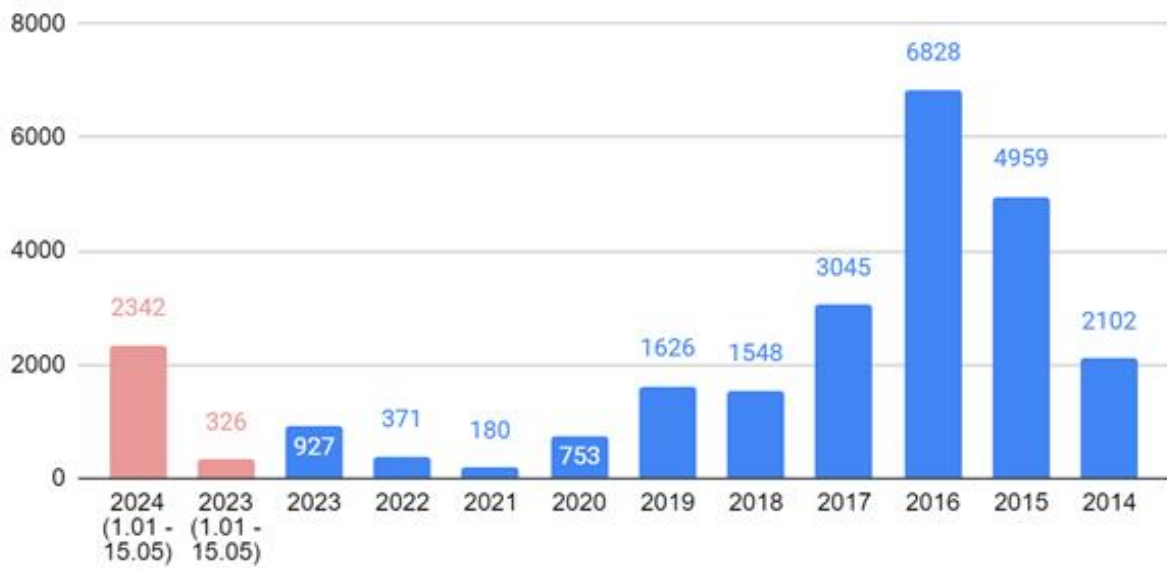


Fig. 4. The Number of Pertussis Cases in Poland (2014 - 2024) [3]

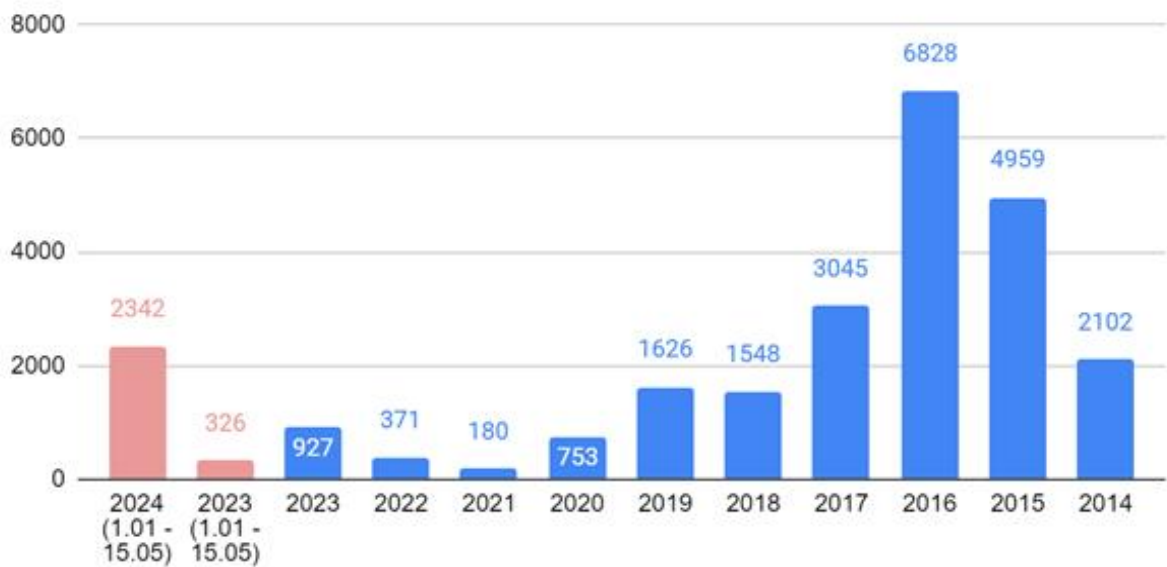


Fig. 5. The Number of cases of invasive disease caused by *Haemophilus influenzae* in Poland (2014 - 2024) [3]

Immunizations are essential medical procedures that significantly impact the health of children and protect them against infectious diseases. They are a fundamental component of the government's comprehensive health policy. Our Preventive Vaccination Program (PSO) mandates immunization for children, adolescents, and individuals at high risk of infection. This vaccination is carried out through a centralized system. On the other hand, recommended vaccinations, which are not funded by the state, are administered through a decentralized system. Primary care physicians are responsible for informing individuals about both mandatory and recommended vaccinations. Efficient implementation of mass vaccinations helps develop population immunity, leading to a decrease in disease incidence. The introduction of universal mandatory vaccination and its consistent enforcement by sanitary-epidemiological surveillance have led to a reduction in the incidence of various infectious diseases, such as diphtheria, tetanus, hepatitis B, and poliomyelitis. One of the collective successes of national vaccination programs coordinated by the World Health Organization (WHO) was the global eradication of smallpox in 1979.

As more people in the population get vaccinated, the risk of an unvaccinated person catching the disease decreases. Community immunity typically occurs when more than 80% of the population is vaccinated, depending on the specific disease. This concept applies to diseases that are widespread and transmitted from person to person. For diseases like measles and pertussis, community immunity is achieved when 92-95% of the population is immunized. At this point, the number of newly infected individuals starts to decrease [4].

MEASLES

Measles is an infectious disease caused by a virus from the Morbillivirus family of the Paramyxoviridae. The disease is highly contagious and can cause systemic complications that are very dangerous to health and life. The disease is transmitted by droplets and enters the human body through the mucous membranes [5]. The incubation or incubation period of the virus lasts up to 12 days (10 days on average). The patient infects people with whom he has been in contact for the first 3-4 days after the first symptoms appear. [6] The presence of prodromal symptoms characterizes measles. They most often appear at the beginning of the infection and include a very high fever of approximately 39 degrees Celsius, cough, runny nose, and conjunctivitis, characterized by photophobia [7]. This period of the disease is called catarrhal. Koplik spots are very characteristic of measles and are white spots appearing on the mucous membrane of the mouth, mainly the cheeks. When the Koplik spots disappear, a rash

appears. In practice, the first day the rash appears is also the day of peak fever. The multiform rash is the most characteristic feature of measles and initially appears on the head and neck, but does not involve the scalp. Over the next few days, the rash appears on the trunk, with more erythematous spots that merge. The rash peels off and disappears within a maximum of 14 days from its appearance [8]. Measles is a viral disease and its symptoms are treated with antipyretic drugs. People who have had measles acquire permanent immunity.

Before the introduction of the vaccination plan, measles was a very common disease occurring everywhere in the world. Each year it caused approximately 130 million infections, and 6 million resulted in death [9]. The measles virus attacks many human organs at the same time. At the cellular level, it mainly affects white blood cells and epithelial cells. The most characteristic multinucleated giant cells were found in the respiratory and digestive systems during histopathological examinations in children dying from infection [10]. Complications of measles are observed in many organs, but their severity and occurrence depend on the severity of the disease and the age of the patient. The most common complications concern the respiratory system, the most common of which are otitis media and pneumonia. Laryngitis, or measles croup, is often observed in hospitalized children, as is pneumonia. These complications are often caused by bacterial superinfections, most often *Staphylococcus aureus*, but also *Staphylococcus pneumoniae* and *Haemophilus influenzae*. Pneumonia may be caused by the measles virus itself, it is the so-called giant cell viral pneumonia [10,11]. The most common complications related to the digestive system include diarrhea, which leads to dehydration, which is particularly dangerous in children. Febrile seizures associated with elevated temperature are a mild complication and occur in approximately 2% of patients hospitalized in the United States and England [12]. Up to 10 days after the onset of the rash, approximately 1% of pediatric patients develop post-infectious encephalomyelitis (PIE). It is characterized by high fever with convulsions and neurological changes, mainly paresis and motor impairment. SPPE, i.e. subacute sclerosing panencephalitis, is caused by the presence of the virus in the brain tissue for many years, during which time there is a slow infection and demyelination of the nervous tissue. This complication is not common, but it is very dangerous, usually ends in death, and is often misdiagnosed as a mental disorder [13]. Vaccinations are intended to reduce the number of infections and thus reduce mortality due to disease complications. The measles vaccine uses weakened viruses, also called an attenuated vaccine. The first vaccinations were performed in 1950-1960, but the strain used in that vaccine (the prototype strain Endomoston) caused atypical infections with the wild

measles virus. Currently, combined vaccines against measles, mumps and rubella (MMR) are used [14]. During the 10 years from 2000 to 2010, vaccinations reduced the number of deaths by approximately 400,000 [15]. In 2010, a special commission appointed by WHO stated that complete elimination of measles is possible through routine vaccinations [16]. In the world, in 2012, WHO introduced a global vaccination plan, which turned out to be very effective and significantly reduced the number of infected patients. When establishing the plan for 2012-2020, the commission appointed by WHO decided that the priority would be the complete elimination of measles and rubella in at least 5 WHO regions. by 2020. Despite all these plans, measles is still common in Africa, and in 2022 most cases were reported by Nigeria (19,033 infected people) [17]. In Poland, spectacular effects of measles vaccination were recorded, as in the years 1974-2002 the disease decreased by as much as 99% [18]. Currently, due to the COVID-19 pandemic and wars in Ukraine, and in connection with the mass migration of people, there is an increase in the number of cases, and only from January to June 2022, 16 cases of measles were recorded. The situation is so serious that WHO has prepared a special document on the rapid identification of measles outbreaks [19]. Due to increasing population density, geopolitical changes, war, and the COVID-19 pandemic, the complete elimination of measles is a problem and a challenge. The situation is dynamic, and measles patients appear in countries where the disease has not existed for a long time or where the number of patients was very small. We should not forget about the important role of vaccinations and every effort should be made to conduct educational campaigns on measles prevention [20].

RUBELLA

Rubella is an infectious disease caused by Rubivirus (RUBV), which is transmitted through droplets or blood through the placenta. The name of the disease comes from the word rubella, a Latin word meaning something slightly red [21]. Another name for rubella is German or three-day measles, because German doctors were the first to notice and describe the disease. Rubella is usually asymptomatic or has few symptoms, so it is difficult to know the real number of infected people. The symptoms that occur are mild and include fever, enlarged lymph nodes - usually in the neck and behind the ears, and a maculopapular rash. Cough, runny nose, muscle pain or mild conjunctivitis (without photophobia) occur up to a week before the rash appears. The rash is descending, first appearing on the head and then on the trunk and lower limbs. It disappears spontaneously after 2-3 days, and in children it may be the first and last symptom of the disease [22]. An increase in the number of rubella cases in

Europe usually occurs every 6-8 years, and in South American countries every 3-8 years. The last rubella epidemic in Poland was in 2013 and 38.5 thousand people fell ill. There is currently a downward trend in Poland, but the disease rates are still among the highest in Europe. [23].

Rubella most often affects preschool and school-age children, but the disease also occurs in adults. Complications are rare in cases of acquired rubella. Rubella is most dangerous in women who are planning or are pregnant because the virus can cross the placenta. In the worst case, if the infection occurs in the first weeks of pregnancy - up to the 12th week - it ends in miscarriage. Congenital rubella syndrome may also occur in children who survived pregnancy despite infection during fetal age. This pregnancy complication is very rare in countries where vaccinations are common, but it still occurs [24]. Congenital rubella syndrome is a severe, fatal disease that leads to the degradation of nerve cells. Symptoms include sensorineural hearing loss, cataracts, meningitis, pneumonia, heart defects (patent ductus arteriosus or ventricular septal defect) or impaired functioning of this organ, hepatosplenomegaly, and jaundice. Characteristic blueberry-muffin lesions may appear on the skin of a sick child as a result of cutaneous erythrocytosis. The lesions are flat, non-shiny, purple lesions with a hard consistency [25]. Diagnosis of congenital rubella syndrome is based on examination of cerebrospinal fluid. However, the most frequently used are immunological diagnostic tests that detect IgM antibodies against RUBV [26].

There is an effective way to prevent rubella virus infection, which greatly minimizes the risk of acquired and congenital rubella, and this is protective vaccination. Currently, a trivalent vaccine is used, i.e. containing weakened measles, mumps and rubella viruses [27]. Unfortunately, despite great efforts, these diseases occur among the population, and the reason for this is the insufficient number of people vaccinated. The main goal of the rubella vaccination policy was to minimize the risk of contracting or giving birth to a child with congenital rubella syndrome. Currently, the number of reported cases has dropped dramatically, so it can be said that the goal is slowly being achieved [28]. There are still many areas where MMR vaccination is not as popular. In countries mainly on the African continent, every effort should be made to expand activities related to stopping the spread of these viruses. Infectious diseases, especially those transmitted by droplets, pose many challenges to today's medicine, and problems related to vaccinations should be solved individually - actions should depend on the geographical region and social factors. The most important thing is to focus on education on the prevention of acquired and congenital measles, mumps and rubella and to

present the benefits of vaccination. Implementing a vaccination schedule so that every child can be vaccinated will also significantly contribute to the elimination of infections [29].

PERTUSSIS

Pertussis is an infectious bacterial disease that manifests as chronic bronchitis with severe coughing fits. It is caused by the gram-negative aerobic bacillus *Bordetella pertussis*, which can produce pertussis toxin. Infection can occur through droplet transmission or direct contact with an infected person. The existence of the pertussis vaccine has significantly reduced the number of severe cases of the disease [30]. *B. pertussis* possesses virulence factors as a result of nature.

Bordetella pertussis utilizes various virulence factors with immunomodulatory properties, including adhesins and toxins, which play vital roles in interactions between the host and the pathogen. Key virulence factors such as FHA, PTX, Prn, and fimbriae are present in current acellular vaccines. FHA is a major adhesin that helps the bacteria adhere to respiratory ciliated cells, while fimbriae assist in bacterial attachment to host cells [31, 32, 33]. PTX is an AB₅-type toxin that disrupts cellular signaling, and ACT, another toxin, modifies target cell function by increasing cAMP levels and forming pores in cell membranes [34, 35, 36]. Additionally, *B. pertussis* produces TCT, which causes inflammation and cell destruction in the respiratory tract, and the BvgAS-regulated T3SS, which contains effectors like BteA that can lead to necrosis and inhibit phagocytosis [37, 38, 39, 40].

The disease has an incubation period ranging from 7 to 21 days, although some sources indicate a shorter period of 7-10 days [44]. Pertussis typically advances through three clinical stages. The initial stage, known as the catarrhal phase, is when infectivity is at its peak. Symptoms may include sneezing, a runny nose, fever, and dry cough, which are non-specific and can be mistaken for other infections [41]. The second phase, the paroxysmal stage, is characterized by intense coughing fits lasting several minutes, accompanied by drooling and tearing. The severe coughing is likely due to difficulty in clearing thick mucus from the airways. Coughing fits can induce laughter or crying and often disrupt sleep, occurring predominantly at night. Patients may experience exhaustion, and vomiting may occur after the attacks. After approximately three weeks into this phase, symptoms gradually subside [41]. The third phase can last up to three weeks, during which symptoms diminish. For some patients, this phase may be prolonged [42, 43].

Complications of the disease can vary. Some include severe pneumonia and subconjunctival hemorrhage [45]. Coughing fits several times a day may lead to neurological complications such as seizures and encephalopathy, associated with disturbance in central nervous system oxygenation [46]. In the literature, a case of an adult with pertussis complication in the form of multiple rib and vertebral fractures due to paroxysmal coughing has been described [47]. Other respiratory system complications include pneumothorax, pulmonary hypertension, and mediastinal emphysema, among others [48].

There are two types of vaccines against pertussis: the whole-cell pertussis (wP) vaccine and the acellular pertussis (aP) vaccine [49]. Vaccination schedules may vary depending on the country. In some countries, the aP vaccine has completely replaced the wP vaccine due to its lower likelihood of causing reactions. The wP vaccine contains lipopolysaccharide (LPS), a component of the bacterial outer membrane, which can cause uncomfortable local reactions after vaccination. In contrast, aP vaccines do not contain LPS and are therefore less likely to cause reactions. It's important to note that having pertussis does not provide complete immunity against reinfection. Additionally, vaccination with the wP vaccine provides greater protection against pertussis compared to the aP vaccine [50].

HIB

Immunization against infections caused by the bacterium *Haemophilus Influenzae* serotype B (Hib) is among the mandatory vaccinations in Poland [51]. This bacterium is a pathogen responsible for respiratory infections, colonizing the upper respiratory tract, causing pneumonia, sinusitis, otitis media, epiglottitis. It can also lead to other types of infections, osteitis, pericarditis, cellulitis and sepsis. It is also a common cause of meningitis worldwide [52].

In their paper, Efron A., Daniel Napoli et. al. confirmed that abroad, before the introduction of routine Hib vaccination, serotype B was responsible for nearly 4 out of 5 cases of invasive infections in children under 5 years of age and the occurrence of bacterial meningitis in this age group [53]. In Poland, on the other hand, despite the introduction of mandatory vaccination, the incidence of diseases caused by Hib is increasing every year. Based on data made available by the National Institute of Public Health – State Institute of Hygiene (PZH) the number of new cases in 2023 was 280. In 2022, the number was lower - 149. A year earlier in 2021, the number of cases was 3 times lower, namely 52 cases. From the most recent PZH data for 2024 in the period from January 1, 2024 to May 15, 2024, there

were 155 cases of Haemophilus Influenzae disease. In the analogous period in 2023, there were 133 cases. Thus, there was an increase in the number of infections by about 17% in the time period studied. Similarly, an upward trend is seen in the number of hospitalizations related to invasive forms of infection such as bacterial meningitis from year to year [54].

This is extremely worrisome, as the most serious diseases caused by Haemophilus Influenzae lead to serious complications such as meningitis. It has been proven that prior to the introduction of Hib vaccination, the Haemophilus Influenzae bacterium was most often responsible for meningitis in the United States, the Netherlands, Iceland and Sweden [55]. Exposure mainly affects older infants, children and adults. Children initially present with respiratory symptoms or otitis media, before meningeal involvement. The clinical picture of meningitis is age-dependent and is usually heterogeneous. Most often there is headache, nausea, vomiting, high fever - symptoms of increased intracranial pressure. In addition, in children in their first year of life, meningitis may also manifest as irritability, photophobia, loss of appetite, hypothermia, dyspnea, or diarrhea [56].

During the course of the disease, non-specific complications of bacterial meningitis can occur, such as subdural effusion, which occurs with a frequency of 20-39% in children with bacterial meningitis and is most common in children <1 year of age [57]. Focal neurological deficits are also mentioned, leading to hemiparesis, limb weakness, speech impairment and visual field deficits, which can withdraw in a few weeks to a few months. Long-term complications include hearing loss, which is the most described neurological sequelae of bacterial meningitis [58]. One in ten children with bacterial meningitis develops unilateral or bilateral sensorineural hearing loss. In contrast, this number rises to about 20% when the infection is caused by H. Influenzae. Unfortunately, children with hearing loss are at risk of speech delay, the development of balance disorders and long-term behavioral problems. Further down the line, there is an increased risk of developing depression, anxiety and a reduced overall quality of life [59]. Other severe and long-term complications of the infection include the occurrence of seizures, epileptic attacks and hydrocephalus [58].

The effects of the disease can be severe and affect the development of children and adults over the long term. Therefore, it is important to consistently monitor the incidence of Hib meningitis to reduce the burden of disease. It also allows for the development of strategies to manage the infection. However, it is extremely important to prevent the development of infection, through vaccination for H. Influenzae serotype B. It has been proven that the introduction of the Hib vaccine nearly three decades ago has led to a dramatic

decrease in the incidence of bacterial meningitis in the neonatal period in countries that have included the vaccine in their mandatory immunization program.

CONCLUSIONS

The literature review underscores the concerning resurgence of childhood infectious diseases in Poland, which is closely linked to a significant decline in vaccination rates. Despite advancements in diagnostic methods and the availability of effective vaccines, there is a growing incidence of diseases such as measles, rubella, pertussis, and *Haemophilus influenzae* infections. The review highlights the critical importance of high vaccination coverage for disease elimination, exemplified by the successful eradication of smallpox and ongoing efforts to eliminate measles and rubella under WHO programs. However, vaccine hesitancy, declining immunization rates, and the impact of the COVID-19 pandemic and geopolitical issues have all contributed to a resurgence of these preventable diseases.

The resurgence of measles is a major concern, as Poland has seen a 30-fold increase in cases from 2023 to 2024. This rise is due to declining vaccination rates, which have fallen below the critical threshold required for herd immunity. As a result, there have been more hospitalizations and deaths, highlighting the severe complications associated with measles, such as pneumonia, encephalitis, and subacute sclerosing panencephalitis.

Rubella, while typically mild, poses significant risks to pregnant women and can result in congenital rubella syndrome (CRS), leading to substantial birth defects. Despite the effectiveness of the MMR vaccine, rubella remains a threat due to insufficient vaccination coverage, especially in regions with limited access to healthcare.

Pertussis, also known as whooping cough, is caused by the bacterium *Bordetella pertussis*. This infectious disease poses a significant challenge, as it has made a resurgence despite the availability of whole-cell and acellular vaccines. This resurgence underscores the critical need for sustained and widespread immunization efforts. Pertussis can lead to severe complications such as pneumonia, neurological damage, and, tragically, can even result in death in some cases.

Despite the implementation of mandatory vaccination programs, there has been a concerning increase in the incidence of *Haemophilus influenzae* type B (Hib) infections in recent years. These infections can lead to serious conditions such as meningitis, and the rise in cases emphasizes the urgent need for continuous vigilance in immunization efforts. Furthermore, it underscores the importance of robust monitoring to detect and prevent long-

term complications such as hearing loss and neurological damage that can result from these infections.

The review underscores the critical role of immunizations as essential medical interventions that play a significant part in reducing the incidence of various diseases and providing protection against severe complications. It emphasizes the necessity of achieving high vaccination coverage rates to effectively safeguard public health, particularly in curbing the spread of highly contagious diseases within communities. Furthermore, the review advocates for the implementation of comprehensive public education campaigns that highlight the myriad benefits of vaccinations while also addressing the potential risks associated with vaccine-preventable diseases. The aim is to combat the proliferation of misinformation and alleviate vaccine hesitancy through accurate and accessible information.

In conclusion, it is absolutely vital to both sustain and enhance vaccination rates in order to control and eventually eradicate infectious diseases. Policymakers, in partnership with healthcare providers, must place high importance on immunization programs and actively confront barriers to vaccine access, all in the interest of safeguarding public health. Moreover, it is imperative to conduct further research aimed at developing comprehensive strategies to boost vaccination coverage and gain deeper insights into the dynamics of vaccine-preventable diseases within the complex landscape of modern public health challenges.

DISCLOSURE

Author's contribution

Izabela Sztybór: conceptualization, writing rough preparation

Klaudia Brygida Kułak: writing rough preparation

Karolina Alicja Palacz: supervision, resources

Marzena Pliszka: visualization, data curation

Izabela Janik: methodology

Katarzyna Gadźala: check

Katarzyna Chamera-Cyrek: investigation,

Anna Maria Koman: writing and editing

Martyna Kuśmierska: formal analysis

Sabina Przygodzka: software

Project administration: Karolina Alicja Palacz

All authors have read and agreed with the published version of the manuscript.

Conflict of interest

The authors deny any conflict of interest

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Not applicable

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