HEALTH ORGANIZATION AND ETHICS

J. Heal Ethics Admin
Volume 12 | Number 1 (Winter 2026)
www.jheaonline.org
ISSN 2474-2309 | doi:10.22461/jhea.6.7166
https://doi.org/10.22461/jhea.6.7166
Published Feb 03, 2026

THE 2024 PERTUSSIS OUTBREAKS IN THE UNITED STATES: A CALL FOR INCREASED PUBLIC HEALTH PREPAREDNESS

Fredy Abboud, Shrijal Desai, Peter Clark
pclark@sju.edu

Abstract: *Pertussis, also known as whooping cough, is an infection of the respiratory system, characterized by inflammation of the lungs and airways, and is caused by Bordetella pertussis. Studies suggest that pertussis is highly contagious, affecting around 90% of individuals exposed to the pathogen in the household and 50-80% of individuals exposed to it in schoolrooms. In 1934, the United States (U.S.) reported around 265,000 pertussis cases, which decreased to about 7,000 cases in 2023; however, the U.S. witnessed a five-fold increase in reported pertussis cases in 2024. Therefore, this paper outlines possible factors contributing to the surge in pertussis cases, lays out evidence-based effective approaches and preventive measures to curtail future pertussis and, possibly, other air-borne disease outbreaks, and provides ethical arguments for adopting the initiatives/changes recommended herein.*

Keywords: *pertussis, whooping cough, Bordetella pertussis, vaccine hesitancy, waning immunity, disease surveillance, and public health funding.*

*Address correspondence to: Peter Clark. Email: pclark@sju.edu

+To cite this article: Abboud, F., Desai, S., Clark, P. "The 2024 Pertussis Outbreaks in the United States: A Call for Increased Public Health Preparedness". The Journal of Healthcare Ethics & Administration Vol. 12, no. 1 (Winter 2026): 1-27, https://doi.org/10.22461/jhea.6.7166

INTRODUCTION

Throughout history, the spread of diseases has shaped societies, thus impacting nations, and sometimes the world at different levels (economics, culture, education, etc.).[1] The Black Plague of the 14th century, which claimed at least a third of Europe's population at the time, the HIV/AIDS pandemic, which has claimed around 42.3 million lives as of 2023, and the 1918 Spanish Flu, which claimed anywhere between a low estimate of 17.3 million and a high estimate of 50-100 million lives, are three of many pandemics that have yielded disastrous human, societal, financial, and geopolitical impacts on different countries throughout the past millennium.[2,3,4,5]

With advancements in medical equipment, strides in medical research, and investments in vaccine development, concerns over uncontrolled disease outbreaks have remained minimal. Data-driven contact tracking, disease surveillance programs, diagnostic screenings and other tools/programs have been in place to help mitigate unexpected disease spreads that would disrupt everyday life. Regardless, the response to the COVID-19 pandemic has reflected international unpreparedness to navigate disease outbreaks and other public health emergencies.[6]

Ever since the onset of the COVID-19 pandemic in the United States (U.S.) in March 2020, concerns over the U.S. public health preparedness have made headlines, with health professionals and scientists calling for reforms to the U.S. public health response to disease spreads.[7] Among the major concerns of the U.S. public health response to the COVID-19 pandemic were inadequate digital infrastructure for data-driven responses, region-specific disparities in capabilities among different health departments, disinvestment in the public health sector, delayed roll-outs of diagnostic tests, inconsistent guidelines on prevention, and insufficient guidance on how to alleviate the disproportionate impacts on high-risk populations.[6,7] Although these shortcomings manifested during the pandemic years, they had been cultivating throughout pre-pandemic years.[7]

Capturing the exact death toll of the COVID-19 pandemic is difficult, given an ineffective early response and relaxed testing rate resulting in many positive cases having their underlying cause reported as other than COVID-19.[8] As of June 2025, COVID-19 has claimed 1,299,590 lives in the U.S., with studies suggesting excess deaths.[9] In fact, one study estimated the occurrence of 649,411 excess deaths (82.9% tied directly to COVID-19) in the U.S. between March 2020 and February 2021.[8] Besides exorbitant death tolls, the COVID-19 pandemic is estimated to have yielded a toll of $14 trillion on the U.S. economy, largely because of mandatory business closures, changes in consumer behavior, and government stimulus packages, among other causes.[10]

Although the COVID-19 pandemic has been curtailed, the U.S. constantly faces threats of disease outbreaks, with hundreds reported and investigated yearly.[11] Among the recently reported outbreaks that merit concern are pertussis, otherwise known as whooping cough, outbreaks, which have made headlines after the number of pertussis cases in the U.S. in 2024 (35,493) exceeded those in 2023 (7,099) by over five-fold.[12,13] This sudden surge in pertussis cases raises a red flag, hence serving as a case in-point to identify shortcomings in the U.S. preparedness to future disease outbreaks.

Therefore, the purpose of this paper is three-fold: first, to provide a short overview of pertussis, second, to identify inadequacies in the U.S. preparedness to disease outbreaks (specifically pertussis), and third, to propose evidence-based approaches to reduce the severity of future outbreaks.

MEDICAL PERSPECTIVE

What is Pertussis?

Pertussis is an upper respiratory tract infection caused by *Bordetella pertussis*, but some milder cases have been linked to *Bordetella parapertussis*.[14] Both *B. pertussis* and *B. parapertussis* are gram-negative and aerobic coccobacilli, but the latter causes milder symptoms than the former.[14] *B. pertussis* is an air-borne pathogen that is transmitted through respiratory droplets (released by coughing or sneezing), but unlike *B. parapertussis*, affects only humans.[14,15] Infection occurs as the pathogen adheres to the ciliary lining of the respiratory epithelial tract, thus inducing inflammation of mucosal lining.[16] Invading *B. pertussis* would release toxins, such as the pertussis toxin and tracheal toxin, which would harm the mucociliary lining, causing mucus buildup in the respiratory tract and thus the characteristic post-cough "whoop" sound as the infected individual attempts to clear his/her airways.[17]

Epidemiology

Ranked among the most rapidly spreading vaccine-preventable diseases, pertussis (highly contagious) affects around 90% of individuals exposed to its etiological agent in the household and 50-80% of individuals exposed to it in schoolrooms.[18] Pertussis has a predilection to children as 38% of positive cases involve infants younger than 6 months of age and 71% involve children younger than 5 years of age; moreover, neonates and infants are at the greatest risk of developing grave complications.[16,18] However, adolescents and adults can contract it.[16]

In 1922, the U.S. reported around 107,473 pertussis cases.[18] In 1934, 265,000 confirmed cases, associated with around 10,000 deaths, were reported, marking the highest annual numbers of confirmed pertussis cases in U.S. history.[18,20] In 1948, DTP – a vaccine for diphtheria, tetanus, and pertussis – became widely available, and was associated with a drastic decrease in the annual numbers of pertussis cases – down to about 14,900 in 1960.[20] Between 1968 and 1992, reported cases remained below 5,000 annually, with an annual average of 2,900 cases between 1980 and 1990.[20,21,22] However, in the past three decades, the U.S. has witnessed a cyclical pattern of pertussis resurgence as cases peak every few years, with the highest peak since 1990 occurring in 2012 (48,277 cases).[20] In 2024, the pre-pandemic incidence rates of pertussis persisted, with the U.S. reporting 35,493 cases – an over five-fold increase from the 7,099 confirmed cases in 2023.[12,13,20]

Signs and Symptoms

Pertussis onset may occur after an incubation time of 5-10 days following exposure to the pathogen; however, that incubation time may stretch for as long as 21 days.[23,24] Signs and symptoms of pertussis can be classified into three distinct phases: (1) catarrhal, (2) paroxysmal, and (3) convalescence.

The catarrhal stage spans across the first one-to-two weeks of infection and manifests in cold-like symptoms – low grade fever, intermittent mild cough, runny nose, and apnea (reported in infants).[21,25]

The paroxysmal stage, during which patients exhibit symptoms characteristic of pertussis, can begin one week following infection and last until six weeks (ten weeks, in some cases). Patients report paroxysmic attacks, which consist of rapid violent coughs, followed by a "whoop" sound as the patient's body attempts to expel mucus from the respiratory tract, and then possibly bluish coloration because of poor oxygen circulation in bloodstream.[21,25] Patients may also experience exhaustion and post-cough vomiting causing dehydration and/or malnutrition.[26] On average, a patient reports experiencing 15 paroxysmal attacks per 24 hours, increasing in frequency in the first one-to-two weeks, stabilizing for another two weeks, and then slowly improving afterward.[25]

Oftentimes, the infection remains localized to the respiratory tract; however, patients may present with systemic symptoms such as dysregulated insulin secretion, lymphocytosis, and altered neurological function (e.g.

fainting and seizures).[26] Other side complications can include hernias, weight loss, urinary incontinence, lung collapse, rib fractures, and nose bleeds, with the more severe complications observed in infants.[25] In fact, almost one-third of patients with pertussis younger than one year are hospitalized, with 1% of those hospitalized passing away.[23]

During the third stage, called convalescent stage, patients recover slowly, with paroxysmal attacks disappearing within two-to-three weeks. However, patients may report paroxysmal attacks if they develop respiratory infections within months of their pertussis infection.[25]

Diagnostic Measures

Given the abovementioned signs and symptoms, patients presenting with a persistent cough on par with paroxysmal attacks should be tested for pertussis.[16] Pertussis cases can be confirmed using nasopharyngeal cultures, polymerase chain reactions (PCRs), or serology.[27] Acquiring nasopharyngeal cultures is the most common practice in emergency departments.[27,28] Another popular diagnostic tool is testing samples obtained through swabbing using PCRs – a measure known for its relative speed.[27] Serology is also resorted to, as it offers more accurate outcomes for patients later in their disease stage.[27] The three tests vary in their timing with the favored time for using cultures, PCR, and serology respectively being 1-2, 3-4, and 2-8 weeks after coughing begins.[27]

Treatment Measures

Treatments may vary depending on age and symptom severity. Hospital admission is recommended for infants younger than 12 months of age and for patients who present with co-morbidities of pneumonia, hypoxia, feeding difficulties, and disruptions of central nervous system functioning.[16] Given that neonates are unvaccinated and maternal antibodies against pertussis acquired in-utero do not offer them the immune protection needed, they must be admitted to a neonatal intensive care unit.[29]

Antibiotics are commonly administered to patients with pertussis to eliminate *B. pertussis* from the respiratory tract. Antibiotic administration earlier in the disease stage can help attenuate pertussis symptoms, with the Centers for Disease Control and Prevention (CDC) recommending antibiotic treatment up to 6 weeks post cough-onset in infants and pregnant women.[30,31] Patients ages 12 months and older should receive antibiotics within three weeks of the cough's onset; otherwise, the antibiotic effect is minimal.[29] However, the recommended administration start-point, duration and type of antibiotic vary depending on the patient's age.[16] Preferred antibiotics are erythromycin, clarithromycin, and azithromycin, but the choice of antibiotic must be determined based on a burden/benefit analysis.[31] Use of erythromycin and azithromycin in infants younger than 12 months of age is associated with infantile hypertrophic pyloric stenosis, leading to vomiting and thus dehydration and malnutrition. However, the benefits of dampened paroxysmal attacks outweigh the unintended side-effects, justifying the cautious use of macrolides.[31] Trimethoprim-sulfamethoxazole is resorted to in macrolide-allergic or resistant patients, but its use is recommended for infants ages 2 months and older.[16,30,31]

Alongside antibiotic-administration, patient isolation is recommended, as pertussis is communicable in the catarrhal stage and three weeks into the paroxysmal stage.[30,32] Patients with pertussis must also remain isolated for 5 days after the start of antibiotic therapy.[33] Furthermore, supportive treatments may be required, depending on symptom intensity. Nasal feeding, avoidance of respiratory irritants, and suctioning may be needed, especially in neonates and infants who are at greater risks of asphyxiation.[16,30] In addition, severe complications of pertussis may necessitate intravenous administration of pertussis immunoglobulins, mechanical ventilation in the event of persistent apnea or respiratory failure, administration of pulmonary vasodilators to resolve pulmonary hypertension, and hyperleukemia treatments.[30]

Besides treating patients, household members and close contacts must also undergo prophylactic treatment, especially when patients are still neonates or infants. Close contacts must receive antibiotics, such as trimethoprim-sulfamethoxazole, precautionarily.[16,30]

With regards to pertussis vaccine-induced immunity, the vaccine schedule involves four doses of DTaP vaccines at 2, 4, 6, and anytime between 15 and 18 months of age, followed by a fifth dose anytime between 4 and 6 years of age.[34] Older adults should then get a dose of tetanus, diphtheria, and acellular pertussis (Tdap) vaccine at 11-12 years of age, followed with a booster vaccine every 10 years.[34] Also, pregnant women are advised to get vaccinated with Tdap vaccine, preferably 27-36 weeks into the pregnancy.[16,34]

SUSPECTED FACTORS BEHIND SURGE IN PERTUSSIS CASES

1) Case Under-reporting

Among the mounting concerns behind the surge in pertussis cases is inadequate surveillance and case reporting that results in deflated incidence rates and thus misinformed decision-making among public health professionals. While the CDC acknowledges underreporting of pertussis cases, a study estimates that as low as 1 in 10, or even 1 in 20 pertussis cases is reported.[35,36] Using common pertussis symptoms, a machine-learning model estimated that the prevalence of pertussis is 110-fold higher in adolescents and adults in the U.S. than is reported.[37] Several reasons lie behind the suspected underreporting.

First, non-severe cases of pertussis may present symptoms typical of other diseases, especially in adults who may display only prolonged coughing, without the other pertussis-specific symptoms.[38] Therefore, healthcare providers may not suspect pertussis and thus not order the appropriate diagnostic tests. Without testing, the underlying pertussis cause of a case would remain unknown.

Besides no testing, untimely testing can contribute to the inaccurately low case count. Nasopharyngeal swabs, which constitute the gold standard, are highly specific (capable of identifying pertussis-negative cases); however, their sensitivities (capacities to identify pertussis-positive patients) are high within the first two weeks of the paroxysmal stage, after which they decrease.[27,39] Decreased sensitivity would then contribute to higher rates of false-negative results (i.e. positive cases going unnoticed).[39] With regards to PCRs, they are highly sensitive but variably specific.[27] A PCR test can be used for up to four weeks since the start of the paroxysmal stage, after which bacterial DNA concentration decreases as a result of the body's immune response. The lower DNA concentration would render PCRs less reliable, thereby increasing the risks of false negatives.[39] Serology tests, although best to use 2-8 weeks into the paroxysmal stage, yield variable results, largely because of antibody titer levels varying depending on vaccination status, previous exposure, and other factors.[27] Furthermore, some commercially sold serology tests haven't shown clinical efficacy.[27] Therefore, untimely testing increases the risk of false negatives, thus leading to epidemiological numbers unreflective of the realistic prevalence of pertussis.

2) Inadequate Surveillance Among Adults

Another phenomenon that contributes to underreporting is the disproportionate focus on pertussis incidences in neonates, infants, and children as compared to adults. One study suggests that only 1 in 10 adult pertussis cases is identified as opposed to 8 in 10 child cases.[40] Furthermore, studies suggest that the actual pertussis incidence rate among adults significantly exceeds that reported cumulatively in databases or to health authorities such as the CDC.[41,42]

The under-identification of pertussis in adults may be the result of patients presenting with respiratory co-morbidities such as chronic obstructive pulmonary disorder (COPD) which would complicate a diagnosis, leading healthcare providers to overlook pertussis as a severe flare-up.[43] In fact, patients with COPD are susceptible to developing pertussis.[44,45,46] However, misdiagnosing pertussis as other respiratory conditions may delay pertinent testing and possibly result in a false diagnosis altogether.[47,48] Also, adults experience longer delays in diagnoses than

younger populations, with the average pertussis diagnostic delay increasing from 5.6 days for patients 2 years of age and younger to 13.9 days for patients 18 years of age and older.[49]

3) Waning Immunity & Asymptomatic Transmission

Another suspected contributor to the multifold increase in pertussis cases is waning immunity among the general population, which, in turn, results in a weakened herd immunity.[50] DTaP and Tdap offer individuals immunity, but that immunity decreases in effectiveness within years following the vaccine shot. The waning immunity has been ascribed to the acellular nature of DTaP and Tdap, which can possibly hinder the vaccine-induced mucosal immunity.[51] Studies have suggested that acellular pertussis vaccines' effectiveness decrease annually. One review has reported the initial vaccine effectiveness at 91% following the five DTaP childhood-series doses, with an annual decrease of 9.6%.[52] Vaccine effectiveness of the DTaP and Tdap series following the Tdap booster at 11-12 years of age was estimated at 85%, with an annual decrease of 11.7%.[52] Another study has found that pertussis vaccine effectiveness decreased from an average of 98.1% in its study participants during the first year following the fifth DTaP dose (administered at ages 4-6) to an average of 71.2% within 60-83 months following the fifth DTaP dose.[53] Lower vaccine effectiveness is further complicated by vaccine-driven selective pressures that have resulted in the emergence of pertactin-deficient *B. pertussis* in the United States, European countries.[54,55]

Furthermore, studies indicate that the acellular pertussis vaccines induce a shorter-lasting immunity than whole-cell pertussis vaccines, thus offering weaker immunity against nasopharyngeal colonization.[56] The weak mucosal immunity may lead vaccinated individuals to asymptomatically carry and transmit pertussis, further weakening the herd immunity.[57] In one study, 80% of participants (ages 18-45; vaccinated with acellular pertussis vaccines within 5 years of the study) experienced pertussis colonization of the nasopharyngeal tract upon being inoculated nasally with *B. pertussis*, but only a few of them reported minor symptoms, in alignment with the concept of asymptomatic infections with *B. pertussis*.[58] A systematic review yielded that 55.6% of all PCR-positive pertussis patients included in studies are asymptomatic and reported seven different studies reflecting transmission patterns indicative of asymptomatic pertussis.[57]

4) Vaccine Hesitancy

Another likely contributor to the resurgence in pertussis cases is vaccine hesitancy, a phenomenon which can be observed when guardians/patients delay or refuse vaccinations in spite of the vaccines' accessibility.[59] Studies have demonstrated associations between vaccine hesitancy and the development of pertussis. In fact, a systematic review has reported gradual increases in the likelihood of developing pertussis in children as the number of vaccine doses they received decreased.[60] This is further exacerbated given a decrease in vaccination rates among kindergartners from around 95% in the 2019-2020 academic year to less than 93% in the 2023-2024 academic year.[61,62]

In addition, nonmedical vaccine exemptions correlate to increases in pertussis cases, with one study identifying overlaps between regions with clusters of pertussis cases and those with clusters of nonmedical vaccine exempt individuals.[63] This is significant given that kindergartners with exemptions from one or more vaccines increased from 3.3% to 3.6% in the U.S. between the 2023-2024 and 2024-2025 academic years.[61]

Aside from exemptions, delayed vaccinations constitute rising concerns as one study shows as low as around 48% of commercially insured and 14% of Medicaid-insured children receiving the five DTaP doses in a timely manner.[64]

Also, maternal vaccine hesitancy has been linked to an increased risk of developing pertussis in infants, as maternal vaccination offers immune protection to infants 3 months of age and younger.[60]

5) Public Health Funding Cuts

For decades, inadequate funding has been a primary contributor to deficient public health responses, with the response to COVID-19 serving as a prime example.[6] In 2018, only 2.5 cents for every dollar spent on health was allocated to public health, with only 1.5 cents being reserved for population-level public health matters.[65] Also, the public health expenditures needed to maintain all Americans' health is about $32 per person, yet the expenditures in 2019 were about $13 short.[66,67] The spending gap results in diminished public health maintenance capabilities, including negatively impacted policy development, community surveillance, community partnerships, and other services.[67]

For about two decades, decreased public health funding has resulted in shrinkage of the public health workforce, with state, county, and municipal health agencies reporting 26,000 less employees in 2020 as compared to 2009.[6] As such, the total number of epidemiologists, contact tracers and other employees directly involved in controlling disease outbreaks decreased.[6] Moreover, a 2019 National Association of County and City Health Officials (NACCHO) report noted that about 64% of U.S. health departments resort to non-preparedness and non-response staff to respond to public health issues – evidence of an insufficient workforce despite health departments serving as front-line barriers against disease spreads.[68]

Even after the COVID-19 pandemic, public health underinvestment remains an issue. The Public Health Emergency Preparedness (PHEP) is a CDC-run program that was established in 2002 and which funds state, local, and territorial health departments to mount timely responses to public health crises; however, PHEP's 2024 budget was $265 million short of the recommended $1 billion.[69,70] In addition, under-funded public health agencies are not as equipped to collaborate with different sectors to initiate swift and adequate responses to public health crises, including disease outbreaks which can worsen into an epidemic.[71] Lastly, CDC expenditure on health promotion and disease prevention in 2024 is less than what it spent in 2015.[71]

Given the abovementioned underinvestment in public health and the associated ramifications, inadequate public health budgets have been regarded as a possible contributing factor to the surging pertussis cases, hindering the proper and sufficient allocation of resources to pre-emptively fight pertussis outbreaks.

EVIDENCE-BASED APPROACHES TO RESOLVE POTENTIAL SHORTCOMINGS

1) Addressing Vaccine Hesitancy:

Despite ranking among the leading concerns of public health officials worldwide, vaccine hesitancy is fortunately an attitude that can change in response to different factors such as vaccine risks, perceptions of the magnitude of the disease threat, and the vaccine under consideration.[72,73] Therefore, healthcare providers can play a role in reversing the rising vaccine hesitancy trends.

1.a. Presumptive, Comprehensible & Transparent Language

Presumptive language, which assumes that a person is already willing to take up what is being mentioned, is one approach physicians can utilize to increase vaccine uptake.[74] One cross-sectional observational study reported parents being about 17.5 times more likely to refuse vaccinations for their children if the pediatric provider used participatory as compared to presumptive language.[75] Another observational study noted a significant 94% of parents consenting to vaccinate their children against influenza when providers used presumptive language compared to just 28% of parents when providers brought up vaccinations in a participatory manner.[76] Furthermore, the vaccination discussion format influences the immunization timeline of children, with a participatory format being associated with children being under-immunized for 10.1% longer than children in the presumptive format.[77]

Another possible intervention is physicians resorting to transparent language that better enables guardians/patients to make a well-informed decision regarding vaccine uptake. In fact, one study in Germany reported that a third of its participants had grown in skepticism of COVID-19 vaccines primarily because of

incomprehensible and inconsistent communication by scientists and politicians;[78] participants were concerned with the communications lacking a full disclosure of uncertainties and possible risks regarding the COVID-19 vaccines.[78] By contrast, the same study reported that the use of full transparency (including about uncertainties and possible harms) decreases vaccine uptake short-term but also significantly increases the public's trust in public health authorities, which is paramount in mounting an effective response to future outbreaks/epidemics/pandemics.[78]

Furthermore, physicians and other health professionals should employ more easily understandable, plain language that accommodates for the different educational backgrounds of the diverse patient populations in a community. One study has reported that the use of "nontechnical" language while refuting common misunderstandings about the mechanism of action and mild side-effects of COVID-19 vaccines significantly reduces vaccine hesitancy and concern over short-term effects as compared to individuals in the control group that didn't receive any information/clarifications.[79] This finding may reasonably translate to cases involving pertussis vaccines. Furthermore, a study in South Korea suggests that individuals who find spoken vaccine information hard to interpret are more likely to refuse vaccination than those who find it easier to understand.[80]

1.b. Motivational Interviewing

Physicians can also employ motivational interviewing – a counseling technique that utilizes social and cognitive psychology to encourage change in a patient's health status, including ambivalence to vaccinations.[81] Motivational interviewing is based on partnership, acceptance (respect for client), compassion and evocation.[82]

In a medical context, *partnership* refers to the need for the physician and patient to collaborate to reach the end goal intended for the latter.[81] *Acceptance* involves respecting the patient 's values, views, concerns; this acceptance depends on four major fundamentals: (1) affirmation – reinforcing a patient's self-confidence by bolstering his/her positive characteristics, (2) accurate empathy – actively pursuing a better understanding of the patient by placing oneself in the patient's shoes, (3) autonomy support – acknowledging the patient's right to coercion-free autonomous decision-making, and (4) absolute worth – recognizing the patient's inherent dignity as a human being.[81] Furthermore, *compassion* relates to prioritizing the patient's best interest, and *evocation* involves better understanding the patient's attributes (e.g. strengths, weaknesses, values, etc.).[81]

In terms of communication, motivational interviewing incorporates skills, such as asking open questions, affirming, reflectively listening, and summarizing, which align with person-focused communication.[81] Therefore, motivational interviewing fosters the development of a strong relationship between healthcare providers and patients/caregivers, which is conducive to a more fruitful conversation regarding the importance of vaccine-induced immunity while also leaving patients/caregivers with room to freely express their concerns and fears.[83] Also, motivational interviewing encourages patients/caregivers to properly weigh the actual risks and benefits of receiving the vaccine under question.[83]

Although data about the effectiveness of in-person vaccination discussions is not definitive, there is increasing evidence supporting the effectiveness of motivational interviewing approaches.[82] One study reported that children (2 years of age and younger) whose parents received an educational strategy involving motivational interviewing in maternity wards were 9% more likely to be completely vaccinated than the children whose parents did not undergo the motivational interviewing-based educational session.[84] Another study involving a different motivational interviewing-based tool reported significantly higher inactivated influenza and haemophiles influenzae type b vaccination rates among children ages 0.5–6 years and 0–18 months (respectively) whose parents were subject to the motivational interviewing-based tool compared to those whose parents were not.[85]

Motivational interviewing-based approaches have also proven effective in community pharmacies, with one study reporting a 33% annual increase in vaccinations at community pharmacies the year the motivational interviewing-based intervention was implemented.[86] The same study reported increases in vaccination rates for four of the five vaccines included in the study's design.[86] Moreover, in a study in which safety and vaccine efficacy were two of the top caregiver concerns, 61% of patients (ages 18 and above) received vaccination or declared interest in

receiving vaccination after an in-person motivational interviewing discussion with a pharmacist.[87] This is significant provided that about 89% of Americans live within a 5–mile radius from a pharmacy.[88]

1.c. Community-based Educational Initiatives and Events

Community-engagement may also help in alleviating vaccine hesitancy, as studies have shown that community and workforce educational interventions can change people's positions on vaccines. For example, one study included a series of virtual and in-person educational seminars aimed at better informing personnel at Wright-Patterson Air Force Base on mRNA-based COVID-19 vaccines.[89] Before the seminars, 98.8% of participants had not received the first COVID-19 vaccine shot.[89] After the seminar, 36% of participants who reported vaccine hesitancy pre-seminar declared openness to getting vaccinated.[89]

Furthermore, community initiatives that involve vaccinated individuals encouraging family, friends, and even acquaintances to get vaccinated might help reduce vaccine hesitancy. In one study, vaccine conversation cards were distributed to recently vaccinated adults.[90] Two weeks later, 51% of respondents reported using the conversation cards to initiate conversations with unvaccinated individuals and 41% of them reported handing the card to an unvaccinated family member or friend.[90]

Vaccine champions and peer ambassadors can also help combat vaccine hesitancy, whether in high-income or low- and middle-income regions. Vaccine champions are individuals who are well educated on vaccines, passionate about boosting vaccination rates, well-trusted, and might hold leadership positions in their communities or workplaces.[91] Vaccine champions may conduct community vaccine-awareness sessions, have personal conversations with individuals reticent to get vaccinated and/or consent to vaccinating their children, and even visit the houses of unvaccinated individuals in certain communities and cultures.[91,92]

In a study on the effectiveness of vaccine champions, COVID-19 booster uptake increased from 41% to 83% of community members after vaccine champions' community discussions in Fiji.[93] Likewise, another study reported that vaccine champions, who educated unvaccinated individuals, contributed to an increase in COVID-19 vaccine coverage from 10% to 22% in a small community in Tanzania in a little over a month and then to 94% about three-months post-intervention.[92]

By comparison, a study in the U.S. reported influenza vaccine uptake significantly increasing from 41% of participants in a control group lacking a vaccine champion to 52% of participants engaging with a vaccine champion.[94] Furthermore, a U.S. national survey study yielded that 49% of surveyed primary care physicians regard the vaccine champions they are closest to as highly effective at improving vaccination rates.[95]

1.d. Greater Social Media Presence to Combat Mis/disinformation

Mis/disinformation on vaccine efficacy and side effects have been propagated on social media platforms, sparking vaccine hesitancy among the public. In fact, several studies attest to the negative impacts exposure to mis- and/or dis-information on social media can yield on people considering getting vaccinated.[96] One modeling study suggests that online exposure to misleading COVID-19 vaccine information contributed to about 750,000 people refusing vaccination between February and August 2021.[97] This mass vaccination refusal may have contributed to about 29,000 additional cases of COVID-19 and around 430 deaths.[97] Another study reports similar associations between misinformation and vaccine hesitancy, as 6.2% and 6.4% of participants in the United Kingdom and U.S., respectively, no longer identified with "definitely take vaccine" category after getting exposed to misinformation.[98] This is alarming, considering the National Assessment of Adult Literacy yielding that only about 12% of U.S. adults have proficient medical illiteracy.[99] Therefore, proper intervention in response to vaccine hesitancy requisites a fight against mis- and dis-information.

Social media interventions against vaccine hesitancy can assume different forms. Vaccine promotion on university campuses is one avenue, with one study reporting the use of yard signs, posters, and social media posts on

a college campus increasing administered HPV vaccine doses by 75% compared to the year prior.[100] Another possibly effective social media intervention is fact-checking. One study that employed text-based refutations reported participants viewing misinformation as less credible than participants not exposed to the refutations.[101] The reported benefits were short-term, so further studies on the long-term effectiveness are still required.[101] Nonetheless, one concern is that the intended effect behind refuting misinformation varies in effectiveness depending on how aligned the misinformation is with the audience's worldview.[101]

1.e. Prebunking Training

Despite the recent technological advancements, fact-checking abilities are limited and cannot address all misinformation propagated on social media platforms; therefore, training individuals to spot misinformation is needed. Prebunking is one intervention which can be defined as priming people to identify misinformation before they encounter it.[102] One study on the effectiveness of prebunking in reducing vaccine hesitancy reported that inoculated individuals (i.e. individuals who have been exposed to tenuous misinformation) are more likely to identify vaccine-related misinformation, to refrain from spreading false information, and to get vaccinated.[103] Furthermore, a study conducted by researchers at Cambridge University reported that people who engaged with a "Bad News" online game that enabled its players to function as producers of fake news regarded misinformation as less credible.[104] Particularly, there were significant decreases in how reliable study participants regarded misinformation that involved impersonation, conspiracy, blame deflection, political polarization, fake tweets, and fake headlines.[105]

2) Addressing Waning Pertussis Immunity & Asymptomatic Transmission:

With a waning immunity, the desired herd-immunity may not be attained at a given point in time, which poses increased risks of infections in communities. This is further exacerbated with the vaccine coverage encompassing only about 31.7% of adults in the U.S. in 2017.[22] Therefore, it is recommended that health authorities place greater emphasis on individuals receiving Tdap boosters every 10 years.[106] Moreover, increasing vaccine access may help strengthen herd immunity, with one study suggesting that children whose providers offer free vaccines are more likely to get vaccinated than children whose providers don't offer free vaccines.[107] Additionally, healthcare professionals employing vaccination reminders (e.g. phone calls, SMS, post-cards, and letters, among other means) have been shown more successful in increasing vaccination uptake.[108,109,110] Moreover, patient education coupled with vaccination reminders is more effective at increasing Human Papillomavirus Vaccine (HPV) uptake than patient education alone; these findings may translate to DTaP/Tdap vaccine uptake.[111]

3) Addressing Surveillance Shortcomings:

In the past, inadequate disease surveillance – slow case identification, tracking, and laxed reporting – has led to delayed public health responses, which have been associated with avoidable harms to the public.

As of August 2025, the CDC-run National Notifiable Diseases Surveillance System (NNDSS) is the most used disease detection software – gathering disease-related data from local, state, and federal health departments across 60 jurisdictions that include the 50 states and 5 U.S. territories.[112] NNDSS compiles information on about 120 diseases, which are deemed notifiable by a joint decision of the CDC and the Council of State and Territorial Epidemiologists (CSTE).[112] NNDSS data is gathered by 3,000 public health departments that then provide that information to 60 specific public health departments, which in turn relay the information to NNDSS.[112]

Despite the wide coverage of NNDSS, the surveillance system presents with some shortcomings, namely that it is based on passive reporting – relies on voluntary physician reporting for accuracy.[112] Subsequently, NNDSS data may not match realistic data on diseases that are historically under-reported, because of either the patient's symptoms mimicking those of other diseases or the patient being asymptomatic, among many other possible scenarios.[112] Furthermore, NNDSS has shown variable data completeness and timeliness rates across states and

jurisdictions.[113,114] Factors contributing to this variability include differences in diagnostic abilities and resources, public and professional awareness of the diseases under investigation, and even differences in case definitions over time.[114]

Given the aforementioned shortcomings of NNDSS, the CDC's Emerging Infections Program established the Enhanced Pertussis Surveillance (EPS) – a system that is built off NNDSS infrastructure but that is dedicated only to a robust surveillance of pertussis cases – in 2011.[115] EPS and NNDSS share common features, such as being population-based systems, adopting the same case definitions as determined by NNDSS and CSTE, and relying on positive diagnostic results from laboratories or healthcare providers who issued the diagnoses.[115] However, EPS and NNDSS differ in many aspects.

While NNDSS is designed to capture a wide range of notifiable diseases, EPS is intended solely for pertussis surveillance.[115] Going off NNDSS foundations, EPS offers enhanced case reporting, detection, and reliability, which is made possible through the additional personnel and the resources employed toward educating healthcare providers to properly and timely test for pertussis.[115] Furthermore, EPS personnel and investigators are tasked with ensuring data reports are accurately completed.[115] Plus, EPS case reports include more variables than NNDSS forms to better capture necessary supplemental information, hence allowing healthcare professionals and health departments to better answer pertussis-related epidemiological questions.[115] Also, EPS dedicates resources to effectively and maximally collect *B. pertussis* isolates and clinical samples routinely, as to better track what new strains are emerging and circulating among a given population in a given region.[115]

Studies have highlighted differences in effectiveness between NNDSS and EPS, with one study reporting EPS yielding significantly higher data completeness rates for many demographic and health variables than NNDSS.[115] The higher completeness rate enables epidemiologists and other researchers to accurately track the distribution and prevalence of disease in a given region. Moreover, a surveillance study in Spain has reported the incidence rate of pertussis among older children and adults as being notably higher when employing enhanced surveillance as opposed to passive surveillance.[116]

In brief, the pertussis-focused EPS is more effective at rendering an accurate picture of an outbreak's spread and severity. However, EPS is operational in only seven states in the U.S., with the remaining states still relying on NNDSS as their primary pertussis tracking system.[117]

ETHICAL PERSPECTIVES

The recent outbreaks of pertussis within the U.S., as exemplified by the sudden spike of cases in recent years, pose pertinent moral challenges to be tackled from the lens of critical public health duties, rights of the person, and community and societal health impacts. This section discusses ethics frameworks impacting public health systems of preparedness and response, encapsulating key areas such as vaccine hesitancy and reluctance, vaccine access equity, and moral authority for the protection of vulnerable populations.

The values of equity and fairness drive the moral responsibility of public health professionals providing for the community's health. With increases in pertussis cases, particularly among susceptible groups of people such as infants and the elderly, there is an increasing need to curtail the spread of the disease through interventions, while also guaranteeing the equitable coverage of prevention services such as immunization.[118,119] In regards to the ethical standard of distributive justice, healthcare facilities should be allocated on an equal basis and the most susceptible or marginal groups of people, such as those residing in impoverished neighborhoods or vaccine-averse communities, should be provided with sufficient help because they are likely to be at a high risk of contracting the infection.[119,120]

There is an ethical obligation for public health professionals to use successful public health interventions and specific communication interventions for vaccine uptake in high-risk groups.[121,122] This comprises culturally appropriate educational interventions capable of eliminating myths and generating community trust in immunization efforts. An example of this includes the application of presumptive language in reference to vaccinations, which

would increase uptake substantially and be in concordance with the ethical obligation to promote public health and simultaneously protect vulnerable babies too young to opt themselves into getting vaccinated.[121] A major factor for ethical practice in public health also necessitates long-term interventions capable of tackling inequality and propelling vaccination not as an individual issue of health choice but as a social issue of responsibility.[123] Vaccine hesitancy constitutes a consistent contributor in the cases of the reported pertussis outbreaks, with evidence to blame non-medical exemptions for pertussis return.[124] The moral risk of vaccine hesitancy is high, as it does compromise the health of the individual on an individual basis and frustrates herd immunity, which is necessary for the protection of people who are unable to get vaccinated. There is an ethical obligation on the part of public health professionals to assist, highlight and overcome causal factors responsible for vaccine hesitancy through respectful discussion and community participation.[125,126]

By utilizing techniques such as motivational interviewing or active listening, healthcare practitioners can efficiently address vaccine-hesitant parents. This moral framework respects the autonomy of an individual yet simultaneously guides them to evidence-informed decision-making through intense risk-benefit analyses of vaccines.[125] An open questioning of the guardian's/patient's misunderstandings and fears allows public health officials to provide evidence-based information to encourage vaccine uptake and ultimately improve community health results.[125]

Of greatest significance in the 2024 pertussis outbreaks is the moral obligation to guard those at highest risk, including infants and immunocompromised individuals. Based on the high pertussis risks and mortality sequelae in younger children, including hospitalization and mortality, prioritizing the vaccination of mothers becomes an overriding moral mandate. Not only does this prevention strategy benefit mothers, but it also transfers immunity to infants and augments immunocompetence in infancy.[127,128] The moral argument for advancing maternal vaccination aligns with the moral standard of beneficence, supporting interventions that benefit people and the public at large.[128] Additionally, it is important that public health measures are not detrimental to poor groups. COVID-19 exposed gaping health care inequities and revealed lessons, which must be translated and utilized to structure existing measures to promote pertussis vaccine administration.[129] Moral public health practice entails an active participation in prevention and being forward thinking to remove barriers that may impede vaccine access, including socioeconomics, health literacy, and abandonment of vulnerable groups.[129,130]

Beyond the rights of a community and an individual, health officials also owe a duty of transparency and responsibility in vaccine allocation and public health policy direction. Ethical public health administration also implies being responsive to data-informed surveillance programs to ensure credible reporting, pertussis case analysis and the implementation of proper interventions.[129,131] Ethical considerations are concerned with partnerships of collaborative efforts between stakeholders, including public health organizations, community leaders, and health practitioners to develop efficient plans for intervention based on empirical evidence.[132]

Public health investments in infrastructure are also what propel the health departments to be well-equipped to educate the population, carry out outreach programs, and effectively monitor and contain disease epidemics. Paternalism is an issue of ethics that comes in here, because it will be on the agenda of public health institutions to promote vaccination in the face of reluctance, especially where the health threat is high and well-established.[122,133]

The current public health scenario reflects a pressing need to counter vaccine hesitancy propagated by false information, especially through avenues like social media. Social media has emerged as a two-edged sword; it acts not only as a platform to disseminate beneficial health messages but also as a hotbed of rumors and anti-immunization attitude.[134,135] From an ethics standpoint, public health practitioners and healthcare professionals are bound to utilize social media as an instrumental tool to counter vaccine misinformation and disseminate trustworthy, reliable vaccine information.

Central to moral medical practice are the values of beneficence and autonomy. Autonomy values an individual's right to well-informed decisions concerning his or her healthcare. For people to be able to effectively make such decisions of autonomy, however, they should also possess accurate and readily accessible information

concerning vaccines.[136,137] The prevalence of misinformation hampers people from being capable of achieving a state of informed consent, resulting in people making harmful choices concerning their health. Therefore, the promotion of public health on the social networking site should be in fulfillment of transparency so that the public would be well-informed concerning the realities of vaccine safety and efficacy.[138] This dedication runs in harmony with the value of beneficence, which obliges us to do good and minimize harm to the public.[135] In taking an active position of countering misinformation and advocating for evidence-based narration, we are capable of aiding not only individuals but also groups of people, and especially the most susceptible groups.[139]

Against the COVID-19 pandemic backdrop, recent history has caused a loss of public trust in health systems and authorities, furthering vaccine reluctance.[140] A collaborative effort to regain confidence through engagement, responsiveness, and accountabilities in communications for health is needed.[141] A historic loss of confidence in healthcare systems creates a collaborative responsibility to be transparent, to actively engage communities, and to counter misinformation. This responsibility extends to public health authorities, healthcare workers, and policymakers who must regain confidence through consistent, evidentiary communications that are pragmatic and credible to the people. Regaining confidence in public health will require a renewed emphasis on conversation and education, including a focus on community voices and a showing of respect for community interests in the vaccination debate.[142]

Moreover, explaining vaccine narratives/background necessitates openness on vaccine development procedures and life-science inquiry limits.[143] Public health officials should accept doubts and discuss contingency plans and realities of vaccine side-effects. Such openness not only adheres to people's autonomy but also facilitates understanding and trust in the public sphere.[141,142] Restoring trust also entails recognizing past mistakes and making a commitment to ensure the community's health needs and concerns are prioritized. Avenues for public comment should be introduced so the public can discuss points of interest or inconvenience regarding vaccinations in an effort to hold health authorities accountable.[138] Within a context of reciprocity and frank communication, public health systems are able to address misinformation and rebuild trust among various groups in the merit of vaccination and public health actions in general.

Therefore, the 2024 U.S. pertussis outbreaks' moral issues demand a triple approach maximizing public health preparedness, countering vaccine hesitancy, and maximizing vaccination access equity. This means a commitment to safety for vulnerable groups along with the promotion of critical decision-making through accountable and transparent public health practice. In exercising the above ethics frameworks and approaches, public health practitioners can strengthen community resilience to existing and impending infectious disease epidemics, ultimately delivering improved population health outcomes.

RECOMMENDATIONS/CONCLUSION

In conclusion, the 2024 pertussis outbreaks in the U.S. have highlighted several weaknesses in the U.S. public health preparedness to disease outbreaks caused by either reemerging or novel pathogens. At the forefront of concerns over the resurgence of previously eradicated diseases are lagging surveillance, vaccine hesitancy, waning public immunity and insufficient public health funding – all of which are possible exacerbators of the pertussis outbreaks.

In response to the numerous possible contributing factors behind the 2024 pertussis outbreaks, evidence-based interventions noted in this article may be adopted to address current and pre-emptively prepare against future pertussis, or even other disease, outbreaks. In brief, we recommend that:

1. Medical professionals employ presumptive language, motivational interviewing, and transparency when communicating with guardians/patients regarding vaccines.

2. Medical professionals amplify community presence through educational forums and local talks in addition to vaccine promotion efforts via seasonal drives, local clinics, and even mobile charitable clinics. Efforts should be concentrated in regions with vulnerable populations.
3. Medical professionals engage different stakeholders from the community to impact health communications, particularly when combating vaccine misinformation. There needs to be joint efforts to advocate for vaccine education.[142] Public health communications should be built on communal messaging from community leaders who are highly trusted, such as healthcare workers, teachers, and community officials that are connected within the population.[143]
4. Medical associations and professionals establish greater social media presence focused on countervailing mis/disinformation.
5. Medical associations allot resources to "pre-bunking" videos aimed at training individuals to better identify the purposeful propagation of false information.
6. Healthcare providers encourage Tdap boosters for young and older adults in addition to pregnant women at regular visits and through vaccination reminders in the form of phone calls, text messages, emails, and post-cards.
7. EPS coverage be expanded to U.S. jurisdictions that still employ NNDSS to track pertussis outbreaks.
8. Healthcare advocacy groups lobby for increased public health funding. According to the Association of State and Territorial Health Officials, state expenditure on public health in 2018 consisted of federal, state and other contributions, with federal sources contributing 53% to state health departments' budgets.[144] Furthermore, health departments at the level of cities, counties, and tribes drew 55% of their budget from federal contributions, 21% from state sources, 14% from local sources, and about 10% from other contributors.[66] Therefore, a considerable increase in public heath funding requires efforts on multiple fronts. Hence, healthcare lobbyists should engage state and federal officials by highlighting the economic benefits of increased public health spending (e.g. vaccinating the estimated 117 million children born in the U.S. between 1994 and 2023 would have prevented approximately 32,000,000 hospitalizations and 1,129,000 deaths, in addition to around $540 billion in direct costs).[145]

REFERENCES

1. Huremović D. Brief History of Pandemics (Pandemics Throughout History). *Psychiatry of Pandemics*. 2019;7-35. Published 2019 May 16. doi:10.1007/978-3-030-15346-5_2

2. Glatter KA, Finkelman P. History of the Plague: An Ancient Pandemic for the Age of COVID-19. *Am J Med*. 2021;134(2):176-181. doi:10.1016/j.amjmed.2020.08.019

3. World Health Organization. HIV data and statistics. WHO. Published 2025. Accessed August 2025. https://www.who.int/teams/global-hiv-hepatitis-and-stis-programmes/hiv/strategic-information/hiv-data-and-statistics

4. Spreeuwenberg P, Kroneman M, Paget J. Reassessing the Global Mortality Burden of the 1918 Influenza Pandemic. *Am J Epidemiol*. 2018;187(12):2561-2567. doi:10.1093/aje/kwy191

5. Johnson NP, Mueller J. Updating the accounts: global mortality of the 1918-1920 "Spanish" influenza pandemic. *Bull Hist Med*. 2002;76(1):105-115. doi:10.1353/bhm.2002.0022

6. Simoes EJ, Jackson-Thompson J. The United States public health services failure to control the coronavirus epidemic. *Prev Med Rep*. 2023;31:102090. doi:10.1016/j.pmedr.2022.102090

7. DeSalvo K, Hughes B, Bassett M, et al. Public Health COVID-19 Impact Assessment: Lessons Learned and Compelling Needs. *NAM Perspect*. 2021;2021:10.31478/202104c. Published 2021 Apr 7. doi:10.31478/202104c

8. Ruhm CJ. Excess deaths in the United States during the first year of COVID-19. *Prev Med*. 2022;162:107174. doi:10.1016/j.ypmed.2022.107174

9. CDC. COVID Data Tracker. U.S. Centers for Disease Control and Prevention. Published March 28, 2020. https://covid.cdc.gov/covid-data-tracker/#trends_totaldeaths_select_00

10. Walmsley T, Rose A, John R, et al. Macroeconomic consequences of the COVID-19 pandemic. *Econ Model*. 2023;120:106147. doi:10.1016/j.econmod.2022.106147

11. Walmsley T, Rose A, John R, et al. Macroeconomic consequences of the COVID-19 pandemic. *Econ Model*. 2023;120:106147. doi:10.1016/j.econmod.2022.106147

12. Pertussis Surveillance and trends. Whooping Cough (Pertussis). Published June 11, 2025. https://www.cdc.gov/pertussis/php/surveillance/index.html

13. Centers for Disease Control and Prevention (U.S.). Center for Surveillance, Epidemiology, and Laboratory Services. National Notifiable Disease Surveillance System. Pertussis: (Week 52) Weekly cases of notifiable diseases, United States, U.S. Territories, and Non-U.S. Residents week ending December 28, 2024. 2024;52. https://stacks.cdc.gov/view/cdc/175367

14. Nieves DJ, Heininger U. Bordetella pertussis. *Microbiology Spectrum*. 2016;4(3). doi:10.1128/microbiolspec.ei10-0008-2015

15. Finger H, von Koenig CHW. Bordetella. In: Baron S, editor. Medical Microbiology. 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996. Chapter 31. Available from: https://www.ncbi.nlm.nih.gov/books/NBK7813/

16. Lauria AM, Zabbo CP. Pertussis. StatPearls - NCBI Bookshelf. Published October 7, 2022. https://www.ncbi.nlm.nih.gov/books/NBK519008/

17. Kroes MM, Miranda-Bedate A, Jacobi RHJ, et al. Bordetella pertussis-infected innate immune cells drive the anti-pertussis response of human airway epithelium. *Sci Rep*. 2022;12(1):3622. Published 2022 Mar 7. doi:10.1038/s41598-022-07603-8

18. Decker, M. D., & Edwards, K. M. (2020). Pertussis (Whooping cough). *The Journal of Infectious Diseases*, *224*(Supplement_4), S310–S320. https://doi.org/10.1093/infdis/jiaa469

19. About whooping cough. Whooping Cough (Pertussis). Published April 2, 2024. https://www.cdc.gov/pertussis/about/index.html#:~:text=from%20getting%20sick.-,Age,having%20severe%20complications%20from%20it

20. *Pertussis cases by year (1922-2022)*. U.S. Centers for Disease Control and Prevention. Published (2024, July 23). https://www.cdc.gov/pertussis/php/surveillance/pertussis-cases-by-year.html

21. *Chapter 16: Pertussis*. Epidemiology and Prevention of Vaccine-Preventable Diseases. Published April 12, 2024. https://www.cdc.gov/pinkbook/hcp/table-of-contents/chapter-16-pertussis.html#:~:text=Pertussis%2Dcontaining%20Vaccines&text=Whole%2Dcell%20pertussis%20vaccines%20were,(as%20DTP)%20in%201948

22. Chapter 16: Pertussis. Epidemiology and Prevention of Vaccine-Preventable Diseases. Published April 12, 2024. https://www.cdc.gov/pinkbook/hcp/table-of-contents/chapter-16-pertussis.html

23. Scruggs-Wodkowski E, Malani P. What Is Pertussis? *JAMA.* 2024;332(12):1030. doi:10.1001/jama.2024.9049

24. Clinical overview of pertussis. Whooping Cough (Pertussis). U.S. Centers for Disease Control and Prevention. Published April 2, 2024. https://www.cdc.gov/pertussis/hcp/clinical-overview/index.html

25. Clinical features of pertussis. Pertussis (Whooping Cough). U.S. Centers for Disease Control and Prevention. Published April 2, 2024. https://www.cdc.gov/pertussis/hcp/clinical-signs/index.html

26. Hewlett EL, Burns DL, Cotter PA, et al. Pertussis Pathogenesis--What We Know and what We Don't know. *The Journal of Infectious Diseases*. 2014;209(7):982-985. doi:10.1093/infdis/jit639

27. Laboratory testing for pertussis. Whooping Cough (Pertussis). U.S. Centers for Disease Control and Prevention. Published April 2, 2024. https://www.cdc.gov/pertussis/php/laboratories/index.html

28. Van Der Zee A, Schellekens JFP, Mooi FR. Laboratory diagnosis of pertussis. *Clinical Microbiology Reviews*. 2015;28(4):1005-1026. doi:10.1128/cmr.00031-15

29. Hoppe JE. Neonatal pertussis. *Pediatr Infect Dis J*. 2000;19(3):244-247. doi:10.1097/00006454-200003000-00014

30. Mi YM, Deng JK, Zhang T, et al. Expert consensus for pertussis in children: new concepts in diagnosis and treatment. *World Journal of Pediatrics*. 2024;20(12):1209-1222. doi:10.1007/s12519-024-00848-5

31. Treatment of pertussis. Whooping Cough (Pertussis). U.S. Centers for Disease Control and Prevention. Published November 6, 2024. https://www.cdc.gov/pertussis/hcp/clinical-care/index.html

32. Pertussis -- Infection Control in Healthcare Personnel: Epidemiology and Control of Selected Infections Transmitted Among Healthcare Personnel and Patients (2024). Centers for Disease Control and Prevention. Published March 25, 2024. Accessed August 2025. https://www.cdc.gov/infection-control/hcp/healthcare-personnel-epidemiology-control/pertussis.html#:~:text=Symptomatic%20persons%20who%20receive%20effective,the%20onset%20of%20paroxysms21

33. Pertussis (whooping cough) resources. American Medical Association. Published May 15, 2025.https://www.ama-assn.org/delivering-care/public-health/pertussis-whooping-cough-resources#:~:text=Infection%20prevention%20&%20control,prolonged%20exposure%20to%20respiratory%20secretions.

34. Administering diphtheria, tetanus, and pertussis vaccines | CDC. Centers for Disease Control and Prevention. Accessed August 2025. https://www.cdc.gov/vaccines/vpd/dtap-tdap-td/hcp/administering-vaccine.html#:~:text=receiving%20the%20vaccine.-,Infants%20and%20young%20children,or%20after%20their%20fourth%20birthday

35. Brooks DA, Clover R. Pertussis infection in the United States: role for vaccination of adolescents and adults. *J Am Board Fam Med*. 2006;19(6):603-611. doi:10.3122/jabfm.19.6.603

36. Sutter RW, Cochi SL. Pertussis Hospitalizations and Mortality in the United States, 1985-1988: Evaluation of the Completeness of National Reporting. *JAMA*. 1992;267(3):386–391. doi:10.1001/jama.1992.03480030064038

37. Macina D, Mathur S, Dvaretskaya M, et al. Estimating the pertussis burden in adolescents and adults in the United States between 2007 and 2019. *Hum Vaccin Immunother*. 2023;19(1):2208514. doi:10.1080/21645515.2023.2208514

38. Nakamura Y, Kamachi K, Toyoizumi-Ajisaka H, et al. Marked difference between adults and children in Bordetella pertussis DNA load in nasopharyngeal swabs. *Clin Microbiol Infect*. 2011;17(3):365-370. doi:10.1111/j.1469-0691.2010.03255.x

39. Pertussis Laboratory Testing - MN Dept. of Health. Accessed August 2025. https://www.health.state.mn.us/diseases/pertussis/hcp/labfacts.html

40. Sanstead E, Kenyon C, Rowley S, et al. Understanding Trends in Pertussis Incidence: An Agent-Based Model Approach. *Am J Public Health*. 2015;105(9):e42-e47. doi:10.2105/AJPH.2015.302794

41. Masseria C, Krishnarajah G. The estimated incidence of pertussis in people aged 50 years old in the United States, 2006–2010. *BMC Infectious Diseases*. 2015;15(1). doi:10.1186/s12879-015-1269-1

42. McGuiness, C.B., Hill, J., Fonseca, E. et al. The disease burden of pertussis in adults 50 years old and older in the United States: a retrospective study. BMC Infect Dis 13, 32 (2013). https://doi.org/10.1186/1471-2334-13-32

43. MacIntyre CR, de Sousa JC, Heininger U, et al. Public health management of pertussis in adults: Practical challenges and future strategies. *Hum Vaccin Immunother*. 2024;20(1):2377904. doi:10.1080/21645515.2024.2377904

44. Wilkinson TMA, Van den Steen P, Cheuvart B, et al. Seroprevalence of *Bordetella pertussis* Infection in Patients With Chronic Obstructive Pulmonary Disease in England: Analysis of the AERIS Cohort. *COPD*. 2021;18(3):341-348. doi:10.1080/15412555.2021.1920904

45. Kwon JH, Wi CI, Seol HY, et al. Risk, Mechanisms and Implications of Asthma-Associated Infectious and Inflammatory Multimorbidities (AIMs) among Individuals With Asthma: a Systematic Review and a Case Study. *Allergy Asthma Immunol Res*. 2021;13(5):697-718. doi:10.4168/aair.2021.13.5.697

46. Liu BC, McIntyre P, Kaldor JM, Quinn HE, Ridda I, Banks E. Pertussis in older adults: prospective study of risk factors and morbidity. *Clin Infect Dis*. 2012;55(11):1450-1456. doi:10.1093/cid/cis627

47. Kardos P, Correia de Sousa J, Heininger U, et al. Understanding the impact of adult pertussis and current approaches to vaccination: A narrative review and expert panel recommendations. *Hum Vaccin Immunother*. 2024;20(1):2324547. doi:10.1080/21645515.2024.2324547

48. Esposito S, Principi N; European Society of Clinical Microbiology and Infectious Diseases (ESCMID) Vaccine Study Group (EVASG). Immunization against pertussis in adolescents and adults. *Clin Microbiol Infect*. 2016;22 Suppl 5:S89-S95. doi:10.1016/j.cmi.2016.01.003

49. Evans NJ, Arakkal AT, Cavanaugh JE, Newland JG, Polgreen PM, Miller AC. The incidence, duration, risk factors, and age-based variation of missed opportunities to diagnose pertussis: A population-based cohort study. *Infect Control Hosp Epidemiol*. 2023;44(10):1629-1636. doi:10.1017/ice.2023.31

50. Damron FH, Barbier M, Dubey P, et al. Overcoming Waning Immunity in Pertussis Vaccines: Workshop of the National Institute of Allergy and Infectious Diseases. *J Immunol*. 2020;205(4):877-882. doi:10.4049/jimmunol.2000676

51. Lapidot R, Gill CJ. The Pertussis resurgence: putting together the pieces of the puzzle. *Trop Dis Travel Med Vaccines*. 2016;2:26. Published 2016 Dec 12. doi:10.1186/s40794-016-0043-8

52. Chit A, Zivaripiran H, Shin T, et al. Acellular pertussis vaccines effectiveness over time: A systematic review, meta-analysis and modeling study. *PLoS One*. 2018;13(6):e0197970. Published 2018 Jun 18. doi:10.1371/journal.pone.0197970

53. Misegades LK, Winter K, Harriman K, et al. Association of childhood pertussis with receipt of 5 doses of pertussis vaccine by time since last vaccine dose, California, 2010. *JAMA*. 2012;308(20):2126-2132. doi:10.1001/jama.2012.14939

54. Pawloski LC, Queenan AM, Cassiday PK, et al. Prevalence and molecular characterization of pertactin-deficient Bordetella pertussis in the United States. *Clin Vaccine Immunol*. 2014;21(2):119-125. doi:10.1128/CVI.00717-13

55. Barkoff AM, Mertsola J, Pierard D, et al. Pertactin-deficient *Bordetella pertussis* isolates: evidence of increased circulation in Europe, 1998 to 2015. *Euro Surveill*. 2019;24(7):1700832. doi:10.2807/1560-7917.ES.2019.24.7.1700832

56. Alghounaim M, Alsaffar Z, Alfraij A, Bin-Hasan S, Hussain E. Whole-Cell and Acellular Pertussis Vaccine: Reflections on Efficacy. *Med Princ Pract*. 2022;31(4):313-321. doi:10.1159/000525468

57. Craig R, Kunkel E, Crowcroft NS, et al. Asymptomatic Infection and Transmission of Pertussis in Households: A Systematic Review. *Clin Infect Dis*. 2020;70(1):152-161. doi:10.1093/cid/ciz531

58. de Graaf H, Ibrahim M, Hill AR, et al. Controlled Human Infection With Bordetella pertussis Induces Asymptomatic, Immunizing Colonization. *Clin Infect Dis*. 2020;71(2):403-411. doi:10.1093/cid/ciz840

59. MacDonald NE; SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: Definition, scope and determinants. *Vaccine*. 2015;33(34):4161-4164. doi:10.1016/j.vaccine.2015.04.036

60. Wang Y, Shi N, Wang Q, Yang L, Cui T, Jin H. The association between vaccine hesitancy and pertussis: a systematic review and meta-analysis. *Ital J Pediatr*. 2023;49(1):81. Published 2023 Jul 13. doi:10.1186/s13052-023-01495-8

61. Vaccination Coverage and Exemptions among Kindergartners. SchoolVaxView. Published July 31, 2025. Accessed August 2025. https://www.cdc.gov/schoolvaxview/data/?CDC_AAref_Val=https://www.cdc.gov/vaccines/imz-managers/coverage/schoolvaxview/data-reports/index.html

62. Seither R, Yusuf OB, Dramann D, et al. Coverage with Selected Vaccines and Exemption Rates Among Children in Kindergarten — United States, 2023–24 School Year. *MMWR Morbidity and Mortality Weekly Report*. 2024;73(41):925-932. doi:10.15585/mmwr.mm7341a3

63. Aloe C, Kulldorff M, Bloom BR. Geospatial analysis of nonmedical vaccine exemptions and pertussis outbreaks in the United States. *Proc Natl Acad Sci U S A*. 2017;114(27):7101-7105. doi:10.1073/pnas.1700240114

64. Krishnarajah G, Malangone-Monaco E, Palmer L, Riehle E, Buck PO. Age-appropriate compliance and completion of up to five doses of pertussis vaccine in US children. *Hum Vaccin Immunother*. 2018;14(12):2932-2939. doi:10.1080/21645515.2018.1502526

65. Leider JP, Resnick B, McCullough JM, Alfonso YN, Bishai D. Inaccuracy of Official Estimates of Public Health Spending in the United States, 2000-2018. *Am J Public Health*. 2020;110(S2):S194-S196. doi:10.2105/AJPH.2020.305709

66. Kffmichaelp. U.S. Public health. KFF. Published August 14, 2025. https://www.kff.org/other-health/health-policy-101-u-s-public-health/?entry=table-of-contents-public-health-funding

67. DeSalvo K, Parekh A, Hoagland GW, et al. Developing a Financing System to Support Public Health Infrastructure. Am J Public Health. 2019;109(10):1358-1361. doi:10.2105/AJPH.2019.305214

68. Alford A, NACCHO, ZS Associates, et al. National Profile of Local Health Departments.; 2019. https://www.naccho.org/uploads/downloadable-resources/Programs/Public-Health-Infrastructure/NACCHO_2019_Profile_final.pdf

69. Public Health Emergency Preparedness (PHEP) program and guidance. State and Local Readiness. Published August 16, 2024. https://www.cdc.gov/readiness/php/phep/index.html

70. Trust for America's Health. The impact of chronic underfunding on America's public Health System 2024: Trends, risks, and Recommendations. TFAH. Published July 23, 2025. Accessed August 2025. https://www.tfah.org/report-details/funding-2024/

71. Alfonso YN, Leider JP, Resnick B, McCullough JM, Bishai D. US Public Health Neglected: Flat Or Declining Spending Left States Ill Equipped To Respond To COVID-19. Health Aff (Millwood). 2021;40(4):664-671. doi:10.1377/hlthaff.2020.01084

72. Ten threats to global health in 2019. https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019

73. Larson HJ, Gakidou E, Murray CJL. The Vaccine-Hesitant Moment. *N Engl J Med*. 2022;387(1):58-65. doi:10.1056/NEJMra2106441

74. Jacobson RM, St Sauver JL, Griffin JM, MacLaughlin KL, Finney Rutten LJ. How health care providers should address vaccine hesitancy in the clinical setting: Evidence for presumptive language in making a strong recommendation. *Hum Vaccin Immunother*. 2020;16(9):2131-2135. doi:10.1080/21645515.2020.1735226

75. Opel DJ, Heritage J, Taylor JA, et al. The architecture of provider-parent vaccine discussions at health supervision visits. *Pediatrics*. 2013;132(6):1037-1046. doi:10.1542/peds.2013-2037

76. Hofstetter AM, Robinson JD, Lepere K, Cunningham M, Etsekson N, Opel DJ. Clinician-parent discussions about influenza vaccination of children and their association with vaccine acceptance. *Vaccine*. 2017;35(20):2709-2715. doi:10.1016/j.vaccine.2017.03.077

77. Opel DJ, Zhou C, Robinson JD, et al. Impact of Childhood Vaccine Discussion Format Over Time on Immunization Status. *Acad Pediatr*. 2018;18(4):430-436. doi:10.1016/j.acap.2017.12.009

78. Wegwarth O, Hertwig R, Giese H, Fineberg HV. The impact of nontransparent health communication during the COVID-19 pandemic on vaccine-hesitant people's perception of vaccines. *Front Public Health*. 2024;11:1256829. Published 2024 Jan 8. doi:10.3389/fpubh.2023.1256829

79. Joslyn S, Qin C, Han JH, Savelli S, Agrawal N. Reducing vaccine hesitancy by explaining vaccine science. *J Exp Psychol Appl*. 2023;29(3):489-528. doi:10.1037/xap0000464

80. Song I, Lee SH. COVID-19 vaccine refusal associated with health literacy: findings from a population-based survey in Korea. *BMC Public Health*. 2023;23(1):255. Published 2023 Feb 6. doi:10.1186/s12889-023-15182-0

81. Emery RL, Wimmer M. Motivational interviewing. StatPearls - NCBI Bookshelf. Published February 9, 2023. https://www.ncbi.nlm.nih.gov/books/NBK589705/

82. Kaufman J, Ryan R, Walsh L, et al. Face-to-face interventions for informing or educating parents about early childhood vaccination. *Cochrane Library*. 2018;2018(5). doi:10.1002/14651858.cd010038.pub3

83. Gagneur A. Motivational interviewing: A powerful tool to address vaccine hesitancy, CCDR 46(4). Canada.ca. Published April 7, 2020. https://www.canada.ca/en/public-health/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2020-46/issue-4-april-2-2020/article-6-canvax-addressing-vaccine-hesitancy.html

84. Lemaitre T, Carrier N, Farrands A, Gosselin V, Petit G, Gagneur A. Impact of a vaccination promotion intervention using motivational interview techniques on long-term vaccine coverage: the PromoVac strategy. *Human Vaccines & Immunotherapeutics*. 2018;15(3):732-739. doi:10.1080/21645515.2018.1549451

85. Cole JW, M H Chen A, McGuire K, Berman S, Gardner J, Teegala Y. Motivational interviewing and vaccine acceptance in children: The MOTIVE study. *Vaccine*. 2022;40(12):1846-1854. doi:10.1016/j.vaccine.2022.01.058

86. Coley KC, Gessler C, McGivney M, Richardson R, DeJames J, Berenbrok LA. Increasing adult vaccinations at a regional supermarket chain pharmacy: A multi-site demonstration project. *Vaccine*. 2020;38(24):4044-4049. doi:10.1016/j.vaccine.2020.02.040

87. Chen AMH, Anthony A, Balogun A, Pereira R, Cole JW. The Impact of Motivational Interviewing and MOTIVE Tool Use by Pharmacists on Vaccine Acceptance. *Pharmacy (Basel)*. 2024;12(4):114. Published 2024 Jul 24. doi:10.3390/pharmacy12040114

88. Berenbrok LA, Tang S, Gabriel N, et al. Access to community pharmacies: A nationwide geographic information systems cross-sectional analysis. *J Am Pharm Assoc (2003)*. 2022;62(6):1816-1822.e2. doi:10.1016/j.japh.2022.07.003

89. Li PC, Theis SR, Kelly D, et al. Impact of an Education Intervention on COVID-19 Vaccine Hesitancy in a Military Base Population. *Mil Med*. 2022;187(11-12):e1449-e1455. doi:10.1093/milmed/usab363

90. Kreuter MW, Butler T, Kinzer H, et al. Addressing COVID-19 Vaccine Hesitancy With Community Distribution of Conversation Cards. *Am J Public Health*. 2024;114(S1):S87-S91. doi:10.2105/AJPH.2023.307481

91. Kaufman J, Overmars I, Leask J, et al. Vaccine Champions Training Program: Empowering Community Leaders to Advocate for COVID-19 Vaccines. Vaccines (Basel). 2022;10(11):1893. Published 2022 Nov 9. doi:10.3390/vaccines10111893

92. Msunyaro E, Rangi J, Haonga T, et al. Contribution of community champions to accelerate the uptake of COVID-19 vaccination in Rukwa region, Tanzania, February - October 2022. Pan Afr Med J. 2023;45(Suppl 1):5. Published 2023 Jun 8. doi:10.11604/pamj.supp.2023.45.1.39705

93. Kaufman J, Overmars I, Fong J, et al. Training health workers and community influencers to be Vaccine Champions: a mixed-methods RE-AIM evaluation. *BMJ Glob Health*. 2024;9(9):e015433. Published 2024 Sep 8. doi:10.1136/bmjgh-2024-015433

94. Slaunwhite JM, Smith SM, Fleming MT, Strang R, Lockhart C. Increasing vaccination rates among health care workers using unit "champions" as a motivator. *Can J Infect Control*. 2009;24(3):159-164.

95. Heisler-MacKinnon JA, Queen T, Yi Kong W, et al. Identifying effective vaccine champions: Findings from a national survey of primary care professionals. *Vaccine*. 2024;42(13):3148-3152. doi:10.1016/j.vaccine.2024.04.003

96. Taubert F, Meyer-Hoeven G, Schmid P, Gerdes P, Betsch C. Conspiracy narratives and vaccine hesitancy: a scoping review of prevalence, impact, and interventions. *BMC Public Health*. 2024;24(1):3325. Published 2024 Nov 29. doi:10.1186/s12889-024-20797-y

97. Bollenbacher J, Menczer F, Bryden J. Effects of antivaccine tweets on COVID-19 vaccinations, cases, and deaths. arXiv.org. Published June 13, 2024. https://arxiv.org/abs/2406.09142

98. Loomba S, de Figueiredo A, Piatek SJ, de Graaf K, Larson HJ. Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nat Hum Behav*. 2021;5(3):337-348. doi:10.1038/s41562-021-01056-1

99. Office of the Surgeon General. Health Literacy Reports And Publications. May 14, 2019. Accessed August 2025. https://www.hhs.gov/surgeongeneral/reports-and-publications/health-literacy/index.html

100. Gerend MA, Murdock C, Grove K. An intervention for increasing HPV vaccination on a university campus. *Vaccine*. 2020;38(4):725-729. doi:10.1016/j.vaccine.2019.11.028

101. van der Linden S, Leiserowitz A, Rosenthal S, Maibach E. Inoculating the Public against Misinformation about Climate Change. *Glob Chall*. 2017;1(2):1600008. Published 2017 Jan 23. doi:10.1002/gch2.201600008

102. Traberg CS, Harjani T, Basol M, et al. Prebunking Against Misinformation in the Modern Digital Age. In: Purnat TD, Nguyen T, Briand S, eds. *Managing Infodemics in the 21st Century: Addressing New Public Health Challenges in the Information Ecosystem*. Cham (CH): Springer; May 10, 2023.99-111.

103. Piltch-Loeb R, Su M, Hughes B, et al. Testing the Efficacy of Attitudinal Inoculation Videos to Enhance COVID-19 Vaccine Acceptance: Quasi-Experimental Intervention Trial. *JMIR Public Health and Surveillance*. 2022;8(6):e34615.https://doi.org/10.2196/34615

104. Kroes MM, Miranda-Bedate A, Jacobi RHJ, et al. Bordetella pertussis-infected innate immune cells drive the anti-pertussis response of human airway epithelium. *Sci Rep*. 2022;12(1):3622. Published 2022 Mar 7. doi:10.1038/s41598-022-07603-8

105. Roozenbeek J, Van Der Linden S. Fake news game confers psychological resistance against online misinformation. *Palgrave Communications*. 2019;5(1). doi:10.1057/s41599-019-0279-9

106. McAlister SM, Van Den Biggelaar AHJ, Woodman TL, Hutton H, Thornton RB, Richmond PC. An observational study of antibody responses to a primary or subsequent pertussis booster vaccination in Australian healthcare workers. *Vaccine*. 2021;39(11):1642-1651. doi:10.1016/j.vaccine.2021.01.041

107. Zimmerman RK, Mieczkowski TA, Michel M. Are vaccination rates higher if providers receive free vaccines and follow contraindication guidelines?. *Fam Med*. 1999;31(5):317-323.

108. Jacobson Vann JC, Jacobson RM, Coyne-Beasley T, Asafu-Adjei JK, Szilagyi PG. Patient reminder and recall interventions to improve immunization rates. *Cochrane Database Syst Rev*. 2018;1(1):CD003941. Published 2018 Jan 18. doi:10.1002/14651858.CD003941.pub3

109. Vann JCJ, Jacobson RM, Coyne-Beasley T, Asafu-Adjei JK, Szilagyi PG. Patient reminder and recall interventions to improve immunization rates. *Cochrane Library*. 2018;2018(1). doi:10.1002/14651858.cd003941.pub3

110. Chang TY, Jacobson M, Shah M, Kopetsky M, Pramanik R, Shah SB. Reminders, but not monetary incentives, increase COVID-19 booster uptake. *Proc Natl Acad Sci U S A*. 2023;120(31):e2302725120. doi:10.1073/pnas.2302725120

111. Chandeying N, Thongseiratch T. Systematic review and meta-analysis comparing educational and reminder digital interventions for promoting HPV vaccination uptake. *Npj Digital Medicine*. 2023;6(1). doi:10.1038/s41746-023-00912-w

112. National Notifiable Diseases Surveillance System (NNDSS) - Health, United States. Accessed August 2025. https://www.cdc.gov/nchs/hus/sources-definitions/nndss.htm

113. Adekoya N, Truman BI, Ajani UA. Completeness of reporting of race and ethnicity data in the nationally notifiable diseases surveillance system, United States, 2006-2010. *J Public Health Manag Pract*. 2015;21(2):E16-E22. doi:10.1097/PHH.0000000000000075

114. National Notifiable Diseases Surveillance System (NNDSS) - Healthy People 2030 | odphp.health.gov. Accessed August 2025. https://odphp.health.gov/healthypeople/objectives-and-data/data-sources-and-methods/data-sources/national-notifiable-diseases-surveillance-system-nndss#:~:text=NNDSS%20data%20must%20be%20interpreted,and%20local%20public%20health%20officials

115. Skoff TH, Baumbach J, Cieslak PR. Tracking Pertussis and Evaluating Control Measures through Enhanced Pertussis Surveillance, Emerging Infections Program, United States. *Emerg Infect Dis*. 2015;21(9):1568-1573. doi:10.3201/eid2109.150023

116. Domínguez A, Godoy P, Toledo D, et al. Importance of Enhanced Surveillance for Prevention of Pertussis in Children. *Pediatr Infect Dis J*. 2015;34(7):729-733. doi:10.1097/INF.0000000000000708

117. Pertussis Surveillance and trends. Whooping Cough (Pertussis). Published June 11, 2025. Accessed July 2025. https://www.cdc.gov/pertussis/php/surveillance/index.html#:~:text=Surveillance%20System%20(NNDSS)-,Enhanced%20pertussis%20surveillance,surveillance%20on%20other%20Bordetella%20species

118. Petridou, C., Gray, H., Heard, M., Sugden, L., Davis-Blues, K., Cortes, N., … & Saeed, K. (2017). Outbreak of pertussis among healthcare workers in a hospital maternity unit. Journal of Infection Prevention, 18(5), 253-255. https://doi.org/10.1177/1757177417693678

119. Goldstein, E., Worby, C., & Lipsitch, M. (2018). On the role of different age groups and pertussis vaccines during the 2012 outbreak in wisconsin. Open Forum Infectious Diseases, 5(5). https://doi.org/10.1093/ofid/ofy082

120. Edmunds, M., Mearkle, R., Folliard, J., Anderson, C., Balasegaram, S., Chandra, N., … & Amirthalingam, G. (2021). Retrospective cohort study investigating extent of pertussis transmission during a boarding school outbreak, england, december 2017 to june 2018. Eurosurveillance, 26(26). https://doi.org/10.2807/1560-7917.es.2021.26.26.1900736

121. Mohammed, H., McMillan, M., Roberts, C., & Marshall, H. (2019). A systematic review of interventions to improve uptake of pertussis vaccination in pregnancy. Plos One, 14(3), e0214538. https://doi.org/10.1371/journal.pone.0214538

122. Furuta, M., Sin, J., Ng, E., & Wang, K. (2017). Efficacy and safety of pertussis vaccination for pregnant women – a systematic review of randomised controlled trials and observational studies. BMC Pregnancy and Childbirth, 17(1). https://doi.org/10.1186/s12884-017-1559-2

123. Matthias, J., Pritchard, P., Martin, S., Dusek, C., Cathey, E., D'Alessio, R., … & Kirsch, M. (2016). Sustained transmission of pertussis in vaccinated, 1–5-year-old children in a preschool, florida, usa. Emerging Infectious Diseases, 22(2), 242-246. https://doi.org/10.3201/eid2202.150325

124. Tariku, M., Belete, A., Worede, D., Bante, S., Alehegn, A., Assen, B., … & Misikir, S. (2024). Attack rate, case fatality rate and predictors of pertussis outbreak during pertussis outbreak investigation in ethiopia:

systematic review and meta-analysis. Journal of Epidemiology and Global Health, 14(2), 327-336. https://doi.org/10.1007/s44197-024-00234-4

125. Maas, N., Sanders, E., Versteegh, F., Baauw, A., Westerhof, A., & Melker, H. (2019). Pertussis hospitalizations among term and preterm infants: clinical course and vaccine effectiveness. BMC Infectious Diseases, 19(1). https://doi.org/10.1186/s12879-019-4563-5

126. Mitiku, A., Argaw, M., Desta, B., Tsegaye, Z., Atsa, A., Tefera, B., … & Mulowa, R. (2019). Pertussis outbreak investigation of dara malo district, gamo administrative zone, southern nations, nationalities and peoples region, southern ethiopia.. https://doi.org/10.21203/rs.2.17809/v1

127. Xu, W., Fu, C., Zheng, C., Gong, X., Fang, Q., & Yin, Z. (2024). Epidemiological characteristics and survival analysis of pertussis in quzhou. Human Vaccines & Immunotherapeutics, 20(1). https://doi.org/10.1080/21645515.2024.2420448

128. Barkoff, A., Mertsola, J., Piérard, D., Dalby, T., Hoegh, S., Guillot, S., … & He, Q. (2018). Surveillance of circulating bordetella pertussis strains in europe during 1998 to 2015. Journal of Clinical Microbiology, 56(5). https://doi.org/10.1128/jcm.01998-17

129. Acosta, A., DeBolt, C., Tasslimi, A., Lewis, M., Stewart, L., Misegades, L., … & Patel, M. (2015). Tdap vaccine effectiveness in adolescents during the 2012 washington state pertussis epidemic. Pediatrics, 135(6), 981-989. https://doi.org/10.1542/peds.2014-3358

130. Argaw, M., Desta, B., Tsegaye, Z., Mitiku, A., Atsa, A., Tefera, B., … & Muloiwa, R. (2022). Immunization data quality and decision making in pertussis outbreak management in southern ethiopia: a cross sectional study. Archives of Public Health, 80(1). https://doi.org/10.1186/s13690-022-00805-6

131. Kamachi, K., Yao, S., Chiang, C., Koide, K., Otsuka, N., & Shibayama, K. (2021). Rapid and simple snp genotyping for bordetella pertussis epidemic strain mt27 based on a multiplexed single-base extension assay. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-84409-0

132. Mitiku, A., Argaw, M., Desta, B., Tsegaye, Z., Atsa, A., Tefera, B., … & Mulowa, R. (2020). Pertussis outbreak in southern ethiopia: challenges of detection, management and response.. https://doi.org/10.21203/rs.2.17809/v4

133. Hara, M., Fukuoka, M., Tashiro, K., Ozaki, I., Ohfuji, S., Okada, K., … & Hirota, Y. (2015). Pertussis outbreak in university students and evaluation of acellular pertussis vaccine effectiveness in japan. BMC Infectious Diseases, 15(1). https://doi.org/10.1186/s12879-015-0777-3

134. Steffens, M., Dunn, A., Wiley, K., & Leask, J. (2019). How organisations promoting vaccination respond to misinformation on social media: a qualitative investigation. BMC Public Health, 19(1). https://doi.org/10.1186/s12889-019-7659-3

135. Al-Uqdah, L., Franklin, F., Chiu, C., & Boyd, B. (2022). Associations between social media engagement and vaccine hesitancy. Journal of Community Health, 47(4), 577-587. https://doi.org/10.1007/s10900-022-01081-9

136. McKinley, C., Olivier, E., & Ward, J. (2023). The influence of social media and institutional trust on vaccine hesitancy in france: examining direct and mediating processes. Vaccines, 11(8), 1319. https://doi.org/10.3390/vaccines11081319

137. Carosella, E., Su, M., Testa, M., Arzilli, G., Conni, A., & Savoia, E. (2024). Covid-19 vaccine hesitancy and misinformation endorsement among a sample of native spanish-speakers in the us: a cross-sectional study. Healthcare, 12(15), 1545. https://doi.org/10.3390/healthcare12151545

138. Shedura, V., Mcharo, J., Hussein, A., Mchau, G., & Kamori, D. (2024). Knowledge and perceptions of covid-19 vaccine uptake among adults: a community-based cross-sectional survey in the kilimanjaro region, tanzania.. https://doi.org/10.21203/rs.3.rs-5596319/v1

139. Hussain, A., Tahir, A., Hussain, Z., Sheikh, Z., Gogate, M., Dashtipour, K., … & Sheikh, A. (2021). Artificial intelligence–enabled analysis of public attitudes on facebook and twitter toward covid-19 vaccines in the united kingdom and the united states: observational study. Journal of Medical Internet Research, 23(4), e26627. https://doi.org/10.2196/26627

140. Carrieri, V., Guthmuller, S., & Wübker, A. (2023). Trust and covid-19 vaccine hesitancy. Scientific Reports, 13(1). https://doi.org/10.1038/s41598-023-35974-z

141. Schoch-Spana, M., Brunson, E., Long, R., Ruth, A., Ravi, S., Trotochaud, M., … & White, A. (2021). The public's role in covid-19 vaccination: human-centered recommendations to enhance pandemic vaccine awareness, access, and acceptance in the united states. Vaccine, 39(40), 6004-6012. https://doi.org/10.1016/j.vaccine.2020.10.059

142. Tustin, J., Crowcroft, N., Gesink, D., Johnson, I., Keelan, J., & Lachapelle, B. (2018). User-driven comments on a facebook advertisement recruiting canadian parents in a study on immunization: content analysis. Jmir Public Health and Surveillance, 4(3), e10090. https://doi.org/10.2196/10090

143. Carrieri, V., Guthmuller, S., & Wübker, A. (2022). „don't look up": trust and covid-19 immunization choices... https://doi.org/10.21203/rs.3.rs-2290805/v1

144. ASTHO. State Health Agency Expenditures: 2010-2018.; 2020. https://www.astho.org/4a267c/globalassets/pdf/state-health-agency-expenditures-2010-2018.pdf

145. Zhou F, Jatlaoui TC, Leidner AJ, et al. Health and Economic Benefits of Routine Childhood Immunizations in the Era of the Vaccines for Children Program — United States, 1994–2023. MMWR Morb Mortal Wkly Rep 2024;73:682–685. DOI: http://dx.doi.org/10.15585/mmwr.mm7331a2

AUTHORS' CONTACT INFORMATION

Fredy Abboud, Senior Research Fellow, Institute of Clinical Bioethics, Saint Joseph's University, Philadelphia, Pennsylvania, United States of America

Peter Clark, S.J., Ph.D., Director, Institute of Clinical Bioethics, Saint Joseph's University, Philadelphia, Pennsylvania, United States of America

Shrijal Desai, M.A., OMS-III, Philadelphia College of Osteopathic Medicine, Philadelphia, Pennsylvania, United States of America