

PRACTICE OBSERVED

Practice Research

Effect of a low pertussis vaccination uptake on a large community

REPORT FROM THE SWANSEA RESEARCH UNIT OF THE ROYAL COLLEGE OF GENERAL PRACTITIONERS

Pertussis vaccination was started by several local authorities in 1942 but it was not until 1957 that it was introduced on a national scale. The number of notifications of whooping cough in England and Wales dropped from 85 004 in 1957 to 8913 in 1975. The three or four yearly peaks of notifications also became smaller, and the last annual peak was in 1974-5. If the trend had continued the next peak would probably have been even smaller. On the contrary, it was the biggest peak of notifications for whooping cough for over 20 years.

In 1974 a good deal of adverse publicity was given to the pertussis vaccine by the media. This had a profound effect on the attitude of parents to this type of vaccination, and there was evidence that the attitude of some doctors had also changed. A preliminary inquiry carried out in 1976 showed that out of 100 general practitioners known to be good recorders, one-third had given up pertussis vaccination, one-third were leaving the decision to the parents, and the remainder were still vaccinating as they had done before. The first effect of this general change of attitude was a marked drop in the acceptance rate for pertussis vaccination. In England and Wales, for example, the acceptance rate had dropped from 78.5% for children born in 1971 to 37% for those born in 1974 (A Smithies, DHSS, personal communication, 1980). One of the worst affected areas was West Glamorgan, where the rate had not only dropped to 9.5% in children born in 1974 but in 1971 was even less than half the average for England and Wales (fig 1).

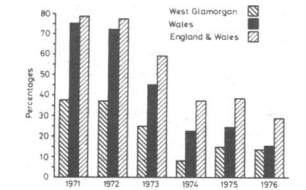


FIG 1—Vaccination acceptance rate for whooping cough according to year of birth for West Glamorgan, Wales, and England and Wales.

Method

All the doctors with patients within the boundaries of West Glamorgan (population 360 000) were asked to participate by notifying cases of whooping cough by telephone to the Swansea Public Health Laboratory, and these were in turn notified to the local authority. All the media for the bacteriological investigations were prepared at this laboratory, but the investigations were carried out there and at the North General Hospital Laboratory. Cultures were sent to Dr Preston at Manchester University for confirmation and typing. A questionnaire was designed to obtain information on social status, clinical pattern, results of laboratory investigations, immunisation details, etc, for each notified case and other members of the household.

On the same day as the notifications were received one of five specially trained nurses visited the household and started filling in

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Age 11 months—Went blue and stiff, couldn't get his breath. Thought he was dead. Put on top, bent his back, couldn't open his mouth, pried it open. Stuck her fingers down his throat to bring up phlegm. Thought it was a fit, but realised that it was an inability to breathe—only lasted seconds but seemed ages."

COMPLICATIONS

Deaths—Three children who had whooping cough died. Their ages were 4 months, 5 months and 13 months, and the illness had lasted 2 weeks, 1 week, and 6 weeks respectively. The first two were found dead in bed, and a necropsy examination was carried out on both. *B pertussis* was isolated from a swab taken at post mortem from the trachea of one of them. In the other pathological comment was—"the clinical history coupled with the histological changes in the lung in this case is strongly suggestive of whooping cough." A necropsy examination was refused by the parents of the third child, who died in hospital. He was thought to have died either as a result of an encephalitis or a cerebral thrombosis following whooping cough. This child had a meningococcal septicaemia repaired shortly after birth and had a history of fits with several admissions to hospital since the age of 6 months. The child who was 5 months old had received one dose of DPT; the other two had none.

Other complications—The commonest complication was loss of weight, occurring in 385 cases (16.8%). There were 224 cases (9.8%) of acute bronchitis, eight cases of atelectasis, and 18 cases complicated by bronchopneumonia. Twenty-six were reported to have had attacks of apnoea. Asthma, developing for the first time, was reported in 17. Acute otitis media occurred in 172 (7.5%), and tonsillitis in 94 (4.1%). Paroxysms of coughing produced subconjunctival haemorrhages in 100 (4.8%), and 19 had pneumonia; 19 had chest and chest tight. Hemoptysis occurred in three children and 20 had epistaxis. Fourteen children had convulsions but only four had a history of similar attacks. No cases of meningitis were reported, but two children had encephalitis and one of them died; both children had a history of several convulsions. Among other complications reported were: hernia 3; squint 5; conjunctivitis 29; deafness 5; and one woman had a spontaneous abortion.

HOSPITAL ADMISSIONS

Sixty-four children were admitted to hospital; all except one were under 5 years, and 30 under 12 months. A far higher proportion was admitted from the lower social class groups than was present in the index households; of the hospital cases, 39% were in social class I compared with 9% in the index group. The severity of illness, however, was not related to social class. Two children had encephalitis—one of them died and the other was on the "danger list" for five days; five had convulsions; seven had pneumonia; 19 had acute bronchitis; and two had atelectasis. None of the children needed assisted ventilation, but 24 needed aspiration and 25 special nursing. Ten children were given oxygen. One child suspected of having meningitis was given a lumbar puncture.

RELEVANCE OF VACCINATION AND AGE

Significantly more children under five years of age were fully vaccinated in the control (31.2%) than in the index group (6.4%). In the older age groups the vaccination state was similar in the control (42.9%) and index (44.2%) groups. The secondary attack rate (table 2) was 17.8% in the index group and 22.7% in the control.

TABLE 1—Secondary attack rates and protection rates in households for children under 10 years

Vaccination state	Without whooping cough	With whooping cough	Total	Protection rate
Not vaccinated	148 (36)	46 (17.3%)	194	46/194 = 23.7%
Fully vaccinated	66 (77.3%)	32 (32.7%)	98	32/98 = 32.7%
Not vaccinated	61 (72.4%)	22 (27.6%)	83	22/83 = 26.5%
Fully vaccinated	31 (38.3%)	49 (61.7%)	80	49/80 = 61.3%

NS = Not significant.

the questionnaire. She also collected pernaal swabs from the notified (index) case and any other member of the household with symptoms. If the swabbing precipitated a paroxysm of coughing, a cough plate was also taken. The pernaal swab was rubbed on to a charcoal agar plate and afterwards placed in a bottle of virus transport medium. The specimens were delivered as soon as possible to the nearest laboratory. A second visit to the household two weeks later was made to look for further cases and take swabs if necessary. A final visit was made three months later to study the outcome and to complete the rest of the questionnaire. A separate questionnaire was designed for patients admitted to hospital requesting details of complications and type of treatment.

A control group of households in West Glamorgan was selected for comparison with index households. As most of the patients with whooping cough were under 6 years of age, a sample comprising 1 in 40 children in this age group in the West Glamorgan Children's Register was selected. Any household with whooping cough was transferred to the index group.

A vaccination history was obtained from the parents or their children's vaccination record cards and from the area health authority records. A validation study using these two sources and general practitioner records of immunisation showed that the parent source was the most reliable and therefore this is used in this analysis. Cases that were bacteriologically negative and not living in contact with a proved case and not resembling whooping cough, either in clinical pattern or length of illness, were excluded from the analysis.

Results

SIZE AND PATTERN OF THE EPIDEMIC

The epidemic started in October 1977, and the study was started in November. Notifications reached the first peak in January 1978 and the second, very much higher peak in November 1978. By the middle of March 1979, the epidemic was abating. Whooping cough continued to occur, however, throughout the rest of the year with a higher incidence than in the previous inter-epidemic period.

Figure 2 shows the number of notifications of whooping cough in a month in the whole of West Glamorgan for 1974-9. It shows the size of the 1977-9 epidemic compared with that of 1974-5. It also shows the expected number of notifications for West Glamorgan as calculated from the number of notifications for England and Wales and the population ratios between the two areas.

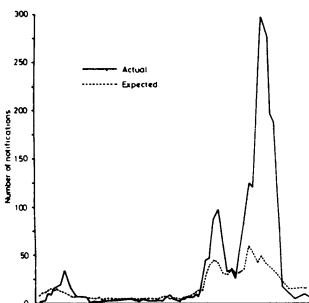


FIG 2—Number of notifications of whooping cough. The expected number of notifications shown for West Glamorgan is calculated from the number of notifications for England and Wales and the population ratios between the two areas.

The total number of households with suspected cases of whooping cough was 2001. Nurses were refused admission in 15 houses, leaving 1986 households that were studied in detail. Of the 3148 cases investigated, 953 (27.1%) were excluded on the grounds mentioned above. The final analysis consisted of 1469 households with 6104 occupants. There were 2295 cases of clinical whooping cough, of whom 905 were confirmed by the isolation of *Bordetella pertussis*.

AGE AND SEX PATTERN

There was a slight preponderance of girls (51.7%) except in the under-5 age group where there was a slight male preponderance (51.6%). The majority of cases (65.4%) were under the age of 5 (table 1). There were 235 cases over 20 years of age with whooping cough, 10% of the clinical cases.

TABLE 1—Incidence of whooping cough according to age at first and second onset and total incidence

Age (years)	First onset	Second onset	Total No.	%
0-1	186	67	253	4.1
1-2	180	62	242	3.9
2-3	144	48	192	3.1
3-4	144	48	192	3.1
4-5	359	77	436	7.1
5-9	124	21	145	2.4
10-14	13	4	17	0.3
15-19	13	4	17	0.3
20-24	13	4	17	0.3
25-29	13	4	17	0.3
30-34	13	4	17	0.3
35-39	13	4	17	0.3
40-44	13	4	17	0.3
45-49	13	4	17	0.3
50-54	13	4	17	0.3
55-59	13	4	17	0.3
60-64	13	4	17	0.3
65-69	13	4	17	0.3
70-74	13	4	17	0.3
75-79	13	4	17	0.3
80-84	13	4	17	0.3
85-89	13	4	17	0.3
90-94	13	4	17	0.3
95-99	13	4	17	0.3
Total	1722	75	1800	29.3

Age range was 2 weeks to 79 years.

SOURCE OF INFECTION

The commonest source of infection of first-onset cases was "at school" (39.5%), followed by "another house" (18.7%), "at work" (2.3%), and in 39.5% the source was unknown. Most first-onset cases were 3 and 4 years old (table 1). The highest incidence of secondary-onset cases were in children under 13 years.

CLINICAL PICTURE

The illness started with a dry, irritating cough in 70% of cases, and this was usually followed by a catarrhal stage. Catarrh was the first symptom in only 22.1% of cases. As the illness progressed coughing became worse at night in 80% of patients. The paroxysms of coughing were described by one adult sufferer as "coughing through a one-way valve." Whooping was present in 44.6% of cases. Paroxysms of coughing were followed by vomiting in 60%. Feeding precipitated a paroxysm in some children, and in the paroxysms were very frequent they failed to take in enough food and fluids daily. These factors, combined with vomiting, caused a noticeable loss of weight in 17% of cases. Cyanosis after paroxysms of coughing was particularly common, occurring in 450 (18.7%) cases.

Complications were often frightening for the children and their parents, especially when the children had convulsions, cyanosis, or apnoea. One father gave his 4-year-old daughter mouth-to-mouth resuscitation on two separate occasions because he thought she was going to die. Here are three verbatim accounts of cases from the nurses' short notes.

"Aged 2 years—Three days after second visit, had an apnoeic attack. The child went very blue and limbs went stiff. Mother held him upside down by his ankles and 'thumped' him on his back. She then put him in the car and rushed him to the health centre but he was much improved when he arrived there. The mother said that he improved after he managed to get 'phlegm' and mucus out of his mouth. The apnoeic attack lasted three minutes. Has gone blue and 'held his breath' on a few occasions since, but mother managed to get him to breathe by hitting him on the back and putting her fingers down his throat—vomited, then child all right after vomiting."

"Aged 5 months—Fell asleep in Gran's arms. Put to bed—but woke coughing. Stopped breathing, cyanosed. Aunt tried blowing on her face, tipped her upside down. Gran then put her fingers down her throat—vomited, then child all right after vomiting."

mitted to hospital had been vaccinated. Two of the children admitted developed encephalitis but had not been vaccinated because they had a history of fits. The only way the risk to such children can be reduced is by maintaining good herd immunity. Children who are too young to be vaccinated are also at great risk if their older brothers and sisters have not been vaccinated and bring the infection home from school. This problem was shown clearly in this study.

The highest incidence in encephalitis occurred in the autumn of 1978 when many of the children born either at the end of 1974 or during 1975 were going to school for the first time. A few of these children developed whooping cough at the end of the summer holidays and were still infectious when they entered school. As most of the other children in the class had not been vaccinated, there was an explosive outbreak of whooping cough in the classroom. The few fully vaccinated children would have been subjected to a challenge from a large number of organisms expelled by their classmates and therefore ran a greater risk of being infected.

There is a correlation between the attack rate among fully immunised children and the degree of immunisation in a given community. Simpson,¹ reporting on testing the efficiency of the S19 vaccine for *Brucella abortus* in calves, found that when the challenge dose of organisms was increased from 15 million to 150 million the protection rate was reduced from 80% to 50%. In the whooping cough outbreak in West Glamorgan vaccinated children were subjected to a considerable weight of infection. It is therefore not surprising that the protection rate was only 49% in fully immunised children under 4 years of age. It would be unreasonable to expect a protection rate much higher when the vaccination rate had dropped to 9.5% and was also already half the average for England and Wales three years earlier. The protection rate in the group of children aged 5-9 is much lower than in the younger age group, but the reason for this is not clear. The size of the epidemic after a dramatic fall in vaccination acceptance rate, however, adds some support to the efficiency of our present vaccine.

It has been argued that the decline in the incidence of whooping cough since 1957 was due largely to the improvement in socioeconomic conditions rather than to vaccination.² This was probably true before 1957, and more so in the years before the second world war when the immunisation rate was very low. Since 1957, when attending the clinic and carefully observing the various occurrences in diphtheria, a great degree of accuracy may be acquired, both in distinguishing their symptoms, and in the application of medicines. Hence fertile pupils, and other persons who will upon the field, often discover a diphtheria focus, while those who have been bred to phylo. We do not however mean to intimate that a medical education is of no use: it is doubtless of the greatest importance; but it never can supply the place of observation and experience.

In Britain we vaccinate to protect the individual who is vaccinated, but if a sufficient number accept vaccination we can also have the bonus of a good herd immunity. This in turn will contribute to the protection of those who are too young to be vaccinated and those in whom vaccination is contraindicated.

Conclusions

A large epidemic of whooping cough broke out in a community of 360 000 people, where the pertussis vaccination acceptance rate had fallen to 9.5%. Out of 2295 cases described as whooping cough, 905 were confirmed bacteriologically. Two thirds of the children who were "not deaths." The disease was more severe and lasted longer in younger children and in those who had not been vaccinated.

It was 32.7% in fully protected children under four years of age compared with 63.7% in the unvaccinated. The protection rate (63.7-32.7/63.7) x 100 was only 49%. The study showed that the illness lasted two weeks longer in the unvaccinated and that their symptoms were more severe. Vomiting and weight loss were appreciably more common in those who had not been vaccinated.

Although most of the symptoms were not more common in the unvaccinated they were more severe. There was also an inverse correlation of severity of symptoms with age, the younger the child the more severe the symptoms.

There was a significant difference in the isolation rate of *B pertussis* in the unvaccinated (44.2%) compared with the fully vaccinated (26.7%) ($\chi^2=49.56$). The number fully vaccinated under 12 months was too small to show differences in this age group.

SOCIAL CLASS

The social class (table III) showed a close similarity in the index and control households. Age patterns and number of bedrooms were also similar in the two groups. There was a small difference in bedroom occupancy (index 1.41, control 1.54 persons per bedroom). There were also slightly more owner-occupiers among the index (69.0%) than the control households (62.0%) ($p<0.05$).

TABLE III—Social class of index and control households

Social class	Index households		Control households	
	No.	%	No.	%
I	100	4.8	19	4.3
II	706	48.1	144	48.0
III	569	38.8	111	36.0
IV	129	8.8	35	11.7
Missing data	2	0.1	0	0.0
Total	1469	100.1	300	100.0

Discussion

It is most likely that the low rate of immunisation in West Glamorgan caused an appreciable drop in herd immunity even before the adverse publicity to the vaccine in 1974 had taken effect. The sudden drop in vaccination that followed made the population of West Glamorgan particularly vulnerable to whooping cough and contributed to the magnitude of the next outbreak. It is expected that a low herd immunity to whooping cough would result in an increase in incidence of the disease. It is not surprising, therefore, that not only was the peak incidence of the 1974-5 outbreak twice as big as that expected but also that the next outbreak starting in 1977 was very much larger, especially during the second peak in November 1978. The doctors in West Glamorgan had been encouraged to notify cases of whooping cough, and this may have contributed somewhat to the number of notifications. Furthermore, 27.1% of the notified cases were not considered to be true whooping cough. If these were excluded from the total the epidemic would still have been large. In such epidemics more doctors make notifications as they become aware of the existence of an outbreak. This was true in West Glamorgan.

Whooping cough was a matter of great concern to parents. Paroxysms of coughing were worse at night, and there was a risk of children becoming apnoeic, inhaling vomit, or having a convulsion when the parents were asleep. Two children died unexpectedly during the night. The descriptions given by the nurses reflect the fortune shown by these parents in the face of serious and distressing crises.

The large number of children who had lost weight illustrates the debilitating effect of the disease, especially when it lasted several weeks. The results of this study confirm the findings of Islar and colleagues³ and also of Miller and Fletcher⁴ that whooping cough was more serious in the very young and in the unvaccinated. It is relevant that none of the children ad-

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References

- 1 Department of Health and Social Security: Joint Committee on Vaccination and Immunisation. *Review of the evidence on whooping cough vaccination*. London: HMSO, 1977.
- 2 Williams WO, Dicks R. Validation of sources of pertussis immunisation data. *Journal of Epidemiology and Community Health* (in press).
- 3 Islar J, Anglin GS, Middleton PJ. The whooping cough syndrome: a continuous pediatric problem. *Clin Pediatr* 1975;14:171.
- 4 Miller CL, Fletcher BW. Severity of notified whooping cough. *Br Med J* 1979;117:9.
- 5 Stuart-Harris CH. Experience of pertussis in the United Kingdom. In: Mandak CR, ed. *Immunisation: Symposium on Pertussis 1978*. Washington, DC: Department of Health, Education and Welfare, Public Health Service, 1979:256-180. (National Institutes of Health (NIH) 79-180).
- 6 Simpson JW. *Brucellosis in Britain*. The problem control: eradication. *Par Res* 1968;28:117.
- 7 Basill WR, Stewart GT. The epidemiological evaluation of immunisation and other factors in the control of whooping cough. *Lancet* 1976;ii:411.

As many of the indications of cure may be answered by diet alone, it is always the first thing to be attended to in the treatment of diphtheria. Those who know no better, imagine that every thing which goes down the throat, is a medicine, and that the patient swallows enough of drugs, that he must do well. This mistake has many ill consequences. It makes people trust to drugs, and neglect the patient's condition, besides, it discourages all attempts to relieve the sick, where medicines cannot be obtained.

Medicines are no doubt useful in their place, and, when administered with prudence, they may do much good; but when they are not put in place of every thing else, or administered at random, which is not seldom the case, they do much mischief. We would therefore wish to call the attention of mankind from the pursuit of secret medicines, to fast things as a rule. The proper regulation of these may often do much good, and there is little danger of their ever doing hurt. (Buchan's Domestic Medicine, 1866.)