Progress Toward Measles Elimination in the People's Republic of China, 2000–2009

Chao Ma,[1,a] Zhijie An,[1,2,a] Lixin Hao,[1] K. Lisa Cairns,[2] Yan Zhang,[3] Jing Ma,[1] Lei Cao,[1] Ning Wen,[1] Wenbo Xu,[3] Xiaofeng Liang,[1] Weizhong Yang,[4] and Huiming Luo[1]

[1]National Immunization Program, Chinese Center for Disease Control and Prevention; [2]Expanded Program on Immunization, World Health Organization Office in China; [3]Institutes for Viral Disease Control and Prevention, Chinese Center for Disease Control and Prevention; and [4]Chinese Center for Disease Control and Prevention, Beijing, China

In 2006, China set a goal of measles elimination by 2012. To describe progress toward this goal, we reviewed relevant policies and strategies and analyzed national data for 2000–2009. In response to implementation of these strategies, including increased routine measles vaccination coverage and province-specific supplementary immunization activities (SIAs), reported measles incidence decreased to a historically low level of 39.5 cases per million in 2009. A synchronized nationwide SIA was scheduled in 2010 to further decrease susceptibility to measles. However, reaching and maintaining measles elimination will require strong political commitment and efforts for strengthening surveillance, increasing 2-dose vaccine coverage to >95%, stricter enforcement of the requirement to check immunization status at school entry, and careful attention to measles susceptibility in those aged ≥15 years.

Globally, major reductions have been achieved in measles mortality, from an estimated 733,000 deaths in 2000 to 164,000 in 2008 [1]. Nonetheless, measles transmission continues to occur and to cause childhood deaths. In 2005, the World Health Organization's (WHO) Regional Committee for the Western Pacific Region set a target date of 2012 for measles elimination in the Region. *Elimination* is defined as the situation in a large geographic area in which endemic transmission of measles has stopped and sustained transmission does not occur following the occurrence of an imported case [2, 3] Approximately 75% of the Western Pacific Region population resides in China, and since 2003 the number of reported cases of measles in China has accounted for a large proportion of the regional total [4]. Hence, successful measles elimination in China is critical to achieving the Western Pacific Region goal.

China is a developing country with a 2009 mainland population of 1.3 billion, of which 46% live in urban and 54% in rural settings. Administratively, the country is divided into provinces, prefectures, counties, and townships. Nineteen percent of the population is <15 years of age, and 99.5% of school-age children are enrolled in primary school [5]. According to the 2000 national census, there were 42.4 million internal migrants seeking work out of their province of origin, primarily in the developed east [5]. China's 31 provinces are divided into 3 groups according to economic and social development (Nine eastern provinces [Beijing, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong], 10 central provinces [Hebei, Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, and Hainan], and 12 western provinces [Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang]). These groupings also predict differing challenges in reaching measles elimination.

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[a]C. M. and Z. A. contributed equally to this work.

Correspondence: Huiming Luo, MB, National Immunization Program, Chinese Center for Disease Control and Prevention, 27 Nanwei Road, Beijing, China (hmluo@vip.sina.com).

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Measles caused many outbreaks in China before the 1965 introduction of liquid measles vaccine (MV) administered as 1 dose to infants aged >8 months. The 1978 establishment of the national Expanded Program on Immunization (EPI) resulted in a standard routine immunization schedule that included 6 antigens (Bacille Calmette-Guerin [BCG], oral polio virus [OPV], diphtheria-tetanus-pertussis [DTP], and measles [MV]). The subsequent expansion of cold chain infrastructure allowed routine immunization with MV to cover the entire country. In 1986, a 2-dose schedule using lyophilized MV at 8 months and at 7 years of age was introduced [6]. The next step was a 1997 national plan of action for accelerated measles control that called for >90% MV coverage, measles surveillance, and catch-up campaigns for provinces that wanted to achieve elimination. In 1998 the Ministry of Health (MOH) issued technical guidelines titled "Standard Operating Procedures for Vaccination" that aimed to ensure the quality and safety of EPI vaccination. Vaccines used in the EPI program, including MV, are domestically produced and undergo approval by the Chinese national regulatory authority. This approval process involves review of clinical trial data and review of the production process and lot release for already-licensed vaccines. To date, no Chinese vaccines are prequalified for purchase through the United Nations system, although it is anticipated that this process will be initiated in the near future. Three MV strains (Chang-47, Jing-55, and Shanghai-191) have been used in China since the 1960s, but Shanghai-191 is the only strain that has been used continually. An earlier study showed that the seroconversion rate of Chinese MV was 64.5% at 4–6 months of age, 94.0% at 7–8 months of age, and 96.8% in children aged >12 months [6].

Historically, 2 different surveillance systems have reported measles cases to China's national level. First, the National Notifiable Diseases Reporting System (NNDRS), in place since the 1950s, reports basic epidemiologic data including age, sex, date of disease onset, and residence on all clinically diagnosed measles cases. In the past, hospitals reported cases by posting a card to the county Center for Disease Control; every month county Centers for Disease Control aggregated data that were then submitted through prefecture and provincial Centers for Disease Control to reach the national level. In addition to the NNDRS, as part of the 1997 plan for accelerated measles control the MOH developed national measles surveillance guidelines and progressively established a case-based Measles Surveillance System (MSS) in selected provinces. The MSS was parallel to NNDRS, was integrated with polio/acute flaccid paralysis surveillance, and used the WHO measles case definition [3]. Nonetheless, the NNDRS remained the official source of data on number of reported measles cases.

In 1980, the MOH issued a document on investigating and compensating adverse events following immunization (AEFI). This document mentioned AEFI surveillance, but no formal AEFI surveillance system was put in place until 2002, at which time AEFI surveillance was established in 6 provinces [7].

In this article we summarize mainland China's progress toward and challenges in achieving measles elimination during 2000-2009.

METHODS

Program Description

We reviewed relevant policy and strategies during 2000-2009 to reach measles elimination.

Coverage Monitoring

Each province reports administrative coverage of the first and second doses of measles-containing vaccine (MCV1 and MCV2) using denominators based on the number of children registered as "target" in the routine EPI system. However, because these denominators differ from National Bureau of Statistics figures, we also calculated estimated coverage of MCV1 and MCV2 for each cohort using denominators from the National Statistical Yearbook [5]. Because studies have shown that the percentage of townships that did not report vaccination status of children to county level is significant [8], we adjusted numerators to take this underreporting into consideration. This adjustment was performed in accordance with China-specific WHO recommendations that take into account the number of children vaccinated and the number of children targeted by EPI [9]. In this adjustment, the numerator consisted of those recorded as vaccinated plus half of the difference between the estimated National Bureau of Statistics birth cohort as drawn from the National Statistical Yearbook and the birth cohort as estimated by the EPI. These are the calculations that have been used annually since 2005 to report China's official vaccine coverage estimates through WHO's Joint Reporting Form. In this article, "administrative" coverage refers to unadjusted figures, whereas "estimated" coverage refers to adjusted figures.

Coverage Survey

In 2004, EPI conducted a national coverage survey using 2-stage sampling with probability proportional to population size. This survey provided an estimate of the MCV1 vaccination status of children born between 2001 and 2003.

School Entry Immunization Check

To assess the effect of the new requirement to check vaccination records at school entry (see below), in 2006 the MOH collected information on these activities from all provinces excluding Tibet. In addition, a multistage stratified field survey was conducted that included 60 counties and 29 districts in these 30 provinces, for a total of 89 primary schools and kindergartens. Investigators collected information at the provincial, county, and school level regarding the implementation of the school entry immunization check.

Supplementary Immunization Activities (SIAs)

The SIAs were mass immunization campaigns targeting all children in specified age groups regardless of previous measles vaccination or disease status. Catch-up campaigns targeted children aged 8 months through 14 years, whereas follow-up campaigns targeted children aged 8 months through 6 years. To calculate SIA coverage, provincial Centers for Disease Control divided the number of children vaccinated by the number of children targeted for vaccination by county during SIAs. Aggregated coverage data were sent to the national level upon completion of the SIA.

Measles Surveillance

Both clinically confirmed and laboratory-confirmed measles cases were reported in NNDRS. We calculated and analyzed reported measles incidence and mortality by time, place, and person on the basis of data from NNDRS using denominators from the National Bureau of Statistics [5]. In 2001, the national measles laboratory network was established to support case-based measles surveillance (see below). We also used data from the MSS to analyze the measles surveillance performance indicators of proportion of suspected cases investigated within 48 hours of reporting, proportion of reported suspected cases with specimens collected for measles immunoglobulin M testing, and proportion of measles cases that were laboratory tested during 2004-2009. Epidemiologic analyses included clinically confirmed and laboratory-confirmed measles cases.

RESULTS

Program Description

The MOH updated the immunization schedule for MCV with consultation from China's Advisory Committee on Immunization Programs on the basis of measles epidemiology, stage of measles control, and MCV supply capacity. In 2005, China changed the timing of MCV2 from 7 years to 18-24 months of age. In 2007, China also replaced MV with measles-rubella as the first dose of MCV and recommended use of measles-mumps-rubella or measles-mumps for the second dose. In 2005, the MOH updated the "Standard Operating Vaccinating Procedures," in which detailed guidance regarding immunization was given, covering vaccination in clinics, fixed-site vaccination in rural areas, and door-to-door vaccination in remote areas. In China, all vaccines are delivered through the public infrastructure.

In 2005, the Chinese State Council (which oversees all Ministries) issued a regulation instituting a requirement that all children have their vaccination records checked at the time of entry to kindergarten and primary school. A document that detailed vaccination guidelines for underimmunized children and required 2 doses of MCV at the time of school entry was jointly issued by the Ministries of Education and Health. In practice, children who are not up-to-date with vaccines at the time of school entry are encouraged to be vaccinated but not excluded from school.

The National Measles Surveillance Guidelines were updated in 2003. These guidelines divided the provinces into 2 groups. Group A had a low ($<$60 cases per million) average reported annual measles incidence in 1997–2001, whereas group B had higher incidence ($\geq$60 cases per million). The MOH recommended that the 18 group A provinces conduct case-based measles surveillance, with reporting and investigation of all suspected cases, to collect basic epidemiologic information including clinical signs, vaccination history, specimen collection, and laboratory results, whereas the 13 group B provinces were to report all suspected measles cases and conduct case-based measles surveillance if possible. The MOH updated these guidelines again in 2009, recommending that all provinces conduct case-based measles surveillance and introducing standardized surveillance performance indicators to monitor progress.

The first indicator was the number of suspected measles cases identified as non-measles following laboratory investigation (target, $>$20 cases per million at province level). Other indicators with a target $>$80% included the proportion of suspected cases investigated within 48 hours of report, the proportion of suspected cases with adequate serum specimens, and the proportion of chains of transmission with specimens collected for virus detection. A target of 90% of laboratory-confirmed measles outbreaks was also established.

Since 2004, the NNDRS has been upgraded to allow hospitals or local Centers for Disease Control to directly report all suspected measles cases immediately to the national level through a web-based real-time reporting system. In 2004, the MSS was also upgraded to permit all provinces to conduct case-based measles surveillance, thus taking advantage of this system's ability to collect detailed epidemiologic information, including immunization status and laboratory results, on suspected cases. In 2009, China CDC combined the MSS with the NNDRS into a single comprehensive measles surveillance information system.

In 2001, the national measles laboratory network was established to support measles surveillance. In 2009, this network was composed of 1 national measles laboratory (appointed a reference measles laboratory by WHO in 2003), 31 provincial measles laboratories performing virus isolation and sending isolates to the national measles laboratory for genotyping, and 331 prefecture laboratories performing serologic testing. In 2004, the national level established 10 pilot provinces for AEFI surveillance that followed WHO guidelines and reported all data to the central level [7].

In 2006, the MOH endorsed the 2006–2012 national action plan for measles elimination. This plan set a target of measles incidence of $<$1 case per million (excluding imported cases) and aimed at the absence of transmission of endemic measles virus.

Table 1. Reported Annual Coverage of Measles Supplementary Immunization Activities, 2004–2009

	8 months–14 years				8 months–6 years[a]			
Year	No. of provinces	No. of targeted, million	No. of vaccinated, million	Average coverage, %	No. of provinces	No. of targeted, million	No. of vaccinated, million	Average coverage, %
2004	2	13.0	12.9	99.2	0	…	…	…
2005	2	5.7	5.6	98.3	0	…	…	…
2006	4	6.9	6.6	95.7	0	…	…	…
2007	2	16.4	16.1	98.2	0	…	…	…
2008	5	35.2	34.6	98.6	4	16.1	15.7	97.5
2009	10	90.3	88.2	97.7	3	6.2	6.0	96.8
Total	25	167.5	164.0	98.0	7	22.3	21.7	97.3

NOTE. Data source was the report of each province.

[a] One province targeted 8 months–7 years in 2009.

The plan of action was based upon 6 elements. First, the immunization strategy aimed at (a) keeping 2-dose routine coverage >95% while covering all children aged 2-7 years immediately with the updated schedule, (b) conducting special activities for hard-to-reach children, (c) implementing school entry immunization checks, and (d) conducting supplemental immunization activities. Second, measles surveillance was strengthened to require that suspected measles cases be reported, investigated, and laboratory tested. Third, provisions were made for the control of measles outbreaks. Fourth, appropriate case management was promoted. Fifth, infection control measures targeted transmission in hospitals. Sixth, rubella control was introduced.

Routine Immunization

The administrative (unadjusted) coverage of MCV1 exceeded 97% each year during 2000–2009 (data not yet available for 2008). The estimated (adjusted) coverage of MCV1 was lower but increased from 80.4% in 2000 to 91.1% in 2009, with an average of 86.3%. Administrative coverage of MCV2 exceeded 96% during 2001–2009 (data not available for 2008); the estimated coverage was <80% before 2005, and it was 84.5% in 2005 and 84.3% in 2009. In 2006 and 2007, because the recommended age for vaccination of MCV2 shifted from 7 years to 18-24 months, coverage data for MCV2 included children in both these age groups. In addition, some provinces conducted mass vaccination targeting all children aged 18 months to 7 years. However, vaccines delivered through mass immunizations were not reported through the routine coverage system. For these reasons, 2006 and 2007 MCV2 coverage has not been estimated.

Coverage Survey

Overall, 92.7% of the 155,954 children investigated during the 2004 national EPI review were vaccinated with MCV1. Coverage for the 2001, 2002, and 2003 birth cohorts was 92.3%, 92.7%, and 93.1%, respectively. Analyzing coverage by geographic area, the average coverage for the 2001–2003 birth cohorts in Eastern, Central, and Western provinces was 96.5%, 94.8% and 85.8%, respectively [10].

School Entry Immunization Checks

Information collected from provinces in 2006 indicated that 91.0% of all counties and 84.5% of all primary schools and kindergartens had conducted checks of students' immunization status on school entry. The field survey showed that 58 (96.7%) of 60 counties visited required school entry vaccination checks, and 82 (92.1%) of 89 primary schools and kindergartens visited were checking vaccination status.

Impact of SIAs

During 2004–2009, 27 provinces conducted unsynchronized province-wide measles SIAs, among which most activities (17 provinces) were conducted during 2008–2009. Of a target population estimated at 189.8 million children and adolescents, 185.7 million were vaccinated through SIAs (reported coverage, 93.1%– 99.9%; median, 97.9%) (Table 1). The incidence of measles in the 15 provinces that conducted province-wide catch-up SIAs (A catch-up SIA is a 1-time immunization activity that targets a wide age range and aims to eliminate all measles-susceptibles in the population; a follow-up SIA is an immunization activity which targets all children born since the last SIA and aims to eliminate measles susceptibles that may have accumulated in the population) during 2004–2008 showed the impact of these activities. The median 5-year average reported incidence before catch-up was 118.6 cases per million (range, 53.0–312.7 cases per million); in the year after SIAs, the median incidence decreased to 14.3 cases per million (range, 3.2–32.7 cases per million); decreases in incidence were found in all age groups. The post-SIA incidence represented an 88.1% decrease in the median (range of decrease, 44.6%–97.8%). In contrast, 2 provinces with 5-year average incidences of 133.7 and 72.3 cases per million that conducted SIAs only in selected prefectures reported persistently high measles incidence at the provincial level (63.8 and 73.7 cases per million, respectively) after the SIAs.

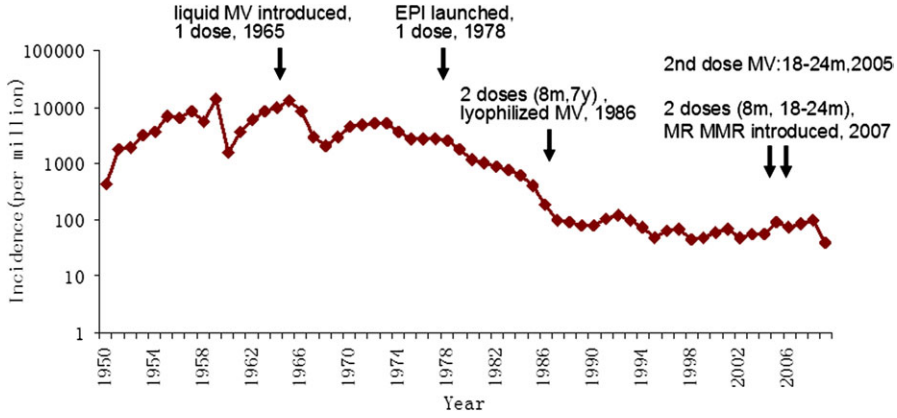

Figure 1. Reported measles incidence per million in China, 1955–2009. Data source: National Notifiable Diseases Reporting System. EPI, Expanded Program on Immunization; MV, measles vaccine; MR, measles-rubella; MMR, measles-mumps-rubella.

In 2004, the provinces of Guizhou and Xinjiang conducted catch-up SIAs. Since then, measles incidence in Guizhou has remained at a low level. However, in 2007–2008, three years after the province-wide catch-up SIA, a large-scale measles outbreak struck the western province of Xinjiang. Reported incidence according to the NNDRS increased to 129.1 cases per million (2646 cases in 2007) and 973.0 cases per million (19,968 cases in 2008), compared with 17.4 cases per million (2005) and 14.9 cases per million (2006). During the outbreak, the highest incidence was reported among children born after the 2004 campaign, with incidence in 2005, 2006, and 2007 birth cohorts being 4069.7 cases per million, 6098.6 cases per million, and 3654.4 cases per million. In total, 30 measles-associated deaths were reported in the outbreak. With the implementation of control measures including emergent immunization during the outbreak and follow-up SIAs (target age group, 8 months—6 years; reported coverage, 98.4%) in late 2008, the outbreak was controlled and measles incidence in 2009 was 18.5 cases per million.

Measles Surveillance: Indicators and Findings

According to MSS data, the proportion of suspected cases investigated within 48 hours of report was >80% annually during 2004–2009. The proportion of cases with clinical specimens increased from 36.5% in 2004 to 70.0% in 2009. The proportion of suspected measles cases that was laboratory tested increased from 32.8% in 2004 to 64.8% in 2009.

Of all cases reported in 2004–2009, 41.4% had received zero doses of vaccine, 12.5% had received 1 dose, 4.7% had received ≥2 doses, and 41.4% had unknown vaccination status. The proportion of cases with unknown vaccination status increased from 13.3% among children aged <1 year to 65.6% among those aged ≥15 years of age. The proportion of cases reporting receiving zero doses of MCV was 77.4% (<1 year), 37.1% (1–4 years), 23.9% (5–9 years), 18.6% (10–14 years), and 29.2% (≥15 years).

During 1993–2009, there were 1730 isolates obtained for genotyping from 30 of 31 provinces (ie, all provinces except Tibet). All of these isolates were H1 genotype, except for one H2, one D4, one D9, and one D7-like genotype, and four A vaccine–related viruses.

Measles Incidence

In 2009, reported measles incidence decreased to 39.5 cases per million, reaching a historically low level (Figure 1, Table 2). Six provinces reported incidence <10 cases per million. In 25 provinces, the reported 2009 measles incidence decreased compared with 2008 (Figure 2). The average annual reported incidence in 2000–2009 (average, 68.0 cases per million; range, 39.5 [2009]–99.5 [2008] cases per million) represented a 9.3% decrease compared with 1990–1999 (average, 75.0 cases per million; range, 45.4 [1998]–121.0 [1992] cases per million). The 2000–2009 reported measles mortality rates ranged from 0.02 per million to 0.13 per million.

Between 1990–1999 and 2000–2009, the average reported measles incidence decreased more in the Western (from 131.2

Table 2. Reported Annual Measles Incidence and Mortality Per Million, China, 2000–2009

Year	No. of cases	Incidence per million	No. of deaths	Mortality rate per million
2000	73,567	59.3	164	0.13
2001	90,935	71.5	160	0.13
2002	63,709	47.6	138	0.10
2003	74,813	55.5	79	0.06
2004	70,549	54.3	26	0.02
2005	123,136	94.7	55	0.04
2006	99,602	76.2	35	0.03
2007	109,023	82.9	66	0.05
2008	131,441	99.5	102	0.08
2009	52,461	39.5	39	0.03

NOTE. Data source: National Notifiable Diseases Reporting System.

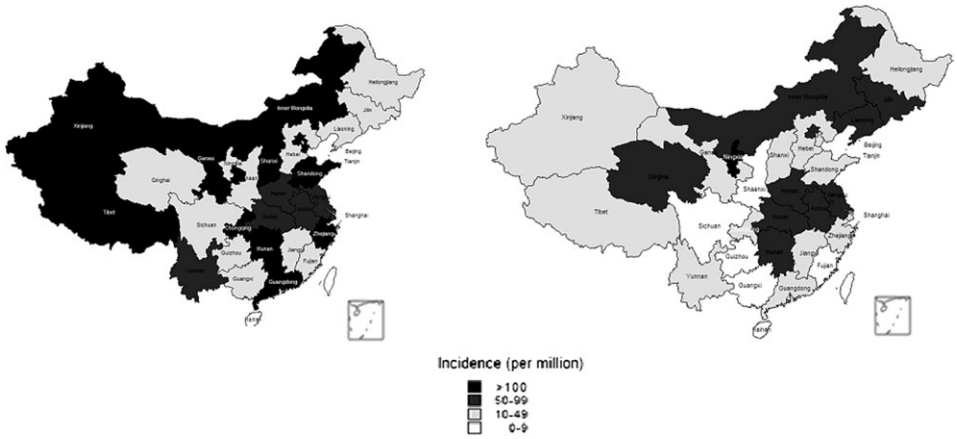

Figure 2. Reported measles incidence by province, China, 2008 and 2009. Data source: National Notifiable Diseases Reporting System.

cases per million to 105.8 cases per million) than in the Central provinces (from 57.6 cases per million to 55.5 cases per million). In contrast, Eastern provinces started from a lower level of reported incidence in 1990–1999 (38.8 cases per million) but increased to 65.0 cases per million in 2000-2009, while remaining under the reported incidence in Western provinces.

Children <1 year of age had the highest reported age-specific incidence each year in 2000-2009, followed by the 1-6 year age group, the 7-14 year age group, and the group aged ≥15 years. The average incidence among children <1 year of age increased from 396.6 cases per million during 2000-2004 to 1542.9 cases per million during 2005-2009, and incidence among young adults aged 15-34 years increased from 243.4 cases per million to 346.9 cases per million. Although the overall number of reported cases decreased from 73,567 in 2000 to 52,461 in 2009, the number of cases reported among infants increased from 5184 in 2000 to 16,969 in 2009. Similarly, the number of cases reported among individuals aged ≥15 years increased from 10,562 in 2000 to 15,638 in 2009 (Figure 3), with the proportion of all cases in this age group varying by region. In 2009 the proportion of all cases aged ≥15 years was 29.8%, and 44.4%, 19.6%, and 35.4% in Eastern, Central, and Western provinces, respectively.

DISCUSSION

Experience in Korea [11] and the Americas [12] has indicated that achieving measles elimination within a short period using WHO-recommended strategies is possible. As a result, China used these strategies to guide its 2006 plan of action. However, despite the implementation of new policies and strategies during 1990–2009, nationwide reported measles incidence did not drop substantially until 2009, although since 2005 a lower percentage of overall cases has occurred in those aged <15 years, most likely reflecting the combined effect of SIAs and school entry immunization check. The reduction in the number of circulating viral genotypes and 2009 reported cases are clear steps toward increased measles control. However, additional efforts are needed in 2010-2011 to achieve the 2012 measles elimination goal.

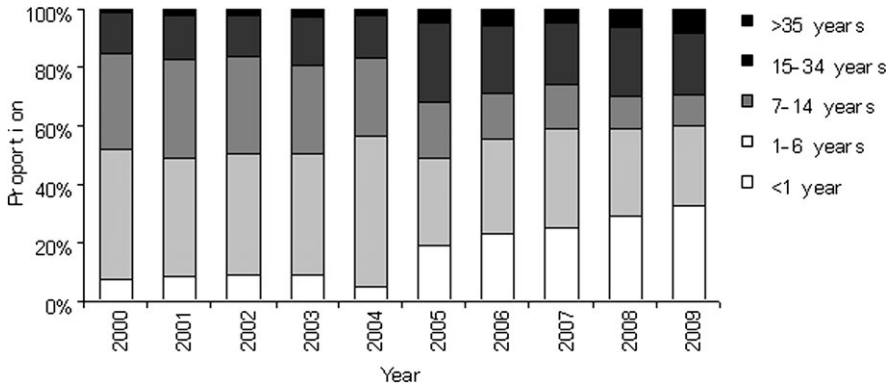

Figure 3. Age group distribution of measles cases, 2000–2009. Data source: National Notifiable Diseases Reporting System.

Reaching very high coverage with 2 doses of MCV through routine immunization is the key vaccination strategy to achieve and to maintain measles elimination. Although estimated (ie, adjusted) MCV1 coverage during 2000-2009 was lower than administrative (ie, unadjusted) coverage, it has increased steadily since 2000 and has exceeded 90% since 2006. Given the seroconversion rate of 80%–85% among children vaccinated between 8 and 9 months of age [13], the age of administration of MCV2 was decreased from 7 years to 18–24 months in 2005 to protect children aged 2–6 years. This resulted in a decrease in susceptibility among children aged 2–6 years and in a steady increase of MCV2 coverage measured both administratively and through estimates. However, a gap remains between the 2-dose routine immunization coverage and the >95% goal. The fact that the highest measles incidence nationally is found in children aged <7 years also indicates that routine coverage has been insufficient to interrupt measles transmission in this age group, especially in underdeveloped Western provinces and some large cities that experience large influxes of migrant children. These weaknesses in the routine program may help to explain the relatively high incidence of measles.

China's EPI recommends that the first dose of MV be administered at 8 months of age. This is the earliest recommended delivery in the world and is considered necessary to protect infants from measles because of extensive community circulation of virus. Because the proportion of vaccinated children developing immunity to measles is lower among infants at 8-9 months than among those vaccinated at 11-12 months [14], an adjustment in the timing of delivery of MCV1 from 8 months to 12-15 months should be considered when measles reported incidence has decreased to elimination levels.

Experiences in the United States [15], Korea [11], and China (since 2005) have documented the impact of school entry immunization checks on achieving measles elimination. In China, >99.5% of children attend school [5] and >50% of measles outbreaks occur in schools or kindergartens [16]. Thus, well-implemented school entry immunization checks and vaccination of underimmunized children can ensure high coverage of 2-dose MCV among students, thus avoiding virus transmission in these institutions. The 2006 survey indicated that >15% of schools did not check incoming students' vaccination status. Furthermore, there was no national system in place to monitor the enforcement of the school entry vaccination check. Strict enforcement of school entry immunization checks associated with vaccinating underimmunized children could greatly decrease measles transmission in children aged ≥6 years. However, because the existing school entry policy was only recently introduced, is not completely enforced, and targets only children entering kindergarten or grade 1, its impact remains incomplete.

Large-scale province-wide measles SIAs have been conducted since 2004. These were followed by a dramatic reduction of the reported measles incidence in most provinces, especially in those that conducted SIAs in the whole province simultaneously [17, 18]. During 2004–2007, less than one-third of all provinces conducted SIAs, while those that were conducted were unsynchronized. Despite province-specific impact, the 2004-2007 SIAs appear to have had relatively little impact on nationwide transmission. Many more provincial SIAs were conducted in 2008-2009, resulting in historically low measles levels in 2009. The re-emergence of measles in new birth cohorts after catch-up campaigns suggests, as mentioned above, an insufficient 2-dose routine coverage that leads to rapid accumulation of susceptible children after SIAs. High levels of 2-dose MCV routine coverage are critical to maintain low measles incidence after campaigns. In addition, timely implementation of follow-up campaigns according to measles epidemiology and routine coverage is critical to protect new birth cohorts. The Chinese government is planning a nationwide follow-up campaign in the second half of 2010.

In 2009, approximately 29.8% of reported measles cases nationwide were in individuals aged ≥15 years. To date, measles elimination activities have targeted those aged <15 years. The extent to which measles transmission will continue in older age groups once high immunity is reached in those aged <15 years is unclear. Assuming that transmission among adults continues, surveillance activities to understand whether certain population subgroups are particularly susceptible to measles will determine whether targeted vaccination efforts could be worthwhile.

Historically, the Chinese public has accepted measles vaccination, and anti-MV lobbies have been virtually nonexistent. However, in 2009, in the context of the Guangdong provincial SIA, questions were raised by the public regarding the need for a third, SIA-administered, dose of vaccine for children who had already received 2 documented doses [19]. Early 2010 saw further reports—both unsubstantiated and substantiated—of AEFI following vaccination with various antigens [20]. These events have increased public wariness regarding vaccines in general. The long-term impact on vaccine uptake remains to be determined.

Monitoring progress toward the achievement of the measles elimination goal can be accomplished only in the presence of a measles surveillance system that is sensitive and specific. Historically, a large proportion of cases reported through NNDRS were not laboratory confirmed. Requiring laboratory confirmation for all cases will increase the specificity of surveillance and will make measles surveillance data a more accurate reflection of the true status of measles control in the country. China's case-based measles surveillance system now has high-quality laboratory support. This infrastructure has been able to detect imported genotypes and to determine that between 1993 and 2009 China had a single, endemic genotype (H1) widely distributed throughout the country. However, insufficient

specimen collection, an insufficient proportion of laboratory-tested measles cases, and limited investigation of cases (eg, a large number of cases with unknown vaccination history) still hamper the performance of the measles surveillance system, which is not yet adequate to support measles elimination.

CONCLUSIONS AND NEXT STEPS

China progressed toward measles elimination in 2000-2009. Key milestones were (1) developing a national plan of action, (2) increasing routine immunization and SIA coverage, (3) improving case-based surveillance, (4) introducing rubella control, and (5) mandating and implementing school entry immunization checks. Nevertheless, in view of the size and density of China's population and its status as a developing nation, China still faces challenges in achieving measles elimination by 2012 and maintaining elimination thereafter. To reach this goal, additional support from internal and international partners will be required.

Strong commitment and effort are urgently needed to reach and to maintain >95% 2-dose routine coverage, especially in unregistered children, and to measure coverage accurately. A national monitoring system under the Ministries of Education and Health is needed to conduct yearly evaluations of the measles immunization status of children entering schools to ensure extremely high 2-dose MCV coverage among kindergarten and school-age children. Special efforts are necessary in the Western and Eastern provinces, which see the most movement of migrant populations. The nationwide synchronized SIA for 2010 was planned to cover all birth cohorts born since the last SIA as well as young migrant children who may have been missed when SIAs were conducted in individual provinces during 2004–2009. The 2010 campaign was also extended to cover the children aged <15 years in provinces that had not conducted SIAs since 2000. Further activities targeting adult populations may be necessary if transmission persists in these groups despite high immunity in those aged <15 years. Finally, the sensitivity and specificity of the surveillance system should be enhanced to support measles elimination.

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