

Low Measles Incidence: Association with Enforcement of School Immunization Laws

KENNETH B. ROBBINS, MD, A. DAVID BRANDLING-BENNETT, MD, AND ALAN R. HINMAN, MD

Abstract: Of 54 federal immunization project areas in the United States, 13 areas with low measles incidence rates in 1977 and 1978 and 10 with high measles incidence rates were compared for differences in surveillance systems, demography, vaccine utilization, school immunization laws, and immunity levels. There was no significant difference between the low incidence and high incidence group for any examined parameter of demographic characteristics, vaccine utilization, or surveillance systems. However, in the low incidence group, school immunization laws were

found to be more comprehensive and more strictly enforced with a statewide policy of exclusion from school of noncompliant students. Furthermore, immunization levels were similar for two-year-olds in both groups but were significantly higher for school entrants in the low incidence group. In all public health efforts to control or eliminate measles, priority should be given to establishing and strictly enforcing comprehensive school immunization laws. (*Am J Public Health* 1981; 71:270-274.)

Introduction

Since the licensure of live measles virus vaccine in 1963, the number of reported measles cases has decreased from 400,000-500,000 cases annually to 20,000-60,000 cases, with a proportionate reduction in measles-associated mortality.^{1, 2} The lack of a carrier state and a nonhuman host for the measles virus and the availability of an effective vaccine generated optimism in the mid-1960s that measles could be eliminated from the United States.³ The national measles eradication effort of 1966-1967 did not succeed, however; failure was attributed in part to a shift in federal fiscal priorities to rubella vaccine and in part to an underestimation of immunity levels necessary to prevent epidemic spread of this highly infectious disease.^{4, 5}

Recently, there has been renewed federal interest in measles control and measles elimination. An initiative, announced by the Secretary of the Department of Health, Education, and Welfare in October 1978, seeks to eliminate indigenous measles from the United States by October 1, 1982.⁶

The Center for Disease Control (CDC) is responsible for developing the national measles elimination program and for coordinating its implementation through the federally supported immunization project areas. In 1966, Sencer, *et al.*,³ defined four essential components of a measles elimination strategy: routine immunization of one-year-olds, immunization of remaining susceptible children at school entry, surveillance, and epidemic control. Other related activities are

also important, including public and professional education, volunteer assistance, legislation, research, and program evaluation. Assessment of the relative effectiveness of each of these activities in reducing measles transmission is an important part of the development of a national measles elimination strategy.

The experience with measles outbreaks in the U.S. States and Territories has been quite variable, with annual reported measles incidence rates consistently low in some areas and consistently high in others. The present study was designed to compare areas which apparently have been successful in controlling measles (as evidenced by consistently low incidence rates) with areas which have consistently reported high measles incidence rates. We hoped that identifying significant differences between the two groups would provide a fuller understanding of the determinants of high and low measles incidence, which could then contribute directly to the establishment of priorities for intervention in the national measles elimination strategy.

Methods

Measles incidence rates (measles cases per 100,000 children less than 18 years of age per year) were calculated for 54 federal immunization project areas (50 states plus Puerto Rico, Guam, New York City, and the District of Columbia) for the individual years 1977 and 1978 and for the combined two-year period 1977-1978. Case data for 1977 and 1978 were obtained from CDC publications^{7, 8} and population data for 1976 were available from the U.S. Bureau of the Census.⁹ Immunization project areas were then ranked (1-54) on the basis of measles incidence, with low rank corresponding to low measles incidence, for the periods 1977, 1978, and 1977-1978.

The selection criteria emphasized a consistently low or

From the Immunization Division, Center for Disease Control, Atlanta. Address reprint requests to Alan R. Hinman, MD, Director, Immunization Division, Bureau of State Services, U.S. Public Health Service, Department of Health and Human Services, Center for Disease Control, Atlanta, GA 30333. This paper, submitted to the *Journal* July 11, 1980, was revised and accepted for publication October 27, 1980.

high measles incidence over the two-year period studied excluding states which showed wide fluctuation in yearly incidence. The selection criteria stressed a consistently high or low 1977-1978 incidence ranking, while allowing slightly more variability for individual 1977 and 1978 incidence rates. The specific criteria were chosen to yield appropriate numbers of low and high incidence areas for a meaningful comparison. The criteria used required a project to be in the top or bottom 30 per cent of project areas in the combined 1977-1978 incidence ranking and the top or bottom 45 per cent in the individual 1977 and 1978 incidence rankings. Thus, a high incidence area was defined as meeting the following three selection criteria:

1. 1977-1978 measles incidence ranked 38 or higher (out of 54)
2. 1977 measles incidence ranked 30 or higher
3. 1978 measles incidence ranked 30 or higher

Ten project areas (Illinois, Maine, Montana, New Hampshire, Oregon, Tennessee, Vermont, Virginia, Wisconsin, and Upstate New York) satisfied these criteria and were designated the high incidence group in this study.

A low incidence area was defined as meeting the following three selection criteria:

1. 1977-1978 measles incidence ranked 17 or lower
2. 1977 measles incidence ranked 25 or lower
3. 1978 measles incidence ranked 25 or lower

Thirteen project areas (Alabama, Alaska, Arkansas, Delaware, Hawaii, Maryland, New Jersey, North Carolina, Oklahoma, Rhode Island, South Dakota, Utah, and Wyoming) satisfied these criteria and were designated the low incidence group in this study.

The high incidence and low incidence groups were then compared for differences in demographic characteristics, surveillance systems, vaccine utilization, school immunization laws, and immunization levels. Population less than 18 years old, metropolitan/nonmetropolitan distribution of the population, and mean annual income per capita were obtained by tables prepared by the Bureau of the Census.¹⁰

Information on the presence of active surveillance and toll-free telephone reporting systems was available from CDC for 1978. Active surveillance was defined as the receipt of regularly scheduled reports from hospitals, schools, and/or local physicians. The quality of surveillance systems was also assessed by the percentage of cases reported in 1977 in which the age of the patient was known.⁷

Data on vaccine utilization were obtained from reports submitted to the CDC. Estimates of the relative proportion of publicly and privately administered measles vaccine were obtained from surveys of two-year-old vaccine recipients conducted in 1977 and 1978 in the individual project areas, except New Hampshire and Oklahoma. The percentage of the total vaccine purchased in the public sectors which was administered to one- to four-year-olds was calculated for each area as a measure of the degree of routine immunization, as opposed to "catch-up" immunization and outbreak control immunization of the school-aged group. The amount of public sector vaccine administered from October 1977 to September 1978 divided by the number of live births per year gave an estimate of the impact on each area of publicly pur-

chased vaccine and associated public and private immunization services.

The actual amounts of vaccine administered by private providers, of vaccine used during outbreaks, and of vaccine used for compliance with school immunization laws were not available.

Each project area was evaluated for the presence of a statewide school immunization law as of March 1978, the number of years the law had been in effect, and the comprehensiveness of the law (school entrants only, including kindergarten, first grade, and transfer students, or the total school population from kindergarten through the 12th grade). In addition, the areas were assessed for the presence in the law of a school exclusion provision for noncompliant students which read: "No student shall be admitted (or retained) without proper documentation of immune status," or "No principal shall admit (or retain) a pupil who is without proper documentation of immune status." Finally, the project areas were assessed for statewide enforcement of school immunization laws by exclusion from school of noncompliant students (either school entrants or the total student population, depending on the law's jurisdiction), as reported by the project areas to CDC.

Immunization levels for two-year-olds and school entrants were obtained at CDC from surveys conducted by the individual project areas. Immunization surveys of two-year-olds had not been done in Alaska, Oklahoma, Wyoming, Maine, New Hampshire, Oregon, or Upstate New York. A survey of school entrants was not done in Arkansas.

Numerical data presented in this study are means of the values for individual high and low incidence areas. Statistical significance was tested using the two-sample rank test (Mann-Whitney U test) or the Fisher exact test (FET), where applicable.

Results

The mean annual reported incidence rate for 1977-1978 for the low measles incidence group was 10.2 cases per 100,000 population less than 18 years of age compared with 128.7 per 100,000 for the high incidence group, a greater than 12-fold difference. The overall reported mean incidence for the United States in 1977-1978 was 63.3 cases per 100,000 population. Prior to measles vaccine licensure in 1963, the reported measles incidence for the United States approximated 700 cases per 100,000 population less than 18 years of age per year.

Approximately 31 per cent of the population was less than 18 years old in both groups (Table 1). The population of the low incidence group was smaller and more metropolitan than that of the high incidence group, but the difference was not statistically significant (two-sample rank test). The mean annual income for the two groups was equivalent.

Passive surveillance systems existed in all high and low incidence areas (Table 2). Active surveillance systems were present in a higher proportion of the low incidence group, and toll-free telephone reporting systems in a higher proportion of the high incidence group. These differences were not

TABLE 1—Demographic Characteristics of Areas with High and Low Measles Incidence, United States, 1977-78

Demographic Characteristics	Groups	
	Low Incidence	High Incidence
No. of Areas	13	10
1976 Population < 18 Years Old (as % of total population)*	723,000 (31.7)	1,255,000 (30.7)
1976 Per Capita Income*	\$6,422	\$6,130
1970 % Metropolitan*	58.4	49.4

*p > 0.05

statistically different (FET). The ages were known for more than 90 per cent of persons with measles cases reported in 1977 for both high and low incidence groups.

The low incidence group reported a higher percentage of vaccine administered by the public (as opposed to private) sector, but the difference was not statistically significant (Table 3, two-sample rank test). The percentage of total public sector vaccine administered to one- to four-year-olds and the amount of public sector vaccine administered per live birth per year were equivalent in both groups, indicating similar emphasis on routine immunization services and equal reliance on publicly purchased vaccine.

State school immunization laws or regulations were present in 12 of 13 low incidence areas and in nine of 10 high incidence areas and had been in effect an equivalent number of years in both groups (Table 4). While jurisdiction included school entrants in all low and high incidence areas with school laws, it included the total school population (kindergarten through 12th grade) for six of the 13 low incidence areas but for none of the high incidence areas (p < 0.025, FET). School exclusion provisions were present in the laws of equivalent numbers of high and low incidence areas (Table 4). However, statewide enforcement of immunization laws with exclusion from school of noncompliant students was noted only in low incidence areas. A school exclusion policy was enforced statewide in 10 of 13 low incidence areas as of March 1978. The absence of an explicit school exclusion provision in the law did not preclude enforcement by

TABLE 2—Surveillance Systems in Areas of High and Low Measles Incidence, United States, 1978

Surveillance System	Groups	
	Low Incidence	High Incidence
Total No. of Areas	13	10
Passive Surveillance System*	13	10
Active Surveillance System*	3	1
Toll-Free Telephone Reporting System*	4	4
% of 1977 Cases Reported by Age*	93.5	91.5

*p > 0.05

TABLE 3—Vaccine Utilization in Areas with High and Low Measles Incidence, United States, 1977-78

Vaccine Utilization	Groups	
	Low Incidence	High Incidence
% of Vaccine Administered by Public Providers*	41.8	28.3
% of Public Sector Vaccine Administered to 1- to 4-year-olds*	47.3	40.0
Doses of Public Sector Vaccine per Live Birth per year 10/77-78*	1.45	1.38

*p > 0.05

exclusion in some instances. In high incidence areas enforcement of school immunization laws by school exclusion of noncompliant students was spotty at best and was never found statewide. The difference in enforcement of school immunization laws between high and low incidence groups was highly significant (p < 0.001, FET).

Immunization levels of two-year-olds were similar in both groups (Table 5). Immunization levels of school entrants were significantly higher for low incidence areas compared with high incidence areas (p < 0.025, two-sample rank test).

Discussion

In this study of several factors possibly related to the reported incidence of measles, there were no differences in

TABLE 4—Existence, Duration, and Jurisdiction of School Immunization Laws, and Their Exclusion Provisions and Enforcement in Areas of High and Low Measles Incidence, United States, March 1978

Status of Immunization Laws and Enforcement	Groups	
	Low Incidence	High Incidence
Total No. Areas	13	10
No. (%) of Areas with State-wide Immunization Laws*	12 (92)	9 (90)
Mean Duration (years) of Existence*	6.4	6.8
No. (%) of Areas with Laws Covering School Entrants*	12 (92)	9 (90)
No. (%) of Areas with Laws Covering Total School Population**	6 (46)	0 (0)
No. (%) of Areas with School Exclusion Present in Law*	7 (54)	5 (50)
No. (%) of Areas with School Exclusion Enforced Statewide***	10 (77)	0 (0)

*p > 0.05

**p < 0.025

***p < 0.001

TABLE 5—Percentage of Two-Year-Olds and School Entrants Adequately Immunized against Measles in Areas with High and Low Measles Incidence, United States, 1977-78

Age Group	Groups	
	Low Incidence	High Incidence
Two-Year-Olds*	84	87
School Entrants**	95	89

*p > 0.05
 **p < 0.025

demographic characteristics, vaccination programs, or surveillance systems in States with high incidence of measles 1977-1978 as compared to States with low incidence. However, school immunization laws were more comprehensive in low incidence areas and were enforced statewide with exclusion from school of noncompliant students in the majority of these areas. In contrast, school immunization laws did not apply to the total school population in the high incidence group, and they were not enforced statewide during the period studied. The evidence indicates a strong association between comprehensive, vigorously enforced school immunization laws and a low incidence of measles. This suggestion is reinforced by the results of immunization surveys. Equivalent immunization levels were noted for two-year-olds, but the immunization level was significantly higher for school entrants in the low incidence group. Although the high incidence group averaged 89 per cent immunization levels for school entrants, experience has shown that measles epidemics can propagate with the level of protection.^{4, 11, 12} Immunization levels averaged 95 per cent in the low incidence group; this 6 per cent increase over high incidence areas may actually afford significantly increased protection to the entering school population. These figures do not reflect the immunization levels of the entire enrolled student population, for whom data were not available.

A number of potentially important variables which affect measles incidence were not included in this study. Although all high and low incidence areas had outbreak control systems judged "adequate" for federal funding, this variable could not be fully assessed because of the lack of measurable parameters. The role of health education and volunteer activities could not be studied for similar reasons.

The history of school immunization laws in the United States dates to the era of smallpox vaccination in the 19th century.¹³ In 1853 Massachusetts became the first state to require smallpox vaccination for schoolchildren. Enactment of compulsory school vaccination laws by other states followed, but enforcement was variable, depending on the degree of cooperation, apathy, or opposition of local school boards. In 1895, in the face of a widespread smallpox epidemic, Pennsylvania passed a compulsory school vaccination law requiring that all children provide a physician's certificate of vaccination or certified history of previous smallpox infection before being permitted to attend school. The

enforcement of this law, which had strong public support throughout the state, was followed by a dramatic reduction in smallpox in the ensuing years. The constitutionality of compulsory school immunization laws was upheld by the U.S. Supreme Court in 1922.¹⁴

The extension of immunization laws to vaccines other than smallpox began in the 1950s with the introduction of poliomyelitis vaccine and continued through the 1960s with the advent of measles, mumps, and rubella vaccines. By 1972, 28 of the states and territories had enacted school immunization laws requiring measles immunization prior to school entry.¹⁵ Forty-six of the states and territories had mandated such a law by 1976.¹⁶

A 1977 study by CDC demonstrated that states with compulsory school immunization laws in 1973 had a 50 per cent lower incidence of measles than those without such laws.¹⁷ In many states, however, either school immunization laws were enacted without providing penalties for non-compliance or penalties were not enforced as mandated by law. In 1978, a further study by CDC demonstrated that 6 states with strictly enforced comprehensive school laws had a 90 per cent lower incidence of measles than the rest of the nation.¹⁸ Several reports have documented the success of individual states in strictly enforcing school immunization laws.^{19, 20}

With more than 80 per cent of measles cases presently occurring in children 5- to 19-years-old, schools are undoubtedly the major site of measles transmission in this country. In this comparison of high and low incidence areas, enforcing comprehensive school immunization laws by excluding noncompliant students from school was the major distinguishing characteristic. Given adequate vaccine accessibility and support from local school administrators and the general public, enforcing school immunization laws with jurisdiction over the entire school population can ensure protection of all schoolchildren for whom immunization is not contraindicated, thereby lowering significantly the potential for epidemic spread. Enacting and strictly enforcing such comprehensive laws should be given high priority in all public health efforts to control or eliminate measles.

REFERENCES

- Orenstein WA, Halsey NA, Hayden GF, *et al*: Current status of measles in the United States, 1973-1977. *J Infect Dis* 1978; 137:847-853.
- Witte JJ, Axnick NW: The benefits from 10 years of measles immunization in the United States. *Public Health Rep* 1975; 90:205-207.
- Sencer DJ, Dull HB, Langmuir AD: Epidemiologic basis for eradication of measles in 1967. *Public Health Rep* 1967; 82:253-256.
- Conrad JL, Wallace R, Witte JJ: The epidemiologic rationale for the failure to eradicate measles in the United States. *Am J Public Health* 1971; 61:2304-2310.
- Schreier HA: On the failure to eradicate measles. *N Engl J Med* 1975; 290:803-804.
- Hinman AR, Brandling-Bennett AD, Nieburg PI: The opportunity and obligation to eliminate measles from the United States. *JAMA* 1979; 242:1157-1162.
- Center for Disease Control: Reported Morbidity and Mortality in the United States, 1977. *MMWR* 1978; 26(suppl):23.
- Center for Disease Control: Reported Morbidity and Mortality in the United States, 1978. *MMWR* 1979; 27(suppl):39.

9. U.S. Bureau of the Census: Estimates of the population of States by age: 1975 and 1976. Current Population Reports, series P-23, No. 646, 1977.
10. U.S. Bureau of the Census: Statistical Abstract of the United States 1977; 98:17, 57, 437.
11. Wyll SA, Witte JJ: Measles in previously vaccinated children. JAMA 1971; 216:1306-1310.
12. Sejda J: Possibility of measles eradication or elimination. Cesk Pediatr 1977; 32:729-731.
13. Duffy J: School vaccination: The precursor to school medical inspection. Hist Med 1978; 33:344-355.
14. Jackson CL: State laws on compulsory immunization in the United States. Public Health Rep 1969; 84:787-795.
15. Center for Disease Control: Measles Surveillance Report No. 9, 1972. Atlanta: CDC, Issued August 1973.
16. Center for Disease Control: Measles Surveillance Report No. 10, 1973-1976. Atlanta: CDC, Issued July 1977.
17. Center for Disease Control: Measles—United States. MMWR 1977; 26:109-111.
18. Center for Disease Control: Measles and school immunization requirements—United States, 1978. MMWR 1978; 27:303-304.
19. Gee L, Sowell RF Jr: A school immunization law is successful in Texas. Public Health Rep 1975; 90:21-24.
20. Middaugh JP, Zyla LD: Enforcement of school immunization law in Alaska. JAMA 1978; 239:2128-2130.

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