Epidemic of mumps in a partially immune population

JACQUELINE E. LEWIS,* MD; MAX A. CHERNESKY, PH D; MARILYN L. RAWLS, RN; WILLIAM E. RAWLS, MD

The incidence of mumps in vaccinated and nonvaccinated schoolchildren was studied after a recent epidemic. Information was collected by telephone interviews with the parents and a review of the physicians' records.

The vaccine appeared to be effective, for the incidence of mumps in the 145 vaccinated children — 5.5%, or 8 cases — was significantly less ($P < 0.001$) than the incidence in the 350 children considered susceptible to infection — 21.7%, or 76 cases. The percentage of children who had been immunized decreased with increasing age, and acquisition of immunity through natural infection had the reverse trend; thus, the proportions of children susceptible to infection in each age group were about the same, and the age-specific attack rates were similar. Although the mothers were accurate in indicating absence of vaccination, they incorrectly indicated vaccination of their children 43.0% of the time; this error in reporting could influence vaccine administration in older children.

Our findings suggest that mumps vaccination may substitute for natural illness in immunizing populations, and that more extensive use of the vaccine over a broader age range is required to prevent similar epidemics in the future.

À l'occasion d'une épidémie récente on a étudié la fréquence des oreillons chez des écoliers vaccinés et non vaccinés. La révision des dossiers médicaux et les entrevues de parents par téléphone ont fourni les renseignements nécessaires.

L'efficacité du vaccin ne fait aucun doute, puisque 5.5% (8 cas) des 145 enfants vaccinés ont été atteints par la maladie (d'une façon significative; $P < 0.001$) par rapport à 21.7% (76 cas) du groupe de 350 que l'on considérait susceptible. La proportion d'enfants immunisés diminue avec l'âge alors que le degré d'immunité va en sens contraire. Ainsi le pourcentage d'enfants prédisposés à l'infection était à peu près le même dans chaque group d'âge et les taux d'atteinte par âge se ressemblaient. Les mères ont indiqué l'absence de vaccination avec précision, mais elles s'étaient trompées dans 43.0% des cas lorsqu'elles ont rapporté la vaccination de leurs enfants; cette erreur pouvait agir sur l'administration du vaccin chez les enfants plus âgés.

D'après nos résultats il semble que l'immunisation par la vaccination puisse se substituer à la maladie elle-même, mais il faudra avoir d'avantage recours au vaccin, et sur une gamme d'âge plus vaste, si l'on veut prévenir d'autres épidémies du même genre à l'avenir.

Mumps virus was successfully attenuated in chick embryo tissue culture in 1963 and the live, attenuated virus vaccine (Jeryl Lynn strain) was licensed in December 1967; it was released in Canada in 1969. Since then there has been a slow but steady decrease in the incidence of mumps in North America[1,2] related to the use of mumps vaccine. An epidemic of mumps occurred in the Hamilton–Wentworth region of southern Ontario in early 1977. Some family physicians saw cases of mumps in children who had been vaccinated. Attempts were made in the study reported in this paper to evaluate the use of mumps vaccine as a factor in the genesis of the epidemic and to determine the frequency of vaccine failure.

From the departments of family medicine, pathology and pediatrics, McMaster University, and the department of laboratory medicine, St. Joseph's Hospital, Hamilton

Reprint requests to: Dr. Max A. Chernesky, Regional diagnostic virology laboratory, St. Joseph's Hospital, 50 Charlton Ave. E, Hamilton, Ont. L8N 1Y4

Methods

Study population

The study population consisted of 757 schoolchildren attending six public schools that served most of a circumscribed suburban area. The proximity of the area to large cities has allowed the once predominantly rural population to be well mixed with urban commuters.

Study design

The study was conducted between June and September 1977 and was initiated by enumerating the children from the registration records of the schools. This source provided information regarding age, sex, grade and home telephone number of the children, as well as the name of the family physician. The attendance records were examined for absences that had occurred between March and June 1977. Children who had been absent from school for 3 days during the week or both Monday and Friday were considered as possibly having suffered from mumps.

An attempt was made to telephone the parents of all the children registered in the schools, and a standardized questionnaire was administered to each parent contacted. The parents were asked about a past history of mumps, the vaccination status and the age at the time of occurrence of mumps or mumps vaccination in the children. The reason for any absence from school was requested, and, when absence was due to illness, specific questions were asked about the occurrence of gland swelling, fever, cough and sore throat. The diagnosis of the family physician was requested from the parent if a physician had been consulted.

After the interviews of the parents had been completed, attempts were made to review the records of the physicians named on the school records or by the parents during the interview. The records were reviewed by the physician or a research assistant to verify the vaccination status of each child; this review was done blind with regard to the results of the parent interviews. In addition, information was collected on the date of mumps vaccination and the age of the child at that time, along with the type of vaccine.

Parents of 21 children could not be reached for interview, and for 12 children the person interviewed was unable to provide the information requested. Physicians' records could not be located to verify the vaccination status for an additional 13 children. Three

children had been vaccinated against mumps during the incubation period of their illness. These 49 children (6.5%) were excluded from the study, and the analysis was carried out on the data for the remaining 708.

Results

The temporal occurrence of mumps and other illnesses causing absence from school during the study period is shown in Fig. 1. During the 3½-month period 141 children (19.9%) had been absent from school and 84 of them had had an illness considered by the parents to be mumps; consultation with a physician confirmed the diagnosis in 59 cases. Four cases of mumps were noted in siblings of affected children after school closure. The distribution of the other illnesses did not peak during the height of the mumps epidemic, so it is unlikely that these illnesses represented "atypical" cases of mumps.[3]

Among the 708 children 213 (30.1%) had a past history of mumps, and evidence of vaccination prior to the epidemic was found in the records of 145 (20.5%) of the children (Table I). There were significant and consistent differences between age groups in the proportions with a past history of mumps and the proportions with evidence of vaccination against mumps: the proportion with a past history of mumps increased with age ($P < 0.001$; linear chi-square test), whereas the proportion that had been vaccinated decreased with age ($P < 0.001$). The additive effects of immunity through previous infection and vaccination left the five age groups about equally protected: overall, 50.6% of the children were still theoretically susceptible to mumps, although this proportion would be reduced somewhat by the expected occurrence of inapparent infections.

The age-specific attack rates during the epidemic are shown in Table II. There was no clear trend by age, although the oldest group had a significantly lower adjusted attack rate than the other age groups combined ($P < 0.005$).

Mumps vaccination

Of the 84 cases of mumps 76 occurred among children thought to be susceptible and 8 occurred among children who had been vaccinated against mumps. The attack rate for those who had been vaccinated (5.5%) was significantly less ($P < 0.001$) than the rate for the 350 children thought to be susceptible to the virus (21.7%).

The eight cases of mumps in vaccinated children were examined to determine if a common factor could be found to account for the vaccine failures. The failures were not related to age at the time of vaccination: only 1 (3.1%) of 32 children vaccinated by 1 year of age acquired mumps, and the remaining 7 children were vaccinated between the ages of 3 and 10 years. The failures were also unrelated to the time since vaccination and to whether the vaccine was monovalent or combined (data not shown). The vaccine had been administered by eight different physicians.

Maternal recall regarding vaccination

A woman's perception of the vaccination status of her child can influence vaccine use. The mother and the physician agreed that the child had been vaccinated in 114 instances and that the child had not been vaccinated in 374 instances (Table III). Of the 200 instances in which the mother thought the child had

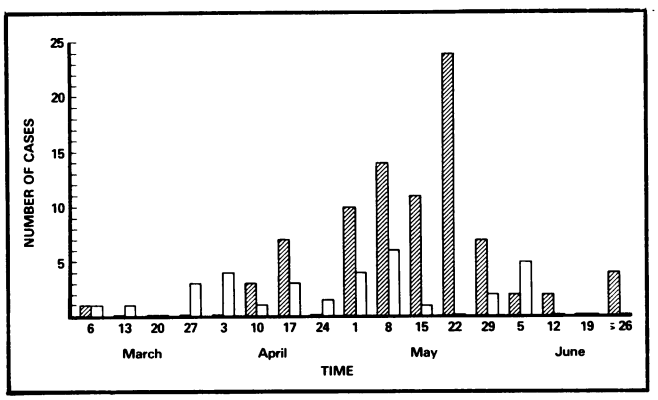

FIG. 1—Distribution of cases of mumps (hatched bars) and other illnesses (unhatched bars) occurring in weeks of 1977 beginning with dates indicated.

Table I—Past history of mumps and evidence of mumps vaccination among children

Age (yr)	No. of children	No. (and %) of children with: Past history of mumps	Evidence of mumps vaccination	Additive % with immunity due to mumps infection and vaccination
5–6	48	2 (4.2)	27 (56.3)	60.5
7–8	92	9 (9.8)	37 (40.2)	50.0
9–10	105	21 (20.0)	36 (34.3)	54.3
11–12	186	67 (36.0)	22 (11.8)	47.8
⩾ 13	277	114 (41.2)	23 (8.3)	49.5
Total	708	213 (30.1)	145 (20.5)	50.6

Table II—Age-specific attack rates of mumps during epidemic

Age (yr)	No. of children; total (and at risk)	Attack rate; no. (and %) of children: Crude	Adjusted*
5–6	48 (19)	5 (10.4)	5 (26.3)
7–8	92 (46)	17 (18.5)	17 (37.0)
9–10	105 (48)	12 (11.4)	12 (25.0)
11–12	186 (97)	29 (15.6)	29 (29.9)
⩾ 13	277 (140)	21 (7.6)	21 (15.0)
Total	708 (350)	84 (11.9)	84 (24.0)

*Adjusted for risk; children at risk were those without a past history of mumps or evidence of mumps vaccination.

Table III—Comparison of mumps vaccination history by source

Physicians' records	Maternal recall: Vaccinated	Not vaccinated	Unknown
Vaccinated	114	11	20
Not vaccinated	86	374	103
Total	200	385	123

been vaccinated the records indicated vaccination in only 57.0%. On the other hand, when the mothers thought that their children had not been vaccinated, 97.1% of the time the records agreed. Of the children whose mothers did not know their child's vaccination status the proportion whose records indicated vaccination was 16.3%. According to the physicians' records this rate was not significantly different ($P > 0.05$) from the vaccination rate in the remainder of the study population — 21.4%. Thus, a negative history of mumps vaccination according to the mother agreed well with the physicians' records, but a positive maternal history could only be confirmed in slightly over half of the cases.

Of the 200 children reported by their mothers to have been vaccinated 26 (13.0%) acquired mumps; this rate is not significantly less than the attack rates for children who were unvaccinated according to their mothers (11.4%) or to their physicians' records (13.5%). Further analysis (not tabulated) showed that when the mother and the physician's records agreed as to the vaccination status the attack rate was significantly lower ($P < 0.05$) than when they disagreed (11.2% v. 19.0%).

Discussion

Mumps is a highly infectious disease characterized in most cases by parotitis associated with low-grade fever and malaise. Complications such as meningoencephalitis and orchitis may occur, but most such cases should be preventable through well administered vaccination programs.

Mumps vaccine (Jeryl Lynn) elicits an antibody response in most recipients and has been shown to confer protection in over 95% of recipients.[2]

In the epidemic we studied, only 8 of 84 cases of mumps had occurred in vaccinated children. This represented an attack rate of 5.5% among the vaccinated children. Similarly, early reports on field trials of the vaccine showed seroconversion failure in 5% of the experimental population,[4] who, when followed, acquired mumps upon exposure.[5] The eight cases of mumps in previously vaccinated children did not appear to be related to age at the time of vaccination, though this has been a problem with measles vaccine.[6]

Long-term studies of recipients of mumps vaccine have shown persistence of antibodies to mumps virus for at least 9.5 years with the monovalent vaccine and for at least 7 years with the triple (measles–mumps–rubella) vaccine.[7] Thus, our findings of mumps in 5.5% of the vaccine recipients and the unrelatedness of these cases to the time since vaccination are in keeping with the published experience with the vaccine.

The incidence of mumps in the United States has declined precipitously since 1967. Analysis of cases in California, Massachusetts and New York City indicates that it is still predominantly a disease of young children, with the highest incidence being in the age group 5 to 9 years.[2] With increasing use of vaccine, mumps in all age groups has declined, but the most pronounced decrease has been in the age group with the highest incidence. In the epidemic we have reported, more than half of the cases of mumps occurred in children more than 10 years of age, but analysis of the data for only the children at risk indicated that the adjusted attack rates were similar for children of different ages. In this population the vaccine had been administered to children primarily before their sixth birthday, and most children more than 6 years old when the vaccine was introduced did not receive it. In studies[8,9] conducted prior to the introduction of the vaccine about 60% of the population was found to be susceptible to mumps by 6 years of age and 20% by 18 years. In our group 56% of the children 7 to 8 years of age were susceptible to mumps, but vaccination rather than natural mumps was the main way immunity was acquired (Table I). Because the percentage of children who had been infected in the past increased with increasing age and the percentage of children acquiring immunity through vaccination decreased with increasing age, immunity through past infection and vaccination left 40% to 50% of the children of all age groups at risk.

The reliance of this epidemiologic study on reported data without serologic confirmation could introduce several biases. The incidence of inapparent mumps is about 30%,[10] and occasionally other forms of parotitis may be identified as mumps. Although maternal histories of prior mumps appear to be reasonably reliable,[11,12] the mothers' tendency to overestimate the frequency of vaccination in their children could reduce the frequency of appropriate vaccination in older children in whom the decision to vaccinate might depend on a negative maternal history.

Despite the apparent efficacy of mumps vaccine, only 29% of the 495 children in our study population who had not had natural mumps had been vaccinated. We are not sure why this proportion should be so great. The large number of physician practices involved (99) made it difficult to evaluate the variation between practices in vaccine administration. Only 11 practices contained 10 or more children from the study population, and among these practices 0 to 36.4% of the children had been vaccinated. All vaccinations were carried out in 34 of the 99 practices and, as indicated above, most of the vaccine was administered before 6 years of age. Children more than 6 years old were unlikely to have received the vaccine. One explanation might be that older children were not seen by physicians as frequently as preschool-aged children and thus did not have an opportunity to receive the new vaccine. However, it is equally possible that neither parent nor physician perceived the older child as a logical recipient of the vaccine owing to the habit of associating vaccination for childhood diseases with the preschool years.

Whatever the cause, the lack of vaccination against mumps does not appear to be unique to the population studied. In 1976, only 26.9% of the children entering Ontario elementary schools had received mumps vaccine.[13] Our survey, conducted in the spring of 1977, found that 40.8% of the children 5 to 10 years of age had been vaccinated against mumps. Data obtained during the United States Immunization Survey of 1974 indicated that 39.2% of children 5 to 9 years of age had received mumps vaccine,[2] and in 1976 a survey

estimated that 50.7% of children of all ages in the United States had received mumps vaccine.[14] Thus, in North America, vaccination for mumps appears to have been underused to date; more extensive use of the vaccine over a broader range is required to prevent epidemics.

References

1. MODLIN JF, ORENSTEIN WA, BRANDLING-BENNETT AD: Current status of mumps in the United States. *J Infect Dis* 132: 106, 1975
2. *Mumps Surveillance, July 1974–December 1976*, US Dept of Health, Education, and Welfare, Center for Disease Control, Atlanta, Ga, 1978
3. FOY HM, COONEY MK, HALL CE: Isolation of mumps virus from children with acute lower respiratory tract disease. *Am J Epidemiol* 94: 467, 1971
4. HILLEMAN MR, WEIBEL RE, BUYNAK EB, et al: Live, attenuated mumps-virus vaccine. 4. Protective efficacy as measured by a field evaluation. *N Engl J Med* 276: 252, 1967
5. WEIBEL RE, BUYNAK EB, MCLEAN AA: Long-term follow-up for immunity after monovalent or combined live measles, mumps, and rubella virus vaccines. *Pediatrics* 56: 380, 1975
6. RAWLS WE, RAWLS ML, CHERNESKY MA: Analysis of a measles epidemic: possible role of vaccine failures. *Can Med Assoc J* 113: 941, 1975
7. WEIBEL RE, BUYNAK EB, MCLEAN AA, et al: Persistence of antibody after administration of monovalent and combined live attenuated measles, mumps, rubella virus vaccines. *Pediatrics* 61: 5, 1978
8. JONES PH: Public acceptance of mumps immunization. Report of one year's experience offering live mumps vaccine in a public health clinic and school immunization program. *JAMA* 209: 901, 1969
9. BLACK FL: A nationwide serum survey of United States military recruits, 1962. III. Measles and mumps antibodies. *Am J Hyg* 80: 304, 1964
10. HENLE G, HENLE W, WENDELL KK, et al: Isolation of mumps virus from human beings with induced apparent or inapparent infections. *J Exp Med* 88: 223, 1948
11. WEIBEL RE, STOKES J JR, BUYNAK EB, et al: Live, attenuated mumps-virus vaccine. 3. Clinical and serologic aspects in a field evaluation. *N Engl J Med* 276: 245, 1967
12. LERNER AM: Guide to immunization against mumps. *J Infect Dis* 122: 116, 1970
13. BEST EWR: Measles, mumps and rubella: epidemiologic considerations. Presented at seminar on infectious problems in general practice, Inn-on-the-Park, Toronto, May 12, 1976
14. HAYDEN GF, PREBLUD SR, ORENSTEIN WA, et al: Current status of mumps and mumps vaccine in the United States. *Pediatrics* 62: 965, 1978