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Surveillance of HIV/AIDS and other sexually transmitted infections in Singapore, 2013

Human immunodeficiency virus (HIV) infection and acquired immunodeficiency syndrome (AIDS)

The HIV which causes AIDS belongs to the lentivirus group of the retrovirus family. Since the disease first appeared in 1981, almost 75 million people have been infected with the virus and about 36 million have died of AIDS worldwide. Globally, 35.3 million people were living with HIV infection at the end of 2012.

HIV can be transmitted from person to person through unprotected sexual intercourse, use of HIV contaminated needles including the sharing of needles among intravenous drug users, transfusion of infected blood or blood products, mucosal exposures with infected body fluid and transplantation of HIV-infected tissues or organs. Mother-to-child or vertical transmission is the most common route of HIV infection in children.

AIDS is the advanced stage of HIV infection, when a person's immune system is severely damaged and vulnerable to opportunistic infections. Previously, people with HIV could progress to AIDS in eight to ten years. However, since the introduction of highly active anti-retroviral therapy (HAART) in the mid 1990s, the lifespan of a HIV-infected individual on treatment has become comparable to someone without HIV infection.

Singapore's multi-pronged National HIV/AIDS Control Programme comprises education of the general public and high-risk groups, protection of the national blood supply through screening of blood and

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blood products, management of cases and contact tracing, epidemiological surveillance, scaling up the prevention and control of sexually-transmitted infections (STIs), and legislation.

The National HIV/AIDS Policy Committee, which comprises representatives from seven ministries (Health; Defence; Home Affairs; Social and Family Development; Manpower; Education; Communications and Information), Communicable Disease Centre, National Skin Centre, Health Promotion Board, the AIDS Business Alliance, Action for AIDS and Singapore National Employers Federation, provides guidance on all policy matters related to HIV infection/AIDS, including public health, legal, ethical, social and economic issues, and coordinates a broad-based multi-sectoral approach to its prevention and control in Singapore.

Notifications

In 2013, a total of 454 new HIV infections were reported among Singapore residents, a decrease of 3.2% from 469 cases in 2012. This brings the cumulative number of HIV infections/AIDS among residents since the first case was diagnosed in 1985 to 6,229. Of these, 3,108 are asymptomatic carriers, 1,450 have or have had AIDS-related illnesses and 1,671 have died.

During 2013, 116 cases of AIDS were reported, including 109 with AIDS at diagnosis of HIV infection and seven previously diagnosed asymptomatic HIV-infected persons who progressed to AIDS. These 109 cases with AIDS at diagnosis comprised 24% of the newly reported cases. Of these new AIDS cases, 41% presented with late-stage HIV infection, as defined by CD4+ cell count of less than 200 per cu mm or AIDS-defining opportunistic infections or both.

The notification rate of HIV infection/AIDS in 2013 was lower at 118.1 per million population, compared to 122.8 per million population in 2012. The AIDS morbidity rate was also lower at 30.2 per million population in 2013, compared to 40.9 per million population in 2012. There were 89 deaths among HIV-infected/AIDS cases, giving a mortality rate of 23.1 million population.

Distribution by age and gender

As in previous years, HIV infected/AIDS cases were predominantly males with a male to female ratio of 16:1. In 2013, the highest notification rates were observed for both males and females in the 30 - 39 years age group (*Table 1*).

Ethnic distribution

Among the three major ethnic groups, Malays had the highest HIV/AIDS notification rate at 183.3 per million population, followed by Chinese (113.2million) and Indians (62.6 per million).

Biographic profile of HIV infected /AIDS patients

Of the 454 new cases in 2013, 66% were single; 23% married; 9% divorced/separated; and 2% widowed at the time of diagnosis (*Table 2*). Among the male cases, 68% were single at the point of diagnosis. For the females, the majority (54%) were married.

Mode of HIV/AIDS transmission

The main mode of HIV transmission was through sexual contact, comprising 95% of the cases in 2013 (*Table 3*). Heterosexual transmission accounted for 39.9% of all cases, while homosexual and bisexual transmission accounted for 54.6%. There were four cases infected via intravenous

Table 1

Age-gender distribution and age-specific notification rates of HIV infection/AIDS among Singapore residents, 2013

Age (years)	Male	Female	Total (%)	Notification rate per million population*		
				Male	Female	Total
0 - 14	0	0	0	0	0	0
15-19	2	1	3 (1)	15.4	8.0	11.8
20-29	86	5	91 (20)	333.3	18.9	174.2
30-39	102	8	110 (24)	353.3	25.5	182.6
40-49	108	6	114 (25)	347.3	18.9	181.3
50-59	86	4	90 (20)	288.0	13.5	151.5
60 & above	44	2	46 (10)	151.2	6.0	73.4
Total	**428**	**26**	**454 (100)**	**226.3**	**13.3**	**118.1**

*Rates are based on 2013 mid-year population.
(Source: Singapore Department of Statistics)

Table 2

Distribution of Singapore residents with HIV infection/AIDS by marital status, 2013

Marital status	Male	Female	Total (%)
Single	292	8	300 (66)
Married	92	14	106 (23)
Divorced	38	3	41 (9)
Widowed	6	1	7 (2)
Total	**428**	**26**	**454 (100)**

Table 3

Distribution of Singapore residents with HIV infection/AIDS by mode of transmission, 2013

Mode of transmission	No.	%
Sexual transmission		
Heterosexual	181	39.9
Homosexual	210	46.3
Bisexual	38	8.4
Intravenous drug use	4	0.9
Blood transfusion	0	0.0
Renal transplant overseas	0	0.0
Perinatal (mother to child)	0	0.0
Uncertain/others	21	4.6
Total	**454**	**100**

drug use, two of them detected as a result of prison screening.

HIV surveillance programmes

The proportion of cases tested positive for HIV in anonymous test sites, the inpatient opt-out testing programme and the antenatal screening programme has remained stable over the last four years (*Table 4*). In 2013, the prevalence of HIV infection among persons tested in anonymous test sites was highest at 1.6%, followed by inpatient opt-out testing at 0.12% and antenatal screening at 0.09%.

HIV unlinked anonymous sero-surveillance programme

Two sentinel populations are currently monitored through unlinked anonymous testing (UAT) to monitor HIV seroprevalence. They are patients with sexually transmitted infections (STIs) attending the Department of STI Control (DSC) clinic; and inpatients at one tertiary restructured hospital. The overall HIV seroprevalence in 2013 was 0.7%, comprising 0.7% among STI attendees and 0.6% among inpatients.

HIV molecular surveillance programme

In 2013, the proportion of recently-infected individuals in newly-diagnosed HIV patients was estimated at 17.1% in treatment-naïve patients (n=123). Among these recently-infected patients, the predominant circulating HIV subtype was CRF01_AE (47.6%), followed by subtype B (42.9%). The overall prevalence of transmitted drug resistance (TDR) to any antiretroviral (ARV) class was 3.3% in 2013. Transmitted resistance to nucleoside reverse transcriptase inhibitors (NRTI) and non-nucleoside reverse transcriptase inhibitors (NNRTI) were 2.4% and 0.8%, respectively.

Sexually transmitted infections

Sexually transmitted infections (STIs) which are legally notifiable under the Infectious Diseases Act (IDA) comprise gonorrhoea, non-gonococcal urethritis, syphilis, chlamydia and genital herpes.

The Department of STI Control (DSC) Clinic of the National Skin Centre (NSC) is a public clinic for the diagnosis, treatment and control of STI in Singapore. The DSC runs the National STI Control Programme in Singapore, and its activities include health and public education on STI/HIV, clinic services, disease detection, patient management and research.

Notifications

In 2013, the overall incidence for all STIs (including those not legally notifiable) was 192 per 100,000 population in 2013 while the incidence of the five legally notifiable STIs was 129 per 100,000.

Distribution of all STIs by gender

Among the legally notifiable STIs, the overall incidence of chlamydia was the highest, followed by gonorrhoea and syphilis. The incidence was higher among males (*Table 5*)

Distribution of all STIs by age and gender

In 2013, the male to female ratio for all STIs was 1.8:1. As in previous years, the age-specific incidence among females was highest in the age group 20 – 24 years. Among the males, the highest age-specific incidence rate was in the age group 25 - 29 years. The overall rate was highest in the 20 – 24 year age group (*Table 6*).

Table 4

HIV surveillance programmes, 2010 – 2013

Programme		2010	2011	2012	2013
Anonymous test sites	Total number of tests done	9,592	9,370	11,243	13,893
	Number tested positive	134	184	173	227
	Percentage tested positive	1.4	2.0	1.5	1.6
Inpatient opt-out testing	Total number of tests done	31,601	35,015	34,515	33,297
	Number tested positive	41	34	39	41
	Prevalence (%)	0.13	0.10	0.11	0.12
Antenatal screening	Total number of tests done	13,915	14,439	14,950	14,877
	Number tested positive	8	11	8	13
	Prevalence (%)	0.06	0.08	0.05	0.09

Table 5

Incidence rates of all sexually transmitted infections (STIs) by gender, 2013

STIs	Incidence rate per 100,000 population		
	Male	**Female**	**Total**
Legally notifiable			
Chlamydia	51.9	32.1	42.5
Gonorrhoea	49.7	10.4	31.0
Non-gonococcal urethritis (NGU) [per 100,000 male population]	28.9	- [1]	- [1]
Syphilis	35.4	24.9	30.4
Genital herpes	23.9	14.7	19.5
Others			
Vaginal discharge (per 100,000 female population)	- [2]	14.6	- [2]
Candidiasis	4.0	20.7	12.0
Genital warts	33.5	6.6	20.7
Mucopurulent cervicitis (MPC) [per 100,000 female population]	- [3]	17.2	- [3]
Chancroid	0	0	0
Others	6.4	4.2	5.4
All types	**233.7**	**145.5**	**191.6**

* Rates are based on 2013 estimated mid-year population.
(Source: Singapore Department of Statistics)

[1 2 3] Not applicable.

Table 6

Age-gender distribution and age-gender specific incidence rates of all sexually transmitted infections, 2013

Age (yrs)	Male	Female	Total (%)	Incidence rate per 100,000 population*		
				Male	Female	Total
0 – 9	0	2	2 (0)	0	0.9	0.4
10 – 14	1	9	10 (0.1)	0.8	7.5	4.0
15 – 19	126	256	382 (3.7)	80.5	175.7	126.4
20 – 24	977	1,033	2,010 (19.4)	363.8	491.1	419.7
25 – 29	1,385	956	2,341 (22.6)	397.1	337.7	370.5
30 – 34	1,222	575	1,797 (17.4)	384.0	212.3	305.0
35 – 39	836	344	1,180 (11.4)	311.0	147.2	234.8
40 – 44	667	247	914 (8.8)	270.4	119.7	201.8
45 – 49	462	131	593 (5.7)	222.4	72.3	152.4
50 – 54	340	73	413 (4.0)	191.0	43.1	118.8
55 – 59	256	41	297 (2.9)	167.7	26.4	96.4
60+	329	79	408 (3.9)	103.7	21.0	58.8
Total	**6,601**	**3,746**	**10,347(100)**	**233.7**	**145.5**	**191.6**

* Rates are based on 2013 estimated mid-year population.
(Source: Singapore Department of Statistics)

Ethnic distribution

Among the three major ethnic groups, Malays had the highest incidence rate at 213.9 per 100,000 population, followed by Chinese (173.5 per 100,000) and Indians (134.5 per 100,000).

Chlamydia

The overall incidence of chlamydia was 43 per 100,000 population in 2013. The incidence of chlamydia among males increased sharply from 11 per 100,000 population in 2006 to 59 per 100,000 in 2010 overtaking the incidence among females in 2009. It decreased to 52 per 100,000 population in 2013. The incidence of chlamydia among females increased from 49 per 100,000 population in 2006 to 62 per 100,000 in 2008 before decreasing to 32 per 100,000 population in 2013 (*Table 5*).

Syphilis

The incidence rate of syphilis was 30 per 100,000 population in 2013 which was a 11.8% decrease from 34 per 100,000 population in 2012. The rate of infectious syphilis declined progressively from 18 per 100,000 population in 1986 to 3 per 100,000 population in 1999. It then increased to 5 per 100,000 population in 2004 and remained stable at 4 per 100,000 population to 2009. In 2013, the rate of infectious syphilis was 3 per 100,000 population. There were no cases of congenital syphilis reported in 2013.

Gonorrhoea

In 2013, the incidence rate of gonorrhoea was 31 per 100,000 population. There were no cases of gonococcal ophthalmia neonatorum reported.

The percentage of penicillinase-producing *Neisseria gonorrhoeae* (PPNG) detected among gonorrhoea positive cultures screened was 45.0% (45 of 100 cultures) in 2013, which was an increase from 36.8% (28 of 76 cultures) in 2012. The percentage of *Neisseria gonorrhoeae* cultures resistant to ciprofloxacin increased from 7.2% (55 of 768 cultures) in 1998 to 74.4% (119 of 160 cultures) in 2008 and 83.1% (133 of 160 cultures) in 2013.

Comments

The notification rate of HIV infection/AIDS appeared to have reached a steady state with its incidence lower in 2013 compared to 2012 (*Fig. 1*). The HIV seroprevalence among STI attendees peaked in 2005 at 1.4% and decreased to 0.7% in 2013. Among inpatients, there has been an increasing trend in the HIV seroprevalence, but it dropped to 0.6% in 2013 (*Fig. 2*).

Following a declining trend from 1980 to the 1990s, the incidence of all STIs increased by 6% from 155 per 100,000 population in 2000 to 165 per 100,000 population in 2002, and then increased sharply by 29% from 199 per 100,000 population in 2003 to 257 in 2004 per 100,000 population. The rate dropped to 250 per 100,000 population in 2006, and thereafter remained the same until 2008. It then dropped further to 192 per 100,000 population in 2013 (*Fig. 3*). For the five legally notifiable STIs, over the past two decades, the incidence was highest at 201 per 100,000 population in 1992, followed by 197 per 100,000 in 2005 and thereafter it decreased to 129 per 100,000 in 2013.

Chlamydia is the most common cause of non-gonococcal urethritis (NGU). Since 2006, there have been more cases of NGU tested for *Chlamydia trachomatis*. NGU cases which test positive for *Chlamydia trachomatis* are classified as chlamydia infection instead of NGU, resulting in a decreasing trend in the

Figure 1
Notification rate of HIV infection/AIDS among Singapore residents, 1985 – 2013

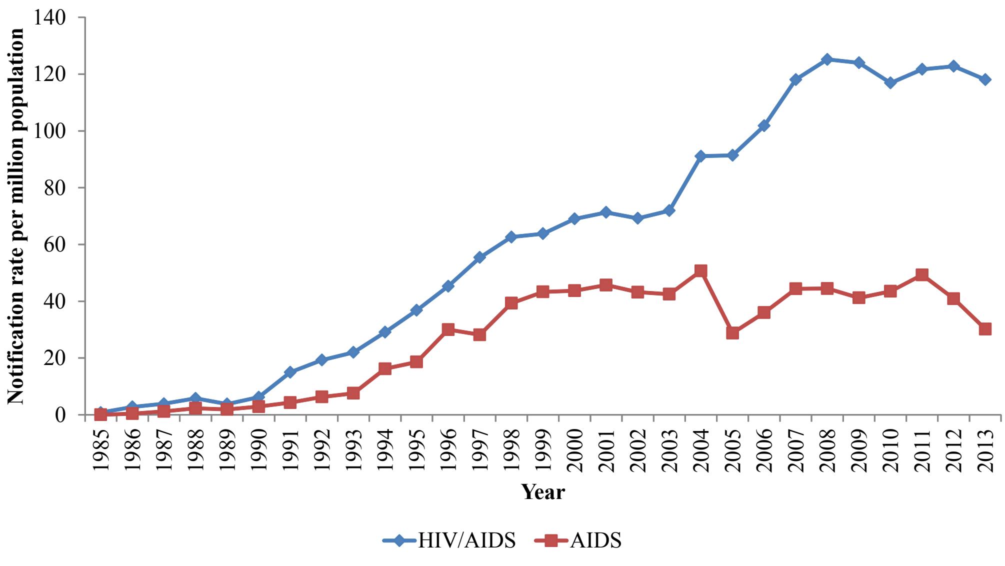
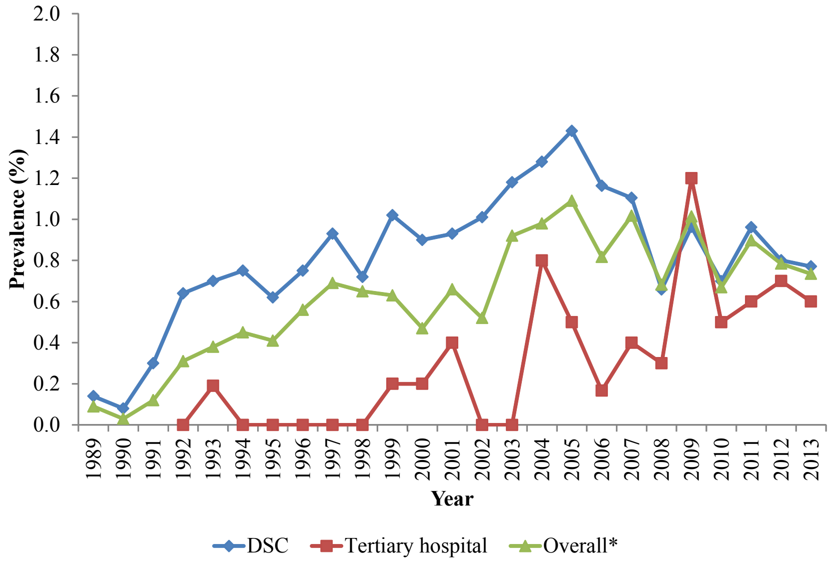
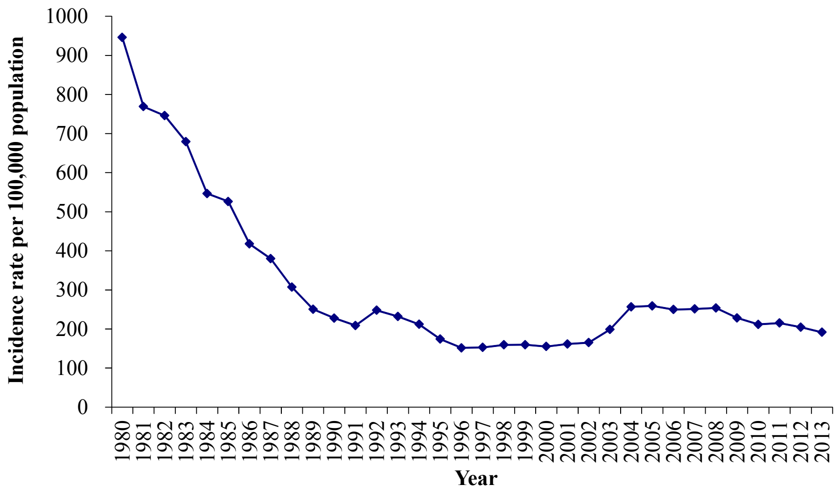


Figure 2
Unlinked HIV seroprevalence at the Department of STI Control (DSC) and a tertiary hospital, 1989-2013



*Overall includes data from the other surveillance populations

Figure 3
Incidence rate of sexually transmitted infections, 1980 – 2013

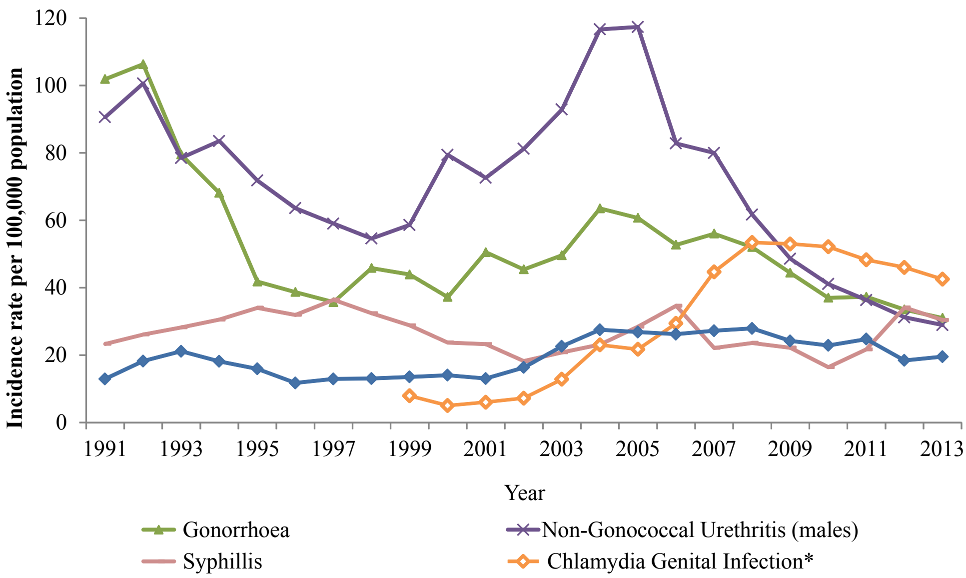


incidence of NGU and a converse trend in the incidence of chlamydia. The overall incidence of chlamydia peaked in 2009 at 55 per 100,000 population and decreased to 43 per 100,000 population in 2013 (*Fig. 4*).

From a historical perspective, the incidence rate of syphilis decreased from 45 per 100,000 population in 1980 to 23 per 100,000 population in 1991. From 1992, there was an increase in the incidence rate from 26 per 100,000 population to 36 per 100,000 population in 1997. Subsequently it declined to 18 per 100,000 population in 2002 before rising to 36 per 100,000 population in 2006 and dropping to its lowest point at 16 per 100,000 population in 2010 (*Fig. 4*).

Gonorrhoea has been on a declining trend since 2004 when the incidence rate was 63 per 100,000 population. It declined to 31 per 100,000 population in 2013 (*Fig. 4*).The percentage of penicillinase-producing *Neisseria gonorrhoeae* (PPNG) detected among gonorrhoea-positive cultures screened increased from 29.6% (2,462 of 8,318 cultures) in 1980 to 59.8% (851 of 1,423 cultures) in 2008. Following a change in testing method in 2009, with fewer and selected cases being tested by culture, the proportion has dropped to 36.8% in 2012. The percentage of *Neisseria gonorrhoeae* cultures resistant to ciprofloxacin increased from 7.2% in 1998, 74.4% in 2008 and 83.1% in 2013.

Figure 4
Incidence rate of legally notifiable sexually transmitted infections, 1991 – 2013



* Monitoring for chlamydia genital infection started in 1999, and it was made legally notifiable since 19 Dec 2008.

(Reported by Huang F, Zhang Y, Jessey M, Lalitha K and Cutter J. Communicable Diseases Division, Ministry of Health)

A review of the local epidemiology and surveillance, prevention and control of foodborne illnesses in Singapore

Background

The World Health Organization defines foodborne illnesses as diseases, usually either infectious or toxic in nature, that are caused by agents that enter the body through the ingestion of food.[1] Foodborne illnesses are increasingly recognized as an important public health issue in both developed and developing countries. In recent years, there have been significant changes in global food production, processing, distribution and preparation, which in turn contribute to changes observed in the epidemiology of foodborne pathogens and the nature of outbreaks (from conventional locally limited outbreaks to widespread trans-regional or international outbreaks). Emerging issues such as antimicrobial resistance in foodborne pathogens as well as the rising awareness and concerns of consumers on food related illnesses have led to increased public health focus and efforts to enhance the prevention and control of foodborne illnesses. This report reviews the epidemiology and surveillance, prevention and control of foodborne illnesses in Singapore.

In Singapore, the Ministry of Health (MOH), Agri-food and Veterinary Authority (AVA) and the National Environment Agency (NEA) are the lead agencies for human health, veterinary public health and the environmental health, respectively. All three agencies work closely together using a One-Heath approach to ensure food safety in Singapore. (One Health approach involves applying coordinated, collaborative, multidisciplinary and cross-sectoral approaches at the animal-human-environment interface to address public health concerns, and to prevent, prepare against, respond to and recover from public health threats.)

Surveillance of foodborne illnesses in human

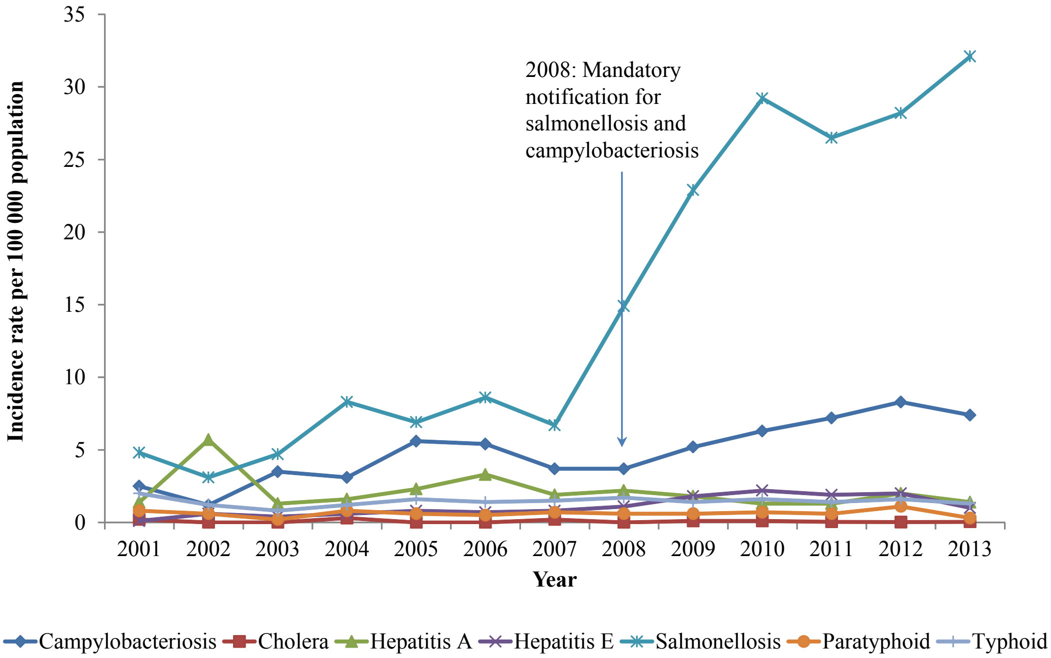
Foodborne illness, also known as food poisoning, foodborne infection or foodborne disease, can be caused by two main factors: intoxication or poisoning, and infection. MOH conducts routine surveillance for seven key foodborne diseases with epidemic potential (i.e., salmonellosis, *Campylobacter* enteritis, hepatitis A and E, cholera, typhoid and paratyphoid). These diseases are legally notifiable under the Infectious Diseases Act (IDA). In the event of a food poisoning incident, the general public can provide feedback through various channels such as the NEA or MOH hotlines and emails. General practitioners and laboratory personnel can inform MOH of foodborne diseases using the infectious diseases notification form (MD131) or via the MOH duty hand phone. MOH works with AVA and NEA to investigate foodborne disease outbreaks and to put in place the necessary control measures. MOH also carries out sentinel surveillance of acute diarrhoeal attendances at polyclinics in order to detect any possible clusters of foodborne incidents.

Epidemiology of foodborne illness in Singapore

Among the seven foodborne diseases that are tracked and reported under the IDA, Singapore has observed increasing trends in the occurrence of foodborne illnesses caused by *Campylobacter* and *Salmonella*. Both these organisms are common causes of foodborne illness in developed countries, including the United States and countries in Europe[2,3]. On the other hand, there has been a marked decline in the local incidence of diseases associated with contaminated water, food and unsanitary environments such as cholera, enteric fevers (typhoid and paratyphoid) and hepatitis A.[45-6] (*Fig. 5* shows the incidence per 100,000 population of seven notifiable foodborne diseases in Singapore from 2001 to 2012)

<u>*Campylobacter* infection</u> showed an increasing trend from 5.4 cases per 100,000 population in 2006 to 8.3 cases per 100,000 population in 2012. The incidence rate then slightly decreased to 7.4 per 100,000 population in 2013. The increasing trend could be explained partially by recent enhanced laboratory testing activities on food poisoning pathogens and the implementation of the mandatory notification of *Campylobacter* infection in 2008. The *Campylobacter* enteritis cases notified to MOH from 2005 to 2013 were predominantly young male infants. In developed countries, the highest incidence of *Campylobacter* infections is observed in children aged less than 5 years.[7] Young children are at risk of foodborne illness as their immune system is immature and developing. In a review of *Campylobacter* enteritis cases in Singapore in 2005, consumption of eggs was found to be significantly associated with increased disease incidence observed from September to December 2005.[8] However, a review of the published literature did not show any relationship between egg consumption and *Campylo-*

Figure 5
Incidence per 100,000 population of seven notifiable foodborne diseases in Singapore, 2001-2013.



Source: Communicable Diseases Division, Ministry of Health, Singapore *bacter* enteritis incidence. Studies have shown that the organism would not penetrate into the contents of the egg even though it could be occasionally isolated from the inner shell and membranes of refrigerated eggs.[9] According to a case-control study conducted during the first six months of 2000 to identify the risk factors of campylobacteriosis, consumption of formula milk, food prepared at home, and failure of caregivers to wash their hands before preparing formula milk and after handling raw poultry were significant risk factors of *Campylobacter* infection.[10]

Non-typhoidal salmonellosis is one of the most common bacterial foodborne diseases in Singapore. It has the highest incidence rate among all food and waterborne diseases notified to MOH.[11] An increasing trend had been observed since 2006 and the incidence rate was 29.2 cases per 100,000 population in 2010. In 2011, the incidence rate slightly decreased to 26.5 cases per 100,000 population; however, it subsequently increased, and was 32.1 cases per 100,000 population in 2013. It should be noted that mandatory notification of all groups of *Salmonella* was only implemented in 2008. The increase in the notifications of salmonellosis from 2008 could have been partially contributed by increased awareness, testing and reporting by the medical professionals and clinical laboratories. *Salmonella* serogroup B, C and D accounted for most of the cases. The high proportion of locally acquired cases suggests that there is ongoing transmission within the community. Similar to *Campylobacter* enteritis, salmonellosis affects predominantly young children.

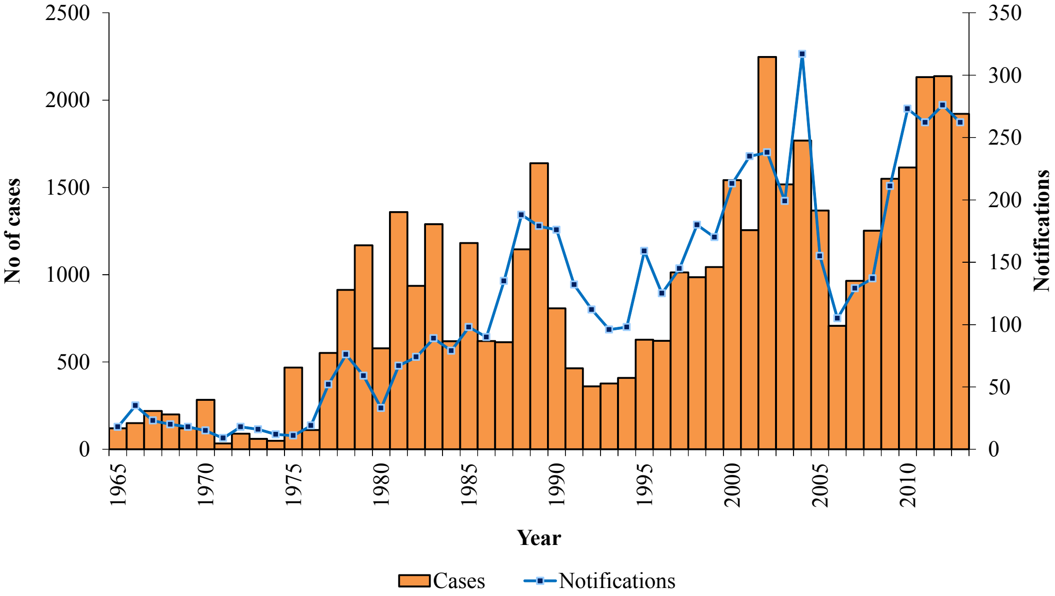
There were also periodic outbreaks of multidrug-resistant *Salmonella* infections in Singapore. The recorded outbreaks included *S.* Typhimurium in 1971-1997[12], *S.* Oranienburg in 1978-1979, *S.* Blockley in 1983, and *S.* Typhimurium in 1999. The last recorded outbreak of multidrug-resistant *S.* Typhimurium in 1999 was associated with the consumption of ground "ikan bilis" (dried anchovies), which was imported from Thailand, Vietnam, Malaysia and Indonesia. While the common practice was to cook dried anchovies in porridge, the investigation found that the anchovies had been either sprinkled onto or added to freshly cooked porridge, instead of boiling with the porridge, and these had been served in the households where the cases had occurred.[13]

Sentinel surveillance of acute diarrhoeal cases at polyclinics has been started since 1977 and the annual number of polyclinic attendances for acute diarrhoeal illnesses had increased in recent years. In 2012, a 7.6% increase in total polyclinic attendances for acute diarrhoeal illness was reported, as compared to the previous year.[14] In addition, the Primary Care Survey 2010 showed that diarrhoeal diseases accounted for 5% of total attendances seen at private clinics and polyclinics. The same proportion was observed in the Primary Care Survey 2005 which implies that diarrhoeal disease is a persistent concern in Singapore. However, an evaluation of the polyclinic attendances for acute diarrhoea over a 10-year period (2001 - 2010) did not reveal any specific trends and no significant correlation was observed between the attendances and foodborne diseases trends.

Outbreaks of foodborne illnesses in the community

The number of notifications of foodborne illnesses and cases involved has been on a general increasing trend between 1965 and 2013, with a recent sharp increase seen between 2006 and 2010 (*Fig. 6*). A review of the epidemiology of foodborne outbreaks in Singapore between 2001 and 2005 showed that

Figure 6
Food poisoning notifications, 1965 - 2013



Source: Communicable Diseases Division, Ministry of Health, Singapore

non-hotel restaurants and eating houses accounted for the majority of the implicated eating establishments. *Salmonella* was the most commonly isolated pathogen in stool samples from cases and *Staphylococcus aureus* was the most frequently isolated pathogen in the food samples.[15] A more recent analysis of foodborne illness outbreaks notified to MOH between 2009 and 2011[16] showed similar findings - the majority of the implicated eating establishments were restaurants (37.3%), followed by eating houses (16.8%), licensed caterers (8.7%) and hawker centers (8.1%).

Field investigations are conducted for specific notifications of outbreak of foodborne illness to establish the cause of infection and prevent the spread of the disease. The investigations include an inspection of the food establishment, collection of food samples and environmental swabs, referral of food handlers for stool screening and collection of stool samples from cases.

From January 2009 to December 2011, field investigations were conducted for 193 established outbreaks. A total of 250 stool samples were collected from cases, of which 128 (51.2%) were positive for common foodborne pathogens. The predominant pathogen detected was *Salmonella* species. 57 out of the 63 stool samples (90.5%) that were tested positive for pathogens in 2011 were positive for *Salmonella*, as compared to 16 out of 35 stool samples (45.7%) in 2009.

Salmonella species was also the most common pathogen isolated from food handlers. Of 1484 food handlers who were screened between 2009 and 2011, 122 (8.2%) tested positive for foodborne pathogens.

In 2011, 15 out of 39 (38.5%) food handlers who tested positive for foodborne pathogens were *Salmonella* positive, while 14 out of 37 (37.8%) food handlers who tested positive for foodborne pathogens were *Salmonella* positive in 2009. The majority of these food handlers were reported to be well prior to the food poisoning outbreak.

Of the 925 food samples and environmental swabs collected during the field investigations between 2009 and 2011, 60 (6.5%) tested positive for foodborne pathogens. *Escherichia coli* was the most frequent pathogen detected among positive samples, followed by *Staphylococcus aureus*. The detection rate for *Escherichia coli* increased from 16.7% in 2009 to 38.5% in 2011.

Surveillance for food poisoning organisms and toxins by AVA

AVA is the national food safety authority in Singapore and its responsibility extends from import up to wholesale. AVA's surveillance on food covers both fresh food and processed food. (The five key fresh foods are pork, poultry, eggs, fish and leafy vegetables). As most of the food consumed locally is imported, AVA's food surveillance focuses mainly on imported food. AVA has implemented an integrated food safety framework that consists of:

- horizon scanning of overseas food recalls and incidents;
- accreditation of overseas sources;
- import requirements for food consignments;
- inspection, sampling and testing of imported food;
- regulation of local slaughterhouses, farms and food processing plants; and
- education on shared food safety responsibility.

AVA scans open information sources to detect overseas reports of food safety incidents, food recalls, as well as industry practices or new food technology, which can lead to unsafe food. <u>Horizon scanning</u> supports AVA's food safety surveillance programmes by providing early alerts on incidents that impact the safety of food in Singapore, so that prompt mitigation measures can be implemented if necessary.

<u>Surveillance for fresh food</u> covers food poisoning organisms and toxins, veterinary drug residues in meat, poultry and seafood, and pesticide residues in vegetables. AVA classifies imported food into several categories based on risk. As examples, meat and infant food are classified as high risk food. (Infant foods are food primarily meant for infants. As infants belong to the vulnerable group with low immunity [immune system still developing] and they are mainly fed on infant food, it is important to ensure that the imported infant foods are safe for consumption. Thus, AVA has categorised this product as high risk food product for stringent import control and checks.) All meat consignments must be inspected by AVA officers before being released for sale. The sampling rate varies according to the risk category of imported food.

In addition, AVA carries out <u>microbiological and chemical surveillance on imported processed food</u>. These are categorised into high risk (food that are more susceptible to contamination or have a poorer compliance history) and low risk food. AVA places greater emphasis on high risk foods and imposes strict import controls. Processed foods are also sampled for the analyses of chemical additives, chemical and microbiological contaminants, pesticide residues and drug residues.

AVA also carries out surveillance on food that is consumed seasonally (known in AVA as seasonal food surveillance). For example during the Chinese dumpling festival, dumplings are collected and tested.

Quality Assurance (QA) in food processing plants is carried out by the plants themselves. Food processing plants are encouraged to have a Hazard Analysis & Critical Control Points (HACCP) based food safety management system (FSMS) plans and they should be made available to AVA for inspection. AVA officers will carry out periodic checks to ensure that hygiene standards are maintained, encourage the use of HACCP and check that HACCP-based FSMS of plants are properly implemented. Food samples are also taken for both microbiological and chemical analyses to check for compliance. Similarly in abattoirs, QA is maintained by the abattoirs themselves with AVA officers carrying out periodic compliance checks.

AVA also carries out surveillance on zoonotic diseases such as highly pathogenic avian influenza (HPAI), rabies (dogs and cats that die in quarantine), Nipah virus (from pigs imported from Pulau Bulan), and *Salmonella* Enteritidis (in imported and local poultry).

The risk management measures undertaken by AVA to ensure food safety in Singapore include (a) implementation of an integrated food safety framework; (b) consumer education; (c) surveillance for food poisoning organisms and toxins; (d) QA in local processing plants; and (e) collaboration with NEA and MOH in the One Health Initiative to further inter-agency cooperation.

Regulation and surveillance programmes for food hygiene by NEA

NEA regulates the safety of food at the retail end in Singapore, specifically ensuring hygienic handling and preparation of food at retail food establishments, such as restaurants, cafes, snack bars, supermarkets, hawker stalls and food caterers. Under the Environmental Public Health (Food Hygiene) Regulations, NEA licenses these retail food premises, and follows up with regular inspections and grading of these retail food premises. Enforcement is taken when food hygiene breaches are observed.

All food handlers are required to be registered and to demonstrate proficiency following the Basic Food Hygiene Course and subsequent refresher training. For premises that are licensed as food caterer, food court, canteen and restaurant (housed in 2 or more adjacent units in private and HDB shophouses; or with a kitchen area exceeding 16m^2), it is mandatory to appoint a Food Hygiene Officer (FHO) with specialised training, to supervise and oversee the food hygiene practices, through daily checks on the cleanliness of the premises and hygiene practices of the food handlers.

Inspections by NEA officers allow hygiene lapses to be detected and dealt with promptly, through enforcement and food handler education, to minimize the likelihood of food poisoning incidents. The Points Demerit System (PDS) was introduced in September 1987 to deter licensees and food handlers from engaging in poor food and personal hygiene practices. In 1997, the hygiene grading scheme was introduced to appraise the cleanliness and hygiene standards of retail food establishments and to motivate licensees to improve or maintain their hygiene level. To enable the public to make informed choices when patronizing food premises, NEA has published information on the grades and accumulated demerit points of food premises on its website since June 2012.

NEA also ensures that food sold to the public is wholesome and fit for human consumption and is of the quality or nature demanded by the purchaser. The hygienic quality of ready-to-eat food sold at NEA-licensed food establishments is also monitored through routine sampling and testing of ready-to-eat food under the surveillance programme. The findings from the surveillance programme help to guide risk assessment activities and research efforts, which in turn support the development of educational materials, public health operations and policies.

The programme aims to uphold the high standards of hygiene in the retail food industry in the face of increasing number of premises and more varied food service concepts. In the past eleven years, there was a 23% increase in the number of food establishments, from 28,176 in 2002 to 34,736 in 2013, with increasing variety of food types.

Conclusion

Foodborne illnesses pose a public health burden to developed and developing countries, including Singapore. Factors including globalisation of food source, population demographics, consumer behaviour, food hygiene practices, as well as enhanced surveillance systems, influence the local epidemiology of foodborne illnesses. Surveillance, prevention and control programmes that spans the farm-to-table food supply chain are implemented by MOH, AVA and NEA, to ensure food safety and human health.

(Jointly prepared by the Agri-food and Veterinary Authority [AVA], the Ministry of Health [MOH], and the National Environment Agency [NEA] of Singapore.)

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Epidemiological assessment of Singapore's progress towards measles elimination

In the 1960s and 1970s, measles epidemics occurred in Singapore every one to three years and most children developed measles after one year of age. Measles vaccination using the monovalent vaccine was first introduced to the National Childhood Immunisation Programme (NCIP) in October 1976 and administered to pre-school children at 12–24 months of age. The initial vaccination acceptance rate was poor as there were cultural beliefs that measles is an innocuous and inevitable childhood infection. To correct this belief and promote the benefits of vaccination, extensive health education programmes were conducted in Singapore between 1977 and 1979. Despite efforts in health education and routine checks of measles vaccination certificates for pre-schools and primary schools, vaccination coverage rate remained low[1].

In October 1980, measles became a notifiable disease under the Infectious Diseases Act (IDA). Cyclical epidemics continued to occur and the highest incidence was recorded in 1984 involving 2,417 cases (including seven deaths). Measles vaccination was made mandatory by law in August 1985 for all children aged 12-24 months with an aim to interrupt measles transmission by achieving vaccination coverage of at least 95% for each birth cohort by the age of two years[2].

The monovalent vaccine was substituted by the trivalent measles, mumps and rubella (MMR) vaccine in January 1990. Following a sharp rise in measles incidence in 1997, a 'catch-up' vaccination campaign was implemented from July to November 1997, targeting children aged 12-18 years regardless of their measles vaccination status or past history of measles infection. Subsequently, a second dose of MMR vaccine was introduced into the NCIP in January 1998 for primary school children aged 11-12 years.

The second dose of MMR vaccine was brought forward from 11-12 years to 6-7 years in 2008. In 2011, another change was made to the schedule, bringing the first dose to 12 months and the second dose to 15-18 months. Changes to the measles vaccination schedule over the years are summarised in *Table 7*.

Epidemiology of measles since the introduction of vaccination

Between 1976 and 1985, cyclical epidemics continued to occur and the highest incidence of measles cases was recorded in 1984 (88.5 per 100,000 population). Since the implementation of compulsory measles vaccination in 1985, the reported measles incidence remained low until surges in measles incidence were observed in 1992, 1993, and 1997 (18.7 - 37.2 per 100,000 population)[3]. Following a 'catch-up' vaccination campaign in 1997 targeting children aged 12 – 18 years and the introduction of two-dose MMR vaccination schedule in 1998, the measles incidence declined to 2.9 per 100,000 population in 1998 and fluctuated between 0.3 and 3.5 per 100,000 population for the next decade. The vaccination coverage for children aged 2 years old steadily increased from 92.0% in 1998 to 95.3% in 2004 and has been maintained at 95% or above thereafter.

In recent years, the reported measles incidence per 100,000 population increased from 0.3 in 2009 to 0.9 and 2.6 in 2010 and 2011, respectively. Analysis of age-specific incidence showed that the increase was highest in infants aged less than one year, followed by young children aged 1-4 years. Further breakdown of cases in the 1-4 year age group shows that two-thirds were in the 12 – 24 months age-group; majority of whom were yet to be vaccinated. To address the rising trend of measles among unvaccinated young children, the timing for both MMR doses was brought forward with effect from December 2011, with the first dose to be given at 12 months of age (from 12 – 24 months) and the second dose at 15 – 18 months of age (from 6 – 7 years). In 2012 and 2013, the measles incidence decreased to 0.7 and 0.9 per 100,000 population (*Fig. 7*).

Characteristics of confirmed measles cases: 2009 – 2013

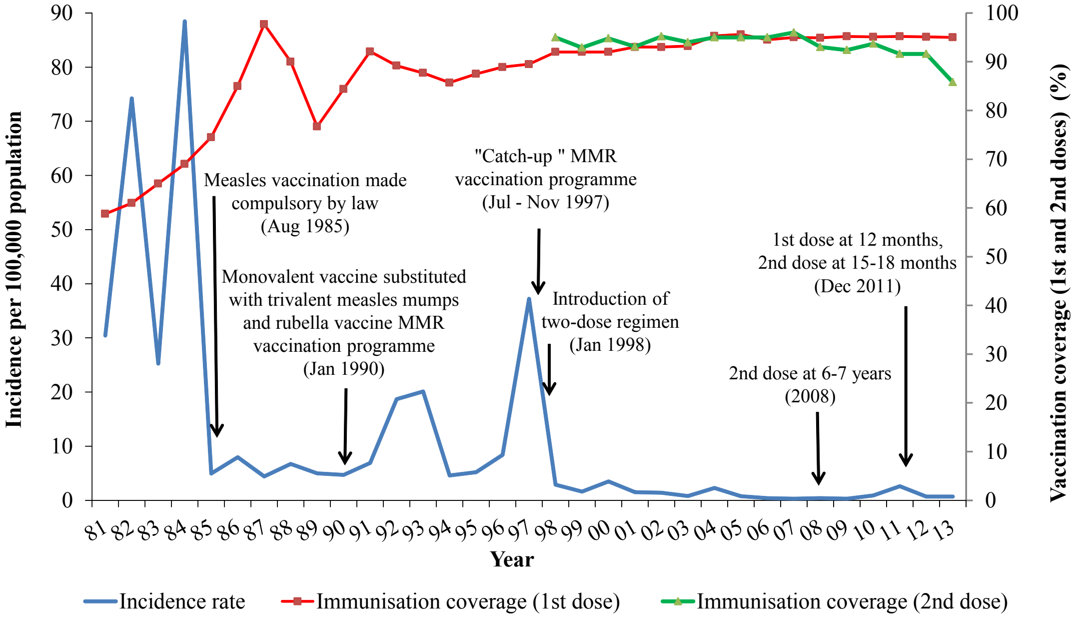
A total of 262 laboratory confirmed cases of measles were reported between 2009 and 2013. The highest incidence rate was observed in infants under

Table 7

Changes to measles vaccination schedule, 1976 – 2011

Year	Changes made	Schedule
1976	Introduction of monovalent measles vaccine	Dose 1: 12–24 months
1990	Monovalent measles vaccine replaced with MMR vaccine	Dose 1: 12–24 months
1998	Introduction of second dose of MMR vaccine	Dose 1: 12–24 months Dose 2: 11–12 years
2008	Change in the timing of second dose of MMR vaccine	Dose 1: 12–24 months Dose 2: 6–7 years
2011 (Dec)	Changes in timing of first and second doses of MMR vaccine	Dose 1: 12 months Dose 2: 15–18 months

Figure 7
Incidence of reported measles cases and immunisation coverage in Singapore 1981 – 2013



*Only laboratory confirmed cases were reported since June 2000.

one year of age, followed by young children aged one to four years (*Table 8* and *9*). Among the three major ethnic groups, Malays had the highest incidence rate, followed by Chinese and Indian (*Table 10* and *11*).

WHO classification of measles cases

A total of 132 laboratory confirmed measles cases were reported to WHO Western Pacific Regional Office (WPRO) from January to November 2014. During this period, 86% of the cases were sporadic and the rest were involved in small clusters.

The source of infection and the method of confirmation based on WHO classification are shown in *Table 12*.

Out of 132 measles cases, 95 were classified as locally acquired and 37 were imported. The majority of imported cases originated from the Philippines, followed by Indonesia (*Table 13*).

From January to November 2014, there were eight small clusters involving two to four cases (*Table 14*). The largest cluster involved four students of a Singapore-based foreign education institution. The onset of rashes occurred between 1 and 20 April 2014, none of the cases were known to each other. Three cases were serologically confirmed for measles IgM while the fourth case was negative. One case was identified to have H1 genotype.

Among the remaining seven clusters; four were due to B3 genotype, one was due to H1 genotype,

Table 8

Age distribution of reported measles cases, 2009 – 2013

Age group (years)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)
< 1	1 (12.5)	7 (15.6)	29 (21.6)	3 (8.1)	16 (42.2)
1 – 4	4 (50.0)	18 (40.0)	60 (44.8)	9 (24.3)	12 (31.6)
5 – 9	0	3 (6.7)	7 (5.2)	3 (8.1)	0
10 – 14	0	0	1 (0.7)	1 (2.7)	1 (2.6)
15 – 24	0	6 (13.3)	6 (4.5)	3 (8.1)	1 (2.6)
25 – 34	2 (25.0)	7 (15.6)	20 (14.9)	11 (29.7)	4 (10.5)
35 – 44	1 (12.5)	4 (8.8)	11 (8.3)	6 (16.3)	4 (10.5)
45 – 54	0	0	0	0	0
55+	0	0	0	1 (2.7)	0
Total	**8 (100)**	**45 (100)**	**134 (100)**	**37 (100)**	**38 (100)**

Table 9

Age-specific incidence per 100,000 population of reported measles cases, 2009 – 2013

Age group (years)	2009	2010	2011	2012	2013
< 1	5.2	38.2	79.9	7.6	39.8
1 – 4	2.2	10.0	32.9	4.9	6.5
5 – 9	0	1.3	3	1.3	0
10 – 14	0	0	0.4	0.4	0.4
15 – 24	0	0.8	0.8	0.4	0.1
25 – 34	0.2	0.6	1.7	0.9	0.3
35 – 44	0.1	0.4	1.2	0.6	0.4
45 – 54	0	0	0	0	0
55+	0	0	0	0.1	0
Total	**0.2**	**0.9**	**2.6**	**0.7**	**0.7**

Table 10

Ethnic distribution of reported measles cases, 2009 – 2013

	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)
Singapore Resident					
Chinese	6 (75.0)	21 (46.7)	53 (39.6)	15 (40.6)	18 (47.4)
Malay	2 (25.0)	6 (13.3)	32 (23.%)	7 (18.9)	5 (13.2)
Indian	0	5 (11.1)	13 (9.7)	0	2 (5.3)
Others	0	4 (8.9)	11 (8.2)	3 (8.1)	4 (10.4)
Foreigner	0	9 (20.0)	25 (18.6)	12 (32.4)	9 (23.7)
Total	**8 (100)**	**45 (100)**	**134 (100)**	**37 (100)**	**38 (100)**

Table 11

Ethnic-specific incidence per 100,000 population of reported measles cases, 2009 – 2013

	2009	2010	2011	2012	2013
Singapore Resident					
Chinese	0.2	0.8	1.9	0.5	0.6
Malay	0.4	1.2	6.3	1.4	1
Indian	0	1.4	3.7	0	0.6
Others	0	3.2	8.8	2.4	3.2
Foreigner	0	0.7	1.8	0.8	0.6
Total	**0.2**	**0.9**	**2.6**	**0.7**	**0.7**

Table 12
WHO classification of measles cases, January – November 2014

Source#	Confirmed measles cases			
	Laboratory confirmed		Epidemiological Linkage	Total
	Respiratory specimen	Blood specimen		
Endemic	20 (2*)	13	0	31
Unknown	41 (7*)	30	0	64
Imported	22 (1*)	16	0	37
Imported-Related	0	0	0	0
Total	**83 (10*)**	**59**	**0**	**132**

#Source – whether the source of virus was imported, import-related, endemic or unknown, as extracted from description provided by WHO in the WHO monthly summary excel spreadsheet.

- **Imported**: A case exposed outside the region or country during the 7-21 days prior onset to rash and supported by epidemiological or virological evidence, or both.
- **Import-related**: A locally acquired infection occurring as part of a chain of transmission originating from an imported case as supported by epidemiological or virological evidence, or both.
- **Endemic**: Laboratory or epidemiologically-linked confirmed cases of measles resulting from endemic transmission of measles virus.
- **Unknown**: A confirmed case for which an epidemiologically or virological link to importation or to endemic transmission cannot be established after a thorough investigation.

* Persons who had both respiratory and blood samples collected

Table 13

Distribution of measles cases by genotype, January - November 2014

Genotypes	Classification			
	Local	Imported	Total	Country of importation (No. of persons)
B3	18	14	32	Philippines (14)
D4	0	0	0	
D8	14	1	15	Indonesia (1)
D9	17	3	20	Philippines (1) Indonesia (1) Malaysia (1)
G3	1	1	2	Indonesia(1)
H1	5	0	5	
Genotyping not performed	40	18	58	Philippines (10) Indonesia (5) Australia (1) China(1) India(1)
Total	**95**	**37**	**132**	

Table 14

Measles clusters in Singapore, January – November 2014

Size of clusters (based on number of cases)		Total no. of clusters	No. of cases in clusters (%)	No. of sporadic cases (%)	Total no. of cases (%)
2	**3 – 5**				
7	1	8	18 (13.6)	114 (86.4)	132 (100)

another was due to D9 genotype, and the last cluster was undetermined.

Epidemiological and laboratory surveillance systems for measles

Quality of epidemiological surveillance system for measles

The Communicable Diseases Division, Ministry of Health (MOH) is responsible for the surveillance and investigation of measles cases. A clinical measles case, based on WHO criteria, is defined as a person with fever, maculopapular rash, and one or more of the following symptoms: cough, coryza, or conjunctivitis. A laboratory confirmed case is defined as a person with positive measles IgM antibodies, or at least a four-fold rise in antibody titre, or positive virus isolation. In recent years, antigen IF and PCR are also used to detect measles antibodies in blood samples or measles virus in respiratory samples, respectively.

In June 2012, MOH enhanced the measles surveillance system by instituting an investigation and follow up of clinically diagnosed cases, in addition to laboratory confirmed cases. Clinical cases were investigated and followed up with laboratory tests via PCR or serology if they met the clinical measles case definition. Cases were discarded if they did not meet the case definition, or if laboratory results were negative for measles.

A total of 116 cases were reported in 2013, comprising of 43 laboratory confirmed cases, seven clinically measles-compatible cases and 66 discarded cases. From January to November 2014, a total of 249 cases were reported, comprising of 132 laboratory confirmed cases, 37 clinically measles-compatible cases and 80 discarded cases. (Clinically measles compatible cases are cases which are not laboratory-confirmed but had fever, rashes and at least one of the following symptoms such as cough, coryza and conjunctivitis.)

Quality of laboratory surveillance systems for measles

The Virology Section, Department of Pathology, Singapore General Hospital (SGH), was designated a WHO National Measles Laboratory (NML) in 2001 and is a member of WHO Measles and Rubella Laboratory Network (LabNet). NML participates in WHO proficiency and confirmatory tests annually, and remains fully accredited. In 2013, 98% of specimens collected from suspected measles cases for measles IgM tests had laboratory results available within seven days after the specimens were received by the laboratory. All data from NML had been consistently reported to WPRO and MOH within the required time intervals. The NML accreditation results are summarised in *Table 15*.

NML performs diagnostic tests for both measles and rubella IgM upon request from attending clinicians. NML also identifies measles cases by measles antigen detection on direct patient samples using immunofluorescence assay (IFA) and by virus isolation, as ordered by clinicians for suspected cases. To enhance surveillance, virus isolation is also performed on specimens sent for measles antigen detection. Sequencing is performed on virus isolates to determine the genotype.

Serological tests and results

In June 2012, measles surveillance was enhanced with serological cross-testing between measles and rubella IgM on specific patient samples requested by MOH. From June 2012 to August 2014, 1,970 samples were tested. A total of 68 samples were positive for measles IgM and 47 samples were positive for rubella IgM. A summary of specimens processed by NML is in *Table 16*.

Virological surveillance

As part of the enhanced measles surveillance system, a higher proportion of measles cases with positive PCR result is followed up with genotypic analysis. This will lead to a better understanding of the origin of measles cases notified in Singapore and aid in the tracing of epidemiological linkages amongst cases.

Table 17 shows the proportion of all lab-confirmed samples with genotyping. *Table 18* shows the measles genotypes identified in Singapore from January 2011 to August 2014. The genotype distribution shirted from D9 genotype in 2010 – 2011, B3/D9 genotypes in 2012, G3/D9 genotypes in 2013, and to B3 genotype in 2014. The B3 genotype was first

Table 15

Summary of NML accreditation results, January 2013 – August 2014

Year	Score of onsite review	Proficiency test score (%)		Confirmatory test score (%)		Results reported within 7 days of receipt of specimen# (%) (within 4 days w.e.f. April 2013)		Virus genotyping completed within 2 months of receipt of specimen (%)	Fully accredited (Yes / No)
		Measles IgM	Rubella IgM	Measles IgM	Rubella IgM	Measles IgM	Rubella IgM	Measles	
2013	99%	95	100	100	100	98.0	96.9	100	Yes
2014	Pending	Pending	Pending	Pending	Pending	96.9	98.3	100	Pending

#With effect from April 2013, reporting of measles IgM and rubella IgM results is changed to within four days from receipt of samples.

Table 16

Specimens submitted to NML for measles and rubella testing, June 2012 – August 2014

Year	Total no. of patient with specimen	Total no. of specimens received	Serology (serum and blood)								Measles virus isolation	
			Measles IgM			Results ≤ 7 days#	Rubella IgM			Results ≤ 7 days#		
			No. tested (-)	No. tested (+)	No. tested equiv	%	No. tested (-)	No. tested (+)	No. tested equiv	%	No. tested	No. of isolates
Jun–Dec 2012	760	834	230	14	5	97.2	363	23	14	97.8	185	4
Jan-Dec 2013	616	667	176	16	7	98.0	266	16	10	96.9	176	5
Jan–Aug 2014	427	469	111	38	11	96.9	170	8	1	98.3	127	6

#With effect from April 2013, reporting of measles IgM and rubella IgM results is changed to within four days from receipt of samples.

Table 17

Proportion of measles cases with genotyping among lab-confirmed samples* in Singapore, January 2011 – November 2014

	Year			
	2011 (%)	2012 (%)	2013 (%)	2014 (%) Jan – Nov
Number of samples genotyped	46 (54.1)	6 (54.4)	33 (86.7)	74 (89.2)
Number of samples not genotyped	39 (45.9)	5 (45.6)	5 (13.3)	9 (10.8)
Total	**85 (100)**	**11 (100)**	**38 (100)**	**83 (100)**

*Lab-confirmed respiratory samples only

Table 18

Distribution of measles genotypes among lab-confirmed samples* identified in Singapore, January 2011 – November 2014

Genotype	Year			
	2011 (%)	2012 (%)	2013 (%)	2014 (%) Jan – Nov
B3	-	3 (50.0)	6 (18.1)	32 (38.6)
D4	1 (2.2)		-	-
D8	11 (23.9)	-	4 (12.1)	15 (18.1)
D9	33 (71.7)	3 (50.0)	9 (27.3)	20 (24.1)
G3	1 (2.2)	-	10 (30.3)	2 (2.4)
H1	-	-	3 (9.1)	5 (6.0)
Vaccine type A	-	-	1 (3.1)	-
Total	**46 (100)**	**6 (100)**	**33 (100)**	**74 (100)**

*Excluding Measles IgM positive samples from serology

detected in 2012 and became predominant in 2014. Two imported cases from the Philippines with B3 genotype were reported in early 2014. Subsequently, locally acquired and imported cases with genotype B3 were reported until e-week 11. Three sporadic cases with genotype B3 were further reported in the year (*Fig. 8*). *Fig. 9 – 11* show the incidence of measles for genotypes B3, D8 and D9 from January – November 2014.

Immunisation Coverage

The National Immunisation Registry (NIR), Health Promotion Board (HPB), monitors and tracks the coverage of immunisations in the NCIP among resident children (Singapore citizens and permanent residents). Immunisation coverage for measles has remained consistently high, and maintained at around 95% (*Table 19*).

A set of indicators was developed by WHO WPRO, covering i) incidence, ii) surveillance, and iii) population immunity. *Table 20* shows Singapore's current status in comparison to WHO targets.

Conclusions

Singapore maintains an established system of measles notification, epidemiological surveillance and outbreak response, including the tracing of contacts if necessary. Each case is investigated thoroughly to determine any common exposures in place and time with other cases. NML remains fully accredited and plays a key role in the system. Vaccination coverage for the first dose is maintained at 95%. Despite maintaining high immunisation coverage, there are still sporadic measles cases occurring in Singapore.

Singapore met most of WHO indicators for measles elimination in 2014, except for incidence of measles cases and adequate blood specimens from clinical cases. Among the 132 laboratory-confirmed cases, 83 (63%) were respiratory specimens. As most of the cases involved infants, respiratory specimens (throat swabs) were collected for confirmation via PCR instead of blood specimens. In this context, Singapore's indicator for the percentage of suspect cases with adequate blood specimens does not truly reflect the effort made to confirm suspect cases, as PCR is the mainstay of laboratory

Figure 8
Measles virus genotypes identified from January - November 2014

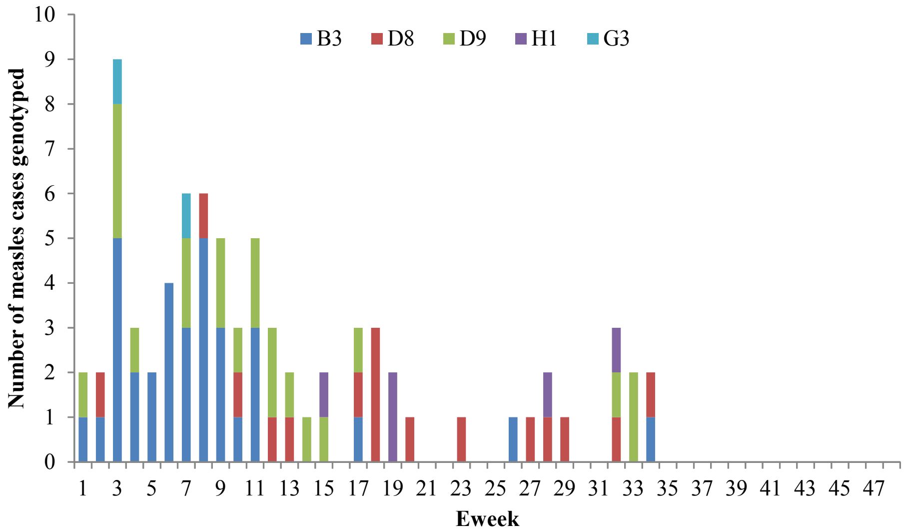


Figure 9
Incidence of measles genotype B3, January - November 2014

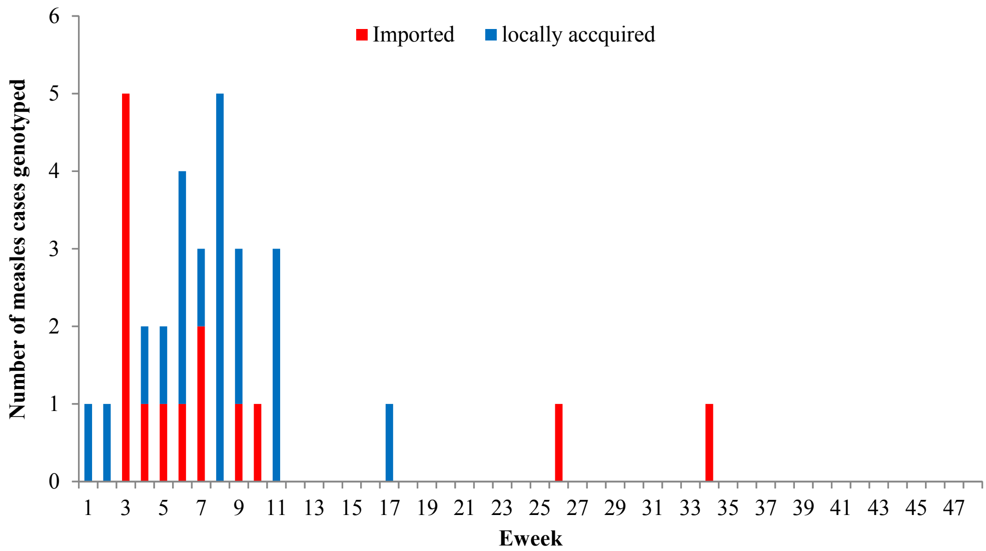


Figure 10
Incidence of measles genotype D8, January – November 2014

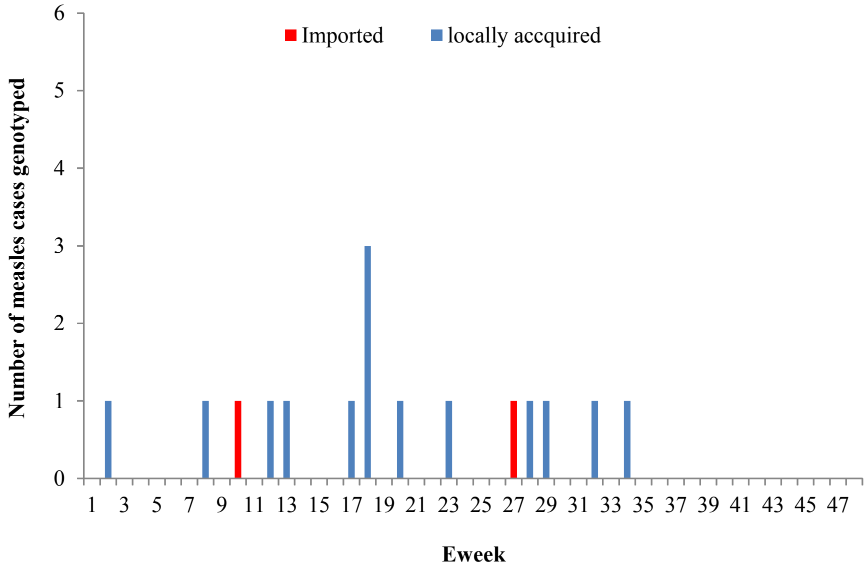


Figure 11
Incidence of measles genotype D9, January – November 2014

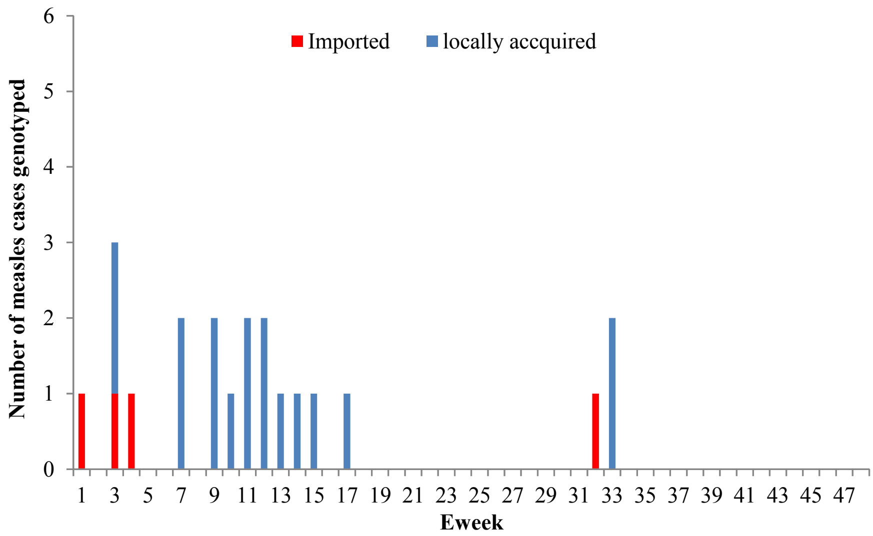


Table 19

Measles, mumps and rubella immunisations, 2003 – 2013

Infants and pre-school children		
No. completed first dose by age 2 years		
Year	**Number**	**Coverage (%)**
2003	36,956	93.2
2004	36,845	95.3
2005	33,843	96.6
2006	31,638	94.5
2007	31,217	95.0
2008	30,352	94.9
2009	34,057	95.2
2010	32,165	95.1
2011	29,992	95.2
2012	28,320	95.1
2013	29,125	95.0

Table 20

Singapore's progress towards measles elimination

Indicator	WHO Targets	Current (2014)*
A. Very Low Incidence		
• Confirmed measles cases (by laboratory, epidemiologic linkage or clinically)	< 1/1,000,000	29.7/1,000,000
B. High Quality Surveillance		
• National reporting of non-measles suspected cases	≥ 2/100,000	1.6/100,000
• Percentage of districts reporting ≥ 1/100,000 non-measles suspected cases	≥ 80%	NA
• Percentage of suspected cases with adequate investigation within 48hrs of notification	≥ 80%	83.7%
• Percentage of suspect cases with adequate blood specimens	≥ 80%	25.5%
• Percentage of specimens with lab results ≤ 4 days after arrival to lab	≥ 80%	85.2%
• Transmission chains (outbreaks) with sufficient samples for virus isolation	≥ 80%	100.0%
C. High Population Immunity		
• National MCV1 and MCV2 coverage	≥ 95	≥ 95
• Percentage of outbreaks or transmission foci with < 10 cases	≥ 80%	100.0%
• Absence of endemic measles virus	No virus	Endemic

*Measles-Rubella Bulletin - Vol 8 Issue 11 (November 2014) http://www.wpro.who.int/immunization/documents/mrbulletinvol8issue11.pdf?ua=1 confirmation. The majority of the specimens in 2010 and 2011 associated with endemic transmission in Singapore were D9 genotype. The dominant genotypes were B3/D9 in 2012, G3/D9 in 2013 and B3 in 2014. Other genotypes (D8, G3 and H1) were also detected. Singapore receives about 15 million international visitors annually[4]. The variation of genotypes detected is indicative of importation from other countries. The ability to collect appropriate specimens from as many of the cases as possible is an important factor in determining the source of infection. Encouraging clinicians to send specimens for laboratory confirmation of clinical cases is a challenge, as the cost of laboratory test would need to be borne by the patient.

Although Singapore has a well-established system for measles notification, there is still progress to be made towards measles elimination[5]. MOH has increased its efforts to perform genotyping for all positive respiratory samples; a 3% increase in 2014 compared to year 2013 and also to ensure harmonisation of genotyping data. Detailed epidemiological analysis is carried out for each notified measles case; all clinical cases are investigated and followed up with recruitment into the enhanced measles and rubella surveillance programme. This will aid establishing chains of transmission and source of infection with genotyping results.

(Based on Progress report on measles elimination in Singapore 2014 compiled by the National Verification Committee for Measles Elimination)

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Prevalence of diphtheria antibodies among children and adults in Singapore

Introduction

In Singapore, the disease burden of diphtheria was high in the early 1900s, with morbidity rate of 11.3 to 50.8 per 100,000 population and mortality rate of 0.9 to 4.4 per 100,000 population during the period 1954-1964.[1] Due to the widespread use of diphtheria toxoid, diphtheria has been rendered a rare disease in developed countries with high vaccination coverage. With the successful implementation of the National

Childhood Immunisation Programme (NCIP) in Singapore, there has not been any indigenous case of diphtheria in the past two decades. The last indigenous case of diphtheria reported in 1992 was a 41 year-old local resident with multiple comorbidities.[2]

Vaccination against diphtheria started in 1938 and was made mandatory by law in April 1962 for infants and children below 7 years of age. Diphtheria is given in combination with tetanus toxoid as bivalent DT vaccine or in combination with tetanus and pertussis as trivalent DTP vaccine. DTP vaccine is routinely administered to infants at 3, 4 and 5 months, with the first booster given at age 18 months. Before 2008, the second and the third boosters of DT vaccine were given to children aged 6-7 years old and 11-12 years old, respectively. Due to the difficulties in procuring a bivalent tetanus-diphtheria (reduced dosage) toxoid (Td) vaccine for older children, the School Health Immunisation Programme was amended in January 2008. The second booster of Td vaccine was replaced by tetanus-diphtheria (reduced dosage)-acellular pertussis (Tdap) vaccine administered to children aged 10-11 years instead of 6 to 7 years. The third booster was no longer required.[3] Since 1988, young men aged 17-21 years entering national service are given one booster dose of tetanus toxoid.[4] Between 2003 and 2013, the coverage of primary DPT vaccination in the NCIP for children aged 2 years ranged from 95% to 97%, while the coverage of the first booster dose ranged from 84% to 91%.[5]

To estimate the immunity levels of the Singapore resident population to diphtheria, we undertook a national seroepidemiological study involving children and adolescents aged 1-17 years over a 24-month period from 2008 to 2010, and adults aged 18-79 years in 2010.

Materials and methods

Seroprevalence surveys

There are two parts to our study. The Ministry of Health (MOH) conducted a national paediatric seroprevalence survey (NPSS) between August 2008 and July 2010 involving prospective collection of residual sera following completion of routine biochemical investigations by the diagnostic laboratories in two public acute hospitals, KK Women's and Children's Hospital and National University Hospital of Singapore.[3] This survey was carried out in accordance to Section 7 of the Infectious Diseases Act, which provides for the use of residual blood samples for the purpose of public health surveillance. The selection of residual sera was confined to Singapore residents (citizens and permanent residents) of Chinese, Malay and Indian ethnicity aged 1-17 years attending inpatient services or day surgery at the two hospitals. Sera of patients known to be immunocompromised, on immunosupressive therapy, or who had been diagnosed with infectious diseases such as diphtheria were excluded. A total of 1,200 sera were collected, comprising 400 in each of the three age groups of 1-6 years, 7-12 years and 13-17 years.

The adult seroprevalence survey was based on 3,293 residual sera obtained from Singapore residents aged 18-79 years who participated in the National Health Survey (NHS) 2010. The NHS was a population-based cross-sectional survey conducted by the MOH to determine the prevalence of major non-communicable diseases and their associated risk factors among Singapore adult residents.[6] The fieldwork for the NHS was carried out over a three-month period from 17 March to 13 June 2010. A total of 4,337 persons aged 18-79 years participated in the NHS 2010, yielding an overall response rate of 57.7%. Of these respondents, 3,293 (75.9%) with sufficient amount of residual sera for laboratory testing were analysed. The adult seroprevalence survey was approved by the Ethics Committee of the Health Promotion Board. Only sera from NHS participants who had consented to having their residual sera used for further research were included in this study.

IgG antibody levels against diphtheria toxoid were determined by enzyme-linked immunosorbent assay (ELISA) using commercial test kits (IBL-America, Minneapolis, MN, USA for the NPSS 2008-2010[3] and Euroimmun, Germany for the adult seroprevalence survey[7]) according to the manufacturers' recommended procedures.

Anti-toxin levels < 0.01 IU/mL denote susceptibility, levels of 0.01–0.099 IU/mL indicate basic protection (i.e. giving basic immunity), and levels ≥ 0.1 IU/mL show full protection.[8]

Statistical analysis

The Chi-square test or Fisher's exact test, where appropriate, was used to test for group differences. The Mantel-Haenszel chi-square test for trend was used to evaluate the difference in seroprevalence across the age groups. Statistical significance was taken at $p < 0.05$.

Results

In the NPSS 2008-2010, the proportion of children and adolescents aged 1-17 years with at least basic protection against diphtheria (≥ 0.01 IU/mL) was 99.7% (95% CI: 99.2 % – 99.9%). About 0.3% were susceptible to diphtheria (< 0.01 IU/mL), 0.3% had basic protective immunity (0.01–0.099 IU/mL), and 99.4% were fully immune (≥ 0.1 IU/mL).

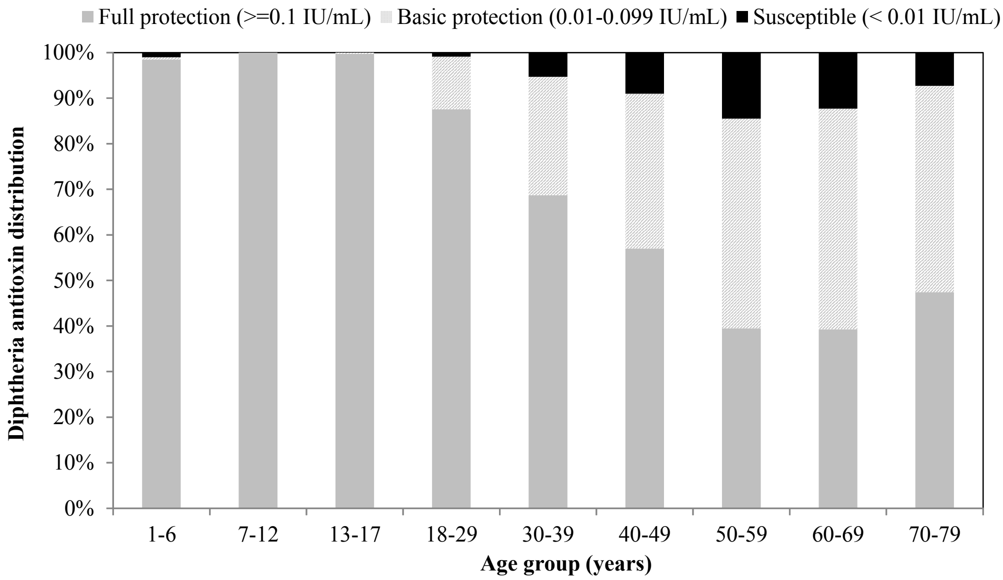
In the adult seroprevalence survey, 92.0% (95% CI, 91.1% – 92.9%) of Singapore residents aged 18-79 years had at least basic protection against diphtheria. About 8.0% were susceptible to diphtheria, 32.5% had basic protective immunity, and 59.5% had full protection against diphtheria.

In the NPSS 2008-2010, 99.0% of the 1-6 year-olds had at least basic protection against diphtheria, while the seroprevalence was 100.0% in the other two older age groups. (*Fig. 12*). The adult seroprevalence survey revealed that the proportion with at least basic protection against diphtheria (≥ 0.01 IU/mL) decreased significantly from 99.1% in young adults aged 18-29 years to 85.5% in those aged 50-59 years (test for trend, $p < 0.0005$). The seroprevalence ranged from 87.7% to 92.7% among the elderly aged 60-79 years. The proportion with full protection (≥ 0.1 IU/mL) declined significantly from 87.6% in young adults aged 18-29 years to 57.0% in those aged 40-49 years, and remained stable (39.9% – 47.4%) in the older age groups.

In the NPSS 2008-2010, the seroprevalence did not differ significantly by gender; 99.6% in boys versus 99.7% in girls ($p = 0.89$) (*Table 21*). There were no significant differences in seroprevalence among the three main ethnic groups ($p > 0.10$).

In the adult survey, there was also no significant difference in seroprevalence by gender; 93.7% in men versus 90.8% in women ($p = 0.39$) (*Table 21*). Among the three main ethnic groups, Chinese had a significantly lower seroprevalence (91.0%) compared to that of Indians (96.2%) ($p = 0.03$) and Malays (94.5%) ($p = 0.01$). There was no significant differ-

Figure 12
Distribution of diphtheria antitoxin titres (%) by age group among children and adolescents aged 1-17 years* and adults aged 18-79 years#



* NPSS 2008-2010
# NHS 2010

Table 21

Prevalence (%) of diphtheria antibodies (≥ 0.01 IU/mL) among children and adolescents aged 1-17 years (NPSS 2008-2010) and adults aged 18-79 years (NHS 2010)

Demographics	Age group	
	1-17 years*	18-79 years#
Gender		
Male	99.6	93.7
Female	99.7	90.8
Ethnic group		
Chinese	99.4	91.0
Malay	99.7	94.5
Indian	99.2	96.2
Others	-	94.4

* NPSS 2008-2010
# NHS 2010

ence in seroprevalence between Malays and Indians ($p = 0.38$). The seroprevalence among Singapore citizens (92.8%) was significantly higher than that of permanent residents (87.1%) ($p = 0.001$).

Comments

According to the World Health Organization's guidelines from the European Region, the proportion of the population with protective level of anti-diphtheria antibodies ($\geq$ 0.01 IU/mL for epidemiological purposes) to achieve sufficient herd immunity was 90% in children and 75% in adults[9]. From our two surveys, 99.7% of children and adolescents aged 1-17 years and 92.0% of adults aged 18-79 years had antitoxin levels $\geq$ 0.01 IU/mL. When the results of the NPSS 2008-2010 and the adult seroprevalence survey in 2010 were combined, we estimated that 93.6% in the general population aged 1-79 years had at least basic protection against diphtheria. This high seroprevalence against diphtheria reflected the successful implementation of the NCIP using the trivalent DPT vaccines. As the vaccination coverage in children is high and no indigenous cases of diphtheria have been reported in the past two decade, the current national childhood immunisation schedule is deemed to offer adequate protection against diphtheria.

It is known that immunity to diphtheria wanes with time after vaccination.[10] While some adults may have protection for life, most have antitoxin levels that only approach the minimal protective level by 10 years after the last dose.[11] A booster dose of Td vaccine for adults is recommended every 10 years in a number of developed countries including the United States[12], Canada[13] and Australia[14]., with the first dose combined with pertussis using Tdap vaccine if it has not been given previously.

In our adult survey, the proportion susceptible to diphtheria increased from 0.9% in the 18-29 year olds to 5.3% in the 30-39 year olds, 9.0% in the 40-49 year olds and 14.5% in the 50-59 year olds. Due to waning antitoxin titres, it may be of value to consider additional vaccination efforts to protect older adults at higher risk of exposure against diphtheria.

From the adult survey, we found that a significantly higher proportion of permanent residents were susceptible to diphtheria compared to Singapore citizens. This could be partly attributed to increases in immigration from diphtheria endemic countries. It is important to maintain a high degree of vigilance against diphtheria. Majority of the diphtheria cases reported in countries such as the United Kingdom[15] and the United States[16,17] were adults who had acquired their infection overseas. This indicates the need for travellers, particularly older adults, who are visiting areas where diphtheria is endemic or epidemic, to consult doctors regarding vaccinations required or recommended before embarking on their trips, so as to reduce their risk of acquiring infections overseas and reintroducing diphtheria upon their return.

(Reported by Ang LW and James L, Epidemiology & Disease Control Division, Ministry of Health, Singapore)

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Any comments or questions should be addressed to:

The Editor
Epidemiological News Bulletin
Communicable Diseases Division, Ministry of Health
College of Medicine Building, 16 College Road,
Singapore 169854
E-mail : Goh_Kee_Tai@moh.gov.sg
Jeffery_Cutter@moh.gov.sg