Pertussis in South Australia 1893 to 1996

Wendy Scheil[1 2 3], Scott Cameron[3], Christine Roberts[2], and Robert Hall[3]

Abstract

This study describes trends in reports of pertussis in South Australia. Data were analysed from three sources: mortality data since 1893 from South Australian yearbooks, notification data from 1917, and hospitalisation data for pertussis or related complications since July 1985. Crude and age-specific rates of mortality, notifications and hospitalisation were compared. Pertussis peaked in 3 to 5 yearly cycles. The mortality and notification rates have generally declined over time. However, since 1993 the notification rate has remained high. The median age for pertussis notifications increased from 4 years in 1984 to 15 years in 1996. Serological testing for pertussis was included in 15% of notifications in 1985 and 90% in 1996. The age specific hospitalisation rate for pertussis was highest in infants ≤ 6 months. Since the turn of the century, mortality and notification rates due to pertussis have declined. Over the past decade the major burden of severe disease resulting in hospitalisation has been borne by infants ≤ 6 months. These infants are too young to be afforded protection from three primary immunisations against pertussis. Despite no substantial increase in mortality nor hospitalisation for pertussis in South Australia, the notification rate has remained high since 1993. This increase may be attributable to the use of more sensitive tests for pertussis, such as serology.

Introduction

Concurrent with the introduction of mass vaccination programmes for pertussis in the 1950s[1] all Australian states, with the exception of South Australia, discontinued surveillance of pertussis. As a result South Australia is believed to be the only source of continuous surveillance data for pertussis.

This study reviews secular trends in mortality, notifications and hospitalisations for pertussis from three sources:

- the Australian Bureau of Statistics (ABS) mortality data available since 1893;
- the South Australian Health Commission's notifiable diseases register medical practitioner notifications since 1909, and laboratory based notifications since 1969; and
- the Inpatient Separations Information System hospital discharge data collected since July 1985.

Methods

Data sources

Numbers of deaths attributed to pertussis from 1893 to 1996 were obtained from South Australian ABS yearbooks.

Pertussis notification data were obtained from records kept at the Communicable Disease Control Branch (CDCB) of the South Australian Health Commission (SAHC). Total numbers of notifications in all council regions were available from 1917 onwards. In 1983 a standard 'notification form' was introduced and records of the age and notification date of cases were available from 1984. Since 1989 modifications to the notification form allowed details to be collected of date of birth, date of disease onset and diagnostic method. Since 1990 the following surveillance case definition for pertussis has been used:

- isolation of *Bordetella pertussis* from a clinical specimen and/or
- elevated *B. pertussis*-specific IgA in serum in the presence of clinically compatible illness and/or
- an illness lasting longer than two weeks with one of the following:
  - paroxysms of coughing
  - inspiratory 'whoop' without other apparent cause
  - post-tussive vomiting and/or
- an illness characterised by a cough lasting at least two weeks in a patient who is epidemiologically related to a laboratory confirmed case.

This definition differs from the recommended national surveillance case definition[2] by excluding '*B. pertussis* in nasopharyngeal specimens using immunofluorescence'.

Notification forms held by the CDCB were retrospectively reviewed to ascertain the laboratory diagnostic method used for cases notified in 1985, 1986, 1991, 1992 and 1996. We selected these years to span the period since serological testing was introduced in 1985.

Hospital discharge data were obtained from the Inpatient Separations Information System (ISIS) database of the Health Information Services Unit, SAHC. This collection started in July 1985 with all public and private hospitals in South Australia being required to code diagnoses of

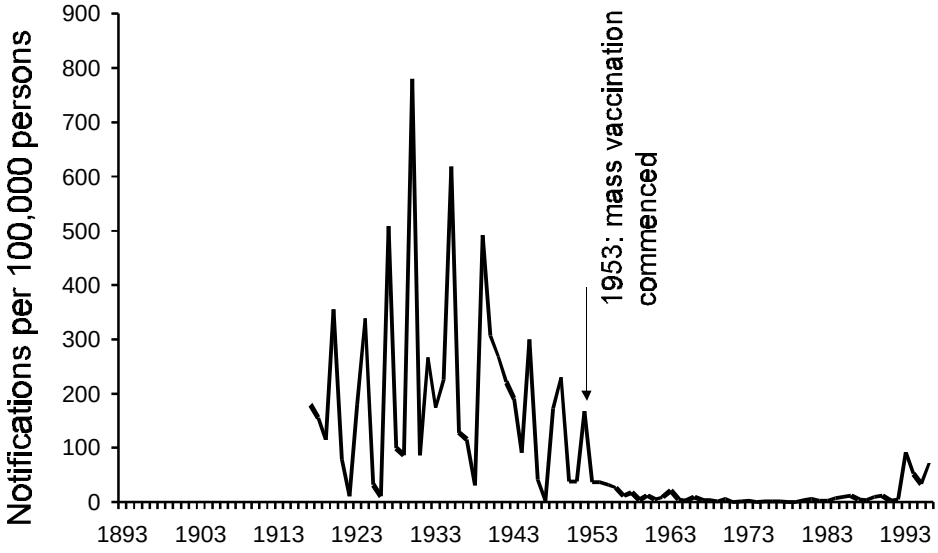
1 Corresponding author: Wendy Sheil, South Australian Tuberculosis Services, 275 North Terrace, Adelaide SA 5000

2 Master of Applied Epidemiology Program, National Centre for Epidemiology and Population Health, Australian National University, Canberra ACT 0200

3 Communicable Disease Control Branch, PO Box 6, Rundle Mall, Adelaide SA 5000

discharged hospital patients according to international disease codes (ICD-9)[3]. The primary diagnosis is recorded with up to 20 secondary diagnoses.

Figure 2. Notification rate for pertussis in South Australia, 1893 to 1996



Analysis

Crude and age-specific rates for mortality, notifications and hospitalisations were calculated using ABS population estimates. Between 1893 and 1970 midyear estimates were used where available, otherwise end of year estimates were used. Between 1971 and 1996 only mid-year population estimates were used.

Pertussis mortality rates per 100,000 population were calculated for each year. We examined the number and rate of persons notified with pertussis between 1917 and 1996. We described the age-specific notification rates of persons with pertussis between 1984 and 1996. We examined the age-specific hospitalisation rates of persons with pertussis recorded as a primary or secondary diagnosis between 1985 and 1996. Only the discharge diagnoses from the final treating hospital were used.

Analysis was conducted using Epi-Info 6.02[4].

Results

Pertussis mortality

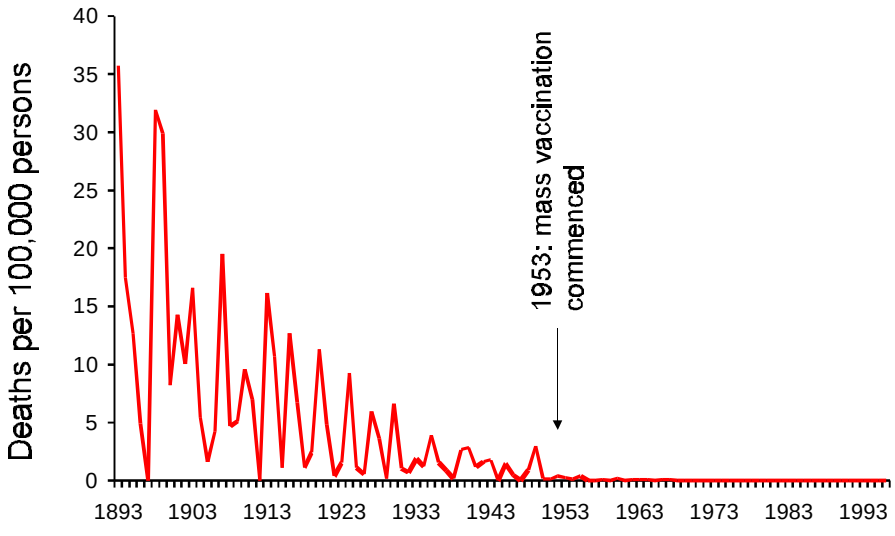
In South Australia between 1893 and 1996 the mortality rate due to pertussis declined (Figure 1). During this time there were 1,504 deaths ascribed to pertussis. The highest number of deaths was recorded in 1893 with 121 (crude rate of 36 deaths per 100,000 population). Until 1949 peaks in mortality occurred every three to five years. The magnitude of these peaks generally decreased, and since 1967 no deaths due to pertussis have been reported in South Australia.

Pertussis notifications

Between 1917 and 1996 there were 48,311 notified cases of pertussis in South Australia. The highest number of notifications (4,466) was recorded in 1930, the lowest (5) in 1974.

Between 1917 and 1996 there were several major shifts in the pattern of notifications of pertussis (Figure 2). Between 1917 and 1952, increased notification rates occurred every three to five years. Each increase was two to sixteen times higher than the average of the two preceding years. After 1930 there was a general decrease in reported cases in each successive epidemic. After the 1952 epidemic the baseline level of notifications was very low until 1993, when there were 1,351 notifications, seven times higher than any of the previous 20 years.

Figure 1. Mortality rate for pertussis in South Australia, 1893 to 1996



Between 1984 and 1992 the age-specific notification rates followed a cyclical pattern (Figure 3). In general, the highest notification rates occurred for infants ≤ 6 months. However, in 1993 the notification rate in the 5 to 14 year age group (223 per 100,000) exceeded the rate for infants ≤ 6 months. From 1993 onward all age groups have maintained a higher notification rate. Over this period, the median age for pertussis notifications increased from 4 years in 1986 to 15 years in 1996. Accordingly, the proportion of notifications for persons ≥ 15

Figure 3. Notification rate for pertussis, 1984 to 1996, by age group and year

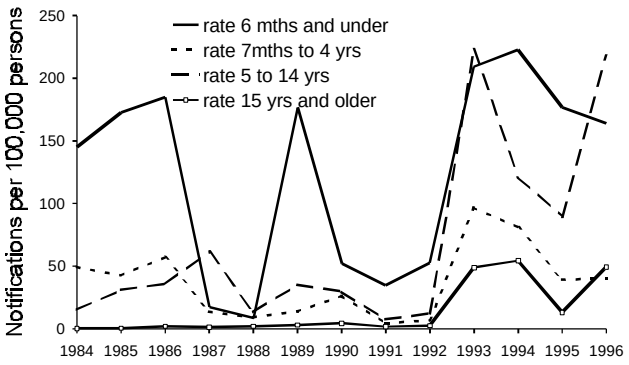
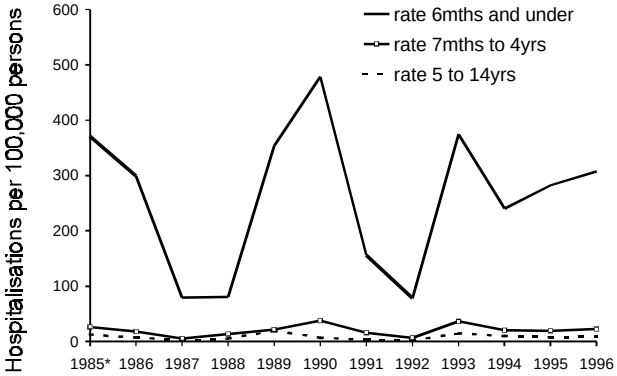


Figure 4. Hospitalisation rate for pertussis, 1985 to 1996, by age group and year



* includes hospital discharges July to December 1985

years gradually increased, such that since 1993 over half of the notifications were for persons ≥ 15 years of age.

Laboratory diagnosis for pertussis

Laboratory testing was performed for more than 67% of notified cases in the years reviewed, and the type of test was stated for 96% (Table 1). In 1985 71% (97)of notified cases had *B. pertussis* cultured from a specimen, decreasing to 2% (21) of cases notified in 1996. In contrast, serological testing for pertussis increased from 15% (20) in 1985 to 90% (955) in 1996.

Table 1. Laboratory confirmed cases of pertussis, by selected years

Year	1985 n (%)	1986 n (%)	1991 n (%)	1992 n (%)	1996 n (%)
Total notifications	136 (100)	164 (100)	46 (100)	66 (100)	1060 (100)
Laboratory tests performed	117 (86)	110 (67)	37 (80)	64 (97)	1028 (97)
Laboratory test results reported	11 (86)	110 (67)	32 (69)	47 (71)	1000 (95)
Type of test					
culture	97 (71)	95 (58)	3 (7)	5 (8)	21 (2)
serology	20 (15)	15 (9)	29 (63)	42 (64)	955[1] (90)
PCR[2]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	24 (2)

1. Includes 170 notifications based on positive IgM result
2. Polymerase chain reaction
3. Not available

Hospital admissions for pertussis

From July 1985 to 1996 there were 878 persons hospitalised for treatment of pertussis or related complications. The highest number of pertussis related hospitalisations was 133 in 1993, and the lowest was 22 in 1992.

Between July 1985 and December 1996, age-specific hospitalisations for pertussis showed cyclical trends (Figure 4). The highest rates of hospital admissions for pertussis occurred in the ≤ 6 months age group. The highest number of admissions in this age group occurred in 1990 with 55 admissions (479 per 100,000). In 1993 the rate of hospital admissions in children under the age of 15 years was 5 to 10 times higher than in 1992. Following this, hospitalisation rates did not return to the previous baseline level.

Discussion

Patterns in pertussis mortality and notifications describe the changing epidemiology of the disease throughout the past century in South Australia. During the first part of this century the three to five yearly cycles of high mortality and notifications due to pertussis gradually decreased, until the 1950s when a dramatic decrease occurred. That era coincided with the introduction of mass public vaccination in South Australia from 1953 onward, and the discovery of antibiotics used for the treatment of pertussis and related complications. Thereafter, both mortality and notification rates remained low until 1993. In 1993, despite the availability of vaccines and prophylactic treatments, an unprecedented rise in notifications occurred.

The characteristics of this epidemic, which began in 1993 in South Australia, can be described by data from the three sources. In particular, no deaths occurred, nor was hospitalisation substantially increased compared with previous levels. The age specific hospitalisation rate was similar to levels recorded in 1985, 1989 and 1990. The most marked change was the 12 fold increase in the rate

of persons ≥ 15 years with pertussis notified to the Health Commission compared to the highest level recorded in the previous eight years. Also, for the first time since age was recorded (1983), the rate of notifications in the 5 to 14 year age group was greater than the age group ≤ 6 months. Thus, only the notifiable diseases register identified 1993 as significantly different compared with previous years of high activity in the past decade.

Notification data are sensitive to changes in diagnostic and reporting practices. During the past decade two diagnostic tests to detect pertussis infections were introduced into South Australia, in 1985 serological tests[5], and in 1994 polymerase chain reaction (PCR). In 1985 the proportion of notified cases supported by serology was 15%. By 1996 this had increased to 90%. Serological testing is a more sensitive test to detect pertussis in older age groups than culture of *B. pertussis* from nasopharyngeal aspiration.[5,6,7] Prior to this date diagnosis of pertussis was unusual in adults as they do not often present with classical symptoms and *B. Pertussis* was rarely cultured from nasopharyngeal aspiration.[8,9,10,11] The use of serology to diagnose pertussis resulted in increased detection and reporting of disease in older age groups. However, it is unclear whether this reflects recognition of previously undetected disease or a true increase in incidence. Unlike adults, infants under one year of age do not mount a marked serological response to pertussis infection.[12] None of the infants with pertussis aged ≤ 6 months were confirmed by serological testing. However, in 1996 the diagnosis in one third of infants notified in this age group as confirmed by a positive PCR result.

Despite a substantial increase in notifications in older age groups, the major burden of severe disease resulting in hospitalisation continues to be borne by infants. Although the age specific hospitalisation rate for pertussis or complications of pertussis fluctuated, the highest admission rate was in the ≤ 6 months age group for all years since 1985. Admission rates in the next most commonly hospitalised group, the 7 month to 4 years age group, were consistently ten fold lower, and may be due to reduced severity of symptoms due to vaccination.

As expected, the age specific notification rates in the 7 month to 4 year age group are also considerably less than the ≤ 6 months age group. Population based estimates of vaccination indicate this may be due to vaccination. Estimates by the ABS in 1989 and 1994 indicated that 55% and 86% respectively of children one year of age had been vaccinated with 3 doses of pertussis vaccine.[13]

All three data sources have limitations, and these must be considered when interpreting these data. Under reporting is evident in the notification data. Comparison of notification data with hospital discharge data between 1984 and 1996 indicates that fewer infants aged ≤ 6 months were notified with pertussis to the health authorities than were hospitalised. We would expect persons hospitalised to represent a smaller proportion of persons with disease in that age group in the community.[14,15]

There may also be misclassification of acute disease in adults. Since the introduction of the case definition in 1990, treating medical practitioners who identified infected persons by a positive serological report were obliged to notify. Laboratories reported both IgA and IgM positive results. However, irrespective of whether a notification was received from the treating practitioner, the person remained as a case on the data base.

Additionally, we are unaware of the accuracy of coding procedures in the ISIS database prior to the first audit conducted in 1994. This audit followed an intensive period of retraining for the data-coders.

Together, with the cyclical nature of pertussis disease, these limitations make the interpretation of only a few years of data complex. There is a suggestion that Australia may be experiencing a sustained Australia wide epidemic since 1993.[16] South Australian data supports this with continued high levels of hospitalisation and notifications of infants ≤ 6 months since 1993. However alternatively, given the limitations of these data sets we may be setting a new baseline of disease prevalence, as a result of more sensitive tests for pertussis, such as serology and PCR testing.

The epidemiology of pertussis in South Australia has undergone several major changes. Mortality has been reduced. There has been an upward shift in the age distribution of notified cases. The use of more sensitive diagnostic tests may have contributed to increased detection and reporting of disease in older age groups. Nonetheless, the major impacts on disease remain despite modern medical treatment and vaccination.

Acknowledgments

We thank the staff of the Communicable Disease Control Branch and Health Information Services Unit of the South Australian Health Commission, and the staff of the Australian Bureau of Statistics for their assistance. Sue Seldon's contribution of archival notification data is particularly appreciated.

References

1. Burgess M, Forrest J. Pertussis and the acellular vaccines. *Comm Dis Intell* 1996;20: 192-196.
2. National Health and Medical Research Council. Surveillance case definitions. Canberra: NHMRC, 1994.
3. The National Centre for Classification in Health. The 1996 Australian ICD-9-CM. Second edition. Australia: University of Sydney, 1996.
4. Dean AG, Dean JA, Coulombier D et al. Epi Info, Version 6: a word processing, database, and statistics program for epidemiology on microcomputers. Centers for Disease Control and Prevention, Atlanta, Georgia, USA, 1994.
5. Lawrence AJ, Paton JC. Efficacy of enzyme-linked immunosorbent assay for rapid diagnosis of *Bordetella pertussis* infection. *J Clin Micro* 1987;25:2102-2104.
6. Onorato IM, Wassilak SG. Laboratory diagnosis of pertussis: the state of the art. Centers for Disease Control: Current issues in Paediatrics. Orenststein WA. editor. *Pediatr Infect Dis J* 1987;6:145-151.
7. Hansman DJ. Whooping cough: diagnosis, prevalence and prevention. *MJA* 1987; 146:511-513.
8. Mandell GL, Bennett JE, Dolin R, editors. Mandell, Douglas and Bennett's principles and practice of infectious diseases. Fourth edition. New York: Churchill Livingstone, 1995.
9. Robertson PW, Goldberg H, Jarvie BH, Smith DD, Whybin LS. *Bordetella pertussis* infection: a cause of persistent cough in adults. *MJA* 1987;146:522-525.
10. Campbell PB, Masters PL, Rohwedder E. Whooping cough diagnosis: a clinical evaluation of complementing culture and immunofluorescence with enzyme-linked immunosorbent assay of pertussis immunoglobulin A in nasopharyngeal secretions. *J Med Microbio*l 1988;27:247-254.

11. Herwaldt LA. Pertussis in adults: what physicians need to know. *Arch Intern Med* 1991;151:1510-1512.
12. Nagel J, Poot-Scholtens EJ. Serum IgA antibody to *Bordetella pertussis* as an indicator of infection. *J Med Microbiol* 1983;16:417-426.
13. Australian Bureau of Statistics. Children's irnmunisation Australia, April 1995. Catalogue No 4352.0. Canberra: Australian Bureau of Statistics, 1996.
14. Cherry JD, Brunell PA, Golden GS. Report on the task force on pertussis and pertussis immunization. *Pediatrics* 1988; 81 (Suppl.):957-971.
15. Romanus V. Jonsell M. Bergquist S. Pertussis in Sweden after the cessation of general immunization in 1979. *Pediatr Infect Dis* 1987;6:364-371.
16. Andrews R, Herceg A, Roberts C. Pertussis notifications in Australia, 1991 to 1997. *Comm Dis Intell* 1997;21:145-148.