



## Outbreak of Human *Streptococcus suis* Cases in Chum Phuang District, Nakhon Ratchasima Province, Thailand, 2018

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### Abstract

*Streptococcus suis* (*S. suis*) is a major public health problem in northeastern Thailand. On 17 Apr 2018, the Office of Disease Prevention and Control 9 received a notification of five patients with *S. suis* infection in Chum Phuang District, Nakhon Ratchasima Province. We investigated to confirm the etiology, describe the epidemiological characteristics, and identify the source of this outbreak. Medical records and laboratory results at the district and provincial Hospitals were reviewed. We interviewed family members and people who shared meals with cases. We surveyed slaughter processes at two implicated slaughterhouses. Surveillance for *S. suis* cases was also enhanced. Six confirmed cases of *S. suis* serotype 2 infection were found in six sub-districts of Chum Phuang District between 1 Jan and 20 Apr 2018. Clinical presentations of confirmed cases were fever (100%), headache (50%) and hearing loss (50%). Five of the six cases ate raw pork with an average incubation period of 2.3 days. Those who ate raw pork were more likely to get infected (RR = 13.5, 95% CI = 1.7-105.1). One from 27 specimens identified *S. suis* serotype 7 from a slaughterhouse in Chum Phuang District. The outbreak continued with an additional 14 confirmed cases in province during the monitoring period from 20 Apr to 25 Jul 2018. Increasing health awareness of the public and physicians beyond ensuring proper management in slaughterhouses should be strengthened.

**Keywords:** *Streptococcus suis*, zoonosis, outbreak, raw pork, slaughterhouses, Thailand

### Introduction

*Streptococcus suis* (*S. suis*) is a Gram-positive, facultative anaerobic bacteria that causes meningitis, septicemia, and arthritis in pigs. There are 33 serotypes and serotype 2 is the most frequently isolated.<sup>1,2</sup> *S. suis* is a zoonotic pathogen that causes invasive infections in humans and is always caused by *S. suis* serotype 2. Most infections are associated with close contact with infected pigs or contaminated pork-derived products. *S. suis* is likely to be due to translocation across the intestines of human hosts who have liver disease and/or consume alcohol. The bacteria can be cultured from cerebrospinal fluid or blood, and serotypes could be identified by multiplex polymerase chain reaction (PCR).<sup>3</sup> However, culture results can be negative as a result of antibiotic use before the collection of specimens. Many reports come from countries where pig raising and pork processing

are of great importance.<sup>4</sup> The average incubation period ranges from a few hours up to 2.2 days with some lasting up to 14 days.<sup>5,6</sup>

*S. suis* has been a major public health problem in Thailand, especially in the northern and northeastern regions. The main route of infection in humans in these areas is by ingestion due to consumption of raw pork and meat products. In a retrospective study in 2006-2008 in northern Thailand, *S. suis* infection was confirmed by blood culture or cerebrospinal fluid specimens from 179 patients who had close contact with infected pigs or contaminated pork-derived products. Human infection with serotype 2 was the most common (92%) with a case fatality of 9.5%.<sup>7</sup>

Nakhon Ratchasima Province is the biggest province in the northeastern region of Thailand<sup>8</sup> that reported many cases of *S. suis*. On 17 Apr 2018, the Office of Disease Prevention and Control 9 received notification

from Nakhon Ratchasima Provincial Health Office of five patients with *S. suis* infection in the same district. The objectives of this investigation were to confirm the etiology, describe the epidemiological characteristics, and identify the source of this outbreak.

## Methods

### Confirmation of the Outbreak and Risk Factors Identification

We reviewed the National Notifiable Disease Surveillance System (R506) during 2010-2017 in order to confirm the outbreak and identify risk factors. Physicians and laboratory technicians at Maharat Nakhon Ratchasima Hospital and Chum Phuang District Hospital were interviewed to confirm the diagnoses and determine their laboratory methods. Medical records and laboratory results at the district and provincial hospitals were reviewed.

A suspected case was defined as any patient diagnosed with unspecified meningitis, unspecified septicemia, or unspecified hearing loss and lived in Chum Phuang District during 1 Jan to 20 Apr 2018. A confirmed case was defined as a patient with laboratory confirmation of *S. suis* infection by PCR method at a standard laboratory. Active case finding was conducted through review of medical records and laboratory results at Maharat Nakhon Ratchasima Hospital and Chum Phuang District Hospital. Family members and neighbors of the infected cases were interviewed to identify new cases.

Following a retrospective cohort design, a group of people was formed from family members, neighbors and people who shared meals with the reported cases during the previous two weeks. Persons who may have been exposed to contaminated food items related with the reported cases were also recruited. We interviewed the reported cases and involved people previously described using a structured questionnaire. Variables collected included demographic characteristics, risk factors, clinical manifestation and laboratory results. Analysis of potential risk factors of *S. suis* infection was performed by calculating the risk ratio (RR) with a 95% confidence interval (CI). The consumption of raw pork was divided into 4 ordinal categories, including not eating, tasting, eating normally and eating until full. The association was explored using a chi-square test for trend. Potential risk factors were analyzed by univariate method and all potential risk factors were included in the multivariate logistic regression analysis.

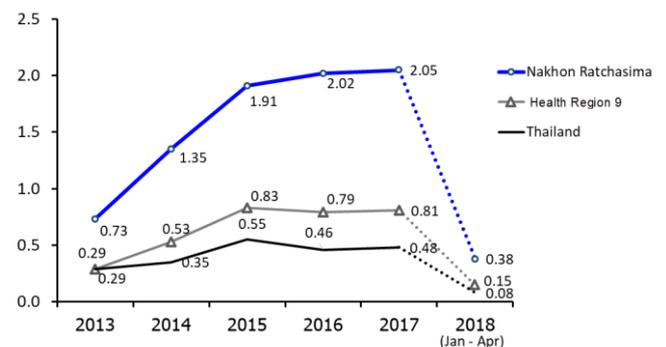
## Environmental Study

Two implicated slaughterhouses in Chum Phuang District were surveyed for slaughtering processes. Specimens collected at these slaughterhouses included tonsil glands, raw pork meat and blood of live pigs before being slaughtered and sent to the Veterinary Research and Development Center of Lower Northeastern Region), Surin Province, for PCR testing to identify *S. suis* serotypes.

## Results

### Situation of *Streptococcus suis* Infection

Nakhon Ratchasima Province is one of the four provinces in Health Region 9. As shown in Figure 1, the rate of *Streptococcus suis* infection per 100,000 population identified in Nakhon Ratchasima Province was higher than the situation reported by Health Region 9 and the whole country. There were 239 cases (attack rate 9.0 per 100,000 population) and 23 deaths from *S. suis* infection reported in Maharat Nakhon Ratchasima Hospital during 2010-2017. Peaks occurred during April and June every year. Patients aged over 65 years had a significantly higher risk of death. In 2017, there were 53 cases (attack rate 2.0 per 100,000 population). The highest number of cases was from Muang District, with 10 cases (attack rate 4.6 per 100,000 population) but there was only 1 case in Chum Phuang District (attack rate 1.3 per 100,000 population).



**Figure 1. Situation of *Streptococcus suis* infection in Nakhon Ratchasima Province, Health Region 9, and Thailand, 2013-2018 (rate per 100,000 population)**

Note: Data source: Office of Disease Prevention and Control Region 9 (ODPC9)

### Description of the Outbreak

From the active case finding, in total we found six confirmed cases of *S. suis* infection during 1 Jan to 20 Apr 2018. All cases were distributed in six separate sub-districts out of a total of nine sub-districts in

Chum Phuang District. The morbidity rate in Chum Phuang District was 9.9 per 100,000 population. No death was reported. The index case was found on 1 Apr 2018 and the primary case was found on 7 Mar 2018. All six confirmed cases ate pork from a different place, but their symptoms occurred during the same time period. Table 1 shows details of the six confirmed cases. Five of the six cases ate raw pork and had an average incubation period of 2.3 days (range 1–7 days). Most cases were farmers (40.3%).

All confirmed cases were positive for *S. suis*, including one case by cerebrospinal fluid culture, three cases by blood culture, and two cases by both blood and cerebrospinal fluid culture. All specimens contained *S. suis* serotype 2. The median age of cases was 56.5 years (range 46-68 years). All cases were male and current drinkers. All cases were admitted to Maharat Nakhon Ratchasima Hospital. Clinical presentations of confirmed cases included fever (100.0%), headache (50.0%), hearing loss (50.0%), myalgia (50.0%), stiffness of neck (50.0%) and signs of shock (16.7%).

From the patient interviews, all said that they recently ate raw or semi-cooked pork products. Two bought raw pork at Chum Phuang fresh market while four bought

cooked pork from barbeque restaurant or at local mobile food vendors. Further investigations revealed that three of the six cases ate raw pork that came from two slaughterhouses (A and B) located in Chum Phuang District.

### Identification of Risk Factors

A total of 63 persons were enrolled in the retrospective cohort study, including the six confirmed cases, one suspected case and 55 non-cases. The male to female ratio was 1:1 and the median age was 46 years (range: 5 months - 73 years).

From bivariate analysis, eating raw pork was a significant risk factor with a risk ratio (RR) of 13.5 (95% CI = 1.75-105.1,  $p = 0.001$ ), as shown in Table 2. There was a positive dose-response relationship between the amount of raw pork eaten and being ill (test for trend:  $p$ -value = 0.002). The results of the multiple logistic regression analysis are shown in Table 3. After adjusting for gender and alcohol consumption, those who ate raw pork were 15.0 times more likely to have confirmed *S. suis* infection compared to those who did not (% CI=1.55-144.8).

**Table 1. Confirmed *Streptococcus suis* cases during 1 Jan to 20 Apr 2018 in Chum Phuang District, Nakhon Ratchasima Province**

No.	Case	Place	Onset	Date of exposure	Type of food	Source of food	Source of raw material
1	Male 46 yr.	Chum Phuang	07/03/2018	06/03/2018	BBQ Pork	K BBQ pork restaurant	Makro super market
2	Male 52 yr.	Pasuck	28/03/2018	27/03/2018	Raw pork salad	Chum Phuang fresh market	Slaughterhouse A
3	Male 53 yr.	Talad	28/03/2018	27/03/2018	Raw pork salad	Chum Phuang fresh market	Slaughterhouse A
4	Male 59 yr.	Nonyoo	31/03/2018	28/03/2018	Raw pork salad with pork blood	Mobile market A	Unknown
5	Male 61 yr.	Nonglak	01/04/2018	24/03/2018	Raw pork salad	Mobile market B	Slaughterhouse B (Bangyai District)
6	Male 68 yr.	Noonrang	01/04/2018	Almost every day	Raw pork salad	Fresh market in the village	Slaughterhouse C

**Table 2. Bivariate analysis of risk factors for *Streptococcus suis* infection in Nakhon Ratchasima Province, 2018 (n=63)**

Exposure factor	Exposure			Non-exposure			Risk ratio	95%CI	
	Case	Non case	Attack rate	Case	Non case	Attack rate		Lower	Upper
Eating raw pork vs not eating raw pork	6	13	31.6%	1	43	2.33%	13.5	1.75	105.1
Male	6	25	19.3%	1	31	3.1%	6.2	0.79	48.52
Alcohol consumption	6	24	20.0%	1	32	3.0%	6.6	0.84	51.7
Smoking	4	16	20.0%	3	40	7.0%	2.87	0.70	11.6

**Table 3. Multivariate analysis of risk factors for *Streptococcus suis* infection in Nakhon Ratchasima Province, 2018**

Risk Factor	Adjusted OR	95% CI
Male	3.71	(0.25-55.72)
Alcohol consumption	2.18	(0.14-33.88)
Raw pork consumption	14.96	(1.55-144.81)

### Environmental Survey

Four slaughterhouses situated close to the outbreak area were investigated, of which two (A and B) were located in Chum Phuang District. We observed the environments and slaughter processes (Figure 2) with the following results.

Slaughterhouse A had 5 employees who started working at 8 PM. Around 7-10 pigs were usually killed per session.

#### Process in slaughterhouse A:

1. The pigs are marshaled at the front of the slaughterhouse.
2. The pigs walk into slaughterhouse.
3. Inside the slaughterhouse, the pigs are stunned with an electrical current until they are unconscious.
4. The pigs are hoisted on a rail and hung head-down before killing them with a stabbing knife and exsanguinations occurs.

5. The pigs are put in a rolling machine under boiling water to remove the hairs from the skin.

6. After removal from the boiler, the pigs are placed on a cutting board to remove the head and slit the testicles. The pigs are then sent for dissection.

In slaughterhouse B, there were 2 employees who worked from 6 PM to 6 AM. One pig is killed per session.

#### Process in slaughterhouse B:

1. The pig is stunned by hitting it on the head three times.
2. While the pig is lying on its side, its throat is pierced and one of the employees steps on the pig to push the blood out.
3. The pig is boiled to remove the hairs from the skin.
4. One of the employees steps on the pig for assistance with evisceration.
5. The employees dissect the pig on a big wooden block.



**Figure 2. Pig slaughtering process in a slaughterhouse, Chum Phuang District, Nakhon Ratchasima Province, 2018**



**Figure 3. Slaughtering process in a slaughterhouse, Chum Phuang District, Nakhon Ratchasima Province, 2018**

**Laboratory Results**

We collected 25 raw pork specimens including fresh blood, tonsil, and skin from four pigs. Two samples were collected from prepared pork salads that were processed in two slaughterhouses in Chum Phuang District. *S. suis* serotype 7 was found by PCR in one of five (20%) collected tonsil specimens. All raw pork salads and whole blood from live pigs were negative (Table 4).

**Table 4. Raw pork specimen results in Chum Phuang District, Nakhon Ratchasima Province, 2018**

Place	Number of specimens			Laboratory result
	Blood	Tonsil	Skin	
Slaughterhouses	5	5	15	1 tonsil specimen positive for <i>Streptococcus suis</i> serotype 7
Market	2	-	-	Negative

**Discussion**

Six confirmed cases of *S. suis* infection were identified in Chum Phuang District between 1Jan to 20Apr 2018.

All cases consumed raw pork before becoming ill. All confirmed cases lived in different sub-districts and they ate pork from different sources. Though eating raw pork was a risk factor for infection, the source of infection could not be identified. Pig specimens obtained from implicated slaughterhouses was found to be serotype 7.

The outbreak of *S. suis* serotype 2 was similar to previous outbreaks in Thailand, resulting from the consumption of raw pork meat or blood. No case was found in swine farmers or butchers.<sup>9</sup> For one case, we suspected that his illness came from eating barbeque pork. Although *S. suis* is easily destroyed by heat, it should be cooked at a temperature of at least 70° C for at least 10 minutes.<sup>2</sup> In this outbreak all cases ate raw pork, and the specimens of confirmed cases were due to serotype 2. Recently, epidemiological investigations proposed that pigs in slaughterhouses could be a major reservoir of *S. suis* serotype 2 with a capacity to cause human infections, but in this outbreak the pig specimens were found to be serotype 7. Previous studies reported that out of 33 serotypes of *S. suis*, serotype 2 was the most frequently isolated in humans. However, human cases of serotypes 1, 4, 5, 14, 16 and 24 have also been reported.<sup>9,10</sup>

It is unlikely that source of the outbreak was the same pig since the six cases all lived in different sub-districts. Eating raw pork is a cultural norm in northeastern Thailand, and most villagers do not know that eating raw pork increases the risk of illness. This study suggests that the raw pork products consumed by most of the cases were contaminated with *S. suis*. In Chum Phuang District, most raw pork products are supplied from local slaughterhouses to the local markets. A recent study of *S. suis* serotype 2 infection reported that slaughterhouse pigs were the source of

infection in southern Vietnam.<sup>14</sup> A previous study in Hong Kong reported that an increase in bacterial density of *S. suis* in raw pork meats in local markets occurs in hot and humid weather.<sup>15</sup> The poor quality of food safety control for raw pork products at the local markets was likely to provide the sources of this infection.

The first report of *S. suis* infection was in Denmark in 1968 and the mode of transmission was thought to be direct contact.<sup>11</sup> In 2005, a large outbreak occurred in Sichuan Province of China, with 215 cases and 62.3% deaths due to streptococcal toxic shock syndrome.<sup>12</sup> In Thailand in 1987, the first cases of *S. suis* infection was reported related to raw pork product consumption. Since, then over 200 cases have been reported per year in Thailand. In Nakhon Phanom Province of northeastern Thailand among 38 hospitalized cases during 2006-2012, 85% had meningitis and 54-80% suffered from hearing loss after recovery.<sup>13</sup> The clinical characteristics of *S. suis* infection were similar in patients with bacterial meningitis caused by other microorganisms, such as *N. meningitis* and *S. pneumoniae*. However, the mortality associated with *S. suis* meningitis was lower than that with bacterial meningitis caused by other pathogens.<sup>19</sup> Skin rash, distal necrosis, jaundice, and renal failure were observed in a number of patients. These symptoms and signs were also observed during the outbreak of *S. suis* infection in China during 2005 and were suggested to form part of a streptococcal toxic shock syndrome.<sup>11</sup> The most striking feature of *S. suis* meningitis is the progressive hearing loss, resulting in mild-to-severe deafness in two-thirds of patients. The pathogenesis of the hearing loss in *S. suis* meningitis is unknown. Studies in guinea pigs have shown direct invasion of the cochlea by *S. suis*.<sup>10</sup> In this investigation, half of confirmed cases also had hearing loss.

### Limitations

Suspected foods could not be collected as most patients were investigated after three weeks of developing symptoms. Information about pork eating behaviors and symptoms may be subject to recall bias. As a result, we could not link the cases with the meat vendors or the slaughterhouses. Moreover, we could not collect implicated pork samples and there was a lack of information about the health of the pigs in this area.

### Actions Taken

Health education on *S. suis* infection and warnings to avoid eating raw pork were provided through

community radio stations, village broadcast and posters. Training workshops to refresh the knowledge of this disease to health care workers were organized in Chum Phuang Hospital. Group discussion sessions were held in villages with patients, staff from district health departments and primary health care units. District livestock officers randomly check raw pork products in Chum Phuang District every 6 months to detect *S. suis*.

Surveillance for *Streptococcus suis* cases was enhanced for one month after the investigation took place. For patients who had signs of systemic inflammatory response syndrome, Hospital staff would collect specimens for laboratory testing and ask about the history of eating or contact with raw pork and report to the Surveillance and Rapid Response Team. From the Hospital-based surveillance we found two cases were diagnosed with *S. suis* having history of eating raw pork and having signs of systemic inflammatory response syndrome. These patients were referred to Maharat Nakhon Ratchasima Provincial Hospital.

### Monitoring the Disease Situation

After this outbreak investigation, the local team continued to monitor the disease situation in Maharat Nakhon Ratchasima Provincial Hospital. They found no new cases in Chum Phuang District but 14 cases, including five deaths, were confirmed in Nakhon Ratchasima Province from other districts between 20 Apr and 25 Jul 2018. It was likely that in Chum Phuang District, villagers were more aware about *S. suis* infection than people from the other Districts, who were still eating raw pork, as reported by all 14 cases. All cases were confirmed to have *S. suis* serotype 2. The median age of the cases was 59 years (range 34-95 years). The common symptoms were fever (93.8%), muscle pain (87.5%) and headache (75.0%).

After the Chum Phuang outbreak we monitored and collected 51 raw pork specimens including fresh blood, tonsil, and skin from three slaughterhouses in Nakhon Ratchasima Province. Two tonsil specimens tested positive to *S. suis* serotype 2. Three samples of blood, tonsil, and skin were found to have an unidentified serotype of *S. suis*.

### Recommendations

The provincial public health office should advise people to stop eating raw pork meat and blood and provide health education in areas where this type of food is sold. Chum Phuang Hospital should develop a

monitoring program for *S. suis* infection. When detecting patients who have any symptoms after eating raw pork meat or blood in hospitals, tests for *S. suis* should be done immediately. Behavioral studies of eating raw pork in communities are recommended for Thailand. Slaughterhouses should follow the recommended guidelines<sup>16,17</sup> in the transportation, pre-slaughter and slaughter processes to reduce the spread of infection.

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### Suggested Citation

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