Comparing Measles With Previous Eradication Programs: Enabling and Constraining Factors

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Background. Five major disease eradication initiatives were initiated during the second half of the 20th century. The enabling and constraining factors—political, social, economic, and other—for these previous and current eradication programs can inform decision making regarding a proposed measles eradication initiative.

Methods. We reviewed the literature on the yaws, malaria, smallpox, guinea worm, and polio eradication programs and compared enabling and constraining factors for each of these programs with the same factors as they relate to a possible measles eradication initiative.

Results. A potential measles eradication program would enjoy distinct advantages in comparison with earlier eradication programs, including strong political and societal support, economic analyses demonstrating a high level of cost-effectiveness, and a rigorous upfront process, compared with previous eradication initiatives, that has validated the feasibility of achieving measles eradication. However, increasing population density, urbanization, and wars/civil conflicts will pose serious challenges.

Conclusions. Measles eradication will be very challenging but probably not as difficult to achieve as polio eradication. Measles eradication should be undertaken only if the commitments and resources will be adequate to meet the political, social, economic, and technical challenges.

More than 22 years have passed since the launching of the polio eradication initiative by the World Health Assembly (WHA) in 1988, the last of 5 global eradication activities initiated in the second half of the 20th century. Given that only 1 of these disease eradication programs has been completed successfully (smallpox), serious consideration of a global measles eradication initiative merits a comparison of the enabling and constraining political, social, economic, and technical factors involved in measles eradication with those of the previous and current eradication programs. This analysis may be helpful to decision-makers weighing the evidence for or against the establishment of a measles eradication initiative. Also, it may illuminate opportunities to build on factors that facilitate success and to mitigate factors that might threaten success if a global measles eradication initiative is launched at a future date.

The malaria, smallpox, and polio eradication initiatives were formally launched by the World Health Assembly in 1955, 1959, and 1988, respectively [1, 2] (Table 1). The yaws eradication program also had its formal beginning in 1955 at the Second International Conference on the Control of Yaws, although it was never formally launched as an eradication initiative by the World Health Organization (WHO) (ie, no WHA resolution was ever passed) [3, 4]. In 1986, the WHA resolved to eliminate Guinea worm (dracunculiasis) and passed a resolution for eradication in 1991 [5]. Other large public health programs launched in the twentieth century and continuing today, including programs to eliminate neonatal tetanus and tuberculosis, do not have eradication as the objective and are not considered in this paper.
We reviewed the literature on the yaws, malaria, smallpox, guinea worm, and polio eradication programs and compared enabling and constraining factors for each of the prior eradication programs with the same factors that might facilitate or hinder global measles eradication in 2010. These programs were selected because they were the only global disease eradication programs initiated during the second half of the twentieth century. These programs meet the definition of eradication established by the International Task Force for Disease Eradication in 1997 [6].

From the literature, we developed a list of political, social, economic, and technical factors perceived to be important in considering the feasibility of candidate diseases for eradication and, ultimately, for the success of the program. We focused our analysis on the following specific factors:

**Political factors.** These include wars and armed conflicts affecting endemic areas, population displacement or migration to or from endemic areas, and endemic country political support for eradication.

**Social factors.** These include the perception of disease burden and risk, motivation and/or acceptance of intervention, competition from other health programs and disease control/elimination/eradication initiatives, social and/or economic inequality, and level of information and communications technology.

**Economic factors.** These include the cost of eradication activities, cost-effectiveness and potential cost savings, ability and willingness of endemic governments to self-fund, and funds potentially available from governmental and nongovernmental donors.

**Other key factors.** Such factors as the level of disease control already achieved at the outset of an eradication effort (number of cases or endemic countries) and changes in population density are addressed. In addition, strong health systems were identified as a key factor in enabling disease eradication. Disease eradication is facilitated in countries that have a functioning network of urban and rural health clinics staffed by trained health workers, effective administrative systems, and adequate supplies.

Effective management at global, regional, and national levels was also identified as a key factor in the success of eradication programs. Disease eradication is facilitated when clear and measurable objectives are established, appropriate strategies are developed and modified, qualified and dedicated staff are deployed and held accountable, and when adequate resources are made available.

Technical factors for measles, such as the properties of the agent (infectiousness, duration of infectious period, genetic stability, and host preference and/or reservoirs), surveillance factors, and the quality of intervention tools, are discussed elsewhere [7].

### RESULTS AND ANALYSIS

#### Political Factors

Wars and armed conflicts have an adverse effect on disease control and eradication, causing displacement of populations,
reduced access to health facilities, and reduced priority and funding [8]. Politically stable governments with strong central and peripheral health systems have more success with eradication than do governments in which control is weak or fragmented [9, 10].

The 1950s, when the yaws, malaria, and smallpox programs were launched, was a period of relative global tranquillity. The Korean War ended in 1953 and the First Indochina War in 1954; the few remaining conflicts were comparatively small and caused relatively little displacement of populations. The onset of the civil war in Sudan in 1955 would cause the greatest adverse effect on eradication initiatives among the wars from this era.

The 1980s, when the polio and Guinea worm eradication programs were launched, was a more violent era than the 1950s, with conflicts in Afghanistan, Angola, El Salvador, Eritrea, Ethiopia, Iran, Iraq, Lebanon, Liberia, Peru, Uganda, Somalia, and Sudan. The conflict in southern Sudan has delayed the eradication of Guinea worm and polio, and the war in Afghanistan has delayed polio eradication in both Afghanistan and Pakistan.

A measles eradication initiative would likely be at a disadvantage from a political and/or security perspective. Wars are ongoing in Afghanistan, Pakistan, Iraq, and Somalia, with smaller conflicts continuing in southern Sudan, Chad, DR Congo, and other countries. Terrorism and threats of terrorism in the contemporary era, rare events in the 1950s and 1980s, pose a challenge to the success of eradication programs and raise costs substantially.

Population displacement and migration may result from armed conflicts or natural disasters or in response to economic or social conditions, often resulting in cross-border disease transmission. Population displacement was a challenge for the smallpox program, especially in Bangladesh, India, Ethiopia, Nigeria, and Somalia. The global polio eradication initiative (GPEI) has also faced such challenges in Afghanistan, Pakistan, China, and various countries in Africa. In addition, the GPEI has been affected by the cross-border transmission of polio associated with annual pilgrimages to Saudi Arabia by religious travelers. The yaws and Guinea worm programs have been comparatively less affected by population displacement because of both the smaller size of the populations among which the disease is endemic and the rural foci of disease.

A measles eradication initiative would also face challenges from population displacement and migration. Currently, there are large displaced populations in Pakistan and economic migrants in China, India, and numerous other countries. The United Nations has predicted that migration will increase in the future as a result of climate changes, including changes in sea level [11]. As a result of exponential increases in air travel for tourism and business, the measles program may face greater challenges than did eradication programs launched earlier.

In terms of endemic country support, the smallpox, Guinea worm, and polio eradication programs had limited progress in their early years as a result of shortages of political commitment and funding. The yaws program never enjoyed the support of a WHA resolution, and the malaria program was never fully operational in many countries of Africa in which malaria is endemic. Although the malaria and polio programs enjoyed the greatest overall political support at their inception, much of this was generated by donor countries. Support for smallpox eradication was weak at the time of the first WHA resolution in 1959.

A measles eradication initiative may benefit from the comparatively exhaustive and unprecedented process being undertaken to evaluate its feasibility and appropriateness. Furthermore, the member states of 5 of 6 WHO regions have already endorsed regional elimination initiatives with target dates. However, the European Region is unlikely to complete regional measles eradication by 2010, as resolved in 1998, in part because of inadequate political commitment. Various western European governments lack urgency regarding measles elimination, because of perceptions that the disease is not serious [12]. India is just beginning to introduce a second dose of measles vaccine through either the routine immunization system or supplemental immunization activities (SIAs). Countries in the African region have been highly supportive of measles mortality reduction as mortality has plummeted, but progress has slowed, with evidence of resurgence in 2009–2010, partly as a result of waning political and financial support [13]. Competition from the GPEI may continue to hamper the political support that a measles initiative could engender, especially in the remaining polio-endemic countries.

Social Factors
Perceptions that a given disease creates a serious risk may engender political and financial support and higher levels of acceptance of interventions. Cultural and religious beliefs may also affect acceptability of the intervention. Smallpox and malaria were perceived as deadly threats in the endemic countries during the preeradication era, whereas yaws and Guinea worm affected comparatively few people and caused little mortality. Polio, despite the existence of safe and effective vaccines, had an aura of threat and engendered fear in industrialized countries as a result of the large and well-publicized epidemics during the prevaccine era. Despite differing perceptions of threat among the 5 diseases in the preeradication era, there was generally widespread acceptance of their principal interventions. However, the polio program in Nigeria suffered a severe setback in 2003 when organized resistance to polio vaccine and SIAs led to a large outbreak that spread widely internationally [14].

Measles has been a disease of high burden historically, and as recently as 2000, an estimated 733,000 individuals, mainly children, died from complications of measles. However, recent
progress in reducing measles mortality may have reduced the perception of threat. Also, in contrast to polio, which causes paralysis and consequently was more feared, measles seldom causes mortality in developed countries. In western Europe, where deaths from measles are rare, there exist pockets of resistance to immunization, especially measles vaccine, as a result of the efforts of antivaccine groups and highly publicized and unfounded vaccine safety concerns. Despite varying perceptions of threat, measles vaccine is generally well accepted outside Europe, and there has been no widespread rejection of measles vaccine based on safety, religious, or cultural grounds.

Competition from other health programs affects the availability of both qualified staff and funds. In the 1950s and 1960s, there were few large health programs competing with the yaws, malaria, and smallpox eradication initiatives. Routine immunization programs had not been started in most developing countries, and health care systems were weak. In the 1980s, the polio and Guinea worm programs competed with human immunodeficiency virus (HIV)/AIDS and the Expanded Programme on Immunization for political and financial support. Pressure to do more to “strengthen health systems” rather than support targeted disease control programs has been a constant challenge for eradication programs, especially the GPEI.

Measles eradication would face competition for political and financial support from the existing GPEI and the introduction of newer vaccines against diarrhea, pneumonia, and cervical cancer, as well as from the other large, ongoing health initiatives (eg, against HIV/AIDS, malaria, and tuberculosis). Some donors have already expressed a specific interest in building health systems rather than focusing on measles eradication. However, a measles eradication initiative may benefit from efforts to merge with one or more other programs (eg, through campaign-style delivery of multiple interventions, such as bed nets, micronutrients, deworming medicines, and so forth), thus avoiding some of the competition. The existence of combination measles-rubella vaccines creates an effective synergy between prevention of congenital rubella syndrome and measles eradication and raises the possibility of a combined eradication program [15].

Social/economic inequality is associated with less access to health care services by the poor, and sometimes the frustration caused by this inequality is expressed through isolated or coordinated acts of noncompliance with eradication interventions [16]. Although globalization has helped bring many of the poor above the poverty line in India and China, per capita income growth in sub-Saharan Africa actually declined between 1980 and 2000 [17]. Although it is difficult to show a specific cause-and-effect relationship between inequality and resistance in the eradication programs, the malaria program experienced problems with resistance to indoor insecticide spraying. Underlying causes for the 2003 polio outbreak in Nigeria included issues of social and/or economic inequality [18]. It is likely that a measles eradication program would face some of these same kinds of social and economic challenges.

Effective modern communications and information systems, including the internet, email, mobile phones, and personal digital assistants, are enabling factors in eradication programs, allowing a greater degree of efficiency and completeness in disseminating and receiving information and compiling and analyzing surveillance and intervention data. However, the new technology may also enable the voices of dissatisfied “resisters” and the anti-vaccine movement to a much greater degree than was possible during the twentieth century. A measles eradication initiative would greatly benefit from the many recent technological advances, enabling strengthened surveillance, monitoring, evaluation, and information activities.

### Economic Factors

Programs requiring large amounts of funds for extended periods of time risk experiencing funding gaps. Programs that are documented or perceived to be cost-effective are more likely to engender support from endemic countries and donors. Potential cost savings from a reduced level of control activities after eradication may serve as an incentive to governments to support eradication. Self-funding by large endemic countries, especially

<table>
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<tr>
<th>Disease</th>
<th>Funds expended</th>
<th>Reference</th>
<th>Cost-effectiveness and savings</th>
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<tbody>
<tr>
<td>Malaria</td>
<td>$2–3 billion</td>
<td>Jeffery 1976 [25]</td>
<td>Global study not done; some</td>
<td></td>
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<tr>
<td>Guinea worm</td>
<td>$250 million</td>
<td>D. Hopkins, 2010 private</td>
<td>Cost-benefit study done in</td>
<td>Kim et al 1997 [26]</td>
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<tr>
<td>Measles</td>
<td>$5–8 billion (provisional estimate)</td>
<td>To be published in 2011</td>
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China and India, may increase chances of success. The need to raise funds from external sources, such as donor governments and nongovernmental agencies, makes it more likely that funding will be erratic.

The smallpox eradication program is estimated to have cost $300 million from endemic and donor governments combined. The yaws program and the Guinea worm eradication program, at $9 million and $250 million respectively, also cost comparatively small amounts. The malaria program spent an estimated $2–3 billion, both in real dollars. The malaria program is estimated to have cost more than $14 billion in inflation-adjusted dollars (Table 2).

Cost estimates for measles eradication prepared by each region in 2010 total $5 billion globally. Including costs for program implementation by WHO and UNICEF headquarters and accounting for differences by the WHO Regions, we anticipate that measles eradication would cost $5–8 billion. We predict that measles eradication would cost less than the polio and malaria eradication programs (measured in 2010 dollars) but more than the yaws, smallpox, and Guinea worm eradication programs. If the financial crisis of 2007–2010 continues into 2011 and beyond, it will pose substantial challenges to financing a measles eradication initiative.

Cost-Effectiveness and Potential Cost Savings

Despite the obvious benefits of preventing disease and death through eradication, an analysis of costs, cost-effectiveness, and cost savings is considered essential by some decision-makers, although cost savings are more likely to accrue to industrialized countries where health care is comparatively expensive. Most eradication programs were justified primarily on the basis of health and technical issues rather than on economic issues (Table 2). Also, potential financial benefits of vaccine-preventable disease eradication programs have changed substantially, because some countries will continue vaccination after eradication as a result of the perceived threat of bioterrorism.

Two cost-effectiveness analyses of measles eradication conclude that measles eradication is highly cost-effective and is cost saving in countries that have already eliminated measles [19, 20].

### Funding by Governments of Endemic Countries

Funding shortfalls helped cause long delays in progress for the smallpox, Guinea worm, and polio eradication programs. Only 4 countries where Guinea worm is endemic undertook the recommended eradication activities from 1981 through 1990, and the GPEI waited 7 years following the WHA resolution in 1988 before initiating substantial activities in Africa, Europe and the former Soviet Union, the Middle East, and south Asia.

A measles eradication initiative may benefit from substantial funding from endemic countries, especially China and India, the Middle East, and countries of the European Region. However, substantial external funding would be required for countries in Africa, south Asia, and the poorest countries of southeast Asia.

### Funding by Donor Governments and Nongovernmental Agencies

Governments of countries where smallpox was not endemic were motivated during smallpox eradication both on humanitarian grounds and by a desire to stop smallpox vaccination because of vaccine adverse events. The business community and governments of nonendemic countries had an interest in malaria eradication because of the health impact of malaria on international and national staff. The GPEI both was motivated by and benefited from an early commitment of $220 million from Rotary International. Countries in the Americas have an interest in measles eradication so they can stop SIAs and save on outbreak response costs due to disease importation.

Donor funding is difficult to predict in 2011 because of lingering effects of the 2008 financial crisis. However, compared with the 1950s and the 1980s, there now exists a stronger culture of donating to immunization programs. The existing Measles Initiative is well positioned to take advantage of this, especially if the partnership builds on fundraising ideas developed by the GPEI. Continuing support from the Centers for Disease Control and Prevention, the UN Foundation, the American Red Cross, and UNICEF and new support from the Bill and Melinda Gates Foundation suggest that fundraising targets might be achievable through a well-managed measles eradication program.

### Other Key Factors

Eradication is made easier when the disease is endemic in fewer areas, has already been eliminated from large geographic areas,
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DISCUSSION

There is increasing recognition that political, societal, economic, and management issues are at least as important as biological factors in assessing the feasibility of a disease eradication initiative [24]. A potential measles eradication program would enjoy distinct advantages in comparison with earlier eradication programs. Perhaps the most important are as follows:

1. Virtually all countries have indicated strong support for accelerated measles control activities, and 5 of 6 WHO regions are currently engaged in regional measles elimination initiatives, suggesting a strong current of governmental interest.
2. The feasibility of measles eradication is being evaluated more intensively than the feasibility of any of the prior eradication initiatives, with the recent conclusion by a WHO

Table 4. World Population and Urbanization, 1955–2010

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<td>Total, billions</td>
<td>2.80</td>
<td>3.04</td>
<td>3.71</td>
<td>4.45</td>
<td>5.29</td>
<td>6.09</td>
<td>6.85</td>
</tr>
<tr>
<td>Urban, billions (%)</td>
<td>0.75 (27)</td>
<td>0.99 (33)</td>
<td>1.33 (35)</td>
<td>1.74 (40)</td>
<td>2.27 (43)</td>
<td>2.85 (48)</td>
<td>3.49 (51)</td>
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advisory committee “that measles can and should be eradicated,” offering the potential to engender greater support among partners and governments [25].

3. Information and communications technology and laboratory technology are exponentially better than in the 1950s and 1980s.

4. Measles eradication, estimated to cost approximately $5–8 billion, would likely cost less than the GPEI in real dollars, and less than the malaria initiative in inflation-adjusted dollars. The burden of measles and the size of the population in areas where measles is endemic could easily justify an initiative. The cost is affordable given the potential benefits.

The most daunting challenges for global measles eradication include the following:

1. Key measles-endemic countries are at war in 2011, and the world is more heavily armed than ever. Terrorism, both real and perceived, adds to the complexity, and reaching high rates of vaccination coverage in conflict-affected areas will be extremely difficult and dangerous.

2. The highly infectious nature of measles, combined with an increasing global population, greater population density, migration, and urbanization, presents greater challenges in comparison with those faced by 20th century eradication programs.

3. Measles is not perceived as a serious problem in some wealthy and middle-income countries, because the development of effective health services has reduced the mortality rate to low levels. The European Region has not eliminated measles, and although changes appear imminent, India, the country with the largest estimated number of measles cases, has not fully embraced existing measles control and mortality reduction strategies.

4. The resistance of the antivaccination lobby in Europe and elsewhere must be overcome.

5. The technical challenges of measles eradication in India may not be fully understood. It remains unclear what level of vaccination coverage will be required to stop transmission in the large, densely populated states of Uttar Pradesh and Bihar or the level of effort that will be required to achieve it.

6. The coexistence of the polio eradication program and other health initiatives could create an unhealthy competition for political commitment and human and financial resources globally. The successful completion of polio eradication would remove this competition and provide renewed confidence in the potential of vaccines to eradicate disease.

CONCLUSIONS

Measles eradication will be very challenging but probably not as difficult to achieve as polio eradication. Although enormous progress has been made by the Measles Initiative, measles eradication will require an exponential increase in resources and commitment. Measles eradication should be undertaken only if the commitments and resources will be adequate to meet the political, social, economic, and technical challenges.

References


