Brief Report

Pertussis Seasonality Evident in Polymerase Chain Reaction and Serological Testing Data, Queensland, Australia

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We investigated the seasonality of pertussis in Queensland, Australia, between 2008 and 2011 using notification and laboratory data. Polymerase chain reaction and serology testing data demonstrate that in the vaccine era, pertussis remains a seasonal illness, with annual peaks in summer months, and that the seasonality of notification data is masked by testing trends.

Key words. PCR; pertussis; serology.

Many infectious diseases show clear seasonal patterns in both temperate and tropical climates, and seasonality has been well documented particularly for viral respiratory infections [1]. The seasonality of pertussis is less clear and it is the cause of debate. There is some suggestion that there is no clear seasonality [2]; however, in the prevaccine era, it was widely accepted that pertussis peaked in the spring and summer months [3].

During the last 5 years, a pertussis resurgence has been observed in a number of countries [4]. Australia experienced a pertussis epidemic between 2008 and 2011, which was larger and more prolonged than previous outbreaks in the vaccine era [5]. With this study, we sought to better understand the seasonality of pertussis in Queensland, an Australian state with a subtropical and tropical climate, using available laboratory and notification data during the recent pertussis epidemic.

METHODS

Two Queensland-based diagnostic laboratory providers, Pathology Queensland (PQ) and Sullivan Nicolaides Pathology (SNP), provided data on pertussis diagnostic tests (polymerase chain reaction [PCR] and serology) performed between January 1, 2008 and December 31, 2011. Pathology Queensland is the only public laboratory, and it provides pathology services to all Queensland public (government funded) hospitals, whereas SNP is a large, privately run, diagnostic laboratory, and it primarily services community-based patients. The 2 laboratories were responsible for 36% of pertussis notifications during the study period (range, 34%–38% per year), with 1 other private laboratory largely responsible for the remainder of notifications (57%). Data from PQ and SNP were combined for this analysis.

In Queensland, pertussis is a notifiable condition, and all cases meeting the case definition must be reported to the state Health Department in accordance with the Public Health Act 2005. Over the study period, a confirmed pertussis case required one of the following conditions to be met: definitive laboratory evidence (isolation of *Bordetella pertussis* by culture or detection by a nucleic acid amplification test, such as a PCR assay); suggestive laboratory evidence (single high-serum immunoglobulin A titer to pertussis antigen or evidence of seroconversion) and clinical evidence (coughing illness lasting $\geq$2 weeks or one of the following: coughing paroxysms, inspiratory whoop, or posttussive vomiting); or clinical evidence and epidemiological evidence (contact between 2 people involving plausible mode of transmission when one of

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them is likely to be infectious and the other has an illness onset within 6–20 days after contact) [6]. Data for all pertussis notifications reported to Queensland Health between January 1, 2008 and December 31, 2011 were obtained.

Both datasets were analyzed by month based on specimen registration date (laboratory data) and onset date (notifications). Using the laboratory data, we calculated the proportion of tests positive for pertussis, and we compared these with counts of Queensland pertussis notification data. The University of Queensland, School of Population Health Human Research Ethics Committee approved this study.

RESULTS

A total of 48 578 pertussis PCR tests and 79 505 pertussis serology tests were conducted by the 2 laboratories between January 1, 2008 and December 31, 2011, of which 4574 (9.4%) and 10 465 (13.2%) were positive, respectively.

Peak serology tests occurred annually in winter or spring months: September 2008 (n = 1514), July 2009 (n = 2090), September 2010 (n = 3425), and August 2011 (n = 2372). Polymerase chain reaction tests could be categorized into 2 low-testing periods, January 2008–January 2009 (mean = 322 per month) and January 2010–October 2010 (mean = 406 per month), and 2 high-testing periods, February 2009–December 2009 (mean = 918 per month) and November 2010–December 2011 (mean = 2160 per month). During the high-testing periods, PCR tests peaked in July 2009 (n = 1495), March 2011 (n = 2662), and August 2011 (n = 3025). When PCR and serology tests were aggregated, 3 primary peaks were observed in July 2009, November 2010, and August 2011.

The proportion of tests positive was highest between October and February (inclusive) compared to between March and September (PCR monthly mean = 13.5% vs 6.9%; serology monthly mean = 15.5% vs 11.7%, respectively). The proportion of tests positive peaked primarily in summer months between 15%–18% for PCR and 16%–22% for serology, decreasing between autumn and early spring (March to September) to lows of approximately 5% for PCR and 10% for serology (Figure 1).

There were a total of 25 688 pertussis notifications in Queensland between January 1, 2008 and December 31, 2011. Seasonal trends were less evident in Queensland notification data, with a broad peak observed between May 2008 and January 2009, followed by distinct peaks in

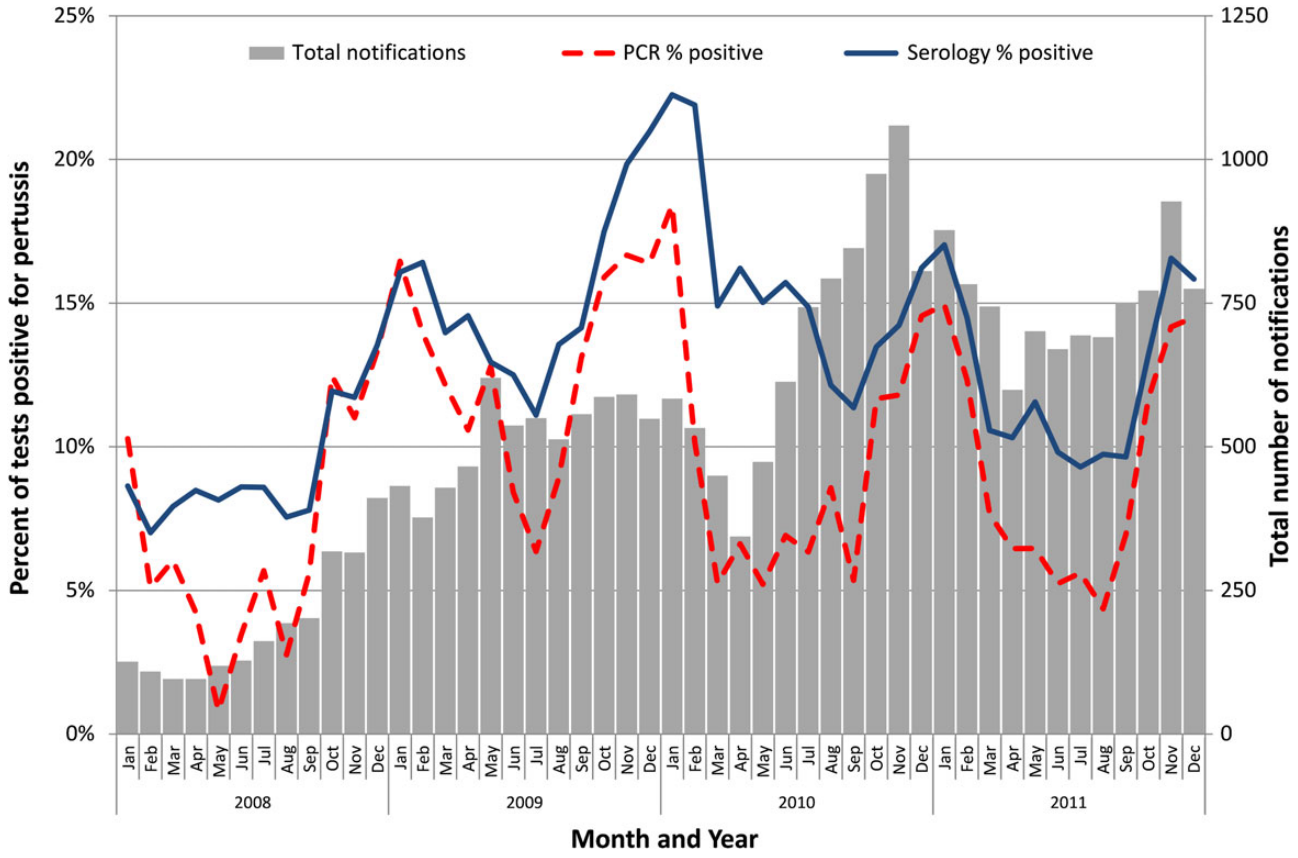

Figure 1. Proportion of tests positive for pertussis (by test type) and pertussis notifications, 01 January 2008–31 December 2011, Queensland Australia.

November 2010 and November 2011 (Figure 1). Notification data and the number of total positive tests were highly correlated (correlation coefficient = 0.97).

DISCUSSION

Using diagnostic test positivity, we have demonstrated that pertussis remains a seasonal illness in Queensland with activity peaking in summer each year between 2008 and 2011. Seasonality was less evident in notification data, with peaks in notifications largely coinciding with the periods during which most diagnostic tests were conducted.

Seasonality trends among notifications have been masked by retrospective testing using serology as well as the increasing use of PCR. We observed that although the proportion of positive serology tests peaked in summer months, it remained high interseasonally. The use of serology for retrospective diagnosis of pertussis, and the lower specificity serology results compared with PCR [7], will have broadened the seasonal peak of pertussis within notification data. Polymerase chain reaction testing for pertussis has been increasing in Australia since 2007, becoming the preferred diagnostic test especially for infants and children, because of its high sensitivity, ease of sample collection, quick turnaround, and ability to test 1 sample for multiple respiratory pathogens [7–10]. Of the 3 testing peaks we observed, 2 occurred during periods of very high influenza activity (winter 2009 and winter 2011) [5]. Polymerase chain reaction testing for multiple respiratory pathogens during these periods has likely resulted in amplified pertussis case detection and increased notifications during these periods.

Testing is ultimately influenced by clinician behavior as well as the clinical presentation and/or behavior of patients. Clinician behavior can be modified by increased awareness or the establishment of a positive feedback loop (where positive results prompt more testing, leading to more positive results and so on) [11]. Substantial media attention during the pertussis epidemic likely prompted changes in both patient and clinician behavior [12], which may have led to differential testing over the study period and/or the establishment of a positive feedback loop. Differential testing may introduce spectrum bias; however, the direction and size of this bias, if any, cannot be determined using the data available.

Similar to notifications, the proportion of tests positive can be influenced by increased testing. We observed the highest proportion positive in summer months, when there is the least testing, and the inverse in winter months, when testing is highest. Although this may have been influenced by variation in tests conducted, in contrast to changes in the circulation of *B pertussis*, PCR testing continued to be used during summer months. Because PCR is used to diagnose acute infection, and other respiratory infections are less common during summer [1], this observation supports the notion that pertussis has summer seasonality.

Our findings are likely to be representative of Queensland patients and demonstrate pertussis seasonality in a subtropical climate. The 2 laboratories service all areas of Queensland (including regional areas), accounted for a stable proportion of total notifications each year, and included community-based and hospitalized patients (mild to severe clinical presentations). Both SNP and the other private pathology provider are present and accessible to patients across Queensland, making it unlikely in our view that data from only 1 laboratory would not be representative of the testing spectrum of both laboratories. In addition, the high correlation between notifications and positive test results suggests the laboratory data included accurately reflect state-wide pertussis cases. Queensland's population primarily lives along the state's south-east coast, in a subtropical climate. As such, we believe our results demonstrate pertussis seasonality in a subtropical climate. Seasonality in other climates warrants further investigation.

CONCLUSIONS

Pertussis seasonality in notification data is masked by the use of serology and general increases in PCR testing. By calculating the proportion of tests positive, we were able to clearly demonstrate the summer seasonality of pertussis in Queensland, Australia.

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Potential conflicts of interest. All authors: No reported conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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