Measles

Control Strategies and Obstacles to Control

William Moss

Major Global Infectious Diseases: Prospects for Control

Winter Institute 2019
Objectives

Goals of measles programs
Disease burden
Basic epidemiology of measles virus
Strategies for control
Obstacles to control
Eradication
Measles History

Rhazes distinguishes smallpox and measles

Francis Home transmits measles through blood, analogous to variolation

Henry Koplik describes spots on the buccal mucosa with measles

Joseph Goldberger and John Anderson show measles is caused by a filterable virus

Licensorate of first attenuated measles vaccine

Start of the Expanded Programme on Immunization

Measles and Rubella Initiative launched

Measles elimination goal for European and Eastern Mediterranean regions

Gavi, the Vaccine Alliance commits support for measles and rubella vaccines

Certification of measles elimination in the Americas September, 2016; rubella declared eliminated in 2015


Thomas Sydenham provides first detailed clinical description of measles

Peter Panum investigates measles outbreak on Faroe Islands and describes incubation period and lifelong immunity

Ludvig Hektoen transmits measles experimentally and studies effects

John Enders and Thomas Peebles isolate measles virus

Maurice Hilleman further attenuates measles vaccine; rubella vaccine introduced in 1969

Cuba conducts first mass measles vaccination catch-up campaign

Measles elimination goal for the Western Pacific region

Measles elimination goal for Africa and South East Asia Regions

Goals of Measles Programs

Measles control
reduce number of measles cases and deaths

Measles elimination
stop indigenous transmission in a region

Measles eradication
stop global transmission
Measles Eradication Goal

SOUTH-EAST ASIA REGION PLANS TO ELIMINATE MEASLES BY 2020

All six WHO regions now have measles elimination goals

13 SEPTEMBER 2013. GENEVA, WASHINGTON D.C.: Today the Measles & Rubella Initiative welcomes the commitment of South-East Asian countries to eliminate measles and control rubella by 2020. All six World Health Organization regions have now resolved to eliminate measles by or before 2020.
The Burden of Disease Due to Measles
Estimated Number of Annual Measles-related Deaths Worldwide, 1999–2003

*In 2002, the World Health Assembly urged Member Countries to reduce measles deaths by half by 2005, compared with 1999 estimates.*

Source: Weekly Epidemiological Record 2005; 80:80
74% Reduction in Measles Deaths 2000 - 2010

Measles contributes 20% to the overall reduction in <5 child mortality (MDG 4)

Projected current trend

Trend to reach goal

FIGURE. Estimated number of measles deaths and number of deaths averted by measles vaccination — worldwide, 2000–2014

- Estimated no. of measles deaths in absence of vaccination
- Estimated no. of measles deaths with vaccination
- 95% confidence limits for no. of measles deaths with vaccination
- Estimated no. of deaths averted by measles vaccination
FIGURE. Estimated annual number of measles deaths with and without vaccination programs — worldwide, 2000–2017*

- Estimated measles deaths in absence of vaccination
- Estimated measles deaths with vaccination

No. of measles deaths (millions)

Year


Transmission Dynamics

Not to be removed before

CONTAGIOUS DISEASE

MEASLES

All persons are notified of the presence of this disease and are warned of the danger of visiting or coming in contact with those sick with it, except by permission of the Bureau of Health, under penalty of NOT LESS THAN FIVE DOLLARS ($5.00), NOR MORE THAN TWENTY FIVE DOLLARS ($25.00), for any violation of this Order.

By Order of the BEAVER FALLS HEALTH DEPT.

[Signature]

Health Officer
Transmission Characteristics

Routes of transmission
   respiratory droplet, airborne and direct contact

Humans only reservoir
   monkeys infected but do not sustain transmission

Incubation period
   10 days to fever, 14 days to rash

Infectious period
   several days before rash until several days after rash

Highly contagious
Measles Virus is Highly Contagious

$R_0$: basic reproductive number

The average number of secondary cases when one index case is introduced into a susceptible population.

Herd immunity threshold

$$H = 1 - \frac{1}{R_0}$$

- measles: $R_0 = 12-18$, $H = 93-95\%$
- polio: $R_0 = 5-7$, $H = 80-85\%$
- small pox: $R_0 = 5-7$, $H = 80-85\%$
Age Distribution

Figure 8-1. Age Distribution of Measles, Kinshasa, Zaire, 1983

Figure 8-2. Age Distribution of Measles, Matlab, Bangladesh, 1975-76

Figure 8-3. Age Distribution of Measles, Lesotho, 1988

Figure 8-4. Age Distribution of Measles, United States, 1989

Source: Lesotho 1990.

Source: MMWR 1990.
Strategies for Measles Control and Elimination

It cost less than $2.00 to vaccinate a child against both measles and rubella in low-income countries.

2 billion vaccinated since 2001.
Vitamin A and Measles Mortality

Measles Vaccines

Types of measles vaccines
- inactivated
- attenuated
- high-titer

Immunization schedules
- 9 vs. 12 months
- second dose

Stability and administration
- relatively heat-stable in lyophilized form
- loss of potency if stored above 8°C (cold chain)
- parenteral administration
Measles Vaccines

Age of Vaccination

Decline in passive maternal antibody vs. rise in measles incidence

“window of opportunity”

Proportion responding at different ages

- 85% at 9 months of age
- 90-95% at 12 months of age

95% who fail to respond to 1\textsuperscript{st} dose will respond to 2\textsuperscript{nd} dose
Summary of 65 published studies

Optimal Age of Vaccination

Neal Halsey
Impact of Measles Vaccine

Measles–United States, 1950-2001

Cases (thousands)


Vaccine Licensed

Measles Mortality Rate, USA, 1900-1997

Mortality Rate / 100,000

Year
Successful Measles Control and Elimination

Measles vaccination prevented 20.4 MILLION child deaths from 2000-2016!
“The build-up of susceptible children over time in a population is the most serious obstacle to measles eradication.”

PAHO Measles Eradication Field Guide
Stop measles with just one shot.

FREE from your local health authority

National Campaign Against Measles
# Measles Population Immunity

<table>
<thead>
<tr>
<th>% Coverage</th>
<th>% Vaccine Efficacy</th>
<th>% Immune 1st dose</th>
<th>% Immune 2nd dose*</th>
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<td>80</td>
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<td>90</td>
<td>85</td>
<td>81</td>
<td>97</td>
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* 95% efficacy & 90% coverage in an independent campaign
Measles Elimination Strategies

- Catch up
- Keep up
- Follow up
- Mop up

"I support the fight against Measles. Get your child vaccinated!"
7th-13th June 2003
Kalusha Bwalya
FIGURE 1
Mass vaccination campaign impact on morbidity: Cuba, 1971–1996*

Source: Cuba, Ministry of Health.
*Measles cases reported through 31 December 1996.
Progress Toward Global Goals

More than 50% of the 20.8 million children who did not receive one dose of measles vaccine in 2016 came from only 6 countries:
- Nigeria 3.3 million
- India 2.9 million
- Pakistan 2.0 million
- Indonesia 1.1 million
- Ethiopia 0.9 million
- DR Congo 0.7 million

Measles is one of the leading causes of death among children around the world.

245 children die every day, 10 every hour – despite the fact that a safe and effective vaccine has been available for over 50 years.
Measles and Rubella Targets

Global targets by 2015:
- Measles vaccination coverage ≥ 90% national and ≥ 80% every district
- Measles reported incidence <5 cases per million
- Measles mortality reduction of ≥ 95% vs. 2000

Regional Elimination targets:
- Measles: AMRO (2000); WPRO (2012); EURO/EMRO (2015); AFRO/SEARO (2020)
- Rubella: AMRO (2010); EURO (2015)

Global Vaccine Action Plan (GVAP) Goals:
By 2015:
- Measles elimination in 4 Regions
- Rubella elimination in 2 Regions
By 2020:
- Measles and rubella elimination in 5 Regions
Global Milestone: Vaccination Coverage

MCV1 Coverage in Infants, 2015

Global Measles Vaccine Coverage

Global Milestone: Measles Incidence

Global Measles Incidence by WHO Region, 2000 to 2015

Global Milestone: Measles Mortality

Estimated Annual Number of Global Measles Deaths, 2000 to 2015

Measles Deaths Fall to a Record Low Worldwide

Global Health
By DONALD G. McNEIL Jr.  DEC. 26, 2017

A child receiving measles vaccine in a refugee camp in Bangladesh last month. Annual deaths from measles have fallen below 100,000 worldwide, according to the World Health Organization.
Mohammad Ponir Hossain/Reuters

For the first time in history, annual deaths around the globe from measles have fallen below 100,000, the World Health Organization announced this year. As recently as the 1980s, measles killed 2.6 million people a year.
21 Million Infants Missed MCV1, 2013

(need to reach ≈ 8.4 m to achieve 90%)

- 60% live in
  - India
  - Nigeria
  - Ethiopia
  - Indonesia
  - Pakistan
  - DRC

Measles in the Americas
2003 - 2018

World Health Organization data through week 40 2018
Measles in the European Region
2014 - 2018

World Health Organization data through July 2018
CASE STUDY: U.S. VACCINE VICTORIES

Since the 1940s, as new vaccines have been released (striped circles), the incidence of infectious diseases that once afflicted hundreds of thousands of Americans—mostly children—has plummeted. Polio and rubella are gone from the U.S.; diphtheria is rare. It used to kill up to 15,000 a year.

- **Rubella**: Vaccine was released in 1967; data available as of 1968.
- **Mumps**: Outbreaks of mumps in recent years have hit colleges, where students live in close quarters, especially hard.
- **Hepatitis A**: Hepatitis B vaccine was recommended only for high-risk groups at first, but in 1991 the recommendation was extended to all infants.
- **Hepatitis B**: Lower vaccination rates, mostly among preschoolers in low-income areas, helped fuel a resurgence of measles from 1989 to 1991.
- **Measles**: A measles outbreak struck 383 people in 2014, primarily in unvaccinated Amish communities in Ohio.
- **Varicella (chickenpox)**
- **Diphtheria**: The first pertussis vaccine was licensed in 1944 but mass distributed only in 1948, when it was combined with diphtheria and tetanus vaccines.
- **Pertussis** (whooping cough): One reason for the rebound in pertussis could be that newer vaccines with fewer side effects also wear off sooner.
- **Polio**: Vaccination wiped out polio in the U.S. Worldwide, 37 cases were reported in 2016—a 99 percent drop since 1988.

Data for 2015 and 2016 are provisional.

MONICA SERRANO, NGM STAFF
KELSEY NOWAKOWSKI SOURCES: U.S. CENTERS FOR DISEASE CONTROL AND PREVENTION; WORLD HEALTH ORGANIZATION; IMMUNIZATION ACTION COALITION
Death by measles and polio can be ended worldwide

Let's talk about the importance of vaccination. It is the most effective way to prevent measles and polio, as well as other deadly diseases. Since the introduction of vaccines, the number of deaths from these diseases has declined dramatically.

In 1980, there were over 1 million measles and 100,000 polio cases worldwide. However, since the introduction of vaccines, the number of cases has been reduced to less than 1 million and 200 cases, respectively.

In the United States, measles has been eradicated since 2000. The last case of measles occurred in 2000. Since then, there have been no new cases of measles in the United States.

Polio has also been eradicated from the Western Hemisphere since 1994. The last case of polio in the Western Hemisphere occurred in 1994.

However, there are still outbreaks of measles and polio in other parts of the world. In Africa, for example, measles continues to be a major killer. In 2019, there were over 200,000 deaths from measles in Africa.

In order to end these diseases, we need to vaccinate everyone, especially children. Vaccines are safe and effective. They work by priming the immune system to recognize and fight off the disease.

Let's work together to end measles and polio. It can be done, and we can do it together.
Biological Feasibility

Characteristics Important for Eradication
- Non-human reservoirs
- Accurate diagnosis
- Effective intervention
- Low infectivity

Potential Obstacles
- High contagiousness
- Prolonged viral shedding
- Subclinical transmission
- Viral evolution and diversity
Technical Feasibility

Vaccine Characteristics for Eradication

- Effective
- Low Cost
- Safe

Potential obstacles

- Need for cold chain
- Cannot immunize young infants
- HIV epidemic
- Disposal of needles
## Logistical Feasibility

<table>
<thead>
<tr>
<th>Effective Control Strategies</th>
<th>Potential Obstacles</th>
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<tbody>
<tr>
<td>High routine vaccination</td>
<td>Misperceptions of risk</td>
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<tr>
<td>2nd opportunity</td>
<td>Political will</td>
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<tr>
<td>Surveillance</td>
<td>Resources</td>
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<td>Outbreak response</td>
<td>War and civil unrest</td>
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<td>International travel</td>
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<td>High population density</td>
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Major Threats to Eradication

Funding gap and sustainability
Weak routine immunization and reporting systems
Measles control in India
Resistance to immunization and anti-vaccine lobbies
Population growth and urbanization
Conflict and emergency settings
Global travel and mobility
Failure to achieve polio eradication
The Measles and Rubella Initiative
Can Measles Vaccination Be Stopped?
Should Measles Eradication be Attempted?