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The Measles Initiative

Before the discovery of a vaccine in 1963, measles claimed the lives of 8 million children each year. In 1999, nearly 40 years after the introduction of the measles vaccine, 873,000 people, mostly children, died from measles. The disease accounted for more than half of all vaccine-preventable deaths. Between 2000 and 2007, measles deaths fell by 74% worldwide and by 89% in Africa as a result of vaccination campaigns and strengthened routine immunizations in more than 60 countries. The Measles Initiative (MI) – a partnership between the World Health Organization (WHO), United Nations Children's Fund (UNICEF), US Centers for Disease Control and Prevention (CDC), American Red Cross (ARC), and United Nations Foundation (UNF) – catalyzed these results. Since its founding in 2001, the MI directed a global effort that worked with governments and other international agencies to carry out measles vaccination campaigns worldwide.

In 2009 MI leadership, including Edward Hoekstra of UNICEF, Andrea Gay of UNF, Peter Strebel of WHO, Steve Cochi of CDC, and Athalia Christie of ARC, reflected on the Initiative's achievements and considered the challenges ahead. With the focus and funding in global health moving away from "vertical" initiatives like vaccination campaigns and towards "horizontal" efforts to build health systems, the leaders thought about how to position their work amidst this shifting tide. With the once-ubiquitous measles now rarely seen in some countries while still causing epidemics in others, the leaders contemplated strategies to maintain the commitment necessary to prevent resurgence and reach their target of a 90% worldwide reduction in measles deaths (from 2000 levels) by 2010.

Measles

Biology and Epidemiology

Measles is a highly contagious, infectious disease of the respiratory system caused by a *paramyxovirus*. The virus infects the respiratory mucosa and is spread by droplets expelled anytime the person coughs or sneezes. Measles usually is transmitted by direct inhalation of these airborne droplets or when someone touches an infected surface and then places fingers on the mucosa of the mouth or nose. The droplets can

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remain infectious after landing on surfaces for up to two hours. Between 75% and 95% of non-immune persons who are exposed to the virus become infected, and nearly all infected persons develop clinical illness.

Prior to 1963, virtually every person, even in developed countries, contracted measles, usually by the time he or she reached the teens. Measles outbreaks typically occurred every two to five years for three to four months at a time. The disease was first described by the Persian physician Rhazes in the seventh century as a scourge "more dreaded than smallpox."

The virus replicates within the newly infected person for 10 to 14 days before causing a syndrome of high fevers, cough, runny nose, inflammation of the conjunctiva underneath the eyes, low energy, and poor appetite. Four to five days after the onset of these symptoms, "Koplik's spots," bluish-gray marks on a red base, appear on the inside of the mouth. This is usually followed by a classic rash that begins at the head and face and, over the course of five days, travels downward to the feet (see **Exhibit 1** for images). In an uncomplicated case, the illness resolves about a week after the rash begins. The infected person is contagious for the four days before and the four days after the onset of the rash. Like chickenpox, an episode of measles leaves the person with lifelong immunity to future infection.

In up to 40% of cases, measles can cause more serious complications, especially in areas where malnutrition, Vitamin A deficiency, HIV/AIDS, and other conditions that compromise the immune system are common. In the ear and respiratory tract, the measles virus can directly invade the mucosa and depress the local immune response, enabling superimposed bacterial infections to occur unchecked. Pneumonia and other respiratory complications account for 60% of deaths due to measles. In some patients who appear to have recovered from a bout of measles, the virus can cause delayed inflammation of the brain that produces severe headaches, seizures, drowsiness, and, if the person survives, often permanent damage. Other common complications of measles infections include diarrhea and damage to the eyes that can result in blindness. In pregnant women, measles can cause miscarriage or premature delivery and lead to babies being born with low birth weight. Altogether, 1% to 3% of measles cases – but up to 30% in some circumstances – result in death. About 90% of measles deaths occur in children under the age of five.

The diagnosis of measles is made by clinical suspicion based on the presence of typical signs and symptoms including the classic rash and mouth sores. For public health monitoring, suspected cases in epidemic areas are confirmed by laboratory testing of blood samples for antibodies against the virus. Treatment is largely supportive and includes rehydration, nutritional support, medicines to reduce fever, antibiotics for superimposed infections, and Vitamin A supplementation. There is no definitive "cure" for measles once infection has taken hold.

The Measles Vaccine

In 1954 John Enders and Thomas Peebles first successfully propagated the measles virus in human culture cells. In 1960 a team led by Samuel Katz published the first reports on an effective measles vaccine and, even before its licensure in 1963, conducted additional studies proving its safety and efficacy among children in Nigeria.

The measles vaccine contains live virus that is weakened so it cannot cause actual infection but still compels the body to produce a lifelong immune response to the proteins on the virus's surface. While many wealthy countries use a form of the measles vaccine that is combined with vaccines for mumps and rubella (known as MMR), most developing countries use a measles-only vaccine due to the higher costs of the MMR and lower disease burden posed by mumps and rubella. The measles-only vaccine is distributed as a freeze-dried powder which becomes active when reconstituted with a diluting agent. Even in powdered form, the

heat-sensitive vaccine must be stored at temperatures between zero and eight degrees Celsius to maintain its efficacy. After reconstitution, the vaccine must be used quickly because it becomes inactive within hours. Cold-chain networks, as used for other vaccines, are needed for preserving the measles vaccine during transport and storage. Facilities used to store measles vaccine should be checked at least twice a day to ensure adequately cool temperatures are maintained.

The measles vaccine is effective against all 21 known strains of the virus but unreliable for children younger than nine months due to the temporary presence of protective antibodies passed from mothers to their newborns. Up to 15% of children receiving a dose of the vaccine before their first birthday fail to develop adequate immunity. To limit the number of failed first-time responders, in the early 1990s many countries began requiring all persons to receive two doses of the vaccine. Because more than 95% of unvaccinated people experience measles by age 15, public immunization efforts focus on providing two doses of the vaccine to all children between nine months and 14 years of age. This approach limits the number of susceptible children who can transmit the virus and prevents outbreaks among unvaccinated infants for whom mortality is especially high if infected.

When immunization coverage reaches extremely high rates, as in many wealthy countries, "herd immunity" develops.[i] Widespread adoption of the measles vaccine in the 1960s virtually eliminated the disease by 2008 in developed countries. For example, only 37 cases were reported in the United States in 2004, all of which were among people who acquired the infection outside the country. With its inclusion in WHO's Expanded Program on Immunization in 1983, measles vaccine coverage expanded rapidly. As a result of a dedicated measles control effort led by the Pan American Health Organization (PAHO), only 537 confirmed cases were reported in the Americas in 2001 compared to 250,000 in 1990.

Despite this progress, measles continued to be a major epidemic in impoverished parts of the world. Ninety-eight percent of the 837,000 deaths due to measles in 1999 occurred in just 47 countries (see **Exhibit 2** for map of countries). Thirty-one of these nations were in sub-Saharan Africa, where more than half of all measles deaths took place. The vaccine was regarded as safe and effective, and delivering immunization was estimated to cost less than USD 1 per child. Nonetheless, vaccination coverage remained low in sub-Saharan Africa and other parts of the developing world.

Birth of the Measles Initiative

The Global Polio Eradication Initiative

In 1988 Rotary International, WHO, UNICEF, and the US CDC united to form the Global Polio Eradication Initiative (GPEI). GPEI aimed to eliminate polio – a vaccine-preventable viral disease that caused paralysis in 1% of cases – using the collaborative, multi-institutional approach established by the smallpox eradication effort. Originally, GPEI aimed to eradicate all polio cases by 2000 through intensive campaigns that attempted to vaccinate all targeted children in a particular country or region on a single day or week. Each member organization assumed different responsibilities in pursuit of this goal (see **Exhibit 3** for a description of the organizations and their roles). Although the GPEI fell short of achieving worldwide eradication by 2000, the initiative's efforts reduced polio from a disease that was relatively common (350,000 cases in over 125 countries) in 1988 to a rare condition (approximately 1,900 cases concentrated in seven endemic countries) in 2002. The GPEI even achieved high rates of coverage in war-afflicted, impoverished, and isolated areas where providing health interventions had previously seemed impossible. The polio effort

[i] Since the measles virus only exists in humans, the remaining few unvaccinated persons are unlikely to contract the disease when such a small percentage of the population can transmit the virus.

relied upon supplementary campaigns to deliver the polio vaccine in areas where health systems were ineffective and could not achieve satisfactory immunization coverage with routine clinic-based programs alone.

The polio program constituted the largest public health effort in human history. Edward Hoekstra, a veteran of international disease control efforts, noted its importance, saying, "The GPEI was highly successful. It created an exciting atmosphere and was really at the cutting edge. It pulled a lot of professionals to the field who really wanted to make a change. With the campaigns, after one day, they could make a major impact on disease."

Initiating a Response to Measles

In light of the GPEI's success, by 2000 Hoekstra, Gay, and others involved with the polio program began to speculate on the possibility of building a similar effort against measles – a disease that WHO and UNICEF were already addressing in a separate effort. In 1999 measles caused 873,000 deaths compared to polio's 719. At the time, Hoekstra was working with WHO in China on improving measles control, while Gay was heavily involved with polio efforts through UNF. In 1999 the CDC approached Gay about the prospect of UNF supporting a program focused on measles. Although UNF declined, deciding instead to focus on its polio program, the CDC convened a meeting in July 2000 with UNF and ARC to again discuss the possibilities of establishing a collaborative effort against measles. While intrigued by the idea, the group decided to continue discussions rather than take immediate action.

At the same time, PAHO, WHO's Western Hemisphere branch, was reporting a 99% reduction in measles deaths between 1990 and 2001. It achieved this by conducting measles vaccination campaigns similar to those of the GPEI. In 1996, seven countries in Southern Africa began a regional measles elimination program, beginning nationwide measles campaigns between 1998 and 2001.

With momentum building, a side meeting was organized at a December 2000 WHO meeting in Pretoria, South Africa, among UNF, ARC, CDC, WHO and UNICEF staff. Each participant agreed to push the idea of a measles program within his or her respective organization. Upon returning to the CDC, Steve Cochi secured a financial commitment to UNF for the first time, with the idea of securing matching funds for a measles program. Shortly thereafter, UNF agreed to match funds provided by CDC and ARC. At an ARC-sponsored meeting in February 2001, the Measles Initiative was launched with the signing of a joint declaration.

Description of the Measles Initiative Partners

WHO, UNICEF, and CDC – all veteran GPEI organizations – partnered with the American Red Cross (ARC) and the United Nations Foundation (UNF) to design and implement the MI. Each organization's mission and history were unique.

World Health Organization

WHO was a multilateral international organization created in 1948 as one of the original United Nations (UN) institutions. Headquartered in Geneva, Switzerland, with regional and national offices all over the world, WHO's stated responsibilities were "providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends."[1]

Having played a key role in the successful smallpox eradication campaign from 1967 to 1977 and in the GPEI more recently, WHO was a natural partner in the MI. Peter Strebel was the WHO's founding partner in MI efforts.

United Nations Children's Fund

UN created UNICEF as a multilateral international organization in 1946 to provide nutrition and health care to European children facing famine after World War II. UNICEF upheld the 1959 Declaration of the Rights of the Child by working to advance and promote child survival and development, basic education and gender equality, and child protection from violence and exploitation, as well as to prevent and treat HIV/AIDS among children. UNICEF worked in 190 countries; in addition to advocacy and social marketing, the organization had developed expertise in the procurement and delivery of commodities used to prevent and treat diseases impacting children.[2] Edward Hoekstra represented UNICEF on the MI leadership team.

United States Centers for Disease Control and Prevention

CDC was an agency of the US Federal Government whose mission was "collaborating to create the expertise, information, and tools that people and communities need to protect their health – through health promotion, prevention of disease, injury and disability, and preparedness for new health threats." In addition to its multiple activities within the US, the CDC had established offices and partnerships around the world to "detect and investigate health problems;" "conduct research to enhance prevention;" and "implement prevention strategies."[3] The CDC often worked with developing countries to build laboratory and other disease surveillance infrastructure and capacity. Steve Cochi, an infectious disease specialist, was the CDC's representative in the MI.

American Red Cross

Clara Barton founded ARC in 1881. Although it received US Congressional Charters in 1900 and 1905 and was "closely associated with the US Federal Government in the promotion of its objectives," ARC was a volunteer-led organization financed by "voluntary public contributions and cost-reimbursement charges." Its mission was to "provide relief to victims of disaster and help people prevent, prepare for, and respond to emergencies." ARC was a founding member of the International Federation of Red Cross and Red Crescent Societies and worked with societies around the world to aid disaster victims.[4] Athalia Christie represented ARC on the MI.

United Nations Foundation

The UNF was a public charity, created in 1998 by entrepreneur and philanthropist Ted Turner's USD 1 billion gift, which supported UN causes and activities. Its stated role was to "help the UN take its best work and ideas to scale through advocacy, partnerships, constituency-building and fund-raising."[5] Andrea Gay was UNF's founding partner in the MI.

Measles Initiative Strategy

With seed funding in tow, the MI leadership team laid out a strategic plan for the effort. The team envisioned it as a temporary collaboration using a common proven strategy to jump start work against measles in highly affected countries. The MI would help governments begin measles efforts, but ultimately the governments would assume all funding and coordination responsibilities.

Partnership Structure

The MI was a collaboration of technical experts. This network of experts, both directly and through partner organizations, coordinated with governments and health ministries to organize and execute measles activities. While officially supported by and working through each of these partner institutions, the MI itself did not reside under the umbrella of any single agency and as such was not confined by the bureaucracies or institutional limitations of any of the partners. This structure also granted the MI more weight within each partner organization than isolated measles programs at each organization would have. Similar to the GPEI, each of the five partner institutions took on distinct roles within the MI.

- **ARC**: The ARC promoted public awareness on the worldwide measles situation, coordinated the partnership with UNF, and provided significant resources. ARC also mobilized Red Cross and Red Crescent societies in target countries to provide volunteers during campaigns.
- **UNF**: UNF managed the funds of the MI through an agreement with the United Nations. UNF also provided matching funds.
- **CDC**: CDC provided funds, lent scientific experts to UNICEF, WHO, and governments, and directly supported national disease surveillance systems.
- **WHO**: WHO led strategy development and provided technical leadership. Through its regional offices, the WHO worked with governments on in-country implementation of activities.
- **UNICEF**: UNICEF used its logistical and procurement capacity to support purchasing and delivery of vaccines. On the ground, UNICEF country teams also helped facilitate logistics, including cold-chain networks and social mobilization.

The MI leaders in each agency (see **Exhibit 4** for biographies) collectively directed the MI by committee; no single person or agency served as the secretariat. With members based in different US cities, Geneva, and Africa, they coordinated through weekly phone conferences during which they reviewed plans, budgets, and logistics, resolved disagreements by discussion, made decisions by unanimous consensus, and volunteered for different tasks. "The conference calls made sure all of the partners were on the same page and had ownership over the initiative," noted Hoekstra. "These calls also allowed us to quickly resolve issues and have rapid impact."

From the MI's inception in 2001, the leadership operated without major disputes or crises of indecision. For this, the initiative's main actors credited the MI's well-defined strategy and responsibilities, as well as the technical and committed nature of its leadership. Gay remarked, "The personalities have always been good. We have all been focused on a common goal, and everyone buys into the structure. Many of us had experience working in the different partner organizations, and we had a good understanding of how all the organizations worked."

Despite being thousands of kilometers away from the places where measles activities unfolded, MI leaders coordinated with national planners and implementers in the field either directly or through advisers based at UNICEF and WHO regional offices. Actors at all levels adhered to a universal strategy, but the development of plans and implementation was left to government and local leaders, with technical support from the MI partners and WHO and UNICEF country offices.

Goals

In 2003 the MI adopted the UN goal of cutting measles deaths in half between 1999 and 2005. Talk of eradication was deferred. Hoekstra explained:

> Countries were weary of the pressure that came with a commitment to eradication. We wanted the language to be about 'mortality reduction.' We just wanted to focus on doing some good with goals that were actually achievable. Without the word 'eradication,' there was less judgment on goals… [At the same time], we didn't want eradication to disappear off the table.

Program Design

The MI began in 2001 by expanding the efforts started by seven Southern African countries to reduce measles mortality. Its strategy for achieving measles control in highly burdened countries consisted of nationwide campaigns to deliver vaccines, case-based disease surveillance, and treatment support for suspected cases.

Campaigns

For Hoekstra the question of how to reduce measles deaths was clear. "You already had a vaccine, and you just needed to figure out how to deliver it," he said. "We knew routine vaccination programs were not going to get it done. We needed another delivery system, and campaigns were a proven delivery system that already worked for polio and for measles in the Americas."

Campaigns for measles immunization in the 1970s failed due to lack of planning and coordination. However, in the 1990s PAHO adapted the polio campaign strategy to measles control in the Americas. Through trial and error and a focus on results, PAHO distilled a formula for making measles campaigns effective. While the local ministries of health (MOH) organized and executed routine vaccination efforts, the MI adopted PAHO's campaign strategy and worked with countries around the world to implement campaigns termed "supplementary immunization activities" (SIAs). SIAs were designed to provide a second vaccine dose to children for whom the first dose may not have produced adequate protection and reach others who did not receive a first dose through routine programs. The first step was to perform massive nationwide "catch-up" campaigns to immunize all children between nine months and 14 years, thereby covering the entire population susceptible to the disease. This target age range was determined after initial vaccination efforts in the Americas and Southern Africa that focused on children under five failed to make a dent in measles transmission. For countries with challenging logistics, incomplete funding, or large numbers of children to be immunized, this "catch-up" campaign was delivered in phases for different regions and completed over the course of several months or a year.

This initial campaign was followed by periodic "follow-up" campaigns every two to four years, usually targeting all those between nine months and five years of age. These smaller campaigns protected children too young or not alive during the first campaign and provided those already immunized with a second dose. They were designed to keep the number of unvaccinated children below a critical threshold, above which outbreaks could occur. The interval between campaigns was dictated by coverage rates from the initial "catch-up" campaign, routine immunization coverage, and the birth rate among the population. Early on PAHO had realized that allowing too long an interval between campaigns led to resurgence in measles cases. Occasional "mop-up" campaigns were also used to address outbreaks or re-canvas areas where campaigns failed to achieve adequate coverage.

Case-Based Surveillance

Another core strategy of the Measles Initiative was the establishment of a case-based surveillance system responsible for confirming suspected cases and monitoring outbreaks. Hoekstra described the need and challenge for such a system:

> There is no way you can look at every kid and every case. But with vaccination coverage improving, doctors will not have seen measles and won't recognize it. You need to make sure you are not missing cases. You also

need a standard and measure where you are. You won't know if you are controlling measles if you don't have disease surveillance.

The measles case-based surveillance system was based on the strategy PAHO developed in the Americas. The blood sample of any patient suspected of having measles was sent for antibody testing. If the sample tested positive, contact tracing – a process of following up all close contacts of the patient – was performed to identify other potential cases. For countries that had already completed catch-up campaigns, five or more suspected cases in a local area within a single month constituted a suspected outbreak. If three or more of these cases were confirmed as measles by laboratory testing, the outbreak was verified and a full outbreak response took place. This involved aggressively investigating all suspected cases, actively searching for cases in the community and neighboring areas, swabbing the nose and throats of symptomatic persons, and sending samples to a regional viral reference laboratory for classification of the viral strain. In certain circumstances, a confirmed outbreak led to "mop-up" campaigns as in the polio effort.

To make this system work, the MI equipped laboratory facilities built for the polio program to test for measles. While less than 40 laboratories had capacity to test for measles in 1998, by 2007, the MI had helped establish 679 laboratory sites in 164 countries (see **Exhibit 5** for map of the global laboratory network). Gay described the laboratory network as a "global public good that would be used for other programs after polio and measles."

In addition to this case-based surveillance, all health facilities were required to make monthly reports of all suspected measles cases to the national immunization program which, in turn, forwarded these figures to the WHO regional offices and international level. As a result of this system, the MI leadership and regional advisers knew the on-the-ground situation and were able to provide prompt support to national and local efforts.

Case Management

The MI also aimed to reduce measles deaths by strengthening treatment. To do so, the MI helped national health ministries train local health staff on the timely detection of the signs, symptoms, complications, and contagiousness of the disease. This training also reinforced administration of vitamin A immediately at the time of diagnosis and again 24 hours later, a strategy shown to reduce measles mortality by 50%.

Political Commitment

The MI only worked in countries at the request of the government, making political commitment essential. In the early 2000s, public demand for the vaccine in countries heavily burdened with measles mortality, along with campaigns held in southern African countries between 1998 and 2001, created momentum for the measles effort. As an ARC measles expert remembered, "The public was practically asking for the vaccine. The governments had no choice but to listen." The MI focused its initial efforts in countries with strong political support and a high disease burden in order to ensure early success and build recognition for its work.

In December 2001 several western African countries including Benin, Bukina Faso, Cameroon, Ghana, and Togo launched catch-up campaigns. Noting the impact and feeling the pressure to follow suit, more and more governments throughout sub-Saharan Africa requested the MI's help to roll out campaigns.

For countries with public services hampered by inadequate funds and pervasive shortcomings, successful campaigns, Gay noted, "gave confidence to countries that they could achieve something on a large scale. It gave them the experience of doing something well." With the MI providing technical support

and full resources for catch-up campaigns, even regimes with questionable governance practices saw the gains of providing this "free" service to their population. In war-afflicted countries such as Afghanistan, Somalia, and Liberia, the MI highlighted the common interest in preventing measles to all sides and, following polio's example, mediated temporary truces termed "days of tranquility" to allow vaccinations to take place. Local staff was enlisted to discuss the MI campaigns with both sides of a conflict. Many faction leaders agreed to allow immunization activities, sometimes hoping that doing so would win them support with local communities.

The leaders of the MI attempted to keep measles on the agenda of governments through annual meetings with ministry of health officials and occasional visits by US-based members. They also leveraged UN country representatives, whose position afforded them a great deal of influence with key national leaders. Gay described the delicate approach, saying, "We had to be persuasive. We tried to remind leaders of the global and regional importance of the measles campaigns to achieve Millennium Development Goal 4 [to reduce child mortality] and emphasize the common motivation of saving children's lives."

Coordinating with Governments

The MI adapted its campaign-based strategy to deliver vaccines in settings where many development programs failed due to unforgiving terrain, poor infrastructure, and limited organizational capacity. The MI attempted to refine approaches utilized during the polio effort for planning, logistics, procurement, cold chain, training, and social mobilization. It developed templates for organizing many of the key components for the measles effort. For example, WHO's Regional Office for Africa (AFRO) provided guidelines on estimating cold chain needs, projecting staff requirements, calculating transport costs, managing post-campaign waste, and even directing crowd flow at immunization posts during a campaign. Local officials adapted these recommendations to their setting based on their experience implementing polio programs.

Campaigns were usually incorporated into multi-year immunization strategies. The planning process started six to nine months before execution. National officials utilized the interagency coordinating committee for immunization (ICC) to review their general plan and budget. The ICC was usually headed by the MOH's director of immunization programs and formed by representatives from partner organizations, including WHO and UNICEF country offices and local Red Cross and Red Crescent Societies. The ministry of health then submitted the ICC-approved plan of action to MI leaders for funding. After the approval of these proposals, the ICC outlined specific tasks for organizing the campaign and assigned these tasks to partner organizations based on their capacities and areas of expertise. For larger or more technical undertakings, the ICC established inter-organizational sub-committees that included specialists from different agencies to focus on a particular component of the campaign. For example, a social mobilization sub-committee oftentimes brought together communications specialists within UNICEF, the ministry of health, Red Cross and Red Crescent Societies, and other partnering organizations to collectively form the mobilization strategy and create radio, television, and print advertisements.

From the national level, district officials formed district-level plans, which incorporated more operational detail, including outlining distinct needs such as waste disposal and transport logistics. The district level plans were informed by "micro-planning," a bottom-up consultative process that engaged leaders at the local-level to outline implementation for the campaign in specific detail. This included mapping of target populations, the exact sites of immunization posts, the number of staff required for each post, and strategies for reaching remote households. These "micro-plans" were integrated into the district-level plans, which guided allocation of resources and execution during the campaign.

The MI's regional advisers (and sometimes members of the international leadership) provided support to the ICC and kept them on task if the progress was lagging. The ICC, in turn, provided support to district

and local officials. During the campaign, supervision teams fanned the countryside to support local implementation, solve on-the-ground challenges, and perform rapid field assessments of children in remote areas to determine if adequate coverage was being reached.

Financing

The MI received annual funding from ARC, CDC, UNICEF, and UNF and tried to raise additional funds by marketing the low cost and high impact of its agenda to outside donors. The MI did not employ any development or fundraising staff. As Gay recalled, "most of us are technical people and had a resistance to dedicating so much to fundraising." From its inception, however, the MI aimed to be a catalyst – igniting initial efforts against measles with a plan for governments to make immunization a priority and take on an increasingly large role in funding future campaigns. The initiative proposed to fully fund all catch-up campaigns, with governments taking on at least 50% of the non-vaccine operational costs of subsequent follow-up SIAs. This portion would increase incrementally until 2015 when countries would assume all costs for periodic follow-up campaigns. Even countries offering two doses of measles vaccine in their routine programs were expected to continue periodic campaigns with longer (five to seven year) intervals.

Gay and Christie, the ARC's MI director, operated at the forefront of the efforts to secure outside funding. Each raised funds from the membership and corporate sponsors of her respective organization. They also applied for grants but found it hard to compete with polio programs, which were already well-entrenched among funders. Gay and her ARC counterpart tried to engage donors directly by inviting them to organizational meetings and to countries conducting campaigns. As the MI began to achieve results and its leadership continued to lobby, the initiative established strong links with large committed donors such as The Church of Latter Day Saints, the Bill and Melinda Gates Foundation, and the Global Alliance for Vaccines and Immunization (GAVI). It also garnered support from corporations like Becton, Dickinson and Company, Vodafone Foundation, and Merck Co. and from bilateral donors such as the Canadian International Development Agency and Japan International Cooperation Agency.

All financial commitments, including resources from ARC and CDC, were granted to UNF. UNF matched some of these commitments and organized the money into a common "measles fund." As the MI leaders gave approvals to national proposals for measles activities, UNF transferred the allocated funds to the United Nations Fund for International Partnerships (UNFIP), which forwarded them to WHO and UNICEF headquarters (see **Exhibit 6** for funding flow). WHO headquarters transferred this money to its regional offices, which then made allocations to national offices. In contrast, UNICEF headquarters transferred money directly to country offices to use for vaccine procurement (from the UNICEF supply division), operational costs, and social mobilization.

At the country level, money was allocated to meet the country's needs, with a portion designated for direct procurement, another portion granted to the national government, and a third portion retained within WHO and UNICEF budgets to finance their direct roles in implementing the campaign. Often a portion of these funds was also used to fund in-country partners such as national Red Cross and Red Crescent Societies to carry out social mobilization activities for campaigns. The funds turned over to the government were pooled with national budget allocations for the campaign and used to finance needs outlined in district-level operational plans or given to district officials for the local purchase of approved supplies. By the time funds were disbursed, the planning process was usually complete and a detailed budget based on "micro-plans" was already established.

The MI leadership tried to ensure sufficient funding for SIAs by carefully considering proposals and staggering the timing of campaigns in different countries. This funding, available in time for countries to plan adequately, was critical for the MI's success. The Director of Immunization Programs in one East

African country noted, "Campaigns are among the few times where adequate resources are available to accomplish what it is you are trying to do." A district health official working in a war-plagued area in the Democratic Republic of Congo (DRC) echoed these sentiments. "During the vaccination campaign is the only time I can actually reach all the areas under my supervision and resources are not an issue."

Results

Altogether, supplementary immunization activities conducted in over 60 countries between 2000 and 2008 reached over 600 million children (see **Exhibit 7** and **8** for SIAs carried out). These efforts reduced worldwide measles mortality between 2000 and 2007 by 74% in Africa and roughly 90% in the Eastern Mediterranean, where the discussion was turning from simply reducing deaths to eliminating all transmission of the disease in the region (as had been done in the Americas; see **Exhibit 9** for map of disease burden). In spite of this momentum, measles still caused 197,000 deaths in 2007, with 74% of deaths taking place in South Asia.

Health Systems Strengthening

Along with the reduction in measles mortality that MI's campaign strategy achieved in affected countries, it provided a number of other benefits. "Campaigns reached children across all wealth groups, which was important because there was usually no health system for the poorest people. For areas in war, routine immunization activities were unstable and campaigns were needed to increase coverage," noted Hoekstra. Measles campaigns also began to integrate the delivery of other interventions including medicines for "deworming" children of intestinal parasites and insecticide-treated anti-malaria nets. By 2007, 84% of campaigns were integrated with at least one other intervention (see **Exhibit 10** for measles campaigns with supplementary immunization activities).

Campaigns installed infrastructure like cold chain equipment that could be used for routine programs and boosted awareness about vaccination among local communities. The single-shot, auto-disable syringe – a device that locks after one use, preventing the unsafe reuse of needles – became the norm in even the most resource-constrained countries after the MI mandated its use during its initial round of catch-up campaigns. Incinerators to destroy used materials and waste pits to bury these materials were also introduced in many countries with resources from the MI campaigns. Hoekstra also noted that for healthcare workers in developing countries, "campaigns provide an incentive for professional capacity building and intellectual engagement. The campaigns have a clear, transparent result that builds their confidence that they know how to set up programs." Between 2000 and 2007, routine measles vaccination rates jumped from 56% to 74% in Africa and from 72% to 82% worldwide (see **Exhibits 11a** for coverage rates of first dose of measles vaccine and **11b** for maps showing measles vaccination coverage for infants).

Shifting Tides

In 2006 the MI had adopted a new strategic plan supporting the UN goal of reducing worldwide measles deaths by 90% by 2010 compared to 2000 levels. To achieve this, the MI continued to expand its activities beyond sub-Saharan Africa to other parts of the world including Asia where, between 2005 and 2008, they supported campaigns in Indonesia, Bangladesh, Cambodia, and China, among others. These efforts included a phased, year-long "catch-up" effort in Pakistan that immunized a record 65 million children.

While campaigns quickly expanded protection to many susceptible children, routine vaccination programs in many countries still struggled to achieve adequate coverage between campaigns. Gaps in routine coverage led to outbreaks in 2006 in several nations, including Benin and Tanzania. In 2007 an estimated 23 million one-year-old children, 15 million of whom lived in just eight countries, still did not receive a first dose of the vaccine.

That year global health commentators were beginning to question whether the campaign strategy for the delivery of a few "vertical" interventions was the best use of limited health resources and, indeed, the most effective way to increase immunization rates. Without stronger routine coverage between SIAs, measles cases would persist and undermine the progress made – and dollars spent – during campaigns. A growing focus on building the "horizontal" capacity of healthcare systems presumed that this approach would also enhance routine vaccination coverage, thereby making campaigns no longer necessary. By 2007 the tide of global health was shifting toward efforts to build health system capacity; focused interventions like measles vaccinations were being crowded out of the limited funding pool. Funding support for MI decreased from USD 150 million in 2007 to only USD 47 million in 2009. The MI request to GAVI for funds from its international finance facility for immunization (IFFim) was not fully funded through 2010. GAVI declined to consider further funding with IFFim resources to the MI. Furthermore, national government contributions, while increasing over time, were not nearly sufficient to fully cover the costs of campaigns. In 2009, just as they were gearing up to try to reach the 2010 target, the MI faced a USD 35 million funding gap for its planned activities and a USD 100 million gap for 2010.

As measles became increasingly rare (see **Exhibit 12** for measles deaths worldwide over time), it no longer seemed an immediate threat and parents' sense of urgency around vaccination declined. This led to waning political attention for follow-up campaigns and other efforts needed to sustain control and prevent resurgence. Delays in conducting follow-up SIAs led to measles outbreaks in Kenya, Zambia, and Ghana in 2006. Moreover, in countries with ethnically marginalized or geographically isolated groups, some communities remained resistant to participating in vaccination programs. Gaining access to violence-ridden areas constituted a continued challenge, resulting in persistent pockets of disease in places such as the eastern districts of the Democratic Republic of Congo – which, in turn, caused the spillover of measles into neighboring areas of Rwanda in 2006. Similarly, Burkina Faso experienced a large outbreak in 2002 due to civil unrest in bordering Cote d'Ivoire.

By 2008 India, though focused on polio elimination and other health priorities, had yet to meaningfully engage with the Measles Initiative's efforts. With 15% of the world population and 10.5 million unvaccinated infants, India accounted for two-thirds of worldwide measles deaths in 2007. Routine immunization programs reached only 46% of one-year-old children, and measles deaths constituted 10% of all under-five mortality in the country. Without a redoubling of focus on measles and the funds to support this effort, the 2010 target would not be reached and the disease would make a comeback.

Future Directions

In 2009 Hoekstra, Gay, and the other leaders of the MI reflected on the progress made and contemplated how they could overcome the challenges to their efforts to achieve a 90% decline worldwide by 2010. How would they move forward to reach their target?

Appendix *Abbreviations*

AFRO	African Region Office, World Health Organization
ARC	American Red Cross
CDC	US Centers for Disease Control and Prevention
DRC	Democratic Republic of Congo
GAVI	Global Alliance for Vaccines and Immunization
GPEI	Global Polio Eradication Initiative
ICC	Interagency Coordinating Committee
PAHO	Pan American Health Organization
SIA	Supplementary Immunization Activities
UNF	United Nations Foundation
UNFIP	United Nations Fund for International Partnerships
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Exhibit 1 *Clinical Presentations of Measles*

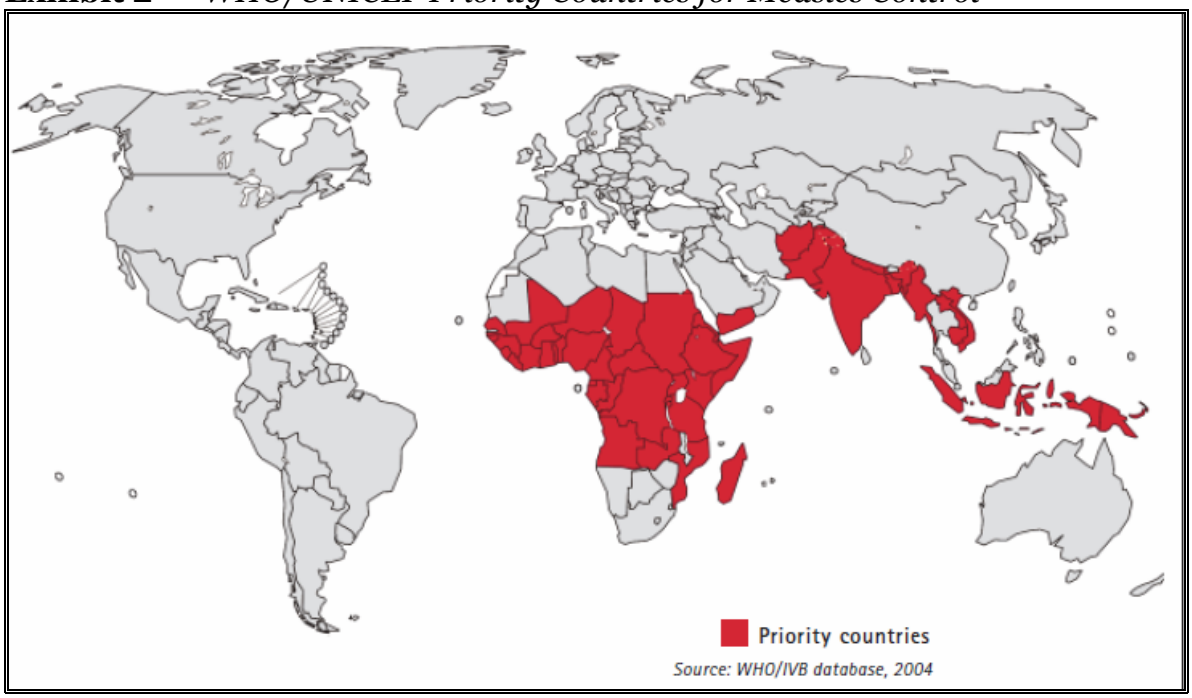
Classic rash of measles infection

Source: CDC: Image 132. Public Health Image Library. Available at: http://phil.cdc.gov/phil/details.asp?pid=132.

Sloughing of the skin after measles rash

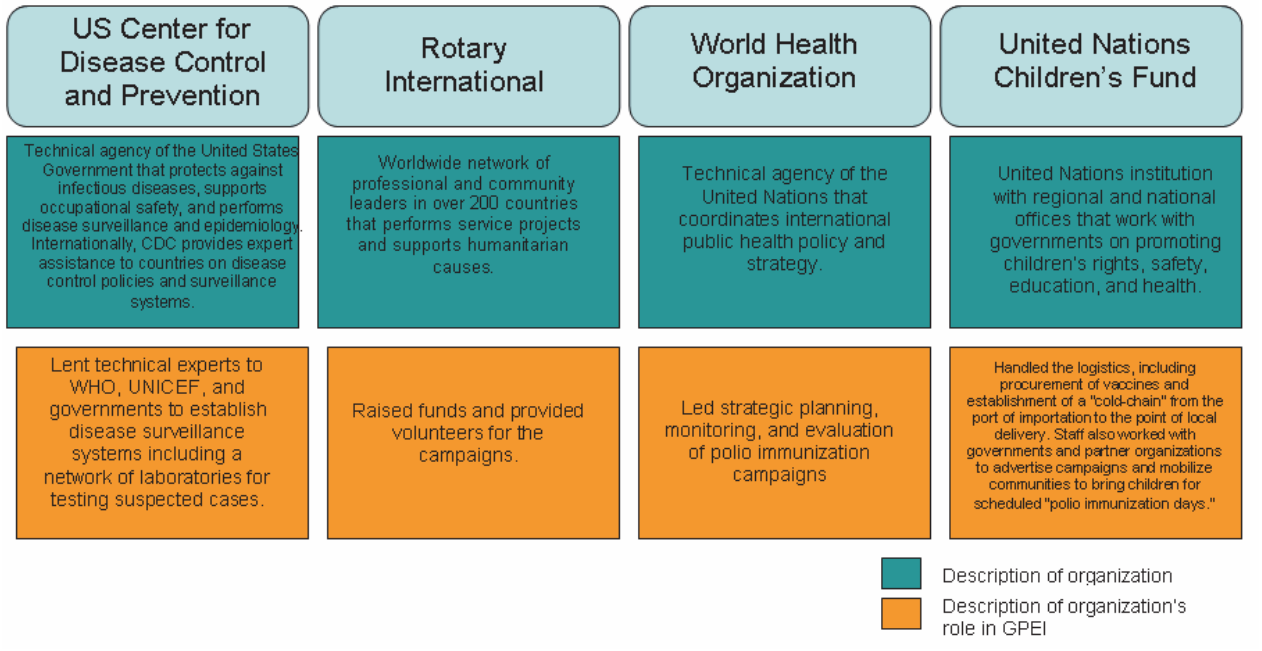
Source: CDC: Image 6887. Public Health Image Library. Available at http://phil.cdc.gov/phil/details.asp?pid=6887.

Exhibit 2 *WHO/UNICEF Priority Countries for Measles Control*



Source: WHO/UNICEF: Global Plan for Reducing Measles Mortality 2006-2010. Available at http://whqlibdoc.who.int/hq/2005/WHO_IVB_05_11_eng.pdf.

Exhibit 3 *Role of Partners in the Global Polio Eradication Initiative*



Source: GPEI.

Exhibit 4 *Leaders of the Measles Initiative, November 2009*

Andrea Gay (United Nations Foundation)
Andrea Gay was the executive director of Children's Health for the United Nations Foundation guiding UNF's work with the Measles Initiative since 1998. She previously worked as a health consultant and with the U.S. Public Health Service.

Athalia Christie (American Red Cross)
Since 2006, Athalia Christie worked as a CDC senior technical advisor for the American Red Cross, leading ARC's involvement in the Measles Initiative. She previously worked as a polio coordinator for the WHO in South Sudan and Somalia and as a public health advisor and prevention specialist with the CDC.

Edward Hoekstra, MD (United Nations Children's Fund)
Edward Hoekstra was a Senior Health Specialist for Global Measles and Health Emergencies for UNICEF's Child Survival Unit. He was previously a senior health advisor to the Global Polio Eradication Initiative (GPEI) for UNICEF and Medical Officer for WHO's Expanded Program on Immunization (EPI) in China. He also worked with the CDC as a medical epidemiologist and acting chief in the National Immunization Program's Immunization Services Division.

Stephen Cochi, MD MPH (US Centers for Disease Control and Prevention)
Stephen Cochi was a senior advisor to the Director of the Global Immunization Division in the CDC's National Center for Immunization and Respiratory Diseases (NCIRD). From 1997 to 2003, he was director of the Global Immunization Division and also served as deputy and acting director of the National Immunization Program and chief of its Polio Eradication Activity.

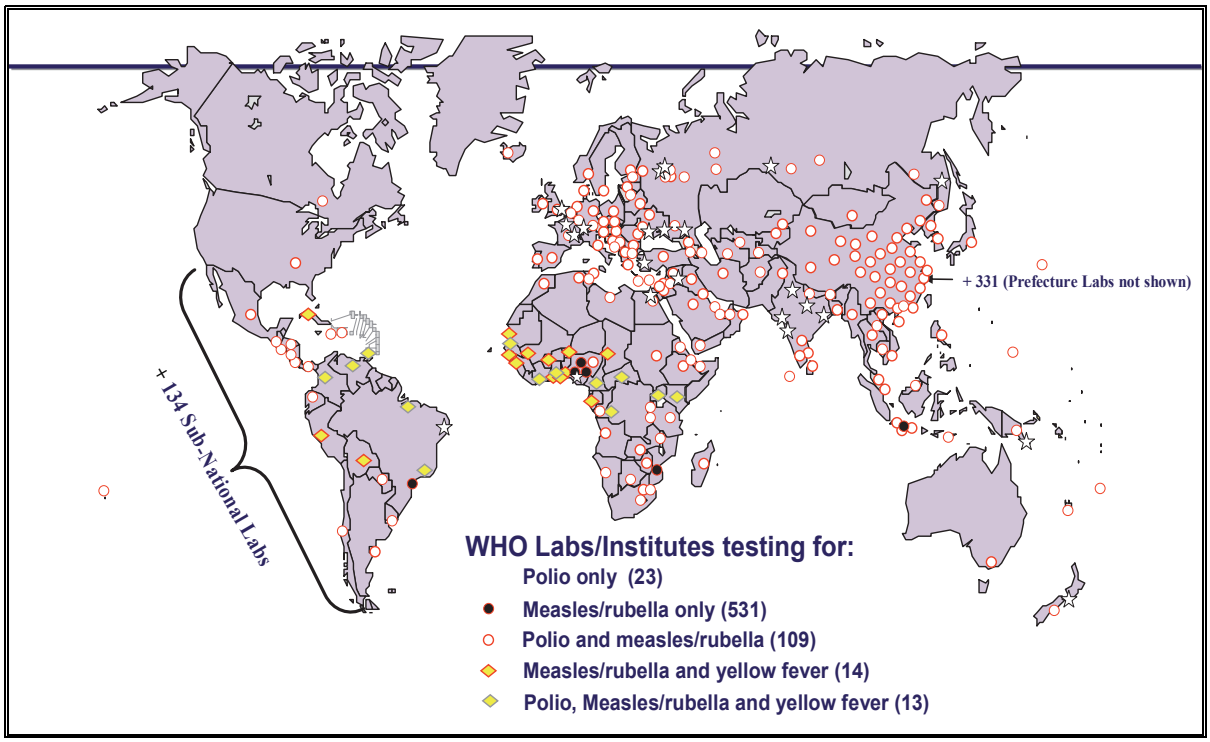
Peter Strebel, MD (World Health Organization)
Peter Strebel was a medical officer in WHO's Immunization, Vaccines, and Biologicals Division, leading its efforts on measles, rubella, and mumps. He previously worked with the CDC, where he was first the deputy branch chief for the Technical Services Branch of the Vaccine Preventable Eradication Division and later chief of the Global Measles Branch within the Global Immunization Division.

Others involved in the MI leadership, past and current:

Vance Dietz	David Gittelman	Tracey Goodman
Mark Grabowsky	Brad Hersh	Robert Kezaala
Frank Mahoney	Balcha Masresha	Jeff McFarland
Leo Weakland	Casey Boudreau	Jean-Marie Okwo-Bele
Mac Otten	Robert Perry	Jean Roy
Catherine Shaw	Steve Sosler	Maya Van den Ent

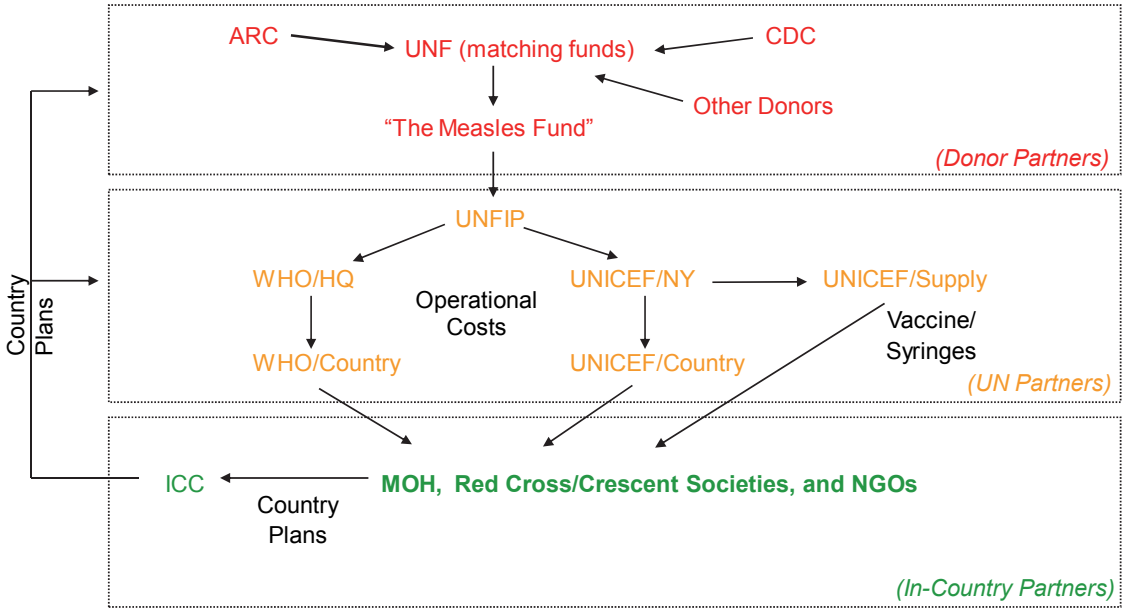
Source: created by case writers using documents from the Measles Initiative.

Exhibit 5 *Global Laboratory Network (N>700), June 2006*



Source: CDC.

Exhibit 6 *Movement of Finances in the Measles Initiative*



Note: Funds are released when ICC-approved country plans are approved by donor partners.
Source: Measles Initiative.

Exhibit 7 *Supplementary Immunization Activities in Sub-Saharan Africa*

COUNTRY	Year	Proportion of eligible population targeted	Type of SIAs	Number of children vaccinated	Coverage (% of target)
Angola	2003	100	Catch-up	7,226,105	95
	2006	100	Follow up	3,210,160	97
Benin	2001	33	Catch-up	950,780	106
	2003	67	Catch-up	2,232,682	100
	2005	100	Follow up	1,137,163	107
	2008	100	Follow up	1,272,621	102
Botswana **	2005	100	Follow-up	179,202	99
Burkina Faso	2001	100	Catch-up	4,943,115	96
	2004	100	Follow-up	2,882,208	101
	2007	100	Follow-up	3,145,255	102
Burundi	2002	100	Catch-up	2,767,054	90
	2006	100	Follow-up	1,226,689	110
Cameroon	2001	33	Catch-up	2,789,542	93
	2002	67	Catch-up	4,570,817	90
	2006	33	Follow up	1,249,041	99
	2007	67	Follow up	1,763,167	91
Cape Verde	2005	100	Follow-up	46,889	93
Central African Republic	2005	70	Catch-up	1,183,583	91
	2008	100	Follow up	683,302	102
Chad	2005	37	Catch-up	1,939,274	83
	2006	63	Catch-up	2,735,760	101
Comoros	2007		catch-up	231,263	81
Congo	2004	100	Catch-up	1,356,625	78
	2007	100	Follow-up	677,390	95
DR Congo	2002		Catch-up	5,554,824	96
	2004	30	Catch-up	8,604,754	86
	2005	30	Catch-up	6,957,653	89
	2006	40	Catch-up	6,970,229	
	2006	30	Follow-up	5,723,858	99
	2007	sub-national	Follow-up	3,768,794	101
	2008	sub-national	Follow-up	2,773,119	100
Côte d'Ivoire	2005	100	Catch-up	7,894,327	88
	2008	100	Follow-up	3,082,438	95
Equatorial Guinea	2005	100	Catch-up	119,462	44
Eritrea	2003	100	Catch-up	1,047,862	82
	2006	100	Follow-up	387,479	95

COUNTRY	Year	Proportion of eligible population targeted	Type of SIAs	Number of children vaccinated	Coverage (% of target)
Ethiopia*	2003	30	Catch-up	5,101,001	91
	2004	33	Catch-up	7,422,074	84
	2005	2	Catch-up	136,935	69
	2005	10	Follow-up	987,221	92
	2006		Follow-up	5,272,255	89
	2006		Follow-up	5,130,295	
	2007		Follow-up	1,072,701	98
	2008	sub-national	Follow-up	10,168,504	4 phases 91-97
Gabon	2004	100	Catch-up	502,959	80
	2007	100	Follow-up	190,035	83
Gambia	2003	100	Catch-up	677,830	92
	2007	100	Follow-up	241,214	96
Ghana	2001	10	Catch-up	790,798	99
	2002	90	Catch-up	7,827,605	102
	2006	100	Follow up	3,994,052	79
Guinea	2003	100	Catch-up	3,202,848	98
	2006	100	Follow up	1,707,633	97
Guinea-Bissau	2006	100	Catch-up	590,602	85
Kenya	2002	100	Catch-up	13,302,991	98
	2006	100	Follow-up	5,260,241	111
Lesotho **	2003	100	Catch-up	178,522	87
	2007	100	Follow-up	196,490	92
Liberia	2007	100	Follow-up	629,676	97
Madagascar	2004	100	Catch-up	8,900,657	99
	2007	100	Follow-up	3,053,702	100
Malawi **	2002	100	Follow-up	1,906,985	120
	2005	100	Follow-up	2,110,341	114
	2008	100	Follow-up	2,087,375	100
Mali	2001	100	Catch-up	4,998,491	99
	2004	100	Follow-up	2,426,497	118
	2007	100	Follow-up	2,562,537	102
Mauritania	2004	100	Catch-up	1,167,307	102
	2008	100	Follow-up	464,564	97
Mozambique	2005	100	Catch-up	8,222,157	97
	2008	100	Follow-up	3,342,280	103
Namibia **	2003	100	Follow-up	318,240	94
	2006	100	Follow-up	318,905	97
Niger	2004	94	Catch-up	5,071,149	99
	2005	6	Catch-up	332,318	102
	2008	100	Follow-up	2,942,498	100

COUNTRY	Year	Proportion of eligible population targeted	Type of SIAs	Number of children vaccinated	Coverage (% of target)
Nigeria	2005	53	Catch-up	28,538,974	96
	2006	47	Catch-up	26,353,793	83
	2008	100	Follow-up	28,363,479	112
Rwanda	2003	100	Catch-up	3,082,583	102
	2006	100	Follow-up	1,380,870	107
Saotome & Principe	2007	100	catch-up	64,487	101
Senegal	2003	100	Catch-up	4,854,077	98
	2006	100	Follow-up	1,833,931	99
Sierra Leone	2003	100	Catch-up	2,404,882	93
	2006	100	Follow-up	751,107	100
South Africa **	2004		Follow-up	3,501,447	
	2007	100	Follow-up	3,784,440	87
Swaziland **	2002	100	Follow-up	127,829	81
	2006	100	Follow-up	140,143	100
Tanzania	2001	33	Catch-up	3,687,390	104
	2002	67	Catch-up	6,739,197	97
	2005	100	Follow-up	6,036,865	99
	2008	100	Follow-up	10,826,519	86
Togo	2001	100	Catch-up	2,393,700	99
	2004	100	Follow-up	887,668	100
	2008	100	Follow-up	906,692	98
Uganda	2001	33	Catch-up	614,516	116
	2003	100	Catch-up	13,457,127	105
	2006	100	Follow-up	5,301,424	100
Zambia	2002	10	Catch-up	729,469	112
	2003	90	Catch-up	4,955,647	108
	2007	100	Follow-up	2,204,553	107
Zimbabwe **	2002	100	Follow-up	1,537,263	85
	2006	100	Follow-up	1,407,510	95
TOTAL				**395,478,509**	

* Emergency measles SIAs in 2002/ 2003 had reached more than 11.4 million children aged 6 months – 14 years in the drought prone and affected areas in Ethiopia.

** Completed catch-up campaigns prior to the Measles Initiative.

Source: Measles Initiative.

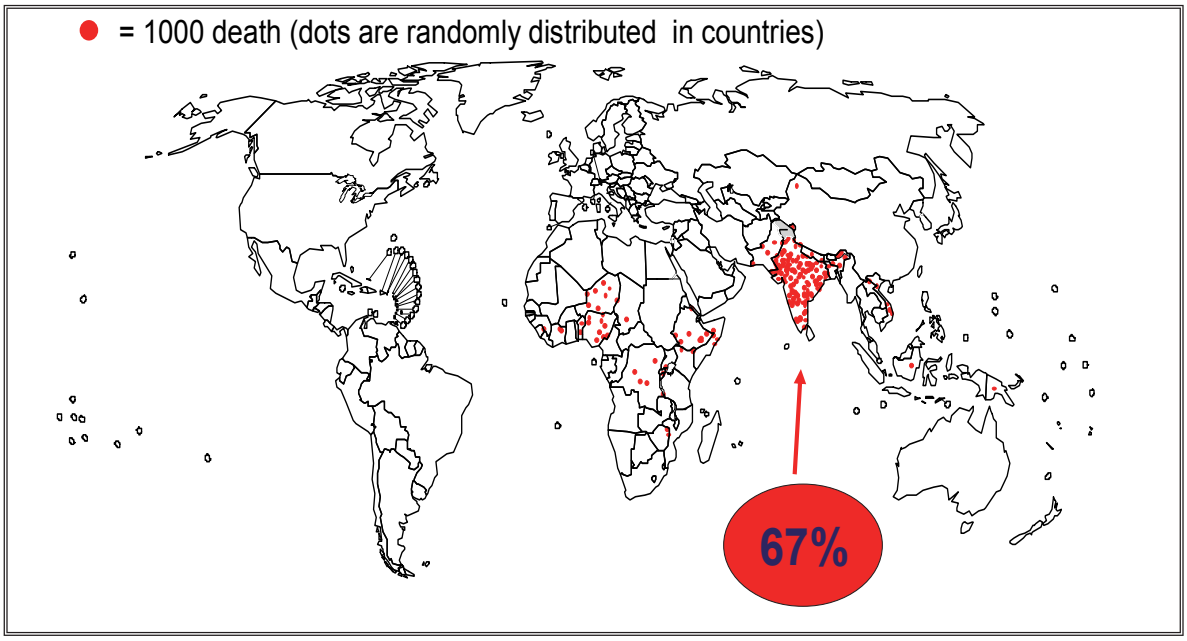
Exhibit 8 *Supplementary Immunization Activities outside of Sub-Saharan Africa*

Country	Year	Number of Children Vaccinated	Coverage (% of target)
	2005	1,374,390	93%
Bangladesh	2006	34,637,764	101%
Bolivia	2007	3,075,963	96%
Cuba	2007	1,991,513	97%
Guyana	2007	5,860	95%
	2007	1,319,342	80%
Haiti	2008	4,676,353	103%
Honduras	2008	687,763	97%
Nicaragua	2008	375,781	95%
Armenia	2007	912,510	97%
Georgia	2008	476,116	47%
Turkmenistan	2007	2,112,704	94%
Ukraine	2008	386,000	4%
Uzbekistan	2007	8,129,804	100%
Myanmar	2007	5,705,351	94%
	2005 to 2006	4,642,650	97%
	2006	836,354	92%
	2006	212,203	81%
	2006	6,490,542	94%
	2007	13,139,214	93%
	2007	6,075,628	94%
Maldives	2005 to 2006	123,642	85%
	2004 to 2005	9,985,161	103%
	2008	909,421	94%
Nepal	2008	2,593,962	88%
	2007	2,511,837	98%
	2007	1,282,232	105%
	2007	6,906,376	100%
	2007	20,566,497	97%
Pakistan	2008	35,315,375	103%
	2005	345,792	82%
	2006	2,226,102	88%
Somalia	2007	450,508	108%
	2005	362,577	76%
	2006	1,514,216	79%
	2007	1,698,058	72%
Sudan	2008	150,619	83%
(South)	2008	142,511	94%
	2006	2,873,823	106%
	2007	1,809,823	105%
Afghanistan	2007	2,085,479	106%

Country	Year	Number of Children Vaccinated	Coverage (% of target)
	2005	186,317	85%
Djibouti	2008	198,096	92%
Egypt	2008	18,212,965	95%
Morocco	2008	3,519,144	99%
	2004	8,146,087	98%
	2005	2,503,900	94%
	2006	3,230,497	75%
Sudan	2007	1,490,822	96%
(North)	2008	2,728,011	97%
	2006	9,322,918	98%
Yemen	2007	1,291,206	91%
DPRK	2007	16,109,432	100%
Cambodia	2007	1,526,530	105%
	2007	3,980,978	99%
	2008	10,318,080	99%
China	2008	3,275,517	98%
Lao	2007	2,086,190	96%
Mongolia	2007	401,575	97%
Philippines	2007	8,197,860	95%
	2007	3,729,848	97%
Vietnam	2008	1,008,690	97%
Total		**292,582,479**	

Source: Measles Initiative.

Exhibit 9 *Measles Mortality Burden, 2007*



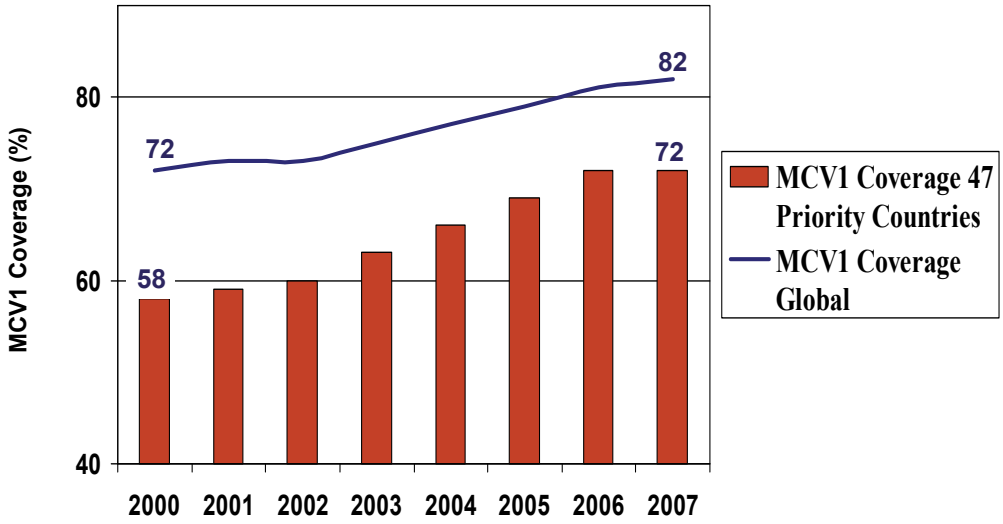
Source: WHO/IVB.

Exhibit 10 *Examples of Supplementary Immunization Activities Including Other Interventions*

WHO region and country	Age group	Extent	No. of children reached	% of targeted children reached[†]	Other interventions delivered[§]				
					Oral polio vaccine	Vitamin A	Insecticide-treated bednets	Deworming medication	Tetanus toxoid vaccination
African									
Burkina Faso	9–59 mos	National	3,145,255	102		Yes			
Cameroon	9–59 mos	Subnational	1,763,167	94		Yes	Yes		
Democratic Republic of the Congo	6–59 mos	National	3,768,794	101		Yes	Yes	Yes	
Ethiopia	6–59 mos	Subnational	1,072,701	96		Yes			
Gabon	9–59 mos	National	190,035	83		Yes	Yes	Yes	
Liberia	9–59 mos	National	629,676	97		Yes	Yes	Yes	
Madagascar	9–59 mos	National	3,053,702	100		Yes	Yes	Yes	
Mali	9–59 mos	National	2,562,537	101	Yes	Yes	Yes	Yes	
Republic of the Congo	9–59 mos	National	677,390	95		Yes	Yes	Yes	
Zambia	9–59 mos	National	2,204,553	107		Yes		Yes	
Eastern Mediterranean									
Afghanistan	9–59 mos	Rollover-National[¶]	2,085,479	106	Yes				Yes
Djibouti	9 mos–5 yrs	Subnational	7,475	37					
Pakistan	9 mos–15 yrs	Rollover-national	2,511,837	98					
	9 mos–13 yrs	Rollover-national	1,282,232	105					
			6,906,376	100					
			20,566,497	97					
Somalia	9 mos–15 yrs	Rollover-national	2,774,178	87		Yes			
Sudan	6 mos–14 yrs	Subnational	1,698,058	72				Yes	
	9–59 mos	Rollover-national	1,491,612	96					
South-East Asian									
Indonesia	6 mos—5 yrs	Rollover-national	10,099,534	90	Yes	Yes			
	6 mos–12 yrs	Rollover-national	3,499,242	95					
			2,863,068	106					
			2,609,301	102					
Myanmar	9 mos–5 yrs	National	5,706,351	94					
Western Pacific									
Cambodia	9–59 mos	National	1,526,530	105		Yes		Yes	
Laos	9 mos–14 yrs	National	2,086,190	96		Yes		Yes	
Vietnam	1–20 yrs	Subnational	3,729,848	97					
Total			**90,511,618**						

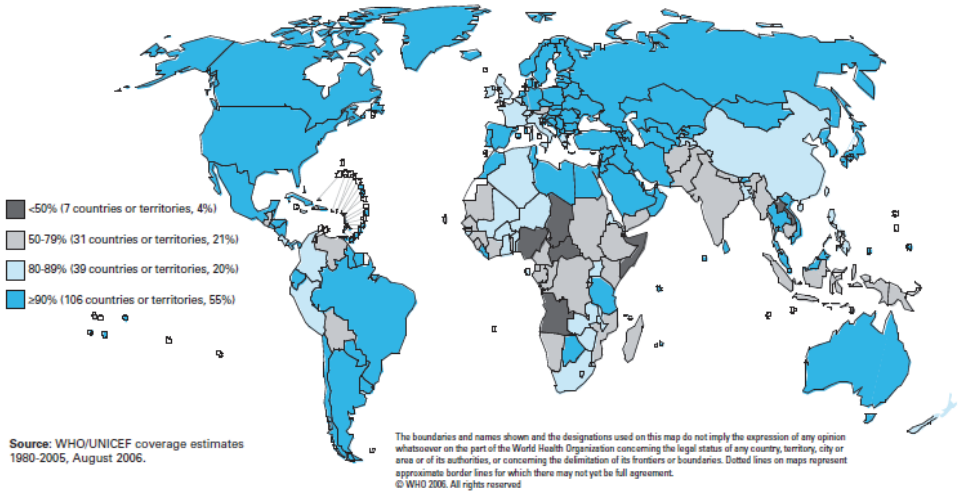
Source: MMWR. Progress in Global Measles Control and Mortality Reduction, 2000 – 2007. Available at http://www.measlesinitiative.org/docs/mi-mmwr-measles-update.pdf.

Exhibit 11a *First Dose Measles Coverage in 47 Priority Countries, 2000-2007*



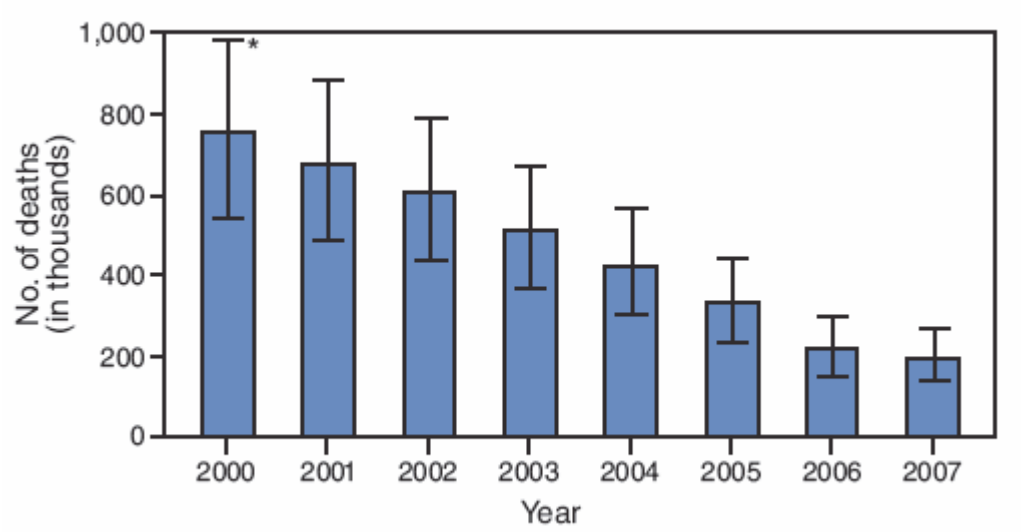
Source: WHO/UNICEF.

Exhibit 11b Immunization Coverage with Measles-containing Vaccines for Infants, 2005



Source: WHO/UNICEF. Available at http://www.unicef.org/publications/files/Immunization_Summary_2007.pdf.

Exhibit 12 *Estimated Number of Measles Deaths Worldwide, 2000 – 2007*



Note: 95% uncertainty interval. Based on Monte Carlo simulations that account for uncertainty in key input variables (i.e., vaccination coverage and case-fatality ratios.

Source: WHO.

References

[1]. WHO website. http://www.who.int/about/en/.
[2]. UNICEF website. http://www.unicef.org/whatwedo/index.html.
[3]. CDC website. http://www.cdc.gov/about/organization/mission.htm.
[4]. ARC website. http://www.redcross.org/portal/site/en/menuitem.d8aaecf214c576bf971e4cfe43181aa0/?vgnextoid=477859f392ce8110VgnVCM10000030f3870aRCRD&vgnextfmt=default.
[5] UNF website. http://www.unfoundation.org/about-unf/.