

Role of Pediatric Departments in Community Hospitals in Countermeasures against Measles Epidemics at Olympic Games Sites

Toru Igarashi¹, Sachiyo Takeda¹, Tsutomu Igarashi²,
Hidehiko Narazaki¹ and Yasuhiko Itoh¹

¹Department of Pediatrics, Nippon Medical School, Tokyo, Japan

²Department of Ophthalmology, Nippon Medical School, Tokyo, Japan

Background: In preparation for the 2021 Tokyo Olympic/Paralympic Games, the Japanese government assessed the risks of infectious disease outbreaks and identified necessary preparations. This present study reviewed efforts made during a previous measles epidemic and describes the roles of hospitals.

Methods: This descriptive study investigated the records of 198 children with measles. All children were treated at a general hospital during the period from January 1997 through February 1998. We also examined the actions of pediatricians during and after a measles outbreak in the community.

Results: Of the 198 children, 145 (73%) were hospitalized. The measles vaccination rate in the previous year was approximately 75%. Of the patients examined, 53% were younger than 2 years of age; mean age was 2.75 years. Pneumonia and gastroenteritis accounted for 46% and 30% of the complications, respectively. Issues requiring attention included the number of hospital beds located in a negative pressure room or private room with a window, the need for gamma globulin preparations with high measles antibody titers, the necessity of increasing vaccination opportunities, and extension of physician working hours.

Conclusions: Visitors from other countries could cause measles outbreaks in Japan. Measures that might mitigate an outbreak were maintenance of high vaccination rates, ready availability of information on the location of negative pressure hospital rooms, knowledge of the status of the measles outbreak, and flexible medical staffing. There is a risk of measles outbreaks among infants and among those who do not have a measles antibody titer. (*J Nippon Med Sch* 2021; 88: 220–227)

Key words: disease outbreaks, epidemics, hospital, measles, role

Introduction

Mass gatherings of international tourists during the 2021 Tokyo Olympics/Paralympics might trigger outbreaks of infectious diseases, including measles^{1,2}. Japan faced a measles epidemic in the 1990s, and pediatricians were occupied with measles patients daily. The epidemic ended after 3 years. The low measles vaccination rate was one cause of the epidemic. During and after the epidemic, we worked to improve measles vaccine coverage. Since the introduction of the two-dose schedule for the measles vaccine in 2006, the number of measles outbreaks has decreased. The Olympic soccer stadium, which is home to a

professional soccer team, can hold 41,800 people and is located within a 1-hour drive from Narita International Airport. International visitors are expected, and those who develop measles are likely to first seek treatment at neighborhood hospitals.

The national government assessed the risk of infectious diseases in light of the circumstances of local governments. Several necessary preparations were identified, including the development of surveillance systems. However, no concrete measures were adopted after the measles outbreak. Responses to outbreaks of measles or other infectious diseases in hospitals, where outbreaks often

Correspondence to Toru Igarashi, Department of Pediatrics, Nippon Medical School, 1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603, Japan

E-mail: iga@nms.ac.jp

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start, have historically been the responsibility of local governments.

Most pediatricians trained after 2006 have limited experience in treating measles. Reports of measles epidemics were sporadic until the 1990s. Our experience of a measles epidemic led us to consider measures to address problems during a future epidemic. By studying past measles countermeasures, we can better prepare for the future. This descriptive epidemiological study attempted to identify measles countermeasures from the perspectives of hospital pediatricians and administrators.

Materials and Methods

This descriptive epidemiology study investigated data from 198 children with measles who were treated at Hakujji General Hospital during a measles epidemic that took place from January 1997 through February 1998. Complications that resulted in the hospitalization of 145 children included pneumonia, laryngitis, gastroenteritis, and otitis media. To formulate suggestions for coping with future outbreaks, we examined the actions of pediatricians during and after the measles outbreak in the community.

Hakujji General Hospital, located in an area separated from Chiba Prefecture by the Pacific Ocean and Tone River, was a principal hospital in Ibaraki Prefecture in 1997. The hospital had two full-time pediatricians, a 16-bed pediatrics ward, and an obstetrics department. A substantial number of infants received medical checkups. The hospital also had three rooms containing four beds each, and four private rooms, for inpatients. When there were more than 16 inpatients, beds in rooms on other floors were used temporarily. Each room had air conditioning units and windows that could be opened. In each room, heat was provided by a radiator connected to a central heating system. Children with infectious diseases such as pneumonia or acute gastroenteritis were admitted to rooms separated from those that had patients with chronic illnesses, such as bronchial asthma or nephrotic syndrome. The closest hospital capable of pediatric admissions was 30 to 40 km away.

The area served by the hospital included eight cities. In 1997, measles vaccinations were mostly administered in groups, and the average vaccination rate in the district was 70% to 80%. This study analyzed anonymously processed data that had been prepared 20 years earlier; consequently, the study was not reviewed for adherence to the Ethical Guidelines for Medical and Health Research Involving Human Subjects.

Results

Measles Epidemics

Measles outbreaks were not uncommon in Japan during the 1990s. In the district studied here, outbreaks occurred in several nursery schools within the medical service area. Some hospitals designated by the prefecture, including the present hospital, sent regular reports to the prefecture on the number of patients examined, by type of infectious disease. The public health office probably monitored trends in measles outbreaks, but the hospital pediatricians did not receive updates, because measles outbreaks were relatively common. During measles outbreaks, the pediatrics department of each hospital provided medical care at the discretion of the hospital doctors. The district containing the present hospital is separated from the neighboring prefecture by a large river, and the measles epidemic in that district occurred 6 months before the physicians at the present hospital were aware of it³.

Patient Characteristics

The total number of patients examined between January 1997 and February 1998 is shown in **Table 1**. Overall, 73% of the examined patients were hospitalized. The measles vaccination rate was 75% in 1996, which was too low to prevent the epidemic. Most communities had group vaccinations; individual vaccinations were available in only two locations. Vaccination coverage for infants aged about 1 year was 0%. Despite obtaining measles vaccination, three children (aged 4, 12, and 13 years) developed measles. Of the patients examined, 53% were younger than age 2 years (**Table 2**). The mean age was 2.75 years.

Measles Complications

Pneumonia and gastroenteritis accounted for 46% and 30% of complications, respectively (**Table 3**). Oxygen was administered to four patients with pneumonia. One patient was younger than 1 year; and four patients—three with pneumonia and one with laryngitis—were 1 year of age. Mechanical ventilation was performed for a patient aged 1 year.

Treatment during the Outbreak

Measles spreads as an airborne infection; consequently, rooms with windows and ventilation are necessary. Measles patients were treated in isolation. The outpatient examination room had windows and was well ventilated. Hospitalized patients with measles are generally admitted to private rooms. However, at the peak of the outbreak, there were too few private rooms, and three rooms

Table 1 Area distribution of measles patients (from January 1997 to February 1998) and vaccination rate (1996)

City	A	B	C	D	E	F	G	H	I	J	K	Total	Average
Total No. of in-patients	8	54	41	2	32	3	5	0	0	0	0	145	-
Total No. of patients examined	10	82	55	2	40	4	5	0	0	0	0	198	-
Vaccination rate in 1996 (%)	72	86	90	49	78	60	79	49	87	100	79	-	75

City	A	B	C	D	E	F	G	H	I	J	K	Total	
Distance from our hospital to city hall (km)	25.3	4.6	8.8	29.4	9.8	14.1	18.9	27.9	34.1	35.9	41.9	-	-
Travel time (minutes)	51	10	18	59	20	29	38	56	69	72	84	-	-
The number of people at 1996 ^{a)}	38,764	45,334	60,910	11,007	25,900	6,154	17,067	10,914	14,168	28,744	11,506	270,468	
0-year-old population in 1996 ^{a)}	435	570	670	77	262	42	103	97	126	275	113	2,770	
1-year-old population in 1996 ^{a)}	439	572	617	79	247	37	136	88	130	265	117	2,727	
2-year-old population in 1996 ^{a)}	473	543	645	94	283	45	117	75	140	258	98	2,771	

a) Ibaraki Prefectural Government. <https://www.pref.ibaraki.jp/kikaku/tokei/fukyu/tokei/betsu/jinko/jinko.html#jinko04>

Table 2 Age distribution of examined patients (in years)

<1	1	2	3	4	≥5	≥15
16.5%	36.5%	11.5%	11.5%	3.5%	19.5%	1.0%

Table 3 Age and complications (people)

	Age (years)								Total No. of people	Mean age (y, m)
	<1	1	2	3	4	5	≥6	≥12		
Pneumonia	20	35	17	11	1	3	2	2	91	2y1m±2y3m
Laryngitis	3	12	4	0	0	0	1	0	20	1y4m±1y3m
Gastroenteritis	14	31	6	2	1	0	3	3	60	2y1m±2y8m
Otitis media	0	4	0	0	0	0	0	0	4	1y0m

y: years; m: month

with four beds each were used. During the outbreak, general patients with diseases other than measles were admitted to private rooms and admitted separately from patients with measles. Inpatient room windows were used for regular ventilation.

Intravenous gamma globulin was frequently administered for severe infections. Pharmacists ordered gamma globulin from production lots with high measles virus antibody titers. Pharmaceutical wholesalers searched for high-titer gamma globulin in warehouses around the country and sent the products to the study hospital. To prevent measles from spreading, every day one to three siblings of children with measles received intramuscular

gamma globulin in the outpatient clinic. Children who had not been vaccinated for measles were vaccinated in the outpatient clinic. The vaccination patterns of the city gradually transitioned from group vaccination to individual vaccination.

Handling after the Outbreak

In 2006, a two-dose schedule of the measles-rubella (MR) vaccine was initiated in Japan. From 2008 to 2013, vaccinations were administered to teenagers. At the suggestion of school nurses, doctors visited high schools and provided group vaccinations with the MR vaccine to students in the present district.

The Daily Lives of Physicians

Physicians' working hours were extended during the outbreak. Two full-time pediatricians who lived on the hospital grounds worked every day. Previously, they received one weekday off per week. On weekends, the doctors worked in shifts. During the measles outbreak, many children were brought to the hospital at night, and normal emergency care was provided daily. When individuals are affected with measles, their antibody titers are maintained for a long period. The attending physicians had measles IgG (enzyme immunoassay) values of ≥ 100 after the outbreak.

Discussion

International mass gatherings entail health risks, including infectious diseases. A mass gathering is defined as an event "attended by a sufficient number of people to strain the planning and response resources of a community, state, or nation⁴." The World Health Organization has defined a mass gathering as a meeting of more than 25,000 people. Measles outbreaks have been attributed to international travel and occurred at the Winter Olympics in 2010 and 2014. Visitors to the Olympics risk importing diseases to their host countries. Risk assessment has been undertaken as a means to control infectious diseases during international mass gatherings.

At the 2021 Olympics, soccer matches will be held in the region analyzed in this study. About 40,000 people, including many international visitors, are expected to visit the soccer venue. To minimize the risk of measles outbreaks at mass gatherings such as the Olympics and Paralympics, we propose the actions below.

Measles can be prevented by vaccination. Currently, Japanese receive two doses of the MR vaccine after reaching age 1 year. The measles vaccination rate has risen from approximately 70% to 80%, the rate at which outbreaks have been observed, to approximately 90% to 100%, the rate at which outbreaks are unlikely. Measles is highly contagious, and infection leads to symptom onset in almost all individuals who lack immunity. Today, children younger than 1 year who have not received the MR vaccine remain at risk. It is expected that future outbreaks will differ from those of the past because of the high vaccination rates among children. Residents or travelers returning from regions with measles epidemics often cause their home region to be established as an epicenter of new measles epidemics. The measles vaccine provides lifelong immunity. Adults develop measles when attenuation of measles antibodies occurs. This may

result in familial infection, especially in infants and children aged 6 years who received a single dose of the measles vaccine. During outbreaks, the measles vaccine can be administered to children as young as 6 months; however, after a child reaches 1 year of age, the measles vaccine is administered twice.

We now discuss two important issues: hospital acceptance, including human factors pertaining to possible fatigue among pediatricians, and administrative issues, including the establishment of a medical community network. We examined preparations before the epidemic, the start of the epidemic, post-epidemic response, physician fatigue during the epidemic, and other issues.

Hospital Acceptance

Previously reported measles outbreaks and this study

Information on measles epidemics was obtained from previous reports^{3,5-13}. The reports in **Table 4** include data from medical records obtained retrospectively. The blanks indicate missing data. **Table 4** lists measles symptoms exhibited by patients. Statistical analysis could not be performed because of the high percentage of missing values.

Until 2006, measles vaccines were administered during a child's second year of life. In areas of group vaccinations, where vaccines were given only once a year, some children did not complete measles vaccinations after they reached age 2 years. Therefore, most measles patients were children aged 1 year. Most of these children were not vaccinated and thus were susceptible during outbreaks (**Table 4**). Hospitalization is required for measles patients younger than 1 year and for those with pneumonia.

Education for patients and their families

Individuals need to review their vaccination history and confirm if they have been vaccinated at least twice or had measles. Even if measles can be eradicated in Japan, it will remain in other countries. Thus, individuals need to protect themselves against measles with the two-dose vaccine¹⁴. Individuals who do not have measles antibodies should be vaccinated before the Olympics. Prevention of measles spread and outbreaks is possible only when active vaccination is available. Measles vaccine shortages are anticipated during outbreaks; consequently, the population must be vaccinated before potential outbreaks.

The number of depressurized rooms in hospitals is limited, and home care rather than hospitalization is expected for patients with uncomplicated measles. With the increase in nuclear families, assistance from grandparents is less likely. Parents must therefore provide care when

Table 4 Measles epidemics in Japan

Area	Kashima/ Namegata	Katori	Okinawa	Kawa- saki	Kawa- saki	Suka- gawa	Kita- ibaraki	Fuku- shima	Sano	Tom- shiro	Tama
Year of epidemic	1997-1998	1996- 1997	1998- 1999	1998- 1999	1998	2002- 2003	2002	1984	1988	1990	
Epidemic duration	2 year	5 months	1 year		3 months	16 months		8 months	7 months		
Observation dura- tion	14 months									6 months	1996- 2008
No. of cases	198	220	2,034						213	160	
No. of inpatients	145	78			33	382		60	76	46 (29%)	158
No. of outpatients	53	109		69	94		84				
No. <1 year of age	32	47		21 (30.4%)	21	104 (27.2%)	4	14 (23%)	28	25 (16%)	43
No. of vaccinations	3	20/220 (5.5%)							4		
No. of vaccinations <1 year of age	0				0	0			0	0	
Deaths	1		8		1	2	0	4			
Family infections						34 (8.9%)			224		
Complications											
Pneumonia	91/198	36/78			19			39		65%	70 (44.3%)
Croup		1/78			8			5			8
Encephalitis								3			
DIC								3			
Otitis media	4/198	2/78			3			3		7%	
Urinary tract in- fection								2			
Tonsillitis								2			
Stomatitis								2			
Febrile seizure		6/78			7						
Laryngitis	20/198										
Gastroenteritis	60/198										
City vaccination rate	75% (mean)	79%							13.3- 63.8%	46-61%	
Cited references	This study	1	3	4	5	6	7	8	9	10	11

their child develops a fever. Core hospitals have many patients, including infants and pregnant women, who are at high risk for measles complications. The presence of hospital visitors infected with measles dramatically increases the risk of nosocomial infection.

Education for healthcare professionals

Doctors and medical staff who have no experience with measles need to be informed in advance of measles complications and skin symptoms. Measles typically follows a course involving prodromal, eruptive, and recovery phases. Early differentiation is difficult, and when fever is observed in foreign patients or Japanese residents returning from abroad, they should be treated in a manner appropriate for patients with measles. Precautions should start at the hospital reception.

Providing information to doctors

During a measles outbreak, doctors are focused on

medical treatment and may not have sufficient time to gather information.

Measures after an outbreak

Medical facilities offered vaccinations on weekends, but many students participate in sports practices and games and only a small number visited hospitals.

Daily lives of physicians

In areas with a shortage of pediatricians, hospitals that accept inpatients were identified and pediatricians were reallocated. The number of pediatricians per hospital increased and on-call duties for doctors decreased. Pediatricians' overtime work decreased, and their quality of life improved. Doctors were not typically required to work excessively during outbreaks of infectious diseases.

Problems faced by hospitals

When many patients visit hospitals during measles outbreaks, hospitals become locations where measles is

Table 5 Problems and countermeasures for measles outbreak

1. Before the outbreak	
Children	Confirmation of the maternal and child health handbook at three years old child medical examination. Confirm the first MR vaccination and inoculation is recommended for non-vaccinated persons. Children who have not been vaccinated against measles at the time of elementary school. Vaccination is recommended for persons who are not affected by measles and who have not been vaccinated against measles twice as often as required.
Adults	Vaccination with measles vaccine or MR vaccine for adults who are not considered to have measles antibodies. Persons who do not receive the MR vaccine due to religion or chronic illness. The risk of having someone nearby who may develop measles increase. Vaccination against the measles vaccine is a positive encouragement but not an obligation. Continue efforts to reduce measles unvaccinated.
School staffs	The history of measles is certain, or blood test shows positive measles antibody titer.
Hospital staffs	Create a list of hospitals with negative pressure rooms.
2. The measles epidemic initiation	
Administrative works	Providing measles epidemic information to doctors working in hospitals. The need to contact doctors directly via email from the public health center. Identify areas where measles is endemic. Map the school districts where measles is prevalent. Preventing epidemics under the age of one. Temporarily change the start time of the measles vaccine from 6 months of age.
Hospital staffs	Visiting patients suspected of developing measles. Make sure that patients with suspected measles have a different place and time when they come to see them so- that they do not come in contact with other patients. Confirm vaccination history for inpatients. Check maternal and child health handbook and interview survey with family. Prevention of nosocomial infection. Make sure that hospital staff have measles antibodies upon entry. Notification to the public health center and collection of samples. Cooperation with active epidemiological surveys at the public health center. Contact with a measles patient who has no or insufficient measles antibodies. Administration of measles vaccine within 72 hours or intramuscular immunoglobulin within 6 days. Increased intake opportunities for students and adults without measles antibodies. The evening or the weekend is available. Check for complications. Hospitalize patients with complications such as pneumonia, convulsions and encephalitis.
Pharmacists	Securing MR vaccine. Securing gammaglobulin preparation for intramuscular injection.
3. The number of hospitalized patients exceeds the number of negative pressure room	
Administrative works	There are several hospitals in the area. The designated hospital for infectious diseases will change to medical treatment centered on measles. Cooperation with active epidemiological surveys at the public health center. Staff other than doctors, such as medical secretaries, also participate because the doctors concentrate on medical care. Home recuperation for patients with mild symptoms. A practitioner visits the patient's home.
Hospital staffs	Medical treatment of measles patients and medical treatment other than measles are performed in parallel. Change the location of the outpatient clinic. Eliminate contact between measles patients and measles susceptible. Admission to another hospital with negative pressure rooms. Moving to other areas may lead to the spread of infectious diseases. Hospitalized in a private room with ventilation.
Pharmacists	Lack of MR vaccine and intramuscular gammaglobulin preparations. At the request of the pharmacist, wholesalers gather from all over the country and deliver them to the hospital.
4. The number of inpatients exceeds the number of private rooms	
Hospital staffs	Hospitalize measles patients in a large room. The room should have windows and be ventilated. Prevent nosocomial infections. Private rooms are used for patients other than measles. Bankruptcy of a doctor's life. Ask the relevant university to secure alternative doctors. The government allows doctors to work flexibly.

transmitted to other children and infants. Well-ventilated rooms are needed when treating measles. Recently renovated hospitals have central air conditioning, but many do not have windows to ensure ventilation. To help prevent airborne infections at hospitals with central air conditioning, measles patients are treated only in negative pressure rooms. However, the number of negative pressure rooms is limited, and the number of facilities that can admit measles patients has declined. The number of hospitals that can admit measles patients has also decreased with the reallocation of pediatricians.

Medical cooperation

There is a shortage of hospital beds for measles patients treated in the community during measles outbreaks. Children with uncomplicated measles are expected to rest at home. The roles fulfilled by pediatricians in private practice, such as providing explanations to families and making home visits, are important. The Olympics should be taken as a good opportunity to familiarize people with measles and measles vaccinations.

Administrative Issues

Educate families during medical examinations of children aged 3 years or older

Measles can be prevented by vaccination. During medical checks of children aged 3 years, physicians should ask whether the child has received the necessary vaccinations. Strong encouragement to get unvaccinated children vaccinated should be provided before they enter elementary school. However, vaccination is not compulsory. The act of refusing vaccination by a small number of parents is accepted, but there is always a risk of measles occurring if the refusal rate is above a threshold.

Create a list of hospitals with negative pressure rooms

To prevent the spread of an epidemic, containment is imperative. If there is a lack of facilities that can admit patients in an outbreak-prone area, then the distance from patients' homes to hospitals increases. With this increase, there is concern that the outbreak area will become larger. With the cooperation of medical associations, prefectures need to prepare lists of hospitals within the prefectures where measles patients can be admitted.

Providing information to doctors

If public health offices start to receive epidemiological information, that information should be communicated in turn to hospital pediatricians.

Measles epidemic initiation

When measles outbreaks occur in nursery schools, there is concern of symptomatic onset in children younger than 1 year. If measles is confirmed, the age of

vaccination must be reduced. The first vaccine in such cases is given at age 6 months. Vaccination of unvaccinated adults is also recommended.

After the measles outbreak

After individual inoculations with the two-dose MR vaccine schedule was started, school nurses negotiated with the municipal government and created opportunities for group vaccinations at city high schools. As a result, the vaccination rate among high school students increased.

Daily lives of physicians

With restrictions regarding working hours for doctors, the number of doctors who work irregular shifts will decrease. If doctors cannot assist temporarily at other hospitals, those hospitals will not be able to respond rapidly during measles outbreaks. Thus, there should be tolerance for flexibility in physician labor.

These challenges and the relevant countermeasures are summarized in **Table 5**. Although measles outbreaks have decreased after the two-dose vaccination schedule was introduced in Japan, international visitors to Japan could cause a measles outbreak. Children younger than 1 year and children and adults who lack measles antibody titers are at risk. Therefore, hospitals that treat measles patients should utilize existing evidence to prepare specific action lists in advance.

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