Epidem. Inf. (1988), **101**, 405–410
Printed in Great Britain

Antibody level of New Zealand children immunized with the triple vaccine DTP (diphtheria–tetanus–pertussis)

By R. C. H. LAU

Immunology Research and Development Unit, National Health Institute, Kenepuru Drive, Porirua, Wellington, New Zealand

(*Accepted 1 May 1988*)

SUMMARY

Enzyme-linked immunosorbent assay (ELISA) tests were used to measure IgG antibody levels in 2638 New Zealand children who had been immunized with the triple vaccine DTP. The percentage of children immune to diphtheria decreased with age. The percentage of children immune to tetanus varied from 67·1 to 55·0%. The percentage of children with measurable antibody to pertussis increased with age. The mean percentages of children with measurable antibody or immunity to one or more DTP components were 34·2% (with 3 components), 34·4% (2 components), and 78·1% (1 component). It appears the immunization strategy for diphtheria and tetanus is satisfactory for herd immunity in New Zealand children. However, the current pertussis strategy may not be providing adequate immunity to 5-year-olds in this country.

INTRODUCTION

The triple vaccine DTP (diphtheria–tetanus–pertussis) was introduced in New Zealand in 1960. Its introduction has played a major role in reducing the incidence of tetanus and diphtheria to insignificance (Lau, 1986, 1987*a*) even though major outbreaks of pertussis have been reported in this country (Campbell Begg, 1984; Canterbury Hospital Board, 1987).

In April 1985, a National Immunization Survey was conducted in which sera from almost 3000 randomly selected children throughout New Zealand were collected. The sera collected were from about 1000 new school entrants (mean age 5 years), 1000 standard-3 students (mean age 10 years), and 1000 form-4 pupils (mean age 15 years). As no previous study has been undertaken to measure the antibody level to DTP in New Zealand children, this paper reports on the antibody level to DTP in sera collected during the 1985 National Immunization Survey.

MATERIALS AND METHODS

Sampling and sera

A two-stage stratified random sampling technique was used to identify a study population of about 3000 children comprising equal numbers of 5-, 10- and 15-year-olds.

Table 1. *Percentage of children with antibody or immunity by age*

Age group (years)	Number studied	Disease category	Percentage with antibody or immunity
5	857	Diphtheria	72·7
		Tetanus	67·1
		Pertussis	54·7
10	913	Diphtheria	64·6
		Tetanus	55·0
		Pertussis	73·8
15	868	Diphtheria	55·8
		Tetanus	63·6
		Pertussis	73·3

Aliquots of serum were placed in plastic flexiplates and stored at −90 °C until tested. Full details of the sampling and sera storage are published by Patel (1986).

In this study, sera from 2638 children who have had a history of diphtheria and tetanus vaccination at 3, 5 and 18 months and of pertussis vaccination at 3 and 5 months were tested.

ELISA

Sera were tested by ELISA for IgG antibody to diphtheria and tetanus toxoids, and whole-cell *Bordetella pertussis*. Details of ELISA tests used in this paper have been published previously (Lau, 1987*b*).

RESULTS

The percentage of vaccinated children with measurable antibody to pertussis or immunity to diphtheria and tetanus by age is shown in Table 1. For diphtheria, the percentage of those immune decreased with age from 72·7% in the 5-year-olds to 55·8% in the 15-year-olds. For tetanus, the percentage of children immune decreased from 67·1% in the 5-year-olds to 55·0% in the 10-year-olds but then increased to 63·6% in the 15-year-olds. An average 73·5% of 10- and 15-year-olds had measurable antibody to pertussis while only 54·7% was recorded for the 5-year-olds.

The percentage of vaccinated children with antibody or immunity to one or more DTP components by age is shown in Table 2. The mean percentages of children with measurable antibody or immunity to DTP components were 34·2% (with 3 components), 34·4% (2 components), and 78·1% (1 component). Of those with antibody or immunity to one component of DTP, the most prevalent was for the diphtheria component.

Table 3 shows that there was a wide range of serum-antibody level in the 5-, 10- and 15-year-olds for diphtheria, tetanus and pertussis.

Table 2. *Percentage of children with antibody or immunity to one or more DTP components by age*

Age group (years)	Number studied	Number DTP components	Percentage with antibody or immunity to component(s)
5	857	3	33·6
		2	38·4
		1*	77·7
10	913	3	33·9
		2	34·6
		1†	80·2
15	868	3	35·2
		2	30·3
		1‡	76·3

* Percentage prevalence by DTP component were diphtheria (85·9), pertussis (8·8), and tetanus (5·2).

† Percentage prevalence by DTP component were diphtheria (76·4), pertussis (19·3), and tetanus (4·4).

‡ Percentage prevalence by DTP component were diphtheria (69·3), pertussis (20·5), and tetanus (10·1).

DISCUSSION

The decrease in diphtheria immunity with age in this study is in agreement with studies elsewhere (Scheibel *et al.* 1966; Kjeldsen, Simonsen & Heron, 1985) which also show that diphtheria antitoxin titre declined with time after primary immunization. Although the number of notified cases of diphtheria in New Zealand has declined to an insignificant level, 76 (80·8%) of the 94 cases notified between 1960 and 1984 were aged under 15 years (The Public Health, 1960–1984). Moreover, in 1974 there was a localized outbreak of diphtheria in the Hamilton health district in which school children were affected. It is of some concern that only 55·8% of the 15-year-olds in this study had a protective level of diphtheria antitoxin (AT); the remainder may not be adequately protected, unless their basal immunity were to permit a rapid rise of AT on exposure.

The tetanus boosters recommended in New Zealand for 5- and 15-year-olds may explain the higher percentage of children immune to tetanus in the 5-year-olds (67·1%) and 15-year-olds (63·6%) when compared to the 10-year-olds (55·0%) in this study. Since 1960 when the triple vaccine was introduced in this country, the number of notified cases of tetanus has fallen substantially (Lau, 1987*a*). The immunity level in New Zealand children appears to be satisfactory since most tetanus cases have occurred mainly in unprotected adults, especially elderly adults.

Although it seems reasonably satisfactory that an average 73·5% of 10- and 15-year-olds in this study have measurable antibody to pertussis, it remains unclear what the association is between the level of measurable antibody and actual protection against the disease. However, the low percentage of 54·7% with antibody to pertussis in the 5-year-olds is of great concern since they are a potential reservoir for disease and a source of transmission of disease to young unimmunized siblings and infants resulting in serious illness and hospitalization.

Table 3. *Analysis of antibody absorbance values in New Zealand children vaccinated with the triple vaccine DTP*

Age group (years)	Number studies	Disease category	Mean absorbance*	S.D.†	Min. value	Max. value	S.E.‡	C.V.§
5	857	Diphtheria	0·516	0·302	0·113	1·995	0·010	58·488
		Tetanus	0·400	0·260	0·088	1·211	0·009	64·981
		Pertussis	0·530	0·231	0·150	1·240	0·008	43·537
10	913	Diphtheria	0·473	0·293	0·117	2·050	0·010	62·028
		Tetanus	0·343	0·245	0·010	1·324	0·008	71·339
		Pertussis	0·606	0·211	0·186	1·226	0·007	34·889
15	868	Diphtheria	0·362	0·186	0·114	1·701	0·006	51·360
		Tetanus	0·417	0·282	0·070	2·240	0·009	67·560
		Pertussis	0·604	0·194	0·188	1·153	0·006	32·160

* Mean absorbance values of negative control sera for diphtheria, tetanus and pertussis were 0·210, 0·150, and 0·318 respectively.
† Standard deviation.
‡ Standard error.
§ Coefficient of variation.

The potential for infection and transmission is particularly important in this country as it appears that since 1974 there has been a 4-year cycle of outbreaks of pertussis, and moreover, in the 1982–83 major outbreak, 82 (44%) of 187 reported primary household cases were aged 7 months to 5 years (Campbell Begg, 1984).

Only a mean 34·2% of vaccinated children studied had measurable antibody or immunity to all three DTP components (Table 2). This probably reflects the decline of antibody titre with time and the possible lack of a booster effect by repeated exposure to diphtheria and tetanus. However, in the case of pertussis, it is probable that subclinical infections may explain the higher percentage of children with antibody (mean 73·5%) in the older 10- and 15-year-olds when compared to only 54·7% in the 5-year-olds. The consistently higher prevalence of immunity to the diphtheria component in children with antibody or immunity to only one DTP component in all age groups, suggests that the diphtheria component used in the triple vaccine in New Zealand is more immunogenic than the tetanus and pertussis components.

There was a wide range in antibody level in each age group studied for all three components of the triple vaccine (Table 3). This is probably due to a number of factors such as varying host response to primary immunization, decline of antibody titre with time, and subclinical infection. The latter is probably most true for pertussis in this country as evidenced by the increase in mean absorbance of pertussis antibody with age.

This study, which investigated the antibody level in New Zealand children to the triple vaccine, is the first undertaken in this country. While it appears that the immunization strategy for diphtheria and tetanus has proven satisfactory in improving herd immunity in New Zealand children, the current pertussis vaccine and the immunization schedule may not be providing adequate immunity for 5-year-olds as evidenced by the 4-year cycle of pertussis outbreaks since 1974 (Campbell Begg, 1984). Perhaps the introduction of pertussis boosters at 18 months and again at 5 years, i.e. prior to or at school entry, may alleviate the potential for a reservoir of disease and subsequent transmission of disease. In 1984, a three dose schedule was recommended at 6 weeks, 3 months, and 5 months. The extra dose at the early age of 6 weeks should increase the protection of infants to pertussis in New Zealand. Finally, it is obvious that active encouragement of primary immunization with the triple vaccine must be pursued in order to maintain and improve herd immunity.

I wish to acknowledge the contribution of Drs J. Clements, K. Bettelheim, and A. Patel to survey design. I wish to thank the parents and children who consented to participate in the study. I am grateful to the staff at the National Serum Bank, departmental medical officers, laboratory staff, and public health nurses involved in collecting and processing the blood samples, and to the Director-General of Health for permission to publish this paper.

REFERENCES

CAMPBELL BEGG, R. (1984). Pertussis – New Zealand 1982/83. *New Zealand Medical Journal* **97**, 408–411.

CANTERBURY HOSPITAL BOARD (1987). Department of Microbiology Newsletter, February 1987.

KJELDSEN, K., SIMONSEN, O. & HERON, I. (1985). Immunity against diphtheria 25–30 years after primary vaccination in childhood. *Lancet* i 900–902.

LAU, R. C. H. (1986). Detection of diphtheria toxin antibodies in human sera in New Zealand by ELISA. *Journal of Hygiene* **96**, 415–418.

LAU, R. C. H. (1987*a*). Detection of tetanus toxoid antibodies in human sera in New Zealand by ELISA. *Epidemiology and Infection* **98**, 199–202.

LAU, R. C. H. (1987*b*). Diphtheria, tetanus, and pertussis: antibody detection in New Zealand. *New Zealand Medical Journal* **100**, 481–483.

PATEL, A. C. (1986). 1985 New Zealand serum survey: methodology. Wellington: New Zealand College of Community Medicine.

SCHEIBEL, I., BENTZON, M. W., CHRISTENSEN, P. E. & BIERING, A. (1966). Duration of immunity to diphtheria and tetanus after active immunization. *Acta Pathologica et Microbiologica Scandinavica* **67**, 380–392.

THE PUBLIC HEALTH. New Zealand Department of Health Annual Reports, 1960–1984.