Welcome to the 2026 MAH Annual Meeting

Jakarta, Indonesia

10 June – Day 1

MEASLES
ANALYTICS HUB

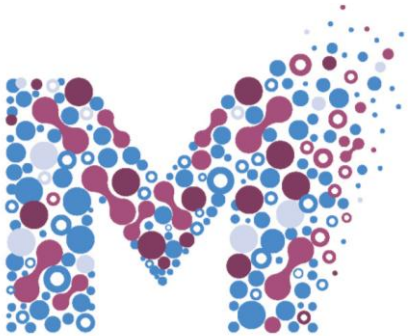
Thank you

- Here today, we have 76 modellers and stakeholders from 52 institutions worldwide (plus many more online)
- 3 days of knowledge exchange and collaboration
  - Also, a time for informal networking, working together on active projects, or brainstorming new ideas

A special thanks to those that travelled long distances to be here, the WHO Indonesia team who worked tirelessly on visas and meeting prep, our session chairs, and the MAH Events Team for organising this event.

Thank you to the Gates Foundation for the funding and all of our stakeholders and country partners who have helped to shape the meeting agenda.

High level meeting overview



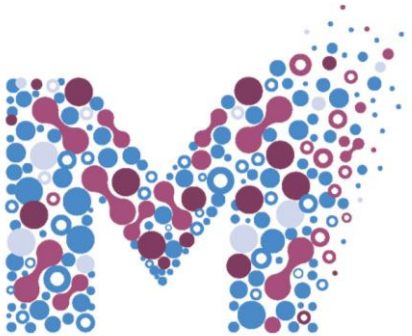
Welcome & agenda overview

- **Day 1:**
  - Regional Showcase
    - Lightning-talks and panel discussions from the Western Pacific and South-East Asia Regions
    - Networking reception
- **Day 2:**
  - Cross-cutting Themes
    - SIAs and novel delivery modalities
    - Surveillance: Outbreak Detection and RDTs
- **Day 3:**
  - Turning modelling tools into decision-support products
  - Perspectives from AFR region
  - Parked topics

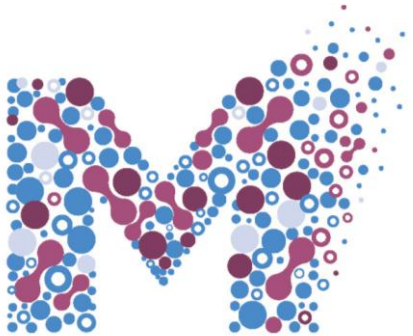
Parked topics - Friday

- As topics emerge during the meeting and you make new connections, the need for a side meeting might arise
  - Let us know and we can book in a parallel session in one of the smaller break-out rooms we have reserved

Code of conduct



Please be respectful



- Engage respectfully and professionally with others.
- Value diverse perspectives and experiences.
- Refrain from behaviour that is disruptive, discriminatory, or otherwise inappropriate.

Throughout the course of this meeting, we hope to…

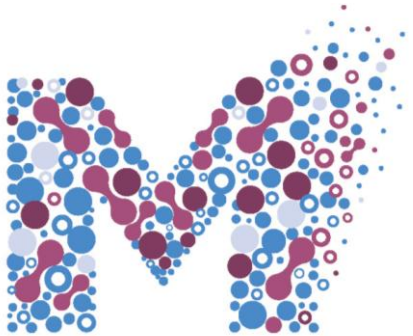
- Advance the application of modelling to support measles and rubella elimination goals, aligned with current epidemiology and regional priorities.
- Evaluate the role of modelling and analytics in addressing immunity gaps, outbreak detection, and optimisation of vaccination strategies.
- Translate modelling insights into actionable, country-relevant guidance for programmes and regional verification efforts.

The Measles Analytics Hub

at a glance

MEASLES
ANALYTICS HUB

Mission statement



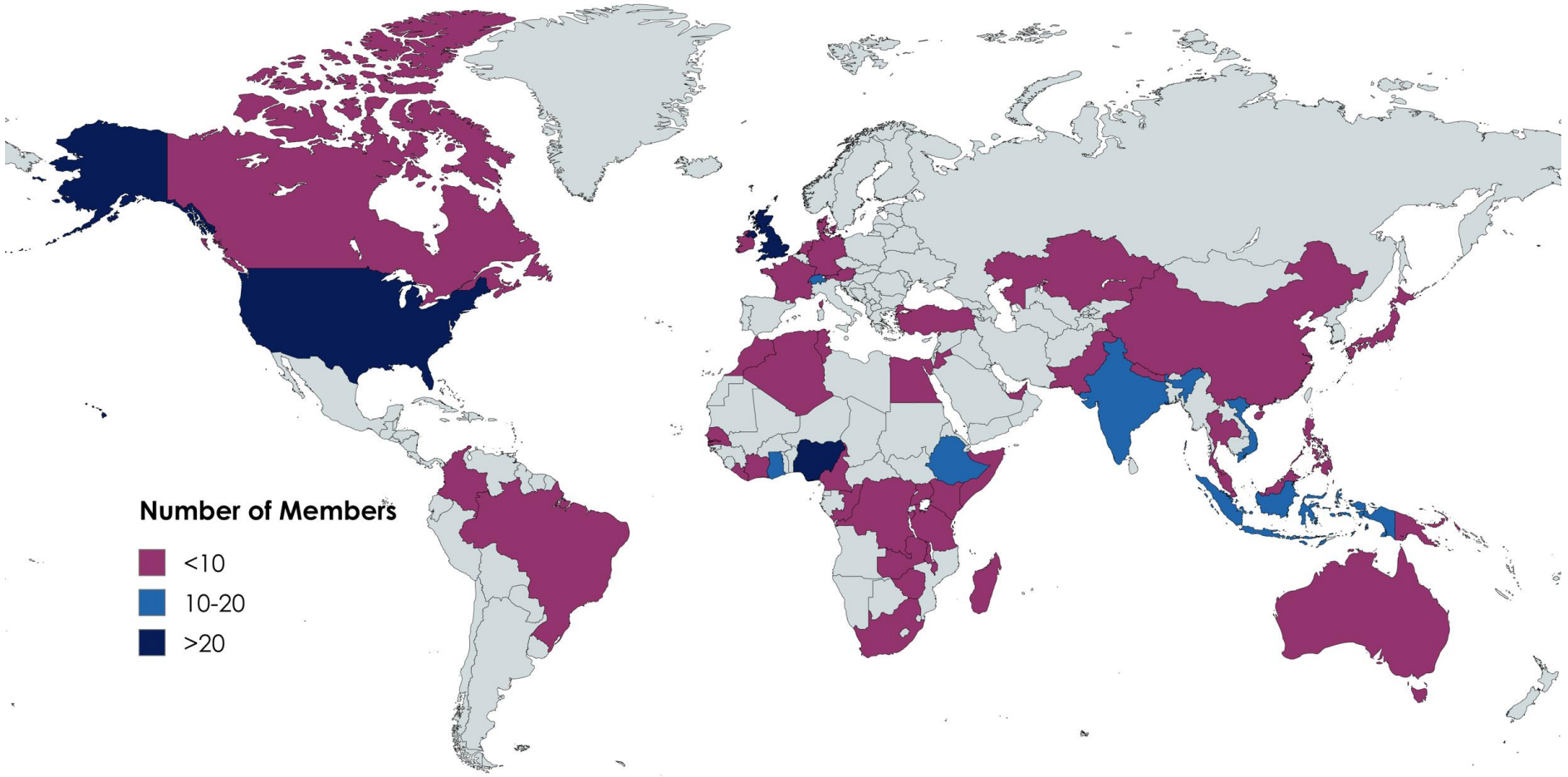
- The Measles Analytics Hub is a global network of measles modellers and stakeholders dedicated to reducing the burden of measles.
- We aim to enable better informed decision-making by ensuring that high-quality contextualised analytical evidence is accessible to those who need it.

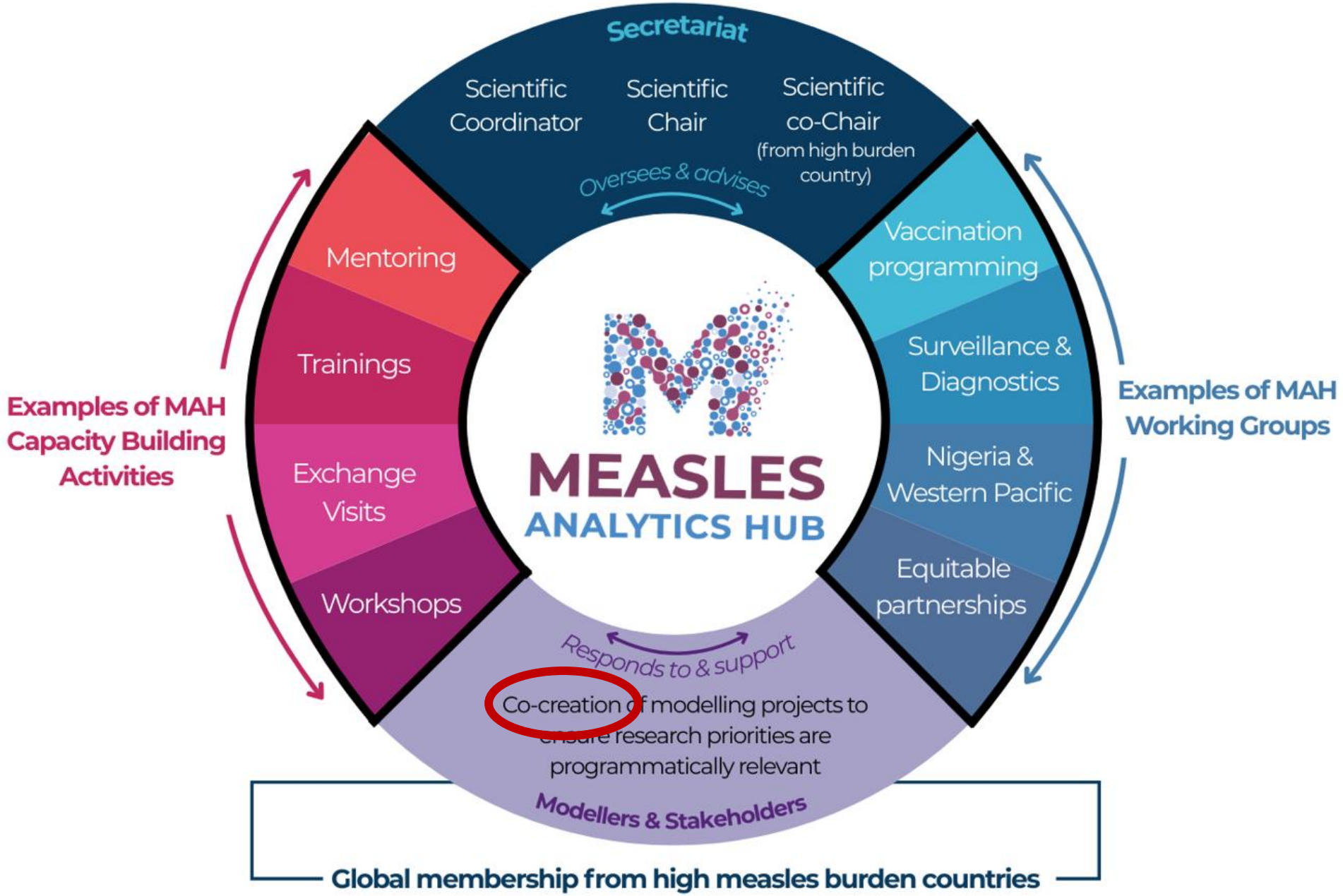
We do this by…

- **Catalysing new and strengthening existing collaborations** among measles modellers, public health practitioners, and partner institutions working across diverse geographies.
- **Facilitating knowledge exchange** through working groups, research showcases, and community forums that bring together methodological expertise and country experience.
- **Synthesising and clarifying evidence**, helping partners navigate modelling outputs, assumptions, and uncertainties to support informed and constructive discussions.
- **Supporting early career researchers** by creating an inclusive and enabling environment for skill building, mentorship, and exposure to global measles analytics.
- **Promoting transparency, reproducibility, and shared standards** across modelling efforts to strengthen confidence in analytical outputs used in decision making.
- **Anchoring activities in partner-driven needs**, ensuring that MAH efforts remain responsive, equitable, and aligned with programmatic priorities.

Global Membership

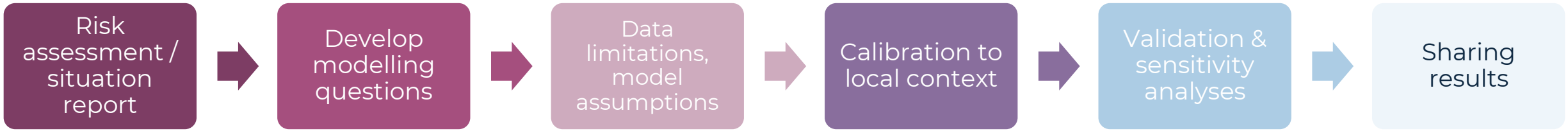
444 members from 58 countries (as of 10 June 2026)




Secretariat
Scientific Coordinator
Scientific Chair
Scientific co-Chair (from high burden country)
Oversees & advises
Examples of MAH Capacity Building Activities
Mentoring
Trainings
Exchange Visits
Workshops
MEASLES ANALYTICS HUB
Examples of MAH Working Groups
Vaccination programming
Surveillance & Diagnostics
Nigeria & Western Pacific
Equitable partnerships
Responds to & support
Co-creation of modelling projects to ensure research priorities are programmatically relevant
Modellers & Stakeholders
Global membership from high measles burden countries

What does co-creation mean to MAH?

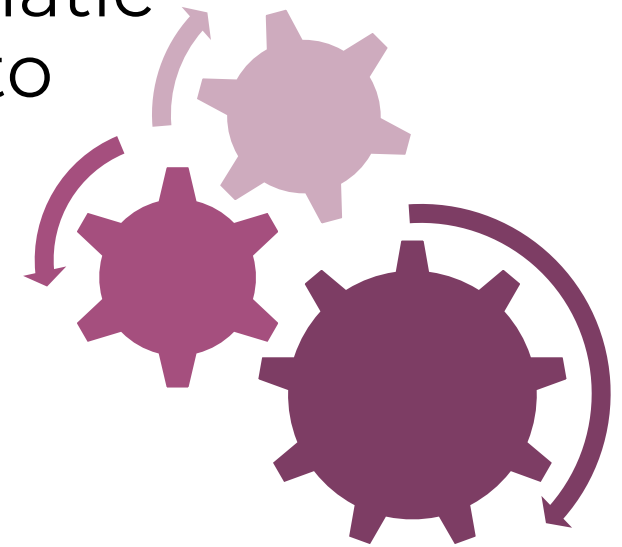
- Involvement of stakeholders across all tiers
  - From local programmatic players, such as EPI managers or other local decision-makers, to WHO Country Offices and Ministries of Health and global partners, such as Measles & Rubella Partnership, WHO, Gavi, Gates Foundation



- *“Co-creation of modelling projects is not just more equitable, but also more effective", Aheto et al. 2026*

MAH structure

- Entirely driven by member input (modellers + stakeholders)
- Discussions we had last year in Ghana directly informed the current working groups and Request for Proposals
- Working groups can arise from a programmatic need, or by a group of members who want to lead a country or topic specific group
  - Input is always welcome in shaping the MAH structure, or future events



Emphasis on active participation and collaboration

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Looking back & Looking ahead

Prof Matt Ferrari (MAH scientific chair)

Prof Justice Moses K. Aheto (MAH scientific co-chair)

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Reflections from the last year

Prof Justice Moses K. Aheto (MAH scientific co-chair)

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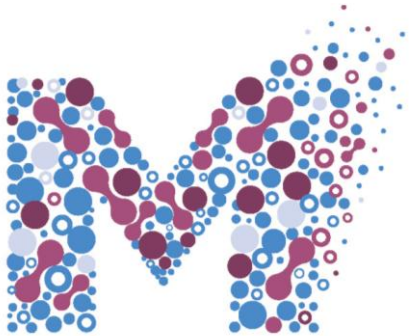
Since annual meeting 2025

- We have grown…
  - Then… 178 members from 33 countries in June 2025
  - **Now….** 444 members from 58 countries in June 2026
- In reality, the number of members who are actively involved is smaller
- But we have managed to maintain representation and diversity amongst modellers based in high measles burden countries

Progress since our annual meeting in Ghana

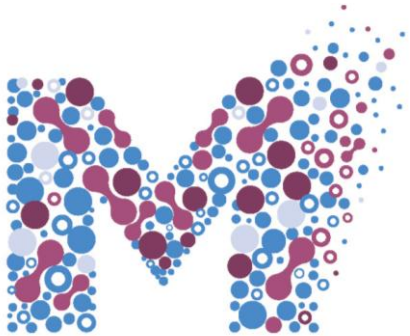
- Attest to the breakout sessions at the annual meeting informing active working groups and RfPs
  - We now have many active working groups covering both cross-cutting themes and geographies
- New collaborations
  - Members left the annual meeting and started new projects together, applied for funding, got in touch with their local stakeholders + much more…
  - This serves as motivation for you all in Jakarta

Examples of past activities



- MAH workshops
  - SACEMA workshop as an example
  - MAH + SACEMA workshop motivated creation of the MAH mentoring scheme
    - A bridge between the SACEMA fellowship and independence as a modeler or PI
    - We have paired 6 mentees in our pilot cohort (all of whom are here today) with expert mentors to improve modelling skills, focus on programmatic needs for their countries and engage local stakeholders
    - This serves as an example of how new ideas and activities emerge from direct engagement with the MAH and the MAH's commitment to capacity building

Reflections



- Over the last year, the MAH has served as a best-practice example of rebalancing scales in infectious disease modelling, by:
  - Prioritising co-creation with country partners
  - Amplifying local expertise
  - Ensuring modelling outputs are grounded in context-specific programme needs rather than solely global analyses.
- This approach aligns with recent calls to shift power and authorship toward those closest to the data and decision-making environments.

Looking at the year ahead

Prof Matt Ferrari (MAH scientific chair)

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POLICY FORUM

INFECTIOUS DISEASE

Rubella and measles: The beginning of the endgame

Benchmarks must be established and progress tracked to set a global target and take action

By **Matthew J. Ferrari**[1] *and* **William J. Moss**[2]

measles or rubella. With planning for this

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Tools

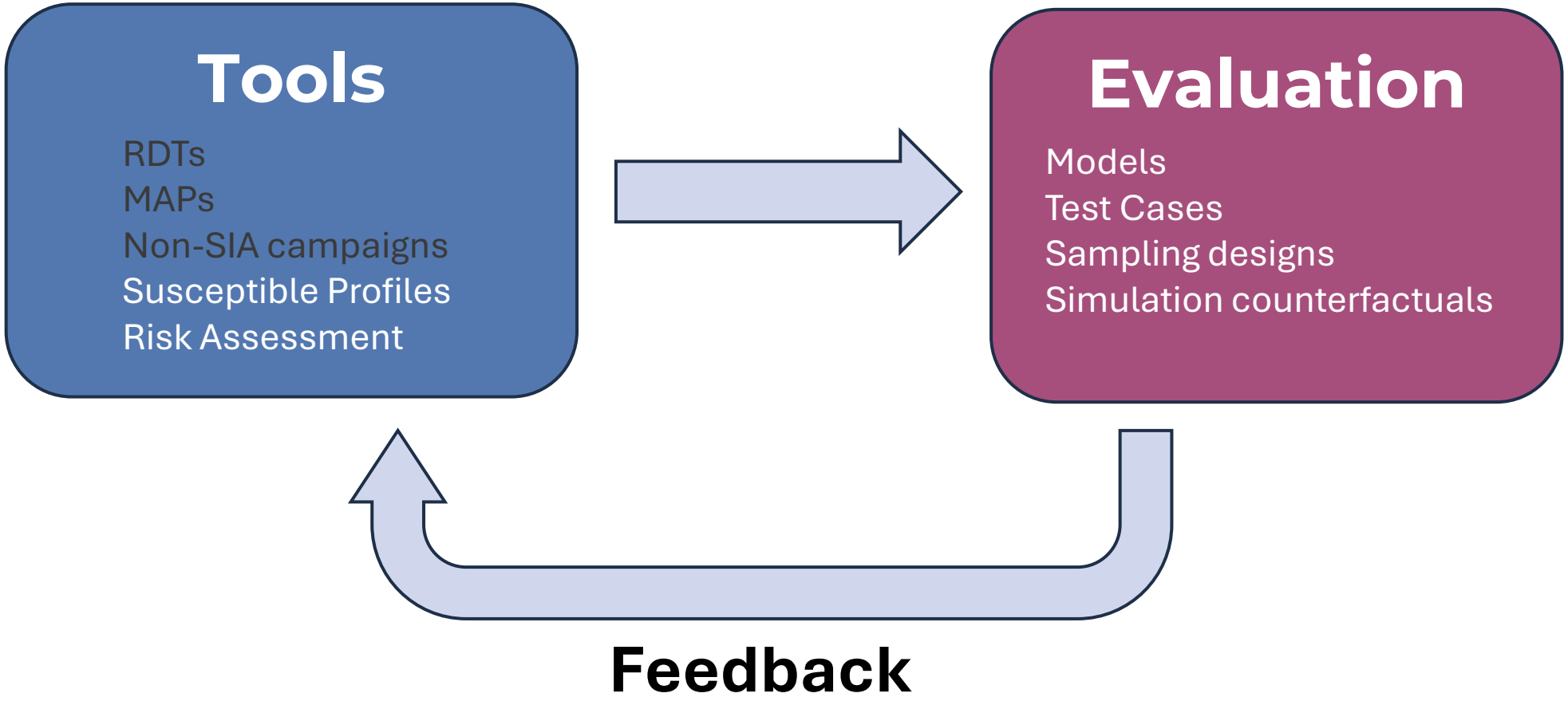
RDTs
MAPs
Non-SIA campaigns
Susceptible Profiles
Risk Assessment

Tools

RDTs
MAPs
Non-SIA campaigns
Susceptible Profiles
Risk Assessment

Evaluation

Models
Test Cases
Sampling designs
Simulation counterfactuals


Tools
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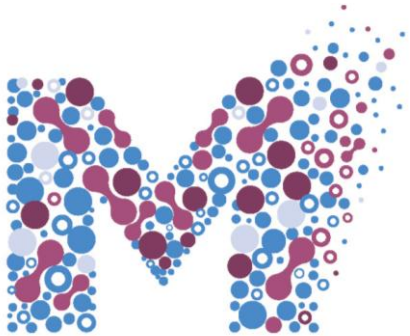
Feedback

Priorities



- **Day 1** – Grounded in context
- **Day 2** – Themes and needs
  - Vaccine Delivery
  - Surveillance
  - Outbreak detection
- **Day 3** – Translation
  - Adoption and implementation

Priorities

- **Day 1** – Grounded in context
- **Day 2** – Themes and needs
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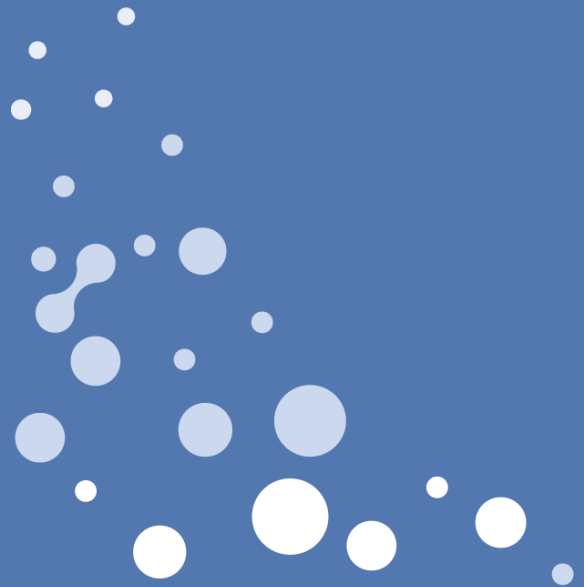
Keep an open mind

Don’t let perfect be the enemy of the good



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Measles modelling in the context of the Western Pacific & South-East Asia Regions

MAH Annual Meeting

Jakarta, Indonesia

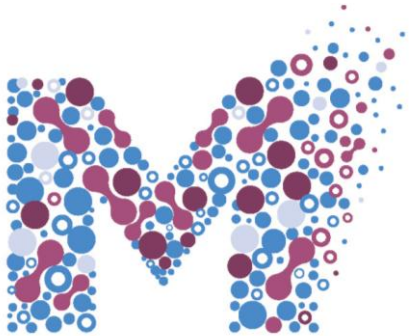
10 June 2026 – Day 1

MEASLES ANALYTICS HUB

Overview

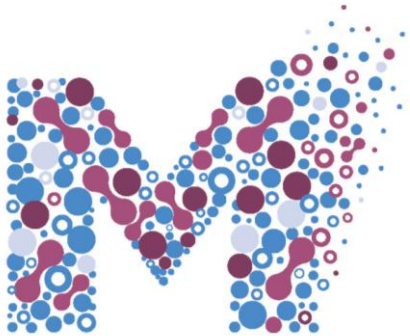
- An opportunity to take advantage of the meeting location and showcase regional work
  - 2025: West Africa
  - 2026: WPR/SEAR
- Also, we aim to draw parallels to methods or approaches that can be useful in other geographies
- Keynote address followed by 4 sessions & a networking reception
  - Introduction to regional priorities
  - Lightening talks followed by a moderated Q&A discussion

Engaging with presenters



- Please save all questions until after the talks
  - Before asking a question, introduce yourself
  - The discussion is intended to allow for clarification questions and also spark discussion…
    - Has anything resonated with your own work?
    - What parallels can you draw to your own country?
    - Is there an opportunity to collaborate?
- All presenters have been asked to give a high-level overview
  - If you want to learn more about their methodological approach or learn more, schedule a side meeting or approach them during the networking reception

Engaging with presenters



- Keep code of conduct in mind
  - All questions and/or comments should be respectful
  - Bear in mind that all presenters have different backgrounds – from students and earlier career researchers, to expert modellers and stakeholders

2026 Keynote Address:
From Regional Priorities to Global Insights

Dr Stephen Chacko,

WHO Indonesia

MEASLES
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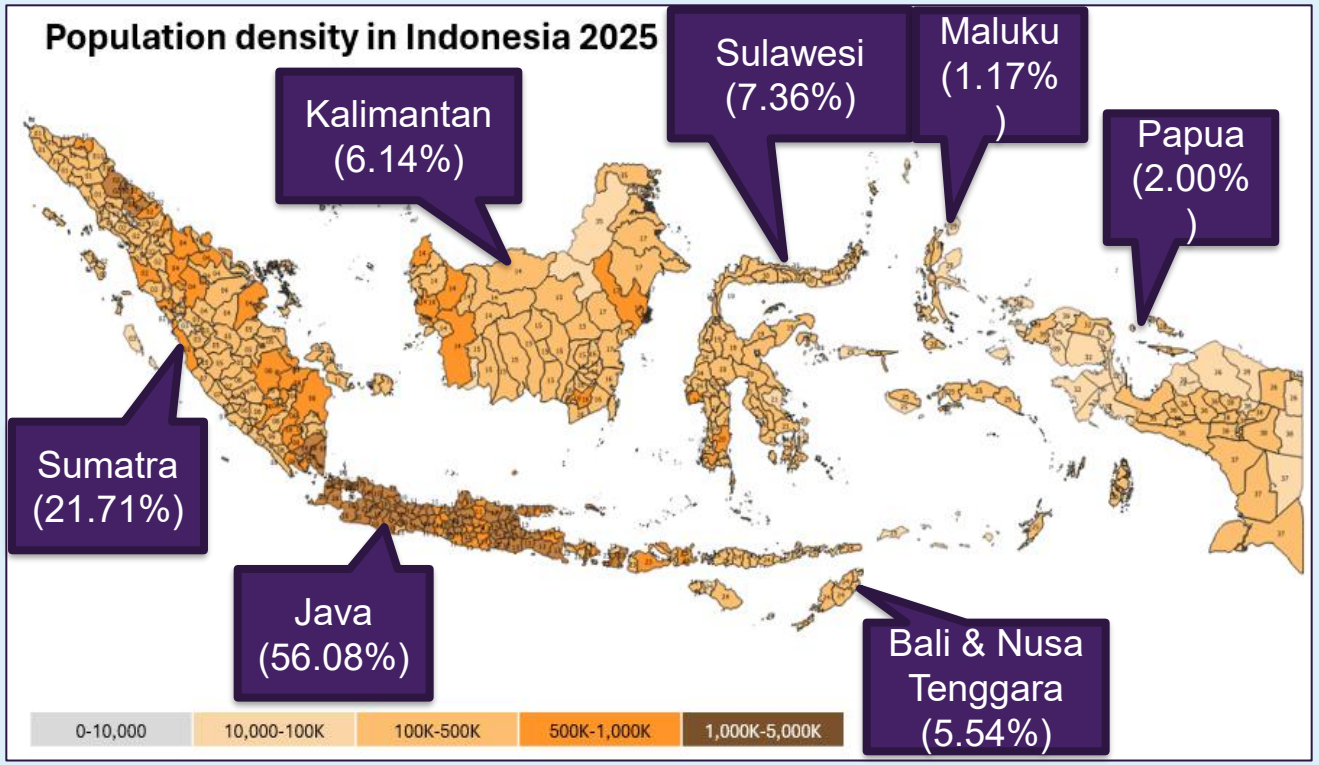
From Regional Priorities to Global Insights:

What Measles Modelling Must Deliver for Countries

MAH Annual Meeting
Jakarta, 10-12 June 2026

Dr Stephen Chacko, MD, MPH
Team Lead for IVD, WHO Indonesia

Welcome to Indonesia: why context matters



Number of islands > 17,000 and 5,000–6,000 are inhabited
Number of time zones = 3 (GMT+7–GMT+9)

Total population	284,438,802
Under one population	4,486,792
Under five population	22,752,569
Under fifteen population	66,659,655
# of provinces / districts / villages	38 / 514 / 84,276
# of primary health centre (*Puskesmas*)	10,212
# of community-based integrated health posts (*Posyandu*)	> 240,000 (~70% vaccination services take place in *Posyandu*)
Hard-to-reach area/at risk population	9,822,210 (62 districts) President regulation no.63 - Designation of Disadvantaged Districts for the Period 2020–2024

PH Lessons Learned from Polio Eradication

01 Strong Political Commitment

02 Community Trust is Everything

03 Microplanning at the Local Level

04 Strong Surveillance Systems

05 Flexibility and Adaptation Use of OPVs

06 Dedicated Workforce and Accountability

Additional Key Lessons

01 Integration with Broader Health Services

02 Reaching Missed and Mobile Populations

03 Data-Driven Decision Making

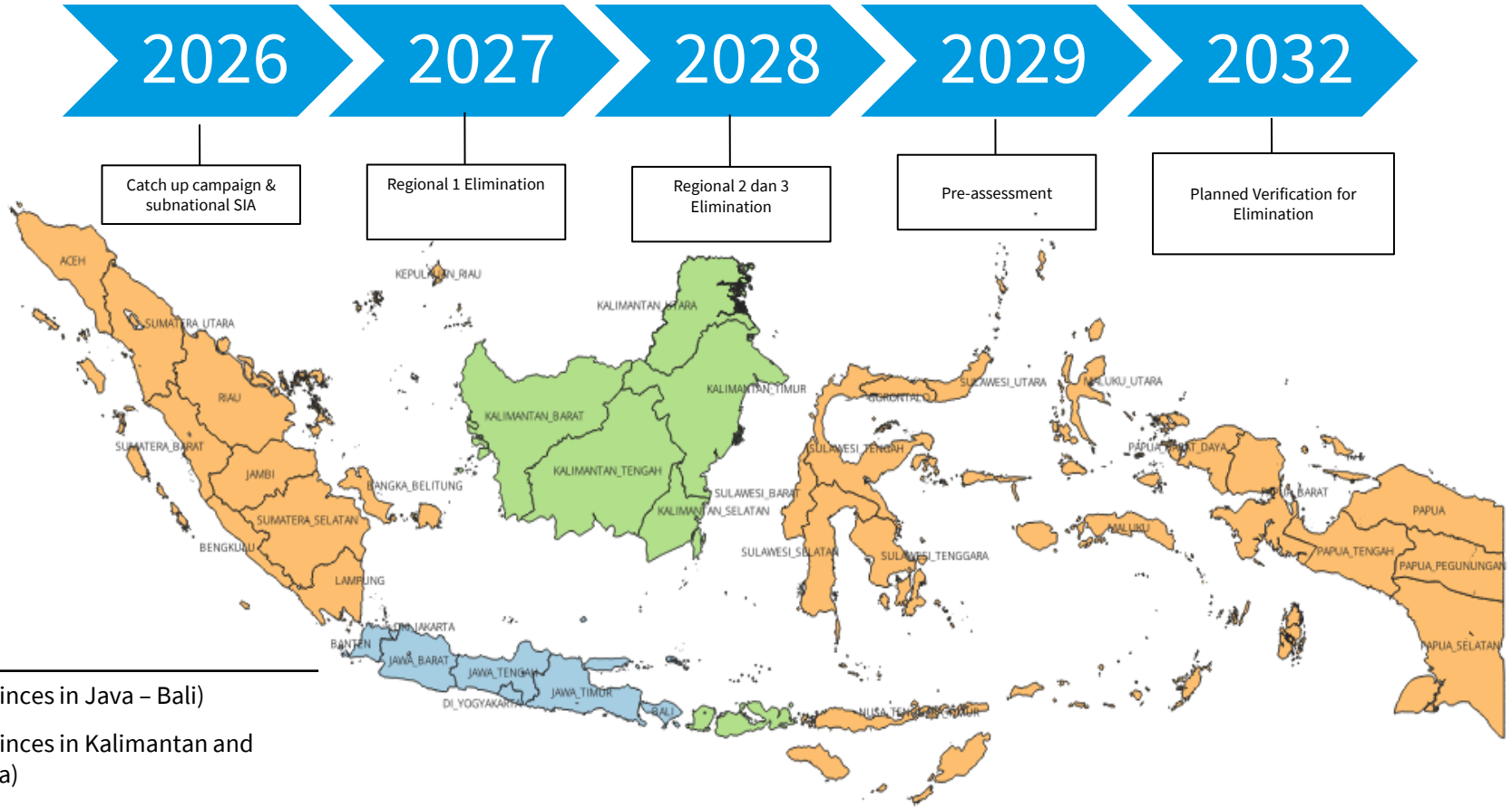
04 Global Coordination and Partnerships

05 Communication and Rumor Management

06 Persistence Over Time

National Strategic Plan for Measles-Rubella Elimination 2026–2032

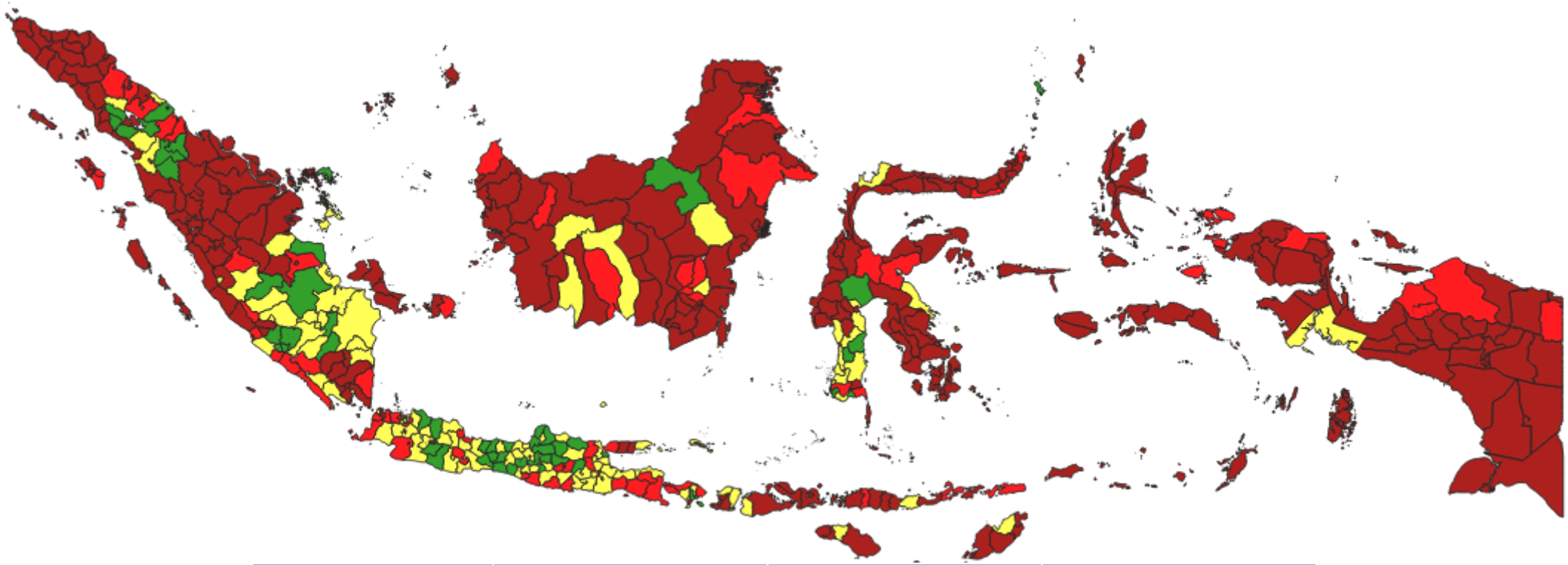
In line with National Immunization Strategy 2025–2029, the MR elimination strategy will be implemented in a phased approach*:



Legend	Regional
	Regional 1 (All provinces in Java – Bali)
	Regional 2 (All provinces in Kalimantan and West Nusa Tenggara)
	Regional 3 (All provinces in Sumatera, Sulawesi, Maluku, Papua, and East Nusa Tenggara)

*This will be reassessed in accordance with the current outbreak status and findings from recent measles research in June 2026

Measles-Rubella Risk Assessment for 2026

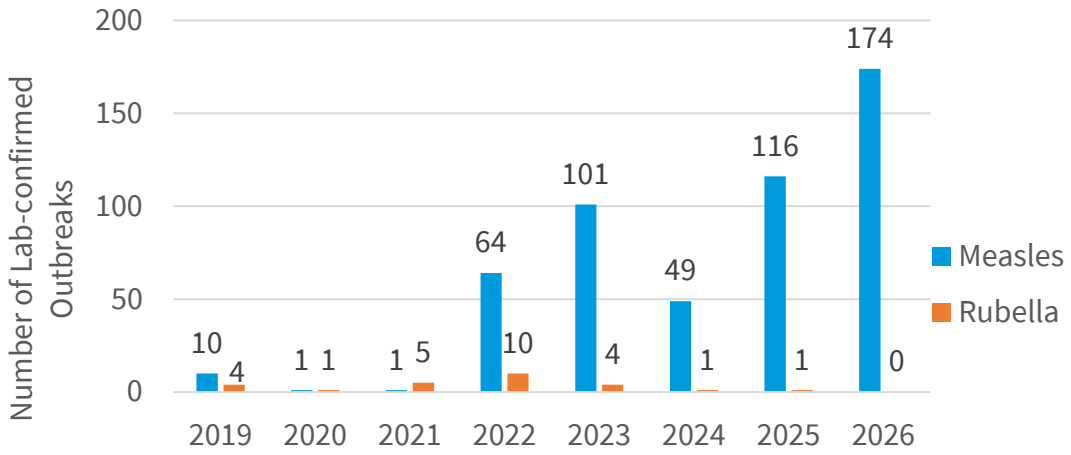


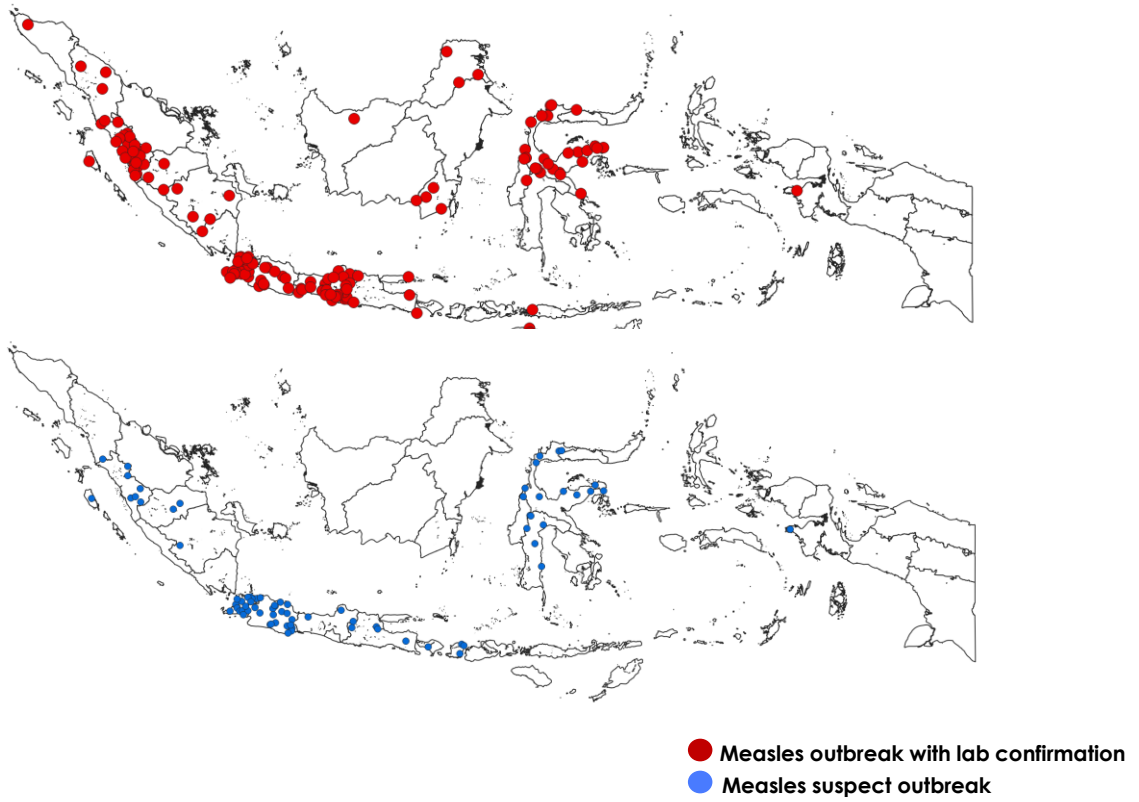
Risk Category	# of District	Population	% of Population
Low Risk	62	49,506,859	17.8%
Medium Risk	107	93,265,750	33.6%
High Risk	76	55,517,488	20.0%
Very High Risk	269	79,142,263	28.5%

Status: endemic for measles and rubella

Source: Finalized 2025 data of VPD Surveillance and Immunization, MoH as of 28 February 2026

Measles Situation in Indonesia, 2026





Total number of measles cases in Indonesia in 2026 (Up to week 21)

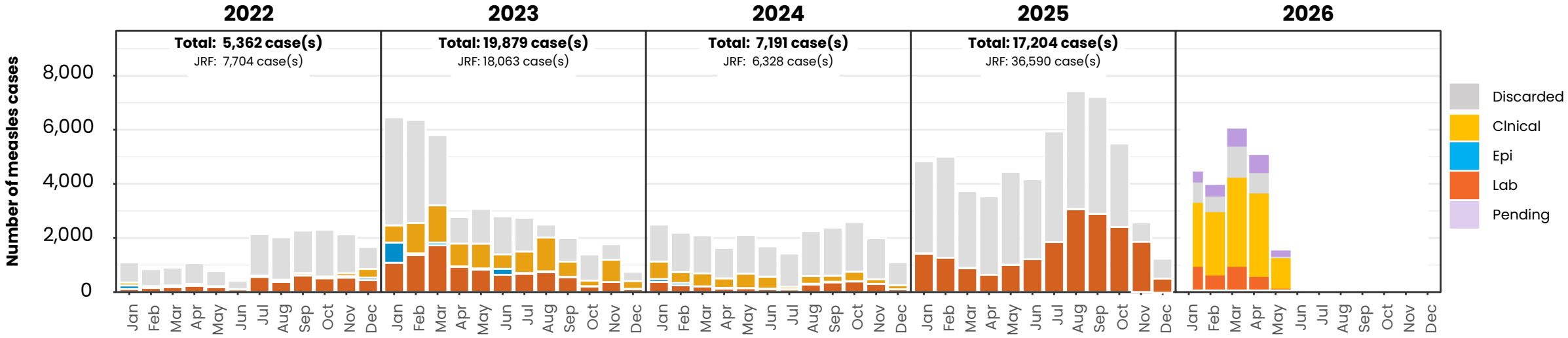
- Suspect: **52.661**
- Lab-confirmed: **6.890**
- Epid-linked: **20**
- Clinical: **31.132**
- Discarded: **6.96/100,000 population**
- Measles-related death cases: **12**

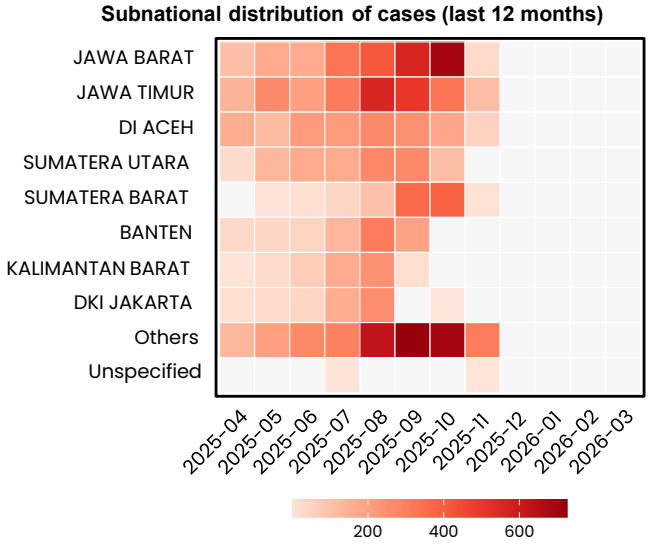
2026: 252 Measles outbreak in 22 provinces, (including **174 laboratory-confirmed measles outbreaks** reported from 65 districts/cities in 17 provinces)

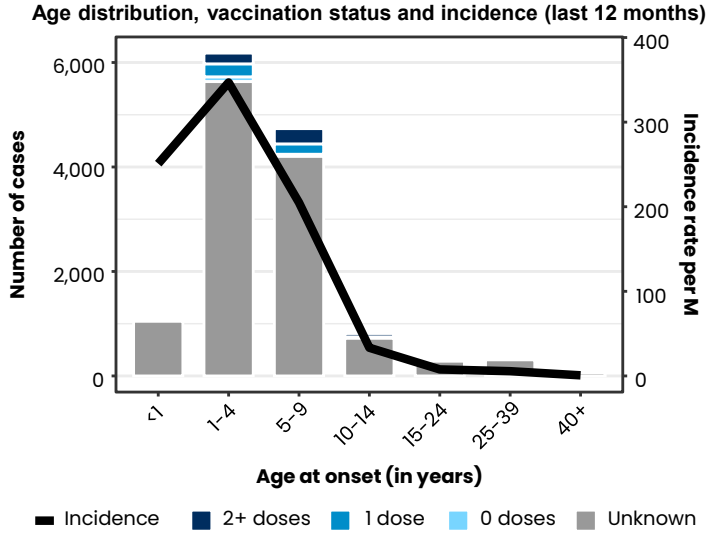
Data as of 30 May 2026

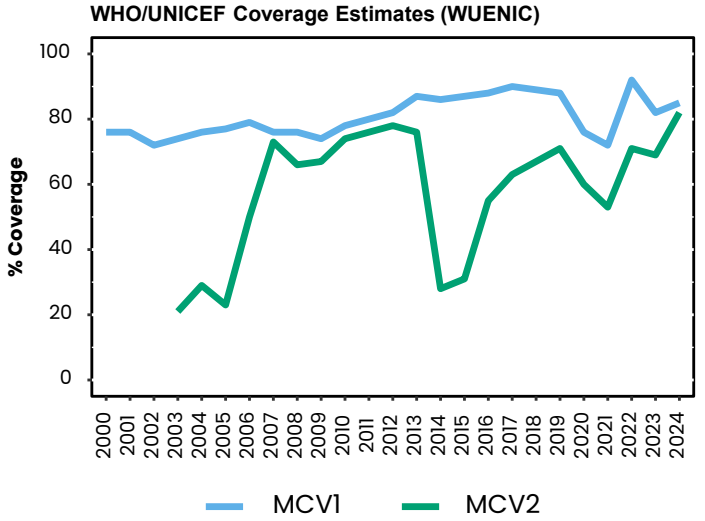
Measles cases: Indonesia

ELIMINATION STATUS: **ENDEMIC**



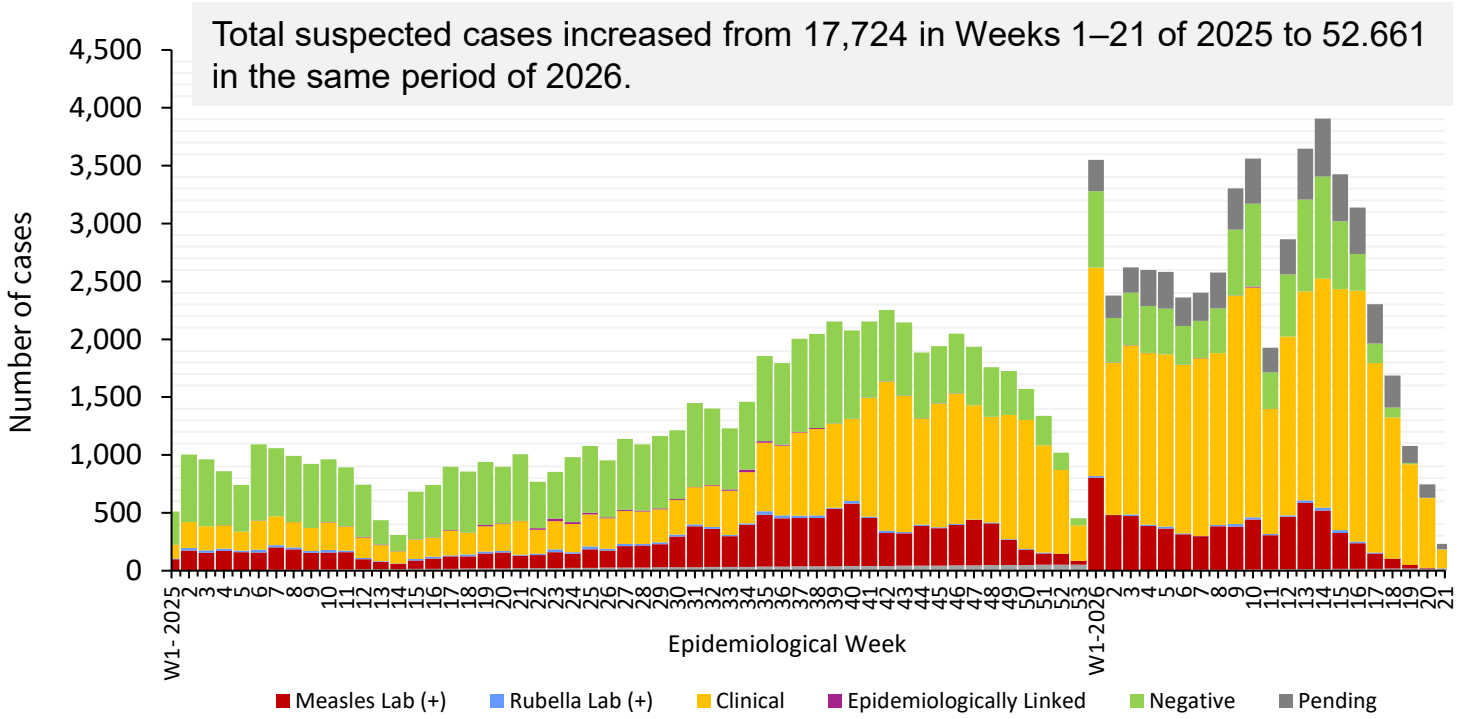






Based on data received 2026-05 - Data Source: IVB Database. Main epi curve was built using a combination of case-based and aggregate surveillance data. Age distribution curve was built using case-based surveillance data. Coverage data from WHO/UNICEF Estimates of National Immunization Coverage (WUENIC)

Measles Rubella Epidemiology in 2025-2026



Data as of 30 May 2026

Surveillance performance indicators for measles and rubella

Indicator	Target	2025	2026 (Q1)
Timeliness of reporting (to national level)	≥80%	85.5%	90.8
National non-measles non-rubella discarded rate	≥ 2/100 000	9.81	2.61
% second–level administrative units reporting ≥2/100 000 discarded measles cases	≥ 80%	78.4%	35.9%
% suspected cases with adequate investigation	≥ 80%	88.9%	84.5%
% suspected cases with adequate blood specimens	≥ 80%	54.9%	18.3%
% specimens received at laboratory within five days of collection	≥ 80%	35.9%	48
% outbreaks with specimens collected for virus detection	≥ 80%	N/A	N/A
% national measles laboratories (NMLs) that are WHO accredited	100%	100%	100%
% laboratories (government & private) that conduct diagnostic testing and are quality accredited	100%	100%	100%
% specimens with results within four days of receipt at the lab	≥ 80%	90.8%	53.4%
% virus detection and genotyping completed within two months of receipt at the lab	≥ 80%	100%	100%

- **Sustained increase in suspected cases** suggests ongoing transmission and potential immunity gaps
- **Surveillance sensitivity is adequate, but key quality indicators remain suboptimal**, with declines adequate specimen collection (54.9% → 18.3%), which may affect timely case confirmation and response
- **Laboratory capacity remains strong, but timeliness gaps persist**, with results within 4 days declining (90.8% → 53.4%) and only 48% of specimens arriving within 5 days, highlighting areas to strengthen end-to-end system performance.

MRCV Coverage Trends and Subnational Distribution, 2020–2026

National MRCV coverage, 2020–2025

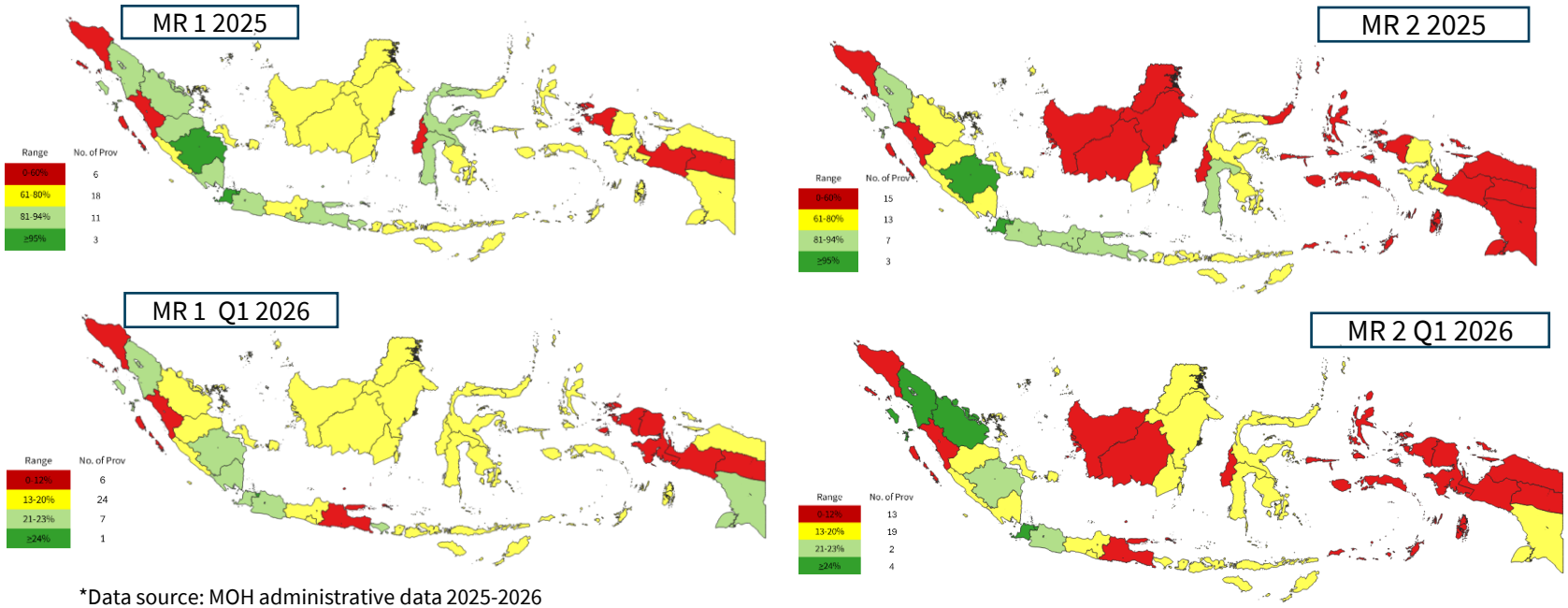
	2020	2021	2022	2023	2024	2025	Q1 2026
Routine Vaccination Coverage							
MRCV-1	86.9	87.3	97.1	95.4	92.0	83.6	15.3
MRCV-2	65.3	58.8	88.0	78.0	82.3	78.1	14.9
MRCV-3	60.9	65.2	95.3	93.1	109.1	93.4	-
National Vaccination Coverage Survey*							
MRCV-1	78.8	75.6	73.0	64.8	78.8	83.9	-
MRCV-2	-	-	-	46.8	-	72.8	-

*Data source: 2020–2022: National Socio-Economic Survey I 2023: Indonesian Health Survey I 2023 : Central Bureau of Statistics : 2025 Vaccination coverage survey

Key milestones of National Immunization Program:

- Nation-wide electronic immunization registry (EIR) started in mid 2023
- Nation wide introduction of PCV in 2022, RV, IPV2 and HPV in 2023
- National nOPV2 SIA in 2023-2024, closure of cVDPV2 polio outbreak in July 2025 following the third OBRA

MR 1 immunization coverage by province in 2025 & Q1 2026



*Data source: MOH administrative data 2025-2026

- **Routine coverage declined after peak performance in 2022–2023**
- **Discrepancy between administrative and survey coverage persist,** suggesting data quality or denominator issues.
- **High subnational inequities in coverage:** Provincial maps show multiple provinces with low coverage (red/yellow) for both MR1 and MR2 in 2025, particularly outside Java
- **Early 2026 coverage remains very low and uneven**

Building Momentum for Measles Elimination in 2026

May 2026

Regional Consultation on achieving measles and rubella elimination by 2030

June 2026

35th Meeting of Technical Advisory Group Meeting on Immunization and Vaccine Preventable Diseases in the Western Pacific Region

August 2026

Subregional Verification Committee meeting on measles and rubella elimination for the Pacific

September 2026

14th annual meeting of the regional verification commission for measles and rubella elimination in the Western Pacific

October 2026

Regional Committee for the Western Pacific – Seventy-Seventh Session, Immunization as a key agenda item

Ambition

Consolidation of elimination timelines

Source: country reports, 12 -14 May 2026

Country	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
China										
Cambodia						Revised				
Indonesia							Revised			
Philippines							Revised			
Lao PDR										
Malaysia									Revised	
Mongolia									Revised	
PNG										
Viet Nam										

Interruption **Verification**

Notes: as of May 2026, no measles case reported since 2023 in PNG

What Measles Modelling Must Deliver for Countries

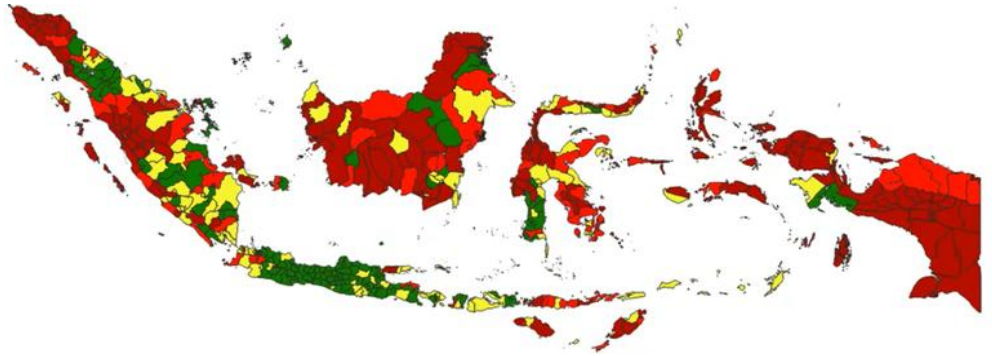
The value of MAH lies in enabling countries to :

- Answer urgent operational questions for timely response
- Identify and quantify immunity gaps across populations and geographies
- Assess outbreak risk and anticipate transmission patterns
- Inform SIA strategies with evidence-based targeting
- Strengthen surveillance and programme guidance
- Support decision-making through actionable, user-friendly tools

Based on co-creation with country stakeholders

Modelling Assessment of Vaccination Strategies for Measles Elimination in Indonesia

- **WHO 3-level team (Indonesia WCO, WPRO, and HQ)** and **Indonesia MOH's collaboration** with **Measles Analytics Hub (MAH) and participating research institutions**
- **Currently:** virtual co-creation ongoing
- **June 2026:** preliminary results and discussion with national stakeholders at MAH's annual in-person meeting in Jakarta
- **September 2026:** final results for deliberation at the Regional Verification Commission meeting in Jakarta
- Lessons learned to be shared with other countries in the Western Pacific Region and globally



Work package 1
Projecting national and subnational trajectories for measles elimination in Indonesia

Work package 2
Evaluating comparative efficiency and cost-effectiveness of alternative SIA strategies

+ Translation and contextualisation of modelling outputs

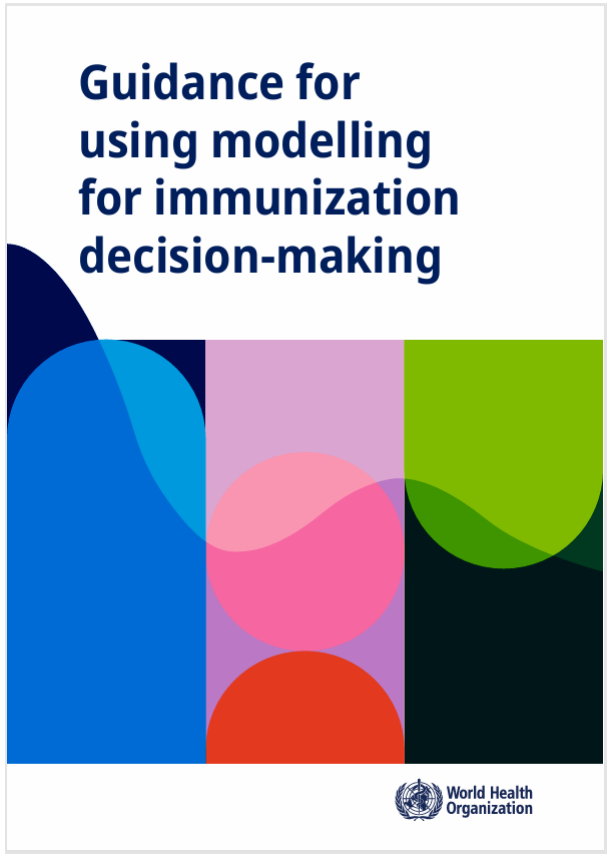
World Health Organization
MEASLES ANALYTICS HUB
UNIVERSITAS GADJAH MADA
Ahmedabad University
NDMC
NUS National University of Singapore

Measles Analytics Hub 2026 annual meeting: Call to Action

- Country and regional priorities must be the starting point for global learning
- Models are only as powerful as the decisions they inform
- Models should be built not only *for* countries, but *with* countries — grounded in local data, local priorities, and local decision-making needs
- Innovation flourishes through partnership
- Let us move beyond shared knowledge toward a shared commitment: turning insights into action for measles and rubella elimination


Thank you

WHO guidance for using modelling for immunization decision-making



Objective
Help decision makers to interpret, use, and apply modelling to support evidence-informed decision-making

Target audience
- ✓ NITAG and RITAG members, including secretariats
- ✓ EPI managers
- ✓ Technical working groups and partners

Link
https://iris.who.int/handle/10665/385083.
License: CC BY-NC-SA 3.0 IGO

QR Code to the guidance document

WPR Lightening Talks 1

Session chair:

Olivi O.P Silalahi,

WHO Indonesia

MEASLES
ANALYTICS HUB

Xiaojun Wang

WHO WPR (online)

MEASLES
ANALYTICS HUB

Regional Priorities Towards Measles and Rubella Elimination in the Western Pacific Region

Dr. Wang Xiaojun
WHO/WPRO

MAH Annual Meeting
10 June 2026

World Health Organization
Western Pacific Region

Regional Committee's Resolutions

World Health Organization
Western Pacific Region

2003 WPR/RC54.R3

- Measles elimination as a pillar to strengthen EPI

2005 WPR/RC56.R8

- To eliminate measles by 2012

2010 WPR/RC.61.R7; **2012** WPR/RC63.R5

- ***To established regional verification mechanisms***

2014 WPR/RC65.R5

- Endorsed rubella elimination goal

2017 WPR/RC68.R1

- Endorsed regional MR Strategy and POA

2020: WPR/RV71.R1 (2020)

- Endorsed regional EPI strategic framework

Program quality and equity marker

WPR Measles Elimination Verification Status

World Health Organization
Western Pacific Region

Country/Area	Population (in million)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Australia	26.9															
Brunei Darussalam	0.5															
China, Hong Kong SAR	7.8															
China, Macao SAR	0.7															
Japan	124.0															
New Zealand	5.0															
Pacific Island Countries and areas	3.6															
Republic of Korea	51.3															
Singapore	6.1															
Cambodia	17.8															
Mongolia	3.5															
China	1457.9															
Indonesia	285.7															
Lao People's Democratic Republic	7.8															
Malaysia	34.3															
Papua New Guinea	9.8															
Philippines	116.8															
Viet Nam	101.1															

Verified as having sustained measles elimination

No endemic measles virus transmission

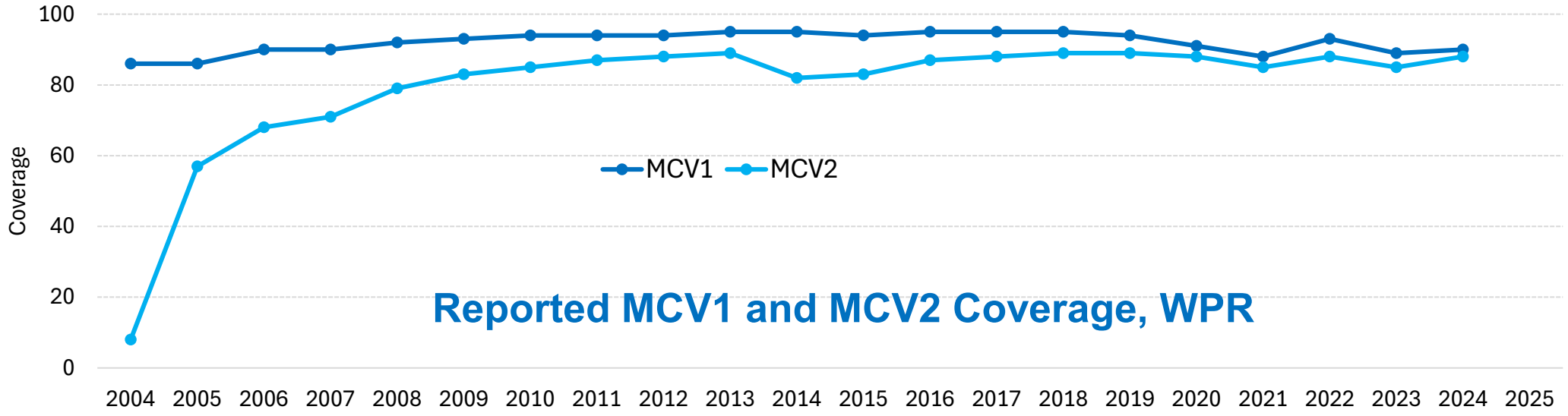
As of September 2025

- **29 countries and areas** verified as measles elimination

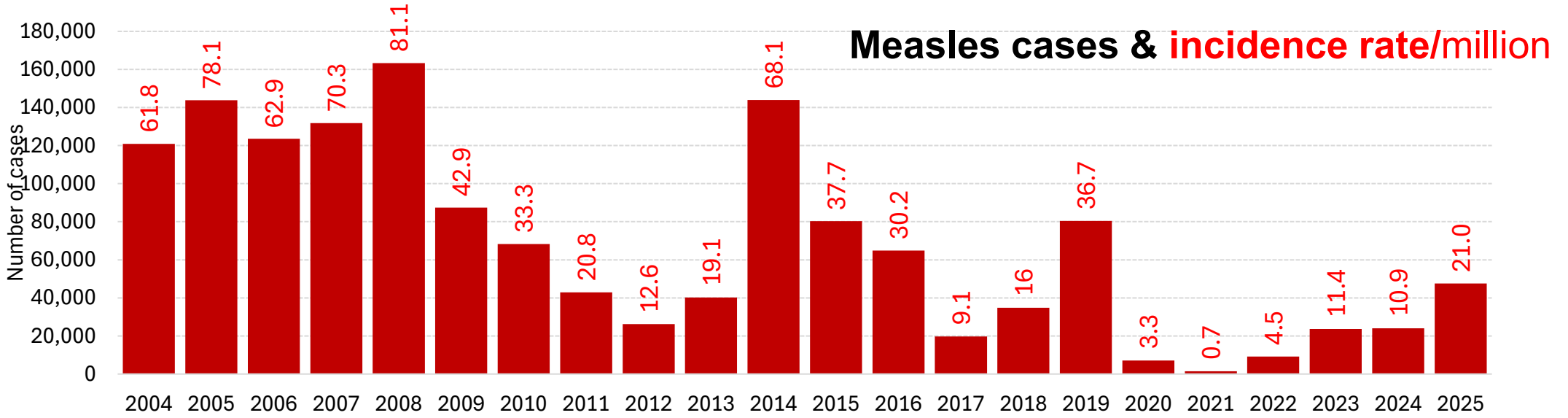
29 out 38 countries and areas

19 of 28 Member States

Regional Journey in the last two decades



Reported MCV1 and MCV2 Coverage, WPR



Source: WHO-UNICEF Joint Reporting Form (as of 07 May 2026); Incidence rate is computed per 1,000,000 total population using UN world population prospects
2025 cases and incidence data are from the national measles and rubella monthly reports

Virus knows no borders – shared risks call collective action

Measles Virus Exportations and Importations
Within and Beyond the Western Pacific Region, 2024

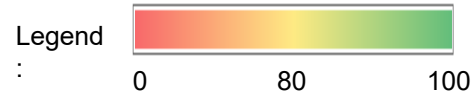
DISCLAIMER: The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement. © WHO Regional Office for the Western Pacific 2026. All rights reserved

MCV1 and MCV2 coverage by country, 2010-2024

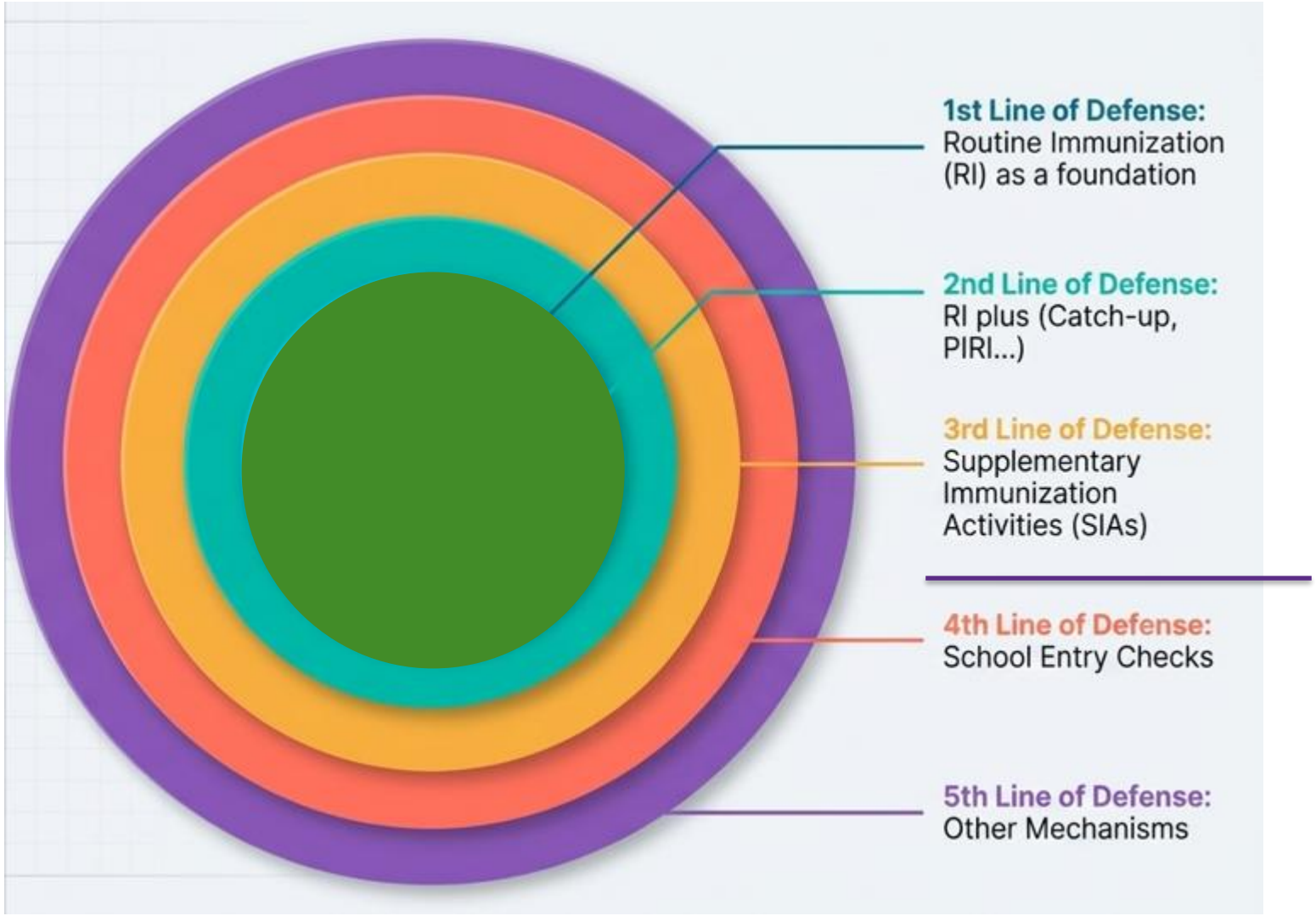
Countries/Areas	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Australia	95	95	94	94	94	93	93	96	91	91
Brunei Darussalam	96	98	97	99	97	99	99	97	97	99
Japan	96	96	97	97	96	98	95	98	94	95
New Zealand	93	92	93	92	92	91	91	90	89	89
Republic of Korea	98	98	97	98	98	98	98	97	97	97
Singapore	95	95	95	97	96	97	96	96	97	97
Cook Islands	99	90	98	99	99	87	74	61	84	99
Fiji	98	97	99	95	94	92	98	99	98	91
Kiribati	84	80	81	84	94	82	80	85	79	79
Marshall Islands	75	75	83	83	85	89	85	81	88	88
Micronesia (Fed States of)	74	70	76	73	78	79	64	69	86	81
Nauru	98	98	95	99	95	98	98	98	98	98
Niue	99	99	99	99	99	99	99	99	99	99
Palau	95	96	93	90	97	93	93	96	96	96
Samoa	75	75	67	40	96	66	62	82	87	85
Solomon Islands	75	82	84	93	81	81	67	90	68	78
Tonga	99	98	99	99	99	99	99	99	99	99
Tuvalu	94	96	95	88	96	93	93	90	98	97
Vanuatu	76	84	80	75	80	78	50	70	70	61
Cambodia	85	85	85	86	87	83	83	83	79	83
China	99	99	99	99	99	99	99	99	95	95
Indonesia	87	88	90	89	88	76	72	92	82	85
Lao PDR	78	76	78	75	70	63	62	65	69	69
Malaysia	93	96	96	98	97	95	96	96	96	96
Mongolia	98	99	99	99	98	97	95	94	96	96
Papua New Guinea	57	46	41	37	37	44	35	41	52	44
Philippines	80	80	81	82	83	79	64	76	81	80
Viet Nam	97	99	97	97	95	97	89	88	82	98

Countries/Area	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Australia	93	94	93	93	94	94	94	91	93	92
Brunei Darussalam	97	97	98	98	98	97	99	99	99	99
Japan	93	93	95	93	93	95	94	95	94	96
New Zealand	87	89	90	90	90	91	82	83	84	87
Republic of Korea	97	97	97	97	96	95	95	95	96	96
Singapore	90	88	90	91	92	94	93	92	92	93
Cook Islands	95	90	95	99	98	82	67	51	77	79
Fiji	94	83	86	89	72	71	78	84	83	75
Kiribati	76	79	79	85	91	57	58	68	47	47
Marshall Islands	70	49	62	61	64	68	59	54	61	61
Micronesia (Fed States of)	74	45	52	48	52	62	38	38	59	60
Nauru	96	97	94	94	95	97	99	99	99	99
Niue	99	99	99	99	99	99	99	99	99	99
Palau	82	95	77	75	88	83	84	85	89	88
Samoa	55	54	54	28	59	59	50	45	75	60
Solomon Islands				54	54	51	40	90	48	66
Tonga	99	99	99	99	99	99	99	99	99	99
Tuvalu	86	92	94	81	92	85	84	89	98	91
Vanuatu									21	53
Cambodia	59	64	67	64	75	72	63	69	64	64
China	99	99	99	99	98	99	99	99	95	95
Indonesia	31	55	63	67	71	60	53	71	69	82
Lao PDR				63	50	52	52	57	69	66
Malaysia	99	99	99	88	87	84	98	96	95	93
Mongolia	98	99	98	98	99	96	94	93	96	95
Papua New Guinea					20	27	20	25	41	26
Philippines	57	62	64	65	67	68	55	64	69	71
Viet Nam	92	95	93	90	92	93	85	81	86	95

Source: WHO and UNICEF estimates of national immunization coverage (WUENIC)



High and Equitable Population Immunity: building an interlocked system of defense



Surveillance performance, WPR, 2025-2026

Table 4. Measles surveillance performance indicators by country and area, WHO Western Pacific Region, 2025–2026

Country/Area	2025				2026			
	Discarded non-measles rate per 100 000 pop	Second level units with ≥ 2 discarded cases per 100 000 pop [annualized][1]	Suspected cases with adequate investigation	Suspected cases with adequate specimens for laboratory confirmation[2]	Annualized discarded non-measles rate per 100 000 pop	Second level units with ≥ 2 discarded cases per 100 000 pop [annualized][1]	Suspected cases with adequate investigation	Suspected cases with adequate specimens for laboratory confirmation[2]
	≥ 2	≥ 80%	≥ 80%	≥ 80%	≥ 2	≥ 80%	≥ 80%	≥ 80%
Australia[3]	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Brunei Darussalam	6.6	Not applicable	93.3%	100.0%	6.0	Not applicable	100.0%	100.0%
China, Hong Kong SAR	0.1	Not applicable	100.0%	100.0%	0.0	Not applicable	100.0%	100.0%
China, Macao SAR	2.6	Not applicable	100.0%	100.0%	3.9	Not applicable	100.0%	100.0%
Japan	1.2	8.5%	Insufficient data	Insufficient data	1.8	17.0%	Insufficient data	Insufficient data
New Zealand	19.5	100.0%	Insufficient data	Insufficient data	12.2	80.0%	Insufficient data	Insufficient data
Republic of Korea	1.9	29.4%	99.3%	95.8%	0.8	5.9%	100.0%	95.5%
Singapore	0.4	Not applicable	94.1%	90.2%	4.7	Not applicable	95.9%	84.7%
Pacific island countries and areas[4]	4.9	5.0%	96.0%	95.5%	3.8	5.0%	97.1%	94.3%
Cambodia	31.6	100.0%	99.0%	98.0%	0.0	0.0%	99.0%	98.0%
China	2.5	96.8%	99.5%	98.8%	1.2	9.7%	98.4%	95.6%
Indonesia	12.5	81.6%	Insufficient data	43.4%	-	-	-	-
Lao People's Democratic Republic	9.1	27.8%	7.4%	11.3%	5.5	22.2%	0.3%	2.9%
Malaysia	23.5	100.0%	92.5%	99.4%	12.3	86.7%	85.0%	98.2%
Mongolia	2.5	13.6%	9.4%	9.4%	0.0	0.0%	49.0%	49.0%
Papua New Guinea	0.2	0.0%	17.6%	70.6%	0.7	10.0%	0.0%	0.0%
Philippines	2.4	50.0%	54.8%	59.1%	1.4	27.8%	63.7%	66.3%
Viet Nam	0.0	1.6%	6.1%	49.7%	-	-	-	-
Western Pacific Region	4.1	44.3%	34.6%	49.2%	1.2	15.6%	76.8%	77.6%

[1] This indicator is not applicable for countries which have no second-level administrative units
[2] Adequate specimen defined as blood specimen collected within 28 days of rash onset or other specimen (throat swab, nasopharyngeal swab, cerebrospinal fluid, urine) collected within 5 days of rash onset; excludes epidemiologically-linked cases
[3] Reports only confirmed cases
[4] Surveillance performance indicators refer to all the Pacific island countries and areas as one epidemiological bloc; each country is considered as second level unit
Source: National measles and rubella monthly reports to the Western Pacific Regional Office by 20 April 2026

Green	Reached or surpassed target
Yellow	Nearly reached target: 1.0–1.9 for non-measles suspected case rate; 60.0–79.9% for other indicators
Red	Substantially below target

Moving Forward Together: The Path to 2030

Consultation on Achieving Measles and Rubella Elimination by 2030 in the Western Pacific Region
12-14 May 2026. Manila, Philippines

1. "Ambition"
   All countries/areas to interrupt endemic measles transmission by 2030

2. "Acceleration"
   Renewing and costing action plan

3. "Resources"
   Domestic resource as key

World Health Organization
Western Pacific Region

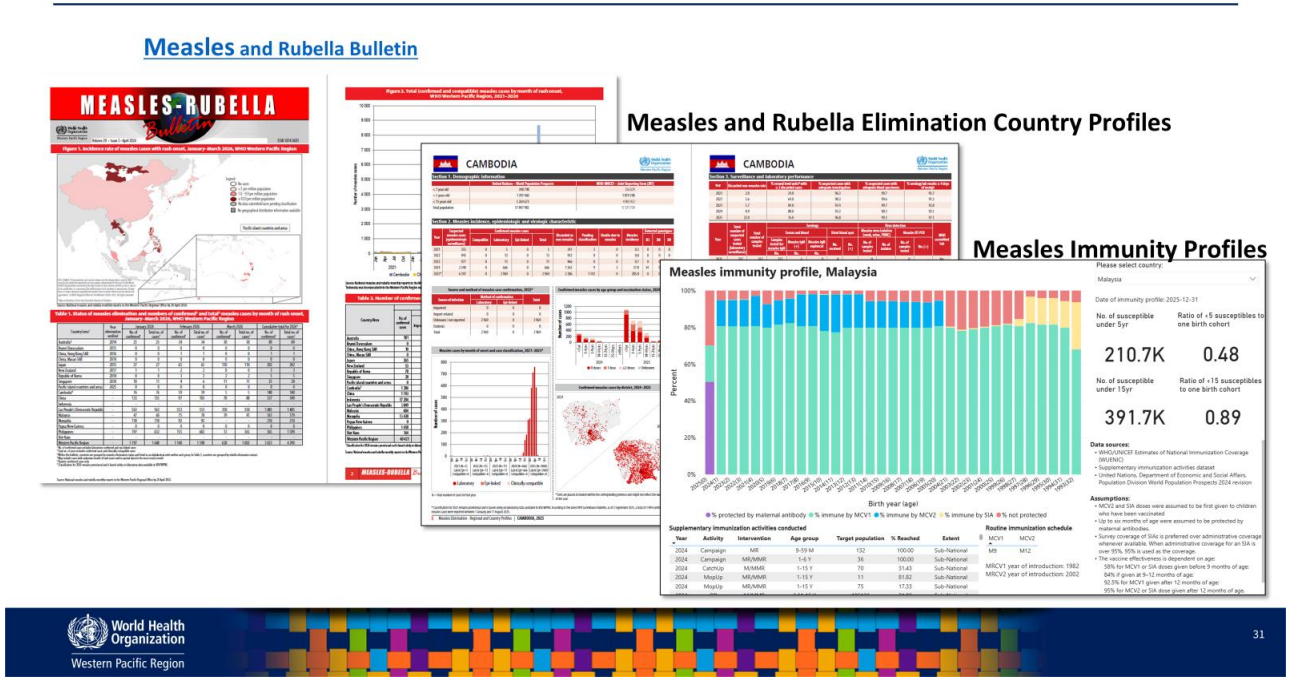
Breaking Barriers to Faster Pace

Enablers for acceleration

- **Essential:** political commitment
- **Alignment:** national and subnational levels
- **Game changer:** advocacy

Core needs

- **Building** uniform high and equitable population immunity
- **Enhancing** surveillance and laboratory systems
- **Strengthening** outbreak preparedness and response
- **Sustaining** trust on immunization and vaccines



We need move faster than measles virus!!

Acting together

We will have more solutions than problems!

Indrajit Ghosh

Ahmedabad University

MEASLES
ANALYTICS HUB

Collaborative and co-created modelling to support measles elimination targets in Indonesia

Indrajit Ghosh, Bimandra Djaafara, Olivi Silalahi, Watsiq Ahmad,
Stephen Chacko, So Yoon Sim, Megan Auzenbergs et. al

Measles Analytics Hub Annual Meeting
10-12 June, 2026
Jakarta, Indonesia

Supported by: WHO Indonesia, MoH Indonesia

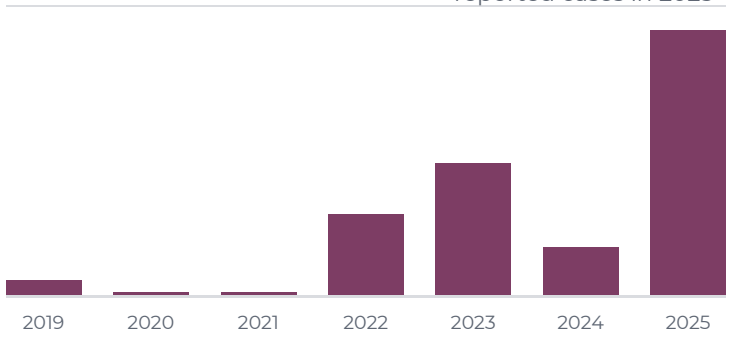
MEASLES
ANALYTICS HUB

Indonesia enters 2026 with recent resurgence and uneven routine protection.

The data frame the MR3 question: high recent reported cases, MR1/MR2 below 95%, and large MR campaigns with variable coverage.

Reported national cases

36.4k
reported cases in 2025



2025 routine coverage

95% programme target

Recent major SIA/MR activities

2016
Measles follow-up
86.0% admin coverage | 4.2M target

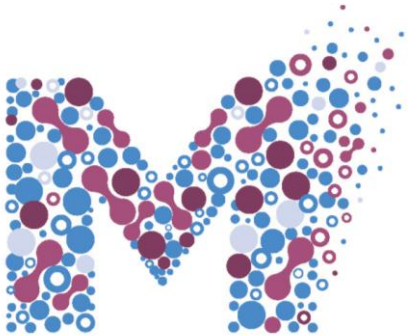
2017
MR catch-up phase 1
101.0% admin coverage | 35.0M target

2018
MR catch-up phase 2
72.4% admin coverage | 32.0M target

2022
MR follow-up
72.7% admin coverage | 36.5M target

DECISION FRAME

The practical question is not MR3 alone; it is what replaces it if MR3 stops.



The model was built with country partners to compare a school-age booster against feasible routine-coverage alternatives and the 2030 elimination target.

Path A: continue MR3

Maintain the school-based booster while MR1 and MR2 stay at 2025 levels. This is the current comparator.

Path B: stop MR3

Hold MR1 and MR2 at 2025 coverage after 2026. This is the baseline for averted-burden comparisons.

Path C: replace MR3

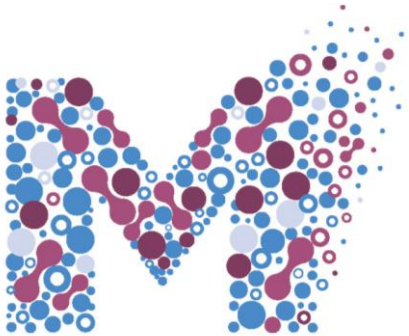
Discontinue MR3 only if MR1, MR2, or both are strengthened enough to compensate.

Output lens: cumulative true infections, deaths, DALYs, routine doses, and whether the 0-cases-for-3-years proxy is reached by 2030.

MODEL IN ONE SLIDE

The model is calibrated to policy-relevant outputs, not just reported cases.

Country-level simulation from 1970 to 2050; accepted fit uses national cases plus deaths, DALYs and 2023 serology.



Inputs

Age-specific population, 20x20 contact matrix, MR1/MR2/MR3 coverage, SIA history, deaths, DALYs, cases and serology.

Calibration

Fitted to national reported cases, normalized deaths and DALYs, and seroprevalence with higher weight on serology.

Assumptions

MR1/MR2/MR3 effectiveness: 85%, 90%, 95%. Reporting rate is monotone and low in the accepted fit.

Outputs

True infections, deaths, DALYs, coverage thresholds, and routine dose counts.

82.6%

MR1 coverage in 2025

78.0%

MR2 coverage in 2025

94.7%

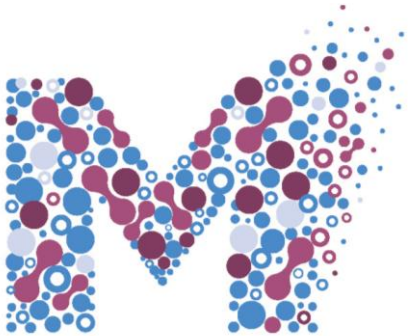
MR3 coverage in 2025

20 age bins

0-3 months through 65+ years

Continuing MR3 has a modest absolute impact under fixed MR1/MR2 coverage.

Versus the no-MR3 baseline, 2026-2030; MR1 and MR2 coverage are held at 2025 levels.



Absolute burden averted versus no-MR3 baseline

18.3k
true infections averted

24
deaths averted

2.24k
DALYs averted

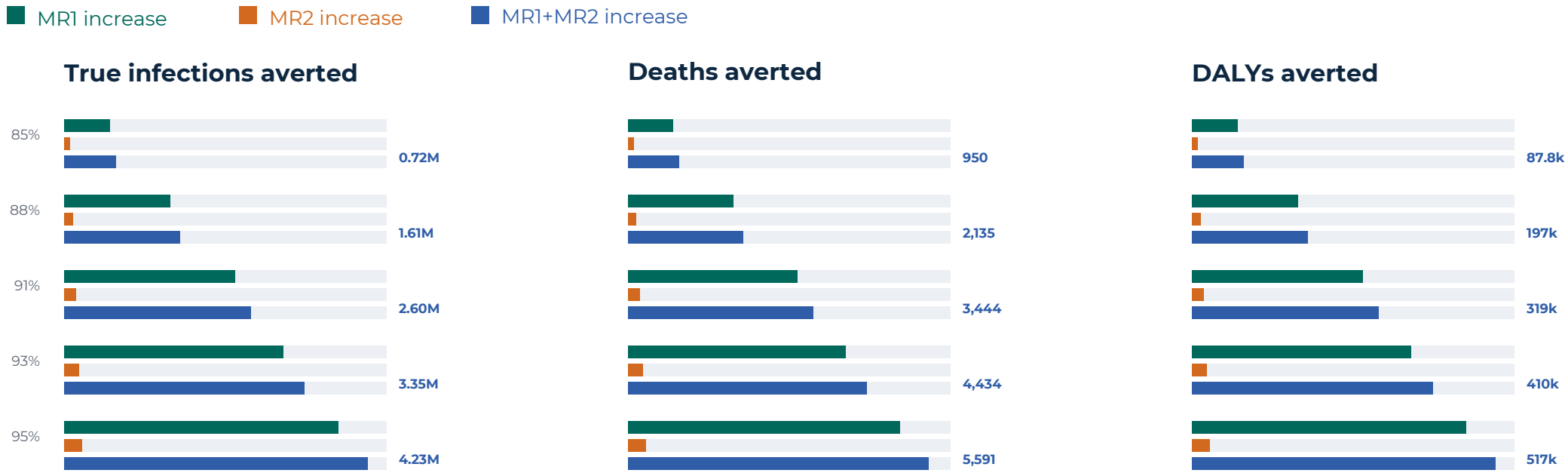
Interpretation: MR3 is protective, but as a standalone continuation strategy it averts relatively few absolute infections compared with routine MR1 strengthening.

22.7M
additional MR3 doses required in 2026-2030

1,236
additional MR3 doses per true infection averted

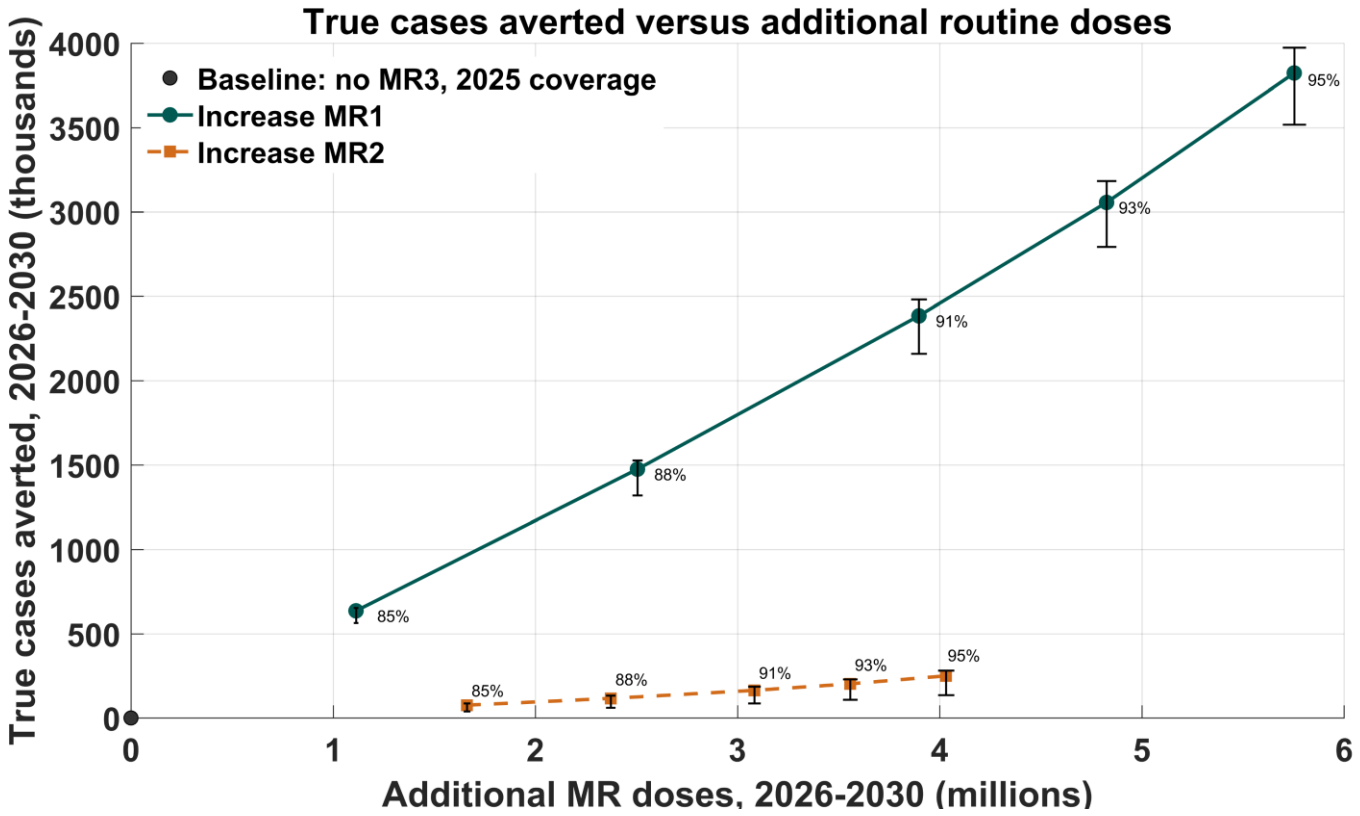
MR1 strengthening averts far more cases, deaths and DALYs than MR2 alone.

Bars show cumulative burden averted in 2026-2030 versus the no-MR3 baseline. Labels show the combined MR1+MR2 strategy.



MR1 strengthening gives far more infections averted per routine dose than MR2 strengthening.

The replacement question is not only epidemiological: it is also about routine vaccine contacts required for each true infection averted.



At 95%, MR1 averts 3.82M true infections using 47.8M doses; MR2 averts 0.25M using 46.1M doses.

Routine coverage alone does not meet the 2030 elimination proxy, even at 95/95/95.

The threshold search screened the optimistic routine-only ceiling first. Because 95% for all three doses did not eliminate, no lower routine combination can meet the proxy.

95% MR1 + 95% MR2 + 95% MR3

No elimination by 2030

20.9k

reported cases remain in 2030

75.1M

routine doses required in 2026-2030

9.90M

true infections, 2026-2030

13.1k

deaths, 2026-2030

Implication

A 2030 elimination plan needs routine strengthening plus a catch-up/SIA or outbreak-response component to reduce the already accumulated susceptible pool.

Discontinue MR3 only with an MR1 acceleration and a potential catch-up plan.

The model does not support MR3 discontinuation as a simple schedule deletion. It supports a conditional replacement strategy.

1. Programme suggestion

MR3 can be discontinued only if MR1 is raised rapidly, ideally to 95%, while MR2 is at least maintained and strengthened where feasible.

2. Elimination result

Routine vaccination alone is not enough for 2030 elimination; plan a targeted catch-up/SIA component for accumulated susceptibility.

3. Next steps

Extend the framework for subnational data: consider three regions in Indonesia, simulate scenarios, check for robustness of results across the regions

4. Transferable lesson

For other settings, model the policy replacement, not only the discontinued dose: burden, dose counts, feasibility, and elimination timing.

MEASLES ANALYTICS HUB

Thank you

For those in the audience from Indonesia WCO or MoH, these findings will be discussed in more detail during our Friday side meeting

MEASLES ANALYTICS HUB

Arifianto Apin

Universitas YARSI

MEASLES
ANALYTICS HUB

From Hospital Cases to Population Risk: Data Challenges in Using Clinical Measles Data for Modelling in Urban Indonesia

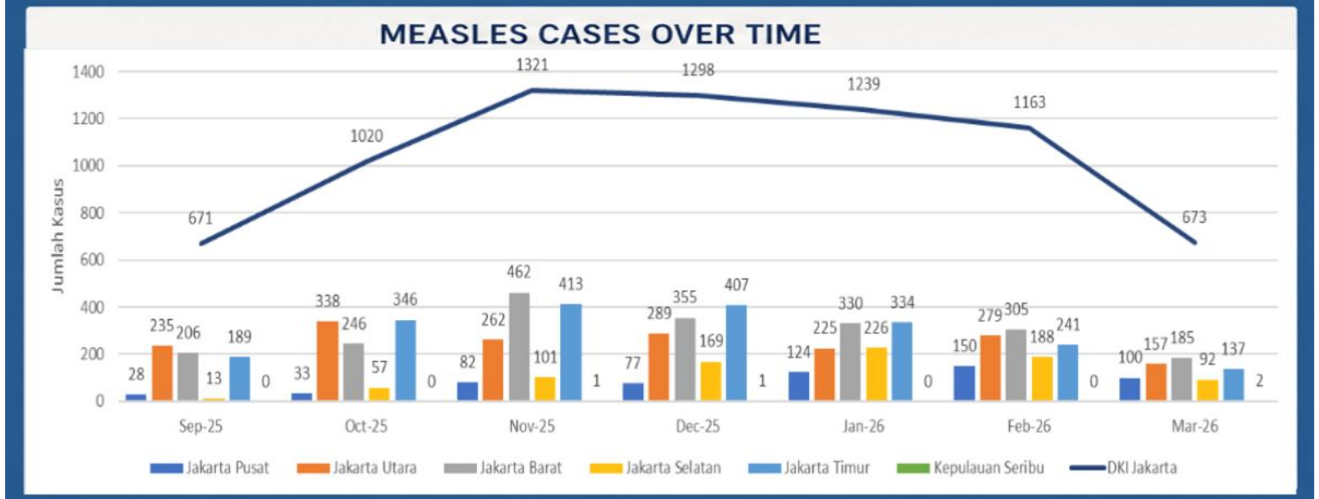
Arifianto, MD
Pasar Rebo General Hospital/YARSI University
Jakarta, Indonesia

Co-authors: Masiya Mawla Putri, Nabiela El Rizqa

MEASLES
ANALYTICS HUB

WHY JAKARTA??

- Dense urban population
- High mobility
- Ongoing measles outbreaks
- Referral hospitals receive concentrated severe cases

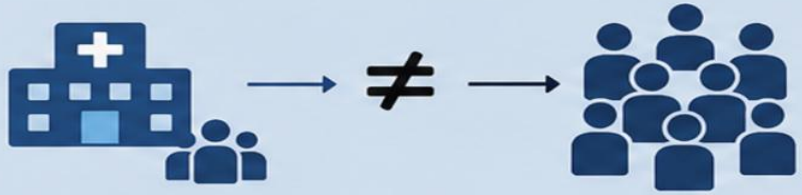


KEY QUESTION

Can hospital-based data represent **population-level** measles risk?

- Population susceptibility?
- Transmission dynamics?
- Spatial outbreak risk?

⚠ Hospital data are influenced by healthcare-seeking patterns and may not capture all community cases.



Hospital surveillance captures disease burden, but **not necessarily population-level risk**.

Population (2025): ~11 million (Indonesia's capital and largest city)

MEASLES ANALYTICS HUB

DATA SOURCE

Hospital-based measles dataset

SETTING

- Pasar Rebo General Hospital
- September 2025 – March 2026
- 184 pediatric measles cases

VARIABLES COLLECTED

- Age
- Vaccination status
- Nutritional status
- Clinical severity

COMPARISON

- Provincial surveillance trends (Jakarta)

Patients
(pediatric measles cases in the community)

↓

Hospital presentation
(Pasar Rebo General Hospital)

↓

Hospital dataset
(n = 184)

↓

Comparison with Jakarta surveillance data

↓

Assessment for modelling suitability

MEASLES ANALYTICS HUB

MAIN FINDINGS

What did we observe?

Respondent Characteristics		n	%
Sex			
	Male	100	54.3
	Female	84	45.7
Age Group			
	< 9 months	25	13.6
	9–11 months	16	8.7
	1–5 years	91	49.5
	> 5 years	52	28.3
Vaccination Status			
	Complete	53	28.8
	Incomplete	131	71.2
Nutritional Status			
	Severe malnutrition	15	8.2
	Undernutrition	30	16.3
	Normal nutritional status	133	72.3
	Overnutrition	6	3.3

Clinical Characteristics		n	%
Fever			
	Present	183	99.5
	Absent	1	0.5
Cough			
	Present	176	95.7
	Absent	8	4.3
Coryza (Runny nose)			
	Present	128	69.6
	Absent	56	30.4
Conjunctivitis			
	Present	95	51.6
	Absent	89	48.4
Maculopapular Rash			
	Present	184	100.0
	Absent	0	0.0
Koplik Spots			
	Present	24	13.0
	Absent	160	87.0
Severity Classification			
	Mild	8	4.3
	Moderate	159	86.4
	Severe	17	9.2

PROVINCIAL TREND (DKI JAKARTA)

Cases increased from 671 cases in September 2025 to a peak of 1,321 cases in November 2025.

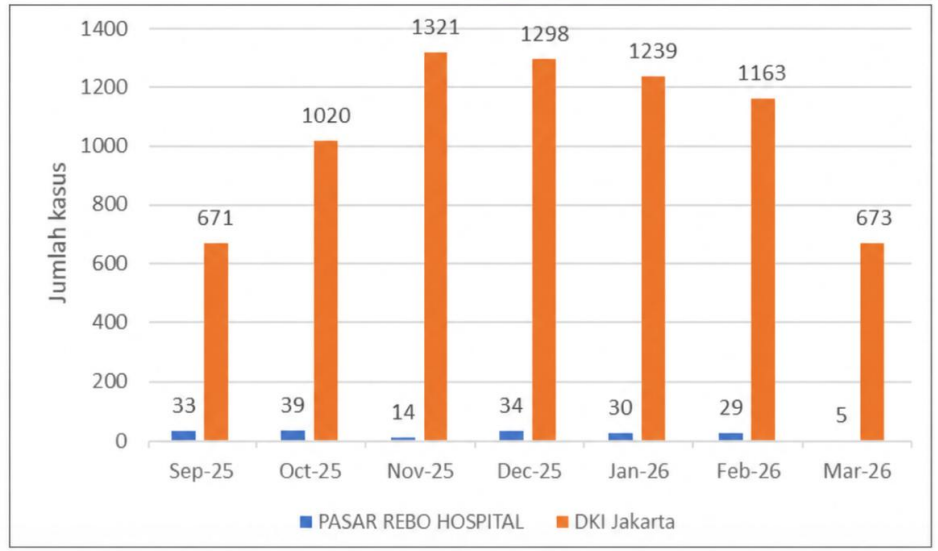
After November, cases gradually declined until February 2026, followed by a sharper decrease in March 2026 (673 cases).

HOSPITAL TREND (PASAR REBO HOSPITAL)

Pasar Rebo Hospital showed a similar temporal pattern, but with substantially lower case numbers.

Cases increased from 33 cases in September 2025 to 39 cases in October 2025, then fluctuated during the following months.

A marked decline was observed in March 2026 (5 cases).



Hospital data captured important outbreak signals,
but may not fully reflect population susceptibility and transmission patterns.

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THE CORE PROBLEM

Why hospital data are difficult to use for modelling

CHALLENGE	IMPACT ON MODELLING
Moderate cases dominated (86.4%)	→ Possible selection bias
Incomplete vaccination status	→ Uncertain immunity estimation
No population denominator	→ Cannot estimate susceptibility
Hospital-based dataset	→ Limited population representativeness
Limited district-level detail	→ Weak spatial prediction

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Policies are only as good as the data behind them

Data

- **Selection bias** moderate-severe cases
- **Incomplete** vaccination history
- **No population** denominator
- **Limited** spatial representativeness

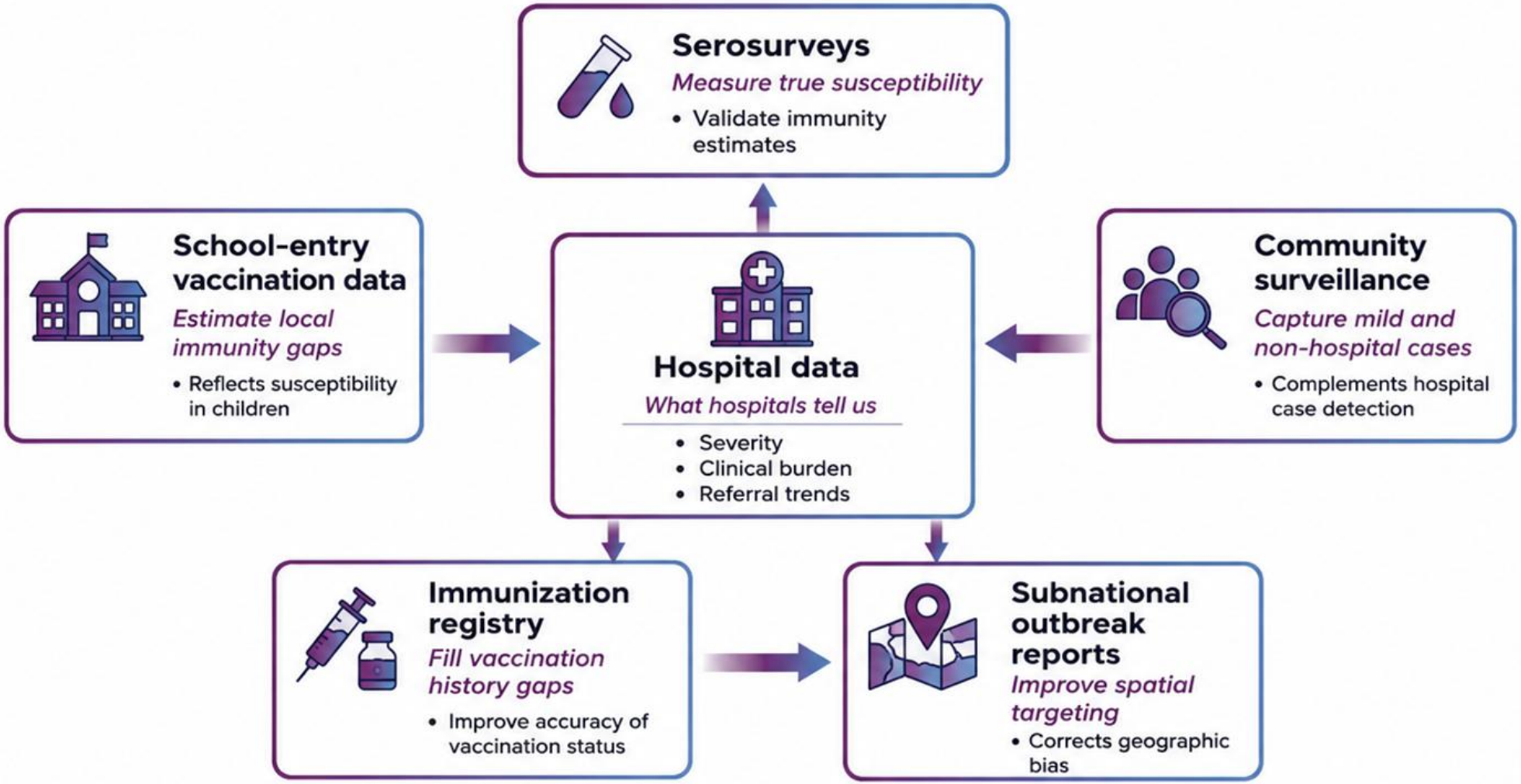
Model

- Susceptibility may be overestimated
- Vaccination gaps may appear larger
- Nutritional drivers may be missed

Policy Result

- SIAs may target the wrong districts
- High-risk children may be missed
- Nutrition-related vulnerability may be overlooked

Better inputs, better models, better targeting



This is not only an Indonesia problem

Lessons that may apply across Southeast Asia

1. **Signals ≠ outbreak dynamics**
   Hospital trends may follow outbreaks—but not exact timing.
2. **Proportions ≠ causality**
   High incomplete vaccination does not always mean the primary driver.
3. **Hidden drivers matter**
   Nutritional vulnerability may shape severity.
4. **Cases ≠ population risk**
   No denominator means no direct susceptibility estimate.

Before trusting models, we need to understand the data behind them.

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MODELS ARE ONLY AS RELIABLE
AS THE DATA BEHIND THEM

Valuable signals

- Capture severity
- Detect outbreak signals

Incomplete representation

- Referral bias
- Missing denominator
- Limited representativeness

Integration is essential

- Linking hospital, surveillance, immunization registries, serosurveys, and spatial data strengthens models and decisions

If we want better models,
we need better data— *not simply more data.*

THANK YOU!!

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MEASLES
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Collaborative and co-created modelling to support MR elimination targets in Indonesia: Work Package 2

Modelling subnational measles SIA campaigns in Indonesia (preliminary results)

Bimandra Djaafara (Andra)
Senior Research Fellow
Saw Swee Hock School of Public Health
National University of Singapore

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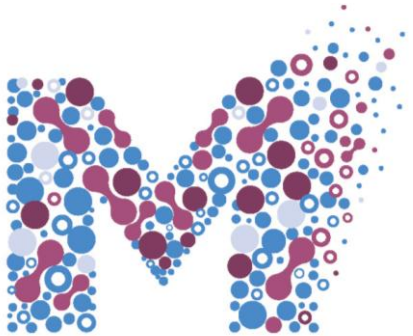
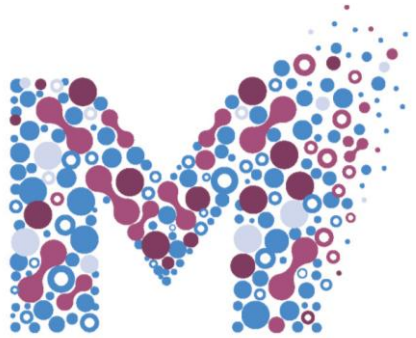
WP 2 of “Modelling Assessment of Vaccination Strategies for Measles Elimination in Indonesia”



- Develop and calibrate an age-structured measles transmission model using Indonesia’s reported case data and historical vaccination coverage
- Compare three scenarios:
  - routine immunisation only (baseline),
  - national SIA,
  - subnational SIA targeting high-risk districts
- Quantify projected outcomes, including cases, deaths, outbreak risk, and estimated year of measles elimination under each strategy
- Assess efficiency and impact using metrics such as number needed to vaccinate (NNV) per case averted

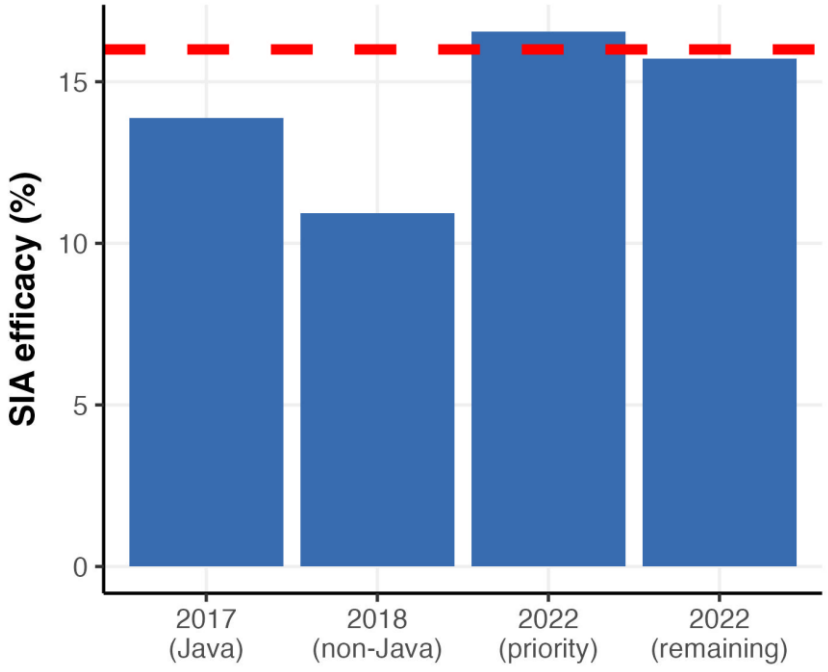
2017-18 & 2022 SIA campaigns efficacy & subnational susceptibility profiles

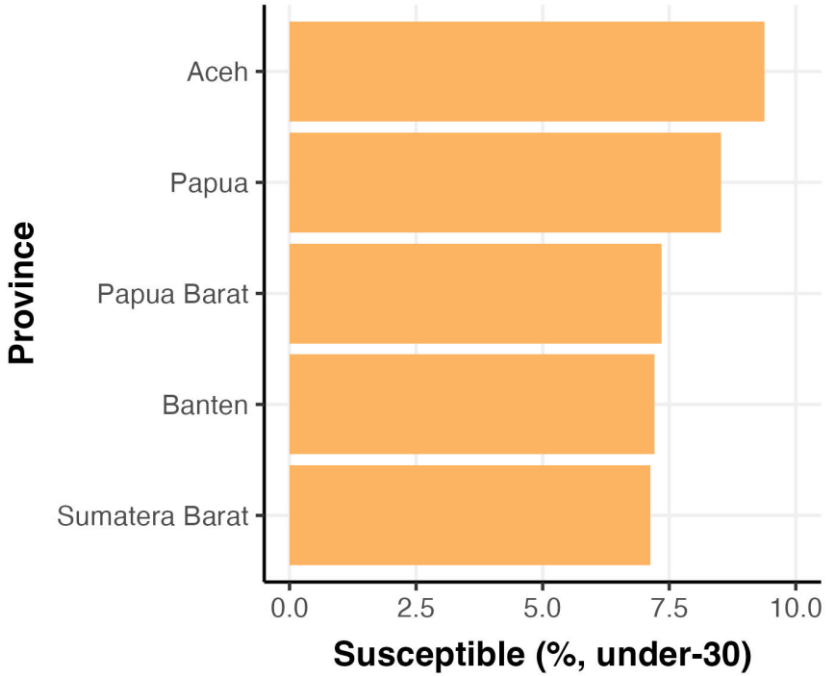


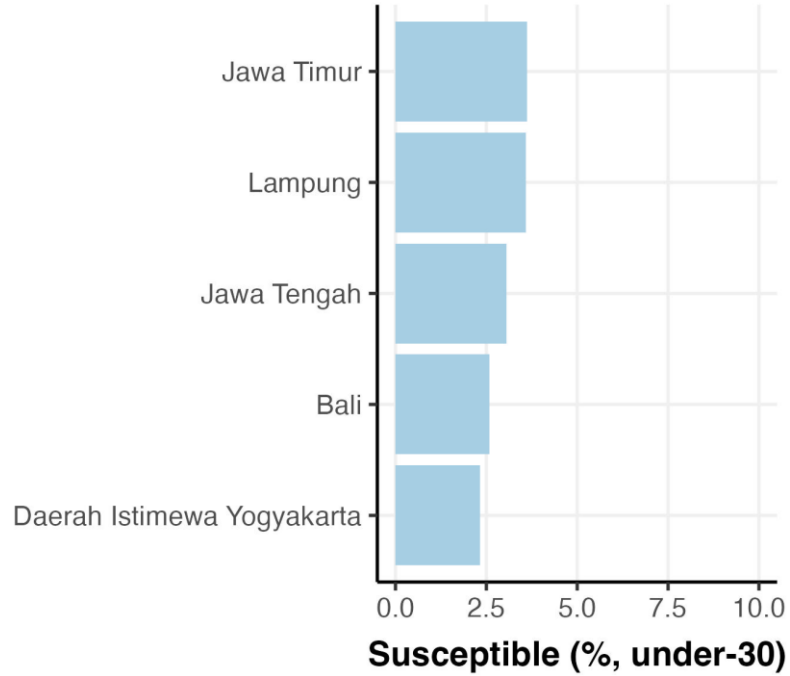
- In **2017-18 & 2022**, Indonesia ran major measles SIA campaigns: MR Phase 1 (Java-Bali, 2017), MR Phase 2 (rest of Indonesia, 2018), and BIAN (national, 2022)
- Official coverage figures tell us how many doses were given — but not how many susceptible children were actually protected
- We used national measles case data (2012–2024) to back-calculate the **per-dose efficacy** of each campaign: the fraction of doses that successfully immunised a previously unprotected child
- These efficacy estimates were then used to reconstruct the current immunity landscape across all 38 provinces

TSIR fit on monthly national cases → per-event μ (efficacy) → province-level cohort ‘survival’ simulation at ρ=0.95 (dose correlation) → validated to seroprevalence survey (2023)

Campaign efficacy was 10–17%, and susceptibility highest in Aceh and Papua







– – – Nigeria estimate, Thakkar et al.

~6.9M children and young adults (aged 0–30) estimated susceptible nationally as of end-2024

In terms of absolute numbers, **provinces in Java** are the highest contributors of susceptible due to large populations

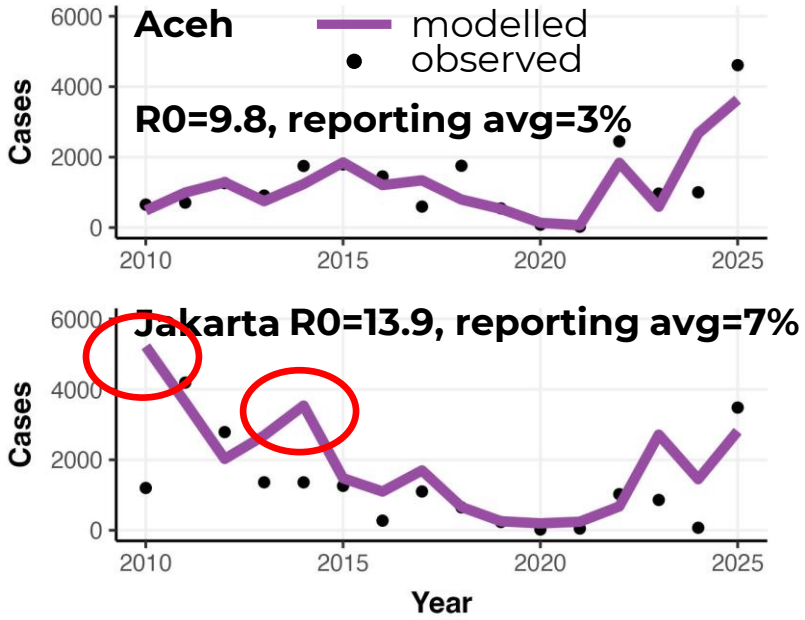
Susceptibility profiles validated against 2023 national seroprevalence survey (SKI 2023): model within 1–5 percentage points across all age groups

Using model to reproduce measles dynamics at the province level

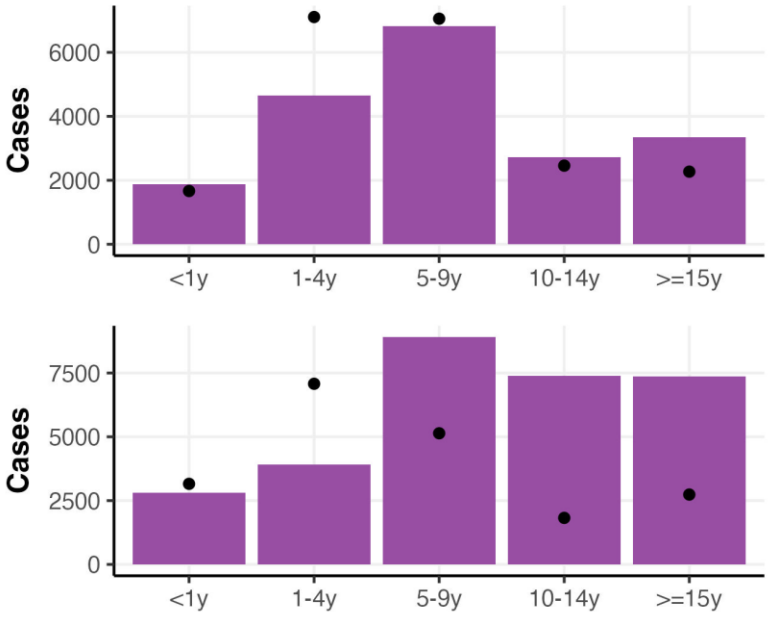
- The MSIR model simulates measles transmission dynamics within each province, accounting for:
  - Age structure (7 bins from infants to adults)
  - Routine vaccination
  - SIA campaigns at **previously estimated efficacy**
  - COVID-period disruption to transmission and surveillance
- Fitted to **annual age-stratified case data (<15 years only)** per province (2010–2025)

Deterministic age-structured MSIR, MAP-fitted via L-BFGS-B with NegBin likelihood, 30-year burn-in based on WUENIC coverage (proportionally distributed across provinces)

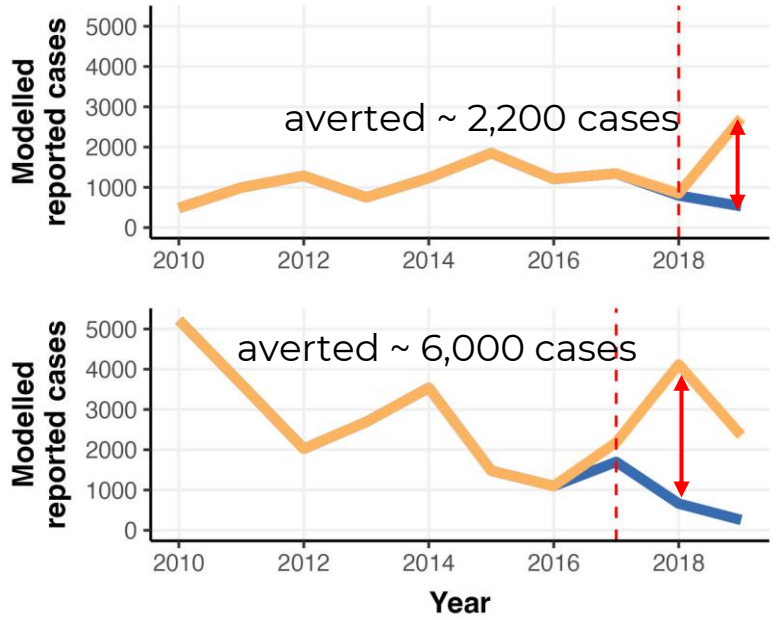
The model reproduces key epidemic features in 2 contrasting provinces (Aceh & Jakarta)



The model managed to capture the qualitative dynamics of Aceh and Jakarta



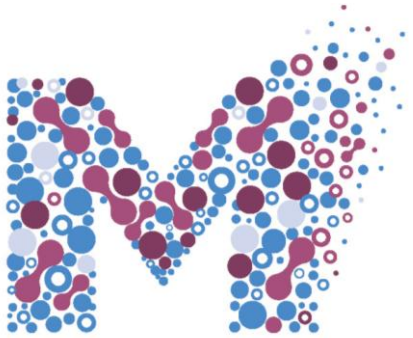
Age-structure-wise, model captured the patterns better in Aceh than in Jakarta



2017-18 campaigns simulated impact on reported measles cases in Jakarta & Aceh up to 2019

In general, the model managed to simulate the dynamics of measles transmission in Aceh & Jakarta, accounting for SIA campaigns

Summary and future directions



- Per-dose efficacy of SIA campaigns 2017 – 2022 in Indonesia = 10-17%
- Aceh, Papua and Papua Barat have the highest susceptible proportions nationally, but absolute number of susceptible were contributed mostly by provinces in Java
- Currently managed to model province-level dynamics
- In high-coverage provinces, may need to go to lower level due to concentrated pockets of susceptible (but may be constrained by data)
- Next steps: 1) Fit MSIR to all 38 provinces, 2) Retrospective evaluations of past SIAs, 3) Forward scenarios, 4) Stochastic simulations with uncertainties

Terima kasih! bimandra.djaafara@nus.edu.sg

Thank you

For those in the audience from Indonesia WCO or MoH, these findings will be discussed in more detail during our Friday side meeting

MEASLES ANALYTICS HUB

Alpha Forna

University of Georgia

MEASLES
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Predicting Measles Outbreak Risk in the Western Pacific and South-East Asia Regions:

A machine learning approach to identifying at-risk countries

Alpha Forna,

University of Georgia

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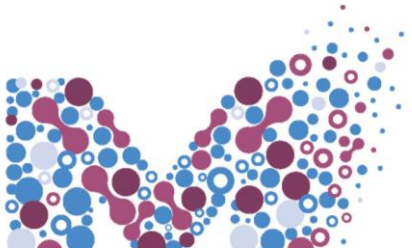
Can we tell, a year ahead, which countries are most at risk?



Coverage is high across much of WPR and SEAR — **yet outbreaks keep recurring.**

Predicting which countries are most at risk could help shift national programmes and regional partners from reactive to proactive responses. But three things make this hard:

1. **Reporting delays**
   Surveillance data lags 6–12 months — we have to predict ahead of incomplete information.

2. **Variable surveillance quality**
   Detection capacity differs widely across WPR and SEAR countries.

3. **Outbreaks are rare events**
   Most country-years are quiet — a model that always says “no outbreak” looks accurate but is useless.

In this talk: the modelling approach · how well it predicts · which WPR & SEAR countries are at risk · **and what we found about the limits of country-year prediction.**

A flexible pipeline applied to 187 countries

Step 1: Collate the data

Step 2: Define prediction target (time step, outbreak definition, prediction horizon)

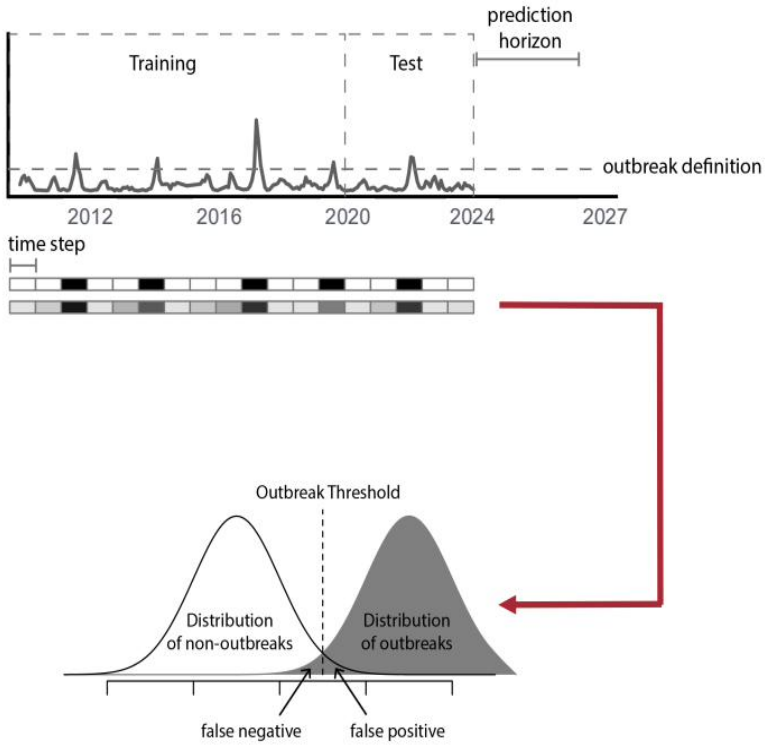
Step 3: Define training, test, and prediction sets

Step 4: Discretize cases by time scale and prediction target definition

Step 5: Quantify the performance of the baseline model

Step 6: Lag and summarize predictors by time step

Step 7: Train ML model on training set and evaluate model performance on test set compared to baseline



We then bins those predicted probabilities into outbreak and non-outbreak time steps by selecting a threshold using the test set that minimizes false positive and false negative classification

Step 3 in practice

Separate years for fitting, tuning, and reporting.

2011–2018 — **TRAIN**

Fit the model with 5-fold cross-validation

2019–2021 — **TEST**

Pick the decision threshold (Youden's index)

2022–2024 — **VALIDATE**

Report performance on years the model has never seen

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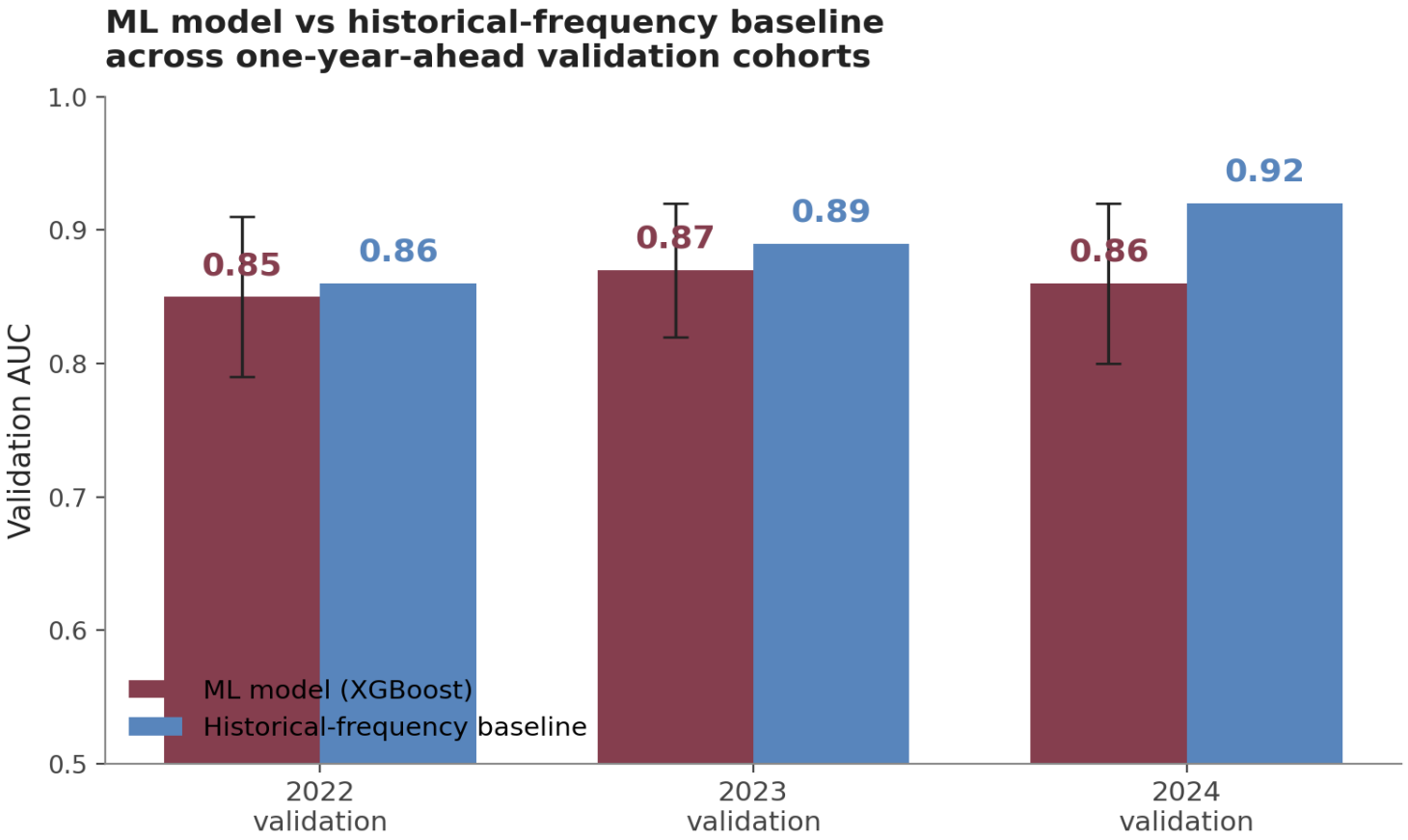
Both Baseline and Model show a strong performance



Three separate validation cohorts, each predicting one year ahead at 20 cases / million / year. These are not 1-, 2-, and 3-year horizons. Error bars: 95% CI on ML AUC. Source: Tables 1, S3, S4.

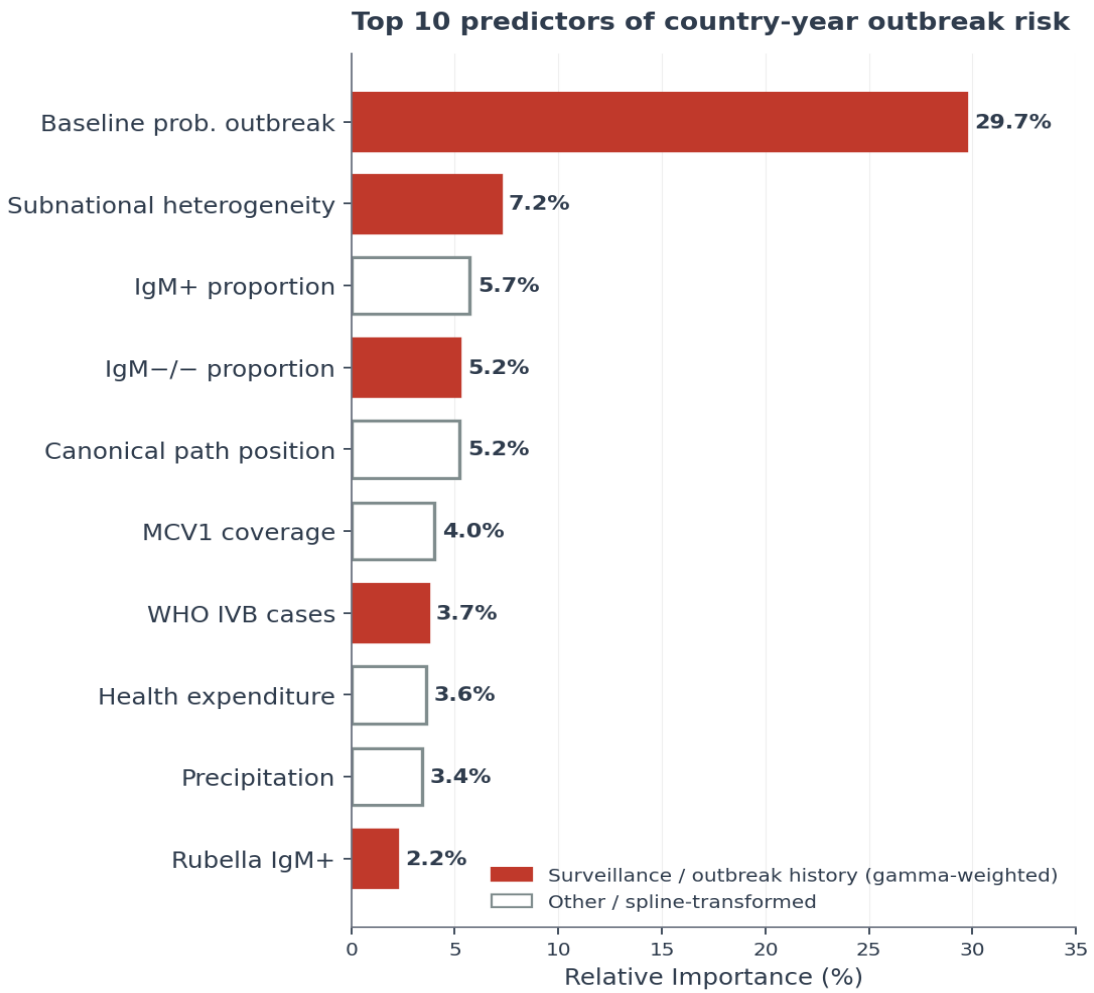
Our XGBoost reaches AUC **0.85–0.87** across three validation cohorts on data the model has never seen.

A simple historical baseline (i.e., how often has this country had an outbreak recently) reaches AUC **0.86–0.92**, matching our model. The gap widens each year: **+0.01** in 2022, **+0.02** in 2023, **+0.06** in 2024.

This is not a failure of the model. It is a finding about how much predictive information country-year outbreak history already contains.

Where the next wins probably come from: sub-national resolution · shorter prediction horizons · better surveillance data.

What actually predicts an outbreak?



Recent outbreak history dominates (Captures most of the prediction signal)

The single strongest predictor is whether the country has had outbreaks recently — which is precisely why the simple baseline is so hard to beat.

Surveillance > vaccination coverage

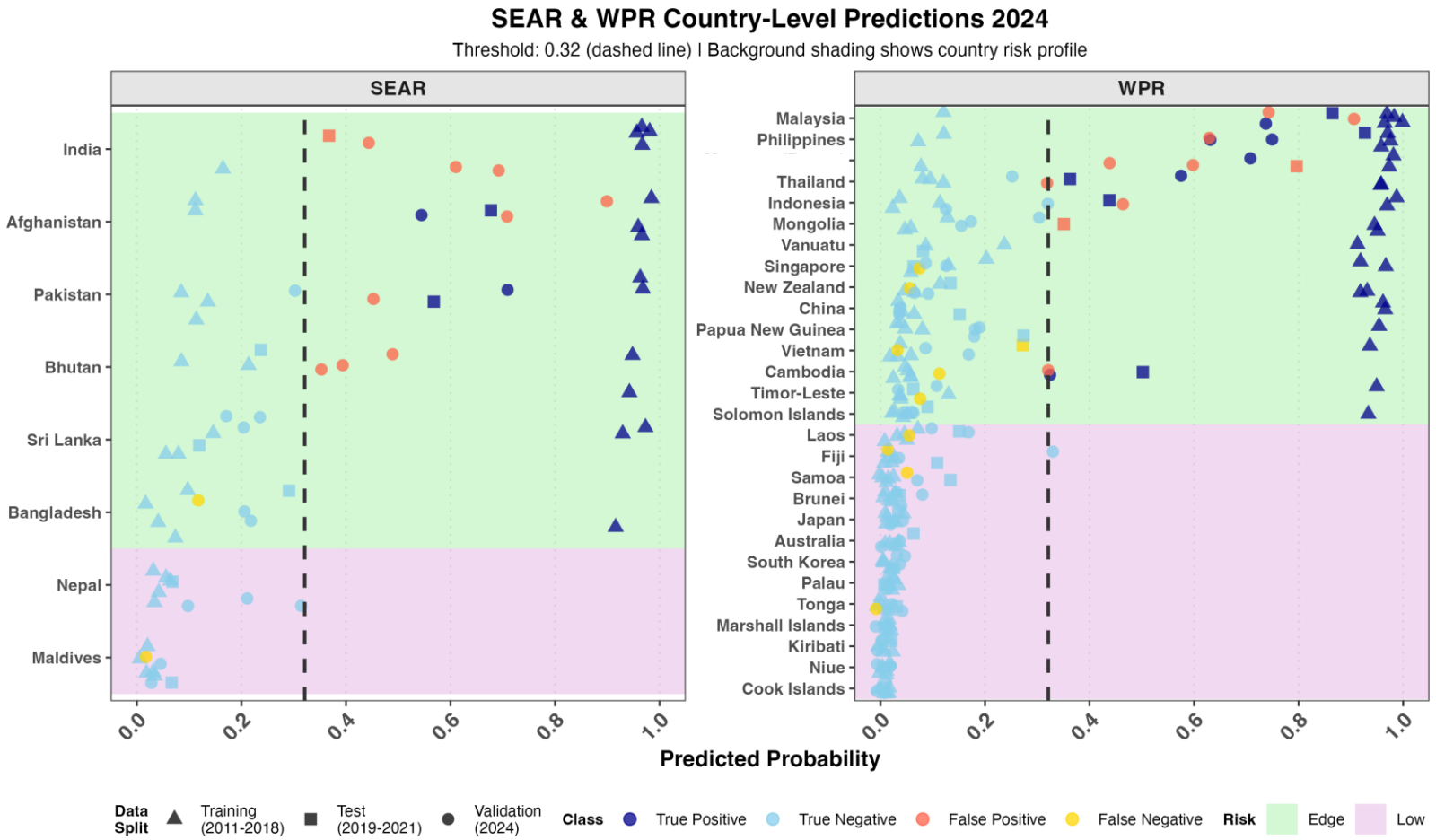
Surveillance-quality indicators contribute **>40%** of predictive power.

Vaccination coverage (MCV1) contributes only **~6.5%** at this resolution.

IMPORTANT: This does ***not*** mean vaccination doesn't prevent outbreaks. It means: at country-year scale, what predicts whether an outbreak gets **detected and reported** is largely the strength of the surveillance system.

SEAR

WPR and SEAR: model predictions for 2024



Predictions for one year ahead. Edge countries = predicted probability crossing the threshold across training, test, and validation periods.

SEAR

Highest-risk countries

India · Myanmar

The pattern across both regions: the countries most vulnerable to outbreaks are often the ones least equipped to detect them early.

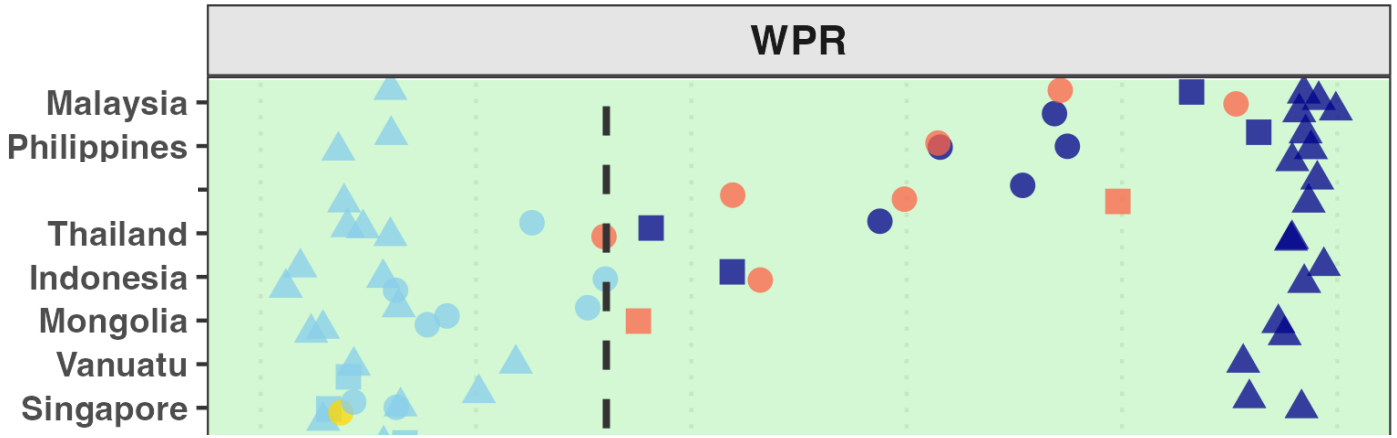
WPR

Edge countries — close to the threshold

Philippines · Thailand · Indonesia · Papua New Guinea Lao PDR · Cambodia

Small changes in surveillance or coverage could tip the balance — exactly where targeted investment matters most.

Zooming in on Philippines & Thailand



Edge countries — close to the threshold

Philippines · Thailand

Small changes in surveillance or coverage could tip the balance — exactly where targeted investment matters most.

Predictions for one year ahead. Edge countries = predicted probability crossing the threshold across training, test, and validation periods.

What this means

There is a ceiling

Country-year measles prediction has a real upper bound. New models should be benchmarked honestly against simple historical baselines — not against random classifiers.

Surveillance is the lever

In edge countries, better detection turns the model into a useful early-warning tool. This is where investment in WPR and SEAR has the highest predictive return.

The framework is flexible

Outbreak thresholds, prediction horizons, and time scales are user-configurable — raising a real question of whether 20 cases / million still makes sense as a single global definition.

Invitation

For those interested — we will discuss a bit more about what we have learnt about building these prediction tools and their adaptability in practice. We would like to hear your experiences using similar tools in your daily work.





Co-authors: Alyssa Sbarra (JHU) · Saki Takahashi (JHU) · John Drake (UGA) · Matt Ferrari (PSU) · Amy Winter (UGA) · *alpha.forna@uga.edu*

Moderated Q&A discussion

Session Chair:

Olivi O.P Silalahi,

WHO Indonesia

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Coffee Break

WPR Lightening Talks 2

Session chair:

Jess Metcalf,

Princeton University

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Dessie Mekonnen

Independent Consultant

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Papua New Guinea Integrated MR–Polio Campaign during the polio outbreak response, 2018/19: Successes & lessons learned

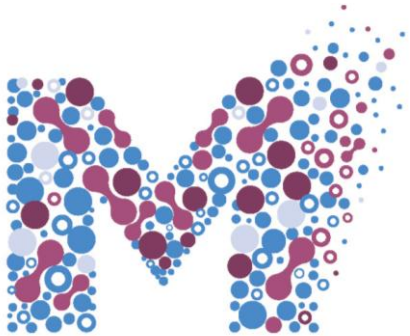
Dessie Mekonnen, PhD, MPH, EMBA

MAH Annual Meeting

10 June 2026

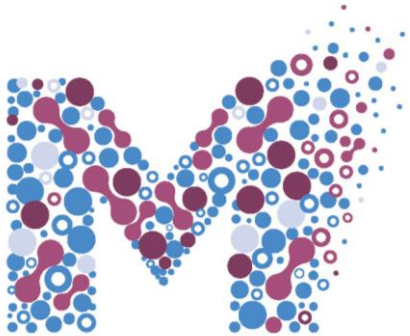
MEASLES ANALYTICS HUB

Outline of the presentation



- Background
- Response of polio outbreak response in 2018-19
- Results of integrated MR-OPV campaign in 2019
- Key Successes of integrated MR-OPV campaign
- Lessons learned
- PNG epidemiology of measles
- RI of measles vaccination

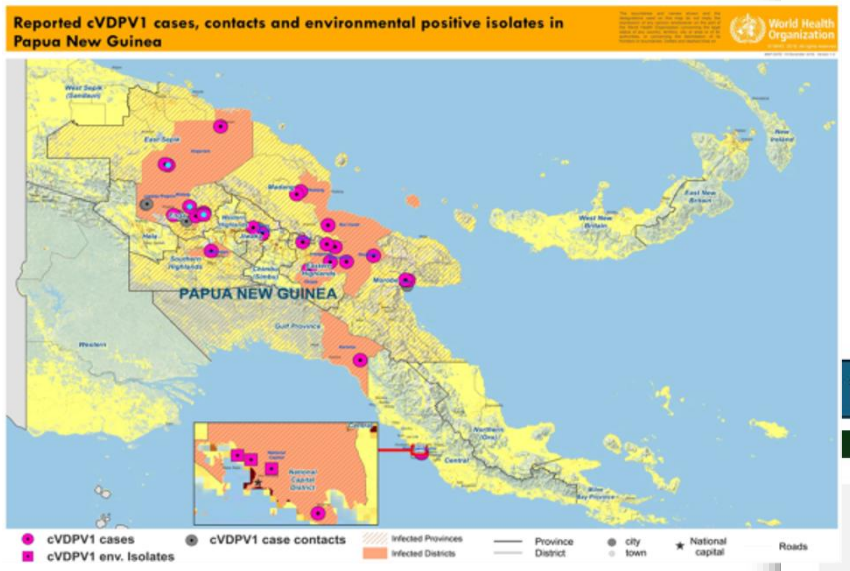
Background

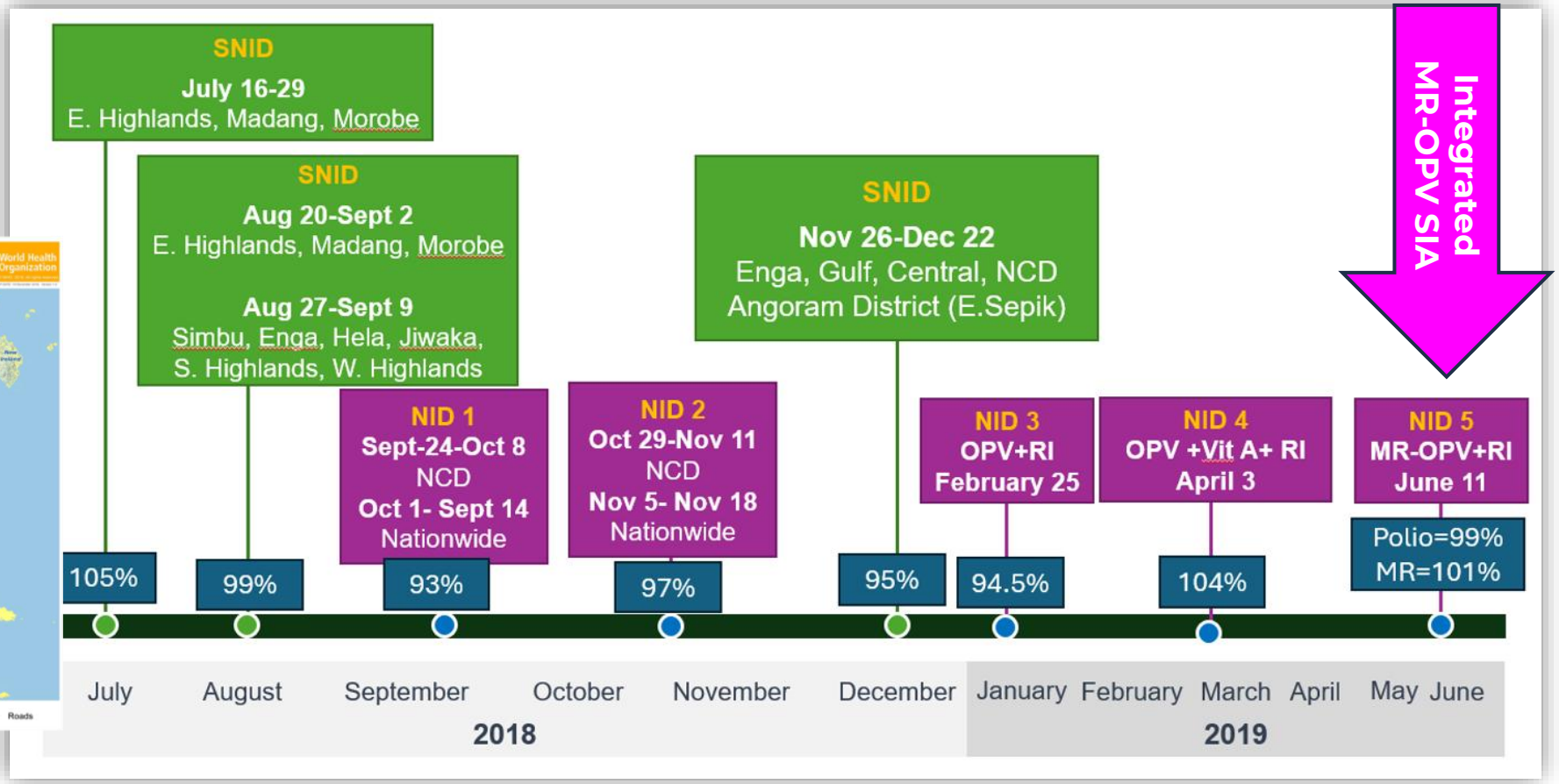


- According to the 2024 national census, the total population is 10,185,363 with an annual growth rate of 2.6%
- Administratively, PNG is made up of:
  - 22 provinces
  - 89 districts
  - Over 800 Health centers/sub centers and 3088 Community Health Posts/Aid Posts
- The child mortality rate (< 5 years of age) is 58 per 1000 live births
- PNG has 0.58 health workers per 1,000 people, while WHO recommends 2.5 health professionals per 1,000 people to maintain primary care
- The current National Immunization Strategy (NIS) 2021-2025 (that includes the elimination of Measles)

Response of cVDPV 1 outbreak in Papua New Guinea 2018-2019*

Total of 26 cVDPV1 cases in 9 provinces

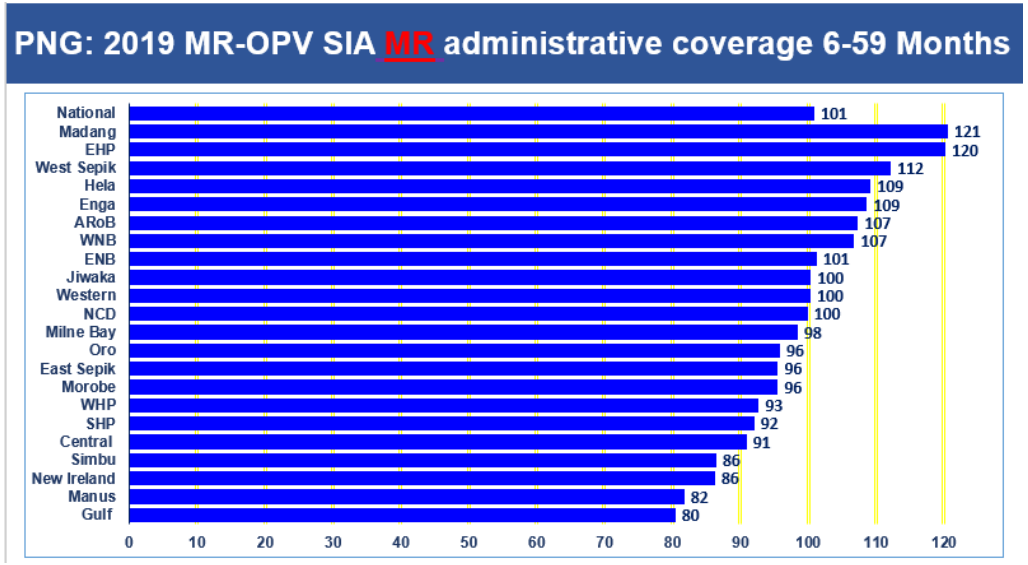




***data source: OBRA 2019 report**

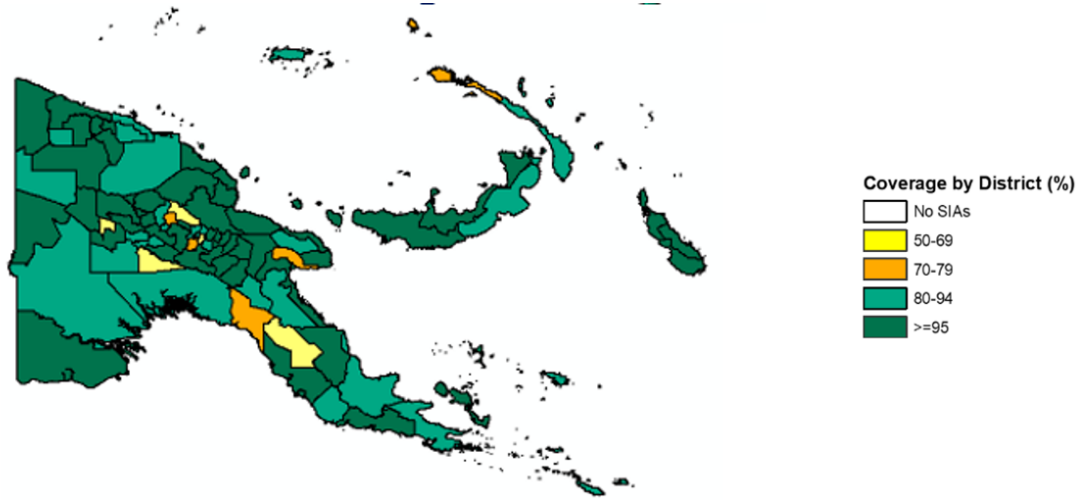
Results of integrated MR-OPV SIA in 2019*

Measles Rubella coverage



- The national NR coverage was very high 101% for MR
- 84/89 districts (94%) achieved >80% MR coverage

bOPV coverage



- National coverage of bOPV was 99%
- 9/89 districts have achieved below 80%

Intra-Campaign Rapid Convenience Monitoring (RCM): Total of 11,690 children assessed and ~9.3% missed children.

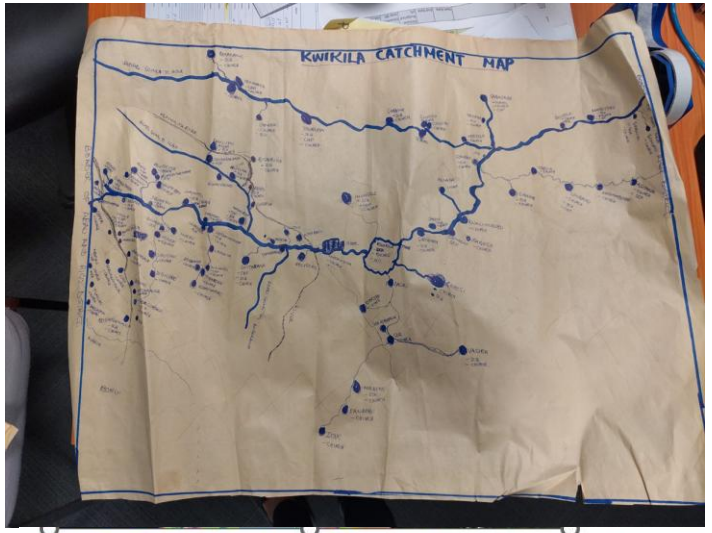
***data source: OBRA 2019 report**

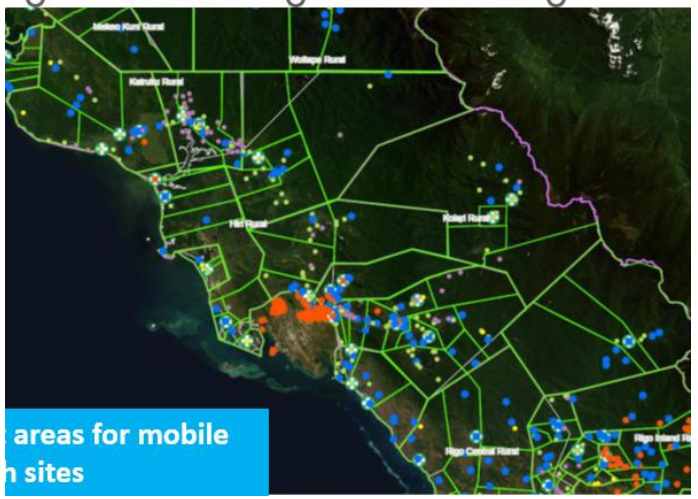
Key Successes: Integrated MR-OPV SIA

- Strong Government Leadership and Political Commitment to integrated campaign
- Effective Collaboration between Gavi, GPEI, UNICEF and WHO, DFAT and other partners
- Cold chain equipment repaired and expanded
- Proper microplanning completed using the new tool
- Enhanced AFP/VPD surveillance guideline developed and distributed
- Strong social mobilization throughout campaign and traditional and religious leaders engaged

Key Successes: RI Strengthening

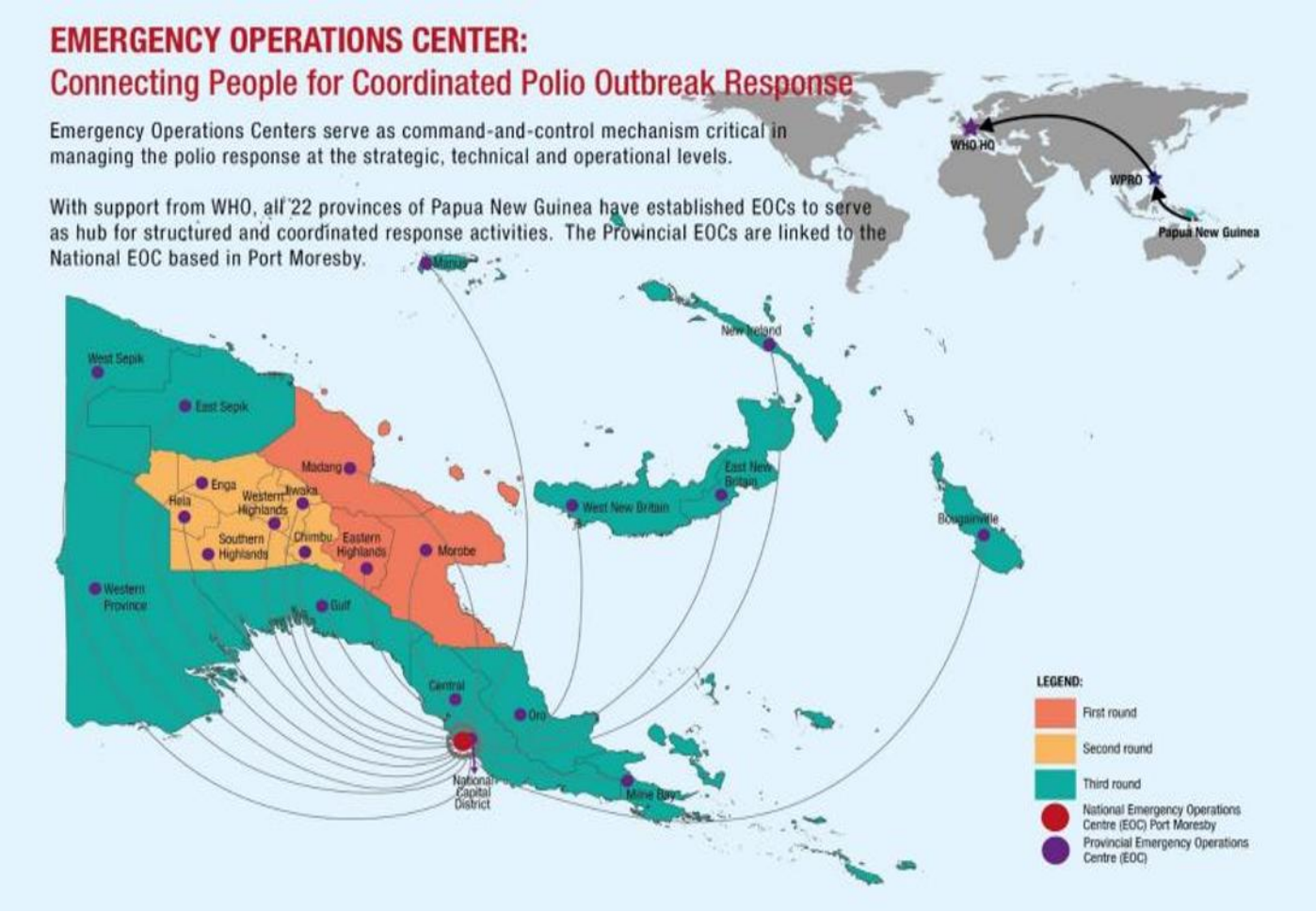
- The campaign generated momentum for strengthening RI services and over 15,000 RI doses were administered during the campaign activities.
- Baseline assessments for RI were successfully completed.
- Health workers received training on injection safety, VPD surveillance, vaccine management, and microplanning using GIS in two pilot provinces.
- Job aids and AEFI kits were distributed nationwide to support service delivery and vaccine safety.





Lessons Learned

- Timely funding and adequate staffing are essential for successful campaign implementation.
- NEOC/PEOC coordination mechanisms strengthened accountability, monitoring, and operational support.
- Subnational technical support was critical to achieving high-quality campaign performance.

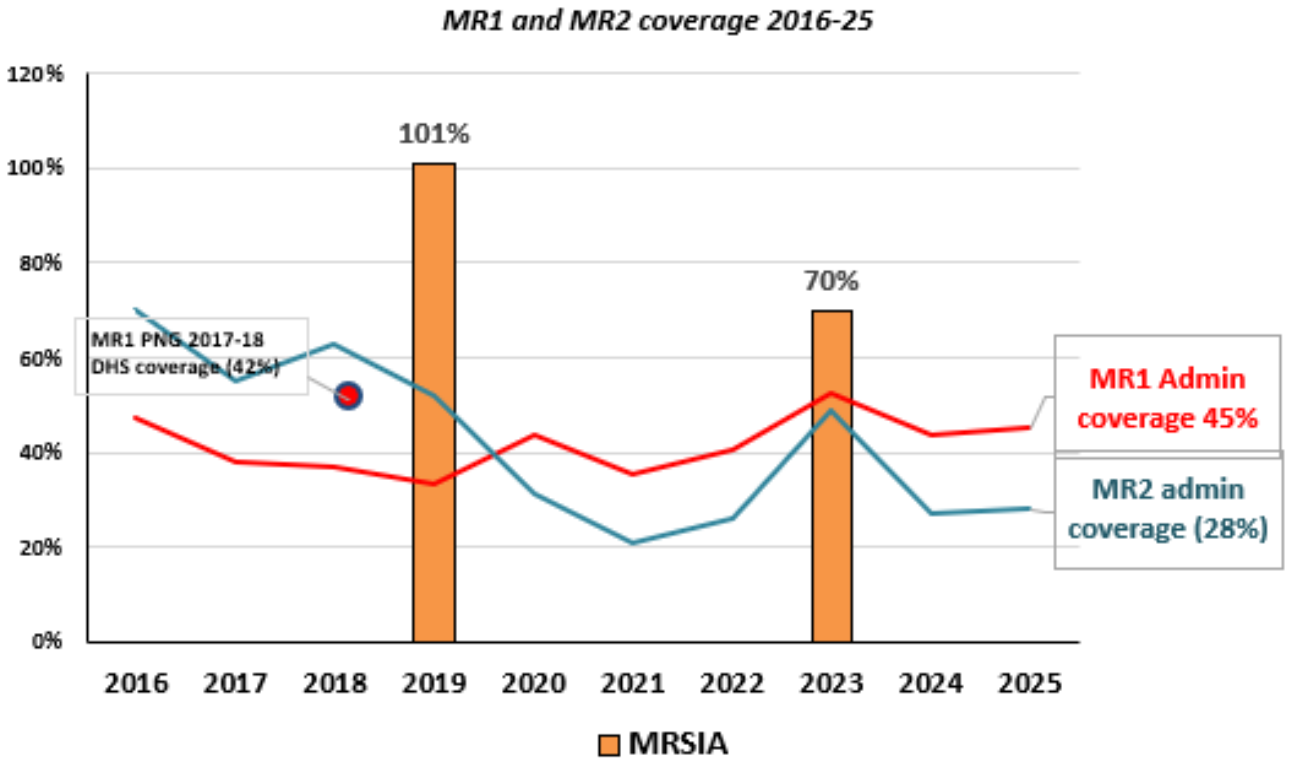


PNG Measles Epidemiology 2017-25*

Measles cases reported		2017	2018	2019	2020	2021	2022	2023	2024	2025
Measles cases (NHIS/eJRF reported)		1843	1237	1913	1206	441	2	12	47	0
Laboratory tested specimen		51	92	93	134	8	2	NA	NA	0
Classification (positives confirmed cases only) cases	Lab confirmed	7	22	1	3	0	0	0	0	0
	Epi linked	0	0	0	0	0	0	0	0	0
Measles incidence per 1,000,000 Pop		8	1.8	.1	.3	0	0	0	0	0

*data source: NHIS/e-JRF and ODK syndromic surveillance data

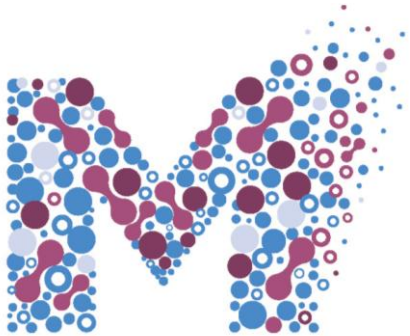
Immunization Coverage, MR, 2016-2025*



- Post-COVID recovery: MR1 coverage increased by ~10% and MR2 by ~8% from the 2021 baseline to 2025,however the overall coverage remain below 50%
- Preventive MR SIAs in 2019 and 2023 were critical in preventing large-scale measles outbreaks.
- More than one birth cohort remained unprotected against measles in 2024 and 2025, creating a high risk of outbreaks.

*data source: NHIS report

Conclusion



- The integrated OPV-MR campaign achieved high vaccination coverage while contributing to the strengthening of RI systems.
- Strong partnerships, effective coordination, and collective commitment from government, communities, and partners were key drivers of success.
- Sustaining the gains achieved through the campaign will require continued investment in RI, surveillance, and community engagement.
- Priority actions moving forward include:
  - Strengthening RI services and surveillance
  - Refining immunity and epidemiological modelling
  - Planning future preventive SIAs to maintain population immunity and prevent outbreaks
  - Develop measles elimination plan of action for the country as part of the next NIS strategy

Thank you!

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Nguyen Ky Nhat Minh

Pasteur Institut Nha Trang

MEASLES
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Linking Outbreak Epidemiology to Vaccine Demand Forecasting

During the 2024-2025 Measles Outbreak in Central Vietnam

Dr. Nguyen Ky Nhat Minh

Department of Disease Prevention, Pasteur Institute in Nha Trang, Vietnam

MAH Jakarta 2026 | WPRO Session 2 | Wednesday 10 June 2026

MEASLES ANALYTICS HUB

Why this matters - Vietnam in 2024-25

Vietnam 2024

45,554 suspected cases

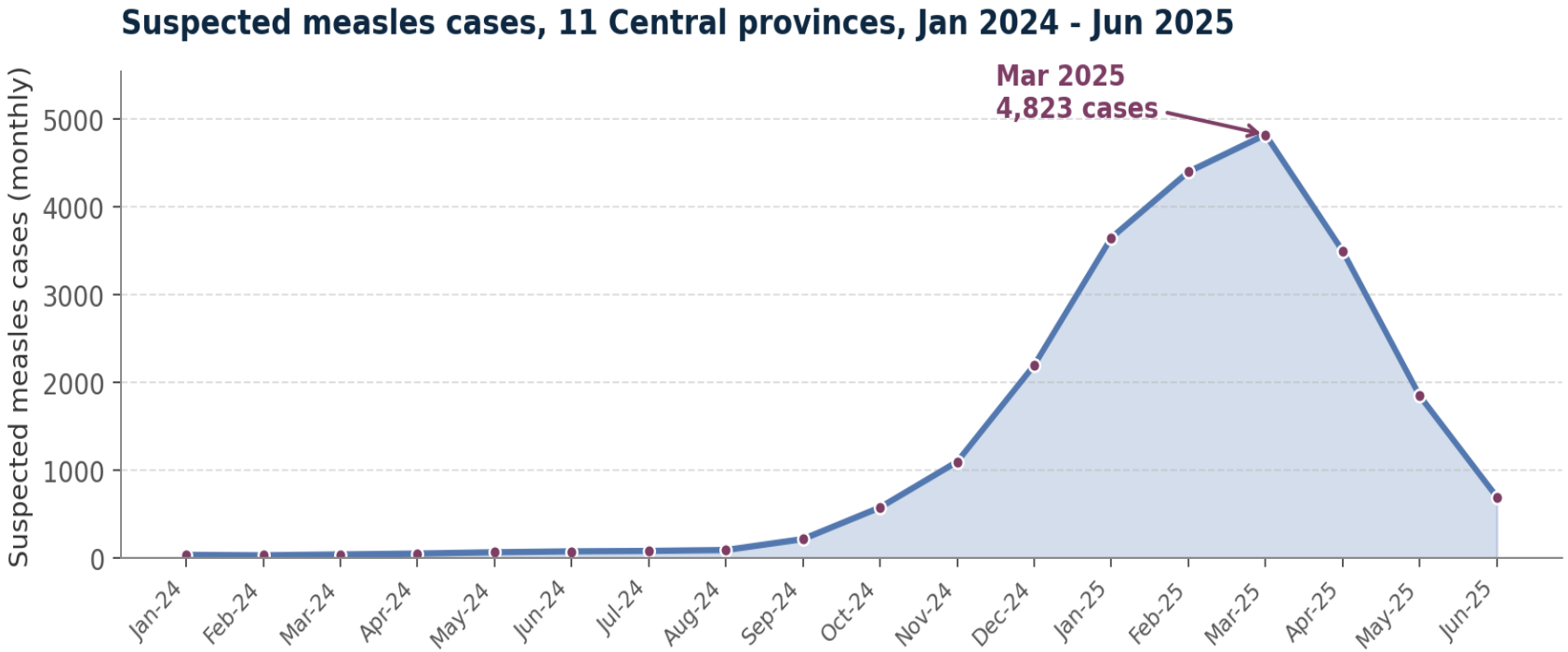
7,583 confirmed | 16 deaths

Early 2025

> 67,000 suspected cases

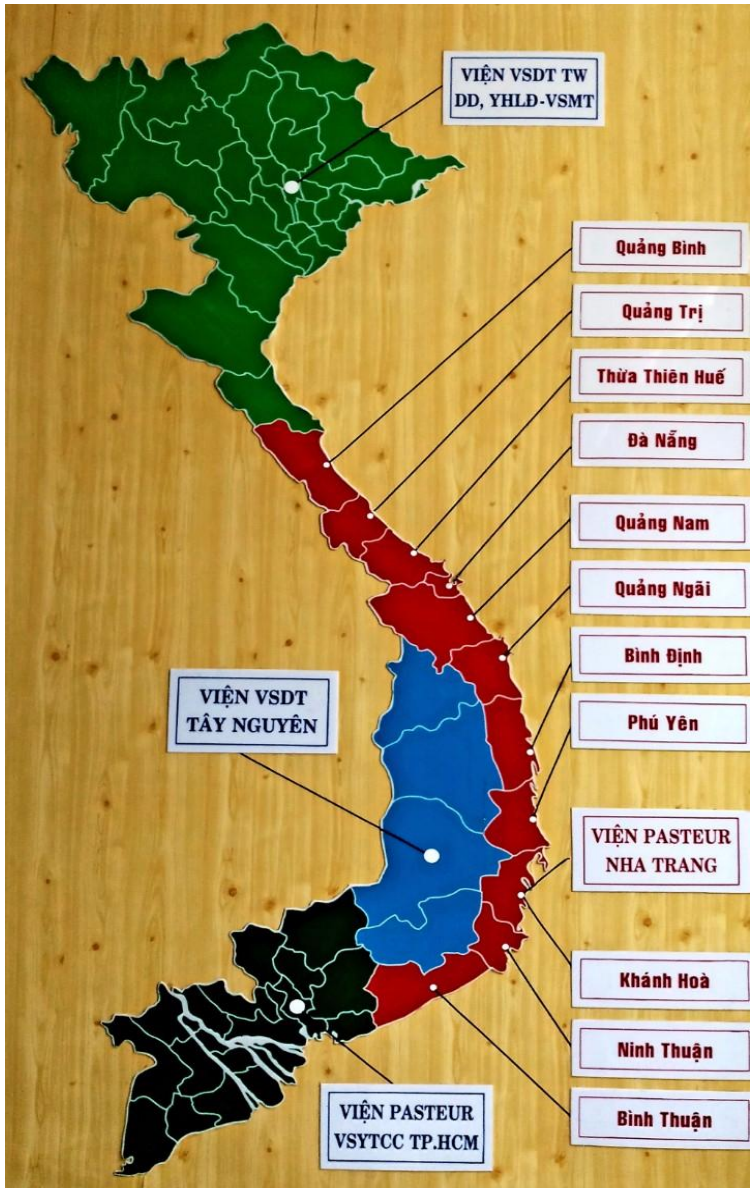
Why now?

- COVID-era drop in MCV1 coverage
- 89.0% (2021) -> 82.0% (2023)
- EPI vaccine supply gap 2022-23



Total: 20,975 suspected cases | 1 death | 11/11 provinces affected

Outbreak in motion: a south-to-north wave



11/11 provinces affected

20,975 suspected cases | 1 death

Da Nang highest burden

6,135 cases in total

480.8 per 100,000 population

15x cases / 18x incidence vs Binh Dinh (lowest)

South-to-north wave

- South: peak Dec 2024 - Jan 2025

(after HCMC declared Aug 2024)

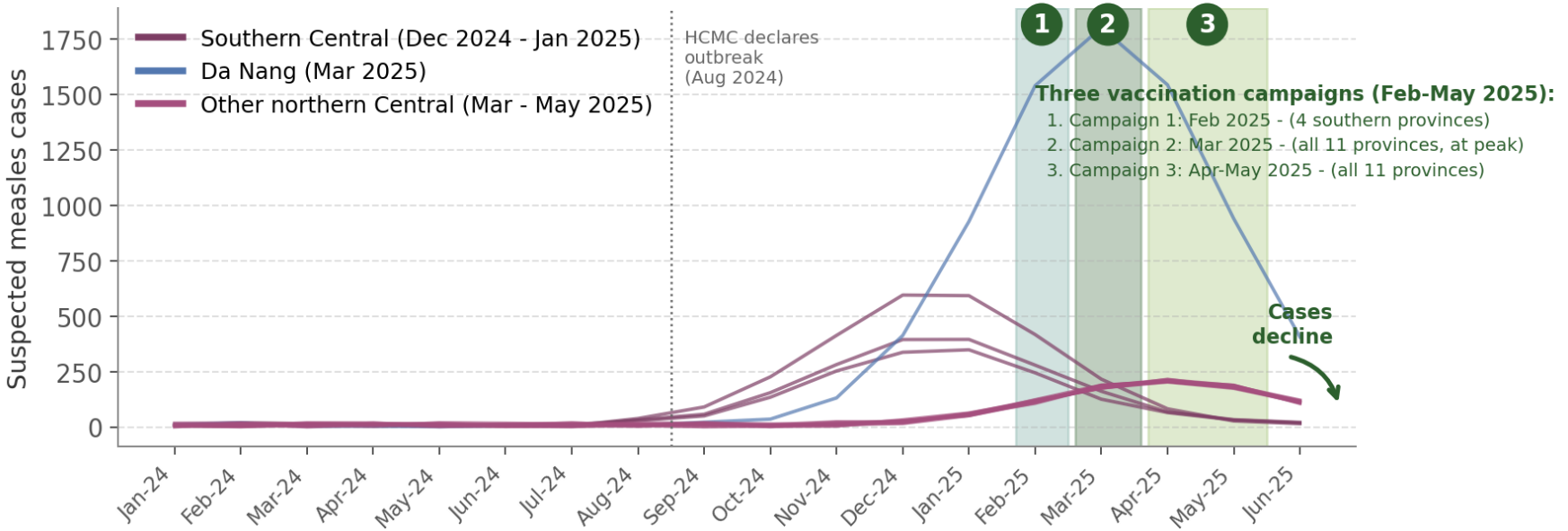
- North + urban: peak Mar - May 2025

3 vaccination campaigns

Feb-May 2025 (1: 4 provinces; 2 & 3: all 11)

Cases fell sharply after Campaign 2 at peak

South-to-north wave: peak month shifted with geography



After HCMC declared outbreak (Aug 2024), the south peaked first, then north and Da Nang

Who is getting measles now? - the age shift

Mean age

10.4 yr (vs 6.0 in 2014)

Median 13 (vs 10.1 in 2014)

Adults >=30 yr

12.5% overall

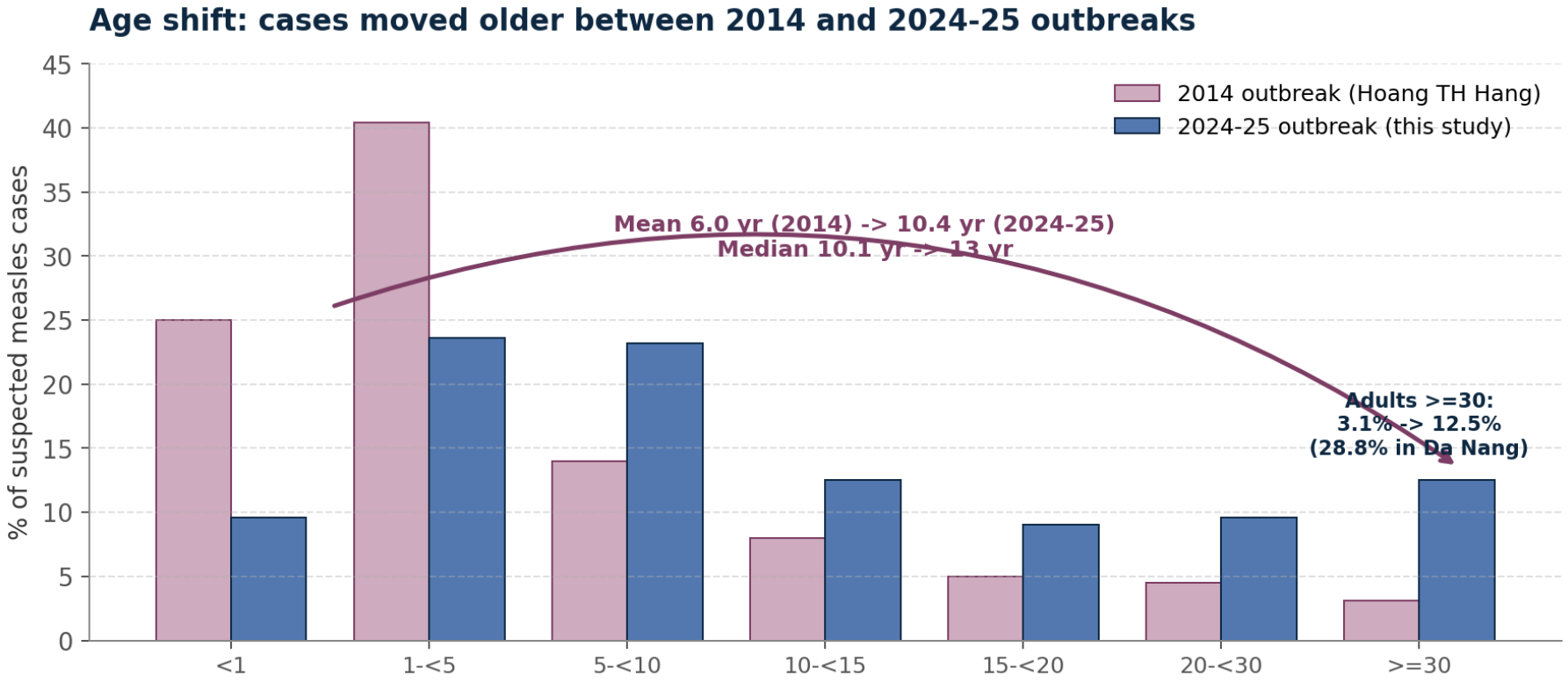
28.8% in Da Nang

Infants (pre-vaccination age)

- 6-8 mo = 44.2% of cases
- Peak at 8 mo (n=678)

Vaccination gaps

- 67.9% unvaccinated overall
- 10/11 provinces >50% unvacc.
- 9-<12 mo: 82.3% unvacc.



From epidemiology to forecasting

Who got infected and where signals where the immunity gaps will be next.

Policy shift since 2023

Vaccine procurement moved from national level to provincial CDCs.

Provinces must now plan, budget AND tender their own measles vaccine.

Unintended side effect (2022-23)

The procurement transition itself contributed to the EPI supply gap of 2022-23 - some provinces could not secure measles vaccine in time.

So, provinces now need monthly forecasts to procure on time and prevent stockouts.

Why Khanh Hoa as the testbed?

1. Data quality

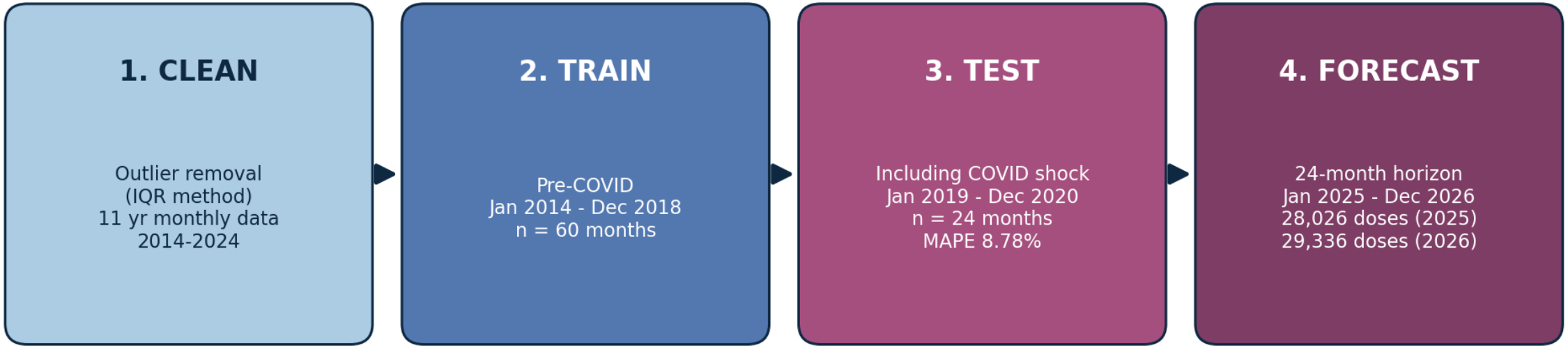
11 years of clean monthly immunisation records (2014-2024), no major reporting gaps.

2. Operational partnership

Khanh Hoa CDC actively wanted a forecasting tool and committed to operationalise the output.

Pasteur Institute Nha Trang co-located in Khanh Hoa - tight loop between modellers and end-users.

How we forecast - high-level approach

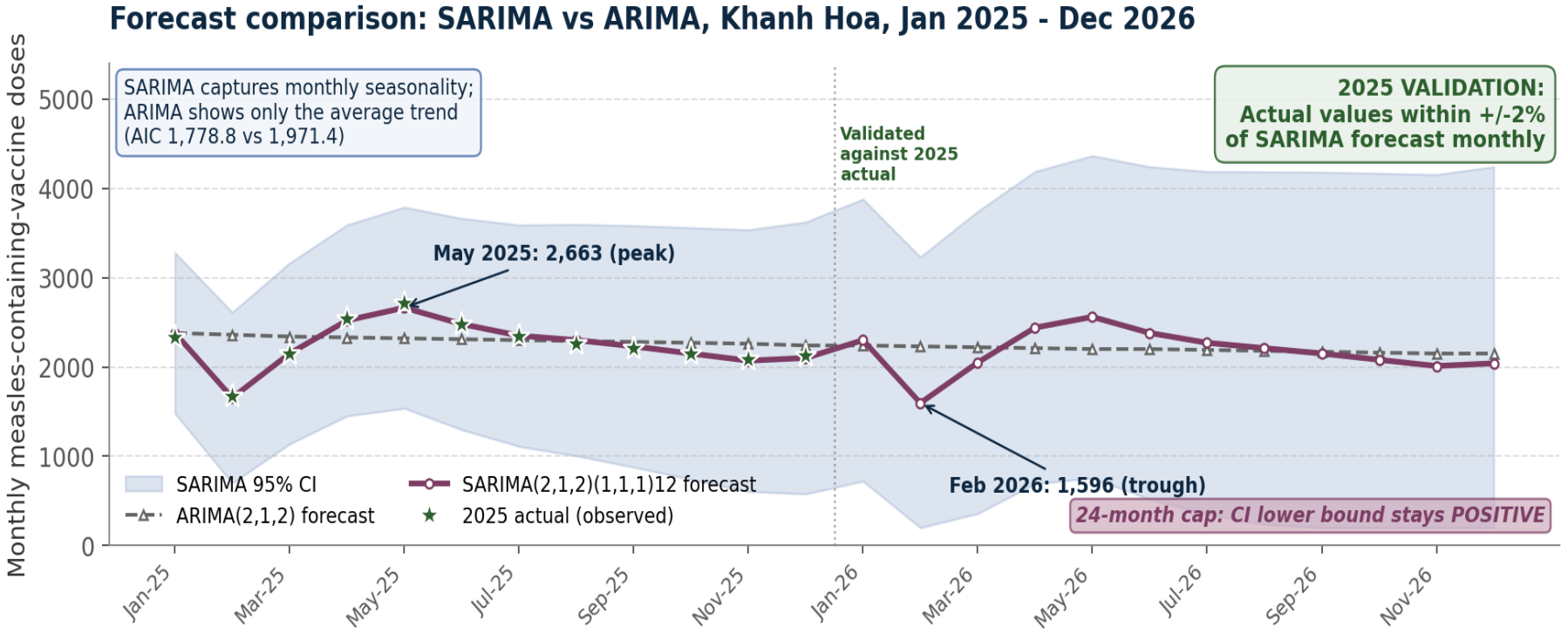


ARIMA(2,1,2) vs SARIMA(2,1,2)(1,1,1)12 | AIC: 1,971.4 vs 1,778.8 (SARIMA wins by 193 pts)

Why SARIMA over ARIMA?

- AIC 1,778.8 (SARIMA) vs 1,971.4 (ARIMA) - a 193-point advantage. SARIMA reproduces monthly seasonality; ARIMA only captures the trend.
- On the 2019-2020 test set (including COVID shock): MAPE 8.78%, RMSE 792.5, MAE 398.3 - model converged back to observed values within months after the 04/2020 disruption.
- Conservative bias: over-predicts by ~5% per year - safer for vaccine planning, where stockouts are riskier than modest over-supply.

Forecast: why a 24-month cap is the right call



Totals: 28,026 doses (2025) | 29,336 doses (2026) | MAPE 8.78% | 2025 actual vs forecast within +/-2%

2025 validation

Actual vs SARIMA: +/-2%

Monthly observed values fall within +/-2% of forecast

Forecast totals

2025: 28,026 doses

2026: 29,336 doses

SARIMA vs ARIMA

- AIC: 1,778.8 vs 1,971.4

SARIMA shapes monthly seasonality; ARIMA flat-lines

Why 24-month cap?

CI lower bound stays positive - operationally interpretable

Why this matters - relevance & transferability

Country relevance (Vietnam)

- Provincial CDCs can now run monthly forecasts in-house
- Catch-up immunisation needed beyond children:
  - ADULTS too (12.5% of cases >=30 yr)
- Consider 6-month dose during outbreaks (per WHO guidance), while maintaining the routine 9-month dose

Transferability (other LMICs)

- Replicable on any country/province with >=8-10 yr of monthly immunisation data
- Cap horizon at 24 months: keeps CI interpretable, avoids false precision
- Use ARIMA-vs-SARIMA AIC comparison to justify seasonality
- Modeller-stakeholder co-design from day one

Thank you

Acknowledgments

Co-authors at Pasteur Institute Nha Trang; provincial CDCs of 11 Central provinces; Khanh Hoa CDC; MAH / VIMC

Contact: Dr. Nguyen Ky Nhat Minh - nguyenkynhatminh2796@gmail.com

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Thinh Ong Phuc

OUCRU Vietnam

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Serosurvey Evidence and Modelling of Immunity Gaps in Vietnam

Ong Phuc Thinh, MD
DPhil student, University of Oxford
Mathematical Modelling, Oxford University Clinical Research Unit, Vietnam

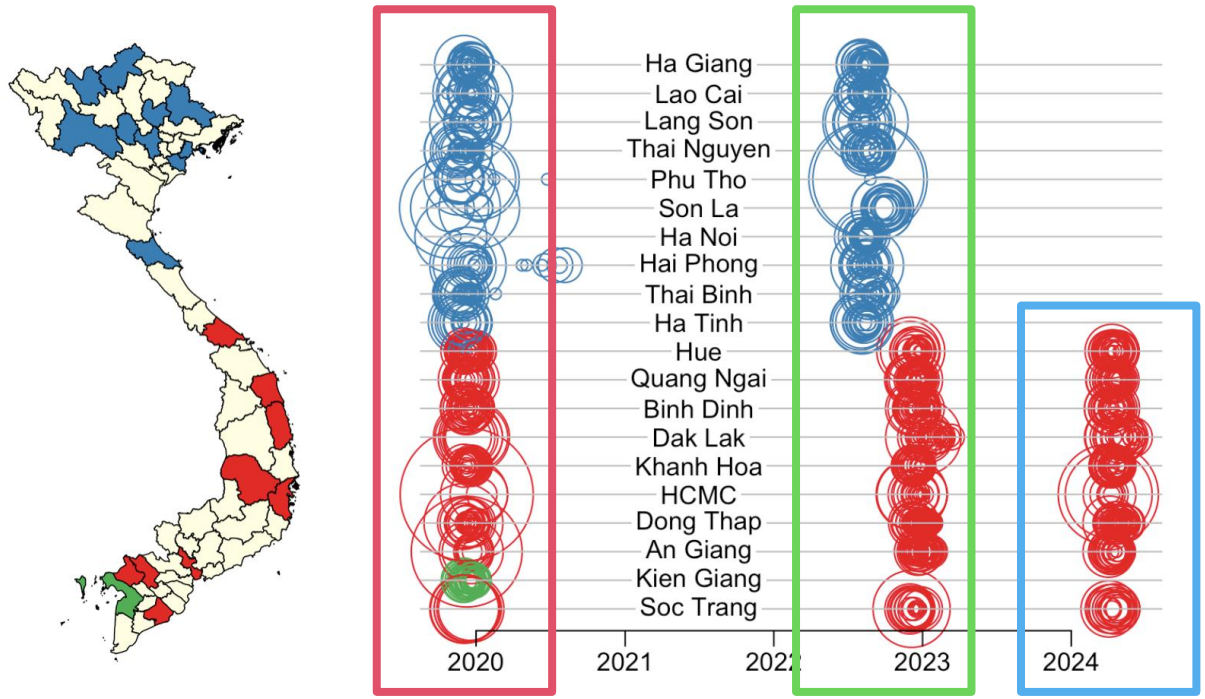
oucru

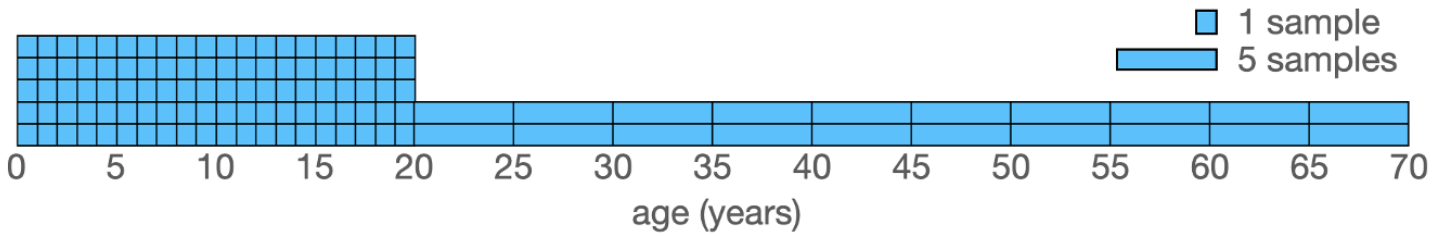
wellcome

UNIVERSITY OF OXFORD

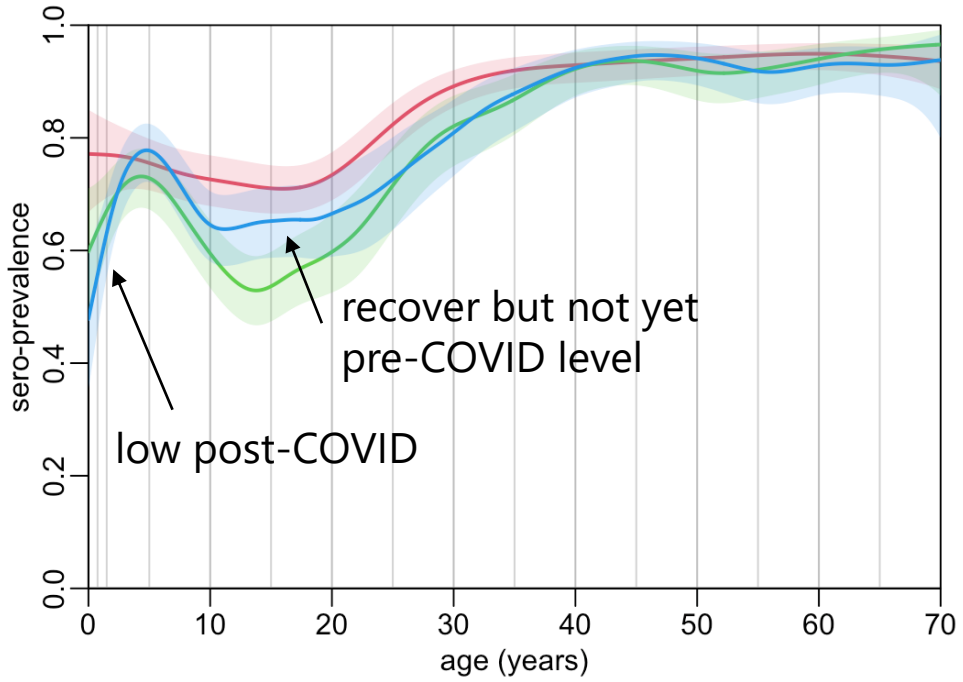
National serosurveillance

9,253 samples



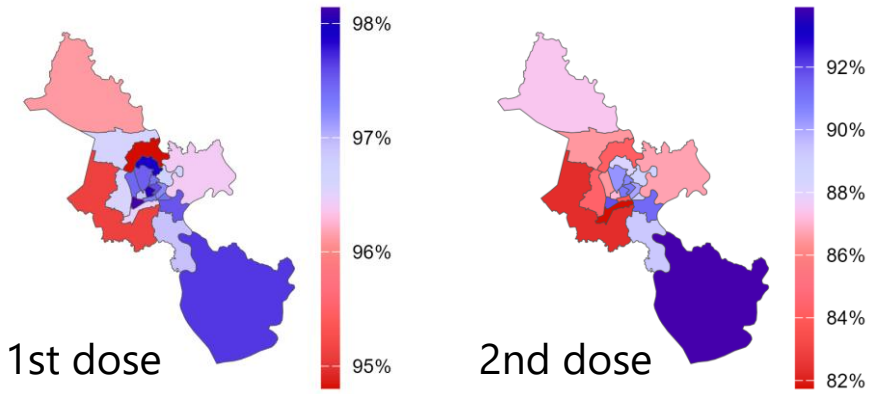


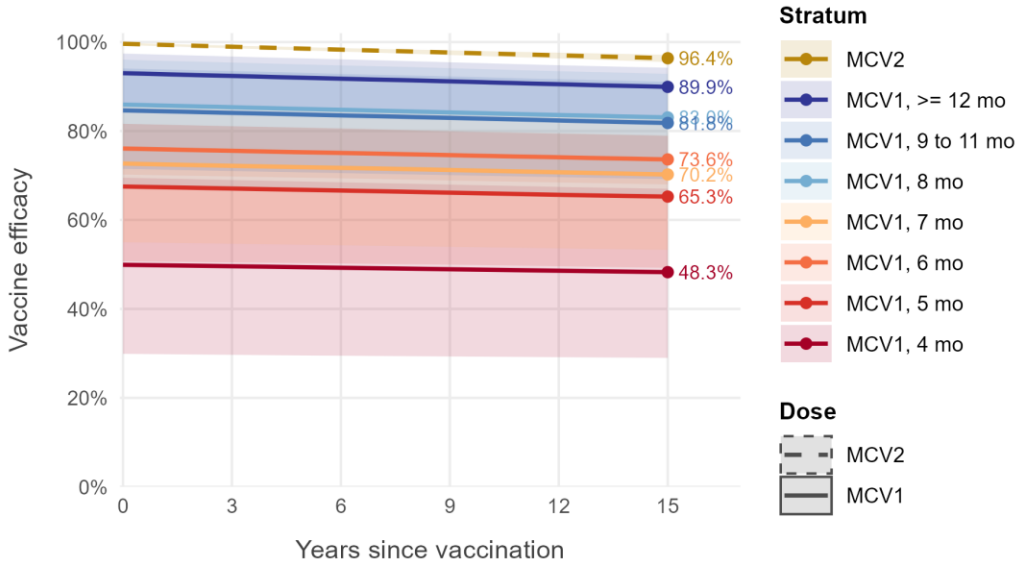
Missed vaccination and waning immunity

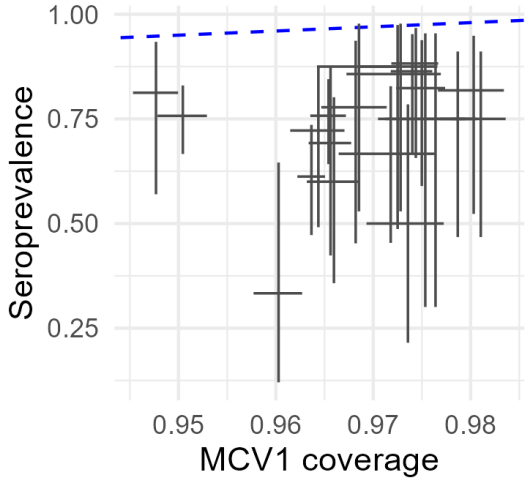


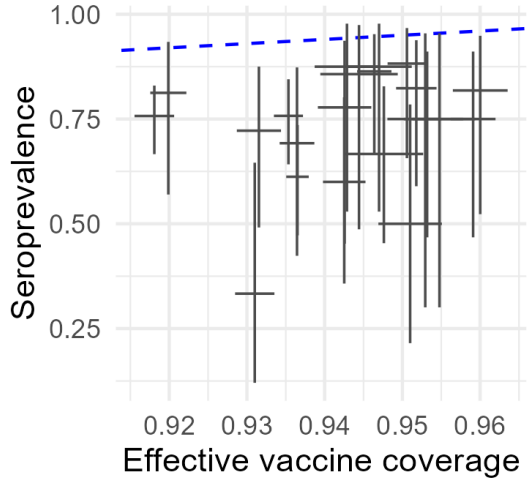
Ho Chi Minh City's Centre for Disease Control

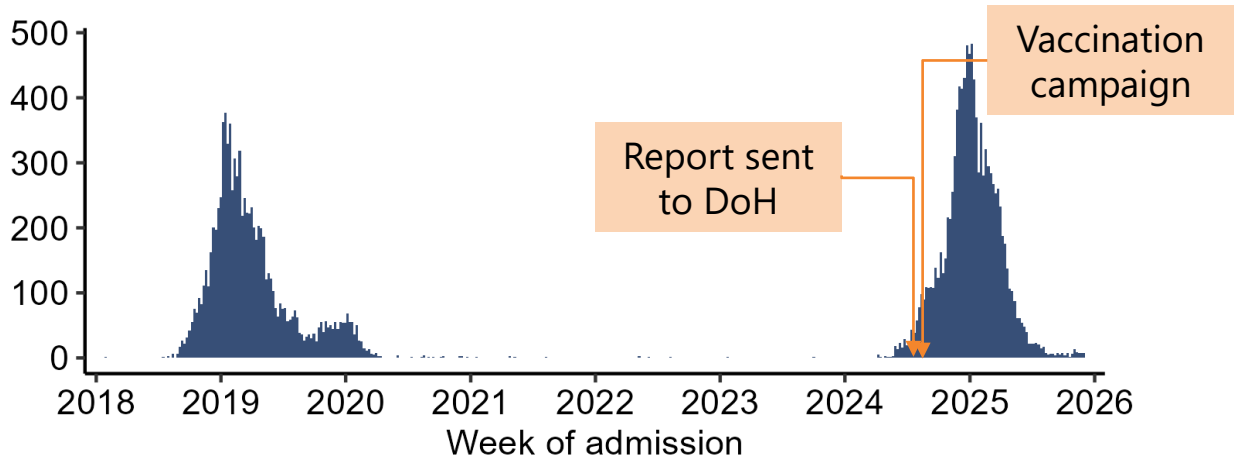
Children 9m-5y in HCMC's immunisation registry











Blind spot of electronic immunisation registry

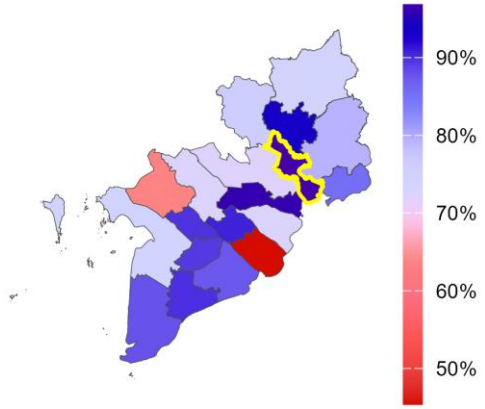
1. Why did the immunisation registry overestimate effective vaccine coverage?

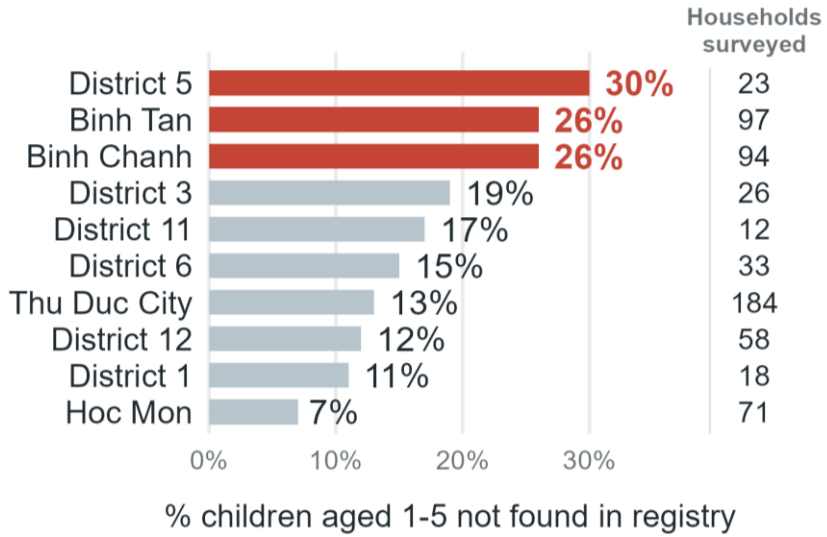
Hypothesis: population movement from low-coverage provinces is not captured in the registry

Method: household survey, n = 1,800 (data collection ongoing)

Next step: model how this blind spot biases the estimated risk of measles

Funded by University of Oxford and Wellcome





Hospital-acquired infections

2. Why do hospital-based residual samples appear to work, despite concerns about representativeness?

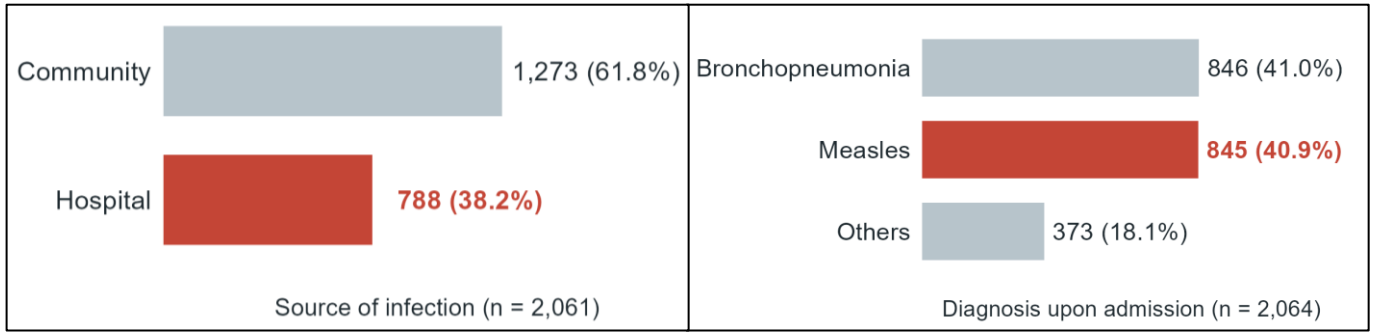
Finding: an estimated 38.2% of cases may have been infected within hospitals

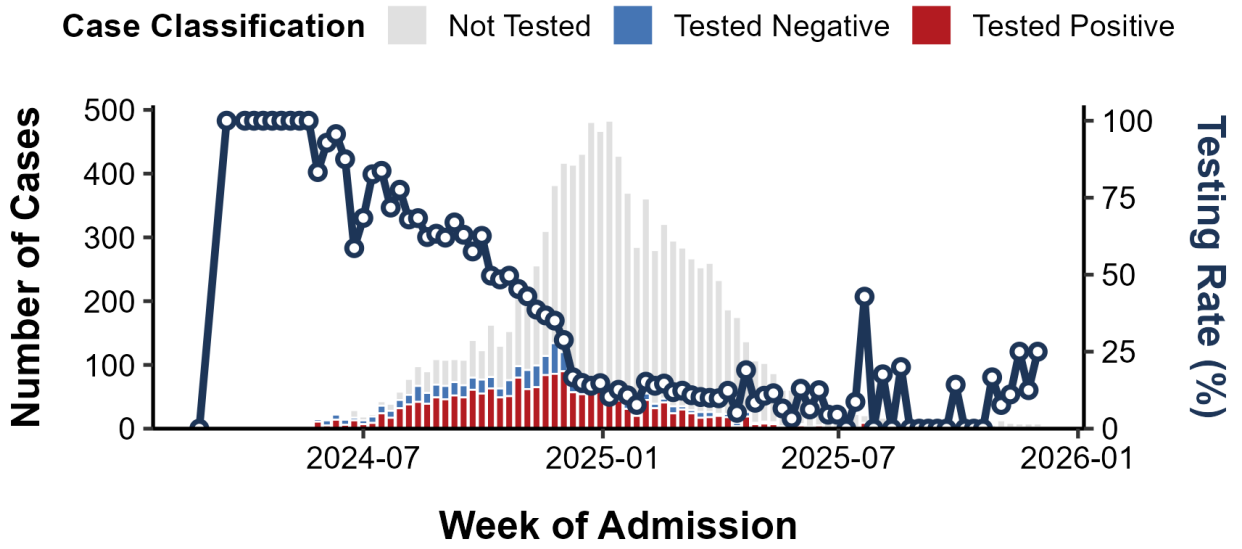
Mechanism 1: nosocomial transmission is a recognised problem in Vietnam

Mechanism 2: misdiagnosis allowed infectious cases to circulate back into the community

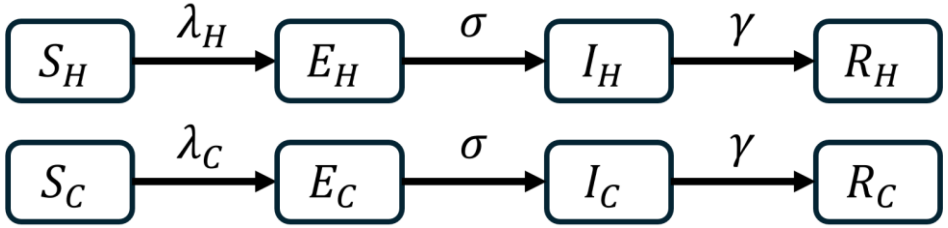
Implication: hospital samples may act as a sentinel surveillance for measles

National Children's Hospital



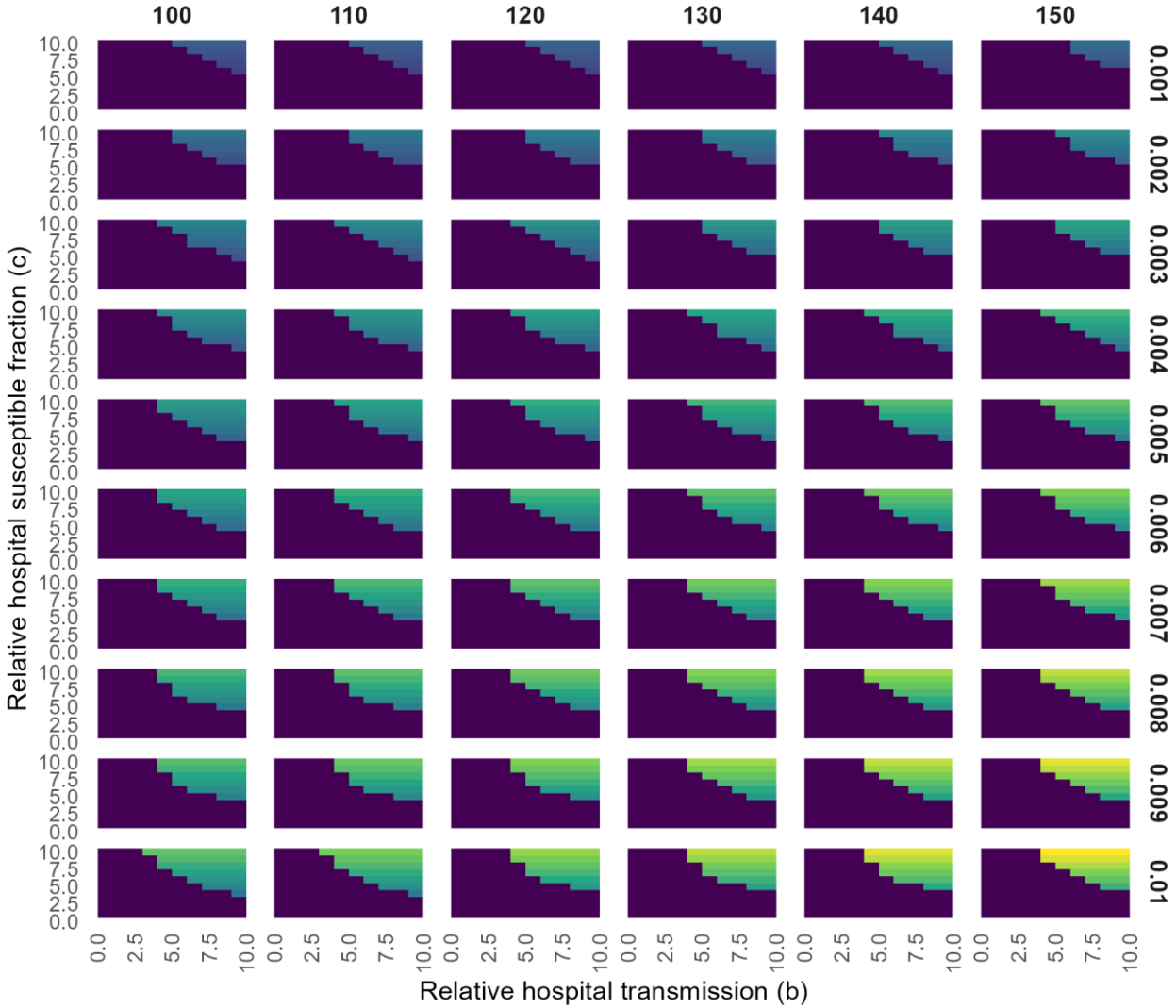


Modelling the outbreak: a recap



$$\lambda_H = \beta_H \left(\frac{I_H}{N_H} + \rho \frac{I_C}{N_C} \right) \qquad \lambda_C = \beta_C \left(\frac{I_C}{N_C} + \rho \frac{I_H}{N_H} \right)$$

- **Status:** ongoing project
- **Objective:** Incorporating all findings into a model, to talk to the CDC and DoH about how can we improve from this outbreak



Conclusion

- Vaccination coverage is the key to control outbreaks, but be aware of blind spots
- Model that turns dose coverage into effective immunity gives policymakers evidence to act on
- Serosurveillance offers an independent check on the registry
- Hospitals can be transmission hubs, which makes hospital-based serosurveillance informative as a sentinel surveillance
- Children who often visited hospitals are pockets of susceptibility: less vaccinated (due to health conditions), more exposed (likely meet measles cases visit hospitals, who may be misdiagnosed)
- Strengthen immunisation surveillance and deploy rapid test could be solutions

Acknowledgements

Thank you for listening!

Asami Anzai

Japan Institute for Health Security

MEASLES
ANALYTICS HUB

Jun 10, 2026
WPRO session 2

Reconstructing Measles Population Immunity in Japan Using Sero-epidemiological Data

original research

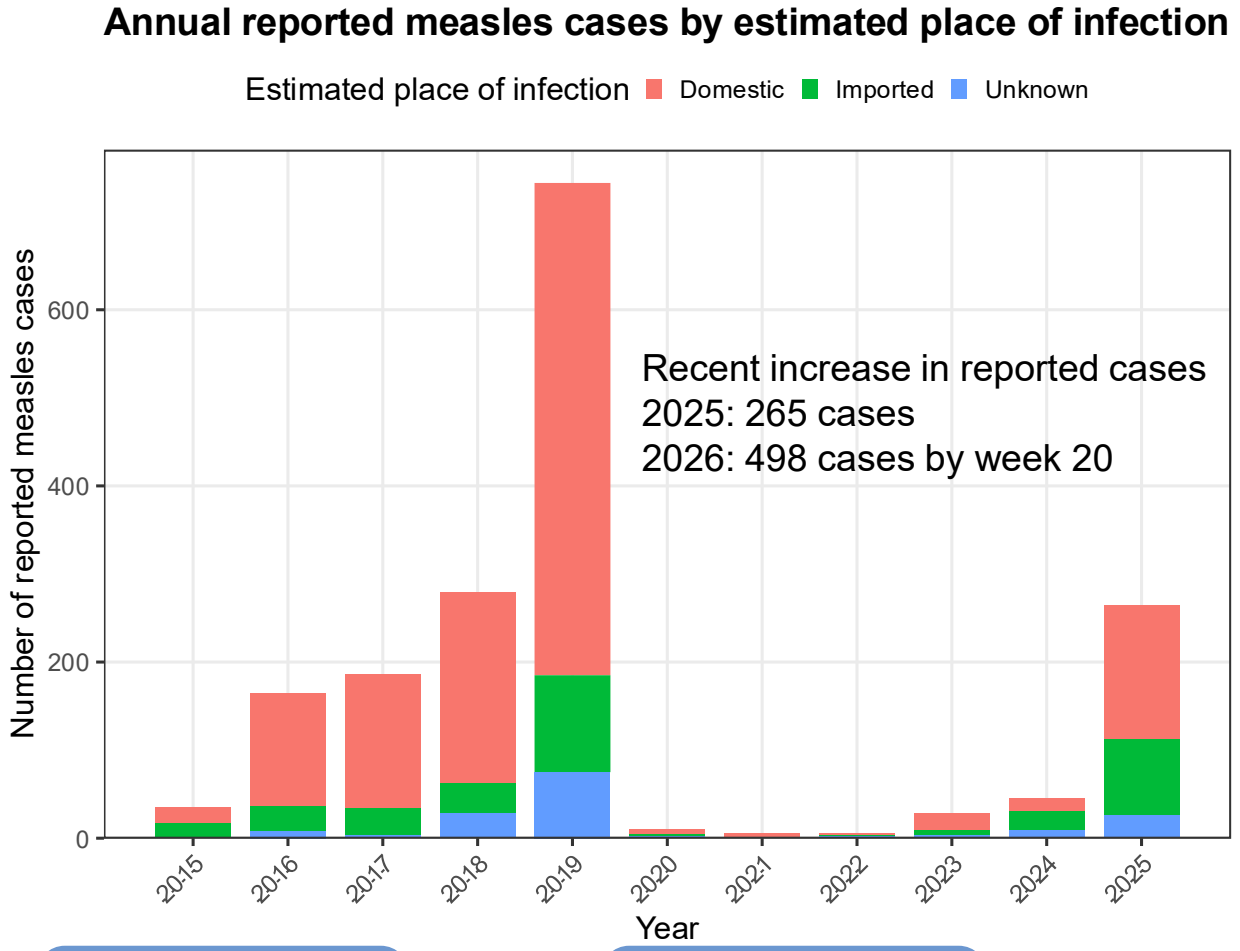
Asami Anzai

National Institute of Infectious Diseases (NIID),

Japan Institute for Health Security (JIHS)

Post-elimination Japan: importations can reveal residual susceptibility

- Japan was verified as having achieved measles elimination in 2015
- Importations continue to create outbreak risk
- Some importations are followed by domestic exposure or transmission
- Key question: Where might residual susceptibility remain?

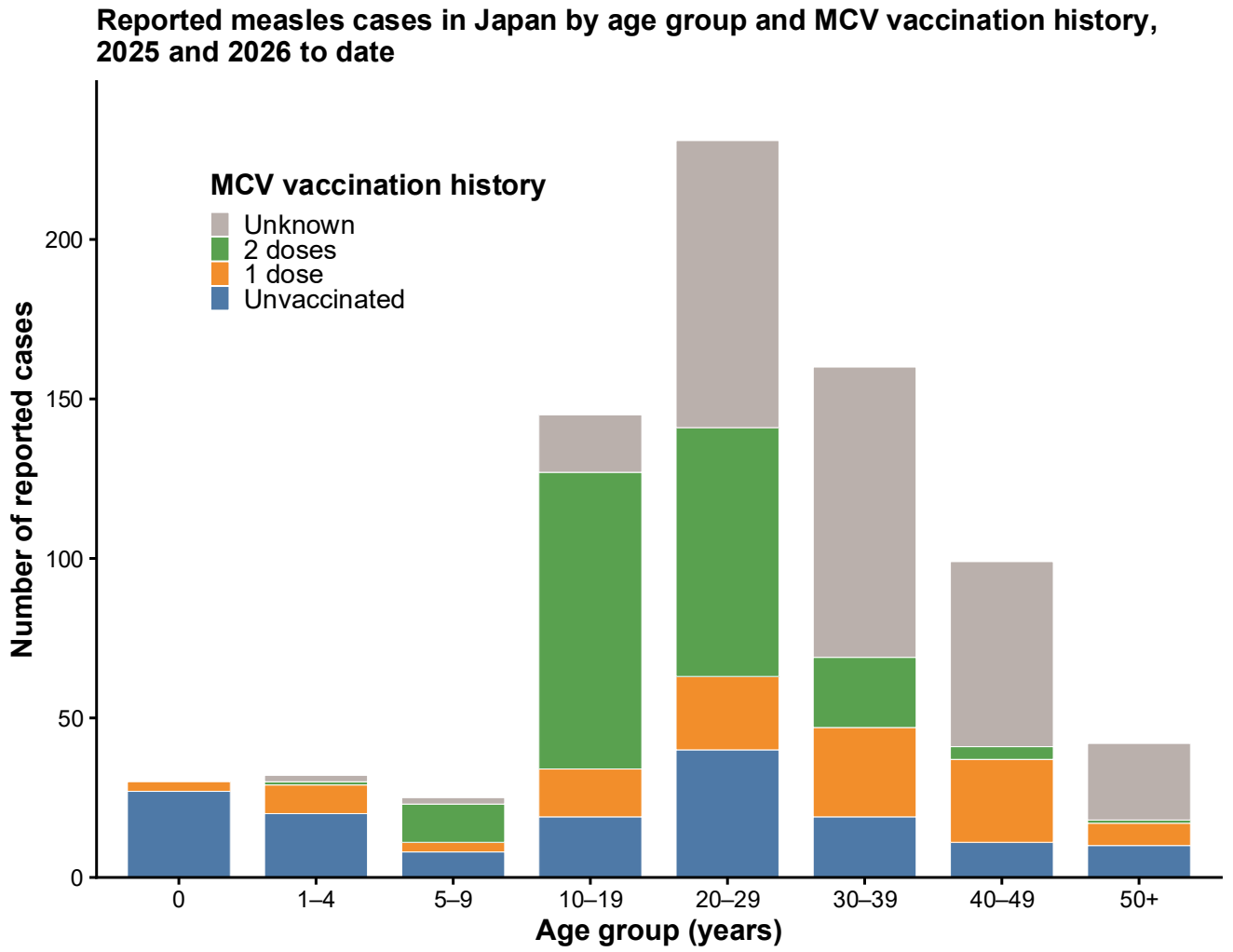


Exposure abroad → Imported case → Domestic contact → Transmission chain

depends on residual susceptibility

Recent case patterns suggest susceptibility is not confined to young unvaccinated children

- Recent cases are not limited to unvaccinated young children
- Adolescents and adults are also represented
- Some reported cases have documented two-dose vaccination
- These patterns raise questions that case counts alone cannot answer



Several mechanisms can produce similar surveillance signals

Possible contributors

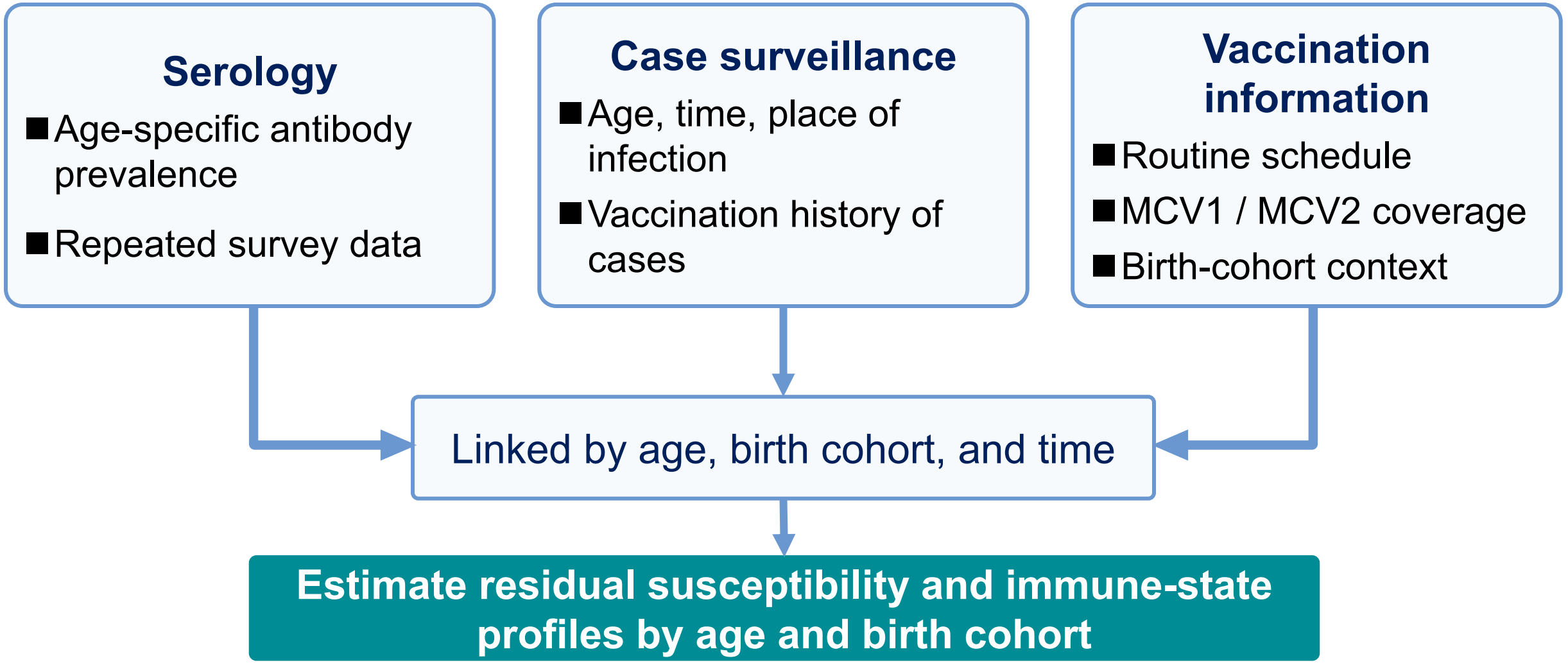
- Incomplete or heterogeneous vaccination coverage
- Primary vaccine failure or reporting uncertainty
- Waning or loss of detectable antibodies
- Reduced natural exposure and reduced natural boosting in a low-incidence setting
- Heterogeneous exposure when importations occur

Why inference is difficult

- Reported cases are not direct risk estimates without appropriate denominators
- Natural boosting is not directly observed
- Seropositivity does not reveal the source or boosting history of immunity
- Different mechanisms can produce similar surveillance patterns

Integrated data are needed to distinguish plausible mechanisms

Triangulating three data streams can identify age/cohort susceptibility



Modeling concept: from observed data to latent immunity

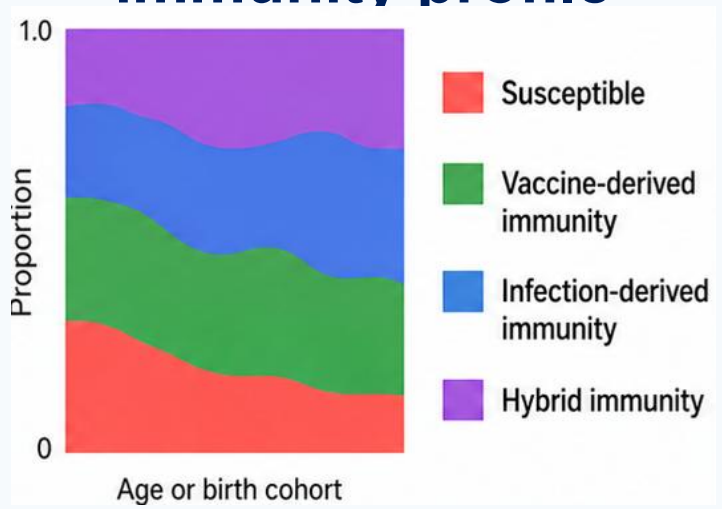
Observed data

- Serology
- Case surveillance
- Vaccination information

Joint inference

- Age
- Birth cohort
- Calendar time
- Waning / boosting assumptions

Age-specific population immunity profile



Key challenge: Seropositivity is observed, but the source and boosting history of immunity are not directly observed

Model outputs should be tied directly to program decisions

Estimated output	Program use
Age- and cohort-specific immunity profile	Identify groups for catch-up discussion
Identify age groups where importation could lead to onward transmission	Support risk assessment after importation
Uncertainty intervals and scenario ranges	Communicate robustness and limits
Sensitivity to waning and exposure assumptions	Guide preparedness in low-incidence settings

Country relevance and transferability

Japan: decision relevance

■ Elimination does not prevent outbreaks after measles importations

■ Recent case patterns raise questions about residual susceptibility and immunity dynamics

■ Model outputs should identify plausible mechanisms and public-health-relevant susceptibility patterns

Transferable lessons

■ Integrate serology, surveillance, and vaccination data by age, birth cohort, and calendar time

■ Use latent-immunity modelling when case counts alone cannot distinguish plausible mechanisms

■ Adapt assumptions on waning, natural boosting, exposure, and reporting to local epidemiology and data

Thank you

Moderated Q&A discussion

Session Chair:

Jess Metcalf,

Princeton University

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Lunch Break

SEAR Lightening Talks 1

Session chair:

Todi Mengitsu,

Gavi, The Vaccine Alliance

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Sudhir Khanal

WHO SEAR (online)

MEASLES
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World Health Organization
South-East Asia Region

Progress towards Measles and Rubella Elimination in WHO South-East Asia Region

Dr Sudhir Khanal
Regional Adviser, Accelerated Diseases Control,
WHO SEARO

SEA Region* committed to eliminate measles and rubella

The Seventy-seventh session of the WHO Regional Committee for South-East Asia endorsed resolution SEA/RC77/R3 on **“MEASLES AND RUBELLA ELIMINATION WITH INTERRUPTION OF TRANSMISSION OF INDEGINOUS MEASLES AND RUBELLA VIRUS BY 2026”.**

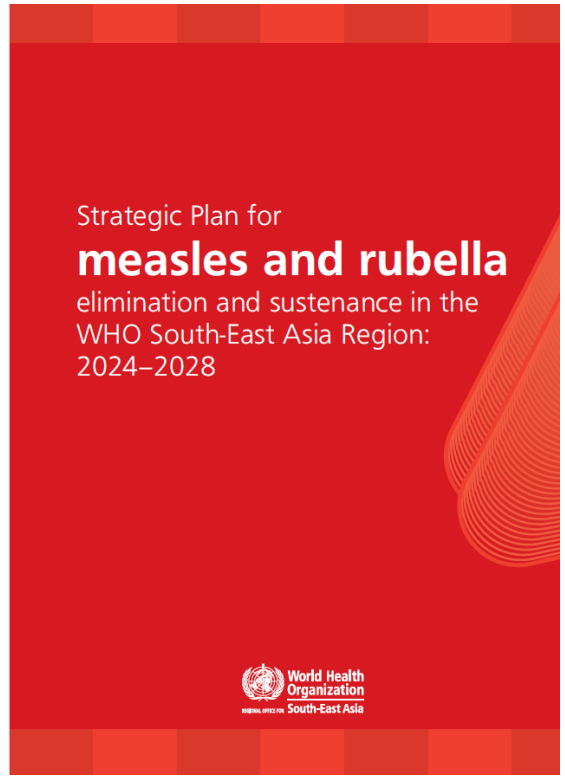
(available at https://iris.who.int/handle/10665/379255)

Regional strategic plan 2024-2028 available

(https://iris.who.int/handle/10665/379066)

Five key strategic objective (SO)areas

1. Immunization
2. Surveillance
3. Laboratory
4. Outbreaks
5. Enablers



*SEAR Region included 11 countries, since May 2025 Indonesia relocated to WRP resulting only 10 countries.

Regional status on progress towards the measles and rubella elimination (1)

- Five countries were verified to have eliminated measles, and six countries for rubella, based on the regional framework for verification (https://apps.who.int/iris/handle/10665/332737)
- Sri Lanka experienced backsliding and reestablished transmission after five years of verification of elimination.
  - Substantial efforts have been made, and no new cases of measles have occurred since January 2025
  - Many good practices and lessons from Sri Lanka

Country	Year in which verified	
	Measles	Rubella
Bhutan	2017	2023
DPR Korea	2018	2023
Maldives	2017	2020
Nepal		2025
Sri Lanka	2019	2020
Timor-Leste	2018	2023

Regional status on progress towards the measles and rubella elimination (2)

- Reported annual incidence of measles high in India and Thailand
- Reported annual incidence of Rubella is very low in countries

  (with surveillance performance at elimination standard)

Country	Incidence * 2025	
	Measles	Rubella
Bangladesh	0.71**	0.63
India	12.2***	1.78
Myanmar	0.17	0.17
Nepal	0.53	
Thailand	13.49***	0.10

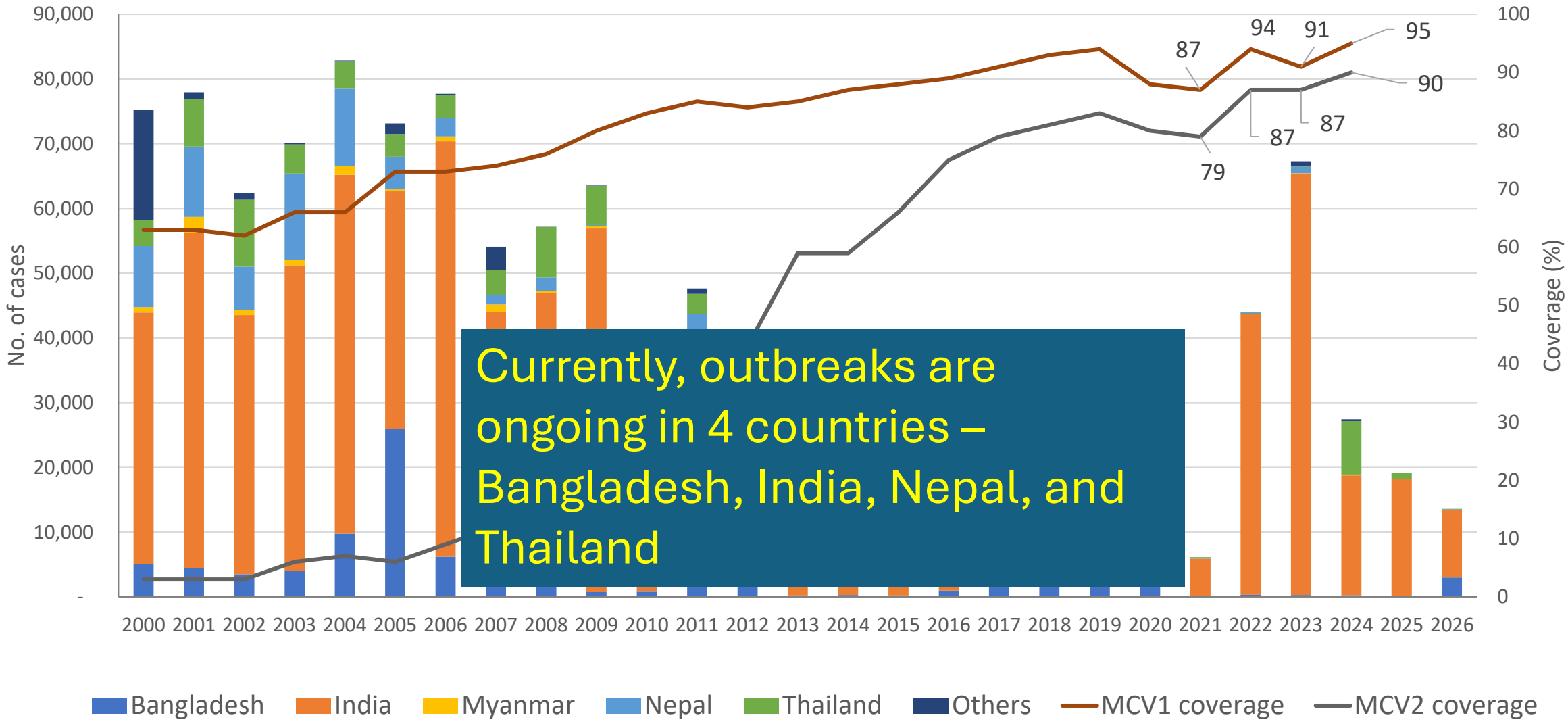
*Incidence of endemic cases measured in per million population

** IN 2026, the incidence jumped to >20 per million in Bangladesh due to an outbreak

*** incidence has gone down significantly in 2026

Data as of 06 April 2026

Immunization: Confirmed measles cases and coverage of MCV1 and MCV2 in SEAR 2000-2026

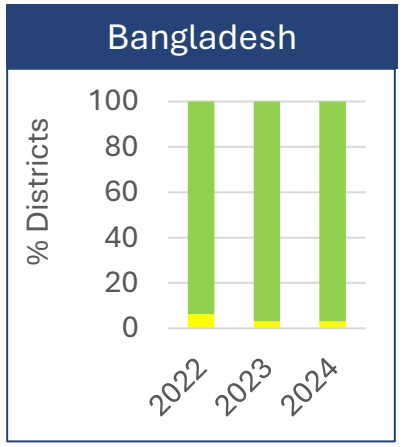


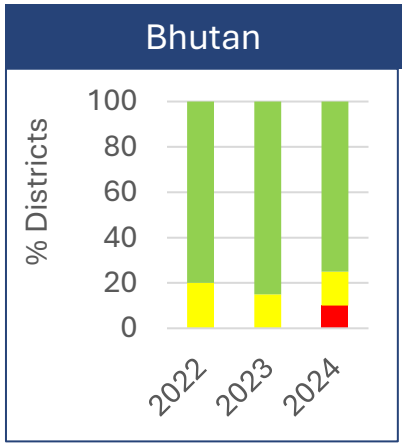
Source: WHO/UNICEF coverage estimates, July 2023 and WHO/UNICEF JRF and EPI/MOHFW; Measles cases from JRF 2000-2024 and 2025-26 from SEAR MR surveillance database

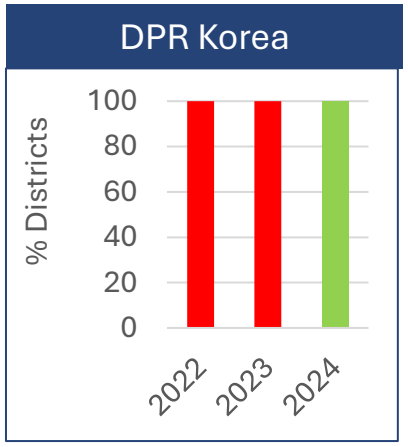
Data as of 06 April 2026

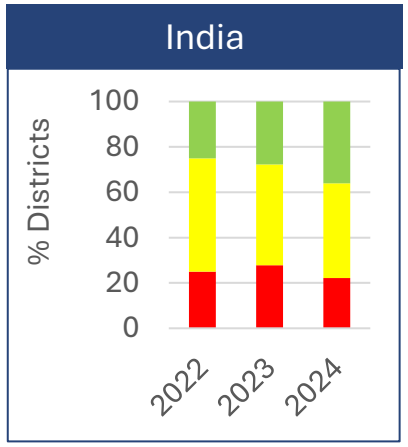
MRCV 2 coverage at district level sub-optimal –>many pockets of susceptible

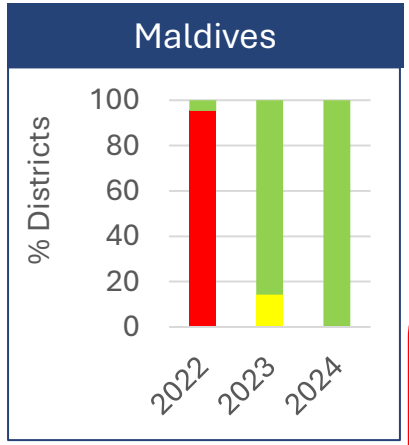
Percent districts with MCV2 coverage

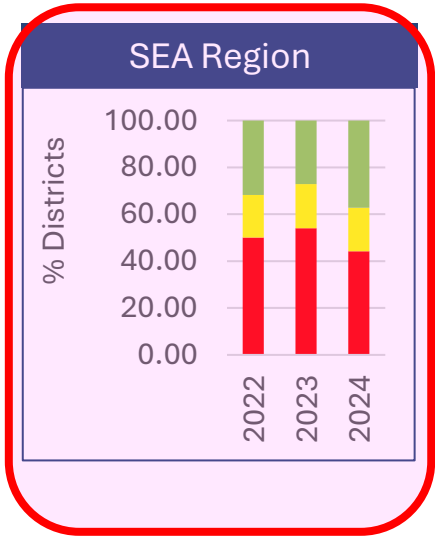


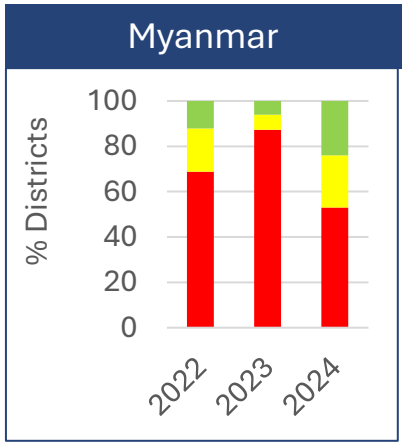


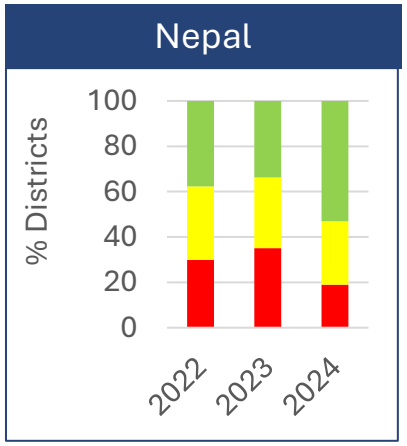


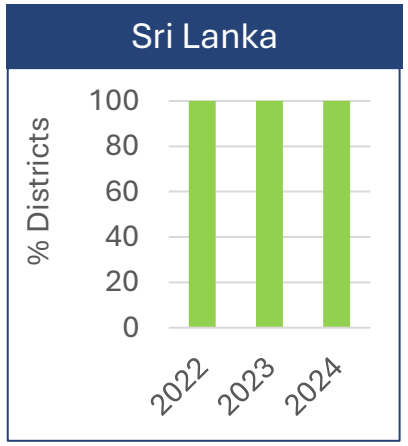


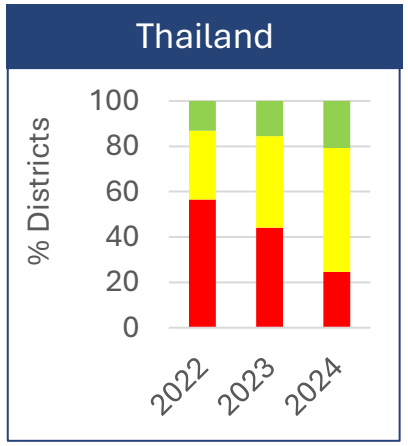


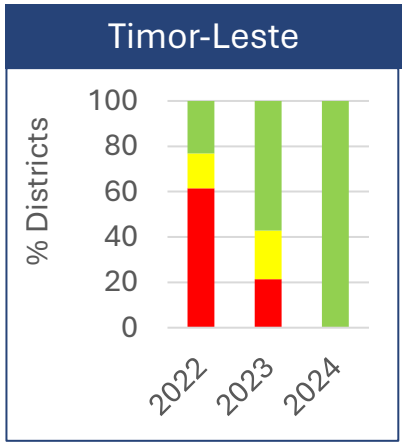




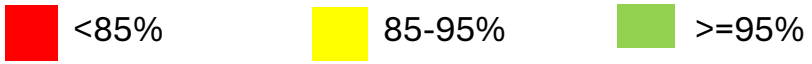




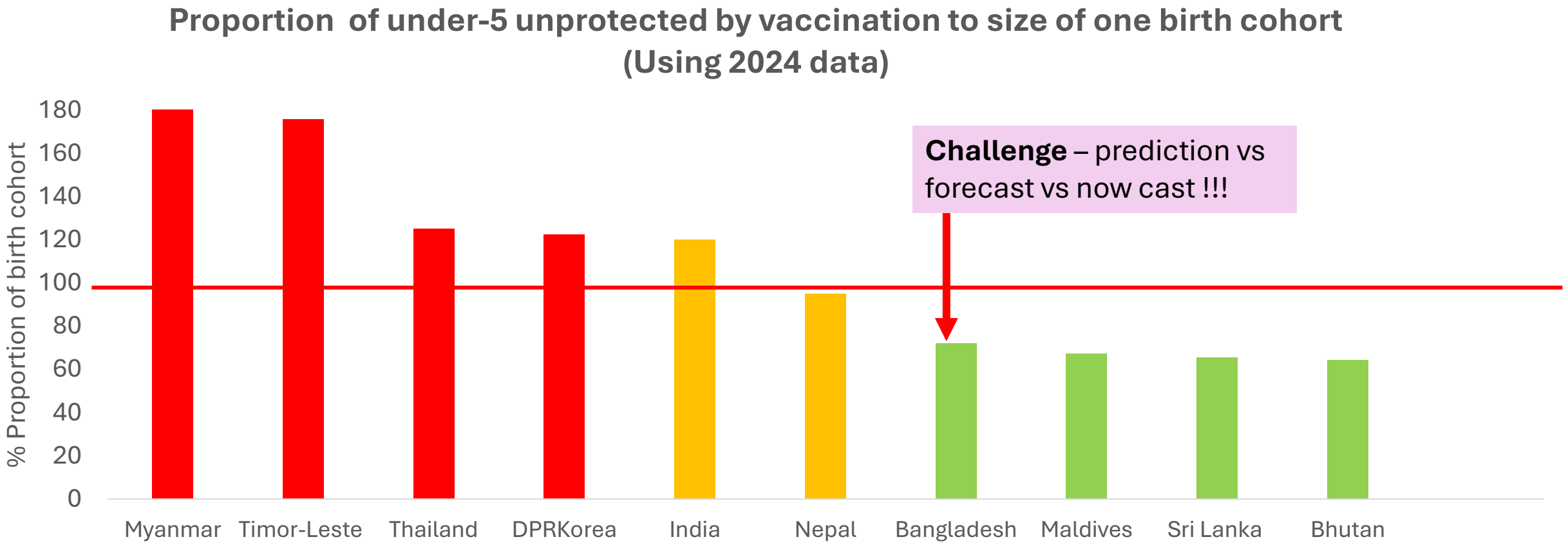




Source: WHO/UNICEF coverage estimates, July 2025 and WHO/UNICEF JRF



Population immunity profile for measles- urgent need for supplementary immunization activities to close immunity gaps



Lab Supported Surveillance :Key surveillance performance indicators have increased but significant variations across countries observed (2013, 2020, 2023, 2025 and 2026)

Countries	Reporting rate of discarded non-measles non-rubella cases per 100,000 population				
	2013	2020	2023	2025	2026
Bangladesh	1.1	1.93	3.93	3.22	3.77
Bhutan	12.9	15.98	28.82	28.84	7.70
DPR Korea	0.26	2.09	2.07	1.93	0.00
India	1.51	0.77	5.76	5.18	4.71
Maldives	0	41.54	29.31	9.74	4.50
Myanmar	0.34	0.43	0.3	0.56	0.77
Nepal	0.9	3.15	6.94	8.77	6.40
Sri Lanka	2.99	0.39	1.69	1.07	0.14
Thailand	0.63	1.61	0.94	2.14	1.30
Timor-Leste	0	7.08	13.99	7.82	7.15
SEAR	0.91	0.98	5.13	4.73	4.30

D8 is the most reported strain for measles.

No viral detection for rubella for the last 5 years in SEAR countries.

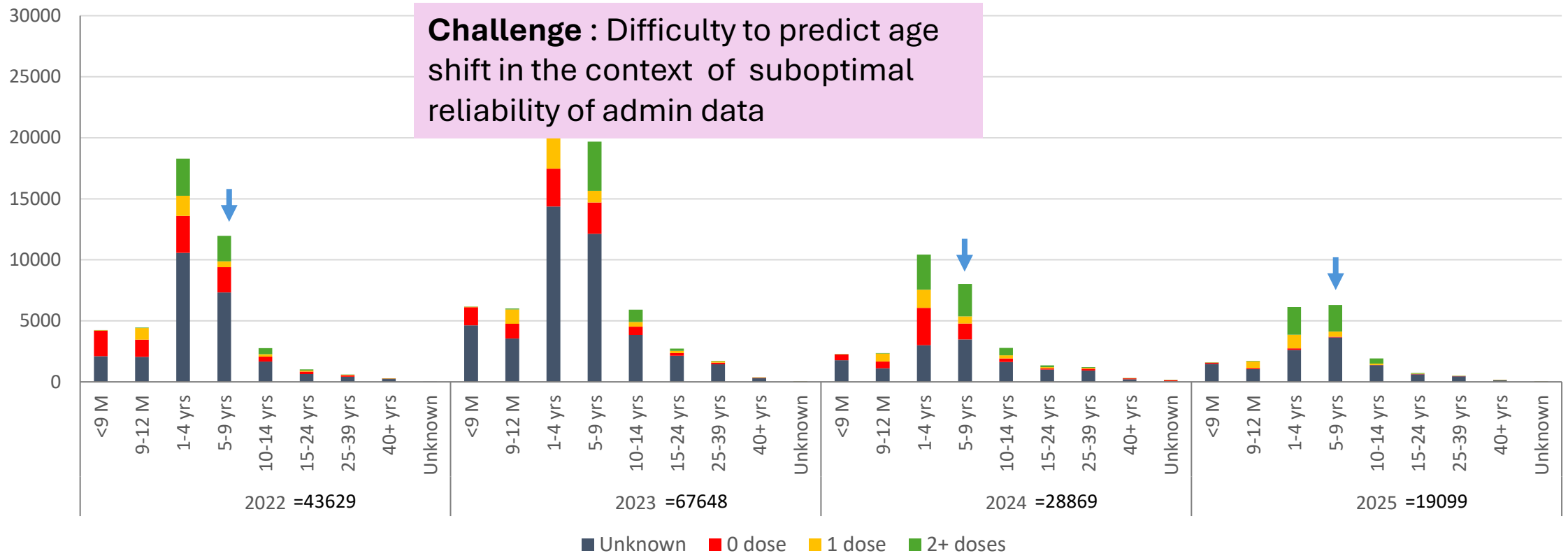
Challenge : NMNR discard rate is a predictor of sensitive surveillance- need validation ; need further data triangulation

Source: VPD surveillance database, WHO SEARO

Data as of 06 April 2026

Measles : Concerns are →age shift of cases ; IgM positive in fully vaccinated person

Age distribution and vaccination status of measles cases- 2020-2025



Source: VPD surveillance database, WHO SEARO, March 2025

Effectiveness of measles vaccine
85% with 1 dose at 9 months
95% with 1 dose at 12 months
>99% with 2 doses given at 9 months and 18 months

Data as of 06 April 2026

Challenges and way forward with elimination initiative

1. Global funding and geopolitical landscape deprioritizing measles and rubella activities- Within partners and even within WHO; No support to MICs and non-Gavi countries

   Rec: Strong advocacy by NVCs for domestic funds, Advocacy with partners for TA;

   "Cost of inaction" is being developed and shared. Program Integration, where possible

2. High national commitment for MR elimination, but not necessarily translated/trickled down to the subnational level

   Rec: Need reactivation of the subnational accountability mechanism and predictable financing and TA to the program at all levels

3. **Delay in closing immunity gap** complicating the elimination process and making it more costly as susceptible cohorts move to older age cohorts. Preventive campaigns in MICs are a challenge

   Rec: Remove policy barriers to vaccinate targeted older age groups, e.g., health providers, army, police, university students; Strengthen RI, Regular catch-up.

Challenges and way forward with elimination initiative

4. **Outbreak preparedness, response**, and cross-border collaboration

   Rec: Outbreak preparedness assessment and preparedness activities to be supported; SimEx; Preparedness and response plan being developed for countries; cross-border framework in place, and need to work closely with IHR for cross-notification

5. With decreasing incidence, positive predictive values of the IgM ELISA test are decreasing, and **need for additional tests to identify true and false positives**

   Rec: Implementation of updated algorithm for lab testing and ensure domestic funding for the same; need to establish an Expert review committee as countries move closer to elimination; advocacy with IRR for additional tests – (ICMR, a potential partner in India, with regional support possibility)

6. Reduced regional and subnational TA (SMO) presence in some countries imposes a risk of accelerating progress

   Rec: Ensure well-planned transition with adequate preparedness of capacities and skills as well as management function for the surveillance into government systems, while maintaining core minimum capacity within WHO

7. WHO Internal capacity to support MICs and countries with no Immunization focal points

SEAR research prioritization exercise

Details available at https://www.who.int/southeastasia/activities/immunization-and-vaccine-research-area-priorities-for-strengthening-the-immunization-programmes-in-the-who-south-east-asia-region-(2025-2030)

Related to MR :

- Strengthening VPD surveillance for better data-informed decision-making
- Digital tools and interoperable systems for surveillance, early warning, and outbreak prediction
- Assessment of surveillance practices, including environmental surveillance approaches
- Reducing zero-dose and under-immunized populations, which is critical for measles elimination
- Socio-behavioural and communication research to address vaccine hesitancy
- Integration with broader health systems to improve equity and service delivery
- Post-introduction / programme performance evaluation to assess public health impact and gaps

Modeling Priorities for shaping the regional elimination agenda

- **Closing Immunity gaps**
  - Models to evaluate/estimate subnational coverage
  - Generating various scenarios (permutation and combination of RI/SIA/PIRI) to have
  - profile in real time in a user-friendly format
- **Lab-supported case-based surveillance**
  - Data triangulation to identify immunity gaps
  - Modeling age shift to guide RI and SIA policy
  - Is the NMNR discard rate the best predictor of the sensitivity of VPD surveillance?

Caution : Need for simple user-friendly models where programme managers can interpret the outcomes and use for programme improvement

- **Outbreak preparedness**
  - What are predictors of outbreaks? (Nowcasting outbreak)
  - Is the rule of thumb of accumulation of susceptible equivalent to 100% of
- **Enablers**
  - Elimination scenarios and possible targets
  - Economic analysis (CBA/CEA/IC)

Conclusion

WHO South-East Asia Region is at elimination mode for measles and rubella elimination and with optimal implementation of strategies measles and rubella elimination is possible.

The research priority for measles is essential to generate practical, program-oriented evidence/ nowcast/ forecast/ models that can help countries in SEAR to accelerate progress by closing immunity gaps, strengthening measles surveillance and outbreak detection, and improving equitable vaccination uptake needed for elimination and sustain beyond.

Learning from countries will help shape further the research agenda .

THANK YOU

No child should die or have disability due to vaccine preventable diseases like measles and rubella No child should die or have disability due to vaccine preventable diseases like measles and rubella .

#VaccinesProtect
#Vacciens-Saves-lives

Md Ariful Islam

WHO Bangladesh

MEASLES
ANALYTICS HUB

Modelling MR Immunity gaps and outbreak predictors in Bangladesh

Dr Ariful Islam

WHO, Bangladesh

Category of abstract:

Data, modelling or methodological challenges & innovations

MEASLES ANALYTICS HUB

Background Information

2026

Total Population	**174,564,926**
Live births	**3,430,201**
Children <1 year	**3,337,585**
Children <5 years	**17,840,535**

Source of population data: Cohort component method was used. Population projection from 2022 Census, Bangladesh Bureau of Statistics

Measles Epidemiology in Bangladesh

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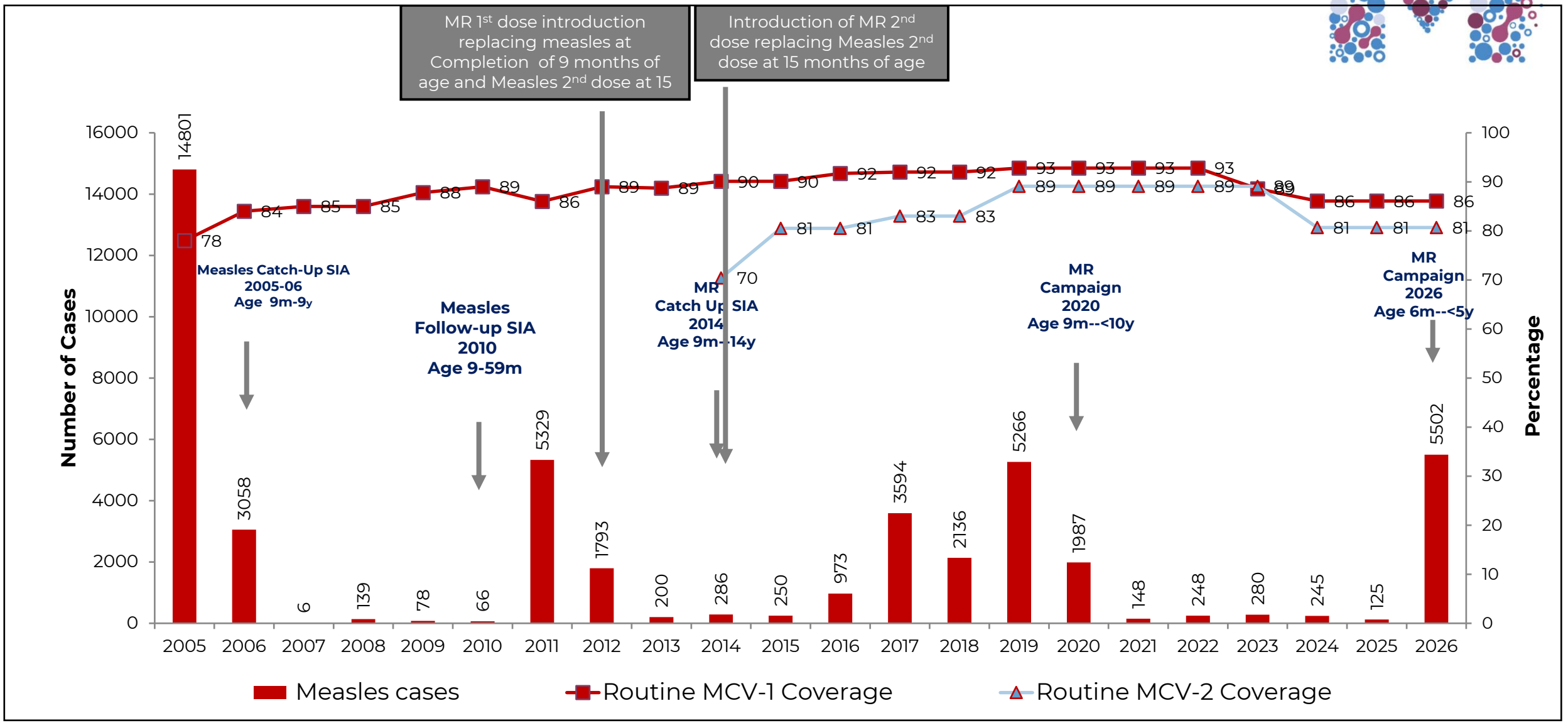
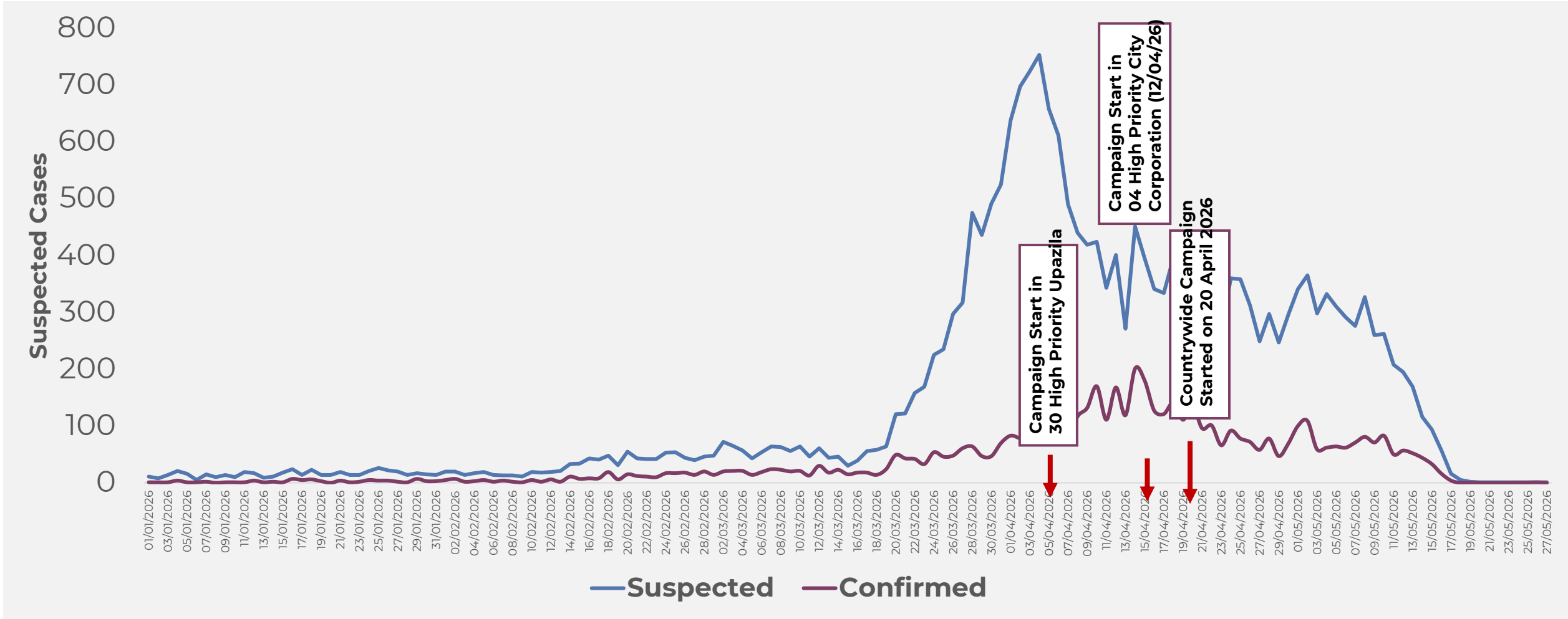
Timestamp and trend of M/MR campaigns, Confirmed Measles cases and RI coverage for MR1 and MR2 (CES)



Data as of 31 May 2026

Trend of Suspected and Confirmed measles cases from Jan-May 2026*

Suspected Case : 20,586*
Confirmed Case : 5,384*



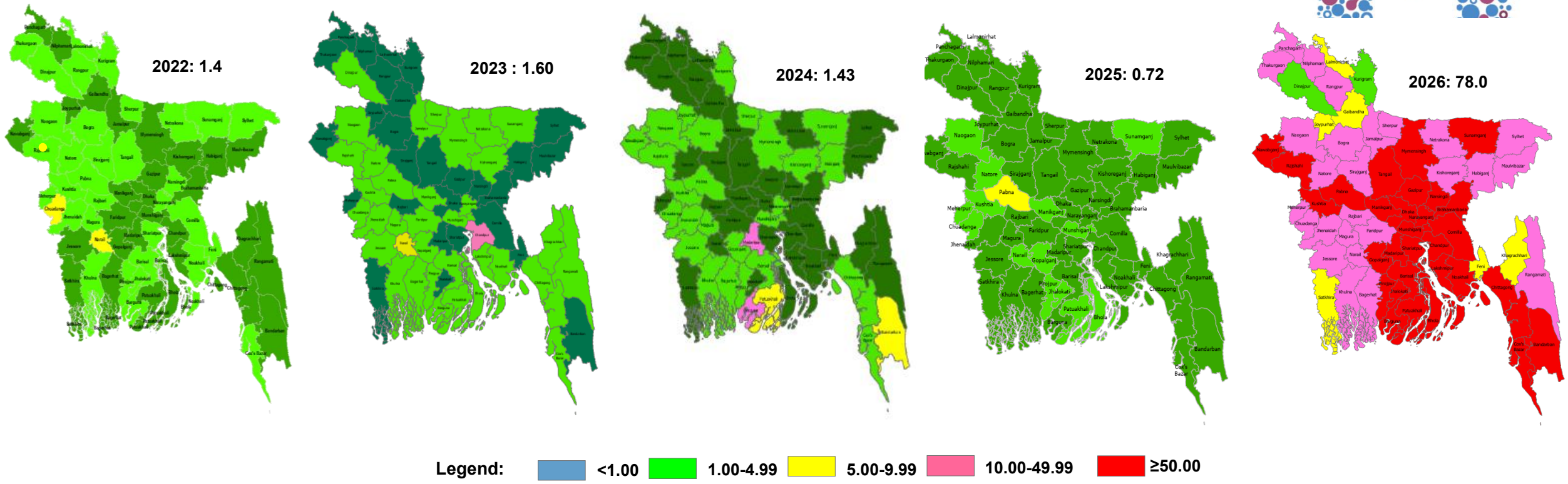
Data source: EPI weekly update, DGHS; Data as of 24 May 2026

Division-wise Measles Incidence in Bangladesh 2021-2026

DIVISION	2021	2022	2023	2024	2025	2026
BARISAL	0.5	1.09	1.48	3.16	1.36	109.17
CHITTAGONG	1.55	0.95	2.46	0.84	0.37	73.24
DHAKA	0.43	0.97	1.01	1.58	0.47	155.36
KHULNA	1.7	2.2	2.62	2.42	1.09	36.05
MYMENSINGH	0.46	0.97	1.57	0.94	0.31	47.90
RAJSHAHI	0.81	2.22	1.6	1.7	2.29	41.67
RANGPUR	0.42	1.72	0.94	0.65	0.22	10.51
SYLHET	0.59	1.91	0.83	0.96	0.6	31.63
National	0.86	1.41	1.6	1.43	0.76	78.05

Data source: EPI weekly update, DGHS; Data as of 31 May 2026

Measles Incidence per million population 2022-2026* (Lab Confirmed + Epi Linked)



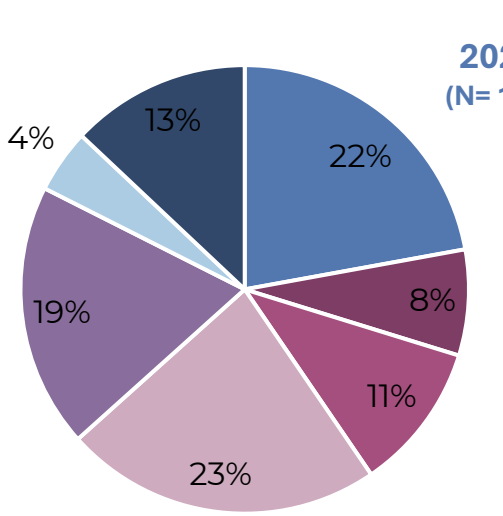
*Data as of 31 May 2026; City Corporations data included in the District

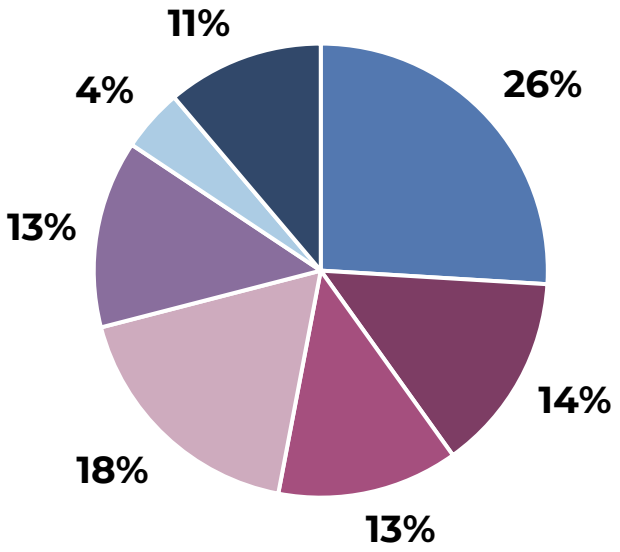
* Source: EPI case-based surveillance is supported through the WHO SIMO Network, with analysis based on rash onset dates; laboratory results are pending

Age group of confirmed Measles & Rubella Case 2025-2026*

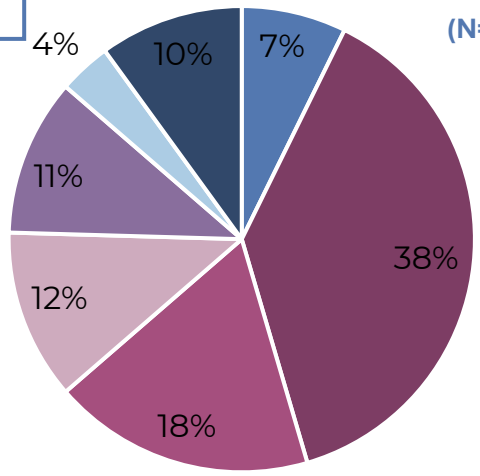
(Confirmed measles=Lab conf+Epi linked cases)

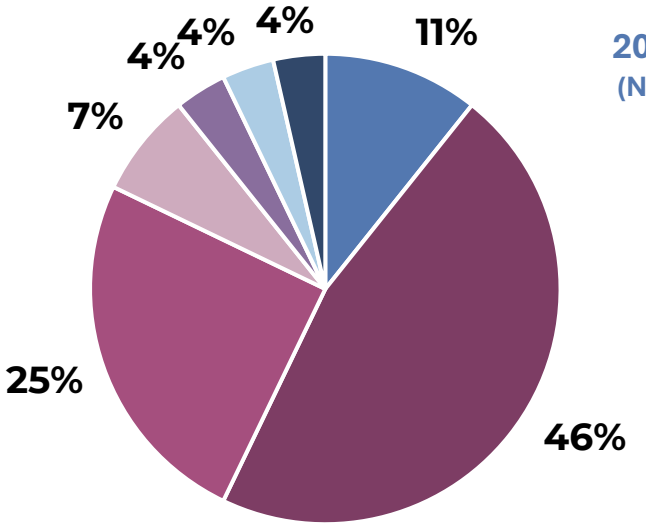
Confirmed Measles





Confirmed Rubella



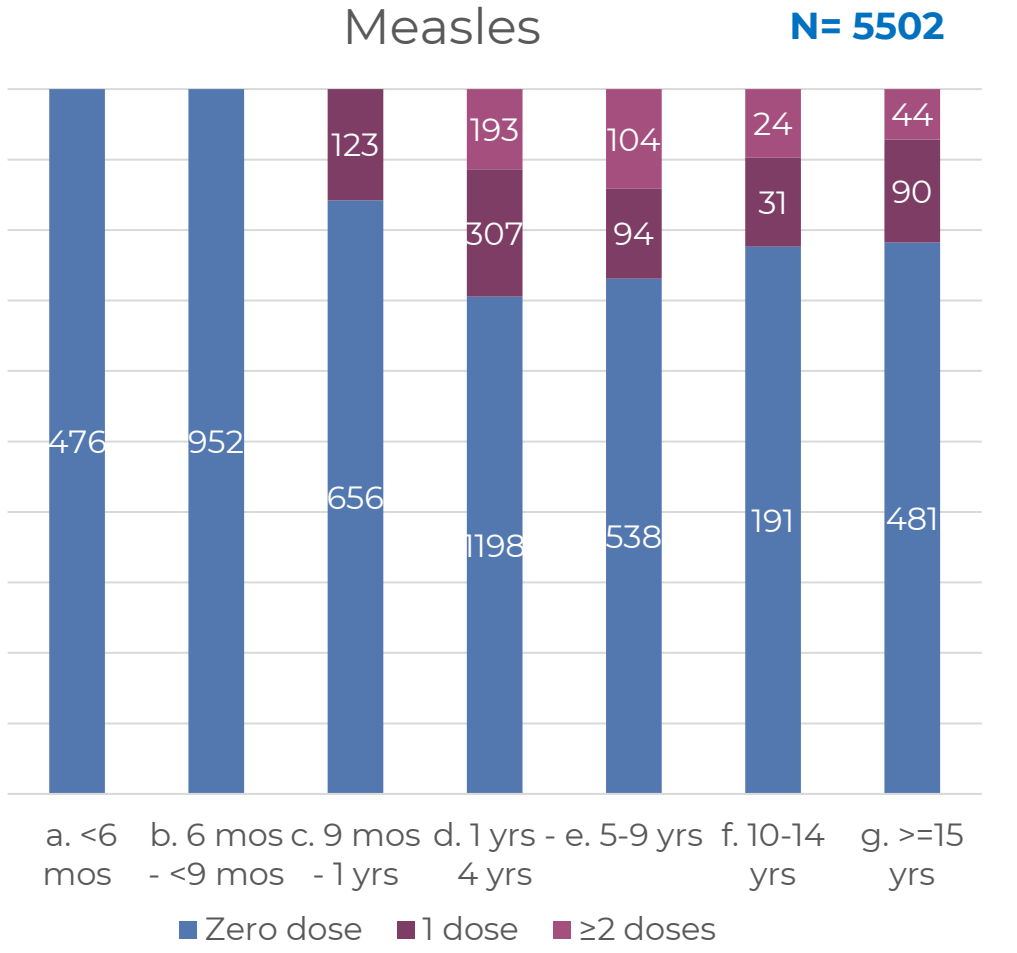


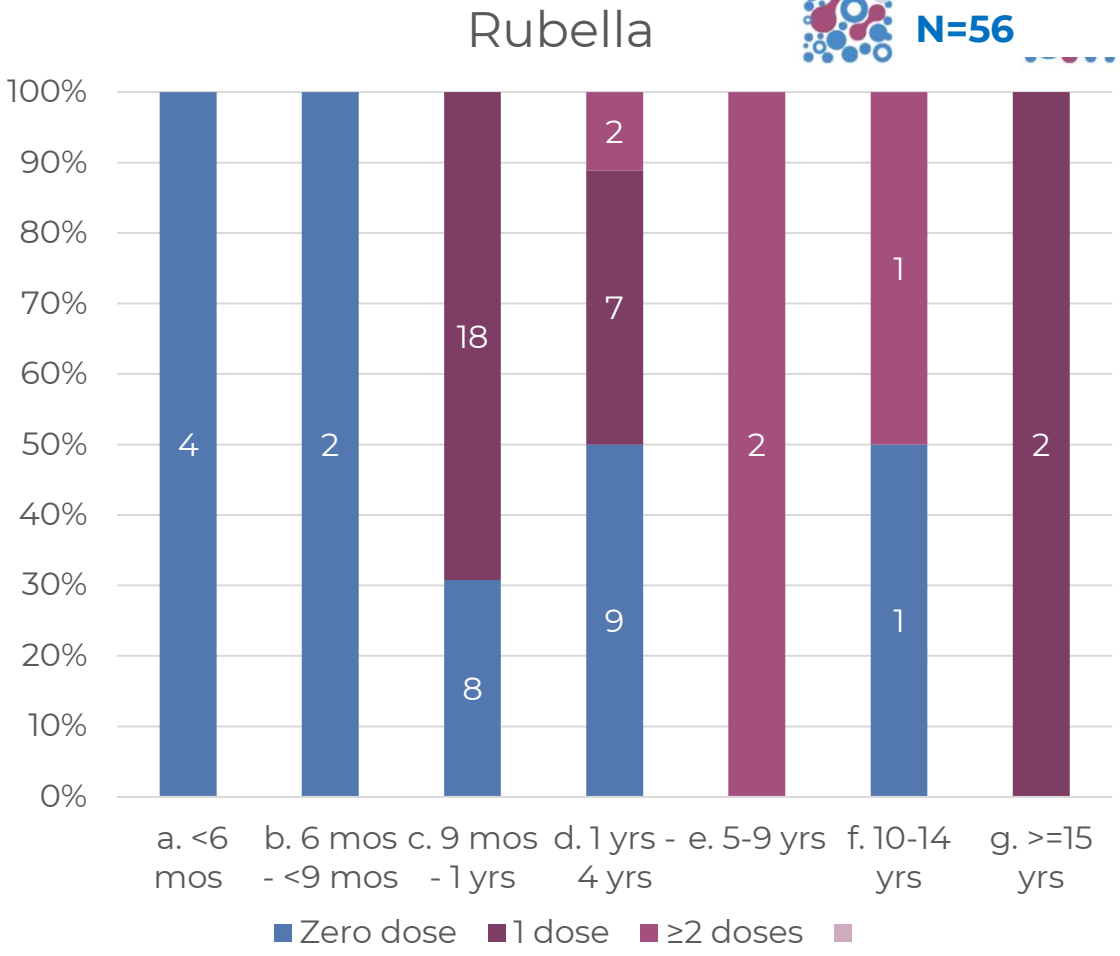
Source: EPI case-based surveillance is supported through the WHO SIMO Network

■ <9 mos ■ 9 mos - 11 mos ■ 1-<2 yrs ■ 2-4 yrs ■ 5-9 yrs ■ 10-14 yrs ■ >=15 yrs

*Data as of 31 May, 2026

Vaccination Status in Confirmed Measles and Rubella Cases in 2026*





*Data as of 31 May, 2026

* Source: EPI case-based surveillance is supported through the WHO SIMO Network, with analysis based on rash onset dates; laboratory results are pending

Division-wise Coverage of MR campaign 2026 Bangladesh

Division	Total Campaign Target	Cumulative Vaccinated	Cumulative Coverage
BARISHAL	1,063,638	1,069,791	100.58%
CHATTOGRAM	4,296,218	4,438,737	103.32%
DHAKA	4,449,632	4,586,579	103.08%
KHULNA	1,614,273	1,629,839	100.96%
MYMENSINGH	1,330,655	1,350,489	101.49%
RAJSHAHI	2,048,435	2,115,107	103.25%
RANGPUR	1,888,247	1,942,864	102.89%
SYLHET	1,323,966	1,315,736	99.38%
Total	**18,015,064**	**18,449,142**	**102.41%**

Data source: https://dashboard.vaxepi.gov.bd/mrcampaign/dashboard,; Data as of 25 May 2026

Measles Status in

Rohingya Camps Cox's Bazar

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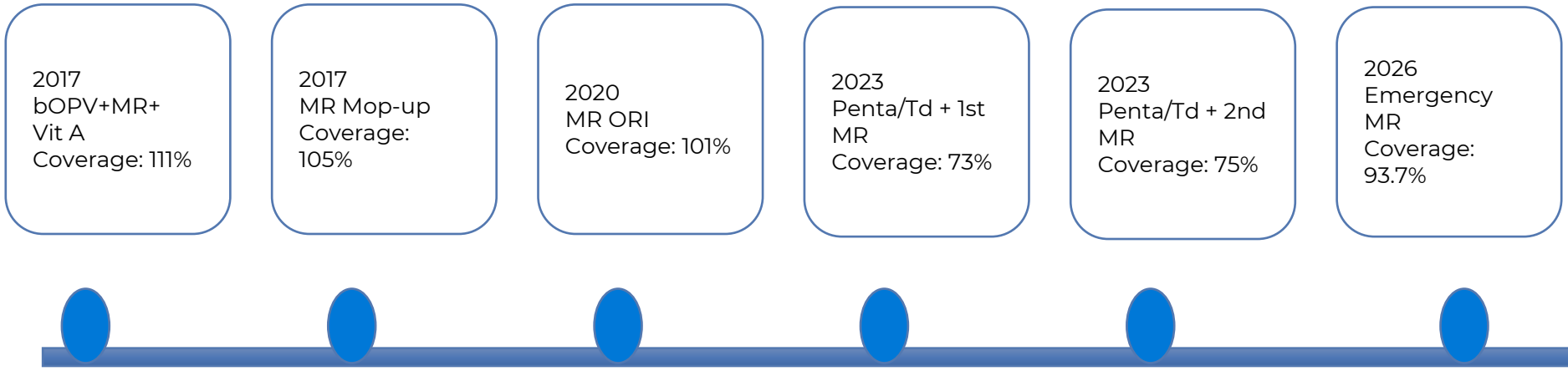
Vaccination Activities among FDMNs, Cox's Bazar

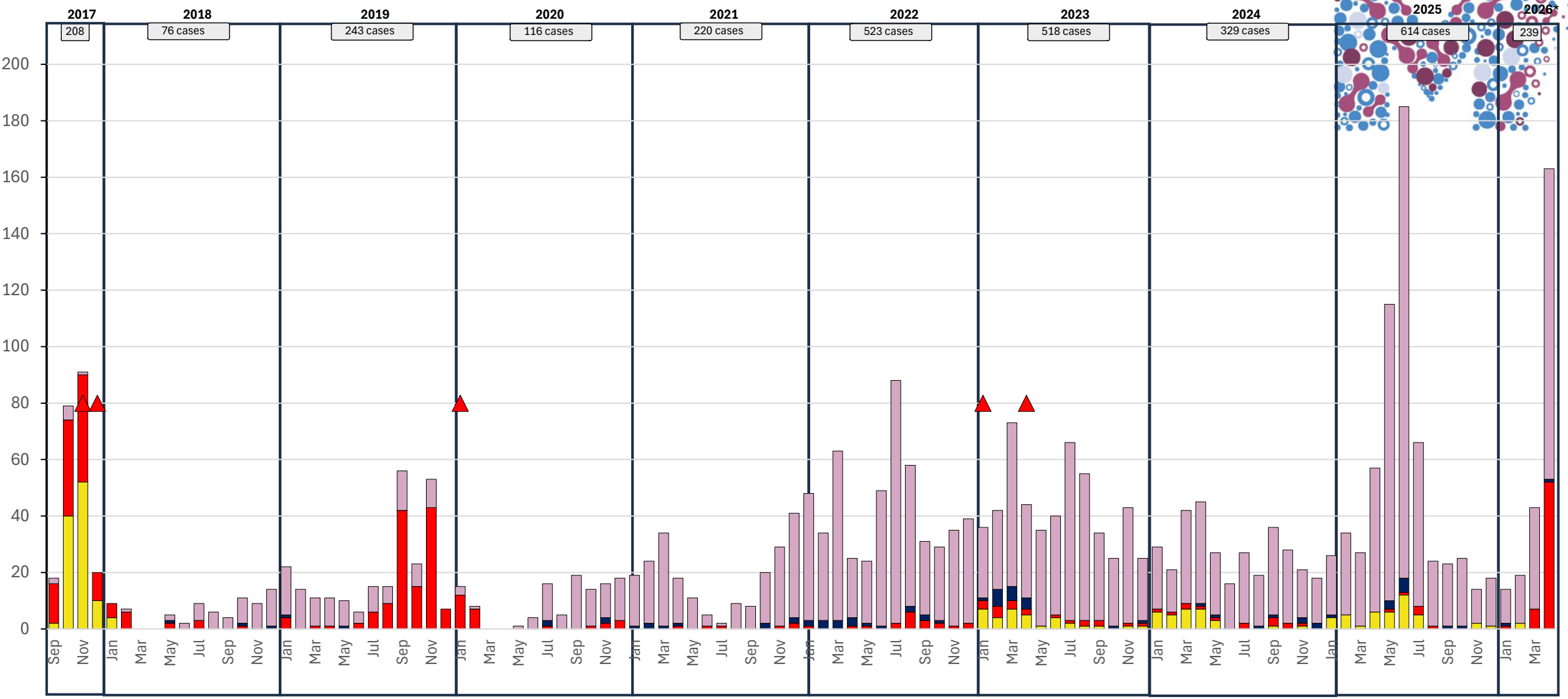
Campaign timeline and reported coverage (2017–2026)



- PIRI activities were introduced in 2024 in selected low-coverage Rohingya camps.
- At least six PIRI rounds have been conducted annually in prioritized camps.

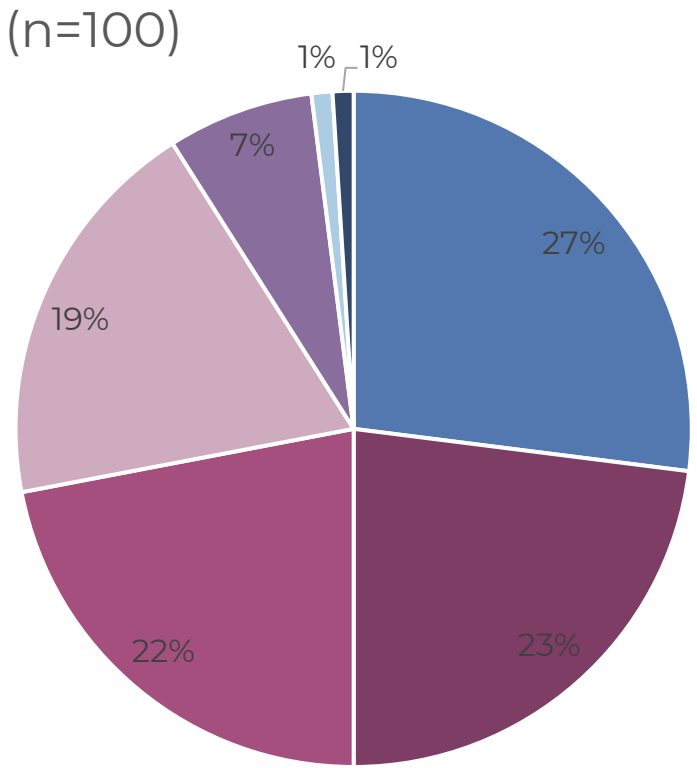
Key message: Multiple supplementary immunization activities have been conducted since 2017 to maintain population immunity among FDMNs, with emergency MR campaigns implemented during outbreak periods.

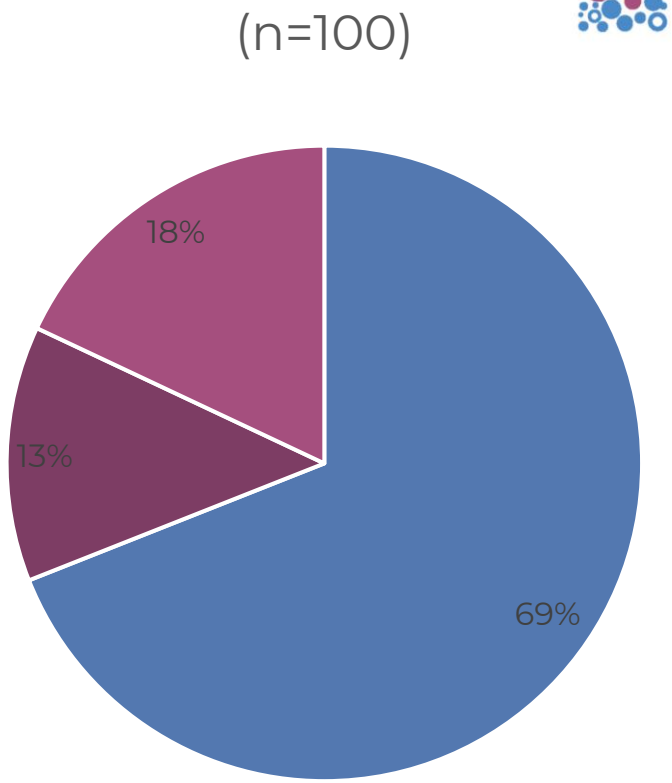
Monthly Measles Cases Trends, Rohingya, 2017-26*



1-Clinically Confirmed Measles
2-Laboratory Confirmed Measles
4-Laboratory Confirmed Rubella
6-Discarded

Age Distribution & Vaccination status of Lab confirmed measles, 2023-26*



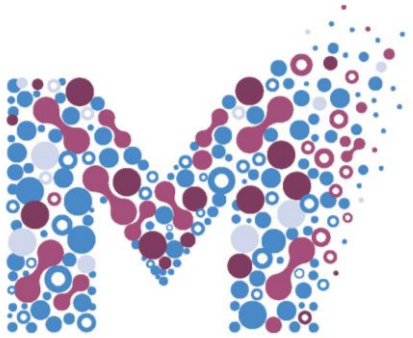


*Vaccination status was verified using the vaccination card where available; otherwise, caregiver recall was used

Abstract Title

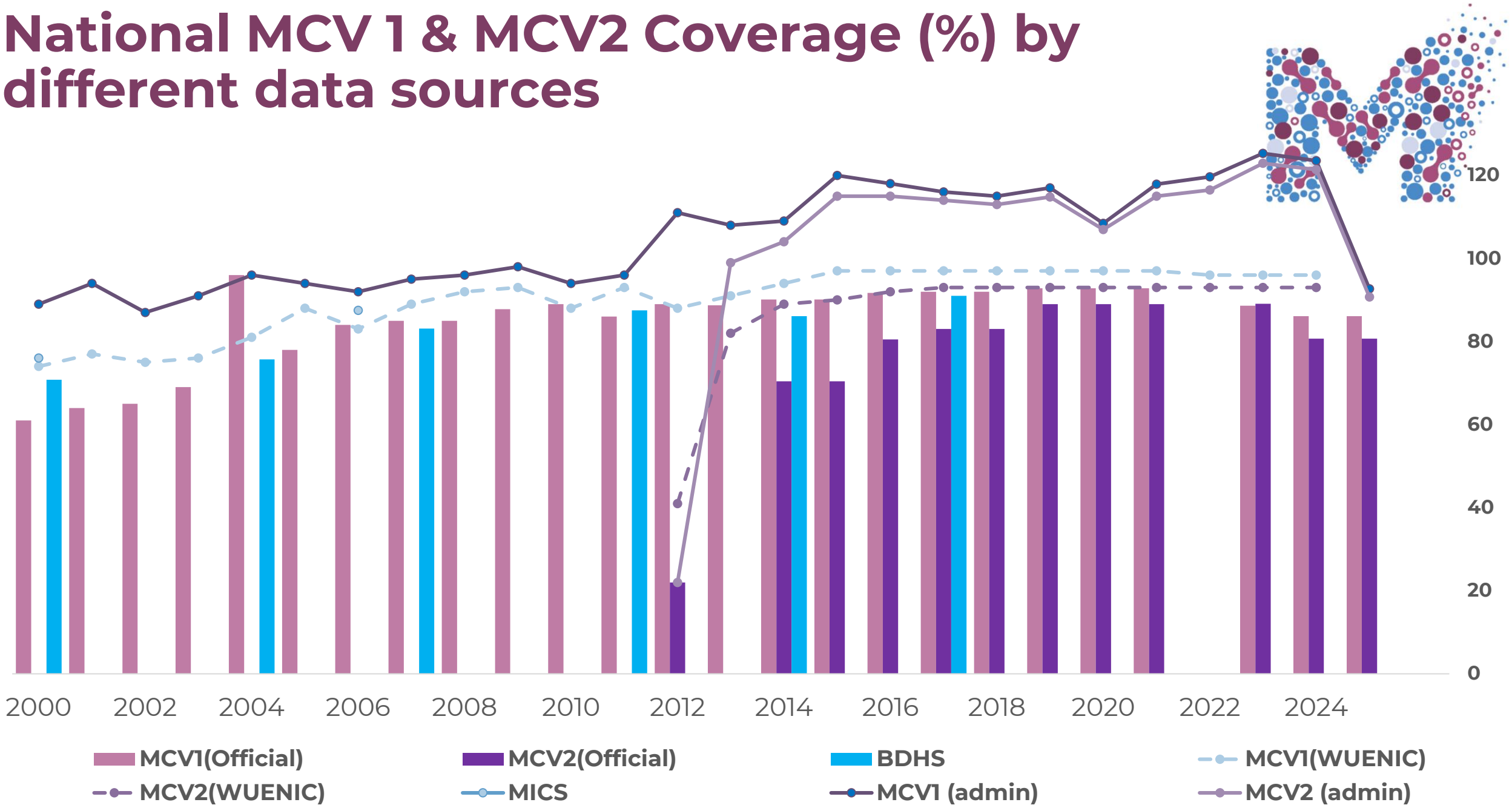
- Modeling measles-rubella Immunity gaps and outbreak predictors in Khulna Division, Bangladesh

Scope of the work



- Multiple data sources with significant difference.
  - Administrative data (DHIS2)
  - WUENIC
  - Coverage surveys e.g. CES, DHS, MICS
- Subnational disparity in coverage
- Immunity gap compounded by
  - High birth rates
  - Interrupted vaccine supply
  - Irregular SIA
- Gaps can be minimized by exploring innovative data modeling technique

National MCV 1 & MCV2 Coverage (%) by different data sources

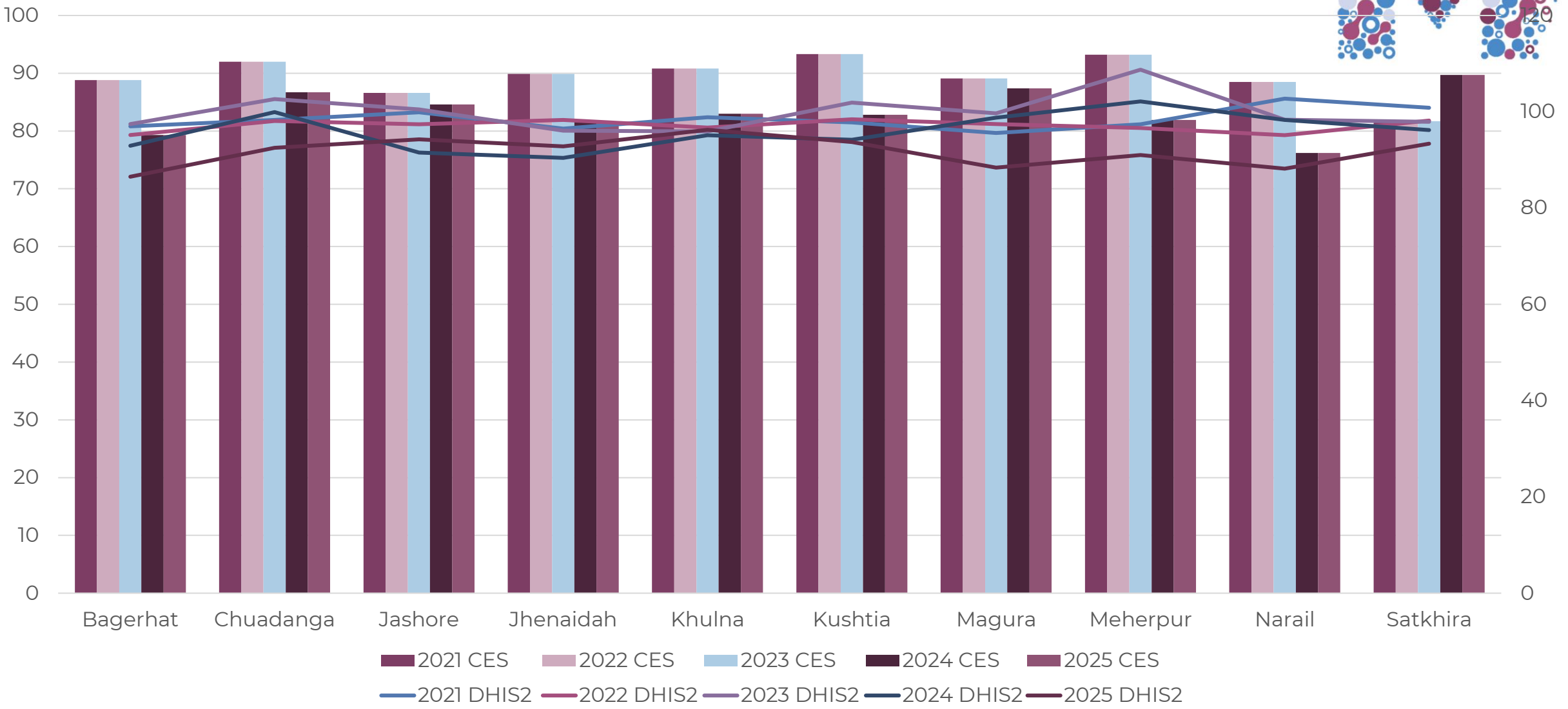


Data source: https://immunizationdata.who.int

Methods

- District-level immunization coverage data (2021–2025) were analyzed for Khulna division using
  - CES data
  - DHIS2 data (validated by CES data)
- Proportion of susceptible birth cohorts were estimated from five-year coverage trends
- R_{eff} was calculated to assess outbreak potential

MCV2 Coverage (%) in the districts of Khulna Division (CES & DHIS2 data)

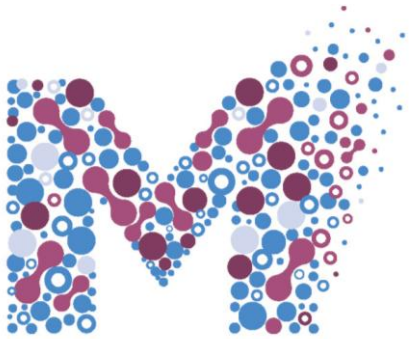


Data source: https://immunizationdata.who.int & DHIS2, DGHS, Bangladesh

Findings

- Significant heterogeneity observed across the districts of Khulna Division
- Findings differ in same district while using different data source.
- R_{eff} >2 in Jashore and >1 in all other districts
- Surveillance data shows
  - measles positive case throughout the division
  - 40% of confirmed cases are <5 years of age
  - 35% of cases missed 2nd dose of MCV

Variation of immunity profile in Khulna Division (using CES & DHIS2 data)



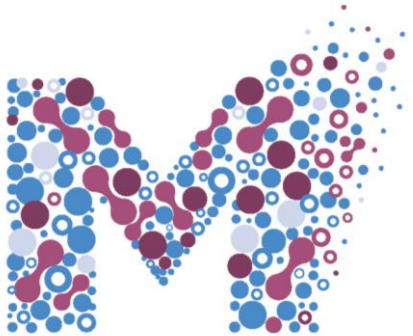
CES

Division	District	Live Birth 2025	Measles		
			Unprotected 2021-2025	Succeptible proportion of Birth cohort	$R_{eff.}$ (MSL)
Khulna	Bagerhat	33,647	23751	71%	1.62
Khulna	Chuadanga	25,441	14344	56%	1.20
Khulna	Jashore	62,630	25482	41%	2.02
Khulna	Jhenaidah	45,000	15698	35%	1.80
Khulna	Khulna	48,432	14438	30%	1.42
Khulna	Kushtia	46,822	17623	38%	1.23
Khulna	Magura	23,388	18638	80%	1.40
Khulna	Meherpur	13,808	32767	237%	1.22
Khulna	Narail	18,696	23072	123%	1.73
Khulna	Satkhira	42,483	16707	39%	1.37

DHIS2

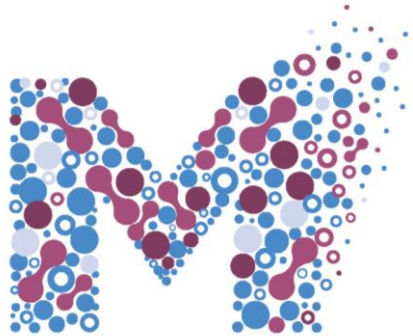
Division	District	Live Birth 2025	Measles		
			Unprotected 2021-2025	Succeptible proportion of Birth cohort	$R_{eff.}$ (MSL)
Khulna	Bagerhat	33,647	28898	86%	1.98
Khulna	Chuadanga	25,441	14192	56%	1.18
Khulna	Jashore	62,630	31633	51%	2.51
Khulna	Jhenaidah	45,000	20687	46%	2.38
Khulna	Khulna	48,432	12921	27%	1.27
Khulna	Kushtia	46,822	20501	44%	1.43
Khulna	Magura	23,388	20575	88%	1.54
Khulna	Meherpur	13,808	20143	146%	0.75
Khulna	Narail	18,696	416	2%	0.03
Khulna	Satkhira	42,483	22590	53%	1.85

Conclusion



- Some districts need urgent intervention to prevent outbreak recurrence
- Data analysis and taking decision is sometimes difficult for using different data source (and unreliable administrative data)
- Data-driven modeling is crucial
  - to identify real immunity gap
  - to detect the predictors of outbreak
  - to guide for targeted interventions

Seeking Expert Opinion



- **Given the high case fatality ratio in Bangladesh, what does this mean for transmission dynamics?**

Thank You

MEASLES
ANALYTICS HUB

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Ministry of Health, Myanmar

MEASLES
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From Surveillance to Strategy: Myanmar's planned evidence-Based MR Campaign for Regional Impact

Category: Data, modelling or methodological challenges & innovations

Dr. Kyaw Kan Kaung
Deputy Director General
MOH Myanmar

MAH Annual Meeting
Jakarta, 10 June 2026

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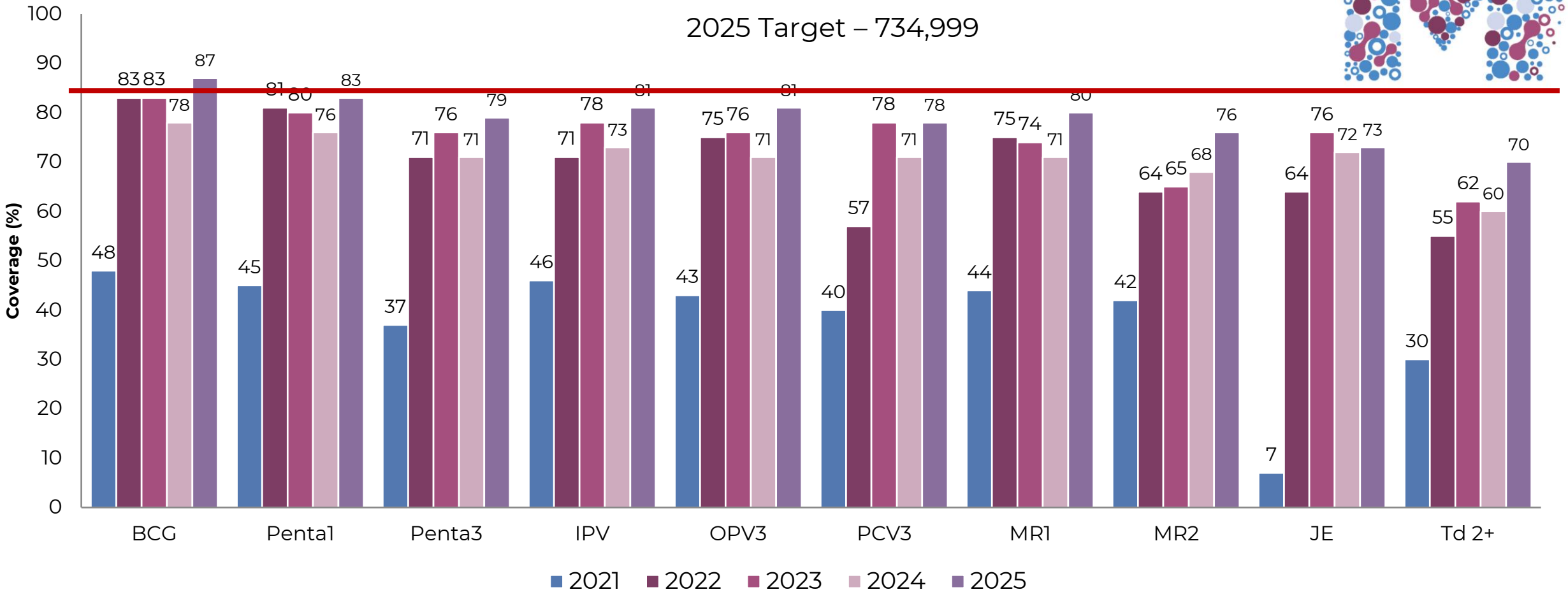
Presentation outline

- Routine immunization coverage 2021-2025
- Immunity Gap analysis using MSP tool2025
- Trends of measles Outbreaks/Campaign by year, Myanmar 2000-2026
- Measles Outbreak 2024
- Suspected / confirmed measles cases by state and region 2022-2026
- Age distribution and Vaccination status of confirmed Measles cases, 2020-2025*
- Measles risk assessment- WHO standard risk assessment tool 2025
- Measles-Rubella follow-up campaign 2026

Routine Immunization coverage, 2021-2025

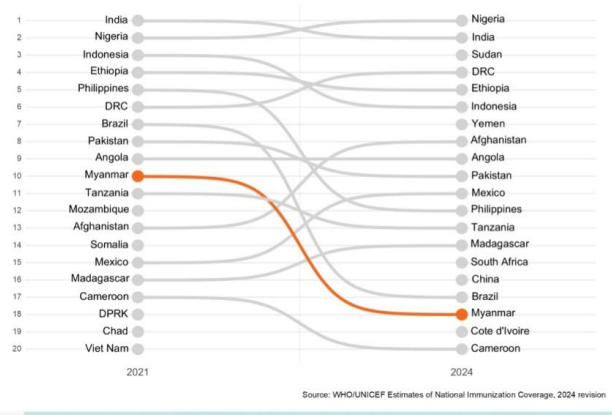


Myanmar has faced major disruptions to routine immunization in 2021, creating a large measles–rubella immunity gap. Although MCV1 and MCV2 coverage reached 80% and 76% in 2025 (up from <50% during COVID-19), susceptible children accumulated beyond one birth cohort. Myanmar conducted “Big Catch-up” campaigns to reduce this gap.

Big Catch-up vaccination in Myanmar

BIG CATCH-UP VACCINATION

IA2030 top 20 zero-dose countries rank, 2021-2024



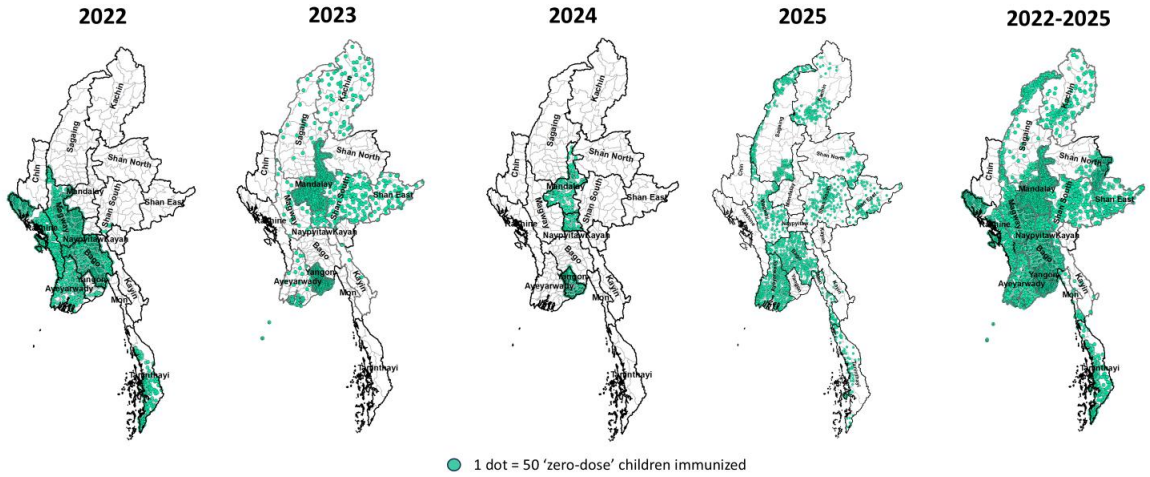
Source: WHO/UNICEF Estimates of National Immunization Coverage, 2024 revision

20 countries were prioritised in the context of the Immunization Agenda 2030 (IA2030), based on their number of zero-dose children in 2021. This chart compares the ranking of the top 20 countries in 2021 and 2024. Rank 1 indicates the country with the highest absolute number of zero-dose children.

Myanmar was in the top 20 zero-dose countries in 2021 and 2024.

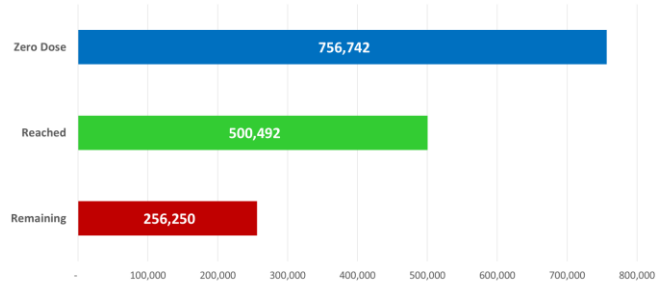
Vaccine Doses Reached Zero-Dose Children (2022-2025)

Township-wise zero-dose children immunized during BCU 2022-2025

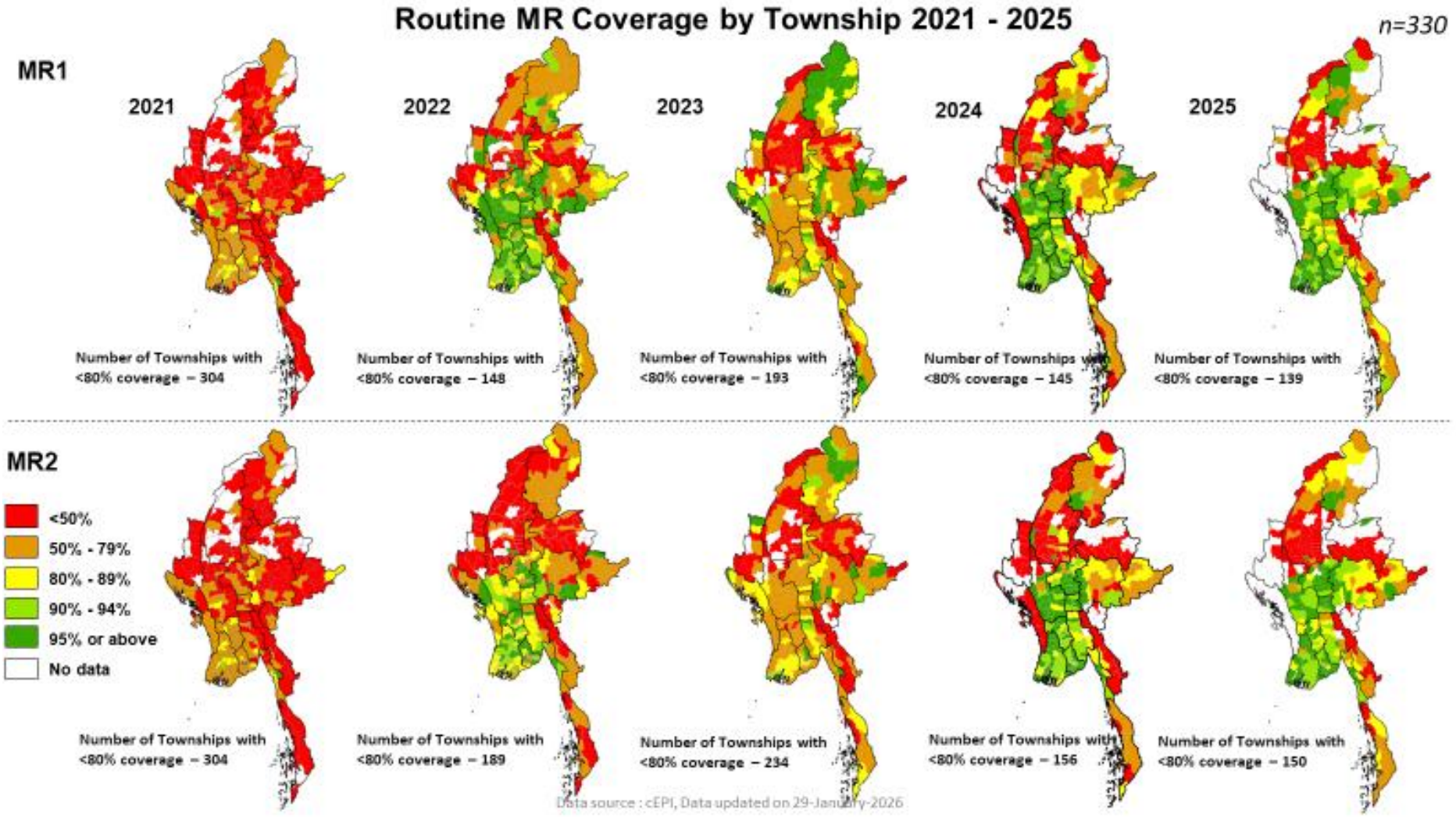


1 dot = 50 'zero-dose' children immunized

Zero-dose children reached since 2021 to 2024

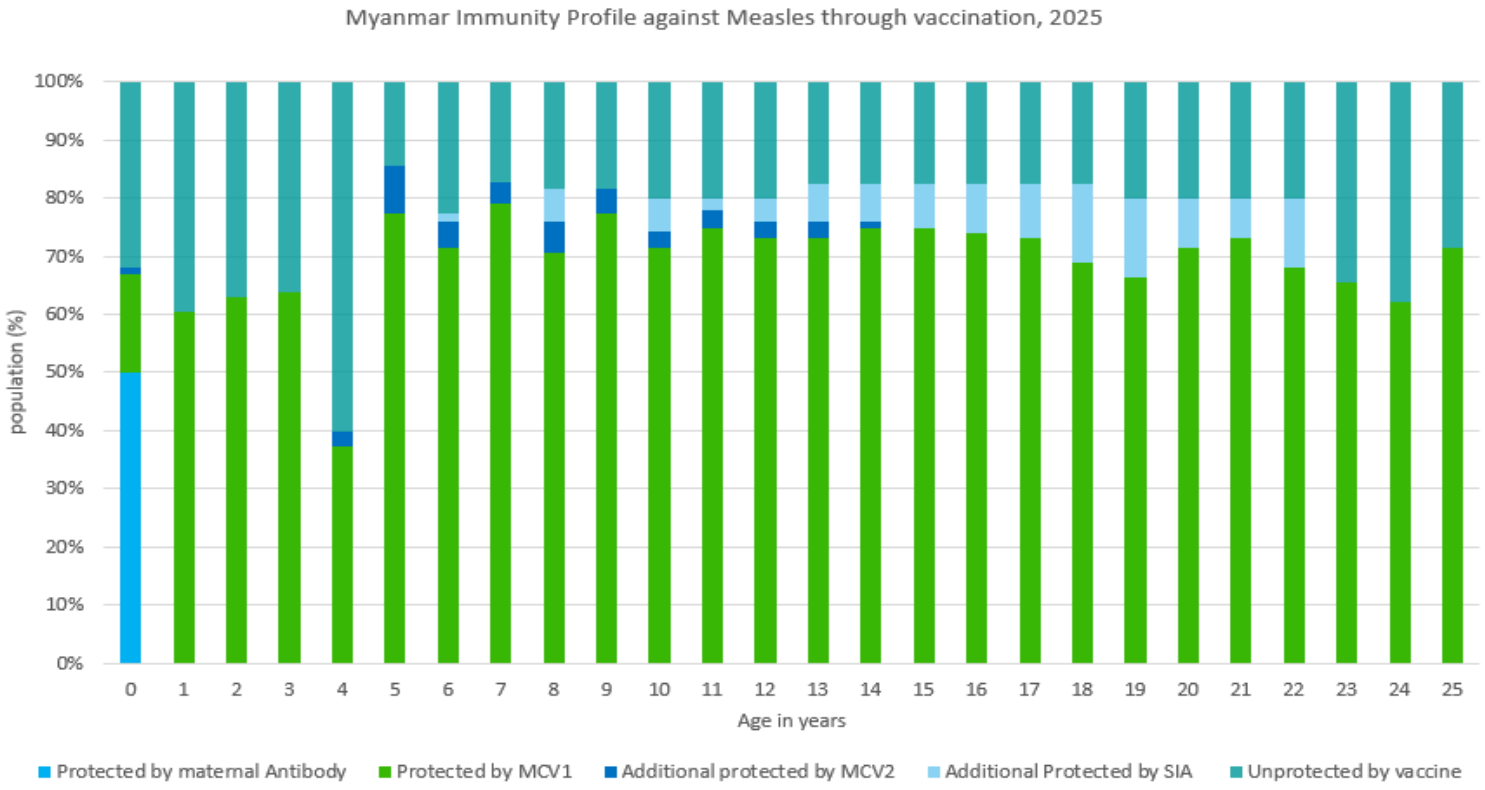


Big Catch up implemented between 2022-2025 covered >500,000 children who missed measles vaccination;



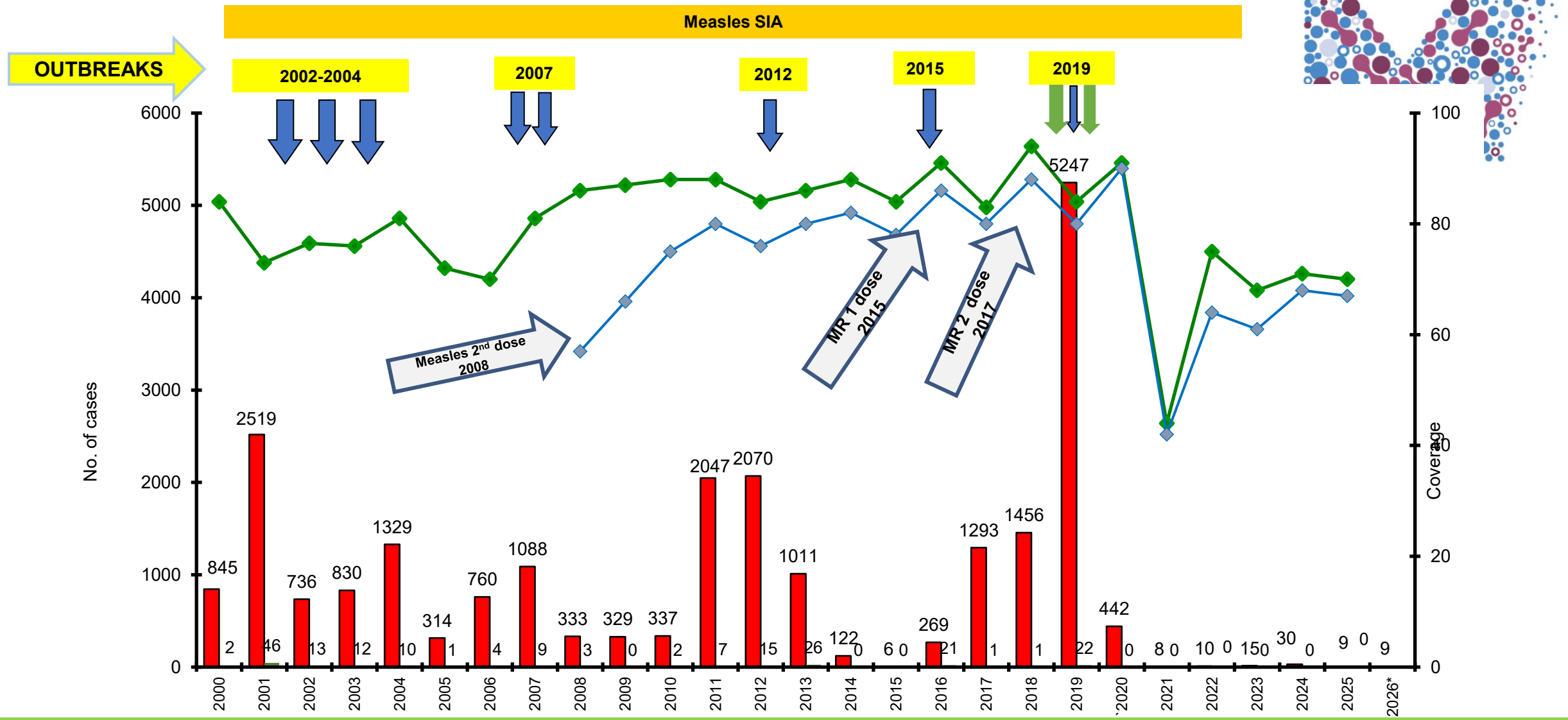
Low and **unequal** MCV1 and MCV2 coverage has **increased zero-dose and under-vaccinated children**, with persistent regional disparities. Coverage remains lowest in peri-urban and hard-to-reach areas, and high MCV1–MCV2 dropout rates continue to widen immunity gaps.

Addressing the immunity gaps- Population immunity presented as a birth cohort analysis



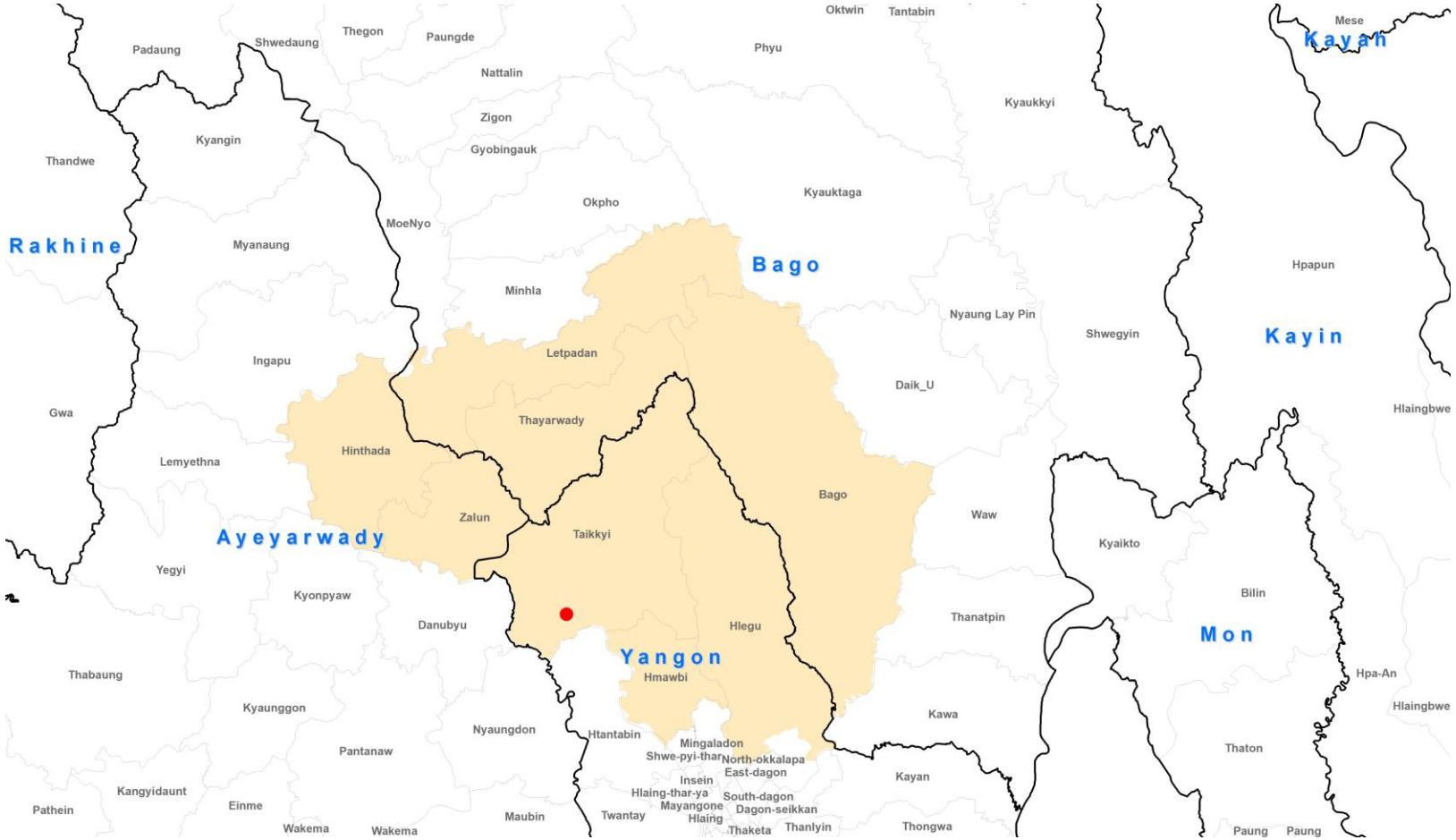
We undertook Immunity gap analysis in 2025 using **MSP tool**; where we found the susceptible amounted >1 birth cohort after discounting the BCU coverage; we looked at the Outbreaks trend of last 20 years and SIAs and age wise case pattern

TRENDS OF MEASLES CASES BY YEAR, MYANMAR, 2000-2026*



Measles outbreaks were annual from 2000–2007. After MCV2 introduction in 2008, they declined to every three years. A major outbreak in 2019 (5,247 cases) was followed by an MR SIA the same year, leading to reduced incidence. a sharp drop in routine immunization during COVID-19 in 2021, no outbreaks occurred. To address coverage gaps, BCU activities were implemented from 2022 to 2025

Measles Outbreak 2024 (Taikkyi township, Yangon)



ORI conducted

Outbreak

Total number of cases: 14 cases

Lab confirmed cases: 4 cases

Epidemiologically link: 8 cases

Discarded: 2 cases

Reported Date: 21 Feb 2024

Date of investigation: 22 Feb 2024

Date of onset of 1st case: 20 Feb 2024

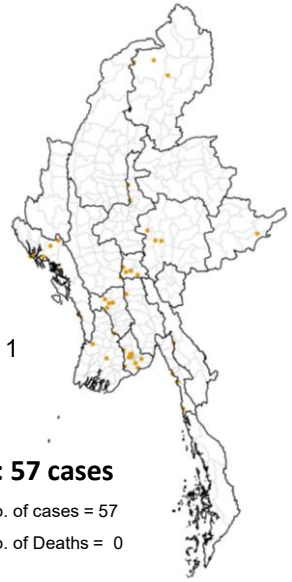
Date of onset of last case: 7 Mar 2024

- Area of ORI - 8 contiguous townships.
  - Yangon (3) – Taikkyi, Hlegu and Hmawbi
  - Bago (3) – Bago, Tharyarwady and Latpadan
  - Ayeyarwady (2)– Zalun and Hinthada
- Vaccine to be used
  - MR – 9 months to 15 years (1 dose)
  - OPV – 0 to 5 years (1 dose)
- Target population
  - < 5 years - 147779
  - 5 to 14 years - 308132
- Total Vaccinated
  - < 5 years - 153262
  - 5 to 14 years - 351463
- Date – 10 to 29 March 2024

Suspected measles cases by state and region 2022-2026*

1 Dot = 1 case

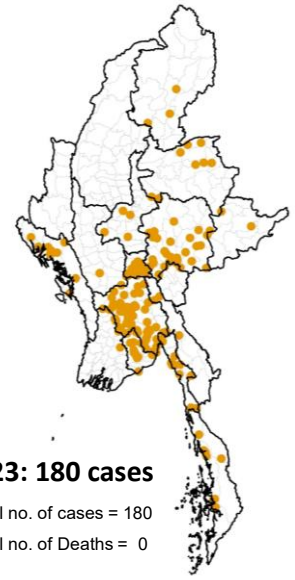
Deaths



2022: 57 cases

Total no. of cases = 57

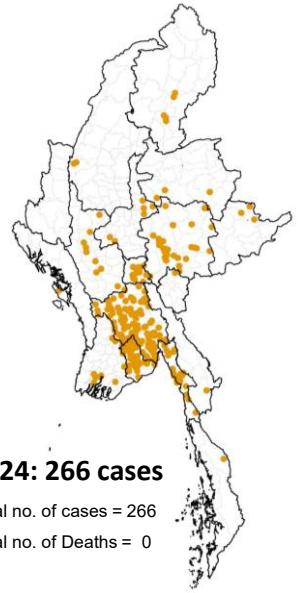
Total no. of Deaths = 0



2023: 180 cases

Total no. of cases = 180

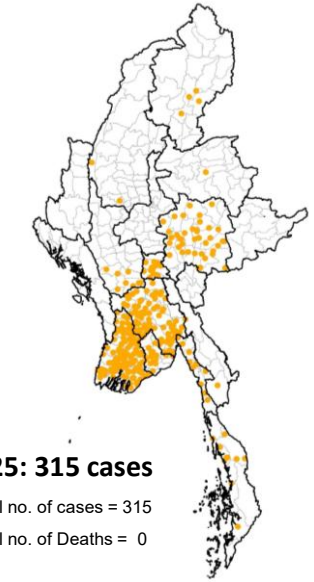
Total no. of Deaths = 0



2024: 266 cases

Total no. of cases = 266

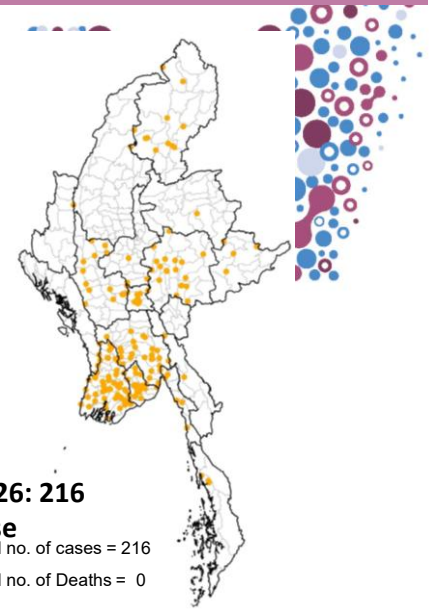
Total no. of Deaths = 0



2025: 315 cases

Total no. of cases = 315

Total no. of Deaths = 0



2026: 216 case

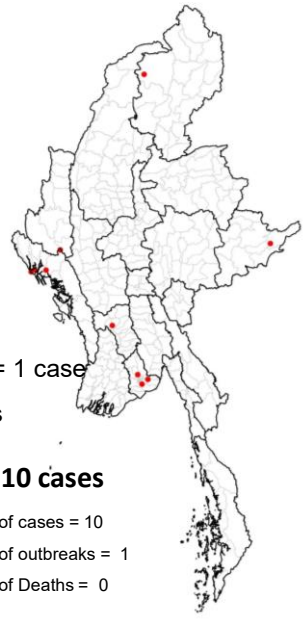
Total no. of cases = 216

Total no. of Deaths = 0

Confirmed measles cases by state and region, 2022-2026*

1 Dot = 1 case

Deaths

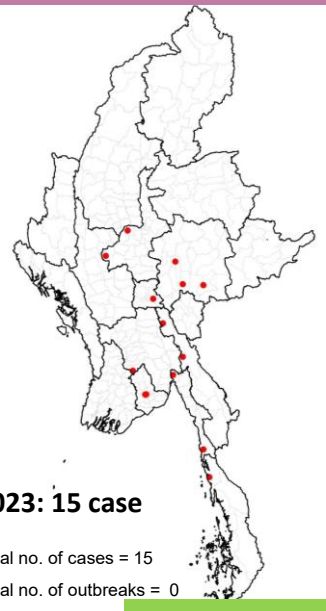


2022: 10 cases

Total no. of cases = 10

Total no. of outbreaks = 1

Total no. of Deaths = 0

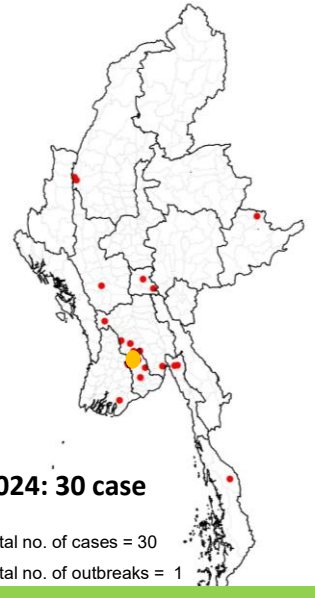


2023: 15 case

Total no. of cases = 15

Total no. of outbreaks = 0

Total no. of Deaths



2024: 30 case

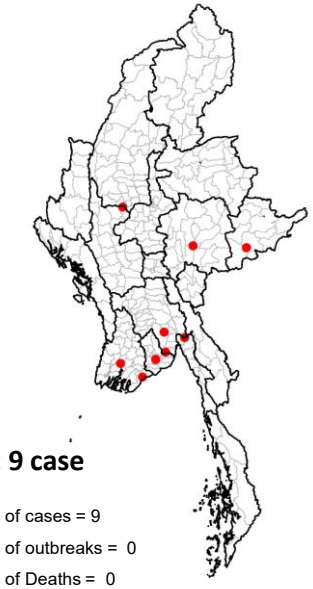
Total no. of cases = 30

Total no. of outbreaks = 1

2025: 9 case

Total no. of cases = 9

Total no. of outbreaks = 0



2026: 9 case

Total no. of cases = 9

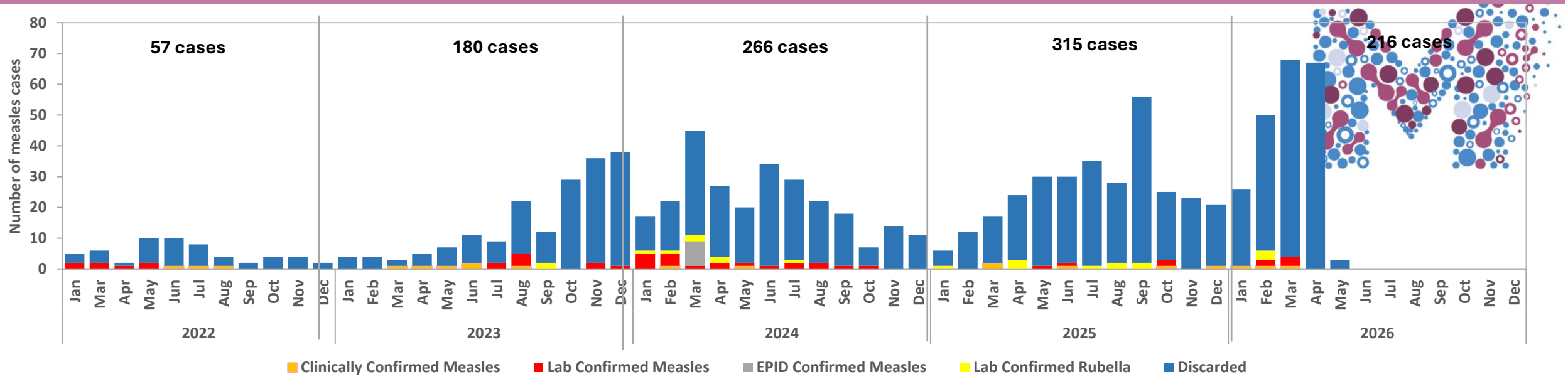
Total no. of outbreaks = 0

Total no. of Deaths = 0

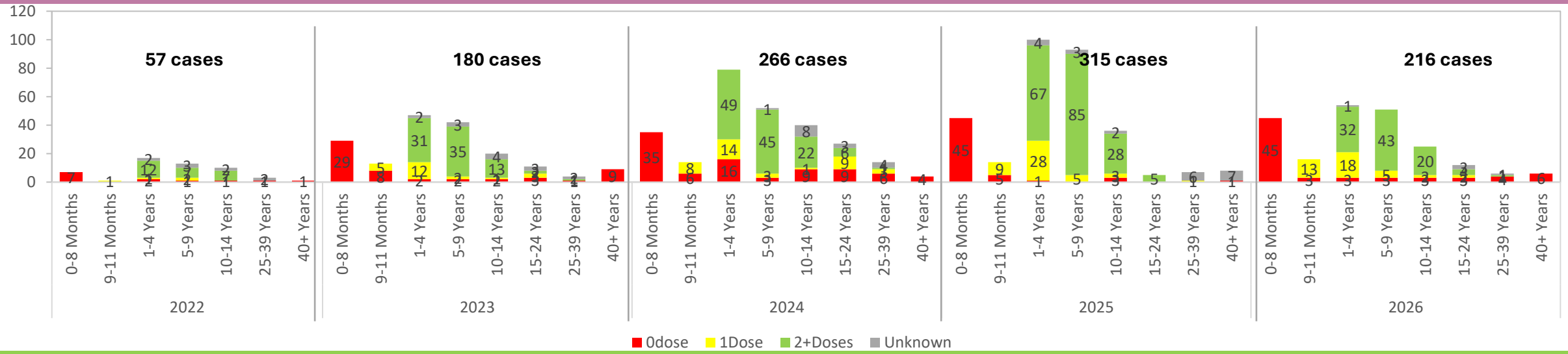
Very sporadic confirmed cases from 2022-2025

* Data as of 08 May 2026

SUSPECTED MEASLES CASES CLASSIFICATION, 2022-2026*

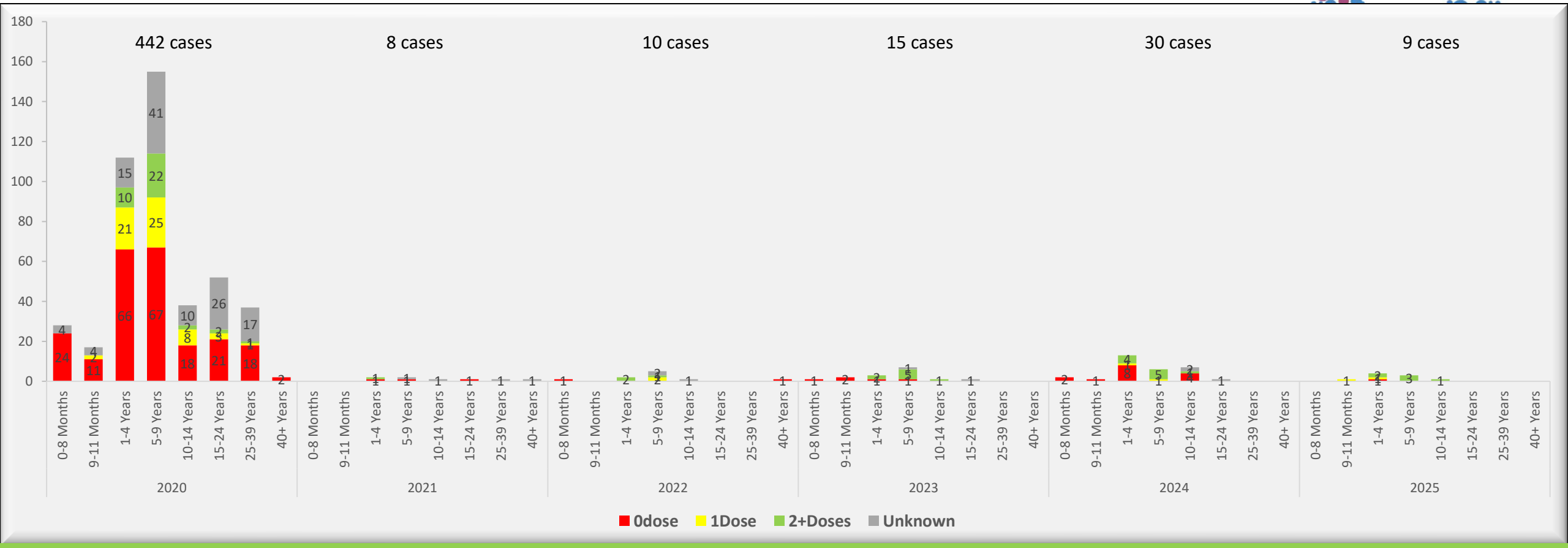


Age distribution and Vaccination status of suspected Measles cases, 2022-2026*



Fewer number of Positive cases –Age group vulnerability difficult to determine due to very low numbers

Age distribution and Vaccination status of confirmed Measles cases, 2020-2025



Very few positive cases, making it difficult to assess age-group vulnerability.

Measles Risk Assessment 2026

	OVER ALL RISK STATUS (All categories)	Population Immunity	Surveillance Quality	Program Delivery	Threat Assessment
AREA	*Status*	*Status*	*Status*	*Status*	*Status*
Ayeyarwady	LR	MR	LR	LR	VHR
Bago	MR	VHR	LR	LR	VHR
Chin	VHR	HR	VHR	MR	MR
Kachin	MR	VHR	LR	LR	MR
Kayah	VHR	VHR	VHR	LR	MR
Kayin	MR	VHR	LR	LR	MR
Magway	MR	VHR	LR	LR	MR
Mandalay	MR	LR	VHR	LR	MR
Mon	LR	LR	LR	LR	LR
Naypyitaw	LR	LR	LR	LR	LR
Rakhine	VHR	HR	VHR	VHR	LR
Sagaing	HR	VHR	LR	MR	MR
Shan East	MR	MR	VHR	LR	LR
Shan North	HR	VHR	LR	HR	MR
Shan South	MR	VHR	LR	LR	MR
Taninthayi	LR	HR	LR	LR	HR
Yangon	MR	MR	LR	LR	VHR

VHR (Very High Risk)	3	8	5	1	3
HR (High Risk)	2	3	0	1	1
MR (Medium Risk)	8	3	0	2	9
LR (Low Risk)	4	3	12	13	4

WHO-based risk assessment (immunity gaps, surveillance, program delivery) classified 8/17 states/regions as very high risk, prompting a phased measles follow-up campaign, advanced due to the Bangladesh outbreak

Conclusion: Evidence informed intervention planning

- Routine immunization disruption (since 2021) led to suboptimal MCV1/MCV2 coverage and a large accumulated immunity gap exceeding one birth cohort, despite catch-up efforts.
- Persistent inequities and zero-dose children, particularly in hard-to-reach and peri-urban areas, continue to widen susceptibility and increase outbreak risk.
- Surveillance and epidemiological trends show cyclical outbreaks, sporadic recent cases, and suboptimal surveillance sensitivity, limiting early detection of immunity gaps
- 2026 risk assessment identifies multiple high and very high-risk regions, compounded by regional threats (e.g., outbreaks in neighboring countries)
- Response: Preponed, phased MR follow-up campaign (2026) targeting ~2.83 million children (9–59 months), aiming for ≥95% coverage, prioritizing zero-dose populations, and integrating AEFI monitoring, routine immunization strengthening, and surveillance improvements.

Thank You!

Krishna Paudel

Ministry of Health, Nepal

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How data-driven microplanning enabled high-impact nationwide MR campaigns in Nepal

Dr Krishna Prasad Paudel, MBBS MD Pediatrics MPH
Chief Consultant Pediatrician
Government of Nepal Ministry of Health and Food safety

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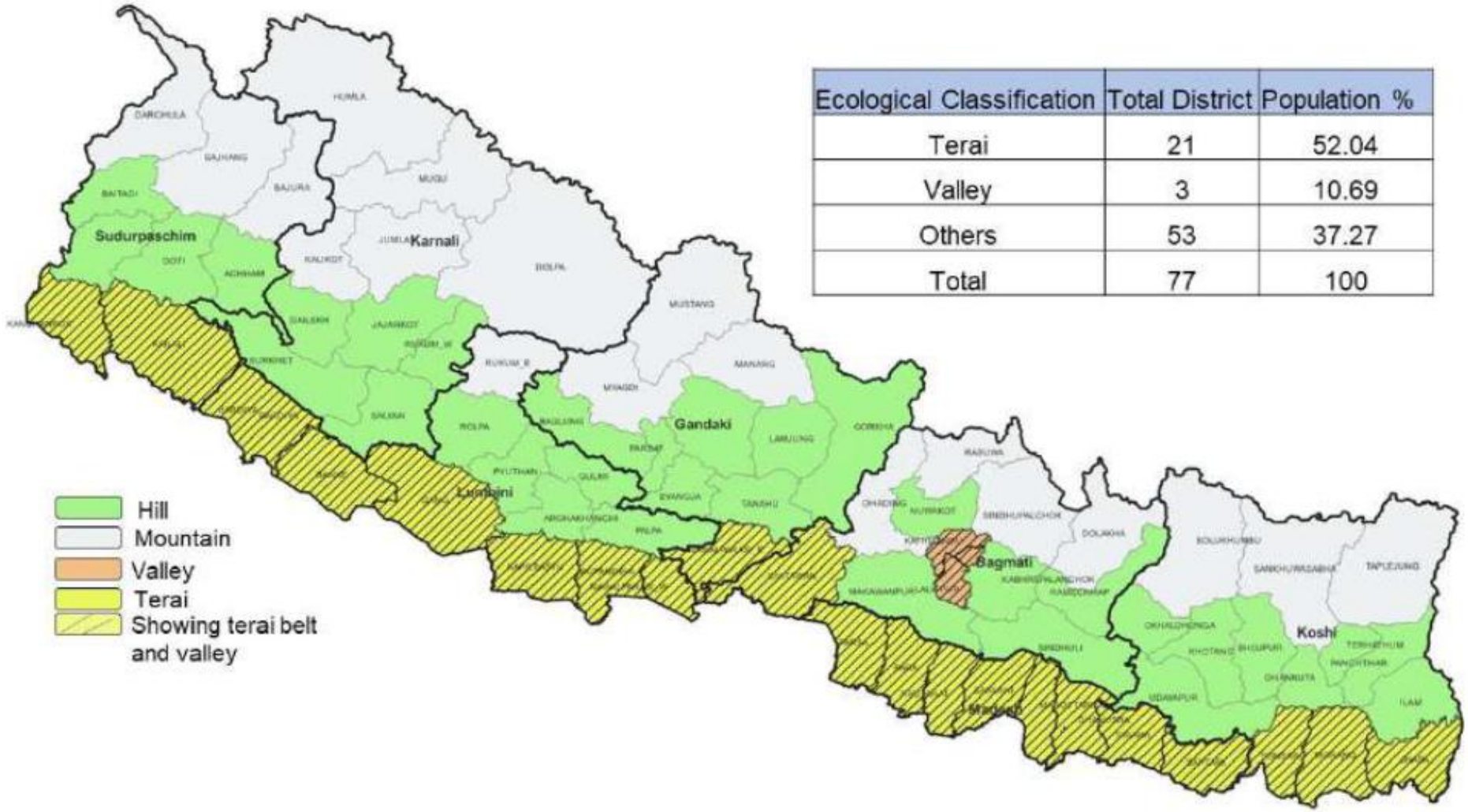


Ecological Classification	Total District	Population %
Terai	21	52.04
Valley	3	10.69
Others	53	37.27
Total	77	100

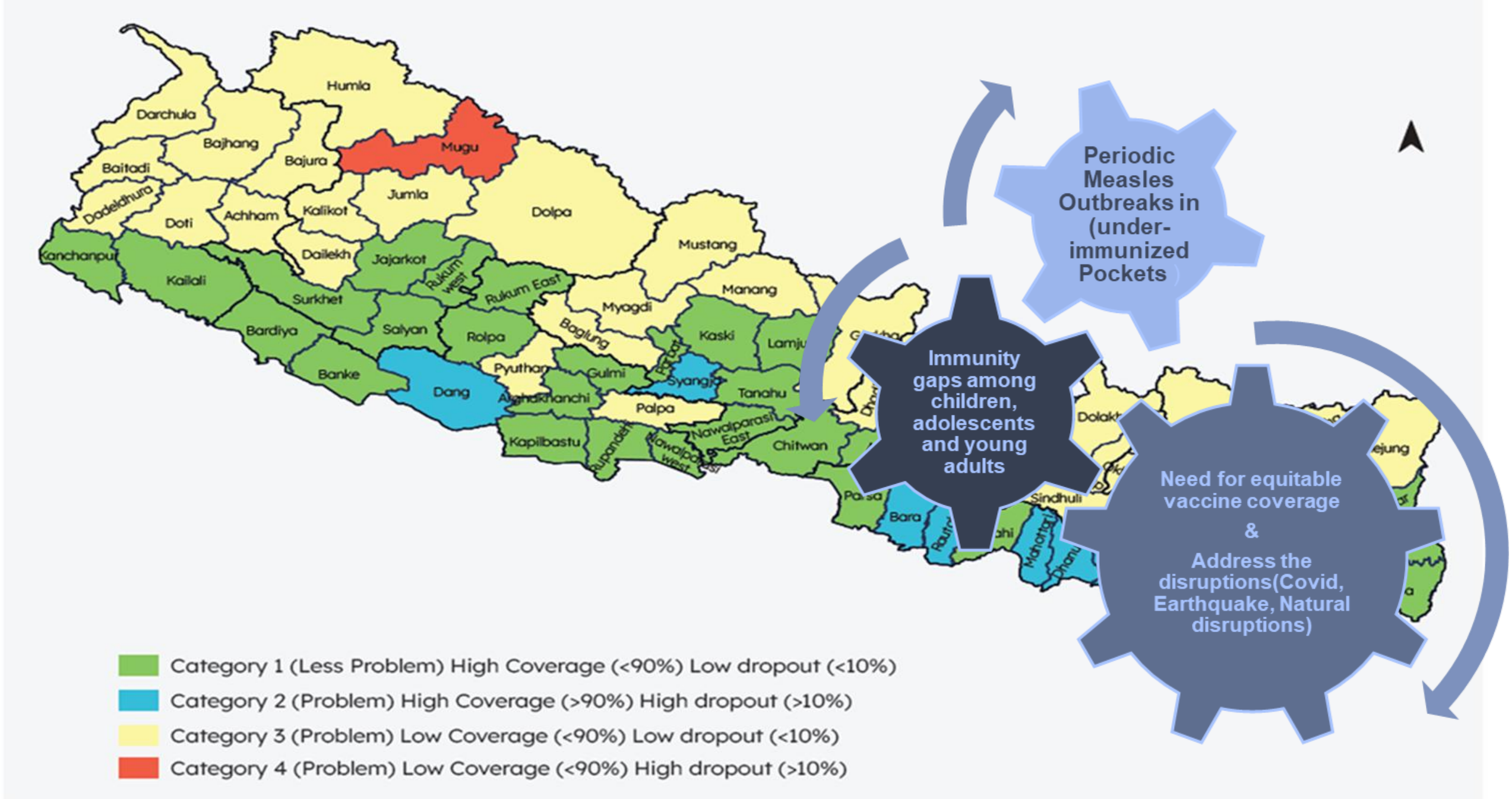


Figure 4.22 District categorization based on access and utilization in FY 2079/80

Closing immunity gap: Our Focus on Three Pillars

Routine Immunization

- Build and sustain Long Term Population Immunity
- MCV 1 and 2 more than 95% coverage
- 0 Zero dose children

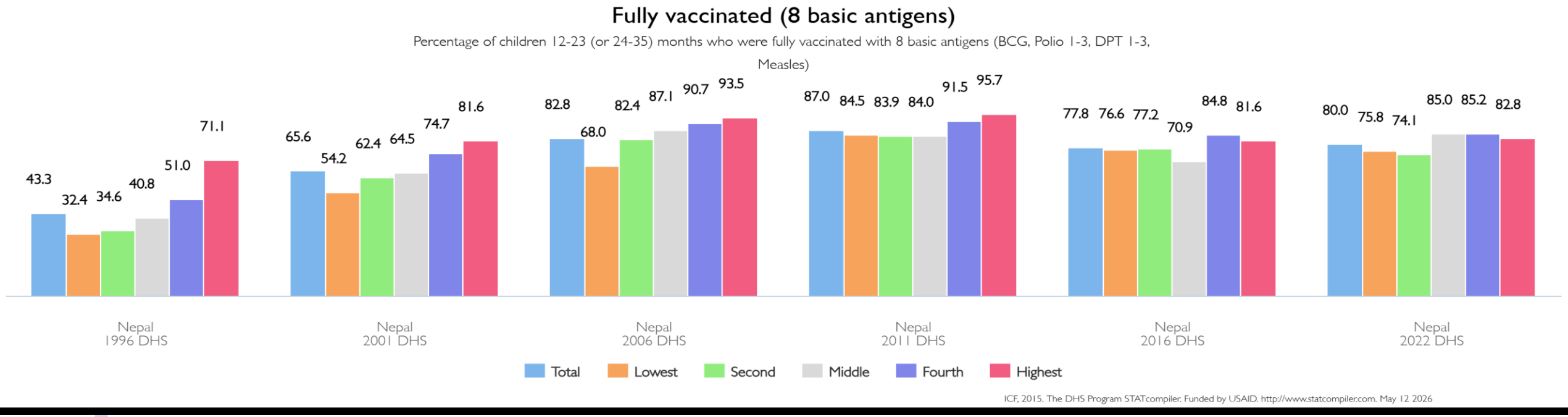
Supplementary immunization

- Close chronic immunity Gap
- Stop ongoing virus transmission
- Strengthen RI
- Periodic focus on high-risk areas and immunity gaps

Robust Surveillance and Outbreak Response

- Early Detection and response
- Laboratory based optimum surveillance and ORI

Evaluated coverage - fully vaccinated child with eight antigens



ICF, 2015. The DHS Program STATcompiler. Funded by USAID. http://www.statcompiler.com. May 12 2026

Exposes chronic immunity gaps across antigens

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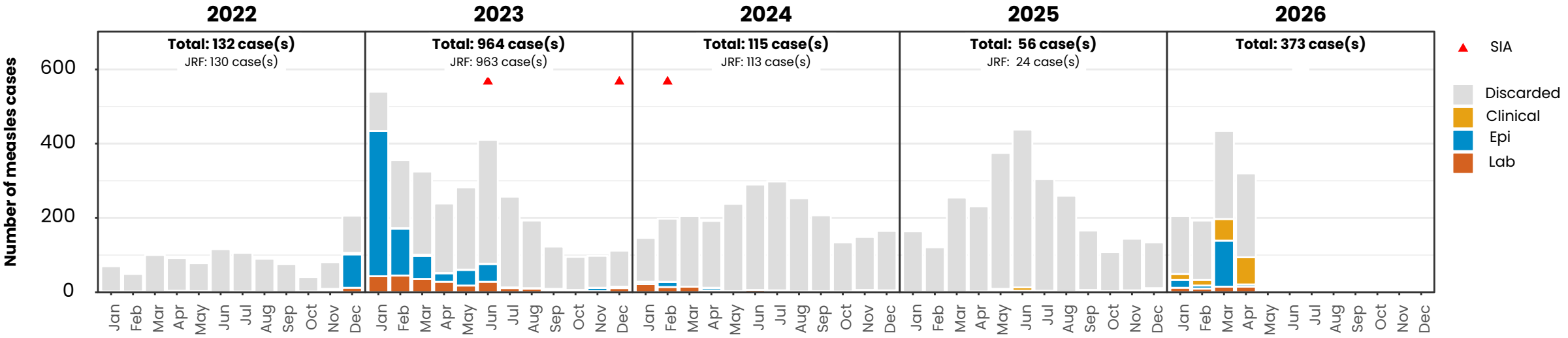
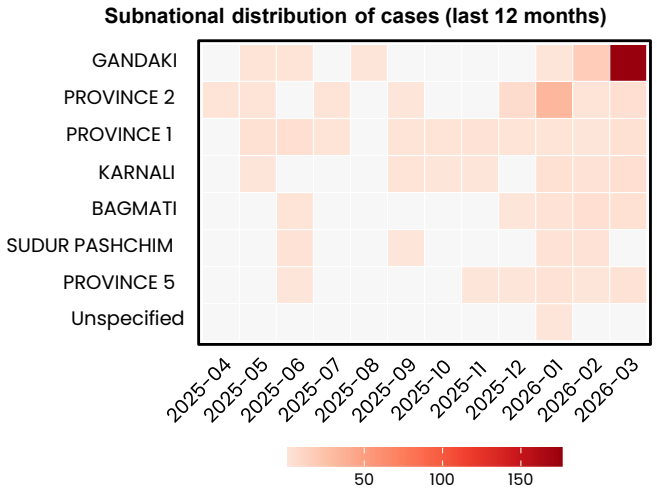
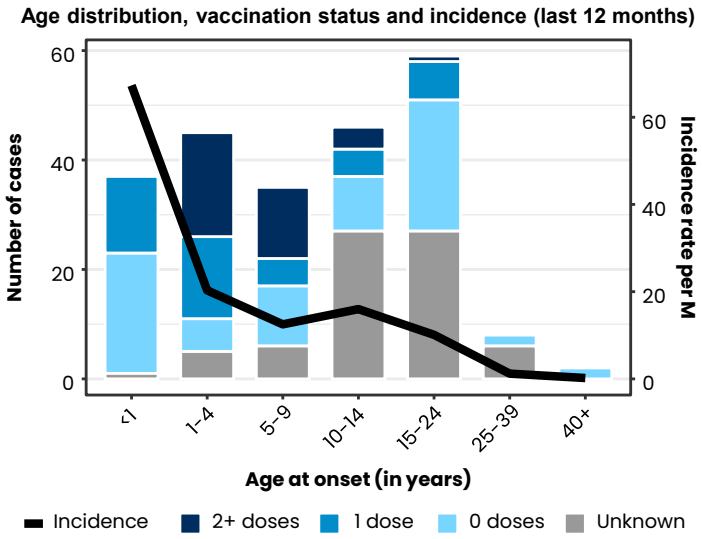
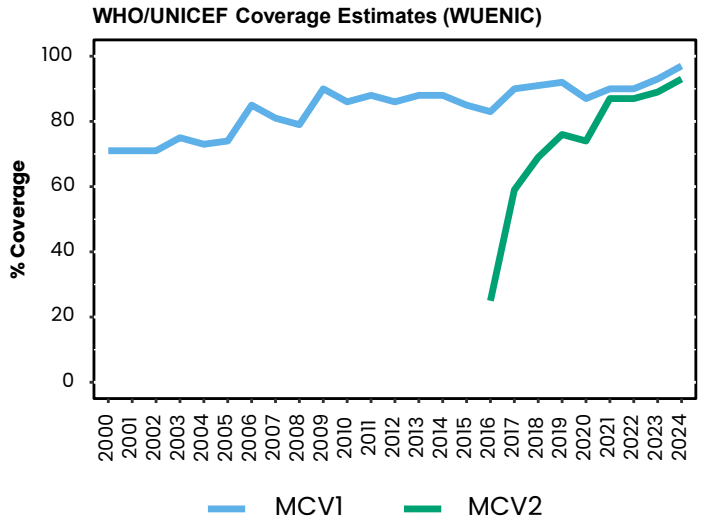
Measles cases: Nepal

ELIMINATION STATUS: **ENDEMIC**





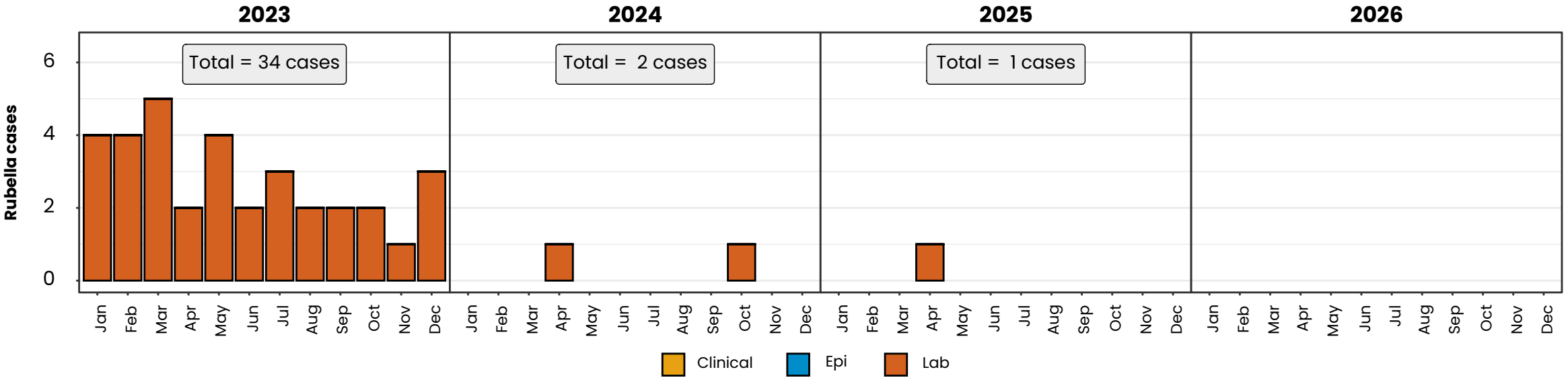


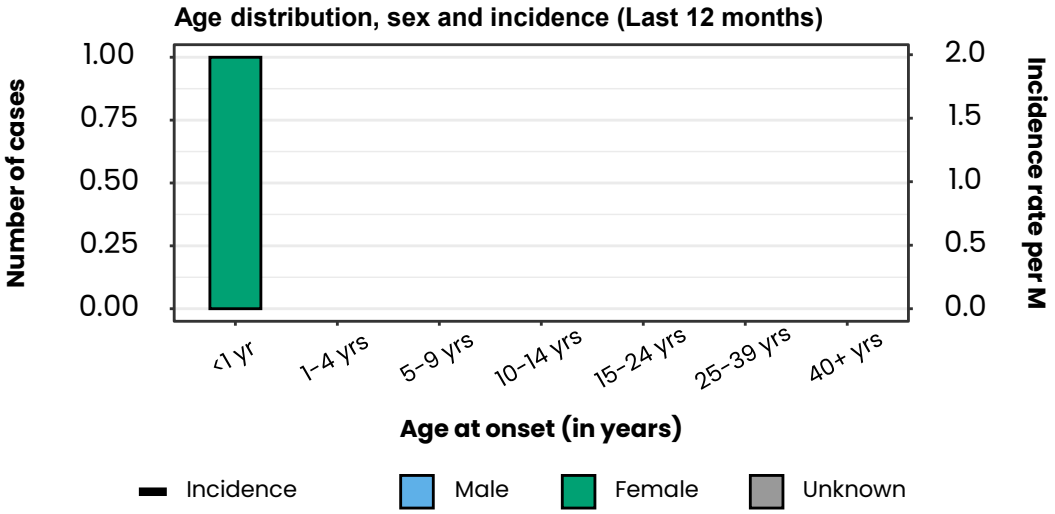


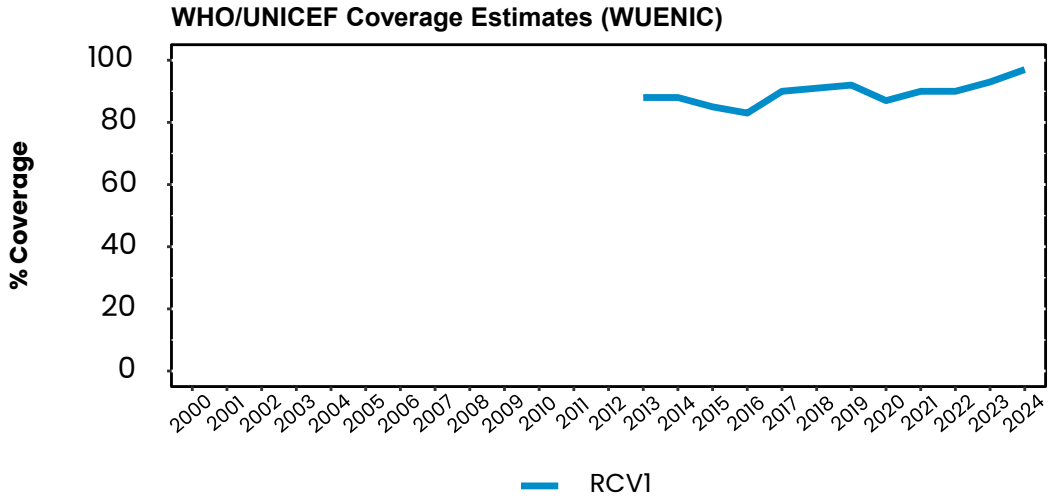
Based on data received 2026-05 - Data Source: IVB Database. Main epi curve was built using case-based surveillance data. Age distribution curve was built using case-based surveillance data. Coverage data from WHO/UNICEF Estimates of National Immunization Coverage (WUENIC)

Rubella cases: Nepal

ELIMINATION STATUS: **VERIFIED**







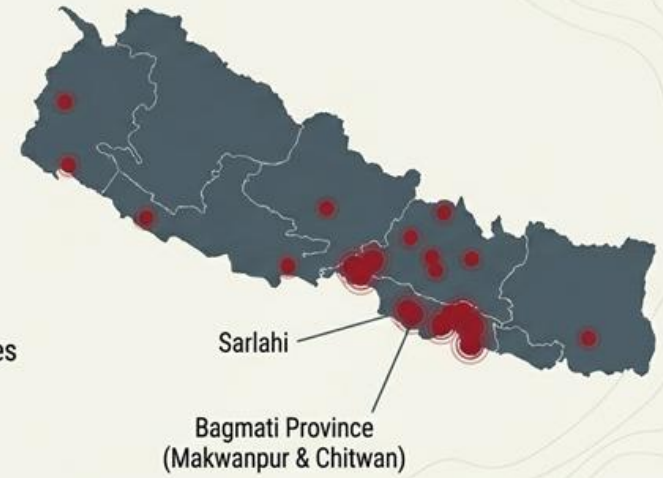
NIP Coverage and challenges

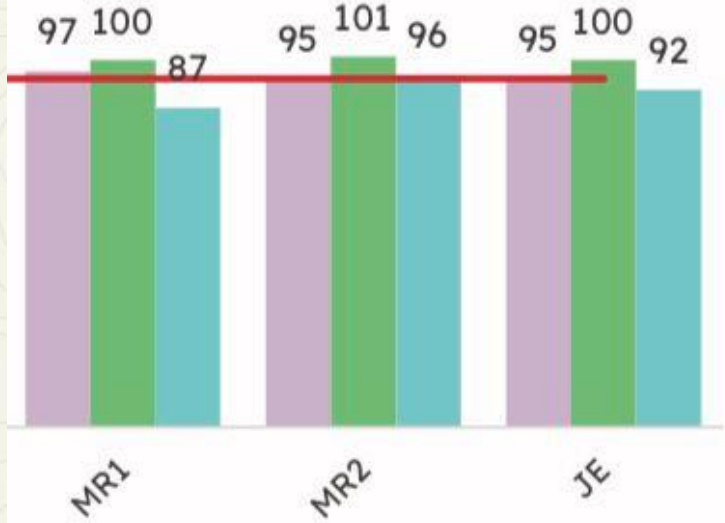
The Virus Exploits Localized Immunity Gaps Despite High National Coverage

The Current Reality:
Over 20 measles outbreaks have been recorded in the past 5 years.

The Paradox:
National aggregate coverage looks excellent (MR1 at 97%, MR2 at 95%), but this aggregate data masks severe local vulnerabilities.

The Mechanism:
Outbreaks are clustering in tight-knit communities where localized immunity drops below the 95% threshold. The virus zeroes in on the final 5% of unvaccinated individuals.

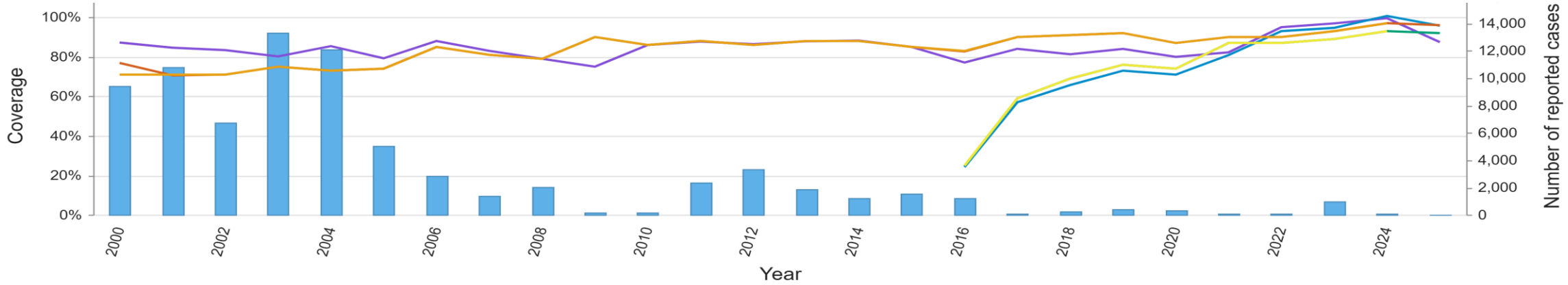




Source: HMIS/DoHS

Figure 4.1 Coverage of Td, BCG, and DPT-HepB-Hib, MR and JE (FY 2079/80 - 2081/82)

Measles coverage and number of reported cases, 2000-2024, Nepal



Source: WHO Immunization Data portal

World Health Organization, WHO, 2026, All rights reserved

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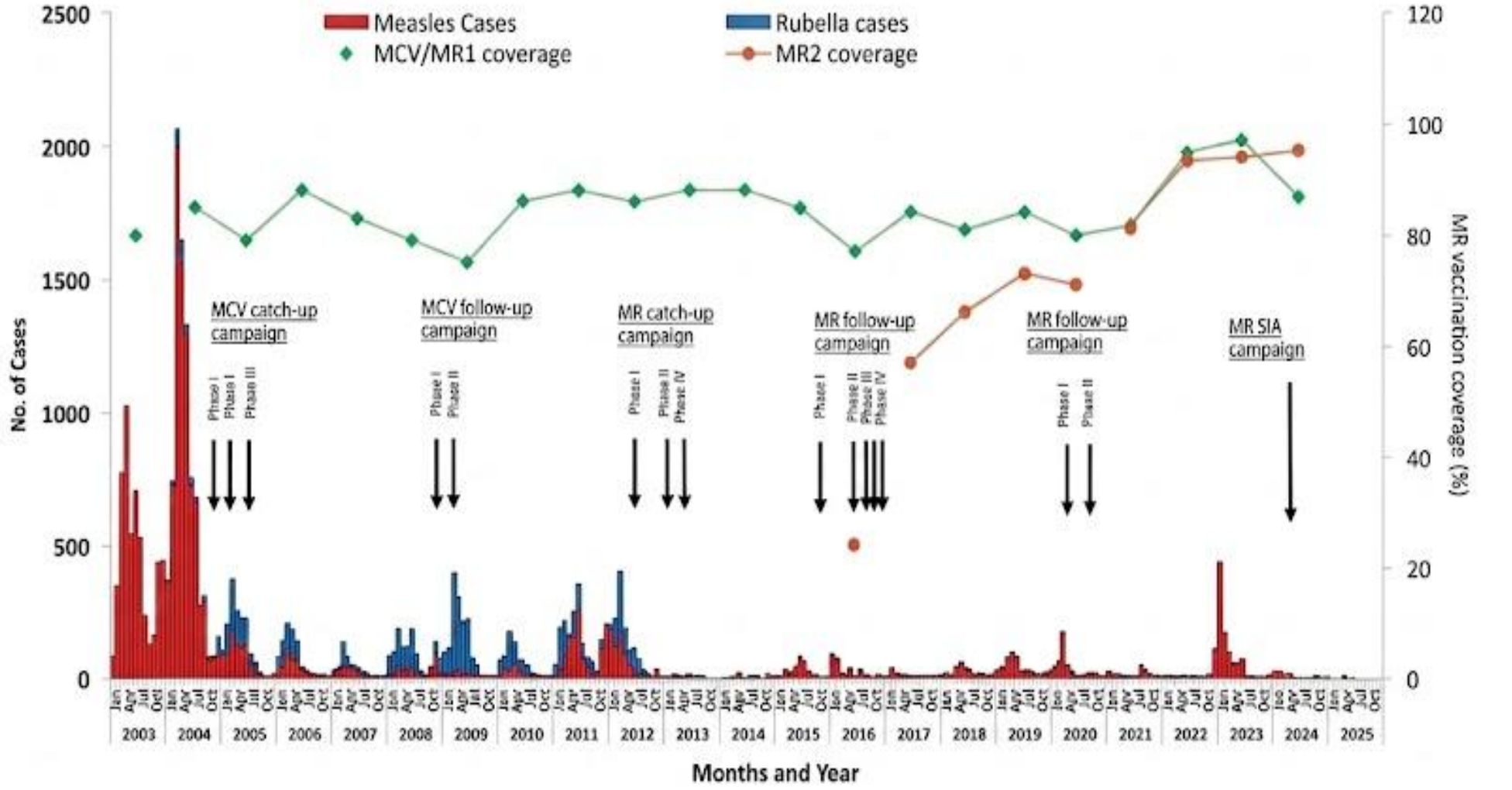

Source: FWD and WHO-IPD, Nepal

Figure 4.8 Confirmed Measles Rubella cases and Measles Containing Vaccine (MCV)/MR1/MR2 coverage, Nepal, 2003-2025

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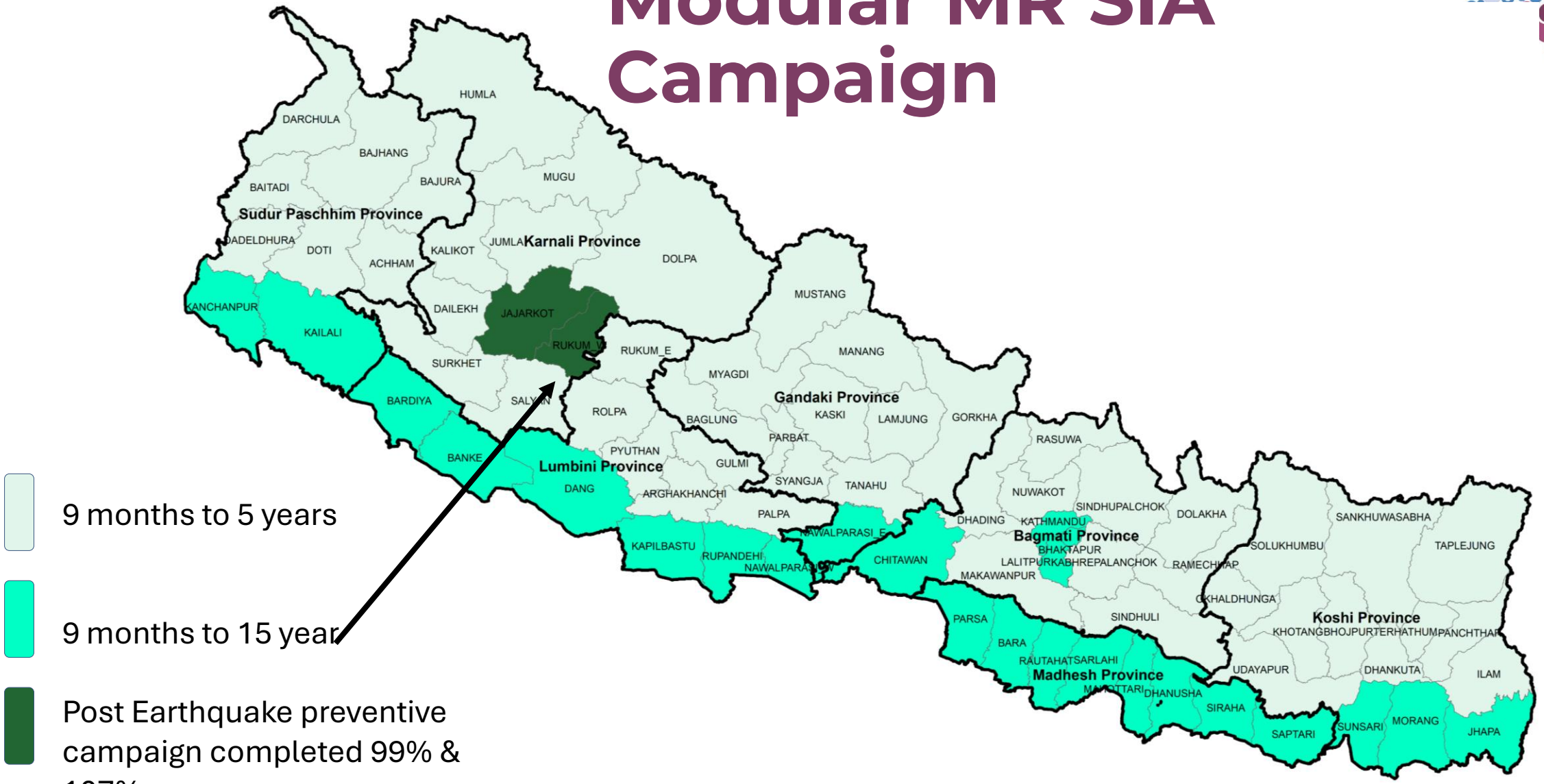
Modular MR SIA Campaign

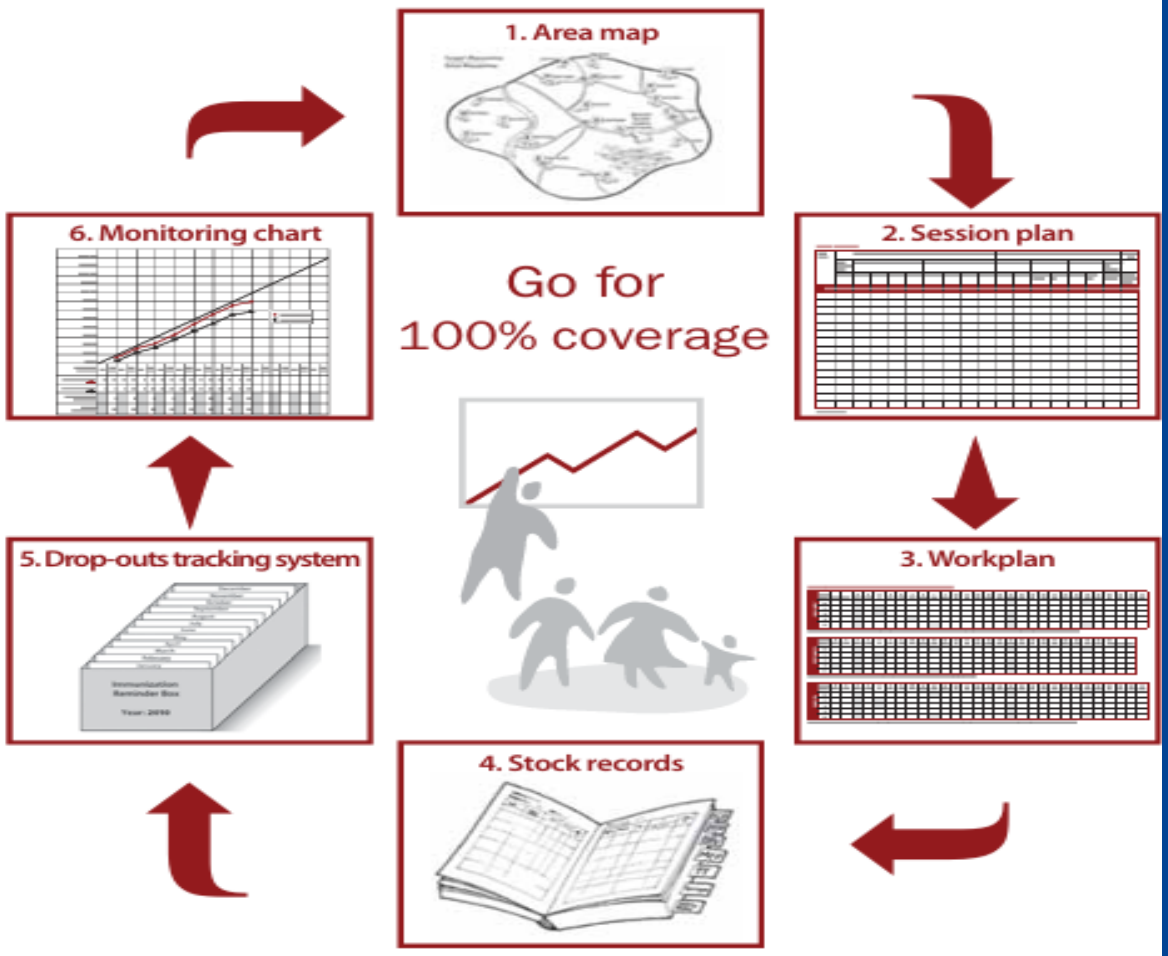


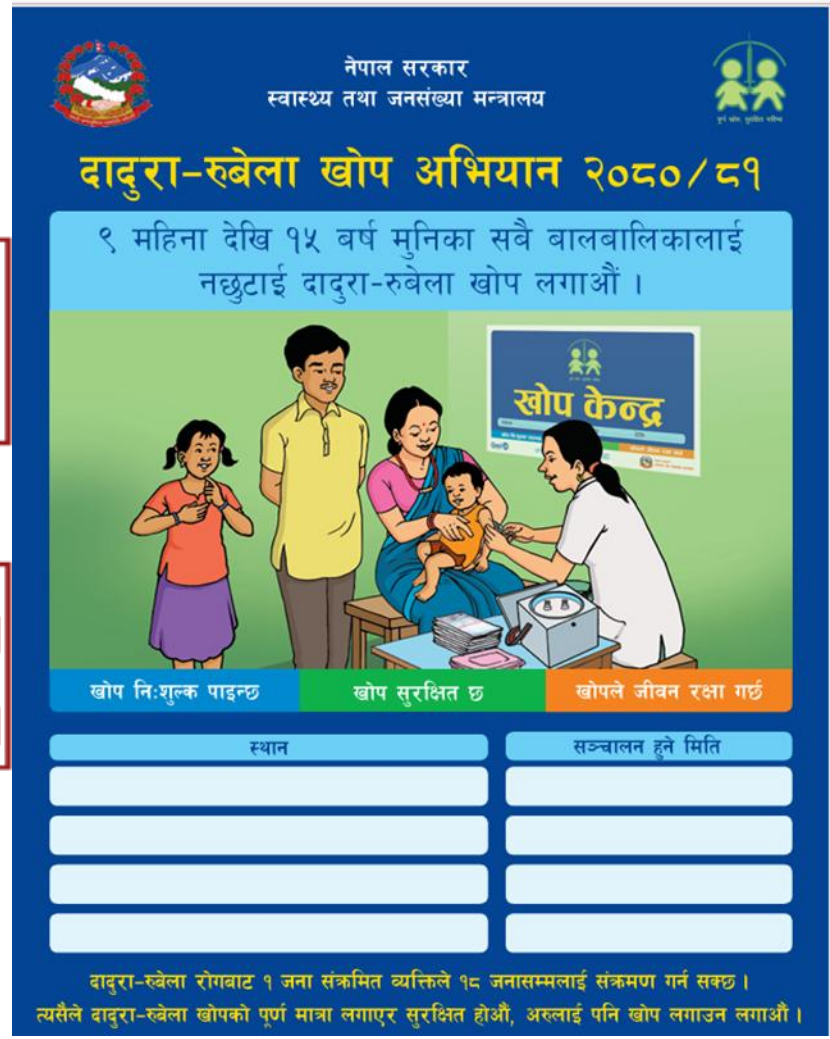
9 months to 5 years

9 months to 15 year

Post Earthquake preventive campaign completed 99% & 107%

Reaching (~~Every District~~) Everyone





Federal **Steering**
and Task Force

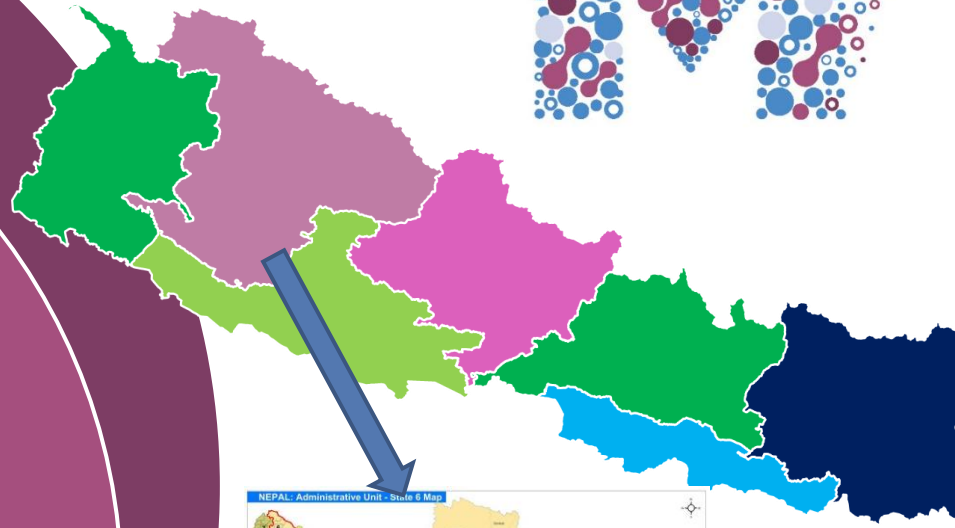
Province
Coordination

District
coordination

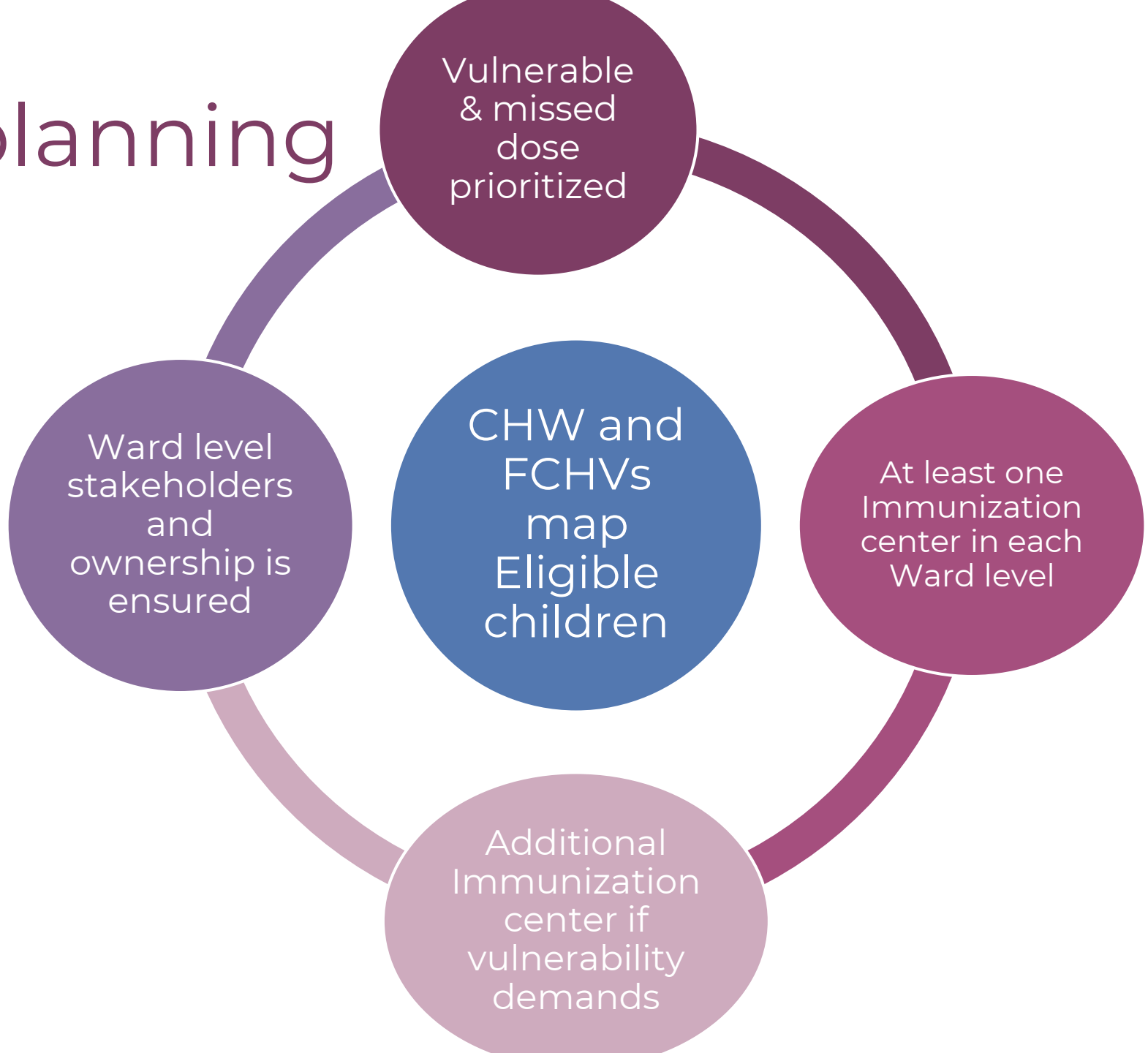
Municipal
Coordination

WARD Coordination and
Action

FCHV
Microplanning
Schools
Settlements



Micro-planning



Precise Microplanning?

Traditional Approach	Precision Microplanning Approach
Top-down estimates	Bottom-up settlement mapping
Static plans	Dynamic risk-informed planning
District averages	Ward and settlement targeting
General implementation	Tailored local strategies
Coverage-focused	Equity and immunity-gap focused

2024 MR SIA Ca

Province	Target Population		lunteers
	9 months – 5 years	5-15 years	
Koshi	334,519	559,224	13918
Madhesh	560,022	1,387,120	20144
Bagmati	348,067	541,110	13390
Gandaki	147,553	66,809	6548
Lumbini	284,196	776,677	14324
Karnali	147,444	NA	5032
Sudurpaschim	208,882	281,370	7884
Total	**21,30,683**	**36,12,310**	81240

Measles Rubella Vaccination Campaign 2024

Campaign Date	Total Target Population	Total children vaccinated	Coverage
13 Fagun-7 Chaitra 2080 (25 FEB – 20 MAR 2024)	5,536,181	6,198,568	112%

From February 25th, a nationwide measles-rubella vaccination campaign was conducted. In this campaign, children aged 9 months to under 15 years in 21 districts of the Terai region and 3 districts in the Kathmandu Valley, which were at high risk for measles, were vaccinated. In the remaining districts, the campaign targeted children aged 9 months to under 5 years.

	Target Population (9m to < 5 years)	Target Population (5 to <15 years)	Target Population	Number of children immunized by MR(9m to < 5 years)	Number of children immunized by MR (5 to <15 years)	RCM	Total children Vaccinated	Coverage (%)
National Total	1969947	3678680	5648627	2120363	4169732	27304	6317399	112
National (excl. earthquake preventive vaccination)	1938537	3597644	5536,181	2085111	4086486	26971	6198568	112

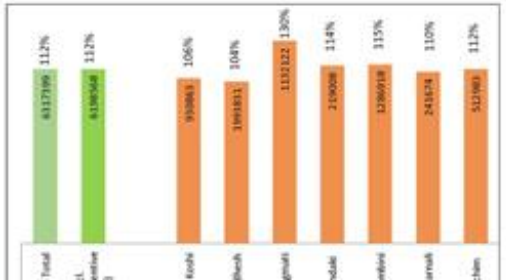
Total Vaccine Consumption
63,55,340 doses

≥95% coverage district : 63 80-94% coverage district : 12

50-79 % coverage district : 2

Photo: Radha Poudel, MR vaccination campaign health worker, Parbat.

Vaccination Progress Percentage



Inquiries at call center number 1115 :

SIA IEC Materials in Local Language

- Program Guidelines
- Invitation card
- Vaccination Card
- Poster
- FAQ

Measles Rubella Vaccination Campaign 2024

Campaign Date	Total Target Population	Total children vaccinated	Coverage
13 Fagun-7 Chaitra 2080 (25 FEB – 20 MAR 2024)	5,536,181	6,198,568	112%

Moving ahead .....

- Well-planned, data-driven SIAs (national > subnational> targeted) remain a powerful tool for measles elimination
- Future preventive SIAs will be more effective with better prediction & better modelling (for age range, geographical scope and strategies)
- Modelling should alert and trigger program before the outbreak! As well as provide simulation on various scenarios to close immunity gaps (RI strengthen vs SIA vs combined etc)
- Risk mapping should answer where? Whom? How? and when?
- SIA integrated with local PH campaigns or events without losing the quality saves cost

Thank you and Namaskar

MEASLES
ANALYTICS HUB

Abhiyan Gautam

Ministry of Health, Nepal

MEASLES
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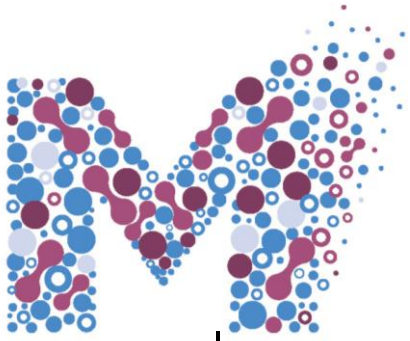
Recent Measles Outbreaks and Programmatic Adaptations in Nepal: Implications for MR Elimination Modelling

Dr Abhiyan Gautam
Chief, National Immunization Program NEPAL

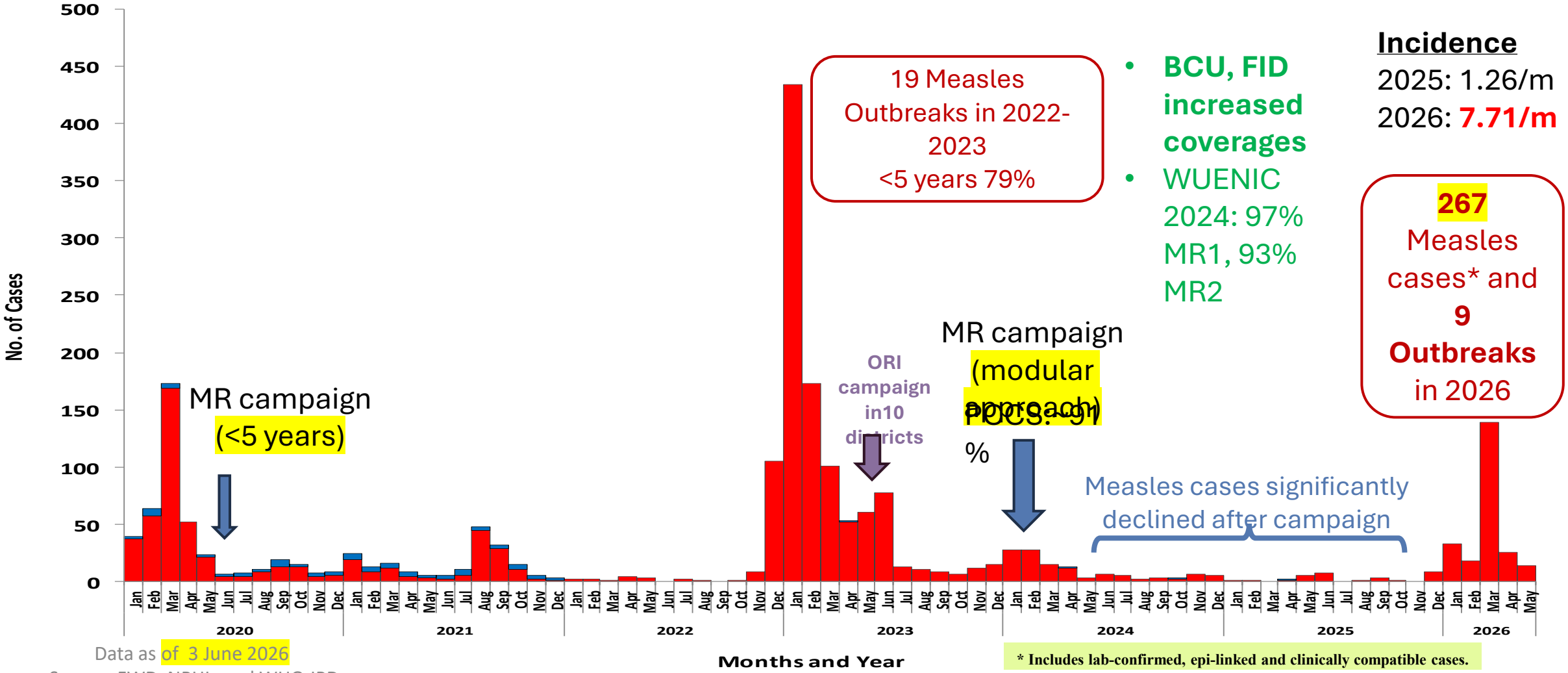
MEASLES ANALYTICS HUB

Measles Epidemiology in Nepal



- Major resurgence in 2023 (964 confirmed cases; **<5 years 79%**) due to large measles outbreaks, possibly due to **immunity gap in under 5 during the pandemic**.
- Strengthened surveillance and routine immunization (**WUENIC 2024: 97% MR1, 93% MR2**)
- **MR campaign conducted in 2024 with modular approach** (<15 years in 24 high-risk district and 2 earthquake district, <5 years in remaining 51 districts; survey coverage: 90.4%)
- **Significant decline in measles** after MR campaign and increasing RI coverage in 2024–2025 (no outbreaks post campaign). **Nepal achieved rubella elimination in 2025.**
  - 267 confirmed cases and 9 outbreaks reported in 2026 (as of 3 June). Measles incidence increased from near elimination phase of **1.26/million (in 2025) to 7.71/million** (in 2026)
- Nepal targets measles elimination by 2026 under the MR Elimination Roadmap 2023–2026.
  - Recent outbreaks provide important evidence for refining elimination strategies and modelling assumptions, especially the need to address immunity gaps not only in under 5 but also the need to intensify immunity gap closure in older age groups.

Trend of Confirmed Measles Cases in Nepal 2020-2026



- **BCU, FID increased coverages**
- WUENIC 2024: 97% MR1, 93% MR2

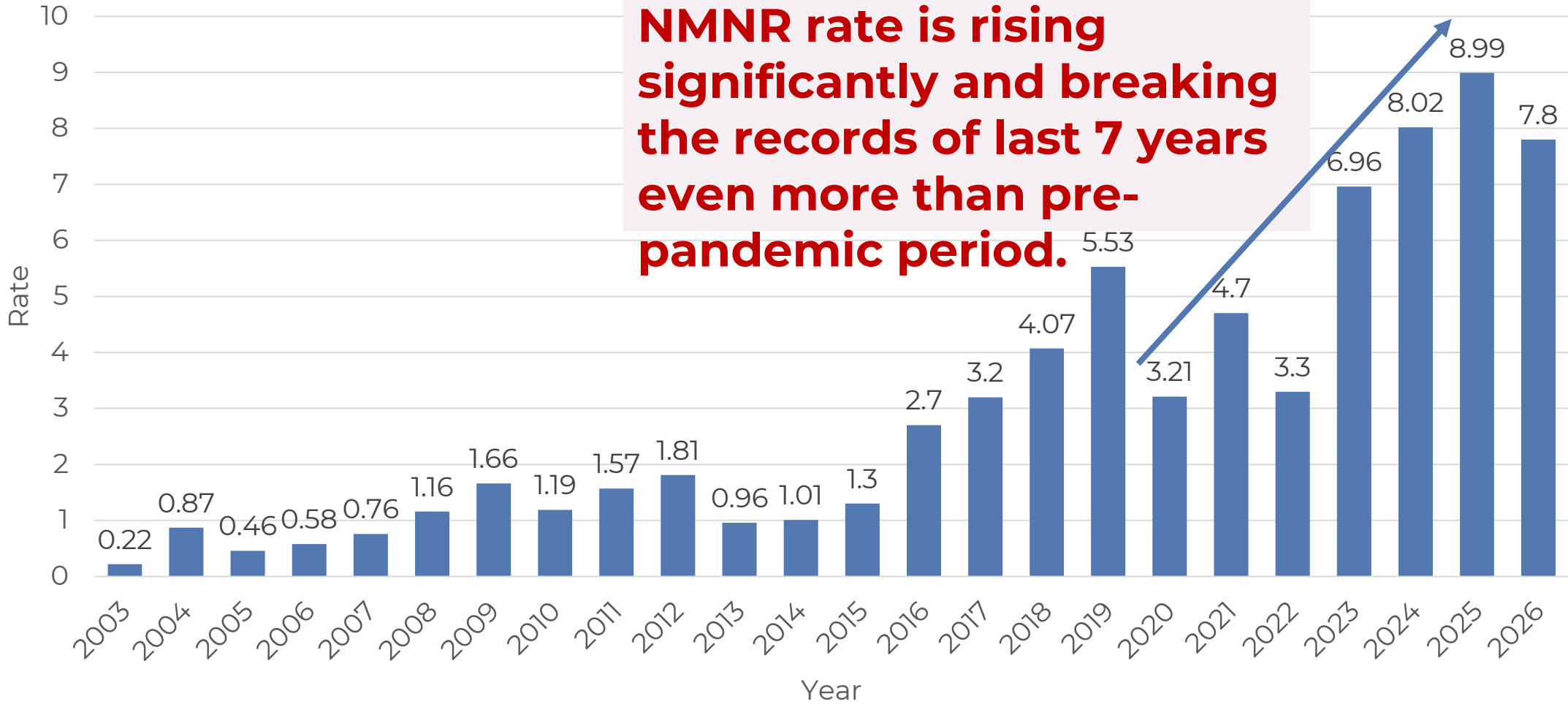
Incidence
2025: 1.26/m
2026: **7.71/m**

267 Measles cases* and **9 Outbreaks** in 2026

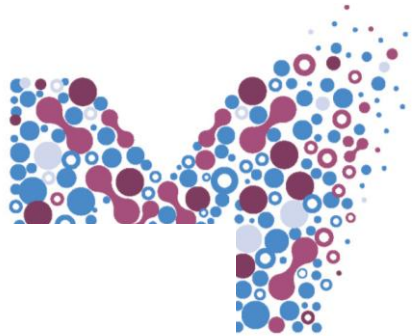
Data as of 3 June 2026
Source: FWD, NPHL and WHO-IPD

* Includes lab-confirmed, epi-linked and clinically compatible cases.

Non-Measles Non-Rubella rate per 100,000 population, Nepal, 2003-2026



Measles Outbreak 2026: 9 Outbreaks



Lab confirmed Measles Outbreak
District: Kalikot
Municipality: Khandchakra, wand no. 11
Total cases: 8

Lab confirmed Measles cases
District: Jajarkot
Municipality: Bheri UM ward-11
Total cases: 15

Lab confirmed Measles Outbreak
District: Baglung
Municipality: Dhorpatan, Badigad, Nisikhola, Tamankhola
Total cases: 180

Lab confirmed Measles cases
District: Mahottari
Municipality: Balawa, ward no. 8,9,11
Total cases: 8

Cluster of suspected Measles cases (Discarded)
District: Morang
Municipality: Biratnagar, ward no. 2
Total cases: 11

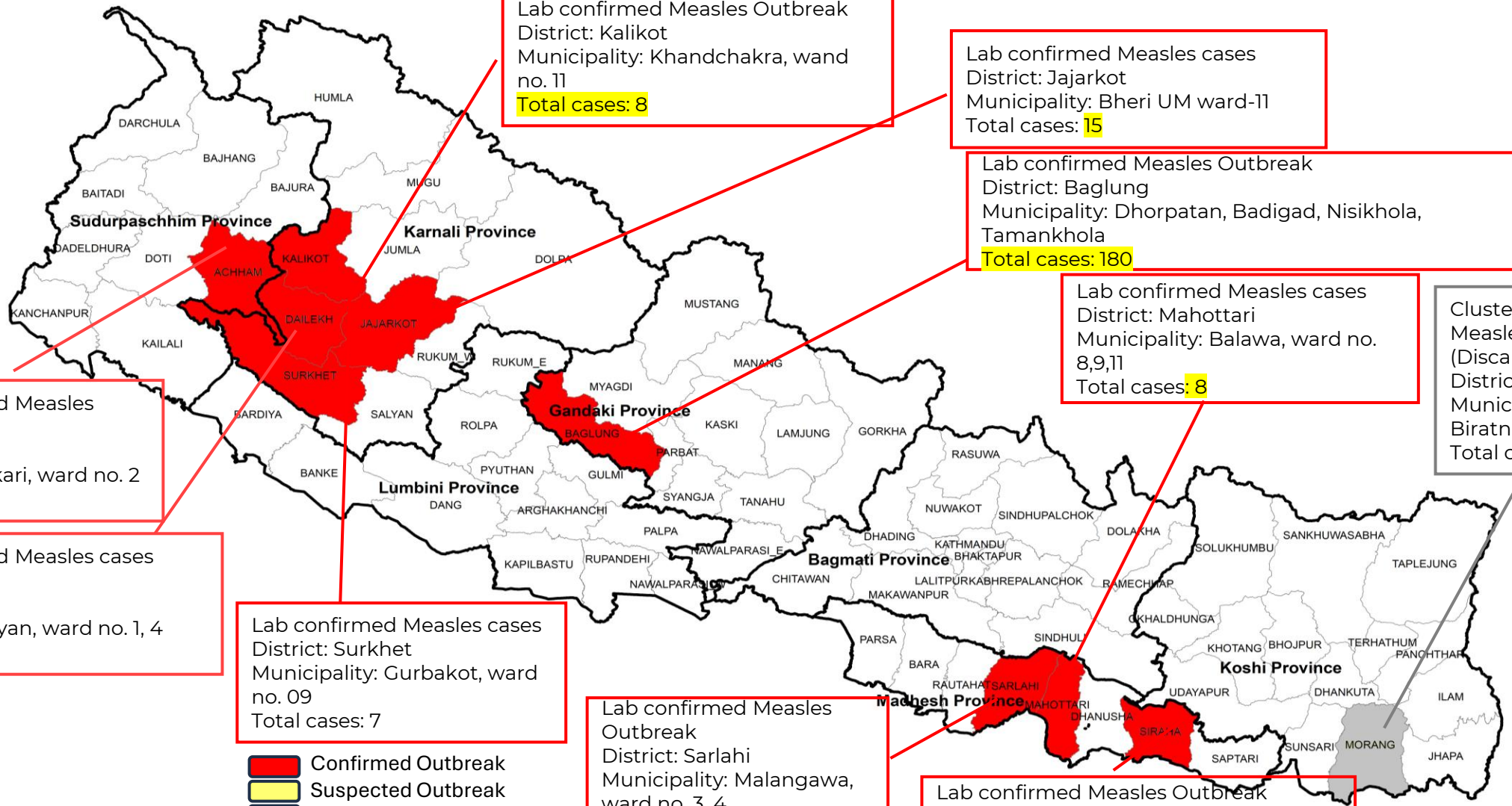
Two Lab confirmed Measles cases
District: Achham
Municipality: Dhakari, ward no. 2
Total cases: 2

Two Lab confirmed Measles cases (Over)
District: Dailekh
Municipality: Narayan, ward no. 1, 4
Total cases: 2

Lab confirmed Measles cases
District: Surkhet
Municipality: Gurbakot, ward no. 09
Total cases: 7

Lab confirmed Measles Outbreak
District: Sarlahi
Municipality: Malangawa, ward no. 3, 4
Total cases: 34

Lab confirmed Measles Outbreak
District: Siraha
Municipality: Baryarpatti RM ward no. 1
Total cases: 7



Confirmed Outbreak
Suspected Outbreak
Discarded Outbreak

Data as of 03 June 2026
Source: FWD/WHO-IPD VPD surveillance data
Note: final case numbers may vary due to pending lab results

Key highlights – Measles outbreak 2026

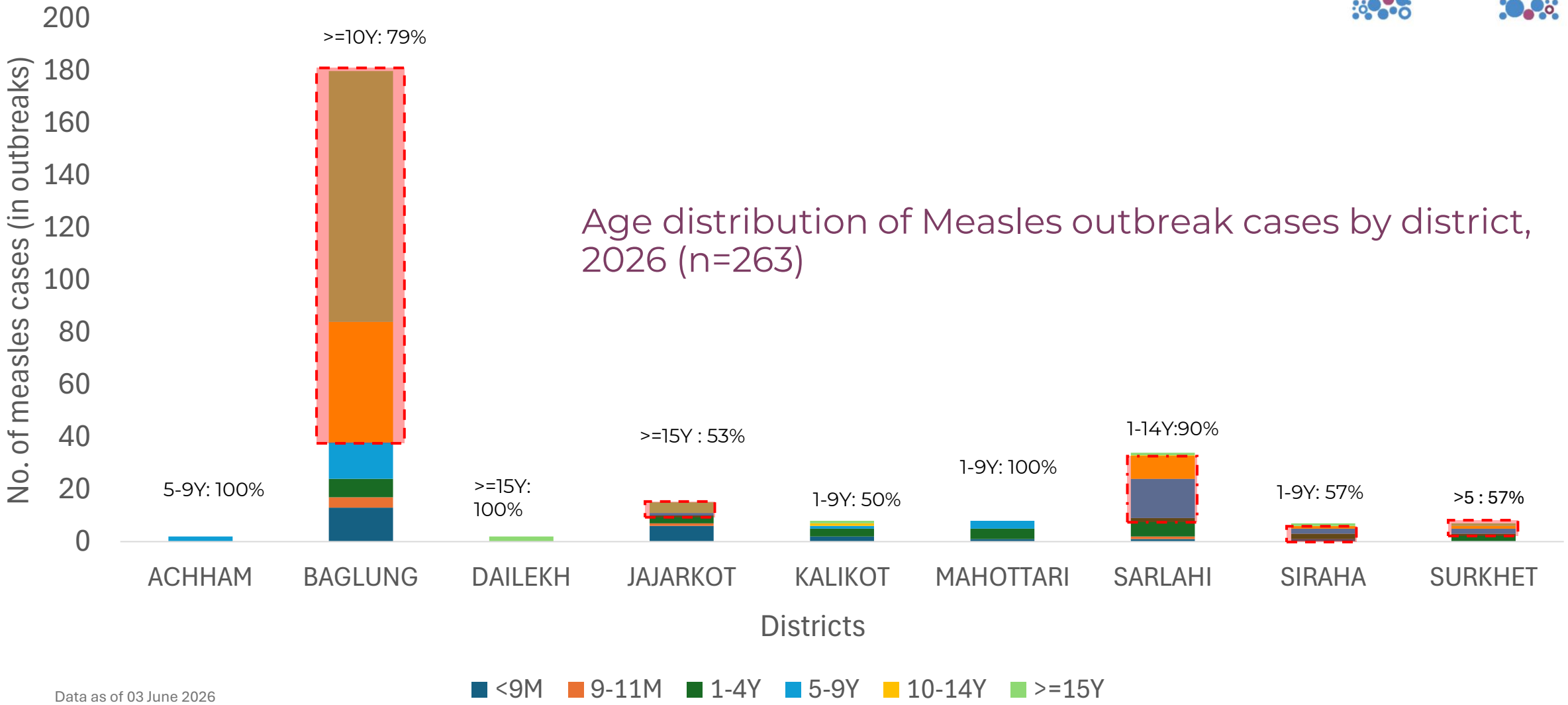
Total suspected Measles Outbreak : 10 | **Lab confirmed Measles Outbreak : 9** | **Discarded : 1**

Province: 4 | **Districts: 9** | **Municipalities: 12**

Districts	No. of confirmed cases (lab+epi)	Most affected age group	Occurred Month	ORI	Current Status
Sarlahi	34	**<15 years**	January	Yes (6m-14yr)	**OBR over: ORI completed**
Baglung	180	**10-20 years**	February	Yes (10-19Yrs)	Last case DoR - 16 May; **ORI in highly affected ward**
Kalikot	8	**<5 years**	March	Yes (6m-14yr)	Last case DoR 29 Apr; **ORI Completed**
Dailekh	2	**15 & 17 years**	March	No	Over
Mahottari	8	**<10 years**	April	Yes (6m-14yr)	Ongoing (Last case DoR 04 May): **ORI ongoing**
Achham	2	**5 & 6 years**	April	No	Over
Siraha	7	**5 years**	May	Yes (6m-14yr)	Ongoing (Last case DoR 22 May): **ORI Ongoing**
Jajarkot	15	**15-22 Years**	May	Yes (6m-24yr)	**New Outbreak –ongoing: ORI Completed**

Data as of 03 June 2026

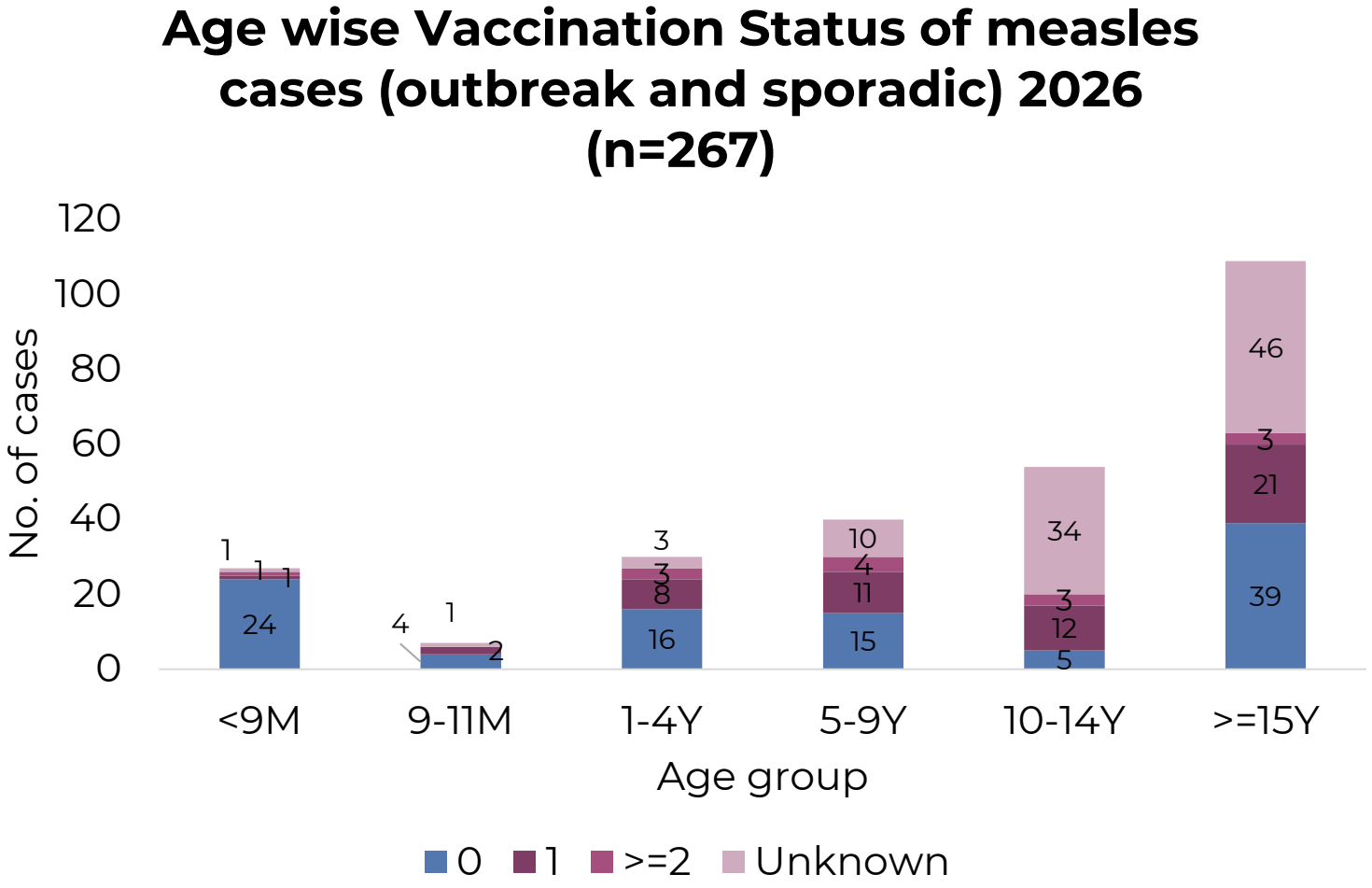
Age shifted from younger to older age groups in 2026

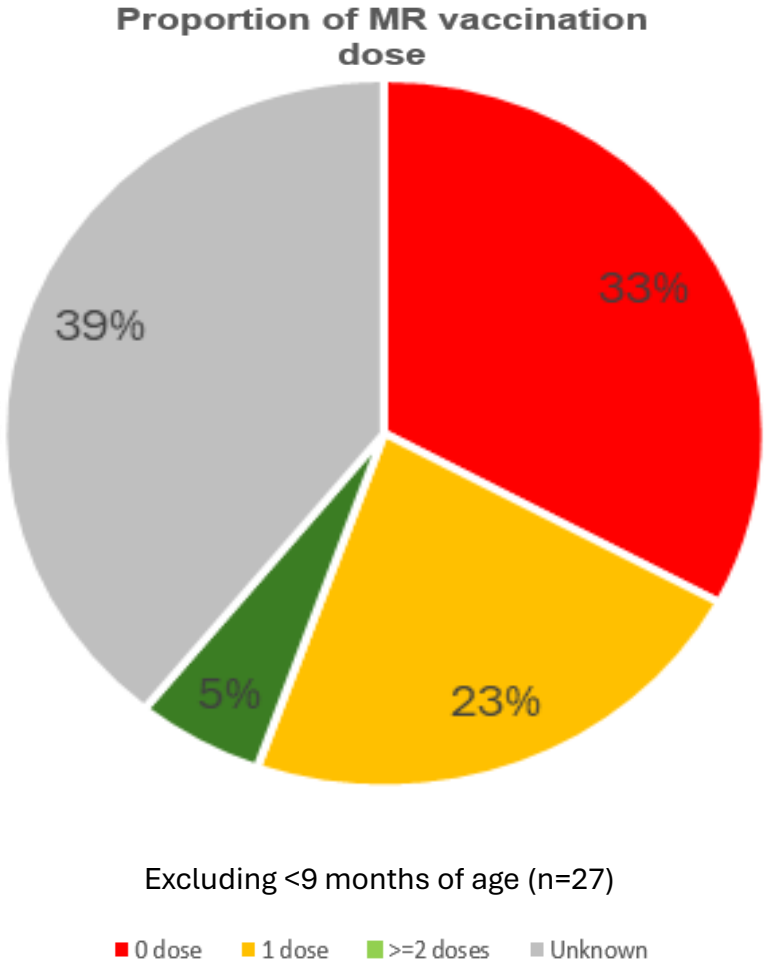


Age distribution of Measles outbreak cases by district, 2026 (n=263)

Data as of 03 June 2026

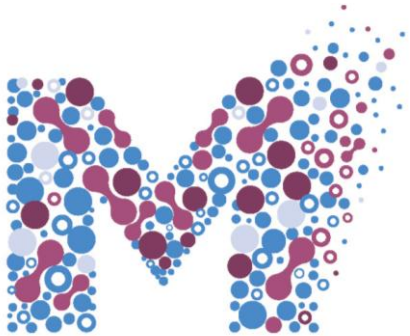
Age shifted from younger to older age groups in 2026





Data as of 03 June 2026

What Do These Outbreaks Reveal?

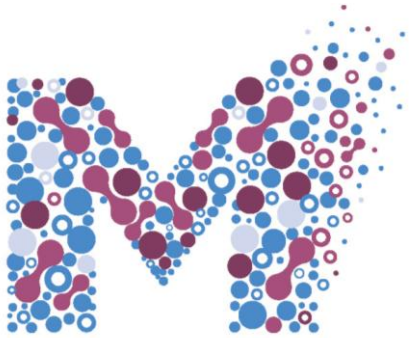


- **Traditional assumption (before reaching near elimination phase)**
  - Measles susceptibility mainly among young children under 5 years.
- **Evidence from current outbreaks**
  - Transmission among **adolescents and young adults** due to immunity gaps (due to past RI coverage).
  - **Wide age distribution of cases**.
  - **Immunity gaps in underserved/marginalized populations.**
  - High national coverage may conceal susceptible pockets.
  - **Cases also seen in < 9 months age (not covered by RI)**
- **Emerging concern**
  - **Age-shift in measles epidemiology causing outbreaks setting back measles elimination progress**

NITAG Recommendations and Programmatic Adaptations

- **NITAG/NIAC Recommendation**
  - **Extend vaccination strategies to older age cohorts**
  - Address immunity gaps identified through outbreaks
  - **Recommended vaccination to missed population of under 15 years through RI**
- **Adaptations**
  - Enhanced active house-to-house case search; prioritization of high-risk municipalities
  - Rapid outbreak investigations and vitamin A supplementation
  - Targeted ORI implementation & expanded vaccination age groups
- **Programmatic Shift**
  - **Focus more on local community (ward) for ORI; faster the response faster the results and containment of outbreak**
  - Child-focused protection → **Population immunity approach**

Implications for MR Elimination Modelling



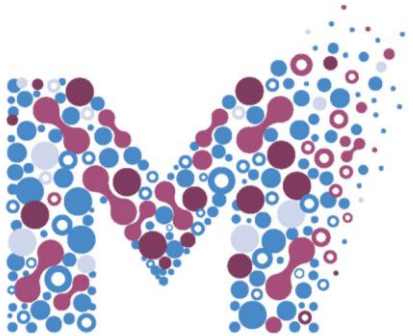
Current models often assume:

- Homogeneous immunity
- Predominantly child susceptibility with **focus on immunity gap closure mainly in children under 5 years of age**
  - Catch-up campaigns: < 15 years
  - Follow up campaigns: < 5 years
- Stable transmission patterns

Findings suggest models should incorporate:

- **Age-shifted susceptibility**, with focus on immunity gap closure in both children and adults (age cut off based on local epidemiology)
- **Subnational immunity gaps**.
- **Marginalized populations**.
- Outbreak response immunization effects.
- Enhanced surveillance sensitivity.
- **Population movement/migration** and importation risk.

Conclusions and Recommendations



- Nepal maintains sensitive MR surveillance, high RI coverages achieved recently, and rapid outbreak response capacity
- **Recent outbreaks highlight residual immunity gaps**
- MRP support was very helpful to conduct immediate ORI
- **Immediate ORI in affected and surrounding wards (small population) and targeted vaccination prioritizing susceptible age group remain critical tools**
- **With strengthened vaccination coverage in under 5, there could be age shift in measles due to immunity gaps in higher age groups, which should be addressed.**
- Elimination models should be dynamic and geographically stratified.

Thank you

Marisa Gaetz

Institute for Disease Modeling

MEASLES
ANALYTICS HUB

Understanding drivers of age shifts in Pakistan's measles cases – lessons learned from EMRO region

MAH Annual Meeting 2026

Category: Original Research

Marisa Gaetz

June 10, 2026

Gates Foundation

Pakistan's vaccination coverage has risen steadily over time. Classical one-dose models predict the mean age at infection should rise with coverage. Pakistan's data show the opposite trend.

Intuition from classical models

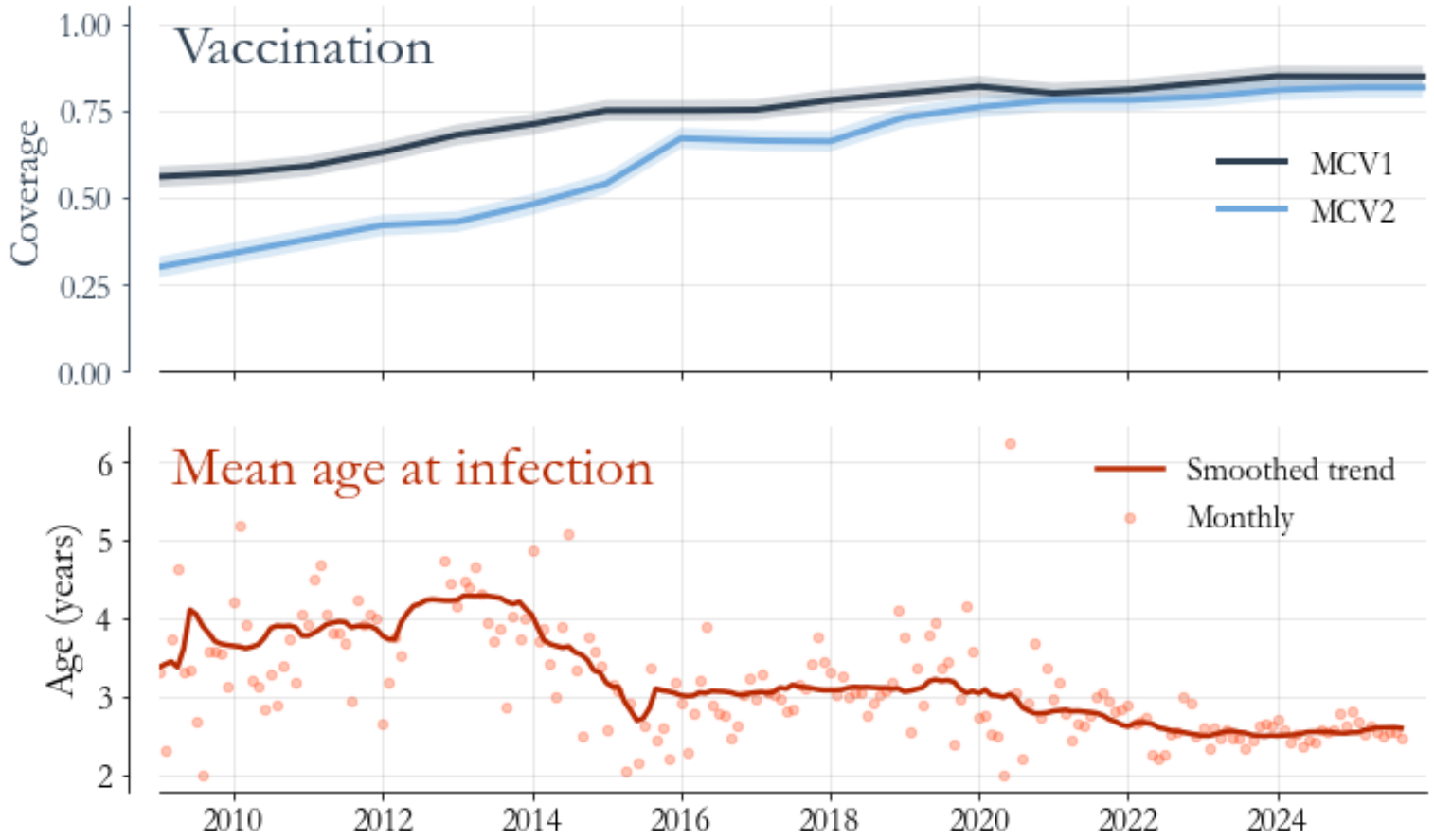
Anderson & May (1991) argued that mass immunization should raise the mean age at infection. They show that at endemic equilibrium, the force of infection λ is constant and the mean age at infection satisfies

$$A \approx 1/\lambda.$$

Vaccinating a fraction p of newborns lowers λ, giving

$$A \propto 1/(1-p).$$

Vaccination and age at infection data from Pakistan



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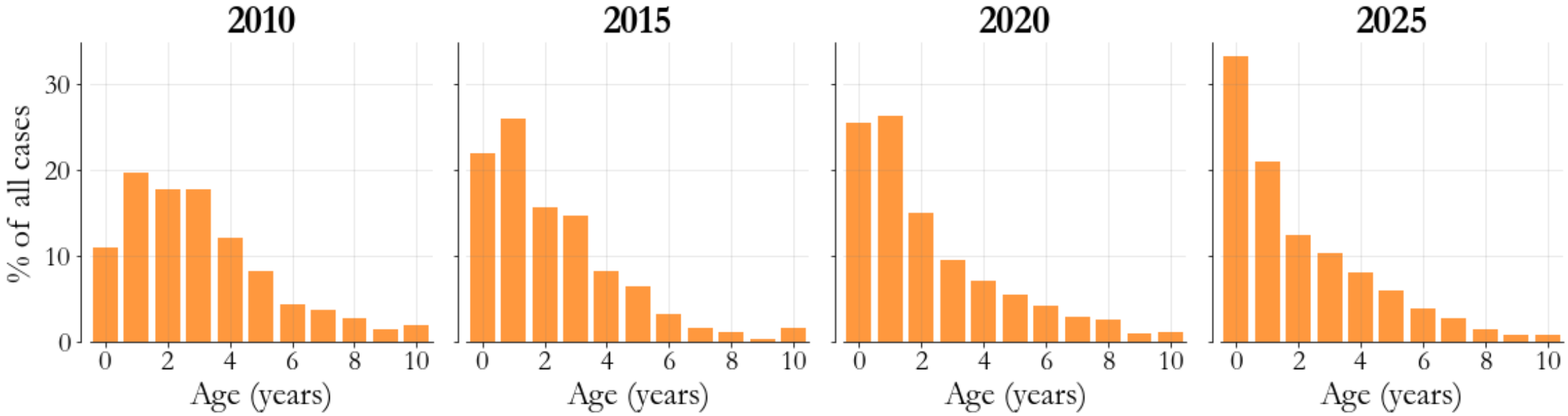
Why do the data depart from the classical prediction?



Of the hypotheses considered, two best explain the observed age at infection distributions:

1. **Multi-dose vaccine schedules:** As RI and SIA coverages increase, the remaining susceptible population is concentrated among children too young to be MCV1-eligible (9 months).
2. **Weakening maternal protection:** As more mothers have vaccine-derived rather than infection-derived immunity, maternal antibodies in infants are weaker and wane sooner.

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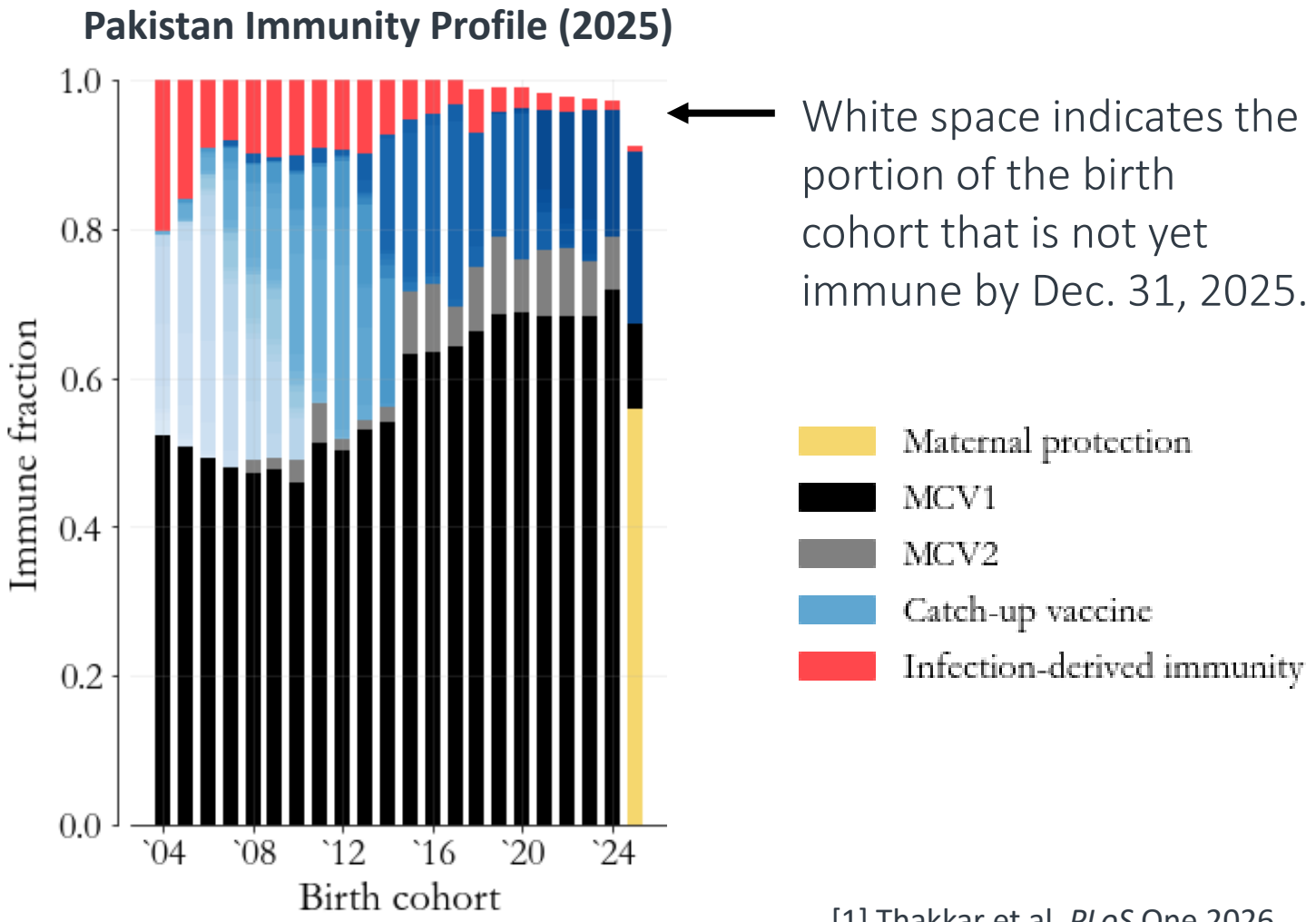
To understand susceptibility shifts, we can use immunity profiles[1] to estimate the portion of each birth cohort with immunity at a given time.

For each birth cohort, we estimate:

- MCV1 coverage
- MCV2 coverage
- SIA eligibility and coverage
- Maternal antibody protection
- Lifetime age at infection distribution

These potential immunity sources "compete" chronologically to confer immunity.



[1] Thakkar et al, *PLoS* One 2026.

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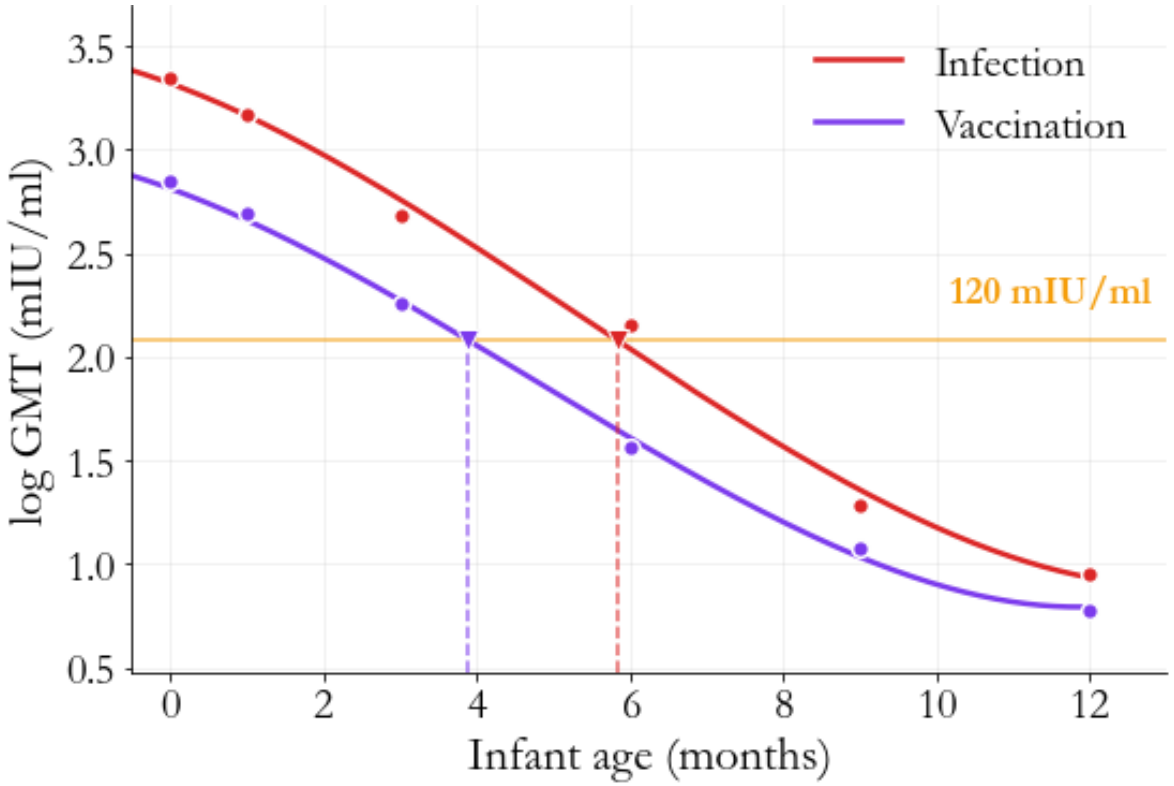
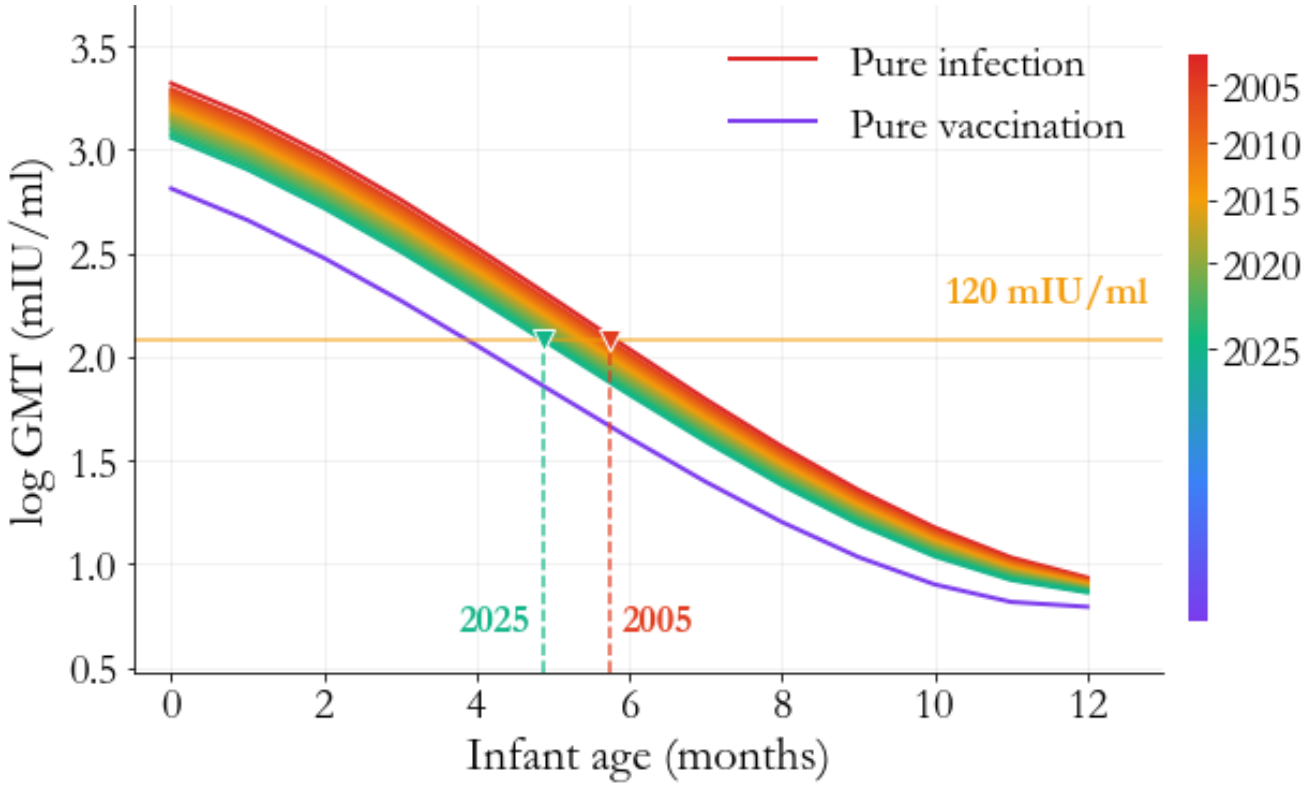
To understand weakening maternal protection, we can use demographic surveys and immunity profiles to estimate maternal immunity source proportions by birth year.

Average maternal antibodies by mother's immunity source[2]



Population-weighted average antibody curves by year



[2] Leuridan et al, *BMJ* 2010.

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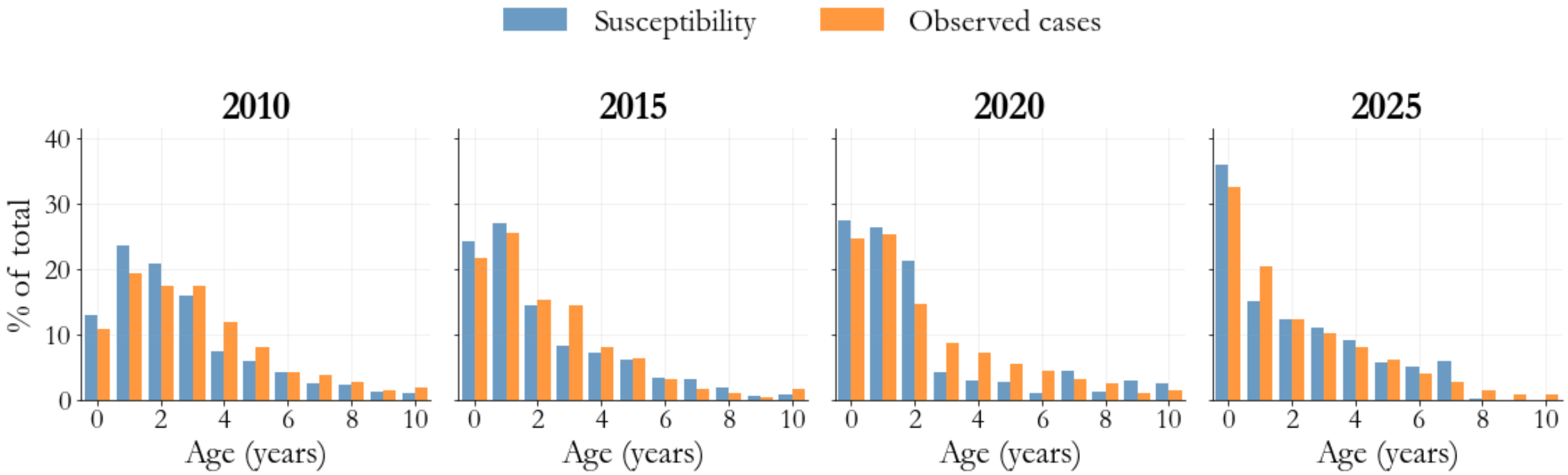
Immunity profiles give us the age distributions of susceptibility in each year. These distributions closely resemble the observed age at infection distributions.

Pakistan susceptibility vs observed age at infection distributions



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Future work and key implications for decision-making

- As vaccination coverage increases, increasing proportions of susceptibility and cases are concentrated in children younger than MCV1 age (9 months).
- Simultaneously, accelerated maternal antibody waning is causing more infants to become susceptible earlier.
- These results could be put together with research on the efficacy of earlier vaccination to guide decision-making on MCV1 and SIA age eligibility in Pakistan.
- This analysis framework can be repeated in other geographies in the EMRO and SEARO regions (and beyond).

Thank you for listening! Please contact me with any comments or questions: Marisa.Gaetz@gatesfoundation.org

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Moderated Q&A discussion

Session Chair:

Todi Mengitsu,

Gavi, The Vaccine Alliance

MEASLES
ANALYTICS HUB

Coffee Break

SEAR Lightening Talks 2

Session chairs:

Parag Govil & Shikha Vardhan,

William J Clinton Foundation & Government of India, Integrated Disease Surveillance Programme (CSU - IDSP)

With online support from Arindam Ray, Gates Foundation India

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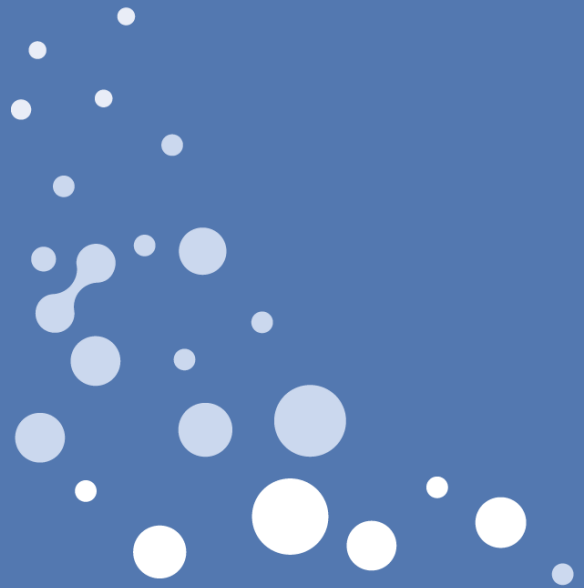
ANALYTICS HUB

Esha Kashyap

IIT Bombay



MEASLES
ANALYTICS HUB

Strategic Intensification of Measles Immunisation in India: Lessons Learned from Subnational Targeting

Esha Kashyap[1], Biplab Maity[1], Pawan Kumar[2], Siuli Mukhopadhyay[1, 3]

[1] National Disease Modelling Consortium, Indian Institute of Technology Bombay
[2] Immunization Division, Ministry of Health and Family Welfare
[3] Department of Mathematics, Indian Institute of Technology Bombay

NDMC NATIONAL DISEASE MODELLING CONSORTIUM राष्ट्रीय रोग प्रतिरूपण केन्द्र

स्वास्थ्य एवं परिवार कल्याण मंत्रालय
MINISTRY OF HEALTH AND FAMILY WELFARE
सत्यमेव जयते

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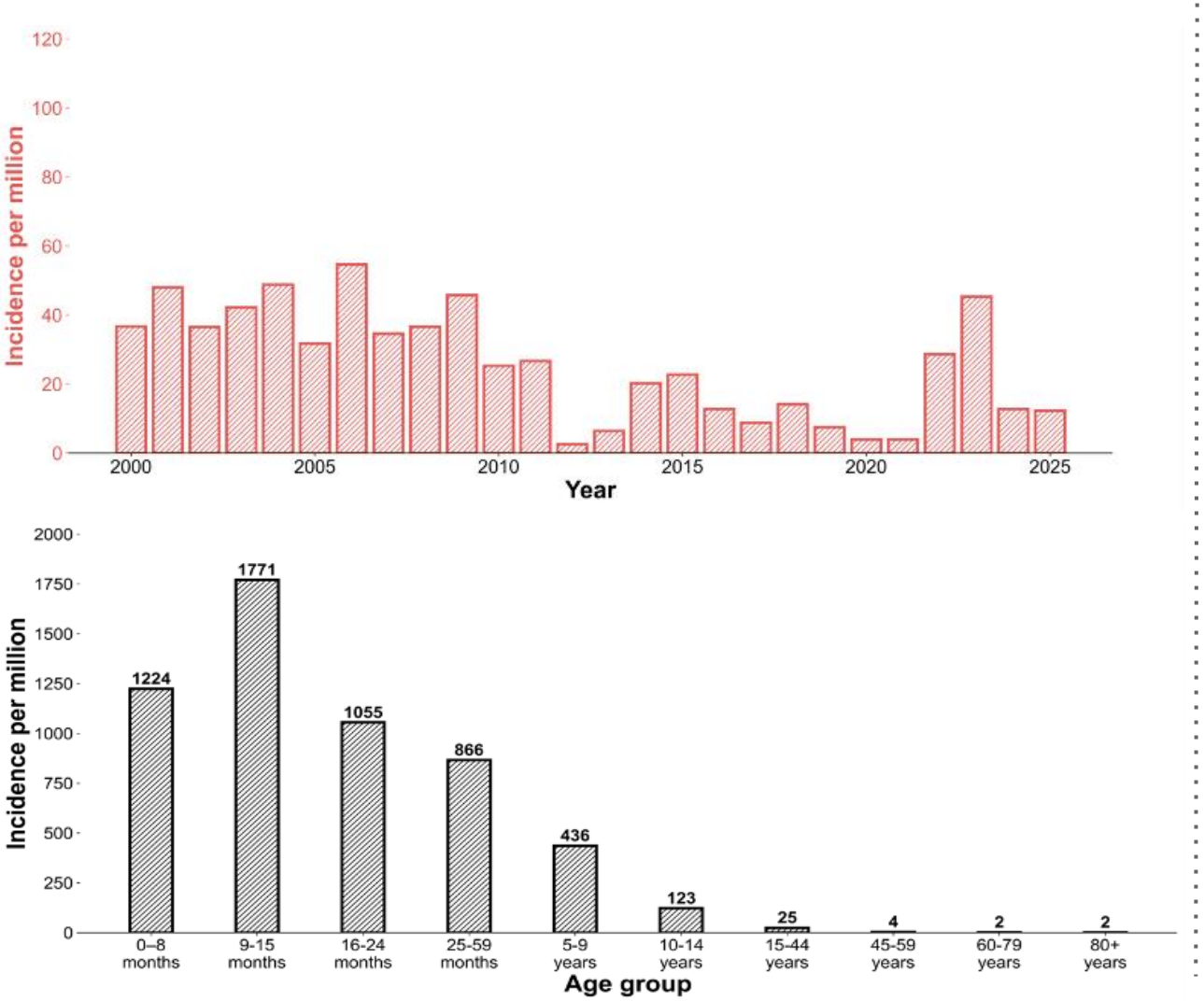
Tracing measles in India



Key India measles statistics:

- **36.7** incidence per million population in **2000** to **12.3** incidence per million population in **2025**
- **1224** measles cases per million population is documented among **infants < 9 months**

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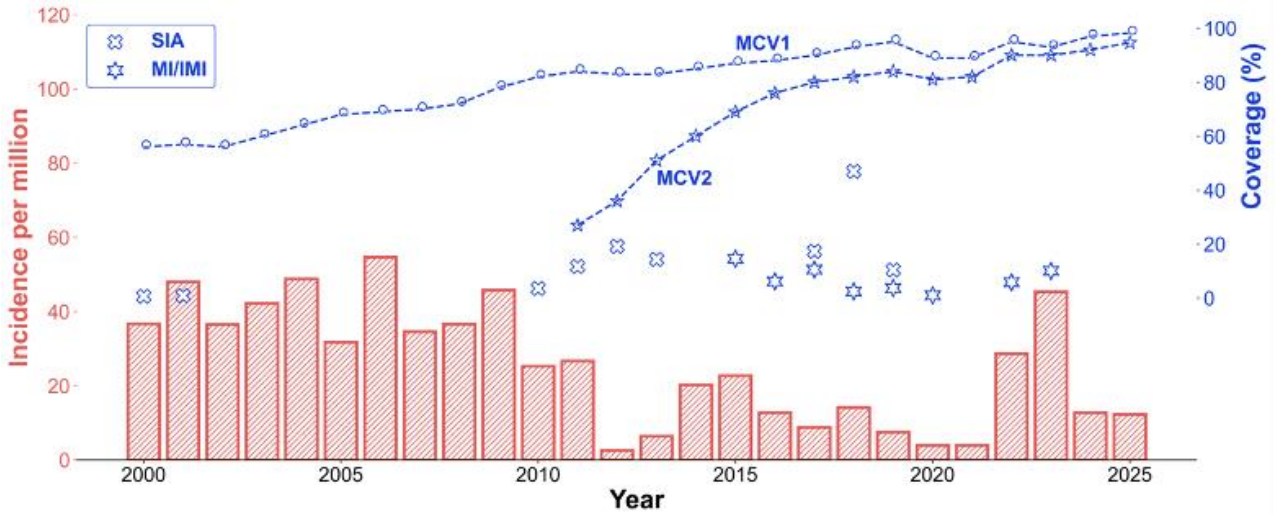
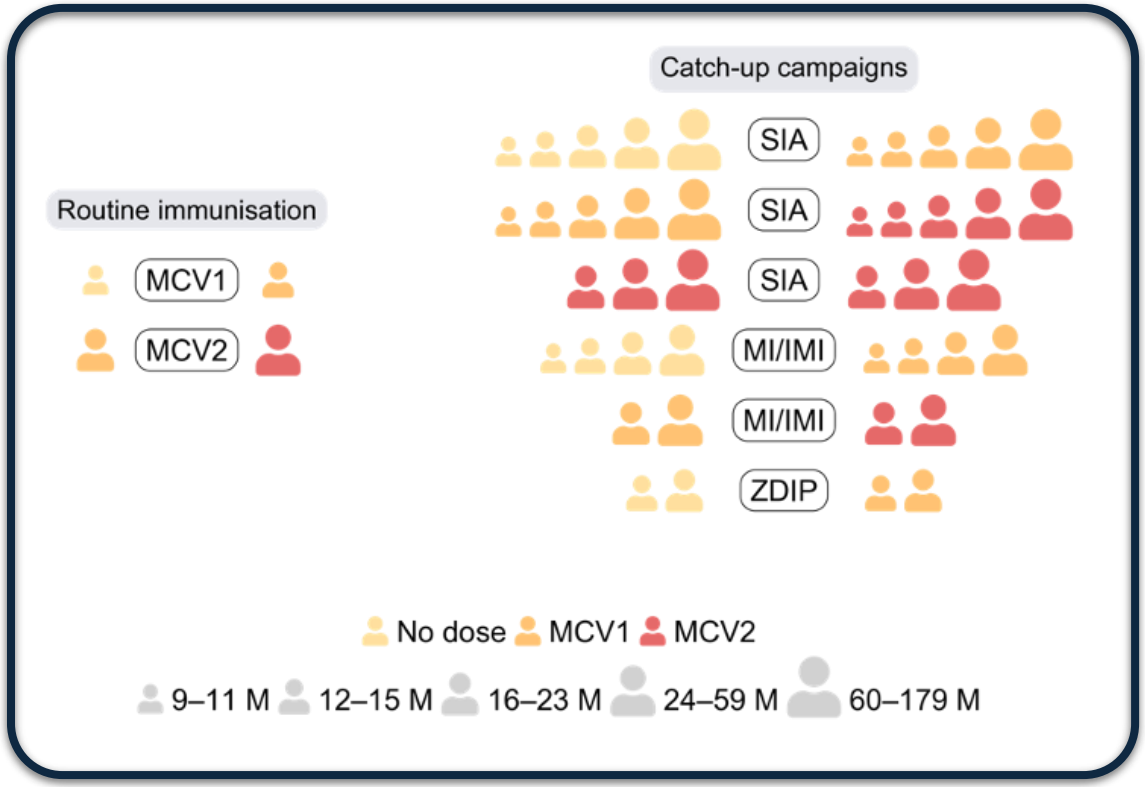
स्वास्थ्य एवं परिवार कल्याण मंत्रालय MINISTRY OF HEALTH AND FAMILY WELFARE सत्यमेव जयते

Measles incidence in India 2000-2025: WHO
Measles incidence: National Measles Rubella Surveillance Data, 2017-2025, MoHFW
Population statistics: Census of India

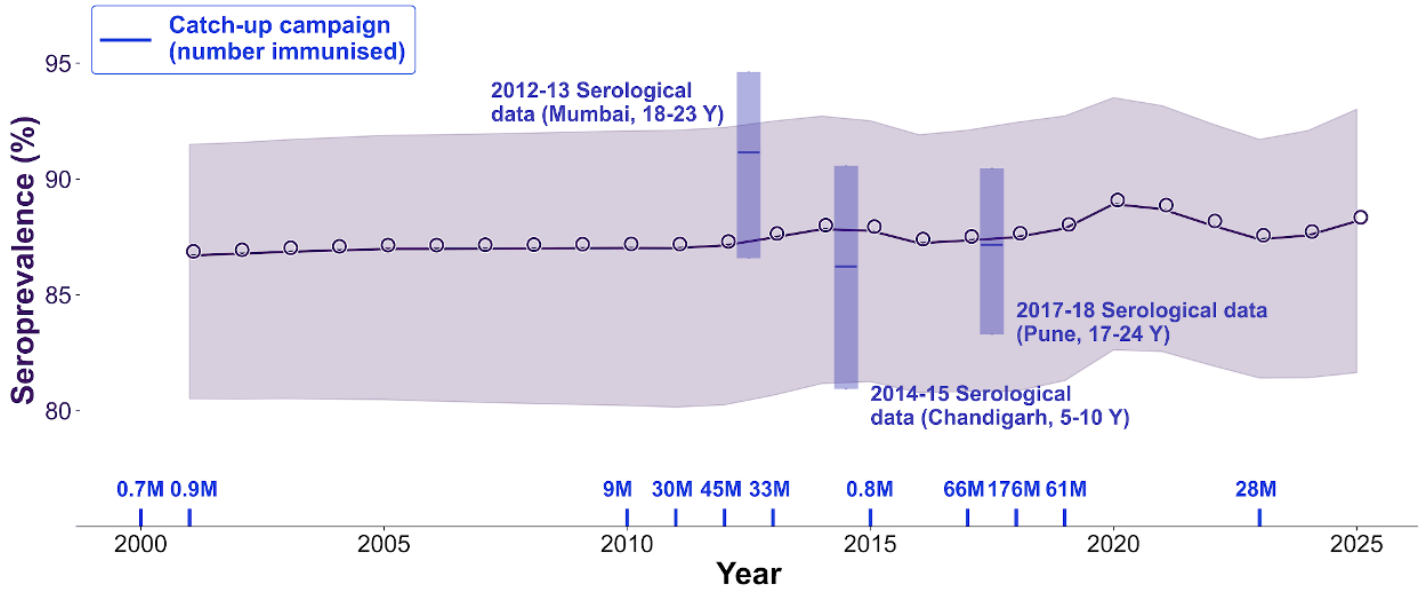
Measles immunisation in India

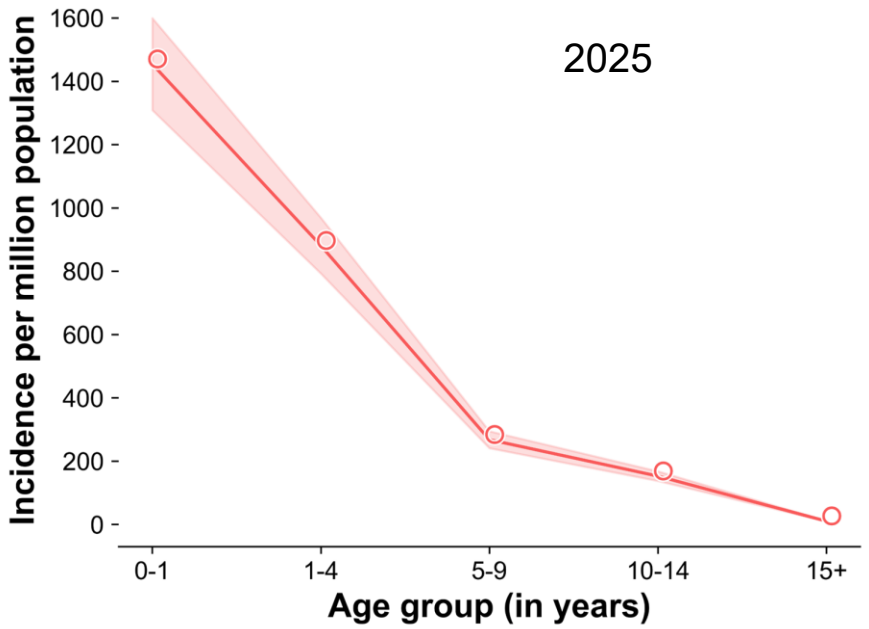




Measles incidence in India 2000-2025: WHO
MCV: Measles containing vaccine
SIA: Supplementary Immunisation Activities, MI: Mission Indradhanush, IMI: Intensified Mission Indradhanush, ZDIP: Zero-dose Implementation Plan

Insights into measles transmission with an age-structured compartmental model





Zero-dose burden (India):11.5% of children had received *no measles vaccination*, according to the National Family Health Survey 2019–21 (NFHS-5) [Dhalaria et.al 2024]

COVID-19 impact on immunity: Disruptions to routine immunisation and missed catch-up campaigns during the pandemic led to an estimated **~1.5% decline in measles seropositivity in 2023** (95% CI: 1.0–1.8%)

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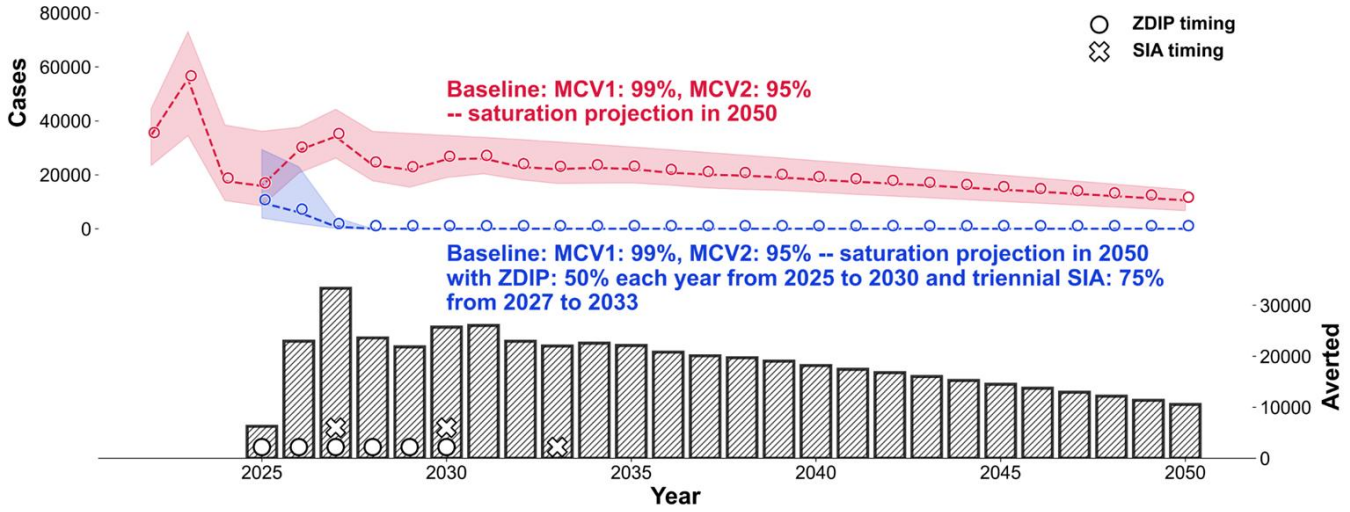
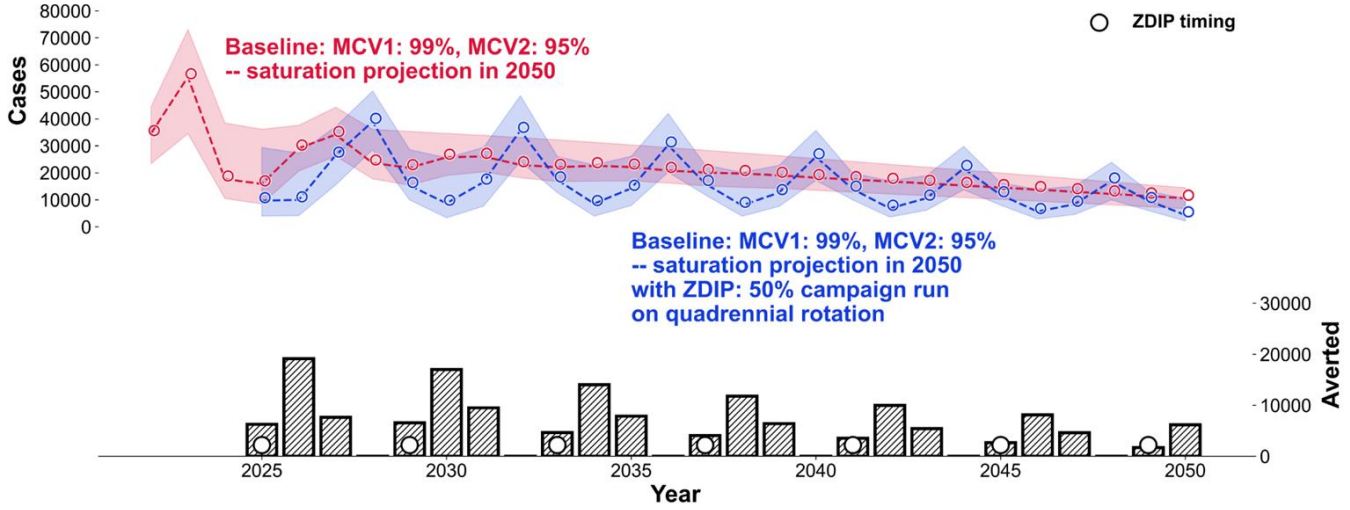
Measles incidence in India 2000-2024: WHO
Birth and death rate, World Bank
Measles incidence & vaccine information (RI & SIA), WHO
MI & IMI vaccine information, MoHFW press release

Insights into measles transmission with an age-structured compartmental model





- **SIA target age group:** 9M–10Y
- **Measles elimination:** Absence of endemic measles > 12 months and sustains more than 36 months
- In strategy 1 measles elimination in 2028
- With strategy 2 there is periodic resurgence of measles

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स्वास्थ्य एवं परिवार कल्याण मंत्रालय MINISTRY OF HEALTH AND FAMILY WELFARE सत्यमेव जयते

Measles incidence in India 2000-2024: WHO
Birth and death rate, World Bank
Measles incidence & vaccine information (RI & SIA), WHO
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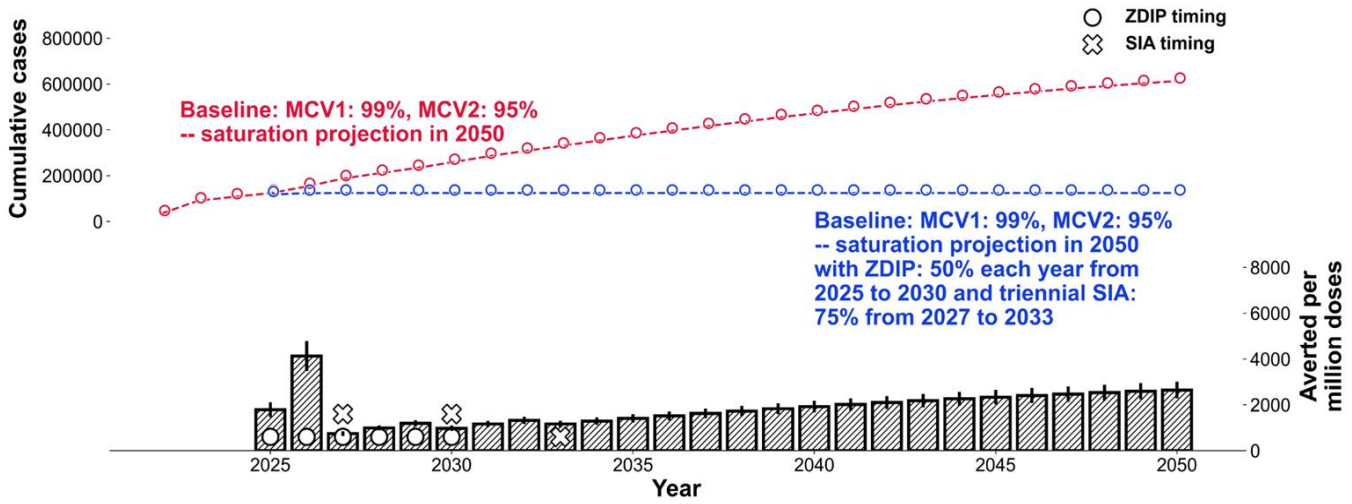

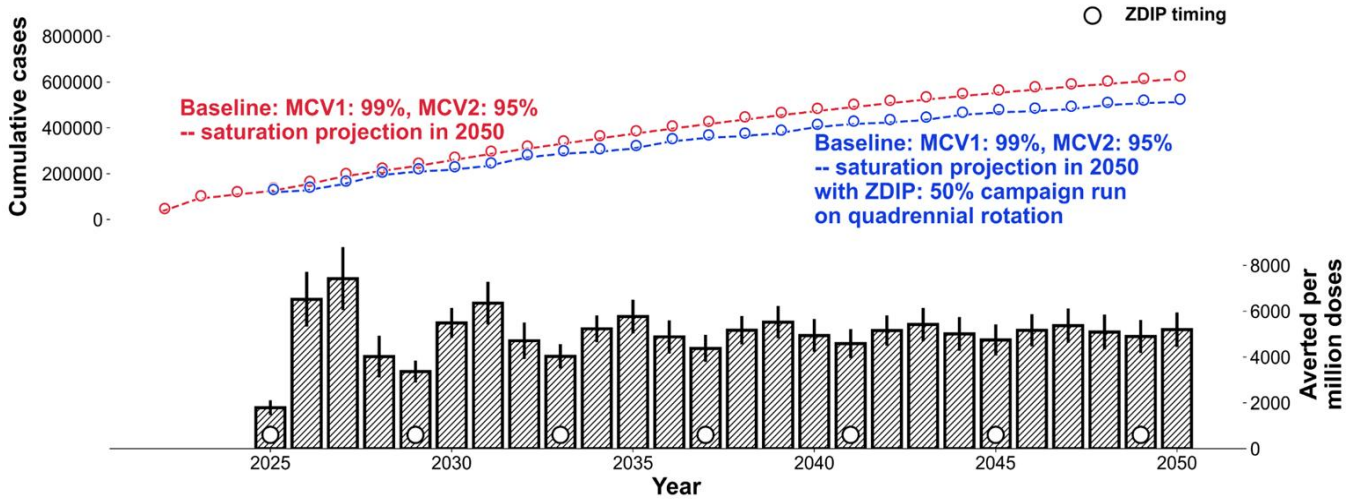

- Slow incremental gains in cumulative cases averted
- Strategy 2 produces larger and more variable annual impact. Double the impact in strategy 1

Strategic alignment of campaign timing and age-specific targeting enhances the efficiency of measles elimination efforts, reducing vaccine demand while increasing return on investment

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Thank you

MEASLES
ANALYTICS HUB

Divya Kappara

IIT Bombay (online)

MEASLES
ANALYTICS HUB

Estimating Measles Relative Risk in India Using Covariate-Balanced Spatial Models

Dr. Divya Kappara

Co-authors: Prof. Siuli Mukhopadhyay, Prof. Subharup Guha

2026 MAH Annual Meeting, Jakarta, Indonesia

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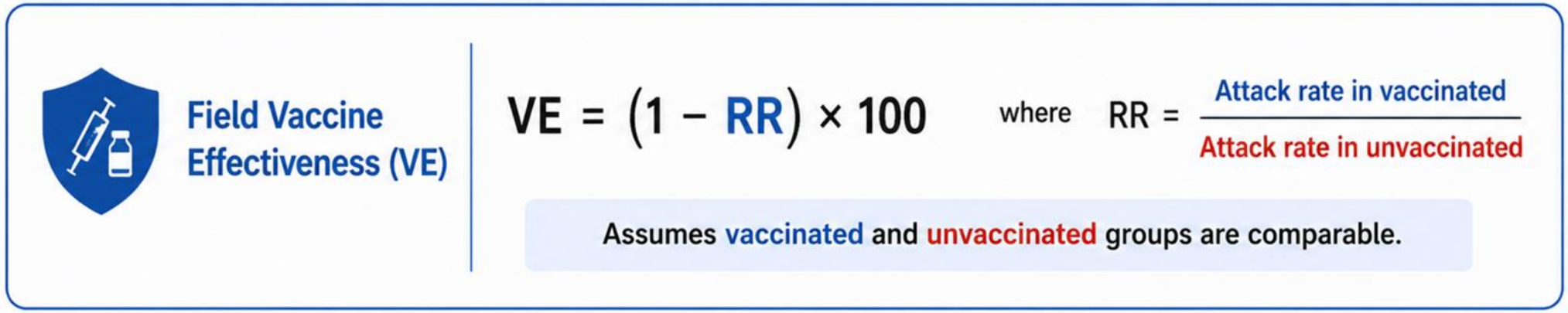
Motivation



When can crude vaccine effectiveness[1] estimates be biased?

- Vaccine uptake varies across regions.
- Populations differ in nutrition, migration, sex, and residence.
- Neighboring districts often share similar risk environments.
- Crude Relative Risk (RR) mixes vaccination effects with population differences.

🔴 **Key challenge:** *Are differences in measles risk due to vaccination or due to underlying population differences?*

Objective

Obtain population representative and covariate-balanced estimated of measles risk

Estimate spatial measles relative risk among vaccinated vs. unvaccinated individuals while:

- Adjusting for observed confounding.
- Accounting for spatial and temporal dependence.
- Incorporating population-level information.
  (vaccine coverage, malnutrition, migration, etc.)
- Improving representativeness of the Indian population.

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Methodology

Spatio-Temporal Bayesian Modelling + FLEXOR propensity weighting

FLEXOR[2] weighting

- Constructs a covariate-balanced pseudo population.
- Incorporates external population information.
- Optimizes effective sample size.
- Improves population representativeness.

Bayesian spatio-temporal model

- Fixed effects + spatio-temporal random effects.
- Structured spatial effects with region level covariates.
- Temporal dependence.

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Data and model inputs

Individual-Level Data

Outcome

- Measles case status* (Positive/Negative)

Covariates

- Vaccination status
- Sex
- Place of residence
- Age group
- Religion

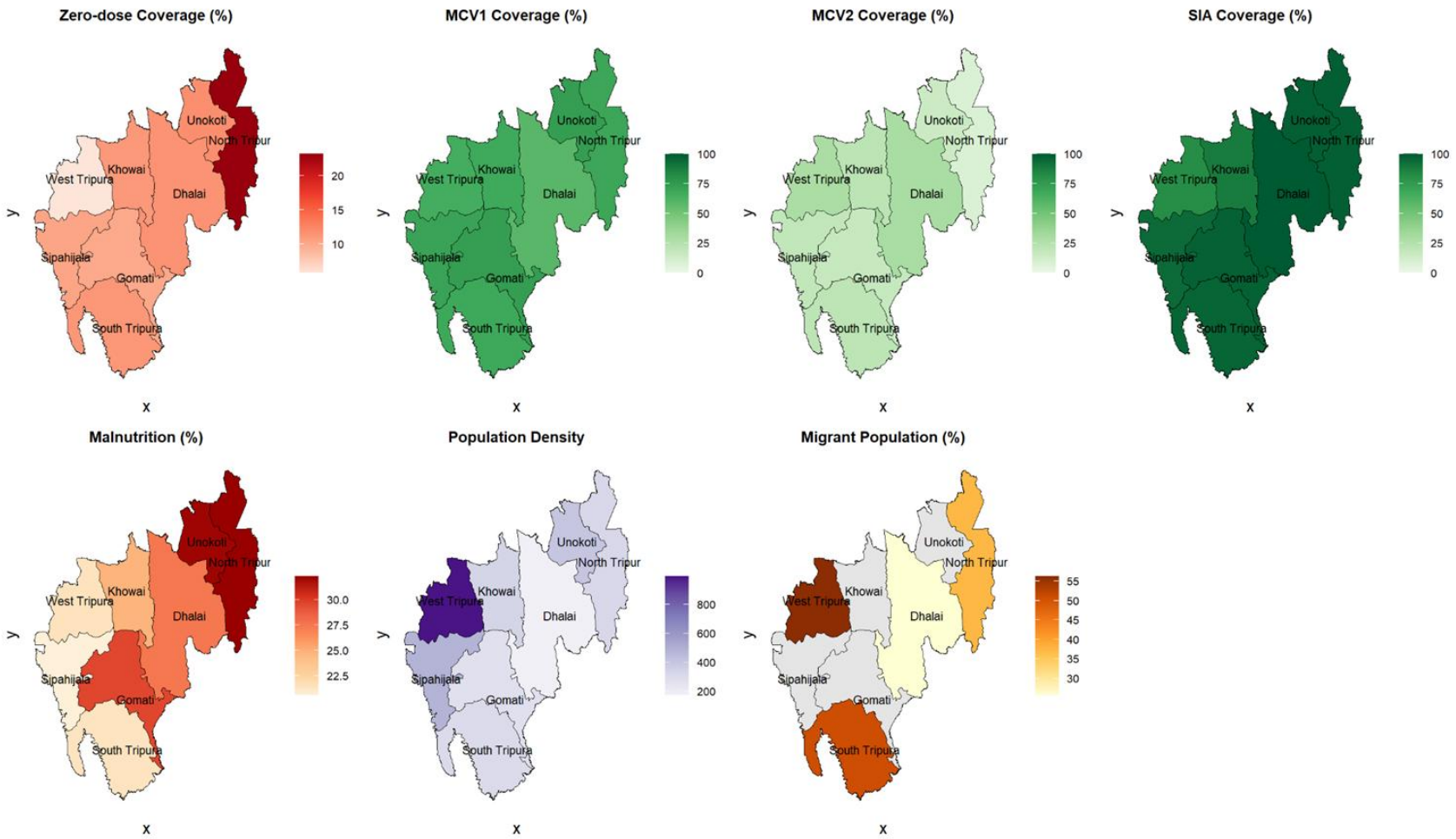
District-Level Covariates

Immunization

- MCV1 coverage
- MCV2 coverage
- MR campaign coverage

Population Characteristics

- % Malnourished children
- Population density
- % Migrant population



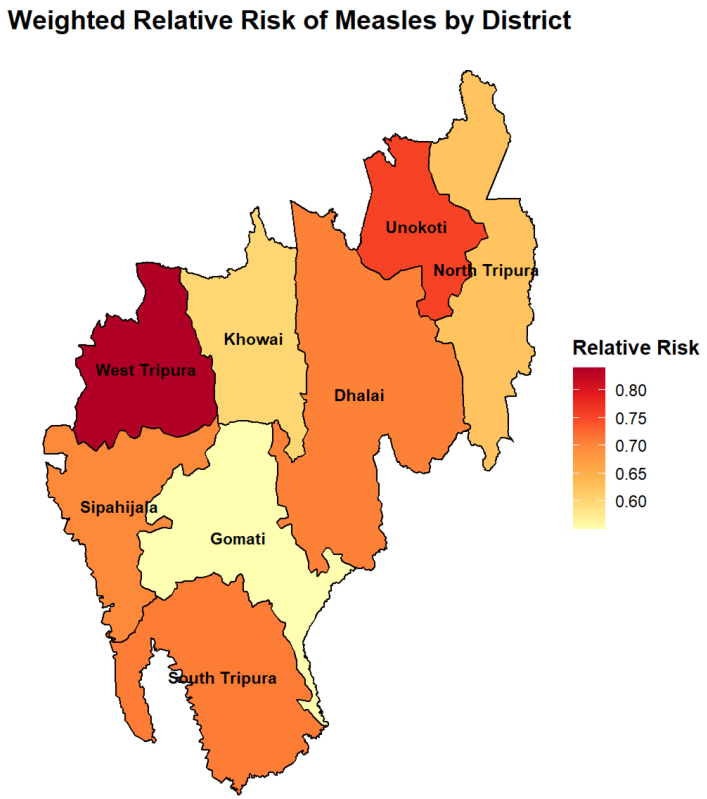
Spatial distribution of district level covariates in state of Tripura India. Data source: NFHS-5, Census-2011[3]

* Measles case status generated under assumed covariate effects from the proposed model.

Results

Adjusted District Relative Risk:

Districts West Tripura, South Tripura, Dhalai, and Unakoti, Sipahijala, exhibited relatively higher measles risk after adjustment for covariates and spatio-temporal effects.



Individual-level effects:

Vaccination Effect - *Significant effects with 40% Lower Odds of Measles with at least one dose.*

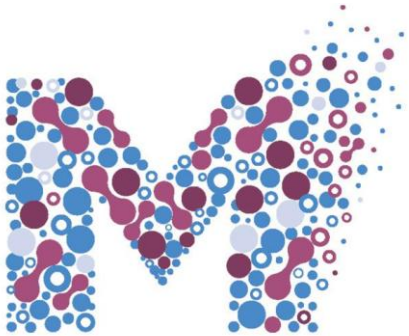
- *Log-odds = −0.511*
- *95% Cr I: (−0.92, −0.10)*

Residence - *Urban individuals showed lower estimated odds of measles compared with rural individuals.*

Age Groups - *Higher estimated risk relative to (9 months–2 years) among:*

- *Infants < 9 months*
- *Adults ≥ 15 years*

Implications and Transferability



More reliable estimates from observational data

- Adjusts for confounding arising from differences in vaccination uptake and population characteristics.
- Identifies regions with persistently higher risk after covariate adjustment.
- Supports ***targeted vaccination and outbreak-response planning.***
- Identify Socio-demographic factors associated with measles cases.

Applicable to other LMIC settings

- Combines routine surveillance, survey, and census data to generate more representative disease risk estimates.
- **Adaptable to other vaccine-preventable diseases and countries** given similar observational data settings and spatial heterogeneity.

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Resources

1. Orenstein, Walter A., et al. "Field evaluation of vaccine efficacy." *Bulletin of the World Health Organization* 63.6 (1985): 1055.
2. Guha, S., & Li, Y. (2024). Causal meta-analysis by integrating multiple observational studies with multivariate outcomes. *Biometrics*, *80*(3), ujae070.
3. Ghosh, S., Kappara, D., Majumder, N., Nath-Sain, S., Roy, A. D., & Mukhopadhyay, S. (2025). A systematic review and modelling insights of factors impacting measles vaccine effectiveness, efficacy and immunogenicity. *Discover Viruses*, *2*(1), 23.

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MEASLES ANALYTICS HUB

Ratnesh Murugan

WHO India

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Block-Level Risk Stratification for Measles and Rubella Elimination in India

Methodological Challenges and Innovations in Sub-National Immunisation Risk Mapping

Dr. Ratnesh Murugan
National Professional Officer
WHO India

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1. Epidemiological Context & Local Setting

Disease Burden	Challenge	2023–2025 Picture
• India accounts for a significant share of global measles cases despite strong routine immunization infrastructure	• 6,214 blocks across India vary enormously in demographics, health infrastructure, and immunization history	• 1,371 (22%) blocks generated 71% of all lab-confirmed measles cases
• Measles remains endemic with sporadic outbreaks particularly in densely populated northern and western states	• Uniform national strategies fail to address localized pockets of susceptibility	• Block “A”: 193 lab confirmed measles cases sustained across all 3 years — a sentinel example of compounding risk
• Rubella burden is less visible but poses serious risk of Congenital Rubella Syndrome (CRS)	• Sub-district data has historically been underutilized in risk classification	• Rubella is largely medium-to-low risk at block level; only 13 blocks classified high-risk

Mapping

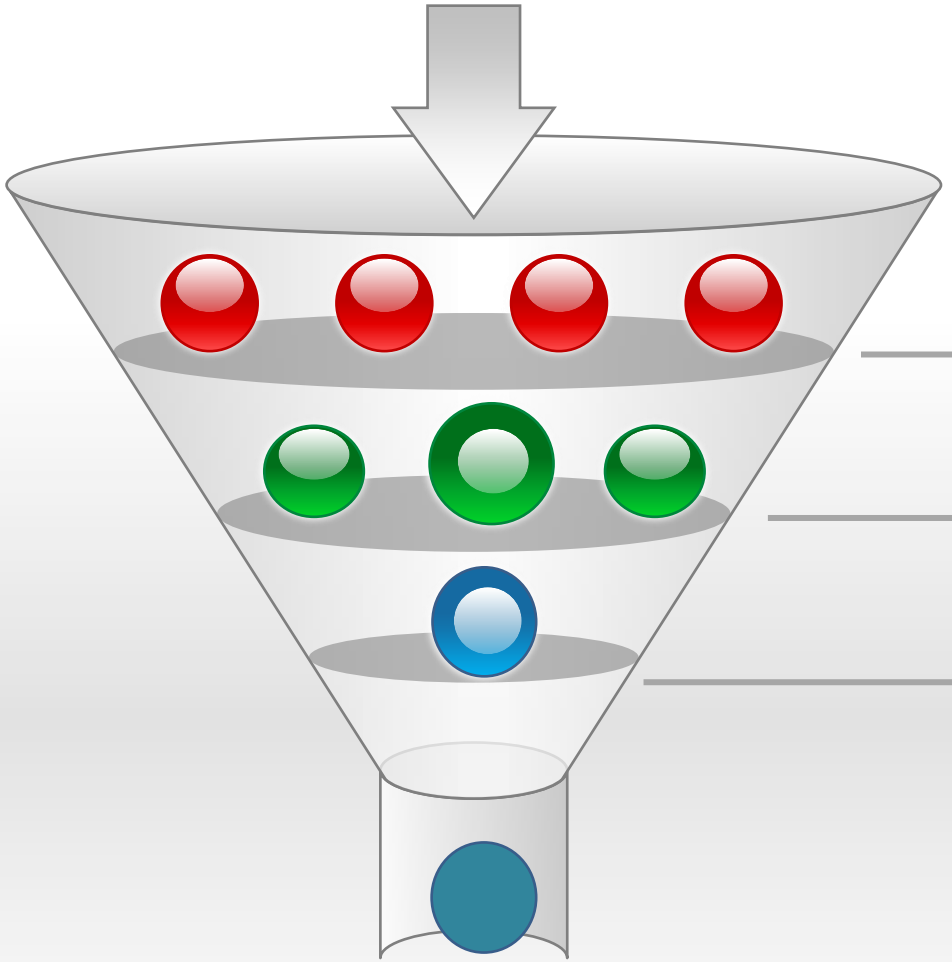
Screening

Selection

Scoring

Recommendation

Step 1: Block level risk mapping based on MR lab positive cases over 36 months



Step 2 – Deep Dive into High-Risk blocks

Step 3 – Selection of one High-Risk block

Step 4 – Deep Dive into one High Risk block

Step 5- Overall assessment of one block

2. Overview of Work & Key Findings

1 Block Risk Mapping

All 6,214 blocks classified: Low (0 cases), Medium (1–10), High (≥11) using 36-month lab-positive data

2 Deep Dive: High-Risk

Year-wise, week-wise epi-curves, age & vaccination-status analysis for 1,371 HR blocks

3 Block Selection

Blocks with >50 confirmed cases in all 3 years, representative of district/state challenges

4 WHO Risk Assessment Tool

Four domains: Population Immunity (40pts), Surveillance Quality (20pts), Program Performance (16pts), Threat Assessment (24pts)

Assessment Domain	Max Points	Key Indicators
Population Immunity	40	MCV1/MCV2 coverage, SIA history, vaccination status of cases
Surveillance Quality	20	NMNR rate, investigation rate, specimen collection, lab turnaround
Program Performance	16	Coverage trends, dropout rates
Threat Assessment	24	Recent case history, population density, border cases, vulnerable populations
TOTAL	**100**	

5 Overall Assessment

Risk Category	Score Range	Implication
Low Risk	<47	Maintenance interventions
Medium Risk	48-54	Strengthening interventions
High Risk	55-60	Immediate action required
Very High Risk	≥ 61	Urgent priority intervention

KEY FINDING: 22% of high-risk blocks generate 71% of all measles cases — targeted intervention is the highest-leverage strategy

2 (cont.). Block “A” –Case Study

CRITICAL	EXCELLENT	POOR	HIGH
34/40	0/20	12/16	17/24
Population Immunity	Surveillance Quality	Program Performance	Threat Assessment

OVERALL RISK SCORE: 63 / 100 — VERY HIGH RISK

Critical Vulnerabilities Identified

- MCV1 dropped to 64% in 2024-25 — a 28% decline from peak
- MCV2 critically low at 56% — 39 percentage points below target
- No MR SIA for 5+ years — zero supplementary protection
- Susceptible cohort accumulated to 116% of birth cohort by 2024-25
- 51–67% of cases aged 9 months–5 years; ~55% with no/unknown vaccination
- Surveillance is exemplary (score 0/20) — the problem is NOT detection

3. Implications for a Disease Modelling Audience

Spatial Granularity Matters

- Block level data shows **6 times variation** in risk within single districts
- District models miss this entirely

Susceptibility Accumulation

- Years of sub-threshold coverage **compound into explosive outbreak potential**

Multi-Domain Model Inputs

The **four-domain WHO tool gives structured inputs for** transmission, detection, and reporting **simultaneously**.

Surveillance ≠ Coverage

- Block "A" paradox: near-perfect surveillance (0/20 risk points) alongside collapsing coverage (34/40 risk points).
- Near perfect detection can mask collapsing coverages (models must decouple these)

Coverage Trend Dynamics

- MCV1 decline from 92% → 64% (3 years)
- Signals programme failure - enables **dynamic** R_0-based threshold modelling.

Cross-Border Transmission Risk

- Block "A" : 1,800+ cases in bordering districts.
- Documented state border corridors demand **spatial spread models**.

4. Country Relevance — Why This Work Matters for India

WHY IMPORTANT

- **India's elimination goal requires interrupting transmission in every block — even 1% of high-risk blocks can sustain national endemicity**
- **22% of blocks drive 71% of cases: without targeted action, elimination timelines will not be met regardless of national average coverage**
- Persistent measles in Block “A” and similar blocks is documented across all 3 years — indicating gaps in these blocks
- Limited/no MR SIA in these high-risk block in 3+ years create a hidden CRS burden undetected by routine surveillance
- India's HMIS data infrastructure enables this methodology at national scale — a global proof-of-concept

IMPLICATIONS FOR DECISION-MAKING

- **Block-level risk scores enable tiered allocation of SIA resources — highest-scoring blocks receive priority and earliest scheduling**
- High-performing surveillance blocks (like Block “A”) need priority immunization action
- **Susceptible cohort estimates provide a quantified target for catch-up campaigns**
- Cross-state high-risk corridors demand coordinated multi-state outbreak response protocols
- Annual re-scoring enables early warning of blocks transitioning from medium to high risk — enabling prevention rather than response

5. Transferability — Lessons for Other Countries & Regions

Element	India Application	Transferability
Core Methodology	WHO Measles Programmatic Risk Assessment Tool (4 domains)	Tool is WHO-standard — directly applicable globally; only thresholds and weights may need contextual calibration
Data Requirements	Lab-confirmed cases, HMIS coverage data, SIA records, population density	Other countries can use community case data + administrative coverage; lab confirmation not essential for risk classification
Spatial Unit	Block (~sub-district, 80,000–120,000 Avg pop.)	Adaptable tehsil (Pakistan), kecamatan (Indonesia); works at any administrative tier with coverage data
Susceptible Cohort Model	Birth cohort × (1-coverage) + dropout cumulated over 5 years	Directly replicable in any setting — only requires birth cohort and dose-level coverage data
Risk Score Thresholds	Low ≤47, Medium 48–54, High 55–60, Very High ≥61	Thresholds are calibrated — may need validation against local outbreak data; process is documented and transparent

6. Bridging Modellers & Programme Managers — The Tool Design

What Modellers Produce	What Programme Managers Need
Probabilistic risk estimates with confidence intervals	A clear Red / Amber / Green classification they can act on immediately
Continuous risk scores (0–100) with sensitivity analyses	Simple thresholds: 'This block needs SIA. This one doesn't'
Transmission dynamic models requiring specialist interpretation	One-page block-level summary sharable in WhatsApp groups
Data stratified by age, dose, geography simultaneously	Coverage numbers for one block, one year, one vaccine
National-scale outputs updated annually with model refinement	Real-time outbreak alerts tied to geographic response protocols

Summary & Call to Action

India's block-level risk stratification identifies 22% high-risk blocks responsible for 71% of measles cases — a high-leverage intervention target

The WHO Measles Programmatic Risk Assessment Tool operationalizes complex multi-domain risk into actionable scores usable by sub national teams

Block “A” exemplifies Very High Risk (63/100): excellent surveillance, significant gap in programme performance — action needed is closing the immunity gap

Susceptible cohort accumulation modelling provides an evidence base for SIA targeting that is transferable to any HMIS-equipped country

The methodology bridges the modeller–manager gap: statistical rigour is preserved but outputs are designed for field-team decision-making

Approach is transferable to other countries: adaptable spatial units, flexible data requirements, WHO-standard scoring framework

Indrajit Ghosh

Ahmedabad University

MEASLES
ANALYTICS HUB

ORIGINAL RESEARCH

Modelling the Impact of Migration and Population Mixing on Measles Transmission in India

Indrajit Ghosh

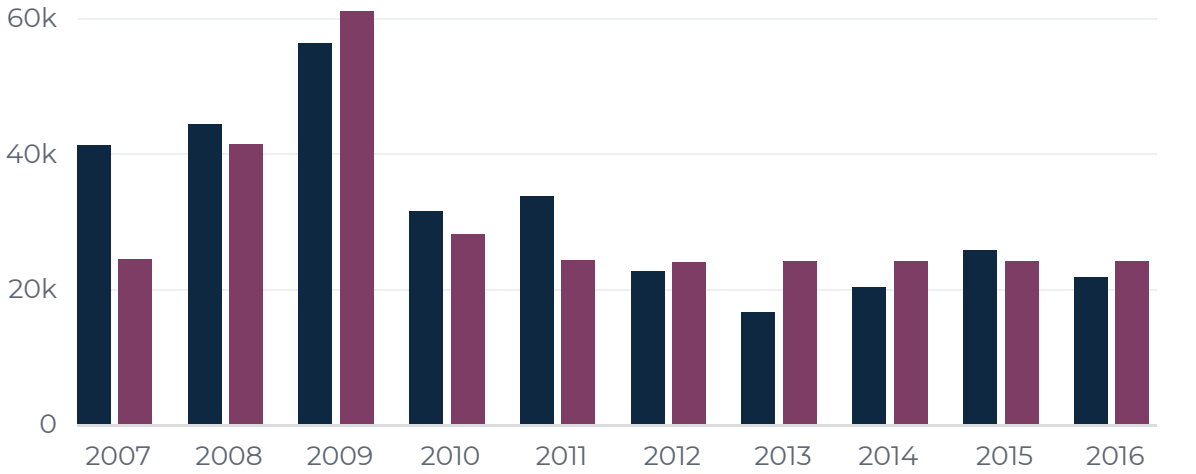
Measles Analytics Hub Annual Meeting
10-12 June, 2026
Jakarta, Indonesia

Funded by: MEASLES ANALYTICS HUB

INDIA CONTEXT

India's national decline masks a state-level mobility problem.

Reported cases fell after 2009, but the states that seed and receive population movement are not interchangeable for outbreak planning.

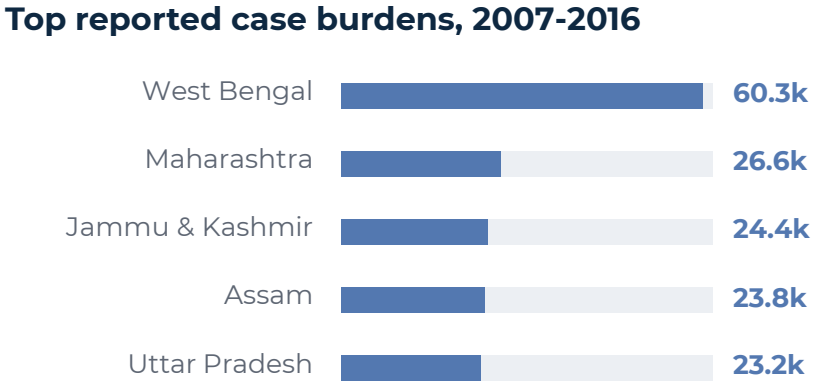


56.2k

reported case peak in 2009

16.5k

reported cases by 2013

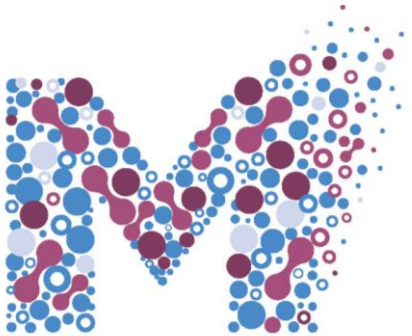


Source: Lok Sabha measles case extraction

MODEL IN ONE SLIDE

The model connects measles dynamics to a state-to-state movement network.

A deterministic SIRV metapopulation model links population, births, MCV1/MCV2, reported measles and Census interstate migration matrices.



Geography

35 state/UT units; Telangana is merged with Andhra Pradesh to match the migration boundary.

Demography

Annual population denominators, live births, and MCV1/MCV2 inputs drive susceptible replenishment and vaccination.

Movement

Census D-2 origin-destination matrices are converted into annual migration probabilities and sensitivity scenarios (1991, 2001 & 2011).

Fit

National reported cases calibrate transmission, initial susceptibility and reporting assumptions.

2007-2013

calibration period

2014-2016

out-of-sample validation

MCV1/MCV2

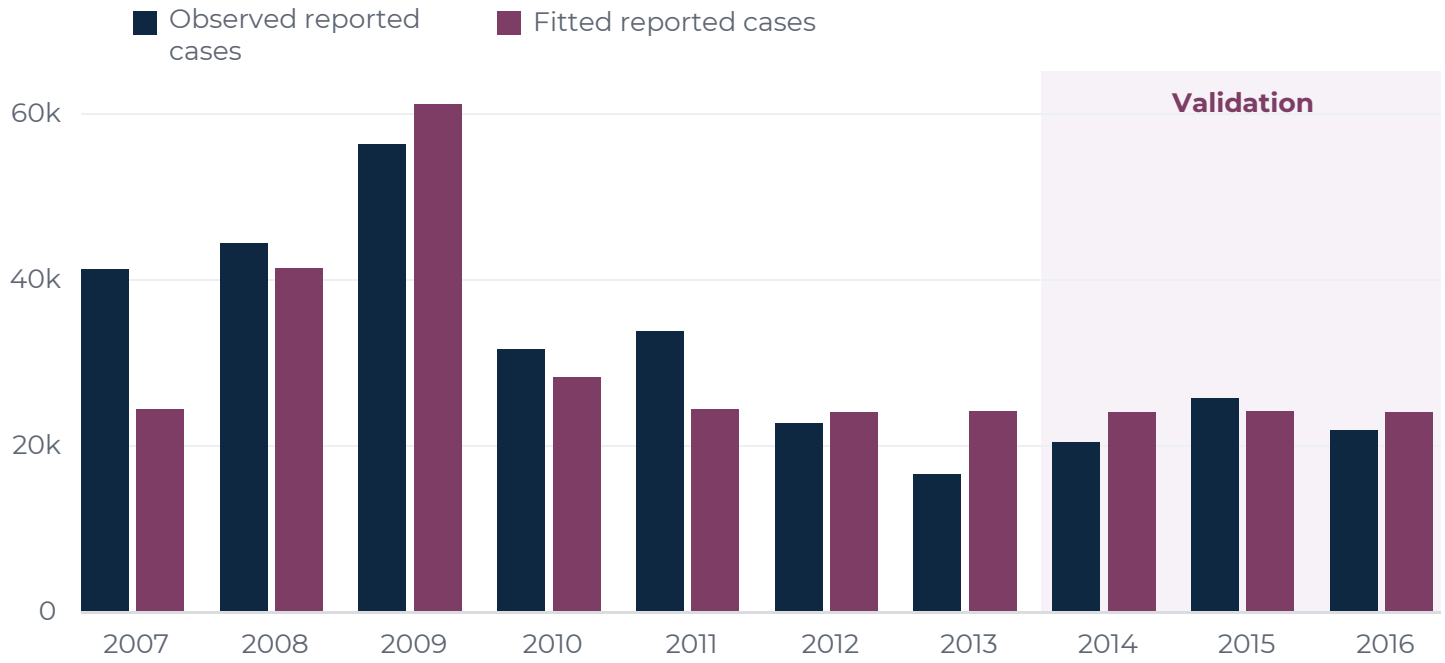
routine vaccination inputs

SIRV

susceptible, infectious, recovered, vaccinated

The national fit captures the broad decline before testing migration effects.

Calibration uses 2008-2013, with 2014-2016 held out for validation



0.91

calibration correlation

0.89

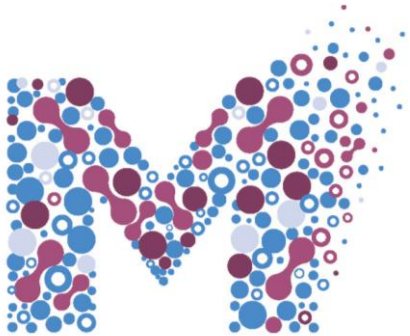
validation correlation

2.7k

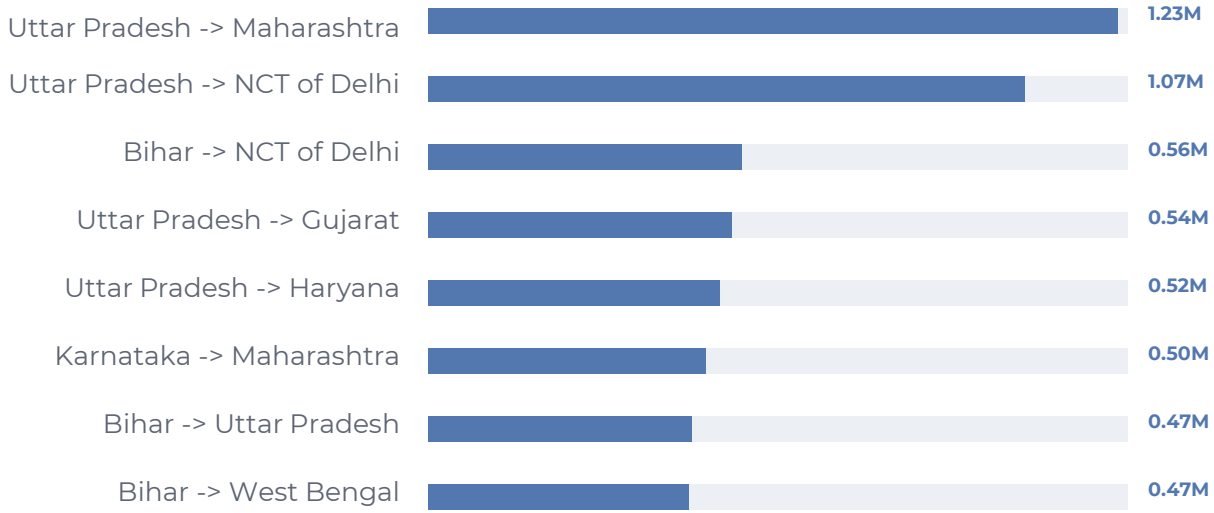
validation RMSE

A small number of interstate corridors dominate recent movement into risk hubs.

Census 2011 0-9 year duration migrants show Uttar Pradesh, Bihar and Karnataka feeding major destinations including Maharashtra and Delhi.



Largest directed interstate flows, 2011



Net migration signal, 2011

Uttar Pradesh **-3.38M**

more out-migrants than in-migrants

Maharashtra **2.56M**

more in-migrants than out-migrants

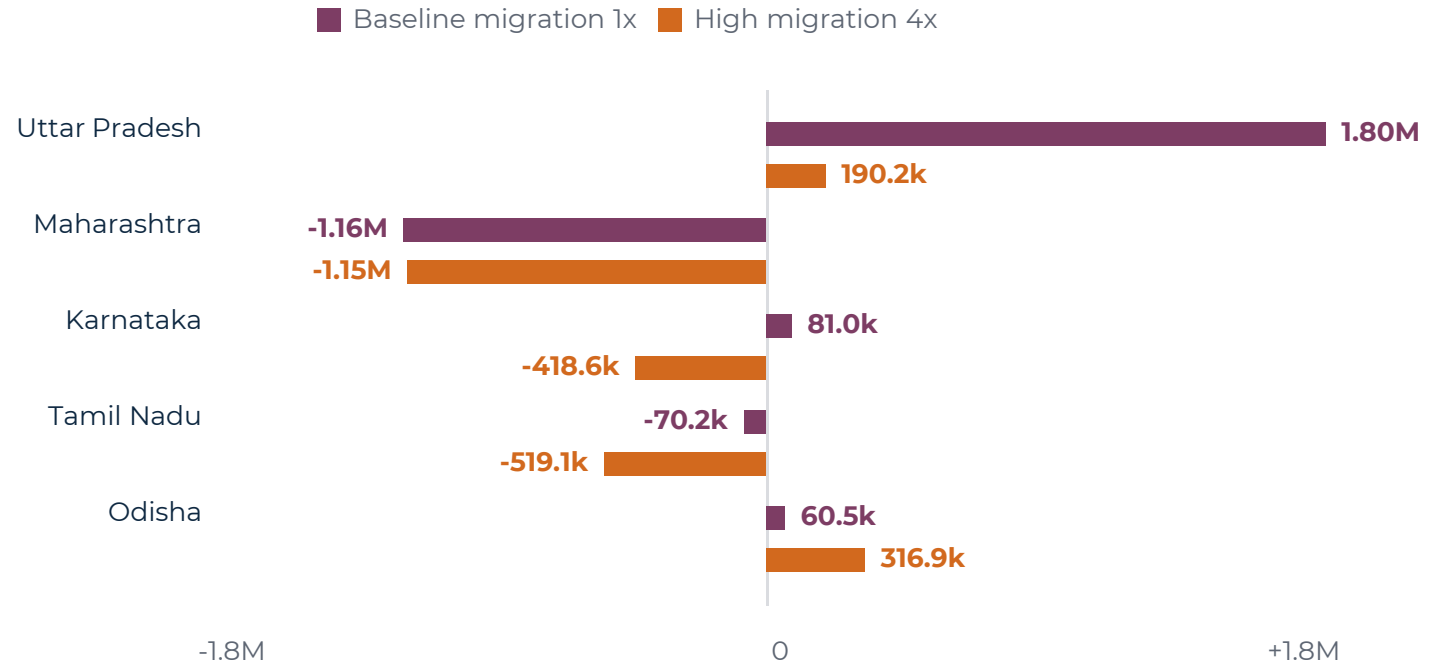
NCT of Delhi **1.51M**

more in-migrants than out-migrants

Interpretation: migration can move susceptible and infectious people in different directions across the network.

The same national model produces very different state-level migration effects.

Bars show change in simulated true infections during validation, compared with a no-migration counterfactual. Direction matters as much as size.



Most useful read

Do not interpret migration as simply increasing national burden. It changes which states gain or lose infections under each scenario.

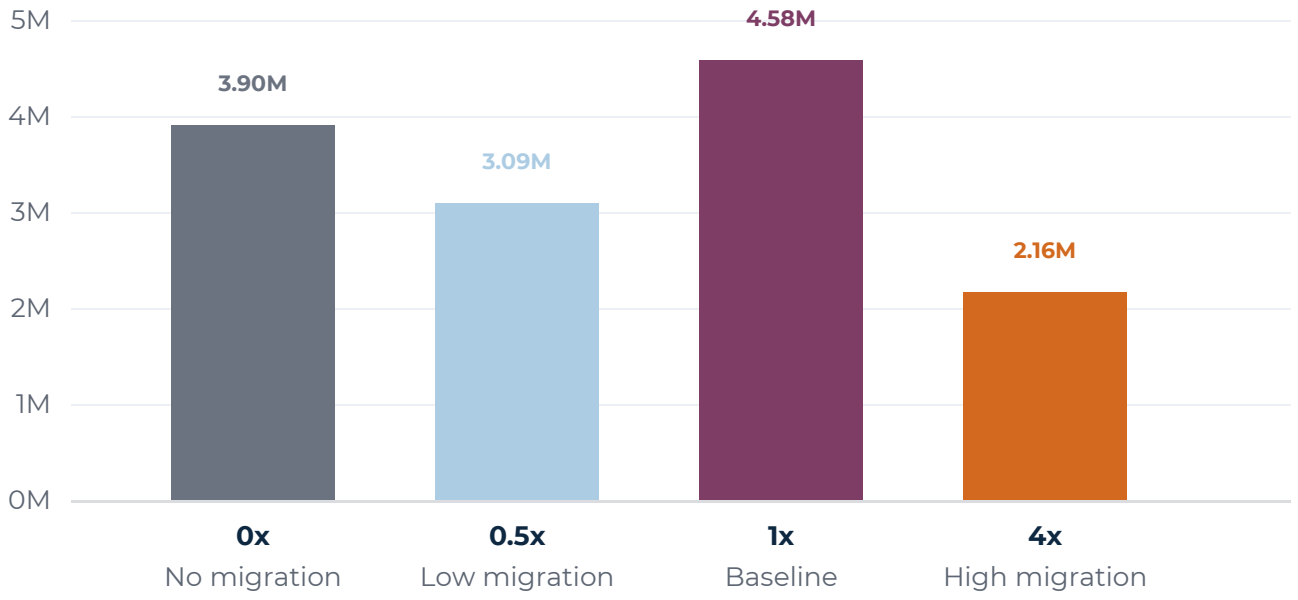
States to stress-test

Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu and Odisha are highlighted in the abstract and sensitivity outputs.

Migration intensity does not move national burden monotonically.

Across sensitivity scenarios, national true infections can rise or fall while state-level risk is redistributed across the network.

Validation true infections, 2014-2016



Programme implication

A national total alone can hide where susceptible buildup and imported seeding interact.

Transferable lesson

Use migration sensitivity as a prioritization layer, not as a one-number burden forecast.

Use migration-aware modelling to make measles planning more geographically precise.

The value of the model is not only estimating national burden; it is identifying where movement, susceptibility and seeding can interact.

1. Country relevance

For India, the state network matters for SIA planning, surveillance interpretation and outbreak preparedness.

2. Priority stress tests

Start with Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu and Odisha, then test corridor-linked states.

3. Next steps

SIAs are not modelled as timed campaign events, calibration is national rather than state-wise, and migration is simplified as annual state-to-state movement.

4. Transferability

Other countries can reuse the approach where subnational migration or commuting data can be linked to vaccination and case data.

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Thank you

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Moderated Q&A discussion

Session Chairs:

Parag Govil & Shikha Vardhan

William J Clinton Foundation & Government of India,
Integrated Disease Surveillance Programme (CSU - IDSP)

*With online support from **Arindam Ray**,*
Gates Foundation India

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This concludes the symposium

Thank you

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