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Global Incidence of Pertussis After the COVID-19 Pandemic

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Abstract

IMPORTANCE Pertussis, or whooping cough, is caused by the *Bordetella pertussis* bacterium. It induces prolonged cough in all age groups and is a severe, life-threatening disease in young infants.

OBSERVATIONS In an online workshop organized by the International Bordetella Society on November 12, 2024, most participating countries reported very low pertussis incidence during and immediately following the COVID-19 pandemic. Since that time, many countries have seen large outbreaks of pertussis, particularly in adolescents. Before the pandemic, several countries, especially those using acellular pertussis vaccine in infants, reported circulating *B pertussis* isolates that lacked the acellular vaccine antigen pertactin. However, most recent isolates have been found to express this antigen. A rise in macrolide-resistant *B pertussis* isolates was also reported by several countries.

CONCLUSIONS AND RELEVANCE The potential for large outbreaks of pertussis highlights the importance of maintaining or increasing vaccine coverage in pregnancy and in infants and children. The data presented herein suggest a need for new pertussis vaccines that protect against both disease and infection and that reduce transmission.

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+ Supplemental content

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Introduction

Pertussis, or whooping cough, is a highly contagious respiratory disease caused by the gram-negative bacterium *Bordetella pertussis*. It can cause prolonged cough in all age groups, but the disease is particularly severe in young infants, where it can be life-threatening. Vaccines to prevent pertussis, consisting of inactivated whole *B pertussis* organisms, have been in use for decades. However, local and systemic reactions associated with their use stimulated the development of vaccines made from isolated *B pertussis* antigens, termed *acellular vaccines*. Whole-cell pertussis (wP) vaccines continue to be recommended by the World Health Organization[1] and are used in most lower-income countries, while acellular pertussis (aP) vaccines are used in most higher-income countries. aP vaccines have been shown to be effective, particularly for prevention of severe disease in infants, with aP vaccines recommended in pregnancy in many countries.[2] Despite sustained high vaccine coverage, peaks of pertussis disease continue to occur every 3 to 5 years in some countries, indicating that *B pertussis* continues to circulate and the resulting population immunity plays a role in pertussis disease prevention.

As did many other respiratory infectious diseases, pertussis incidence sharply declined during the COVID-19 pandemic, likely due to nonpharmaceutical interventions such as social distancing and mask wearing. Since the relaxation of these measures, there has been a reestablishment of respiratory virus infections such as respiratory syncytial virus and influenza.[3,4] In contrast to some respiratory viruses, pertussis incidence remained low in the months immediately following relaxation of COVID-19 pandemic restrictions.[5] However, the European Centre for Disease Prevention and Control noted a rise in pertussis cases in several European countries (Austria, Denmark, and Norway) beginning in the second half of 2023.[6] Incidence of pertussis in Denmark reached levels not seen for

over 20 years,[7] and a large outbreak developed in Czechia.[8] In Northern Spain, a pertussis outbreak developed during 2023 that mainly affected children aged between 11 and 15 years, with a rate of 409 cases per 100 000 population in this age group.[9] Between March and September 2024, France experienced a large pertussis outbreak, with total monthly cases rising sharply from a mean (SD) of 16 (26) between 2020 and 2023 to 1123 (1250) in 2024.[10] Reports of very large rises in pertussis incidence also started to appear in China[11,12] and the US.[13] Some geographic regions have less robust pertussis surveillance, and other outbreaks may have been missed.

In response to these increases in pertussis incidence, the International Bordetella Society organized an online workshop on November 12, 2024, to characterize the extent of the problem.[14] At the workshop, pertussis surveillance data from Australia, Japan, China, South Africa, several European and Latin American countries, and the US were presented. Variations in incidence, alongside differences in vaccination schedules, diagnostics, and surveillance systems, were noted in these countries, but most countries reported a marked resurgence of pertussis following the COVID-19 pandemic to levels that exceeded those seen in recent peak years.

Methods

Countries included in the workshop were selected to represent diverse geographic regions and a range of postpandemic pertussis outcomes, based on data quality and availability. Presenting groups were asked to (1) provide information on the country's pertussis vaccination strategy, including vaccine type, schedule, and coverage; (2) describe how pertussis cases are diagnosed and reported; (3) report pertussis case numbers and incidence since the COVID-19 pandemic by age group; and (4) provide any additional available information on current pertussis isolates, including but not limited to pertactin production, antibiotic resistance, and changes in genomic profile.

Results

Pertussis Epidemiology

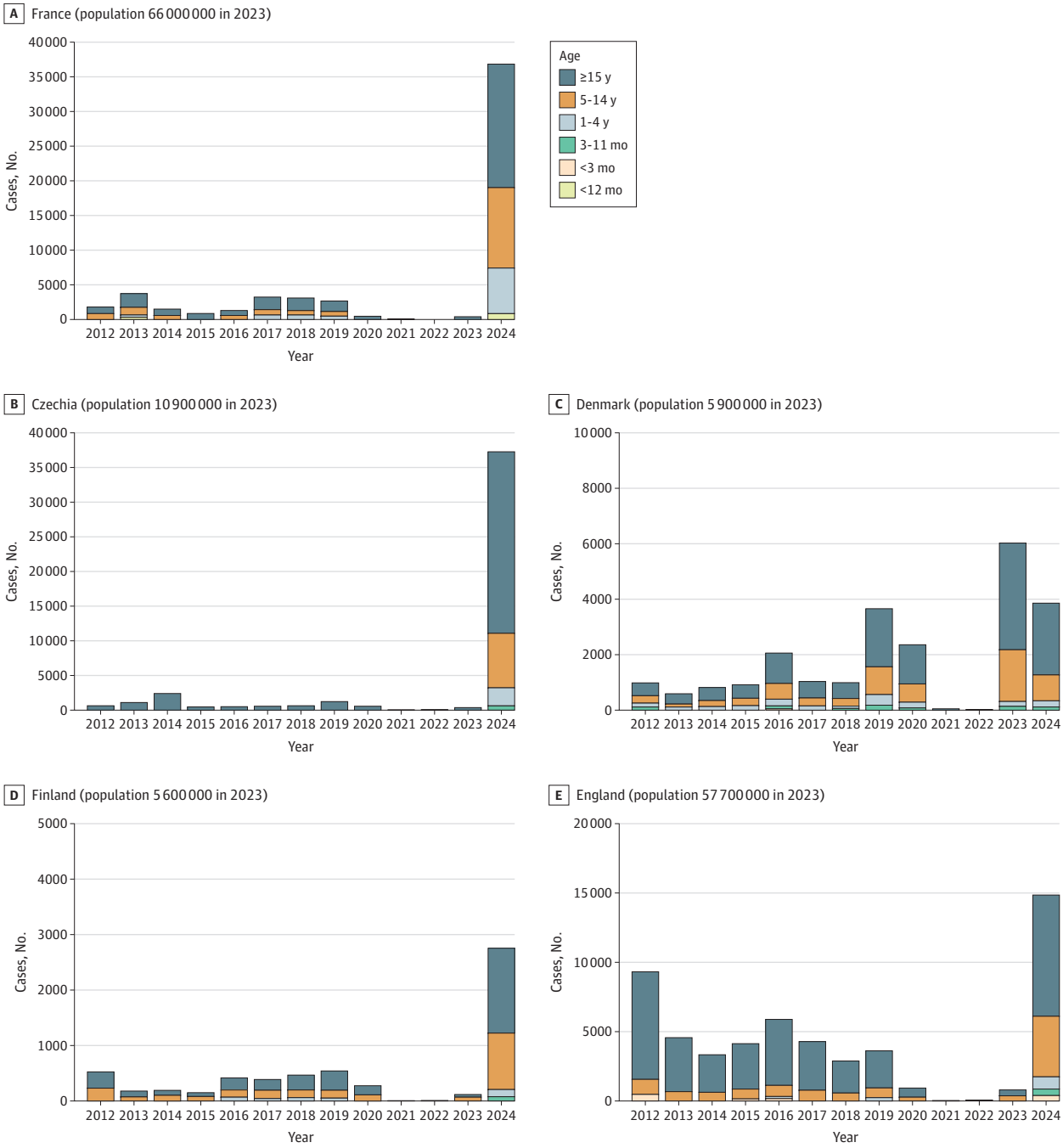
The number of cases of pertussis from 2012 to 2024 for the European countries of France, Czechia, Denmark, Finland, and England are shown in **Figure 1**. Cases of pertussis in Argentina; the US; Japan; the Children's Hospital of Fudan University in Shanghai, China; and Australia are shown in **Figure 2**. Total incidence of pertussis cases in all of the countries except China is shown in **Figure 3**, and incidence rates by age group are shown in eFigures 1 and 2 in the Supplement. Details of the vaccine schedules and coverage for all countries are given in eTable 1 in the Supplement. The key features of pertussis epidemiology from 2012 to 2024 in each country are briefly described herein. The fold increases of pertussis cases (total and by age group) from 2019 to 2024 for Australia, Czechia, Denmark, England, Finland, France, and the US are given in eTable 2 in the Supplement. In addition, the case numbers by age group as a percentage of total cases are plotted in **Figure 4** for the countries that experienced resurgence (Australia, Czechia, Denmark, England, Finland, France, and the US), comparing the latest complete prepandemic year (2019) with the earliest complete postpandemic year (2024). There was an increase in the percentage of cases reported in the group aged 5 to 14 years in Australia (from 41.4% to 57.7%), Czechia (7.4% to 21.1%), France (23.0% to 31.5%), Finland (25.8% to 36.7%), and England (18.7% to 29.3%). The percentage of total cases in children younger than 1 year was similar or reduced when comparing 2019 with 2024, indicating the protection provided by infant and maternal vaccines likely remained effective. COVID-19 mitigation strategies differed across all included countries (eTable 3 in the Supplement), but the findings suggest general reduction in population mixing had a major impact on pertussis and likely many other respiratory diseases. Furthermore, while some countries recently introduced new diagnostic multiplex testing, this had largely been introduced before the COVID-19 pandemic, indicating that changes in case numbers were not due to diagnostic differences alone (eTable 4 in the Supplement).

Specific Countries

France

Vaccines containing aP were introduced in France between 1998 and 2001, with primary aP doses given since 2013 at 2, 4, and 11 months of age and boosters at 6, 11 to 13, and 25 years. Since 2025, boosters at age 45 years and 65 years and every 10 years after 65 years have also been introduced into the French national vaccination plan. Pertussis is not a notifiable disease in France, but Public

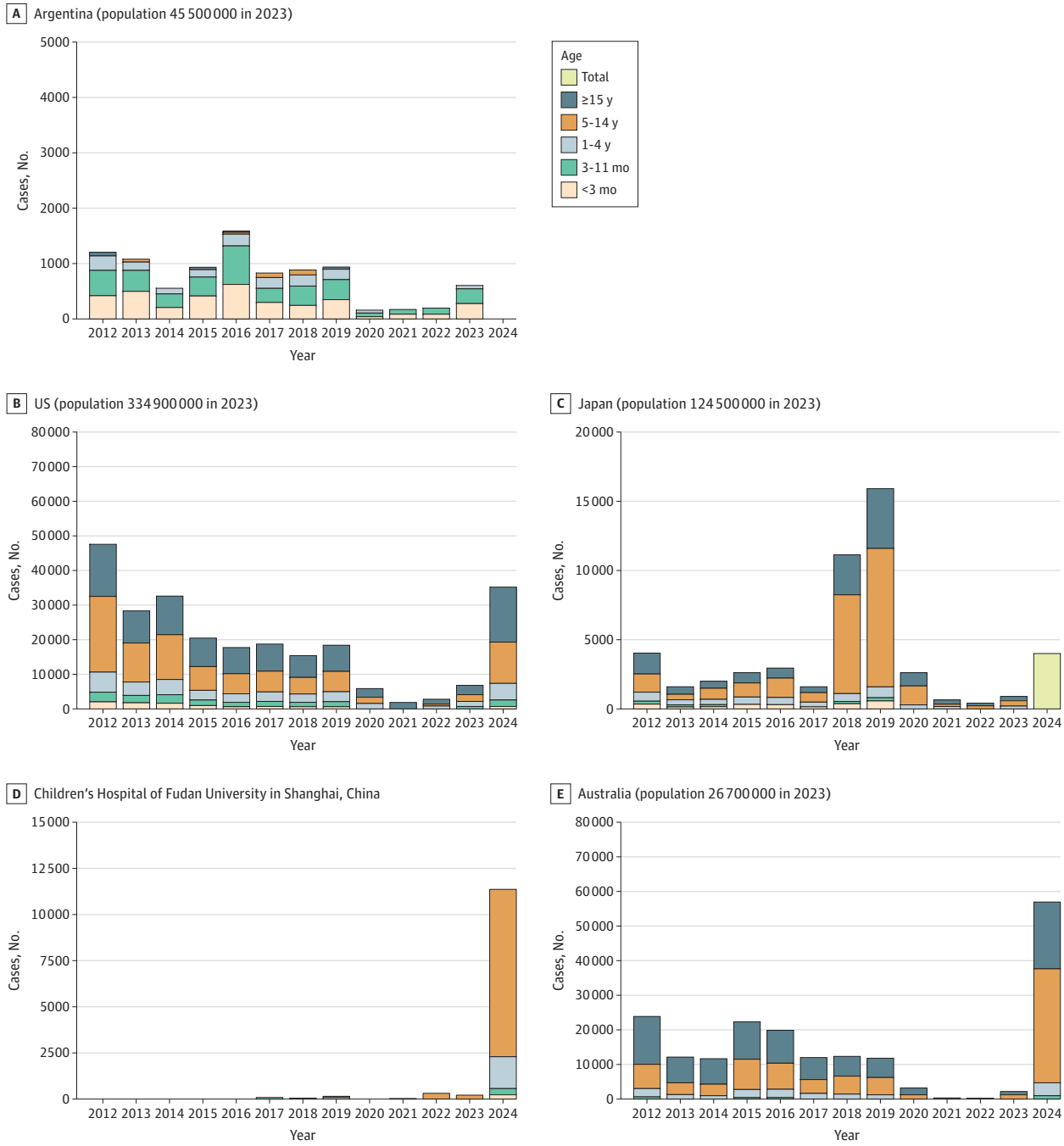
Figure 1. Pertussis Case Numbers From 2012 to 2024 in 5 European Countries



There were very small numbers of pertussis cases (often single digits) in infants and children in all countries from 2020 to 2023 and in Czechia from 2012 to 2023; thus, these numbers may not be evident with the scale selected to show the 2024 case numbers. The data from France did not include specific infant data for ages less than 3 months and 3 to 11 months.

Health France uses several systems to monitor its incidence. Among these, the outpatient laboratory surveillance system provides the most accurate real-time data. According to this surveillance system, almost no cases of pertussis were observed during the COVID-19 pandemic.[15] In 2023, 510 pertussis cases were recorded, but cases began to increase rapidly in early 2024, reaching a total of 5072 cases by May 31 and 36 938 total cases by the end of December 2024 (Figure 1A).[10] Comparing 2019 with 2024, the number of cases increased 13.1-fold, with an 18.7-fold increase in children aged 5 to 14 years

Figure 2. Pertussis Case Numbers From 2012 to 2024 in Argentina, the US, Japan, and Australia and at the Children's Hospital of Fudan University in Shanghai, China



Data were not available from South Africa at the time of submission. There were very small numbers of pertussis cases (often single digits) in infants and children in all countries from 2020 to 2023 and at the Children's Hospital of Fudan University in Shanghai, China, from 2016 to 2023; thus, these numbers may not be evident with the scale selected to show the 2024 case numbers. A, No data were available for 2024. D, No data were available for 2012 to 2015.

(eTable 2 in the Supplement). The overall incidence rate was 58 per 100 000 population, but it was much higher in children aged 1 to 4 years (245 per 100 000 population), followed by children younger than 1 year of age (150 per 100 000) and those aged 5 to 14 years (149 per 100 000 population); these findings were consistent with observations reported by the French national pertussis surveillance system based on reporting by general practitioners.[16]

During this same period, 42 pertussis deaths (20 in infants) were reported in France.[17] In addition, there were several notable changes in the isolated strains. In contrast to prepandemic isolates detected from 2016 to 2020, approximately 50% of which were pertactin-negative and less than 30% were FIM2-positive, almost all postpandemic isolates expressed pertactin (96%) and FIM2 (76%). Another concerning issue was the detection of 17 macrolide-resistant *B pertussis* (MRBP) isolates, representing nearly 2% of the samples processed at France's national reference center. Of the 14 isolates cultured, genomic and microbiological analyses identified them as belonging to the *ptxP3*-MRBP lineage circulating in China (previously designated as MR-MT28). Unlike most isolates collected in 2024, these MRBP isolates were predominantly deficient in pertactin (13 out of 14 [93%]).[18]

Czechia

Czechia introduced aP-containing vaccines in 2004 as a booster for children aged 5 to 6 years, who were previously vaccinated with wP vaccines. Since 2007, Czechia has used only aP-containing vaccines with primary doses at ages 2, 3, and 11 months and boosters at just before 18 months and at

Figure 3. Total Incidence of Pertussis From 2012 to 2024 in Argentina, Australia, Czechia, Denmark, England, Finland, France, Japan, and the US

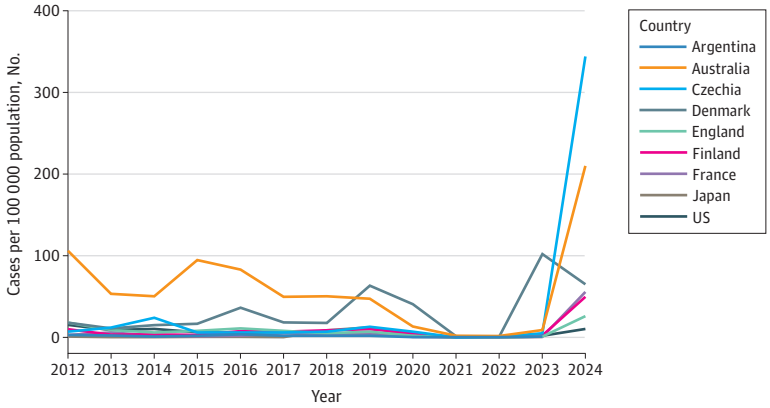
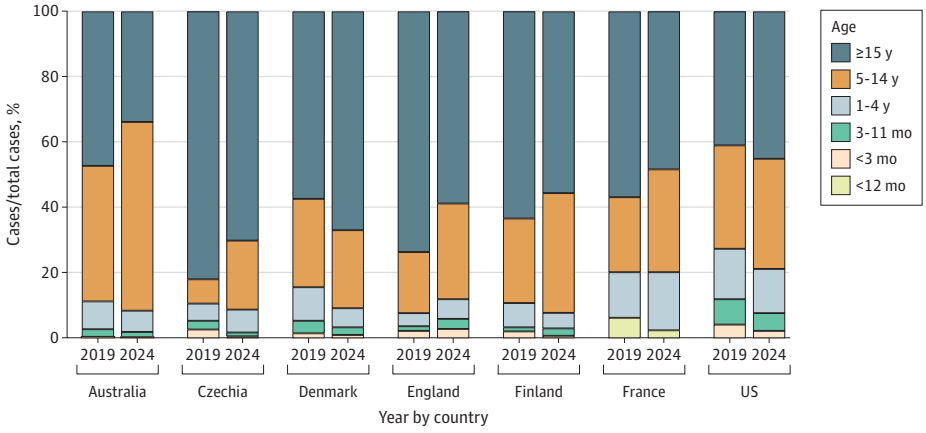


Figure 4. Cases of Pertussis in 2019 and 2024 as a Percentage of the Total Cases by Age



5 to 6 and 10 to 11 years. In 2018, the primary vaccination schedule was changed to doses at 2, 3, and 11 to 13 months. The mean number of pertussis cases between 2012 and 2019 was 977 per year. In 2024, 37 375 cases of pertussis were reported in a population of 10.9 million (Figure 1B), a 26.5-fold increase from 2019 (eTable 2 in the Supplement). This was the highest number of cases seen since the late 1950s.[19] Rates of pertussis disease were highest in infants (695 per 100 000), followed by children aged 5 to 14 years (661 per 100 000) and 1 to 4 years (577 per 100 000). Total incidence in Czechia was 344 per 100 000 population, the highest reported in the countries presented herein (Figure 3 and eFigure 1 in the Supplement). More than 300 *B pertussis* isolates were tested for antibiotic resistance in Czechia, with 3 shown to be resistant to erythromycin and 2 resistant to cotrimoxazole.

Denmark

Denmark has used aP-containing vaccines since 1997, when a pertussis toxin (PT)–only vaccine was introduced. Other multicomponent aP vaccines have been used in Denmark since 2014, with doses given at 3, 5, and 12 months of age and a booster at 5 years. There was a peak of pertussis disease in Denmark in late 2019 before the COVID-19 pandemic, very low incidence during the pandemic, and a resurgence that started in mid-2023 (Figure 1C). This peaked in November 2023 and declined rapidly. Before the COVID-19 pandemic, the highest pertussis rates were seen in individuals aged younger than 1 year in Denmark, but postpandemic, the rate in children aged 5 to 14 years approached that reported in infants aged less than 3 months.

Finland

In Finland, aP-containing vaccines have been in use since 2005, with doses at ages 3, 5, and 12 months followed by boosters at 4, 14, and 25 years, with high coverage for the childhood doses. Incidence of pertussis was extremely low during the COVID-19 pandemic, but like many countries, Finland saw a postpandemic resurgence in 2024 with a total of 2769 cases (Figure 1D), a 4.9-fold increase from 2019 (eTable 2 in the Supplement). Like France, Finland has also seen a switch from pertactin-negative to pertactin-expressing isolates, and 3 of 565 isolates tested were macrolide resistant.[20]

England

In England, aP-containing vaccines replaced wP vaccines for infants in 2004 and are now given at 8, 12, and 16 weeks of age. An aP booster at 3 years, 4 months of age was introduced in 2001. There was a large outbreak of pertussis in England in 2012, with 9357 cases reported.[21] Increased cases with hospitalizations and deaths occurred in young infants aged less than 3 months during this outbreak, leading to the introduction of a pertussis vaccination program in pregnant women in October 2012, which still persists. For individuals aged 1 year or older, case numbers of pertussis remained at elevated levels after 2012, while case numbers in infants fell to levels similar to those in the preoutbreak period (Figure 1E). Historically low numbers of pertussis cases were reported in England during the COVID-19 pandemic period. However, from late 2023, a large postpandemic resurgence was observed, with cases increasing across all ages; 14 905 total cases were confirmed in 2024. One macrolide-resistant isolate was identified in England in 2023 and another in 2024; the proportion of isolates with the *ptxP1* allele also increased.

Argentina

Argentina was the only country represented in the workshop that uses wP-containing vaccines, with doses given at 2, 4, and 6 months of age and boosters at 15 to 18 months and 5 to 6 years. A further booster with an aP-containing vaccine is given at age 11 years. Since 2012, vaccination with an aP-containing vaccine during pregnancy has also been recommended in Argentina, initially as a 1-time recommendation for a single pregnancy. In 2016, the recommendation was expanded to include vaccination during every pregnancy. From 2012 to 2019, the mean (SD) number of cases of

pertussis in Argentina was 1039 (328) per year. During the COVID-19 pandemic, it was less than 200 per year; 605 cases were reported in 2023; and there were no available data from 2024 at the time of the presentation (Figure 2A).

US

In the US, aP-containing vaccines replaced wP-containing vaccines during the 1990s, beginning with aP boosters at ages 15 to 18 months and 4 to 6 years in 1992 and an infant series at 2, 4, and 6 months of age in 1997. Adolescent vaccination with an aP-containing vaccine was introduced in 2005, and aP vaccination in the third trimester of every pregnancy was recommended in 2012. As seen in England, there was a large pertussis outbreak in the US in 2012, with 48 277 reported cases. Between 2013 and 2019, a mean (SD) of 21 935 (6372) cases were reported annually, with progressively smaller peaks during that time. During the COVID-19 pandemic through early 2023, pertussis case reporting in the US was at a historic low. Reporting started to increase in late 2023, and 35 435 total cases were reported in 2024, the largest number of cases since 2014 (Figure 2B).[22] Preliminary data based on a small number of isolates revealed that the proportion of pertactin-negative strains declined from prepandemic years, as seen in other countries. Macrolide resistance continued to be rare, with a single isolate from 2024 resistant to macrolide.

Japan

Japan has used aP-containing vaccines since 1981 and is currently using a 2-component pertussis vaccine containing PT and filamentous hemagglutinin with doses at 2, 3, and 4 months of age and a booster at 12 to 18 months. Before 2018, pertussis cases in Japan were reported from pediatric sentinel sites based solely on clinical symptoms without the requirement for laboratory confirmation. In 2018, the surveillance system transitioned to a case-based notifiable disease system including individuals of all ages, and laboratory confirmation was required. In 2018 and 2019, a combined total of approximately 27 000 cases was reported. Case numbers began to decline at the end of 2019 and remained low, with less than 50 cases reported per week after mid-2020. However, an upward trend in reported cases was observed in 2024 (Figure 2C).

China

Vaccines containing aP have been widely used in China since 2012, with doses at 3, 4, and 5 months of age and boosters at 18 to 24 months and, since 2024, at 6 years. The recent rise in pertussis cases reported at the Children's Hospital of Fudan University, Shanghai, China, is shown in Figure 2D. Of particular concern across China is the recent dominance of MRBP isolates from a *ptxP3* lineage, particularly macrolide-resistant clone MR-MT28, and the predominance of resistant isolates in older, vaccinated children.[23] Similar trends have been reported in Southern China.[24] A recent publication also provides countrywide data documenting the rapid rise in total pertussis cases in China,[25] from 1512 cases reported in June 2023 to 15 275 in January 2024, 91 272 in April 2024, and 97 669 in May 2024, with 25 deaths reported from November 2023 to May 2024.

Australia

Australia has reported some of the highest rates of pertussis in recent years despite high coverage of aP-containing vaccines given as primary doses at 2, 4, and 6 months and boosters at 18 months, 4 years, and 12 to 13 years. Very low numbers of cases were reported during the COVID-19 pandemic.[26] There was a delayed postpandemic resurgence of pertussis compared with that seen in Europe, with a large rise in incidence observed in 2024 (Figure 2E). The highest rates were seen in children aged 5 to 14 years (1003 per 100 000), followed by those aged 1 to 4 years (409 per 100 000). It was reported that the percentage of isolates that lack pertactin in Australia has fallen from nearly 100% prepandemic[27] to 60% postpandemic, with some MRBP isolates detected.

South Africa

South Africa has used aP-containing vaccines since 2009, with primary doses in infants at ages 6, 10, and 12 weeks and a booster at 18 months. Additional boosters at 6 and 12 years were introduced in 2024. Data from a pneumonia surveillance program showed peaks of pertussis cases in 2015, 2017, and 2018. Very few cases were detected during 2020 and 2021, but an increase in cases was observed starting in mid-2022, when COVID-19 restrictions were removed and pertussis case numbers returned to prepandemic levels. The highest number of recent pertussis cases in South Africa was detected in infants younger than 3 months.

Discussion

Pertussis is endemic worldwide, with periodic peaks of disease, suggesting that transmission of *B pertussis* continues in vaccinated populations.[28] Evidence from animal models also suggests that aP-containing vaccines have very little effect on transmission.[5]

Most countries did not see significant drops in pertussis vaccine coverage during the COVID-19 pandemic. However, with less circulation of the *B pertussis* organism during the COVID-19 pandemic, there was likely less asymptomatic infection to boost immunity, making an increased proportion of the population susceptible to pertussis, and this is likely partially responsible for the increases observed in 2023 and 2024. Both vaccine- and infection-induced pertussis immunity wanes over time. Infection with *B pertussis* can be asymptomatic or cause only mild symptoms in previously immune individuals, particularly in adolescents, and this will provide a natural booster to immunity.[29] This natural boosting was likely minimal with COVID-19 mitigation measures, allowing waning of both vaccine-induced immunity and natural boosting on a population level. Of note, some of the highest incidences reported herein were seen in countries that use multiple aP boosters (eg, Australia and Czechia) (Figure 3), suggesting the effectiveness of multiple doses of aP-containing vaccines warrants further investigation. Children aged 5 to 14 years have been shown to be important for transmission to older teenagers and adults,[30] and it is likely this age group maintains population-level immunity against transmission of *B pertussis* that waned during COVID-19 mitigation measures.

Genome diversity in *B pertussis*, measured by single-nucleotide polymorphisms and gene content, is low compared with many other bacteria and has been described by the allelic profiles of the aP antigen genes *ptxA*, *prn*, *fim2*, and *fim3* and the allele of the promoter of the PT locus (primarily either *ptxP1* or *ptxP3*).[31] *ptxP1* isolates have been associated with countries using wP-containing vaccines, while the *ptxP3* allele was first reported in the 1990s in the Netherlands[32] and Finland[33] before the switch to aP-containing vaccines and subsequently became predominant in many countries using aP-containing vaccines.[31] After the COVID-19 pandemic, countries using aP-containing vaccines with stringent COVID-19 mitigation measures had a higher proportion of pertactin-producing *B pertussis* isolates compared with the prepandemic period. It is possible that population immunity to pertactin declined when pertactin-negative strains predominated, reducing the advantage for pertactin-negative strains after the COVID-19 pandemic. In contrast, in Argentina, where wP-containing vaccines are used for primary vaccination, very few pertactin-negative *B pertussis* isolates were observed before[34] or after the COVID-19 pandemic. In addition, following the pandemic, *ptxP1* PT promoter allele isolates were observed in countries that previously had only *ptxP3* isolates (England, France, and Finland). This may suggest reintroduction from areas using wP-containing vaccines, where *ptxP1* strains are more prevalent, and a reduced advantage for *ptxP3* organisms following the decline in population immunity. Cameron and Preston[35] suggest that there is no evidence of expansion of a hyperinfectious clone and rather that the lack of immunity permitted the population diversity to expand.

Macrolide resistance of *B pertussis* has been reported for several years in China.[36] Resistance is due to alterations in 23S ribosomal RNA, which hinder the antibiotic's binding to the ribosome. Likely, the spread of resistance results from independent sequence variations rather than the dissemination and expansion of a single resistant strain,[35] although introduction by travelers from Asia, where

resistant strains predominate, is a possibility. As macrolides are used in the treatment of pertussis, resistance may delay effective treatment, particularly of infants with severe illness, and alternative treatments are required. Macrolides are also used to reduce transmission to close contacts, including susceptible infants.[37] The growing resistance trend is having negative consequences for pertussis treatment[38,39] and must be closely monitored, underscoring the need to perform real-time polymerase chain reaction (PCR) amplification and genotyping for direct detection of resistant variants in clinical samples.[40]

Limitations

These findings have limitations. The epidemiologic data and comparisons between countries need to be interpreted with caution due to the differences in surveillance systems, laboratory diagnostic methods (such as multiplex PCR panels including *B pertussis*, the use of which was greatly accelerated during the COVID-19 pandemic), and testing practices (eTable 4 in the Supplement). For example, the change of the US pertussis case definition in 2020 to include PCR-positive cases regardless of case definition likely contributed to an increase in reported cases after the COVID-19 pandemic.[41] Increased clinician awareness of pertussis as a cause of persistent cough in adolescents and adults may have led to a greater number of patients being tested, but the high proportion of positive tests presented by some countries suggests this is not a major contributor to the resurgence observed.

Conclusions

The data on resurgence of pertussis presented herein and in other published studies highlight the importance of maintaining or increasing vaccination coverage during this period of high pertussis incidence after the COVID-19 pandemic, in particular to protect infants both by vaccines given during pregnancy and in the primary schedule.[6-13,15-18] These data also confirm the need for new pertussis vaccines that protect against both disease and infection and thus reduce transmission.

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Author Contributions: Dr Gorringe had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Gorringe, He, Campbell, Hozbor, Scanlon, Edwards.

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Administrative, technical, or material support: Gorringe, Beard, Tsukada, Otsuka, Moosa, Rodrigues, Toubiana, Dalby, He, Campbell, Hozbor, Scanlon, Edwards.

Supervision: Gorringe, Brisse, He, Scanlon, Edwards.

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REFERENCES

1. World Health Organization. Weekly Epidemiological Record, 2015, vol 90, 35:[full issue]. Accessed June 4, 2025. https://iris.who.int/handle/10665/242416

2. Decker MD, Edwards KM. Acellular pertussis vaccines. *Pediatr Clin North Am*. 2000;47(2):309-335. doi:10.1016/S0031-3955(05)70209-1

3. Maglione M, Tipo V, Barbieri E, et al. Changes in respiratory viruses' activity in children during the COVID-19 pandemic: a systematic review. *J Clin Med*. 2025;14(4):1387. doi:10.3390/jcm14041387

4. Feinmann J. Analysis reveals global post-COVID surge in infectious diseases. *BMJ*. 2024;385:q1348. doi:10.1136/bmj.q1348

5. Locht C. Pertussis before, during and after COVID-19. *EMBO Mol Med*. 2025;17(4):594-598. doi:10.1038/s44321-025-00199-2

6. European Centre for Disease Prevention and Control. Increase of pertussis cases in the EU/EEA. May 8, 2024. Accessed April 30, 2025. https://www.ecdc.europa.eu/en/publications-data/increase-pertussis-cases-eueea

7. Nordholm AC, Emborg HD, Nørgaard SK, et al. Pertussis epidemic in Denmark, August 2023 to February 2024. *Euro Surveill*. 2024;29(14):2400160. doi:10.2807/1560-7917.ES.2024.29.14.2400160

8. Holt E. Pertussis outbreak in Czech Republic. *Lancet Infect Dis*. 2024;24(6):e359. doi:10.1016/S1473-3099(24)00291-3

9. Marimón JM, Montes M, Vizuete N, et al. Pertussis outbreak during 2023 in Gipuzkoa, North Spain. *Vaccines (Basel)*. 2024;12(10):1192. doi:10.3390/vaccines12101192

10. Rodrigues C, Bouchez V, Soares A, et al; REMICOQ study group. Resurgence of *Bordetella pertussis*, including one macrolide-resistant isolate, France, 2024. *Euro Surveill*. 2024;29(31):2400459. doi:10.2807/1560-7917.ES.2024.29.31.2400459

11. Hu Y, Shi W, Meng Q, et al. Detection of *Bordetella* spp in children with pertussis-like illness from 2018 to 2024 in China. *J Infect*. 2024;89(3):106222. doi:10.1016/j.jinf.2024.106222

12. Mengyang G, Yahong H, Qinghong M, Wei S, Kaihu Y. Resurgence and atypical patterns of pertussis in China. *J Infect*. 2024;88(4):106140. doi:10.1016/j.jinf.2024.106140

13. Tanne JH. Whooping cough: fivefold rise in US cases spells return to pre-pandemic levels. *BMJ*. 2024;386:q2114. doi:10.1136/bmj.q2114

14. International Bordetella Society. Meetings: current and ongoing meetings. Accessed October 22, 2025. https://bordetella.org/meetings/

15. Matczak S, Levy C, Fortas C, et al. Association between the COVID-19 pandemic and pertussis derived from multiple nationwide data sources, France, 2013 to 2020. *Euro Surveill*. 2022;27(25):2100933. doi:10.2807/1560-7917.ES.2022.27.25.2100933

16. Monchausse T, Launay T, Rossignol L, et al. Clinical characteristics of cases during the 2024 pertussis epidemic in France, January 2024 to December 2024. *Vaccine*. 2025;51:126862. doi:10.1016/j.vaccine.2025.126862

17. Whooping cough in France. Bulletin of November 22, 2024. Santé publique France. Accessed June 16, 2025. https://www.santepubliquefrance.fr/maladies-et-traumatismes/maladies-a-prevention-vaccinale/coqueluche/documents/bulletin-national/coqueluche-en-france.-bulletin-du-22-novembre-2024

18. Bouchez V, Lefrancq N, Toubiana J, Rodrigues C, Brisse S. Emergence of macrolide-resistant *Bordetella pertussis* in France, 2024: out of China. *medRxiv*. Preprint posted online May 21, 2025. doi:10.1101/2025.03.15.25324024

19. Fabiánová K, Beneš C, Kríz B. A steady rise in incidence of pertussis since nineties in the Czech Republic. *Epidemiol Mikrobiol Imunol*. 2010;59(1):25-33.

20. Miettinen M, Barkoff AM, Nyqvist A, et al. Macrolide-resistant *Bordetella pertussis* strain identified during an ongoing epidemic, Finland, January to October 2024. *Euro Surveill*. 2024;29(49):2400765. doi:10.2807/1560-7917.ES.2024.29.49.2400765

21. Amirthalingam G, Gupta S, Campbell H. Pertussis immunisation and control in England and Wales, 1957 to 2012: a historical review. *Euro Surveill*. 2013;18(38):20587. doi:10.2807/1560-7917.ES2013.18.38.20587

22. National Center for Immunization and Respiratory Diseases. 2024 Provisional pertussis surveillance report. Centers for Disease Control and Prevention. January 2025. Accessed June 16, 2025. https://www.cdc.gov/pertussis/media/pdfs/2025/01/pertuss-surv-report-2024_PROVISIONAL-508.pdf

23. Fu P, Yan G, Li Y, et al. Pertussis upsurge, age shift and vaccine escape post-COVID-19 caused by ptxP3 macrolide-resistant *Bordetella pertussis* MT28 clone in China. *Clin Microbiol Infect*. 2024;30(11):1439-1446. doi:10.1016/j.cmi.2024.08.016

24. Tian S, Chen Y, Su Q, et al. Pertussis clinical profile shift, severity, prediction in a tertiary hospital: a comparative study before, during, and after COVID-19 in Southern China. *J Infect Public Health*. 2025;18(1):102610. doi:10.1016/j.jiph.2024.102610

25. Yahong H, Mengyang G, Meng Q, Yu D, Kaihu Y. Rising pertussis cases and deaths in China: current trends and clinical solutions. *Emerg Microbes Infect*. 2024;13(1):2389086. doi:10.1080/22221751.2024.2389086

26. van der Kooi S, Beard F, Dey A, McIntyre P, Imai C, Amin J. Pertussis notifications decline in Australia during COVID-19 non-pharmaceutical interventions, 2020-2021. *Commun Dis Intell (2018)*. Published online June 24, 2024. doi:10.33321/cdi.2024.48.24

27. Lam C, Octavia S, Ricafort L, et al. Rapid increase in pertactin-deficient *Bordetella pertussis* isolates, Australia. *Emerg Infect Dis*. 2014;20(4):626-633. doi:10.3201/eid2004.131478

28. Althouse BM, Scarpino SV. Asymptomatic transmission and the resurgence of *Bordetella pertussis*. *BMC Med*. 2015;13(1):146. doi:10.1186/s12916-015-0382-8

29. Domenech de Cellès M, Rohani P. Pertussis vaccines, epidemiology and evolution. *Nat Rev Microbiol*. 2024;22(11):722-735. doi:10.1038/s41579-024-01064-8

30. Wensley A, Hughes GJ, Campbell H, et al. Risk factors for pertussis in adults and teenagers in England. *Epidemiol Infect*. 2017;145(5):1025-1036. doi:10.1017/S0950268816002983

31. Bart MJ, Harris SR, Advani A, et al. Global population structure and evolution of *Bordetella pertussis* and their relationship with vaccination. *mBio*. 2014;5(2):e01074. doi:10.1128/mBio.01074-14

32. Mooi FR, van Loo IHM, van Gent M, et al. *Bordetella pertussis* strains with increased toxin production associated with pertussis resurgence. *Emerg Infect Dis*. 2009;15(8):1206-1213. doi:10.3201/eid1508.081511

33. Kallonen T, Mertsola J, Mooi FR, He Q. Rapid detection of the recently emerged *Bordetella pertussis* strains with the ptxP3 pertussis toxin promoter allele by real-time PCR. *Clin Microbiol Infect*. 2012;18(10):E377-E379. doi:10.1111/j.1469-0691.2012.04000.x

34. Carriquiriborde F, Regidor V, Aispuro PM, et al. Rare detection of *Bordetella pertussis* pertactin-deficient strains in Argentina. *Emerg Infect Dis*. 2019;25(11):2048-2054. doi:10.3201/eid2511.190329

35. Cameron SK, Preston A. A role for genomics-based studies of *Bordetella pertussis* adaptation. *Curr Opin Infect Dis*. 2025;38(3):201-207. doi:10.1097/QCO.0000000000001109

36. Fu P, Zhou J, Yang C, et al. Molecular evolution and increasing macrolide resistance of *Bordetella pertussis*, Shanghai, China, 2016-2022. *Emerg Infect Dis*. 2023;30(1):29-38. doi:10.3201/eid3001.221588

37. Pertussis: guidelines for public health management. GOV.UK. October 25, 2012. Accessed June 9, 2025. https://www.gov.uk/government/publications/pertussis-guidelines-for-public-health-management

38. Prabhakar D, Fong W, Sim EM, et al. Microbiological treatment failure associated with macrolide-resistant *Bordetella pertussis*. *ASM Case Rep*. 2025;1:e00093-24. doi:10.1128/asmcr.00093-24

39. Iwasaki T, Koide K, Kido T, et al. Fatal case of macrolide-resistant *Bordetella pertussis* infection, Japan, 2024. *J Infect Chemother*. 2025;31(7):102727. doi:10.1016/j.jiac.2025.102727

40. Bouchez V, Brisse S, Rodrigues C. Real-time PCR amplification and genotyping of the 23s rRNA from *Bordetella pertussis* using the LightCycler 480 v1. *protocols.io*. Published online November 4, 2024. doi:10.17504/protocols.io.kqdg3q4y1v25/v1

41. Rubis AB, Cole M, Tondella ML, et al. Assessing the impact of the 2020 council of state and territorial epidemiologists case definition for pertussis on reported pertussis cases. *Clin Infect Dis*. 2024;78(6):1727-1731. doi:10.1093/cid/ciae207

SUPPLEMENT.

eFigure 1. Incidence of Pertussis per 100 000 Population by Age Group From 2012 to 2024 in 5 European Countries

eFigure 2. Incidence of Pertussis per 100 000 Population by Age Group From 2012 to 2024 in Argentina, the US, and Australia

eTable 1. Pertussis Vaccine Schedules and Coverage

eTable 2. Fold Rise in Pertussis Cases From 2019 to 2024 by Age Group and Total

eTable 3. Information on Lockdown Restrictions Implemented During the COVID-19 Pandemic

eTable 4. Diagnosis, National Reporting, and Surveillance of Pertussis Cases