community, it is advisable to wear a N-95 mask in when seeing any patient with respiratory symptoms. Contacts of proved cases should isolate themselves until the incubation period is over. After contact with patients with respiratory symptoms, careful hand hygiene is necessary, with washing with soap and water.

On 27 March the Department of Health finally announced drastic measures, including vigorous contact tracing and examination, quarantine of contacts in their homes, and closure of all schools and universities. A major hospital has been designated for infected patients. On 1 April all residents from the building in the housing estate where the outbreak occurred were evacuated to a holiday camp. Most public gatherings have been postponed to later dates.

## Conclusions

Severe acute respiratory syndrome is highly infectious and potentially lethal. It caught the medical profession in Hong Kong unaware. The drastic measures introduced by the Hong Kong government, together with intensive education of the public on personal hygiene and the wearing of masks in public places, will, we hope, halt this epidemic. Other health authorities faced with this disease should consider early introduction of quarantine procedures.

Contributors: WCY helped care for the patients. MC-Y collected data for this report and is guarantor.

Competing interests: None declared.

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# Delayed immunisation and risk of pertussis in infants: unmatched case-control study

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Pertussis remains a severe disease in infants. As about two thirds of infants with pertussis are admitted to hospital, factors that seem to be associated with an increased risk of pertussis may in fact be associated with an increased risk of hospital admission.[1 2] The admission rate for pertussis in New Zealand is five to 10 times higher than in England and Wales and the United States.[3] We determined whether immunisation reduced the risk of admission to hospital for pertussis by comparing infants admitted with pertussis and infants admitted with other acute respiratory illnesses.

## Participants, methods, and results

We performed an unmatched case-control study during the 1995-7 pertussis epidemic in Auckland, New Zealand. Pertussis was defined as cough lasting at least two weeks, with coughing paroxysms, inspiratory "whoop," or vomiting after coughing. The control group consisted of 98 infants admitted to hospital with a coughing illness who were culture negative for *Bordetella pertussis* and had no *B pertussis* DNA detected in their nasopharyngeal sample after amplification by polymerase chain reaction. We interviewed each infant's care giver and determined written confirmation of the infant's immunisation status from his or her health record book or the family doctor's records.

In New Zealand, immunisations are scheduled at age 6 weeks, 3 months, and 5 months. An immunisation was delayed if it had not been received within 30 days of its first being due.[4] We used logistic regression to calculate odds ratios and 95% confidence intervals to determine the risk of pertussis associated with delayed immunisation. We defined socioeconomic status by the occupation of the household's main income earner. We measured social deprivation by using the 1996 New Zealand social deprivation index.[5]

Odds ratios (95% confidence intervals) of catching pertussis associated with delays in giving pertussis vaccine

| | No/total (%) of participating infants with delayed dose | | Adjustment for | |
|---|---|---|---|---|
| Delayed immunisation | Pertussis cases (n=97) | Hospital controls (n=98) | Age only | Other variables* |
| First dose of DTPH† | 13/70 (19) | 10/71 (14) | 2.13 (0.77 to 6.20) | 2.23 (0.64 to 8.67) |
| Second dose of DTPH† | 10/25 (40) | 18/49 (37) | 1.60 (0.53 to 4.94) | 2.37 (0.59 to 10.40) |
| Third dose of DTPH† | 9/13 (69) | 9/26 (35) | 4.25 (1.07 to 19.54) | 6.09 (1.00 to 49.64) |
| Any immunisation | 21/70 (30) | 23/71 (33) | 2.66 (1.02 to 7.71) | 4.50 (1.22 to 20.94) |

*Multivariate analyses included variables describing infants' age, social deprivation, and crowding in households, and, in the analysis of delay for any immunisation, maternal education.
†DTPH=Diphtheria-tetanus-pertussis-haemophilus type B whole cell vaccine (Tetramune; Wyeth Lederle, United States).

We identified 179 infants with a diagnosis of pertussis at discharge and enrolled 97 (54%). These did not differ from the non-enrolled infants in age, sex, ethnicity, gestation, birth weight, or social deprivation score. To ensure that the controls were a representative sample of children with non-pertussis coughing illnesses we compared the 98 enrolled control infants with two other groups of infants admitted to hospital with such illnesses: 227 infants with cough who had not been approached for enrolment and 78 infants with cough who had been identified as eligible but for whom informed consent was not obtained. The controls and the other two groups did not differ in age, proportion of infants of non-European ethnicity, or social deprivation index.

We obtained nasopharyngeal samples for culture from 95 (98%) of the 97 infants with pertussis and for polymerase chain reaction from 83 (86%). We identified *B pertussis* by culture in 32 (34%), by polymerase chain reaction in 73 (75%), and by either method in 76 (80%) infants.

The infants with pertussis were younger than the controls and more likely to have mothers with only primary school education (odds ratio 11.78, 95% confidence interval 2.02 to 225.37) and to live in more crowded households (2.12, 1.17 to 3.89) and households in the most socially deprived fifth (2.21, 1.18 to 4.23). We found no differences between the two groups in other characteristics of the infant (gestation, birth weight, ethnicity, or breast feeding), mother (age, marital status, and smoking), or household (mobility, smokers, occupation, and socioeconomic status).

The table shows associations between delayed immunisations and risk of admission to hospital with pertussis. In the multivariate analysis we found an increased risk associated with delay in the first, second, or third immunisation or any combination of these (odds ratio 4.50). Analysis by individual dose of vaccine showed that an increased risk of pertussis was associated with delay in the third dose (odds ratio 6.09). Including all variables describing infant, maternal, and household characteristics in the model did not alter the importance of increased risk associated with any delayed immunisations (odds ratio 6.13, 1.13 to 47.07).

## Comment

Delayed immunisation is a specific risk factor for admission to hospital with pertussis rather than being a marker of infants at increased risk of admission to hospital for any acute respiratory illness. Improving on-time delivery of immunisations can be expected to decrease the admission rate for pertussis in New Zealand.

Contributors: CCG enrolled participants, analysed the data, and drafted the paper. RS directed study design and data analysis. DL initiated and designed the project. RF enrolled cases and assisted with the ethical application. JS advised on study design, data management, and analysis. RM designed and performed all of the polymerase chain reaction assays. DK identified cases and controls. MR enrolled cases and controls and supervised other interviewers. All authors revised the paper, CCG wrote the paper and is the guarantor.

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The regional ethics committee approved the study.

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# Science commentary: Pertussis immunisation

Science commentary

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Tolerance for pertussis (whooping cough) immunisation is highest when given early, and on time. Since the disease is most severe in young infants, early completion of immunisation is critical. Pertussis immunisation in the United Kingdom is presently given at 2, 3, and 4 months. This "accelerated" course was introduced in 1990, and there is good direct evidence that the early schedule is tolerated better than the previous (later) schedule.[1] This negates the idea that parents sometimes have that babies "cope" better with vaccination when they are older and bigger. Efficacy of the pertussis vaccine used in England and Wales is high although it wanes with increasing age.[2]

If primary immunisation is delayed or not completed, child health will be compromised. While typhoid, diphtheria, and tetanus are not endemic in the United Kingdom, pertussis is present and does cause morbidity and mortality. Pertussis causes most morbidity before the age of 8 weeks (before immunisation begins). The number of hospital admissions for pertussis in all ages was 853 in 1999 (E Miller, personal communication, 2001) and almost half of these were in children under 3 months of age. Without the accelerated course, these rates would be higher, and overall protection depends on the course being completed.

The youngest babies are probably getting pertussis from older children, who usually suffer only a mild illness, and for this reason preschool boosters for pertussis were introduced from October 2001. One study that looked at whole cell pertussis preschool boosters found that while antibody responses were high, the rate of reactions increased,[3] whereas another study found that acellular pertussis boosters result in good immunogenicity and do not produce more reactions.[4]

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