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Original Research

Seroepidemiology of diphtheria and pertussis in Chongqing, China: serology-based evidence of *Bordetella pertussis* infection

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ABSTRACT

Objectives: In order to gain further insight into the seroepidemiology of *Bordetella pertussis* infection and immunity against diphtheria in Chongqing, China, the concentrations of antibodies to pertussis toxin (PT) and diphtheria toxin (DT) were investigated in a healthy population.

Study design: Cross-sectional study.

Methods: In total, 1080 healthy people were recruited into this study. Sera antibodies to DT and PT were measured quantitatively using commercial enzyme-linked immunosorbent assay kits. Age-specific incidence of infection with *B. pertussis* was estimated and compared with notified cases of pertussis.

Results: The mean concentration of anti-DT IgG was 0.71 IU/ml (95% confidence interval [CI] = 0.60–0.82), with a positive rate (>0.01 IU/ml) of 97.41% (1052/1080). The mean concentration of anti-PT IgG was 7.65 IU/ml (95% CI = 6.65–8.65), with a positive rate (>100 IU/ml) of 1.17% (11/944). The estimated pertussis infection rate was 7290/100,000, which was far higher than the reported incidence of 1.29/100,000 in 2015. The peaks of estimated incidence of infection were found in subjects aged 7–14 years (9971/100,000) and ≥20 years (13,898/100,000).

Conclusions: *B. pertussis* infection occurs frequently in young infants and adolescents/adults; the latter are often responsible for the transmission of pertussis to young infants. The existing surveillance system may underestimate the true incidence of pertussis in older age groups in Chongqing, and the immunisation programme should be improved to provide protection against pertussis for adolescents and young adults.

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Introduction

Diphtheria and pertussis (whooping cough) are vaccine-preventable respiratory infectious diseases caused by *Corynebacterium diphtheriae*¹ and *Bordetella pertussis*,² respectively. Diphtheria toxoid vaccine was first introduced in Chongqing in 1950, and pertussis vaccine has been used since 1953. Since 1970, a combined diphtheria, tetanus and whole-cell pertussis vaccine (DTwP) has replaced the monovalent pertussis vaccine. Initially, the vaccination was only offered during winter and spring months (campaign vaccination). In 1978, programmed immunisation was implemented throughout China, and a standard immunisation schedule was recommended consisting of three doses of primary vaccination at 3, 4 and 5 months of age and a booster dose at 18–24 months of age. Since the implementation of the expanded programme of immunisation in 2007, the immunisation schedule has been supplemented by one dose of combined diphtheria and tetanus vaccine at 6 years of age. A combined diphtheria, tetanus and acellular pertussis vaccine (DTaP) replaced DTwP in 2010, and the immunisation schedule has remained the same to date.

Diphtheria and pertussis immunisation significantly reduced the incidence of these diseases. The reported incidence of diphtheria decreased from 43.54 per 100,000 in 1951 to 0.01 per 100,000 in 1990; no case of diphtheria have been reported in Chongqing since 1992. The incidence of pertussis decreased from 697.58 per 100,000 in 1955 to 0.83 per 100,000 in 1990 and remained less than 1.0 per 100,000 between 2000 and 2014. As neither infection nor immunisation produces lifelong immunity to pertussis, pertussis continues to reach epidemic proportions every 2–5 years, the same as in the prevaccine era.^{3–5} Despite sustained high vaccine coverage, several developed countries have experienced large outbreaks of pertussis in recent years and a shift in the burden of disease from children to adults.⁶ Substantial epidemics occurred in the United States in 2005, 2010 and 2012,³ and a resurgence of

pertussis was noted in the UK in 2012.⁷ In 2015, the reported incidence of pertussis in Chongqing increased to 1.29/100,000, which was 2380% higher than that in 2009 (Fig. 1).

Pertussis is usually diagnosed in hospitals and then reported to the China national infectious diseases surveillance system. The methods for laboratory confirmation of *B. pertussis* infection, such as a four-fold increase in serology on enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR) and culture, are not used routinely in Chongqing. Pertussis toxin (PT) is the most specific antigen for *B. pertussis* infection. It is only produced following exposure to *B. pertussis*, and cross-reacting antigens have not been described to date.⁸ Previous research has shown that high serum immunoglobulin G (IgG) antibodies to PT represent a highly specific indicator of active infection with *B. pertussis* in the general population.⁹ Cross-sectional population serological surveys of pertussis have measured serum PT-IgG of healthy people. These provide evidence for population infection rates, but not *B. pertussis* illness rates.⁴ As serosurveillance can also detect mild and asymptomatic cases, this method provides a better estimate of the infection level in the population. A study conducted in Guangdong province¹⁰ found that the estimated incidence of recent infection was 9395 per 100,000 for individuals aged >7 years, which was 10,000 times higher than that reported in 2010 (0.176/100,000). Also, the estimated incidence of pertussis infection was higher than 6000/100,000 in Beijing residents aged 0–74 years.¹¹ It appears that the notification data underestimate the true incidence of pertussis.

The aim of this study was to determine the concentrations of PT-IgG and antibodies to diphtheria toxin (DT) among healthy people in Chongqing to gain further insight into age-specific seroepidemiology of *B. pertussis* infection and immunity against diphtheria. The incidence of pertussis infection was estimated in various age groups and compared with reported cases of pertussis from the surveillance system. In addition, the relationship between vaccination and the PT-IgG level in children was assessed.

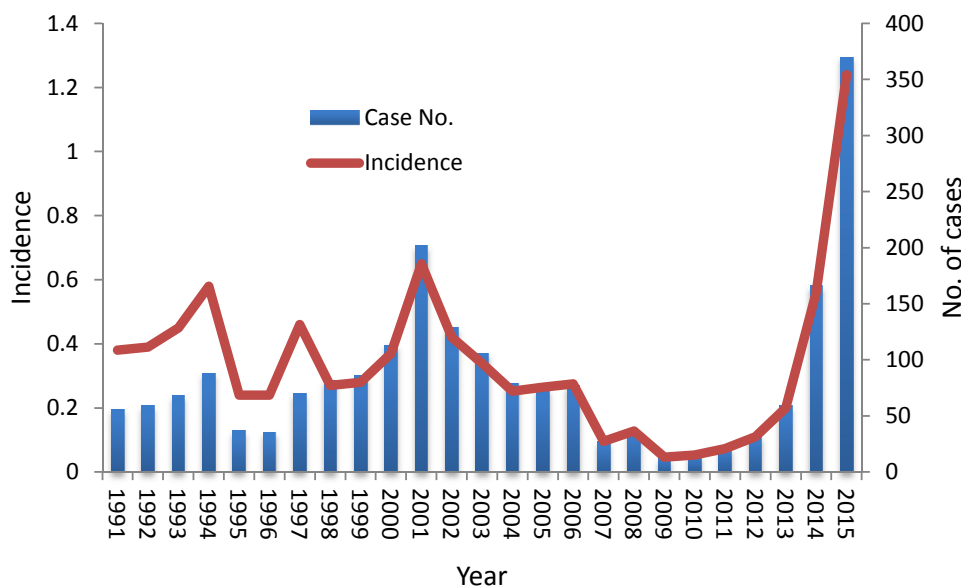


Fig. 1 – Reported number of cases and incidence of pertussis in Chongqing over time based on notifications.

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