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SHORT COMMUNICATION

Whooping Cough Epidemic in Casablanca in 2024

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SUMMARY

Background: **Whooping cough is a respiratory infection primarily caused by a bacterium called *Bordetella pertussis*. It is a cyclical disease occurring every 3 to 5 years. This infection leads to high morbidity and mortality among infants too young to be vaccinated. In Morocco, as in many countries, three epidemic peaks have been observed despite high vaccination coverage. The aim of this study was to analyze the epidemiological, clinical, biological, and progression profiles of children hospitalized for whooping cough.**
Methods: **This prospective study included 30 infants hospitalized for whooping cough over one year (from January 1 to December 2024). Data was collected using a preestablished data collection form.**
Results: **The average age was 2 months and 26 days, ranging from 31 days to 1 year and 7 months. Vaccination status analysis revealed: 13 infants were unvaccinated (43.33%), 15 were partially vaccinated for their age (50%); however, only 2 were fully vaccinated (6.6%). A source of contamination was identified in all cases, with mothers being the primary source of contamination (18 cases, 60%), followed by siblings (3 cases), fathers (3 cases), grandparents (3 cases), and cousins (3 cases). Complicated cases were dominated by secondary infections (18 infants, 60%), severe apnea (12 infants), and pneumonia (1 infant). Blood tests showed lymphocytosis between 8,000 and 10,000/mm³ in 7 infants (23.3%), between 10,000 and 20,000/mm³ in 12 infants (40%), and above 20,000/mm³ in 1 infant (3.3%). PCR testing of nasal secretions was positive in 21 out of 29 cases (72.4%). Chest X-rays were normal except for 5 infants with alveolar opacities. All patients received a 3-day course of azithromycin, and their mothers were also treated. The outcome was favorable for 28 patients, while 2 were transferred to intensive care for severe apnea and convulsive status. One death was recorded.**
Conclusions: **Whooping cough remains a significant public health issue. Morocco is currently experiencing an epidemic resurgence. Prevention relies on booster vaccinations for adolescents and young adults, as well as infants at the age for vaccination. Maternal vaccination during pregnancy is currently the most effective strategy to protect unvaccinated newborns.**
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KEYWORDS

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INTRODUCTION

Whooping cough is a highly contagious respiratory infection caused by *Bordetella pertussis* [1]. It remains a global health concern due to its severity, particularly in young infants, which makes it the most widespread vaccine-preventable infectious disease [2]. In recent years,

recent outbreaks have been reported even in countries with high vaccination coverage, such as the United States, Australia, the UK, France, and Canada.

According to the European Centre for Disease Prevention and Control (ECDC), over 32,000 cases were reported between January and March 2024 [3]. France recorded more than 7,000 cases from January to May 2024 [4]. In low- and middle-income countries, vaccination coverage is heterogeneous and data on whooping cough in Africa are insufficient [5].

In Casablanca, 500 cases were reported between 2012 and 2019 among infants under 18 months, despite optimal vaccination coverage [6].

The WHO estimates that whooping cough caused 60,000 to 100,000 deaths in children under 5 in 2020, though these figures are likely underestimated due to limited disease surveillance networks in developing countries [1].

Morocco has recently seen increased whooping cough activity. Its cyclical nature peaking every 3 - 5 years raises several questions: Is this a predictable peak? Has the bacterium become more virulent? Is vaccine efficacy declining? Should booster doses for adolescents and young adults be prioritized? What is the status of maternal vaccination in Morocco? This study aims to outline the epidemiological, clinical, and therapeutic profile of whooping cough in a pediatric department.

MATERIALS AND METHODS

Study design

This prospective study was conducted over one year (January 1 to December 31, 2024) at the Pediatric Pneumo-Allergology Unit of Mother-Child Hospital Abderrahim Harouchi, Casablanca. This study enrolled 30 children hospitalized for whooping cough.

Study population

The inclusion criteria were children under 15 years hospitalized with clinical suspicion of whooping cough, confirmed or unconfirmed by PCR (Polymerase Chain Reaction). The clinical case definition was "paroxysmal vomiting cough with or without an inspiratory whooping sound".

Data collection

The records were analyzed according to a preestablished data collecting form. Computerized data entry was performed using Microsoft Excel 2013 version.

Data gathering

The collected variables included the age and gender of the sick child, vaccination status, date of symptom onset, disease progression, and presence of infectious contact in the close environment. Regarding the clinical presentation, the recorded clinical data included characteristics of the cough, presence of cyanosis, whooping sound, apnea, and pulmonary auscultation abnormalities.

For paraclinical data, we collected radiological findings (primarily chest X-ray results), biological test results (complete blood count) and nasopharyngeal swab PCR test results. PCR was performed in real time using the GeneProof *Bordetella pertussis/Para pertussis* kit.

Twenty-seven whooping cough PCR tests were performed at the bacteriology laboratory of Ibn Rochd University Hospital in Casablanca, while 2 additional PCR tests were conducted in private facilities.

Statistical analysis

The data were entered and analyzed using Microsoft Excel software. Quantitative variables were expressed as percentages and means.

RESULTS

In this study, we documented 30 hospitalized cases of suspected whooping cough over a one-year period from January 1 to December 31, 2024. Patient ages ranged from 31 days to 1 year and 7 months, with a mean age of 2 months and 26 days. 13 infants (43.33%) were younger than 2 months, 8 infants were 2 - 3 months old, 7 patients (23.33%) were aged 3 - 4 months, and 2 infants (6.66%) were 4 - 19 months old.

During the study period, the majority of cases occurred in June (7 cases) and July (8 cases) (Figure 1).

Regarding vaccination status, 13 infants were unvaccinated (43.33%), 15 infants had incomplete vaccination for their age (50%), while only 2 infants were fully vaccinated (6.66%) (Table 1).

In all cases, we identified a probable source of infection in close contacts including mothers (18 cases, 60%), siblings (3 cases), fathers (3 cases), grandparents (3 cases), and cousins (3 cases) - each representing 10% of cases (Table 2).

In this study, all patients had clinical symptoms evolving for less than 2 weeks. The primary reason for consultation was paroxysmal vomiting cough. All infants exhibited sonorous inspiratory whooping following these coughing fits. Episodes of cyanosis and apnea were reported in 29 cases (96.6%) and 17 cases (56.6%), respectively. Pulmonary auscultation revealed wheezing in 3 infants (10%).

All patients underwent chest radiography. Pulmonary X-rays appeared normal in 25 patients (83.3%), while 5 infants (16.6%) showed alveolar opacities. The complete blood count was performed in all patients. It revealed lymphocytosis between 8,000 and 10,000/mm³ in 7 infants (23.3%), between 10,000 and 20,000/mm³ in 12 infants (40%), and only one patient (3.3%) had lymphocytosis beyond 20,000/mm³.

Regarding microbiological analysis, the polymerase chain reaction (PCR) tests using nasal secretions was performed in 29 patients and came back positive in 21 children (72.4%). We detected *Bordetella pertussis* in all cases. No cases of *Bordetella para pertussis* were re-

Table 1. Distribution of whooping cough cases by vaccination status.

Variable	Vaccine dose			
Age	0 dose	1 dose	2 doses	3 doses
< 2 months	13	-	-	-
≥ 2 - 3 months	-	8	-	-
≥ 3 - 4 months	-	-	7	-
≥ 4 - 19 months	-	-	-	2

Table 2. Probable source of infection in close contacts.

Source of infection	Number of cases	Percentage
Mother	18 cases	60%
Siblings	3 cases	10%
Father	3 cases	10%
Grandparents	3 cases	10%
Cousins	3 cases	10%

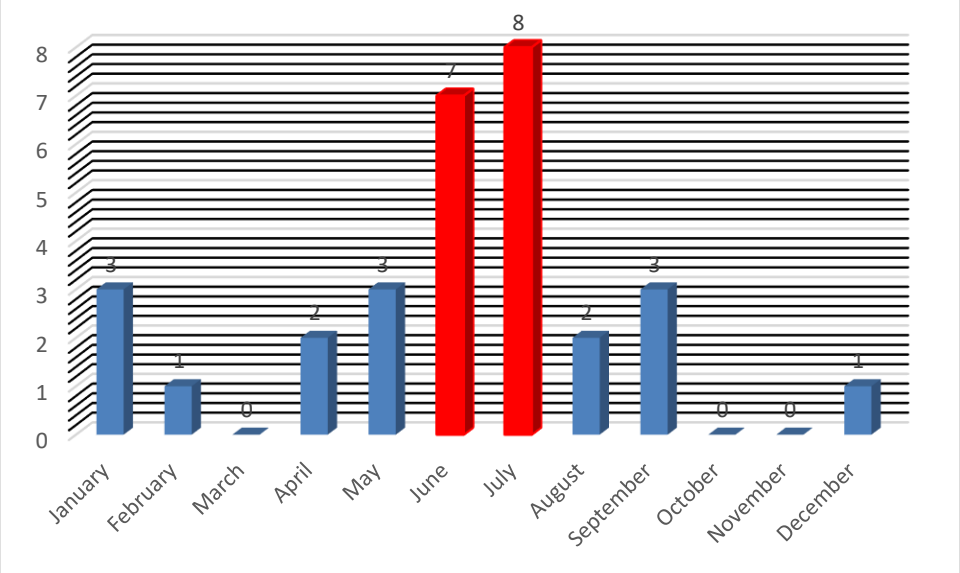

Figure 1. Monthly distribution of hospitalized whooping cough cases in 2024.

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In all cases, antibiotic therapy was initiated using azithromycin at 20 mg/kg/day in a single daily dose for 3 days. All mothers received azithromycin 500 mg per day for 3 days. Whooping cough was reported as a notifiable disease in every case. We recorded complicated forms in 18 patients (60%). These were predominantly severe apnea in 12 infants (66.6%), secondary infected

whooping cough in 5 patients (27.7%), and whooping cough pneumonia in one patient (5.5%). Regarding clinical outcomes, the course was favorable in 28 infants. Two patients were transferred to intensive care for severe apnea and convulsive status. We regret to report one death occurring in intensive care.
The average hospital stay duration was 16 days, ranging from 3 days to one month.

DISCUSSION

Whooping cough remains a serious infectious disease among young, unvaccinated or incompletely vaccinated infants, representing a persistent public health challenge even in countries with high vaccination coverage [7]. The infection follows a cyclical pattern with epidemic peaks occurring every 3 to 5 years [8,9]. Morocco's most recent epidemic peaks were recorded in 2012 and 2016. In Casablanca, Slaoui et al. documented two incidence peaks in 2012 and 2016 among 500 hospitalized infants with suspected whooping cough [6].
The expected global epidemic peak in 2020 coincided with the COVID-19 pandemic. This period saw markedly reduced circulation of *Bordetella pertussis*, mirroring trends observed with other respiratory pathogens worldwide, particularly in Morocco. Since 2023, we have observed a resurgence of whooping cough cases in Morocco. Consistent with its cyclical nature, the number of hospitalized cases in 2024 (30 cases) remains lower than the 2023 peak when 117 children were hospitalized in the same unit (article in progress).
In recent years, numerous countries worldwide have reported outbreaks of whooping cough, including those with high vaccination coverage such as the United States, France, Denmark, Finland, and Spain [9-11]. Morocco maintains optimal vaccination coverage reaching 95% [6]. France has documented a significant outbreak since January 2024, with 277 hospitalizations among infants under 12 months (79% under 6 months), including 35 deaths predominantly in young children [9].
The resurgence of whooping cough may stem from multiple contributing factors. Numerous studies have been conducted to examine the various hypotheses that could explain its reemergence.
While acellular vaccines have led to a marked reduction in whooping cough cases - particularly in countries with high vaccination coverage - several studies indicate that protective immunity may diminish within 3 - 4 years, thereby increasing the risk of disease resurgence [12-14].
The whooping cough resurgence may also be attributed to the immune debt phenomenon that emerged during the COVID-19 pandemic. This immune debt has triggered the reemergence of infectious diseases, including whooping cough, particularly among individuals who lacked exposure to pathogens due to the social distancing and hygiene measures implemented during the pandemic [14].
Another potential explanation for this resurgence relates to insufficient protection due to inadequate booster vaccination against whooping cough in adolescents and young adults. In this study, mothers followed by fathers were identified as the primary sources of infection. Additionally, the 5-year booster vaccination, crucial for ensuring prolonged immunity according to WHO recommendations, is not consistently administered despite its demonstrated importance [1].
Genomic modifications in *Bordetella pertussis* have also been implicated in the whooping cough resurgence. The *Bordetella pertussis* bacterium produces ten distinct toxin species, beginning with pertussis toxin which plays a major role in disease pathogenesis, along with other virulence factors including filamentous hemagglutinin (FHA), pertactin (PRN), fimbriae types 2 and 3 (FIM), adenylate cyclase toxin, tracheal cytotoxin, and lipooligosaccharide [15,16]. Several studies link the resurgence to emerging *Bordetella pertussis* strains resulting from acellular vaccine use. These vaccines appear to select for strains producing increased pertussis toxin [17]. Post-COVID-19, pertactin-deficient isolates have become more prevalent, with fim3-1 emerging as the dominant genotype in multiple countries. However, fim3-1 and fim3-2 remain the predominant genotypes in specific nations including Finland, Iran, and South Africa [11,18]. A French genomic study sequenced 67 *Bordetella pertussis* isolates, specifically analyzing vaccine antigen production. Researchers found 66 isolates produced pertactin and 56 expressed fim2 adhesin - antigens rarely observed pre-pandemic. These proteins facilitate bacterial adhesion to respiratory epithelium and modulate host immune responses, potentially explaining the current high transmission rates [9].
Chinese studies have confirmed the emergence of a prn1/ptxP1/ptxA1/fim3-1/fim2-1 *Bordetella pertussis* genotype exhibiting macrolide resistance. This resistance stems from an A2047G mutation in the 23S rRNA gene [1]. The ptxP1 allele is currently detected in 20 - 30% of strains from Chinese children hospitalized with whooping cough - a significant genotypic shift directly linked to widespread acellular vaccine use [18]. In France, macrolide-resistant alleles including ptxP3 and fim3-1/fim2 have been isolated [9]. Strains carrying the ptxP3 allele demonstrate enhanced virulence and are epidemiologically associated with whooping cough resurgence [18]. While macrolide resistance remains rare globally, Asia (particularly China and Vietnam) has reported increasing prevalence of resistant isolates in recent years [19].
Prevention remains the cornerstone of whooping cough management, with decades of concerted efforts through expanded immunization programs achieving high childhood vaccination coverage. In Morocco, where whooping cough is a notifiable disease, the national immunization program administers whole-cell vaccines in public sectors and acellular vaccines in private practice, following a schedule of primary vaccination at 8, 12, and

16 weeks with boosters at 18 months and 5 years [20]. France modified its infant vaccination strategy in 2013, replacing the three-dose schedule (2/3/4 months) with two doses at 8 weeks and 4 months plus boosters at 11 months and 6 years [21], demonstrating evolving approaches to optimizing protection against this resurgent pathogen.

The critical importance of vaccinating adolescents and young adults cannot be overstated, as higher vaccination coverage in these groups would significantly reduce disease circulation among vaccinated populations while decreasing transmission to vulnerable, unimmunized infants who experience the highest morbidity and mortality rates [22]. Maternal vaccination, now widely adopted in developed countries, has proven more cost-effective and clinically beneficial than cocooning strategies. Canada observed a substantial decline in hospitalization rates for infants under four months following the 2019 implementation of maternal pertussis vaccination, with reductions exceeding baseline 2005 - 2018 averages [23]. Similarly, a 2020 Brazilian study by Friedrich et al. demonstrated a 47.7% decrease in annual whooping cough incidence among neonates following prenatal vaccination programs [24], underscoring the intervention's dual benefit of directly protecting both mothers and newborns during the highest risk period.

CONCLUSION

Whooping cough remains a significant public health challenge, with Morocco currently experiencing an epidemic resurgence mirroring global trends. Prevention hinges on two key strategies: vaccinating household contacts and age-eligible infants, and implementing maternal immunization - currently the most effective approach for protecting unvaccinated newborns. Further research is urgently needed to elucidate how bacterial genomic evolution impacts vaccine efficacy and contributes to disease resurgence.

Declaration of Interest:

The authors declare that they have no conflict of interest.

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