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Widespread Hand, Foot, and Mouth Disease Outbreaks: Interventions and Control Measures, Surin Province, 2020

Chutima Siripanumas[1]*, Sasiya Aparsuwonnakul[2], Natchanok Laksanawilai[2], Putsarat Youngthong[3], Siwaporn Bunsake[4], Chuleeporn Jiraphongsa[5]

1 Division of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand

2 Office of Disease Prevention and Control Region 9 Nakhon Ratchasima, Department of Disease Control, Ministry of Public Health, Thailand

3 Surin Provincial Health Office, Ministry of Public Health, Thailand

4 Surin Hospital, Ministry of Public Health, Thailand

5 Office of the Senior Expert Committee, Department of Disease Control, Ministry of Public Health, Thailand

*Corresponding author email: csiripanumas@gmail.com

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Abstract

In 2020, Surin Province had the highest incidence proportion of hand, foot, and mouth disease (HFMD) in Thailand, primarily concentrated in Mueang District. Numerous outbreaks occurred in kindergarten schools and child development centers despite the implementation of prevention and control measures. This study aimed to evaluate these interventions using observation and interviews and assess associated factors for the prolonged outbreaks. A cross-sectional study was conducted among 37 facilities that reported HFMD outbreaks. Linear regression analysis was performed to assess the association between factors and the duration of the outbreak. There were 369 confirmed HFMD cases. The attack rate in child development centers was 11.6%; in kindergarten schools was 5.1%. Most facilities with outbreak followed the recommendations and control measures issued by the Department of Disease Control; however, improper sanitation was observed in some facilities. A high student-toilet ratio (coefficient 0.64 days, [95% CI 0.11–1.17]) and a high student-janitor ratio (coefficient 0.12 days, [95% CI 0.07-0.17]) were associated with a longer outbreak duration. Prevention and control measures should include promoting personal hygiene, using an appropriate concentration of disinfectant solution, training teachers about common communicable diseases, early screening for detection and isolation of sick children, and communication with parents about HFMD.

Keywords: HFMD, kindergarten school, child development center, Thailand

Introduction

Hand, foot, and mouth disease (HFMD) is a common communicable disease among children. It is caused by a group of human enteroviruses from the family *Picornaviridae*. Enteroviruses are non-enveloped viruses with a single-stranded RNA genome. The common pathogens are Coxsackievirus A16 (CV-A16), Coxsackievirus A6 (CV-A6), and Enterovirus 71 (EV-A71). The most common clinical manifestation is a nonspecific febrile illness. Other manifestations include coryza, pharyngitis, herpangina, hand, foot, and mouth ulcer, and aseptic meningitis. Although HFMD is usually mild, it can also lead to severe conditions such as viral sepsis, meningoencephalitis, myocarditis, hepatitis, coagulopathy, and pneumonitis.[1,2]

HFMD spreads through direct contact with nasal and throat discharges via aerosol droplets and the feces of infected people. The incubation period ranges from 3–6 days and the median is about 4.4 days for children in

kindergartens.[3] Enteroviruses can survive on environmental surfaces for periods long enough to allow transmission from fomites.[1] The antiviral action of chloroxylenol, benzalkonium chloride, and cetrimide/chlorhexidine is ineffective in inactivating enteroviruses.[4] Alcohol-based hand disinfectants with 70% ethanol or isopropanol also have poor effectiveness against EV-A71. Ninety-five percent ethanol is the most effective concentration, but this level still cannot fully inactivate EV-A71 and may be impractical in many instances.[5] Appropriate disinfectants include sodium hypochlorite, chlorine, glutaraldehyde, and formaldehyde, boiling at 50–60 °C for 30 minutes, sterilization, and ultraviolet light.[6]

The Department of Disease Control (DDC) of Thailand has provided recommendations for prevention and control measures toward common communicable diseases to kindergarten schools and child development centers. These recommendations include promoting proper personal hygiene, cleaning and disinfection, screening, isolation and administrative control, and health promotion.[7] A previous systematic review in China found that timely notification of HFMD outbreaks to national health authorities, effective communication, environmental disinfection and sanitation instructed by the facility, and control supervision from the local health authorities, are essential for minimizing the outbreak duration in childcare facilities.[8]

HFMD in Thailand is an epidemic. Historical data shows that there is a sharp peak during the rainy season (June–August).[9] However, as shown in Figure 1, the peak in 2020 occurred in November. This changed pattern might be caused by school closures during the COVID-19 pandemic.[10,11]

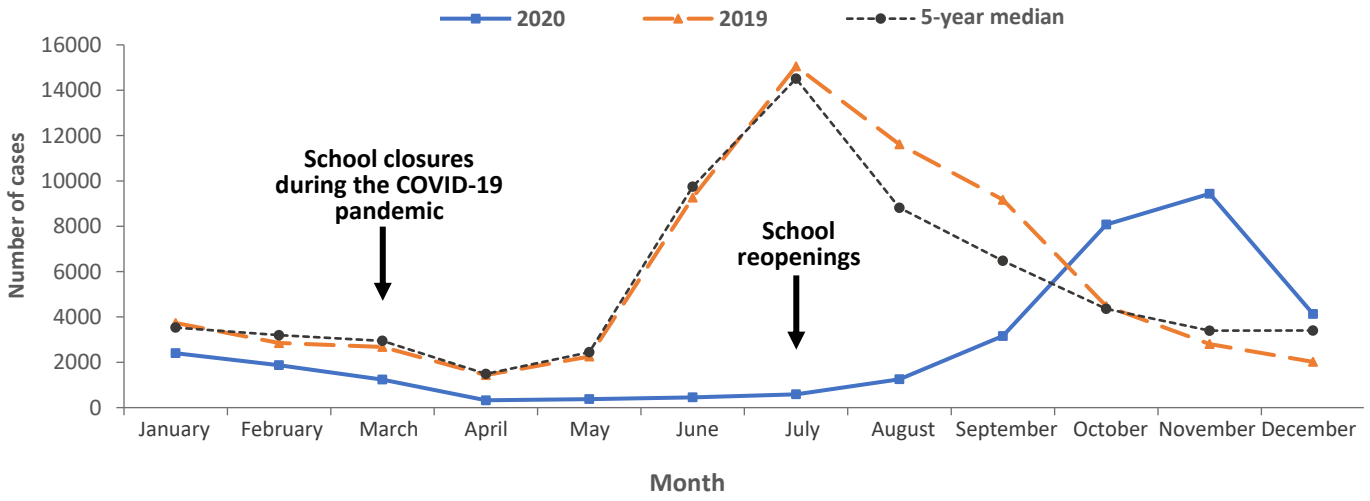

Figure 1. Illustration of the number of HFMD cases reported in National Disease Surveillance System, Thailand, in 2019, 2020 and the 5-year median (2015–2019)

On 2 Nov 2020, the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima received a notification stating that the cumulative number of suspected HFMD cases in Surin Province was 1,223 (87.5 cases per 100,000 population). Despite conducting an investigation and receiving recommendations from the surveillance and rapid response team, the number of cases in Surin Province continued to rise and remained high. Consequently, a joint field investigation involving the Division of Epidemiology and Surin Provincial Health Office, investigated from 2–3 Nov 2020 and 16–18 Nov 2020.

The objectives of this study were to describe the epidemiological characteristics of HFMD outbreaks, evaluate the interventions implemented by kindergarten schools and child development centers, identify possible risk factors, and provide health education to prevent further outbreaks. We also aim to provide recommendations to health authorities for effective control measures of HFMD.

Methods

Study Area and Sampling Method

The study was conducted in Mueang District, Surin Province, which, in 2020, comprised 121 kindergarten schools and 68 child development centers. The child development center is a facility that provides daytime childcare and early childhood education for children aged 3–5 years, while the older children attend kindergarten schools. A facility with an outbreak was defined as a kindergarten school or child development center in the study area and had two or more HFMD cases in the same class or five or more cases in the facility between 1 Aug and 18 Nov 2020. Conversely, a facility without an outbreak was defined as one that did not meet any of the above criteria.[8,12] Purposive

sampling was used to recruit facilities. We investigated every facility with an outbreak except ones that were closed during the 3-day field investigation period. Each of the four evaluation teams also investigated one facility without an outbreak per day. Provincial health officers who were responsible in the study area were actively participating in the investigation. We recruited 49 facilities, 37 with an outbreak, and 12 without. Figure 2 shows a flowchart of recruitment.

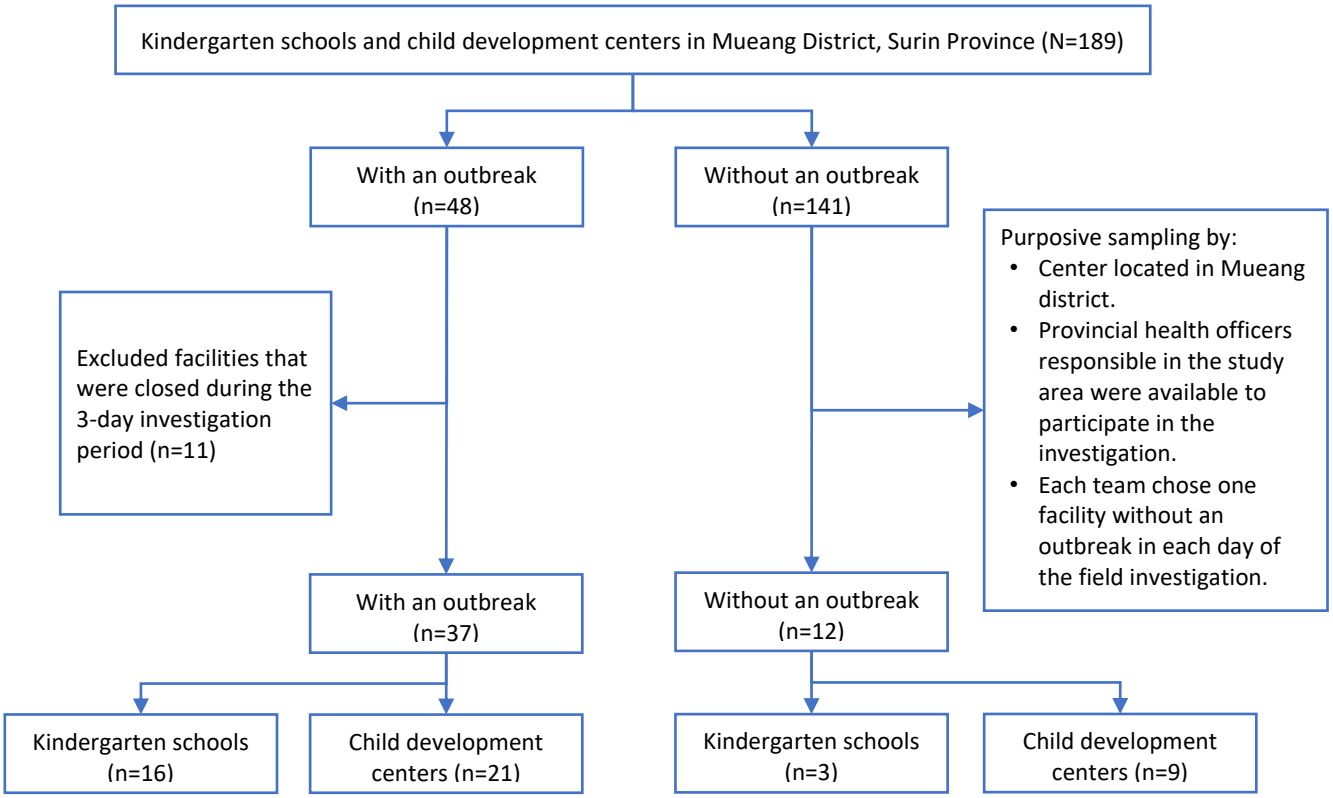

Figure 2. Recruitment flowchart for the study

Descriptive Study

A descriptive study was performed at both the individual and facility levels. We reviewed the classroom logbooks for absentees, and, for HFMD cases, we ascertained the date of symptoms onset (if any) among sick children. For facility-level data, we interviewed class teachers and school directors about their staff, HFMD cases, facilities, control measures, and school policies. We interviewed school teachers and cleaners about the use of the classrooms, toys, library, computer room, music room and toilets, and the cleaning methods and schedules during November 2022. We observed and interviewed teachers about student hygiene, daily screening methods, and teacher-parent management, and observed physical structures, toilets, and sanitation systems.

An active case finding was conducted among kindergarten students and children in child development centers. The suspected case was a student or child who met at least one of the following criteria from 1 Aug–18 Nov 2020: 1) maculopapular rash or vesicular rash on the palm, sole, oral cavity, trunk, or buttocks; and 2) diagnosed with HFMD by a clinician. A confirmed case was a suspected case who tested positive by reverse transcription-polymerase chain reaction (RT-PCR) for one of the Enterovirus genera from a throat swab, rectal swab, stool, or cerebrospinal fluid (CSF).[12]

Data Collection

We used a semi-structured questionnaire for data collection. The items in the questionnaire were arranged into characteristics, risk factors, and center interventions for HFMD. We arranged risk factors and interventions into four sections: personal hygiene; cleaning; screening, isolation, and administrative control; and communication. The sections were arranged according to the DDC recommendations and the communication part was an additional section. Proper cleaning was defined as 75–100% of items in facilities being cleaned properly. The cleaning recommendations were adopted from the DDC guideline. For items without DDC recommendations, sodium hypochlorite solution cleaning was considered proper.

Data Analysis

Continuous data were summarized as median with interquartile range (IQR) and categorical data were presented as frequency with percentage. An analytic

study was performed to explore potential risk factors, especially behaviors and environments, among 37 facilities with an outbreak using a cross-sectional study design. Exposures were characteristics of the facility including the number of students or children, class size, number of teachers, cleaners and janitors, personal hygiene, and sanitation behaviors of the children such as use of toilets, sink, and drinking glasses. The dependent variable was the duration of the outbreak, defined as the days between the onset of the first case and the onset of the last case in each facility. Linear regression was performed to assess the association of potential risk factors and the outcome. All factors were presented as a coefficient with 95% confidence interval (CI). All *p*-values were two-tailed and the significance level was <0.05. All analyses were performed using STATA version 14.

Results

Of 189 kindergarten schools and child development centers in Mueang District, we recruited 49 facilities (19 kindergarten schools and 30 child development centers), 37 with and 12 without an outbreak. The first case was reported on 24 Aug 2020. The number of cases gradually increased and peaked in the first week of October. On 9 November, the last facility reported its first case.

Characteristic of Cases

Of 1,580 children from the 30 child development centers and 3,655 students from the 19 kindergarten schools, there were 369 suspected cases. The attack rate in child development centers was 11.6% (184 cases) and the attack rate in kindergarten schools was 5.1% (185 cases). From 37 facilities that we recorded symptoms from 191 children, most cases had an oral ulcer (69.1%), followed by a rash on the palms (51.3%), and fever (31.4%). Other less common symptoms included sore throat, fatigue, nausea (18.8% each), and rash on the soles (13.1%).

Characteristics of HFMD Outbreaks in Facilities

The median number of cases reported from facilities with an outbreak and those without an outbreak was six and one, respectively. Most facilities with an outbreak had cases in two classrooms and those without an outbreak in one classroom. Attack rates among facilities with and without an outbreak were 9.8% and 3.1%, respectively. As shown in Table 1, the median (IQR) duration of outbreaks in centers with an outbreak was 11.0 (3.0–24.0) days while the duration in centers without an outbreak was 0 (0–3.3) days.

Table 1. Characteristics of hand, foot, and mouth disease outbreaks in facilities with and without an outbreak, Surin Province, 2020

Characteristic	Facilities with an outbreak			Facilities without an outbreak		
	Kindergarten schools (n=16)	Child development centers (n=21)	Total (n=37)	Kindergarten schools (n=3)	Child development centers (n=9)	Total (n=12)
No. of cases						
median	5.0	6.0	6.0	1.0	1.0	1.0
(IQR)	(3.0–14.5)	(4.0–10.0)	(4.0–11.0)	(0.0–3.0)	(1.0–1.5)	(1.0–1.8)
No. of classes with a case						
median	3.0	2.0	2.0	1.0	1.0	1.0
(IQR)	(1.3–4.0)	(1.3–2.0)	(1.3–3.0)	(0.0–3.0)	(1.0–1.5)	(1.0–1.8)
Attack rate (%)						
median	6.8	9.9	9.8	4.2	2.9	3.1
(IQR)	(3.5–17.6)	(7.4–19.1)	(6.1–18.2)	(0.0–6.7)	(2.2–4.8)	(2.2–4.9)
Duration of outbreak						
median	17.0	9.0	11.0	0.0	0.0	0.0
(IQR)	(1.5–34.5)	(4.0–18.0)	(3.0–24.0)	(0.0–41.0)	(0.0–1.0)	(0.0–3.3)

IQR: Interquartile range

Characteristics of Facilities

Characteristics of studied facilities are presented in Table 2. The median number of classrooms was three among facilities with an outbreak and two among those without. Most facilities had less than 15 students per teacher, which was within the standard requirements.[13] However, the median student per teacher ratio was 21 in kindergarten schools without an outbreak. All study facilities had an adequate student per sink ratio. However, most facilities had an inadequate student per toilet ratio; the median ratio in facilities with and without an outbreak was 11.0 and 15.5, respectively. The median (IQR) number of students per janitor and students per playground was 37.5 (16.0–72.3) and 41.0 (32.3–74.3) in facilities with an outbreak, and 35.5 (25.5–41.8) and 27.0 (17.4–44.3) in facilities without an outbreak, respectively.

Table 2. Characteristic of facilities with and without an outbreak, Surin Province, 2020

Characteristic	Facilities with an outbreak			Facilities without an outbreak			Requirement[16]
	Kindergarten schools (n=16)	Child development centers (n=21)	Total (n=37)	Kindergarten schools (n=3)	Child development centers (n=9)	Total (n=12)	
No. classrooms							
median	4.0	2.0	3.0	2.0	2.0	2.0	-
(IQR)	(2.0–15.8)	(2.0–3.0)	(2.0–5.0)	(2.0–2.0)	(1.0–2.5)	(1.0–2.0)	
Student/teacher							
median	13.6	12.8	12.9	21.0	11.3	12.2	15/1
(IQR)	(10.2–14.9)	(10.8–15.6)	(10.7–15.0)	(12.0–22.5)	(10.1–16.9)	(10.3–20.4)	
Student/janitor							
median	31.1	38.0	37.5	42.0	34.0	35.5	-
(IQR)	(17.0–106.8)	(8.0–65.0)	(16.0–72.3)	(24.0–45.0)	(15.0–39.0)	(25.5–41.8)	
Student/playground							
median	59.0	41.0	41.0	42.0	23.0	27.0	-
(IQR)	(16.3–133.0)	(33.0–60.5)	(32.3–74.3)	(24.0–45.0)	(8.5–41.5)	(17.4–44.3)	
Student/sink							
median	5.8	8.8	6.8	5.6	6.3	6.0	10/1
(IQR)	(4.2–14.0)	(4.7–15.0)	(4.5–14.1)	(2.2–14.0)	(2.6–8.9)	(2.5–9.1)	
Student/toilet							
median	13.0	10.0	11.0	14.0	16.0	15.5	10–12/1
(IQR)	(6.4–25.3)	(7.8–17.3)	(7.8–20.3)	(12.0–22.5)	(10.9–19.8)	(11.6–20.4)	

IQR: Interquartile range

Personal Hygiene

We found that 70% of facilities with an outbreak and 50% of those without an outbreak had student face towels in contact with each other. From our observations, the space for hanging towels appeared inadequate. Sharing of hand towels was observed in 43% and 25% of facilities with and without an outbreak, respectively, while sharing of hand-washing basins was seen in 14% and 8%, respectively. The sharing of drinking glasses and/or glasses that were in contact with each other stored on glass racks was seen in 16% and 17% of facilities with and without an outbreak, respectively (Figure 3).

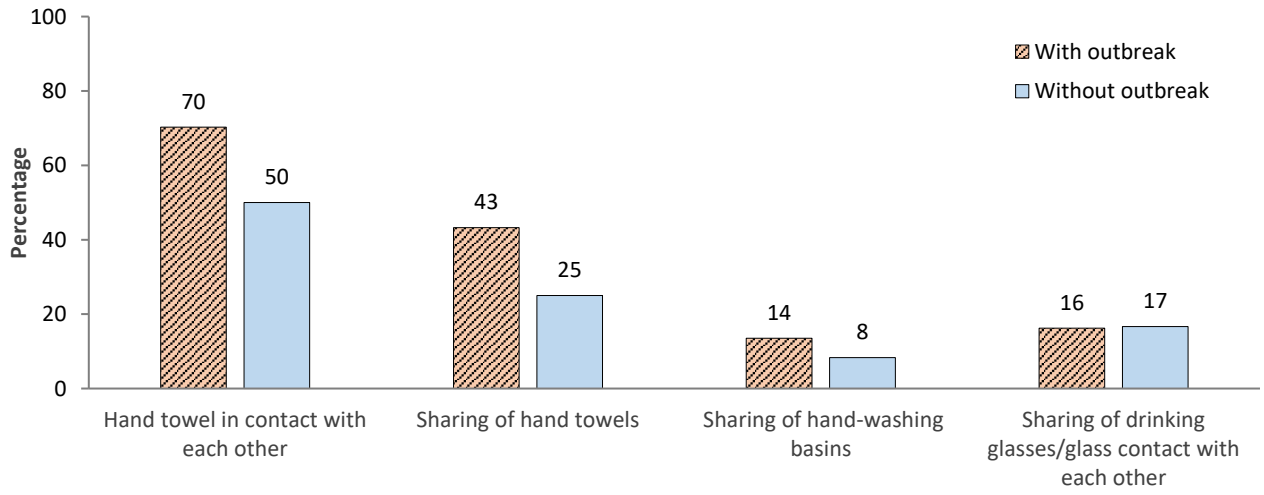

Figure 3. Personal hygiene levels in facilities with and without an outbreak, Surin Province, 2020

HFMD Prevention Measures

Cleaning

Most facilities used chloroxylenol and diluted hypochlorite for cleaning purposes. From our observations, items were cleaned with improper methods and inadequate frequency. We found only three facilities (8%) with an outbreak properly cleaned all six items recommended in the guideline, plus the three we added in based on the school context. The top three items with proper cleaning methods in facilities with an outbreak were dolls, drinking glasses, and books while in centers without an outbreak were drinking glasses, hand towels, and books. Compared to facilities without an outbreak, facilities with an outbreak had more proportion of cleaning computers, musical instruments and playgrounds with sodium hypochlorite solution (Table 3).

Table 3. Implementation of proper cleaning interventions in facilities with and without an outbreak (%), Surin Province, 2020

Intervention	Recommendation [a]	Facilities with an outbreak (n=37)	Facilities without an outbreak (n=12)
Cleaning			
Drinking glasses	Use personal drinking glasses and clean with dishwashing liquid (once a day)	83.8	83.3
Hand towels	Use personal towels and clean with detergent and air dry (once a day)	56.8	75.0
Toys	Should clean with disinfectant and air dry (once a day for sucking toys and once a week for other toys)	29.7	25.0
Dolls	Should clean with disinfectant and air dry (once a week)	100.0	50.0
Books	Should dust (once a week)	60.9	55.6
Floors	Clean with detergent or disinfectant (once or twice a day)	24.3	16.7
Computers [b]	-	33.3 [c]	
Musical instruments [b]	-	25.0	0.0
Playgrounds [b]	-	21.4	10.0

[a] *Department of Disease Control recommendations unless stated otherwise.*
[b] *Additional evaluation items.*
[c] *Among facilities that had computers for students to use.*

Screening, isolation, and administrative control

Thirty-six facilities with an outbreak (97%) and 12 without (75%) implemented temperature screening to staff and students/children on entering the facilities. Twenty-eight facilities with an outbreak (76%) and 6 without an outbreak (50%) implemented HFMD screening for those entering classrooms. However, in only 13 facilities (11 with an outbreak and 2 without an outbreak) teachers/staff used a torch while screening for oral lesions. Half of all facilities implemented isolation measures for sick children (20 with an outbreak and 6 without). We found that 35 facilities with an outbreak and 8 without suspended classes during disease outbreak periods and 34 facilities with an outbreak and 10 without closed their facility. Only 22 centers with an outbreak (59.5%) and 5 without an outbreak (41.7%) trained teachers about common communicable diseases that can occur in schools every year (Table 4).

Communication

Parent-teacher communication about the HFMD situation or provided health information to parents was good with 89% of facilities with an outbreak and 75% without, implementing this control measure (Table 4).

Table 4. Implementation of screening, isolation, and administrative control and communication measures completely done in facilities with and without an outbreak (%), Surin Province, 2020

Intervention	Recommendation [a]	Facilities with an outbreak (n=37)	Facilities without an outbreak (n=12)
Screening, isolation and administrative control			
Temperature screening [b]	-	97.3	75.0
HFMD screening	Screen at least two weeks after the last case had occurred.	75.7	50.0
Use of a torch while screening for oral lesions [b]	-	29.7	16.7
Separation zone	Isolate sick children at a distance of at least one meter from others	54.0	50.0
Class suspension	Suspend if more than two cases in one week in the same class occurred.	94.6	66.7
Facility closure	Close if more than five cases in the school or more than two classes occurred.	91.9	83.3
Training of teachers/staff about communicable diseases	Train at least once a year	59.5	41.7
Communication			
Communicates with parents about HFMD situation or provides health information to parents [b]	-	89.2	75.0

[a] *Department of Disease Control recommendations unless stated otherwise.*
[b] *Additional evaluation items.*

Risk factors for duration of HFMD outbreaks

The univariable analysis results are summarized in Table 5. A high student per toilet ratio and a high student per cleaner and janitor ratio were significantly associated with a longer outbreak duration. For every unit increase in student per toilet ratio and student per cleaner and janitor ratio the outbreak duration would increase by 0.64 day or approximately 15 hours and 0.12 day or 3 hours, respectively.

Table 5. Coefficients of risk factors relating to duration of outbreak (n=37)

Variables	Coefficients relating to duration of outbreak	95% CI	*P*-value
Characteristics			
Student/teacher ratio	-0.49	-1.96–0.98	0.500
Student/toilet ratio	0.64	0.11–1.17	0.020
Student/sink ratio	-0.08	-0.56–0.39	0.722
Student/cleaner and janitor ratio	0.12	0.07–0.17	<0.001
Practices			
Towel contact with each other	8.89	-2.02–19.80	0.107
Sharing hand towels	-0.39	-10.85–10.06	0.940
Sharing basin for hand washing	-4.83	-19.88–10.23	0.520
Sharing drinking glasses	-5.54	-19.46–8.38	0.425

CI: confidence interval

Discussion

Most kindergarten schools and some child development centers lacked adequate toilet facilities. The minimum requirement is one toilet per 10–12 students.[14] In our analytic study, we found that in centers with an outbreak, a high student per toilet ratio was significantly associated with a longer outbreak duration. Without enough toilets, waste from infected individuals can contaminate school sanitation facilities. The absence of basic sanitation facilities can both result in an unhealthy environment contaminated by human waste and contribute to the spread of many diseases.[15]

The analytical study also showed that a high student per cleaner and janitor ratio was associated with a longer duration of the outbreak. Cleaning and disinfecting are part of a broad approach for the prevention of infectious diseases in schools.[16] Maintaining cleanliness is linked to the health of students, and janitors bear the responsibility for ensuring a hygienic environment.[13] They reduce the risk of illnesses being spread and can help keep the school a healthier and safer place.[17] One study even reported a relationship between inadequate janitorial service and student attendance.[18] In the US, the requirement for janitors is to clean 30,000 square feet within 8 hours.[19] However, in Thailand, there are no specific requirements regarding the workload for janitors. Differences in the size of school buildings and the extent of school grounds requires different duties assigned to janitor and determine the amount of work required for them.[20]

In most facilities we observed, the child's towels were in contact with each other, and in some facilities, students shared hand towels. An outbreak of methicillin-resistant Staphylococcus aureus among college football players found that sharing towels on the field facilitated the transmission of infectious diseases.[21] Another study found the presence of *Escherichia coli* bacteria and coliform on kitchen hand towels, and the number of bacteria negatively correlated with frequency of towel washing.[22]

Most facilities used improper disinfectants for cleaning or washing. Few facilities used proper interventions on cleaning. Diseases can spread easily in the community if control measures such as use of disinfectants are not applied properly. The appropriate concentration of sodium hypochlorite in disinfectants is 600 parts per million (ppm) for toys and 1,000 ppm for floors and surfaces.[6,21,23] However, there are no recommendations about proper disinfectants and concentrations for cleaning in the DDC guideline. In addition, the guideline does not include recommendations for cleaning some items such as computers, musical instruments, and playground equipment.

Many facilities did not follow the teacher training recommendations. Moreover, some did not screen for HFMD symptoms at least 2 weeks after the last case had occurred and few facilities used a torch when performing oral examinations. HFMD screening should be implemented for at least 2 weeks after the last case had occurred.[7] Torches should be used for oral mucosa examination.[24,25]

Half of the facilities did not isolate sick children and some did not implement class suspension or facility closure. These practices are risky because children with HFMD are usually most contagious during the first week of infection.[26] A study in China found that the median basic reproduction number for HFMD was 4.6 indicating that the virus can spread easily.[3] Home isolation is a key strategy for preventing the spread of disease and limiting person-to-person contact is one of the prevention measures of HFMD.[27,28]

We found that in 90% of facilities with an outbreak and 75% without an outbreak teachers communicated with parents about HFMD and provided relevant health information. A previous study showed that prevention behaviors of parents had a significantly positive relationship with health literacy, especially in access to information.[29] Factors affecting prevention behaviors of HFMD included perceptions of the severity, disease prevention, and barriers to the prevention of disease, and obtaining support from relevant persons.[30] Providing knowledge and disseminating health information related to HFMD regularly to parents can also enhance preventive health behaviors.[31]

Public Health Actions and Recommendations

We provided health education about the mode of transmission and clinical manifestations. We demonstrated how to perform HFMD screening and clarified the proper disinfectant and concentration of hypochlorite for cleaning.

Kindergarten schools/child development centers should provide sufficiently clean and functioning toilets to children and provide appropriate hand-washing facilities. Having an adequate number of cleaners and janitors are also important. The number depends on the duties and size of the facility. The facilities should provide adequate spaces for hanging towels and the sharing of hand towels should be discouraged. Classroom toys, floors, and common areas should be cleaned with proper hypochlorite solution

and optimal frequency. An isolation room for sick children should be provided. facilities should consider DDC recommendations on class suspensions and facility closures. When the facility is reopened, staff should screen children before they enter the facility every day for at least two weeks. The facilities should also communicate and provide information about HFMD to parents. Moreover, having empowerment activities for parents to encourage them to have a better awareness of HFMD and to promote the health of children is essential.[30] For the DDC, instructions on the proper disinfectants for cleaning purposes should be provided in the guideline.

Limitations

As this study design was retrospective, virus isolation of causative strains to confirm HFMD cases was not conducted. In addition, limitations in resources, time, and human workforce prevented us from selecting a random sample of facilities; thus, some selection bias may have occurred.

A demonstration by the teachers, cleaners, and janitors in their cleaning and screening processes might have differed from their actual practices. Inaccurately measured or classified practices may have caused information bias. However, where possible, we used direct observation to reduce the bias.

Observations from the classroom logbooks indicated that the absentee students had unknown dates of symptom onset, which might have led to misclassification bias.

In many facilities, an outbreak occurred before we had conducted the investigation. In those facilities, interventions and control measures had already been implemented. Therefore, facilities with outbreaks had a higher proportion of proper interventions than those without an outbreak. Finally, cross-sectional studies cannot provide firm evidence of causation. Results from this study may be inadequate for establishing a clear temporal sequence. We were therefore unable to determine causality between some risk factors and the duration of HFMD outbreaks.

Conclusion

We reported HFMD outbreaks in kindergarten schools and child development centers in Mueang District, Surin Province. The attack rate in child development centers was higher than in kindergarten schools. Common symptoms included oral ulcers, rash on the palms, and fever. No case developed severe symptoms or conditions. Most facilities reporting an outbreak followed recommendations and control measures issued by the DDC. However, we found improper sanitation methods used in some facilities. Facilities with a high student per toilet ratio and student per cleaner and janitor ratio had a significantly longer outbreak duration. Prevention and control measures should include promoting personal hygiene, using an appropriate concentration of disinfectant solution, training teachers about common communicable diseases, early screening for detection and isolation of sick children, and increased communication with parents about HFMD.

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