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A review of the epidemiology and control of legionellosis in Singapore, 2000-2010

Introduction

Legionellosis, comprising legionnaire's disease and Pontiac fever, is an environment-related, acute respiratory infection caused by the gram negative rod-shaped *Legionella* bacteria. While Pontiac fever is a self-limiting flu-like syndrome, legionnaires' disease is the more severe form with pneumonia as the predominant clinical finding and is a potentially fatal illness. At present, there are 52 *Legionella* species[1] and 70 serogroups[2]. Of these, 25 species are known to cause disease in humans.[1] The majority of human infections are due to *Legionella pneumophila*[3], and the predominant serogroup is serogroup 1[4]. Other species that, together with *Legionella pneumophila*, account for the majority of human infections include *Legionella longbeachae* and *Legionella micdadei*. The main mode of transmission of legionellosis is believed to be via aerosols and inhalation.[5] Other possible modes of transmission such as aspiration of contaminated potable water have also been widely discussed.[6-8] Several outbreaks linked to a variety of aerosol-producing devices, such as cooling towers[9-12], whirpool spas[13], decorative fountains[14], mist machines[15,16] and industrial air scrubbers[17] have been reported. To date, the world's largest outbreak of the disease with 449 confirmed cases attributed to cooling towers in a city hospital was reported in Murcia, Spain in July 2001.[9]

In Singapore, legionnaires' disease was recognised to be a potential public health threat as environmental surveys showed that cooling towers were found to be heavily colonised by the *Legionella* bacteria. A

local study conducted in 1987 showed that *Legionella* bacteria was prevalent in 7 of the 15 sites (46.7%) of cooling towers sampled.[18] With the air-conditioning system in operation most of the time throughout the year, a significant heat load is imposed on the water cooling systems, thus facilitating an increased rate of colonization and multiplication of *Legionella* bacteria. [19] Further, the viability of *Legionella* bacteria in contaminated aerosols would be well supported by the high relative humidity.[19]

Legionella pneumonia accounts for 2% to 7% of community-acquired pneumonia among hospitalised patients in Singapore.[20] Risk factors of legionellosis include cigarette smoking, chronic lung disease, and immunosuppression (especially that due to corticosteroid therapy and organ transplant).[8] Environmental factors such as high humidity and increased rainfall also increase the risk of legionellosis.[21] Legionnaires' disease was made an administratively notifiable infectious disease in 1985 and legally notifiable in 2000. A code of practice for the prevention and control of *Legionella* bacteria in cooling towers for building owners and water treatment contractors was published in 1992, and revised in 1994 and 1998. Subsequently, a piece of legislation entitled the Environmental Public Health (Cooling Towers and Water Fountains) Regulations was enacted and implemented nationwide in 2001.[22]

We studied the trends, clinical and epidemiological features of legionellosis reported from 2000 to 2010. We also reviewed the prevalence of *Legionella* bacteria in cooling towers and water fountains during the same period to determine if there was any relationship between the disease incidence and prevalence of *Legionella* bacteria in these artificial water systems.

Materials and methods

Case surveillance

The Ministry of Health (MOH) is responsible for the surveillance of legionellosis in Singapore. Under the Infectious Diseases Act, all registered medical practitioners and directors of clinical laboratories are required to notify MOH of all cases of legionellosis via fax or electronically through a dedicated website using a standard notification form within 24 hours from time of diagnosis. Clinical and laboratory criteria for notification are based on the guidelines published by MOH.[23] A confirmed case of legionnaires' disease or Pontiac fever was defined as a clinically compatible disease with a four-fold increase in *Legionella* antibody titre in paired sera or presence of urinary *Legionella* antigen or positive immunofluorescence or isolation of *Legionella* bacteria in respiratory specimens. If the clinical diagnosis was based on a positive *Legionella* antibody titre of ≥1024 in a single serum sample, the case was classified as presumptive.

Each notified case was investigated thoroughly by a trained public health officer using a standard questionnaire, which also included determination of any clustering of cases by person, place and time. A cluster was defined as a locality where there were 2 or more cases occurring within 6 months of each other and with the same residential or workplace addresses within 500 metres of each other. If the case-patient had a recent travel history outside Singapore 10 days before the onset of illness, it was considered as an imported case.

Environmental surveillance

The National Environment Agency (NEA), Ministry of Environment and Water Resources, is

responsible for environmental surveillance and control of *Legionella* bacteria in cooling towers, water fountains and other artificial water systems in Singapore. NEA and MOH work closely together in the prevention of outbreaks of legionellosis.

The Food and Water Microbiology Laboratory at Singapore General Hospital (SGH) was the reference laboratory for the testing of *Legionella* bacteria in Singapore. However, it has ceased to perform testing of *Legionella* bacteria in water samples as of September 2008. The data maintained by the Food and Water Microbiology Laboratory, SGH, was used for our study, as it was the only public sector laboratory with reliable records.

Data analysis

The estimated mid-year population of the corresponding years obtained from the Department of Statistics, Singapore, was used to compute the incidence rates. Statistical analyses were performed by using SPSS software version 17.0 (SPSS Inc., Chicago, IL, USA). Association between existence of medical conditions and whether the case survived or died was examined using Fisher's exact test. In all data analyses, a p value of less than 0.05 was considered statistically significant.

Results

During the 11-year period from 2000 to 2010, a total of 250 indigenous and 35 imported cases were reported. An additional 4 reported cases among tourists and 49 foreigners who sought medical treatment in Singapore were excluded. Of the 285 reported cases included in the study, 205 were classified as legionnaires' disease (76 confirmed and 129 presumptive) and 80 as Pontiac fever (9 confirmed and 71 presumptive) (*Table 1*).

The highest mean annual age-specific incidence per 100,000 population was in those aged 55 years or older with a male to female ratio of 1.1:1 (*Fig. 1*). A significant increase in the proportion of cases aged 55 years or older, from 44.4% in 2004 to 76.1% in 2009, was observed ($p<0.0005$), and it then dropped to 21.4% in 2010. Among the three major ethnic groups, Indians had the highest mean annual incidence (0.86 per 100,000), followed by Chinese (0.73 per 100,000) and Malays (0.54 per 100,000) (*Fig. 2*). Retirees (34.4%) made up the majority of the reported cases,

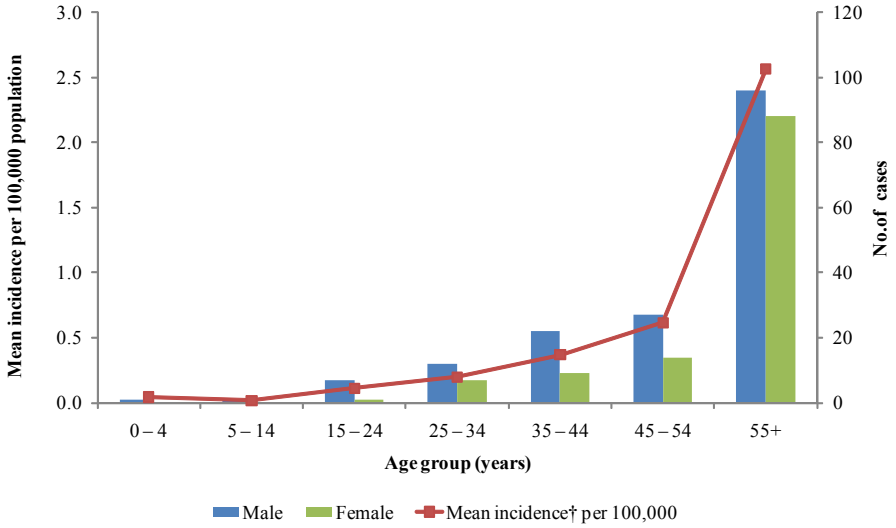
Table 1

Classification of reported legionellosis cases (indigenous and imported)* in Singapore, 2000-2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2000-2010
Confirmed												
Pontiac fever	0	4	1	3	1	0	0	0	0	0	0	9
Legionnaires' disease	3	15	12	16	4	5	1	0	5	11	4	76
Presumptive												
Pontiac fever	7	12	9	16	4	0	0	4	8	7	4	71
Legionnaires' disease	47	15	15	6	4	13	12	8	2	1	6	129
Total	57	46	37	41	13	18	13	12	15	19	14	285

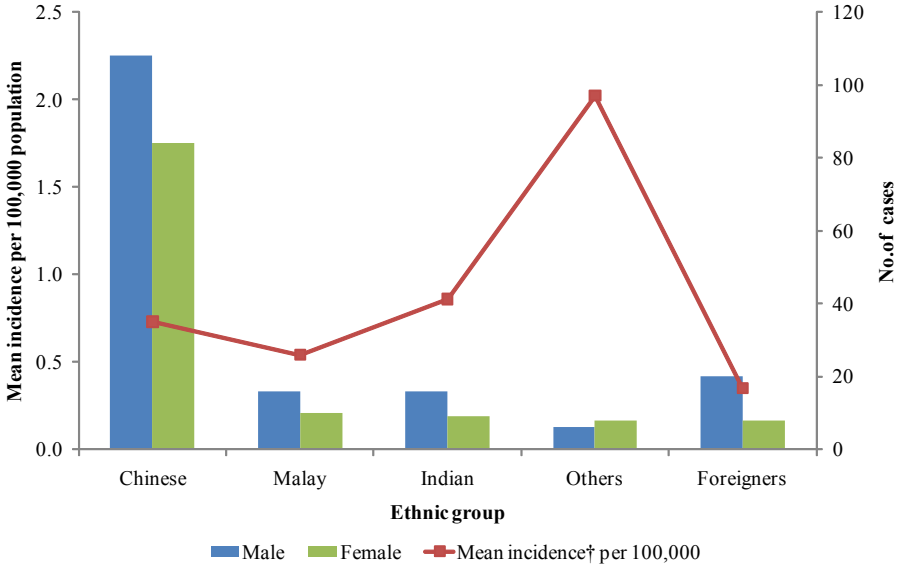
* Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore

Figure 1
Age-gender distribution and mean age-specific incidence* (per 100,000 population) of reported legionellosis (indigenous and imported) in Singapore, 2000-2010**



* Based on estimated mid-year population of 2005.
** Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore.

Figure 2
Ethnic-gender distribution and mean ethnic-specific incidence* (per 100,000 population) of reported legionellosis (indigenous and imported) in Singapore, 2000-2010**



* Based on estimated mid-year population of 2005.
** Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore.

followed by housewives (21.8%) and professionals, self employed and managers (18.9%). Cases occurred singly and sporadically throughout the year and no cluster was detected.

There was a marked decreasing trend in the annual incidence rate of indigenous cases (confirmed and presumptive) from 1.37 per 100,000 in 2000 to 0.24 per 100,000 in 2010 (p=0.001) with a corresponding increase in proportion of imported cases from 6.2% between 2000 and 2004 to 25.3% between 2005 and 2010 (p<0.0005) (*Fig. 3*). The countries of origin of these imported cases were largely in Asia. The annual incidence rate for confirmed indigenous cases also decreased from 0.46 per 100,000 population in 2003 to 0.08 per 100,000 population in 2010. The overall case-fatality rate (CFR) was 2.1% for both confirmed and presumptive cases and 3.6% for confirmed cases only.

The main clinical presentations of the reported cases were cough (77.9%), fever (73.0%), shortness of breath (33.0%), chest pain or discomfort (12.6%), chills (12.3%) and nausea or vomiting (11.2%) (*Table 2*). Majority (52.3%) had co-morbidities such as hypertension (32.9%), diabetes mellitus (24.2%), ischaemic heart disease (16.1%), renal failure (11.4%) and asthma (10.7%). 6 deaths were reported; 3 in 2000, 1 in 2001, 1 in 2002 and 1 in 2009. All but one of the deaths were aged 55 years and older, and all had co-morbidities of the cardiovascular system. The case-fatality rate among those with concurrent medical conditions (6/149) was significantly higher compared with those without (0/136) (p=0.031).

Based on available data, 18,164 samples from cooling towers and 1,277 samples from water fountains that were tested at the Food and Water Microbiology Laboratory, Singapore General Hospital (SGH),

Figure 3
Incidence rate (per 100,000 population) of indigenous cases and proportion (%) of imported cases in Singapore, 2000 – 2010

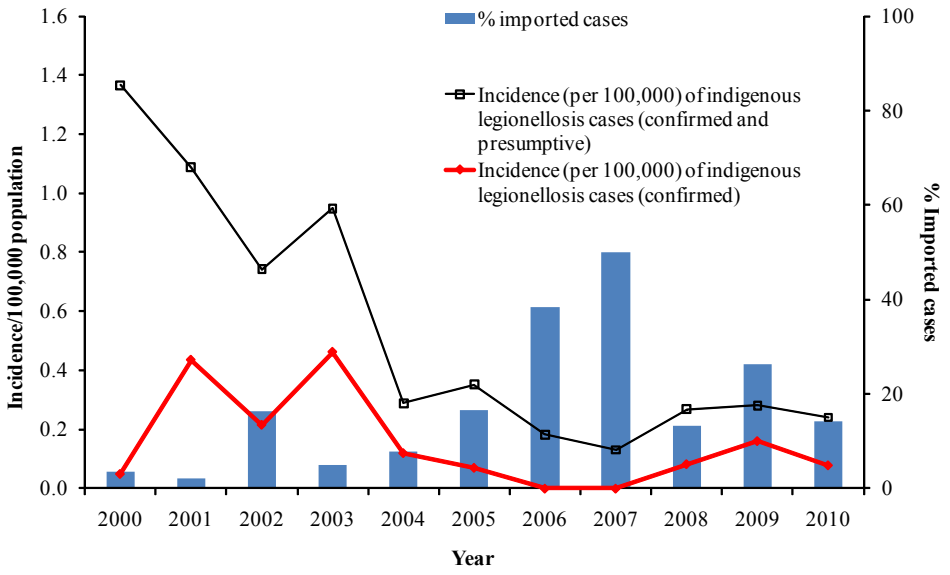


Table 2
Clinical presentations (%) of 285 cases of legionellosis (indigenous and imported)* in Singapore, 2000 – 2010

Clinical presentation**	Number	Percentage
Fever (with/without chills and rigors)	208	73.0
Respiratory symptoms		
Cough (productive and non-productive)	222	77.9
Shortness of breath	94	33.0
Chest pain and discomfort	36	12.6
Running nose	8	2.8
Rhinorrhoea	1	0.4
Bronchitis	2	0.7
Sore throat	7	2.5
Gastrointestinal symptoms		
Nausea/vomiting	32	11.2
Abdominal pain/epigastric pain	13	4.6
Diarrhoea	9	3.2
Neurologic symptoms		
Drowiness/giddiness	15	5.3
Headache	11	3.9
Other signs and symptoms		
Chills	35	12.3
Generalised weakness	10	3.5
Myalgia	5	1.8
Lethargy	8	2.8
Loss of appetite	16	5.6
Others	23	8.1

* Exclude 4 tourists and 59 foreigners seeking medical treatment in Singapore.
** Cases may have one or more clinical presentations.

between 2000 and 2008 were used as it was the only public sector laboratory with reliable records. These were all random samples routinely collected by water treatment contractors, building management and environmental health officers from the former Quarantine and Epidemiology Department (QED), Ministry of the Environment. The data obtained between 2000 and 2002, obtained from the annual reports of QED, was a subset of the total number of samples tested in this laboratory and the data for 2003 was unavailable. This was because this laboratory kept its records for 5 years before they were discarded. The mean positivity rates for *Legionella* bacteria were 15.6% in cooling tower samples and 12.4% in water fountain samples. There was a significant decrease in isolation rates of *Legionella* bacteria in both cooling towers and water fountains, from an average of 58.4% between 2000 and 2002 to an average of 13.7% between 2004 and 2008 ($p<0.0005$) (*Table 3*).

Comments

The incidence of legionellosis in Singapore has declined significantly during the last 11 years. Its

incidence for indigenous cases in 2010 was 0.24 per 100,000 population (0.08 per 100,000 population for confirmed cases only), which was much lower than that in Europe (1.18 per 100,000 in 2008)[24] and Hong Kong (0.53 per 100,000 population in 2009)[25]. The percentage of imported cases of legionellosis has also increased significantly for the period between 2005 and 2010 as compared to the period between 2000 and 2004. Imported legionellosis is often related to overnight stays in public accommodations.[26] The number of imported cases is expected to rise further with improved reporting and surveillance as well as increasing regional and international travel.

The epidemiological and clinical features of legionellosis in Singapore are comparable to those of the temperate countries.[2,25,27] The incidence rate in Singapore was highest among those who were 55 years old or older with a slight males pre-dominance, and in those who had co-morbidities. Retirees were more susceptible to legionellosis as compared to those of other occupations, which was also a reflection of the higher disease burden in those aged 55 years old and above. During the period from 2000 to 2010, the overall case-fatality rate (CFR) was 2.1% for both confirmed and presumptive cases and 3.6% for confirmed cases only, lower than that in Europe (6.5% in 2008)[24]. The CFR was significantly higher among those with co-morbidities. There has been an improvement in CFR over the years compared to 14.7% between 1986 and 1996.[28] One possible reason could be as a result of a wider use of urinary *Legionella* antigen test from 10.8% in 2000 to 45.5% in 2009 in the diagnosis of legionnaire's disease, leading to a quicker diagnosis than traditional serological tests. A delay in appropriate antibiotics therapy has been associated with increased mortality.[29] Although the clinical practice guidelines for the use of antibiotics in adults from the Ministry of Health, Singapore in use since 2000 had recommended antibiotics active against *Legionella*, specifically macrolides (erythromycin/clarithromycin/azithromycin) or fluoquinolones (levofloxacin)[30,31], as first line empirical treatment for community acquired pneumonia in individuals based on risk stratification, laboratory testing for legionnaires' disease remains important to ensure that patients are in clinical practice adequately treated for legionnaires' disease. Hence, results from the urinary *Legionella* antigen would assist clinicians in deciding targeted antibiotics therapy and this could also have led to a low CFR.

Table 3
Isolation rate of *Legionella* bacteria in environmental samples collected from cooling towers and fountains in Singapore, 2000 – August 2008[+]

Year	No. tested	No. positive	% positive
2000*	193	114	59.1
2001*	323	220	68.1
2002*	291	140	48.1
2004	7284	883	12.1
2005	4160	635	15.3
2006	3073	448	14.6
2007	2711	385	14.2
2008 Jan - Aug	1406	172	12.2

[+] Data was unavailable for year 2003.
* Data was incomplete.

During the same time period, there has also been a significant decrease in the prevalence of *Legionella* bacteria in cooling towers and water fountains in Singapore. This could be due to the Environmental Public Health (Cooling Towers and Water Fountains) Regulations which was enacted and implemented nationwide in 2001. This legislation

specifies the frequency of inspection, maintenance and testing of water for *Legionella* bacteria. In the event that the cooling towers or water fountains were found to endanger health of any person by the Director-General (DG) of Public Health, the DG could require the owner or occupier to cease using or operating the cooling tower or water fountain and to cordon off the immediate vicinity. For first offence, the penalty is a fine not exceeding 5,000 Singapore dollars (SGD) and for a second and subsequent offence, the penalty is a fine not exceeding SGD 10,000.[22]

Although it is tempting to attribute the declining disease trend to the introduction of legislation to prevent and control *Legionella* bacteria in cooling towers and water fountains, there are a number of limitations, which should be considered before any conclusion could be made on this relationship. Furthermore, other factors could have also contributed to the decline of indigenous cases of legionellosis in Singapore.

Firstly, there has been no epidemiological evidence to link reported cases of legionellosis to environmental isolates of *Legionella* bacteria as the bacteria have never been isolated from infected patients in Singapore since the disease was made notifiable in 1985. Although isolation of *Legionella* bacteria from respiratory specimens is recognised as the gold standard for the diagnosis of legionellosis, this laboratory method is not the method of choice for many clinicians, as there are other more convenient methods for testing.

Secondly, *Legionella* bacteria is ubiquitous in the environment. Its prevalence in other artificial water systems was 31.8% in spa establishments.[32] In another study conducted between 1998 and 2002, *Legionella* bacteria were found in 16.2% of mist fans and 23.7% of water taps and shower heads.[33] However, *Legionella* bacteria were not detected in the municipal potable water system since the surveillance programme by Public Utilities Board, the National Water Agency, started in 2003**.** A major contributing factor that has possibly resulted in the decrease of *Legionella* bacteria colonisation in the potable water system was replacing chlorination with chloramination in disinfecting the potable water system since 2005. Monochloramine disinfection of municipal water supplies is associated with decreased risk of legionnaires' disease.[34,35] Hence, the use of chloramine since 2005 could have also led to the decreasing incidence of indigenous cases of legionellosis (confirmed and presumptive).

Thirdly, the disease surveillance system favours identification of the more severe form of legionellosis which represents a fraction of the actual extent of the infections in the community. A sero-epidemiological survey of the general population in Singapore showed a prevalence of 10.3% for *Legionella* antibody in persons below 20 years of age and 21.9% in those 20 years old and above.[28] Fourthly, the wider use of the rapid immunochromatographic assay for the detection of *Legionella pneumophila* serogroup 1 antigen in urine specimens[36], would mean that legionellosis caused by other species or serogroups would not be detected.

Fifthly, the majority of the reported legionellosis cases (70.2%) were classified as presumptive, which would not constitute a definite case of legionnaires' disease in the United States and some other countries. A decreasing trend was also observed when we took into consideration the confirmed indigenous cases only. Although the annual incidence rate for confirmed indigenous cases decreased from 0.46 per

100,000 population in 2003 to 0.08 per 100,000 population in 2010, this was not statistically significant. This could be due to the smaller sample size (n=85) of confirmed indigenous cases of legionellosis between 2000 and 2010. Sixthly, changes in clinical testing pattern could also have resulted in the observed fall in incidence rate. Unfortunately, except for the clinical laboratories at SGH, we did not have data from other hospitals and clinical laboratories where *Legionella* testing was performed.

Lastly, the results of the water samples obtained from cooling towers and water fountains and submitted to the Food and Water Microbiology Laboratory at SGH may not represent the complete situation in Singapore. Hence, results and conclusions derived from this study should be interpreted with caution. More research should be planned and conducted to evaluate the effectiveness of legislation in the control of legionellosis.

The absence of outbreaks of legionellosis, coupled with the decline in the incidence rate, CFR, prevalence rate of *Legionella* bacteria in our cooling towers and water fountains is re-assuring. However, a high level of vigilance should continue in the maintenance and inspection of cooling towers and water fountains. Studies should be conducted to determine the epidemiological and molecular linkage between legionellosis cases and environmental *Legionella* isolates. At the same time, the prevalence of *Legionella* bacteria in other aerosol-producing artificial water systems should be periodically assessed and appropriate preventive and control measures taken.

(Reported by Lam MC[1], Ang LW[1], Tan AL[2], James L[1] and Goh KT[1], Ministry of Health[1] and Singapore General Hospital[2], Singapore)

[This article is partly adapted from Lam MC, Ang LW, Tan AL, James L, Goh KT. Epidemiology and control of legionellosis, Singapore. Emerg Infect Dis. 2011; 17:1209-15.]

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Trends in cough duration among smear-positive pulmonary tuberculosis patients in Singapore, 2002-2008

Delayed diagnosis and treatment of pulmonary tuberculosis (PTB) can result in significant patient morbidity and continued transmission of *Mycobacterium tuberculosis* to close contacts[1]. In 2008, the incidence of new TB cases in Singapore citizens and permanent residents increased for the first time in a decade to 39.8 per 100,000 from 35 per 100,000 the previous year. It remained at this level for the next two years ie 38.6 and 39.2 per 100,000 for the years 2009 and 2010, respectively[2]. We hypothesized that this rise was partly contributed to by increased community transmission from delayed diagnosis of infectious PTB. To investigate this hypothesis, we utilized surveillance data from the national TB notification registry and case records of the Singapore TB Control Unit (TBCU) to determine the trends in prolonged cough duration (defined as more than 8 weeks prior to diagnosis) as a surrogate for delayed diagnosis among smear-positive PTB patients in Singapore from 2002 to 2008.

Methods

TB notification is mandated by Singapore law. All TB notifications are sent to the Singapore TB Elimination Programme (STEP) Registry which captures information on patient demographics, disease characteristics and information pertaining to the infectiousness of the patient such as the presence of cough, sputum AFB smear status and cavitation on chest radiograph. We extracted data from the Registry for all notified sputum AFB smear positive pulmonary TB patients from 2002 to 2008 with cough of more than 8 weeks duration. Statistical analysis using SPSS was performed to determine significant variables associated with prolonged cough. Comparison of age, sex, ethnicity, marital status, residential status, hous-

ing type, occupation, country of birth, presence of diabetes and presence of cavitation was made between smear-positive patients with cough less than 4 weeks versus those with cough more than 8 weeks in 2008.

Multivariate analysis using logistic regression was used to investigate factors that were independently associated with delay. All statistical tests were two-tailed and statistical significance was defined by a p value < 0.05.

Results

Among smear-positive PTB patients with cough > 8 weeks, the median cough duration rose from 16 weeks in 2004 to 20 weeks in 2008. Following stability in the years 2002 to 2004, the number and proportion of smear-positive PTB patients presenting with cough > 8 weeks rose steadily, from 146 (21.5%) in 2004 to 214 (29%) in 2008. The number and proportion of smear-positive cases with cough > 24 weeks similarly increased, from 42 (6.2%) in 2004 to 71(9.6%) in 2008 (*Fig. 4*). Multivariate analysis of study variables of smear-positive patients with cough < 4 weeks (n = 181) versus those with cough > 8 weeks (n =214) in 2008 (*Table 4*) showed those with cough > 8 weeks were more likely to be of Chinese ethnicity (p = 0.054) and to have radiological cavitary disease (p = 0.02). There was no significant difference in age, sex, marital status, residential status, housing type, occupation, country of birth and presence of diabetes between those with cough < 4 weeks and > 8 weeks duration.

Discussion

In Singapore, a decade-long decline in TB rates was reversed in 2008. Although this may be due to factors such as our rapidly ageing population, the increasing prevalence of diabetes mellitus (an important risk factor for TB)[3,4], and the influx of immigrants from high TB burden countries[5], we

Figures 4 (a) (b)
The number and proportion of smear-positive PTB patients presenting with cough> 8 weeks rose steadily, from 146(21.5%) in 2004 to 214(29%) in 2008. The number and proportion of smear-positive cases with cough > 24 weeks similarly increased, from 42(6.2%) in 2004 to 71(9.6%) in 2008

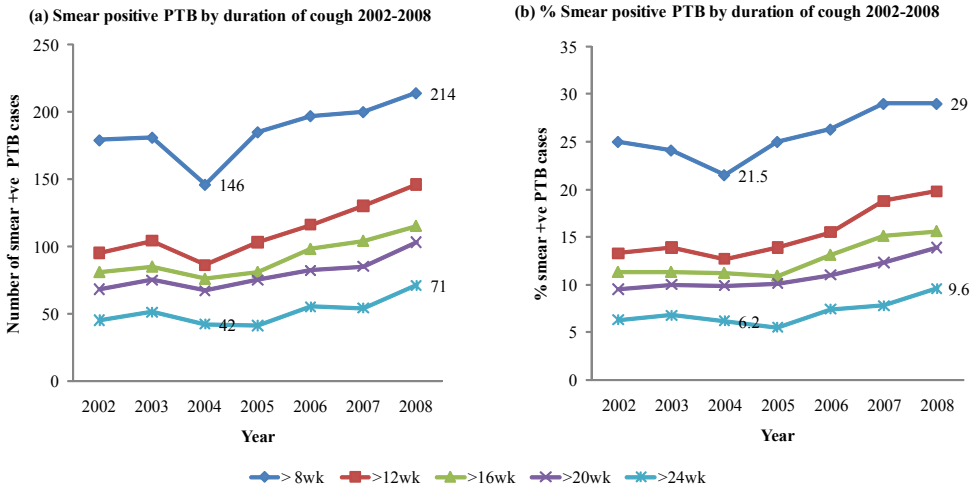

Table 4

Multivariate analysis of factors associated with diagnostic delay in 2008

Covariate	Cases with < 4 weeks cough	Cases with > 8 weeks cough	Adjusted odds Ratio	95% CI†	* p value
Chinese race	103	142	1.579	1.043-2.391	0.031
CXR with cavity	71	109	1.685	1.122-2.530	0.012

* using χ^2 or Fischer's exact test

† confidence limit

suspect that this was also exacerbated by increased community transmission due to delayed diagnosis of infectious TB cases. The most infectious patients are those with smear-positive pulmonary disease. Delay in the diagnosis and institution of effective treatment for these patients increases their duration of infectiousness. TB diagnosis can be delayed when patients themselves postpone seeking care after the onset of symptoms or when health providers take more time than required to diagnose TB.[6] We postulate that the decade-long decline in Singapore's TB rates from 57 / 100,000 population in 1998 to 35 / 100,000 population in 2007 may have led to a lower index of suspicion for TB as a cause of prolonged cough among patients and medical practitioners.

This was borne out by our study where surveillance data showed that the median cough duration of smear-positive PTB patients with cough more than 8 weeks rose from 16 week to 20 weeks between 2004 and 2008. Also, the number and proportion of smear-positive patients presenting with prolonged cough increased from 2004 to 2008. The main study limitation was that it was a retrospective study using registry data based on information furnished by the notifying physician.

It was not surprising that the presence of radiological cavitary disease was associated with prolonged cough as this reflects mycobacterial load[7]. Our study also showed that Chinese patients had longer cough duration than the other ethnic groups at the time of diagnosis. This could be related to cultural or social factors affecting their health-seeking behavior and merits further study.

In conclusion, a trend of increasing cough duration of sputum smear-positive PTB patients was seen in Singapore from 2004 to 2008. This trend is worrying as it was followed by a rise in Singapore's TB rate from 2008. Improved measures to facilitate the early diagnosis of TB and firm action to hold patients under treatment until cure are needed to help reverse the recent rise in Singapore's TB rate.

(Reported by Chua A[2], Kyi-win K[2], Cutter J[1], James L[1], Chee CBE [2], and Wang YT[2] Communicable Diseases Division[1], Ministry of Health and TB Control Unit, Department of Respiratory Medicine[2], Tan Tock Seng Hospital, Singapore)

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Horizon scanning and risk assessment in public health

Introduction

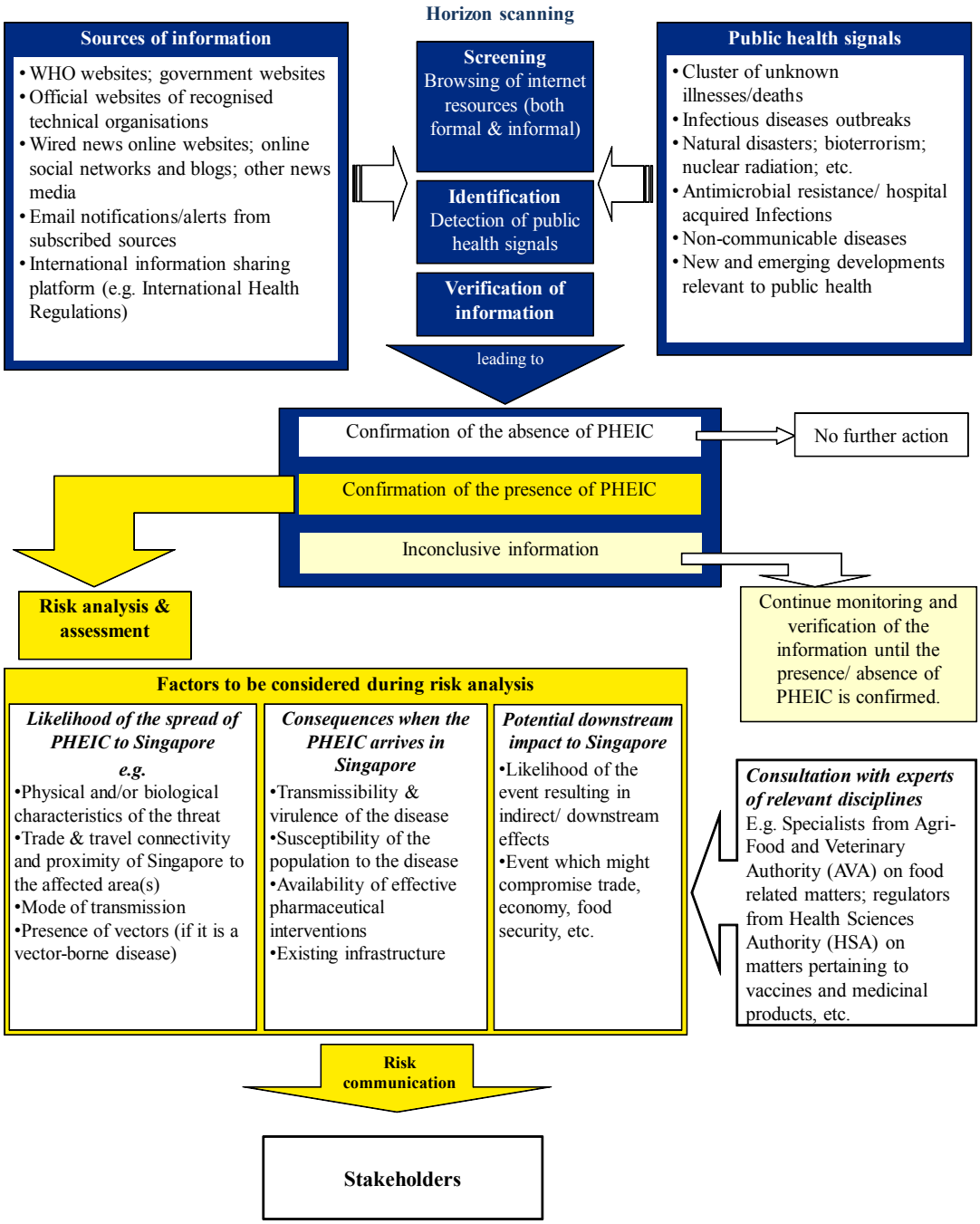
Horizon scanning, as well as risk assessment and analysis, are important components of our public health system to (a) provide early detection and warning of potential public health threats (including communicable diseases, bioterrorism, nuclear radiation, natural disasters, etc), (b) prevent the entry of these threats into Singapore, (c) mitigate the impact of such threats to the local community after entry into Singapore, and (d) monitor new and emerging developments relevant to public health (such as diagnostics, therapeutics, prevention and control strategies as well as the latest related technology, innovation and research).

The ability to analyze and respond to the risk of events that may constitute public health emergency of international concern (PHEIC)[1] in a timely manner, as well as the ability to stay abreast of new developments largely depend on the regular collection of up-to-date information to facilitate real-time situational awareness on the local and international environments, the assimilation of available data to carry out assessment of public health risk, and the development of triggers for preventive action.

Process of horizon scanning

Horizon scanning is an iterative process which involves (a) *environment scanning* of relevant information from formal and informal websites on various subjects of interest which range from communicable diseases, non-communicable diseases, antimicrobial resistance and hospital acquired infections (HAIs) to natural disasters, bioterrorism, and nuclear radiation, (b) *hazard identification*, i.e. the detection of signals of potential public health threats from the scanned information, and (c) *verification of information* with official sources of information and direct communications with overseas public health agencies / networks to determine if the detected signals were true indications of a PHEIC *(Fig. 5)*.[2] Horizon scanning also facilitates access to information on the latest developments in public health.

Figure 5
Flow-chart of the process of horizon scanning and risk assessment



Risk assessment

Risk assessment is carried out upon confirmation of the presence of an event / incidence of public health concern. Three main factors are taken into consideration on conducting risk assessment: (a) the *likelihood of the occurrence* of PHEIC in Singapore; (b) the *likely consequences* once the PHEIC arrives in Singapore; and (c) the *potential downstream impact* if the PHEIC were to occur in Singapore.

The assessment of the likelihood of the occurrence of PHEIC in Singapore would include considerations such as the trade and travel connectivity and proximity of Singapore to the affected area, the mode of transmission of disease concerned, and the presence of vectors (if it is a vector-borne disease).

The possible consequences of the PHEIC in Singapore would depend on factors like transmissibility and virulence of the disease, the susceptibility of the community to the disease (e.g. presence of innate immunity), the availability of effective pharmaceutical interventions (e.g. antibiotics / antiviral therapy, vaccines, etc.), existing infrastructure (e.g. water and sanitation system which will halt any further spread of water-borne diseases).

The assessment of the risk of a particular PHEIC also takes into account of the likelihood of the event resulting in indirect / downstream effects, e.g. nuclear fallout from a meltdown of a nearby nuclear power plant, chemical spillage into the regional seawaters; events which might compromise trade, economy, food security, etc.

The assessment of the potential risk of a public health threat to Singapore is carried out in consultation with experts of relevant disciplines, such as the specialists from the Agri-Food & Veterinary Authority of Singapore (AVA) on matters pertaining to food sources, and the regulators of pharmaceutical products from the Health Sciences Authority (HSA) on matters pertaining to vaccines and medicinal products.

Risk communication

The assessments of local and external public health threats are routinely communicated on a regular basis to key stakeholders for information and necessary follow-up action through various platforms such as the quarterly Epidemiological News Bulletin (ENB) published by the Ministry of Health, as well as the dissemination of professional circulars and guidelines to the medical community. Follow-up actions may include the implementation of coordinated public health responses, or continued monitoring of the threat.

Practical application - West Nile virus

An outbreak of West Nile virus (WNV) infection in Greece, largely limited to the region of Central Macedonia was detected through our horizon scanning in 2010.[3] From May to October 2010, an unusually large number of WNV cases were reported in several countries in the European region, including large scale outbreaks in southern Russian Federation and northern Greece. Hungary, Israel, Italy, Romania and Turkey also experienced WNV outbreaks.[4,5]

The WNV is a member of the genus *Flavivirus*. Human infection is most often the result of bites from infected ornithophilic mosquitoes, mainly *Culex* species. Mosquitoes become infected when they feed on infected birds. Transmission of the disease can also occur through contact with other infected animals, their blood, or other tissues. A very small proportion

of human infections have occurred through organ transplant, blood transfusions and breast milk. Transplacental (mother-to-child) WNV transmission has also been reported in one case.[6] WNV is the cause of periodic, often severe, outbreaks in humans and animals such as horses, and is commonly found in Africa, Europe, the Middle East, North America and West Asia.

In humans, WNV infection is often an asymptomatic (about 80%) or mild febrile illness (about 20%). However, the neuro-invasive form of WNV disease (encephalitis or meningitis) which develops in less than 1% of the cases can cause some fatalities, particularly in elderly and immunocompromised patients.

In response to the reports of outbreaks of WNV infection in Europe last year, we undertook an in-depth risk assessment report together with the various agencies on the likelihood of the spread of WNV in Singapore. Based on the epidemiological characteristics of WNV (host, vectors and mode of transmission), the possible routes of introduction of WNV into Singapore were identified to be (a) migration of infected birds, (b) importation of infected birds or other animals, and (c) international travel of infected persons to Singapore. There have been no clinical cases of WNV infection reported in Singapore thus far. In addition, WNV has not been detected in the surveillance of WNV in humans, migratory and resident birds, as well as mosquitoes trapped in areas where migratory birds are present. The assessment of the risk of the transmission of WNV to the local population through blood transfusion was sought from the Blood Services Group (BSG) of the Health Sciences Authority (HSA). Based on the joint risk assessment, the likelihood of a WNV disease outbreak is considered 'unlikely'.[7]

Given that less than 1% of the infected will develop neuroinvasive diseases and the case fatality rate among such neuroinvasive diseases is about 10%, the overall case fatality rate is less than 0.1%. As such, the consequence of WNV infection at the population level is considered 'moderate to minor'.

Conclusion

The practice of environmental scanning / screening and risk analysis and assessment is an ongoing process which is vital for the early detection and preparedness against potential public health threats.

(Reported by Nandar K[1], Han HK[1], Ang LW[1], Lai FY[1], Tey SH[1], Cutter JL[2], Heng D[1], Epidemiology and Disease Control Division[1], and Communicable Diseases Division[2], Ministry of Health)

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Food poisoning outbreak at a sports school in Singapore

Introduction

On 4 Nov 2010, the Ministry of Health (MOH) was notified of 139 students suffering from food poisoning after consuming meals provided at the school canteen on 1-3 Nov 2010. The school had a total enrollment of 420 students from Secondary 1 – 5 (of which 331 students were hostelites) and is supported by 145 staff. Six meals supplied by a licensed caterer were served at the school canteen, consisting of breakfast, morning tea, lunch, afternoon tea, dinner and supper.

Field investigations were carried out immediately at the school. This report summarised the investigation into the outbreak.

Methods

A case was defined as a person who developed symptoms of gastroenteritis after consuming food from the school canteen from 1-2 Nov 2010. The students of the school were identified and their personal particulars such as age, gender, and ethnicity were recorded. Signs and symptoms of those who were ill and the types of medical treatment sought were obtained. A case-control study was conducted using a standard questionnaire to determine the vehicle of transmission based on the food items consumed over the two days by both well and unwell students of the school.

As part of field investigations, food and environmental samples were taken from the school canteen and the food premises of the caterer for microbial analysis. Implicated food handlers and cases reported were screened for enteropathogens (*Shigella, Campylobacter, Vibrio, Salmonella, rotavirus* and *norovirus*). A total of 39 food samples, 13 environmental swabs and 15 food handlers from the school canteen were tested. Another 3 food samples were collected from the food premises. There were also 2 stool samples collected from the affected cases.

Differences in attack rates between cases and controls using the Chi-square or Fisher's exact test were examined first by day and then by meal. Differences in food-specific attack rates by meals were

subsequently examined using bivariate analyses, with crude odds ratio (OR) and 95% confidence intervals (CI) computed. Multivariate logistic regression was used to determine independent food items associated with the outbreak, using forward stepwise selection based on maximum partial likelihood estimates. The adjusted odds ratio (AOR) and 95% CI were computed. Statistical analyses were performed using PASW Statistics Version 18.0 (SPSS Chicago, IL). A p value of 0.05 was considered statistically significant.

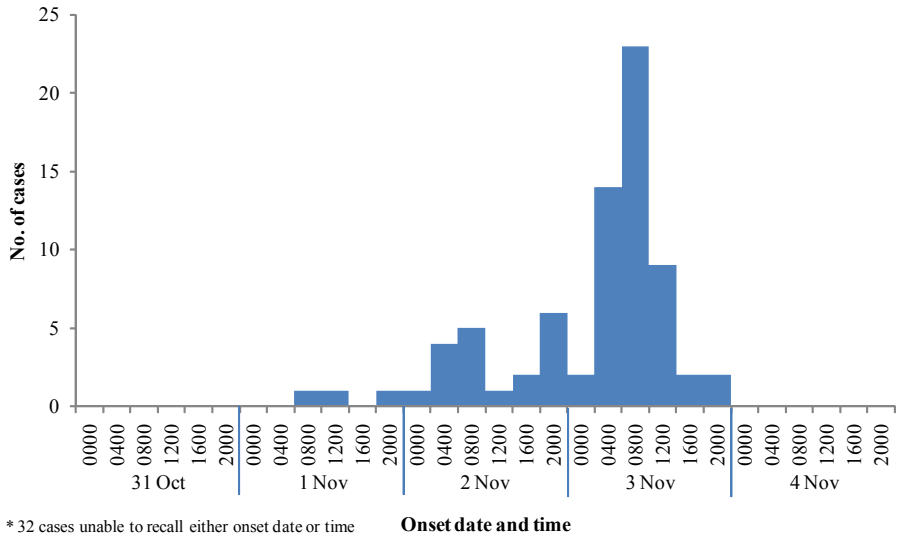
Findings

A total of 106 cases were identified, giving an attack rate of 32%. The cases were aged between 13 and 16 years, and the male to female ratio was 1.36:1. The attack rate was highest in Malays (56%), followed by Chinese (29%), Indians (18%) and Others (17%). Their clinical features comprised diarrhoea (99%), abdominal pain (91%), headache (24%), nausea (10%), vomiting (7%) and fever (4%). Eleven cases (10.4%) sought outpatient treatment while the rest self-medicated. None were hospitalized. All recovered uneventfully.

Of the 106 cases reported, we were able to obtain the time of onset of illness from 74 cases. Based on the available information, the mean and median incubation periods were 44.5 hours, and ranged from 3 – 58 hours. The epidemic curve is shown in *Fig. 6*.

A total of 76 students responded to the questionnaire and remained well served as controls. Based on the case-control data, food served on 1 Nov 2010 was significantly associated with the illness (p=0.032). The specific food items which showed significant association with the outbreak were cordial drinks (odds ratio 4.6, p<0.0005) and mini chicken frank rolls (odds ratio 2.4, p=0.016). The mini chicken frank rolls were provided for morning tea-break while the drinks had been available for all the meals that day. Multivariate logistic regression showed significant associations between the occurrence of illness and the consumption of cordial drinks (adjusted odds ratio

Figure 6
Onset of illness of 106* food poisoning cases at a school in Singapore, 1-3 Nov 2010



* 32 cases unable to recall either onset date or time

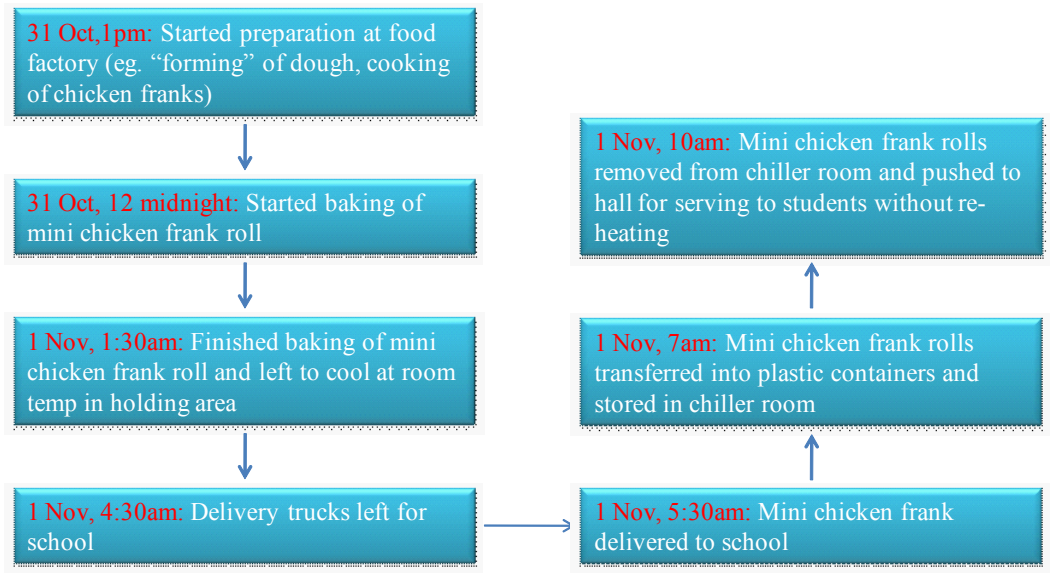
3.7, 95% confidence interval 1.980 – 6.975; p<0.0005) and mini chicken frank rolls (adjusted odds ratio 2.7, 95% confidence interval 1.280 – 5.854; p=0.009) on 1 Nov 2010.

Of the 15 food handlers screened, one of them from the school canteen was found to be positive for *Salmonella* Group D. She was asymptomatic prior to the screening. Further investigation revealed that this food handler was involved in the handling of the mini chicken frank rolls on 1 Nov 10. One food sample taken from the food factory was positive for *Bacillus cereus* (10 cfu/g).

The mini chicken frank rolls were prepared for the school canteen in a licensed food premises. The production processes involved forming of the dough, cooking of the chicken franks, and baking of the final product which was completed by 1.30 am on 1 Nov. The rolls were then placed in a holding area (at room temperature) and delivered to the school by 5.30 am on the same day. At the school, they were transferred by the food handler found to be positive for *Salmonella* Group D into plastic containers in a serving area before being put into the chiller by 7 am. The mini chicken frank rolls were served at 10 am. The sequence from the time of preparation of the mini chicken frank rolls to the time of delivery to the school is depicted in *Fig. 7.*

The cordial drinks were prepared at the school from cordial syrup using a plastic bucket, measuring container and ladle. Water was collected directly from a tap using a bucket before ice and syrup were added.

Figure 7
Manufacture and distribution process of mini chicken frank rolls from food premises to the school



After thorough mixing, the mixture was then poured into the respective drink dispensers. It should be noted that the foodhandler preparing the cordial drink was not the one tested positive for *Salmonella* Group D.

Discussion

This is a common source outbreak of gastro-enteritis with clinical and epidemiological features suggestive of salmonella food poisoning. However, there is insufficient evidence to pin point the exact causative agent and source of contamination. No salmonella bacteria were isolated from the implicated food items and reported cases. The asymptomatic food handler tested positive for *Salmonella* group D could have acquired the infection through handling the implicated food (or other contaminated foods) rather than being the source of infection in this outbreak.

Our investigations revealed lapses in personal and food hygiene practices. A food handler was observed to be handling ready-to-eat food with bare hands during our inspection of the food premises where chicken frank rolls were prepared. The long duration of storage at ambient temperatures between preparation and consumption of the implicated food would have allowed the bacteria to multiply to high infectious doses. The exact mechanism by which the cordial drink was contaminated could not be determined.

The caterer was directed to ensure a tighter supervision of food preparation, storage, handling and transportation and to implement a good system for monitoring the hygienic quality of all ready-to-eat food served at the canteen, including those obtained from external suppliers.

(Contributed by Toh HY[1], Tan JD[1], Ang LW[2], Foong BH[1], Badaruddin H[1], Ooi PL[1] and Cutter J[1], Communicable Diseases Division[1] and Epidemiology and Disease Control Division[2], Ministry of Health)

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