CHAPTER 7

CHILDHOOD IMMUNISATION

Immunisation is one of the best ways to protect infants, children and teenagers from vaccine-preventable diseases. Some of these diseases can be very serious, requiring hospitalisation or even resulting in death. Vaccines contain an agent that resembles a disease-causing microorganism to stimulate the body's immune response to recognise the infectious agent, which allows for an effective response during a real encounter.

HISTORY OF THE IMMUNISATION PROGRAMME

The National Childhood Immunisation Programme (NCIP) in Singapore covers vaccination against TB (BCG); hepatitis B (HepB); diphtheria, pertussis and tetanus (DTaP); poliomyelitis (IPV/OPV); *Haemophilus influenzae* type b (Hib); measles, mumps and rubella (MMR); pneumococcal disease (PCV); and human papillomavirus (HPV) (Table 7.1). Only vaccinations against diphtheria and measles are compulsory by law.

BCG immunisation began in mid-1950s as part of the NCIP. All newborns were vaccinated at birth. Although parental consent is required, acceptance has been high and close to 100% of children has been vaccinated in the last decade (Table 7.2). The BCG immunisation programme has contributed significantly to the eradication of TB meningitis in young children. BCG was discontinued for Mantoux non-reactors and BCG booster dose was also discontinued in July 2001.

Hepatitis B immunisation for infants born to hepatitis B carrier mothers was incorporated into the NCIP in October 1985. This was extended to all newborns in September 1987. To protect those born before 1987, a four-year hepatitis B immunisation programme was implemented for students from secondary schools to tertiary institutions as well as full-time national servicemen (NSFs) starting from January 2001.

Since January 1990, the monovalent measles vaccine given to one-year-old children was replaced by the trivalent MMR vaccine. From January 1998, the monovalent rubella vaccine given to primary six children (11-12 years of age) was also replaced by the second dose of MMR vaccine. The MMR immunisation was last reviewed by the Expert Committee on Immunisation (ECI) in 2011 and a revised schedule was implemented in December of the same year. With the change in the immunisation schedule, both doses of MMR vaccine were brought forward to 12 months and 15-18 months of age respectively. School Health Service continues to provide MMR vaccine to primary one students (6-7 years of age) who did not receive the second dose in their pre-school years. This was discontinued in 2013.

Pneumococcal conjugate vaccine (PCV) was included as the 10th vaccine in the NCIP in November 2009 to reduce morbidity and mortality of invasive pneumococcal disease in Singapore. The ECI recommended a schedule of two doses for the primary series and one booster dose (2+1 schedule). The two doses in the primary series are given at ages 3 and 5 months and a single booster dose at 12 – 24 months of age (changed to 12 months of age in December 2011).

The polio immunisation schedule prior to June 2013 comprised of six doses of oral polio vaccine (OPV). Inactivated polio vaccine (IPV) had been available on request and at full cost. In order to reduce the risk of vaccine-associated paralytic poliomyelitis (VAPP) associated with the use of OPV, the all-OPV schedule was replaced with a sequential IPV-OPV schedule. The ECI recommended a four-dose IPV schedule with three primary doses to be given at 3, 4, and 5 months of age and the first booster dose at 18 months of age. A fifth dose using OPV was recommended at 10-11 years of age (primary five). The OPV dose at 6-7 years of age (primary one) was discontinued at the end of 2013. Trivalent OPV (containing types 1, 2 and 3) was replaced with bivalent OPV (containing types 1 and 3) in 2016 to meet the World Health Organization's (WHO) requirement.

Haemophilus influenzae type b (Hib) immunisation was introduced into the NCIP to reduce the risk of serious complications such as meningitis and pneumonia which may lead to long-term disabilities and deaths. The ECI recommended a four-dose schedule, in line with the schedule for DTaP and IPV at 3, 4, and 5 months of age and a single booster dose at 18 months of age.

The ECI also recommended the use of combination vaccines containing IPV and Hib for the routine schedule. The recommendations for IPV and Hib became effective in June 2013.

PROGRAMME IMPLEMENTATION

The NCIP is carried out by:

(a) National Healthcare Group (NHG) polyclinics, National University Polyclinics and SingHealth (SH) polyclinics,
(b) Youth Preventive Services Division (YPSD), the Health Promotion Board (HPB), and
(c) Private medical practitioners.

Immunisation of pre-school children is carried out at the polyclinics and by private medical practitioners. The target population is based on notification of births obtained from the Registry of Births and Deaths.

Immunisation of primary school children is carried out by YPSD. The target population is based on student population data from the Ministry of Education.

Table 7.1
Singapore national childhood immunisation schedule, 2016

Vaccination against	Birth	1 month	3 months	4 months	5 months	6 months	12 months	15 months	18 months	10-11 years^
Tuberculosis	**BCG**									
Hepatitis B	**HepB (D1)**	**HepB (D2)**			**HepB (D3)#**					
Diphtheria, tetanus and pertussis			**DTaP (D1)**	**DTaP (D2)**	**DTaP (D3)**				**DTaP (B1)**	**Tdap (B2)**
Poliovirus			**IPV (D1)**	**IPV (D2)**	**IPV (D3)**				**IPV (B1)**	**OPV (B2)**
Haemophilus influenzae type b			**Hib (D1)**	**Hib (D2)**	**Hib (D3)**				**Hib (B1)**	
Measles, mumps and rubella							**MMR (D1)**	**MMR (D2)##**		
Pneumococcal disease			**PCV (D1)**		**PCV (D2)**		**PCV (B1)**			
Human papillomavirus	*HPV2 and HPV4 are recommended for **females aged 9 to 25 and 9 to 26 years**, respectively.* ***Females aged 9 to 13 years**: two doses are recommended at the interval of **0 and 6 months**.* ***Females aged 14 to 26 years**: three doses are recommended at the interval of **0, 1-2, 6 months**.*									

Notes:

BCG	Bacillus Calmette-Guérin vaccine
HepB	Hepatitis B vaccine
DTaP	Paediatric diphtheria and tetanus toxoid and acellular pertussis vaccine
Tdap	Tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine
IPV	Inactivated polio vaccine
OPV	Oral polio vaccine
Hib	*Haemophilus influenzae* type b vaccine
MMR	Measles, mumps, and rubella vaccine
PCV	Pneumococcal conjugate vaccine
HPV2	Bivalent human papillomavirus vaccine
HPV4	Quadrivalent human papillomavirus vaccine
^	Primary 5
D1/D2/D3	1st dose, 2nd dose, 3rd dose
B1/B2	1st booster, 2nd booster
#	3rd dose of HepB can be given at the same time as the 3rd dose of DTaP, IPV, and Hib for the convenience of parents.
##	2nd dose of MMR can be given between 15-18 months

Notification of immunisation

The data utilised in this report was based on:

(a) notifications of all immunisation carried out in pre-school children by healthcare institutions in both the public and private sectors to the National Immunisation Registry (NIR) at HPB. (Note: notifications of diphtheria and measles immunisation are compulsory.)

(b) immunisation records kept by YPSD (immunisations administered in schools and at the Immunisation Clinic, Student Health Centre, HPB).

Immunisation against TB

In 2016, BCG immunisation was completed in 32,196 infants, giving coverage of 99.2% (Table 7.2).

Table 7.2
BCG immunisation of infants in Singapore, 2007-2016

Year	Public Hospitals (%)	Polyclinics (%)	Private Clinics & Hospitals (%)	Total	Coverage for children at 2 years of age*
2007	16,399 (43.8)	205 (0.5)	20,796 (55.6)	37,400	99.4
2008	16,120 (42.1)	176 (0.5)	21,963 (57.4)	38,259	99.5
2009	15,967 (41.7)	123 (0.3)	22,228 (58.0)	38,318	99.3
2010	13,878 (42.6)	85 (0.3)	18,623 (57.2)	33,454	98.9
2011	13,123 (41.8)	67 (0.2)	18,172 (57.9)	31,362	99.6
2012	12,145 (41.2)	110 (0.4)	17,225 (58.4)	29,480	99.2
2013	15,756 (40.5)	70 (0.2)	23,076 (59.3)	38,902	99.3
2014	12,908 (39.6)	44 (0.1)	19,683 (60.3)	32,625	98.6
2015	12,460 (40.6)	54 (0.2)	18,191 (59.2)	30,705	99.6
2016	13,309 (41.3)	109 (0.4)	18,778 (58.3)	32,196	99.2

* Coverage referred to immunisation given to all Singaporean and Singapore-PR children.

Immunisation against diphtheria, pertussis and tetanus

Infants and pre-school children
The primary immunisation course was completed in 31,501 children in 2016 giving an estimated coverage of 97.0% (Table 7.3). The first booster dose was given to 29,189 children under two years of age (89.9%).

Table 7.3
Diphtheria, pertussis and tetanus immunisation, 2007-2016

Year	Coverage for children at 2 years of age*			
	Completed primary course		1st booster dose given	
	No.	Coverage (%)	No.	Coverage (%)
2007	31,778	96.6	29,050	88.3
2008	30,975	96.9	27,888	87.3
2009	34,481	96.8	32,431	91.0
2010	32,523	96.1	30,377	89.8
2011	30,242	96.0	28,642	90.9
2012	28,776	96.7	27,196	91.4
2013	29,733	96.8	27,987	91.1
2014	31,878	96.3	29,856	90.2
2015	30,147	97.8	27,666	89.7
2016	31,501	97.0	29,189	89.9

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.

School children
In 2016, the second booster dose (using Tdap) was given to 36,670 (91.6%) primary five students (Table 7.4).

Table 7.4
Diphtheria, tetanus and pertussis 2nd booster given to primary five students (10-11 years of age), 2008-2016 (Tdap)

Year	Total no. of primary 5 students	2nd booster dose given*	
		No.	Coverage (%)
2008	49,126	47,146	96.0
2009	45,498	43,240	95.0
2010	45,555	43,238	94.9
2011	49,071	45,848	93.4
2012	43,579	40,079	92.0
2013	42,901	39,217	91.4
2014	40,065	36,392	90.8
2015	39,865	36,748	92.2
2016	40,044	36,670	91.6

* Coverage by YPSD did not include booster immunisations done by private practitioners.

Immunisation against *Haemophilus influenzae* type b

In 2016, the primary course of *Haemophilus influenzae* type b (Hib) immunisation was completed in 31,256 children (96.3%). The overall coverage for children who have completed the full course of Hib immunisation (primary and booster doses) at two years of age was 89.8% (Table 7.5).

Table 7.5
***Haemophilus influenzae* type b immunisation, 2009-2016**

Year	Coverage for children at 2 years of age*			
	Completed primary course		Booster dose given	
	No.	Coverage (%)	No.	Coverage (%)
2009	27,406	92.0	26,716	89.6
2010	25,524	85.6	24,126	81.0
2011	25,262	84.8	24,223	81.3
2012	24,319	81.6	23,289	78.1
2013	25,764	83.9	24,796	80.7
2014	28,221	85.3	27,675	83.6
2015	29,573	95.9	24,028	77.9
2016	31,256	96.3	29,143	89.8

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.

Immunisation against poliomyelitis

Infants and pre-school children
Primary poliomyelitis immunisation was completed in 31,284 children, giving coverage of 96.3% (Table 7.6). The first booster dose was given to 29,165 children under two years of age (89.8%).

School children
In 2016, 38,815 (96.9%) primary five students received the second booster dose (Table 7.7).

Table 7.6
Poliomyelitis immunisation of infants, pre-school and school children, 2007-2016

Year	Coverage for children at 2 years of age*				School Children		
	Completed primary course		1st booster dose given		2nd booster dose given†§		
	No.	Coverage (%)	No.	Coverage (%)	School entrants	No.	Coverage (%)
2007	31,768	96.6	28,909	87.9	48,122	44,380	92.0
2008	30,964	96.9	27,679	86.6	43,548	40,055	92.0
2009	34,466	96.7	32,272	90.6	43,142	39,752	92.1
2010	32,496	96.0	30,299	89.5	39,465	37,037	93.8
2011	30,230	95.9	28,597	90.8	39,886	36,714	92.1
2012	28,767	96.6	27,159	91.2	39,682	36,782	92.7
2013	29,726	96.8	27,945	90.9	40,385	37,275	92.3
2014	31,878	96.3	29,768	90.0	-	-	-
2015	29,720	96.4	27,587	89.5	-	-	-
2016	31,284	96.3	29,165	89.8	-	-	-

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.
† Coverage by YPSD did not include booster immunisations done by private practitioners.
§ The OPV booster dose for school entrants was discontinued at the end of 2013.

Table 7.7
Poliomyelitis booster dose given to primary five students (10-11 years of age), 2008-2016

Year	Total no. of primary 5 students	Booster given*	
		No	Coverage (%)
2008	49,126	47,314	96.0
2009	45,498	43,895	96.5
2010	45,555	44,286	97.2
2011	49,071	47,531	96.9
2012	43,579	42,091	96.6
2013	42,901	41,661	97.1
2014	40,065	38,819	96.9
2015	39,865	38,663	97.0
2016	40,004	38,815	96.9

* Coverage by YPSD did not include booster immunisations done by private practitioners.

Immunisation against measles, mumps and rubella

Infants and pre-school children
In 2016, a total of 30,750 children were immunised against the first dose of measles, mumps and rubella by two years of age, giving coverage of 94.7% (Table 7.8). The second dose was given to 28,628 children by two years of age (88.2%).

Table 7.8
Measles, mumps and rubella immunisation, 2007-2016

Year	Coverage for children at 2 years of age*				Primary school children†	
	Dose 1		Dose 2§		Dose 2§	
	No.	Coverage (%)	No.	Coverage (%)	No.	Coverage (%)
2007	31,217	95.0	-	-	47,351	96.0
2008	30,352	94.9	-	-	40,342	93.0
2009	34,057	95.2	-	-	39,852	92.4
2010	32,165	95.1	-	-	36,979	93.7
2011	29,992	95.2	-	-	36,548	91.6
2012	28,320	95.1	-	-	36,341	91.6
2013	29,195	95.0	26,482	86.2	-	-
2014	31,473	95.1	29,259	88.4	-	-
2015	29,334	95.1	27,243	89.5	-	-
2016	30,750	94.7	28,628	88.2	-	-

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.
† Coverage among all students in respective cohorts [11-12 years of age (primary six) up to 2007, 6-7 years of age (primary one) from 2008 to 2011 (reported up to 2012)].
§ Dose 2 was administered in primary schools, at 11-12 years of age (primary six) up to 2007 and 6-7 years of age (primary one) from 2008 to 2011 (reported up to 2012). From December 2011, dose 2 was administered at 15-18 months of age (reported from 2013).

Immunisation against hepatitis B

In 2016, the primary course of hepatitis B immunisation was completed in 31,209 children. The overall coverage for children who completed the full course of immunisation under two years of age remained high at 96.1% (Table 7.9).

Table 7.9
Hepatitis B immunisation, 2007-2016

Year	Full course of Hepatitis B vaccination completed by age 2 years	
	No.	Coverage (%)*
2007	31,449	95.6
2008	30,924	96.8
2009	34,341	96.4
2010	32,376	95.7
2011	30,159	95.7
2012	28,730	96.5
2013	29,668	96.6
2014	31,824	96.2
2015	29,677	96.3
2016	31,209	96.1

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.

Immunisation against pneumococcal disease

In 2016, a total of 26,179 children received at least two doses of PCV by age one year, giving an estimated coverage of 80.6% (Table 7.10).

Table 7.10
Pneumococcal vaccination, 2009-2016

Year	No. completed two doses by age 1 year		No. completed booster (3rd) dose by age 2 years	
	No.	Coverage (%)*	No.	Coverage (%)*
2009	7,180	24.1	5,514	18.5
2010	16,930	56.8	6,906	23.2
2011	15,981	53.6	12,327	41.4
2012	18,834	61.3	15,169	50.9
2013	22,829	76.6	18,081	58.9
2014	25,955	78.2	22,824	68.8
2015	25,349	82.2	23,202	75.3
2016	26,179	80.6	25,222	77.7

* Coverage referred to immunisation given to all Singaporean and Singapore PR children.

EVALUATION OF PROGRAMME EFFECTIVENESS

The effectiveness of childhood immunisation programme against poliomyelitis and diphtheria is shown in Figures 7.1 and 7.2. In 2016, no indigenous case of diphtheria, poliomyelitis and neonatal tetanus was reported.

With the implementation of the 'catch-up' measles vaccination programme using the MMR vaccine in 1997, and the introduction of the second dose of MMR vaccine to all primary six school children (11-12 years of age) in 1998 and subsequent changes in the immunisation schedule for the second dose (to primary one school children (6-7 years of age) in 2008 and 15-18 months of age in 2011), the incidence of measles decreased from 1,413 cases in 1997 to 136 in 2016 (Figure 7.3).

Rubella incidence decreased from 48 cases in 2013 to 12 cases in 2016. There were no reported cases of indigenous congenital rubella and no termination of pregnancy due to rubella infection was carried out in 2016 (Table 7.11).

The resurgence of mumps which began in 1998, continued until the year 2002. The resurgence was due to poor protection conferred by the Rubini strain of the MMR vaccine which was subsequently de-registered in 1999. The incidence of mumps remained largely unchanged in recent years; there were 478 cases in 2014, 473 cases in 2015 and 540 cases in 2016 (Table 7.12).

The incidence of acute hepatitis B for all age groups has declined from 243 cases in 1985 to 47 cases in 2016 (Figure 7.4). During the same period, the reported number of cases in children <15 years decreased from 10 to 0 (Table 7.12).

A national sero-prevalence survey was conducted in 2012 to determine the prevalence of antibody against vaccine preventable diseases and other diseases of public health importance in the adult Singapore resident population aged 18-79 years using residual sera from the National Health Survey 2010. The overall sero-prevalence was 85.0% for rubella in those aged 18 – 79 years. 11.1% of women 18 – 44 years of age remained susceptible to rubella infection. About 43.9% of Singapore residents aged 18 – 79 years possessed immunity against hepatitis B virus (anti-HBs ≥10 mIU/mL). The overall prevalence of HBsAg in the population was 3.6%.

Figure 7.1
Incidence of reported poliomyelitis cases and immunisation coverage in Singapore, 1946-2016

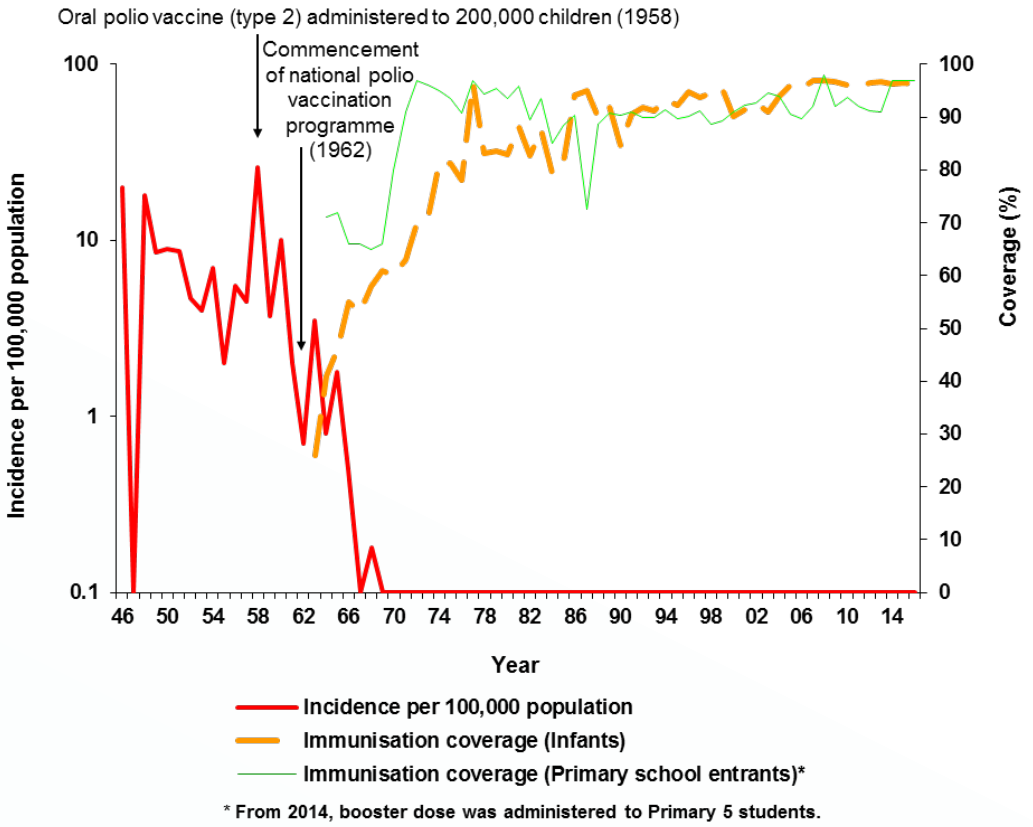


Figure 7.2
Incidence of reported diphtheria cases and immunisation coverage in Singapore, 1946-2016

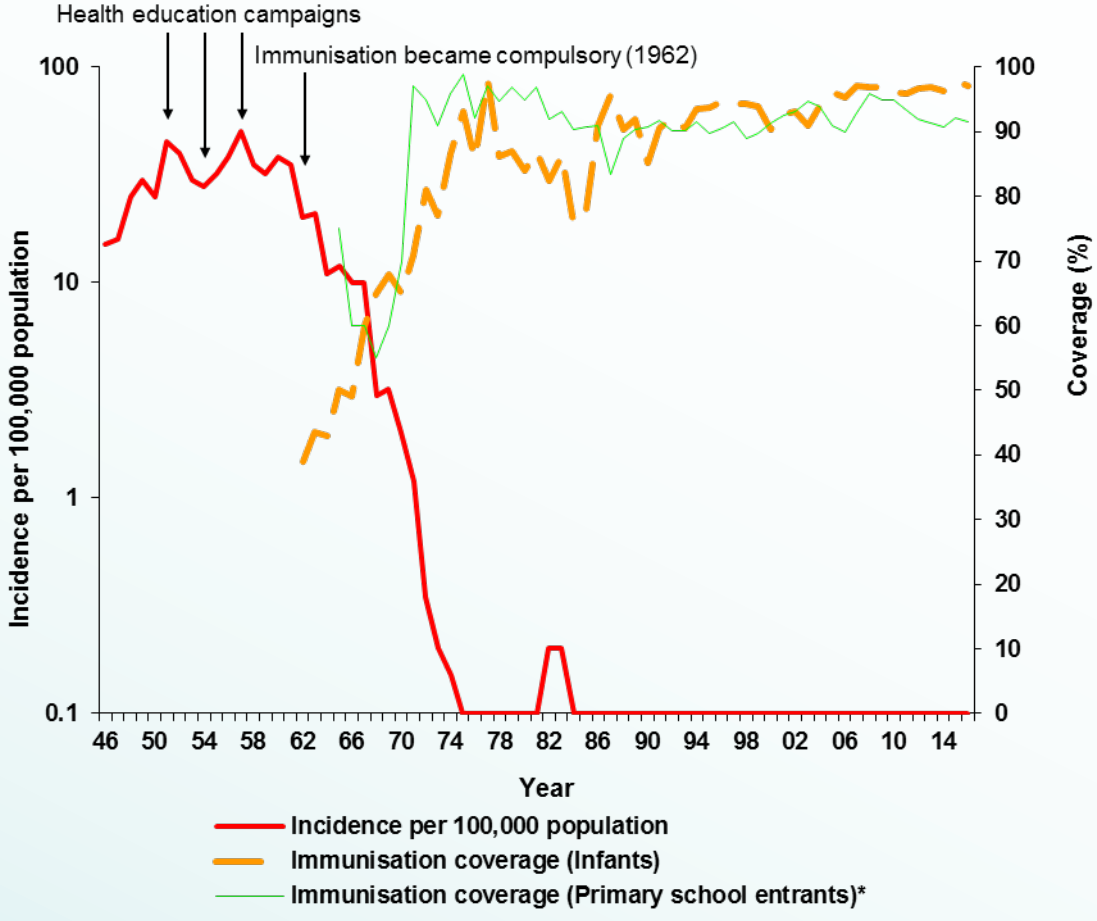
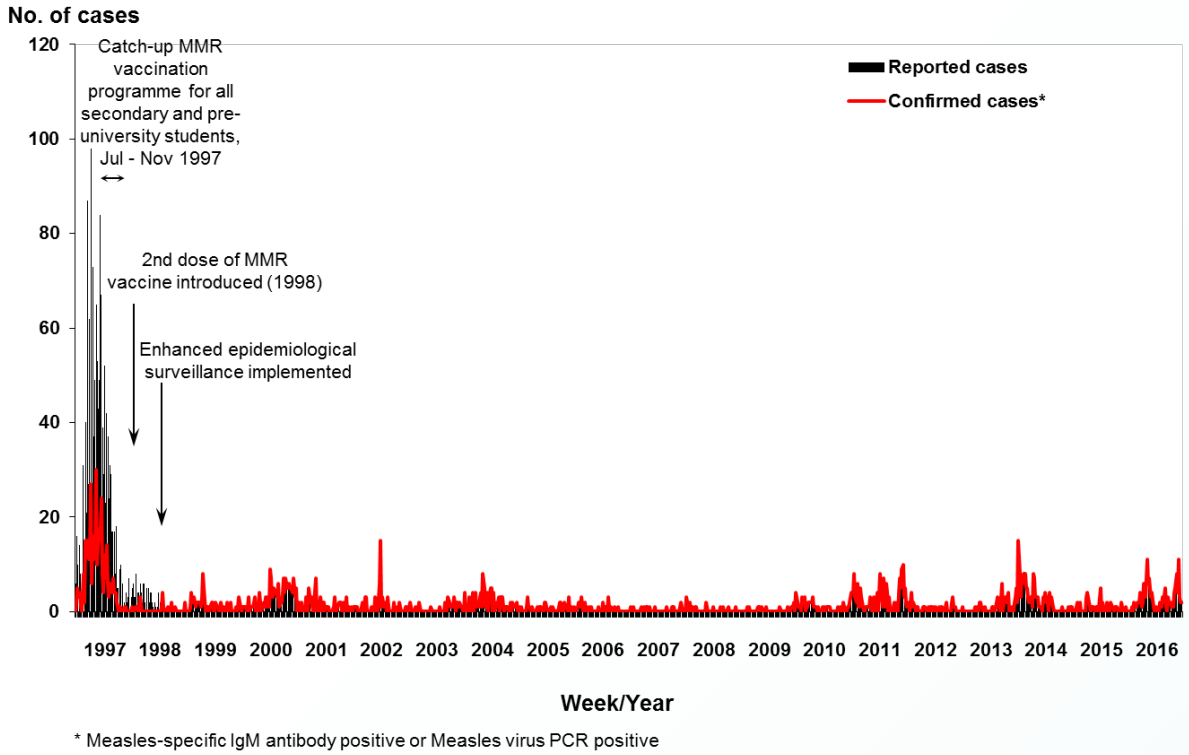


Figure 7.3
Impact of catch-up MMR vaccination programme and introduction of second dose of MMR vaccine on the incidence of reported measles cases in Singapore, 1997-2016



* Measles-specific IgM antibody positive or Measles virus PCR positive

Figure 7.4
Incidence of reported acute hepatitis B cases and immunisation coverage in Singapore, 1985-2016

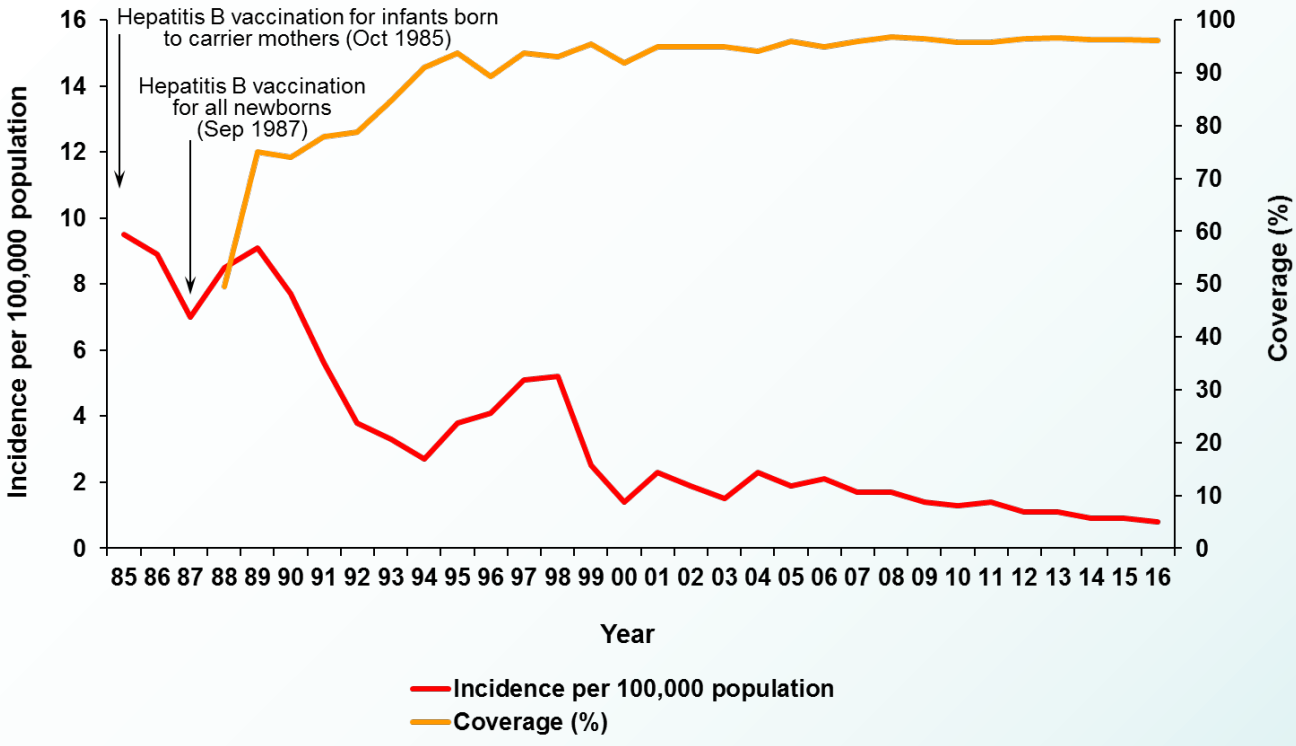


Table 7.11
No. of therapeutic abortions performed for rubella infection, 2007-2016

Year	Total no. of abortions	No. of therapeutic abortions performed for rubella infections	
		No.	(%)
2007	11,933	1	0.01
2008	12,222	0	0
2009	12,316	0	0
2010	12,082	0	0
2011	11,940	0	0
2012	10,624	1	0.01
2013	9,282	2	0.02
2014	8,515	0	0
2015	7,942	1	0
2016	7,217	0	0

Table 7.12
Reported cases of diphtheria, poliomyelitis, measles, acute hepatitis B, neonatal tetanus, pertussis, congenital rubella, and childhood tuberculous meningitis in Singapore, 1990-2016

Year	Diphtheria	Poliomyelitis	Measles	Mumps*	Rubella*	Acute hepatitis B†	Neonatal tetanus‡	Pertussis§	Congenital rubella¶	Childhood tuberculous meningitis#
1990	1	1(1)	143	-	-	1	0	8‡‡	4	0
1991	1(1)	0	216	636	51	3	0	5††	1	0
1992	1	0	606	1,981	370	3	0	14††	4	0
1993	0	0	665	1,962	423	2	0	1††	4	0
1994	0	0	159	1,636	299	2	1	2††	2	0
1995	0	0	185	786	326	0	0	1††	2*	2*
1996	1(1)	0	308	765	487	3	0	4(1)‡‡	2*	2*
1997	0	0	1,413	674	360	0	0	2††	0*	2*
1998	0	0	114	1,183	179	0	0	1**	0*	0
1999	0	0	65††	6,384(28)	432	0	0	1††	2*	1*
2000	0	0	141††	5,981**	312**	0	0	2(1)‡‡	0	1*
2001	0	0	61††	1,399**	242**	0	0	1**	2*	0
2002	0	0	57††	1,090**	152**	0	0	0	1	1
2003	0	0	33††	878**	88**	0	0	1‡‡	0	0
2004	0	0	96††	1,003**	141**	0	0	1‡‡	0	0
2005	0	0	33††	1,004**	139**	0	0	2††	1	0
2006	0	1(1)§§	28††	844**	90**	0	0	3‡‡	0	0
2007	0	0	15††	780**	83**	0	0	38††	0	0
2008	0	0	18††	801**	180**	0	0	33††	2	0
2009	0	0	13††	631**	178**	0	0	13	0	0
2010	0	0	49††	452‡‡	158‡‡	0	0	8††	2§§	2
2011	0	0	148††	501‡‡	110‡‡	0	0	29††	2	0
2012	0	0	38††	521‡‡	64‡‡	0	0	24††	2§§	0
2013	0	0	46††	495‡‡	48‡‡	0	0	17††	1§§	0
2014	0	0	148††	478‡‡	17‡‡	0	0	21††	0	0
2015	0	0	42††	473‡‡	15‡‡	0	0	57††	0	0
2016	0	0	126††	540‡‡	10‡‡	0	0	82††	0	0

( ) Imported cases.
* Notifiable with effect from April 1990.
† Indigenous cases below 15 years of age.
‡ Source: Central Claims Processing System, Ministry of Health.
§ All pertussis cases reported prior to 1986 were based on clinically diagnosed cases seen at the Communicable Disease Centre.
¶ Cases diagnosed in KK Women's and Children's Hospital, Singapore General Hospital and National University Hospital.
# Below 10 years of age.
** Based on clinically diagnosed cases.
†† Based on laboratory confirmed cases.
‡‡ Based on laboratory confirmed and clinically diagnosed cases.
§§ Foreigner who came for treatment.

PUBLIC EDUCATION

HPB educates parents on the importance of childhood immunisations through educational materials such as “Childhood Immunisations: Give your child the best protection” and “Protect your child against Measles, Mumps and Rubella with the MMR vaccination”. These are distributed in the polyclinics and other healthcare institutions. Under the Healthier Child, Brighter Future initiative, the “Healthy start for your baby” guide also contains a chapter on childhood immunisations. This educates parents the importance of immunisation and to immunise their children according to the recommended National Childhood Immunisation Schedule. The guide is distributed to mothers who have delivered and before they are discharged from the maternity hospitals.

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