Measles elimination strategies in Kenya: a modelling study

Goal: Measles elimination in Kenya by 2030

Defined as *the absence of endemic measles virus transmission for ≥12 months in the presence of a high-quality surveillance system*

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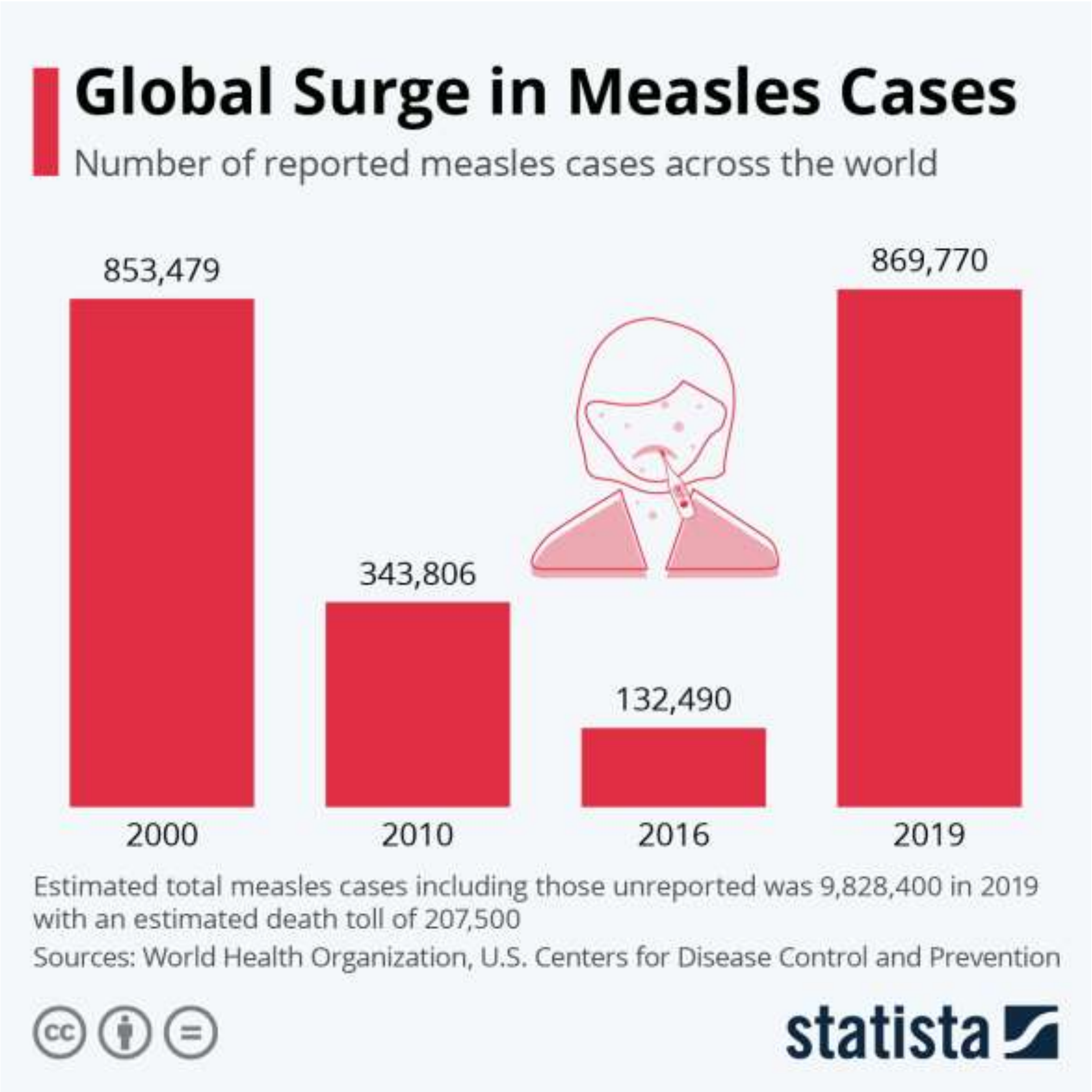
~~Eliminate measles in at least five WHO regions by 2020~~

Achieve measles elimination in 80% of countries in AFRICA by 2030

95% MCV1 and 2 coverage with SIAs to maintain population immunity at 95%



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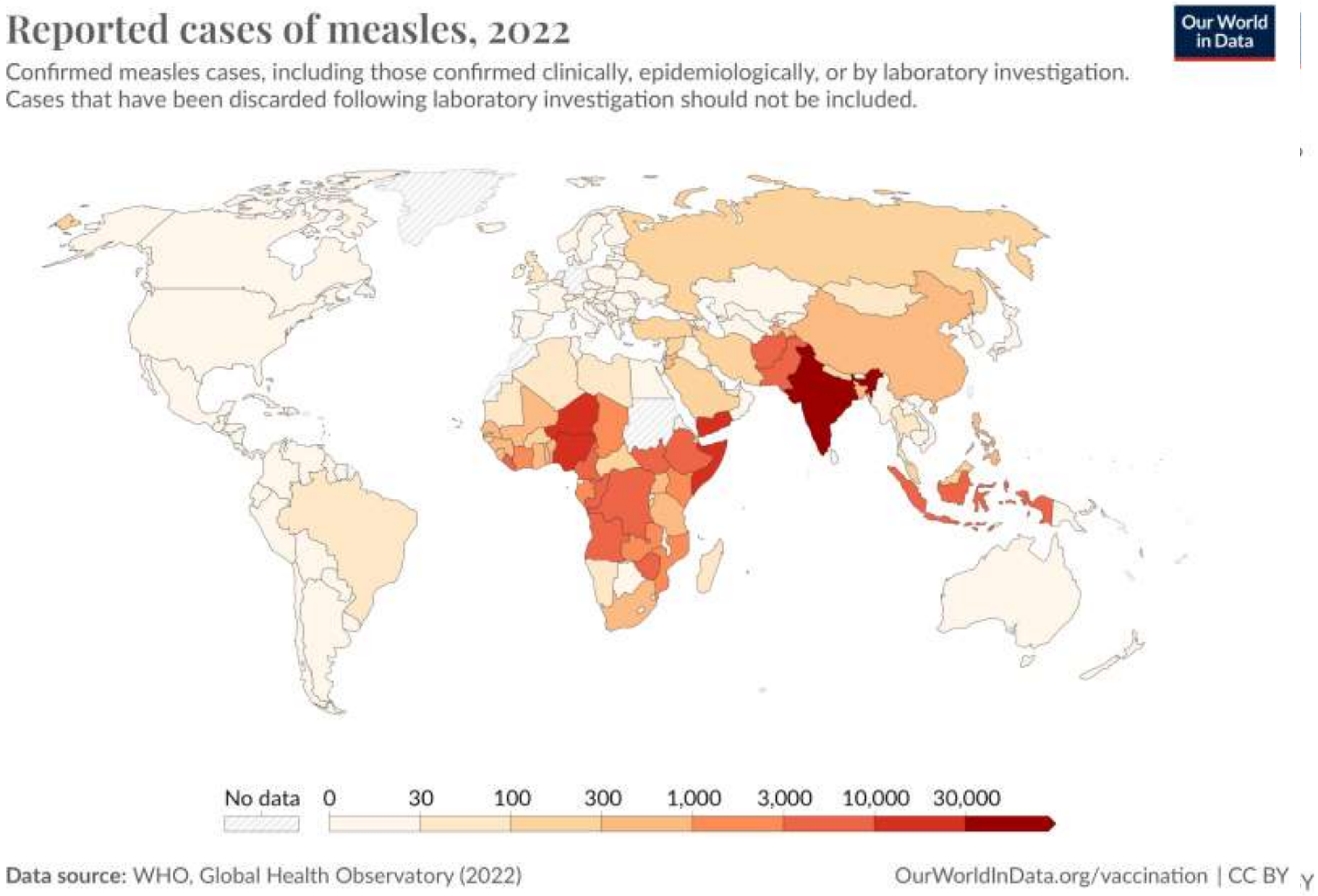
Research gap

- Measles transmission continues despite improvements in measles vaccination
- Most countries failed to meet 2020 targets
- Kenya reports up to 3000 cases each year



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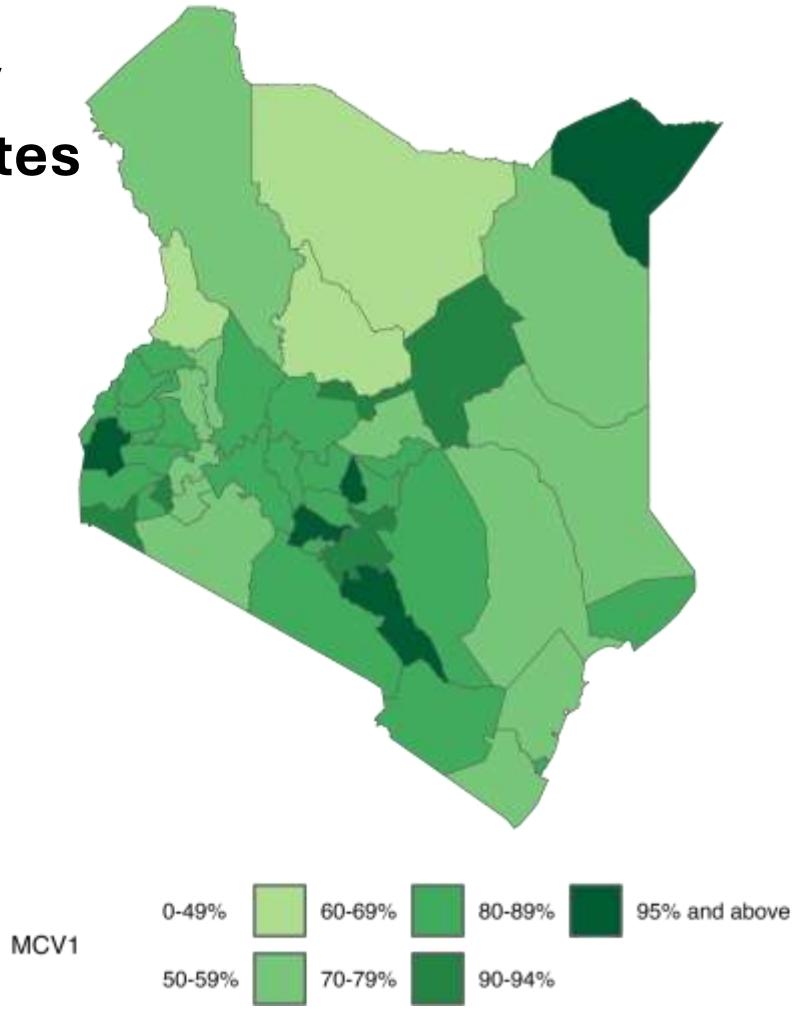
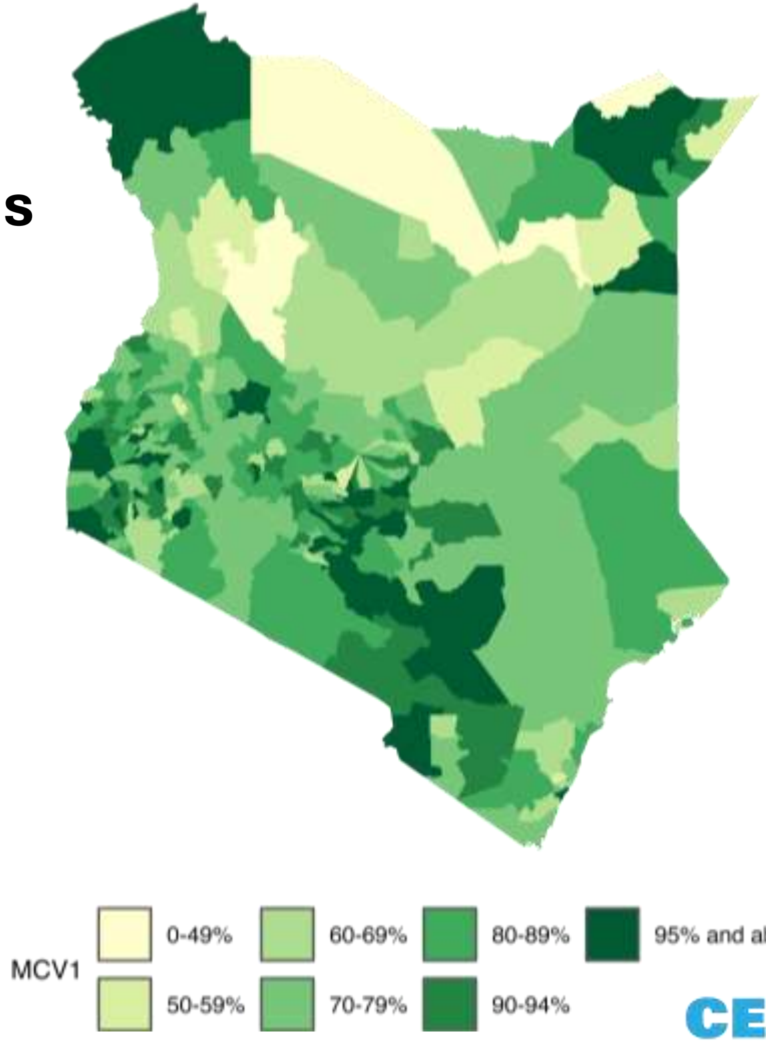
MCV 1 coverage Kenya in 2023 (83%)

County estimates



Sub county estimates



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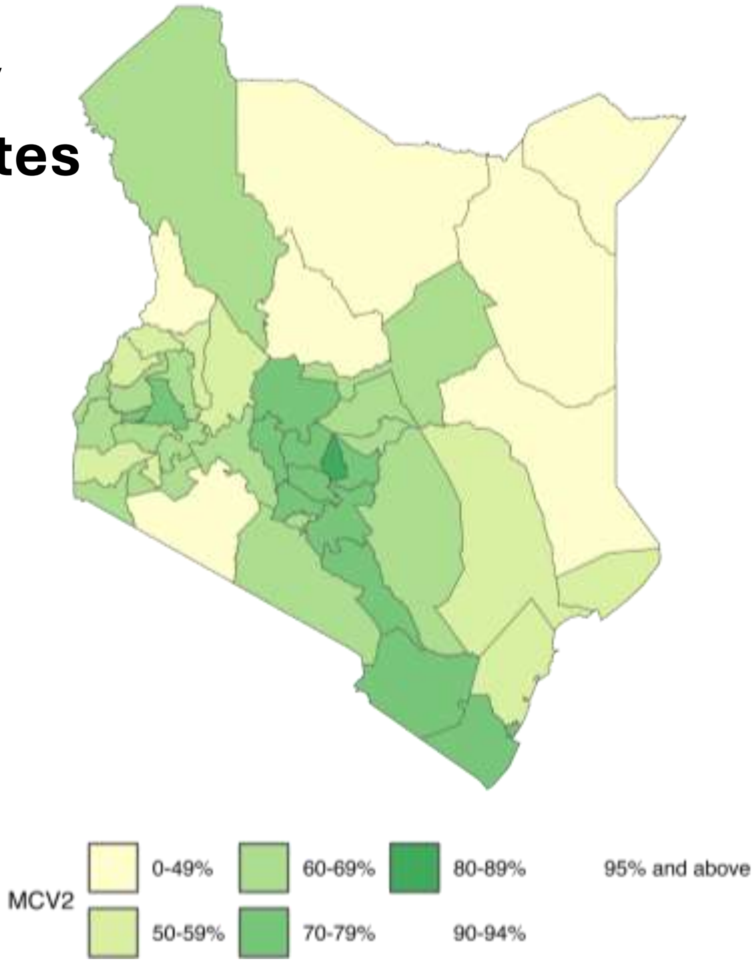
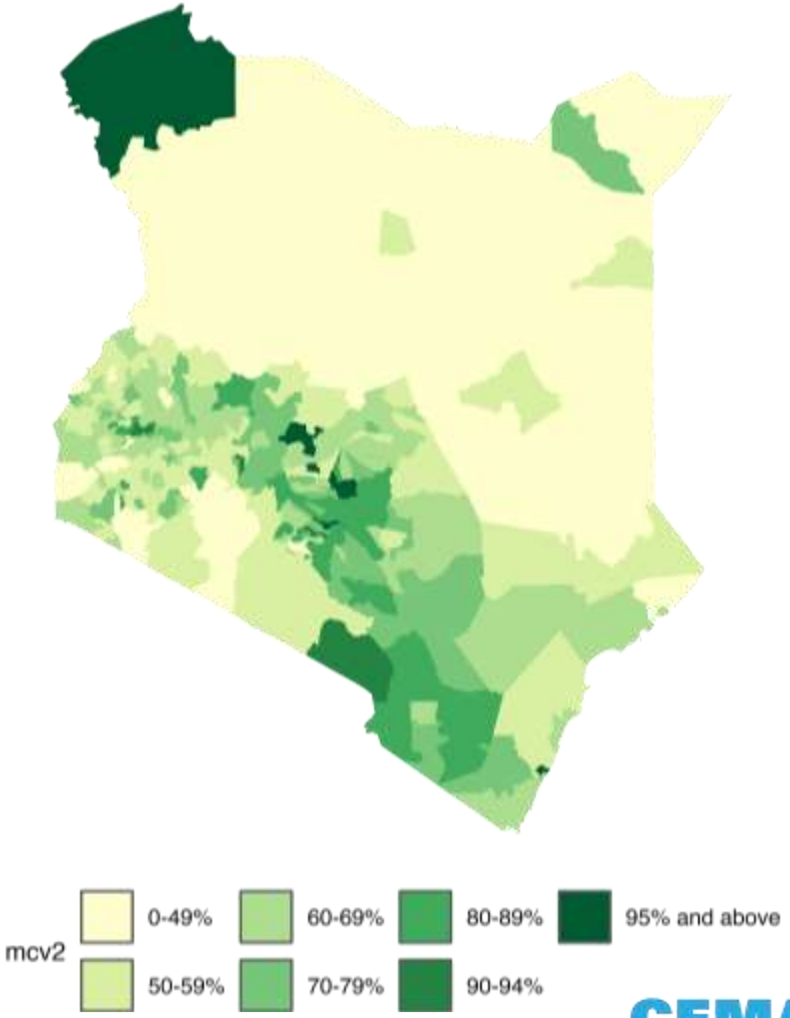
MCV 2 coverage Kenya in 2023 (62%)

County estimates



Sub county estimates



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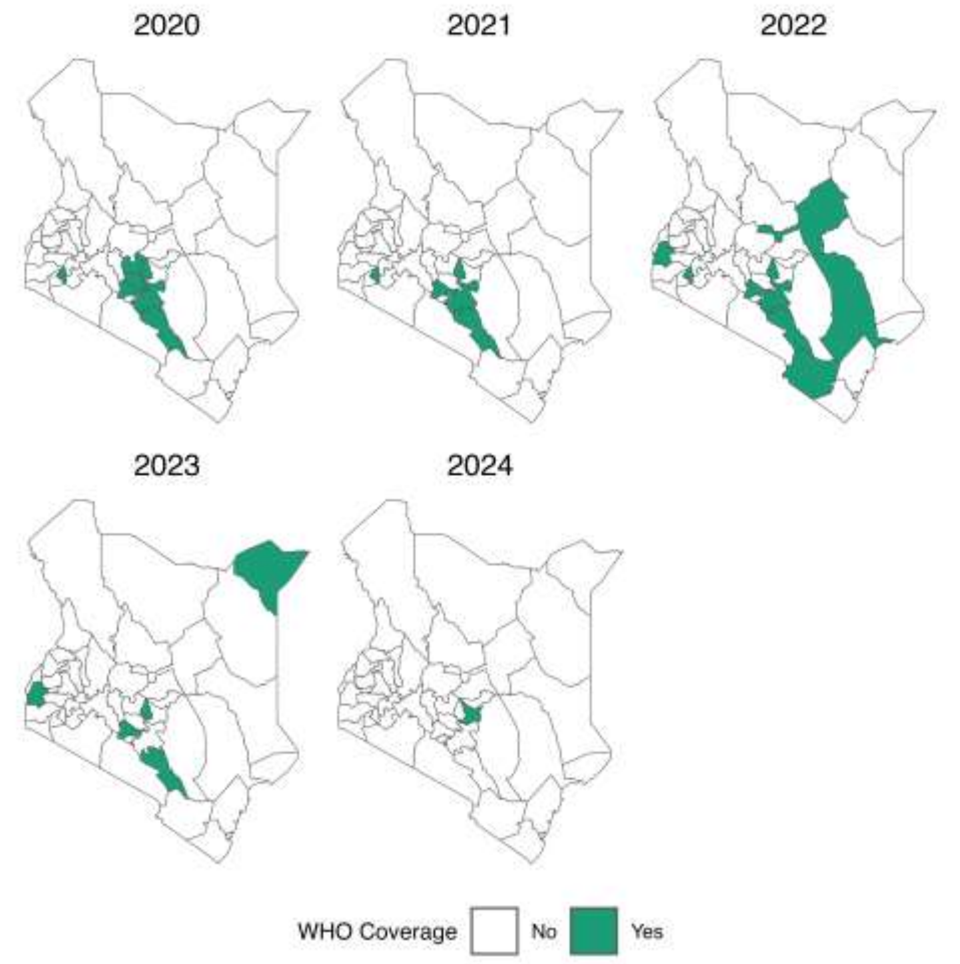
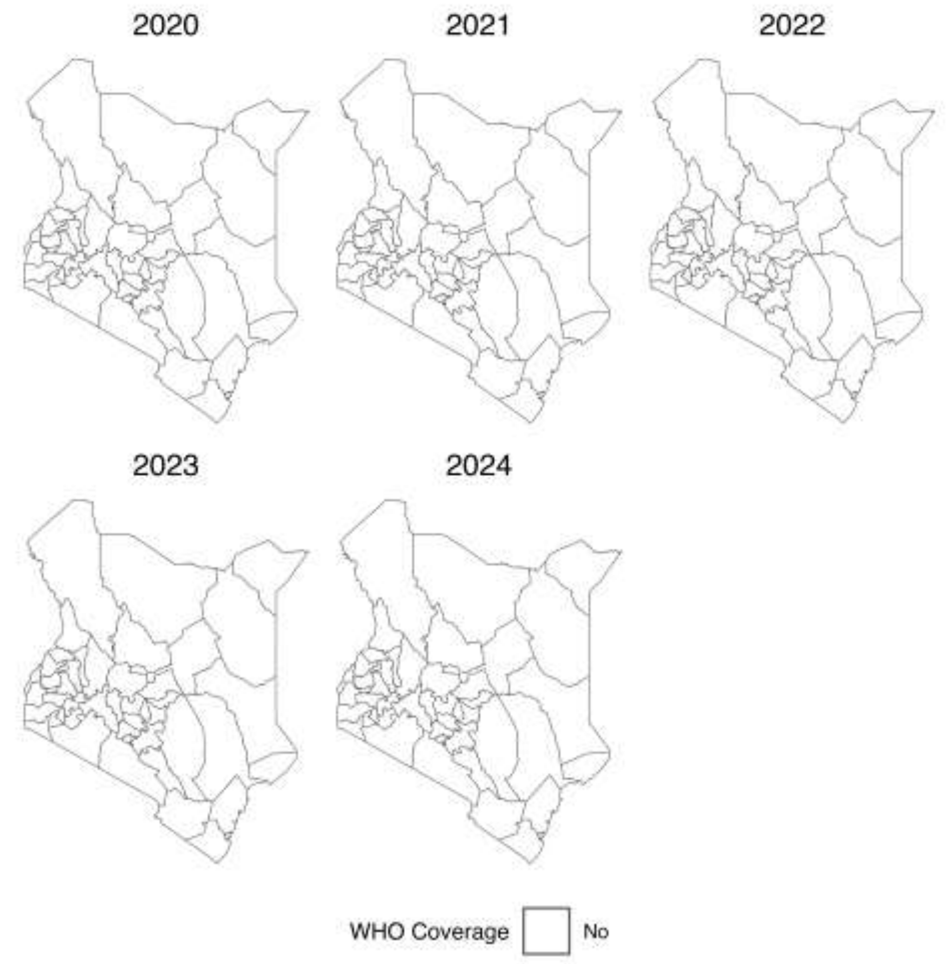
WHO recommended vaccination coverage

MCV1



MCV2



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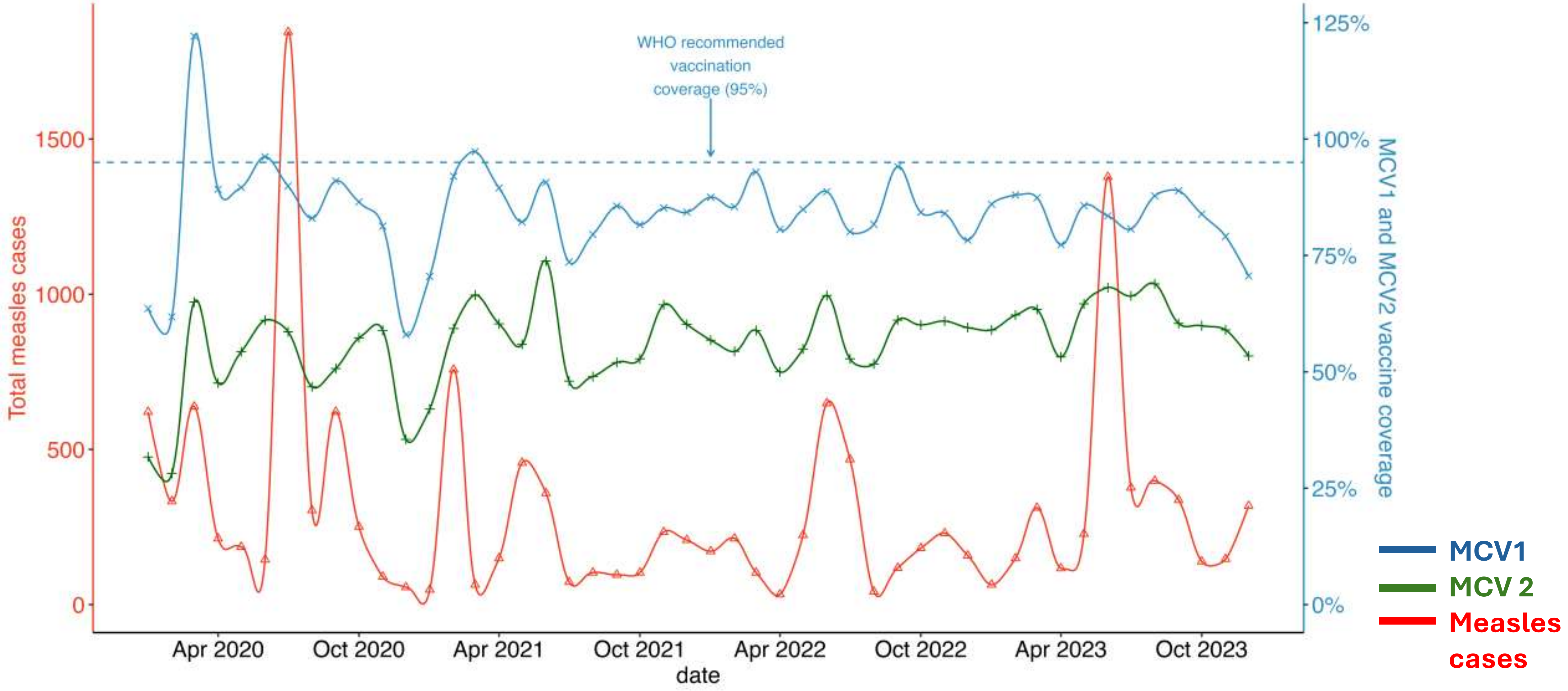
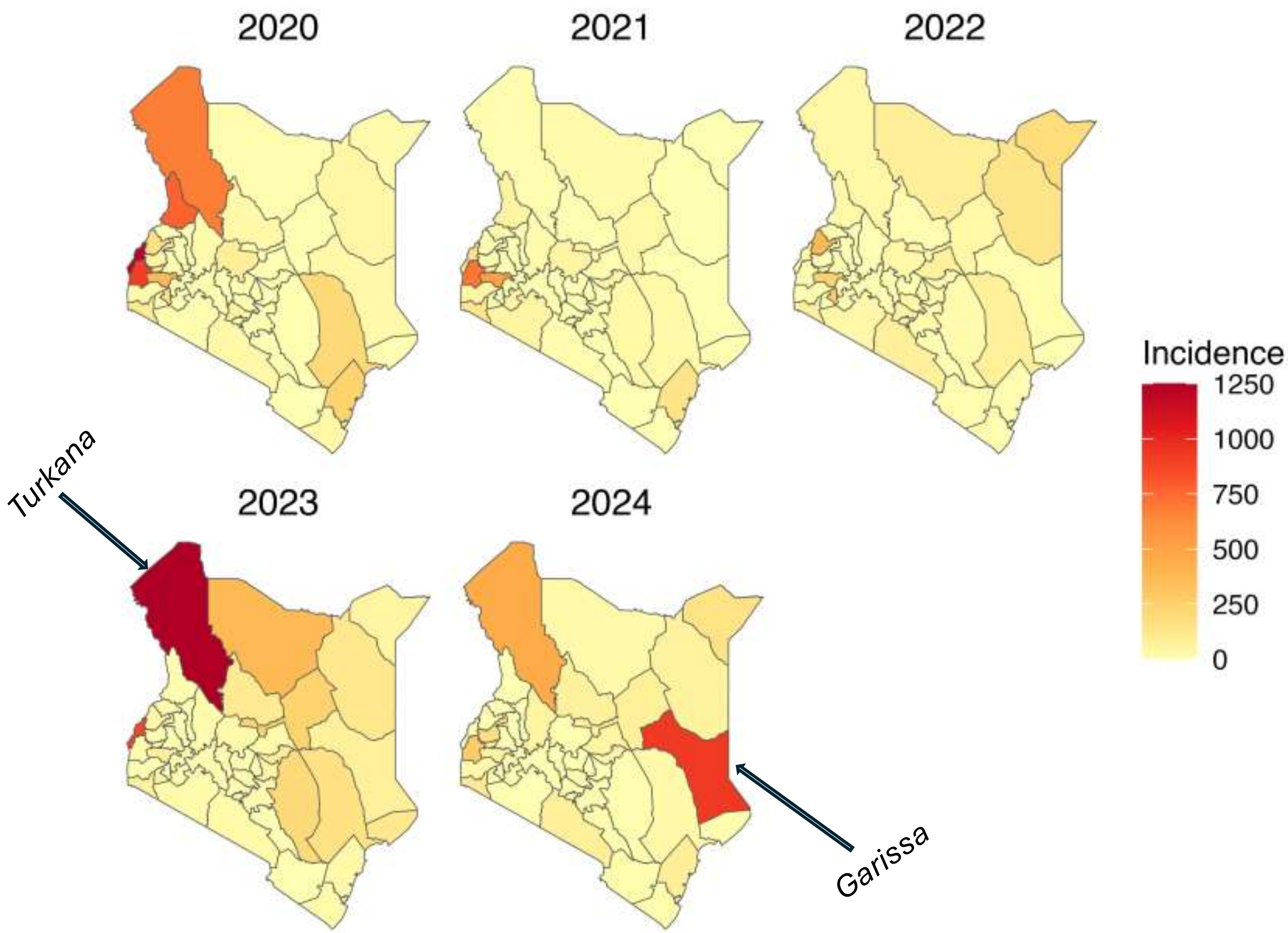
MCV coverage and measles infections in Kenya Jan ‘20 – Dec ‘23



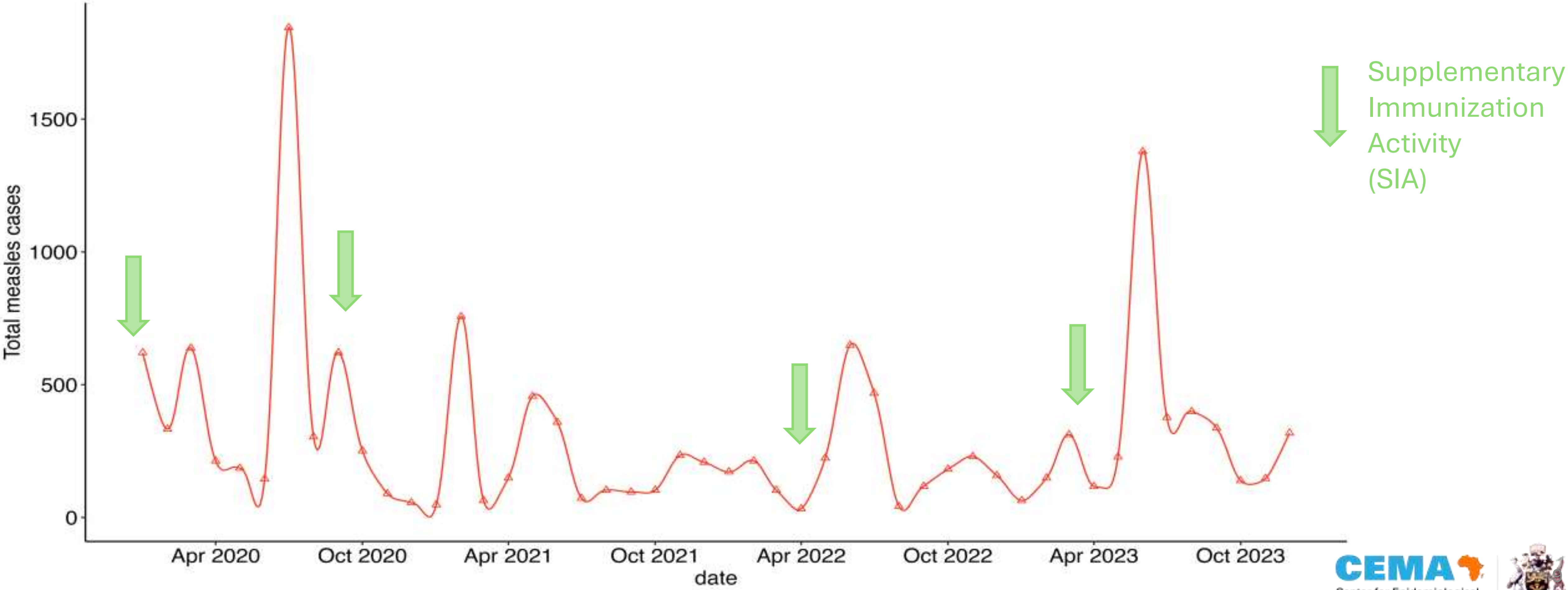
County measles incidence

- Turkana county has had periodic measles incidence
- Most counties had <250 measles incidence.



Research question

What are the optimal vaccination strategies to achieve measles elimination in Kenya by 2030?



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Agent based model Starsim (SEIR)

Setting: Kenya – Counties

Time horizon: 2020 - 2040

Parameters
Transmissibility: 0.9
CFR: 5%[2]
Contacts: 4 per
Birth rate: 27 per 1000[1]
Death rate: 8 per 1000[1]
MCV 1 effectiveness: 85%[2]
MCV 2 effectiveness: 95%[2]

Intervention:
SIA (measles campaign)

Outcome: no. of infections

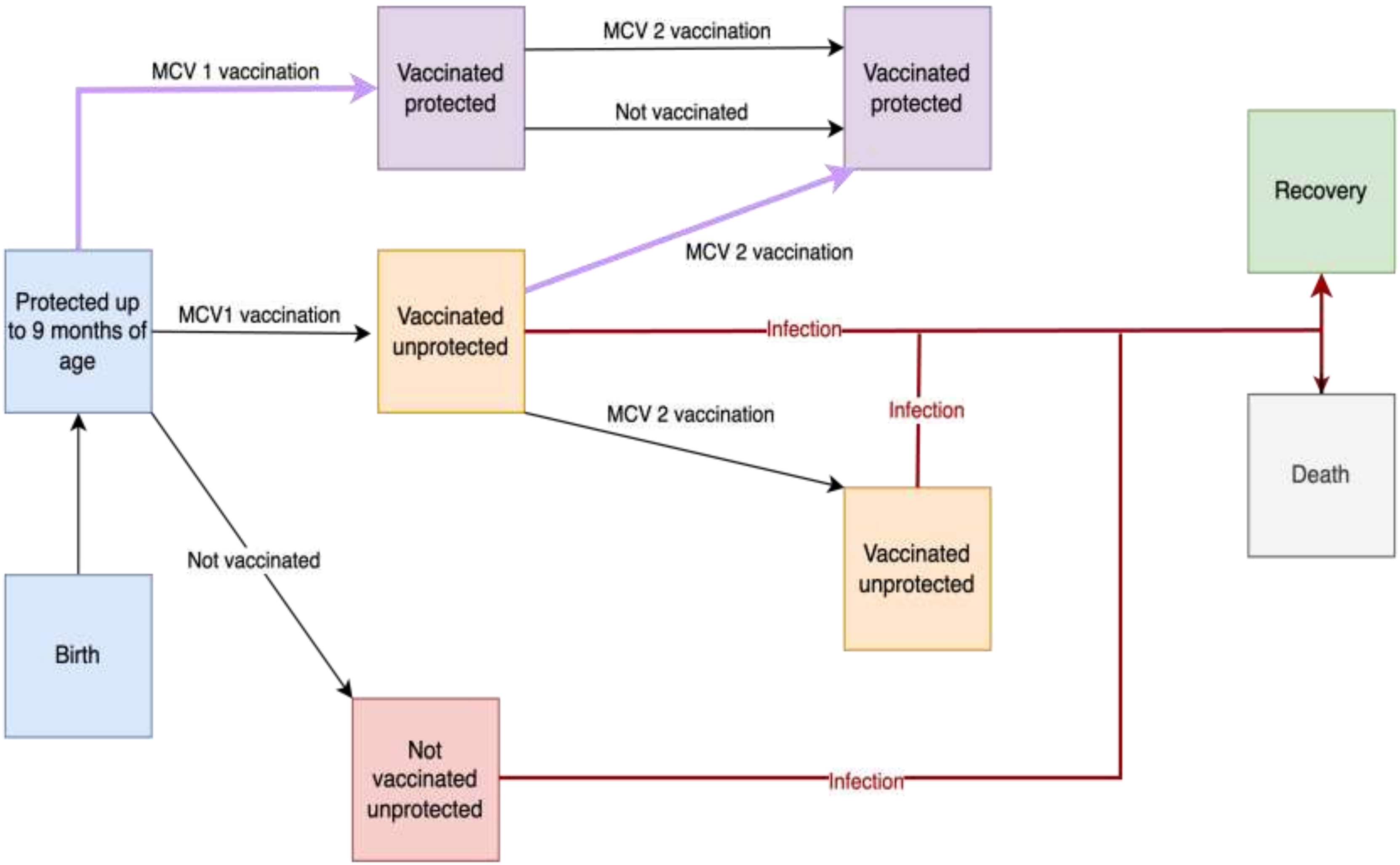

Figure: ABM flow chart

NB: Additional measles doses beyond MCV1 are to protect children who did not develop protective immunity after the 1st dose.
SIAs can reach up to 85% of previously unvaccinated and vaccinated children.

1. Macrotrends; 2. WHO

Results: MCV coverage that will achieve 2030 elimination strategy

Measles vaccine dose 1 coverage	Measles vaccine dose 2 coverage	Number of years
95%	0%	4
95%	10%	4
95%	20%	4
95%	30%	4
95%	40%	4
95%	50%	3
95%	60%	3
95%	70%	3
95%	80%	3
95%	95%	3

Makueni County

- *Scenario: An area with a low incidence of measles (1case per a million)*
- *Maintenance of MCV1 at >95% for 4 years prior to 2020*
- *Maintenance of the 95% coverage of MCV1 would reach the county to elimination within the 2030 target*

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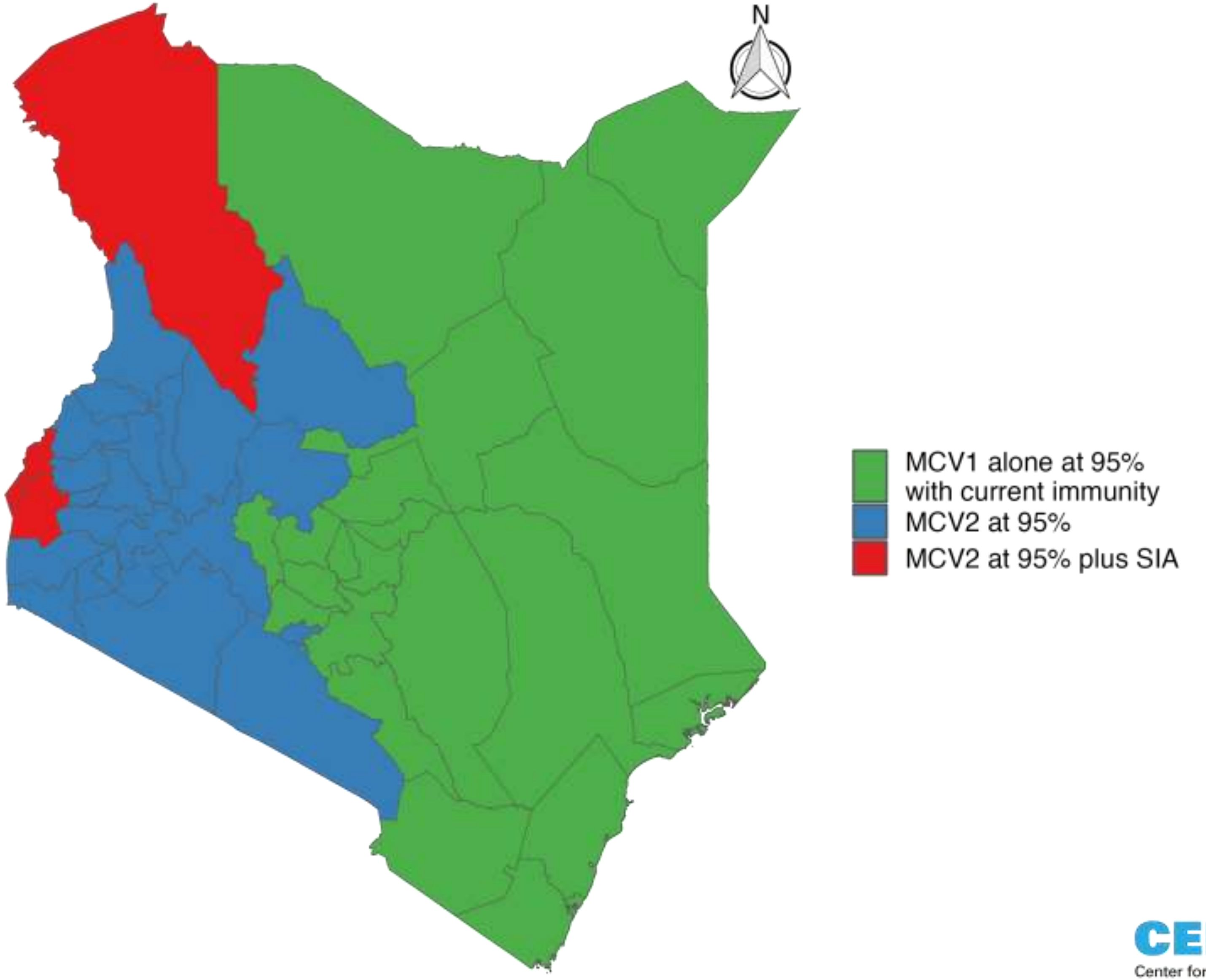
Results: MCV coverage that will achieve 2030 elimination strategy

Measles vaccine dose 1 coverage	Measles vaccine dose 2 coverage	Number of years
95%	0%	>20
95%	10%	>20
95%	20%	>20
95%	30%	>20
95%	40%	>20 (2045)
95%	50%	10
95%	60%	10
95%	70%	10
95%	80%	10
95%	95%	10

Kisumu County

- *Scenario: An area with a moderate incidence of measles (300 cases per a million)*
- *Maintenance of MCV1 at >95% and MCV2 at 80%.*

Interventions required to meet 2030 elimination targets



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Uncertainty and Limitations

- Assumptions – random contact rates, vaccine effectiveness, campaign coverage (reaching the unvaccinated child), perfect surveillance system
- Incorporating uncertainty/stochasticity for incidence of measles cases (cross sub count/border movements)
- Incorporating uncertainty around results


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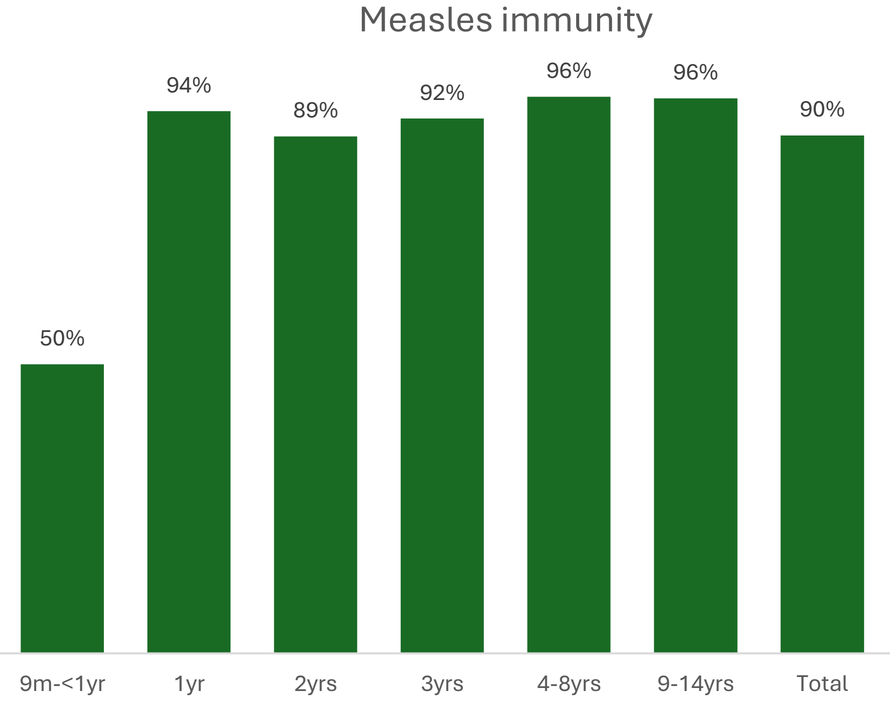
The importance of supplementary immunisation activities to prevent measles outbreaks during the COVID-19 pandemic in Kenya

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Use of the revised World Health Organization cluster survey methodology to classify measles-rubella vaccination campaign coverage in 47 counties in Kenya, 2016


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Factors affecting the infant antibody response to measles immunisation in Entebbe-Uganda

HIV, wasting

What we are currently implementing...

- Vaccination for children between (9-12months for MCV1 and 18-24months for MCV2).
- Waning of maternal immunity for children between (0 to 9months).
- Initial immunity, contact rate and initial prevalence parameters.
- Seasonality in measles transmission parameter.

$$\beta(t) = \beta_0(1 + \alpha \cos(2\pi t)$$ [1,2]

Determinants of measles persistence in Beijing, China: A modelling study

Jianjiu Chen[1], Wenyi Zhang[2], Yong Wang[2] and Wan Yang[1,3]

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Abstract

In Beijing, the capital of China, routine measles mass vaccination has been in place for decades with high coverage; and since the 2000s, catch-up vaccination programmes have been implemented for migrant workers coming to the city. However, measles epidemics in Beijing persisted. Here, we explored the contributing factors of persistent measles transmission in Beijing using an epidemic model in conjunction with a particle filter. Model inputs included data on birth, death, migration, and vaccination. We formulated a series of hypotheses covering the impact of migrant influx, early waning of maternal immunity, and increased mixing among infants; we compared the plausibility of the hypotheses based on model fit to age-grouped, weekly measles incidence data from January 2005 to December 2014, and out-of-fit prediction during 2015–2019. Our best models showed close agreement with the data, and the out-of-fit prediction generally captured the trend of measles incidence from 2015 to 2019. We found that large influx of migrants with considerably higher susceptibility likely contributed to the persistent measles transmission in Beijing. Our findings suggest that stronger catch-up vaccination programmes for migrants may help eliminate measles transmission in Beijing.

A century of transitions in New York City's measles dynamics

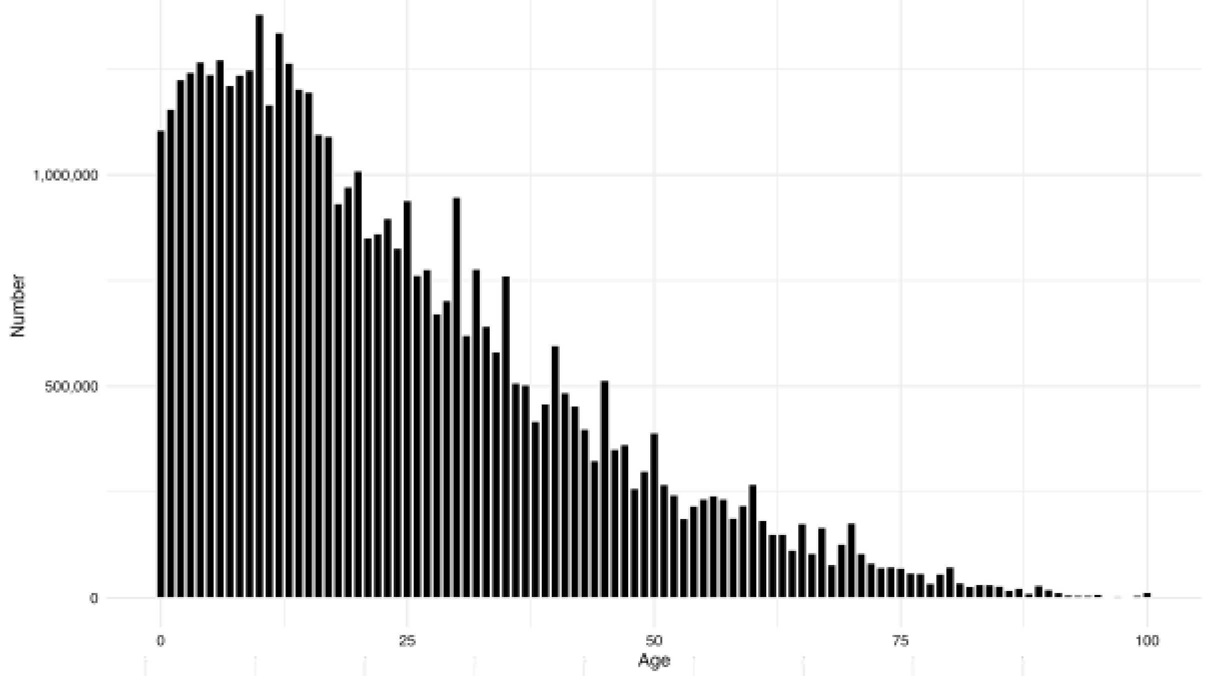
Karsten Hempel and David J. D. Earn

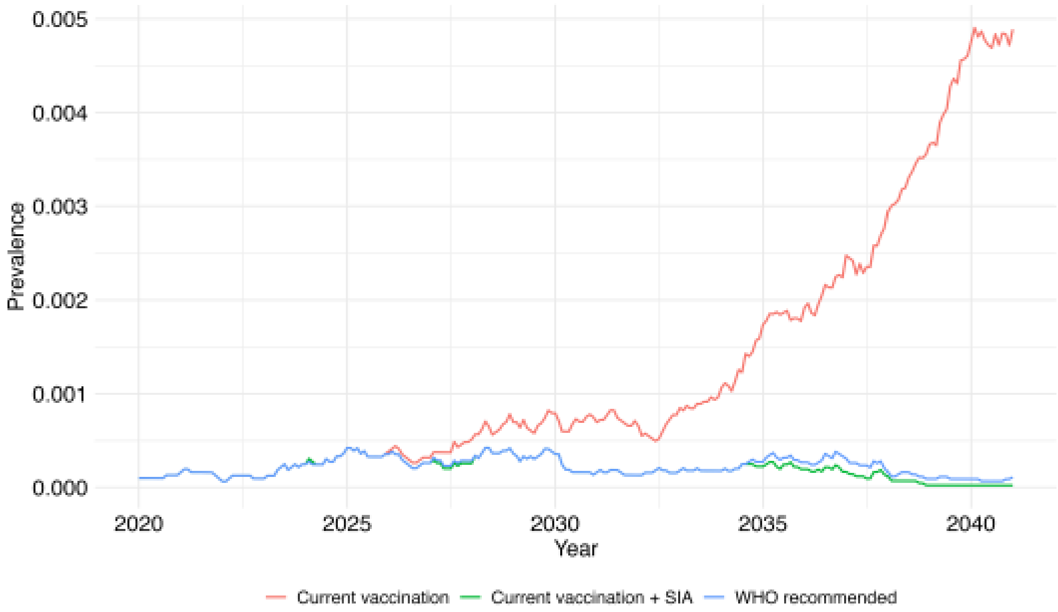
Department of Mathematics and Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario, Canada L8S 4K1

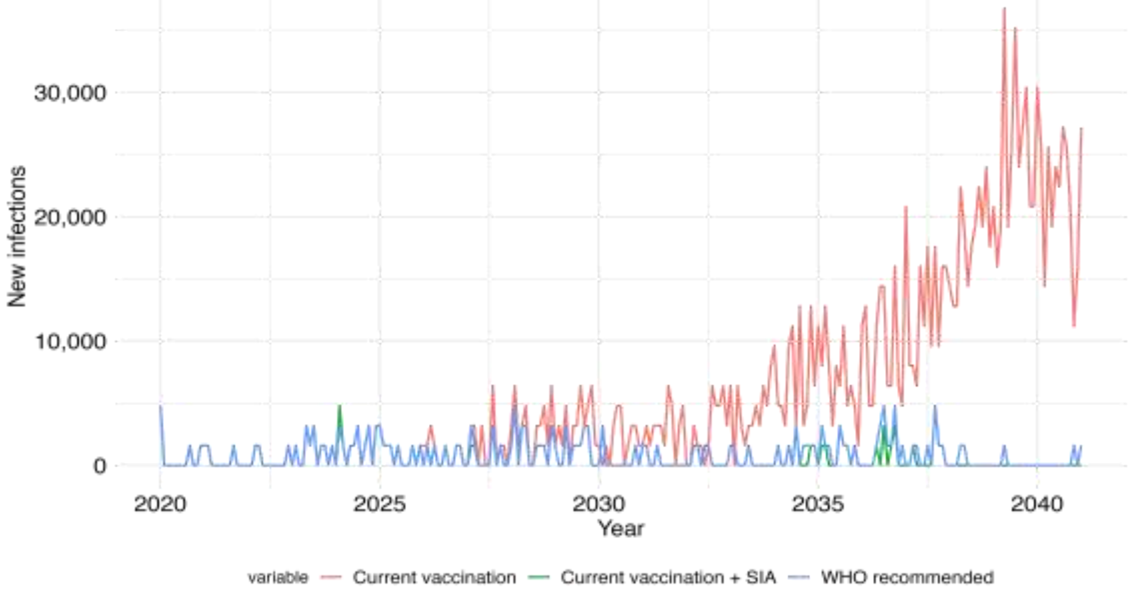
Infectious diseases spreading in a human population occasionally exhibit sudden transitions in their qualitative dynamics. Previous work has successfully predicted such transitions in New York City's historical measles incidence using the seasonally forced susceptible–infectious–recovered (SIR) model. This work relied on a dataset spanning 45 years (1928–1973), which we have extended to 93 years (1891–1984). We identify additional dynamical transitions in the longer dataset and successfully explain them by analysing attractors and transients of the same mechanistic epidemiological model.

1. A century of transitions in New York City's measles dynamics
2. Determinants of measles persistence in Beijing, China: A modelling study

- Kenya age structure
- Age of vaccination
- Maternal immunity
- Starting parameters such as initial immunity and initial prevalence
- Age structured contact rate







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Next steps

Model improvement

- Model calibration with Kenyan data.
- Incorporation of effects of HIV and wasting on developing immunity
- Test different SIA scenarios at a sub national level (sub county)

Outputs

- Sub county analysis
- Optimal number and frequency of SIAs to reach elimination goal (at the sub county level)
- Cost effectiveness analysis of SIA – what is the cost of reaching 1 unvaccinated child through SIA

Conclusion from preliminary results

- Differences in measles incidence and MCV coverage between sub national units
- A uniform strategy to eliminate measles in Kenya is not appropriate – wastage of resources

AT WHAT COST?

ECONOMIC EVALUATION

Vaccines (Basel). 2020 Jun; 8(2): 218. PMCID: PMC7349949
Published online 2020 May 13. doi: 10.3390/vaccines8020218 PMID: 32414021

Are the Objectives Proposed by the WHO for Routine Measles Vaccination Coverage and Population Measles Immunity Sufficient to Achieve Measles Elimination from Europe?

Pedro Plans-Rubió[1,2]

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Time for Q and A