THE EPIDEMIOLOGY OF PERTUSSIS IN NEW ZEALAND AND RISK FACTORS FOR PERTUSSIS IN NEW ZEALAND INFANTS

VOLUME 1 (TEXT)

Cameron Charles Grant

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Paediatrics and Epidemiology, The University of Auckland, Auckland, New Zealand, March 2004

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VOLUME 2 (TABLES, FIGURES AND APPENDICES)

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PREFACE

Pertussis was devastating in the pre-immunisation era and continues to kill infants. It is a disease against which the successes of immunisation have been considerable but have been clouded by controversies relating to the vaccines used. In contrast to other vaccine preventable diseases, pertussis cannot currently be eradicated by immunisation. New Zealand experiences a disproportionately large disease burden from pertussis.

The epidemiology of pertussis is complex and has been modified substantially by immunisation. In this thesis the epidemiology of pertussis in the pre-immunisation era and since mass immunisation will be described with the New Zealand literature compared with that from other developed countries. This literature review will identify the current limitations in our knowledge of pertussis epidemiology in New Zealand and in our knowledge of the risk factors for pertussis both in New Zealand and internationally.

The research questions generated will then be answered from a historical review of New Zealand pertussis epidemiology and a contemporary case control study of risk factors for pertussis in infants.

Following a discussion of the strength and weaknesses of the study and of the study findings, recommendations will be made on how immunisation coverage and pertussis control can be improved and on potential future directions for research on pertussis and immunisation.

ABSTRACT

Literature review

Pertussis mortality and morbidity

Mass immunisation was associated with a decrease in pertussis mortality and a profound reduction in pertussis incidence. Despite this pertussis remains prevalent. Infants account for the majority of pertussis deaths and hospitalisations.

Immunisation

Pertussis vaccines protect against disease rather than infection. Despite immunisation pertussis remains endemic. The efficacy of different whole cell and acellular pertussis vaccines varies considerably.

There has only been a small increase in immunisation coverage in New Zealand over the past 25 years. Currently between 80% and 90% of New Zealand children receive the primary immunisation series.

Other epidemiological features

Bordetella pertussis is a highly infectious organism. Neither infection nor immunisation results in lifelong immunity. Pertussis affects all age groups. It is more severe in females than in males. The incidence has always been highest in infants and children but the reported incidence in adults is increasing. Pertussis epidemics occur at four yearly intervals. The epidemic periodicity has not been changed by immunisation.

Risk factors for pertussis

Contemporary case control studies from the United States have shown that exposure to someone outside of the home with pertussis increases the risk of introduction of pertussis into the home and that infants of adolescent mothers and of mothers with a preceding coughing illness are at increased risk of pertussis. Small sample size and imprecise measurement of immunisation status have compromised these studies.

Other factors associated with an increased risk of pertussis in infants include younger age, low birth weight, the infant's immunisation status and household crowding.

Prior to this current case control study there was no knowledge on the effect of infant characteristics, infant immunisation status, parental and household characteristics, or socioeconomic factors on the risk of pertussis in infants.

Methods

The pertussis mortality and hospital discharge statistics and notification data from 1872 to 2000 were reviewed. The characteristics of children hospitalised with pertussis during the 1995 to 1997 epidemic were described. Risk factors for pertussis in infants were determined using a case control study with two different control groups. A matched case-control design was used to compare infants with pertussis with well control infants from the community. An unmatched design was used to compare infants hospitalised with pertussis to infants hospitalised with other acute respiratory illnesses.

Results

Historical review of pertussis epidemiology

Immunisation was associated with a significant decline in pertussis mortality rates in New Zealand. Pertussis incidence rates in New Zealand are five and 10 times higher than in the United Kingdom or the United States.

New Zealand pertussis hospital discharge rates increased from 1920 to 1950, decreased from 1950 to 1970 and have been increasing since then. The severity of disease among those hospitalised in New Zealand is comparable to other developed countries.

Case control study of risk factors for pertussis in infants

In the community control sample factors associated with incomplete immunisation included poverty and household crowding, advice from a doctor that immunisations be delayed and the caregiver not having a record of the infant's immunisations.

Primary and secondary pertussis in case households occurred in all age groups. Over half of the primary cases were infants.

Factors associated with an increased risk of pertussis included incomplete immunisation of the infant, children five to nine years of age living in the household, household members with pertussis during the preceding two months and the family doctor advising that an immunisation be delayed.

Preschool attendance by a household member was associated with a decreased risk of pertussis. Infants of low birth weight and infants with younger mothers were not at increased risk of pertussis.

In a multivariate analysis, non-immunisation of other children in the household and the presence of someone in the household with clinical pertussis were associated with an increased risk of pertussis in infants.

The associations between household members with cough and the risk of pertussis varied with the age of the household members and imply an age dependent disease modifying effect of immunisation.

For many of the children in the study households it seems unlikely that any health professional knew whether or not they were fully immunised.

Conclusions

Immunisation reduced pertussis mortality in New Zealand. Pertussis hospitalisation rates are increasing despite improvements in the immunisation schedule. Sustained sub-optimal immunisation coverage appears to be the dominant reason for New Zealand's excessive pertussis disease burden. Primary school aged children are important in household pertussis transmission.

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ABBREVIATIONS

CDC	Centers for Disease Control
CI	Confidence interval
CPHA-PAS	Commission on Professional and Hospital Activities-Professional Activities Survey
DT	Diphtheria-tetanus
DTaP	Acellular diphtheria-tetanus-pertussis
DTP	Diphtheria-tetanus-pertussis
FHA	Filamentous hemagglutinin
FIM	Fimbrial agglutinin
GDP	Gross domestic product
ICD	International classification of diseases, injuries and causes of death
ICD-9 CM	International classification of diseases, injuries and causes of death, ninth revision clinical modification
IgA	Immunoglobulin class A
IgG	Immunoglobulin class G
NZSEI	New Zealand socioeconomic index score
OECD	Organisation for Economic Co-operation and Development
OPV	Oral polio vaccine
OR	Odds ratio
PCR	Polymerase chain reaction
PRN	Pertactin
PT	Pertussis toxin
RR	Relative risk
UNICEF	United Nations Children's Fund
WHO	World Health Organization
s.d.	Standard deviation
SPSS	Supplementary Pertussis Surveillance System
vs.	Versus