Global Disease Eradication

The Race for the Last Child
Global
Disease
Eradication
The Race for the Last Child

Cynthia A. Needham and
Richard Canning

ASM Press • Washington, DC
Contents

Acknowledgments vii

Eradication: a Prologue 1

Malaria and the Magic Bullet 5
  Two Children 7
  Swamps, Farms, and Bad Air 10
  Escalating Pressure 12
  Learning from the Past: Hard Lessons, Hard Work 15
  Biology Plays Its Hand 20
  Social Issues Loom Large 22
  Fatal Inflexibility: One Plan To Fit All 27
  The Price of Failure 28
  Forward to the Present 30
  Magic Bullets 36
  ♦ Malaria, Man, and Mosquito: the Biologic Perspective 38

Smallpox: the Right Disease, the Right Time 43
  Fading Scars 45
  From Golden Needles to Vaccine 46
  Moving Toward Control 49
  Thinking about Eradication 50
  Commitment, Evolution, Success 56
  Smallpox Zero 60
  The Smallpox Dividend 68
  ♦ An Incomplete Life: the Biologic Perspective 72

Polio: the Rise and Fall of a Disease 77
  Biologic Realities 81
  The Invisible Disease 83
Acknowledgments

This book turned out to be a very special collaboration for us, one that would not have happened without the influence of a friend and colleague, Rita Colwell, Director of the National Science Foundation, who introduced us. We are grateful for that introduction. We are also grateful to all the friends, family, and professional colleagues who helped us along the way. Their critical comments, valuable insights, and support helped to make this a better book.

We would particularly like to express our appreciation to those scientists who allowed us to interview them and who willingly shared their experiences with us.
In the spring of his 13th year, a young boy in Dubuque, Iowa, developed a rare and deadly neurological disorder called subacute sclerosing panencephalitis. As his adoptive parents stood by and watched helplessly, their son became increasingly withdrawn and confused. His grades slipped; he lost much of his language and mathematical skills; he even lost the ability to follow simple directions. Over the weeks he gradually lost control of his muscles, falling to the floor with increasing frequency. In the end, amid the nurses and doctors at one of Iowa’s most sophisticated medical centers, he slipped quietly into a coma and died.

The young boy’s death could have been easily prevented. His disorder was a complication of measles, a disease he contracted sometime during the first four years of his life when he lived in an orphanage in Thailand. Millions of other children around the world contract measles every year, and at least a million of these children die. Although it is uncommon in the United States, measles is the eighth most common cause of childhood death in the world. Most of these children die in countries where parents are too poor to afford vaccinations and where there is limited or no access to health care. Increasingly, however, American children are at risk, as parents refuse to have their children vaccinated. These parents don’t refuse because they are poor. They refuse because they fear complications from the vaccine or because their religion forbids vaccination. More ominously, in recent months the vaccine itself has been in short supply and, therefore, unavailable to some. All these events set the stage for a measles epidemic in our own backyard.

But what if it were possible that no child would ever again die from measles? What if it were unnecessary to vaccinate any child against this disease? Such a time may be closer at hand than you might think. Measles is high on the list of diseases that public health experts believe it may be possible to eradicate—that is, to stop all transmission so that the disease no longer exists anywhere in the world. Smallpox was the first
and, so far, the only disease ever eradicated, but at least two more are likely to join it in the archives of human disease.

The history of eradication itself is such, however, that it raises serious questions about whether we can and whether we should attempt to eradicate another disease.

As this book makes clear, the eradication of smallpox was a public health victory of remarkable proportions. Nothing like it had ever been done before, and perhaps nothing quite like it ever will again. The point is not to cast doubt on whether society should strive for such an achievement in the future, but instead to begin to indicate some of the complexities that surround the notion of eradication and the reasons we must choose our battles extremely carefully. To the average person, what goes on in a doctor’s office often seems mind bogglingly complex in itself. Disease eradication, because it takes the globe as its clinic, faces monster-sized versions of these complexities. The facilities are worse, the money scarcer, the sun hotter, the cold colder, the workers harder to find and to train, and the results harder to verify. Then, should the attempt, against all odds, succeed, the danger is always present that two or three decades later, someone who thinks he’s got the voice of God in his head might undo the work. More than anything else, eradication is a contingent sort of work, contingent especially on geopolitics, cultural values, and luck.

Eradication programs are as delicate as a child’s health. This is fitting because, like much of international public health, eradication is built around the child. It isn’t going too far to say that without suffering children, there would be no disease eradication. On one hand, children are the main victims of many infectious diseases—malaria, for example, or polio or measles. Adults can suffer and die from these illnesses, too, of course—the world’s last victim of smallpox was an adult—but in general they strike early. And because infectious diseases are prominent among the few diseases that can be eradicated, children are, therefore, also the prime beneficiaries of eradication.

Children are vital to eradication in another sense as well: as the chief means by which it is sold to the world. We have even chosen to shape this book around that image in order to dramatize the human consequences of eradicating a disease (or failing to). While Global Disease Eradication: the Race for the Last Child focuses on all aspects of disease eradication, the image of the child remains most powerful. The desire to make certain that no child will suffer the consequences of a particular disease ever again—that no parent will suffer the loss of a child because of that disease—makes the race to find that last child, to immunize him

Global Disease Eradication: the Race for the Last Child
or treat her, the most compelling argument for eradication. For that rea­son, the face of eradication is a child’s face to the world at large.

Children are powerful motivators. Consider the March of Dimes, founded to raise money for victims of polio and for research into a cure. Its publicists used the most heart-wrenching images they could find, and these were almost always images of children struggling in braces. The forceful personality of Franklin Roosevelt undergirded the effort, and his experience made stopping polio seem like a matter of national, even in­ternational, importance. Still, the pictures on the March of Dimes posters were, more often than not, pictures of children—not presidents or prime ministers, just little kids who would never kick a ball again. The images were extremely effective. Hundreds of millions of dollars were raised and disbursed by the March of Dimes, and in what seems like almost no time at all, an effective vaccine was developed, tested, approved, and put to use.

Today, the number of cases of polio has shrunk almost to nothing; in the next few months, the number will probably reach zero. Although this dramatic reduction could never have been achieved without an effective vaccine, the vaccine alone is not enough. To take that vaccine to the poorest corners of the world, a worldwide campaign was required. And to get that campaign organized, funded, and moving, and to keep it moving, children were crucial. Children are the most effective way the propo­nents of eradication make their case, particularly to the public at large. To health ministers, the organizers of an eradication campaign might talk about cost/benefit ratios; they might discuss among themselves the tech­nical innovations that make the campaign feasible. But to the volunteer in the field, giving her time and risking her health, to the suspicious parent who has never even heard of vaccination, to the consumer back home, whose donations are an increasingly important source of funds, the talk is more often about saving children.

Concern for children runs so deep, in fact, that civil wars and guer­rilla actions have been interrupted so that eradication efforts can pro­ceed. During the late 1960s, for example, Nigerian troops carried smallpox vaccine halfway out onto a bridge and then withdrew so that their Biafran opponents could collect it. Of course, the smallpox eradica­tion campaign did not bring peace to Nigeria or anywhere else. Exam­ples like this, however, sometimes make it seem as though, because it concerns itself so directly with children, eradication operates outside of politics, above the sectarian issues that move one set of people to try to kill another.
This both is and isn’t true, as this book shows. Eradication cherishes an ideal—freedom from disease—that makes sense to most people and that transcends mere ethnic or national divisions. Often this message gets across, even in the most difficult of circumstances. On the other hand, eradication, or rather an eradication program, is also a shambling, bureaucratic reality that falls under the control of the highly political World Health Organization. A great deal of money and prestige are at stake, and, therefore, eradication is vulnerable not only to world events—coups, floods, famines, wars against terrorism—but also to politics of a more banal, institutional kind.

The tensions between these idealistic and realistic elements are traced in the sections that follow. Three global campaigns—the races to eradicate malaria, smallpox, and polio—tell the story of disease eradication and herald its future. Each campaign was interesting in its own right, but more importantly, each shaped the international programs that will follow in our race to save the last child.
Index

A
Acute flaccid paralysis, surveillance of, 103–104, 122, 138
Afghanistan, National Immunization Day in, 106–107
AIDS, eradication programs for, 141–144
Anemia, in malaria, 38
Angola, eradication program difficulties in, 135
Animals, as mosquito targets, 11–12
Annan, Kofi, at Global Polio Partners Summit, 78, 80
Anopheles mosquitoes, as malaria vectors, see Mosquitoes
Atabrine, for malaria, 14

B
Babangida, Ibrahim, Nigerian guinea worm eradication and, 130
Bangladesh
polio eradication in, 106, 161–162, 168–170
smallpox eradication in, 66
Belize, malaria eradication in, 29
Bellamy, Carol
at Global Polio Partners Summit, 78, 79
on polio eradication, 77
Bill and Melinda Gates Foundation in guinea worm eradication, 126
in polio eradication, 79, 102, 125
Biologic feasibility, of eradication programs, 119–123

Bioterrorism
poliovirus in, 110
smallpox in, 70–71, 74–75, 122
Bloom, Sharon, on politics, 154–155
Brazil
malaria eradication in, 13–14, 16
measles transmission to Chile from, 140
polio eradication in, 94–97
Brundtland, Gro Harlem
at Global Polio Partners Summit, 78
on polio eradication, 77
Bulgaria, polio outbreak in (2001), 82–83
Burkina Faso, polio eradication in, 106

C
Cambodia, health system improvement in, 134
Carter Center (Jimmy and Rosalynn Carter), guinea worm eradication program of, 126, 130, 174–176
Cerebral malaria, 8–9
Chad, polio eradication in, 171–173
Chile, measles eradication in, 140
Chimpanzees, as potential smallpox reservoirs, 121
China
national immunization days in, 102
polio eradication in, 130
Chloroquine, for malaria, 15, 17, 29–31
Cinchona tree bark, extract of, for malaria, 11
Cochi, Steve, on polio eradication, 107, 108, 111, 135–136, 179–180
Côte d'Ivoire, polio eradication in, 130–131
Countdown Clock, for polio eradication, 77–80
Cowpox virus
for smallpox vaccine, 48
traveling cow with, 49
Cuba
measles eradication in, 139–140
National Vaccination Day in, 97

D
DDT, in malaria eradication, 15–24, 120
deQuadros, Ciro
in measles eradication, 139–140
in polio eradication, 97–101, 121, 179
Devlyn, Frank, at Global Polio Partners Summit, 78
Dichloro-diphenyl-trichloroethane (DDT), in malaria eradication, 15–24, 120
Djimde, Abdoulaye, malaria research of, 36, 147–148
Dominican Republic, polio outbreak in (2001), 81–82
Dowdle, Walter
on national priorities, 135
on polio eradication, 108
public health work of, 177–178
on smallpox in bioterrorism, 70–71
on social benefits of eradication programs, 136
Downs, Wilbur, on malaria eradication program, 27–28
Dracunculiasis eradication, see Guinea worm eradication
Drinking water treatment, for guinea worm eradication, 126–127
Dubos, René, on disease eradication, 51
Duombo, Ogobara, malaria research of, 33–35
DuPont Company, contributions of, to guinea worm eradication, 126

E
El Salvador, polio eradication in, 100
Enders, John, poliovirus culture methods of, 3, 89–90
England, smallpox inoculation and vaccination in, 47–49
Epidemic Intelligence Service, 158
Eradication programs, see also specific diseases
biologic feasibility of, 119–123
failure of, 118
financial resources for, 123–128
health care service expansion due to, 136–138
health system improvement due to, 134–135
human resources mobilized by, 135–136
national health policies and, 133–134
new technologies developed during, 138–139
next targets for, 139–145
political aspects of, 128–131
social benefits of, 131–133
strategies for, 117–118
Erythrotherapy, for smallpox, 46–47
Ethiopia
malaria eradication in, 132
smallpox eradication in, 61–67, 130
Expanded Program for Immunization, 69
Expenditures, see Financial considerations

F
Farrow, Mia, as polio victim, 78–79
Farrow, Thaddeus, as polio victim, 77–79
Filariasis, lymphatic, control of, corporate contributions to, 127
Financial considerations
in eradication programs
malaria, 123–124, 127
polio, 124–125
resources for, 123–128
smallpox, 53, 55–56, 68, 123–125
in HIV control, 144
in tuberculosis treatment, 142
Foege, William
on eradication as social justice, 117
polio eradication work of, 101
smallpox eradication work of, 59, 152–153

G
Gallup, John, on malaria and poverty, 127–128
Gates, Bill and Melinda, foundation of
in guinea worm eradication, 126
in polio eradication, 79, 102, 125
Genetic factors, in malaria resistance, 39–40
GlaxoSmithKline, contributions of, to trachoma control, 127
Global Polio Eradication Initiative, 101
Global Polio Partners Summit, 78–81
Glucose-6-phosphate dehydrogenase, malaria and, 40
Grant, Jim, on polio eradication, 98, 129
Guei, Robert, Côte d’Ivoire polio eradication program and, 131
Guinea worm eradication, 174–176
biologic feasibility of, 126
health system organization and services development in, 134–137
human resources for, 135–136
national health policy on, 134
new technology development due to, 138–139
political aspects of, 130
social benefits of, 132–133

H
Haiti, polio outbreak in (2001), 81–82
Hasina, Sheikh, on polio eradication, 79
Health care services and systems, eradication program influence on, 134–138
Health policies, eradication program influence on, 133–134
Hemoglobin gene, mutations of, in malaria resistance, 39–40
Henderson, Donald Ainslie
on eradication program approval, 129
malaria eradication work of, 13
on polio eradication, 98, 99
on politics and public health, 149–151
smallpox eradication work of, 46, 55, 56, 60, 67, 69
Hepatitis B, eradication of, 141
Hingis, Martina, on polio eradication, 79
Hippocrates, on polio, 84
Hispaniola, polio outbreak in (2001), 81–82
HIV infection, eradication programs for, 141–144
Hopkins, Donald, at Carter Center, 126, 139, 174–176
Human immunodeficiency virus infection, eradication programs for, 141–144
Human resources, from eradication programs, application to other projects, 135–136

I
Immunity
to malaria, 9, 39–42
to polio, 87–88, 90
Immunodeficiency, poliovirus reservoirs in, 110
India
malaria eradication in, 26–27
polio eradication in, 161–162
smallpox eradication in, 54, 66

Index 189
Infantile paralysis, see Polio
Influenza, mortality statistics in, 25
Inoculation, for smallpox, 47–48
Insecticides, in malaria eradication, 15–24
Intensified Smallpox Eradication Program, 56–60
Italy
smallpox vaccination in, with traveling cows, 49
swamp drainage project in, 12–13
J
Jenner, Edward, smallpox vaccine development by, 48, 50
Jiang, Zemin, polio eradication program and, 130
Johnson, Lyndon, African vaccination campaign of, 55, 150
K
Kilgus, Duane, on STOP team, 163–165
Kohler, Kathy, in polio eradication, 161–162
Kosara, Petrus Aswin, in smallpox eradication program, 65
L
Laboratories
for polio surveillance, 138
smallpox virus release from, 122
Lievano, Fabio, in polio eradication, 171–173
Lymphatic filariasis, control of, corporate contributions to, 127
M
Maalin, Ali Maow, as last natural smallpox victim, 43–45, 67
MacArthur, General Douglas, on malaria, 14
MacDonald, George, mosquito reduction model of, 16
Macedo, Carlyle, on polio eradication, 98
Mahler, Halfdan, on disease eradication, 98, 101
Malaria, 5–42, 6
attitudes toward, vs. smallpox, 45
cerebral, 8
clinical features of, 8
drug resistance in, 29–30
eradication of, 142, 147–148
in Belize, 29
biologic feasibility of, 120
biological complexities of, 20–22
in Brazil, 13–14, 16
DDT in, 15–24
early efforts for, 9–10
in Ethiopia, 132
failure of, 28–30, 80
financial considerations in, 123–124, 127
future of, 36–37, 40–42
in India, 26–27
inflexible plan for, 27–28
in Italy, 12–13
Malaria Research and Training Center in, 35
in Mali, 30–36, 147–148
National Malaria Control Programs for, 32, 35–36, 129–130
in Nigeria, 21–22
in Panama Canal building, 12
politics of, 80
Roll Back Malaria program, 31–32, 126
vs. smallpox eradication, 45, 53–54
social issues in, 22–27, 132
from United States, 5–6
in World War II, 14
historical view of, 10–12
human genetics and, 39–40
immunity to, 9, 39–42
Malaria Eradication Programme for, 10, 18–19, 22–30, 123–124, 132
organisms causing, 38–39, 41
pathophysiology of, 8–9, 38–39
poverty and, 9, 128
prophylaxis for, 14–15
recovery from, 8–9
resistance to, genetic factors in, 39–40
transmission of
air travel in, 6–7
environmental changes and, 11–12
factors affecting, 6–7
global warming and, 7
mosquitoes in, see Mosquitoes
treatment of, 14–15, 34–35
historical, 11
vaccines for, 40–42
Malaria Eradication Programme, 10, 18–19, 22–30, 123–124, 132
Malaria Research and Training
Center, in Mali, 35
Malaya, mosquito spraying program in, 23–24
Mali
malaria eradication in, 30–36, 147–148
smallpox eradication in, 59
Malthus, Thomas, on smallpox and population growth, 49
Mandela, Nelson, polio eradication program support from, 130
March of Dimes, 3, 89
Measles
death in, 1
as future eradication target, 139–141
vaccines for
measles, mumps, and rubella, 141
trials of, 149
MEP (Malaria Eradication Programme), 10, 18–19, 22–30, 123–124, 132
Merck & Co., contributions of, to disease control, 126
Monkeypox, 121
Montagu, Lady Mary Wortley, promotion of smallpox inoculation, 47
Mosquitoes, as malaria vectors
in Belize, 29
in Brazil, 13–14
DDT spraying programs for, 15–24, 120
habitat of, 39
on house walls, 20–24
in India, 26–27
land use changes and, 10–12
in Mali, 30–36
nets for, 36
in Nigeria, 21–22
in Panama Canal building, 12
parasite biology in, 6, 39
in Pontina, Italy, 12–13
species variations in, 26–27, 39
in United States, 5–6
Mozambique, national immunization days in, 133–134
Mussolini, Benito, swamp drainage project of, 12–13
Mutations
in malaria resistance, 39–40
in poliovirus, 114–115
N
National Eradication Program, for malaria, 17
National Foundation for Infantile Paralysis, 89–90, 92–93
National immunization days, 102–103
in Afghanistan, 106–107
in Brazil, 96–97
in China, 102
in Côte d'Ivoire, 131
in Cuba, 97
human resources for, 137
in Mozambique, 133–134
in Pakistan, 106–107
National Malaria Control Programs, 32, 35–36, 129–130
National Polio Control Program, in Brazil, 94–97
National Vaccination Day
in Brazil, 96–97
in Cuba, 97
Nepal, polio eradication in, 106, 156–157
New York City, polio epidemic in (1916), 86–87
Nigeria
  guinea worm eradication in, 130
  malaria eradication in, 21–22
  polio eradication in, 106
  safe water supplies developed in, 138–139
  smallpox eradication in, 152–153
Novartis, contributions of, to leprosy control, 127

O
Obasanjo, Olusegun, on polio eradication, 79
Oblapenko, George, in polio eradication, 82–83
Operation Crocodile, in smallpox eradication, 65–66
Oral polio vaccines, see Polio vaccines, live, attenuated (Sabin)

P
Pakistan
  national immunization day in, 106–107
  polio eradication in, 154–155, 161–163
Pan American Health Organization
  measles eradication program of, 139
  on polio eradication, 81–82, 98–102
Pan American Sanitary Organization
  on smallpox eradication, 50–51
Panama Canal, building of, malaria and, 12
Paralysis, infantile, see Polio
Peru, polio eradication in, 100–101
*Plasmodium* infections, see Malaria
Plowe, Christopher, malaria research of, 33–35, 147–148
Polio, 77–115
  in bioterrorism, 110
  bulbar, 114
  clinical features of, 114
  description of, by Sir Walter Scott, 112
  disease vs. infection, 114
  epidemics of
    in New York City (1916), 86–87
    in Sweden (1906), 84–86
    in United States, 86–87
  eradication of
    in Americas, 97–101
    in Bangladesh, 106, 161–162, 168–170
    biologic feasibility of, 121–122
    in Brazil, 94–97
    in Burkina Faso, 106
    in Chad, 171–173
    in China, 130
    in Côte d’Ivoire, 130–131
down clock for, 77–81
doubts about, 102
Dowdle on, 177
evaluation of, 103–107
financial considerations in, 124–125
Global Polio Eradication Initiative, 101
globalization of, 97–103
health system effects of, 134–135
human resource increase due to, 135–136
immunization policy after, 107–111
March of Dimes campaign for, 3, 89
national health policy changes due to, 133–134
in Nepal, 106, 156–157
in Nigeria, 106
in Pakistan, 154–155, 161–163
politics of, 81, 154–155
resistance to, 97–98
Rotary International in, 78, 79, 100–101, 102, 125, 129, 131, 179
social benefits of, 132–133
Stop Transmission of Polio program in, see Stop Transmission of Polio
strategy after, 123
surveillance in, 94, 102–104, 122, 137, 138
terrorism effects on, 106–107
vaccines for, see Polio vaccines
vitamin A deficiency campaign with, 136–137
in Yemen, 106
history of, 83–87
immunity to, 87–88, 90
mild cases of, 94
National Foundation for Infantile Paralysis, 89–90, 92–93
outbreaks of, 84–87
in Brazil (1979), 96
in Bulgaria (2001), 82–83
in Hispaniola (2001), 81–82
pathophysiology of, 87–88, 90, 113–114
post-polio syndrome after, 114
President Roosevelt as victim of, 88–92
serotypes of, 115
transmission of, 87–88, 112–113
by vaccines, 81–82, 108–110
virus causing, see Poliovirus
Polio Pledge, 80
Polio Plus campaign, 100
Polio vaccines
infections from, 81–82, 108–110
killed (Salk)
defective, with live virus, 92
in developing world, 92
efficacy of, 91–92
vs. live, attenuated vaccine, 91–92
testing of, 91–92
live, attenuated (Sabin)
in Brazil eradication program, 94–97
in developing world, 92
vs. killed vaccine, 91–92
testing of, 92–93
manufacture of, accidental virus release in, 109–110
after outbreaks, 82–83
strategy after eradication, 123
testing of, 91–92
Poliovirus
accidental release of, in vaccine manufacture, 110
biology of, 112–113
culture of, 89–90
in immunocompromised persons, 110
mutations of, 114–115
replication of, 113
reservoirs of, 110–111
repositories of, 109–110
revertant strains of, 108
Politics
eradication programs and, 80, 128–131
of polio vaccination, 154–155
Pope, Alice, in polio eradication, 161–162
Post-polio syndrome, 114
Poverty, malaria and, 9, 128
Precision Fabrics Group, of DuPont Company, contributions of, to guinea worm eradication, 126
Primates, as potential smallpox reservoirs, 121
Q
Quick, Linda, polio eradication work of, 105–107
Quinine, for malaria, 11, 14
R
Resistance
of malaria drugs, 29–30
of mosquitoes to DDT, 21–22
Risi, João Baptista, in polio eradication, 96–97, 101, 121
River blindness, control of, corporate contributions to, 126–127
Robbins, Frederick, poliovirus culture methods of, 3, 89–90
Roll Back Malaria program, 31–32, 126
Roma population, polio in, 82–83
Roosevelt, Franklin Delano, as polio victim, 88–92

Index 193
Rotary International, in polio eradication, 78, 79, 100–101, 102, 125, 129, 131, 179
Rubin, Benjamin, smallpox vaccination needle developed by, 59
Russell, Paul, on malaria, 15

S
Sabin, Albert, polio vaccine of, 91, 93, 94–97
Sachs, Jeffrey, on malaria and poverty, 127–128
Salat, Amina, as last smallpox case in Ethiopia, 66–67
Salk, Jonas, polio vaccine of, 91–93
Sardinia, malaria eradication in, 16–17
Scott, Sir Walter, as polio victim, 112
Selassie, Haile, Ethiopian smallpox eradication program and, 130
Shalala, Donna, at Global Polio Partners Summit, 78, 79
Shining Path, in Peru polio eradication, 100–101
Sickle cell disease, malaria and, 40
Sierra Leone, smallpox eradication in, 59
Smallpox, 43–75
in bioterrorism, 70–71, 74–75, 122
clinical features of, 44
epidemiology of, 49–50
eradication of, see also Smallpox, vaccines for
in Africa, 150
in Bangladesh, 66
benefits of, 68–70
biologic feasibility of, 120–122
early indifference to, 50–51
in Ethiopia, 61–67, 130
Expanded Program for Immunization outgrowth from, 69
financial considerations in, 53, 55–56, 68, 123–125
in India, 54, 66
intensified program for, 56–60
vs. malaria eradication, 45, 53–54
in Nigeria, 152–153
Operation Crocodile in, 65–66
politics of, 80–81
Smallpox Eradication Programme, 46, 52–62, 68, 124–125
social benefits of, 132
in Somalia, 66, 67
Soviet arguments for, 52
surveillance in, 57–59, 64
World Health Organization in, 52–62, 68
forms of, variola major vs. variola minor, 73
gods of, 46
history of famous victims in, 45–46
treatment methods, 46–47
inoculation for, 47–48
last natural cases of, 43–45, 67
mortality rate in, 45
transmission of, 58, 73
treatment of, history of, 46–47
vaccines for bifurcated needle for, 59
for bioterrorism, 70
compulsory use of, 49
discontinuation of, 122
early use of, 49–50
efficacy of, 54
hydraulic delivery device for, 55
improvements in, 59
Jenner work on, 48, 50
opposition to, 49–50
revaccination with, 49
stockpiled for terrorism, 122
virus causing (variola virus) biology of, 72–73
destruction of, 122–123
laboratory accident with, 122
replication of, 73
repositories for, 70, 74–75, 122–123
reservoirs for, 121
Smallpox Eradication Programme, 46, 52–62, 68, 124–125
Social issues, in eradication programs, 22–27, 131–133
Somalia
last natural smallpox case in, 43–45, 67
smallpox eradication in, 66, 67
Soper, Fred, malaria eradication work of, 13, 16–17, 27–28
Soviet Union
polio vaccine testing in, 93
smallpox eradication in, 52
Spradling, Phillip, in Nepal polio eradication, 156–157
Stewart, Steve, in polio eradication, 168–170
Stop Transmission of Polio, 105–107, 166–167
in Bangladesh, 161–162, 168–170
in Chad, 171–173
in Pakistan, 154–155, 161–163
Sudan
eradication program difficulties in, 135
guinea worm eradication in, 137
preventive health services in, 137
Swamps, malaria and, 10–12
Sweden, polio epidemic in (1906), 84–86
Swezy, Virginia, as STOP Deputy Director, 166–167
T
Tao Te Ching, on leadership, 117
Trachoma, control of, corporate contributions to, 127
Tuberculosis, eradication programs for, 141–144
Turner, Ted, 78, 125
U
United Nations Children’s Fund, polio Countdown Clock of, 77–81
United Nations Foundation, 125
USAID, measles vaccine program of, 149–150
V
Vaccines
for malaria, 40–42
measles, 139–141, 149
for polio, see Polio vaccines
refrigeration equipment for, 138
for smallpox, see Smallpox, vaccines for
Variola infections, see Smallpox
Viruses, see also specific viruses
description of, 72
Vitamin A deficiency, supplements for, 136–137
W
Warm Springs Foundation, Georgia, 89
Water, drinking, treatment of, for guinea worm eradication, 126–127
Water and Sanitation Decade, 138–139
Weller, Thomas, poliovirus culture methods of, 3, 89–90
Wickman, Ivar, on Swedish polio epidemic, 85–86
Wilson, John Rowan, on polio, 77
World Health Assembly
description of, 181
on malaria eradication, 18
on polio eradication, 101, 133
program approval by, 129
on smallpox eradication, 51–52
World Health Organization, see also World Health Assembly
Alma-Ata, Kazakhstan, conference of (1978), 132
endorsement of, 129
World Health Organization  
(Continued)  
functions of, 181  
history of, 181  
Malaria Eradication Programme of,  
10, 18–19, 22–30, 123–124  
organization of, 181  
on polio eradication, 78, 82–83,  
97–98, 101–104, 106–107  
smallpox eradication program of,  
46, 52–62, 68, 124–125  
Water and Sanitation Decade,  
138–139

World War II, malaria in, 14  

Y

Yaws eradication, 129  

Yemen

polio eradication in, 106  
preventive health services in, 134

Z

Zhadanov, Viktor, on smallpox  
eradication, 52, 129