Treating Measles: The Appropriateness of Admission to a Wisconsin Children's Hospital

ABSTRACT

Objectives. A large number of children with measles were hospitalized at a children's hospital during a metropolitan measles outbreak. In this study we addressed the appropriateness of those admissions.

Methods. Charts of all 634 patients with a diagnosis of measles who were treated between August 1989 and April 1990 were reviewed. Determination of the appropriateness of hospital admission was based on severity of illness and presence of severe complications of measles.

Results. Of 564 patients with clinical measles or serologic evidence of recent infection, 252 were inpatients (median age 1.5 years) and 312 were outpatients (median age 2.1 years). Fifty-nine (23.4%) of the inpatients had been inappropriately admitted. Inpatients were significantly more likely than outpatients to have physiologic instability or a clinical complication. Children 15 months of age or younger were more likely to be hospitalized, as were children evaluated in the first 3 months of the outbreak period, even if admission was not appropriate on the basis of physiologic instability or complications.

Conclusions. Younger patients with measles and patients evaluated earlier in the epidemic were more likely to be admitted to the hospital even when admission was inappropriate as assessed by degree of physiologic instability or presence of complications. (*Am J Public Health.* 1993;83:379–384)

Peter L. Havens, MD, MS, Jay C. Butler, MD, Susan E. Day, MD, Barbara A. Mohr, RN, Jeffrey P. Davis, MD, and Michael J. Chusid, MD

Introduction

During 1989 and 1990 widespread outbreaks of measles occurred in the United States.[1] Unlike outbreaks in the United States earlier in the 1980s, which occurred primarily in heavily vaccinated adolescent populations,[2] recent large outbreaks of measles in Dallas, Chicago, Los Angeles, and Milwaukee have occurred predominantly in unvaccinated preschool-aged children.[1] Of 17 850 patients with cases of measles occurring during 1989 that were reported to the Centers for Disease Control, 17.4% had reported complications (diarrhea, otitis media, pneumonia, or encephalitis) and 15.8% were hospitalized; the case-fatality rate was 2.3 deaths per 1000 reported cases.[1]

Children's Hospital of Wisconsin is a pediatric referral hospital in Milwaukee County, Wisconsin. Between August 1, 1989, and June 26, 1990, a sustained outbreak of measles occurred in Wisconsin. Of 1419 reported cases, 87% occurred in residents of Milwaukee County, 59% in children younger than 5 years, and 24% in children who had been vaccinated. Twenty-four percent of the patients were hospitalized, and there were six deaths (Wisconsin Division of Health, unpublished data). The case-fatality rate was 6/1419, or 4.2 deaths per 1000 cases.

During this outbreak, we were impressed with the large numbers of admissions to the hospital and the apparently high rate of complications. We questioned whether the high proportion of hospitalized patients reflected a truly high frequency of severe disease or factors other than disease severity that were important determinants of hospitalization for measles. The present evaluation was conducted to assess the determinants of hospital admission for all patients with measles who were treated at Children's Hospital of Wisconsin between August 1, 1989, and April 30, 1990.

Materials and Methods

Inpatient and outpatient records of 638 patients with a diagnosis of measles who were treated at the hospital between August 1, 1989, and April 30, 1990, were reviewed. Three patients were excluded because their records had been miscoded; thus 635 records were available for complete review.

Data from each medical record were abstracted by one of the authors onto coded data sheets. The abstracted information included age, race, gender, residence address, maternal age, receipt of Aid to Families with Dependent Children, method of payment (self-pay or insurance company name), name of primary physician (if any), presence of underlying dis-

Peter L. Havens, Susan E. Day, and Michael J. Chusid are with the Department of Pediatrics, Medical College of Wisconsin, Milwaukee, and Children's Hospital of Wisconsin, Milwaukee. Peter L. Havens is also with the Division of Biostatistics/Clinical Epidemiology, Medical College of Wisconsin. Jay C. Butler and Jeffrey P. Davis are with the Bureau of Public Health, Wisconsin Division of Health, Madison. Jay C. Butler is also with Epidemiology Program Office, Centers for Disease Control, Atlanta, Ga. Barbara A. Mohr is with Children's Hospital of Wisconsin, Milwaukee.

Requests for reprints should be sent to Peter L. Havens, MD, MS, Children's Hospital of Wisconsin, 9000 W Wisconsin Ave, PO Box 1997, Milwaukee, WI 53201.

This paper was submitted to the Journal January 8, 1992, and accepted with revisions October 27, 1992.

The use of trade names is for identification only and does not imply endorsement by the Department of Health and Human Services or the US Public Health Service.

TABLE 1—The Assessment of Physiologic Instability with a Modification of the Pediatric Risk of Mortality (PRISM) Score

Variable	Low	Normal	High	Score
Age < 12 mo				
Heart rate		90–160		0
	<90		>160	4
Respiratory rate		<60		0
			61–90	1
	Apnea		>90	5
Systolic BP		66–129		0
	55–65		130–160	2
	40–54		>160	6
	<40			7
Age ≥ 12 mo				
Heart rate		81–149		0
	<80		>150	4
Respiratory rate		<50		0
			51–70	1
	Apnea		>70	5
Systolic BP		76–149		0
	65–75		150–200	2
	50–64		>200	6
	<50			7
All ages				
Diastolic BP			>110	6
Glascow Coma Score	<8			6
Pupils	Unequal/dilated			4
	Fixed/dilated			10
PT/PTT			>1.5 × control	2
Total bilirubin			>3.5 (>1 mo)	6
Potassium		3.6–6.4		0
	3.0–3.5		6.5–7.5	1
	<3.0		>7.5	5
Calcium		8.1–11.9		0
	7.0–8.0		12.0–15.0	2
	<7.0		>15.0	6
Glucose		61–249		0
	40–60		250–400	4
	<40		>400	8
Bicarbonate	<16		>32	3
Maximum total score				68

Note. Our score for physiologic instability was adapted from the PRISM score.[6] PRISM scores are based on the summation of weighted values for the degree of abnormality of the above variables plus weights for arterial pO_2 and pCO_2 and can range from 0 to a maximum of 76. To calculate the score for physiologic instability, the value of each variable recorded at the time of the hospital visit is assigned a weighted value based on the degree of variation from normal. Variables not measured are assumed to be normal. The weighted scores are then summed to assess the overall amount of physiologic instability. BP = blood pressure; PT = prothrombin time; PTT = partial thromboplastin time.

ease, and parent-reported history of measles vaccination or measles exposure. Abstracted data on clinical characteristics of disease course included presence of the primary manifestations of measles (fever, cough, coryza, conjunctivitis, Koplik spots, and rash), vital signs and neurologic findings on admission, presence of complications (respiratory, gastrointestinal, neurologic, and cardiac), and selected aspects of therapy, including treatment with antibiotics, adrenal corticosteroids, intravenous fluids, oxygen, and endotracheal intubation. Laboratory results were abstracted to facilitate assessment of physiologic instability (see below).

To characterize cases, we used the following clinical case definition: presence of rash or parent-reported history of rash; fever, with measured temperature ≥ 38.3°C, or parent-reported history of fever; and at least one of the following: cough, coryza, or conjunctivitis. A case was alternatively defined by a fourfold or larger rise in measles complement fixation or hemagglutination antibody titer or detection of measles-specific immunoglobulin (IgM) antibody in the patient's serum. Serologic testing was performed by the Virus Section, State Laboratory of Hygiene, Madison, Wisc. Total antibody determinations were made on paired serum samples by the complement fixation test[3] and by the hemagglutination inhibition test performed with African green monkey erythrocytes.[4] After removal of human immunoglobulin G (IgG) antibodies either by column chromatography (Quick-Sep System II, Isolab Inc, Akron, Ohio) or by elution with goat antihuman–IgG antibody (Gull Laboratory, Salt Lake City, Utah), all samples were screened for the presence of measles-specific IgM antibody by means of indirect fluorescent antibody test methods previously described.[5]

Patients were grouped by age into three categories: ≤ 15 months (the recommended age for the first routine measles vaccination in the nonepidemic setting), 16 months through 4 years (preschool age), and ≥ 5 years (school age).

Hospital admission was considered appropriate for patients who (1) were immunosuppressed because of underlying disease or therapy; (2) had significant physiologic instability (defined below); (3) had objective evidence of dehydration (defined below); (4) had evidence of a severe complication on presentation to the hospital (defined by the presence of croup, tracheitis, pneumomediastinum, pneumothorax, myocarditis, pericarditis, or any neurologic abnormality); or (5) were treated with oxygen.

The assessment of physiologic instability was based on a score calculated from the degree of derangement of the 12 variables listed in Table 1. Our score for physiologic instability was adapted from the Pediatric Risk of Mortality (PRISM) score.[6] A PRISM score of > 0 is associated with an increased risk of death in children admitted to an intensive care unit.[6] Accordingly, we classified all patients with a physiologic instability score ≥ 1 as appropriate for hospital admission.

Patients were considered to display objective evidence of dehydration if they demonstrated any one of the following abnormalities: admission serum urea nitrogen > 6.5 mmol/L (18 mg/dL), admission serum sodium < 134 mmol/L or > 145 mmol/L, or initial urine specific gravity > 1.020.

Comparisons were made between the group of patients who were admitted to the hospital and the group of patients treated as outpatients (in the emergency room or the acute care walk-in clinic). These two groups were examined for differences in the variables that were considered possible determinants of hospital admission, including patient's age, mother's age, method of payment, primary care provider, receipt of Aid to Families with

Dependent Children, and each criterion considered appropriate for hospital admission. To determine the statistical significance of the differences between these two groups, the chi-square test was used for categorical variables and the Wilcoxon two-sample test was used for continuous variables. Logistic regression was used for multivariate analysis. The 95% confidence intervals (CIs) were determined by standard methods for all proportions and odds ratios.[7] The analysis was conducted with PC-SAS, version 6.04 (SAS Institute Inc, Cary, NC).

Results

Description of the Patient Population

During the 9-month study interval, 635 patients with a discharge diagnosis of measles were treated at Children's Hospital of Wisconsin, including 266 inpatients and 369 outpatients. Of the 635 patients, 559 (88%) met the criteria for the clinical case definition for measles. An additional 5 patients had illnesses that did not meet the clinical case definition for measles but had diagnoses of measles serologically confirmed. These 564 patients (252 inpatients and 312 outpatients) constituted the study sample with measles included in this analysis. Of the 200 patients for whom results of serologic testing were available, 181 (91%) had measles serologically confirmed and 19 (9%) were seronegative. Figure 1 shows the number of patients evaluated by month and the proportion of those patients admitted to the hospital.

Of the 564 patients, 283 (50%) were female and 449 (80%) were Black, 65 (11%) were White, 41 (7%) were Hispanic, and 11 (2%) were of other race/ethnicity. The mean age of the entire patient population was 3.4 years (SD 3.6 years); the median age was 1.8 years (range, 1 month to 17 years). Seventy-eight percent of the patients were < 5 years of age.

Of 378 patients > 15 months of age, the age at which routine vaccination against measles is recommended in nonepidemic settings,[8,9] 178 (47%) had no reported history of vaccination.

The outbreak occurred primarily in central city residents; 246 (79%) outpatients and 201 (80%) inpatients resided in 10 central Milwaukee ZIP code areas. Only 6 (1%) patients lived outside the 27 ZIP code areas of Milwaukee County. By contrast, in 1989, only 4100 (37%) of all 11 061 inpatients at Children's Hospital of Milwaukee resided in the area defined by these 10 downtown ZIP codes, and 3478 (31%) resided outside Milwaukee County.

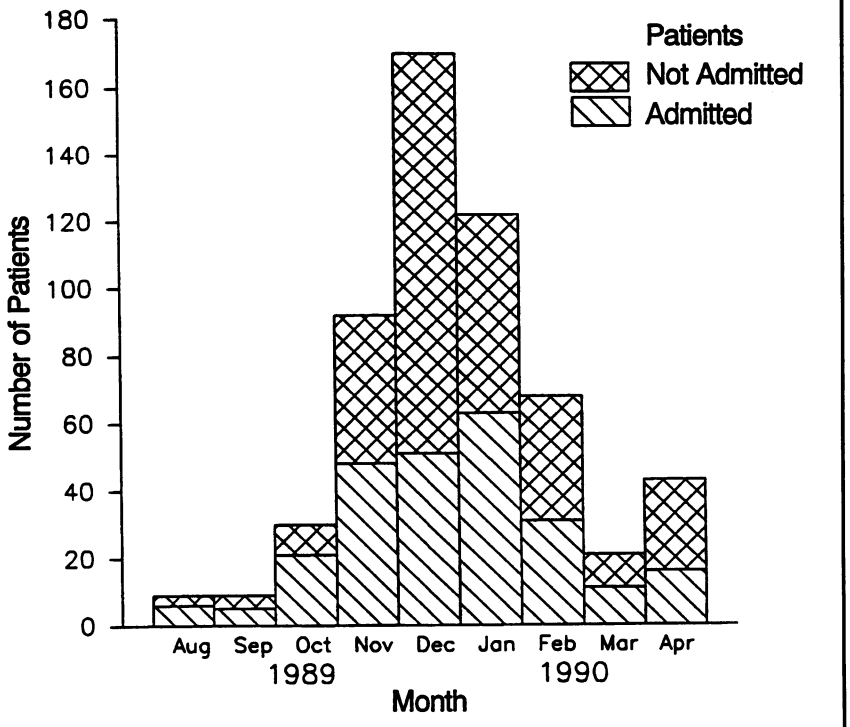

FIGURE 1—Number of patients with measles by admission status and month of evaluation, Children's Hospital of Wisconsin, August 1989 to April 1990.

TABLE 2—Criteria for Appropriateness of Hospital Admission Met by Inpatients and Outpatients with Measles, Children's Hospital of Wisconsin, August 1989 to April 1990

Criteria for Appropriate Admission[a]	Inpatients (n = 252)		Outpatients (n = 312)		Total (n = 564)		
	No.	%	No.	%	No.	%	P^b
Immunosuppression	3	1	1	0.3	4	0.7	.2
Physiologic instability	128	51	88	28	216	38	<.0001
Dehydration	103	41	26	8	129	23	<.0001
Severe complication	33	13	7	2	40	7	<.0001
Oxygen treatment	67	29	0	0	67	14	<.0001
Meets ≥ 1 criterion	193	77	112	36	305	54	<.0001

[a]See Materials and Methods section in text for definitions fo the criteria.
[b]*P* value for the difference between inpatients and outpatients, by chi-square test or Fisher's Exact Test.

The outbreak occurred in a population that included many children from families receiving Aid to Families with Dependent Children; 211 (68%) outpatients and 191 (76%) inpatients were members of families receiving aid, whereas 45% of all inpatients at the hospital in 1989 were members of families receiving aid.

There were 305 (54%) patients considered to have illness appropriate for hospital admission according to the defined criteria. The specific criteria supporting these determinations for the inpatient and outpatient groups are presented in Table 2. The distribution of specific complications in 40 patients with severe complications was as follows: croup, 20; tracheitis, 5; pneumomediastinum, 1; pneumothorax, 2; myocarditis, 0; pericarditis, 0; and neurologic abnormality, 14. These numbers include only complications present at the time of the outpatient visit.

There were 5 (0.9%) deaths among the 564 patients treated at the hospital. Two deaths occurred in immunosuppressed patients > 10 years old from outside Milwaukee County who had previously been immunized against measles,

TABLE 3—Distribution of Hospital Admission, Disease Severity, and Appropriateness of Admission for Measles, by Age and Time, Children's Hospital of Wisconsin, August 1989 to April 1990

	Age ≤ 15 mo			Age 16 mo–4 y			Age ≥ 5 y		
	Aug–Oct (n = 18)	Nov–Jan (n = 118)	Feb–Apr (n = 50)	Aug–Oct (n = 14)	Nov–Jan (n = 181)	Feb–Apr (n = 61)	Aug–Oct (n = 16)	Nov–Jan (n = 85)	Feb–Apr (n = 21)
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Admission	12 (67)	54 (46)	26 (52)	10 (71)	78 (43)	28 (46)	10 (63)	30 (35)	4 (19)
Physiologic instability[a]	6 (33)	46 (39)	20 (40)	8 (57)	80 (44)	28 (46)	3 (19)	20 (24)	5 (24)
Appropriate diagnosis for admission[b]	5 (28)	24 (20)	16 (32)	5 (36)	62 (34)	21 (34)	8 (50)	36 (42)	6 (29)
Inappropriate for admission[c]	9 (50)	61 (52)	23 (46)	3 (21)	77 (43)	25 (41)	8 (50)	41 (48)	12 (57)
Inappropriate, but admitted	6 (33)	18 (15)	8 (16)	2 (14)	15 (8)	5 (8)	2 (13)	2 (2)	1 (5)

[a]Defined in text.
[b]Based on criteria defined in Materials and Methods section in text and listed in Table 1, but not including physiologic instability.
[c]Satisfying none of the criteria defined in Materials and Methods section in text and listed in Table 1, including physiologic instability.

and three occurred in previously healthy Milwaukee County residents ≤ 24 months of age who had not been appropriately immunized against measles.

Determinants of Hospital Admission

Age of the patients was an important determinant of hospital admission. The median age of the inpatients was 1.5 years (range 1 month to 17 years), whereas the median age of the outpatients was 2.1 years (range, 2 months to 17 years; $P = .008$, Wilcoxon two-sample test). School-aged children were least likely to be hospitalized during all periods of the outbreak (Table 3). Moreover, the proportion of all patients who were of school age decreased as the outbreak progressed. During the first 3 months, 33% of the patients were ≥ 5 years old, compared with 22% during the second 3 months and 16% during the final 3 months (trend $\chi^2 = 3.4$, $P = .06$). The proportion of school-aged patients who were admitted to the hospital declined more steeply with time. During the first 3 months of the outbreak, 63% of all school-aged patients were admitted to the hospital; in the second 3 months, 35% were admitted; and in the last 3 months, 19% were admitted (trend $\chi^2 = 7.1$, $P = .008$; Table 3).

The number of patients evaluated in each month of the study period is shown in Figure 1. During the first 3 months of the study period, 32 (67%) of 48 patients were admitted, compared with 58 (44%) of 132 patients during the final 3 months ($\chi^2 = 10.4$, $P = .006$).

Severity of illness was strongly associated with hospitalization. The occurrence of physiologic instability (as defined in Materials and Methods) was significantly greater in inpatients than in outpatients (Table 2). Inpatients were more likely than outpatients to be dehydrated or to have a severe complication at the time of initial evaluation (Table 2). Patients who did not satisfy the criteria for hospitalization were said to be inappropriately hospitalized; by this definition, 59 (23%) of 252 hospitalized patients were inappropriately hospitalized (Table 2).

Inappropriate hospitalization was associated both with age and with date of evaluation. School-aged children were least likely to be inappropriately hospitalized; 32 (17%) of 186 patients < 15 months of age were inappropriately admitted, compared with 14 (5%) of 256 patients aged from 16 months through 4 years and 5 (4%) of 122 patients ≥ 5 years of age (trend $\chi^2 = 14.7$, $P = .0001$) (Table 3). Earlier in the outbreak a larger proportion of patients were inappropriately admitted to the hospital. During the first 3 months of the study period 10 (50%) of 20 patients with illness not meeting our criteria for appropriate hospitalization were admitted, compared with 35 (20%) of 179 patients during the second 3 months and 14 (23%) of 60 patients during the final 3 months ($\chi^2 = 9.5$, $P = .009$). Examination of admission rates stratified by age and time of evaluation demonstrates that in all periods of the study interval children younger than 15 months of age were more likely to be inappropriately admitted than were children in older age groups (Table 3).

Patients with health insurance were more likely to be admitted to the hospital than were those without it. Of all patients, 519 (92%) were reported to have health insurance. Only 4% of the inpatients lacked health insurance, whereas 12% of outpatients were uninsured ($\chi^2 = 12.1$, $P = .001$). A higher percentage of uninsured patients were treated as outpatients even when appropriateness of admission was controlled for: in the group of 305 patients for whom admission was considered appropriate by our criteria, 4% of the inpatients and 14% of the outpatients had no health insurance ($\chi^2 = 11.5$, $P = .001$). Maternal age, receipt of Aid to Families with Dependent Children, identification of a defined primary care physician, and history of previous immunization against measles were not significantly associated with hospitalization.

To more fully understand the determinants of hospital admission, we performed forward selection logistic regression analysis, using factors associated with hospital admission in the univariate analysis as well as race, gender, maternal age, receipt of Aid to Families with Dependent Children, identification of a defined primary care physician, and history of immunization. Regression coefficients, odds ratios, and 95% confidence intervals for the variables in one model are presented in Table 4. For the variables in this model, $\chi^2 = 217.9$ (−2 times the log likelihood method), $df = 12$, $P = .0001$. Patients who were immunosuppressed, were dehydrated, had a severe complication, or required oxygen therapy (see Table 2) were more likely to be hospitalized than were patients who did not meet any of these criteria (OR = 16.6, 95% CI = 10.0,

27.8). Physiologic instability was independently associated with hospitalization even when the other criteria for appropriate admission were controlled for (OR = 2.0, 95% CI = 1.3, 3.1). Patients ≤ 15 months old and those aged 16 months through 4 years were more likely than school-aged children to be hospitalized for any degree of disease severity (ORs = 3.6 and 2.0, respectively). Patients evaluated during the first 3 months of the outbreak were more likely than those evaluated later to be hospitalized (OR = 2.9, 95% CI = 1.3, 6.1), independent of age, presence of complications, or physiologic instability. Patients evaluated during the month of December 1989 were much less likely to be admitted to the hospital than were patients evaluated during April 1990 (OR = 0.49, 95% CI = 0.30, 0.79).

Forward selection logistic regression was also used to characterize determinants of inappropriate hospital admission, starting with the same variables used for the analysis of determinants of hospitalization. The only variables significantly associated with inappropriate hospitalization were age ≤ 15 months (OR = 2.7, 95% CI = 1.5, 4.6) and evaluation in the first 3 months of the outbreak (OR = 2.4, 95% CI = 1.1, 5.3).

TABLE 4—Determinants of Hospital Admission for Measles, Children's Hospital of Wisconsin, August 1989 to April 1990, Based on the Logistic Regression Model

Variable	Coefficient	Odds Ratio	95% CI
Physiologic instability[a]	0.6895	2.0	1.3, 3.1
Immunosuppressed, dehydrated, severe complication, or required oxygen[b]	2.8124	16.6	10.0, 27.8
Age ≤ 15 months[c]	1.2799	3.6	1.9, 6.8
Age 16 months to 4 years[c]	0.7158	2.0	1.1, 3.7
First 3 months of outbreak[d]	1.0491	2.9	1.3, 6.1
Presence of medical insurance[e]	1.6828	5.4	2.1, 13.7
December 1989[f]	−0.7233	0.49	0.3, 0.79
Intercept	−2.2003		

Note. The odds ratio for hospitalization of each referent population is defined as 1.0.
[a]Referent to patients not deemed physiologically unstable.
[b]Referent to patients who were not classified as immunosuppressed, dehydrated, having a severe complication, or receiving oxygen therapy.
[c]Referent to patients ≥ 5 years old.
[d]Referent to patients evaluated in the last 6 months of the outbreak.
[e]Referent to patients with no medical insurance.
[f]Referent to patients evaluated in April 1990, the last month of the outbreak.

Discussion

Of the 564 patients with measles evaluated at the hospital between August 1989 and April 1990, 45% were ultimately admitted to the hospital. Most of these patients had severe disease requiring inhospital therapy and were admitted appropriately. The major determinants of hospital admission were presence of complications or physiologic instability, date of evaluation, and age. To our knowledge, this is the first report evaluating determinants of measles-related hospital admission.

The Centers for Disease Control clinical case definition of measles is an illness with a generalized maculopapular rash for ≥ 3 days; fever, with temperature ≥ 38.3°C; and at least one of the following: cough, coryza, or conjunctivitis.[10] We modified this definition for this retrospective review. Although it is possible that some patients in this study did not have measles, 91% of the patients who were tested had serologic confirmation of measles.

Hospitalization was more likely early in the outbreak than later, even when age, severity of illness, and presence of complications were controlled for in a logistic regression model. Furthermore, the proportion of inappropriate admissions declined over the course of the outbreak. Physicians who have not recently managed patients with measles may not recognize the infection, even in children with febrile rash illness.[11] As physicians became reacquainted with the clinical spectrum of measles, they may have become more comfortable with outpatient management of affected patients.

Other factors besides severity of illness and physician experience may have partially accounted for the varying admission rate during the outbreak. On occasion, patients with measles had to be directed to other local hospitals for admission. The likelihood of hospitalization for measles was lowest in December, the month during which the largest number of patients were treated. It is possible that this lower likelihood of admission was related to the limited availability of isolation beds in the hospital during this period of peak activity.

To categorize the appropriateness of a patient's admission to the hospital, we developed a classification system to retrospectively identify justifiable admissions. To avoid the possibility that more complications were diagnosed among inpatients because of the longer period of observation available after hospital admission, we used only data available on the outpatient record to make the determination of a severe complication. Treatment with oxygen rather than the diagnosis of pneumonia was used in the criteria for appropriate admission because more than half of children with measles may have infiltrates detected by chest x-ray.[12] Therefore, only patients with sufficient respiratory distress to require oxygen therapy were classified as appropriate for admission. Because oxygen therapy was available to each patient at the time of initial outpatient evaluation, this criterion for appropriateness of hospitalization applied equally to inpatients and outpatients with measles.

To assess physiologic instability, we used variables and weights adapted from the PRISM score, which has been used to predict the risk of death for children in pediatric intensive care units.[6] The PRISM score ranks the degree of physiologic derangement present in 14 variables, including vital signs, neurologic abnormalities, and laboratory results. Missing values are assumed to be normal. This assumption could potentially lead to falsely low estimates of physiologic instability in outpatients, who may have had fewer laboratory tests than inpatients. However, the effects of this potential bias are minimal because any PRISM score > 0 increases the calculated probability of death[6] and we used a physiologic instability score ≥ 1 to define illness sufficiently severe to justify hospitalization. Moreover, because our analysis was restricted to data collected in the outpatient setting, the chance for systematic misclassification of severity of illness is very low.

We examined the relationship of a number of variables to hospital admission status. Patients with illness appropriate for admission but who lacked medical insurance were more likely to be treated as out-

patients. It is possible that this tendency results from increased scrutiny for insurance coverage that may have occurred when patients were being evaluated for hospital admission.

The increase in the proportion of preschool-aged patients evaluated at the hospital during the course of the outbreak may represent the "classic" form of a measles outbreak, in which the disease initially appears in older school-aged children who then expose their younger siblings at home.[13] A similar trend was observed among 1133 reported patients with measles who resided in Milwaukee County and had rash onsets during the study period: 51% were younger than 5 years during the first 3 months, compared with 59% during the second 3 months and 63% during the final 3 months (trend $\chi^2 = 4.9, P = .03$) (Wisconsin Division of Health, unpublished data).

We have shown that most patients hospitalized at a children's hospital for management of measles during this outbreak were appropriately hospitalized. Although most admissions to the hospital were based on the presence of severe disease or complications of measles, the trend to treat more patients as outpatients later in the epidemic may reflect increased experience with the diagnosis and management of measles by hospital staff. □

Acknowledgments

This paper was presented in part at the 30th Interscience Conference on Antimicrobial Agents and Chemotherapy, Atlanta, Ga, October 23, 1990.

We thank Dawn Schlechta for general assistance with this project and Linda Quindt for assistance in data management.

References

1. Centers for Disease Control. Measles—United States, 1989 and first 20 weeks 1990. *MMWR.* 1990;39:353–355, 361–363.
2. Markowitz LE, Preblud SR, Orenstein WA, et al. Patterns of transmission in measles outbreaks in the United States, 1985–1986. *N Engl J Med.* 1989;320:75–81.
3. *Standardized Diagnostic Fixation Method to Micro Test.* 1st ed. Washington, DC: US Department of Health, Education, and Welfare; 1969.
4. Gershon AA, Krugman S. Measles virus. In: Lennette EH, Schmidt NJ, eds. *Diagnostic Procedures for Viral, Rickettsial, and Chlamydial Infections.* 5th ed. New York, NY: American Public Health Association; 1979:665–693.
5. Edmonson MB, Addiss DG, McPherson JT, Berg JL, Circo SR, Davis JP. Mild measles and secondary vaccine failure during a sustained outbreak in a highly vaccinated population. *JAMA.* 1990;263:2467–2471.
6. Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. *Crit Care Med.* 1988;16:1110–1116.
7. Fleiss JL. *Statistical Tests for Rates and Proportions.* 2nd ed. New York, NY: John Wiley & Sons Inc; 1981:14, 71–75.
8. *Report of the Committee on Infectious Diseases.* 21st ed. Elk Grove Village, Ill: American Academy of Pediatrics; 1988: 277–289.
9. Centers for Disease Control. Measles prevention: recommendations of the Immunization Practices Advisory Committee (ACIP). *MMWR.* 1989;38(S-9):7.
10. Centers for Disease Control. Classification of measles cases and categorization of measles elimination programs. *MMWR.* 1983; 31:707–711.
11. Bennish M, Arnow PM, Beem MO, Doveikis S. Epidemic measles in Chicago in 1983: sustained transmission in the preschool population. *Am J Dis Child.* 1986; 140:341–344.
12. Kohn JL, Koiransky H. Successive roentgenograms of the chest of children during measles. *Am J Dis Child.* 1929;38:258–270.
13. Babbott FL Jr, Gordon JE. Modern measles. *Am J Med Sci.* 1954;228:334–361.