

Progress Toward Regional Measles Elimination — Worldwide, 2000–2015

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Adopted in 2000, United Nations Millennium Development Goal 4 set a target to reduce child mortality by two thirds by 2015, with measles vaccination coverage as one of the progress indicators. In 2010, the World Health Assembly (WHA) set three milestones for measles control by 2015: 1) increase routine coverage with the first dose of measles-containing vaccine (MCV1) for children aged 1 year to $\geq 90\%$ nationally and $\geq 80\%$ in every district; 2) reduce global annual measles incidence to < 5 cases per 1 million population; and 3) reduce global measles mortality by 95% from the 2000 estimate (1,2).^{*} In 2012, WHA endorsed the Global Vaccine Action Plan[†] with the objective to eliminate measles in four World Health Organization (WHO) regions by 2015. Countries in all six WHO regions have adopted measles elimination goals. Measles elimination is the absence of endemic measles transmission in a region or other defined geographical area for ≥ 12 months in the presence of a well performing surveillance system. This report updates a previous report (3) and describes progress toward global measles control milestones and regional measles elimination goals during 2000–2015. During this period, annual reported measles incidence decreased 75%, from 146 to 36 cases per 1 million persons, and annual estimated measles deaths decreased 79%, from 651,600 to 134,200. However, none of the 2015 milestones or elimination goals were met. Countries and their partners need to act urgently to secure political commitment, raise the visibility of measles, increase vaccination coverage, strengthen surveillance, and mitigate the threat of decreasing resources for immunization once polio eradication is achieved.

Immunization Activities

To estimate coverage with MCV1 and the second dose of measles-containing vaccine (MCV2) through routine immunization services,[§] WHO and the United Nations Children's

Fund (UNICEF) use data from administrative records and surveys reported annually by 194 countries. During 2000–2015, estimated MCV1 coverage increased globally from 72% to 85%, although coverage has not increased since 2009. The number of countries with $\geq 90\%$ MCV1 coverage increased from 84 (44%) in 2000 to 129 (66%) in 2012, but then declined to 119 (61%) in 2015. Since 2003, countries also have reported the number of districts with $\geq 80\%$ MCV1 coverage. Among countries with $\geq 90\%$ MCV1 coverage nationally, the percentage with $\geq 80\%$ MCV1 coverage reported in all districts increased from 2% of countries (one of 43) in 2003 to 44% (57 of 129) in 2012 and then declined to 39% (47 of 119) in 2015. Among the estimated 20.8 million infants who did not receive MCV1 through routine immunization services in 2015, approximately 11 million (53%) were in six countries: India (3.2 million), Nigeria (3 million), Pakistan (2 million), Indonesia (1.5 million), Ethiopia (0.7 million), and the Democratic Republic of the Congo (0.6 million).

During 2000–2015, the number of countries providing MCV2 nationally through routine immunization services increased from 97 (51%) to 160 (82%), with six countries (Angola, Malawi, Mozambique, Nepal, Sierra Leone, and Zimbabwe) introducing MCV2 in 2015. Estimated global MCV2 coverage increased from 15% in 2000 to 61% in 2015. During 2015, approximately 184 million persons received MCV during mass immunization campaigns known as supplementary immunization activities (SIAs)[¶] implemented in 41 countries, with 32 (78%) providing one or more additional child health interventions during the SIA (Table 1). Based on doses administered, SIA coverage was $\geq 95\%$ in 21 (51%) countries; however, among the four countries conducting post-SIA coverage surveys, only one estimated coverage at $\geq 95\%$.

^{*}The coverage milestone is to be met by every country, whereas the incidence and mortality reduction milestones are to be met globally.

[†]The Global Vaccine Action Plan is the implementation plan of the Decade of Vaccines, a collaboration between WHO, UNICEF, the Bill and Melinda Gates Foundation, the National Institute of Allergy and Infectious Diseases, the African Leaders Malaria Alliance, Gavi, the Vaccine Alliance, and others to extend the full benefit of immunization to all persons by 2020 and beyond. In addition to 2015 targets, it also set a target for measles and rubella elimination in five of the six WHO regions by 2020. http://www.who.int/immunization/global_vaccine_action_plan/en and http://apps.who.int/gb/ebwha/pdf_files/wha65/a65_22-en.pdf.

[§]For MCV1, among children aged 1 year or, if MCV1 is given at age ≥ 1 year, among children aged 24 months. For MCV2, among children at the recommended age of administration of MCV2, per the national immunization schedule. WHO/UNICEF estimates of national immunization coverage are available at http://www.who.int/immunization/monitoring_surveillance/data/en.

[¶]Supplemental immunization activities (SIAs) generally are carried out using two target age ranges. An initial, nationwide catch-up SIA focuses on all children aged 9 months–14 years, with the goal of eliminating susceptibility to measles in the general population. Periodic follow-up SIAs then focus on all children born since the last SIA. Follow-up SIAs generally are conducted nationwide every 2–4 years and focus on children aged 9–59 months; their goal is to eliminate any measles susceptibility that has developed in recent birth cohorts and to protect children who did not respond to MCV1.

Disease Incidence

Countries report the number of measles cases^{**},^{††} from either case-based^{§§} or aggregate surveillance systems to WHO and UNICEF annually. In 2015, 189 (97%)^{¶¶} countries conducted case-based surveillance in at least part of the country, and 191 (98%)^{***} had access to standardized quality-controlled testing through the WHO Global Measles and Rubella Laboratory Network. However, surveillance is weak in many countries, and 43% did not achieve the sensitivity indicator of reporting ≥ 2 discarded measles^{†††} cases per 100,000 population

During 2000–2015, the number of measles cases reported annually worldwide decreased 70%, from 853,479 to 254,928, and measles incidence decreased 75%, from 146 to 36 cases per 1 million population (Table 2). During 2013–2015, incidence declined from 40 to 36 per 1 million, although fewer countries reported case data in 2015 (169) than did in 2013 (176).^{§§§} The percentage of reporting countries with an incidence of < 5 cases per 1 million increased from 38% (64 of 169) in 2000

** http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tsincidence measles.html.

†† Measles cases are defined differently in different countries. Some countries define measles cases as those that are laboratory-confirmed or epidemiologically confirmed; others define measles cases as those that are laboratory-confirmed, epidemiologically confirmed, or clinically compatible. Laboratory-confirmed cases are suspected measles cases with specimens with detectable measles virus-specific immunoglobulin class M (IgM) antibodies, or specimens from which measles virus can be isolated or measles virus genome can be detected in appropriate clinical specimens by a proficient laboratory. Epidemiologically linked confirmed measles cases are suspected measles cases that have not been confirmed by a laboratory but are geographically and temporally related to a laboratory-confirmed case or, in the event of a chain of transmission, to another epidemiologically confirmed measles case, with dates of rash onset between cases occurring 7–21 days apart. Clinically compatible measles cases are suspected measles cases with fever and maculopapular rash and cough, coryza, or conjunctivitis, for which no adequate clinical specimen was collected and which have not been linked epidemiologically to a laboratory-confirmed case of measles or to a laboratory-confirmed case of another communicable disease.

§§ A case-based surveillance system is defined as one that collects information about each case at the individual level; in the case of measles, effective case-based surveillance includes confirmatory laboratory testing.

¶¶ Countries without case-based measles surveillance in 2015 were Mauritius, Sao Tome and Principe, Seychelles, and Somalia.

*** Countries without access to standardized quality-controlled testing by the WHO Measles and Rubella Laboratory Network in 2015 were Cape Verde, Sao Tome and Principe, and Seychelles.

††† A discarded case is defined as a suspected case that has been investigated and discarded as nonmeasles using 1) laboratory testing in a proficient laboratory or 2) epidemiological linkage to a laboratory-confirmed outbreak of a communicable disease that is not measles. The discarded case rate is used to measure the sensitivity of measles surveillance.

§§§ Countries not reporting in 2013 were Cuba (AMR); Bahrain, Libya, and the United Arab Emirates (EMR); Austria, Bosnia and Herzegovina, Italy, Malta, Monaco, San Marino, and Ukraine (EUR); and Brunei Darussalam, Cook Islands, Fiji, the Marshall Islands, Nauru, Samoa, and Tuvalu (WPR). In 2015, member states not reporting were Mauritius (AFR); El Salvador and the United States of America (AMR); Libya (EMR); Albania, Andorra, Finland, Greece, Monaco, Montenegro, Netherlands, Poland, Portugal, and San Marino (EUR); Indonesia (SEAR); and Cook Islands, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Samoa, Singapore, Tonga, and Tuvalu (WPR). Delays in reporting could affect 2015 data.

TABLE 1. Measles supplementary immunization activities (SIAs)* and the delivery of other child health interventions, by World Health Organization (WHO) region and country — worldwide, 2015

WHO region/ Country	Age group targeted	Extent of SIA	Children reached in targeted age group		Coverage survey results (%)	Other interventions delivered
			No.	(%) [†]		
African						
Benin	9 m–9 y	N	408,511	102		
Burundi	18–23 m	N	22,650	8		Vitamin A, deworming, micronutrient supplementation
Cameroon	9 m–14 y	N	9,229,739	98		Rubella vaccine
Eritrea	9–59 m	N	350,765	80		
Guinea-Bissau	9–59 m	N	223,673	86		Vitamin A, deworming
Liberia	9–59 m	N	596,545	99		OPV, deworming
Malawi	9–59 m	SN	453,202	104		Vitamin A, deworming
Mali	9 m–14 y	N	9,327,708	112		
Niger	9–59 m	N	3,299,923	96		
Nigeria (2015–2016) [§]	6 m–10 y	SN	24,069,024	100	84	
Sierra Leone	9–59 m	N	1,205,865	97	69	OPV
South Sudan	6 m–15 y	SN	690,951	51		Vitamin A
South Sudan	6–59 m	SN	12,169	119		Vitamin A
Togo	9 m–9 y	SN	820,335	99		
Uganda	6–59 m	N	6,349,182	95		OPV
Zimbabwe	9 m–14 y	N	5,337,029	103		Rubella vaccine, Vitamin A
Americas						
Chile	1–5 y	N	1,023,997	83		Rubella vaccine
Dominican Republic	1–4 y	N	742,792	95		Rubella vaccine
Eastern Mediterranean						
Afghanistan	9–59 m	N	6,191,955	113	92	OPV
Djibouti	9 m–25 y	N	446,612	85		OPV
Egypt	9 m–10 y	N	23,356,156	102		Rubella vaccine
Iran	9 m–15 y	SN	1,804,000	99		Rubella vaccine
Iraq	9 m–5 y	N	4,461,653	94		Rubella vaccine
Pakistan	6 m–10 y	SN	36,511,184	103		
Saudi Arabia	6–18 y	N	Unknown	Unknown		Mumps and Rubella vaccine
Somalia	9 m–9 y	SN	3,518,358	91		Vitamin A
Syria	6–59 m	N	1,619,630	61		Mumps and Rubella vaccine, Vitamin A, Other routine vaccines if missing
United Arab Emirates	1–18 y	N	915,480	69		Mumps and Rubella vaccine
Yemen	6 m–15 y	SN	1,590,462	85		Rubella vaccine, OPV
European						
Azerbaijan	Adults	N	10,642	Unknown		Rubella vaccine
Georgia	2–30 y	N	23,417	13		Mumps and Rubella vaccine
Kazakhstan	15–19 y	N	851,484	97		
South-East Asia						
India	9 m–15 y	SN	890,070	Unknown		
Myanmar	9 m–14 y	N	13,160,764	94		Rubella vaccine
Nepal	6 m–5 y	SN	453,665	91		Rubella vaccine, OPV
Thailand	30 m–7 y	N	2,244,906	88		Rubella vaccine
Timor-Leste	6 m–15 y	N	484,850	97	95	Rubella vaccine, OPV

See table footnotes on next page.

TABLE 1. (Continued) Measles supplementary immunization activities (SIAs)* and the delivery of other child health interventions, by World Health Organization (WHO) region and country — worldwide, 2015

WHO region/ Country	Age group targeted	Extent of SIA	Children reached in targeted age group		Coverage survey results (%)	Other interventions delivered
			No.	(%) [†]		
Western Pacific						
Malaysia	6 m–16 y	SN	21,518	90		Mumps and Rubella vaccine
Mongolia	6 m–6 y	N	347,685	94		Vitamin A
Papua New Guinea	9 m–14 y	SN	801,436	62		Rubella vaccine, OPV, IPV, Vitamin A, deworming
Vanuatu	1–15 y	N	103,676	103		Rubella vaccine, OPV, Vitamin A, deworming
Vietnam (2014–2015) [§]	1–14 y	N	19,740,181	98		Rubella vaccine
Total			183,713,844			

Abbreviations: IPV = inactivated poliovirus vaccine; m = months; N = national; OPV = oral poliovirus vaccine; SIA = supplementary immunization activity; SN = subnational; y = years. * SIAs generally are carried out using two approaches: 1) An initial, nationwide catch-up SIA targets all children aged 9 months to 14 years; it has the goal of eliminating susceptibility to measles in the general population. Periodic follow-up SIAs then target all children born since the last SIA. 2) Follow-up SIAs are generally conducted nationwide every 2–4 years and generally target children aged 9–59 months; their goal is to eliminate any measles susceptibility that has developed in recent birth cohorts and to protect children who did not respond to the first measles vaccination. The exact age range for follow-up SIAs depends on the age-specific incidence of measles, coverage with 1 dose of measles-containing vaccine, and the time since the last SIA.

[†] Values >100% indicate that the intervention reached more persons than the estimated target population.

[§] Rollover national campaigns started the previous year or will continue into the next year.

to 58% (98 of 168) in 2014, and to 65% (109 of 169) in 2015. During 2000–2015, the Region of the Americas (AMR) maintained measles incidence of <5 cases per 1 million.

From 2014 to 2015, the number of reported measles cases increased 33% in the African Region (AFR), 18% in the Eastern Mediterranean Region (EMR), and 83% in the European Region (EUR), primarily because of outbreaks in several countries. There was minimal change in reported cases in the South-East Asia Region (SEAR), and reported cases decreased 78% in AMR, with interruption of outbreaks in Brazil, Canada, and the United States. In the Western Pacific Region (WPR), reported measles cases declined 50%, with decreases in the three most populous countries in the region: China, the Philippines, and Vietnam (Table 2).

Genotypes of viruses isolated from measles cases were reported by 80 (51%) of the 157 countries that reported measles cases in 2015. Among the 24 recognized measles virus genotypes, 11 were detected during 2005–2008, eight during 2009–2014, and six during 2015, excluding those from vaccine reactions and cases of subacute sclerosing panencephalitis, a fatal progressive neurologic disorder caused by persistent measles infection.^{¶¶¶}

^{¶¶¶} Griffin DE. Measles virus and the nervous system. *Handb Clin Neurol* 2014;123:577–90. <http://dx.doi.org/10.1016/B978-0-444-53488-0.00027-4>.

(4). In 2015, among 8,076 reported measles virus sequences,^{****} 847 (from 48 countries) were genotype B3; 70 (10 countries) were D4; 1,801 (52 countries) were D8; 76 (10 countries) were D9; one was G3; and 5,281 (20 countries) were H1 (Table 1).

Disease and Mortality Estimates

A previously described model for estimating measles disease and mortality was updated with new measles vaccination coverage data, case data, and United Nations population estimates for all countries during 2000–2015, enabling a new series of disease and mortality estimates (5,6). According to the updated data, the estimated number of measles cases declined from 32,768,300 (95% confidence interval [CI] = 23,393,300–63,222,700) in 2000 to 9,719,600 (CI = 5,731,800–35,451,000) in 2015. During this period, the number of estimated annual measles deaths decreased 79%, from 651,600 to 134,200 (Table 2). Compared with no measles vaccination, measles vaccination prevented an estimated 20.3 million deaths during 2000–2015 (Figure).

Regional Verification of Measles Elimination

In September 2016, the AMR regional verification commission declared the region free of endemic measles (7). The WPR regional verification commission reclassified Mongolia as having reestablished endemic measles virus transmission because of an outbreak that lasted for >1 year; thus, five WPR member states have been verified as having eliminated endemic measles (8). In 2015, the EUR regional verification commission verified measles elimination in 21 countries (9).

Discussion

During 2000–2015, increased coverage worldwide with routine doses of MCV, combined with SIAs, contributed to a 75% decrease in reported measles incidence and a 79% reduction in estimated measles mortality. During this period, measles vaccination prevented an estimated 20.3 million deaths. Moreover, the number of countries with measles incidence <5 per million has increased, although there is a large amount of underreporting. The decreasing number of circulating measles virus genotypes suggests interruption of some chains of transmission. However, despite progress since 2000, the 2015 global control milestones and regional measles elimination goals were not achieved and much effort is needed if elimination in five of six regions is to be achieved by 2020. Countries and immunization partners need to substantially

^{****} Sequences were for the 450 nucleotide carboxy-terminal of the nucleocapsid gene in the measles virus genome. Data (as of September 6, 2016) are available from the Measles Nucleotide Surveillance (MeaNS) database, http://www.who-measles.org/Public/Web_Front/main.php.

TABLE 2. Estimates of coverage with the first and second doses of measles-containing vaccine administered through routine immunization services, reported measles cases and incidence, estimated measles deaths,* and reported measles genotypes, by World Health Organization (WHO) region — worldwide, 2000 and 2015

WHO region	Coverage with first dose (%) [†]	Countries with ≥90% coverage (%)	Coverage with second dose (%) [†]	Reported cases (No.) [§]	Incidence ^{§,¶}	% of countries with incidence <5 per 1 million	Reported measles genotypes (2015)**	Estimated no. of deaths (95% CI)	Estimated % mortality reduction from 2000 to 2015
African									
2000	53	9	5	520,102	837	5		414,500 (287,600–650,600)	
2015	74	26	18	98,621	100	52	B3	61,600 (27,600–163,600)	85
Americas									
2000	93	63	44	1,754	2.1	89		NA	
2015	94	83	53	423	0.6	97	B3, D4, D8, D9, H1	NA	
Eastern Mediterranean									
2000	72	57	29	38,592	91	17		67,000 (39,300–114,300)	
2015	76	57	68	21,335	33	40	B3, D8, D9	15,900 (8,400–57,500)	76
European									
2000	91	58	48	37,421	50	45		400 (100–1,900)	
2015	94	81	89	25,947	31	70	B3, D4, D8, D9, H1	80 (4–1,500)	79
South-East Asia									
2000	63	27	3	78,558	51	0		159,200 (117,700–212,700)	
2015	85	46	71	29,109	17	45	B3, D4, D8, D9, G3, H1	54,500 (37,500–85,000)	66
South-East Asia (excluding India)									
2000	78	30	9	39,723	80	0		59,200 (36,200–91,900)	
2015	80	50	78	3,621	10	56	B3, D4, D8, D9, G3, H1	5,300 (2,100–19,600)	91
India									
2000	56	NA	0	38,835	36	0		100,000 (81,500–120,800)	
2015	87	NA	69	25,488	19	0	D4, D8	49,200 (35,400–65,500)	51
Western Pacific									
2000	85	44	2	177,052	105	30		10,600 (5,200–55,000)	
2015	96	67	93	65,176	35	59	B3, D4, D8, D9, H1	2,100 (800–46,000)	80
Total									
2000	72	43	15	853,479	146	38		651,600 (449,900–1,034,500)	
2015	85	61	61	245,928	36	65		134,200 (74,400–353,600)	79

Abbreviations: CI = confidence interval; NA = not applicable; WHO=World Health Organization.

* Mortality estimates for 2000 might be different from previous reports. When the model used to generate estimated measles deaths is rerun each year using the new WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) data, as well as updated surveillance data, adjusted results for each year, including the baseline year, are also produced and updated.

[†] Coverage data: WUENIC. Geneva, World Health Organization, 2015 (as of July 15, 2016). http://www.who.int/immunization/monitoring_surveillance/data/en.

[§] Reported case data: measles cases (2015) from World Health Organization, 2015 (as of July 15, 2016); http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tsincidence measles.html. Reported cases are a sizeable underestimate of the actual number of cases, accounting for the inconsistency between reported cases and estimated deaths.

[¶] Cases per 1 million population; population data from United Nations, Department of Economic and Social Affairs, Population Division (2015). Any country not reporting data on measles cases for that year was removed from both the numerator and denominator.

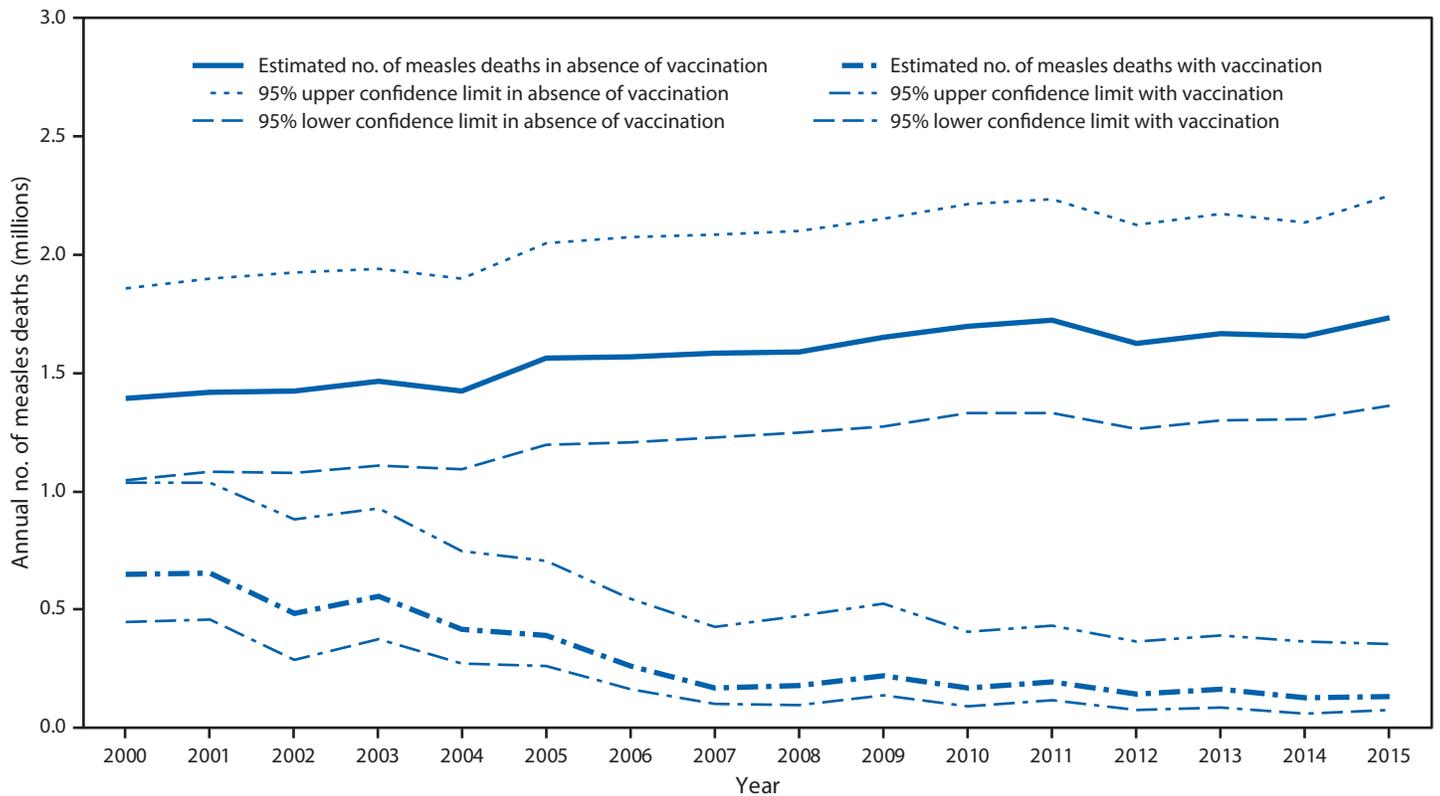
** Data for calendar year 2015, as reported to the Measles Nucleotide Surveillance (MeaNS) database; http://www.who-measles.org/Public/Web_Front/main.php.

increase their commitment for additional financial and human resources to 1) enable public education on the importance of vaccination; 2) strengthen health systems with staff, outreach services, and access to reliable vaccine supply to deliver 2 doses of measles vaccine; 3) improve surveillance; and 4) invest in research and innovations to overcome hurdles to achieving high vaccination coverage.

The 2015 global control milestones and regional measles elimination goals were not met because vaccination coverage gaps persist. Globally, MCV1 coverage has stagnated at 84%–85% since 2009 and MCV2 coverage only reached 61% in 2015. SIA quality was inadequate to achieve ≥95% coverage

in the majority of countries. Furthermore, the discrepancy between high SIA coverage reported by administrative methods and lower coverage found by a limited number of post-SIA coverage surveys indicates that SIA quality might also be inadequate in countries with high reported administrative coverage. Countries need to allocate more time for early planning and preparation for high-quality immunization campaigns, with careful assessment of pre-SIA readiness, well-conducted intra-campaign and postcampaign monitoring, and proper implementation of appropriately budgeted activities to vaccinate persons missed during the SIA.

FIGURE. Estimated annual number of measles deaths with vaccination and had there been no vaccination — worldwide, 2000–2015*



* Compared with no measles vaccination, measles vaccination prevented an estimated cumulative total of 20.3 million deaths during 2000–2015.

The findings in this report are subject to at least three limitations. First, SIA coverage data might be biased by inaccurate reports of the number of doses delivered, doses administered to children outside the target age group, and inaccurate estimates of the target population size. Second, there are large differences between the estimated and reported incidence, indicating variable surveillance sensitivity, making comparisons difficult; in addition, not all ill persons seek care. Finally, misclassification might occur for reported cases that are not laboratory-confirmed or in countries that report aggregate numbers of unconfirmed cases rather than case-based data for confirmed cases.

The decrease in measles mortality is one of four main contributors (the others are decrease in mortality from diarrhea, malaria, and pneumonia) to the decline in overall child mortality worldwide and progress toward Millennium Development Goal 4, but continued work is needed to help achieve regional elimination (10). Of serious concern is the possibility that the gains made so far and future progress in measles control and elimination could be threatened if polio-funded resources that support routine immunization services, measles SIAs, and measles surveillance activities diminish or disappear following polio eradication. Those countries with the highest measles

Summary

What is already known about this topic?

During 2000–2010, global vaccination coverage with the first dose of measles-containing vaccine (MCV1) increased from 72% to 85%, and annual measles incidence decreased from 146 reported cases per 1 million population to 50 cases per 1 million.

What is added by this report?

During 2000–2015, an estimated 20.3 million deaths were prevented by measles vaccination, and measles incidence decreased 75%, from 146 to 36 cases per 1 million population. The number of countries providing the second dose of measles-containing vaccine (MCV2) nationally through routine immunization services increased to 160 (82%) in 2015, and global MCV2 coverage was 61%. In 2015, a total of 184 million persons were vaccinated against measles during supplementary immunization activities. Although measles vaccination has saved millions of lives since 2000, data indicate that the progress toward elimination goals has slowed since 2010.

What are the implications for public health practice?

Reaching measles control and elimination goals will require addressing policy and practice gaps that prevent reaching larger numbers of children with measles vaccination, increasing visibility of measles elimination efforts, assuring funding as polio funding decreases, and ensuring adequate resources for strengthening health systems.

mortality rely most heavily on polio-funded resources and are at highest risk if these resources are not transitioned to adequately support other parts of the immunization program after polio eradication is achieved. Countries and partners need to act urgently to secure political commitment, raise the visibility of measles, increase vaccination coverage, strengthen surveillance, and mitigate the threat of resources for immunization programs decreasing once polio eradication is achieved.

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