An outbreak of chickenpox at a child care centre in Western Australia. Costs to the community and implications for vaccination policy

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Chickenpox (CP) is an acute viral disease, characterised by the sudden onset of slight fever, mild constitutional symptoms and a vesicular skin eruption. It is caused by the varicella-zoster virus, a member of the herpes virus family, which has a worldwide distribution and is typically associated with epidemics among children. CP is highly infectious and spread from person to person by direct contact or through the air by aerosols from infected persons. CP usually lasts between 5-10 days and, although it typically has a benign clinical course, infection can lead to serious complications and occasional fatalities, particularly in infants and immunocompromised persons. Individuals who had CP may develop herpes zoster (shingles) at a later date because of the reactivation of the varicella virus, which is capable of persisting in a latent form in the dorsal root ganglia. In Australia, more than 240,000 cases, 1,500 hospitalisations and seven fatalities have been estimated to occur annually due to infection with varicella zoster virus.

CP is one of the most common childhood diseases and approximately 90% of the population will have contracted CP by the age of 15 years, with the highest incidence occurring among children aged 1-6 years. Outbreaks of CP are particularly common in child care centres and schools; these outbreaks can last several months, causing much disruption. A live, attenuated varicella vaccine was licensed in Australia in 2000 and recommended for administration to non-immune children older than 12 months.

Abstract

Objective: Between May and June 2002 an outbreak of chickenpox (CP) occurred at a child care centre in Perth, Western Australia. An epidemiological study was undertaken in order to determine the characteristics of the outbreak, assess vaccine effectiveness, and to define the direct and indirect costs associated with CP infections in young children.

Methods: A cohort study of the outbreak utilising attendance records and a telephone survey of parents was conducted.

Results: Of the 211 children attending the child care centre at the time of the outbreak, 44 contracted CP (attack rate 25.7%). In addition, two staff members, five secondary household contacts (secondary attack rate 38.5%) and four secondary non-household associated contacts were infected. There were no severe complications or any hospitalisations recorded in infected persons. Two cases had been vaccinated previously. Vaccine effectiveness for CP of any severity was 78.0% (95% CI 15.4-94.3%) while vaccine effectiveness against severe CP was 100%. Direct costs during this outbreak were estimated to be $54 per case and the total costs, including cost of parental time off work or study, were estimated to be $525.73 per case.

Conclusions and Implications: Although morbidity associated with CP in young children is not great, infection in childhood is almost universal. This study found that the average costs associated with each CP case were considerable. Since varicella vaccine affords good protection against CP, the recent inclusion of this vaccine in the Australian childhood vaccination schedule should save the community a considerable amount in direct and indirect costs if high coverage rates can be achieved.

Key words: Chickenpox, outbreak, child care centre, costs, vaccination.
This vaccine has been shown to be both safe and effective, with vaccine effectiveness estimates ranging from 71-100%. Although several studies have indicated the significant direct and indirect costs associated with varicella infection, there is still controversy surrounding the cost-effectiveness of universal varicella vaccination. This is largely due to the extent to which indirect savings such as reductions in lost work time attributable to varicella contribute to such calculations and the inherent difficulty in estimating these savings.

The varicella vaccine was added to the Australian Standard Vaccination Schedule in Australia in 2003, but initially it was not subsidised by the Federal Government and hence the full costs of the vaccine had to be met by parents. In March 2005, the Government announced funding for a program starting in November 2005 to provide free vaccine for all children at 18 months of age and for a catch-up program in children 10-13 years of age who had neither received the vaccine nor had the disease.

This article describes an outbreak of CP in a large child care centre in Perth, Western Australia. An investigation was initiated following anecdotal reports of vaccine failures and to assess the direct and indirect costs of CP in young children. These data inform the debate as to the value of varicella vaccine and the public health benefits of universal vaccination of young children against varicella in Australia.

Methods

Setting

The outbreak occurred at a child care centre attached to a tertiary education institution in metropolitan Perth, Western Australia, and was reported to the Communicable Disease Control Directorate (CDCD) on 7 June 2002, several weeks after it started. The outbreak began on 10 May 2002, with symptoms in the last case resolving on 3 July 2002. Because of reported vaccine failures, CDCD initiated an investigation of the outbreak. At the time there were more than 200 children in regular attendance at the child care centre and approximately 40 staff employed. The parents of children attending the centre consisted of an approximately equal mix of staff and students, with a widely varied ethnicity reflecting the diversity of the campus.

The child care centre consisted of nine rooms to which children were allocated on the basis of age, with the rooms being essentially separate in terms of the movements of children and staff. Before the outbreak, all staff at the centre had been offered free vaccinations to encourage uptake, but anecdotal information from the manager indicated that the level of CP vaccination for staff was low. All generally recommended hygiene and infection control measures were maintained at the centre, as were recommendations specific for the control of CP, such as washing and disinfection of toys, appropriate hand washing and disposal of tissues. Children were excluded from attending the child care centre for the duration of infectious CP.

Case definition

An individual was classified as a primary case of CP if they had visited, attended, or worked at the child care centre between 1 May and 3 July 2002 and had been diagnosed with varicella by a medical practitioner (with or without the aid of pathology tests), or had a rash consistent with varicella (maculopapular rash developing into vesicles and finally granular crusty lesions), as described by either parents or a member of the child care centre staff. Polymerase chain reaction (PCR) testing of blister fluid was performed in one child with presumed CP and confirmed the presence of varicella-zoster virus DNA.

Epidemiological investigation

A questionnaire administered by telephone was designed specifically for this study. The questionnaire recorded demographic details, the presence of chronic medical conditions, breastfeeding history, child care attendance, history of previous CP illness or vaccination, and parental knowledge and attitudes towards vaccination. For those who had developed CP, details of the illness including symptoms and duration of illness were collected. Parents were also asked to provide a subjective assessment of the severity of illness in their children. In addition, information assessing the economic cost of CP was sought, including the use of medical care (doctor and hospital visits), use of prescription and non-prescription medicines, days of missed care due to illness, work days lost by parents and the need to make alternative care arrangements. Questions were also asked to enable an assessment of any possible violation in the cold-chain between purchase of the vaccine and administration.

Data collection occurred over approximately four weeks beginning 20 June 2002. Initially, a letter and consent form for interview were distributed by the child care centre to parents and consent forms were returned to the centre directly. For those parents not returning consent forms, verbal consent was sought subsequently by centre staff, either personally as children were brought in for care or by telephone. Detailed records of absences, which were routinely collected by the child care centre, were used to ascertain the number of children who had CP.

Cost assessment

The methodology for the estimation of costs was based on the study of Ferson et al. Costs were separated into those that were directly and those that were indirectly associated with varicella infection. Direct costs included costs of seeking medical attention or of medications, and indirect costs included costs that had to be paid to the child care centre despite the absence of the child and costs of time off from paid employment to care for ill children. The cost of a medical consultation ($29.45) reflected the Medicare Benefits Schedule standard general practitioner fee (Item 23) at the time of the outbreak. It is important to note that no attempt was made in this study to factor in the time and travel costs associated with accessing health care services. The recommended retail price at the time of the outbreak was used for the cost of medications or, where this was not available, the retail cost at a local pharmacy.
In all instances, prices were sought for the smallest volume and presentation most appropriate for use in young children. All costs reflect 2002 Australian dollars.

The cost of usual child care, which had to be paid irrespective of the absence of the child from the centre due to illness, was calculated using the daily rate of $48. The cost of time lost from paid employment was calculated by multiplying the number of days of paid work missed by the average daily ordinary time earnings (May 2002) for adult males and females employed full time ($183.88 and $155.82, respectively). The cost of time lost from studies for those parents who were students was calculated by equating this with time lost from paid employment. Costs associated with infection of staff members and secondary cases were not considered in this analysis.

**Statistical analyses**

Data were entered into Microsoft Access 2000 and analysed using SPSS for Windows. Fisher’s exact test was used for the comparison of proportions. The Student’s t test was used for the comparison of means for parametric data and Welch’s t test was used to compare the means for data with significantly different standard deviations. All p values were two sided, with a significance level of p<0.05.

Attack rates were calculated by dividing the number of cases by the number of children who were susceptible to infection. Those reported to have had CP previously or who had been vaccinated prior to the beginning of the outbreak were considered to be immune. For the calculation of attack rates, children for whom data were not available were assumed to have been susceptible to infection. For calculation of secondary attack rates in the households of cases, the number of secondary cases was divided by the number of susceptible individuals in these households. Vaccine coverage at the start of the outbreak was defined as the proportion of children eligible for vaccination (at least 12 months of age and without a history of CP) who had received the vaccine prior to onset in the first recognised case.

Vaccine effectiveness and 95% confidence intervals were calculated by the cohort method. Children who had previously had CP or who were less than 12 months of age (vaccine not recommended) were excluded from these calculations, while children vaccinated during the course of the outbreak (11 children) were considered to be susceptible to infection. Attack rates for unvaccinated children (ARU) and vaccinated children (ARV) were calculated and the percentage effectiveness of the vaccine was then calculated as follows: [(ARU-ARV)/ARU] x 100. The effectiveness of the vaccine against severe disease was calculated by reclassifying mild to moderate cases as non-cases.

![Figure 1: Epidemic curve indicating children affected during the chickenpox outbreak. (Note: no cases were observed in Room D.)](image)
Results

Response rate

There were 211 children regularly attending the child care centre at the time of the outbreak occurred. The overall response rate for this study was 76.3% (161 out of 211 children accounted for by parental interviews). The parents of 100% (44 of 44) of those children reported by the child care centre to have CP and the parents of 70.1% (117 of 167) of those children with no record of recent CP were interviewed. The child care centre maintained an up-to-date list of those children who were absent due to CP and results from interviews were in accord with the child care centre records of illness.

Response rates and attack rates for each of the rooms at the child care centre are summarised in Table 1. Response rates varied, from a low of 41.7% in Room D (the only room in which CP cases were not identified) to a high of 93.3% in Room A.

Outbreak characteristics

The outbreak lasted eight weeks, beginning on 10 May 2002 with the development of blisters in the index case (see Figure 1). Blisters in the last case developed on 26 June and had resolved by 3 July 2002. In total, 44 of 211 children at the centre contracted CP during the outbreak. After excluding those who had had CP previously (18 children) and those who had been vaccinated before the onset of the outbreak (22 children), the attack rate in susceptible children was 25.7% (44 of 171).

The index case appeared to have been infected with CP at another child care centre, at which he was also a regular attendee. He introduced CP to Room H (3-5 year-old children) at the centre, which was the most affected during the outbreak, with 26 of 31 susceptible children (83.9%) in this room contracting CP (see Table 1). Room G, the next most affected room, had an attack rate of 45%. Rooms H and G were adjacent to each other, but did not share any common areas. The remainder of the affected rooms had between 1-2 cases (attack rates <10%).

The mean age of infected children was 2.9 years, which was significantly older than those children who remained unaffected (mean 2.4 years). There were no differences between infected and uninfected children in terms of gender, country of birth, history of breast feeding, number of days of child care or history of atopic diseases (see Table 2). Diagnosis of CP was made by a doctor in 28 cases (63.6%), by parents in 11 cases (25%), by a nurse in two cases (4.5%), by a child care worker in two cases (4.5%) and by an undetermined third party in one case (2.3%). Thirty parents (68.2%) reported taking their child to the doctor at some point during their illness, but none of the cases required hospitalisation.

In addition to the presence of a rash and the formation of blisters and crusts, a large proportion of parents reported fever (75%) and malaise (68.2%) in their children, while headaches (13.6%) and abdominal (6.8%) upsets were reported by a few. Children were unwell for a median of 4.5 days (range 0-42 days), while the median duration of infectious CP, defined by the time between the onset of rash to the crusting of blisters, was seven days (range 3-12 days). Parents indicated that the majority of cases were either of mild (40%) or moderate (42.5%) severity, while 15% were severe and 2.5% very severe (n=40).

Table 1: Response rates, case numbers and attack rates for rooms at the child care centre.

<table>
<thead>
<tr>
<th>Room</th>
<th>Age group (years)</th>
<th>Number of children</th>
<th>Number of responses</th>
<th>Response rate (%)</th>
<th>Children with CP</th>
<th>Infected rate (%)</th>
<th>Attack rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room A</td>
<td>0-1</td>
<td>15</td>
<td>14</td>
<td>93.3</td>
<td>1</td>
<td>6.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Room B</td>
<td>0-1</td>
<td>13</td>
<td>7</td>
<td>53.8</td>
<td>1</td>
<td>7.7</td>
<td>7.7</td>
</tr>
<tr>
<td>Room C</td>
<td>1-2</td>
<td>24</td>
<td>18</td>
<td>75.0</td>
<td>2</td>
<td>8.3</td>
<td>8.7</td>
</tr>
<tr>
<td>Room D</td>
<td>1-2</td>
<td>12</td>
<td>5</td>
<td>41.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Room E</td>
<td>1-2</td>
<td>18</td>
<td>15</td>
<td>83.3</td>
<td>1</td>
<td>5.6</td>
<td>7.7</td>
</tr>
<tr>
<td>Room F</td>
<td>2-3</td>
<td>29</td>
<td>23</td>
<td>79.3</td>
<td>2</td>
<td>6.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Room G</td>
<td>2-3</td>
<td>28</td>
<td>24</td>
<td>85.7</td>
<td>9</td>
<td>32.1</td>
<td>45.0</td>
</tr>
<tr>
<td>Room H</td>
<td>3-5</td>
<td>35</td>
<td>32</td>
<td>91.4</td>
<td>26</td>
<td>74.3</td>
<td>83.9</td>
</tr>
<tr>
<td>Room I</td>
<td>3-5</td>
<td>37</td>
<td>23</td>
<td>62.2</td>
<td>2</td>
<td>5.4</td>
<td>8.3</td>
</tr>
<tr>
<td>Total</td>
<td>0-5</td>
<td>211</td>
<td>161</td>
<td>76.3</td>
<td>44</td>
<td>20.9</td>
<td>25.7</td>
</tr>
</tbody>
</table>

Notes:
(a) Number of children with chickenpox divided by the number of children in each room.
(b) Number of children with chickenpox divided by the number of susceptible children in each room.

Table 2: Selected characteristics of infected and non-infected children.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Infected (n=44)</th>
<th>Not infected (n=117)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>2.9 (±0.7)</td>
<td>2.4 (±1.1)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Male</td>
<td>26 (59.1%)</td>
<td>58 (49.6%)</td>
<td>0.29*</td>
</tr>
<tr>
<td>Born in Australia</td>
<td>39 (88.6%)</td>
<td>109 (93.2%)</td>
<td>0.34*</td>
</tr>
<tr>
<td>Breastfed</td>
<td>41 (93.2%)</td>
<td>111 (94.1%)</td>
<td>0.71*</td>
</tr>
<tr>
<td>Days at centre</td>
<td>2.8 (±1.1)</td>
<td>2.6 (±1.3)</td>
<td>0.37*</td>
</tr>
<tr>
<td>Medical conditions</td>
<td>12 (27.3%)</td>
<td>26 (22.0%)</td>
<td>0.54*</td>
</tr>
<tr>
<td>Asthma</td>
<td>4 (9.1%)</td>
<td>6 (5.1%)</td>
<td>0.46*</td>
</tr>
<tr>
<td>Eczema</td>
<td>8 (18.2%)</td>
<td>16 (13.7%)</td>
<td>0.47*</td>
</tr>
<tr>
<td>Hayfever</td>
<td>1 (2.3%)</td>
<td>0</td>
<td>0.27*</td>
</tr>
<tr>
<td>Other</td>
<td>1 (2.3%)</td>
<td>3 (2.6%)</td>
<td>1.00*</td>
</tr>
</tbody>
</table>

Notes:
(a) Welch’s test.
(b) Fisher’s exact test.
(c) Student’s t test.
(d) Miscellaneous allergies and/or intolerances.
Data are mean (± standard deviation) or number (percentage).
There were five secondary household cases comprising four siblings and one parent among the 88 non-child care centre associated household contacts of the 44 outbreak cases. Of these, 75 (85.2%) reported previous CP, 10 had not had CP previously and three contacts were not sure. None of these 13 household contacts had been vaccinated. Consequently, the secondary attack rate among susceptible contacts was 38.5% (five of 13). There were also four non-household associated contacts reported to be infected, including two cousins and two unrelated play friends of cases.

A total of 24 children were vaccinated against varicella, with 22 children receiving the Varilrix® (GlaxoSmithKline) vaccine and two receiving Varivax® (CSL/Merck Sharpe Dohme). Two of these cases experienced breakthrough disease, with both cases receiving the Varilrix® vaccine and no apparent violation of cold-chain between the purchase of the vaccine and subsequent administration apparent. These children were 3.6 and 3.1 years old at the time of the outbreak and had been vaccinated at ages 1.6 and 2.8 years, respectively. In both breakthrough cases, the severity of CP was assessed by parents as being mild (duration of symptoms three and seven days, respectively), and in one case the presentation was atypical, with no noticeable maculopapular rash reported, just the formation of blisters/crusts.

**Attitudes towards vaccination**

The 42 infected children who were not vaccinated came from 37 separate households. Parents from these households were questioned about the reasons for not having their children vaccinated. While nine parents (24.3%) indicated that they did not know about the vaccine at the time of interview, 28 parents (75.7%) were aware of it. Clear reasons for not vaccinating were obtained from 24 of these parents. Of these, five (20.1%) indicated that they learnt about the vaccine only after their child was infected and two (8.3%) felt that vaccination had not been appropriate as their child had already been exposed to the virus. Five parents (20.1%) felt that vaccination was not important because CP is a mild disease, three (12.5%) were specifically advised by their doctor not to vaccinate, three (12.5%) were planning to vaccinate but their child became infected, two (8.3%) mistakenly thought their children had already been vaccinated, one parent (4.2%) forgot, and three (12.5%) felt the vaccine was too expensive.

**Vaccine effectiveness**

Among children who were at least 12 months of age, the attack rate among unvaccinated susceptibles was 38.0% (41 of 108), and the attack rate for vaccinated susceptible children was 8.3% (two of 24), giving an estimated vaccine effectiveness of 78% (95% CI 15.4-94.3%). Vaccine effectiveness against moderate to severe disease was 100%.

**Direct and indirect costs**

Thirty infected children (68.2%) had at least one medical consultation because of their CP, with one child having four doctor visits. In total, there were 46 medical consultations for CP, equating to a mean of 1.05 consultations per case at an average cost of $30.92. The main topical medications used to treat symptoms of skin itching were Calamine lotion and bath additives, with a mean cost of $14.22 per child (see Table 3). Paracetamol and antihistamines were the most commonly used oral medications, with a mean cost per affected child of $8.86.

Total mean direct medical costs, taking into account both general practice consultations and medication usage, were $54 per affected child.

The distribution of the number of days of child care missed by CP cases is shown in Figure 2. Based on records maintained by the child care centre, children with CP missed a mean of 3.2 days (range 0-8 days), which cost parents an average of $153.60 per affected child. In addition, mothers of affected children missed an average of 0.62 days of full-time employment, 0.14 days from full-time studies, 0.24 days from part-time employment and 0.66 days from part-time studies in

![Figure 2: Number of days missed from child care caused by chickenpox infection (n=44).](image)

**Table 3: Costs of topical and oral medications used in children with chickenpox (n=44).**

<table>
<thead>
<tr>
<th>Medications</th>
<th>Children n (%)</th>
<th>Total cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topical preparations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bath additives</td>
<td>22 (50.0%)</td>
<td>$230.34</td>
</tr>
<tr>
<td>Calamine lotion</td>
<td>24 (54.5%)</td>
<td>$138.00</td>
</tr>
<tr>
<td>SoluMed®</td>
<td>9 (20.5%)</td>
<td>$60.21</td>
</tr>
<tr>
<td>Other*</td>
<td>11 (25.0%)</td>
<td>$197.00</td>
</tr>
<tr>
<td>Sub total</td>
<td></td>
<td>$625.55</td>
</tr>
<tr>
<td><strong>Oral medications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>25 (56.8%)</td>
<td>$197.10</td>
</tr>
<tr>
<td>Antihistamines</td>
<td>11 (25.0%)</td>
<td>$136.83</td>
</tr>
<tr>
<td>Non-steroidal anti-inflammatory medicines</td>
<td>1 (2.3%)</td>
<td>$4.20</td>
</tr>
<tr>
<td>Other*</td>
<td>4 (9.1%)</td>
<td>$51.68</td>
</tr>
<tr>
<td>Sub total</td>
<td></td>
<td>$389.91</td>
</tr>
<tr>
<td><strong>Overall cost</strong></td>
<td></td>
<td>$1,015.36</td>
</tr>
</tbody>
</table>

Notes:
(a) Included the following topical preparations: Paraderm Plus®, Lignicaine lotion, Savlon®, various commercial oils and gels, Betadine®, corticosteroid cream, antibiotic eye drops.
(b) Included the following: cold and flu tablets, Robitussin®, laxative and Painstop®.
order to care for their children. Fathers missed an average of 0.66
days from full-time employment, 0.02 days from full-time studies
and 0.05 days from part-time employment. The estimated mean
lost earnings per affected child, calculated on the basis of average
daily earnings, was $188.58 for mothers and $129.55 for fathers.
In all households affected by CP, parents were able to organise
unpaid alternative care arrangements. Addition of the costs due
to missed child care and lost earnings gave a mean indirect cost
per child case of $471.73.

The total direct and indirect cost for each child with CP was
therefore estimated to be $525.73

Discussion

One-quarter of susceptible children at this large child care centre
contracted chickenpox during the outbreak, causing significant
disruption to the centre and to the families involved. In addition
to 44 infected child care centre attendees, two staff members, five
secondary household contacts and four secondary non-household
associated contacts were also infected. Although no specific risk
factors for contracting CP could be identified, infected children
were significantly older than those unaffected. This, however,
was a reflection of the fact that the index case attended one of
the rooms dedicated to older children (age 3-5 years) and this
room was by far the worst affected by the outbreak (attack rate
83.9%). Other rooms at the centre were affected to a lesser degree,
at least in part reflecting competent handling of the outbreak by
the child care centre, including prompt exclusion of infected
children and effective communication with parents to promote
awareness of CP.

As would be expected for a vaccine that had only been available
for a few years, was not part of the childhood vaccination schedule
at the time of the outbreak, and which protects against what is
considered to be a relatively mild disease, vaccine coverage at the
beginning of the outbreak was low (14.9%). Furthermore, only
11 children were vaccinated over the period of the outbreak. This
is likely to have been due to the vaccine being poorly promoted,
at least initially. Interviews indicated that vaccination was not
considered to be important by many parents, as well as some
doctors. Furthermore, the cost of the vaccine was also a barrier
to uptake for some parents. These data were only available for
parents of children who were infected with CP, and it is likely that
attitudes to CP vaccination would have been even less favourable
in parents of children who were not infected. Clearly, a greater
vaccine uptake at the beginning of the outbreak may have reduced
the size and the associated economic and social costs.

Two of the children who developed CP had previously been
vaccinated. Studies have suggested that there may be a greater
risk of primary vaccine failure associated with vaccination at age
<15 months. In addition, vaccine failure has been associated
with vaccination occurring three or more years before exposure
to the varicella-zoster virus during an outbreak, presumably
due to waning immunity. Both breakthrough cases in this
outbreak were, however, greater than 18 months old at the time of
vaccination and were vaccinated within two years of the outbreak.
Primary vaccine failure has also been reported to be associated
with a history of asthma and administration of the varicella
vaccine and another live vaccine within 30 days of each other. However, none of these factors were associated with breakthrough
cases in this outbreak. Despite the fact that both breakthrough
cases were vaccinated with Varilrix, which needs to be stored and
maintained between +2 °C and +8 °C in order to retain potency,
no violation of the cold-chain between purchase of the vaccine
at community pharmacies and subsequent administration could
be identified.

Although breakthrough disease does occur following varicella
vaccination, it is typically mild, with fewer lesions, complications,
and systemic symptoms than infections in unvaccinated
individuals. Although disease severity was graded subjectively by parents in this study, both breakthrough cases were
found to have mild disease. In this study, vaccine effectiveness
against disease of any severity was 78%, while its effectiveness
against severe disease was 100%. This is in agreement with the
literature, with vaccine effectiveness being reported as ranging
from 71% to 100% against disease of any severity and 95% to
100% against severe disease.

The total mean costs associated with each infected child in this
outbreak were estimated to be $525.73. Direct medical costs,
either due to medical consultations or purchase of medicines,
contributed approximately 10% of the total cost, with lost child
care fees and lost earnings because of time taken to look after
sick children contributing approximately 90% of these costs.
Interestingly, the time lost by mothers to care for sick children
in the present study was less than half that reported in a previous
Australian study, perhaps reflecting the flexibility afforded to
university employees and students relative to more typical parental
roles in the community study. Nonetheless, this flexibility to
defer work or study to later is also associated with an opportunity
cost due to forgone leisure or household production time. The
overall importance of lost earnings, however, was consistent with
estimates in the earlier Australian study, as well as data from
France and Canada.

The fact that approximately half the parents of children
attending the child care centre were students added another
level of complexity to the estimation of costs associated with
the outbreak. In order to simplify this calculation, time lost from
studies was equated with time lost from employment. Although
an oversimplification, it may be argued that these students had
potential earning capacity similar to those in employment if they
were not studying. Moreover, there is also a significant opportunity
cost of missed student time, given student fees and the considerable
public expenditure on university infrastructure and staff salaries.
It is also important to note that other outcomes such as quality of
life, pain and suffering, parental anxiety and so on, which are also
significant but very difficult to assess, were not taken into account
in this study. For instance, the outbreak occurred during exam time,
and students and staff of the university were already under stress.
Also of importance is the value of lost learning and socialisation
in children resulting from illness and missed care.

In conclusion, this outbreak highlights the significant social and economic costs associated with chickenpox, despite the fact that it is generally a relatively mild disease in young children. Although there are occasional cases of breakthrough disease among those who have been vaccinated, the vaccine affords good protection against infection and excellent protection against severe disease. While there is a concern that universal childhood vaccination against varicella may increase the incidence of herpes zoster (shingles) in adults, available data do not support this hypothesis. Close monitoring of the incidence of both varicella and herpes zoster in those countries using the vaccine will provide an answer to this question and even if the theorised effect is observed, modification of the vaccination strategy may minimise the impact. Interestingly, a recently completed trial in the United States has indicated that the vaccination of older adults with the varicella vaccine may itself prevent herpes zoster.

Varicella vaccination was added to the Australian Standard Vaccine Schedule in 2003, with vaccination recommended at 18 months of age and as a catch up in 10-13 year-old children. More recently, the Federal Government began fully funding the vaccine (from November 2005) for children at these ages. If coverage rates of around 90% or more are achieved for the scheduled free 18-month varicella vaccine dose, as might be expected based on coverage levels for other scheduled vaccines, the program will have a significant impact on the health and economic burden of this disease.

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References

25. MIMS. St Leonards (AUST): MediMedia Australia; 2002.