PERTUSSIS: current epidemiology, diagnosis, and strategies to prevent disease

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Associate Director, Growing Up in New Zealand
Paediatrician, Starship Children’s Hospital, Auckland, New Zealand
Is whooping cough (pertussis) really still such a problem?
I am a paediatrician
I am a paediatrician at the Starship Children’s Hospital.
I see lots of children with whooping cough

Whooping cough = pertussis

http://www.cdc.gov/pertussis/pubs-tools/multimedia.html#pertussis-sounds

Latin derivation Pertussis: per = excess, tussis = cough

“Whooping” is from the horrible noise that people with this illness make as they desperately try to breathe in
Case 1  Baby girl age 5 weeks

• Born 5 weeks early
• Unwell for 2 weeks with cough
  – More recently poor oral intake
  – Going blue with cough
  – Increased breathing effort 2 days
  – Cough more severe 2 days
• Mother cough 5 weeks, worse at night
Clinical signs on admission

- Weight 2.6 kg (skinny)
- Afebrile
- Cough
  - Not paroxysmal (not in long bursts)
  - No vomiting after cough
  - No apnoea
- Pink, reactive
- Vital signs
  - Temp 37°C,
  - Heart rate 180 per minute ↑
  - Breathing rate 38
- Mild chest wall indrawing = sucking in of skin between ribs
Investigations

• Full blood count
  – Haemoglobin 118 \textcolor{red}{Normal}
  – White cell count 49 $\uparrow \uparrow$ (5-15) \textcolor{red}{Way} \textcolor{red}{Way}

• Chest xray
  – Showed pneumonia \textcolor{red}{Way} \textcolor{red}{to high!}
Impression: whooping cough

• Nasogastric feeds
• Antibiotics
• Progress
  – Heart rate 180 to 200 (really fast)
  – Increased breathing effort
  – Day 3 stopped breathing
    • Resuscitation with return of heart rate & breathing
  – Transfer to Paediatric Intensive Care Unit
Progress in PICU

• Put on a breathing machine
• IV fluids and cardiac drugs

• Blood pressure very low
• No urine output
• Acidosis
• Death 2 days after transfer to PICU
• Naospharyngeal sample grew *Bordetella pertussis*: the whooping cough bug
Doctors warn parents to keep newborns at home as whooping cough epidemic escalates

David and Toni McCaffery with baby Sarah who lost their daughter Dana to whooping cough. Picture: Brian Pamphilon.

- Whooping cough epidemic hits NSW
Gone

Dana Elizabeth McCaffery
5th February 2009 - 9th March 2009
Upon completion of this presentation, and even allowing for the odd senior or junior moment, you should be able to:

- Identify that pertussis remains a big problem globally
- List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA
- Recognise why pertussis remains a diagnostic challenge
- State why our immunisation policy should remain focussed on prevention of severe disease in infants
A senior moment

An instance of momentary forgetfulness or confusion that is attributed to the aging process

A junior moment
A senior having a “junior” moment

A junior having a “senior” moment
Upon completion of this presentation you should be able to:

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Immunisation programmes have decreased the incidence of pertussis

1980:
- almost 2 million reported cases
- low (~20%) vaccination coverage

2010:
- ~91,000 reported cases
- High (~80%) vaccination coverage

Global pertussis disease burden 2003

- 300,000 deaths per year
- 50 million cases in children worldwide each year
- Disability-adjusted life years in 2000

Disability adjusted life years = years of life lost + years lived with disability
- Pertussis 12.7 million
- Lung cancer 11.4 million
- Meningitis 5.8 million

Pertussis still causes significant global mortality...

Deaths in children younger than 5 years from vaccine-preventable diseases

Pertussis: 195,000 deaths per year

Pertussis 13%
Measles 8%
Tetanus 4%
Hib* 13%
Pneumococcal diseases* 32%
Rotavirus* 30%

Recent trouble with pertussis
California: pertussis from 1947–2011*

Previous peak in 1947
number of cases: 9,394

Previous peak in 1958
incidence: 26.0/100,000

9,146 cases

23.4/100,000

Recent trouble with pertussis

- California 2010

- 9,000 cases, 10 infant deaths

California Department of Public Health. CDPH says no whooping cough deaths in California during 2011. Available at http://www.cdph.ca.gov/Pages/NR12-005.aspx
Australia: annual pertussis notifications 1991-2010

Australia’s National Notifiable Diseases Surveillance System.
Pertussis epidemic in Australia since 2007

Western Australia (WA): One death from pertussis in each of 2008, 2009, 2010 and
Current epidemic in New Zealand

NZ pertussis notifications & hospitalisations
1997 to March 2012

New Zealand: notifications are rising

Figure 1: Comparative trend of pertussis notifications by week reported during years 2010, 2011 and 2012

Identify that pertussis remains a big problem globally.
Identify that pertussis remains a big problem globally

• Pertussis is ranked among the 10 leading causes of child death
• It is a bigger cause of disability than lung cancer or meningitis
• It kills young babies even if they are in the best intensive care units in the world and despite every piece of technology known to mankind
• There have been recent large epidemics in the USA and Australia with a number of fatalities
• There is an epidemic currently in New Zealand
Pertussis remains a big problem globally
Upon completion of this presentation you should be able to:

• Identify that pertussis remains a big problem globally
• List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA
• Recognise why pertussis remains a diagnostic challenge
• State why our immunisation policy should remain focussed on prevention of severe disease in infants
Life for an infant in New Zealand was 6 times more dangerous than life for an infant in the USA.
Nine reasons why pertussis has been a bigger problem in New Zealand
Coverage

Coverage

Coverage

Coverage

Coverage

Coverage

Coverage

Coverage
To control pertussis you have to do immunisation well

Thomas MG. Reviews of Infectious Diseases 1989;11:255-62
Ministry of Health. The National Childhood Immunisation Coverage Survey 2005
Lennon D et al. Immunisation coverage in North Health. 1996 immunisation coverage survey
Anonymous. Immunisation coverage in New Zealand 1992
Increasing immunisation coverage has been one of New Zealand’s national health targets since these were first introduced in 2007.

**Fully immunised @ age 2 years**
- 85% by July 2010
- 90% by July 2011
- 95% by July 2012

**Coverage @ age 2 years for 3 months to end March 2012**
92%!

National coverage at age 24 months 2008 to March 2012

National coverage at age 24 months 2008 to 2011 by ethnicity and social deprivation

Annual pertussis hospital discharge in New Zealand per 100,000 population 1950 to 2009

Annual average pertussis hospital discharge rate per decade per 100,000 person-years 1950 to 2009

The 2000s was the first decade since the 1960s during which there was a decrease in pertussis hospital discharge rates in New Zealand

2000s vs. 1990s
RR = 0.79, 95% CI 0.74 to 0.84

Pertussis hospital admission rates all ages per decade versus 1960s

Rate ratio

<table>
<thead>
<tr>
<th>Decade</th>
<th>Rate ratio</th>
<th>95% confidence intervals</th>
</tr>
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<tbody>
<tr>
<td>2000s</td>
<td>1.03</td>
<td>0.95 – 1.11</td>
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<tr>
<td>1990s</td>
<td>1.32</td>
<td>1.21 – 1.41</td>
</tr>
<tr>
<td>1980s</td>
<td>1.10</td>
<td>1.01 – 1.19</td>
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<tr>
<td>1970s</td>
<td>0.99</td>
<td>0.91 – 1.08</td>
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<tr>
<td>1960s</td>
<td>1.00</td>
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Average annual infant pertussis hospital discharge rate per decade per 100,000 person-births 1951 to 2009

The 2000s was the first decade since the 1960s during which there was a decrease in the infant pertussis hospital discharge rate in New Zealand

2000s vs. 1990s
RR = 0.88, 95% CI 0.81 to 0.96

Infant pertussis hospitalisation rate in each decade since the 1960s is greater than it was in the 1960s.

International comparison pertussis hospitalisation rates

Life for an infant in New Zealand is now 3 times more dangerous than life for an infant in the USA

Grant CC. *Australian and New Zealand Journal of Public Health* 2012;In press.
Annual pertussis hospital discharge rate per decade per 100,000 person years 1873 to 2009

Grant CC. Aust NZ J Public Health 2012 in press
Pertussis Vaccination Schedule in New Zealand

Average annual infant pertussis hospitalisation rate in the 2000s = 196 per 100,000

Boosters
2006: 4 yr, 11 yr
2002: 15 m, 4 yr
1996: 15 m

Number of doses

<table>
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<tr>
<th>Year</th>
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<tr>
<td>1970</td>
</tr>
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<td>1985</td>
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<tr>
<td>2000</td>
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Primary series

Boosters

2006: 4 yr, 11 yr
2002: 15 m, 4 yr
1996: 15 m

6 week
3 month
5 month

Pertussis Vaccination Schedule in USA

Annual infant pertussis hospitalisation rate 2000 (66 per 100,000), 2003 (65 per 100,000).

Boosters 1960 onwards:
- 4 year
- 15 months

Boosters 2005 onwards:
- 11 to 18 years

Number of doses

Year

1970 1985 2000
Upon completion of this presentation you should be able to:

List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA
List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA

• Low coverage of the primary immunisation series at least since the 1990s
• Late introduction of booster doses
• Scheduling changes that have been driven by concerns about vaccine safety more than greater disease control
Upon completion of this presentation you should be able to:

• Identify that pertussis remains a big problem globally
• List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA
• Recognise why pertussis remains a diagnostic challenge
• State why our immunisation policy should remain focussed on prevention of severe disease in infants
Recognise why pertussis remains a diagnostic challenge
Babies with pertussis

- Can become very sick quickly
- Can present with apnoea rather than cough
- Can look well in between episodes
Infant pertussis

Presenting History
- 4 weeks old
  - 4 days loud breathing
  - 2 days paroxysmal cough

Past History
- 39/40 gestation
- BW 3535 g
- Healthy until now

GP visit
- Looked well
- Viral illness

Paramedic visit
- Middle of night 3
- Better on arrival
- Mums call

Family history 1
- 3 year old sister
  - Cough for 3 weeks
  - Bronchiolitis
  - Fully immunised

Family history 2
- Mum + Dad prolonged cough
  - During pregnancy

Emergency department
- Paroxysmal cough 5 days
  - Vomiting with cough 2 days
  - Poor feeding 1 day
In the Emergency Department

- 5 apnoeic episodes with associated coughing
  - Desaturation to 50%
  - Heart Rate to 60/minute
- Oxygen
- Chest radiograph: pneumonia
- Admit to PICU
In Intensive Care Unit

• Day 2
  – Intubated & ventilated (with difficulty)
  – Multiple apnoeas
  – Thick secretions

• Day 8: Extubated (apnoeas)
• Day 12: To ward
• Day 17 norovirus diarrhoea
Of those requiring PICU care

• Cough present for a median of 7 days

• Presenting symptoms/signs
  – Paroxysmal cough 75%
  – Apnoea 47%

• Only 31% meet clinical case definition at time of PICU admission

School children with pertussis

Have vaccine modified disease

What does this do to their clinical presentation?
It makes it more subtle

Harder to differentiate from other causes of cough
Which school aged child with 2 weeks of cough has pertussis?

- Vomiting with cough: Quadrupled
- Whooping: Tripled
- Sputum production: Doubled
- Wheeze: Halved

Symptoms that don’t differentiate pertussis from other causes of cough in school aged children

- Apnoea
- Cyanosis
- Sinus pain
- Sweating
- Sneezing

Adults with pertussis have the symptoms, but people don’t think of the disease.
To think could this be pertussis
Which adolescent or adult with any cough has pertussis?

- Vomiting with cough: Decreased risk if absent
- Halved
- Doubled

- Whooping: Decreased risk if absent
- Halved
- Doubled

- Paroxysmal cough: Decreased risk if absent
- Halved
- Doubled

Increase risk if present

Recognise why pertussis remains a diagnostic challenge
Recognise why pertussis remains a diagnostic challenge

• **Babies with pertussis**
  – Can become very sick quickly
  – Can present with apnoea rather than cough
  – Can look well in between episodes

• **School aged children with pertussis**
  – Have vaccine modified disease
  – In those with cough for 2 weeks
    • Vomiting with cough, whooping & sputum make pertussis more likely
    • Wheeze makes pertussis less likely

• **Adolescents and adults with pertussis**
  – Pertussis not considered
  – In adults with any cough
    • Vomiting with cough & whooping if present make pertussis more likely
    • If paroxysmal cough & vomiting are not present then pertussis less likely
Upon completion of this presentation you should be able to:

• Identify that pertussis remains a big problem globally
• Describe the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA
• Recognise why pertussis remains a diagnostic challenge
• State why our immunisation policy should remain focussed on prevention of severe disease in infants
Why our immunisation policy should remain focussed on prevention of severe disease in infants

Because pertussis is not the same as other vaccine preventable diseases
Diphtheria cases in New Zealand 1909-2000

1941 mass immunisation started

Ministry of Health; *Immunisation Handbook 2011*. Wellington: Ministry of Health; 2011
Pertussis hospital discharge rate in New Zealand 1873 to 2009

Pertussis is contagious
The reproductive rate of various infections

Reproductive rate = expected number of secondary cases caused by an infectious individual

Anderson RM, May RM. Science 1982;215:1053-60
The exquisite vulnerability of the young
In the USA during the 1940s pertussis resulted in more infant deaths than measles, diphtheria, poliomyelitis and scarlet fever combined.

Young infants remain vulnerable

• A recent (2010) epidemic in California killed eight infants
• Risk factors for death (US)
  – Age < 2 months
  – Low birth weight
  – Female gender
  – 5 minute apgar score < 8
  – Maternal education < 12 years

Roehr B. *BMJ* 2010;341:c4627.
Haberling DL, Holman RC, Paddock CD, Murphy TV. *PIDJ* 2009;28:194-8
Young infants remain vulnerable

Six out of 10 infants who get pertussis will need to be hospitalised

One in 10 of infants who are hospitalised with pertussis require intensive care

One in 6 infants who are admitted to intensive care with pertussis will die or be left with lung or brain damage

For all of these reasons prevention of severe disease in infants requires good timing.
Better control is dependent upon timeliness

- Timeliness
  - Timeliness
  - Timeliness
    » Timeliness
      - Timeliness
      - Timeliness

Cortese MM. Pediatrics 2008;121:484-492
NZ Immunisation coverage and timeliness at age 1 year

Ministry of Health National Immunisation Coverage Survey 2005
National immunisation coverage data by age for 3 months to end June 2011

Coverage by age

Any one of 3 doses
- Quadrupled

Dose 2 due @ 3 months
- Doubled

Dose 3 due @ 5 months
- 6 fold increase

Dose 1 due @ 6 weeks
- Doubled

Increase in risk of dose delayed

The best timing in the world can’t protect the youngest infants
Global pertussis initiative:
Pertussis control strategies

1. Reinforce and/or improve current infant and toddler immunisation strategies
   - Direct protection
2. Create a cocoon of contacts who are immunised and hence less able to spread pertussis to infants
   - Indirect protection

Cocoon immunisation
Universal adult immunisation?

Could change dT to dTap
• Coverage not high enough
• Dose interval not frequent enough
• 45 years and 65 years

Minimum interval gap between receipt of Td and Tdap vaccine has been removed

Ministry of Health. Outbreaks update. Wellington: Ministry of Health; December 2011
Selective immunisation of health care workers
Selective immunisation of health care workers

- Health care workers are at increased risk of pertussis
- Outbreaks in maternity wards, neonatal units and in outpatient settings
- Fatalities occur as a result
- Benefit for the hospital is estimated to be 2.4 times the dollar amount spent on vaccinating health care workers
Whooping cough scare at Middlemore Hospital

By: Juliette Silvertan | Latest Health News | Thursday May 10 2012 13:32

At least 150 mothers and their babies may have been exposed to whooping cough at Middlemore Hospital.

Auckland Regional Public Health Service has confirmed a health professional in maternity services has been diagnosed with the infectious disease.

Clinical Director Dr Julia Peters says they've tried to identify all people who have been close contacts with the case.

"Contacting all the families by phone and letter, also all the general practitioners and all the relevant lead maternity carers so that we are sure that people have received the advice they need."

Advertisement
Cocoon immunisation

Recommended now funded in some DHBs

Recommended but not funded

Recommended but not funded

Recommended but not funded

Recommended but not funded

Recommended but not funded

Recommended but not funded
State why our immunisation policy should remain focussed on prevention of severe disease in infants
Why our immunisation policy should remain focussed on prevention of severe disease in infants

• **Pertussis is not the same as other vaccine preventable diseases**
  – Pertussis vaccines prevent severe disease
  – Pertussis vaccines prevent infection less completely

• **Pertussis is very infectious**
  – As infectious as measles
  – Twice as infectious as most other vaccine preventable diseases

• **Young infants are exquisitely vulnerable to pertussis**
  – This has always been the case
  – Even today they can quickly get into a dangerous pertussis space
  – Because of this a combination of approaches is recommended
    • Complete immunisation
    • Timely immunisation
    • Cocoon immunisation
Upon completion of this presentation you should be able to:

- **Identify that pertussis remains a big problem globally**
  - Among the 10 leading causes of child death
  - Epidemic disease remains a global threat
  - Recent epidemics in Australia, USA
  - Current epidemic in New Zealand

- **List the main reasons New Zealand has a bigger pertussis problem than Australia, the UK and the USA**
  - Low coverage of the primary immunisation series at least since the 1990s
  - Late introduction of booster doses
  - Scheduling changes that have been driven by concerns about vaccine safety more than disease control
Upon completion of this presentation you should be able to:

Recognise why pertussis remains a diagnostic challenge
- Babies with pertussis
  - Have atypical and rapidly evolving disease
- School aged children with pertussis
  - Have vaccine modified disease
- Adolescents and adults with pertussis
  - Pertussis not considered
  - Have vaccine modified disease

State why our immunisation policy should remain focussed on prevention of severe disease in infants
- Pertussis is not as vaccine preventable as other vaccine preventable diseases
- Pertussis is very infectious
- Infants are exquisitely vulnerable to severe pertussis
Next Steps...

• Ensure infants / adolescent vaccines received on time

• Check whether you (and practice staff) have had a recent booster for whooping cough

• Remind new mothers and mothers to be and their families (grandparents etc.) about disease transmission and the importance of whooping cough boosters
**Boostrix®**

Combined diphtheria-tetanus-acellular pertussis (dTpa) vaccine

*Boostrix* is the only dTpa vaccine available in a pre-filled syringe¹,²

**Administration:** *Boostrix* is administered by deep intramuscular injection. **THE VACCINE SHOULD NEVER BE ADMINISTERED INTRAVENOUSLY.**

*Boostrix* is well tolerated; in clinical trials, common side effects were mild and transient. They included fever, malaise, fatigue, headache, irritability, loss of appetite, vomiting, diarrhoea, dizziness, and local reactions such as pain, redness, bruising, itching, or swelling at the injection site.¹

Boostrix® (combined diphtheria-tetanus-acellular pertussis (dTpa or Tdap) vaccine) is available as an injection. A 0.5 mL dose contains not less than 2.5 LfU of diphtheria toxoid, not less than 5 LfU of tetanus toxoid, and three purified Bordetella pertussis antigens (8mcg of pertussis toxoid, 8 mcg of filamentous haemagglutinin, and 2.5 mcg of 69 kDa outer membrane protein). Boostrix is a private-purchase prescription medicine for booster vaccination against diphtheria, tetanus, and pertussis in individuals aged 10 years and older – a prescription charge will apply. Adequate data on use during pregnancy or breastfeeding are not available; therefore prescribing decisions should be based on the possible risks and benefits for each patient. **Contraindications:** known hypersensitivity to any component of the vaccine, encephalopathy after previous pertussis vaccination, or transient thrombocytopenia or neurological complications after previous vaccination against diphtheria and/or tetanus. **Precautions:** do not administer intravenously; ensure medical treatment is readily available in case of rare anaphylactic reaction following administration. **Common side effects** include fever, malaise, fatigue, headache, irritability, loss of appetite, vomiting, diarrhoea, and local reactions such as pain, redness, bruising, itching, or swelling at the injection site. Before prescribing Boostrix, please review the full Data Sheet at [www.medsafe.govt.nz](http://www.medsafe.govt.nz). Boostrix is a registered trade mark of the GlaxoSmithKline group of companies. Marketed by GlaxoSmithKline NZ Limited, Auckland. TAPS DA5312IG/NZ/BOO/0009/12