

Kawasaki Syndrome Hospitalizations Among Children in Hawaii and Connecticut

Robert C. Holman, MS; Abtin Shahriari, MPH; Paul V. Effler, MD;
Ermias D. Belay, MD; Lawrence B. Schonberger, MD

Objectives: To estimate the incidence and describe recent trends of Kawasaki syndrome (KS) in 2 different areas of the United States.

Methods: Retrospective analysis of Hawaii and Connecticut State KS hospital discharge records for children younger than 5 years.

Results: In Hawaii, 175 KS hospitalizations for children younger than 5 years were reported during 1994 through 1997; the annual hospitalization rate per 100 000 children was 47.7. The rate for Hawaiian children younger than 1 year (83.2) was greater than that for 1- to 4-year-old children (39.0), and most hospitalizations occurred prior to age 2 years (median age, 17 months). In Connecticut, 171 KS hospitalizations for children younger

than 5 years were reported during 1993 through 1996; the annual hospitalization rate per 100 000 children was 18.8, and the median age at hospitalization was 28 months. For both states, most hospitalizations were for boys. Although no clear seasonality was apparent, monthly peaks occurred in some of the years from December through March.

Conclusions: Kawasaki syndrome seems to remain an endemic disease in the United States. A high KS annual hospitalization rate was seen in Hawaii, especially in children younger than 1 year, whereas in Connecticut, the KS rate was more consistent with those previously reported in the continental United States.

Arch Pediatr Adolesc Med. 2000;154:804-808

KAWASAKI syndrome (KS) was first described by Tomisaku Kawasaki, MD, in 1967.¹ In 1976, the first cases of KS outside Japan were reported in Hawaii.² Since the original description of KS more than 30 years ago, the cause continues to be a puzzle to researchers.^{3,4} A recent study in Japan showed that the annual incidence of KS had increased in recent years to 108.0 per 100 000 children younger than 5 years in 1996.⁵

Kawasaki syndrome is the leading cause of acquired heart disease among children in the United States.^{6,7} It is characterized by high fever, bilateral conjunctivitis, cervical lymphadenopathy, rash, and oral mucosal and extremity changes. The diagnosis of KS is based on the presence of fever and at least 4 of these clinical findings after exclusion of other childhood conditions that may give rise to similar signs and symptoms. Coronary artery ectasia has been reported in about 20% of untreated patients with KS, including the potentially serious compli-

cation of coronary artery aneurysm, which can lead to myocardial infarction, long-term complications, and occasionally death.^{6,8} Intravenous immunoglobulin treatment has improved the clinical outcome of patients with KS,⁹ as evidenced by a substantial decline in coronary artery ectasia.¹⁰ Various etiologic agents and environmental factors have been proposed to cause KS, but none of these agents has been consistently identified in patients with KS. Epidemiologic studies suggest that host factors, including age, race, and sex, may play an important role in the occurrence of KS¹¹ and that KS can occur in outbreaks.^{3,12-18}

In this study, we present an analysis of the epidemiologic characteristics and trends in children younger than 5 years hospitalized for KS in Hawaii and Connecticut. These states represent different populations and locations within the United States. Both states collect 100% of the state hospitalization discharge data, which provide robust and representative epidemiologic information for children hospitalized for KS.

From the Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, US Department of Health and Human Services, Atlanta, Ga (Messrs Holman and Shahriari and Drs Belay and Schonberger); and the Hawaii Department of Health, Honolulu (Dr Effler).

MATERIALS AND METHODS

Hospital discharge data for patients with KS were obtained from the Hawaii Health Information Corporation (HHIC) for 1994 through 1997 and from the Connecticut Health Information Management and Exchange (CHIME) program for 1987 through 1996.^{19,20} The HHIC is a Hawaiian nonprofit corporation established in 1994 that collects inpatient data submitted voluntarily from each of Hawaii's 22 acute-care hospitals.¹⁹ The CHIME program in Connecticut was initiated in 1980 with the collection of systematic data on patients admitted to acute-care hospitals.²⁰ Data are submitted voluntarily to CHIME from all non-government acute-care hospitals in Connecticut. Through data exchange or purchasing agreements, CHIME obtains discharge data from bordering states (New York, Massachusetts, and Rhode Island) for Connecticut residents treated at border state hospitals as well as for residents of selected border state towns treated at border state hospitals. For both HHIC and CHIME, patient records are processed through a comprehensive error identification and correction process and are available for analysis within 6 to 12 months of collection.

Hospitalizations for children younger than 5 years with an *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* code for KS (446.1) listed as one of the diagnoses on the discharge record were included in the analysis.²¹ A child may have been hospitalized with KS more than once during the study period. We examined KS hospitalizations by age, sex, and month of admission; race was examined for Connecticut hospitalizations by using reported race/ethnicity groups, but race was not available for Hawaii hospitalizations. Hospitalizations for KS in Connecticut were analyzed for 1993 through 1996, unless otherwise indicated. Annual hospitalization rates (per 100 000 children) were calculated by using the state census population of children for the corresponding age group (<1 year, 1-4 years, and <5 years).²² Risk ratios (RRs) with 95% confidence intervals (CIs) were calculated using Poisson regression analysis.²³ Comparisons of age at hospital admission and hospital length of stay were analyzed using the Wilcoxon rank sum test.²⁴

RESULTS

HAWAII

During the 4-year period of 1994 through 1997, 175 children younger than 5 years were hospitalized for KS (**Table**). The annual hospitalization rate was 47.7. The rate for children younger than 1 year was higher than that for children aged 1 to 4 years (83.2 and 39.0, respectively) (RR, 2.1; 95% CI, 1.6-2.9). The difference in rates between age groups was also found for both boys and girls. Most of the KS hospitalizations (64.0%) occurred in children younger than 2 years; 78.9% occurred in children younger than 3 years (median age, 17 months). The age

distribution showed peak hospitalizations occurring from age 7 through 11 months.

The annual KS hospitalization rate varied by year; the rates were 55.0, 31.1, 56.1, and 48.6 from 1994 to 1997, respectively (**Figure**, top). The rates for children younger than 1 year fluctuated by year (114.4, 34.8, 124.9, and 79.4, respectively), and this variation was most likely owing to small numbers, whereas the rates for 1- to 4-year-old children ranged from 34.8 to 41.6. Boys had a higher number of KS hospitalizations (59.4%), and KS rates were higher for boys than girls during the 4-year period (RR, 1.4; 95% CI, 1.0-1.9) (Table). This sex difference in KS rates was also found, although not statistically significant, by age group (<1 year: RR, 1.5; 95% CI, 0.9-2.6) (1-4 years: RR, 1.3; 95% CI, 0.9-1.9). The age at hospitalization was similar for boys and girls (median ages, 17.5 and 17.0 months, respectively).

Kawasaki syndrome hospitalizations were examined by month of admission. The numbers of monthly hospitalizations were small and fluctuated over time. Peaks primarily occurred in August 1994 (n=10), January and February 1996 (n=12 and n=7, respectively), and January 1997 (n=8). Examination of diagnoses listed on KS hospitalization records indicated that KS was the principal diagnosis for 93.7% of children younger than 5 years hospitalized for KS. Other diagnoses listed with KS included 15 hospitalizations for cardiovascular abnormalities as follows: 6 with rhythm disturbances (ICD-9-CM codes 427.89 and 426.13), 4 with aneurysm of coronary vessels (414.11), 2 with chronic ischemic heart disease (414), and 1 each with mitral valve disorder (424.0), myocarditis (429.0), and secondary cardiomyopathy (425.9). One patient with aneurysm of coronary vessels also had carditis (429.89). The median duration for KS hospitalizations was 2 days and was consistent by year, sex, and age group. No deaths were reported for KS hospitalizations.

CONNECTICUT

During the 10-year period of 1986 through 1996, there were 366 KS hospitalizations among children younger than 5 years and 171 during the 4-year period of 1993 through 1996 (Table). During 1993 through 1996, the annual hospitalization rate was 18.8. The rate was similar for both children younger than 1 year and children aged 1 to 4 years. Most KS hospitalizations (65.7%) occurred among children younger than 3 years (median age, 28 months).

The annual KS hospitalization rate varied by year, ranging from 12.6 in 1989 to 21.8 in 1996 (Figure, bottom). The rates for infants ranged from 6.3 in 1991 to 29.9 in 1995, and rates for 1- to 4-year-old children ranged from 9.8 to 22.1. During 1993 through 1996, boys had a higher number of KS hospitalizations (53.8%), although a similar KS rate was seen for boys and girls (RR, 1.1; 95% CI, 0.8-1.5) (Table). In addition, there was no difference by age group. More hospitalizations occurred at a younger age for boys than for girls (median age, 24 and 33 months, respectively) ($P=.04$). Most hospitalizations were for non-Hispanic white children. However, the hospitalization rate for non-Hispanic black children was

Kawasaki Syndrome Hospitalizations and Hospitalization Rates Among Children Younger Than 5 Years by State and Period*

Characteristic	Hawaii, 1994-1997		Connecticut			
	No.	Rate (95% CI)†	1993-1996		1987-1996	
			No.	Rate (95% CI)†	No.	Rate
Total	175	47.7 (41.0-55.4)	171	18.8 (16.1-21.8)	366	16.0
Age group, y‡						
<1	60	83.2 (64.0-107.8)	32	18.1 (12.6-25.9)	63	13.8
1-4	115	39.0 (32.3-47.0)	135	18.4 (15.5-21.8)	296	16.1
Sex						
Male	104	55.1 (45.3-67.1)	92	19.7 (15.9-24.2)	210	17.8
Female	71	39.8 (31.3-50.5)	79	17.8 (14.2-22.3)	156	14.0
Sex and age group, y						
Male						
<1	37	100.2 (71.6-139.7)	21	23.2 (14.7-36.1)	39	16.7
1-4	67	44.2 (34.5-56.4)	69	18.3 (14.3-23.3)	167	17.7
Female						
<1	23	65.3 (42.4-99.7)	11	12.8 (6.7-23.6)	24	10.8
1-4	48	33.5 (25.0-44.9)	66	18.4 (14.4-23.6)	129	14.4
Race‡						
Non-Hispanic white	...	...	103	15.3 (12.5-18.6)	236	13.7
Non-Hispanic black	...	...	35	36.1 (25.5-50.8)	68	27.7
Non-Hispanic Asian	...	...	4	17.0 (5.5-46.8)	9	18.1
Hispanic	...	...	25	21.6 (14.3-32.4)	36	13.9
Length of stay, d						
Median (range)		2 (1-28)		2 (1-13)		3 (1-17)

*CI indicates confidence interval; ellipses, not applicable.

†Rates are per 100 000 population based on corresponding age group of children. The average annual population for Hawaii was 91 744 for children <5 years old and 18 032 for children <1 year old; for Connecticut, 227 964 for children <5 years old and 44 189 for children <1 year old.

‡Seven hospitalizations with unknown month of age and 17 hospitalizations with unknown race for Connecticut.

greater than both that for non-Hispanic white children (RR, 2.0; 95% CI, 1.5-2.7) and Hispanic children (RR, 2.0; 95% CI, 1.3-3.0). There was a small proportion of Asian children with only 4 hospitalizations reported and a rate of 17.0. The age at hospitalization was similar by race (non-Hispanic white, 32.5 months; non-Hispanic black, 26.0 months; and Hispanic, 21.0 months).

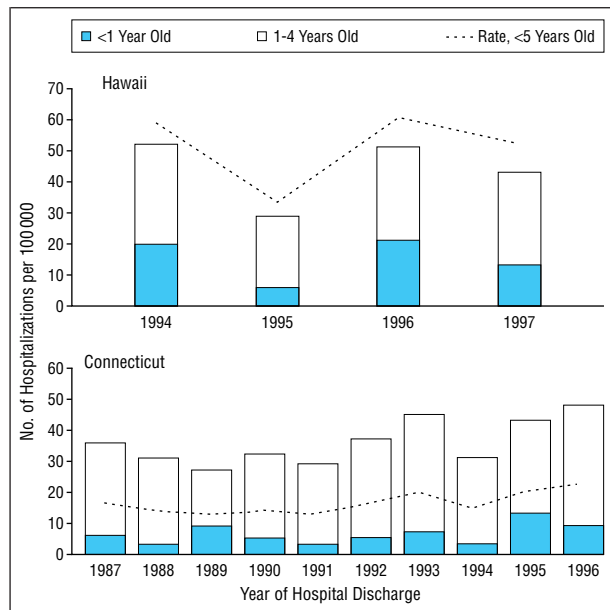
Kawasaki syndrome hospitalizations fluctuated by month of admission without any prominent peaks. The highest number of hospitalizations in any month was 8, which occurred in March 1994, and January and December 1996. Examination of diagnoses listed on the KS hospitalization records indicated that KS was the principal diagnosis for 97.1% of children younger than 5 years hospitalized for KS. Other diagnoses listed with KS included 3 children hospitalized with aneurysm of coronary vessels (414.11). The median duration for KS hospitalizations was 2 days and was consistent by year, sex, and age. No deaths were reported for KS hospitalizations.

COMMENT

This study provides a unique description of the trends and rates of KS hospitalizations in Hawaii and Connecticut and is the first study to our knowledge to analyze a state's KS hospitalization records since the studies of KS in Washington State during 1985 through 1989.^{25,26} In particular, we were able to analyze KS hospitalizations in Hawaii, where KS was first detected in the United States

and which has shown a high incidence of KS in the country.^{2,27}

A high KS annual hospitalization rate (47.7) was seen in Hawaii, whereas Connecticut showed a rate more consistent with those previously reported in the continental United States (18.8).^{15,17,25,26,28} In a study in Washington State, the annual incidence of patients younger than 5 years hospitalized for KS was 15.2 in 1987 through 1988.^{25,26} In KS hospital discharge data studies in Washington State and among American Indians and natives of Alaska, approximately 10% of the hospitalization records were found to be multiple hospitalizations.^{25,26,29} If this observation is applied to our study areas, the annual incidence of children hospitalized for KS would be 42.9 for Hawaii and 16.9 for Connecticut. The high rate in Hawaii may be likely associated with the high proportion of persons of Asian ancestry; a higher incidence rate for Japanese and other Asian children has been shown in several studies.^{10,12,16,25-28,30} The annual incidence of KS for children younger than 5 years in Japan was 108 in 1996 (nearly twice that of Hawaii), and the rate is increasing steadily.⁵ Most of the Hawaii State population in 1995 (56%) were Asian or Pacific Islander, and the remainder was predominantly white.³¹ Active surveillance for KS in Hawaii during 1979 through 1983 showed the annual incidence on Oahu (the state's most populous island) to range from 21 to 100 cases per 100 000 children younger than 5 years; the rates were high for children of Japanese ancestry, while rates for white children ranged from 0 to 9.²⁷ We were unable to examine



Kawasaki syndrome hospitalizations by age group and hospitalization rates for children younger than 5 years by hospital discharge year for Hawaii (top), 1994 through 1997, and Connecticut (bottom), 1987 through 1996.

the KS rate by racial group in Hawaii since this information was unavailable. In contrast, we did analyze Connecticut hospitalizations by reported race/ethnicity. The hospitalization rate for non-Hispanic blacks was higher than that for non-Hispanic whites and Hispanics; these differences are similar to those seen in Washington State.^{25,26} The 1995 Connecticut State population is predominantly white (89%),³¹ and the small proportion (<2%) of Asians in Connecticut may account for an unstable KS rate among Asians.

A high KS hospitalization rate was observed among Hawaiian children younger than 1 year (83.2). This rate was greater than that for 1- to 4-year-old Hawaiian children, a similar trend found in other populations,^{5,29} but no such difference was seen in Connecticut. As described in earlier studies,^{5,9-11,17,25-27,32} more KS hospitalizations occurred for boys than for girls, and the rate was significantly higher for boys in Hawaii. A high proportion of hospitalizations were reported for children younger than 3 years in both states, as reported in earlier studies.^{27,29} In Hawaii, most hospitalizations were for children younger than 2 years; the peak hospitalizations occurred at age 7 through 11 months, which seems similar to that reported for Japan.⁵ The median age at hospitalization in Hawaii was 17 months and was similar for boys and girls. However, in Connecticut, the median age at hospitalization was older (28 months) and was younger for boys than for girls.

In both states, although some fluctuation in the annual KS hospitalization rates was observed, the overall trend during the years of the study was relatively stable. No clear seasonality was apparent, but in some of the years, monthly peaks occurred during December through March. The increased occurrence of KS in these months has been described in earlier studies.^{3,11,13,16,17,30,32}

The use of hospital discharge data for the study of KS has some limitations. It is not known if all KS hospi-

talizations are for confirmed KS cases. Moreover, some children with KS may not have been hospitalized, or a child may have been admitted into a hospital more than once for the same KS episode. In Washington State, a chart review of unique potential KS cases identified through the state hospital discharge data by using the KS ICD-9-CM code indicated that 88% were confirmed KS cases.²⁵ In our study, some hospitalizations for nonresidents of Hawaii and Connecticut may have been included.

State hospital discharge data are a useful tool for augmenting national surveillance for KS and provide valuable estimates of the incidence of KS in specific areas of the United States. This study indicates that KS remains an endemic disease in the United States, and the elevated rate for Hawaii, with a population that is more than 50% Asian or Pacific Islander, is almost one-half that for children in Japan. Further studies using state hospital discharge data should become even more important once the cause of KS is better understood and preventive measures are available.

Accepted for publication February 4, 2000.

We thank Roger Glass, MD, PhD, for his essential help in obtaining the data; John O'Connor, MS, for editorial assistance; Mary Cahill, RRA, and Jill Miyamura, PhD, of Hawaii Health Information Corporation and Mary Lyons, BS, of Connecticut Health Information Management and Exchange for technical assistance; and James Hadler, MD, of the Connecticut Department of Public Health for his helpful review.

Reprints: Robert C. Holman, MS, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, MS A-39, Atlanta, GA 30333.

REFERENCES

1. Kawasaki T, Kosaki F, Okawa S, Shigematsu I, Yanagawa H. A new infantile acute febrile mucocutaneous lymph node syndrome prevailing in Japan. *Pediatrics*. 1974; 54:271-276.
2. Melish ME, Hicks RM, Larson EJ. Mucocutaneous lymph node syndrome in the United States. *AJDC*. 1976;130:599-607.
3. Bradley DJ, Glode MP. Kawasaki disease: the mystery continues. *West J Med*. 1998;168:23-29.
4. Curtis N, Levin M. Kawasaki disease thirty years on. *Curr Opin Pediatr*. 1998;10: 24-33.
5. Yanagawa H, Nakamura Y, Yashiro M, et al. Results of the nationwide epidemiologic survey of Kawasaki disease in 1995 and 1996 in Japan. *Pediatrics*. 1998; 102:e65.
6. Rowley AH, Shulman ST. Kawasaki syndrome. *Clin Microbiol Rev*. 1998;11:405-414.
7. Taubert KA, Rowley AH, Shulman ST. Seven-year national survey of Kawasaki disease and acute rheumatic fever. *Pediatr Infect Dis J*. 1994;13:704-708.
8. Kato H, Ichinose E, Yoshioka F, et al. Fate of coronary aneurysms in Kawasaki disease: serial coronary angiography and long-term follow-up study. *Am J Cardiol*. 1982;49:1758-1766.
9. Barron KS. Kawasaki disease in children. *Curr Opin Rheumatol*. 1998;10:29-37.
10. Khan SA, Holman RC, Clarke MJ, Vernon LL, Gyurik TP, Schonberger LB. Kawasaki syndrome surveillance United States, 1991-1993. In: Kato H, ed. *Kawasaki Disease*. Amsterdam, The Netherlands: Elsevier Science BB; 1995:80-84.
11. Rauch AM. Kawasaki syndrome: clinical review of US epidemiology. In: Shulman ST, ed. *Kawasaki Disease*. New York, NY: Alan R Liss; 1987:33-44.
12. Dean AG, Melish ME, Hicks R, Palumbo NE. An epidemic of Kawasaki syndrome in Hawaii. *J Pediatr*. 1982;100:552-557.
13. Rauch AM, Glode MP, Wiggins JW, et al. Outbreak of Kawasaki syndrome in Den-

- ver, Colorado: association with rug and carpet cleaning. *Pediatrics*. 1991;87:663-669.
14. Klein BS, Rogers MF, Patrican LA, et al. Kawasaki syndrome: a controlled study of an outbreak in Wisconsin. *Am J Epidemiol*. 1986;124:306-316.
 15. Bell DM, Brink EW, Nitzkin JL, et al. Kawasaki syndrome: description of two outbreaks in the United States. *N Engl J Med*. 1981;304:1568-1575.
 16. Bell DM, Morens DM, Holman RC, Hurwitz ES, Hunter MK. Kawasaki syndrome in the United States, 1976 to 1980. *AJDC*. 1983;137:211-214.
 17. Rauch AM. Kawasaki syndrome: issues in etiology and treatment. *Adv Pediatr Infect Dis*. 1989;4:163-182.
 18. Centers for Disease Control. Multiple outbreaks of Kawasaki syndrome: United States. *MMWR Morbid Mortal Wkly Rep*. 1985;253:957-958.
 19. Hawaii Health Information Corporation. *Hospital Inpatient Data, 1994-1997*. Honolulu, Hawaii: Hawaii Health Information Corporation; 1998.
 20. Connecticut Health Information Management and Exchange. *Hospital Inpatient Data Tapes, Fiscal Years 1987-1997*. Wallingford, Conn: CHIME Inc, an affiliate of the Connecticut Hospital Association; 1998.
 21. *International Classification of Diseases, Ninth Revision, Clinical Modification* [book on CD-ROM]. 6th ed. Washington, DC: Public Health Service, US Dept of Health and Human Services; 1998.
 22. Bureau of the Census. *Intercensal Estimates of the Population of States by Age, Sex, and Race: 1970-1997*. Washington, DC: Bureau of the Census; 1998.
 23. Kleinbaum DG, Kupper LL, Muller KE, Nizam A, eds. *Applied Regression Analysis and Other Multivariable Methods*. New York, NY: Duxbury Press; 1998.
 24. Lehmann EL. *Nonparametrics: Statistical Methods Based on Ranks*. San Francisco, Calif: Holden-Day Inc; 1975.
 25. Dykewicz CA, Davis RL, Khan AS, Schonberger LB. Kawasaki syndrome in Washington State, 1985-1989. In: Takahashi M, Taubert K, eds. *Proceedings of the Fourth International Symposium on Kawasaki Disease*. Dallas, Tex: American Heart Association; 1991:10-15.
 26. Davis RL, Waller PL, Mueller BA, Dykewicz CA, Schonberger LB. Kawasaki syndrome in Washington State: race-specific incidence rates and residential proximity to water. *Arch Pediatr Adolesc Med*. 1995;149:66-69.
 27. Hicks RV, Melish MF. Kawasaki syndrome. *Pediatric Clin North*. 1986;33:1151-1175.
 28. Rauch AM, Kaplan SL, Nihill MR, Pappas PG, Hurwitz ES, Schonberger LB. Kawasaki syndrome clusters in Harris County, Texas, and eastern North Carolina: a high endemic rate and a new environmental risk factor. *AJDC*. 1988;142:441-444.
 29. Holman RC, Belay EB, Clarke MJ, Kaufman SF, Schonberger LB. Kawasaki syndrome among American Indian and Alaska native children, 1980 through 1995. *Pediatr Infect Dis J*. 1999;18:451-455.
 30. Melish ME, Ching D. Kawasaki syndrome epidemiology: Hawaii 1971-1986 [abstract]. *Prog Clin Biol Res*. 1987;250:547.
 31. Bureau of the Census. *Statistical Abstract of the United States: 1995*. 115th ed. Washington, DC: Bureau of the Census; 1995.
 32. Windsor AMB, Schell WL, Davis JB. Kawasaki syndrome in Wisconsin. *Wis Med J*. 1991;90:227-231.