Occasional Review

Efficacy of pertussis vaccination in England

REPORT FROM THE PHLS EPIDEMIOLOGICAL RESEARCH LABORATORY AND 21 AREA HEALTH AUTHORITIES

Abstract

A national assessment of the efficacy of pertussis vaccination was made in 21 area health authorities in England. Notification rates for children given either three doses of diphtheria/tetanus/pertussis vaccine or diphtheria/tetanus vaccine were studied during the two and a half-year period January 1978-June 1980. A survey of home circumstances showed that the two vaccine groups could be validly compared. Home visits were made to assess the severity of the illness, the attack rates in home contacts, and to take pernasal swabs. Pertussis vaccination was found to be of outstanding value in preventing serious disease. Nevertheless, its effect in controlling whooping cough is limited by the fact that protection for home contacts is less satisfactory, and by the occurrence of mild cases in vaccinated children which may contribute to the spread of the disease.

Introduction

The efficacy of pertussis vaccination was last assessed nationally in 1966-7.[1 2] In view of the continuing controversy about the vaccine a fresh assessment was made during the outbreak that began in 1977. This assessment was based on a comparison of the whooping cough notification rates in children under 6 years of age who had received routinely either three doses of diphtheria/tetanus/pertussis vaccine (DTP) or three doses of diphtheria/tetanus vaccine (DT). Since these vaccine groups could differ in other ways that might affect attack rates and thus bias this comparison, a separate survey was made of the home circumstances of children given either vaccine.

Procedures

The 21 areas that took part comprised about one-quarter of the total area health authorities in England. The investigation began in January 1978 and continued until June 1980. Children were routinely immunised during the first year of life, the first dose being given at 3-6 months. The vaccination state both of the population under 6 years of age and of the notified cases was provided by each area health authority from their computer records.

Home visits by nurses and health visitors from the AHA were made to notified cases to record the severity of the attack, as judged by the frequency of paroxysms and vomiting, the family circumstances, and to take pernasal swabs. A subsequent home visit about six weeks later was also made to record symptoms in contacts under 6 years. Since infection with *Bordetella pertussis* is not invariably associated with characteristic symptoms,[3] the nurses were asked to report all cases of cough whether or not these were associated with typical paroxysms.

The trial was planned and co-ordinated, and the report prepared at the Epidemiological Research Laboratory, Colindale, by Dr T M Pollock, Dr Elizabeth Miller, Mr J Lobb, and Mrs Gwendoline Smith.

Area health authorities were: Bedford, Bolton, Brent and Harrow, Buckinghamshire, Cleveland, Cornwall, Cumbria, Derbyshire, Devon, Dorset, Hampshire, Kent, Lancashire, Leicestershire, Leeds, Manchester, Northamptonshire, Newcastle, Salford, Salop, Somerset.

Results

NOTIFICATION RATES IN DTP AND DT VACCINATED CHILDREN

In each of the two vaccine groups roughly 90% of the notifications received were visited. A total of 11 776 cases under 6 years of age, including those discovered at the home visit, had received either three doses of DTP (2261) or three doses of DT (9515).

For each year of birth the attack rate in the DT group was consistently six times greater than in the DTP group; an efficacy of more than 80%* (table I).

TABLE I—*Notification rates according to year of birth and vaccine group*

Year of birth	3 DTP			3 DT			Relative rate DTP:DT
	No of cases	Average population*	Rate (per 1000)	No of cases	Average population*	Rate (per 1000)	
1973	609	58 098	10·5	519	7 354	70·6	1:6·7
1974	565	46 040	12·3	2348	35 227	66·7	1:5·4
1975	488	48 826	10·0	2365	37 800	62·6	1:6·3
1976	326	35 689	9·1	2450	46 099	53·1	1:5·8
1977	193	32 241	6·0	1411	37 888	37·2	1:6·2
1978	67	21 315	3·1	367	17 796	20·6	1:6·6
1979	13	7 954	1·6	55	5 431	10·1	1:6·3
1973–9	2261	250 163	9·0	9515	187 595	50·7	1:5·6

*Average of the half-yearly return made by the AHAs.

Individual analyses were also made for each combination of year of birth and half-year of study. Efficacy ranged from 74% to 89% (mean 84%).

The decreasing attack rates in both vaccine groups in the younger children (table I) are only partly due to age. By the time children born in 1979, for example, had been fully vaccinated they could be exposed for a short time only during the closing stages of the investigation, when the outbreak was declining (figure).

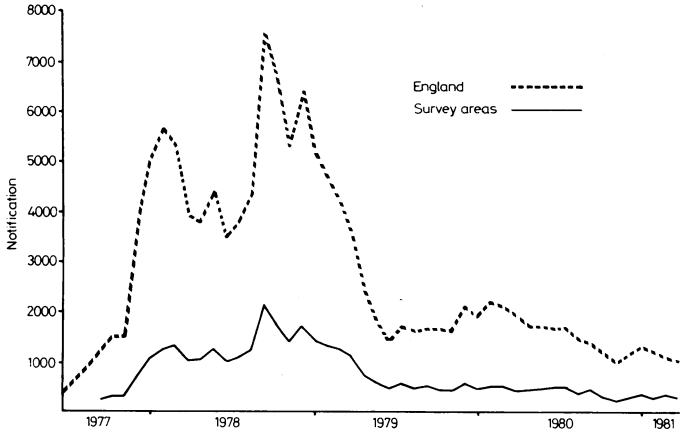
As judged by the number of daily paroxysms attacks tended to be less severe in DTP-vaccinated children. In a small proportion in each vaccine group—4% DTP and 2% DT—cough without typical paroxysms was reported, whereas 53% of cases in the DTP and 63% in the DT group had 10 or more paroxysms daily. Vomiting also tended to be more frequently reported in the DT group. Within each of the two vaccine groups no relation between age and the number

*The reduction in attack rate as a percentage of the attack rate in the DT vaccinated group—for instance, overall efficacy

$$= \frac{50{\cdot}7 - 9{\cdot}0}{50{\cdot}7} \times 100 = 82\%$$

of paroxysms was evident when the few children under 1 year were excluded.

The relative attack rates in the DTP and DT groups varied directly with the occurrence and number of paroxysms (table II), being least —1 to 2·8—in cases of cough without paroxysms and greatest—1 to 6·7—in cases with 10 or more. Even greater differences were evident when the hospital admission rates were compared.



Four-weekly notifications of whooping cough.

TABLE II—*Notification rates according to number of daily paroxysms, admission to hospital, and vaccine group*

Paroxysms	3 DTP Average population = 250 163		3 DT Average population = 187 595		Relative rate DTP:DT
	No of cases	Rate (per 1000)	No of cases	Rate (per 1000)	
None	89	0·4	201	1·1	1:2·8
1–9	944	3·8	3244	17·3	1:4·6
⩾10	1161	4·6	5786	30·8	1:6·7
Hospital admissions	13	0·05	158	0·84	1:16·8

NB—In a further 67 DTP and 284 DT vaccinated children the number of paroxysms was not stated.

ATTACK RATES IN HOME CONTACTS UNDER 6 YEARS

The relative attack rate in two-child families in which symptoms in the contact began at least one week after those of the index case is shown in table III. Efficacy was consistently about 50% except in contacts under 1 year where the available numbers are small.

As in the assessment based on the notifications as a whole, the difference in attack rates in home contacts was least in children with no paroxysms and greatest in children with 10 paroxysms or more in whom the estimated efficacy was 71%.

ISOLATION RATES

The isolation rate for *B pertussis* in the DTP group was considerably less than in the DT group (table IV). As a result, when the assessment is restricted to bacteriologically proved cases the efficacy is high—93% for general notifications and 81% for home contacts.

TABLE III—*Attack rates in home contacts according to age and vaccine group*

Age of contact (years)	3 DTP			3 DT			Relative rate DTP:DT
	Contacts	No of cases	Rate (%)	Contacts	No of cases	Rate (%)	
0–<1	28	12	(43)	56	34	(61)	1:1·4
1–<2	108	35	(32)	399	316	(79)	1:2·5
2–<3	97	36	(37)	384	299	(78)	1:2·1
3–<4	108	34	(31)	284	170	(60)	1:1·9
4–<6	476	92	(19)	428	165	(39)	1:2·0

TABLE IV—*Isolation rates according to vaccine group for notifications as a whole and for home contacts*

	Notified cases			Home contacts		
	No of cases	Swabbed	Positive (%)	No of cases	Swabbed	Positive (%)
3 DTP	2261	941	94 (10)	209	100	13 (13)
3 DT	9515	4225	1026 (24)	984	480	134 (28)

Differences in isolation rates between the vaccine groups were apparent for all grades of severity. Thus for children without paroxysms *B pertussis* was isolated in 9% of 47 children in the DTP group and from 15% of 101 in the DT group.

In both vaccine groups most strains were serotype 1,3; 84% in the DTP group and 81% in the DT group.

Survey of home circumstances of DTP and DT vaccinated children

During 1978 the names of 3600 children who had received at least one dose of either DTP or DT were randomly selected from the immunisation records. Successful visits to record the home circumstances and history of infectious diseases were made to 75% of homes in the DTP group and 80% in the DT group. By the time of the visit 823 children had received three doses of DTP and 1165 three doses of DT.

There was no appreciable difference between the vaccine groups in the history of three childhood infections (table V) when allowance is made for year of birth.

TABLE V—*Survey of home circumstances. Children visited according to vaccine group and history of three infectious diseases*

Vaccine	Total visited	Chickenpox		Measles		Mumps	
		No	%	No	%	No	%
3 DTP	823	135	*16* (13)	155	*19* (16)	148	*18* (14)
3 DT	1165	158	*13* (15)	202	*17* (14)	131	*11* (13)

( )% standardised for year of birth.

The distribution of social class in each vaccine group was similar to that for the registered births in the relevant years.[4] The notification rates within each vaccine group were not materially affected by social class (table VI).

TABLE VI—*Notification rates according to social class and vaccine group*

Social class	3 DTP			3 DT			Relative rate DTP:DT
	No of cases	Population*	Rate (per 1000)	No of cases	Population*	Rate (per 1000)	
I, II, and III non-manual	818	90 233	9·1	3973	78 054	50·9	1:5·6
III manual	855	96 145	8·9	3406	70 597	48·2	1:5·4
IV, V, and other	537	63 785	8·4	1858	38 944	47·7	1:5·7
All	2210	250 163	8·8	9237	187 595	49·2	1:5·6

NB—Excludes 51 DTP and 278 DT vaccinated children where the head of the household was employed in the armed Forces or whose occupation was not known.
*Social class distribution, estimated from survey of home circumstances.

Several other characteristics were also examined; these included the number of people in the household, ethnic group, parents' educational attainment, whether or not the mother had a job outside the home, and whether or not the child came from a single parent family, but no material differences were found between the vaccine groups.

Discussion

In this investigation the whooping cough notification rates were found to be much greater in DT vaccinated children than in a similar group of DTP vaccinated children. Notifications are incomplete, and selective under-reporting for one or other of the vaccine groups would affect the estimated efficacy. To account for the findings, however, selective under-reporting on a large scale would have had to occur in the DTP group and to have become progressively more frequent with the increasing severity of the cases; this seems unlikely.

The conclusion that pertussis vaccine is effective is in keeping with most of the assessments in recent years,[5-12] and with the demonstration by Pollard[13] of the direct association between vaccination rates and notification rates in England and Wales. Social factors are sometimes believed to affect assessments of pertussis vaccination, but in Pollard's study the influence of vaccination was apparent even when social factors were taken into account; in the current investigation there was no indication that for the fully vaccinated children in both vaccine groups social class influenced notifications.

Failure to isolate *B pertussis* does not exclude a diagnosis of whooping cough, and the difficulties of isolation are sometimes greater when whooping cough occurs in those vaccinated.[6 14-16] In assessing the efficacy of the vaccine therefore it is not possible to rely on bacteriologically proved cases alone. Furthermore, the identification of *B pertussis* in cases without paroxysmal cough—also reported elsewhere[1 3 17]—necessitates the inclusion in the assessment of cases both with and without paroxysms.

The criteria adopted for the diagnosis of whooping cough considerably affects the degree of efficacy attributed to pertussis vaccine. Thus in the present assessment bacteriologically proved whooping cough was about 14 times more frequent in DT than in DTP vaccinated children, an efficacy of about 93%. This degree of efficacy is much the same as estimated by Preston[7] for bacteriologically proved cases. A similar degree of efficacy was also apparent for children sufficiently ill to require hospital admission. Overall the vaccine is highly effective in reducing dissemination, and in protecting the individual against typical whooping cough. But efficacy was much less when the assessment was confined to attacks without typical paroxysms. Such mild attacks might be expected to include a relatively large proportion of cases due to agents other than *B pertussis*, whose inclusion in both vaccine groups would reduce the estimated efficacy. On the other hand, the decreased efficacy in mild cases may reflect the capacity of the vaccine to attenuate attacks.[3 6 10 14 18] Mild attacks—whatever their origin—in DTP vaccinated children may be of little importance to the individual affected but *B pertussis* can sometimes be isolated from these patients, and they are therefore a potential risk to contacts.

In the stringent conditions of home exposure protection was less than that exhibited by the notifications as a whole. A low degree of efficacy was also observed in home contacts given vaccine of adequate potency in the previous PHLS study,[2] and again in a recent investigation in Swansea.[6]

The results of this assessment, therefore, while confirming the outstanding benefits conferred by vaccination in preventing and modifying attacks and in reducing infectivity, illustrate also the limitations of the current vaccines in controlling whooping cough. Firstly, complete protection is not invariable and severe attacks can occur in vaccinated children. Secondly, for one important group, home contacts, the degree of protection falls short of that expected from most vaccines in current use. Thirdly, mild attacks, in vaccinated children, may contribute to the spread of the disease. Given these limitations and the fact that for some years before 1968 some of the vaccines used were of low potency,[1] it is not surprising that widespread pertussis immunisation—even the high rates pertaining before 1974—did not eradicate the disease in England.

Nevertheless, high vaccination rates were gradually bringing whooping cough under control. But there is little room for complacency. A return to these rates and the development of more effective vaccines based on identifiable protective antigens are urgently required.

Local administration was undertaken by the area medical officers and specialists in community medicine; follow-up was organised by the AHA senior nursing officers; and the home visits were made either by nurses recruited for the purpose or by AHA nurses and health visitors. Pernasal swabs were examined by the local PHLS or other laboratories in the areas. Isolates were sent for serotyping to Dr N Preston, Manchester University, who, with Dr J D Abbott, PHLS Laboratory, Manchester, advised on the bacteriological aspects of the investigation.

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Are Syria and Jordan countries in which bilharzia is a risk to anyone swimming in their rivers?

Schistosoma haematobium infection is a risk to people swimming in rivers in Syria.[1] Static pools and irrigation channels are more of a hazard for schistosomiasis than swiftly flowing rivers. Indigenous schistosomiasis is practically unknown in Jordan, although a possible vector (*Bulinus truncatus*) has been identified.[2] Therefore there would seem to be no real risk of schistosomiasis from swimming in rivers in Jordan.—D R W HADDOCK, senior lecturer in tropical medicine, Liverpool.

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