Thorax Online First, published on November 7, 2006 as 10.1136/thx.2006.062547

IS CHILDHOOD IMMUNISATION ASSOCIATED WITH ATOPIC DISEASE FROM AGE 7 TO 32 YEARS?

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Word count: 3,000

Keywords: immunisation, asthma, atopic disease.

ABSTRACT

Background: There is ongoing conjecture over whether childhood immunisation leads to an increased risk of developing atopic diseases.

Objective: To examine associations between childhood immunisation and the risk of atopic disease.

Methodology: Immunisation histories of 8,443 Tasmanian children born in 1961 obtained from School Medical Records were linked to the Tasmanian Asthma Study. Associations between immunisation status and atopic diseases were examined while adjusting for possible confounders using multiple logistic regression.

Results: Diphtheria immunisation was weakly associated with an increased risk of asthma by age 7 years (OR 1.3, 95% CI 1.1-1.7), but there was no evidence of any association for four other vaccinations studied. An increased risk of eczema by age 7 years was associated with immunisation against diphtheria (OR 1.5, 95% CI 1.1-2.1), tetanus (OR 1.5, 95% CI 1.1-2.0), pertussis (OR 1.5, 95% CI 1.1-1.9) and polio (OR 1.4, 95% CI 1.0-1.9) but not small pox. Similar but slightly weaker patterns of association were observed between the risk of food allergies and immunisation against diphtheria (OR 1.5, 95% CI 1.0-2.1), pertussis (OR 1.4, 95% CI 1.1-1.9), polio (OR 1.4, 95% CI 1.00-2.1) and tetanus (OR 1.30 95% CI 0.99-1.70), but not with small pox. There was no evidence of associations between immunisation history and hay fever, or incidence of later-onset atopic outcomes.

Conclusions: The few effects seen in this study are small and age-dependent, and nearly all our findings support numerous previous studies reporting no effect of vaccines on asthma. Based on these findings the fear of their child developing atopic disease should not deter parents from immunizing their children, especially when weighed against the benefits.

INTRODUCTION

More than a quarter of children have some manifestation of atopic (allergic) disease and the prevalence of such diseases world-wide, especially in "westernised" countries, has risen dramatically in the past few decades.[1-3] Much has been written theorising that infants who are exposed to frequent infections may develop a TH1-predominant rather than a TH2-predominant immune system, thereby decreasing the risk of atopic diseases. The global increase in atopic disease prevalence has thus been hypothesised to be attributed to either an increased use of vaccines with a subsequent reduction in infectious diseases, or to a direct immune potentiating effect of vaccines. Further fuelling parental concerns are reports that most childhood asthma diagnoses are made before age five [4-5], corresponding to the period in which children are usually immunised.

Several studies of pertussis vaccine have been conducted, as it is a potent stimulus for IgE production.[6-8] Some report no association [9-11] with atopic disease, while others report an increased risk [12] and some report that it is protective.[13-15] Similarly, conflicting evidence has been reported for other vaccines including diphtheria, tetanus and polio.[10, 13, 16-18] However, none of the studies have found any harmful effect for measles [10, 12, 13, 19], BCG [20-22] and smallpox vaccine [23, 24] on the development of atopic diseases.

Most of these studies have generally suffered from lack of power, misclassification of retrospectively collected immunisation data or incomplete adjustment for potential confounding factors, all of which may have contributed to their inconsistent findings. The few studies that have overcome these methodological issues have reported no associations [25, 26], or a possible early protective effect.[14] This inconsistency highlights the importance of investigating such associations within cohort studies that span childhood and adulthood.
In this paper, we report an analysis of associations between immunisation history and the development of asthma and atopic diseases in a cohort born in a single year followed from age seven for three subsequent decades.

METHODS

Study Design

The Tasmanian Asthma Study (TAS) is a prospective population-based cohort study which commenced in 1968 (Figure 1). All children who were born in 1961 and attended primary schools in Tasmania (hereafter termed probands) were eligible and 8,583 (99%) participated.[27] Parents were asked to complete questionnaires regarding the socio-demographic characteristics, lifestyle factors and medical history of the probands, with particular attention to symptoms and/or physician diagnosis of asthma and other atopic diseases.

In 1974, a questionnaire was administered to all probands who were still at school in Tasmania and 7,484 (87.2% of the original cohort) participated. In 1991, 1,000 probands who had asthma by age seven years and 1,000 probands who did not have asthma by age 7 years were randomly selected

from the original sample. A total of 1,763 probands were traced and 1,501 responded to a postal survey (74.7%).

Parent-completed school medical records were available for 8,443 (98.3%) of the total cohort of probands, and these formed the main data set for the current analysis. Data were scanned. School medical records were available for 7,334 (98.0%) of the 7,484 children who participated in the 1974 (age 13) follow-up, and 1,465 (98.1%) of the 1,494 people who participated in the 1991 (age 30) follow-up. Parent reported vaccination status of diphtheria, tetanus, pertussis, polio and smallpox was unavailable for 2.2%, 2.4%, 2.4%, 2.5% and 2.2% respectively of the total cohort.

Data Collection

Information regarding the outcomes of interest (asthma and other atopic conditions) was extracted from the 1968 survey, and the 1974 and 1991 follow-up studies. The outcomes were: 1) having ever had each of the atopic conditions (asthma or wheezy bronchitis, eczema, food allergies and hay fever) by age 7 years, as recorded in the 1968 study 2) having ever had asthma or wheezy bronchitis by age 13 years, as recorded in the 1974 study. In 1968 and 1974 proband asthma and other atopic conditions were reported by parents, whereas in 1991 the probands themselves reported this information, and 3)'late-onset atopic disease' (late-onset asthma was defined as reporting not having had asthma or wheezy bronchitis by age 13, but reporting having had it by age 30 years; as the information on eczema, food allergy and hay fever was not collected in 1974, late-onset eczema, food allergy and hay fever were defined as not having had these diseases by age seven years but having had them by age 30 years). The comparison groups for these late onset atopic outcomes comprised individuals who had not developed asthma by age 13 years, and not developed eczema, food allergy or hay fever by age 7 years.

The main exposures of interest were immunisations against diphtheria, tetanus, pertussis, polio and smallpox. Immunisation data were obtained from the children's school medical records completed by their parents. These records have collected data on immunisation against diphtheria, pertussis, tetanus, poliomyelitis and smallpox using specific questions.

Data on potential confounders of the association between immunisation and atopic disease were extracted from the 1968 survey and school medical records. These included the child's gender, birthplace and feeding in the first three months after birth (bottle fed only, bottle and breast fed, breast fed only), parental asthma and smoking and maternal employment, probands' birth order, and any past bacterial infections (diphtheria, pertussis), pneumonia and any past viral infections (measles, mumps, rubella and chicken pox) among probands.

Data Analysis

Odds ratios (OR), with 95% confidence intervals and p-values, for associations between immunisation status and outcomes were estimated using multiple logistic regression. Effect modification due to family history of atopic disease was examined by stratification and inclusion of interaction terms. Potential confounders were included and their impact assessed. The best

model was identified by conducting likelihood ratio tests between nested models, with and without each potential confounder. Variables were retained in the final model if the likelihood ratio test for their inclusion indicated $p < 0.15$. To account for the random stratified sampling used in the 1991 study, the associations between immunisation status and late onset eczema, food allergy and hay fever were examined while stratifying by the sampling variable (asthma status in 1968). If the relevant associations were similar across strata, the sampling variable was then included in multivariate analysis of the association between immunisation status and these outcomes.

RESULTS

At age seven, 87.2% (n=7,314) of the probands had been immunised against diphtheria, 85.8% (n=7,187) against tetanus, 85.6% (n=7,172) against pertussis, 88.9% (n=7,450) against polio and 13.6% (n=1,142) against smallpox. The correlation between immunisation against diphtheria, tetanus, pertussis, and polio was high (kappa ranged from 0.5-0.9).

Immunisation and participant characteristics

Participant characteristics and the cumulative prevalence of reported atopic diseases are described in Table 1. Information on the age at onset of atopic diseases and dates of immunisation were not available.

Some participant characteristics were closely associated with immunisation status. Children born in the United Kingdom, United States, New Zealand, Canada or South Africa were more likely to have been immunised against diphtheria, pertussis, and polio than those born in Tasmania (odds ratios ranged from 1.7 to 2.0; all $p<0.01$). On the other hand, those born in other countries were less likely to be immunised against pertussis and tetanus (odds ratios ranged from 0.3 to 0.6; $p<0.05$). One exception was smallpox vaccine, with those born anywhere outside of Australia being much more likely to have been immunised compared with those born in Tasmania (OR=33; $p<0.001$). Within Australia, those born in other states were 2.5 fold more likely to have been immunised against smallpox than those born in Tasmania ($p<0.001$).

Children who were exclusively breastfed in the first three months of life were more likely to have been immunised against diphtheria, tetanus, pertussis and polio than those who were exclusively bottle-fed (odds ratios from 1.5 to 1.8; all $p<0.001$). Similarly, children with a history of viral infections (odds ratios ranged from 1.3 to 1.4; $p<0.001$), and first born children (odds ratios ranged from 1.3 to 1.4; $p<0.001$), were more likely to have been immunised against diphtheria, tetanus, pertussis and polio. First-born children were also 1.6 fold more likely to have been immunised against smallpox ($p<0.001$). Children whose parents both smoked were less likely to have been immunised against diphtheria, tetanus and polio than when neither parent smoked (odds ratios from 0.5 to 0.6; all $p<0.001$). Children who had a history of bacterial infection before age 7 years were less likely to have had all the immunisations investigated in the study (odds ratios from 0.6 to 0.7; all $p<0.001$). Parental asthma and maternal employment were not associated with immunisation levels (all $p>0.05$).

Table 1 Characteristics of the study participants

	n (N)	%
Sex		
Female	4014 (8215)	49
Birthplace		
Tasmania	7396 (8179)	90.4
Other states in Australia	480 (8179)	5.9
UK, US, NZ, Canada, or S. Africa	237 (8179)	3.0
Other	66 (8179)	0.1
Feeding in 1st 3 months		
Bottle-fed only	2327 (8142)	28.6
Bottle + breast fed	2620 (8142)	32.2
Breastfed only	3195 (8142)	39.2
Parental smoking in 1968		
Neither parents smoke	2291 (7291)	31.4
Father smokes	2404 (7291)	33.0
Mother smokes	593 (7291)	8.1
Both mother and father smoke	2003 (7291)	27.5
Parental Asthma in 1968		
Neither parents have/had asthma	5929 (7395)	80.2
Father has/had asthma	661 (7395)	8.9
Mother has/had asthma	674 (7395)	9.1
Both parents have/had asthma	131 (7395)	1.8
Mother employed * in 1968	1699 (7634)	22.2
First born child	2330 (8054)	28.9
Any past bacterial infection §	1428 (8167)	17.5
Any past viral infection †	6570 (8169)	80.0
Any past history of pneumonia	812 (8179)	9.9
Any past history of pertussis	719 (8173)	9.0
Had asthma by age 7	1319 (8215)	16.1
Had asthma by age 13	1717 (7436)	23.1
Had eczema by age 7	783 (8126)	9.6
Had food allergy by age 7	564 (8158)	6.9
Had hay fever by age 7	1032 (8193)	12.6

*Was mother working in 1968? § history of pneumonia, diphtheria or pertussis
† History of measles, mumps, rubella or chicken pox

Immunisation and atopic disease by ages 7 and 13 years

There was little evidence for an association between any immunisation and asthma by ages 7 or 13 years (Table 2). However, immunisation against diphtheria, tetanus, pertussis and polio were all associated with an increased risk of having eczema and food allergy by age 7 years. This effect appeared to be more consistent for eczema. Further, diphtheria and pertussis vaccines were also associated with an increased risk of hay fever by age 7 years. There were no effect modifications of

the associations between immunisation and asthma, food allergy or eczema by parental asthma (all p>0.05).

Table 2: Cumulative prevalence of childhood atopic diseases by vaccination status, with crude odds ratio (OR) comparing those immunized with those not immunized.

	Non Immunized	Immunized	Odds ratio for disease		
	N (%)*	N (%)*	OR	95% CI	p
Asthma by age 7					
Diphtheria	1032(14.2)	7135(16.3)	1.17	0.98-1.41	0.09
Tetanus	1148(15.3)	7007(16.2)	1.07	0.90-1.27	0.47
Pertussis	1161(14.8)	6999(16.3)	1.12	0.94-1.33	0.21
Polio	894(16.3)	7264(16.0)	0.98	0.81-1.18	0.81
Smallpox	7038(16.4)	1111(14.1)	0.84	0.70-1.01	0.06
Asthma by age 13					
Diphtheria	903(21.8)	6492(23.2)	1.08	0.87-1.34	0.49
Tetanus	997(21.1)	6386(23.2)	1.13	0.90-1.42	0.27
Pertussis	1010(22.1)	6378(23.2)	1.07	0.90-1.26	0.45
Polio	775(23.2)	6615(23.1)	0.99	0.80-1.24	0.96
Smallpox	6461(22.2)	919(22.6)	1.02	0.88-1.18	0.77
Eczema by age 7					
Diphtheria	1006(6.9)	7073(10.2)	1.51	1.17-1.95	<0.01
Tetanus	1121 (7.1)	6946(10.1)	1.47	1.16-1.88	<0.01
Pertussis	1132 (6.9)	6940(10.1)	1.51	1.19-1.93	<0.001
Polio	867 (7.4)	7204(9.9)	1.38	1.06-1.80	0.02
smallpox	6959 (9.6)	1102(9.4)	0.98	0.79-1.22	0.85
Food allergy by age 7					
Diphtheria	1018 (5.2)	7092 (7.2)	1.40	1.05-1.87	0.02
Tetanus	1135 (5.6)	6963(7.1)	1.30	0.99-1.70	0.06
Pertussis	1147 (5.1)	6956(7.1)	1.42	1.08-1.87	0.01
Polio	882 (5.3)	7220(7.1)	1.36	1.00-1.85	0.05
Smallpox	6988 (6.8)	1104(7.2)	1.05	0.82-1.34	0.70
Hay fever by age 7					
Diphtheria	1028(10.2)	7119(13.0)	1.31	1.06-1.62	0.01
Tetanus	1145(11.3)	6990(12.9)	1.16	0.95-1.41	0.14
Pertussis	1159(10.9)	6981(12.9)	1.21	0.99-1.48	0.06
Polio	892(12.4)	7246(12.6)	1.02	0.82-1.25	0.88
smallpox	7019(12.5)	1110(13.1)	1.05	0.87-1.27	0.61

N Total number in each group * Percentage of each disease outcome

The results of the multiple logistic regression analysis of the associations between immunisation and atopic diseases by ages 7 and 13 years are summarised in Table 3. The analysis adjusted for potential confounding by gender, birthplace, history of bacterial infection, parental smoking, parental asthma, history of viral infection, birth order and history of pneumonia. After adjustment, there was substantially stronger evidence for a positive association between diphtheria immunisation and risk of asthma by age 7 years and a slightly weaker association with risk of

asthma by age 13 years. The change in estimates was due to a negative confounding effect of bacterial infection and parental smoking. None of the other vaccines was clearly associated with having asthma by ages 7 or 13 years, although odds ratios for tetanus and pertussis were greater than 1, possibly reflecting the fact that these vaccines are very often given in conjunction with diphtheria.

Adjustment for confounders made little difference to the estimated associations between diphtheria, tetanus, pertussis, polio vaccine and combination of diphtheria, tetanus and pertussis and increased risk of eczema, nor to the associations between food allergies and immunisations for diphtheria, pertussis and polio.

Table 3: Association between immunisation and childhood atopic diseases: odds ratios (OR) adjusted for sex, birthplace, history of bacterial infection, parental smoking, parental asthma, history of viral infection, birth order and history of pneumonia.

Outcome	Vaccine	OR	95% CI	p=
Asthma by age 7	Diphtheria	1.33	1.06-1.68	0.01
	Tetanus	1.16	0.94-1.43	0.16
	Pertussis	1.19	0.96-1.47	0.11
	Polio	1.05	0.83-1.32	0.69
	Smallpox	0.94	0.75-1.19	0.62
Asthma by age 13	Diphtheria	1.28	0.98-1.66	0.07
	Tetanus	1.18	0.89-1.55	0.24
	Pertussis	1.11	0.91-1.37	0.31
	Polio	1.03	0.79-1.35	0.84
	Smallpox	1.08	0.90-1.29	0.39
Eczema by age 7	Diphtheria	1.53	1.13-2.07	<0.01
	Tetanus	1.53	1.15-2.04	<0.01
	Pertussis	1.46	1.10-1.93	<0.01
	Polio	1.36	1.00-1.87	0.05
	Smallpox	0.95	0.73-1.23	0.69
Food allergy by age7	Diphtheria	1.47	1.04-2.07	0.03
	Tetanus	1.26	0.93-1.71	0.14
	Pertussis	1.39	1.01-1.91	0.04
	Polio	1.44	1.00-2.07	0.05
	Smallpox	1.18	0.88-1.58	0.28
Hay fever by age 7	Diphtheria	1.20	0.94-1.53	0.15
	Tetanus	1.05	0.84-1.31	0.67
	Pertussis	1.10	0.88-1.38	0.42
	Polio	0.88	0.69-1.12	0.30
	Smallpox	1.07	0.85-1.34	0.59

Immunisation and late-onset atopic disease by age 30 years

Of the 753 who did not have asthma by age 7 years, 55 (7%) developed asthma by age 13 years. Among 698 who remained free of asthma by age 13 years, 81 (11%) developed asthma by age 30 years. Univariate analysis showed that diphtheria, pertussis, tetanus and polio immunisations were generally associated with a lower risk of developing asthma after age 13 years, with the strongest evidence for negative association between immunisations against pertussis (OR=0.55; 95% CI 0.30-1.00; p=0.05) and polio (OR=0.45; 95% CI=0.21-0.95; p=0.04). Among those who did not have asthma by age 7 years, the cumulative incidences of eczema, food allergy and hay fever from age 7 to 30 years were 9.2%, 17.9% and 37.3%. Among those who had asthma by age 7 years, the cumulative incidences of eczema, food allergy and hay fever from age 7 to 30 years were 11.3%, 21.5% and 49.4%. None of the immunisations was associated with onset of other atopic diseases after age 7 years. After adjustment for confounders, there remained little evidence for an association between immunisation status and late-onset asthma or atopic diseases (Table 4), with, if anything, a tendency for lower risk of late-onset asthma and eczema among those immunised against diphtheria, pertussis, tetanus and polio.

Table 4: Association between immunisation status and reporting asthma after the age of 13 years and other atopic diseases after the age of 7 years: odds ratios (OR) adjusted for confounders as listed

Outcome/vaccine	OR	95% CI	p=	Confounders
Asthma				
Diphtheria	0.58	0.26-1.27	0.17	
Tetanus	0.79	0.32-1.96	0.61	
Pertussis	0.57	0.30-1.09	0.09	Sex, parental asthma
Polio	0.50	0.22-1.10	0.08	
Smallpox	0.91	0.50-1.65	0.76	
Eczema				
Diphtheria	0.68	0.36-1.29	0.24	
Tetanus	0.76	0.38-1.52	0.44	Age 7 asthma status,
Pertussis	0.57	0.35-0.93	0.03	sex, parental asthma,
Polio	0.76	0.39-1.48	0.43	parental smoking
Smallpox	1.20	0.79-1.85	0.39	
Food allergy				
Diphtheria	1.50	0.81-2.79	0.20	
Tetanus	0.98	0.54-1.75	0.94	Age 7 asthma status,
Pertussis	0.88	0.57-1.35	0.55	sex, parental smoking
Polio	1.02	0.57-1.83	0.94	
Smallpox	1.29	0.91-1.82	0.15	
Hay fever				
Diphtheria	1.19	0.75-1.89	0.45	
Tetanus	1.09	0.67-1.78	0.72	Age 7 asthma status,
Pertussis	0.96	0.67-1.38	0.83	sex, parental smoking,
Polio	0.78	0.47-1.28	0.32	feeding in 1st 3 months
Smallpox	0.98	0.73-1.33	0.91	

DISCUSSION

This appears to be the first prospective cohort study examining the association between multiple immunisations in childhood and atopic outcomes up to the age of 30 years. We found that diphtheria immunisation was weakly associated with a small increase in reporting of having asthma by age 7 years. However none of the other immunisations were associated with an increased risk of asthma. A modestly higher reported incidence of eczema, and food allergies by age 7 years was associated with immunisation against diphtheria, tetanus, pertussis and polio but not with small pox. There was no evidence of associations between immunisation and hay fever, or incidence of later-onset atopic outcomes.

Our findings are consistent with the large number of studies [9, 10, 25, 28, 29] which found no associations between asthma and immunisations like DTP, measles, pertussis and rubella. The exception in our study, the diphtheria vaccine, supports one previous study which reported that immunisation against diphtheria, pertussis, tetanus and polio was a risk factor for having had asthma before age 10 years.[16] However, there are conflicting reports regarding the association between pertussis vaccine and the risk of asthma [12, 14, 26]. The retrospective nature of some of these studies, subsequent misclassification of exposure or outcome status and inadequate data on confounders may have contributed to these conflicting results.

Our study provided evidence that diphtheria, tetanus, pertussis and polio immunisations were associated with approximately 50% higher risk of eczema, and food allergies in 7 year olds. We cannot conclude that the effects of these vaccines were independent of each other because of the overlap in use between vaccines. Our findings are consistent with those from a previous study that found associations between whole-cell pertussis vaccine and atopic diseases such as eczema and hay fever up to the age of 12 years.[12] In contrast, another longitudinal study found that rubella and pertussis vaccines were associated with a decreased risk of atopic dermatitis, and allergic sensitisation levels in 5 year olds.[14]

In our study, children immunised against diphtheria, pertussis, tetanus and polio had a somewhat lower risk of late-onset asthma and eczema, especially for pertussis vaccine. These findings suggest that certain vaccines produce age-dependent effects on the development of atopic disease, indicating that biological mechanisms underlying some early-onset atopic diseases may differ to those for the late-onset atopic diseases.

First-born children in this study were more likely to have been immunised. This offers a possible alternative explanation for the effect of family size and/or number of siblings on risk of developing atopic diseases, as noted by previous studies.[20,30] Previously this has been attributed to the hygiene hypothesis, with older children not having the benefit of endotoxin and viral exposures from siblings.

Some strengths of our study include its prospective design and lack of selection bias. Both the original study and the follow-up at age 13 years were representative of the population as the participation rates for the two surveys were high (98.9% and 87.2% respectively).[27, 31] The response to the 1991 questionnaire was similar for those with and without childhood asthma

(74.1% vs. 75.3%), and for males (73.7%) and females (76.0%), showing no evidence of response bias [32].

A major limitation of our study was that immunisation data would have been subject to recall error given that they were obtained from school medical records completed by parents after children commenced schooling. Parents of children with allergies/asthma may have either recalled the immunisation status better or wrongly classified their children as having been immunized. Such differential misclassification could have exaggerated the observed association between immunisation and allergies and asthma. The use of parental reporting of atopic conditions is another limitation as it is likely to be less reliable than physician reporting. Only the question used to define asthma has been validated against physician diagnosis [33].

Furthermore, parental health attitudes may have affected both seeking a diagnosis of an atopic condition and having their children vaccinated, which may also have contributed to the risk of atopic conditions being associated with vaccination. Such a detection bias is more likely with eczema given that eczema is more likely to develop in early childhood, during which timeframe childhood immunisations are given. The observed associations may also suggest that there is a higher likelihood of childhood immunisations in those already at greater risk of atopic disease. However, this is an unlikely explanation for observed associations as parental asthma was not associated with the propensity to immunise, suggesting that parents of children with atopic diseases are unlikely to immunise their children more than the rest of the population.

Another limitation was a lack of precise dates of immunisation for all subjects and, as a consequence, the temporal relationship could not be examined for early-onset atopic diseases, especially for eczema. As immunisations are usually given in the first years of life it is most likely that they were completed prior to asthma development, but we cannot be certain about this. Also, the different types of vaccines given could not be established. This was a problem when examining smallpox immunisation, where children from other countries were more likely to be immunised with different strains. In Australia there were two forms of polio vaccine – the Salk (Injected Polio Vaccine) was commonly used before the introduction of Sabin (Oral Polio Vaccine) in 1966. Such differences may limit the generalisability of some findings.

In summary, our study provides some evidence that some immunisation may be associated with a small increased risk of atopic disease, mostly for eczema, by age 7 years; the evidence for an association with asthma risk was minimal. Our findings are consistent with range of hypotheses: that immunisations may lead to increased atopic disease in early childhood, that parents who have children with allergies recall their children having had immunisation better than other parents and /or that parental health attitudes may have affected both seeking a diagnosis of an atopic condition and having their children vaccinated. None of these immunisations appeared to be associated with the incidence of late onset atopic disease with, if anything, reduced rates of atopic disease among those immunised (clearest with pertussis vaccine and eczema).

In this study the few effects seen are small and age-dependent, the general prevalence of atopic disease is low (<10%) and nearly all the findings of this study support numerous previous studies reporting no effect of vaccines on asthma. Based on these findings, the fear of their child

developing atopic disease should not deter parents from immunizing their children, especially when weighed against the benefits.

ACKNOWLEDGMENTS

The 1968 and 1974 studies were funded by the Tasmanian Asthma Foundation and the 1991 study was funded by the National Health Medical Research Council. Computerisation of the 1974 study was funded by the Victorian Asthma Foundation. Researchers declare that their work was independent of these funding bodies.

COMPETING INTERESTS

None declared.

ETHICS

Ethics approval for the study has been granted by the Human Research Ethics Committee, The University of Melbourne.

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Thorax published online November 7, 2006