Outbreak, Surveillance & Investigation Reports (OSIR) Journal

Volume 11, Issue 2
June 2018

www.osirjournal.net

OSIR Outbreak, Surveillance and Investigation Reports

eISSN: 2286-8933

Outbreak, Surveillance and Investigation Reports (OSIR) Journal

Field Epidemiology Training Program, Bureau of Epidemiology, Department of Disease Control,
Ministry of Public Health, Tiwanond Road, Muang District, Nonthaburi 11000, Thailand

Tel: +662-5901734, Fax: +662-5918581, Email: osireditor@osirjournal.net

Website: <**http://www.osirjournal.net**>

Outbreak, Surveillance and Investigation Reports

Volume 11, Issue 2, June 2018

Contents

OSIR
Outbreak, Surveillance and Investigation Reports
Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Editorial

Field Epidemiologists in the SDGs Era

Wiwat Rojanapithayakorn

From a personal observation, most field epidemiologists are a group of experts with the following characteristics:

1. They are problem seekers trying their best to identify unhealthy medical and health conditions, the trends and the causes of such problems.
2. They try to disseminate their findings in the forms of technical articles or reports to let other people share the worry and the anxiety.
3. They work mainly in their comfort zone or convenient issues which are communicable disease outbreaks, epidemics, endemics and pandemics. The three articles in this issue of OSIR demonstrate clearly this comfort zone. They are all about communicable diseases: HIV, influenza and pneumonia. This is true for almost all articles in the OSIR. For the current field epidemiologists, the term 'agent', one of the three determinants of epidemiology (host, agent and environment), represents mainly pathogenic microorganisms.

It is true that such characteristics have contributed significantly to the prevention and control of various communicable disease outbreaks and epidemics since very long time ago, both at the local and wider levels depending on the scope and scale of the diseases. However, with the current global health situation, it is now the time for field epidemiologists to change! Communicable diseases are no longer the main human killers. Currently, most countries are facing the high mortality from non-communicable diseases (NCDs).

Although some emerging and re-emerging infectious diseases continue to become threats to human health, particularly those with pandemic potential like severe forms of influenza, SARS and Ebola, the global health risks have become more complex. Nowadays, the scope of health risks has extended to cover risky lifestyles, natural disasters, domestic and inter-country political conflicts, terrorisms, global warming, international trade and food safety, and various social environmental determinants of health. Such health risks are the main causes of the high burden of NCDs; natural and man-made disasters; increasing trends of malignancies; increasing problems relating to migration and border health; and increasing environmental health problems like all types of pollutions, occupational health, and chemical hazards. Many social problems are also common which include increased ageing population, high level of mental illnesses, reproductive health problems such as teen pregnancy, financial health risk from high cost of medical services, as well as problems relating to the health services such as availability, accessibility, equity, quality, etc. Not to mention that such problems have resulted in high morbidity and mortality of the world population from NCDs (over 70% of all deaths around the world).

With such magnitude of global health problems, the United Nations Sustainable Development Summit in 2015 agreed to establish a set of long-term Sustainable Development Goals or SDGs that include the aims to address them. Many global health targets are now pooled in the SDG3, to "ensure healthy lives and promote well-being for all at all ages". There are 13 sub-goals in SDG3 which include some main issues like maternal mortality, neonatal mortality, AIDS and a few other communicable diseases, non-communicable diseases, substance abuse, road traffic accidents, sexual and reproductive health-care, and environmental hazards. All of them were selected to demonstrate concerns on major health problems faced by most countries around the world.

It should be noted that communicable diseases are just one target in the SDG3 collection. Thus, to strengthen the roles of field epidemiologists in addressing global health problems, there is a need to advocate an expansion of their scope of work to cover all targets of the SDG3. In the meantime, health policy makers and academicians should set a new direction of field epidemiology training programs by incorporating all the SDG targets into the training curricula. In addition, epidemiology is also useful and should be applied to address determinants of health, which are represented by other SDGs such as SDG1 (poverty), SDG2 (hunger), SDG4 (education), etc. Applying the three main tasks of field epidemiologists - surveillance, outbreak investigation and epidemiological research – in all the health and non-health targets will be a very important mechanism to advance countries toward achievement of the SDGs.

Modern field epidemiologists will also need to be good sale persons. Dissemination of epidemiological reports is not enough to change the world. Field epidemiologists should provide appropriate recommendations to address the problems and proactively advocate the solutions to policy makers so as to come up with effective policies, strategies and programs. With this approach, achievement of the SDGs within the timeframe can be ensured. Once it happens, contributions of field epidemiologists in the SDGs will be certainly recognized.

OSIR, June 2018, Volume 11, Issue 2, p.1-9

Outbreak, Surveillance and Investigation Reports

Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Non-pharmaceutical Control Measures in Response to a Large Cluster of Influenza A(H3N2) in a Workplace, Northeastern Thailand, August-September 2015

Achara Nithiapinyasakul[1], Anek Mungaomklang[2,*], Unchulee Pruankratoke[2], Pongchan Na-Lampang[3], Claire Elizabeth North[4], Pilaipan Puthavathana[5]

1 Collaborative Project to Increase Production of Rural Doctor, Nonthaburi Province, Ministry of Public Health, Thailand

2 Occupational Health Department, Debaratana Nakhon Ratchasima Hospital, Nakhon Ratchasima Province, Ministry of Public Health, Thailand

3 School of Animal Production Technology, Suranaree University of Technology, Nakhon Ratchasima Province, Thailand

4 General Education and English Language Division, Khon Kaen University International College, Thailand

5 Center for Research and Innovation, Faculty of Medical Technology, Mahidol University, Nakhon Pathom Province, Thailand

*Corresponding author, email address: fetp28@gmail.com

Abstract

The study reports on an epidemiological investigation of an influenza A(H3N2) outbreak which occurred in a manufacturing company in Thailand during September 2015. The workplace consisted of three buildings. Employees in building 1 did not wear protective equipment and masks while those in buildings 2 and 3 wore C-level suit for protection from chemicals inhalation. The disease spread and involved 216 (8.4%) cases from a total of 2,585 employees. Nine out of 18 throat swab samples were found to have influenza A(H3N2) virus. Influenza illness mostly occurred in building 1, with attack rate of 22%. The investigation revealed that the first case possibly contacted the disease from a family member and spread it among employees through direct contact with clinically active cases, and sharing of hand towels in the company toilets. The study emphasized practical control measures, particularly in health education and strong policy regulations in the workplace. It enforced all employees in building 1 to wear masks which lead to the successful control of the outbreak within 10 days without using oseltamivir post-exposure prophylaxis. The event-based surveillance system should be implemented in every workplace for outbreak detection as well as for rapid response.

Keywords: influenza outbreak, non-pharmacological intervention, control measures, work-related infection

Introduction

Influenza outbreaks cause about 250,000-500,000 hospitalizations every year. The influenza infection can occur in all age groups, and outbreaks can be mainly found in schools, hospitals, child care centers and workplaces.[1] Influenza virus can spread through direct or indirect contact with respiratory droplets when the infected persons cough or sneeze. The incubation period of influenza ranges from 1-4 days, with average two days. Infected persons with normal immune function can spread the virus from one day before onset of symptoms to seven days after the illness.[2]

Severity for influenza illness may occur, depending on types and strains of the virus, and strength of the host responses. Risk factors for severe complications include diabetes mellitus, chronic kidney disease, congestive heart failure, immunocompromised state, asthma, elderly, children under five and pregnant women.[3]

United States Occupational Safety and Health Administration (OSHA) suggested engineering controls, administrative controls, healthy work practices and personal protective equipment (PPE) to prevent an influenza outbreak in the workplace.[4] In general, guidance for influenza prevention in workplace simply focuses on personal hygiene such as frequent hand washing, not sharing utensils and wearing protective masks. Sick leave of an employee should follow physician's recommendations and the policy of each workplace. Moreover, there was no standard guideline or regulation for disinfection in manufacturing companies available in Thailand.[5]

On 7 Sep 2015, a nurse in a company in the northeast of Thailand detected influenza-like illness (ILI) in a cluster of four employees working in the same department. The onset of illness varied between 4 and 6 Sep 2015. The nurse immediately reported to local public health authorities for prevention and control measures. This study aimed to describe an epidemiological investigation of an influenza outbreak which occurred in a private manufacturer and the activities intended to stop the outbreak without using anti-viral post-exposure prophylaxis.

Methods

The influenza outbreak occurred in a company manufacturing electronics and automobile devices in the Nakhon Ratchasima Province of Thailand, which is approximately 295 km northeast of Bangkok.

Epidemiologists from the local health authority, Ministry of Public Health, together with nurses of the manufacturer investigated this ILI outbreak. The investigation team conducted case finding retrospectively by reviewing patient records at the nursing unit in the company and the local hospital from 17 Aug to 10 Sep 2015, and developed a cross-sectional questionnaire survey based on ILI definition to find out more patients. The team walked through the surroundings and sent out a risk-behavior survey to trace back to an implicated source of the outbreak at the workplace. They established a proactive surveillance system which was composed of daily employee and families self-monitoring for ILI symptoms and screening of staff in other departments before start to work from 10 Sep until the end of the outbreak on 20 Sep 2015 when no new case was detected after 14 days from the onset date of the last reported case.

An influenza suspected case was a patient with at least two symptoms of: sore throat, rhinorrhea, malaise and headache while an influenza probable case was a suspected case with fever above 38°C and an epidemiologically linked to a confirmed case. An influenza confirmed case was a probable or suspected case with laboratory confirmed influenza virus infection.

Laboratory Testing

Throat swab samples were collected and tested for influenza virus by antigen detection using rapid diagnostic test (SD Bioline, Gyeonggi-do, Republic of Korea[9]) at the workplace and also by viral genome detection using real time reverse transcription-polymerase chain reaction (RT-PCR) at King Chulalongkorn Memorial Hospital, Faculty of Medicine, Chulalongkorn University.

Analytical Study

The data of this study were analyzed via distributions of time, place and person, using frequency and percentage. Risk of influenza among the group without using PPE (Building 1) compared to workers who wore a level-C equivalent suit (Buildings 2 and 3) were determined by risk ratio (RR) and 95% confidence interval (CI).

Ethical Consideration

This descriptive epidemiological study was approved by the Institutional Review Board (COA no. 144/2015, IRB no. 479/57) of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand. All participants signed a written informed consent document prior to their participation.

Results

Description of the First Case

After tracing back, the first case of the outbreak was a 24 year-old managing staff working in building 1. She never had an influenza vaccination or influenza infection diagnosed by a physician during previous three years. She reported having a family member developed ILI on 15 Aug 2015 as well as having history of contact with that family member three days before she developed ILI on 20 Aug 2015. The disease was then transmitted to other managing staff and rapidly spread to the workers in the production line of the same building (Figures 1, 2).

Outbreak Description

On 7 Sep 2015, the nurse team in the manufacturing plant detected four ILI patients in the same department. The characteristics of each department: all divisions were in the same building area. There were several units without divisions or partition walls with a common air system.

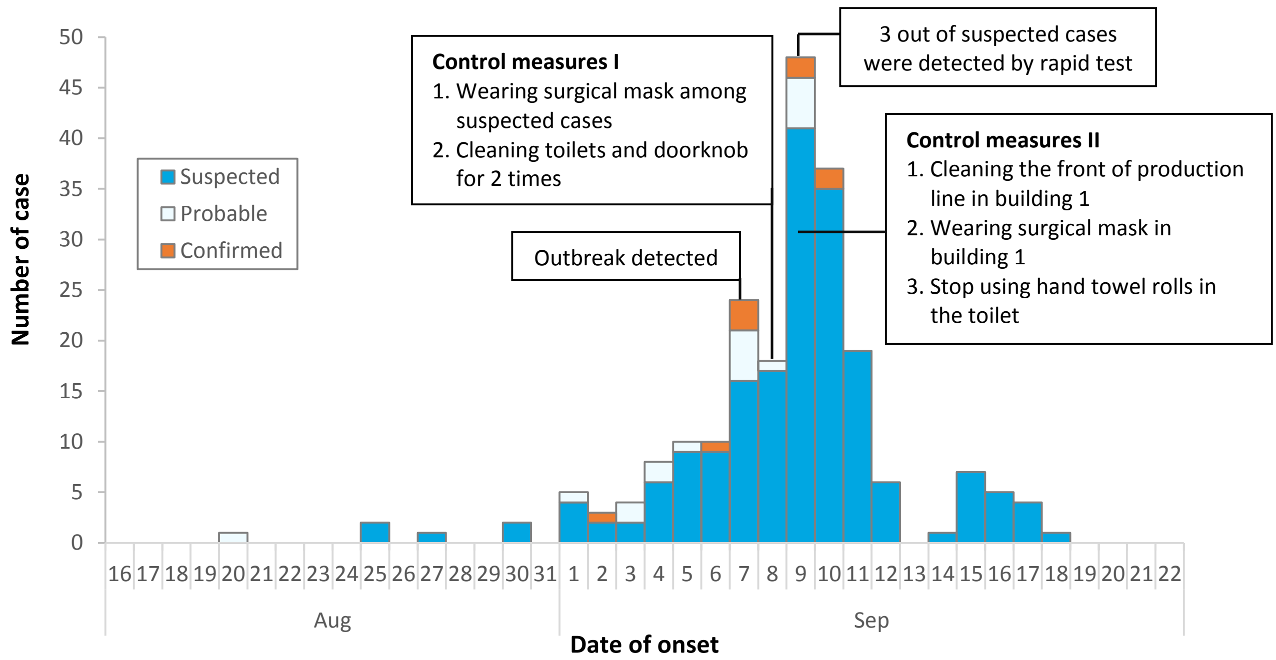


Figure 1. An epidemic curve and control measures of an influenza outbreak at a workplace in Nakhon Ratchasima Province, Thailand, 17 Aug - 20 Sep 2015 (n=216)

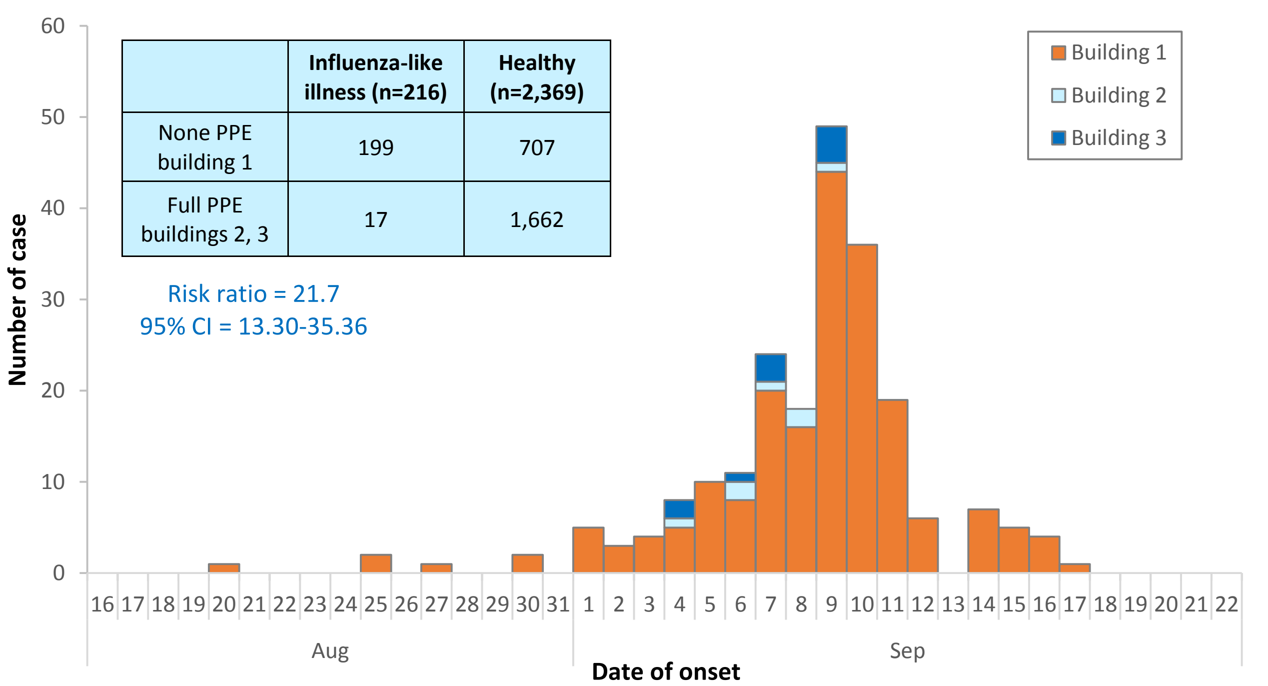


Figure 2. An epidemic curve by buildings 1, 2 and 3 of an influenza outbreak at a workplace in Nakhon Ratchasima Province, Thailand, 17 Aug - 20 Sep 2015 (n=216)

Employees were able to walk through the entire building. The onset dates of illnesses were between 4 and 6 Sep 2015. On 8 Sep, a discussion was conducted among the nurse team, human resource management office, and executive safety officers of the workplace to develop a guideline for patient screening and set up an active surveillance system which composed of daily employee self-monitoring for ILI symptoms and screening of other department staff before starting the work. Data of sick employees from both active and passive surveillance systems were reported to the nursing unit.

On 9 Sep 2015, 10 throat swab specimens collected from recently ill workers were sent to a local hospital for rapid diagnostic test, and three of them were positive for influenza A virus infection, which later also found to have influenza A(H3N2) by RT-PCR. The influenza outbreak in this manufacturing plant was the second outbreak in Nakhon Ratchasima Province in 2015 (Figure 3).

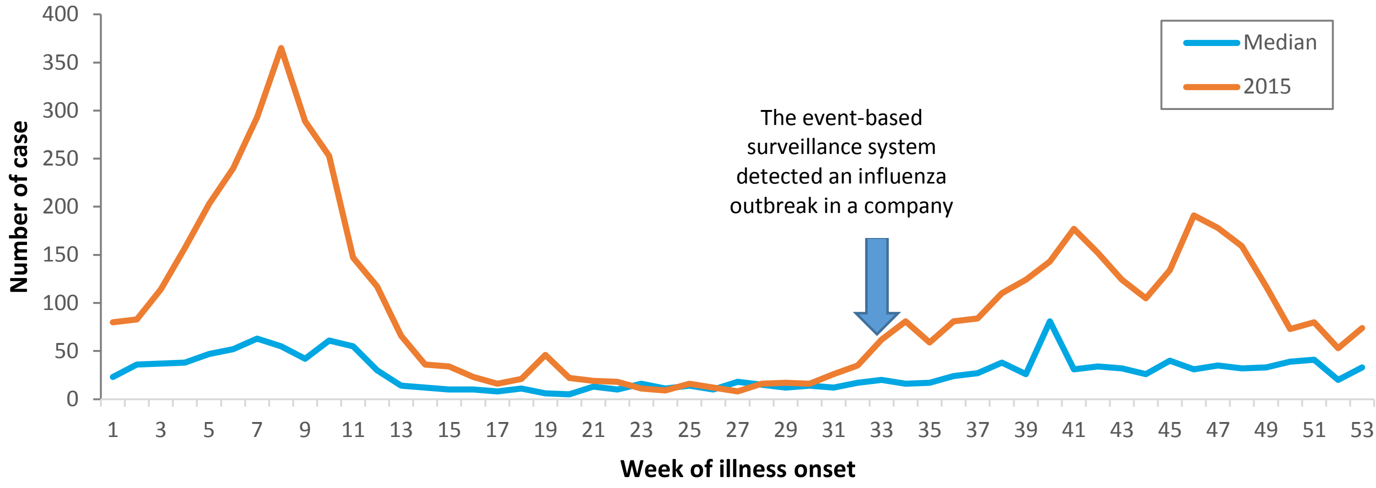


Figure 3. Influenza-like illness cases reported by week in 2015 compared to 3-year median (2012-2014) in Nakhon Ratchasima Province, Thailand

Descriptive Findings

A total of 216 (8.4%) cases out of 2,585 employees were identified. There were 41 (6.8%) cases out of 601 male employees and 175 (8.8%) out of 1,984 female employees. With respect to buildings 1, 2 and 3, there were 199 (22.0%), 7 (1.1%) and 10 (0.9%) cases respectively. In terms of age, the highest attack rate group was 21-25 years old, followed by 26-30 years and 31-35 years (Figure 4). None of the employees had been vaccinated for influenza infection in 2013-2015.

Cough (91.2%) was most commonly observed among 216 cases, followed by sore throat (90.3%), rhinorrhea (43.5%), fever (30.1%), headache (18.1%) and malaise or myalgia (1.4%). Three patients received oseltamivir (75 mg) every 12 hours for five days and stayed home for three days. The rest of the patients received no treatment and were able to carry on their works.

Laboratory Findings

A total of 18 throat swab samples was sent for laboratory investigation, and influenza A(H3N2) virus was diagnosed in nine samples by RT-PCR, which included seven samples from building 1, and one each from buildings 2 and 3. Collectively, 216 cases were classified as 189 suspected, 18 probable and nine confirmed influenza cases.

Analytical Findings

The outbreak investigation showed that most of the cases occurred in the production line of every building, particularly in building 1. Not only workers in the production line, but also managing staff and office workers were affected (Table 1). The attack rate in building 1 was 21.7 times higher than those of buildings 2 and 3 (95% CI = 13.30-35.36).

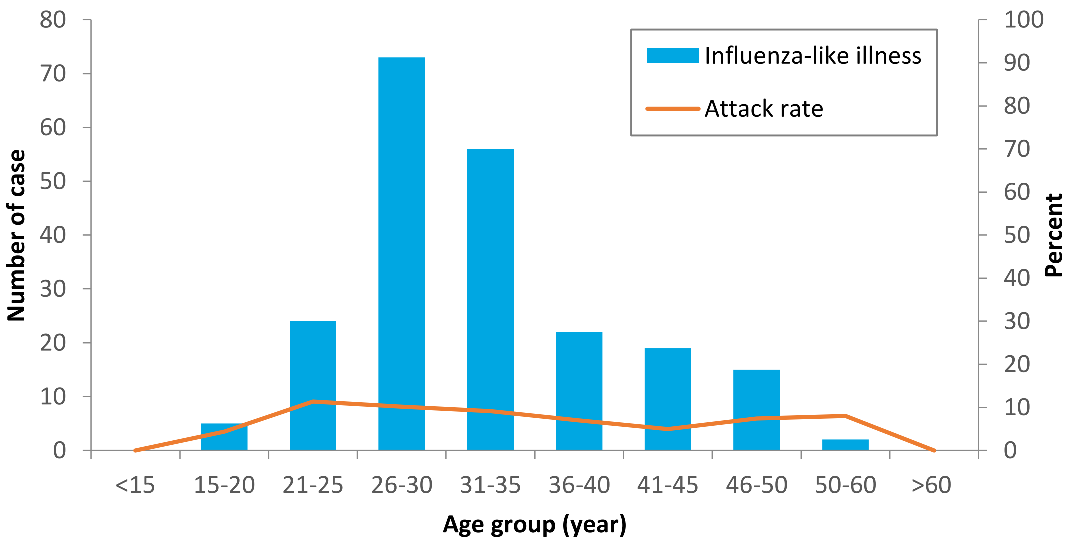


Figure 4. Age-specific attack rate of an influenza outbreak at a workplace in Nakhon Ratchasima Province, Thailand, 17 Aug - 20 Sep 2015 (n=216)

Table 1. Attack rate of influenza by nature of work and building at a workplace in Nakhon Ratchasima Province, Thailand, 17 Aug - 20 Sep 2015 (n=216)

Nature of work	Building 1 (Percent)	Building 2 (Percent)	Building 3 (Percent)
Production line worker	23.9 (192/803)	1.3 (7/545)	1.0 (10/965)
Managing staff	15.8 (6/38)	0 (0/46)	0 (0/77)
Office worker	1.6 (1/62)	0 (0/19)	0 (0/20)
Manager	0 (0/3)	0 (0/2)	0 (0/5)
Attack rate	22.0 (199/906)	1.1 (7/612)	0.9 (10/1,067)

Contacts

Moreover, 278 family members of 216 patients were also monitored for influenza associated-symptoms. The disease spread to eight persons in five families, which revealed the secondary attack rate as 2.9% (8/278 family members).

Workplace Environment

The company employed a total of 2,585 people who were working in three buildings and shared a common cafeteria. Each building served different functions in the production line, with individual air-conditioning (AC) system. Watch cases were produced in building 1, and employees did not wear protective equipment or protective masks (Figure 5). Activity in buildings 2 and 3 were in clean rooms for production of electronic parts and thus, employees were required to wear anti-static protection suits, protective cloth masks and boots (Figure 6). This type of suit was equivalent to level C suit for protection from chemicals inhalation[6].

Figure 5. Employees in building 1 without wearing protective equipment or masks at a workplace in Nakhon Ratchasima Province, Thailand, 2015

Figure 6. Employees in buildings 2 and 3 with anti-static protection suits, protective masks and boots at a workplace in Nakhon Ratchasima Province, Thailand, 2015

Surveillance and Response

A surveillance program pertaining to occupational diseases, work-related illnesses and communicable diseases, including ILI had been implemented in this manufacturing plant for two years before the outbreak. There was a comprehensive training of the nurse team working in the infirmary, which belonged to a social enterprise company. An ILI surveillance program was set up with the notification criteria to report to local health authority, defining the trigger as the disease occurring in two or more workers in the same production line within a week.[5]

In this event, the nurses immediately reported the outbreak information to local public health authorities. Subsequently, all employees in building 1 were screened for ILI symptoms in each department before employees entered the workplace. Initially, health education on frequent hand washing and protective masks for ILI cases were provided to contain the outbreak. In the same period of time, the national notifiable disease (R506) surveillance detected a wave of influenza outbreak in the community of Nakhon Ratchasima Province as well (Figure 3).

Public Health Actions

On 10 Sep 2015, a medical epidemiologist team examined the workplace and found that sharing cloth towel rolls in the restrooms and sharing drinking cups were the potential sources of disease transmission. The prevention and control measures of this influenza outbreak were conducted according to the recommendations from the OSHA on work practice, administrative controls and PPE. Nevertheless, there was no change in engineering controls which included usage of AC and ventilation system while several aspects of control measures were implemented in the workplace, particularly on intensive health education (Table 2).

At the initial phase of the outbreak, only cases were requested to wear protective masks before entering building 1. However, poor cooperation achieved, with merely 20% compliance. On the following day, stricter policies were implemented in demanding all employees to wear masks and on-site checking for ILI symptoms before employees entered the workplace. This increased wearing of mask to 80% on the second day and 100% on the third day until the outbreak stopped.

Table 2. Interventions for an influenza A(H3N2) outbreak at a workplace in Nakhon Ratchasima Province, Thailand, 17 Aug - 20 Sep 2015

Intervention	Monitoring period		Duration of intervention
	Start date	End date	
Engineering controls - Use of air-conditioning	No change	No change	No change
Work practices			
1. Intensive health education - Hand washing with alcohol gel - Use of personal drinking cups - Use a serving spoon for shared dishes - Avoid direct contact with the patients	7 Sep	19 Sep	13 days
2. Stop using hand towel rolls in toilet	10 Sep	Current	
3. Hand washing with alcohol gel	10 Sep	Current	
4. Increase frequency of toilet cleaning from 2 to 4 times a day	10 Sep	19 Sep	10 days
5. Cleaning door knobs frequently and wiping surface of working benches with alcohol for 1 time	9 Sep	19 Sep	11 days
6. Active surveillance set up in workplace - On-site managing staff to check for influenza-like symptoms before entering the workplace - Self monitoring influenza-like symptoms among employees and their family members - Nursing unit of workplace	10 Sep	31 Sep	22 days
Administrative controls Isolation precautions		3 out of 216 patients received oseltamivir and stayed at home for 3 days	
Personal protective equipment in building 1			
1. Wearing protective mask among suspected cases	8 Sep	19 Sep	12 days
2. Informing all employees and staff to wear protective masks	9 Sep	19 Sep	11 days

The nursing unit at the workplace was strengthened with medical screening and an observation room for detecting workers who needed hospitalization as well as on-site respiratory specimen collection for influenza rapid test. Employees requiring hospitalization had to inform the nurse team to record their symptoms and evaluate disease control compliance. Moreover, influenza cases were detected through hospital-based surveillance, active screening in the nursing unit, and self-monitoring of employees and their family members.

All employees were followed up until the end of September 2015. No new case occurred after 14 days of observation, which implied that the outbreak had ended (Figures 4, 5). The cost belonged to workplace for prevention and control measures during the outbreak was 40,400 Baht (1,222 USD) in total, including 700 Baht (21 USD) for environmental cleaning at workplace with 70% alcohol, 2,500 Baht (75 USD) for cotton roll, 12,000 Baht (363 USD) for 68.5% alcohol gel for hand washing and 25,200 Baht (762 USD) for protective masks.

Discussion

An outbreak of influenza A(H3N2) virus occurred in a manufacturing plant in the northeastern Nakhon Ratchasima Province of Thailand. This was the second outbreak of influenza in this province in 2015.

The influenza attack rates in employees working in buildings 2 and 3 were lower than those working in building 1 possibly due to the mandatory requirement to wear a C-level suit for protection from chemicals inhalation. The first case was found in building 1 who might have contacted the disease from a family member. This suggested that the disease might spread among employees through direct contact with clinically active cases who coughed and sneezed without wearing protective masks. This study clearly demonstrated that a key to success of influenza epidemic control was wearing protective masks.

One factor that might contribute to occurrence of an influenza outbreak was lack of vaccination among employees for seasonal influenza. The United States Centers for Disease Control and Prevention (US CDC) recommends vaccination to prevent influenza illness or severe illness. Effective control measure include combination of various methods such as seasonal influenza vaccination, decontamination in the environment, encouraging sick employees to stay home and installing a ventilation system to prevent the spread of the disease.[4]

In Thailand, the health care system provides influenza vaccination free of charge to high risk people, e.g. health care workers and elderly, yet not for the general population.[3] Of 65 million population in Thailand, around 12 million are in high risk groups to receive influenza vaccination. The National Health Security Office purchases and delivers around 2.1-3 million vaccine doses annually to these population.[7] Therefore, influenza vaccination for employees in private sectors have to rely on welfare plans in the workplace.

The Ministry of Public Health, Thailand, followed the guidelines on influenza treatment as recommended by US CDC. Hence, oseltamivir should be administered to patients at risk of developing complications and for prophylaxis in contact cases who might develop serious illness or death[8,9]. On the other hand, systematic reviews with meta-analysis suggested that oseltamivir prophylaxis could reduce the risk of symptomatic influenza in healthy individuals and household contacts.[10,11] Oseltamivir prophylaxis decreased the odds of developing influenza among the elderly in long-term care facilities by 50%, and significantly reduced the attack rate and deaths as well.[12] There was an evidence that implementation of oseltamivir prophylaxis in a nursing home had stopped the influenza outbreak within 10 days.[13]

Despite that, oseltamivir prophylaxis and influenza vaccination were not provided to most employees as the primary control measures in this study. Oseltamivir was prescribed merely for treatment of three patients who developed high fever with malaise. Whereas, the duration of this influenza outbreak with non-pharmaceutical measures was not different from the one with oseltamivir prophylaxis[13]. The control of influenza epidemic within 10 days without oseltamivir prophylaxis was previously reported in a primary school in Thailand in 2007[14]. Nonetheless, the control measures in both outbreaks were different. School closure was one of the measures carried out in the previous study. However, the sick employees in this study continued working due to mild infection and financial constraints.

A study among health care workers during 1999 proved AC systems as a risk factor in the workplace.[15] However, this study did not engage engineering controls through AC system to stop the outbreak due to obstacles for the manufacturing processes. The systematic reviews were not conclusive that upper respiratory tract infection was not related to AC systems, outdoor air ventilation, poorer thermal control or lack of openable windows[16].

In most workplaces in Thailand, the nursing unit as required by the Labor Law of an infirmary is just a place for medicine dispensing. This minimal requirement is not adequate for early detection of clusters with similar symptoms. The event based-surveillance system recommended by the World Health Organization (WHO)[17] should be implemented in every workplace to assess the outbreak situation. This unit should serve as the first line for rapid response to prevent the disease spread, which could lessened business impacts and treatment costs to the public health system. A linkage system among workplaces, communities and public health sectors could facilitate the control of a disease and stop the disease spread to the surrounding communities or other workplaces. This complex health care system was pending for good coordination and trust between government agencies and the private sectors, and it could be implemented successfully through the social enterprise system, according to reports from Thailand[5] and elsewhere[18].

Conclusion

An influenza A(H3N2) epidemic in a workplace was successfully controlled without using anti-viral drugs or influenza vaccination. Early detection of sick employees by the nursing unit at the workplace, together with rapid response from the public sectors on epidemiological investigation, contributed to the success of the outbreak control. This incident supported the recommendations of WHO in using an event-based surveillance system at the workplace in complement to the passive surveillance system in the hospital.

Public Health and Policy Recommendations

Effective detection of this outbreak should apply to every nursing unit in workplaces to set up an ILI event based-surveillance system along with the passive surveillance system in hospitals. The Department of Disease Control, Ministry of Public Health, and the Department of Labor Protection and Welfare, Ministry of Labor should encourage the manufacturing companies to develop an on-site surveillance program pertaining to occupational diseases, work-related illnesses and communicable diseases in their nursing unit. This investigation revealed high value of an event based-surveillance system for outbreak detection and rapid response, and therefore, an event-based surveillance should be implemented in every workplace.

Acknowledgement

The research team wishes to thank employees and managers of the company for their great support in controlling the influenza outbreak. This study was supported by the Research Chair Grant (P13-01091) and the Cluster and Program Management Office (P-15-50535) from the National Science and Technology Development Agency, Thailand.

Suggested Citation

Nithiapinyasakul A, Mungaomklang A, Pruankratoke U, Na-Lampang P, North CE, Puthavathana P. Non-pharmaceutical control measures in response to a large cluster of influenza A(H3N2) in a workplace, northeastern Thailand, August-September 2015. OSIR. 2018 Jun;11(2):1-9.

References

1. Lenee B, Krista K, Sophie S, Desiree M, Craig S, Brendan F, et al. Update: influenza activity - United States and worldwide, May 24 - September 5, 2015. MMWR. 2015 Sep 18; 64(36):1011-6.1 [cited 2017 Feb 10]. <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6436a4.htm>.
2. Fiore AE, Shay DK, Broder K, Iskander JK, Uyeki TM, Mootrey G, et al. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2008. MMWR Recomm Rep. 2008 Aug 8;57(RR-7):1-60.
3. Centers for Disease Control and Prevention. People at high risk of developing flu-related complications. 2016 [cited 2017 Feb 13]. <http://www.cdc.gov/flu/about/disease/high_risk.htm>.
4. United States. Occupational Safety and Health Administration. Department of Labor. Guidance on preparing workplaces for an influenza pandemic. 2009 [cited 2017 Feb 12]. <https://www.osha.gov/Publications/OSHA3327pandemic.pdf>.
5. Kuttiyawithayakoon S, Pruankratoke U, Mungaomrlang A. Strengthening of occupational health surveillance and prevention system using social enterprise concept. Journal of Health Science. 2014(23):719-29. Thai [cited 2017 Feb 15]. <http://thailand.digitaljournals.org/tdj/index.php/JHS/article/view/738>.
6. Centers for Disease Control and Prevention. Protective clothing and ensembles. 2014 Dec 12 [cited 2017 Feb 15]. <https://www.cdc.gov/niosh/topics/protclothing/default.html>.
7. Owusu JT, Prapasiri P, Ditsungnoen D, Leetongin G, Yoocharoen P, Rattanayot J, et al. Seasonal influenza vaccine coverage among high-risk populations in Thailand, 2010-2012. Vaccine. 2015 Jan 29;33(5):742-7.
8. Centers for Disease Control and Prevention. Influenza antiviral medications: summary for clinicians. 2017 [cited 2017 Feb 13]. <https://www.cdc.gov/flu/professionals/antivirals/summary-clinicians.htmtm>.
9. Fiore AE, Fry A, Shay D, Gubareva L, Bresee JS, Uyeki TM. Antiviral agents for the treatment and chemoprophylaxis of influenza --- recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep. 2011 Jan 21;60(1):1-24.
10. Jefferson T, Jones MA, Doshi P, Del Mar CB, Hama R, Thompson MJ, et al. Neuraminidase inhibitors for preventing and treating influenza in healthy adults and children. Cochrane Database Syst Rev. 2014 Apr 10;(4):CD008965.
11. Heneghan CJ, Onakpoya I, Jones MA, Doshi P, Del Mar CB, Hama R, et al. Neuraminidase inhibitors for influenza: a systematic review and meta-analysis of regulatory and mortality data. Health Technol Assess. 2016 May;20(42):1-242.
12. Rainwater-Lovett K, Chun K, Lessler J. Influenza outbreak control practices and the effectiveness of interventions in long-term care facilities: a systematic review. Influenza Other Respir Viruses.2014 Jan (8):74-82.
13. Gorišek Miksić N, Uršič T, Simonović Z, Lusa L, Lobnik Rojko P, Petrovec M, et al. Oseltamivir prophylaxis in controlling influenza outbreak in nursing homes: a comparison between three different approaches. Infection. 2015 Feb;43(1):73-81. Epub 2014 Nov 18.
14. Sonthichai C, Iamsirithaworn S, Cummings DAT, Shokekird P, Khumket S, Niramitsantipong A, et al. Effectiveness of

non-pharmaceutical interventions in controlling an influenza A outbreak in a school, Thailand, November 2007. OSIR. 2011 Dec (4):6-11.

15. Preziosi P, Czernichow S, Gehanno P, Hercberg S. Workplace air-conditioning and health services attendance among French middle-aged women: a prospective cohort study. Int J Epidemiol. 2004 Oct;33(5):1120-3.

16. Mendell MJ. Commentary: air conditioning as a risk for increased use of health services. Int J Epidemiol. 2004 Oct;33(5):1123-6. Epub 2004 Aug 19.

17. World Health Organization. A guide to establishing event-based surveillance. Geneva: World Health Organization; 2008.

18. Roy MJ, Donaldson C, Baker R, Kay A. Social enterprise: new pathways to health and well-being? J Public Health Policy. 2013 Jan;34(1):55-68.

Outbreak, Surveillance and Investigation Reports
Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Risk Factors for Community-acquired Pneumonia in Malaysian Pilgrims Attending the Hajj, 2012

Ahmad Faudzi Yusoff[1,*], Amal Nasir Mustafa[1], Mohd Hanif Zailani[2], Nuur Hafizah Md Iderus[1], Zamtira Seman[1], Lokman Hakim Sulaiman[3]

1 Institute for Medical Research, Kuala Lumpur, Malaysia

2 Hulu Langat District Health Office, Selangor, Malaysia

3 Deputy Director General's (Public Health) Office, Ministry of Health, Malaysia

*Corresponding author, email address: faudzi@imr.gov.my

Abstract

Community-acquired pneumonia (CAP) is an important cause of morbidity and mortality in Malaysian pilgrims attending the Hajj every year. This study aimed to determine risk factors associated with CAP in Malaysians attending the Hajj. We conducted an unmatched case-control study at a Malaysian hospital in Mecca from September 2012 to January 2013, during the Hajj season. Individuals who met the definition of CAP were selected as cases. Controls were randomly selected among Malaysian pilgrims staying in the same accommodation as the cases, and followed up two weeks after returning to Malaysia. Information on risk factors was gathered using a structured questionnaire, and the strength of association was assessed using adjusted odds ratios (AOR) and 95% confidence intervals (CI) through a multiple logistic regression model. The study identified 108 cases and 673 unmatched controls. Among cases, 57.4% were males and 98.1% were aged more than 50 years. CAP was significantly associated with drinking over three liters of water daily (AOR = 0.2, 95% CI = 0.9-0.4), taking multivitamins (AOR = 0.2, 95% CI = 0.9-0.5), age 60 years or more (AOR = 20.2, 95% CI = 10.6-38.3), asthma/chronic obstructive airway disease (AOR = 5.9, 95% CI = 2.4-14.7) and congestive cardiac failure (AOR = 5.4, 95% CI = 2.0-14.7). Determining potentially preventable risk factors for CAP could help to inform public health programs for future Hajj pilgrims and might potentially reduce the associated morbidity and mortality.

Keywords: Hajj, pilgrims, community-acquired pneumonia, risk factors, multivitamin

Introduction

Every year, about 28,000 people or 0.1% of Malaysian population perform Hajj in Mecca, Saudi Arabia.[1,2,3] Hajj activities are physically very demanding[4] and expose pilgrims to excessive heat, extreme congestion and other hazards[5]. These activities increase the risk of developing health problems such as respiratory infectious diseases that are transmitted by droplets or aerosols.[1,6,7] Preventing outbreak-prone infectious diseases such as influenza[8], community-acquired pneumonia (CAP), tuberculosis[9], meningococcal meningitis and severe acute respiratory syndrome in pilgrims has thus presented significant challenges to Malaysian medical teams.[2,3]

In addition to wearing face masks and practicing proper personal hygiene, vaccination has been the mainstay of preventive measures for pilgrims.[3] Following directives of Saudi Health Authority[5,10,11,12], Malaysian policy requires vaccination against meningococcal meningitis at least two weeks prior to embarking on the Hajj[13]. Pilgrims aged over 59 years or with co-morbidities are also encouraged to take influenza vaccination[10,12,14,15] and pneumococcal vaccination[1].

In 2003, infectious diseases and pneumonia accounted for 36.4% and 19.7% respectively for admissions to Saudi health facilities in Mecca during the Hajj[6,10,11,16]. In addition, high mortality of pneumonia (22%) were observed among pilgrims admitted to intensive care units during the Hajj period of 2004.[16] The objectives of this study were to determine risk factors associated with CAP among Malaysian pilgrims performing the Hajj in 2012, and identify potential preventive measures in the Hajj.

Methods

An unmatched case-control study was designed to determine risk factors associated with CAP in Malaysian pilgrims. This study was conducted in Mecca, Saudi Arabia, during the Hajj season in October 2012.

The study defined CAP as acquiring fever (temperature >37.8°C), chest X-ray findings consistent with pneumonia, and one or more of the following signs and symptoms: cough, purulent sputum, change in sputum characteristics, dyspnea, tachypnea, cyanosis and auscultation evidence of pulmonary consolidation (dullness, crepitation, bronchial breathing) or changes in complete blood count, especially neutropenia. Cases were identified in Malaysian pilgrims admitted to Malaysian hospitals. Controls were those with no stated clinical symptoms and were drawn from Malaysian pilgrims staying in local accommodations.

The sample size was calculated based on a type I error set at 5% (95% confidence level), a power of 80%, and a case-to-control ratio of 1:4. The percentage of controls exposed to pneumonia was deemed, based on estimation from the previous episodes of pneumonia occurred among Malaysian pilgrims, to be 15% and odds ratio (OR) to be detected was two. By using Open Epi software version 7, the calculated sample size was 570. After considering a non-response rate of 20%, the required sample size was increased to 684 participants.

Cases were selected among those admitted and diagnosed to have CAP by systematic random sampling from the admission list in Malaysian hospitals. Controls were selected by simple random sampling from lists of Malaysian Hajj pilgrims staying in the same accommodation and at the same floor with the selected cases. Controls were then followed up by home visit or telephone call for two weeks after returning to Malaysia in order to exclude episodes of pneumonia infection[5].

Identification of cases and controls was undertaken from September 2012 to January 2013. Demographic data were obtained from the Pilgrims Health Information System (PHIS), Tabung Haji, Malaysia, and data on risk factors were gathered through face-to-face interviews by attending physicians using structured questionnaires. A written informed consent was obtained from all participants prior to interview. Known risk factors and preventive measures for CAP, including prior vaccination, wearing a face mask and taking oral multivitamin, food and volume of water intake, were selected for analysis.

Collected data were entered into the PHIS system by the attending physicians. All data from the PHIS were exported to statistical databases for analysis. Descriptive analyses were performed and univariate analysis conducted using binary logistic regression. Variables having a p-value less than 0.25 from the univariate analysis were included in the initial multivariate logistic regression model. Variables were then selected by a forward-and-stepwise method to arrive at the final model. Multicollinearity and interaction terms were checked, and the Hosmer-Lemeshow test, classification table and ROC curve were applied to check the model fitness. The strength of association for each risk factor was assessed using crude and adjusted odds ratios (AOR).

This study had been registered with the Malaysian National Medical Research Register (NMRR-11-1000-10694) and approved by the Medical Research Ethics Committee Malaysia.

Results

Descriptive Analysis

The study recruited 108 peoples with pneumonia and 673 unmatched controls among Malaysian pilgrims. Most of the cases (57.4%) were males. The mean age was 68.2 years for cases (range 50-85 years) and 51.3 years for controls (range 24-81 years). Most (81.1%) of the pilgrims lived at accommodations more than 700 m from the Great Mosque of Mecca (Masjid al Haram). Upper respiratory tract infection (URTI) was observed among most of the cases (79.6%) and the controls (69.2%). Pneumococcal vaccination was received in 27.8% of cases and 38.0% of controls. Most of the controls (83.8%) wore a clinical mask as a preventive measure while only 58.3% of cases used the mask. Low multivitamin (21.3%) and adequate water (20.4%) intakes were found among cases as compared to multivitamin (66.3%) and water (67.0%) intake among the controls (Table 1).

Univariate Analysis

Statistically significant and positive associations were observed for increasing age (OR = 36.1, 95% CI = 20.5-63.4 for age 60 and above) and distance from the pilgrim's hotel to the Masjid al Haram mosque between 800-899 m (OR = 5.1, 95% CI = 1.8-14.7). Pre-existing medical conditions, including diabetes mellitus, tuberculosis, asthma/chronic obstructive airway disease (COAD), congestive cardiac failure (CCF), hypertension and end stage renal failure were also revealed as significant risk factors. Pneumococcal vaccination, wearing a facemask, intake of supplemental multivitamin and intake of extra food in addition to food served by Hajj organizers, and drinking more than three liters of water per day were significantly associated with reduced risk of CAP (Table 2).

Table 1. Distribution of cases and controls among Malaysian pilgrims performing the Hajj in 2012

Factor	Cases (n=108)		Controls (n=673)	
	Number	Percent	Number	Percent
Gender				
Male	62	57.4	333	49.5
Female	46	42.6	340	50.5
Age group (year)				
≤50	2	1.9	292	43.4
>50-60	24	22.2	321	47.7
>60-70	36	33.3	52	7.7
>70-80	38	35.2	7	1.0
>80	8	7.4	1	0.1
State of residence				
Johor	15	13.9	22	3.3
Kedah	11	10.2	79	11.7
Kelantan	8	7.4	80	11.9
Kuala Lumpur	6	5.6	43	6.4
Melaka	4	3.7	37	5.5
Negeri Sembilan	3	2.8	54	8.0
Pahang	10	9.3	42	6.2
Perak	13	12.0	74	11.0
Perlis	3	2.8	17	2.5
Pulau Pinang	3	2.8	35	5.2
Sabah	4	3.7	22	3.3
Sarawak	1	0.9	19	2.8
Selangor	21	19.4	80	11.9
Terengganu	6	5.6	69	10.3
Distance from hotel to Masjid al Haram (meter)				
Less than 600	5	6.3	89	12.3
600-699	4	5.1	50	7.4
700-799	38	48.1	300	44.6
800-899	18	22.8	58	8.6
900-999	10	12.7	125	18.6
≥1000	4	5.1	57	8.5
Pre-existing medical conditions and risk related behavior				
Diabetes mellitus	34	31.5	96	14.3
Tuberculosis	8	7.4	1	0.1
Asthma/Chronic obstructive airway disease	30	27.8	35	5.2
Congestive cardiac failure	20	18.5	16	2.4
Hypertension	63	58.3	146	21.7
End stage renal failure	4	3.7	2	0.3
Splenectomy	3	2.8	6	0.9
Upper respiratory tract infection	86	79.6	466	69.2
Smoking	10	9.3	45	6.7
Preventive measures				
Vaccination (pneumococcal)	30	27.8	25.6	38.0
Wearing mask	63	58.3	56.4	83.8
Multivitamin intake	23	21.3	44.6	66.3
Additional food intake	67	62.0	57.1	84.8
Water intake (>3 liters)	22	20.4	45.1	67.0

Table 2. Univariate analysis of the risk factors associated with community-acquired pneumonia among Malaysian pilgrims performing the Hajj in 2012

Factor	Odds ratio	95% CI		P-value
Gender				
Male	1.4	0.9	2.1	0.1
Age group (year)				
≤50	Ref			
>50-60	10.9	2.6	46.6	0.001
>60-70	101.1	23.6	432.7	<0.001
>70-80	792.6	158.8	3954.8	<0.001
>80	1168.0	95.8	14244.9	<0.001
Distance from hotel to Masjid al Haram (meter)				
Less than 600	Ref			
600-699	1.3	0.3	5.2	>0.05
700-799	2.1	0.8	5.6	>0.05
800-899	5.1	1.8	14.7	0.002
900-999	1.3	0.4	4.0	>0.05
1000 and above	1.2	0.3	4.5	>0.05
Pre-existing medical conditions and risk related behavior				
Diabetes Mellitus	2.8	1.7	4.4	<0.001
Tuberculosis	53.8	6.7	434.4	<0.001
Asthma/Chronic obstructive airways disease	7.0	4.1	12.1	<0.001
Congestive cardiac failure	9.3	4.7	18.9	<0.001
Hypertension	5.1	3.3	7.7	<0.001
End stage renal failure	12.9	2.3	71.3	<0.001
Splenectomy	3.2	0.8	13.0	>0.05
Upper respiratory tract infection	1.7	1.1	2.8	0.028
Smoking	1.4	0.7	2.9	>0.05
Preventive Measures				
Vaccination (pneumococcal)	0.6	0.4	0.9	0.040
Wearing mask	0.3	0.2	0.4	<0.001
Multivitamin intake	0.1	0.1	0.2	<0.001
Additional food intake	0.3	0.2	0.5	<0.001
Water intake (>3 liters)	0.1	0.1	0.3	<0.001

Multivariate Analysis

The multivariate analysis showed significantly increased risk of CAP with age 60 years or more (AOR = 20.2, 95% CI = 10.6-38.3) and with asthma/COAD (AOR = 5.9, 95% CI = 2.4-14.7) and CCF (AOR = 5.4, 95% CI = 2.0-14.7). Intake of water more than three liters per day (AOR = 0.2, 95% CI = 0.9-0.4) and supplemental multivitamin (AOR = 0.2, 95% CI = 0.9-0.5) were independently associated with a significantly reduced risk of CAP (Table 3).

The final model was checked for multicollinearity using the correlation estimates and standard errors found to be relatively small for age, CCF and asthma/COAD. With ROC curve applied to check the model fitness, the area under the curve (AUC) was more than 80%, with AUC 0.93, p-value less than 0.05, cut-off point at age 58.5 years produced (1-specificity) 0.13 and sensitivity 0.84.

Table 3. Adjusted odds ratios of factors associated with community-acquired pneumonia among Malaysian pilgrims performing the Hajj in 2012

Risk factor	Adjusted odds ratio	95% CI
Age (≥60 years)	20.2	10.6-38.3
Water intake (≥3 liters)	0.2	0.9-0.4
Multivitamin intake	0.2	0.9-0.5
Asthma/chronic obstructive airway disease	5.9	2.4-14.7
Congestive cardiac failure	5.4	2.0-14.7

Remark: Odds ratio was adjusted for all variables.

Discussion

In this study of Hajj pilgrims from Malaysia, we identified several risk factors for CAP, including age 60 years and above, and pre-existing conditions of asthma/COAD, CCF and hypertension. In addition, we identified significant protective factors, including intake of water more than three liters per day and intake one tablet of supplemental multivitamin on daily basis. Education on importance of health screening, health examination, vaccination, daily water intake and nutritional supplements was provided to the pilgrims before leaving to Saudi Arabia. This played an important role in helping them to lessen the risk of getting CAP during the Hajj season.

In our study, the likelihood of acquiring CAP rose with increasing age, a result consistent with other studies of Hajj pilgrims[12,17,18], and was especially high in pilgrims aged 60 years or more and with underlying cardiorespiratory illnesses such as asthma/COAD, CCF and hypertension. Most of the Malaysian Hajj pilgrims were aged more than 50 years and most of them had at least one pre-existing medical condition or chronic disease such as diabetes, hypertension or heart diseases. During the pilgrimage, pilgrims must be physically fit to do all related activities.[5] One of the physical activities is walking to the Masjid al Haram mosque. We noticed that pilgrim's accommodations were generally quite far away from the mosque (more than 700m). Some of the pilgrims might be exhausted after several trips to and from the mosque, and thus, might have increased the risk of acquiring CAP. The compulsory health screening and examinations for the Malaysian pilgrims evaluates their fitness to travel and participate in the Hajj activities. In addition, health information and vaccinations are given during their health examination[19]. Those diagnosed to have any illnesses are managed accordingly. If the process of management needs a longer time, they are advised to postpone the trip and reapply when their conditions were satisfactory, fit to travel and physically able to perform the Hajj activities in the future[19].

Although the health status of pilgrims participating in the Hajj is typically satisfactory prior to departure, the sudden change of environment may increase the susceptibility of some pilgrims to acquire respiratory diseases.[3,5,6,7] The changing environment is related to overcrowding and congested conditions in the mosques where the situation creates the possibility of exposing them to diseases via the respiratory system.[3,8,19] Their situation worsens with some activities related to ongoing construction work and renovation of the mosque, indirectly contributing to the air pollution. These situations might also contribute to an increased risk of CAP among those who had history of asthma or COAD.[20] The risk could be higher when they are not taking any extra preventive measures such as wearing a protective face mask[5,16]. As we found, pilgrims were more prone to develop CAP if they had pre-existing medical conditions. It is possible that these vulnerable individuals might have sustained CAP from the changing environment, depending on their daily activities or attitudes towards taking care of their own health[21].

Prolonged exposure to sunlight and excessive heat may cause dehydration and increase vulnerability to infection,[1,5] including URTI and pneumonia, which if not treated promptly, can become severe[7,17] . We found that intake of three or more liter of water per day was associated with a reduced risk of CAP[22]. Another protective factor was intake of supplementary multivitamin. Medical screening of pilgrims prior to departure did not typically include evaluation of nutritional status, and/or presence of vitamin deficiencies and related conditions. Pilgrims were provided with two meals, namely lunch and dinner, and were given a choice to buy other foods which are readily accessible. The suggestion that multivitamin could play an important role in preventing pneumonia merits further research. Since multivitamins are proactively provided to all pilgrims, declining intake could be indirectly linked to other important health behaviors that could influence acquisition of CAP.

In this study, we assumed that all the pilgrims were physically well before departing for Saudi Arabia since they were declared medically fit to travel. We also observed that there were no cases of pneumonia or any pneumonia-related hospital admissions among those staying in Medina during eight days before moving to Mecca. Respiratory diseases have also been described as the most common cause for hospital admission during the Hajj.[8,20,17,23] Known organisms found in some studies included *Klebsiella pneumoniae*, *Hemophilus influenza*e, *Streptococcus pneumoniae*, and *Mycobacterium tuberculosis.*[19,24,25] Influenza[5,6] and pneumococcal vaccines are two alternative vaccines recommended for the pilgrims by the Ministry of Health, Malaysia.[19,26,27] Since neither of these vaccines are compulsory, there is no official documentation to confirm whether the pilgrims have received the vaccinations. In addition, the vaccines are only available at private health facilities.

Limitations

One of the main limitations of our study was that no laboratory support was available to differentiate the organisms causing pneumonia. As eligible non-cases were all willing to respond to the study, data were collected from more controls than we had planned. Since people who needed further investigations were referred to Arab hospitals for further management, the treatment outcome of those people were not be able to retrieve.

Public Health Action and Recommendations

Hajj is an example of a mass gathering and CAP is one of the important infectious diseases that are associated with mass gatherings. Though no death was identified among the respondents, reduction of mortality and morbidity associated with CAP was possible via appropriate preventive measures as suggested by results in this study. High risk groups included those who are aged 60 years or over, and those with co-morbidities such as asthma, COAD and CCF. These groups were advised to strictly follow health management, perform merely the essential Hajj activities, drink the appropriate amount of water and take supplementary multivitamin.

Conclusion

Association of CAP with the risk factors found in this study might be useful for implementing preventive measures during the Hajj pilgrimage. The risk of getting CAP could be reduced in pilgrims who were aged 60 years or more and those with co-morbidities if they supplemented their diet with multivitamin, kept well hydrated, and strictly followed advice by health authorities.

Acknowledgement

We would like to thank the Director General of Health Malaysia for his permission to publish this paper. We also appreciate the Deputy Director General of Health (Research and Technical Support) and Deputy Director General of Health (Public Health) for their support and guidance in completing this study. Special thanks go to all the Malaysian Medical Team 2012, staff of Tabung Haji Malaysia and all reviewers of this paper.

Suggested Citation

Yusoff AF, Mustafa AN, Zailani MH, Md Iderus NH, Seman Z, Sulaiman LH. Risk factors for community acquired pneumonia in Malaysian pilgrims attending the Hajj, 2012. OSIR. 2018 Jun;11(2):10-6.

References

1. Abubakar I, Gautret P, Brunette GW, Blumberg L, Johnson D, Poumerol G, et al. Global perspectives for prevention of infectious diseases associated with mass gatherings. Lancet Infect Dis. 2012 Jan;12(1):66-74.
2. Ahmed QA, Arabi YM, Memish ZA. Health risks at the Hajj. Lancet. 2006 Mar 25;367(9515):1008-15.
3. Alborzi A, Oskoee S, Pourabbas B, Alborzi S, Astaneh B, Gooya MM, et al. Meningococcal carrier rate before and after hajj pilgrimage: effect of single dose ciprofloxacin on carriage. East Mediterr Health J. 2008 Mar-Apr;14(2):277-82.
4. Al-Tawfiq JA, Memish ZA. The Hajj: updated health hazards and current recommendations for 2012. Euro Surveill. 2012 Oct 11;17(41):20295.
5. Al-Tawfiq JA, Zumla A, Gautret P, Gray GC, Hui DS, Al-Rabeeah AA, et al. Surveillance for emerging respiratory viruses. Lancet Infect Dis. 2014 Oct;14(10):992-1000.
6. Balkhy HH, Memish ZA, Bafaqeer S, Almuneef MA. Influenza a common viral infection among Hajj pilgrims: time for routine surveillance and vaccination. J Travel Med. 2004 Mar-Apr;11(2):82-6.
7. Benkouiten S, Charrel R, Belhouchat K, Drali T, Nougairede A, Salez N, et al. Respiratory viruses and bacteria among pilgrims during the 2013 Hajj. Emerg Infect Dis. 2014 Nov;20(11):1821-7.
8. Cox NJ, Subbarao K. Influenza. Lancet. 1999 Oct 9;354(9186):1277-82.
9. El-Sheikh SM, El-Assouli SM, Mohammed KA, Albar M. Bacteria and viruses that cause respiratory tract infections during the pilgrimage (Haj) season in Makkah, Saudi Arabia. Trop Med Int Health. 1998 Mar;3(3):205-9.
10. Habib AG, Abdulmumini M, Dalhat MM, Hamza M, Iliyasu G. Anti-retroviral therapy among HIV infected travelers to Hajj pilgrimage. J Travel Med. 2010 May-Jun;17(3):176-81.
11. Kandeel A, Deming M, Elkreem EA, El-Refay S, Afifi S, Abukela M, et al. Pandemic (H1N1) 2009 and Hajj Pilgrims who received Predeparture Vaccination, Egypt. Emerg Infect Dis. 2011 Jul;17(7):1266-8.
12. Khan MY, Kinsara AJ, Osoba AO, Wali S, Samman Y, Memish Z. Increasing resistance of M. tuberculosis to anti-TB drugs in Saudi Arabia. Int J Antimicrob Agents. 2001 May;17(5):415-8.
13. Lin LC, Hsieh PC, Wu SC. Prevalence and associated factors of pneumonia in patients with vegetative state in Taiwan. J Clin Nurs. 2008 Apr;17(7):861-8.

14. Madani TA, Albarrak AM, Alhazmi MA, Alazraqi TA, Althaqafi AO, Ishaq AH. Steady improvement of infection control services in six community hospitals in Makkah following annual audits during Hajj for four consecutive years. BMC Infect Dis. 2006 Aug 25;6:135.

15. Madani TA, Ghabrah TM, Albarrak AM, Alhazmi MA, Alazraqi TA, Althaqafi AO, et al. Causes of admission to intensive care units in the Hajj period of the Islamic year 1424 (2004). Ann Saudi Med. 2007 Mar-Apr;27(2):101-5.

16. Madani TA, Ghabrah TM, Al-Hedaithy MA, Alhazmi MA, Alazraqi TA, Albarrak AM, et al. Causes of hospitalization of pilgrims in the Hajj season of the Islamic year 1423 (2003). Ann Saudi Med. 2006 Sep-Oct;26(5):346-51.

17. Memish ZA, Zumla A, Alhakeem RF, Assiri A, Turkestani A, Al Harby KD, et al. Hajj: infectious disease surveillance and control. Lancet. 2014 Jun 14;383(9934):2073-82.

18. Mustafa AN, Gessner BD, Ismail R, Yusoff AF, Abdullah N, Ishak I, et al. A case-control study of influenza vaccine effectiveness among Malaysian pilgrims attending the Haj in Saudi Arabia. Int J Infect Dis. 2003 Sep;7(3):210-4.

19. Nichol KL, Lind A, Margolis KL, Murdoch M, McFadden R, Hauge M, et al. The effectiveness of vaccination against influenza in healthy, working adults. N Engl J Med. 1995 Oct 5;333(14):889-93.

20. Nichol KL, Margolis KL, Wuorenma J, Von Sternberg T. The efficacy and cost effectiveness of vaccination against influenza among elderly persons living in the community. N Engl J Med. 1994 Sep 22;331(12):778-84.

21. Razavi S, Ziaee H, Mokhtari Azad T, Rasoul H, Doroodi T, Mirsalehian A, et al. Surveying respiratory infections among Iranian Hajj pilgrims. Arch Clin Infect Dis. 2007;2(2):67-70.

22. Reza I, Ali K, Roya H. Acute respiratory viral infections among Tamattu' Hajj pilgrims in Iran. Life Sci J. 2013;10:449-53.

23. Ridda I, King C, Rashid H. Pneumococcal infections at Hajj: current knowledge gaps. Infect Disord Drug Targets. 2014;14(3):177-84.

24. Shafi S, Booy R, Haworth E, Rashid H, Memish ZA. Hajj: health lessons for mass gatherings. J Infect Public Health. 2008;1(1):27-32.

25. Tashani M, Barasheed O, Azeem M, Alfelali M, Badahdah AM, Bokhary H, et al. Pneumococcal Vaccine Uptake Among Australian Hajj Pilgrims in 2011-13. Infect Disord Drug Targets. 2014;14(2):117-24.

26. Yezli S, Memish ZA. Tuberculosis in Saudi Arabia: prevalence and antimicrobial resistance. J Chemother. 2012 Feb;24(1):1-5.

OSIR, June 2018, Volume 11, Issue 2, p.17-23

Outbreak, Surveillance and Investigation Reports

Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Identifying Female Sex Worker Sites and Gaps of HIV Prevention Programs Using a Programmatic Mapping Method in 9 Provinces of Thailand

Dusita Phuengsamran[1,*], Natthaprang Nittayasoot[2], Panithee Thammawijaya[2]

1 Institute for Population and Social Research, Mahidol University, Thailand

2 Field Epidemiology Training Program, Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand

*Corresponding author, email address: dusita.phu@mahidol.ac.th

Abstract

Programmatic mapping is an internationally recommended and systematic method of providing crucial data for human immunodeficiency virus (HIV) prevention programs. It identifies the "hot spots" or gathering sites of key populations such as female sex workers (FSWs) and estimates their population size. This mapping was conducted in nine selected provinces of Thailand during 2015-2016 to identify and characterize hot spots of FSWs and gaps of HIV prevention. The mapping included two major steps: "site identification", interviewing various key informants in and around the areas to extensively compile lists of potential hot spots; and "site validation", visiting these hot spots, using a mobile application to geographically map their locations, and collecting data on characteristics and estimated number of FSWs at each site. In the nine selected provinces, 1,039 explicit and non-explicit venues where FSWs employed were successfully mapped. Of which, 357 (34%) had no available HIV service. The estimated number of FSWs was 15,092, of which approximately 24% were working in venues where HIV services were not available. This mapping identified areas where HIV service delivery is needed and the number of FSWs that the services should accommodate thus allowing for the establishment of strategic programs and planning of budgets. It is therefore recommended that this mapping program be expanded and regularly conducted.

Keywords: programmatic mapping, HIV services, female sex worker, Thailand, size estimation

Introduction

Human immunodeficiency virus (HIV) infections are still a very challenging public health problem in many parts of the world, including Thailand. Female sex workers (FSWs), with an HIV prevalence rate of 1.9%, are one of the key populations who continuously play an important role in the HIV epidemic in the country.[1] Thailand's Spectrum and Aids Epidemic Model, established in July 2016, estimated that 10% of new infections in 2016 occurred among FSWs and their clients.[2] An analysis on the level of risk behavior and service utilization of FSWs found that over 50% were at moderate to high risk (i.e. not using a condom during sex) and had less access to HIV services.[3] Importantly, random police crackdowns on their trade made them harder to reach and consequently, became one of the main factors affecting their access to HIV services and their own health.

In 2015, with financial support from the Global Fund to fight against acquired immune deficiency syndrome (AIDS), tuberculosis and malaria, the national AIDS Management Center at the Department of Disease Control implemented a programmatic mapping exercise which has been recommended as a method for obtaining information to improve service delivery for HIV-related key, yet hard-to-reach and highly dynamic, populations, including female and male sex workers. Conceptually, the aims of the mapping exercise, which include identifying and characterizing hot spots and estimating the magnitude of key populations, are comparable to the "active case finding" procedure usually conducted during a traditional outbreak investigation. This was the first time the mapping exercise was implemented in Thailand, which was an exercise focusing on the sites where key populations could be reached or in particular 'hot spots' of the key populations[4]. A 'hot spot' refers to any place where key populations congregate, arrange to meet prior to having sexual activities with their lovers or sexual partners, or use or sell injecting drug equipment, including sharing injecting drugs and its equipment or other similar types of activities. It was simultaneously conducted in 12 provinces, representing 12 health service regions and the capital city of Bangkok. The objectives of the overall exercise were to map and characterize the hot spots, i.e. gathering sites, where key populations (men having sex with men, transgenders, sex workers and people injecting drugs) could be reached, as well as to identify the areas where HIV services were not available. The size estimation of key populations reachable at the mapped sites was also obtained.

This study utilized data from the programmatic mapping performed for FSWs in nine provinces during 2015. Defined by United Nations Programme on HIV/AIDS and applied by this study, FSWs were consenting females who regularly or occasionally receive money or goods in exchange for providing sexual services[4]. In particular, for FSWs, a 'hot spot' was defined as any venue where FSWs regularly frequent to meet potential clients. The categorization of a FSW hot spot was based on that defined by the Department of Disease Control[5]. This procedure had four categorizations for FSW venues: explicit sex establishments (brothels, massage parlors and go-go bars), non-explicit sex establishments (Thai massage parlors, karaoke clubs), explicit non-venue sex work sites (public parks, bus stations, cattle and buffalo markets), and online sex sites (internet websites and social networks).

This paper presented an analysis on FSWs, which was part of the stated mapping exercise, to identify types of venues frequented by FSWs, find out gaps in HIV prevention programs within these venues, and estimate the population size of FSWs in the mapped sites.

Methods

This analysis utilized data obtained from the programmatic mapping exercise for FSWs done in nine provinces. As mentioned earlier, this was a pilot exercise, these nine provinces were selected by the Department of Disease Control and represented nine regions of the Ministry of Public Health. The mapping was a systematic combination of qualitative method and cross-sectional survey. The process included two steps.

Site Identification

A number of key informants were interviewed to compile a list of hot spots and HIV service delivery points which were accessible to FSWs. Key informants were defined as either FSWs themselves or anyone knowledgeable about where to reach FSWs such as taxi drivers, street vendors, bar workers and outreach workers. The number and types of key informants varied by study site.

Site Validation

The listed places were mapped and data concerning the places where key populations congregated as well as available HIV services were collected. The data were collected by interviewing one key informant from each site. The selection criteria was assessed by screening likely candidates via a structured set of questions. The selection criteria included being involved with sex workers at the hot spot by some means, being sex workers themselves or frequenting the hot spot often enough to be knowledgeable about the hot spot. At this step, the mobile application containing a structured questionnaire and a geographical information system were used to collect data by the data collection teams in each province.

The interview with the key informant at each site collected data concerning the locational characteristics (busiest time, number of FSWs and type of venue), and visibility of commodities for the prevention of HIV and other sexually transmitted infections (STI) such as free condoms, mobile voluntary counselling and testing clinics, and outreach and referral systems. For each hot spot, the data collection team selected one respondent deemed to be most reliable in answering questions about the hot spot. For FSWs, the interview was performed with FSWs, bar owners, managers or gatekeepers as well as clients. The geographical locations of the hot spots were automatically recorded at the same time as the interview.

Data from the site validation were stored in a spreadsheet file format and were downloaded after the data collection was complete. Descriptive analyses of the hot spot characteristics was conducted in Microsoft Excel.

The estimated number of FSWs at the mapped sites were calculated in the spreadsheet software using the data collected during the site validation process. This included minimum and maximum number of FSWs at each venue during the peak times. The minimum and maximum numbers were summed separately across all sites. The crude estimate of key population size was calculated by using the average of the minimum and maximum summations.

The location and characteristics of the hot spots were visualized in the geographic information system (GIS) mapping application and accessed via the internet under the control of central-level authorities and other stakeholders with password protection to restrict the accessibility of data for different levels according to necessity of data utilization. The programmatic mapping website was linked with other national AIDS data to encourage data utilization at all levels.

The programmatic mapping research protocol was approved by the Ethical Review Committee of the Institution for Population and Social Research, Mahidol University. The certificate of ethical approval no. 2015/1-1-32, was dated 30 Apr 2015.

Results

A total of 1,039 sites were mapped, including 757 non-explicit establishments, 258 explicit establishments and 24 explicit non-venue sex work sites. The mapping could not identify any online sex sites. In three provinces where the mapping covered a whole province, the number of mapped sites was 342 (average 114) which included 124 non-explicit establishments, 207 explicit establishments and 11 explicit non-venue sex work sites. For the other six provinces where the mapping covered only some selected areas of the province, there were 697 sites mapped (average 116), including 134 non-explicit establishments, 550 explicit establishments and 13 explicit non-venue sex work sites (Table 1).

The crude estimated number of FSWs at 1,039 mapped sites was 15,092. Of which, 11,424 (75.7%) worked in the 757 non-explicit establishments (15 on average). In addition, 258 explicit establishments employed 3,049 sex workers (12 on average) and 24 explicit non-venue sex work sites having 619 sex workers (26 on average) (Table 1).

This mapping found that during the data collection period, about one in three (357/1,039) mapped venues were not covered by any HIV-related prevention service (Table 2). This accounted approximately 24.6% (3,720/15,092) of sex workers who were not working where HIV services were available. These included venues that had never had any HIV service available at all and those where services used to exist, yet were no longer available during the data collection period. HIV services existed mainly among the explicit establishments while less than half of the non-explicit establishments and explicit non-venue sex work sites had no available HIV service in the vicinity. Free condoms and outreach activities were the most obtainable type of service, mostly for sex workers at explicit establishments (Table 3).

Figure 1 presents two examples of data visualizations from the mapping software showing the size of the population and the location of hot spots for each population. Other information visualized included results of size estimation, hot spots by population group, types of hot spots and hot spots with and without HIV services.

Discussion

The pilot mapping exercise conducted in nine out of total 77 provinces found that FSWs existed in both explicit and non-explicit venue and non-venue sex work sites. Based on the estimates, most FSWs congregated at non-explicit venue-based establishments. Comparing the average number of sex workers at each venue, the non-explicit venue-based establishments, including street-based venues were the biggest sites, with average number of 26 sex workers at each sites. According to the Bureau of AIDS, Tuberculosis, and STI (BATS) of Thailand, the latest annual surveys of sex workers and sex establishments in all provinces across Thailand during 2015 reported a total of 57,066 sex workers of all genders[6]. The estimated number of FSWs in the whole country was 123,530, with possibly on-fourth working at explicit non-venue sex work sites such as public parks, bus stations and cattle and buffalo markets.[1]

The BATS annual survey is carried out throughout each province, and thus, the estimated number of sex workers and sex establishments are intended to reflect the provincial level. Our programmatic mapping exercise was conducted thoroughly in three provinces while merely some districts or municipal areas in the other six study provinces were included. A comparison of the BATS annual survey in 2015 with our programmatic mapping suggested that advantage from the site identification step of the programmatic mapping might help the provincial team to discover new sex work venues as well as relocation of other venues.

The analysis of trends during 2006-2015 revealed an increase in the number of sex workers employed in karaoke clubs and beer bars.[6] This rise in numbers was probably due to the government enforcement on anti-drug trafficking and prostitution suppression laws. Random police raids of known sex establishments had caused a change in the market places where sex worker now prefer to work in non-explicit sex establishments for fear of being arrested. Information on service availability was the key information that made this programmatic mapping different from the annual surveys conducted by the Department of Disease Control. This programmatic mapping revealed that about half of all non-explicit establishments and explicit non-venue sex work sites were lacked with HIV services.

FSWs employed by non-explicit establishments and explicit non-venue sex work sites had higher risk behaviors than other FSWs, as measured by their level of condom use and experiences on STI.[3] Those employed by explicit non-venue sex work sites had a

Table 1. Distribution of female sex worker (FSW) venues in 9 provinces of Thailand by type of venue and province, 2015

Province†	Venue type (n)	Number of mapped venues	Crude estimated number of FSW
Total	Explicit establishment	258	3,049
	Non-explicit establishment	757	11,424
	Explicit non-venue sex work sites	24	619
	Total	1,039	15,092
A	Explicit establishment	32	970
	Non-explicit establishment	115	3,936
	Explicit non-venue sex work sites	11	571
	Total	158	5,477
B	Explicit establishment	82	848
	Non-explicit establishment	79	588
	Total	161	1,436
C	Explicit establishment	10	141
	Non-explicit establishment	13	58
	Total	23	199
D	Explicit establishment	56	606
	Non-explicit establishment	457	6351
	Total	513	6957
E	Explicit establishment	4	38
	Non-e establishment	14	112
	Total	18	150
F	Explicit establishment	11	63
	Non-explicit establishment	24	120
	Explicit non-venue sex work sites	1	7
	Total	36	190
G	Explicit establishment	16	120
	Non-explicit establishment	2	20
	Explicit non-venue sex work sites	8	21
	Total	26	161
H	Explicit establishment	36	220
	Non-explicit establishment	34	173
	Explicit non-venue sex work sites	4	20
	Total	74	413
I	Explicit establishment	11	43
	Non-explicit establishment	19	66
	Total	30	109

† Provinces A, B and C did the programmatic mapping at full-scale throughout the whole province while other provinces selected only some areas (district or municipality).

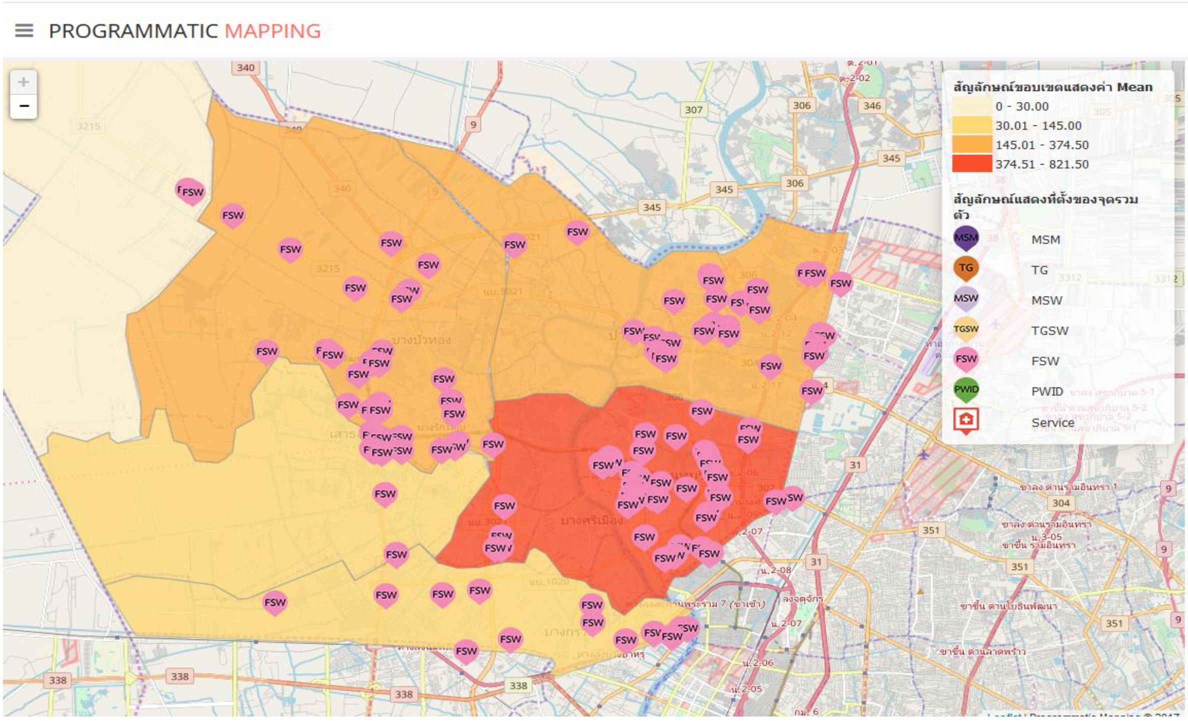
Table 2. Estimated number of female sex workers in 9 provinces of Thailand, 2015

Type of venue	Mapped venues			Estimated number of FSWs		
	All	Venues with no HIV services	Percent	All mapped sites	All mapped sites with no HIV services	Percent
Non-explicit establishment	258	129	50.0	3,049	1,248	40.9
Explicit establishment	757	218	28.8	11,424	2,318	20.3
Explicit non-venue sex work sites	24	10	41.7	619	154	24.9
Total	1,039	357	34.4	15,092	3,720	24.6

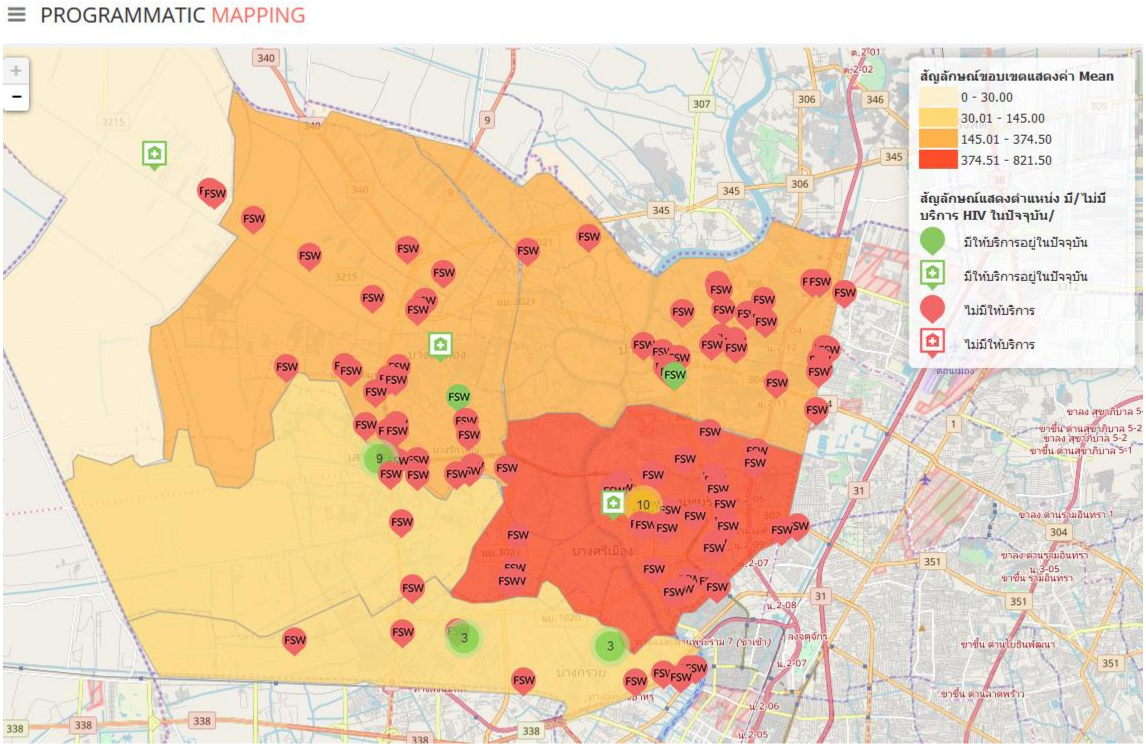
Table 3. Mapped venues for female sex workers (FSWs) and availability of HIV-related services in 9 provinces of Thailand, 2015

Type of venues/ Availability of HIV services	% of mapped venues by type of HIV services					No HIV service (Percent)	
	Condom	Outreach	Mobile STI	Mobile VCT	Referring services*	Mapped venues	FSWs
Non-explicit establishment (n=258)						50.0 (n=129)	40.9 (1,248/3,049)
Currently available	46.3	30.1	20.8	21.6	18.5		
May be available but not currently	44.0	64.5	73.7	72.6	76.1		
Never will be available or unknown	9.7	5.4	5.4	5.8	5.4		
Explicit establishment (n=757)						28.8 (n=218)	20.3 (2,318/11,424)
Currently available	68.1	51.1	37.7	34.2	26.6		
May be available but not currently	28.1	46.4	60.2	63.6	70.8		
Never will be available or unknown	3.8	2.5	2.1	2.2	2.5		
Explicit non-venue sex work sites (n=24)						41.7 (n=10)	24.9 (154/619)
Currently available	54.2	45.8	29.2	37.5	29.2		
May be available but not currently	41.7	45.8	62.5	50.0	58.3		
Never will be available or unknown	4.2	8.3	8.3	12.5	12.5		

*Referring services could be done by outreach workers visiting the hot spots and helping any key populations at the hot spots to access any services they may need, especially HIV testing or STI screening and treatment9+



Note: The two descriptions in Thai language shown in the legend are: first, the shading of the map represents the different numbers of FSWs based on crude estimates; second, markers for each key population.



Note: The markers in green represent the venues where HIV-related services were available, and those in red represent those without HIV-related services. Two descriptions in Thai language shown in the legend are: first, the shading of the map represents the different size estimation of FSWs based on crude estimates; second, the markers for each key population.

Figure 1. Examples of web-based visualization of programmatic mapping results in 9 provinces of Thailand, 2015

higher HIV prevalence compared to those employed by explicit and non-explicit sex establishments.[7,8] Apart from HIV-related risk behaviors, about one-third of FSWs working at explicit non-venue sex work sites reported client violence during their work.[9] Areas where FSWs work and HIV services are non-existent as well as the number of FSWs being unable to access HIV services (about 34% overall). Therefore, the data could be useful for program planning and policy making.

Limitations

This programmatic mapping exercise was a pilot study in Thailand during 2015. The selection of study sites or provinces was conducted purposively as to represent the administrative regions of the Department of Disease Control. The different scales of programmatic mapping in nine provinces were important as it affected the interpretation of the results and implications to program management. However, the community and stakeholder engagement that took place in all provinces is crucial for effectiveness of the implementation and can also maximize the data utilization.

Conclusion and Recommendations

After the programmatic mapping was performed, the provincial teams made arrangements for HIV services at the sites where HIV services were non-existent or unavailable to be reachable by key populations at the sites. This programmatic mapping thus served as an important tool for HIV program planning. The findings demonstrated the need to increase the coverage of HIV service delivery in areas lacking HIV services. Our study also indicated the type and scale of HIV services required in these areas. Size estimation obtained by this programmatic mapping was the number of FSWs reachable by HIV program, in contrast to other estimation methods which provided the size of a population, yet with no information on where FSWs actually worked. It was reported by all provincial teams that the size estimation obtained by this programmatic mapping exercise was used by the provincial team in their HIV program and budget planning.

Moreover, the mapping identified venues where HIV services were not available, which filled the gaps of the BATS annual surveys. Therefore, this programmatic mapping exercise should be conducted regularly or routinely across the whole country to monitor the coverage of HIV services accessible by this particular population.

Acknowledgements

The authors would like to express special gratitude to Dr. Taweesap Siraprapasiri and Ms. Porntip

Kemngern who were part of the investigator team for this study. We acknowledge and appreciate the efforts of the teams from Bangkok and 9 selected provinces, including those from the Office of Disease Prevention and Control, provincial health offices and community-based organizations working with key populations, and all representatives of key populations at each site.

Suggested Citation

Phuengsamran D, Nittayasoot N, Thammawijaya P. Identifying female sex worker sites and gaps of HIV prevention programs using a programmatic mapping method in 9 provinces of Thailand. OSIR. 2018 Jun;11(2):17-23.

References

1. National AIDS Management Center. Thailand AIDS response progress report, 2015. Nonthaburi: Ministry of Public Health; 2015 [cited 2018 Mar 29]. <http://www.unaids.org/sites/default/files/country/documents/THA_narrative_report_2015.pdf>.
2. National AIDS Management Center. Thailand AIDS response progress report, 2017. Nonthaburi: Ministry of Public Health; 2017.
3. Phuengsamran D. Higer-risk female sex workers and access to HIV prevention services: key factors to ending AIDS in Thailand. In: Population and social diversity in Thailand, 2015. Nakorn Pathom: Institute for Population and Social Research; 2015. p. 97-110.
4. United Nations Programme on HIV/AIDS. UNAIDS terminology guidelines. 2015 [cited 2018 Apr 1]. <http://www.unaids.org/sites/default/files/media_asset/2015_terminology_guidelines_en.pdf>.
5. Vipada M, editor. Standard operating procedure for HIV/STI prevention and sexual and reproductive health services for female sex workers. Bangkok: Bureau of AIDS, TB and STIs; 2013. Thai [cited 2018 Mar 29]. <http://www.cqihiv.com/book_dsc%5CB_DiseasesTouch-24.pdf>.
6. Sangwanprakaisang T. Sex establishments and sex workers in Thailand 2015, Bangkok: Bureau of AIDS, TB and STIs; 2015.
7. Manopaiboon C, Prybylski D, Subhachaturas W, Tanpradech S, Suksripanich O, Siangphoe U, et al. Unexpectedly high HIV prevalence among female sex workers in Bangkok, Thailand in a respondent-driven sampling survey. Int J STD AIDS. 2013 Jan;24(1):34-8. Epub 2013 May 6.
8. Nhurod P, Bollen LJM, Smutraprapoot P, Suksripanich O, Siangphoe U, Lolekha R, et al. Access to HIV testing for sex workers in Bangkok, Thailand: a high prevalence of HIV among street-based sex workers. Southeast Asian J Trop Med Public Health. 2010 Jan;41(1):153-62.
9. Phuengsamran D, Janyam S, Sherwood J DM. PrEP Acceptability among female sex workers in Thailand: key research findings. Bangkok: TreatAsia; 2014.

OSIR, June 2018, Volume 11, Issue 2, p.24-27

Outbreak, Surveillance and Investigation Reports
Field Epidemiology Training Program, Bureau of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625901734-5, Fax: +6625918581, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Bayesian Statistics in Epidemiological Investigations

Ying Lu[1,*], Christopher J Gregory[1,2,3]

1 Division of Global Health Protection, Thailand Ministry of Public Health–US Centers for Disease Control and Prevention Collaboration, Thailand

2 Division of Global Health Protection, Centers for Disease Control and Prevention, United States

3 Current affiliation, Division of Vector-borne Diseases, Centers for Disease Control and Prevention, United States

* Corresponding author, email address: ryluzhang@yahoo.com

On a stormy night on 31 May 2009, Air France Flight 447 took off from Rio de Janeiro bound for Paris and disappeared over the South Atlantic without trace. On board were 228 passengers and crew. After more than a year of searching for the plane wreckage yielded no results, and on the verge of giving up, the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA), the French authority responsible for safety investigations in civil aviation, contracted Metron, Inc. to launch a search using Bayesian methodology. Before Metron began physically searching the ocean, information was gathered from all previous searches, regardless of success or failure, and previous accidents occurring in the area and known ocean current dynamic factors. The Metron statisticians quantified the uncertainties in terms of probabilities to be used in formulating the search plan. The probabilities of the location where the plane went down were updated after each physical search. Using this strategic search plan, the plane wreckage and remaining bodies were found in less than a week. While the emotional news of the family members finally being reunited with the recovered bodies of their loved ones made the headlines, backstage the Metron statisticians realized the importance of the Bayesian method in solving a previously intractable mystery.

In this article, we will explore how the same Bayesian method can be used in epidemiology investigations starting with the long established history of Bayes' theorem in section one followed by the underlying philosophy behind the theorem in section two. Applications to various epidemiological investigations will be reviewed in section three and followed by an overall summary in section four.

Section 1. History of Bayes' theorem

Over the past 200 years the use of statistics has revolutionized science, and Bayesian statistics has been presented and evolved during that time. Bayesian statistics is based on Bayes' theorem, or Bayes' rule, invented by the English statistician, philosopher and Presbyterian minister, Thomas Bayes, in the 18th century. This theorem provides a way to draw inferences not only from current study data, but also from other knowledge such as previous studies or expert opinion. During his lifetime, Bayes did not publish his theorem; it was only posthumously that his friend Richard Price published it. The first recognized Bayesian analysis was conducted by a French scholar, Pierre-Simon Laplace, in a study of birth data in France that included a total of 241,945 girls and 251,527 boys born in Paris from 1745 to 1770[1]. After calculating the probability that more boys than girls would be born, he concluded that the birth of more boys than girls was "a general law for the human race"[2]. This finding inspired further research that looked at factors that could influence the sex ratio.

During World War II (WWII), an English mathematician Alan Turing secretly used Bayes' rule to decrypt Germany's Enigma code by continuously updating the probability of the alphabetic letters using prior decrypted messages. He successfully located the U-boat submarines which were tying up thousands of ships and troops needed to support British war efforts[3]. This discovery was estimated to shorten the war by at least two years[4]. Even before the WWII, due to the rapid industrialization of the United States, Edward C. Molina, a leading expert in Bayesian theory, was urgently requested to evaluate the Bell telephone communication system to automate its labor intensive structure. Analyzing information of dialed phone numbers with the economics of various combinations of switches, selectors and trunking lines, Molina's calculating of probabilities based on Bayes' rule increased the automation capacity and reduced costs. This work played a critical role in making the Bell system more competitive[3]. The post-war building boom highlighted the need to set up the insurance schemes for sick and injured workers. Isaac M. Rubinow, a physician and statistician, and Albert Wurts Whitney, a specialist in insurance mathematics, used Bayes' rule to set up the models for actuaries in the insurance industry[3]. With its long established theory and successful applications, Bayesian statistics effectively informed decision making and solved the problems that were previously impossible to solve by conventional analysis.

Section 2. Bayesian Philosophy

The philosophy behind Bayes' theorem is that knowledge of an interest is best provided not only from data of a single study, but also from incorporating other relevant information or prior knowledge of the interest. Many people apply Bayes' rule subconsciously, but in Bayesian statistical analysis, all the common sense ways of double checking can be quantified into a probability measure to estimate, or predict, uncertain situations to assist in decision making. This methodology imitates the approach that clinicians use routinely in diagnosing patients or the common sense that people use in daily life. For example, when an employer needs to hire qualified staff, the employer usually not only interviews the candidates, but also checks past work references of the candidates before making a decision. In this example, the qualification of a candidate is the main interest. The employer gets the evidence about the candidate's qualification not only through a face-to-face interview (the data from the study), but also through reference checking (other relevant information). Thus, the employer has comprehensive knowledge about the qualifications of a candidate based on two sources in order to select the best candidate.

The examples above and in section 1 include three components: uncertain prior knowledge of reality, the data generated based on current investigation or study, and the posterior probability of the reality. The Bayesian approach incorporates prior knowledge about the reality in the form of a prior distribution, which is then updated by information in the data, in the form of a likelihood function. Quantifying the prior distribution with the likelihood function generates a posterior distribution of the reality, which contains updated knowledge taking into account the information added by the data. This principle is Bayes' theorem[1].

Section 3. Bayesian in Epidemiological Investigations

Over time, Bayes' theorem has been applied in many areas, including epidemiology and medical research. After WWII, the claim that smoking potentially caused lung cancer was fiercely debated. Epidemiological studies had been conducted because a spike in lung cancer incidence was observed after the wars when smoking was very prevalent. Among the research, the famous "Doll and Hill" case-control study that was published in 1954 showed a strong association between smoking and lung cancer[5]. In fact, both the authors were motivated to quit smoking because of this finding. The potential causal relationship between lung cancer and smoking attracted more attention from epidemiologists and the public health sector. A famous epidemiological investigation using Bayesian analysis was conducted in the 1950s by Jerome Cornfield, a biostatistician from the U.S. National Institutes of Health (NIH). He used lung cancer incidence data from the NIH as prior information and combined it with Doll and Hill's study data to calculate the probability of developing lung cancer caused by smoking[6]. Cornfield's analyses contributed in definitively establishing the causal relationship between smoking and lung cancer and this is considered as the most influential Bayesian analysis in the 1950s. One consequence has been that many populations, such as men in America, have seen a sharp decrease of lung cancer mortality since the 1990s because of decreased smoking prevalence starting in the 1960s[7].

Another impactful Bayesian epidemiological analysis was the re-assessment of mammogram screening as a tool in preventing breast cancer in the United States. Before 2009, it was recommended that all women aged 40 years or older have an annual mammogram to diagnosis early stage breast cancer. However, the majority of women who tested positive had a subsequent negative result by ultrasound indicating that they were free from breast cancer. The main interest in the reassessment was "what is the probability of breast cancer given a positive mammogram result?" The researchers used Bayes' rule to consider the prevalence of breast cancer as the prior probability in the population and the test result (data of the study) to update the probability of breast cancer given a positive test. For example, if there was a hypothetical population of 10,000 with breast cancer prevalence 0.4%, there would be 40 true breast cancer cases (10,000*0.4%). As sensitivity of the mammogram was 80%, there would be 40*80% = 32 true positive cases among breast cancer cases. Because of 90% specificity of the test, 996 would also test positive but be free of breast cancer. So the probability of having breast cancer given a positive mammogram would be only ~3% (32/(32+996)) (Table 1). This means that 97 out of 100 women with positive mammograms would have a false positive test, causing unnecessary worry and recommendations for further testing leading to a waste of money. With this evidence, in 2009, the United States Preventive Services Task Force changed the breast cancer screening recommendation against routine screening starting at age 40[8].

Table 1. Mammogram screening result in a hypothetical population with prevalence of breast cancer 0.4%, sensitivity as 80%* and specificity as 90%† of mammogram

Mammogram	Breast cancer	Not breast cancer	Total
Positive	32	996	1,028
Negative	8	8,964	8,972
Total	40	9,960	10,000

* National Cancer Institute at National Institute of Health, USA
† New England Journal of Medicine

Bayesian methodology is increasingly embraced by investigators in the United States Centers for Disease Control and Prevention (US CDC) in various studies. Using Bayesian methodology[9] in a pneumonia prevalence study by the Thailand Ministry of Public Health and US CDC, incidence of chest radiograph confirmed pneumonia in rural Thailand in children under five years old was 38% higher than estimated from conventional analysis. In a multi-site Pneumonia Etiology Research for Child Health (PERCH) study, Bayesian methods were similarly utilized to estimate the etiologies of childhood pneumonia[10,11]. In this study, multiple diagnostic tests were used to detect the specific pathogen that potentially could cause pneumonia, but none of the tests were 'gold standard' reference test with 100% sensitivity and specificity. In conventional analysis, one test must be considered as the perfect gold standard. However, Bayesian methodology can take into account the uncertain accuracy of all the tests (<100% sensitivity and specificity) and better estimate the probability of pneumonia etiology. The same Bayesian methods used in PERCH can be applied in other studies[10]. For example, the etiology of neonatal infections in South Asia case-control study aims to determine the etiology of serious neonatal infections, including sepsis and meningitis, using Bayes' theorem[12].

Section 4. Summary

Given that the principles of Bayes' theorem were established many years ago and many successful applications were demonstrated in various fields, Bayesian analysis is considered a very important statistical method. However, it wasn't widely appreciated even among statisticians until the late 20th century, when computers with high speed computation capacity became available. Using this new capacity, the statisticians from the British Medical Research Council and Imperial College developed openBUGS for Linux and WinBUGS for Windows (https://www.mrc-bsu.cam.ac.uk/software/bugs/), free software used to facilitate previously difficult to calculate Bayesian formulas. With more powerful personal computers and the availability of free software and more statisticians with Bayesian expertise, the scientific community can embrace analysis using Bayesian methods more easily than ever before. Nowadays, in more and more institutions, Bayesian methodology is taught along with conventional statistical methodology so that more researchers from all disciplines, including public health, are able to apply it. Bayesian methods can solve many problems that weren't solvable by conventional methods due to its ability to effectively deal with uncertainties by considering multiple sources of information. In this booming information era, Bayesian methodology will almost certainly play an increasingly important role in statistical analyses for epidemiological investigations.

Acknowledgements

We thank Dorothy L. Southern for providing help in scientific writing.

Suggested Citation

Lu Y, Gregory CJ. Bayesian statistics in epidemiological investigations. OSIR. 2018 Jun;11(2):24-7.

References

1. Gelman A, Carlin JB, Stern HS, Dunson DB, Vehtari A, Rubin DB. Bayesian data analysis. 3rd ed. New York: CRC Press; 2014.
2. Hald A. A detailed discussion of Laplace's birth studies. 1998.
3. Mcgrayne SB, The theory that would not die. London: Yale university press; 2012.
4. Copeland J. Alan Turing: The codebreaker who saved 'millions of lives'. 2012 [cited 2018 Feb 5]. <http://www.bbc.com/news/technology-18419691>.

5. Doll R. Hill AB, The mortality of doctors in relation to their smoking habits; a preliminary report. Br Med J. 1954 Jun 26;1(4877):1451-5.

6. Cornfield J. The estimation of the probability of developing a disease in the presence of competing risks. Am J Public Health Nations Health. 1957;47(5):601-7.

7. Islami F, Torre LA, Jemal A. Global trends of lung cancer mortality and smoking prevalence. Transl Lung Cancer Res. 2015 Aug;4(4):327-38.

8. Siu AL, U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2016 Feb 16;164(4):279-96. Epub 2016 Jan 12.

9. Lu Y, Baggett HC, Rhodes J, Thamthitiwat S, Joseph L, Gregory CJ. Bayesian latent class estimation of the incidence of chest radiograph-confirmed pneumonia in rural Thailand. Epidemiol Infect. 2016 Oct;144(13):2858-65. Epub 2016 Mar 2.

10. Deloria Knoll M, Fu W, Shi Q, Prosperi C, Wu Z, Hammitt LL, et al. Bayesian estimation of pneumonia etiology: epidemiologic considerations and applications to the pneumonia etiology research for child health study. Clin Infect Dis. 2017 Jun 15;64(suppl_3):S213-S227.

11. Wu Z, Deloria-Knoll M, Hammitt LL, Zeger SL. Partially latent class models for case-control studies of childhood pneumonia aetiology. JR Stat Soc C. 2016;65:97-114.

12. Saha SK, Islam MS, Qureshi SM, Hossain B, Islam M, Zaidi AK, et al. Laboratory methods for fetermining rtiology of neonatal infection at population-based sites in South Asia: the ANISA study. Pediatr Infect Dis J. 2016;35(5 Suppl 1):S16-22.