The long road to disease eradication and waning vaccine immunity

Peter McIntyre

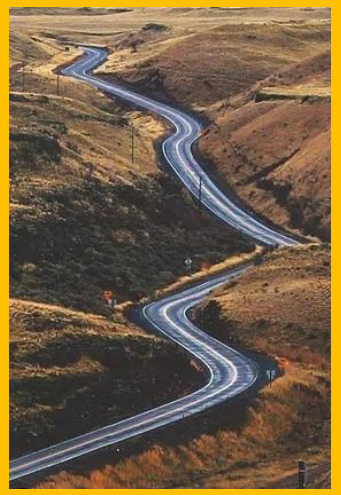
University of Otago
ŌTĀKOU WHAKAIHU WAKA

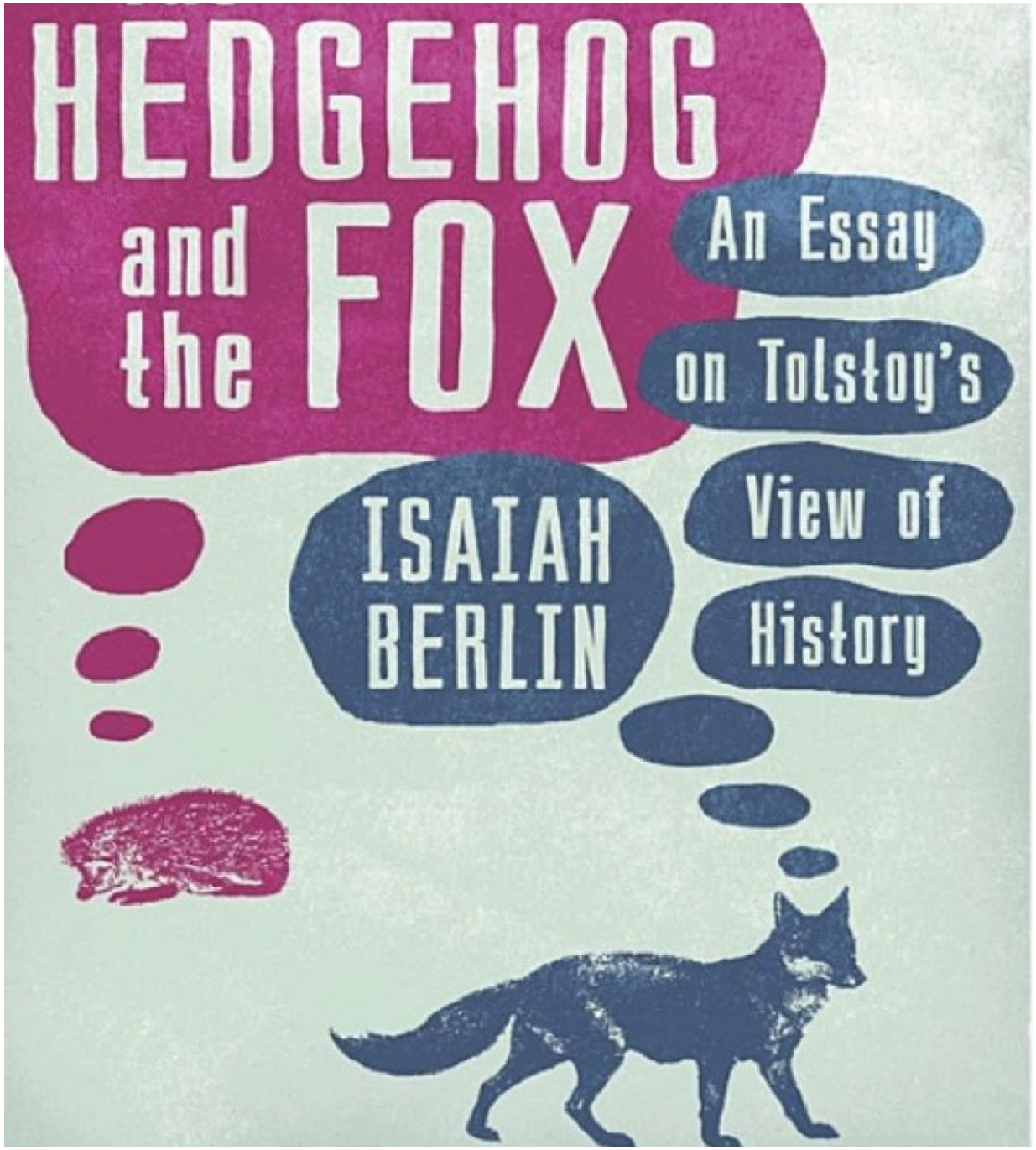
Walking backwards into the future

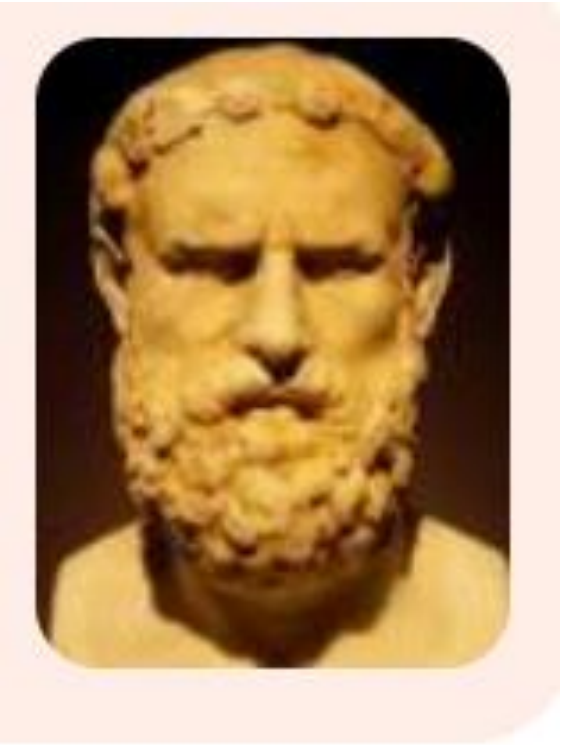
With my eyes fixed on the past

THREE DISEASES

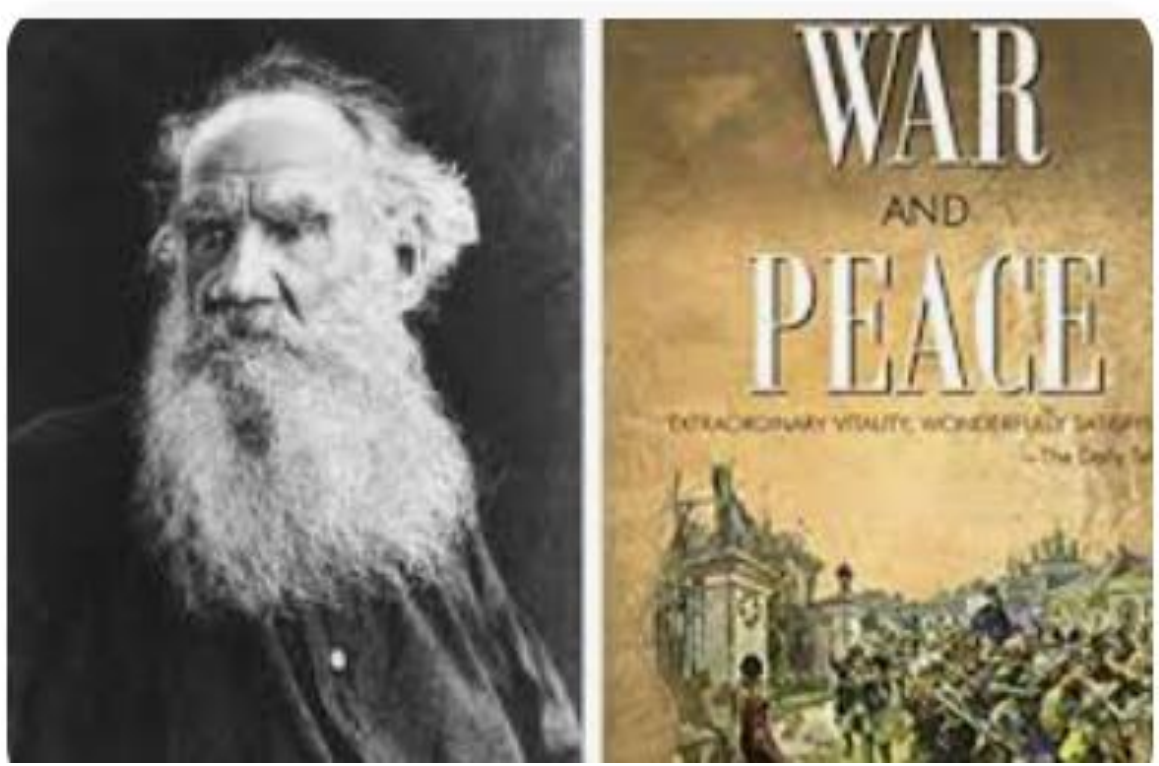
THREE THEMES







Archlicous 680 – 645 BC



OPINION

JENEEN INTERLANDI

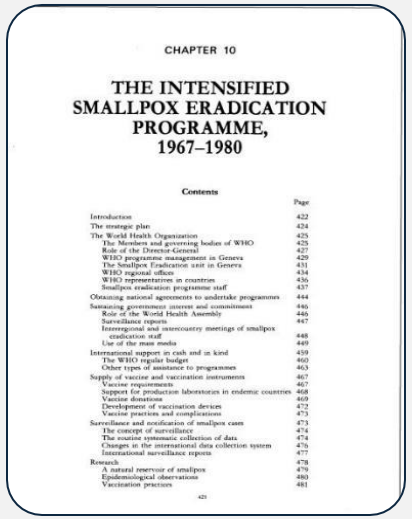
The Public Health Disaster Everyone Saw Coming

Aug. 28, 2025

Susan Monarez was fired as director of the Centers for Disease Control this week,

VPD elimination strategies – 8 diseases

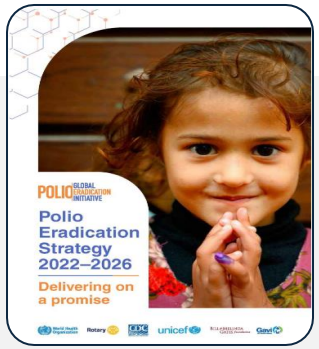
At founding of EPI, one disease - specific strategy: **smallpox**

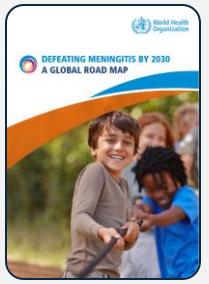


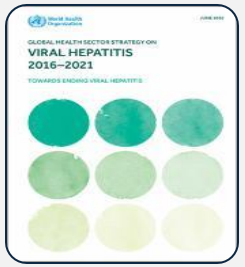
CHAPTER 10

THE INTENSIFIED SMALLPOX ERADICATION PROGRAMME, 1967–1980

Contents

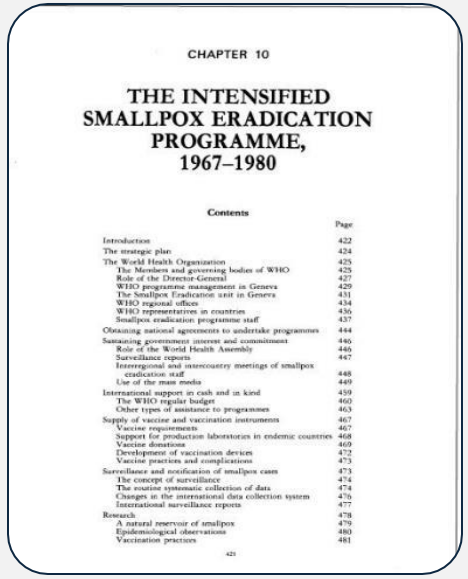






1967 1974 2024

VPD elimination strategies
Smallpox

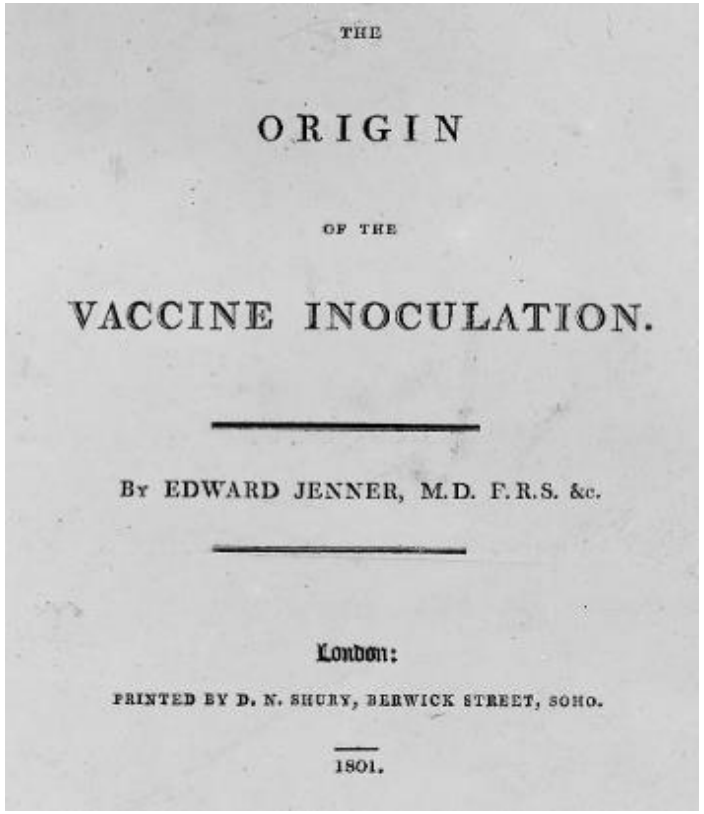


CHAPTER 10

THE INTENSIFIED SMALLPOX ERADICATION PROGRAMME, 1967–1980

Contents

1801


THE

ORIGIN

OF THE

VACCINE INOCULATION.

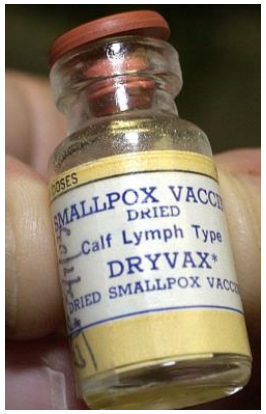
By EDWARD JENNER, M.D. F.R.S. &c.

London:

PRINTED BY D. N. SHURY, BERWICK STREET, SOHO.

1801.

"It now becomes too manifest to admit of controversy that the annihilation of the smallpox, the most dreadful scourge of the human species, must be the result of this practice (vaccination)."



- **1801**
- **1958** – 11th World Health Assembly – Eradication proposed
- **1967** – Programme began

10 years

- **1977** – Last case

- Stable vaccine
- Mass production
- Special needle

- Shift in strategy
  100% coverage
  to
  “search and destroy”

GLOBAL SMALLPOX ERADICATION

The historically important dates highlighted in the map show countries in which the last naturally acquired cases of smallpox occured.

The years for each continent correspond to the year when the disease was eradicated there.

Rahima Banu

NORTH AMERICA
1952

EUROPE
1953

ASIA
1975

AFRICA
1977

SOUTH AMERICA
1971

AUSTRALIA*

Ecuador, 1962
Last known case of variola major on the continent

Brazil, April 19, 1971
Last known case of variola minor on the continent

Bangladesh, October 16, 1975
Last known case of variola major in the world

Somalia, October 12, 1977
Last known case of variola minor in the world

Ali Maalin

Australia
NZ

1952, North America

1953, Europe

>10 M cases
> 2M deaths

1971, South America

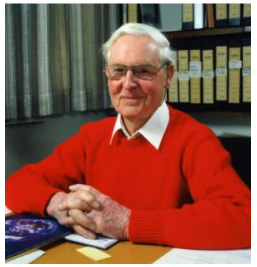
1975, Asia

1977, Africa

1980, WHO declares the world free of smallpox

1919 — 1950 — 1960 — 1967 — 1970 — 1980

“Smallpox eradication was achieved, but just barely achieved”



Frank Fenner

D. A. Henderson

Had the biological and epidemiologic characteristics of the disease, or the world political situation, been even slightly more negative, the effort might have failed” [2]

1. Fenner F. Global eradication of smallpox. Reviews of infectious diseases. 1982;4:916-30
2. Arita I, Nakane M, Fenner F. Is polio eradication realistic. Science. 2006;312:852-4.

DA Henderson 2000: **20 years post smallpox eradication**

Smallpox eradication has spared the global community

- 350 million cases
- 40 million deaths
- Annual savings > US$ 2 billion

2011

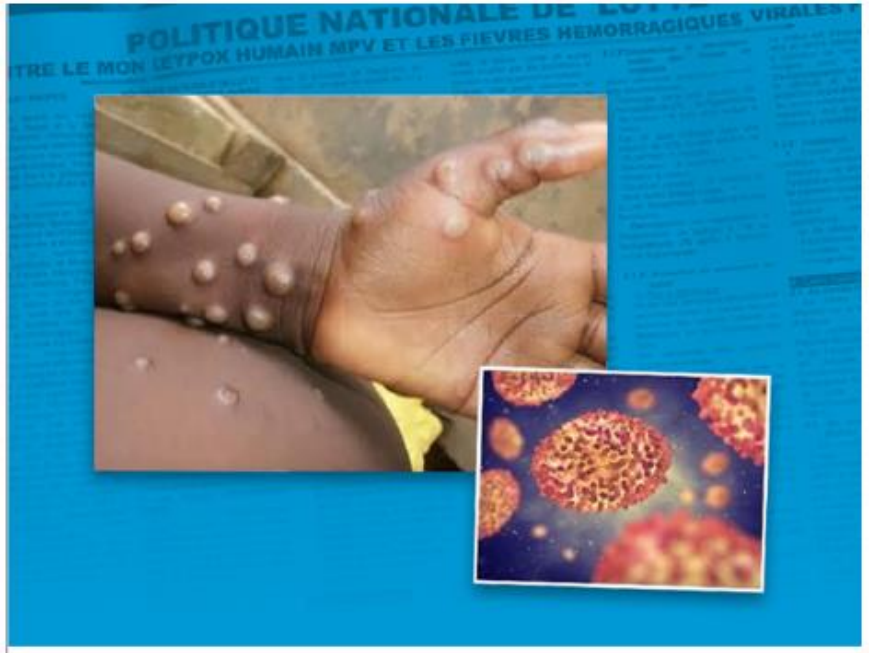
Whither monkeypox vaccination

Anne W. Rimoin [a], Barney S. Graham [b,*]

Monkeypox probably always around
Not recognised until 1970
- post smallpox elimination in DRC

> Thirty years later, the incidence of human MPX in the same region appears to have markedly increased

2023



La variole simienne (monkeypox) en République démocratique du Congo

Evaluation de la situation
Rapport de mission conjointe

Le Ministère de la Santé publique, Hygiène et Prévention
avec
L'Organisation mondiale de la Santé

22 novembre – 12 décembre 2023

MINISTÈRE DE LA SANTÉ PUBLIQUE, HYGIÈNE ET PRÉVENTION

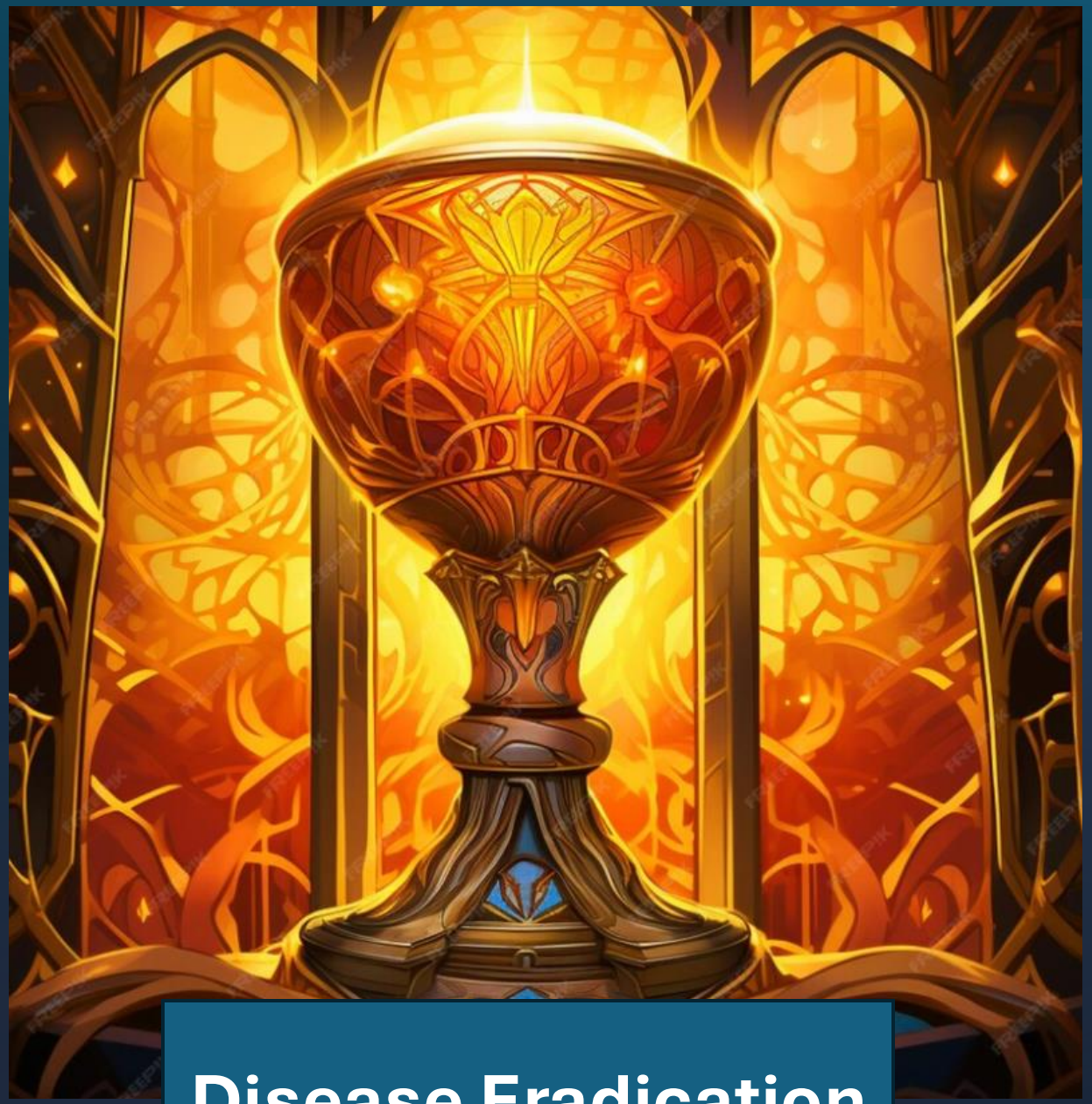
Organisation mondiale de la Santé

Driven to Extinction

Rinderpest

Mortality approached 100%
Eradicated 2011
Morbillivirus related to measles
Live attenuated vaccine
Heat stable

"What made eradication possible was a really good vaccine and political support. **You don't ask a cow if it wants to be vaccinated”**



Disease Eradication

Gains

- Enormous potential cost savings
- Builds health infrastructure
- Only sure route to equity


ZERO
(IS THE LONELIEST NUMBER)

Gates Foundation

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Home / Ideas / A three-part plan to eliminate COVID-19

A THREE-PART PLAN TO ELIMINATE COVID-19

By Bill Gates

Chair, Board Member, Gates Foundation

Sep 29, 2020

The Guardian

Int

All countries should pursue a Covid-19 elimination strategy: here are 16 reasons why

Michael Baker and Martin McKee

Thu 28 Jan 2021 01.37 GMT

The New York Times

Video: Eliminating Covid-19 Is ‘Incredibly Difficult,’ Jacinda Ardern Says

Prime Minister Jacinda Ardern of New Zealand acknowledged an end to the country's “Covid zero” strategy, seven weeks into a lockdown that...

4 Oct 2021

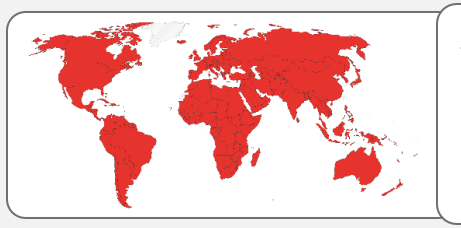
VPD elimination strategies – Polio

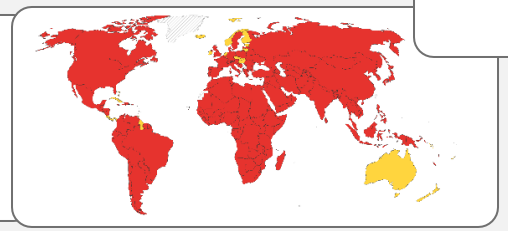
Eradication of a second human disease?

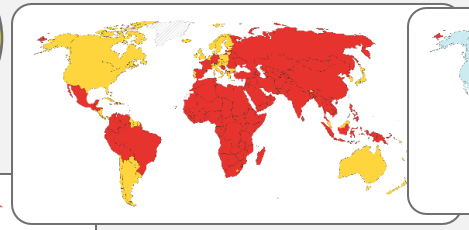
Endemic

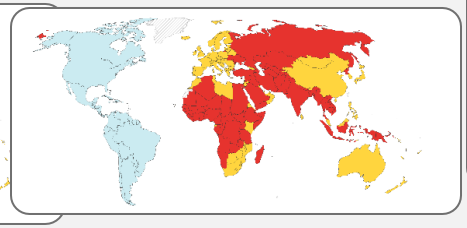
Polio-free (not certified)

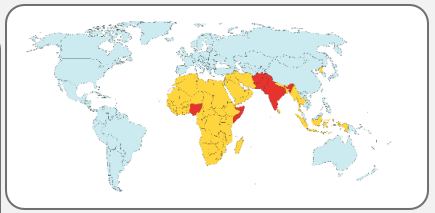
WHO Regions polio free







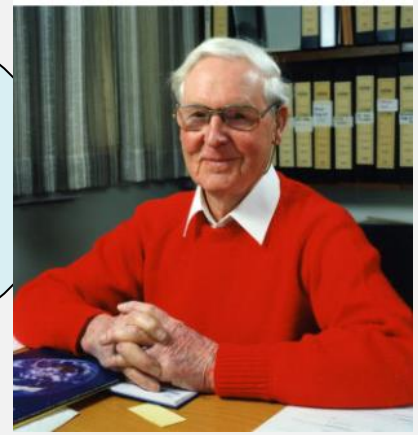




POLIO GLOBAL ERADICATION INITIATIVE

World Health Organization · unicef · CDC · Rotary · Bill & Melinda Gates foundation

4 endemic countries
India
Pakistan
Afghanistan
Nigeria



Salk developed polio inactivated vaccine

Sabin develops a "live" oral polio vaccine

NZ 1962
Australia 1973

125 countries
> 350,000 cases

23 countries
99% case reduction

1955 1961 1974 1988 2000 2005

PUBLIC HEALTH

Is Polio Eradication Realistic?

Isao Arita[1*], Miyuki Nakane[1], Frank Fenner[2]

All maps from: https://ourworldindata.org/grapher/progress-towards-polio-eradication?time

Smallpox vs Polio

Eradication easier if…	Smallpox	Polio
Only in humans	Yes	Yes
Cases are obvious	Old cases: scars New cases – sick Contacts traced ✓✓	Undetected cases ++ Paralysis 1/200 Contacts traced ✗✗
Transmission only *after* rash	Yes	No
Infectiousness	+	++
Serotypes	One	Three
Vaccine delivery	Single dose No cold chain	Multiple doses Cold chain required

‘The Final Inch’ Towards Eradication in India

2010-12

- No Type 2 Poliovirus since 1999
- **New science:**
  - Bivalent OPV (Types 1 and 3)
  - Improve immune “take”
- **New delivery strategies:**
  - Including other health campaigns
  - House to house

The Original Plan

35 years and counting

CERTIFICATION (GPEI DISSOLVES)

2013 — 2019 — WHA — 2023

Polio Eradication Endgame Strategic Plan & Midterm Review

2013–2019

Polio Endgame Strategy 2019–2023

A review of:

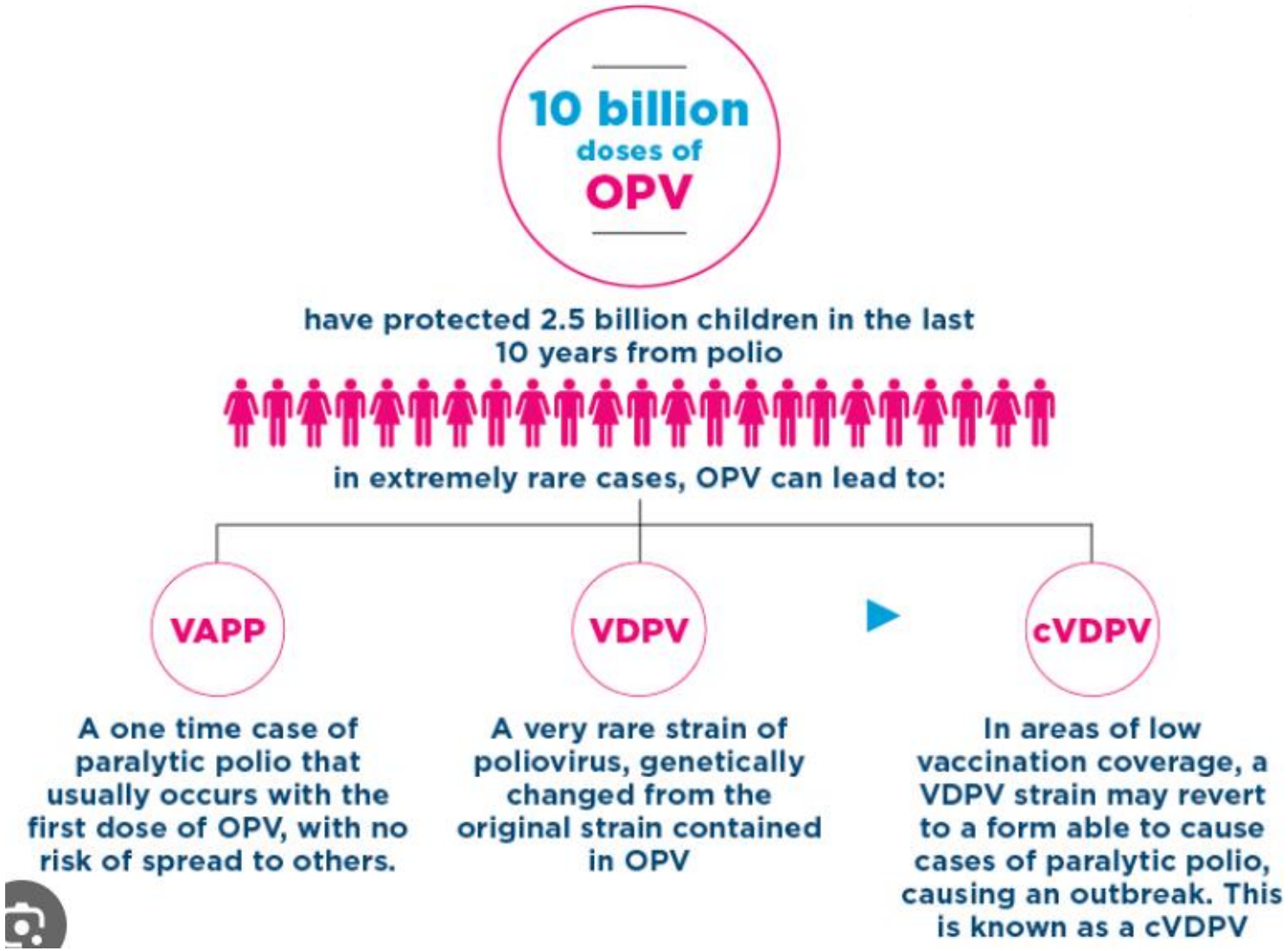
- what activities will remain
- what changes will be introduced
- what innovations will be needed

2019–2023

- GVAP 2.0
- Gavi 5.0
- WHO IVB Strategy
- UNICEF Immunization Strategy
- Global Health Security Agenda

2024+

Vaccine-derived polioviruses – OPV



Global OPV2 withdrawl “the “switch”
April 2016: 155 countries

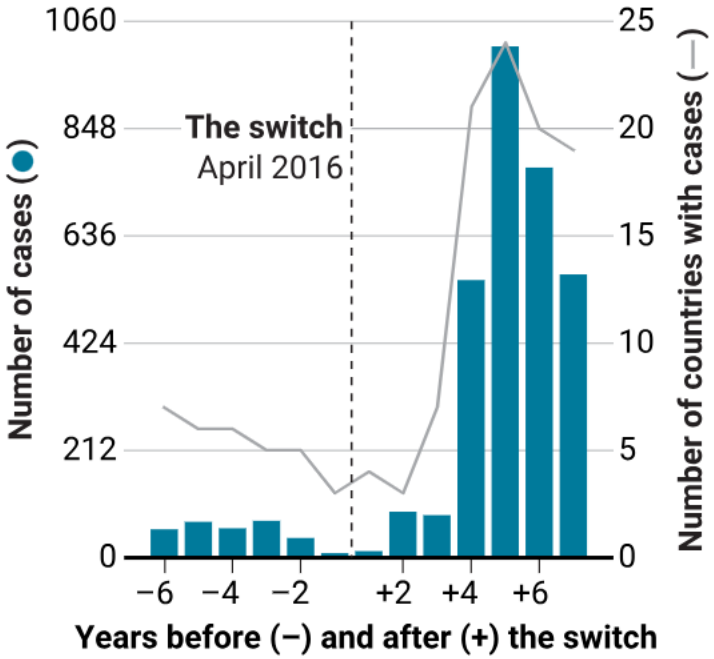
‘Unqualified failure’ in polio vaccine policy left thousands of kids paralyzed

Well-intentioned decision to switch oral polio vaccines in 2016 backfired, new draft report says

7 MAY 2024 • 4:45 PM ET • BY LESLIE ROBERTS

A fateful decision

Type 2 vaccine-derived polio cases soared, and many more countries saw outbreaks, after the 2016 decision to drop the type 2 component from oral polio vaccines.

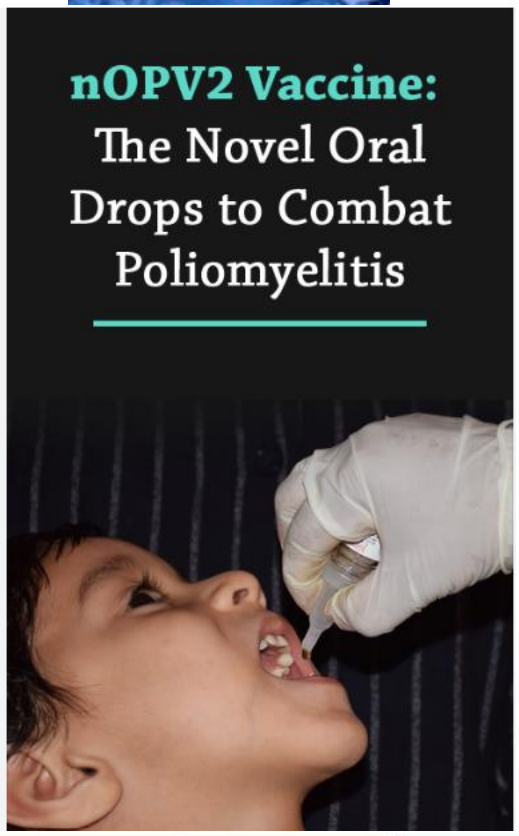


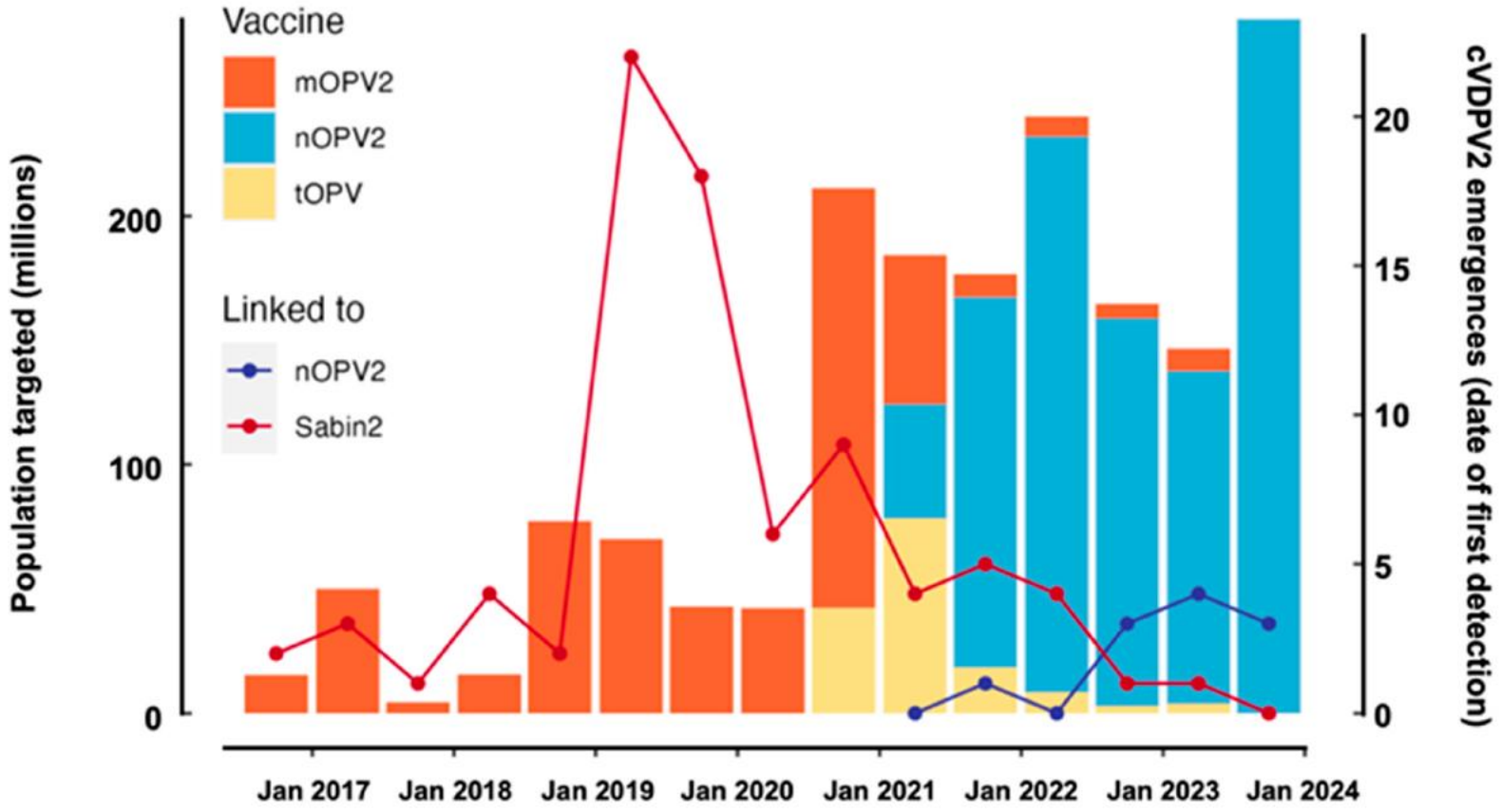
*Years range from 1 May to 30 April.

cVDPV2 cases: 318
Countries: 15

cVDPV2 cases: 3375
Countries: 44

Novel OPV 2 vaccine – vaccine-derived polio reduced >80%

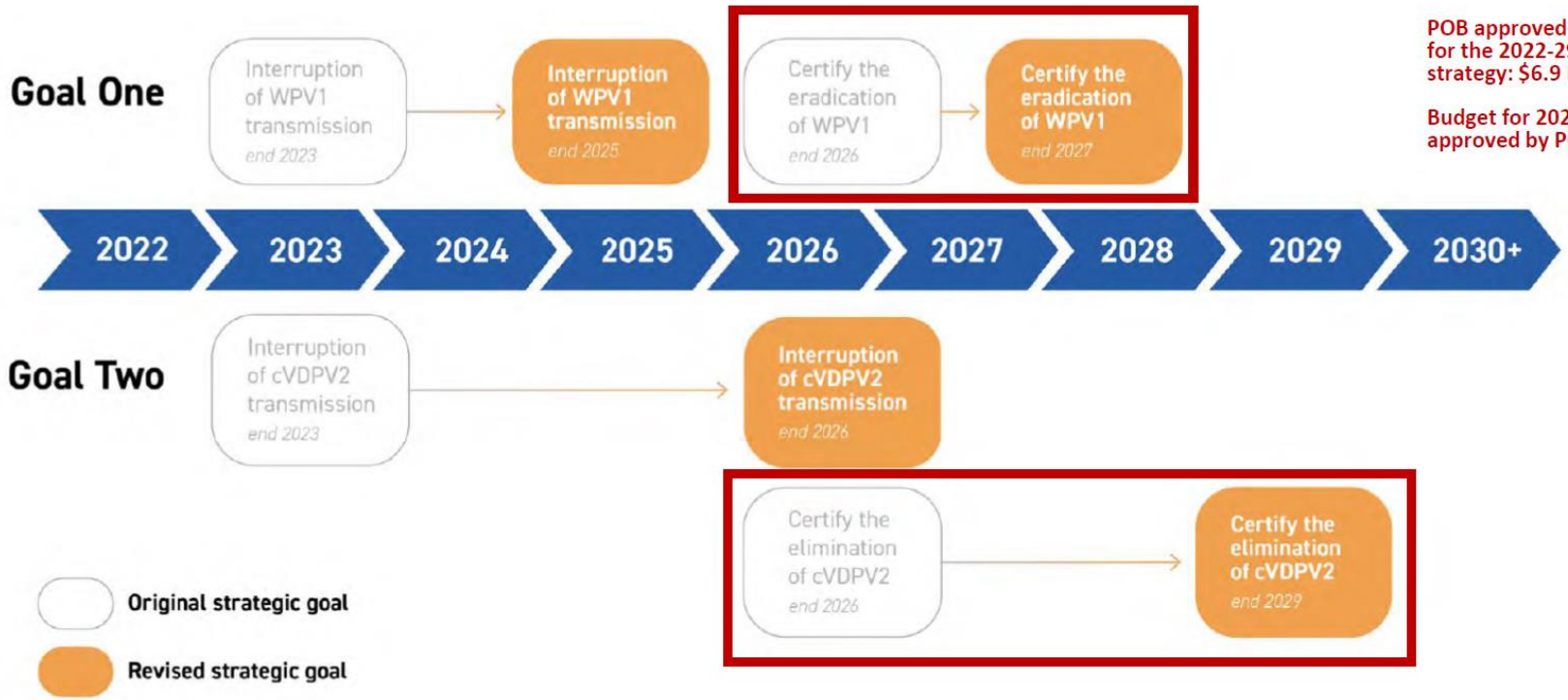




The New Plan

40 years
$A1B in 2025

Global Polio Eradication Strategy 2022-26; Extension to 2029



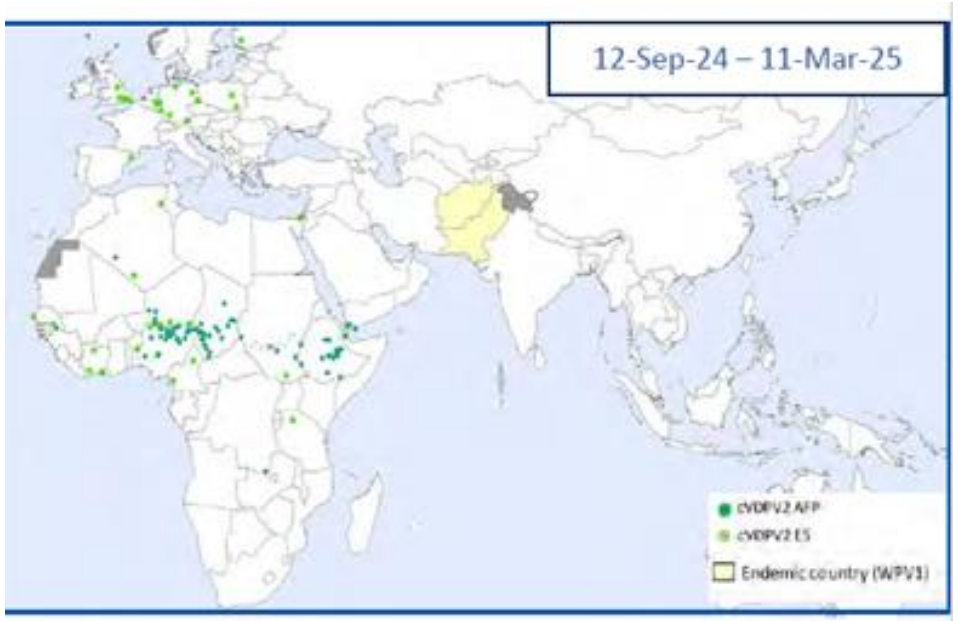
POB approved budget for the 2022-29 strategy: $6.9 B

Budget for 2025 approved by POB: $1.1 B

https://polioeradication.org/wp-content/uploads/2024/11/GPEI-Strategy-extension-20241113.pdf

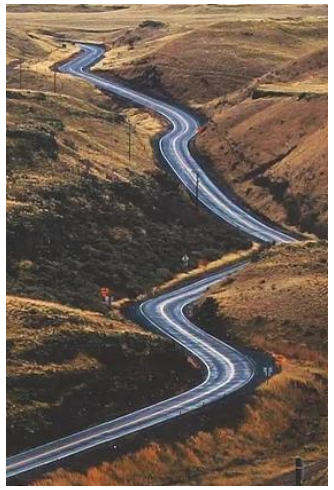
EVERY LAST CHILD

Wild type polio (type 1)



Vaccine derived polio (type 2)

Polio - summary

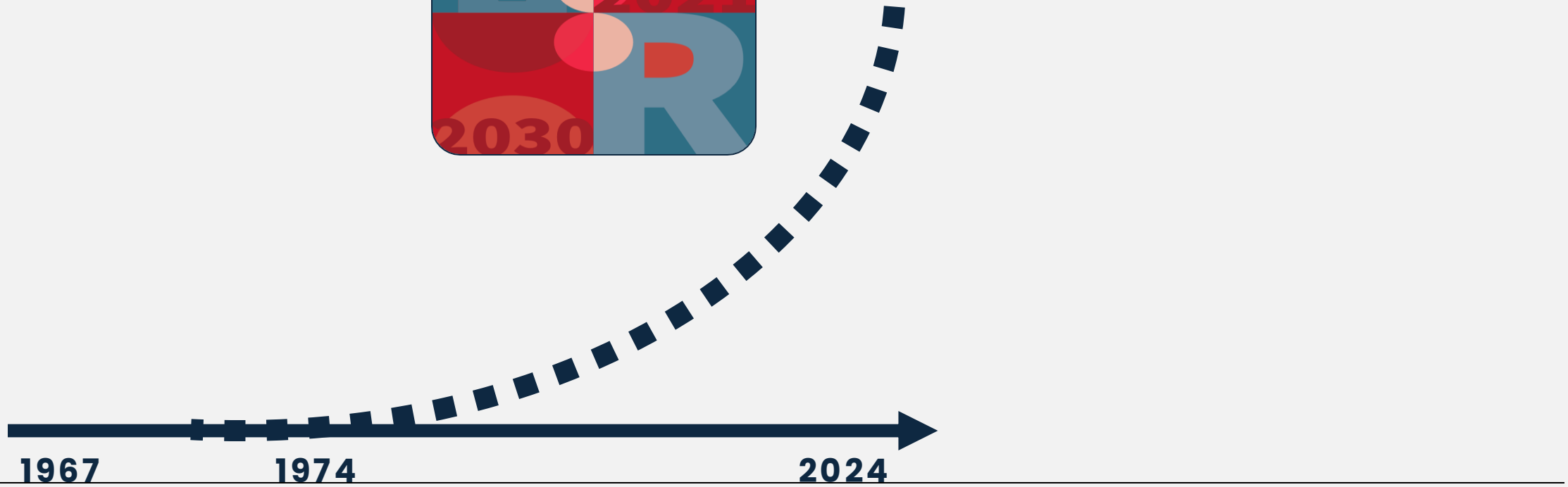


A LONG WAY TO GO
2030 +

ENCOURAGING
TRENDS

NEW VACCINES

VPD elimination strategies - measles



Eradication criteria

Eradication easier if…	Measles	Polio
Only in humans	Yes	Yes
Cases are obvious	Transmission before symptoms	Undetected cases ++ Paralysis 1/200
Transmission only *after* rash	No	No
Infectiousness	++++	++
Serotypes	One	Three
Vaccine delivery	Two doses Cold chain required	Multiple doses Cold chain required

Table 1. Criteria for assessing whether a disease can be eradicated—International Task Force for Disease Eradication, 1993.

Scientific feasibility
• Epidemiologic characteristics, including the potential existence of non-human reservoirs, ease of spread, induction of natural immunity, and ease of diagnosis; ✓ • Availability of an intervention, such as a vaccine, that ideally should be effective, safe, inexpensive, long-lasting, and easily deployed; ✓ • Demonstrated feasibility of elimination, such as documented elimination from a defined country or region. ✓
Political will and popular support
• Perceived burden of disease; • Expected cost of eradication; • Synergy of eradication efforts with other interventions.

World Health Assembly 2010

Measles Eradication should be pursued

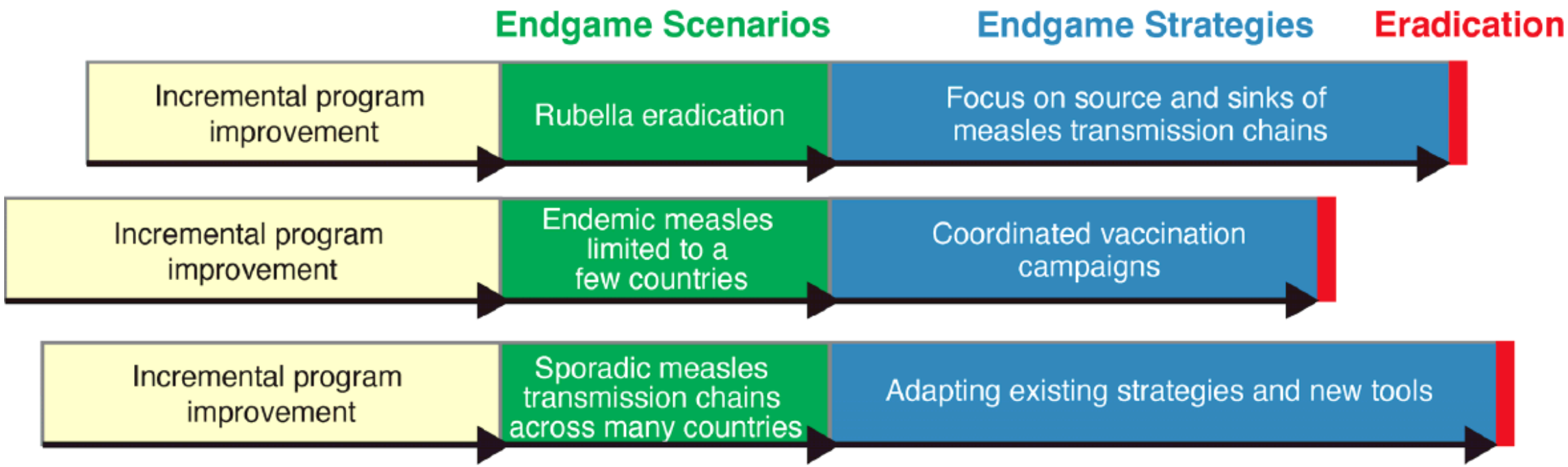
SAGE Meeting October 2019

Low probability of global eradication before 2050

Review

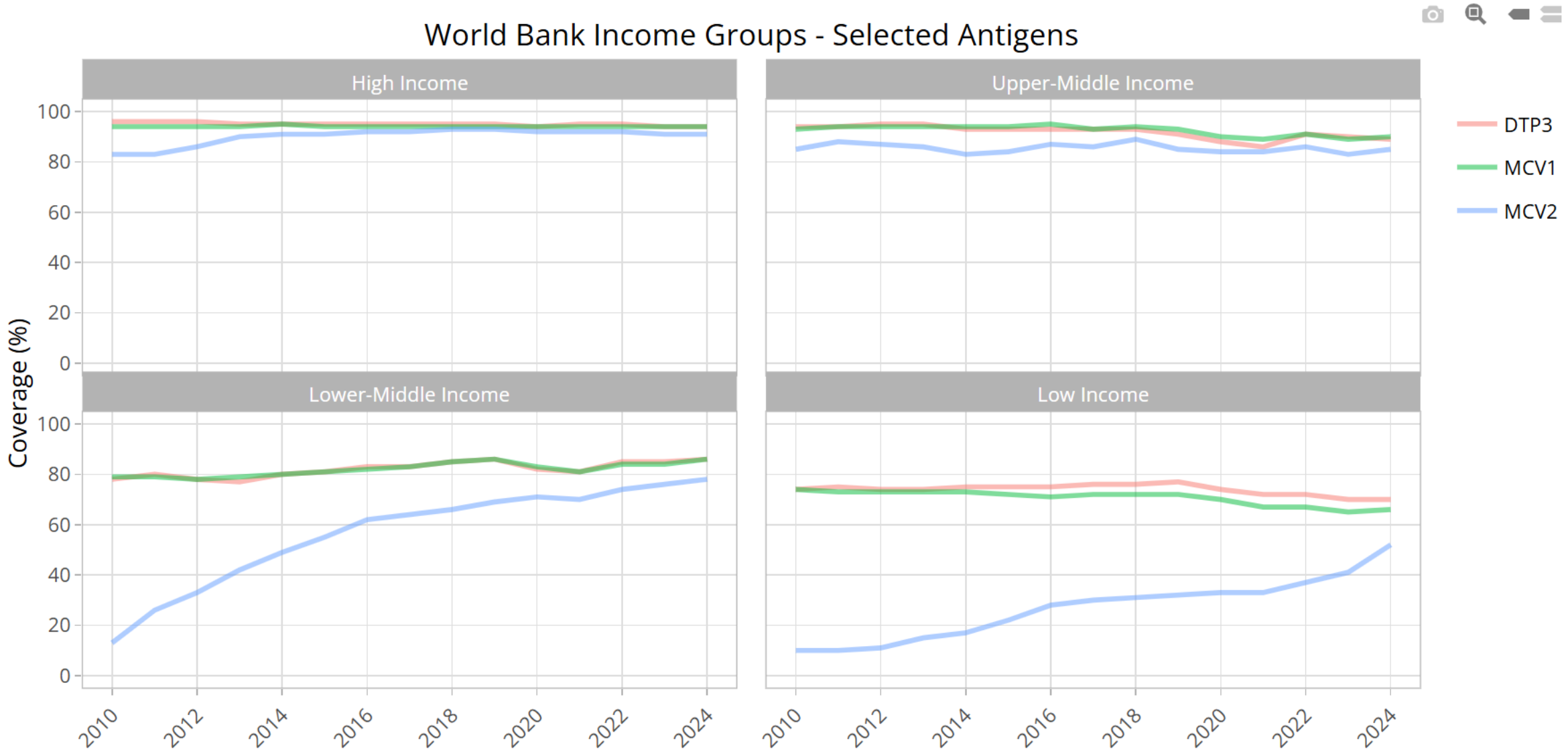
Possible Paths to Measles Eradication: Conceptual Frameworks, Strategies, and Tactics

Amy K. Winter [1] and William J. Moss [2,3,*]

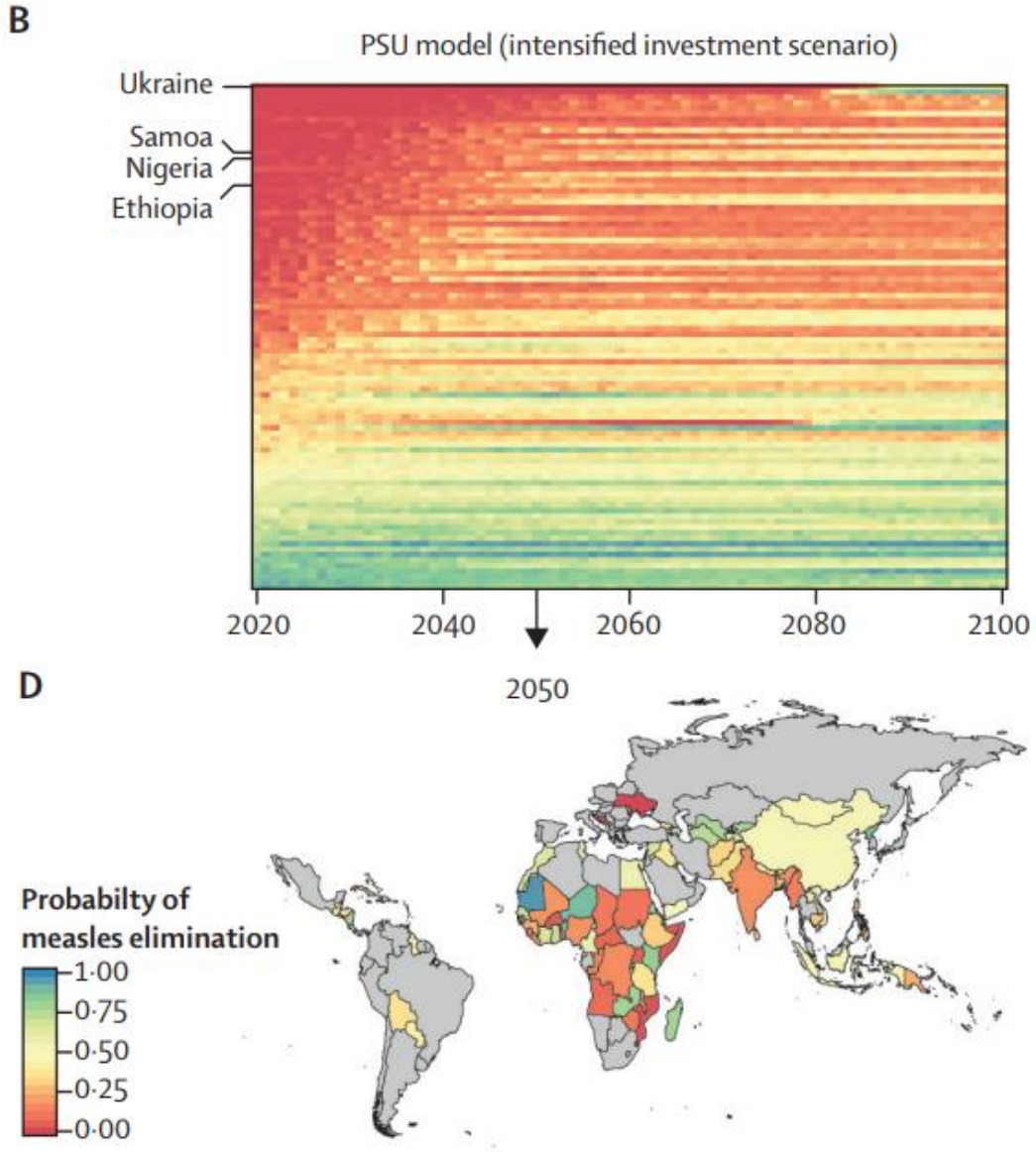


WUENIC 2024 Revision

Trends | Selected Antigens | Global/Regional | Data



Feasibility of measles and rubella vaccination programmes for disease elimination: a modelling study



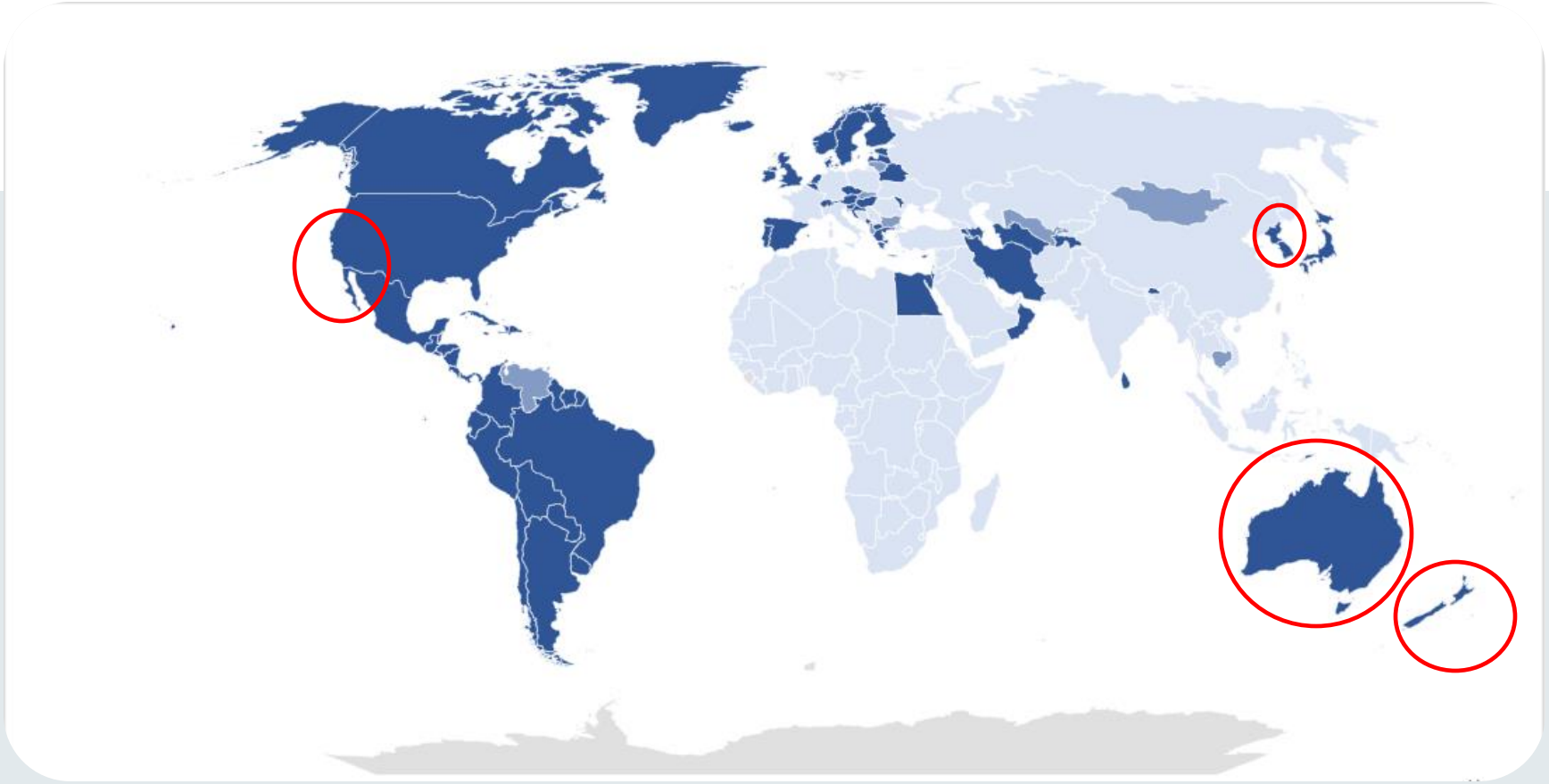
Model conclusions

93 countries with lowest MCV coverage

With intensified investment by 2050:

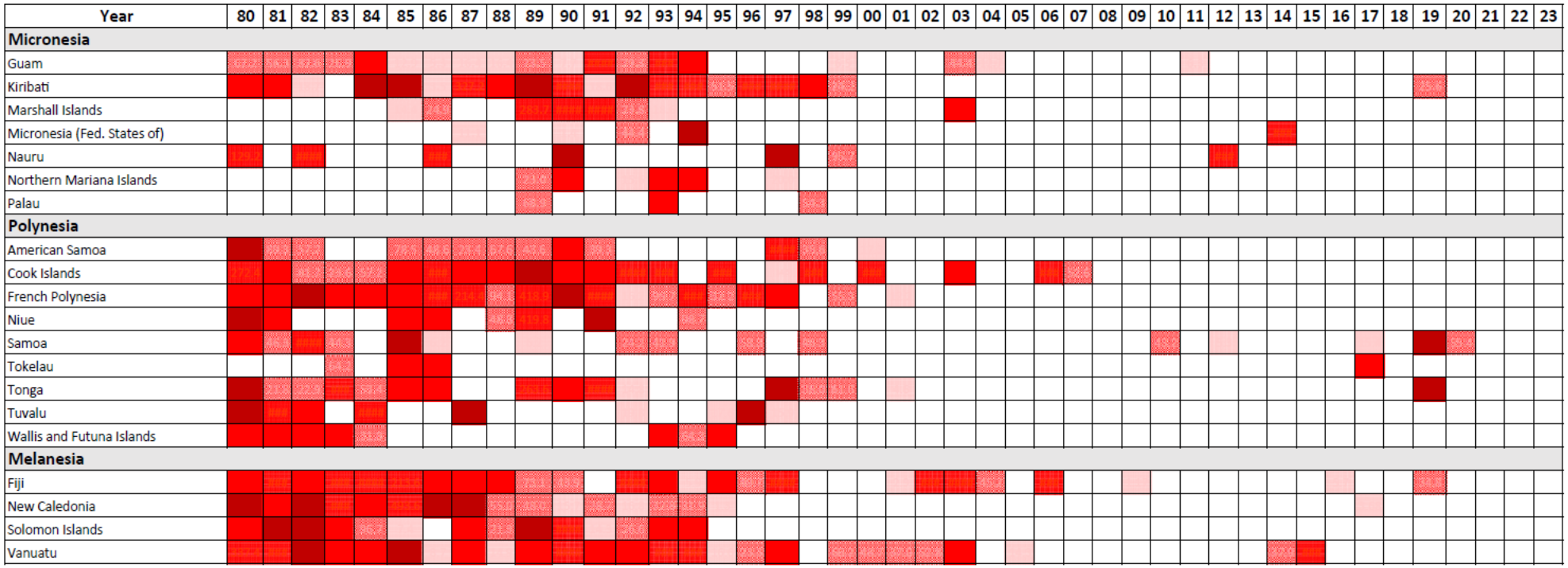
- Probabilty of elimination > 75% in 14%
- Level of regional inequity crucial

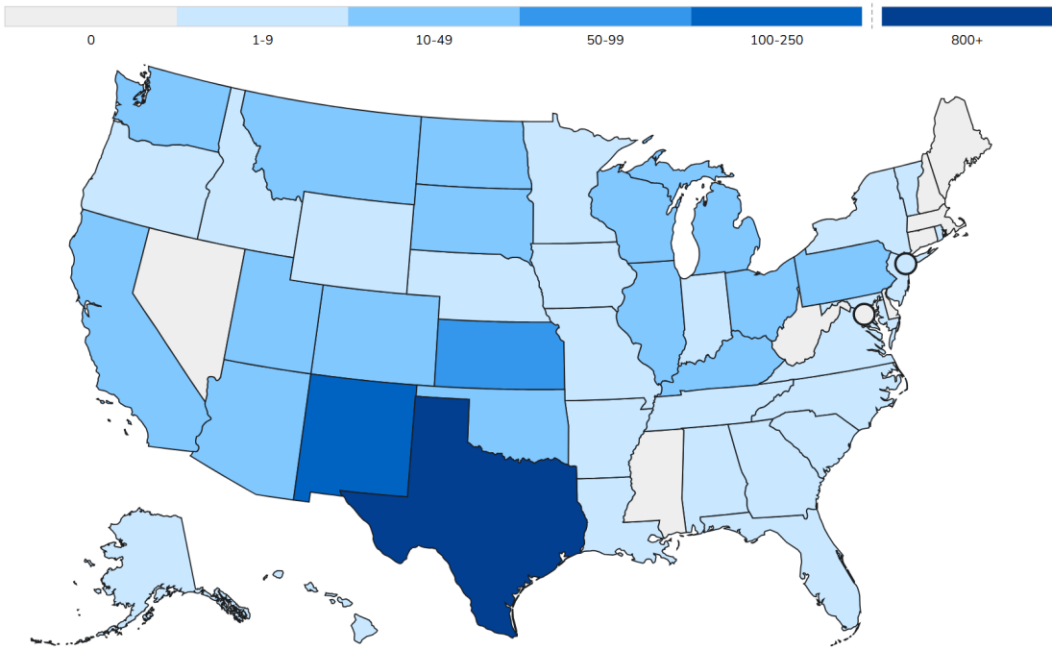
Countries with verified measles elimination - 2023

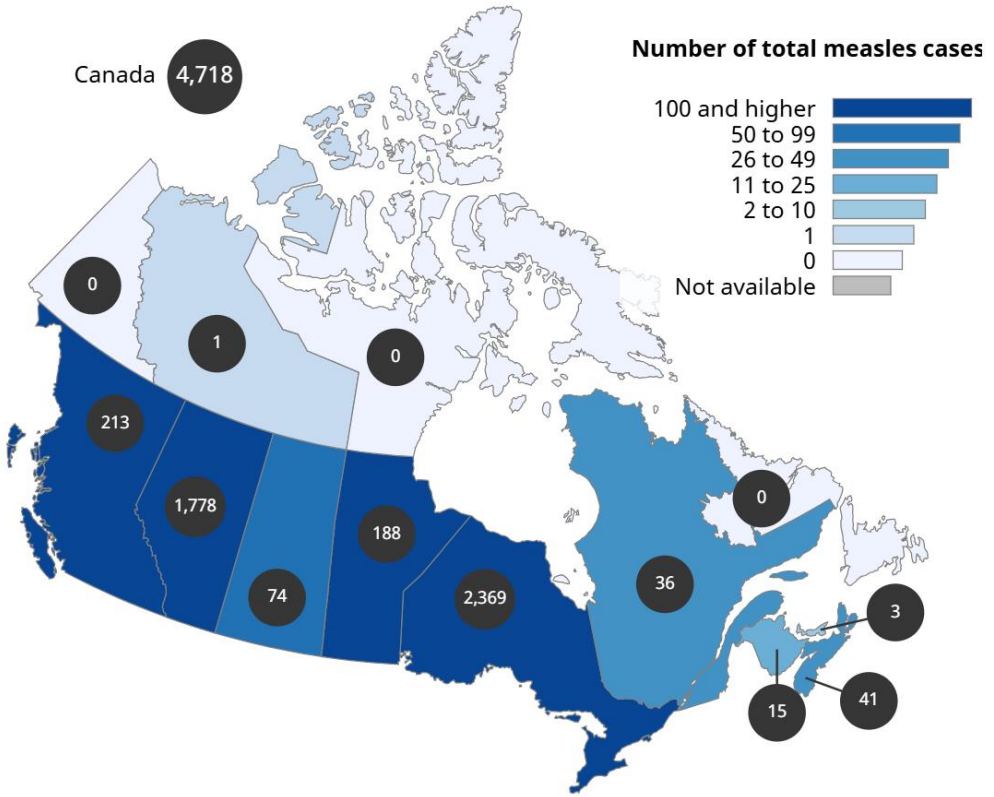


Pacific Island Countries demonstrate the sustained success of a coordinated measles mass vaccination campaign

David N. Durrheim,[a,] Ilisapeci Vereti Tuibeqa,[b] George Siaosi Aho,[c] Jean-Paul Grangeon,[d] Divinal Ogaoga,[e] Andre Wattiaux,[f] Kayla Mae Mariano,[g] Roger Evans,[g] Shafiqul Hossain,[g] and Syeda Kanwal Aslam[g]*

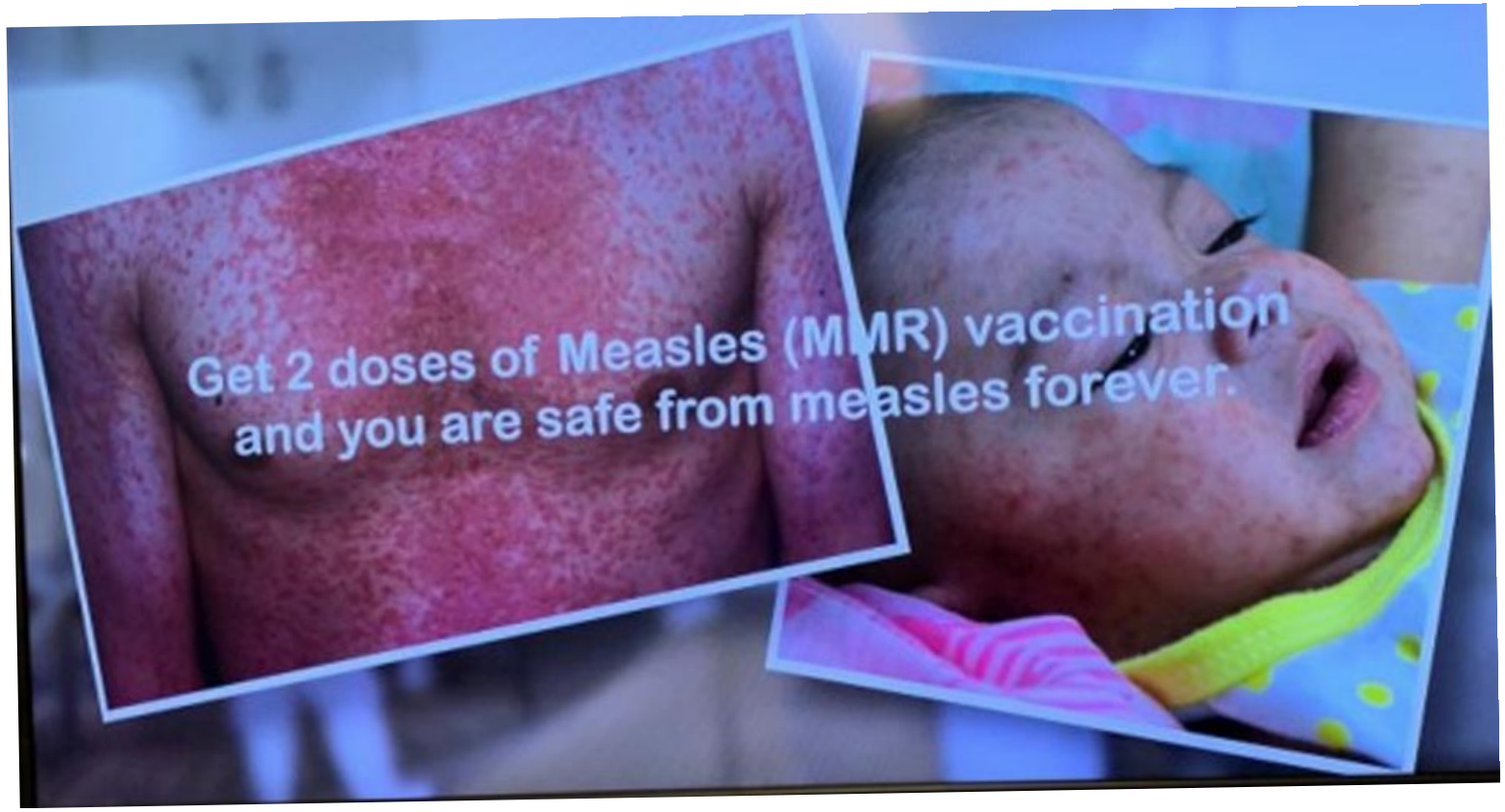






1478
3.7 per million
Last week 19
Years > 5 per million since 2000 - zero

4718
100 per million
Last week 85
Years > 5 per million since 2000 - 4


Get 2 doses of Measles (MMR) vaccination
and you are safe from measles forever.

Clinical Infectious Diseases

EDITORIAL COMMENTARY

Measles in Vaccinated Individuals and the Future of Measles Elimination

William Moss

Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

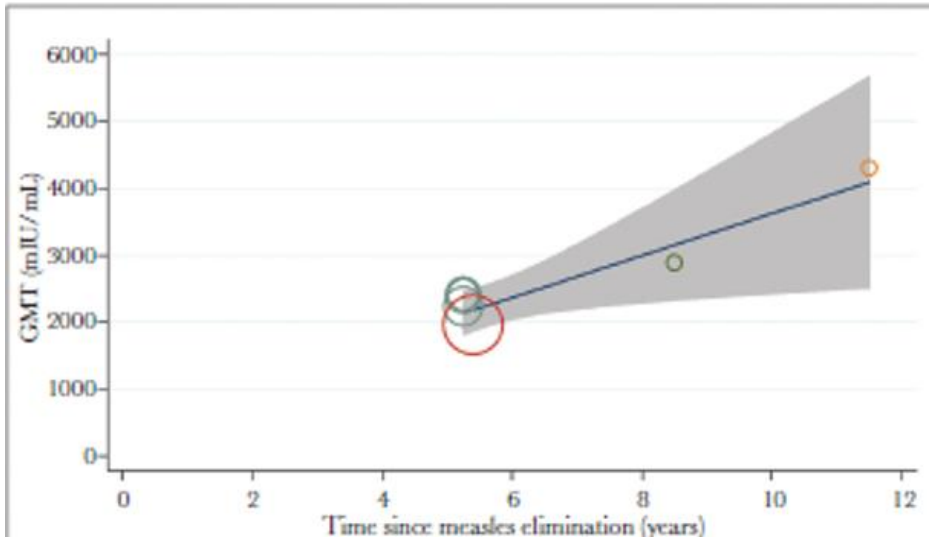
- California 2000-2015:
  - 20% of measles cases = 1 or 2 dose MMR
- Australia 2012-19:
  - 17% of cases 20-29 years = 2 doses MMR
- S Korea: University outbreak 2014:
  - Index case had 2 MMR doses
    - 2 doses only 60% effective

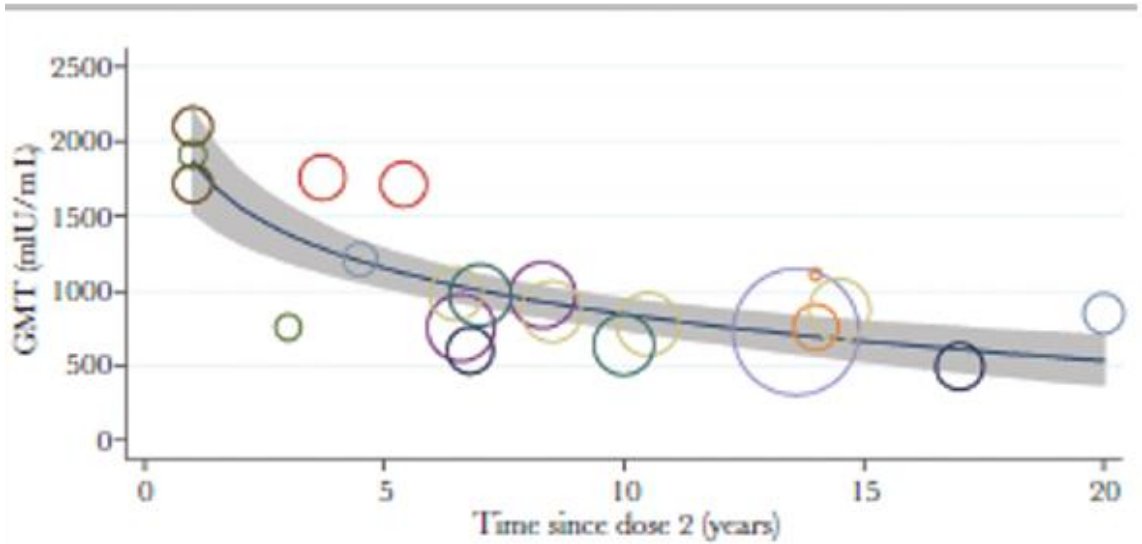
The Journal of Infectious Diseases
REVIEW

In Elimination Settings, Measles Antibodies Wane After Vaccination but Not After Infection: A Systematic Review and Meta-Analysis

The Journal of Infectious Diseases® 2022;226:1127–39

Shelly Bolotin,[1,2,3,4] Selma Osman,[1] Stephanie L. Hughes,[1] Archchun Ariyarajah,[2] Andrea C. Tricco,[2,5,6] Sumaiya Khan,[1] Lennon Li,[1,2] Caitlin Johnson,[1] Lindsay Friedman,[1] Nazish Gul,[1] Rachel Jardine,[1,2] Maryrose Faulkner,[1,2] Susan J. M. Hahné,[7] Jane M. Heffernan,[8] Alya Dabbagh,[9] Paul A. Rota,[10] Alberto Severini,[11,12] Mark Jit,[13,14,©] David N. Durrheim,[15] Walter A. Orenstein,[16] William J. Moss,[17] Sebastian Funk,[13,18] Nikki Turner,[19] William Schluter,[10] Jaleela S. Jawad,[20] and Natasha S. Crowcroft[2,3,4,9]





In people with previous measles infection, antibody levels stable

In vaccinated people antibody levels go down

Would aerosolised measles vaccine be more like measles infection and more effective than IM?

Dr. Sabin at the National Institutes of Health, Ca. mid-1980's

"Mass immunization of almost of all susceptible children in a short period of time, has the potential of rapidly eliminating measles as a public health problem. Immunization by **inhalation of aerosolized measles vaccine** provides a

The Mexican Device

4 million schoolchildren in Mexico

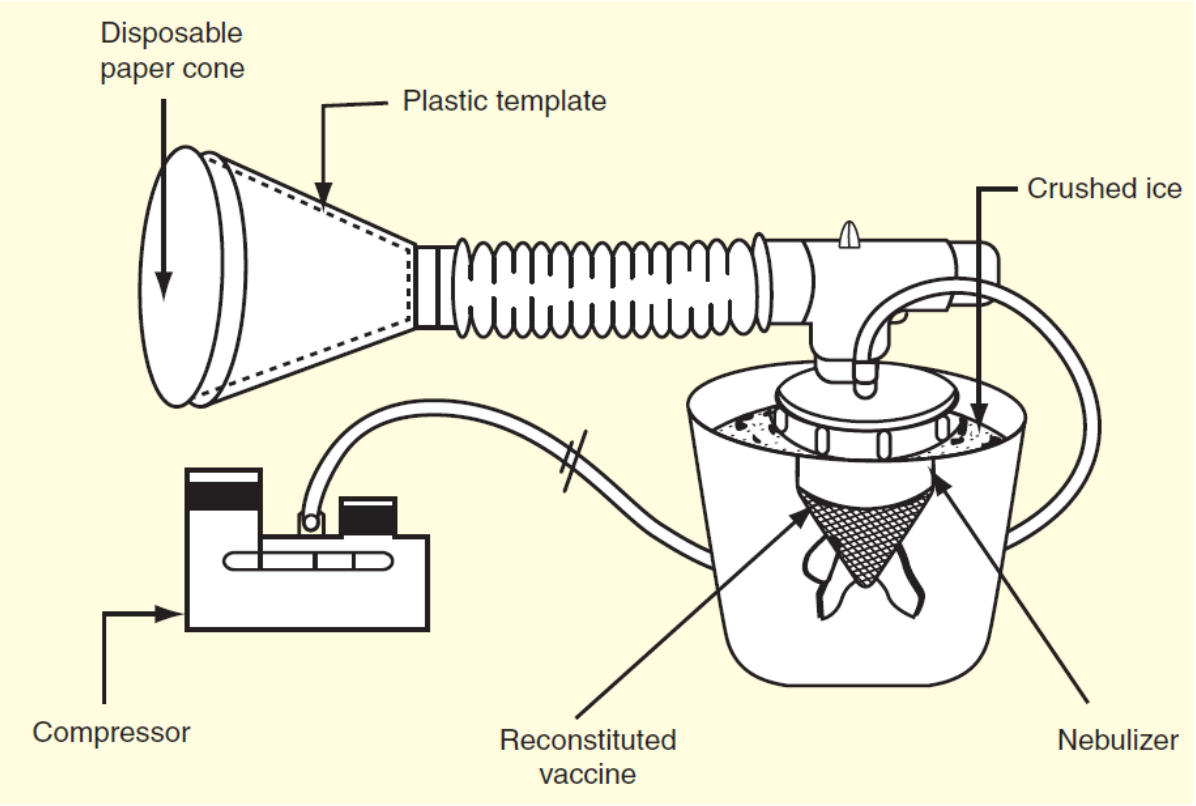
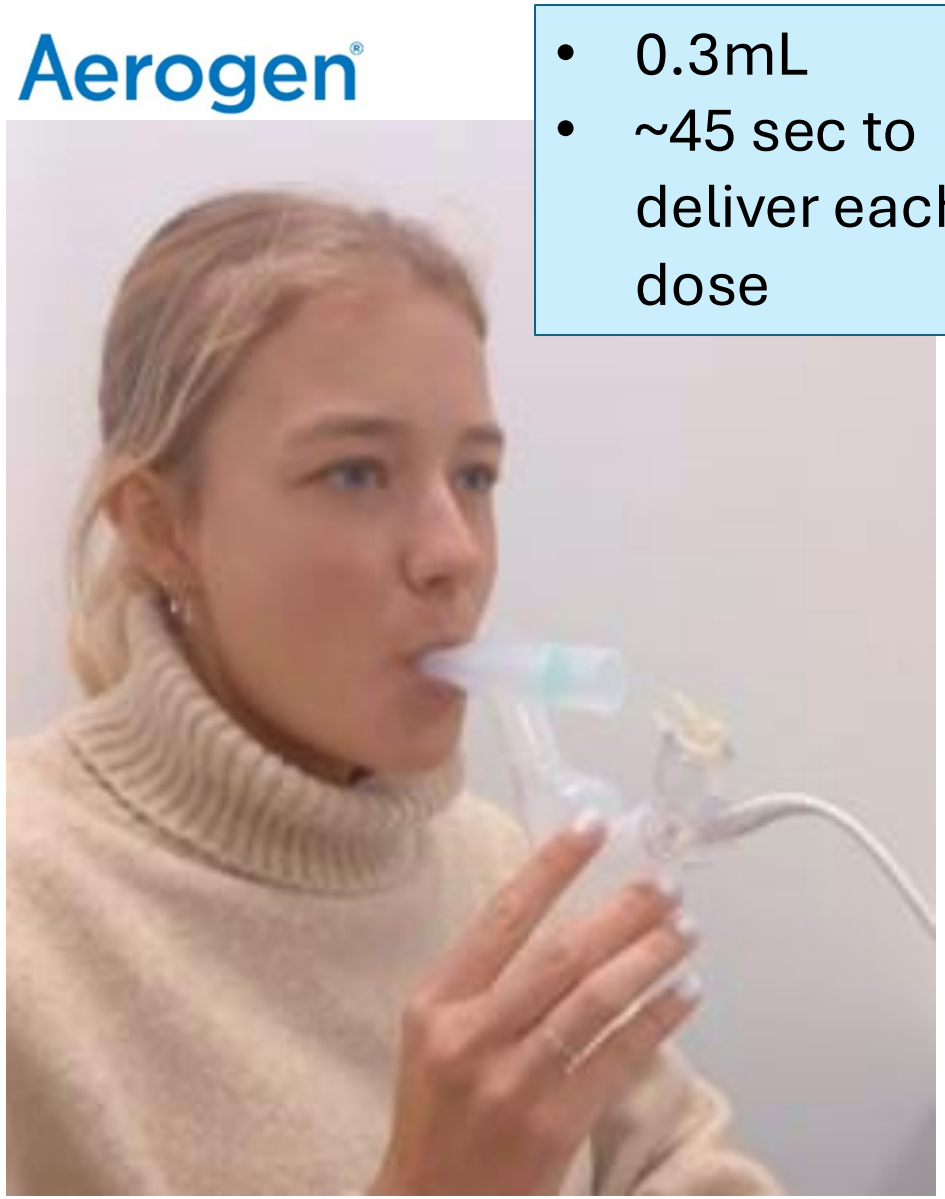


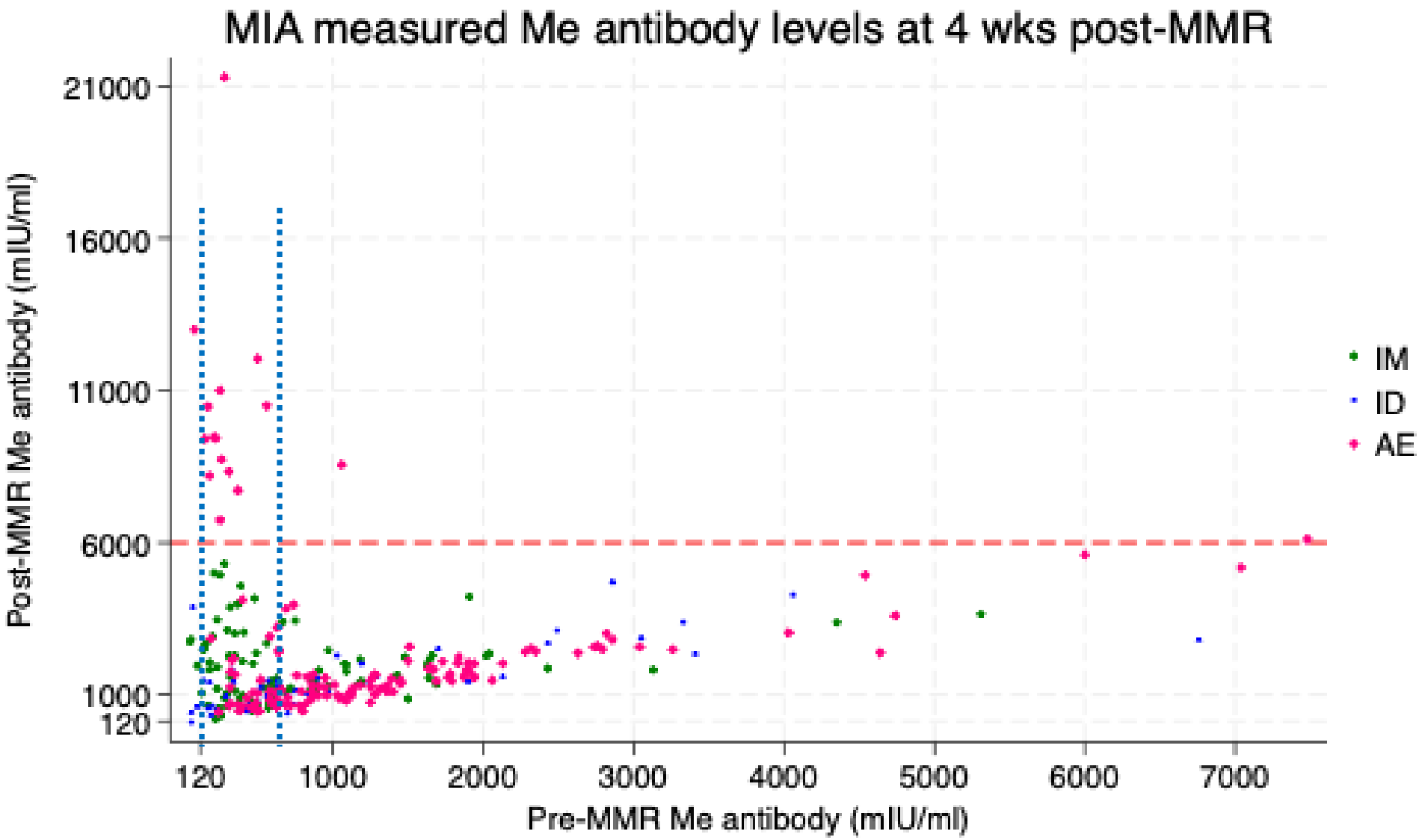
Figure 1. Diagram of the classical Mexican device used to aerosolize liquid measles virus vaccine.

Aerosol delivery with a modern nebuliser



- 0.3mL
- ~45 sec to deliver each dose

Antibody 4 weeks after MMR (n~280)



Aerosol in a cup ?