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The 2009 Pandemic Influenza A Virus in an Outbreak during 2014 in Samut Prakan Province, Thailand

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Abstract

On 30 Jan 2014, a company employee in Samut Prakan Province developed severe pneumonia. Since many other employees also developed influenza-like illness (ILI), an investigation was conducted to describe the situation, identify risk factors and provide recommendations. Medical records and company employees' medical notes were reviewed. Case definition for ILI was based on the guideline of World Health Organization. Probable ILI cases were randomly sampled to confirm influenza A(H1N1)pdm09 using real-time polymerase chain reaction. A retrospective cohort study was performed using a self-administered questionnaire and a walk-through survey of the company was conducted. Total 102 respondents (18.8%) reported having ILI and among them, two were diagnosed with pneumonia. Seven of 21 throat swab specimens were positive for an influenza virus strain that appeared to be influenza A(H1N1)pdm09. The highest reproductive number (R_0) of this outbreak was 2.7 (95% CI=1.9-3.8). Risk factors for illness included attending the company party (adjusted OR = 9.1, 95% CI = 2.73-56.35, PAF = 0.86) and having contact with persons who developed ILI (adjusted OR = 2.7, 95% CI = 1.46-4.93, PAF = 0.24). This outbreak showed that the pandemic strain of influenza in 2009 became the circulating strain during 2014.

Key words: outbreak, influenza A(H1N1)pdm09, company, employee, Thailand

Introduction

In April 2009, a new strain of influenza, influenza A(H1N1)pdm09, caused 1,300 illnesses and 83 deaths in Mexico. The disease quickly spread throughout the world. In Thailand, the first imported case was reported in May 2009, with the first local transmission occurred in June 2009 and almost half of the population had influenza-like illness (ILI) by the end of the pandemic in October 2010.[1]

Influenza vaccination in Thailand is voluntary, which is recommended for high risk population such as health care workers, people who are likely to develop complications after being infected with influenza viruses and relatives of high risk people.[2,3] Number of influenza cases declined after launching of the influenza vaccination program. However, sporadic influenza outbreaks still occur in some specific population such as students, military personnel and participants in training camp.[4]

On 30 Jan 2014, the Bureau of Epidemiology (BOE) was notified of a cluster of ILI cases and one severe pneumonia case in a copper alloy valve production company (Company A) in Samut Prakan Province. The outbreak investigation was conducted from 30 Jan 2014 to 24 Feb 2014 by the BOE team in order to confirm an influenza outbreak, describe the situation, identify risk factors for the outbreak, and provide control measures and recommendations for local health authorities and employees in Company A.

Methods

We reviewed medical records of the index case and interviewed medical personnel who cared for the patients and the index case's family and co-workers. Active case finding consisted of reviewing medical notes and absenteeism records in Company A. We administered a self-report questionnaire to all employees about their symptoms, risk behaviors and history of contact with ILI cases since 1 Jan 2014.

The case definition of ILI was a person with fever and cough or sore throat, based on World Health Organization (WHO)[5]. We defined a probable case as an employee of Company A who developed symptoms compatible with ILI during 2-30 Jan 2014 which was seven days before onset date of the first confirmed case and seven days after onset date of the last confirmed case. A confirmed case was an employee of Company A who developed ILI and had a positive test for influenza A(H1N1)pdm09 by polymerase chain reaction (PCR) during 2-30 Jan 2014. A severe case was a confirmed case who developed severe respiratory illness that needed respiratory assist devices.

All specimens from probable cases were sent to the National Institute of Health (NIH), Thailand. Fluid specimens from tracheal lavage of a severe case were tested for respiratory virus multiplex and atypical respiratory bacteria pathogens. The respiratory virus multiplex PCR assay was then tested for influenza A and B viruses, human respiratory syncytial virus (types A and B), human adenovirus, human metapnuemovirus, human coronavirus (229E, NL63, OC43), human parainfluenza virus (types 1, 2, 3 and 4), human rhinovirus, human bocavirus and human enterovirus. Atypical respiratory bacteria pathogens tested were *Mycoplasma pneumoniae* and *Chlamydophila pneumoniae*. Throat swab specimens were randomly collected from probable cases who had symptoms on 1 Feb 2014 and sent to NIH for testing influenza A(H1N1)pdm09 by real-time reverse transcription polymerase chain reaction technique.

An on-site investigation was conducted on 30 Jan 2014 and 21 Feb 2014 to describe the workplace, and identify risk processes and events that might contribute to disease transmission.

Descriptive data was stratified by cases and non-cases, and presented in percent, mean and standard deviation. Chi-square, Fisher's exact test and t-test were used to assess differences between the two groups. Attack rate calculation used all the employees as population at risk because we could not verify their immunization status before the outbreak.

A retrospective cohort study was conducted to identify risk factors related to ILI among employees in Company A. Risk ratio and 95% confidence interval (CI) were calculated to determine strength of association of each factor with ILI. Multiple logistic regression was used to control for possible confounders and adjusted odds ratio of each factor was reported. To quantify the contribution of risk factors to this outbreak, population attributable fraction (PAF) was calculated.

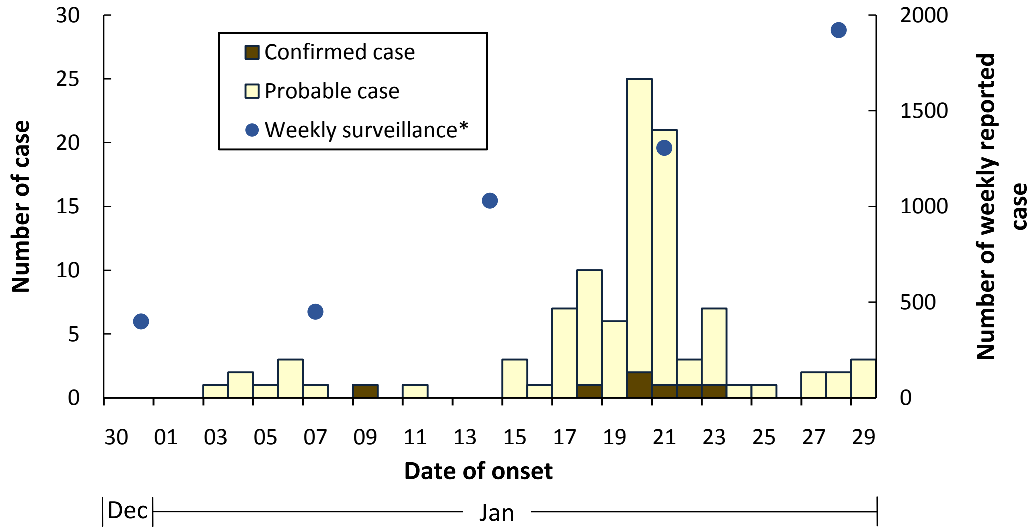
To describe the outbreak situation after the New Year Party, we assumed that employees who developed ILI symptoms before the party were not at risk. Thus, probable or confirmed cases that developed ILI symptoms before 18 Jan 2014 were excluded from the risk factor analysis.

An estimated reproduction number (R) was calculated on the method described by Cori et al with mean serial interval (SI) as 2.6 days, standard deviation (SD) as 1.5 days[6], aimed posterior coefficient of variance (CV) as 0.2, length of time step as 2-day periods by every day estimation, and mean of prior distribution for R was 1.96 (SD=0.5)[7].

Results

The outbreak occurred in Company A located in Bangplee Industrial Estate, Bang Sao Thong District, Samut Prakan Province, Thailand. The company had total 572 employees in 18 departments and produced copper alloy valves. Ninety five percent of the employees were Thai, 2% Cambodian, and 1% each of Laotian, Myanmar and Japanese.

Response proportion of the questionnaire was 95.1% (544 out of 572 employees). Mean age of the respondents was 33.8 years (SD=7.3). Total 102 (18.8%) out of 544 met probable case definition (Figure 1). Among them, two developed pneumonia and 21 throat swabs were collected which seven were tested positive for influenza A(H1N1)pdm09.



* *Weekly aggregated number of influenza cases reported to R506 surveillance system in Thailand, 2014*[1]

Figure 1. Probable and confirmed influenza A(H1N1)pdm09 cases among employees in Company A, Samut Prakan Province, Thailand, 2-30 Jan 2014 (n=102)

There were no significant differences in gender, nationality, or reported weight, height and BMI between cases and non-cases. Cases were significantly younger though the difference was small (Table 1). The most common symptoms among probable and confirmed cases were fever (100%), cough (91%), headache (81%) and sore throat (81%) (Figure 2).

Among two cases who developed pneumonia, one had severe pneumonia and multi-organ failure. The case with severe pneumonia was a 42-year-old male with hypertension. He was deputy chief engineer of casting department. He developed fever, headache, cough and sore throat on 22 Jan 2014, and visited a physician on 25 Jan 2014. His vital signs at the first visit were body temperature 39°C, pulse rate 100 bpm, respiratory rate 16 per min and blood pressure 110/70 mmHg. Rapid tests of influenza A and B were negative. He was diagnosed as systemic infection and admitted to a private hospital. On 26 Jan 2014, he developed dyspnea and acute respiratory failure. He was then intubated and treated with oseltamivir (75 mg oral twice a day). During treatment, he developed renal failure, followed by multi-organ failure. Finally, he stayed in hospital for 58 days at a cost of nearly 1 million Baht (30,500 USD). From the investigation, his tracheal suction was positive for influenza A(H1N1)pdm09 by real-time PCR. *Mycoplasma pneumoniae* and *Chlamydophila pneumonia* were also identified by PCR testing. However, the immunology test for these pathogens could not be performed due to limitation of laboratory facilities.

From active case finding, we found another employee with pneumonia who was a 30-year-old female working in quality control department. Her onset of illness was on 20 Jan 2014 and was diagnosed as community-acquired pneumonia at a private hospital on 24 Jan 2014. Later, she fully recovered and was discharged from the hospital on 28 Jan 2014. Her medical records showed no laboratory evidence of influenza A(H1N1)pdm09.

Table 1. Demographic data of cases and non-cases in influenza A(H1N1)pdm09 outbreak among employees of Company A, Samut Prakan Province, Thailand, 2014

	Case (n=101) ¶	Non-case (n=442) ¶	P-value
Mean age in years (SD)	31.9 (5.9)	34.3 (7.5)	<0.001*
Gender (Male/Female)	0.91	1.08	0.479
Nationality (%)			
Thai	100 (99.0)	386 (87.3)	0.148**
Cambodia	0(0)	9 (2.0)	
Laotian	1 (1.0)	5 (1.1)	
Myanmar	0 (0)	5(1.1)	
Mean body weight in kg (SD)	58.8 (9.5)	60.1 (11.0)	0.267*
Mean height in cm (SD)	161.5 (6.9)	162.4 (8.0)	0.257*
Mean BMI (SD)	22.5 (3.3)	22.7 (3.4)	0.678*

** T-test*

*** Fisher's exact test, compared Thai and non-Thai nationalities*

¶ Regarding mean body weight, height and BMI, there was missing data for 4 cases and 35 non-cases.

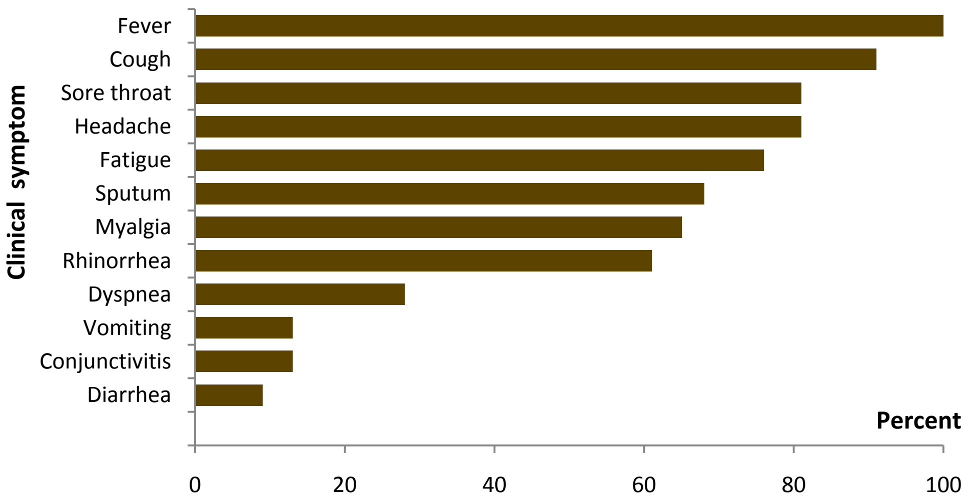


Figure 2. Clinical symptoms of probable and confirmed influenza A(H1N1)pdm09 cases among employees of Company A, Samut Prakan Province, Thailand, 2014

Among 544 employees who responded to the questionnaire, none had an influenza vaccination in the previous year or an underlying disease. Total 100 persons (18.4%) had a history of ILI contact within one month before the outbreak and nearly half of them (49.0%) shared a bedroom with an ILI case. More than half of the employees (61.0%) reported using a N95 mask regularly as a dust protector and seven persons reported sharing a face mask with others. There were 406 employees (74.6%) that attended New Year Party in the company. The party was held in an air-conditioned room of a restaurant near the company, which started at 18:00 and ended at 24:00. During the party, 26.4% of the employees shared drinking glasses and 33.7% reported contact with an ILI case at the same table (Table 2).

Table 2. Behavioral risk factors in influenza A(H1N1)pdm09 outbreak among employees in Company A, Samut Prakan Province, Thailand, 2014

Behavioral risk factor	Number of exposed (%)
Contact history	
Contacted with ILI case (n=100)	100 (18.4)
Shared bedroom with ILI case	49 (49.0)*
Vehicle	
Used company provided vehicle	169 (31.1)
Shared vehicle with ILI case	96 (17.6)
New Year Party on 18 Jan 2014	
Attended the party (n=406)	406 (74.6)
Shared glass with others	107 (26.4)*
Shared table with ILI case	137 (33.7)*
Cafeteria in the company	
Used the company cafeteria (n=419)	419 (77.0)
Shared dining table with ILI case	79 (18.9)*
Drinking glass	
Have individual water glass	405 (74.4)
Used company provided glass	179 (32.9)
Used straw for drinking	18 (3.3)
Face mask and outfit	
Used face mask regularly	332 (61.0)
Shared face mask with others	7 (1.3)
Shared outfit with others	11 (2.0)

** Percentage calculated among exposed group*

After the New Year Party, high number of employees took sick leave, including 71 employees who were sick during the outbreak. The company did not deduct the sick period from employee's wages or the vacation time. Subgroup analysis was conducted for 513 employees since 31 cases were excluded due to having onset of illness before the party. The results showed that employees who went to the party and share a dining table with ILI cases in the company cafeteria were higher risk to develop ILI symptoms (Table 3).

Total 463 persons were included in multiple logistic regression since 50 observations were excluded due to missing information. Having a history of going to the New Year Party on 18 Jan 2014 (adjusted OR=9.1, 95% CI=2.73-56.35, PAF=0.86), using company cafeteria (adjusted OR=2.7, 95% CI=1.12-8.03, PAF=0.55), and having a contact history with ILI cases (adjusted OR= 2.7, 95% CI=1.46-4.93, PAF=0.24) were associated with ILI symptoms (Table 4). Thus, history of going to the party contributed the strongest impact to ILI occurrence in this population.

The highest reproductive number (R_0) of this outbreak was 2.7 (95% CI=1.9-3.8) during 17-18 Jan 2014 and dramatically dropped to 1.1 (95% CI=0.8-1.5) on 21-22 Jan 2014, a week before the investigation.

The surveillance was continued until late February 2014. There were 2-4 employees with ILI per week for three consecutive weeks.

Discussion

An outbreak of influenza A(H1N1)pdm09 occurred in Company A because employees were not vaccinated before. No employees reported receiving the seasonal influenza vaccine. This was not surprising because they were not included in the targeted population for influenza vaccination which was for only young people, elderly, persons with underlying diseases such as cardiovascular and pulmonary diseases and immunocompromised persons[2].

A study that modeled influenza transmission and vaccination in employees in a large company showed that immunization has an important role to mitigate epidemic.[8] Thus, studies were needed to assess cost effectiveness and risk-benefit of influenza vaccination among the specific high risk population in Thailand such as company employees, military personnel and prisoners.

The attack rate of ILI among company employees in this study was 18.8% while outbreaks of influenza A(H1N1)pdm09 had attack rates, ranging from 7% to 37%[9-13]. In confined settings such as cruise ships, military camps or schools, the attack rate could be even higher, ranging from 22-37%.[11-13]

In this outbreak, we found two pneumonia cases while one of them developed severe symptoms. Although severe cases are uncommon, about 0.01-5.00% of persons infected with influenza A(H1N1)pdm09 could have severe outcomes.[13-15] Fortunately, the employees with severe cases in this outbreak recovered later.

Transmissibility of ILI in this outbreak was high when compared with median seasonal influenza

Table 3. Behavioral risk factors and risk ratio in influenza A(H1N1)pdm09 outbreak among employees in Company A, Samut Prakan Province, Thailand, 2014

Risk factor	Percent		Risk ratio	95% CI
	Expose	Non-expose		
Contact history				
Contacted with ILI case	25.3 (22/87)	11.3 (48/425)	2.2	1.43-3.51
Shared bedroom with ILI case	28.3 (13/46)	22.5(9/40)	1.3	0.60-2.62
Vehicle				
Used company provided vehicle	12.9 (20/155)	14.7 (46/312)	0.9	0.54-1.43
Shared vehicle with ILI case	15.1 (13/86)	14.4 (44/306)	1.1	0.59-1.86
New Year Party on 18 Jan 2014				
Attended the party	16.9 (64/378)	2.0 (2/98)	8.3	2.07-33.30
Shared glass with others	21.6 (21/97)	16.6 (37/223)	1.3	0.81-2.11
Shared table with ILI case	26.2 (32/122)	13.2 (18/136)	2.0	1.17-3.34
Cafeteria in the company				
Used the company cafeteria	15.8 (62/392)	5.6 (5/89)	2.8	1.17-6.80
Shared dining table with ILI case	22.1 (15/68)	11.8 (23/195)	1.9	1.04-3.37
Drinking glass				
Have individual water glass	12.7 (48/378)	17.6 (18/102)	0.7	0.44-1.18
Used company provided glass	15.6 (27/173)	13.1 (39/298)	1.2	0.76-1.88
Used straw for drinking	5.9 (1/17)	14.0 (65/464)	0.4	0.06-2.85
Face mask and outfit				
Used face mask regularly	13.0 (41/315)	13.5 (20/148)	1.0	0.59-1.58
Shared face mask with others	0 (0/7)	13.9 (67/483)	0	Undefined
Shared outfit with others	10.0 (1/10)	13.6 (65/478)	0.7	0.11-4.79

Table4. Multiple logistic regression of behavioral risk factors and adjusted odds ratio in influenza A(H1N1)pdm09 outbreak among employees of Company A, Samut Prakan Province, Thailand, 2014

Risk factor	Adjusted odds ratio	95% CI	Population attributable fraction
Contacted with ILI case	2.7	1.46-4.93	0.24
Went to the company party on 18 Jan 2014	9.1	2.73-56.35	0.86
Used the company cafeteria	2.7	1.12-8.03	0.55

reproductive number that was 1.5[7]. However, some outbreaks in institutional settings reported that confined settings might promote disease spread as well.[11-13] We found that attending the New Year Party promoted spread of disease from ill persons to other healthy individuals. Activities such as sharing a dining table with ill persons and drinking from the same glass might have contributed to the outbreak.

We identified no other report of ILI outbreak associated with large group gatherings, including dining in the cafeteria. There were reports that a person with ILI who came to work might be the first case of ILI outbreak in the company. Sick employees who continue to work can spread the disease to others. Thus, ill employees in this outbreak might also have attended the company party, contributing to the outbreak.

However, we found that the transmission rate reached the peak and dramatically dropped before the investigation was conducted. It might be due to the fact that many employees took sick leave after the company party. Thus, timeliness reporting of outbreak is needed in order to prevent severe disease and spreading in the community.

In 2004-2005, influenza A subtypes H1N1 and H3N2 were predominant strains circulating in Thailand.[16] Since after 2009, influenza A(H1N1)pdm09 became more significant than other strains until 2011 when the dominant strain changed to be influenza A subtype H3N2.[17] Nevertheless, occurrence of influenza

A(H1N1)pdm09 was higher again during 2014 as the same period of this outbreak.[18]

This study was subjected to limitations such as recall bias and social desirability bias for response to the questionnaire. However, we tried to find other evidences to support our findings with the environmental survey and employees' records. Finally, we could not confirm the co-infecting agent of the severe pneumonia cases due to limitations in laboratory testing.

Conclusions

During 2-30 Jan 2014, there was an influenza A(H1N1)pdm09 outbreak among employees in a valve production company. One employee developed pneumonia and another one had severe illness with respiratory and multi-organ failure. Attending the company party was associated with developing ILI.

Recommendations

Continuous surveillance on influenza strains and study on vaccine prevention intervention in specific population of Thailand should be encouraged to prevent sporadic outbreaks and severe cases.

We provided recommendations to the company in order to prevent influenza outbreaks in the future. First, the company should allow employees who developed ILI symptoms to have paid sick leave for at least 2-3 days or until they have no symptoms. In addition, all company workers should avoid contact with ILI cases, especially during company gatherings, which could cause rapid disease spreading. The company should also provide a drinking glass for every employee to prevent sharing of glasses. In addition, hand hygiene should be promoted among the company workers. Finally, an influenza vaccination campaign should be considered in big company. In February 2014, Company A implemented an influenza vaccination campaign and totally 322 workers (56.3%) had received the vaccination.

Acknowledgements

We would like to sincerely thank managers and workers in Company A who supported us during field investigation. We also appreciate local surveillance and rapid response team of health promotion hospital in sub-district for assisting in investigation and conducting intervention activities. Finally, we would like to express our gratitude to Dr. Matthew Biggerstaff in editing the manuscript and providing guidance for calculating the reproductive number.

Suggested Citation

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An Outbreak of Multi-drug Resistant Enterotoxigenic *Escherichia coli* (ETEC) Infection among Infants in a City of Southwest China, 2012

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Abstract

Multi-drug resistant (MDR) diarrheagenic *Escherichia coli* has rapidly spread worldwide and represents the most serious threat to management of diarrhea in developing countries. We investigated an outbreak of severe diarrhea in a neonatal ward during 1 Apr-30 Jul 2012, where 60 suspected cases were found. To identify possible sources of infection, we conducted a case-control study through which we identified the increased infection risk of 4.6 fold for each liter of bottle milk feeding (OR = 4.6, 95%CI = 1.50-14.70). *E. coli* serotype O128:H45 with virulence gene stIb was found in 14 out of 18 stool or diaper swab samples and were MDR. This was a neonatal diarrhea outbreak caused by multi-drug resistant *E. coli* while bottle milk feeding was the possible vehicle in facilitating the transmission. This outbreak reinforces that enterotoxigenic *Escherichia coli* (ETEC) should be considered when the clinical picture is consistent and common gastrointestinal pathogens are not found.

Key words: multi-drug resistant, ETEC, hospital-associated infections

Introduction

Enterotoxigenic *Escherichia coli* (ETEC) is responsible for large proportion of infant diarrhea, especially in developing countries.[1,2]ETEC produces one or both of two enterotoxins: heat-labile enterotoxin and heat-stable enterotoxin. Diseases caused by ETEC may range from mild diarrhea to severe diarrhea similar to cholera, with profuse watery diarrhea, abdominal cramp, fever, nausea, chills, loss of appetite, headache, muscle aches and, finally, dehydration from loss of fluid.[3]

ETEC produces an immunologic protective response, reflecting the observation that attack rates are higher in children and decrease with age.[4,5] People are usually infected by ETEC through contaminated food and water consumption, and breastfeeding provides some protection in infants.[6] Researches on ETEC that target diarrhea patients suggested 4-6% prevalence in China.[7,8]

On 24 Jun 2012, Center of Disease Control (CDC) in Zigong City received a report from Hospital A, indicating that its neonatal ward received three patients with severe diarrhea. Symptoms of the patients were cholera-like and two had developed severe dehydration. Bacteria culture of stool specimens and rotavirus tests were negative and empiric antimicrobial treatment (amoxicillin, cefotaxime and piperacillin) failed. Two out of the three patients were hospitalized in Hospital B before onset of illness. The local health bureau conducted an investigation to determine whether this event was an outbreak, identify the pathogen and infection sources, and implement control measures.

Methods

Initial Investigation and Case Definition

Zigong is an industrialized city in the southwest of China (Figure 1), with a population of about three million. There were four hospitals that had neonatal wards in Zigong. The investigation team included experts in epidemiology, pediatrics, hospital infection control and laboratory testing. The team searched for cases by probing medical records in all neonatal wards of Zigong from 1 Apr 2012.

A suspected case was defined as a hospitalized neonate aged less than 28 days with loose stool seven or more times, or watery stool one or more times

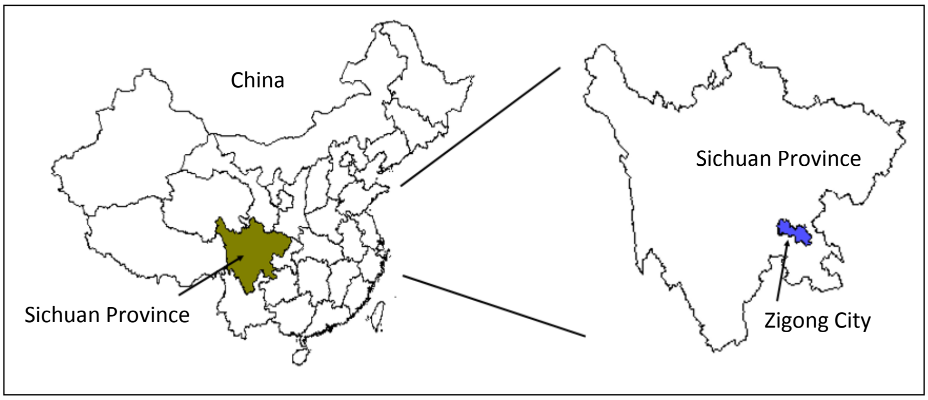

Figure 1. Location of Zigong City, Sichuan Province, China

within 24 hours during 1 Apr-30 Jul 2012 in Zigong City. A confirmed case was defined as a suspected case with stool specimen tested positive for *Escherichia coli* (*E. coli*) O128:H45. As the patients might have been hospitalized more than once, we defined 12 to 48 hours before onset of illness as the exposure period to identify the exposed hospital. In this way, all patients could have only one exposed hospital under this definition.

Environmental and Epidemiological Investigation

The investigation team reviewed the supply records of milk powder and water, and collected (both opened and sealed) milk powder samples for microbial testing. The team checked the layout of neonatal ward and observed milk preparing process, bottle feeding and hand hygiene behavior of the nurses in neonatal ward of Hospital B.

Case-control Study

The investigation team matched medical records of Hospital B by hospitalization date in a case-control study. A control was defined as a patient without diarrhea who was hospitalized in the neonatal ward during exposed period of a corresponding infected cased. Each case was matched with two controls. Variables collected were gender, age, birth weight and volume of bottle milk feeding.

Microbiological Testing

The investigation team also collected clinical samples from patients, nurses and doctors, and environmental samples from the neonatal ward of Hospital B. The collected samples were transported immediately to the laboratory in the municipal CDC for testing.

Stool and diaper swab samples were tested for pathogenic *E. coli*, *Listeria monocytogenes*, *Enterobacter sakazakii*, *Bacillus cereus*, *Salmonella*, *Shigella*, *Vibrio cholera* and *Vibrio parahaemolyticus* according to Chinese testing standards.[9] Environmental swabs from neonatal wards of Hospitals A, B, C and D were tested for bacterial count and pathogenic *E. coli*. In addition, milk powder from the hospitals were collected and tested for bacteria culture using tryptic soytone broth produced by China Beijing Luqiao Tech Co. Limited.

Pathogenic *E. coli* was isolated by CHROMagar ECC medium (produced by China Zhenzhou Biocell Biotech Co. Limited) and pathogenicity of isolated clones was identified by API 20E biochemical identification system (produced by France bioMérieux). Then, isolated clones were typed by O and H diagnostic serum (first typed with the serum produced by China Tianrun Biomedical Co. Limited and then confirmed by serum produced by Denmark Serological Research Institute). Finally, polymerase chain reaction (PCR) testing was done using *E. coli* virulence genes stx1, stx2, eaeA, lt, stIb, aggR, ipaH, rrs sequence probes.[10] In addition, drug resistance was tested by Etest method, according to Clinical and Laboratory Standards Institute standard 2009[11].

Data Analysis

The data was analyzed by Epi Info7[12]. The analytical methods were Fisher's exact test and matched logistic regression (Binary logistic regression, forward and stratified by match group).

Results

The investigation team identified a total of 532 patients who were admitted in four hospitals during 1 Apr-30 Jul 2012, with 60 suspected cases and 13 confirmed cases. Among the suspected cases, 38 (63.3%) had diarrhea seven times or more within 24 hours while 48 (80.0%) had watery stool and 10 (1.7%) had axillary temperature more than 38°C. However, none of them had mucus stool. There were 44 (73.3%) suspected cases hospitalized in Hospital B. Attack rate of the neonatal ward of Hospital B was significantly higher than the baseline of Zigong and the other three hospitals (Table 1). Geographic distribution of cases' residence scattered throughout Zigong and two nearby cities (Figure 2).

Table 1. Distribution of cases in Zigong City, Sichuan Province, China, 1 Apr-30 Jul 2012

Hospital	Number of neonate	Number of case	Attack rate (%)	Relative risk (95%CI)
B	285	44	15.4	228.5 (110.3-473.3)
A	57	2	3.5	45.5 (9.6-215.5)
C	161	1	0.6	7.8 (1.0-61.7)
D	29	0	0	-
Not hospitalized	11272*	9#	0.2	reference

** Average population growth in Zigong City was 2,818 per month in 2010.*

#Four cases had no hospitalization history during exposure period and lived outside Zigong City.

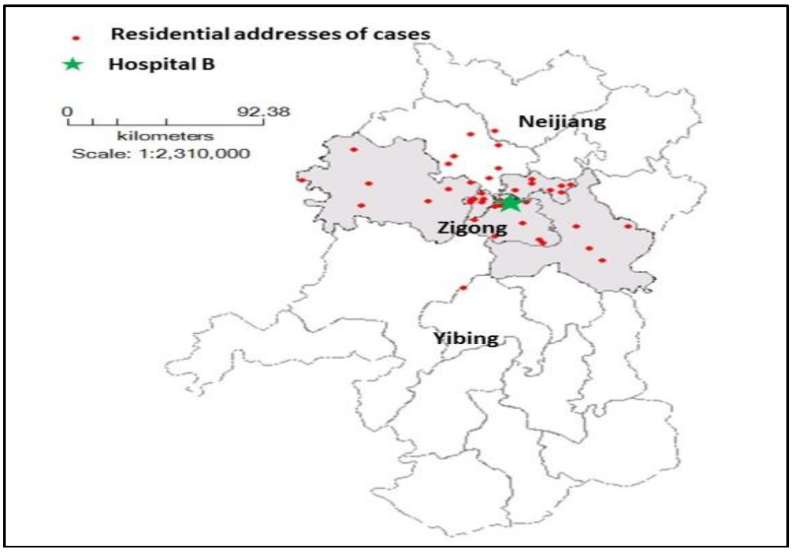

Figure 2. Distribution of cases by residential address in Zigong City, Sichuan Province, China, 1 Apr-30 Jul 2012

Out of 44 cases in Hospital B, 23 (52.3%) were males, with average birth weight 3.2 kilogram (median 3.1 kg, range 2.1-4.3 kg),and average age at the onset of symptoms was 10.4 days (median 9 days, range 3-28 days).

Environmental and Epidemiological Investigation

The investigation team identified that bacterial contamination of baby incubator button, sink edge and bed label, was higher than the acceptable standard levels (less than 5 CFU/m^2)[13] in the neonatal ward. The milk preparation room, neonatal bathroom and toilet were located nearby and used the same water supply and sewer pipes (Figure 3). Nurses prepared milk by mixing boiling water with pre-cooled boiled water in a measuring cup before adding milk powder. Nurses cared for neonates with bare hands and washed hands with cleaning solution before changing to care another neonate. One nurse might perform various duties of patient care, such as milk preparation, manual feeding and bathing during one shift. A neonate with diarrhea was not isolated because the isolation room was occupied by other patients.

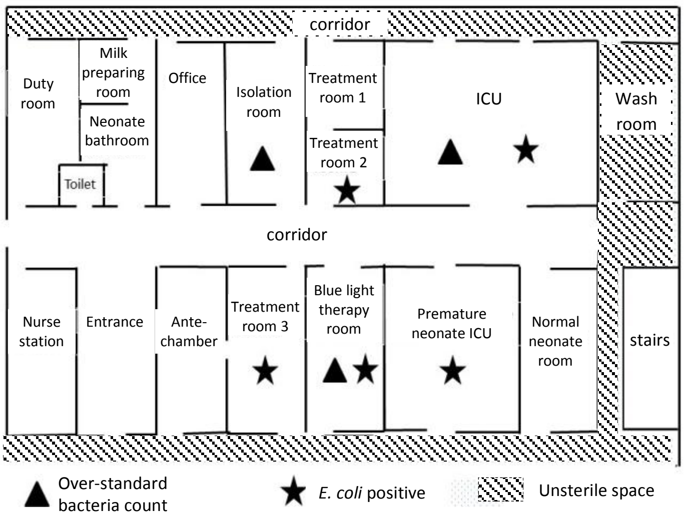

Figure 3. Ward layout and distribution of bacterial contamination in neonatal ward of Hospital B, Zigong City, Sichuan Province, China, 1 Apr-30 Jul 2012

Case-control Study

In the case-control study, 44 cases were matched to 82 controls. The study revealed that risk of infection increased 4.6 fold for each liter of bottle milk feeding (OR=4.6, 95% CI=1.50-14.70) (Table 2). The transmission chain revealed the expose period of most cases (93.2%, 41/44) overlapped with at least one case's diarrhea period (Figure 4).

Microbiological Testing

The clinical samples were classified by the exposed hospitals. Since Hospital B stopped receiving diarrhea patients on 19 Jun 2012, many patients went to Hospitals A and C. Thus, samples from exposed patients admitted in Hospitals A and C were collected as well. The investigation team isolated 14 pathogenic *E. coli* clones from 18 stool or anal swab samples (15 from Hospital B, 2 from Hospital A and 1 from Hospital C). Among which, 13 clones were serotype O128:H45, including 11 exposed in Hospital B and the other two in Hospitals A and C. We found heat-stable enterotoxin gene stIb in all 13 clones. These clones exhibited full resistance to amoxicillin, piperacillin, cefalotin, cefotaxime and sulfamethoxazole; intermediate resistance to ceftazidime; and sensitive to amoxicillin-clavulanic acid, piperacillin-tazobactam, cephalosporin thiophene, cefepime, meropenem, imipenem, gentamicin, kanamycin, amikacin, tobramycin, norfloxacin, levofloxacin, tetracycline and chloramphenicol. Physical features of milk powder met the related Chinese regulation standards and were negative for bacteria culture. Among 11 stool or anal swab samples from doctors and nurses working in the neonatal ward of Hospital B, all were pathogenic *E. coli* negative.

Table 2. Case-control study in neonatal ward of Hospital B, Zigong City, Sichuan Province, China, 1 Apr-30 Jul 2012

	Average		Odds ratio	95% CI	P-value
	Case	Control			
Body weight (kg)	3.2	2.8	2.9	1.30-6.20	<0.01
Milk feeding (liter/24 hours)	0.6	0.4	4.6	1.50-14.70	<0.01
Age (day)	10	9	1	0.98-1.11	>0.05
Gender ratio (male)	1.3	1.1	1.2	0.60-2.40	>0.05

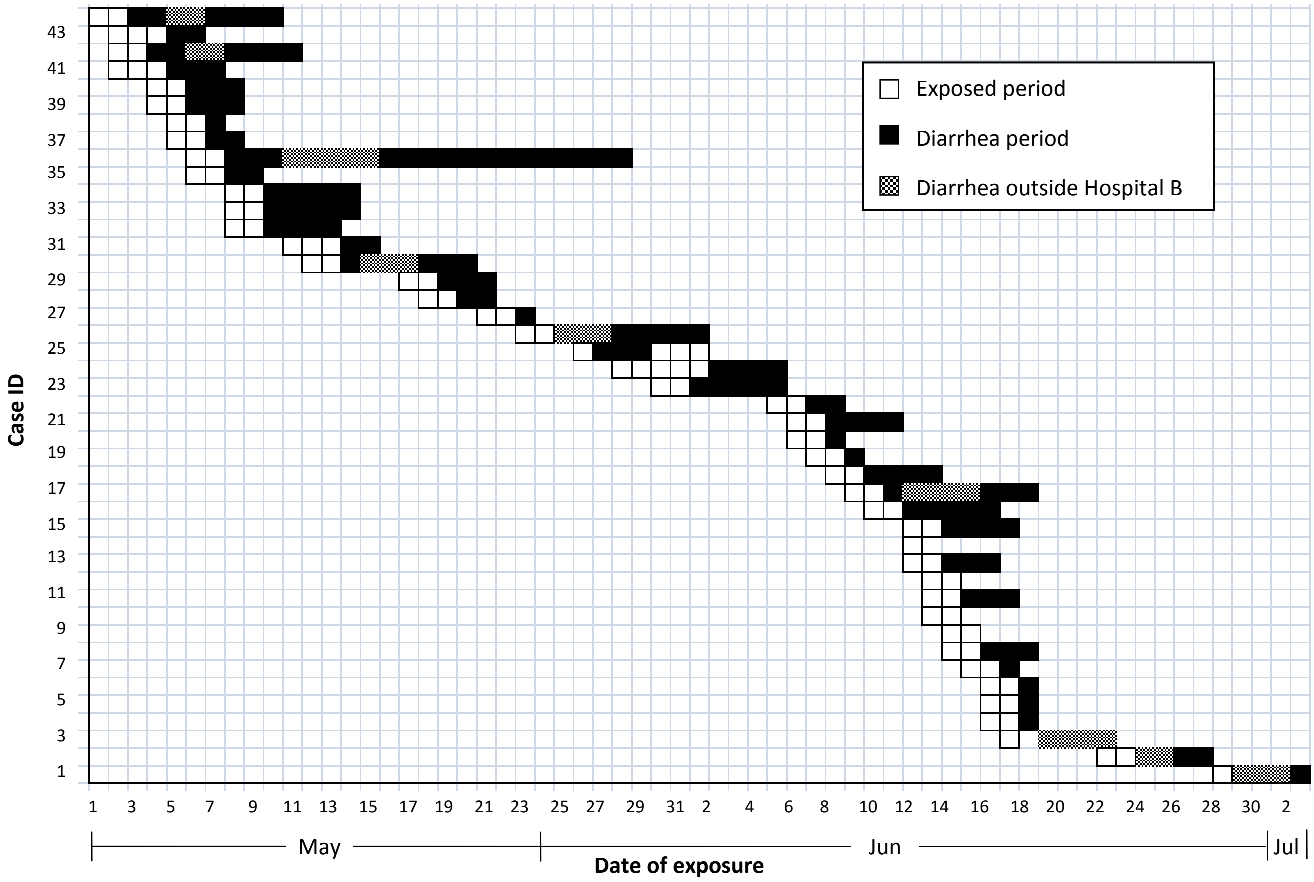

Figure 4. Exposure and diarrhea period of cases in neonatal ward of Hospital B, Zigong City, Sichuan Province, China, 1 May-2 Jul 2012

Outbreak Management

Hospital B noticed an unusual rise of diarrhea patients in the neonatal ward in early May 2012. Therefore, they reinforced hand hygiene management, and changed the brand of milk powder and water source from tap water to bottled water. Nevertheless, new cases were still increasing. In addition to fluid infusion, Hospital B administered antibiotics and antiviral drugs, which had little effect. Hospital B later reduced frequency of milk feeding to patients in early June 2012, which led to a drop of patients with diarrhea. The number of cases reached its peak on 15 Jun 2012 and the neonatal ward in Hospital B stopped admitting new diarrhea patients on 19 Jun 2012. The number of new cases dropped sharply thereafter (Figure 5).

Epidemiological investigation began on 25 Jun 2012 and control measures were implemented by local health bureau according to the recommendations of the investigation team on 26 Jun 2012. Control measures included treating cases with ceftazidime (50-100 mcg/kg) and placing in isolated rooms, dividing nurses in each neonatal ward into two teams with one team provided care specifically for patients with diarrhea, and redesigning and sanitizing the milk preparation room in neonatal ward of Hospital B. All cases recovered soon after and the last case was reported on 1 Jul 2012.

Discussion

Acute infectious diarrhea is the second most common cause of death in children living in developing countries.[3] Major etiologic agents that account for the estimated 1.5 million deaths per year include ETEC, rotavirus, *Vibrio cholerae* and *Shigella spp.*[14,15]Diagnosis of ETEC depends upon identification of enterotoxin genes, which is fastidious and expensive. None of laboratories in four hospitals in Zigong City included ETEC identification in their routine laboratory tests, resulting in late diagnosis of the pathogen. In this outbreak, although symptoms of cases were distinguishable from the usual neonatal diarrhea, case records were not systematically collected and analyzed in Hospital B until the investigation. Doctors responsible for hospital infection control should include ETEC infection as part of their differential diagnoses when facing clusters of patients with cholera-like diarrhea.

Drug resistance was widely reported and discussed for ETEC infection control.[16,17] In this outbreak, multi-drug resistance of the responsible ETEC clone not only hampered the treatment of patients, but also misled the investigation to consider viral infections as the cause of diarrhea since there was little effect following antibiotic treatment.

Based on the medical records and before identification of pathogens by laboratory, the board of pediatricians determined to use high doses of ceftazidime to treat patients and found instant effect in spite of the fact that this ETEC clone exhibited intermediate resistance to ceftazidime. Antibiotic may stimulate further verotoxin production by *Shigella*-like toxin-producing bacteria such as enterohemorrhagic *Escherichia coli* (EHEC) and thereby increasing the risk of hemolytic uremic syndrome (HUS). It was worth to mention that the pediatricians excluded the risk of inducing HUS before using antibiotic treatment because low fever and absence of mucus stool strongly suggested that the symptoms could be caused by exotoxin. High doses of new generation antimicrobials might be a substitutive option to treat diarrhea in children with cholera-like symptom where ETEC test methods yet to be established.[3]

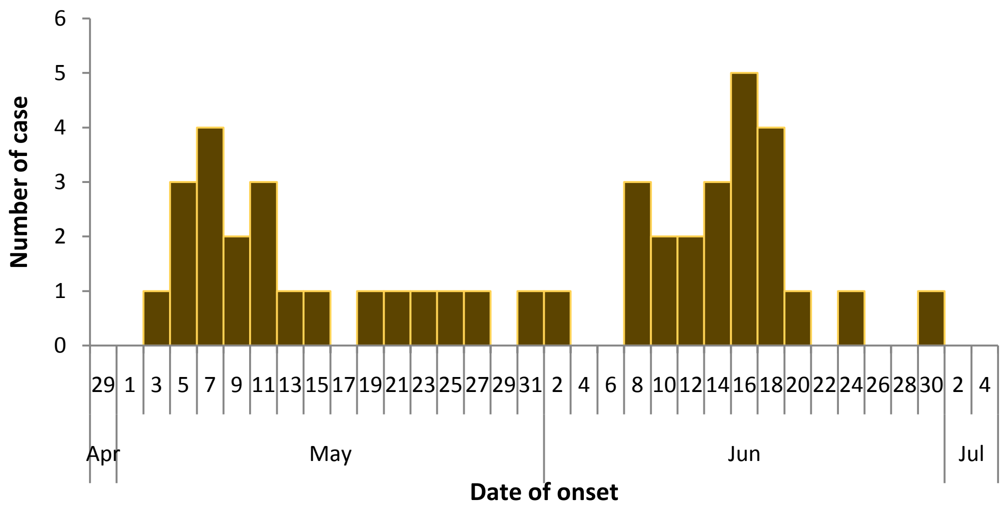

Figure 5. Number of patients by date of onset in Hospital B, Zigong City, Sichuan Province, China, 29 Apr-4 Jul 2012

ETEC usually infects patients through consumption of contaminated food or water.[3] Changing water and milk powder did not control the outbreak, which indicated that the water and milk powder were not the source of infection. ETEC infecting dose is high (106-1010 CFU), with lower doses being less pathogenic.[18] Though the definition of controls could not exclude patients who might be infected with ETEC, the case-control study provided strong evidence that the diarrhea cases were most likely associated with bottle milk feeding as attack rate of the patients with more body weight (often need more milk feeds) was significantly higher than that of the patients with lower body weight. Considering the milk preparation room of this neonatal ward was placed next to the bathroom and the nurse prepared milk at appropriate feeding temperature by mixing pre-cooled boiled water with boiling water, the main contamination source of ETEC might be the measuring cup used to measure the pre-cooled water and mixed milk powder at temperature not high enough to kill bacteria.

Bottle milk feeding alone could not explain failure in hygiene enforcement of Hospital B and the confirmed cases who were exposed in Hospitals A and C. There were also reports stating that ETEC could be transmitted by contacts.[19] Though the neonates were not isolated in separate rooms, they were prevented from direct contact by being kept in baby incubators. After we ruled out the water and milk powder contamination, nurses and health care set-up were the remaining possible vehicles to facilitate *E. coli* transmission. Isolation of not only patients, but also nurses who took care of diarrhea patients might be a practical supplement to prevent *E. coli* hospital infection. Although reducing diarrhea patient density might be another option to interrupt the transmission chain as Hospital B did, that might drive patients to go to other hospitals and increase the risk for a larger outbreak and social problems.

The biggest challenge of this outbreak investigation was to identify cases and exposed hospitals because neonates often have physiological diarrhea and go to hospitals very often. It was a successful experience that the epidemiologists consulted pediatricians from either the investigation team or staff from the involved hospitals when defining case and exposed period. Main limitation of this investigation was that although this ETEC clone was multi-drug resistant which implied that it probably evolved in Hospital B or another antimicrobial-rich environment, the investigation did not identify the clone as having evolved in Hospital B or brought in by a patient. The investigation team did not find direct evidence of milk contamination because disinfection and changing of milk preparing instruments were already conducted in Hospital B after mid-June 2012.

Neonatal wards are confined environment with vulnerable patients, where ETEC outbreaks may cause severe consequences. Access to ETEC identification methods should be established to provide laboratory testing in hospitals with neonatal ward.

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Suggested Citation

Chen X, Yuan W, Zhang LJ, Li Q, Zhang ZD, Wang H, et al. An outbreak of multi-drug resistant enterotoxigenic *Escherichia coli* (ETEC) infection among infants in a city of southwest China, 2012. OSIR. 2015 Sep;8(3):8-14.
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Situation of Heat-related Illness in Thailand, and the Proposing of Heat Warning System

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Abstract

Many countries in the world experienced heat waves. While the impact of heat on health was well documented in developed countries, there were very few studies of heat-related illnesses (HRI) in tropical countries. Our aim was to describe HRI in Thailand and examine usefulness of the National Health Reporting System in Ministry of Public Health to track HRI during 2010-2013. A descriptive study examined the relationship between hospital visit with ICD-10 codes of T67-679 (effects of heat and light) and temperature from the Meteorological Department. Among 3,963 HRI visits with nine deaths, median age was 43 years (IQR 22-61) with the highest incidence rate 3.8, 2.3 and 1.6 per 100,000 person-year for 65 and above, 55-65 and 45-55 age groups respectively. Male-to-female ratio was 1:1.7. Occupations included skilled agricultural workers (35.7%), odd job persons (15.1%) and students (13.5%). Northern region reported the highest incidence rate (9.3 per 100,000 person-year). This was the first countrywide study describing HRI in Thailand and has been presented to the policy levels. This data could be used to establish a sentinel surveillance and formalize a heat warning collaboration with the Meteorological Department.

Key words: heat-related illness, climate change, heat stroke, Thailand

Introduction

Nowadays, morbidity and mortality attributable to heat related illnesses (HRI) has been increasing around the world while five of the most deadliest heat waves occurred in this century,[1] including the 2003 European heat wave[2] which claimed about 70,000 lives, 56,000 deaths in Russia during 2010, 10,000 deaths in United States during 1988, 3,418 deaths in Europe during 2006 and 2,541 deaths in India during 1998[3].[1] Although the impact of heat on health was well documented in developed countries, very few studies has focused in tropical climates countries.[4]

A thermoregulation system keeps core body temperature between 36.6-37.0°C. When thermoregulation is overcome by high ambient temperature, heat exhaustion can occur from excessive loss of water and electrolytes through sweating. Later, confusion, seizure, multiorgan failure and death may occur. This stage is called heat stroke. HRI is classified as heat stroke, heat exhaustion, heat rash and heat cramp.

Thailand is a tropical country in Southeast Asia with most people working as farmers in the agriculture industry.[5] There are three seasons in Thailand, rainy (mid-May to mid-October), winter (mid-October to mid-February) and summer (mid-February to mid-May).[6] The highest temperatures occur in April (average 34.5°C), with the lowest in December (average 23.5°C). The country has a single climate and time zone.

There are two reports of HRI in Thailand which were descriptive studies examining certain population such as soldiers who were admitted to a military hospital and school-aged children from grades 1-6 in Bangkok.[7-8] However, the overall national HRI prevalence and risk factors were still unknown.

Thailand has never experienced a heat wave.[9] Existing surveillance systems reported HRI in occupational and military settings. Illness of patients visiting public health facilities are reported through the National Health Reporting System (NHRS). However, the HRI situation was not aware or reported by the Ministry of Public Health (MOPH) as additional data extraction was time-consuming and expensive. This study aimed to describe HRI in Thailand and examine the usefulness of utilizing the NHRS for HRI.

Methods

We conducted a descriptive study using official health service utilization data from NHRS under the Bureau of Policy and Strategy, MOPH.

Study Population

The NHRS captures official health data from every public health care unit such as hospitals and health centers, except for the capital city of Thailand, Bangkok. These data are managed by the Bureau of Policy and Strategy. A separate reporting system is utilized in Bangkok which was integrated into the NHRS later and not available for this study.

Health centers in Thailand are small public clinics located in rural areas that provide only basic primary care and often lack capacity to offer laboratory services or admit patients overnight. Staff in health centers typically consist of non-medical health personnel (registered nurses, nurse's aides) who diagnose and treat patients. Bed capacity in public hospitals can range from 500 to 1,000, and offer specialists and sub-specialist services.

Data Sources

All health care visits are assigned a diagnosis codes using International Classification of Disease – 10 codes (ICD-10) by staff in health care units at health centers or hospitals. The staff in health care units electronically submit health services utilization data monthly to MOPH. These data are collected, cleaned and maintained by the Bureau of Policy and Strategy.

Heat-related visits in data of the Bureau of Policy and Strategy were identified by the ICD-10 codes of T67-67.9 for effects of heat and light. Data from 1 Jan 2010 to 30 Sep 2013 was obtained.

Health Outcome Variables

Individual records contained age, gender, level of highest completed education, occupation, ICD-10 codes, date of visit and name of health care unit.

Age was grouped into 10-year intervals. Health care units were grouped by official census regions and categorized either as health center or hospital, based on the status reported in MOPH records.

Data Analysis

We employed descriptive statistics and calculated incidence rate and case-fatality rate using number of visit with relevant ICD-10 codes from NHRS database and 2010-2013 provisional census denominators available from National Statistic Organization.[10] Data were analyzed using R version 3.1.2.[11]

Weather Data

Monthly data for 1996-2013 were obtained from the Ministry of Information and Communication Technology and the Meteorological Department in Thailand. Data available included spatial coordinates of weather stations, monthly highest and average temperature, and relative humidity. At least one weather station is located in 63 out of total 76 provinces in Thailand. However, for the other 13 provinces without a weather station, we used the Kriging interpolation with zonal statistic to estimate the monthly temperatures.[12] Heat index was calculated from average highest temperature and relative humidity, and reported in degree Celsius by using Steadman's equation[13] as below.

$$\begin{aligned} HI = & -42.379 + (2.04901523 \times T) + (10.14333127 \times R) \\ & - (0.22475541 \times T \times R) - (6.83783 \times 10^{-3} \times T^2) \\ & - (5.481717 \times 10^{-2} \times R^2) + (1.22874 \times 10^{-3} \times T^2 \times R) \\ & + (8.5282 \times 10^{-4} \times T \times R^2) - (1.99 \times 10^{-6} \times T^2 \times R^2) \end{aligned}$$

HI = Heat index (°C), T = Ambient temperature (°C), R = Relative humidity (%)

Results

During 2010-2013, there were 3,963 HRI visits and nine deaths reported. There were 1.7 visits per 100,000 person-year. Majority of them were Thai (97.9%) and Myanmar (0.7%). Median age was 43 years (interquartile range IQR = 22-61) and male to female ratio was 1:1.7. About 36% of the visits were the most vulnerable persons of those older than 65 years (20.9%) and younger than 14 years (15.3%). The highest visit incidence per 100,000 person-year were 3.8, 2.3 and 1.6 per 100,000 person-year for more than 65, 55-65 and 45-55 age groups respectively. Nearly half of the patients had primary school education, and over a third worked in agricultural, fishery and forestry. Most of the agricultural workers were female (63.7%). Most of the refuse workers and other elementary service workers were odd job persons (persons skilled in various odd jobs and other small tasks). Students also made up 13.5% of the visits. Other types of occupation included free-lance workers, sex workers, service and sale workers, housekeepers, parental supervision and retired government officers (Table 1).

The highest frequency of heat-related visit was in the northeastern census region. Rates in the northern and southern regions (9.3 and 8.7 per 100,000 population) were almost double when compared with that of the other census regions (5.3 and 5.1 per 100,000 population).

Stratifying across census regions revealed that variables were similar, except the fact that young age groups were prevalent in the northeastern region. The central region had the highest proportion of people with no education level (16.8%) and the lowest proportion of skilled agricultural workers (16.5%) when compared to that of the other three regions (Table 2).

Table 1. Characteristics of heat-related illness visits and incidence rate per 100,000 person-year, Ministry of Public Health, Thailand (excluding Bangkok), 2010-2013

	Visit (%)	Incidence rate per 100,000 person-year
Gender		
Male	1,490 (37.6)	
Female	2,471 (62.4)	
Education (n=3,790)		
None	401 (10.6)	
Elementary	352 (9.3)	
Primary	1,804 (47.6)	
Secondary	415 (10.9)	
Diploma and above	202 (5.3)	
Invalid codes	616 (16.3)	
Age (year)		
0-14	607 (15.3)	1.3
0-6	131 (3.3)	0.6
7-14	476 (12.0)	2.1
15-24	482 (12.2)	1.3
25-34	357 (9.0)	0.9
35-44	520 (13.1)	1.2
45-54	599 (15.1)	1.6
55-64	571 (14.4)	2.3
≥ 65	825 (20.9)	3.8
Occupation (n=3,953)		
Skilled agricultural, fishery and forestry workers	1,412 (35.7)	2.6
Market-oriented skilled agricultural, fishery and forestry workers	1411 (35.7)	N/A
Subsistence farmers, fishers, hunters and gatherers	1 (0.0)	N/A
Refuse workers and other elementary service workers	683 (17.3)	4.0
Refuse sorters	1 (0)	
Odd job persons	596 (15.1)	
Messengers, package and luggage porters, and deliverers	2 (0)	
Other elementary service workers	84 (2.2)	N/A
Students	533 (13.5)	1.0
Unemployed	417 (10.5)	N/A
Others	908 (23.0)	N/A
Census regions		
Northern	1,115 (28.1)	9.3
Southern	808 (20.4)	8.7
Northeastern	1,183 (29.9)	5.3
Central (exclude Bangkok)	855 (21.6)	5.1

The number of reported HRI visits increased over the study period. Heat index was the highest in April and May (Figure 1). HRI visits peaked in April and November almost every year, specifically in those provinces with the highest incidence rate per 100,000 person-year located in the northern and southern regions (Figure 2a). During 2010-2013, the national annual average temperature was 27.6°C and maximum temperature was 44°C in the northern region (Figure 2b). On average, humidity in Thailand was 76.1% during the study period while the highest relative humidity was 92% in the southern region. The highest maximum heat index was 50°C in the central region during May.

The overall national average heat index was calculated as 31°C. Areas with the highest heat index were in the central, southern and lower part of northern region in Thailand (Figure 2b). No extreme heat events were recorded during the study period.

While examining HRI visits by health units and census regions, more HRI visits were treated in health centers than hospitals across all census regions (Table 3). Females made up a greater proportion of the HRI visits at health centers compared to that of in hospitals across all census regions.

Table 2. Characteristics of heat-related illness visits by census regions and types of occupation, Ministry of Public Health, Thailand (excluding Bangkok), 2010-2013 (n=3,961)

Variable	Central (%) (n=855)	Northern (%) (n=1,115)	Northeastern (%) (n=1,183)	Southern (%) (n=808)
Number of province	26	17	19	14
Median age (IQR)	43 (23-56)	49 (29.8-62)	35 (16.8-51)	47 (24-63.3)
Age (year)				
0-14	100 (11.7)	132 (11.8)	247 (20.9)	128 (15.8)
0-6	27 (3.2)	29 (2.6)	49 (4.1)	26 (3.2)
7-14	73 (8.5)	103(9.2)	198 (16.8)	102 (12.6)
15-24	120 (14.0)	92 (8.2)	198 (16.8)	72 (8.9)
25-34	88 (10.3)	90 (8.1)	120 (10.1)	59 (7.3)
35-44	115 (13.4)	129 (11.6)	168 (14.2)	108 (13.4)
45-55	150 (17.5)	192 (17.2)	140 (11.8)	117 (14.5)
55-64	110 (12.9)	224 (20.1)	119 (10.1)	118 (14.6)
≥65	172 (20.2)	256 (23.0)	191 (16.1)	206 (25.5)
Gender				
Male	353 (41.3)	417 (37.4)	472 (39.9)	248 (30.7)
Female	502 (58.7)	698 (62.6)	711 (60.1)	560 (69.3)
Education (n=3,790)				
None	135 (16.8)	92 (8.5)	92 (8.1)	82 (10.7)
Elementary	64 (8.0)	164 (15.1)	80 (7.1)	44 (5.7)
Primary	339 (42.2)	505 (46.6)	536 (47.2)	424 (55.2)
Secondary	85 (10.6)	99 (9.1)	155 (13.6)	76 (9.9)
≥ Diploma	32 (4.0)	53 (5.0)	58 (5.1)	59 (7.7)
Invalid codes	148 (18.4)	170 (15.7)	215 (18.9)	83 (10.8)
Occupation (n=3,953)				
Skilled agricultural, fishery and forestry workers	141 (16.5)	413 (37.1)	512 (43.5)	346 (42.9)
Refuse workers and other elementary service workers	242 (28.3)	225 (20.2)	111 (9.4)	105 (13.0)
Students	104 (12.2)	113 (10.2)	217 (18.4)	99 (12.3)
Unemployed	78 (9.1)	107 (9.6)	123 (10.4)	109 (13.5)
Others*	290 (33.9)	255 (22.9)	216 (18.3)	147 (18.3)

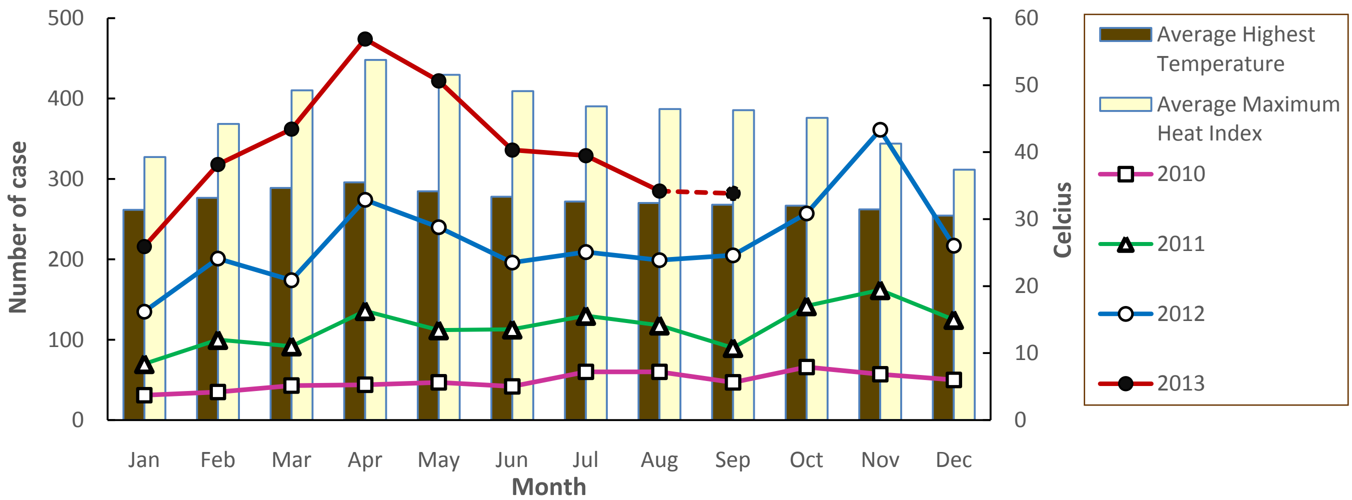

Figure 1. Heat-related illness visits by months, Ministry of Public Health, Thailand (excluding Bangkok), 2010-2013 (n=3,859)

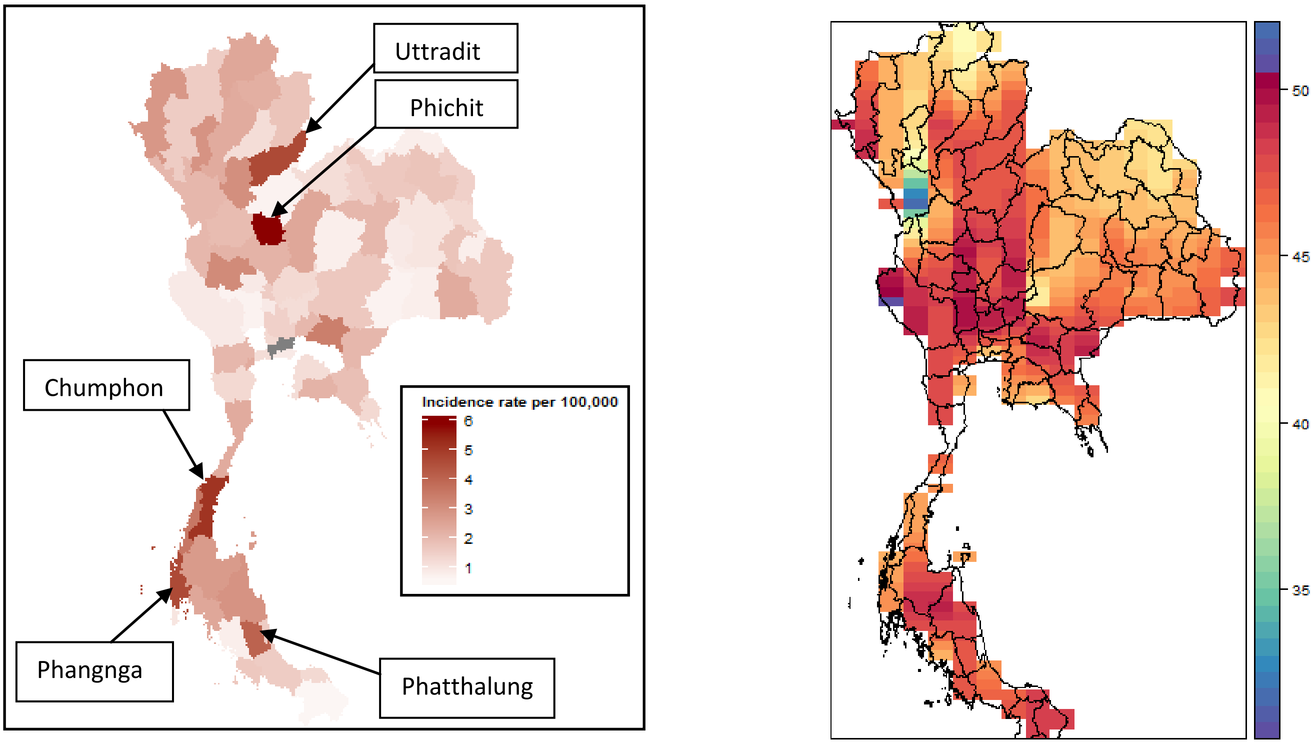

Figure 2. (a) Incidence rate per 100,000 person-year by provinces in Thailand (excluding Bangkok), 2010-2013 (n=3,961) (b) Average maximum heat index (°C) by provinces in Thailand, 2010-2013

Data Quality: HRI Diagnoses, Occupation and Invalid Codes

Staff in health centers diagnosed nearly 60% of all HRI visits as heat stroke (Table 4). Of 1,600 visits of heat stroke diagnosed at health centers, five died, yielding a case fatality rate of 0.3% of all heat stroke visits. In contrast, hospitals reported a variety of HRI without any death (Table 4).

In September 2011, we noted refuse workers and elementary service workers visited for HRI as the first time, and decrease in HRI visits among skilled agricultural workers (Figure 3). Invalid and missing educational codes were noted from all reporting regions and hospitals (Tables 2-3). Overall, education variable had the highest proportion of invalid codes, increased from 8.6% in 2010 to 22.8% in 2013.

Discussion

This was the first study to examine human health impact of environmental heat throughout Thailand, excluding Bangkok. Frequency of HRI visits increased with a few deaths. Incidence rates were varied across geographical regions and could not be fully explained by temperature. Majority of visits were female, and agricultural and elementary workers.

Majority of female identified among agricultural workers was the opposite finding to most of other HRI studies[14]. This was interesting given the fact that male farmers were two times more than female farmers in Thailand[15]. Previous literature noted that females might have less tolerance to heat exposure[16]. Other reason could be the time they spent outside for working, including informal work often intertwined with their household duties and awareness of HRI signs and symptoms.

Maximum heat index is the strongest weather parameters with positive correlation to HRI[17,18]. Despite that, heat index alone could not explain the increasing trends and seasonal patterns of HRI over the study period since temperature and heat index trends remained stable and the HRI rate went up while the temperature went lower in the early winter. Cultural activity might explain this phenomenon as several studies found occurrence of HRI among mass gatherings and festivals[19,20]. Thai people generally gather in summer for the tradition of New Year festival and also planting. Harvesting begins in winter and the intensity of the labor might explain the second HRI peak in November.

Another consideration of the HRI visit pattern could be variability of the ambient temperature. The northeastern region, despite having the highest agriculture activity[21], reported the low HRI rates. The northern and southern regions reported the first and the second highest rates even though these regions had less agricultural activity than the northeastern region. However, the northern and southern regions Did experience the higher temperature variability as well.[22]

Table 3. Characteristics of heat-related illness visits by census regions and types of health care unit, Ministry of Public Health, Thailand (excluding Bangkok), 2010-2013

	Central		Northern		Northeastern		Southern	
	Health Center (%)	Hospital (%)	Health Center (%)	Hospital (%)	Health Center (%)	Hospital (%)	Health Center (%)	Hospital (%)
Total units	2,566	301	2,239	218	3,474	334	1,515	175
Total visits	540	283	858	245	742	405	673	109
Median age (IQR)	47 (28-60)	44 (24-61)	49 (27-61)	49 (28.8-61)	32 (14-53)	39 (18-57)	50 (28-66)	48 (25-65)
Age (year)								
0-14	60 (11.1)	32 (11.3)	102 (11.9)	28 (11.4)	189 (25.5)	53 (13.1)	96 (14.3)	22 (20.2)
0-6	17 (3.2)	8 (2.8)	22 (2.6)	6 (2.5)	41 (5.5)	7 (1.8)	24 (3.6)	2 (1.8)
7-14	43 (7.9)	24 (8.5)	80 (9.3)	22 (8.9)	148 (20.0)	46 (11.3)	72 (10.7)	20 (18.4)
15-24	63 (11.7)	55 (19.4)	58 (6.7)	34 (13.9)	117 (15.8)	72 (17.8)	47 (7.0)	20 (18.4)
25-34	51 (9.4)	34 (12.0)	65 (7.6)	24 (9.8)	65 (8.7)	50 (12.3)	46 (6.8)	11 10.1)
35-44	74 (13.7)	39 (13.8)	101 (11.8)	26 (10.6)	96 (12.9)	68 (16.8)	91 (13.5)	13 (11.9)
45-54	104 (19.2)	41(14.5)	147 (17.1)	42 (17.2)	84 (11.3)	53 (13.1)	103 (15.3)	12 (11.0)
55-64	84 (15.6)	21 (7.4)	182 (21.2)	39 (15.9)	77 (10.4)	38 (9.4)	105 (15.6)	12 (11.0)
≥ 65	103 (19.3)	61 (21.6)	203 (23.7)	52 (21.2)	114 (15.4)	71 (17.5)	185 (27.5)	19 (17.4)
Gender								
Male	212 (39.3)	131 (46.3)	293 (34.2)	118 (48.2)	280 (37.7)	177 (43.7)	186 (27.6)	53 (48.6)
Female	328 (60.7)	152 (53.7)	565 (65.9)	127 (51.8)	462 (62.3)	228 (56.3)	487 (72.4)	56 (51.4)
Education								
None	77 (14.8)	56(22.2)	67 (7.9)	24 (10.7)	52 (7.2)	38 (10.2)	66 (10.2)	14 (14.3)
Elementary	55 (10.6)	6 (2.4)	151 (17.8)	13 (5.8)	64 (8.8)	15 (4.0)	38 (5.9)	4 (4.1)
Primary	285 (54.8)	46 (18.3)	456 (53.8)	41 (18.3)	436 (60.0)	84 (22.5)	399 (61.6)	13 (13.3)
Secondary	55 (10.6)	22 (8.7)	73 (8.6)	25 (11.2)	96 (13.2)	55 (14.7)	66 (10.2)	8 (8.2)
Diploma and above	19 (3.6)	10 (4.0)	34 (4.1)	18 (8.0)	30 (4.1)	21 (5.6)	50 (7.7)	6 (6.1)
Invalid codes	29 (5.6)	112 (44.4)	66 (7.8)	103 (46.0)	49 (6.7)	161 (43.0)	29 (4.4)	53 (54.0)

Remark: missing data 106 records for health care unit and 65 records for education

Table 4. Diagnosis codes of heat-related illnesses reported by health care units, Ministry of Public Health, Thailand (excluding Bangkok), 2010-2013

ICD diagnosis code	Health center		Hospital	
	Visit (%)	Death	Visit (%)	Death
T67 Effects of heat and light	42 (1.5)	0	10 (1.0)	0
T67.5 Heat exhaustion	1 (0)	0	0 (0)	0
T67.0 Heat stroke and sun stroke	1,600 (57.1)	5	198 (19.1)	0
T67.1 Heat syncope	187 (6.7)	1	388 (37.3)	0
T67.2 Heat cramp	340 (12.1)	0	89 (8.6)	0
T67.3 Heat exhaustion, anhidrotic	106 (3.8)	1	6 (0.6)	0
T67.4 Heat exhaustion	39 (1.4)	0	2 (0.2)	0
T67.5 Heat exhaustion, unspecified	80 (2.9)	0	30 (2.9)	0
T67.6 Heat fatigue transient	137 (4.9)	1	228 (21.9)	0
T67.7 Heat edema	198 (7.0)	1	20 (1.9)	0
T67.8 Other effects of heat and light	32 (1.1)	0	27 (2.6)	0
T67.9 Effects of heat and light, unspecified	42 (1.5)	0	41 (3.9)	0
Total	2,804	9	1,039	0

Remark: missing data 109 records for health unit

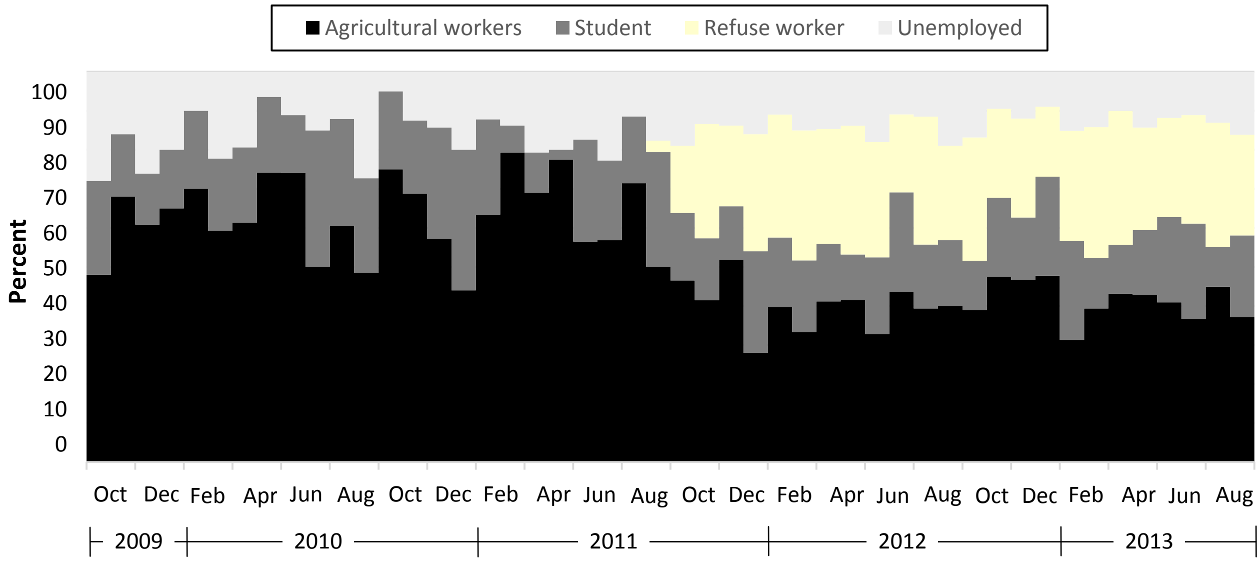

Figure 3. Proportion of heat-related illnesses by most common reported occupation, Thailand (excluding Bangkok), 2010-2013 (n=2,776)

Data Quality

We questioned the accuracy of heat stroke diagnoses in the data set for two reasons. First, heat stroke is a severe disease with very high case fatality rate (10-35%) while the result showed 0.3% which was surprising, especially as most of these were reported from health centers. Secondly, it was likely that staff in health centers had less experience and training to differentiate among various types of HRI such as heat exhaustion and heat fatigue, and might miscode them as heat stroke. Although the heat stroke visits were probably over diagnosed, these diagnoses provided strong evidence that heat contributed significantly to the reason for the patients' visit.

In addition, the mortality data did not include people who died at home or outside hospitals and might underestimate the number of heat-related deaths.

Limitations

There were several limitations to this study. Our data source collected information from only the public health care units. Private clinics and hospitals are not required to report health data to MOPH. This likely had little impact on our findings as majority of private health units are located in Bangkok which was not included in this study. Although 12% of population resided in Bangkok, one of the previous HRI studies that examined urban cities in Thailand[23] reported more HRI in rural area[24]. Bangkok population was excluded for calculating rates in this study as a separate system is used for reporting in Bangkok, which was not available for our study.

This study use number of visit, instead of number of illness episode, as numerator for calculating incidence rate since unavailability of patient identification in the database. However, HRI is acute disease with very short illness duration and able to recur. It is unlikely that patients will seek care from multiple hospitals, were being recorded as multiple visits and can still get HRI again. Therefore, number of visit should acceptably represent number of illness episode using visit in the calculation and would not substantially overestimate the incidence rate of HRI in this study.

Recommendations

To improve management, outcomes and reporting of HRI, the MOPH should provide training for staff in health centers, including training on diagnosis of heat stroke. The provinces with the highest HRI rates should be targeted during peak seasons using simple reminders or refresher courses.

Public education or health campaigns on HRI signs, symptoms, protection and first aid should be encouraged among agricultural, odd job and elementary service workers because HRI is preventable and treatable even without accessing a health center or hospital. Majority of HRI patients in our study reported having had at least primary school education. Therefore, Thai government could request to include HRI messages in existing projects such as agricultural, water and sanitation hygiene (WASH), health and climate change.

Consideration for a Heat Warning System

Heat warning system is an important intervention to alert citizens for dangerous levels of heat, especially for those working outdoor such as agricultural workers. The exact threshold for Thai heat warning was needed to be examined using human health data and daily weather patterns in the various provinces. The recent deadly heat wave in India demonstrated the need for alerting public on the danger of heat.[25]

Collaboration among the Ministry of Information and Communication Technology, the Meteorological Department and the MOPH was necessary. The Meteorological Department has access to the forecasted weather information and should have the authority to issue and disseminate heat warning to health centers and local NGOs.

Findings of this study initiated discussions on collaboration to conduct a HRI cohort study and establish sentinel surveillance in provinces with high HRI rates. The objectives would be to gather additional essential information which was not collected by the NHRS such as behaviors, locations of HRI and types of activity. Data captured by these projects would be of better quality, more detailed and ultimately more useful to understand HRI risk factors and achieve better data quality in order to define a temperature threshold for Thailand.

Conclusion

This was the first study of national data to report and describe HRI in Thailand. HRI is an important public health issue because during the 3-year study period, the trend appeared to be increasing, and disproportionate number of women and those with low socio-economic status seemed to be affected.

The study findings had been well received by the policy makers, including Deputy Permanent Secretary of MOPH and Director of Bureau of Occupational and Environmental Diseases, and actions had been supported. A sentinel surveillance establishing plan was proposed in collaboration with the Meteorological Department in order to formalize a heat warning system. This study should encourage other tropical countries to explore their available health data to examine if they could identify and track heat-related illnesses in their country as well.

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