Various scenarios on resetting the target date for M&R elimination: Findings from modelling

14 March 2023
Introduction

This group conducted similar work for the WHO in 2018/2019

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

Amy K Winter, Brian Lambert, Daniel Klein, Petra Klapac, Timos Papadopoulos, Shaun Truelove, Colleen Burgess, Heather Santos, Jennifer K Knapp, Susan E Redd, Lida K Kayembe, Stephanie Shendale, Katrina Krebsinger, Justin Leveson, Emilia Vynnycky, Kevin McCarthy, Matthew Ferson, Mark Jit

Summary
Background Marked reductions in the incidence of measles and rubella have been observed since the widespread use of the measles and rubella vaccines. Although no global goal for measles eradication has been established, all six WHO regions have set measles elimination targets. However, a gap remains between current control levels and elimination targets, as shown by large measles outbreaks between 2017 and 2019. We aimed to model the potential for measles and rubella elimination globally to inform a WHO report to the 73rd World Health Assembly on the feasibility of measles and rubella eradication.

Vaccine Impact Modelling Consortium (VIMC)

- Measles: Pennsylvania State University (PSU)
- Measles: Dynamic Measles Immunisation Calculation Engine (DynaMICE)
- Rubella: University of Georgia (UGA)
- Rubella: UK Health Security Agency (UKHSA)
Overview of the modelling work

Model Inputs
- Vaccination Scenario
- Demography
- Disease Parameters

Disease Model

Model Outputs
- Annual Incidence
- Elimination Indicator
Overview of the modelling work

- Model Inputs:
  - Vaccination Scenario
  - Demography
  - Disease Parameters

- Disease Model

- Model Outputs:
  - Annual Incidence
  - Elimination Indicator

200 model runs (i.e., simulations) for each country
Conditions for achieving elimination

Elimination Indicator:
Are the conditions for elimination achieved?
≤ 5 annual infections per million people
Achieving Elimination vs Maintaining Elimination

(getting to zero) (staying at zero)
Conditions for achieving elimination

Elimination Indicator:
Are the conditions for elimination achieved?
≤ 5 annual infections per million people

Summarized in two ways:

1. The probability that conditions for elimination are met in any given year
   - the year-specific proportion of 200 simulations in which the annual incidence is less than or equal to 5.

2. The cumulative probability that the conditions for elimination have been met by a given year
   - the proportion of 200 simulations in which the annual incidence of less than or equal to 5 has been met by a given year
SEAR Measles and Rubella Elimination Project
Project Timeline

- Early Nov - SEAR reached out to VIMC
- Nov 29 - Scoping meeting b/w VIMC & SEAR: SEAR begin generating vaccination scenario(s)
- Dec 19 - VIMC meeting - discuss feasibility and timeline
- Jan 3 - Engagement with India National Disease Modelling Consortium
- Jan 19 - Meeting all contributors to finalize vaccination scenarios
- Jan 21 - Vaccination scenarios finalized - models can begin running
- Feb 10 - Model output uploaded to VIMC secretariat
- Feb 16 - Preliminary report draft and emailed to all contributors
- Feb 21 - Meeting all contributors to discuss model output
- Feb 23 - Meeting all contributors to finalize the report
- Feb 24 - Final report sent to SEAR
- Mar 14-16 - Regional consultation meeting
Project Details

- Time of interest: 2022 to 2040
- Countries of interest: Bangladesh, India, Indonesia, Myanmar, Nepal, Thailand
- 2 models for each disease simulated 200 times for each country
- 5 vaccination scenarios
Vaccination Scenarios

The vaccination scenarios specify:
- routine (MR1 and MR2) vaccination coverages
- MR vaccination campaign timing, age targets, and coverage

5 scenarios

- WUENIC routine child targeted campaigns
- Intensified routine child targeted campaigns
- Intensified routine child, adolescent, and adult targeted campaigns

Baseline
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Measles Nowcast:
Age-Specific Proportion Susceptible
by country 2019-2021, per the PSU model

![Graph showing age-specific proportion susceptible by country (BGD, IDN, IND, MMR, NPL, THA) over years 2019 to 2021. The x-axis represents age in years, while the y-axis represents the proportion susceptible. The graph contains six subplots, each representing a different country, with lines indicating the proportion susceptible over time.](image-url)
Vaccination Scenarios

The vaccination scenarios specify:

- routine (MR1 and MR2) vaccination coverages
- MR vaccination campaign timing, age targets, and coverage

5 scenarios

- Baseline
- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4

- WUENIC routine child targeted campaigns
- Optimistic
- Intensified routine child targeted campaigns
- Pessimistic
- Intensified routine child, adolescent, and adult targeted campaigns
- Optimistic
- Pessimistic
Conclusions

1. Achieving the conditions necessary for rubella elimination is highly probable for all vaccination scenarios by 2025.

2. Achieving the conditions necessary for measles elimination is probable under these vaccination scenarios.
   
   - By 2025 and 2026, the regional probability of achieving the conditions for elimination for all vaccination scenarios are at least 76% and 89%, respectively.

   - The timing and probability of achieving the conditions for elimination differ across vaccination scenario for each country.
Regional Probability of Achieving the Conditions for Rubella Elimination by a Given Year

The regional probability of a population-weighted average of country-specific probabilities that elimination is achieved by a given year.
Regional Probability of Achieving the Conditions for Measles Elimination by a Given Year

The regional probability of a population-weighted average of country-specific probabilities that elimination is achieved by a given year.

The chart shows the regional probability of achieving the conditions for measles elimination by a given year, based on different scenarios and baseline projections. The probabilities are represented by color gradients, with darker shades indicating lower probabilities and lighter shades indicating higher probabilities.
Regional Probability of Achieving the Conditions for Measles Elimination by a Given Year

The regional probability of a population-weighted average of country-specific probabilities that elimination is achieved by a given year.

Optimistic Scenarios for Improvement in Routine Coverage
Regional Probability of Achieving the Conditions for Measles Elimination by a Given Year

The regional probability of a population-weighted average of country-specific probabilities that elimination is achieved by a given year.

Scenarios for Targeting Adolescents and Adults
Country-Specific Probability of Achieving the Conditions for Measles Elimination by a Given Year

<table>
<thead>
<tr>
<th>Country</th>
<th>2025</th>
<th>2030</th>
<th>2040</th>
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<tbody>
<tr>
<td>Bangladesh</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
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<tr>
<td>India</td>
<td>0.92</td>
<td>0.92</td>
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<tr>
<td>Indonesia</td>
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<tr>
<td>Myanmar</td>
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<tr>
<td>Nepal</td>
<td>0.94</td>
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<tr>
<td>Thailand</td>
<td>0.97</td>
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</tbody>
</table>

The probability that conditions for elimination have been achieved by a given year.
Country-Specific Probability of Achieving the Conditions for Measles Elimination by a Given Year

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<tr>
<th>Country</th>
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The probability that conditions for elimination have been achieved by a given year.
## Country-Specific Probability of Achieving the Conditions for Measles Elimination by a Given Year

**DynaMice**

<table>
<thead>
<tr>
<th>Scenario 1</th>
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### Probability that Conditions for Elimination Have Been Achieved by a Given Year

The probability values range from 0.00 to 1.00, with darker shades indicating a higher probability of achieving the conditions for measles elimination by a given year.
Conclusions

1. Achieving the conditions necessary for rubella elimination is highly probable for all vaccination scenarios by 2025

2. Achieving the conditions necessary for measles elimination is probable under these vaccination scenarios.

- By 2025 and 2026, the regional probability of achieving the conditions for elimination for all vaccination scenarios are at least 76% and 89%, respectively

- The timing and probability of achieving the conditions for elimination differ across vaccination scenario for each country
Contributors

**WHO South-East Asia** (Sudhir Khanal, Sunil Bahl, Patrick O’Connor)

**US Centers for Disease Control and Prevention** (Michelle Morales)

**Bill and Melinda Gates Foundation** (Arindam Ray, Niket Thakkar)

**India National Disease Modelling Consortium** (Siuli Mukhopadhyay, Rama Pal)

**Vaccine Impact Modelling Consortium** (Caroline Trotter, Kim Woodruff, Anna-Maria Hartner, Matt Ferrari, Emilia Vynnycky, Timos Papadopoulos, Mark Jit, Han Fu, Amy Winter)

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Supplemental Slides
Figure 1: Probability that the conditions for rubella elimination (\(\leq 5\) infections per one million population) have been achieved by a given year (x-axis) for each country (y-axis), scenario (panel rows), and model (panel columns).
Figure 2: Annually estimated mean number of CRS cases (2022 - 2040) for each scenario (panel rows), model (panel columns), and country (colors)

Indonesia: 217
Myanmar: 419
Thailand: 8
Myanmar: 166
Myanmar: 420
Thailand: 3
Myanmar: 167
Myanmar: 421
Thailand: 6
Figure 3: Annually estimated mean number of measles infections (2022 - 2040) for each scenario (panel rows), model (panel columns), and country (colors)
Figure 4: Annually estimated mean probability of achieving conditions for measles elimination (<= 5 infections per one million population) (2022 - 2040) for each country (panel rows), model (panel columns) and scenario (line colors).
Bangladesh
Vaccination Scenarios (Baseline, Scenario1, Scenario2, Scenario3, Scenario4)
India
Vaccination Scenarios (Baseline, Scenario1, Scenario2, Scenario3, Scenario4)

The diagram shows the vaccination coverage (percentage) for different target populations in India over the years 2020 to 2040. The target populations are divided into 1-4 years and 5-15 years old. The scenarios are represented by lines and markers, with different colors and styles for each scenario (MR1, MR2, SIAs). The vaccination coverage is expected to increase significantly over the years, with different projection rates for each scenario.
Myanmar
Vaccination Scenarios (Baseline, Scenario1, Scenario2, Scenario3, Scenario4)

Years: 2020, 2025, 2030, 2035, 2040

Target Population:
- 1-4
- 15-30

Scenarios:
- Baseline (bl)
- Scenario 1 (s1)
- Scenario 2 (s2)
- Scenario 3 (s3)
- Scenario 4 (s4)

Vaccination Coverage (percentage)
Nepal
Vaccination Scenarios (Baseline, Scenario1, Scenario2, Scenario3, Scenario4)

Nepal
Vaccination coverage (percentage)

target population

year

vaccination coverage (percentage)

scenario

MR1

MR2

SIAs

2020 2025 2030 2035 2040

2020 2025 2030 2035 2040

2020 2025 2030 2035 2040

1 4

20 40

bl

s1

s2

s3

s4
Thailand
Vaccination Scenarios (Baseline, Scenario1, Scenario2, Scenario3, Scenario4)

Target population: 1–4 (yellow line), 20–40 (green line)
Scenario: baseline (BL), Scenario1 (s1), Scenario2 (s2), Scenario3 (s3), Scenario4 (s4)