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VACCINATION CRISIS AS AN ENVIRONMENTAL THREAT TO PUBLIC HEALTH. AN ANALYSIS OF THE RESURGENCE OF DIPHTHERIA, PERTUSSIS AND MEASLES IN POLAND

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ABSTRACT

Introduction and Purpose of the Study: Protective vaccinations represent one of the greatest achievements in medicine. They have led to the elimination or reduction of many life-threatening infectious diseases. However, their success has also led to diminished awareness of the real threat posed by diseases, causing their resurgence in Poland and worldwide in recent years. This paper aims to analyze the current epidemiological situation of diphtheria, pertussis, and measles in Poland based on data concerning case numbers and the vaccination status of the population between 2010 and 2024.
Current state of Knowledge: Analysis of National Institute of Public Health data has revealed a systematic decline in the percentage of individuals vaccinated against all three diseases, often falling below the herd immunity threshold. This resulted in a significant increase in the measles cases in 2019 and an alarming surge in pertussis cases in the 2024- 2025. After years of absence, there have also been isolated cases of diphtheria. Data indicate insufficient adult immunity, low booster uptake, and persistent vaccine-related myths.
Conclusions: These findings clearly indicate that diphtheria, pertussis, and measles can pose a real threat to public health in Poland that can be directly linked to the decline in vaccination coverage. Urgent measures are needed, including improving coverage, promoting booster vaccinations in adults, education, and addressing vaccine hesitancy. Herd immunity remains essential for protecting public health and is a shared public responsibility.

KEYWORDS

Whooping Cough/Prevention and Control, Diphtheria/Prevention and Control, Measles/Prevention and Control, Vaccination Coverage/Trends, Immunity, Herd, Poland/Epidemiology

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Introduction and Purpose of the Study

Protective vaccination programs are the cornerstone of both environmental hygiene and modern public health, contributing to the elimination or significant control of many dangerous infectious diseases that have historically decimated populations[1,2]. However, the success of these programs may cause people to forget the real threat posed by diseases such as diphtheria, pertussis and measles.

These programs' effectiveness hinges on achieving and maintaining a high level of vaccination coverage to ensure herd immunity, which also protects unvaccinated individuals and those who did not develop post-vaccination immunity. For pathogens like measles virus, where immunity acquired through vaccination is highly effective in preventing infection, vaccinating the population above the herd immunity threshold can lead to the complete elimination of the disease[(3)].

In recent years, however, a concerning trend of declining trust in vaccinations and decreasing vaccination coverage rates has been observed in many countries, including Poland[4,5].

The aim of this paper is to analyze the current epidemiological situation of diphtheria, pertussis, and measles in Poland based on data on the number of cases and population vaccination status from 2010 to 2025 (with data up to March 31, 2025), in order to assess the scale of the threat and identify trends requiring public health intervention.

Current state of Knowledge

This study analyzed trends in diphtheria, pertussis, and measles incidence (2010- 2024) and DTP/MMR vaccination coverage (from 2010) in Poland, using official annual reports and surveillance data from the National Institute of Public Health PZH – National Research Institute (NIZP PZH – PIB). Additionally open access articles in English describing diphtheria, pertussis, and measles and data from the World Health Organization (WHO) websites were used.

Vaccination coverage in Poland against diphtheria, pertussis, and measles

An analysis of data from the 'Protective Vaccinations in Poland' annual bulletins, published by NIZP PZH – PIB, demonstrated a clear downward trend for all three analyzed vaccine components (DTP – diphtheria, tetanus, pertussis; MMR – measles, mumps, rubella).

The percentage of individuals vaccinated against diphtheria and pertussis (DTP vaccine) fell from 99.7% in 2010 to 94.5% in 2022.

Similarly, the percentage of individuals vaccinated against measles (MMR vaccine) decreased from 99.4% in 2010 to 94.7% in 2019, and then to 91.8% in 2021. By 2019 for measles and by 2022 for diphtheria and pertussis, the vaccination coverage rate dropped below 95%, the threshold considered minimal for ensuring herd immunity, which is especially critical for highly contagious measles virus[4].

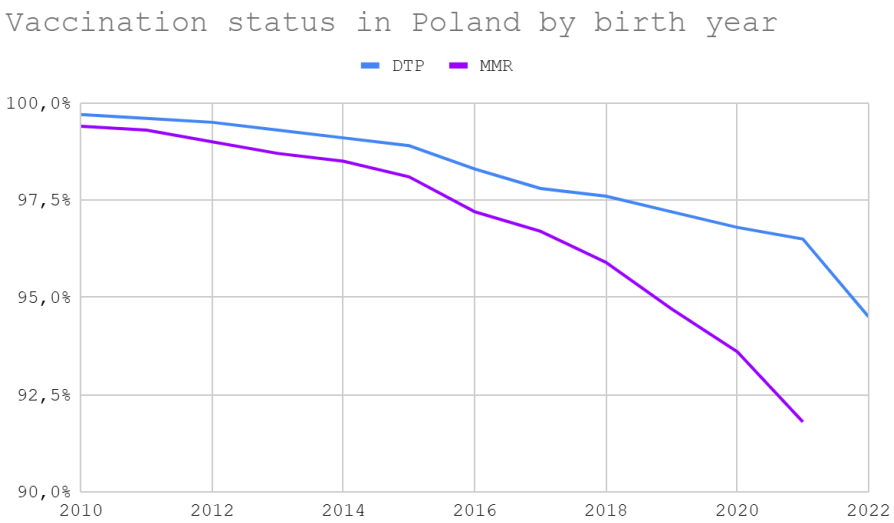

Fig. 1. *Vaccination coverage rates in Poland against pertussis (DTP), diphtheria (DTP), and measles (MMR), 2010-2022. [Based on data from NIZP PZH – PIB[4]]*

Pertussis- definition and epidemiological situation

Pertussis (whooping cough) is a highly contagious respiratory disease caused by the bacterium *Bordetella pertussis*, which is preventable by vaccination. It is easily transmitted from person to person, primarily through respiratory droplets. The disease presents the greatest danger to infants, in whom it is a notable cause of morbidity and mortality. First symptoms, including mild fever, runny nose, and cough, typically appear 7 to 10 days after infection. Pneumonia is a relatively common complication. Individuals with pertussis are most contagious for about 3 weeks after the cough begins, and many infected children experience coughing fits that last for 4 to 8 weeks. Antibiotics are used to treat the infection[6].

In Poland, vaccination against pertussis is mandatory and free for children. It is administered as a combination vaccine against diphtheria, tetanus and pertusis (DTP). The standard vaccine is the DTPw, which contains a whole- cell pertussis component. Children with contraindications, those born before the 37th week of gestation, or with a birth weight below 2500 g receive the DTaP vaccine, which has an acellular pertussis component. The basic vaccination schedule includes 4 doses: at 2 months, 3-4 months and 5-6 months of age, plus a supplementary dose at 16-18 months of age. Additionally, 3 booster doses are administered: at age 6 (DTaP), at age 14 (Tdap, with reduced diphtheria and pertussis antigen content), and at age 19 (Td, without pertussis component)[7].

The duration of protection depends on the type of vaccine: the whole-cell pertussis component (DTPw) protects for about 10 years, while the acellular vaccine protects for about 5 years, which is why booster vaccinations are recommended for adults every 10 years[8].

The incidence of pertussis cases in Poland showed significant variations in the period from 2010 to 2024, with notable peaks in 2012 (4,684 cases) and 2016 (6,828 cases). A period of relative decline with a minimum of 182 cases was followed by an alarming and sharp increase in 2021. A staggering 32,430 cases were reported in 2024, compared to cases 922 in 2023. Furthermore, 6,711 cases were registered in the first quarter of 2025 alone, which is nearly ten times the number from the first quarter of 2024 (691 cases)[9].

European data also record high numbers of cases, with a marked increase in 2023 (87,558 cases)[10].

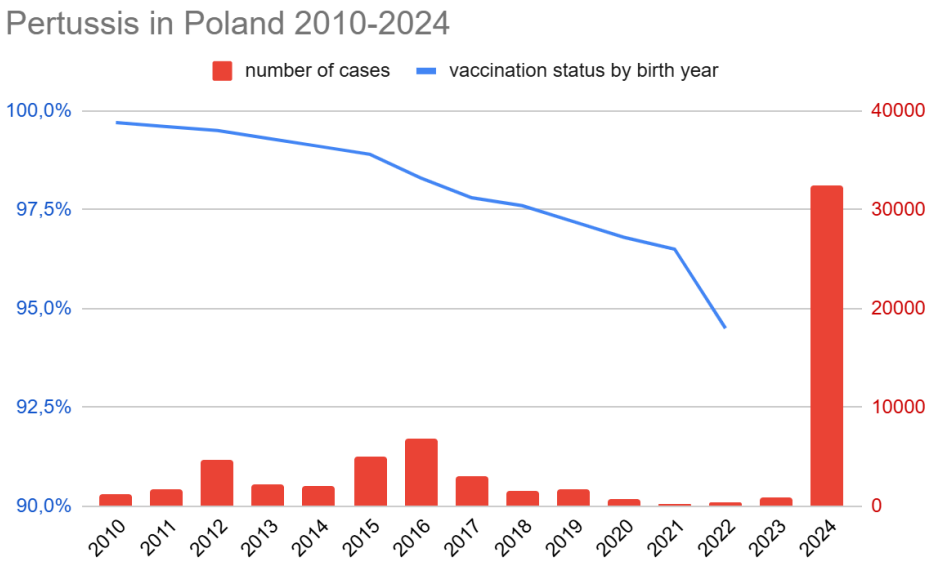

Fig. 2. *Relationship between pertussis vaccination coverage (2010-2022) and the number of pertussis cases in Poland (2010-2024). [Based on data from NIZP PZH – PIB[4,9]]*

Pertussis is most dangerous for infants; therefore, vaccination of mothers during pregnancy has been recommended since 2015[6,11]. Maternal vaccination during pregnancy is likely the most cost-effective additional strategy for preventing disease in infants too young to be vaccinated[12]. The pertussis vaccine administered to a pregnant woman is safe and does not increase the risk of adverse effects[13–18].

This vaccination increases the mother's antibody levels, which are then transferred to the infant via the placenta, potentially preventing pertussis in newborns[19–22]. However, the potential for blunting of the infant's own immune response to DTP vaccination has been observed if the mother was vaccinated during pregnancy, which requires further investigation[20,22].

In a study comparing the aP and wP vaccines, a similar reduction in pertussis antibody titers occurred in both groups five years after the preschool booster, indicating a similar duration of protection[23].

Vaccination during pregnancy appears to be more effective and beneficial than cocooning[11]. Cocooning is a strategy to protect vulnerable individuals who cannot be vaccinated themselves, which is particularly important in the context of pertussis. This method involves vaccinating close contactsto create a protective "cocoon"]24]. In contrast, vaccinating parents within 4 weeks postpartum did not reduce the incidence of disease in their infants[25].

Diphtheria- definition and epidemiological situation

Diphtheria is a highly contagious and particularly dangerous disease caused by the bacterium *Corynebacterium diphtheriae*. It is spread through airborne droplets, direct contact with the secretions or contaminated personal items. Humans are the main reservoir of infection and the incubation period is typically 2-5 days. Some strains of the bacterium produce diphtheria toxin, which can damage the heart muscle, brain or kidneys. In most cases, the bacterium attacks the upper respiratory tract, usually causing pharyngitis and laryngitis. It can also cause inflammation of the skin, conjunctiva, or genitals. In the early stages of the disease, symptoms may include fever, chills, a sore throat, a headache and difficulty swallowing. As the infection progresses, the lymph nodes significantly enlarge and edema occurs in the neck. Whitish-gray patches (pseudomembranes) characteristic of the disease appear on the mucous membrane of the throat and tonsils. The narrowing of the airway lumen increases the risk of asphyxiation, which is why the disease was formerly known as the 'strangling angel'. Cardiac arrhythmias, seizures, muscle paralysis, and even death may occur[26–28].

In Poland, the diphtheria vaccine is administered as part of the DTP (diphtheria-tetanus-pertussis) vaccine, as discussed in the pertussis chapter[7].

Because the diphtheria-tetanus-pertussis vaccine is combinated, the percentage of individuals vaccinated against diphtheria is analogous to the percentage vaccinated against pertussis. This percentage fell from 99.7% in 2010 to 94.5% in 2022.

No cases of diphtheria were recorded in Poland for over two decades starting from 2001, until 2023 when one case was registered, followed by two more in 2024[9]. In March 2025, Poland registered its first full-blown case of diphtheria in years, caused by a toxigenic strain of *Corynebacterium diphtheriae* in an unvaccinated 6-year-old child who had returned from Africa[29].

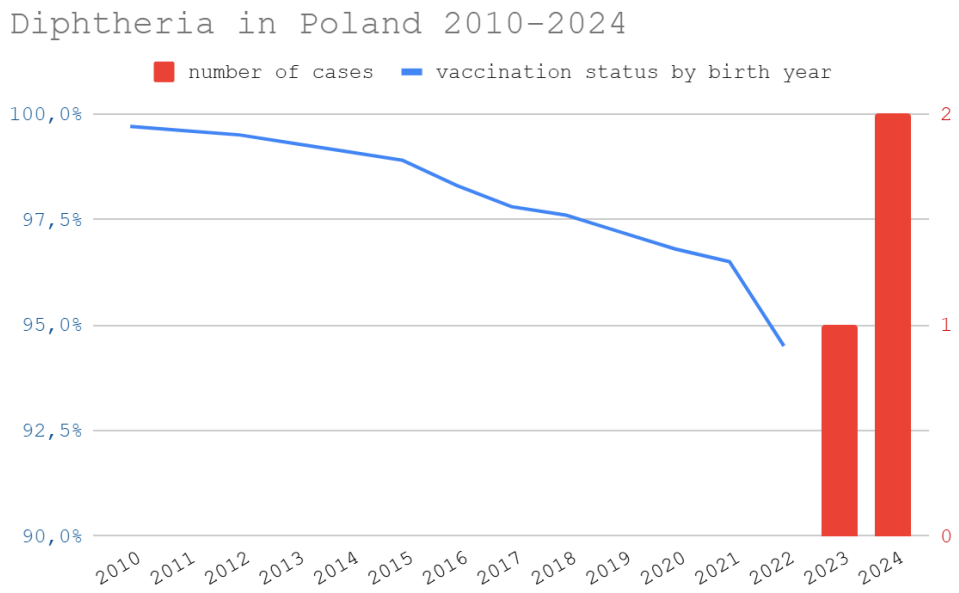

Fig. 3. *Relationship between diphtheria vaccination coverage (2010-2022) and the number of diphtheria cases in Poland (2010-2024). [Based on data from NIZP PZH – PIB[4,9]]*

Studies show that between 23% to 82% of the middle-aged individuals lack antibodies against diphtheria, suggesting that protection against the disease may be inadequate[30]. The level of immunity 5 years after vaccination is insufficient; therefore, it is recommended that adults receive a single booster dose of the diphtheria vaccine every 10 years, inn combination with the tetanus and pertussis vaccines[31]. Along with treatment of asymptomatic cases, this is one of the most effective strategies for preventing diphtheria[32,33]. However, there was one study that showed no benefit from adult diphtheria vaccination[34].

Measles- definition and epidemiological situation

Measles is a highly contagious disease caused by a paramyxovirus present in the nasopharyngeal secretions, urine, tears, and blood of an infected person. The virus is transmitted through respiratory droplets. The disease is characterized by a distinctive rash, high fever, cough, coryza (runny nose), conjunctivitis and photophobia. It is a dangerous disease that can lead to pneumonia, subglottic laryngitis (croup), neurological complications and the most severe possible late complication is subacute sclerosing panencephalitis (SSPE)[35]. Prior to the implementation of the measles vaccine in 1963 and the following widespread vaccination efforts, significant epidemics occurred at intervals of about two to three years, resulting in an estimated annual global mortality of 2.6 milion. It is estimated that 60.3 million deaths from measles were prevented due to the implementation of vaccination programs between 2000 and 2023. The measles virus has a high reproduction number (R0), indicating that to achieve herd community, the vaccination rate must be 95%. However, the vaccination rate is inadequate, resulting in a 20% increase in the estimated number of measles cases worldwide between 2022 and 2023[1].

In Poland, the measles vaccination program uses the combined measles, mumps and rubella (MMR) vaccine that provides protection against these three diseases. The vaccine is a live, attenuated strain, and the vaccination schedule consists of two doses: the first administered between the 13th and 15th month of life, and the second in the 6th year of life[7].

Following years marked by exceptionally low case numbers in Poland, a discernible escalation in the incidence of the condition was observed in 2019, with a total of 1,502 cases reported. From 2020 to 2023, the number of cases decreased significantly (30, 14, 28, and 35 cases, respectively), which may have been partly related to the restrictions imposed by the pandemic COVID-19. However, in 2024, there was a resurgence in cases with total of 279 cases reported, which is the highest number since 2019[9]. In recent years, a surge in the number of measles cases has been documented on a global scale[1,36,37].

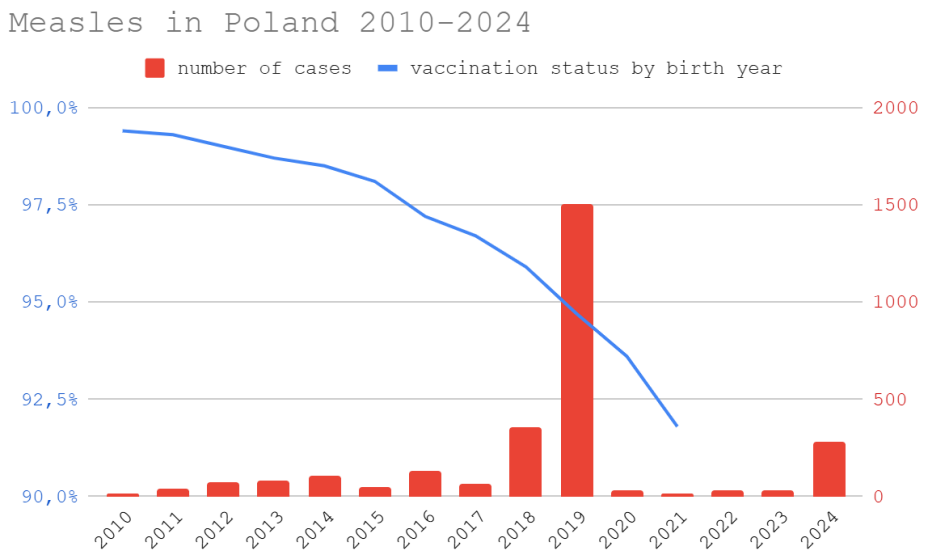

Fig. 4. *Relationship between measles vaccination coverage (2010-2022) and the number of measles cases in Poland (2010-2024). [Based on data from NIZP PZH – PIB[4,9]]*

The vaccine has been demonstrated to be highly effective; therefore, if the population is vaccinated above the "herd immunity threshold" the disease can be completely eliminated[3]. Unfortunately, a publication that purported to show a correlation between the vaccine and autism occurring in children provoked a clearly negative reaction. On February 28, 1998, Andrew Wakefield published an article in medical journal The Lancet, in which he described the cases of eight children whose first symptoms of autism appeared within one month of receiving the MMR vaccine[38]. The article provoked a significant reaction in the scientific community and among individuals who oppose vaccines. However, numerous reliable scientific studies conducted in a short period of time on huge groups of patients not only failed to confirm this thesis, but definitely disproved it and ruled out any connection between the MMR vaccine and autism[39–43]. Moreover, in 2010, The Lancet journal officially withdrew Wakefield's publication after it was proven that the study was unreliable, contained falsified data, was unreliable, and represented a serious breach of scientific ethics[38]. Andrew Wakefield himself, as a consequence of the proven scientific fraud and conflict of interest, was stripped of his right to practice medicine (44). Despite the complete discrediting of this work, the myth that vaccines cause autism in children persists among many groups, tragically affecting childhood vaccination rates.

Commentary

Vaccinations are one of the most effective strategies for preventing infectious diseases as well as one of the most cost-effective public health investments. Poland has a pediatric vaccination program that significantly reduces morbidity and mortality. A study was conducted to estimate the effectiveness of vaccines in preventing diseases and their financial benefits. The study estimated that in the 2019 birth cohort 452,300 disease cases and 1,600 premature deaths were avoided. Additionally, the economic benefits of vaccinations were estimated. For every €1 invested in the pediatric vaccination program, the healthcare payer received over €2 and society received over €7 in savings. These data demonstrate the essential role of vaccinations in health care[45].

Nevertheless, studies have shown that 86% of women were not vaccinated during the pregnancy planning, which may be because doctors do not recommend vaccination often enough. According to the study, only 3% of doctors recommended influenza or pertussis vaccinations during pregnancy. About 6% of pregnant women or those planning a pregnancy supported anti-vaccination movements and approximately 12% of

women were undecided about vaccinating their children[46]. An important role of doctors is to respond to their patients' concerns and educate them about disease prevention.

A study was conducted in Poland to investigate why people refuse vaccinations. The study showed that negative experiences after receiving a vaccine significantly influence people's attitudes toward vaccinations. Opponents of vaccines have an unequivocally negative attitude towards them. In contrast, undecided individuals believe that vaccines are effective and have been adequately tested; however, they fear serious negative side effects and suspect hidden motives of pharmaceutical companies[5].

Data on pertussis clearly indicate a serious resurgence of the disease in Poland unseen in recent years. The decline in vaccination coverage observed over the years, which reached 94.5% in 2022, created conditions for the widespread transmission of the *Bordetella pertussis* bacterium[4]. The sharp rise in the number of cases in 2024, followed by a continuation of this trend in 2025 is an alarming signal of the collapse of herd immunity[9]. Another reason for the decline in herd immunity is the adults' reluctance to receive booster vaccinations ten years after an illness or their last vaccination[47].

Despite the implementation of childhood vaccination programs, B. pertussis continues to curculate within the Polish population. Furthermore, studies indicate that the number of pertussis cases is significantly underestimated, including among middle-aged people. The current pertussis monitoring system, which relies on case reporting, underestimates the incidence of the disease[30].

Pertussis is particularly dangerous for infants who have not yet received all the vaccinations[6]. The current epidemiological situation requires urgent public health measures, including intensifying booster vaccinations and raising public awareness about the threat. This is a classic example of a disease that is returning forcefully due to decreased population immunity.

Based on the presented data, the epidemiological situation of diphtheria in Poland is essentially stable, but the first warning signs are appearing. The zero case count maintained for many years was a success of the vaccination program. However, the emergence of isolated cases from 2023 to 2025, coupked with a systematic decline in the percentage of vaccinated individuals to 94.5%, is concerning[4,9]. While one cannot yet speak of large- scale return of the disease, these cases suggest that the pathogen may be circulating. Declining level of herd immunity creates a potential risk of future outbreaks or epidemics of this dangerous disease. These data underscore the importance of maintaining a high vaccination rates to prevent a resurgence of diphtheria.

Data on measles clearly shows that a drop in MMR vaccination coverage below the herd immunity threshold (approximately 95% for measles) leads to a resurgence of the disease[(4)]. The sudden increase in cases in 2019 was a direct consequence of this, providing a serious warning. Although the situation was brought under control and transmission decreased during the pandemic period, the increase in number of cases in 2024 shows that the problem has not disappeared[(9)]. A significant increase in measles cases in Poland in the near future is possible. The persistently low level of vaccination in the population creates a constant risk of further outbreaks and epidemics. Measles is one of the most contagious viral diseases and can lead to dangerous complications. These data emphasize that measles is not a "forgotten" disease, but rather a constant threat that can spread rapidly as soon as the level of population protection drops. It is necessary to constantly monitor the situation and make efforts to achieve and maintain a high vaccination rates.

Conclusions

The presented data provide strong evidence of the resurgance of so-called "forgotten" infectious diseases in Poland. The main reason is probably the decline in the level of vaccination rate in the population. The situation regarding pertussis is currently alarming and represents the most serious threat among the analyzed diseases. Therefore, urgent intervention measures are needed. Measles remains a significant threat, as evidenced by the sudden increase in the number of cases in 2019 and the following increase in 2024. The appearance of isolated diphtheria cases is a warning sign of its potential resurgence. Herd immunity is crucial for protecting public health, especially the most vulnerable population groups. Maintaining high vaccination coverage is not just an individual choice, but a collective responsibility essential for preserving a healthy shared environment.

Author's contribution

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

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