

## Pertussis outbreak investigation, Amreli district, Gujarat state, India, December 2022 -August 2023

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### ARTICLE CYCLE

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### ABSTRACT

**Background:** Pertussis, is an important cause of infant deaths worldwide. In high mortality countries, CFR is estimated to be 4 % among infants and 1 % among older children. It is a vaccine preventable disease covered under the Universal Immunization Programme in India. In January 2023, a private paediatrician reported several cases of cough, suspected as pertussis, to the Amreli district health authorities. We investigated this outbreak to describe the epidemiology, confirm diagnosis, assess vaccination services through field verification and provide evidence-based recommendations.

**Methods:** We reviewed pertussis cases of the last three years in Amreli district to confirm an outbreak. We defined a suspect case as cough of  $\geq 2$  weeks (or any duration in an infant) with paroxysms of coughing, inspiratory whooping, or clinician suspicion of pertussis in Amreli district from 1st December 2022 to 31st August 2023 and a positive culture or serology as confirmed case. We identified cases by house-search in community, school visits and record review of health facilities and interviewed cases using a semi-structured questionnaire for sociodemographic, clinical manifestations and vaccination status. We collected throat swab and serum samples for bacterial culture and serology. **Results:** We identified 81 suspected cases; 26 were laboratory confirmed by serology or culture. The median age was 6.8 years (range: 9 days-16 years), 54% male and 69% in low-socio-economic class. Cases were mainly clustered in two blocks namely Amreli and Savarkundala with 54% cases in urban areas. The outbreak began in December 2022, peaked in mid-March, and subsided in August 2023. While 29.1% did not receive a single dose of Pertussis Containing Vaccine (PCV), 50% missed one or more dose. The average duration between last vaccination and illness onset date was 64 months. **Conclusions:** We report a laboratory confirmed pertussis outbreak among higher age group in the low-socio-economic class with major gaps in vaccination services. There is long time lag between last vaccination and illness onset. We recommended district to improve urban immunization services and provide additional diphtheria pertussis tetanus vaccine dose among higher age group children from 5 years up to 7 years in schools.

### KEYWORDS

Pertussis, Paroxysm, Whooping, Infant Mortality, Urban Vaccination

## INTRODUCTION

Though being a vaccine-preventable disease, Pertussis (whooping cough) is an important cause of morbidity and mortality in infants worldwide and continues to be a public health concern despite high vaccination coverage.

Pertussis (whooping cough) is caused by the bacteria *Bordetella pertussis* and is transmitted from person to person via exposure to the respiratory secretions of infected individuals, primarily through large droplets produced during coughing or sneezing (1). It is endemic in all countries. Epidemic cycles have been occurring every 2 to 5 years (typically 3 to 4 years), even after the introduction of effective vaccination program and the achievement of high vaccination coverage (2). Pertussis typically has three stages of symptoms. The first stage of the disease is the catarrhal stage, which is associated with sneezing, conjunctival suffusion, rhinorrhea or nasal congestion, low-grade fever (minimal), and a mild, occasional cough. The second stage is the paroxysmal stage; characterized by bursts of rapid coughs followed by a long inspiratory whoop and patients often become cyanotic during these episodes. Cough is particularly severe at night and frequently followed by post-tussive vomiting (emesis) in typical cases. This stage usually lasts for 1–6 weeks but may persist for up to 10 weeks. The last stage is the convalescent stage, in which recovery is gradual. The cough becomes less paroxysmal and usually disappears within 2 to 3 weeks. However, paroxysms may recur, and this stage may last for several months (3)

Pertussis is generally considered as a childhood disease, but it was well documented in adults during the twentieth century (4–6). Recently, in the United States, there has been an increase in pertussis among adolescents and adults (7, 8)

In 1970, there were 200,932 cases of pertussis in India with 106 deaths attributable to pertussis. With the launch of the Universal Immunization Program in 1985, this figure plummeted to 31,122 in 2005 (9).

Unfortunately, there has been a resurgence of pertussis recently; 174,177 cases of pertussis were reported globally and 21% (37,274) cases from India in 2016 (9).

Waning immunity following vaccination with DTaP compared to DTwP has also been proposed as one of reasons for the recent rise in pertussis (10). Antigenic shifts in *B. pertussis* and pathogen adaptation have also emerged as a significant issue. The more virulent ptxP3 strains of *B. pertussis* has been shown to replace the resident ptxP1 strains. The antigenic shift poses a serious concern as the current vaccines may not produce neutralizing antibodies and effective memory T-helper cells (11).

## MATERIAL & METHODS

This pertussis outbreak was investigated in Amreli district, which is one of the coastal districts in the state of Gujarat, with a population of a little over 1.5 million. We included pertussis cases notified from December 2022 to August 2023 in this outbreak investigation.

### Case definitions

**Suspect Case:** A suspect pertussis case was defined as a person of any age with a cough lasting  $\geq 2$  weeks, **or** of any duration in an infant or in any person in an outbreak setting without a more likely diagnosis and with at least one of the following symptoms on observation or parent report -paroxysms (i.e., fits of coughing), inspiratory whooping, post-tussive vomiting without other apparent cause, apnoea in infants **or** clinician suspicion of pertussis.

**Laboratory-confirmed:** A suspect case with laboratory-confirmation by isolation of *Bordetella pertussis* or detection of genomic sequences by means of the polymerase chain reaction (PCR) or positive paired serology for IgG immunoglobulins, done only in WHO accredited laboratory at BJ Medical college, Ahmedabad.

Each of the suspect case was investigated using a semi-structured Case Investigation Form (CIF), followed by case management, search for additional cases by community level Active Case Search (ACS), school visits & review of record of nearby health facilities, contact tracing with antibiotic prophylaxis and Outbreak Response Immunization (ORI) by local health functionaries. We collected samples (serum or throat swabs) for laboratory testing as appropriate to each case. The CIF data of pertussis cases were entered in Virtual Surveillance Information Management System (VSIMS) & analyzed using the same portal & excel tool. The outbreak was confirmed by comparing the frequency of lab confirmed pertussis cases for the same period for the last 3 years (January to August month for year 2020-2022).

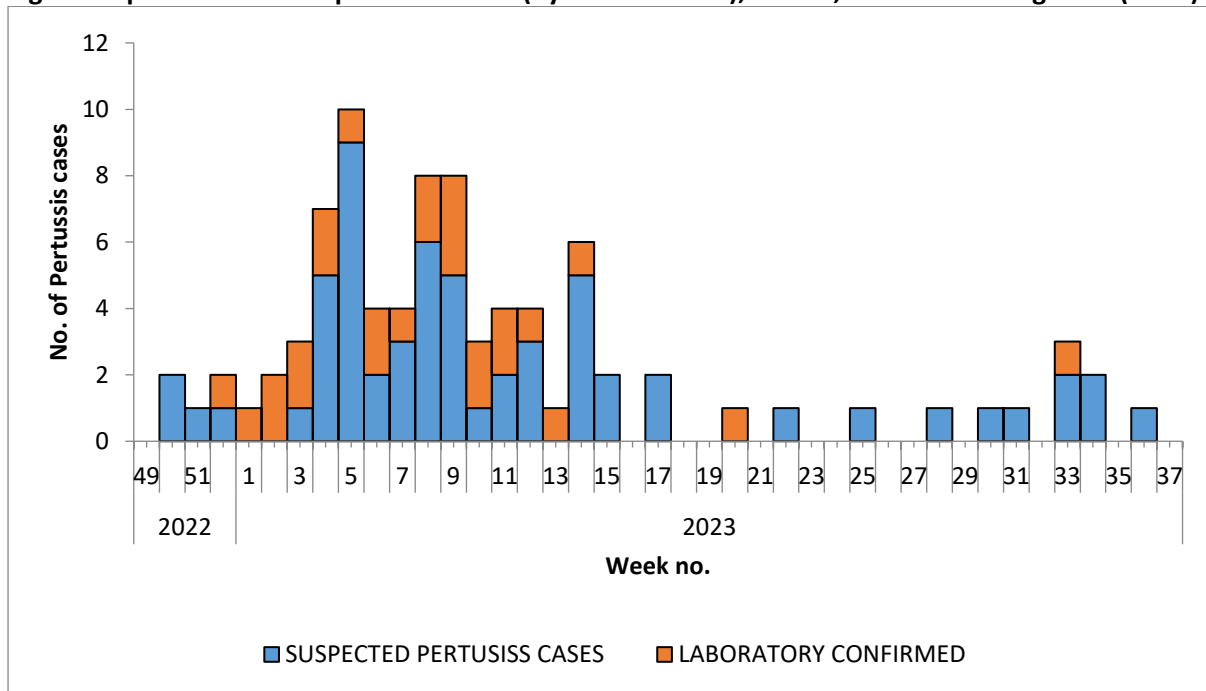
**RESULTS**

There were 81 suspect cases reported during the outbreak period, 32.1% (26/81) of which were laboratory confirmed pertussis cases, either serology or virology. 42.3% (11/26) cases tested positive for serology whereas 57.7% (15/26) cases tested positive for virology. None of the sample tested positive for both tests.

**Confirmation of Pertussis Outbreak:**

A rise in reporting of pertussis cases in Amreli district has been noticed in Dec 2022 to Aug 2023. The number of pertussis notifications in the district during Dec 2022–Aug 2023 was 82 compared to 4 cases in Dec 2021- Aug 2022 and 5 cases in Dec 2020- Aug 2021.

**Figure 1 Epidemic curve of pertussis cases (by date of onset), Amreli, Dec 2022 to Aug 2023 (n- 81)**



**Socio-demographic characteristics of laboratory confirmed Pertussis cases:**

53.8% (14/26) pertussis cases were male, infants consisted of 34.6% (9/26) cases & 53.8% (14/26) of cases were of >5 years of age. Age range was 9 days to 16 years with a median age of 6.8 years. 76.9% (20/26) were among Hindu community, 53.8% (14/26) pertussis cases belonged from urban areas, 92.3% (24/26) were from settled population groups,

69.2% (18/26) parents of the cases were from low socio-economic class & engaged in low paying activity like labor/farmer/driver/worker. Lab confirmed pertussis cases were found in 72.7 % (8/11) blocks of Amreli district, however, Amreli (30.8%, 8/26) & Savarkundala (23.1%, 6/26) blocks had the highest number of cases.

**Table 1. Socio-demographic characteristics of pertussis cases**

Characteristics	Frequency (n=26)	Prevalence (%)
<b>Gender Distribution</b>		
Male	14	53.8
Female	12	46.2
<b>Age</b>		
<1 years	9	34.6
1 to <5 years	3	11.6
>5 years	14	53.8
<b>Setting</b>		
Urban	14	53.8
Rural	12	46.2
<b>Occupation</b>		
Low Paying activity	18	69.2
Business	6	23.1
Job	2	7.7
<b>Mobility</b>		
Migratory	2	7.7
Non-Migratory	24	92.3
<b>Location (Blocks)</b>		
Amreli Block	8	30.8
Savarkundala Block	6	23.1
Other Blocks	12	46.1

**Clinical characteristic of Lab confirmed pertussis cases:**

In clinical symptomatology, paroxysm of coughing was present in 61.5% (16/26), the hallmark finding of whooping & cough leading to vomiting were present in 34.6% (9/26)

cases. Cyanosis was observed only in 3.9% (1/26) cases. Hospitalization during illness was required for 19.2% (5/26) cases. None of the child was found to have developed any complication on 60 days follow up examination and there was no mortality (zero CFR).

**Table 2. Clinical characteristic of pertussis cases**

Characteristics	Frequency (n=26)	Prevalence (%)
Paroxysm of coughing	16	61.5
Cough leading to vomiting	9	34.6
Whooping	9	34.6
Cough >14 days	5	19.2
Apnea	2	7.7
Cyanosis	1	3.9
Hospitalization	5	19.2
Complications found in 60 day follow up exam	0	0.0
Death outcome	0	0.0

**Vaccination status of Lab confirmed pertussis cases:**

Based on age-eligibility of cases, 29.2% (7/24) had not received any Pertussis Containing Vaccine (PCV), 25.0% (4/16) had not received DPT 1<sup>st</sup> booster and 50.0% (7/14) had not received DPT 2<sup>nd</sup> booster. The PCV coverage

was lowest among the most vulnerable age group namely infants (<1 year age group) at 71.4% (5/7) unvaccinated cases were among infants, The PCV coverage among children >2 years age group was 46.7% (7/15). 50% (12/24) children who were eligible for age appropriate PCV, did not receive the PCV.

**Table 3. Antigen wise vaccination status of eligible Lab confirmed pertussis cases**

Antigen	Eligible (n)	Not vaccinated (n)	Not vaccinated (%)
Penta/DPT1	24	7	29.2
Penta/DPT2	21	7	33.3
Penta/DPT3	20	7	35.0
DPT Booster-1	16	4	25.0
DPT Booster-2	14	7	50.0

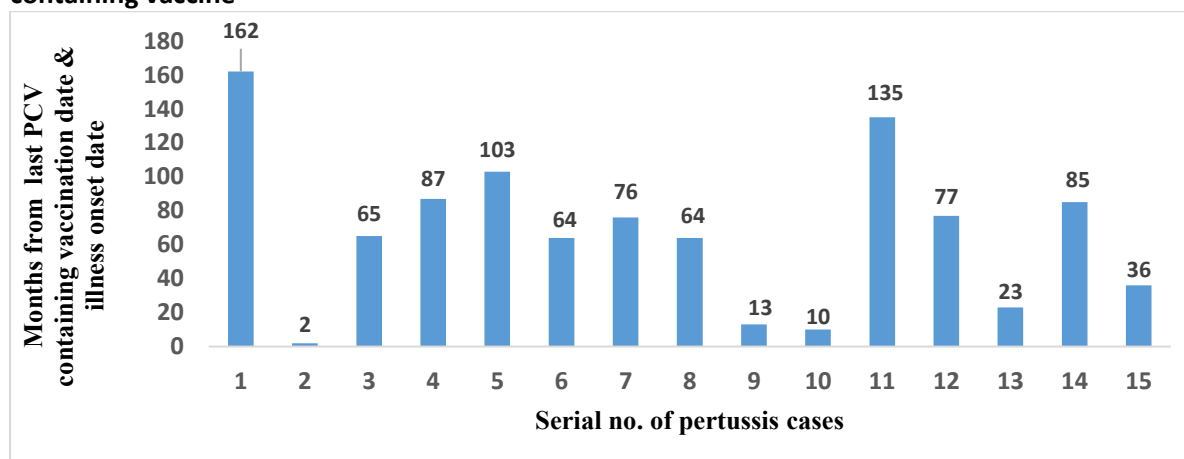
**Table 4. Age group wise vaccination status of eligible Lab confirmed pertussis cases**

Age group	Eligible (n)	Not vaccinated (n)	Not vaccinated (%)
<1 year	7	5	71.4
1-2 years	2	1	50.0
>2 years	15	7	46.7
Total	24	12	50%

**Pertussis containing vaccine Date to pertussis onset date among lab confirmed cases:**

There was an average gap of 64.4 months (range 2-162 months) between the last dose of Pertussis containing vaccine & the date of onset of illness among those who received at least 1 dose of PCV

**Figure 2. Status of pertussis positive cases from days of onset to date of received last Pertussis containing vaccine**



**DISCUSSION**

We investigated pertussis outbreaks in 2023 in Amreli district of Gujarat. In this study, we found that though the cases were distributed in most parts of district, there was clustering in Amreli block & Savarkundala block, particularly in urban areas (both are NUHM cities). Though suspected cases were reported throughout year, which shows sensitive surveillance system, but peak of suspected cases & lab confirmed pertussis cases were found In Dec 2022 to Aug 2023, which is contrary to other research where outbreaks were found in July to Sep months (12, 13). We found that children <1 years of age were most affected followed by children of 10 to 15 years age group which is like data of European Centre for Disease

Prevention and Control agency (14) & other study (15). Though most cases were found among Hindu community, this is likely to be due to Hindu’s being the predominant population group in the affected areas. Not much of differences in the distribution of cases were found by gender & by overall urban or rural settings.

In our study 50 % eligible have received age-appropriate vaccination, 50% (7/14) eligible have not received DPT 2nd booster dose, 50% cases (13/26) have received 3/>3 doses of Pertussis containing vaccines This shows inadequate vaccination is the main cause of pertussis cases which is similar to study from Ethiopia by Almaw et al.13 2017 which also

reported 51% uptake among cases for the three doses of the pentavalent vaccine (17). In our study 29.1% (7/24) cases have not received any pertussis containing vaccine which is similar to study by A Apte, inadequate vaccination or delayed vaccination for pertussis was found to be an important risk factor & almost 30% infants had not received vaccine for pertussis (18).

In this study, 50 (12/24) % eligible cases had received 4 to 5 doses of vaccine, 53.8% (14/26) cases are of >5 years of age group and Inter Quartile Range (IQR) for duration from date of receiving last dose of pertussis containing vaccine to date of illness onset was 36 months to 87 months which suggest waning of immunity. Similar finding was seen in California outbreak, where apart from infant adolescent fully vaccinate with pertussis containing vaccine were also developed disease (15).

In this investigation, for 100 % cases, physician had strongly suspected of pertussis, in 62% of cases Paroxysm of cough was present. High paroxysm of coughing was also found in Arunachal Pradesh outbreak (12), in 35% of cases cough leading to vomiting & whooping was present, 4% cases cyanosis was present. Similar less % cyanosis among pertussis cases were seen in Nigeria study (13), We did not see any mortality (zero CFR) which was similar to outbreak study of Ethiopia (19).

## CONCLUSION

Infants are highly susceptible to Pertussis in pockets with sub-optimal immunization coverage and the poor economic conditions are making them even more vulnerable to disease. It also showed vulnerability of children of > 10 years of age, likely due to waning of immunity & suboptimal DPT booster coverage. We recommend strengthening routine immunization services in high-risk areas (pockets with poor socio-economic conditions), especially in urban areas and provide additional diphtheria pertussis tetanus (DPT) vaccine dose among higher age group children from 5 years up to 7 years, preferably in schools.

## AUTHORS CONTRIBUTION

All authors have contributed equally.

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Nil

## CONFLICT OF INTEREST

There are no conflicts of interest.

## DECLARATION OF GENERATIVE AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors haven't used any generative AI/AI assisted technologies in the writing process.

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