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CURRENT EPIDEMIOLOGICAL SITUATION OF PERTUSSIS

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Abstract. Despite high vaccination coverage, pertussis remains a significant problem for both international and national healthcare systems. The increasing incidence of pertussis across different age groups encourages researchers to search for new strategies to combat this infection and to improve laboratory diagnostic methods for pertussis.

Keywords: pertussis, Bordetella pertussis, epidemiological situation of pertussis, vaccination.

Despite the high level of vaccination coverage, whooping cough remains an important cause of lethality among children. Whooping cough is an acute respiratory infectious disease, the causative agent of which is Bordetella pertussis, and the most characteristic sign of which is a paroxysmal cough. Despite the availability of effective vaccines, whooping cough continues to be an important cause of morbidity and mortality among children, as well as a serious problem for the healthcare system worldwide [1]. According to the World Health Organization (WHO), approximately 60 million cases of pertussis are reported globally each year, with nearly 1 million deaths occurring predominantly among children under one year of age [2]. In 2023, the number of reported pertussis cases in the European Region exceeded 87,000, representing the highest incidence recorded in the past 29 years (WHO and UNICEF report No vaccines, no healthy future, statement by Hans Kluge, May 4, 2025). In Russia in 2014, 4,705 cases of whooping cough were registered, which constitutes 3.23 cases per 100 thousand population. The highest incidence rates were noted among children under the age of 1 year—54.2 per 100 thousand children. Deaths from whooping cough persist (0.007 per 100 thousand population). In the structure of those who fell ill, school-age children from 7 to 14 years old predominate (37.9%), children up to 1 year old make up 25%, children aged 3–6 years make up 18.2%, and children aged 1–2 years make up 15.3%. At the same time, the majority of the sick (65%) were vaccinated[3]. Official surveillance data are likely to underestimate the true burden of pertussis, as only 10–12% of cases are believed to be accurately diagnosed.

Several factors may contribute to the observed increase in pertussis incidence, including the implementation of more sensitive diagnostic methods such as polymerase chain reaction (PCR), antigenic variation of *B. pertussis*, waning post-vaccination immunity, suboptimal effectiveness of current vaccines, and declining vaccination coverage in certain populations [4–6].

Although traditionally considered a childhood infection, pertussis has increasingly affected adolescents and adults in recent years, often presenting with atypical or mild clinical manifestations. These age groups serve as the primary reservoir of infection within households, transmitting pertussis to unvaccinated infants, in whom the disease is particularly severe and potentially life-threatening. Transmission occurs via airborne droplets during close contact with infected individuals or asymptomatic carriers. Vaccinated individuals may also act as carriers and contribute to disease transmission.

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Pertussis exhibits marked seasonality, with peak incidence observed during the autumn and winter months. The contagiosity index ranges from 0.7 to 1.0. Typical clinical manifestations are more frequently observed in unvaccinated individuals.

Despite ongoing immunization efforts, pertussis continues to pose a serious threat to child health worldwide. Recent epidemiological trends indicate a resurgence of the disease in many countries, with a substantial proportion of cases occurring among vaccinated individuals. This suggests that vaccination, while effective in reducing disease severity and transmission, does not confer absolute protection. Possible explanations include waning immunity over time, the emergence of new bacterial strains, and individual variability in immune responses. Infants under six months of age remain the most vulnerable population and experience the most severe disease courses. These observations highlight the need for continued research and the development of more effective preventive strategies, including improved vaccines and optimized immunization schedules.

Etiology and Pathogenesis

Pertussis is caused by the small (0.8 × 0.4 μm), non-motile, Gram-negative bacterium Bordetella pertussis, an obligate aerobe requiring oxygen for survival. The optimal growth temperature ranges from 35 to 36°C. The pathogen is relatively unstable in the external environment and is easily inactivated by environmental factors. Less commonly, Bordetella parapertussis is identified as the causative agent of parapertussis, a clinically similar but milder infection that is therefore underreported in epidemiological statistics. B. pertussis is a strictly human pathogen, classifying pertussis as an obligate anthroponotic infection. A central role in disease pathogenesis is played by pertussis toxin, which disrupts central respiratory regulation by affecting the respiratory center. This results in altered respiratory rhythm and reduced sensitivity of medullary chemoreceptors to carbon dioxide. A dominant excitatory focus develops in the central nervous system, activating the cough reflex and leading to the characteristic spasmodic coughing episodes. In addition to hypoxemia caused by reduced oxygen saturation, impaired cellular oxygen utilization results in inhibition of cytochrome oxidase and the development of cytotoxic hypoxia. Hypoxia induces secondary changes in the cardiovascular system. Pertussis toxin also affects vascular centers by suppressing β-adrenergic receptors in vascular walls, leading to hemodynamic disturbances. These changes may result in necrobiotic alterations of neuronal cells followed by glial reactions. Pertussis-associated encephalopathy is primarily attributable to cerebral circulatory disturbances and intracellular metabolic dysfunction. Immunopathological changes in pertussis involve suppression of both T-cell-mediated immunity and phagocytic activity. Molecular genetic studies indicate substantial variability of B. pertussis, particularly in the context of prolonged mass immunization. Alterations have been identified in 16 genes encoding surface proteins. Ongoing microbiological and molecular surveillance demonstrates that more than 80% of currently circulating strains exhibit increased virulence, contributing to more severe clinical courses.

Epidemiology

Pertussis demonstrates cyclical recurrence at intervals of 2–3 years. In Uzbekistan, the most recent increase in incidence was observed during 2022–2023. The disease shows pronounced seasonality, with higher incidence during autumn and winter and lower rates in spring. Despite expanded vaccination coverage among children under five years of age in recent years, conditions facilitating pertussis transmission persist [7]. Main epidemiological patterns

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remain the same: infections are registered in childcare facilities, and high incidence rates are observed in children under 1 year and schoolchildren.

Infection occurs through contact with an infected child or adult. Talking, sneezing, and especially coughing release tiny droplets of mucus containing millions of pathogenic microbes into the air. These microbes are not very viable and cannot travel long distances, so infection is most likely through close contact (1-2 meters) in enclosed spaces or on public transport. In unvaccinated individuals, the contagiousness index reaches 75%, with similar susceptibility recorded in unvaccinated children under 1 year of age and in adults with weakened immune systems. Newborns are highly susceptible because the antibodies transferred from their mothers do not protect them from infection. Whooping cough bacteria settle on the mucous membranes of the respiratory tract [8,9]. The incubation period ranges from 7 to 21 days, and after 6 weeks from the onset of the disease, the risk of transmission disappears, eliminating the need for final disinfection in hospitals and at home. Official statistics indicate that the incidence of whooping cough among children is low, but this may not be accurate. Lack of timely diagnosis creates a risk of whooping cough in adolescents and adults, which can lead to transmission to young children.

Clinical Manifestations

At the start of the disease, whooping cough does not manifest specific differences from an ordinary respiratory infection. The main sign of the disease is damage to the respiratory organs. A child may have a fever, and a dry cough appears from the first days. As the disease develops, the cough intensifies and becomes the main symptom, while general well-being gradually improves. Coughing paroxysms increase gradually, reaching a peak in the second week of the spasmodic period, which usually lasts 4–6 weeks. In this period, so-called spasmodic, or convulsive, coughing is characteristic, appearing at the 2nd–3rd week of the illness. A paroxysm begins with a series of short cough strokes interrupted by a whistling breath. Cough strokes follow one after another for several minutes. The child's face becomes purple-red and bloated, and the eyelids swell. Usually, the paroxysm ends with vomiting, during which thick viscous mucus is released. Paroxysmal whooping cough coughing intensifies at night. Due to the strong tension during coughing, hemorrhages into the sclera of the eye and the development of pneumonia may occur. Nevertheless, between paroxysms, the child usually feels satisfactory, plays calmly, appetite is preserved, and temperature is normal. In the resolution period, which lasts 2–3 weeks, the cough loses its characteristic tone, becomes rarer and less intense. On average, the disease lasts 1.5–2 months. In "pneumopertussis," the so-called "whooping cough lung," physical signs are characterized by symptoms of lung tissue inflation. Breathing can be either normal or harsh. For pneumopertussis, radiological signs are characteristic: pulmonary emphysema and intensification of the pulmonary pattern in the medial sections of the lung fields, manifestation of infiltrates in the cardio-hepatic angle or in the lower-medial sections on both sides, which in some cases is interpreted by radiologists as pneumonia. The described changes can manifest in any form of whooping cough. They arise already in the prodromal period, intensify in the spasmodic period, and persist for a long time, often for many weeks.

Criteria for the severity of the disease are: 1) frequency of cough paroxysms; 2) presence of facial cyanosis during coughing; 3) appearance of facial cyanosis during coughing in the early stages of the disease; 4) signs of hypoxia outside cough paroxysms; 5) disturbances of the respiratory and cardiovascular systems; 6) damage to the nervous system, in particular hypoxic encephalopathy.

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The more severe the disease, the longer the paroxysms of spasmodic coughing last and the more often they appear. The patient may begin to cough from any irritant—a loud sound, bright light, or anxiety.In the mild form, the number of paroxysms is up to 10–15 per day, and the number of reprises is 3–5. The general condition does not deteriorate, and vomiting occurs rarely. In moderate severity, the number of paroxysms reaches 15–25, and the number of reprises is up to 10. In the severe form, paroxysms can be over 25–50 per day, and the number of reprises exceeds 10. Cough paroxysms are accompanied by general cyanosis and breathing disturbances up to apnea.

Analysis of factors contributing to the development of severe and complicated forms of whooping cough indicates the important role of co-infections, among which influenza, respiratory syncytial infection, respiratory mycoplasmosis, and cytomegalovirus infection are of greatest importance (Popova O.P., Gorelov A.V., 2017).

In newborns in the first months of life, reprises can be accompanied by breathing stops (apnea).

Two types of apnea are registered in whooping cough: spasmodic and syncopal. Spasmodic apnea occurs at the moment of a cough paroxysm and lasts from 30 seconds to a minute. Syncopal apnea is not related to a cough paroxysm. The child becomes lethargic with reduced muscle tone. First, paleness appears, then cyanosis of the skin develops. A breathing stop occurs while heart function is maintained. Such apneas last 1–2 minutes and represent a direct threat to life.

For this reason, there is a recommendation to hospitalize children in the first three months of life from the very beginning of the disease. Apnea occurs more often and can have a longer character in premature infants, as well as in infants with perinatal damage to the central nervous system or mixed infections, especially when combined with cytomegalovirus infection. Adolescents and adults tolerate whooping cough as a prolonged cough without a rise in body temperature. Currently, serious breathing rhythm disturbances in whooping cough in children over one year old practically do not occur. Leukocytosis and lymphocytosis are not observed in all cases.

Complications

Whooping cough, despite its apparent harmlessness in most cases, represents a serious threat to a child's health, especially for the very young. Although many children tolerate it relatively easily, significant changes occur underlyingly in the body, affecting the respiratory and nervous systems and other internal organs. It might seem like "just a cough," but long, exhausting paroxysms of whooping cough lead to the development of hypoxia—oxygen starvation.

This is a critical state, as the lack of oxygen affects absolutely all tissues and organs, disrupting their normal functioning. The heart is forced to work with double strength to compensate for the oxygen deficit, which in turn can lead to additional problems. The brain, especially in infants, is extremely sensitive to hypoxia, which can lead to irreversible consequences. Complications of whooping cough can be very serious and even life-threatening. Among them are atelectases, which disrupt gas exchange and lead to even more pronounced hypoxia. Seizures, resulting from oxygen starvation of the brain, represent a significant danger, especially in children with an immature nervous system. Meningism (inflammation of the meninges) is another formidable complication capable of leading to meningitis. Pneumothorax disrupts lung function, causing acute respiratory failure. Subcutaneous and mediastinal emphysema indicate serious damage to the respiratory system. Nosebleeds, skin and conjunctival hemorrhages are signs of increased vessel fragility caused by hypoxia and blood clotting disorders. Additionally, whooping cough

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can provoke the development of umbilical or inguinal hernias due to increased intra-abdominal pressure during cough paroxysms. Often, whooping cough is complicated by the attachment of a secondary bacterial infection, most often pneumonia. It is important to understand that the whooping cough bacillus itself is not the direct cause of pneumonia, but it creates favorable conditions for the development of other bacteria by weakening the body's defenses. One of the key causes of pneumonia development is a concomitant mycoplasma infection. If whooping cough proceeds as a mono-infection, the risk of pneumonia development is significantly reduced—less than 1% of cases in children. However, even in the absence of obvious pneumonia, lung damage can be significant, and this is important to consider when assessing the severity of the condition.

Pathological studies have repeatedly shown that complications play a decisive role in deaths from whooping cough. Cytomegalovirus infection and hospital-acquired pneumonia significantly increase the risk of death. In an uncomplicated course of whooping cough, the main cause of death is brain edema, developing due to hypoxia. In newborns and children in the first months of life, in whom brain structures are still immature, death can occur due to a disruption of central breathing regulation under the influence of whooping cough pathogen toxins. Their immature nervous system turns out to be particularly vulnerable to toxic impact. Thus, even with a mild course of whooping cough, hidden pathological processes can lead to serious consequences.

Early and correct diagnosis of whooping cough is extremely important for preventing complications and starting treatment on time. The diagnosis is based on the clinical manifestations of the disease and an assessment of the epidemiological situation. Therefore, it is important to see a doctor at the first signs of whooping cough to conduct necessary research and prescribe adequate treatment, which will prevent the development of serious complications and protect the child's health. One should not rely on self-treatment; timely consultation with a specialist is the key to a favorable outcome of the disease. It is doubtful that such information is available to a doctor on duty or a doctor working in the emergency service. Unfortunately, identifying the source of infection is not always possible. The importance of clinical diagnosis remains at the forefront. It must be remembered that the cough in whooping cough can persist for a long time even after recovery (sometimes up to six months) and can resume with the appearance of any new cold.

Laboratory methods of diagnosis are supplementary. If whooping cough is suspected, a bacteriological analysis is mandatory. Throat swab analysis is a fairly simple process: using a sterile swab, mucus is taken from the back wall of the pharynx and then placed on special nutrient media. The diagnosis is confirmed upon detection of the whooping cough bacillus. Currently, in Uzbekistan, the main methods of whooping cough diagnosis are serological tests based on agglutination reaction time and the presence of antibodies to whooping cough bacillus agglutinogens. Confirmation of the diagnosis is also served by determining a fourfold increase in antibody titers to the pathogen of classes IgM, IgA, and IgG. The first serum should be taken no earlier than three weeks after the onset of the illness, and the second after one to two weeks. A more accurate diagnostic method is PCR, which is applied during the first six weeks after the onset of the disease. This method is especially effective for young children; however, false-negative results are possible in children under two years old.

Treatment of whooping cough patients is generally carried out at home. Hospitalization is required for children in cases where the number of severe cough paroxysms exceeds 20 times per day or in the presence of complications. A sick child must be provided with a calm environment. Noisy games and physical activity should be avoided. Any irritants, including

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loud sounds, can trigger cough paroxysms. It is not recommended to wake the child even if it is time for feeding, as forced awakening can lead to the most serious paroxysms. The main focus in treatment should be on fighting oxygen starvation. In severe cases, oxygen therapy is used, while the share of pure oxygen in the inhaled mixture should not exceed 40%. If a child with whooping cough frequently and for a long time stops breathing, they must be hospitalized in the intensive care unit. As a rule, long-term mechanical ventilation is not required in whooping cough to stop apnea paroxysms. For mild and moderate forms of whooping cough, long walks in the fresh air are useful (at least 2 hours a day). Low temperature is not a contraindication; children tolerate temperatures even below -10°C well, but it is necessary to monitor their condition closely. It is important to regularly ventilate the room and perform wet cleaning. The air in the room should be cool (not higher than 20–22°C) and sufficiently humid. The child should not be overfed. It is better to feed more often but in small portions. A special diet is not required, but vitamin-mineral complexes are useful. Whooping cough cannot be treated with ordinary cold cough remedies. To suppress the cough, drugs affecting the cough center are used, such as Sinecod (from 2 months), Codelac (from 2 years), Butamirate (from 3 years), Terpincode (from 12 years). Phenobarbital is prescribed to protect brain cells from oxygen deficiency. In severe cough paroxysms with breathing stops, facial cyanosis, and neurological disorders, short courses of inhaled glucocorticoids are used. An important component of treatment is aminophylline, which improves lung ventilation by relieving bronchospasm and reducing pressure in the pulmonary veins. It also helps prevent apnea in small children by reducing the sensitivity of the respiratory center to carbon dioxide. Aminophylline is prescribed orally as a mixture combined with potassium iodide. In whooping cough, sputum discharge is often disrupted due to its increased viscosity. Mucolytic agents, such as ambroxol (Ambrobene, Lazolvan) and potassium iodide, are used to thin the sputum. To relieve whooping cough symptoms, a doctor may prescribe sedative drugs that calm the nervous system, reduce the frequency and intensity of cough paroxysms, and also reduce or prevent reprises, breathing stops, and vomiting occurring during paroxysms. For improved breathing, drugs containing ascorbic acid and alpha-tocopherol acetate are recommended. To fight the whooping cough pathogen, antibiotics such as erythromycin and other macrolides (Macropen, Azithromycin), as well as ampicillin and its derivatives (Amoxicillin, Flemoxin), are effective. However, antibiotics are most effective at the beginning of the disease and in the development of complications. In the latter case, cephalosporins like cefotaxime or ceftriaxone are preferred. If mycoplasma pneumonia is suspected, only macrolides are prescribed. Pneumonias that developed as a complication of whooping cough are always treated with antibiotics.

In the recovery period, which can last up to a year or more, reflex cough paroxysms may persist when the child coughs "out of habit". In such cases, a correct daily routine is important.

Specific immunoglobulin against whooping cough of domestic production is absent. Since whooping cough is often combined with ARI, it is advisable to use drugs containing recombinant interferon-alpha, and for older children—cycloferon. In hospital settings during the spasmodic cough period, electrophoresis with chlorpromazine is applied. For bronchitis and bronchiolitis, UHF therapy and inductothermy on the tracheal area are prescribed. In the recovery stage, electrophoresis with calcium and magnesium ions is used. It is important to timely remove mucus from the child's respiratory tract, if necessary using an electric suction or a rubber bulb. In whooping cough, it is not recommended to perform inhalations, use suction cups or compresses, as any warming procedures can be dangerous. First-generation antihistamines and drugs containing atropine or ephedrine should not be used, as they thicken the sputum, make its discharge difficult, and can excite the nervous system.

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Prevention

Vaccination against whooping cough starts at 2 months. The complex adsorbed pertussis-diphtheria-tetanus (DPT) vaccine is administered 3 times at 2, 3, and 4 months with strictly established intervals (minimum 30 days within the primary course), which must be observed. At 16 months, children are revaccinated with the DPT-4 vaccine. If the vaccination schedule is disrupted, it is not critical; the immunization course must be completed. Despite the availability of vaccines, whooping cough remains a problem. Vaccination provides protection: 2/3 of vaccinated children do not fall ill upon contact with whooping cough, and in the rest, the disease proceeds more easily. Various vaccines are available in Uzbekistan, including DPT and its acellular analogs, such as "Infanrix," "Infanrix Hexa," "Pentaxim," "Tetraxim," and "Hexaxim". However, over time, immunity acquired after vaccination weakens, so even vaccinated children can fall ill. To further reduce whooping cough incidence, it is necessary to maintain a high level of vaccination and improve vaccines and immunization schemes. In developed countries, revaccination is carried out at school age. Acellular vaccines, such as "Infanrix," cause complications less frequently than whole-cell vaccines. Having had whooping cough provides lifelong immunity. For prevention, whooping cough patients are isolated for 30 days. Unvaccinated children under 7 years old who have been in contact with a patient are also subject to isolation for 14 days. Infants under one year old, who have not been ill and are not vaccinated, are given immunoglobulin after contact with a patient.

Despite successful vaccination at an early age, whooping cough continues to strike schoolchildren and adolescents. The epidemiological situation for whooping cough in the capital has a significant impact on the overall incidence picture in the country. More than 30% of all whooping cough cases in the country are recorded in the capital, and the incidence level significantly exceeds others. An increase in incidence is observed, especially among children 7–14 years old, which leads to outbreaks in schools. The economic consequences of whooping cough disease among this age group are significant. At the same time, vaccination against whooping cough demonstrates high effectiveness, providing significant protection from the disease for children of different ages.

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