Global reductions in measles mortality 2000–2008 and the risk of measles resurgence

Measles is one of the most contagious human diseases. In 1980 before the use of measles vaccine was widespread, there were an estimated 2.6 million deaths from measles worldwide. The aim of Millennium Development Goal 4 is to reduce deaths among children overall by two thirds by 2015 compared with the level in 1990. Recognizing the potential of measles vaccination to reduce mortality among children and that measles vaccination coverage may be considered a marker of access to children’s health services, routine measles vaccination coverage was selected as an indicator of progress towards this goal. At the Sixty-first World Health Assembly in 2008, all Member States reaffirmed their commitment to achieving a 90% reduction in measles mortality by 2010 compared with 2000.

The WHO–UNICEF accelerated strategy for reducing measles mortality focuses on 47 priority countries where the burden of measles is highest. The strategy aims to (i) achieve and maintain high coverage (≥90% nationally and ≥80% in each district) of 2 doses of measles-containing vaccine (MCV) delivered either through routine services or supplementary immunization activities (SIAs), (ii) implement effective laboratory-supported disease surveillance, and (iii) provide appropriate clinical management for measles cases. This report updates previously published reports, provides details on activities undertaken to reduce measles mortality during 2008, and evaluates the potential impact of decreased political and financial commitments on the global reduction of measles mortality. During 2000–2008 global mortality attributed


7 SIAs are generally carried out using 2 approaches. 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. Follow-up SIAs are generally conducted nationwide every 2–4 years and 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.

to measles declined by 78%, from an estimated 733,000 deaths in 2000 to 164,000 in 2008, but the reduction in measles mortality began to level off after 2007. Furthermore, a considerable decline in funding for measles-control activities since 2008 may result in a resurgence in deaths from measles globally and slow progress towards achieving Millennium Development Goal 4.

**Immunization activities**

WHO and UNICEF estimate routine coverage of the first dose of MCV (MCV1) among children aged 1 year using data from administrative records and surveys. Coverage levels achieved during measles SIAs are estimated using the reported number of doses administered and dividing this by the target population.

According to these estimates, global routine coverage of MCV1 increased to 83% in 2008, up 1% from 2007. Coverage varied substantially by geographical region (Table 1), with coverage during 2008 in WHO’s African Region and the South-East Asia Region still <80%. Of the 22.7 million infants and young children in 2008 who missed receiving MCV1 through routine immunization services, 58% reside in 6 large countries: India (7.63 million children missed), Nigeria (2.04 million missed), China (1.1 million missed), Democratic Republic of the Congo (0.84 million missed), Pakistan (0.75 million missed) and Ethiopia (0.74 million missed).

During 2000–2008, a second opportunity for measles immunization was provided in 46/47 priority countries (with the exception of India), leading to vaccination of approximately 686 million children aged 9 months to 14 years through SIAs. In 2008, 16 (34%) of these countries conducted SIAs that reached nearly 109 million children, and in 13 countries measles SIAs were combined with at least 1 other intervention used to improve child survival (Table 2).

**Surveillance activities**

Effective surveillance for measles entails establishing case-based surveillance that includes investigating all patients who are suspected of having measles and testing samples from the first 5–10 patients in each outbreak as well as testing samples from all patients who meet the case-definition for measles but who are not part of a laboratory-confirmed outbreak. In 2008, 173/193 (90%) WHO Member States had implemented case-based surveillance compared with 120 (62%) Member States in 2004 (data prior to 2004 are not available). The WHO measles and rubella laboratory network provided standardized quality-controlled measles and rubella testing for 183 Member States (95%) in 2008 compared with 71 (37%) in 2000.

In 2008, 180 Member States (94%) reported measles surveillance data to WHO and UNICEF through the annual Joint Reporting Form compared with 169 countries (88%) reporting in 2000. Worldwide, the number of reported measles cases declined by 67%, from 852,937 in 2000 to 278,358 in 2008. All WHO regions reported a decrease in measles cases; the highest percentage reductions occurred in the Region of the

---


Americas\textsuperscript{11} (99.9\% reduction) and the African Region (93\%); the smallest reduction occurred in the South-East Asia Region (3.6\%). However, a number of countries experienced large outbreaks during 2008, including the Democratic Republic of the Congo (12 461 reported cases), Nigeria (9960), Ethiopia (3511) and Niger (1317).

**Mortality estimates for 2008**

Despite the global progress made in measles surveillance and reporting, accurate reported numbers of measles deaths are lacking for many countries, particularly those where the burden is highest. To estimate measles mortality, WHO used a published natural history model,\textsuperscript{12} updated with the most recent time-series of population data,\textsuperscript{13} WHO–UNICEF estimates of routine immunization coverage and reported coverage of SIAs, as well as measles incidence as reported to WHO.\textsuperscript{14} This process produced the 2008 mortality estimates and also updated the estimates from 2000–2007.

Global mortality attributed to measles was reduced by 78\% between 2000 and 2008, from an estimated 733 000 deaths to 164 000 deaths, but the decline levelled off during 2006–2008 (Table 1, Fig. 1). The estimated percentage reduction in measles mortality for each region reached the 90\% target in the African Region, accounting for 60\% of the global reduction; in the Eastern Mediterranean Region, accounting for 17\% of the global reduction; and in the Western Pacific Region, accounting for 4\% of the global reduction. Measles mortality was reduced in the South-East Asia Region by 46\% during this period, accounting for 19\% of the global reduction. The Region of the Americas and the European Region had already reduced measles mortality to low levels by 2000. In 2008, the South-East Asia region accounted for 77\% of the total estimated number of measles deaths globally.

Cumulatively, approximately 12.7 million measles deaths were averted during 2000-2008 as a result of immunization activities; of these an estimated 8.4 million (66\%) deaths were averted by maintaining routine immunization coverage at the 2000 level and an additional 4.3 million (33\%) estimated deaths were averted as a result of increases in routine immunization coverage since 2000 and implementation of measles SIAs.

**Global mortality projections, 2009–2013**

\textsuperscript{11} The Region of the Americas interrupted endogenous measles transmission in November 2002, and cases reported since 2002 are either imported or linked to importation.


\textsuperscript{14} In 2008, the Quantitative Immunization and Vaccines-Related Research Advisory Committee recommended refinements to the natural history model to take into account measles transmission dynamics, incorporate surveillance data and account for herd immunity. In 2010, WHO’s Department of Immunization, Vaccines and Biologicals plans to use this next-generation model to revise the time-series estimates of global measles mortality for 2000–2009, taking into account additional information on deaths in India.
Concerns have been raised about the possible impact of a decline in funding for measles-control activities that has occurred since 2008. Financial support to the Measles Initiative has decreased from US$ 150 million in 2007 to slightly more than US$ 50 million in 2009 (Measles Initiative, unpublished data, 2009). In addition, many priority countries have not been able to raise the expected 50% of operational costs for SIAs.

To evaluate the impact of inadequate resources, the natural history model was used to project global measles mortality for the period 2009–2013 for 2 scenarios. The worst-case scenario assumed that routine MCV1 coverage in the 47 priority countries remained at 2008 levels during 2009–2013 and that none of these countries carried out nationwide SIAs during 2010–2013. The status quo scenario assumed that routine MCV1 coverage increased 1% per year among priority countries, with <90% coverage in 2008, and that SIAs are conducted during 2010–2013 in 46/47 priority countries. India was excluded from the second scenario because of uncertainty about the timing and extent of implementation of recommendations for delivering a second dose. Both scenarios assume that all non-priority countries continue to increase routine coverage of MCV1 at current rates and conduct regular high-quality SIAs as required.

Results from these projections suggest that if the 47 priority countries are unable to maintain current recommended strategies during 2010–2013, the annual number of measles deaths may rebound, resulting in approximately 1.7 million measles-related deaths, with >500 000 deaths in 2013 alone (Fig. 1). If the priority countries (excluding India) implement high-quality SIAs and continue to increase routine coverage of MCV1, projected global mortality during 2010–2013 may remain at 2008 levels, resulting in approximately 0.6 million measles-related deaths (Fig. 1).

Editorial note. Following a period of rapid progress in reducing global mortality from measles during 2000–2006, the reduction in mortality has levelled off since 2007. An estimated three quarters of the remaining measles deaths are concentrated in only 1 region: the South-East Asia Region. Further progress towards reaching the goal of reducing mortality by 90% is curtailed by 2 key factors: (i) the strategy for accelerating the reduction of measles mortality has not been implemented in India and (ii) political and financial commitments to measles control in many of the remaining 46 countries with the highest burden has been declining.

Efforts to reduce deaths from measles since 2000 have contributed substantially to the overall reduction in child mortality. From 2000 to 2008, child mortality decreased by 1.6 million, from an estimated 10.4 million to 8.8 million deaths; during the same period measles deaths declined by over 0.5 million suggesting that the decline in measles has played a part in the overall decline in child mortality. The projections of a

16 Partners in the Measles Initiative include the American Red Cross, the United States Centers for Disease Control and Prevention, the United Nations Foundation, UNICEF and WHO. Key principles of the partnership include building strong ownership and commitment to measles control in countries, appreciating the specific role each partner can play, and recognizing contributions from all partners.
resurgence in the global burden of measles mortality (that is, 1.1 million additional measles deaths during the next 4 years) made under a worst-case scenario, quantify concerns about the inability of many countries with a high burden to continue supporting improvements in routine immunization, regular measles SIAs and laboratory-supported surveillance. If the strategy to accelerate reductions in measles mortality cannot be sustained, global measles mortality will increase, resulting in a slowing down of progress towards reaching Millennium Development Goal 4.

Several limitations should be considered when interpreting the measles mortality burden estimates and projections presented in this report. The natural history model used by WHO keeps age-specific measles case-fatality ratios (CFRs) constant, and mortality estimates are primarily determined by changes in the size of the birth cohort and coverage of measles vaccination over time. Measles CFRs are known to differ significantly within populations over time. Multiple factors have been associated with increased measles CFRs, including low socioeconomic status, malnutrition, vitamin A deficiency, HIV infection, young age at infection and lack of measles immunization. Increased coverage of measles vaccination is thought to be the major factor contributing to declines in overall measles CFRs. As measles vaccination coverage increases, the average age of infection rises and a larger proportion of measles cases occur among previously vaccinated children. Although vitamin A deficiency is a known risk factor for measles mortality, access to vitamin A treatment has been found to be low in a number of studies.

Routine immunization is a cornerstone of the WHO–UNICEF recommended strategy, and increasing routine coverage of MCV must be made a priority in order to achieve and sustain the global goal. Experience from 46/47 priority countries indicates that a 90% reduction in global measles mortality can be achieved and sustained if the strategy is fully implemented. Key factors related to a possible delay in achieving a 90% reduction beyond 2010 and the risk of a measles resurgence include delayed implementation of catch-up SIAs in India and suboptimal coverage of routine MCV1 and SIAs, particularly in the African Region. Without implementation in India of the recommended strategies to reduce measles mortality, the global goal of reducing this mortality by 90% cannot be met.

High level advocacy is critical to ensure that immunization and measles control are given priority on national agendas and that political commitment is sustained. In addition, increased funding from donors could help improve coverage of routine MCV, implement high-quality SIAs and link measles immunization and surveillance activities with other efforts to improve children’s survival and strengthen health systems.

---


### Table 1  Coverage of the first-dose of measles-containing vaccine administered through routine immunization services among children aged 1 year,\(^a\) and estimated number of deaths from measles, by WHO region, 2000 and 2008\(^b\)

<table>
<thead>
<tr>
<th>WHO region</th>
<th>% coverage with first-dose of measles-containing vaccine</th>
<th>Estimated number of measles deaths (uncertainty bounds)(^c)</th>
<th>% coverage with first-dose of measles-containing vaccine</th>
<th>Estimated number of measles deaths (uncertainty bounds)(^c)</th>
<th>Decrease in measles deaths 2000–2008</th>
<th>Number (%)</th>
<th>% of estimated global decrease in measles deaths attributable to region or priority countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td>56</td>
<td>371 000 (270 000–483 000)</td>
<td>73</td>
<td>28 000 (19 000–40 000)</td>
<td>343 000 (92)</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Americas</td>
<td>92</td>
<td>&lt;1000(^d) (93)</td>
<td>93</td>
<td>&lt;1000(^d) (83)</td>
<td>94 000 (93)</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td>72</td>
<td>101 000 (75 000–131 000)</td>
<td>83</td>
<td>7 000 (5 000–10 000)</td>
<td>94 000 (93)</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>91</td>
<td>&lt;1000(^d) (94)</td>
<td>94</td>
<td>&lt;1000(^d) (94)</td>
<td>94 000 (93)</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>South-East Asia</td>
<td>61</td>
<td>234 000 (169 000–309 000)</td>
<td>75</td>
<td>126 000 (90 000–168 000)</td>
<td>108 000 (46)</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Western Pacific</td>
<td>85</td>
<td>25 000 (17 000–35 000)</td>
<td>93</td>
<td>2 000 (1 000–4 000)</td>
<td>23 000 (92)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td>733 000 (530 000–959 000)</td>
<td>83</td>
<td>164 000 (115 000–222 000)</td>
<td>569 000 (78)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>47 priority countries</td>
<td>58</td>
<td>709 000 (517 000–925 000)</td>
<td>74</td>
<td>160 000(^e) (112 000–215 000)</td>
<td>549 000 (81)</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>


\(^b\) Coverage of routine first-dose vaccination and second-opportunity coverage for measles vaccine are the biggest contributors to decreases in estimated deaths.

\(^c\) Uncertainty bounds are based on Monte Carlo simulations that account for uncertainty in key input variables (that is, vaccination coverage and case-fatality rates).

\(^d\) The static natural history model is not sufficiently precise at low incidence levels.

\(^e\) Numbers and percentages in tables do not necessarily add to totals due to rounding.
Table 2 Measles supplementary immunization activities undertaken among the 47 WHO–UNICEF priority countries, 2008

<table>
<thead>
<tr>
<th>WHO region and country</th>
<th>Age group</th>
<th>Extent of supplementary immunization activities</th>
<th>No. of children reached</th>
<th>% of targeted children reached</th>
<th>Oral polio vaccine</th>
<th>Vitamin A</th>
<th>Insecticide-treated bednets</th>
<th>De-worming medication</th>
<th>Tetanus toxoid vaccination</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benin</td>
<td>9–59 months</td>
<td>National</td>
<td>1,272,621</td>
<td>102</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>9–59 months</td>
<td>National</td>
<td>683,302</td>
<td>102</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>9–59 months</td>
<td>National</td>
<td>3,082,438</td>
<td>95</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Democratic Republic of the Congo</td>
<td>9–59 months</td>
<td>Rollover national</td>
<td>2,811,092</td>
<td>99</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>6–59 months</td>
<td>National</td>
<td>10,848,474</td>
<td>92</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mozambique</td>
<td>9–59 months</td>
<td>National</td>
<td>3,342,280</td>
<td>103</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Niger</td>
<td>9–59 months</td>
<td>National</td>
<td>2,942,498</td>
<td>100</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nigeria</td>
<td>9–59 months</td>
<td>National</td>
<td>28,363,479</td>
<td>112</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Togo</td>
<td>9–59 months</td>
<td>National</td>
<td>906,692</td>
<td>98</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>United Republic of Tanzania</td>
<td>6 months–10 years</td>
<td>National</td>
<td>10,826,519</td>
<td>86</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Djibouti</td>
<td>9 months–15 years</td>
<td>National</td>
<td>184,638</td>
<td>86</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Pakistan</td>
<td>9 months–13 years</td>
<td>Rollover national</td>
<td>35,315,375</td>
<td>103</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sudan</td>
<td>9–59 months</td>
<td>Rollover national</td>
<td>3,021,141</td>
<td>96</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>South-East Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>9 months–5 years</td>
<td>National</td>
<td>909,421</td>
<td>94</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>9 months–5 years</td>
<td>National</td>
<td>2,724,856</td>
<td>93</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Western Pacific</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>6–83 months</td>
<td>National</td>
<td>945 582</td>
<td>84</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viet Nam</td>
<td>7–20 years</td>
<td>Subnational</td>
<td>1 008 690</td>
<td>97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>109 189 098</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a “✓” denotes that an intervention was delivered.*

*b Values >100% indicate that the intervention reached more people than the estimated target population.*

*c Anti-helminthics were used for de-worming. Tetanus toxoid vaccinations were delivered to women of childbearing age. Other interventions were distributed according to national plans and in some cases targeted only high-risk districts or age groups, or both.*

*d Rollover national campaigns started the previous year or will continue into the next year.*
Fig. 1 Estimated number of measles deaths worldwide, 2000–2008\textsuperscript{a} and projections of possible resurgence in measles deaths worldwide, 2009–2013 (See text for description of worst-case and status quo scenarios and the 47 priority countries)

\begin{center}
\begin{tabular}{|c|c|c|c|}
\hline
Year & \textbf{No. of deaths} & \textbf{Estimates}\textsuperscript{*} & \textbf{Projected worst case}\textsuperscript{†} & \textbf{Projected status quo}\textsuperscript{†} \\
\hline
2000 & 800,000 & 750,000 & 700,000 & 650,000 \\
2001 & 700,000 & 650,000 & 600,000 & 550,000 \\
2002 & 600,000 & 550,000 & 500,000 & 450,000 \\
2003 & 500,000 & 450,000 & 400,000 & 350,000 \\
2004 & 400,000 & 350,000 & 300,000 & 250,000 \\
2005 & 300,000 & 250,000 & 200,000 & 150,000 \\
2006 & 200,000 & 150,000 & 100,000 & 50,000 \\
2007 & 100,000 & 50,000 & 0 & 0 \\
2008 & 0 & 0 & 0 & 0 \\
2009 & 0 & 0 & 0 & 0 \\
2010 & 0 & 0 & 0 & 0 \\
2011 & 0 & 0 & 0 & 0 \\
2012 & 0 & 0 & 0 & 0 \\
2013 & 0 & 0 & 0 & 0 \\
\hline
\end{tabular}
\end{center}

Source: WHO.

\textsuperscript{a} Lines indicate 95\% uncertainty intervals based on Monte Carlo stimulations that account for uncertainty in key input variables (that is, vaccination coverage and case-fatality ratios).