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Field Epidemiology Training Program, Division of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625903894, Fax: +6625903845, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Behavioral and Environmental Factors Associated with an Influenza Outbreak in a Prison of Thailand

Suphanat Wongsanuphat[1]*, Thanachol Wonghirundecha[1], Peewara Boonwisat[1], Kawinna Kerdsalung[1], Kritchavat Ploddi[2], Itsarate Sawangjaeng[2], Kanchana Kongcha[3], Supaporn Midtrapanon[3], Pimthai Ananthawan[4], Thitipong Yingyong[1], Panithee Thammawijaya[1]

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

2 Office of Disease Prevention and Control 7, Khon Kaen Province, Department of Disease Control, Ministry of Public Health, Thailand

3 Roi Et Provincial Public Health Office, Ministry of Public Health, Thailand

4 Ministry of Justice, Thailand

*Corresponding author, email address: at_acoustic@hotmail.com

Abstract

Influenza is a highly contagious disease. Due to a high number of reported cases with influenza-like illnesses in a prison, a joint investigation by the Department of Disease Control and local public health teams was conducted to confirm the reports and implement control measures. Suspected influenza cases were defined as a prison inmate or an officer who developed fever with coughing and/or a sore throat. A confirmed case was a suspected case that had a nasopharyngeal swab testing positive for influenza by RT-PCR. The prison environment and health practices were observed. A retrospective cohort study was conducted to determine factors associated with influenza diagnosis. The overall attack rate was 12.7% (326/346) and 16 out of 19 tested positive for influenza A (H1N1) pandemic 2009. Vaccine effectiveness among prisoners who had history of influenza vaccination more than or equal to 2 weeks and less than 2 weeks prior to the outbreak was 25.9% and 13.8%, respectively. Sleeping near a case (adjusted odds ratio (OR) = 3.60, 95% confidence interval (CI) = 1.62-8.00), working near cases (adjusted OR = 3.39, 95% CI = 1.59-7.22), and sharing cigarettes with other cases (adjusted OR = 2.46, 95% CI = 1.15-4.56) were significant risk factors. A strong correlation between attack rate in each area and inmate density was found (r = 0.68, *p*-value = 0.025). Rapid transmission and high attack rates were probably attributed to overcrowded conditions. Expanded provision of vaccination in prisons should be implemented.

Keywords: influenza A (H1N1) 2009, influenza-like illness, vaccine effectiveness, prison, inmate

Introduction

Seasonal influenza represents a year-round disease burden. It causes illnesses that range in severity and sometimes leads to hospitalization and death.[1] In 2018, thirty-seven influenza outbreaks were reported to the Department of Disease Control (DDC), Ministry of Public Health. Of those, prisons are the most common place.[2] Among outbreaks reported from prisons, influenza ranks the highest in magnitude.[2] In addition, morbidity and case fatality rates of influenza in prisons are also higher than in the community.[2]

On 1 Aug 2018, the DDC was notified of an outbreak in a Thai prison in the northeastern region involving nearly 200 prisoners with influenza symptoms. The DDC, Office of Diseases Prevention and Control 7, and the Provincial Health Office conducted an investigation during 7 to 9 Aug 2018. The objectives of the investigation were to confirm the outbreak, to describe its epidemiological characteristics, to determine the risk factors associated with influenza sickness and to control the outbreak.

Methods

We undertook a descriptive study of all

prisoners and staff in the prison to identify anyone with influenza-like illnesses which included suspected and confirmed cases. A suspected case of influenza was defined as a person with a current or history of fever (>38 degrees Celsius) with coughing or sore throat during 16 Jul to 8 Aug 2018. A confirmed case was a suspected case who had a throat or nasopharyngeal swab testing positive for influenza by reverse transcription polymerase chain reaction (RT-PCR) at Bamrasnaradura Infectious Diseases Institute. Severe complications including pneumonia and respiratory failure were identified.

A semi-structured questionnaire was used to collect data. We collected data on demographic characteristics (age and sex), signs and symptoms, risk behaviors including inadequate washing of hands, sharing glasses, cigarettes, spoons and towels, contact with suspected cases and protective factors including current year vaccination history.

Either nasopharyngeal or pharyngeal swabs were collected among 10% (20/200) of initial notified cases who had an onset of illness less than four days prior to the interview or who had severe complications. The specimens were sent to identify the type and subtype of any influenza viruses detected by RT-PCR at Bamrasnaradura Infectious Diseases Institute.

For the environmental study, we inspected physical structures focusing on the numbers of buildings, work zones, dormitories and dining zones. We calculated the density of inmates using the size of a utility space divide by the number of prisoners in those areas. We calculated the correlation between attack rate in each area and inmate density using Pearson's method. Among activities, observations were focused on dining, drinking behavior and personal hygiene. We interviewed staff and directly observed activities by walk-through survey to assess infection control measures for acute respiratory diseases according to guidelines developed by the World Health Organization.[5]

We conducted a retrospective cohort study in order to identify factors associated with influenza-like illnesses (both suspected and confirmed cases). Our cohort was defined as male prisoners who had been in the study prison during 16 Jul to 8 Aug 2018. A case was defined as a suspected or confirmed case in the descriptive study. The prevalence of influenza was used to determine adequate sample size by reviewing the medical literature.[6] The proportion of people working and not working near a case and among influenza cases were 0.76 and 0.63, respectively.[6] From calculation, the required sample size was 422 which provided 80% power and 95% confidence. We performed stratified random sampling by dormitories for sample selection.

Statistical Analysis

For descriptive statistics, continuous data were presented using median with inter-quartile range (IQR). Categorical data were presented using frequency and proportion. The basic reproductive number (R_0) was calculated based on the attack rate using the R-program and the R_0 package, in order to estimate the transmission rate of influenza.[7,8] The effective reproduction number (R) was calculated based on the epidemic curve and the serial interval from previous literature with the Wallinga and Teunis method using the EpiEstim package, in order to estimate the Cohort appropriation of control measure.[9,10]

For analytic statistics, bivariable and multivariable logistic regression models were used to determine factors associated with being a case. In bivariable analyses, a risk ratio and its 95% confidence interval (95% CI) were calculated. All variables having *p*-value less than 0.1 in bivariable analyses were put into the initial multivariable model. We reported adjusted odds ratios (OR), 95% confidence intervals (95% CI), and population attributable fraction (PAF). Vaccine effectiveness was calculated by comparing the number of prisoners with an influenza-like illness (both suspected and confirmed cases) who received at least one dose of influenza vaccine more than or equal to 2 weeks and less than 2 weeks prior to the outbreak occurring. Both groups were compared to prisoners who had no vaccination in the study year.

Ethics

Ethical clearance was omitted as this investigation was conducted as part of a response to a disease outbreak.

Results

Setting and General Description

The study setting is a provincial prison located in Mueang District, Roi Et Province. Although the penitentiary system was designed to accommodate 1,000 inmates as deemed by the Ministry of Justice, the actual prison population was 2,728 prisoners. In Aug 2018, the mean incarceration rate was 18.4 prisoners/day (range 5-84) and the mean release rate was 14.2 prisoners/day (range 6-34). The total weekly turnover rate was 8.7% (244.5/2,800).[11]

Outbreak Description

From the active case finding, we found 346 influenza cases. Of these, 326 (94.3%) were male and all were prisoners. Nineteen nasopharyngeal swabs were collected from prisoners and 16 (84.2%) tested positive for influenza A (H1N1) 2009. The overall attack rate was 12.7%. The zone-specific attack rates ranged from 0% to 42.8% (Table 1, 2). The median (IQR) age of influenza cases was 31 years (24-38 years). According to the Thai Clinical Practice Guideline for Influenza, 19 prisoners were classified as high risk due to their asthma, diabetes mellitus, tuberculosis and HIV status.[12] However, there were no hospitalizations, no serious complications and no deaths.

Table 1. Number of influenza cases by dormitory between 16 Jul and 8 Aug 2018

Characteristics	Total population screened	Number of cases	Attack rate (%)
Male	2458	326	13.26
Dorm Male 1	841	119	14.15
Dorm Male 2	853	115	13.48
Dorm male 3	764	86	11.26
Female	270	20	7.41
Total	2728	346	12.68

During 19 to 26 Jul 2018, about one week prior to the current outbreak, a prison parade competition was held and included prisoners from other Northeast prisons including a reported recent influenza A (H1N1) outbreak prison. After the parade competition, influenza outbreaks occurred in two other prisons.

Table 2. Number of influenza cases by physical structures between 16 Jul and 8 Aug 2018

Characteristics	Total population screened	Number of cases	Attack rate (%)
Occupational training zone (5 zones)	473	77	16.28
Central zone	1750	246	14.06
Education zone	38	1	2.63
Supporting zone	22	3	13.64
Kitchen zone	304	13	4.28
First aid ward zone	15	0	0.00
TB isolation room	14	6	42.86

Figure 1 shows the epidemic curve, which indicated a propagated source outbreak. The first case was a 23-year-old male with no underlying disease. He joined the parade competition and had close contact with other prisoners who had symptoms of cough and nasal congestion. In addition, we found 34 Influenza cases among prisoners (36.9%) who joined parade competition. The first cluster of female cases appeared on 5 Aug 2018. They joined a justice video conference and sat in close proximity to male cases on 2 Aug.

Reproductive Number

The basic reproductive number (R_0) was 1.08 (95% CI = 1.06-1.14). The effective reproductive number (R) during the early period of the outbreak was 5.41 and decreased rapidly afterward. On investigation day, it decreased to below 1 (Figure 2).

Environmental Study

For physical structures, there were 13 zones in this prison: five occupational training zones, a central zone, an education zone, a supporting zone, a kitchen area, a dining zone, a first aid room, tuberculosis (TB) isolation room and 3 dormitories.

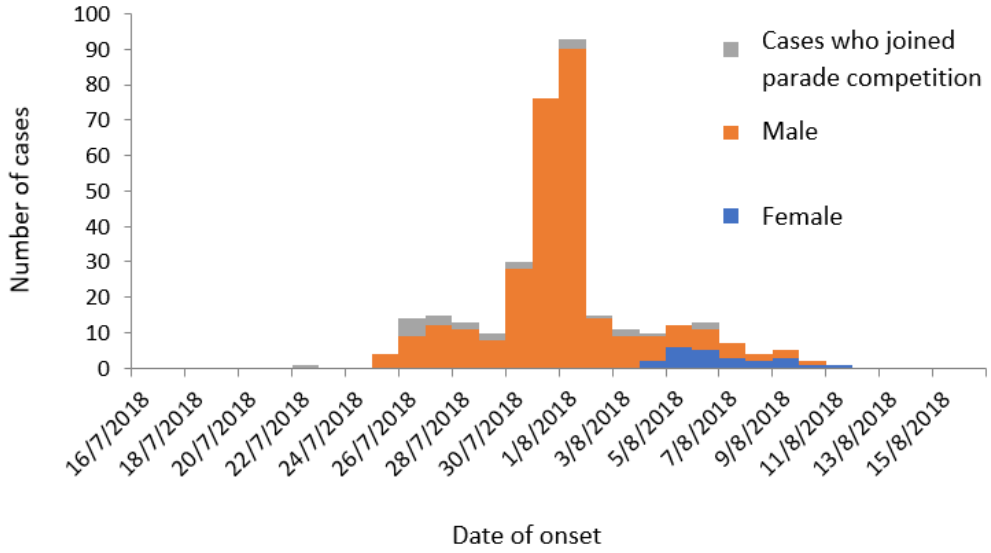

Figure 1. Number of influenza cases in the prison by date of onset between 16 Jul and 8 Aug 2018

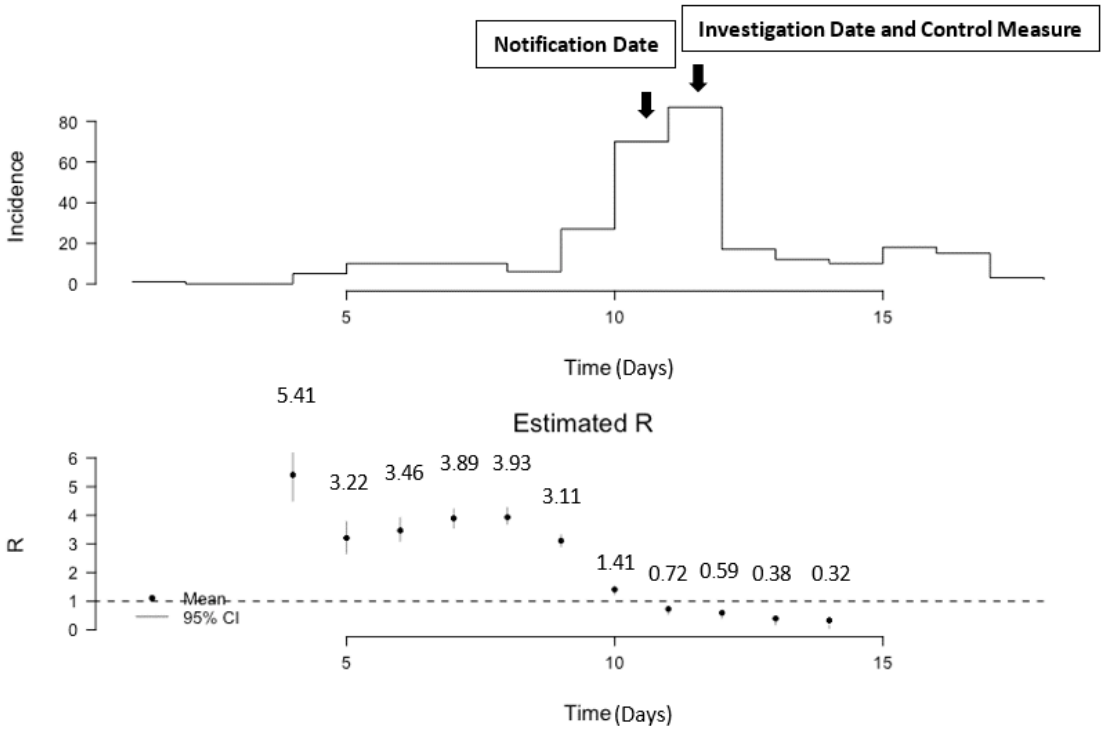

Figure 2. The effective reproductive number of influenza outbreak in the prison between 16 Jul and 8 Aug 2018

Occupational training zones are for work practice prisoners. The number of prisoners per training room ranges from 30-220 (0.76–7.33 m^2/prisoner). The central zone is used to house general prisoners around 1,500-1,600 prisoners (0.50 m^2/prisoner). The education zone, which includes a library, accommodates a maximum of 40 prisoners (4.00 m^2/prisoner). The supporting zone is occupied by 20 prisoners (1.60 m^2/prisoner). The dining area can accommodate up to 450 prisoners comfortably, however, due to overcrowding, approximately 800 prisoners dine together during mealtimes (0.40 m^2/prisoner). The first aid room can occupy for around 30 patients, and some of its area is separated for TB isolation room. There are 3 dormitories with 6 rooms in each and there are around 200 prisoners/room (0.90 m^2/prisoner).

In overcrowded areas (density <1.1 m^2/person, Department of Corrections), the median attack rate was 33.2% while for non-crowded areas

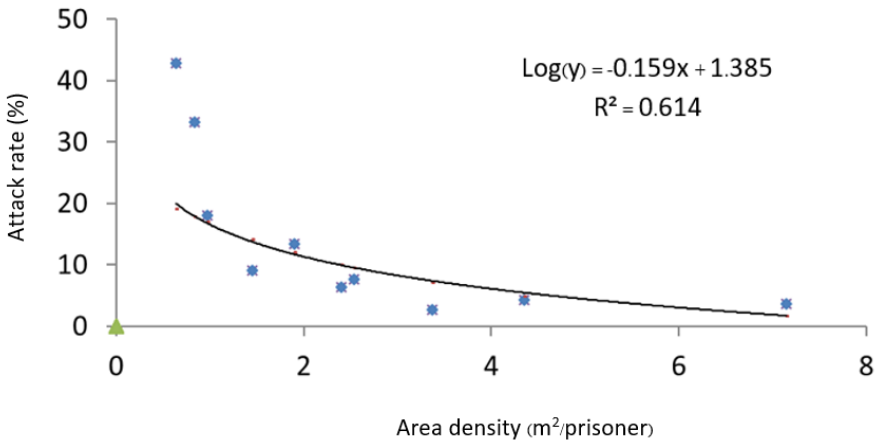

Figure 3. Relationship between attack rate of influenza outbreak by work type and area density in the prison between 16 Jul and 8 Aug 2018

(density >3.2 m^2/person, United Nations[12,13]) it was 3.6%. There was a strong correlation (r = 0.68, *p*-value = 0.025) between the logarithm of the area-specific attack rate and area density (Figure 3).

The daily schedule of prisoners is as follows: wake up at 5.30 AM. Then, practice daily personal hygiene and stand in line for roll call. Breakfast is provided in two sittings: 7.00 and 7.30 AM. Because of the lack of seats, many prisoners sit on the floor during mealtimes. Moreover, food is often served on a plate without a serving spoon. Prisoners usually share glasses used for drinking. Many prisoners had inadequate hand washing due to a time limitation and a lack of hand washing sinks. At 8.00 AM, all prisoners are gathered to listen to the national anthem at the central zone before they are marshaled to other zones. Then, prisoners stay in their dormitory until dawn.

Analytic Study

A total of 217 prisoners were selected using quota sampling. Bivariable and multivariable analysis showed sleeping near an influenza case, adjusted OR = 3.60 (95% CI = 1.62-8.00) and PAF = 33.1%, working near an influenza case, adjusted OR = 3.39 (95% CI = 1.59-7.22) and PAF = 23.4%, and sharing cigarettes with an influenza case, adjusted OR = 2.46 (95% CI = 1.15-4.56) and PAF = 19.7%, were statistically significant (Table 3 and 4).

In 2018, 604 doses of influenza vaccines were provided to the investigated prison. Among the 2,728 prisoners incarcerated, 93 (3.4%) received the vaccine more than or equal to 2 weeks prior to the outbreak. Five hundred and eleven (18.7%) received the vaccine less than 2 weeks prior to the outbreak, while 2,124 (77.9%) did not receive the vaccine at all within the past 12 months. Among prisoners who received the vaccination more than or equal to 2 weeks prior to the outbreak, the vaccine effectiveness was 25.9% (RR = 0.74, 95% CI = 0.41-1.34). Among those who received the vaccine less than 2 weeks prior to the outbreak, the vaccine effectiveness was 13.8% (RR = 0.86, 95% CI = 0.67-1.11).

Control Measures Implemented

To control the outbreak, influenza cases were isolated until 7 days after the onset of their symptoms. Preventive tools (face mask and alcohol gel) and knowledge (i.e. keeping social distance, avoiding shared personal equipment, washing hand) were provided to prisoners. Oseltamivir was given to 250 cases. Daily screening was established by nurses in the first aid room.

Discussion

An influenza A (H1N1) outbreak occurred in a prison located in the northeast region of Thailand. The virus was the circulating subtype (influenza A (H1N1) pandemic 2009) which has been reported in other recent outbreaks across Thailand.[2] The attack rate was 12.7% which was higher than the annual global attack rate (5–10%) and higher than the median attack rate of an influenza outbreak in a Thai prison in 2018 (6.79, range 2.8-20.5%).[1,2] However, it was

Table 3. Bivariable analysis of risk and preventive factors associated with influenza sickness (n=217)

Factors	Exposed		Unexposed		Crude RR	95% CI	*p*-value
	Cases	Non-cases	Cases	Non-cases			
Contact history							
• Sleeping near an infuenza case	36	71	11	99	3.36	1.80, 6.25	<0.01
• Working in same area with an influenza case	27	39	20	131	3.09	1.87, 5.10	<0.01
• Sharing table during meal with an influenza case	25	42	22	128	2.54	1.55, 4.17	<0.01
Share personal use							
• Sharing same glass with an influenza case	43	136	4	169	2.23	0.87, 5.98	0.07
• Sharing spoon with an influenza case	4	5	43	165	2.15	0.98, 4.67	0.10
• Sharing cigarette with case with an influenza case	10	34	28	136	2.10	1.28, 3.44	<0.01
Personal hygiene							
• Adequate hand washing with soap	18	82	29	88	0.73	0.42, 1.22	0.23
Risk of introduce source of infection							
• Joining parade competition	1	3	46	167	1.16	0.21, 6.41	0.87
• Using telephone in relative contacting room	27	108	20	61	0.81	0.48, 1.34	0.42
Flu immunization							
• History of recent influenza infection in last 6 months	7	36	40	133	0.70	0.41, 1.63	0.33

lower than two previous outbreaks in prisons.[14,15] There were recent clusters of influenza A (H1N1) outbreaks in three other prisons in the upper northeast region of Thailand. A common factor was a recent parade competition in which many prisoners partook. Cross infection from prison to prison due to this inter-prison activity was suspected.[16,17]

The number of inmates is rising which causes overcrowded prisons. Currently, the occupancy level in the study prison is 280% according to the standard occupancy level for prisons by the International Committee of the Red Cross.[12] The median attack rate was higher in overcrowded areas, and a strong correlation between zone-specific attack rate and area density was identified. In addition, Thailand ranks the sixth in terms of countries with the highest number of inmates.[18]

Table 4. Multivariable analysis of risk and preventive factors associated with influenza sickness (n=217)

Factors	Adjusted OR*	95% CI	Attributable fraction among exposure (%)	Attributable fraction among population (%)
Sleeping near an influenza case	3.48	1.58, 7.60	71.26%	54.99%
Sharing table during meal with an influenza case	1.93	0.90, 4.13	48.19%	20.67%
Working in same area with an influenza case	2.87	1.35, 6.10	65.16%	36.22%
Sharing cigarette with an influenza case	2.16	1.00, 4.63	53.70%	19.12%
Sharing glass with an influenza case	1.86	0.57, 6.03	46.24%	41.39%

*Note: *Adjusted for all variables in the table*

Between 2017 and 2018, the number of inmates has risen by 163% and the incarceration rate has risen by 128%.[12,19] In 2018, the penitentiary system occupancy level was 304%.[12,19] Therefore, mandatory rehabilitation for drug-related offenses and use of alternatives to prison sentences by developing non-custodial measures within the legal system in line with the United Nations standard minimum rules for non-custodial measures are recommended to address the issue of overcrowding in Thai prisons.[12]

The effective reproductive number during the early period of the outbreak (R = 5.40) was higher than a previous influenza outbreak in a prison in 2009 (R = 4.50) in which control measures were undertaken earlier.[14] Moreover, the reproductive number was decreasing rapidly prior to control measures being undertaken which implies that the decrease may not have been due to the control measure. The multivariable analysis found that sleeping near an influenza case, working in the same area as an influenza case, and sharing cigarettes with an influenza case were significant risk factors, which were consistent with previous studies.[6,20,21] The PAF among all risk factors were not high, thus instead of a single policy, multiple policies is suggested. Use of an isolation area for cases is strongly suggested during influenza outbreaks.[22]

Outbreaks in Thai correctional facility was different to other outbreaks in different settings. Limited staffs and access to vaccines were found to lead to difficulty in outbreak control.[23,24]

The vaccine's effectiveness in this event was lower than that from previous reports in 2017 and 2018 from the US (40%) and among young children in Thailand during 2011 to 2013 (55%).[26,27] One possible reason is that the previous investigations used laboratory-confirmed influenza infections as a case while we combined both suspected and confirmed influenza cases. Therefore, other non-influenza respiratory pathogens may be included. These cases would not have benefitted from the influenza vaccine and therefore we may have underestimated the vaccine's effectiveness.

Limitations

Due to restrictions in the prison setting, we could not implement the planned sampling procedure, which may lead to a non-probability sample and inadequate sample size. However, we could include several subpopulation groups within the prison and used a quota sampling technique, although not statistically representative, which would be acceptable to use in this various and dynamic populations.

Another limitation is that we could not directly observe routine activities before the outbreak,

particularly during the parade competition, which would cause us to miss some risk behaviors during that period. However, consistent information obtained from face-to-face interviews of several prison officers and prisoners helped to increase reliability of this information.

Due to limited resources, the preventive and control measures were not fully implemented leading to the prolonged outbreak.

Recommendations

To prevent future influenza outbreaks, seasonal flu vaccinations for prisoners and staff should be provided prior to the influenza season. Under the limited resources of a corrections facility, the vaccination should be secured for the high-risk groups according to the Thai Clinical Practice Guideline for influenza and, if possible, target vaccination coverage of at least 55% among all inmates should be achieved.[22,23] Moreover, antiviral drugs should be considered in institutional settings.[28] Influenza knowledge, especially symptoms should be enhanced for effective influenza cases detection. Moreover, influenza cases isolation, personal hygiene education and additional equipment such as sinks and drinking water fountains are required to reduce transmission during an outbreak. Lastly, long-term policies are required to solve overcrowded conditions, for example, developing non-custodial measures.

Conclusion

We reported an outbreak of influenza A (H1N1) in a prison setting with an attack rate of 12.7%. The affected population included only prisoners, most of whom were male. Risk factors identified were working and sleeping near an influenza case and sharing cigarettes with influenza cases. The effectiveness of the influenza vaccine among prisoners who received the vaccine more than or equal to 2 weeks prior to the outbreak was higher than that among those who didn't receive the vaccine. A strong correlation between attack rate by work zone and area density was found. We recommend earlier influenza vaccination prior to the influenza season, increasing awareness of the symptoms of influenza for early outbreak detection and having measures to resolve the issue of overcrowding in prisons.

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