Estimating the historical impact of outbreak response immunization programs across 210 outbreaks in low- and middle-income countries

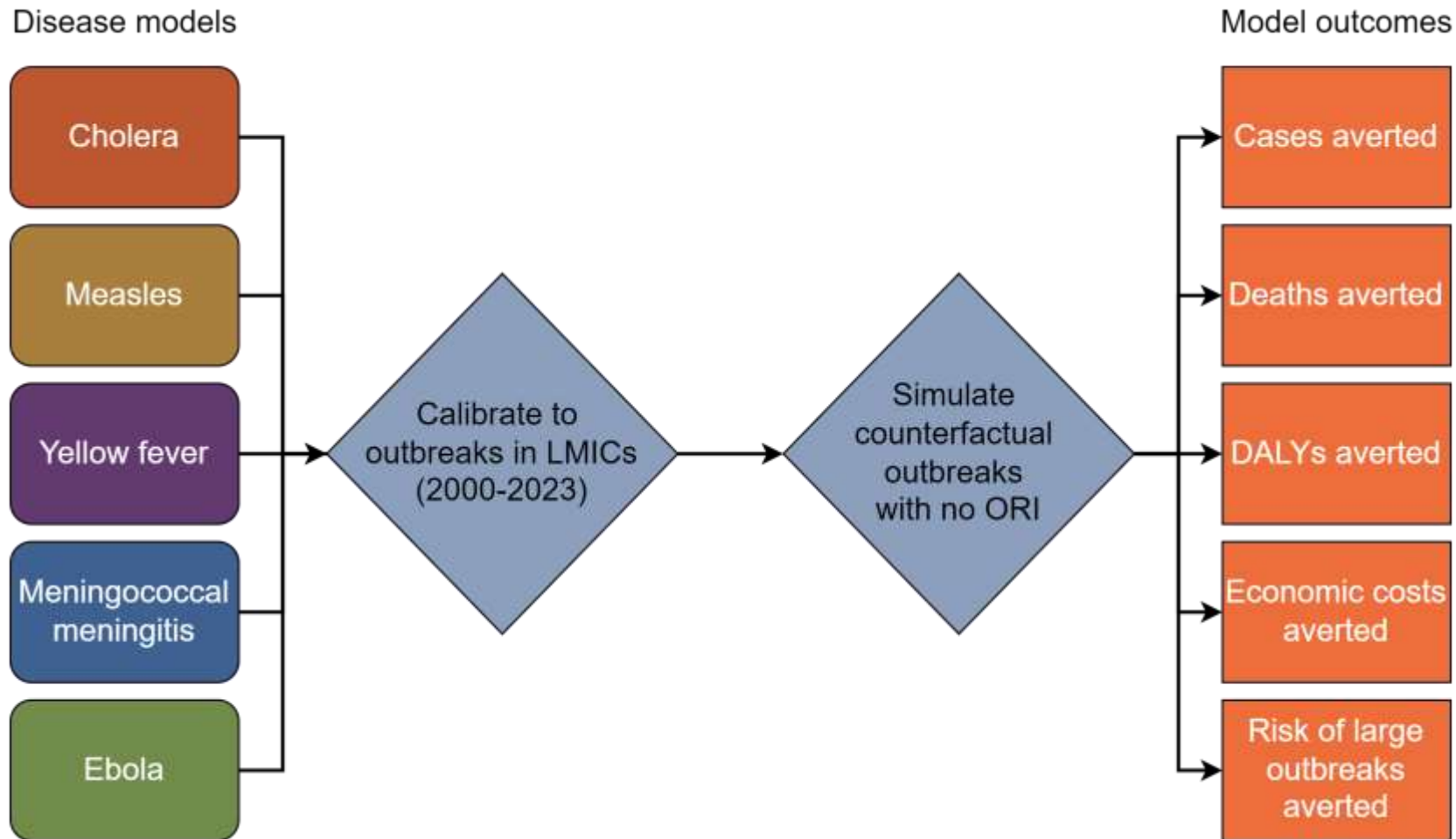Measles, cholera, yellow fever, meningococcal meningitis, Ebola

01 October 2024

Burnet
reach for the many

Overview

- Evidence is needed to quantify the value of vaccine stockpiles for **outbreak response immunization (ORI)** to inform future investment by Gavi, the Vaccine Alliance and other funders

Methods

- Model choice and implementation:
  - **Agent-based models**;
  - Used *Starsim* for five disease models with consistent characteristics and implementations.

Disease	Key features
Measles	Highly infectious, routine vaccination, primarily in young children
Cholera	Environmental transmission, WASH programs
Yellow fever	Vector-borne transmission, routine vaccination, impacted by temperature/rainfall
Meningococcal meningitis	Highly seasonal, high asymptomatic presentation, two vaccine types
Ebola	Very deadly, contact tracing key part of response, transmissible from corpses

ORI impact

- Error bars coloured by assigned **response time.**
- ORI found to have **higher impact** in settings with **faster response times.**
- In data, cholera outbreaks typically last **4-6 months** unless very large.

Proportion of cases/deaths (%) averted by the ORI for cholera
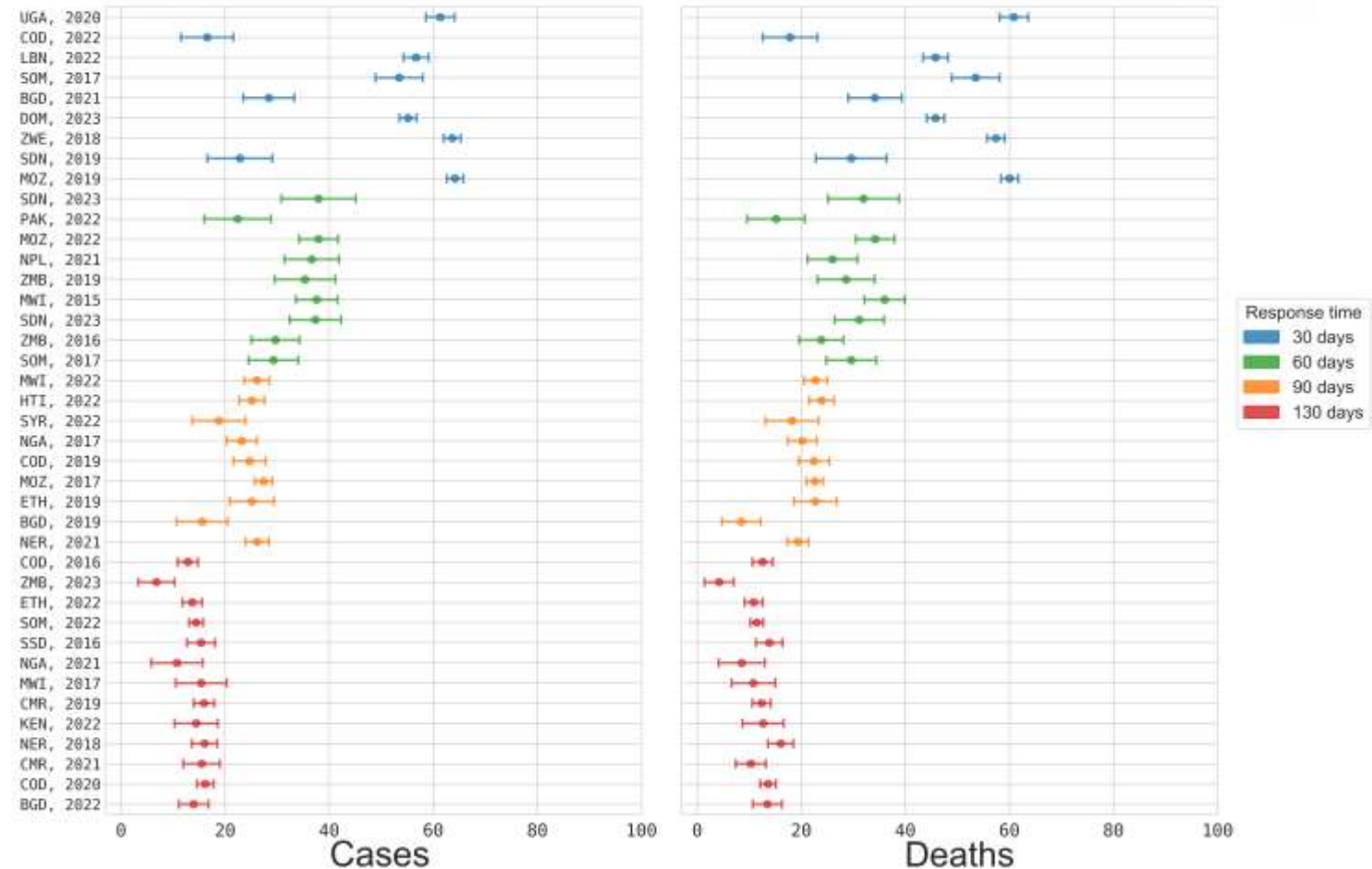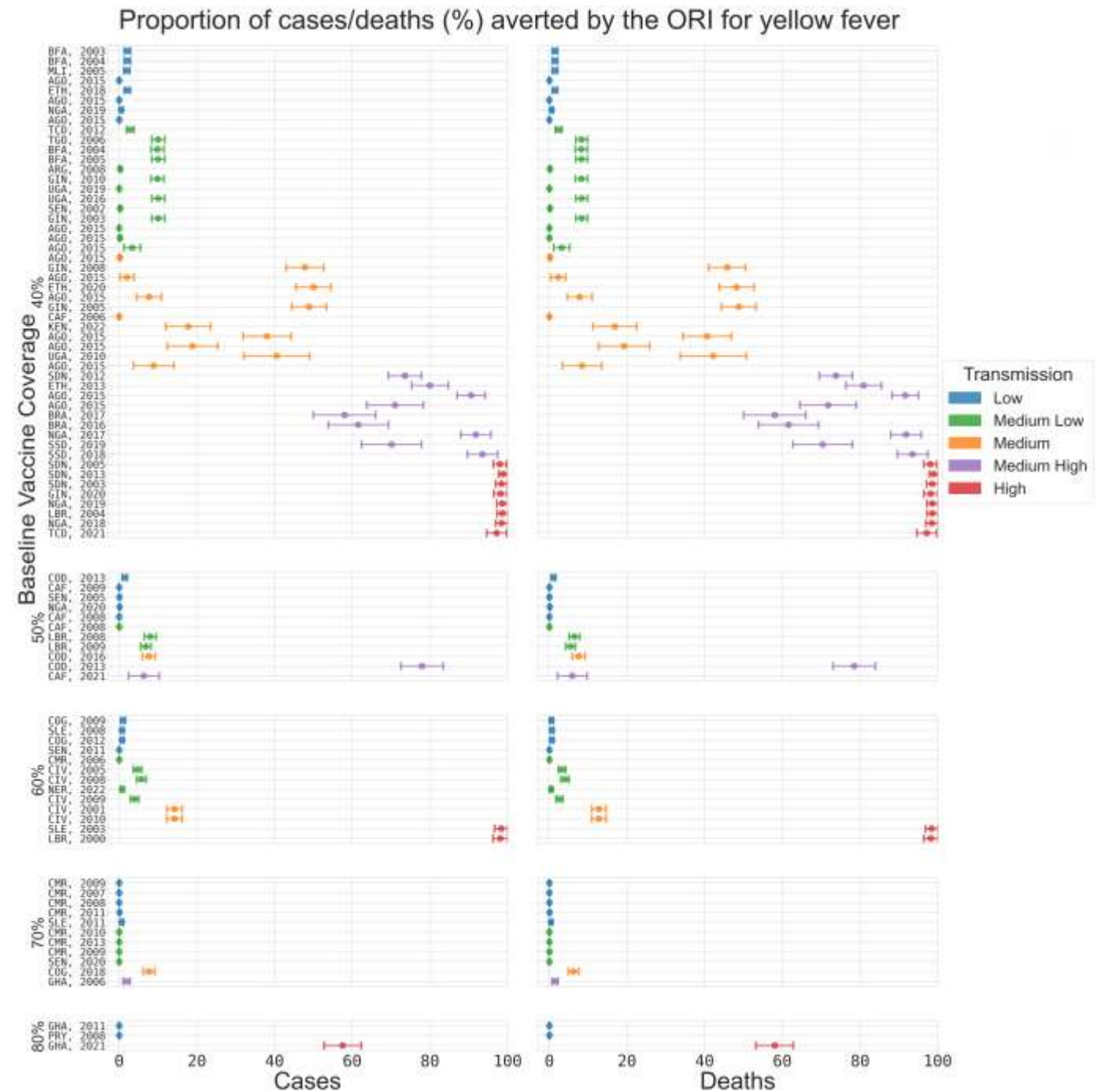
Measles
ORI impact

- Error bars coloured by assigned **response time.**

- Outbreaks grouped **by baseline vaccine coverage.**

- ORI found to have **higher impact** in settings with **lower baseline coverage.**

- Highlights the importance of routine vaccination campaigns.

Proportion of cases/deaths (%) averted by the ORI for measles
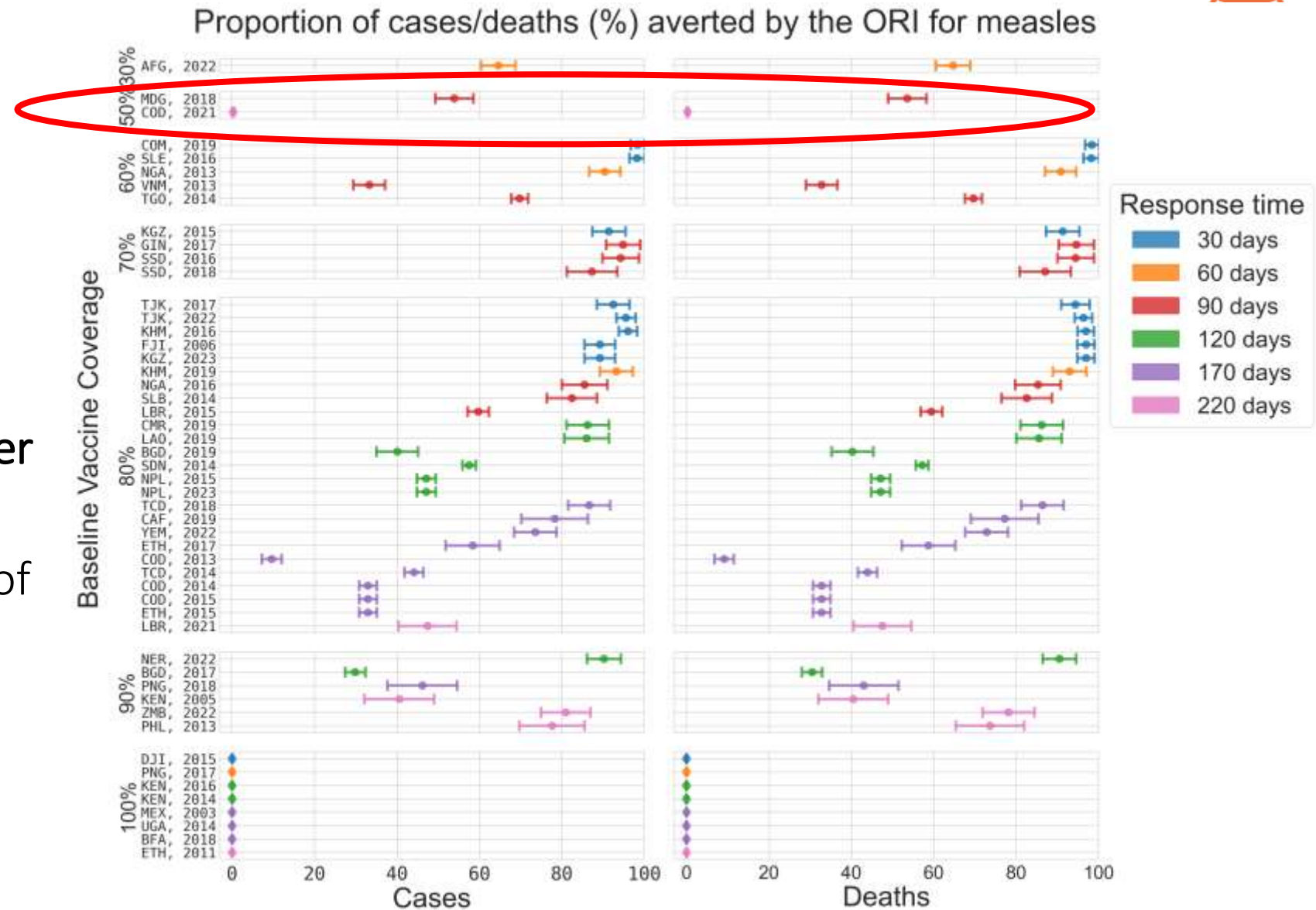
Yellow Fever

ORI impact

- Error bars coloured by **transmission level** (effect of rainfall/temperature).

- Outbreaks grouped by **baseline vaccine coverage.**

- ORI found to have **higher impact** in settings with **higher transmission level.**

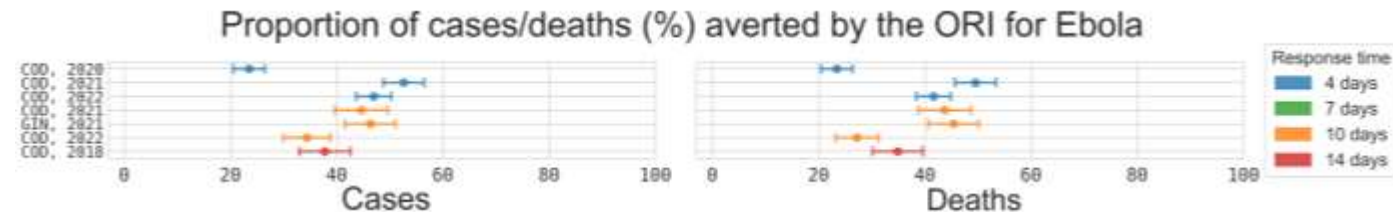Proportion of cases/deaths (%) averted by the ORI for yellow fever

ORI impact - meningitis

- Error bars coloured by assigned **response time.**

- Outbreaks grouped by **vaccine type** used in response.

- ORI found to have **higher impact** in settings with **faster response times.**
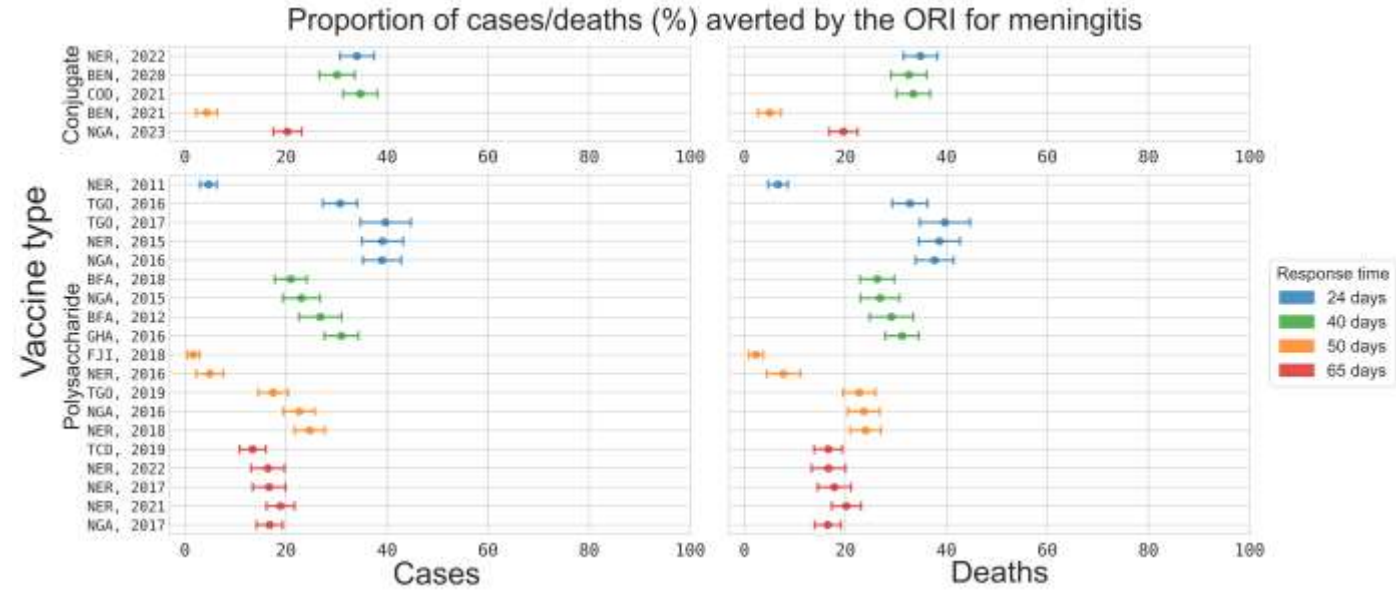
ORI impact - Ebola

- Error bars coloured by assigned **response time.**

- ORI impact varied by outbreak, but even without vaccine response any counterfactual would be constrained by contact tracing and quarantine/isolation.

Proportion of cases/deaths (%) averted by the ORI for meningitis

Proportion of cases/deaths (%) averted by the ORI for Ebola

Impact on outbreak size

- Across 5 diseases, presence of ORI reduced observed outbreak size
- For cholera, measles, and yellow fever, presence of ORI reduced frequency of large outbreaks
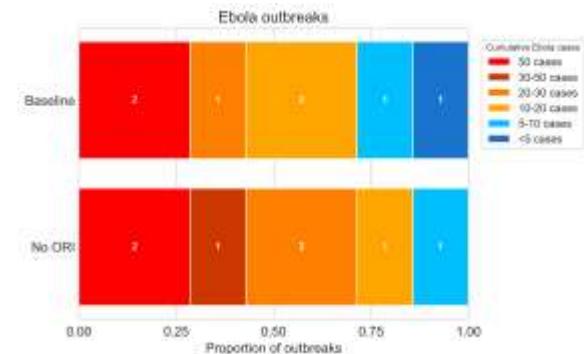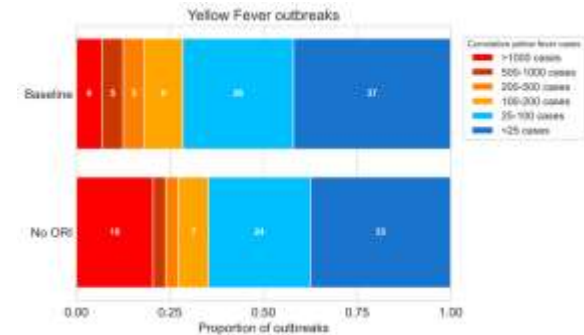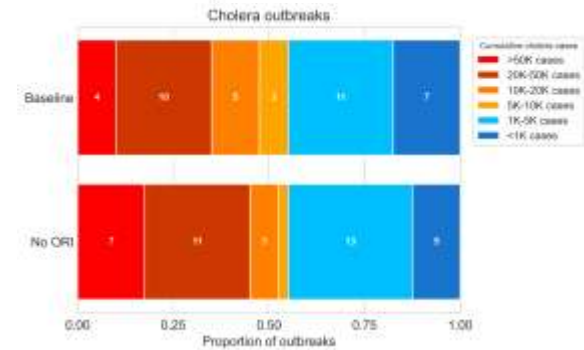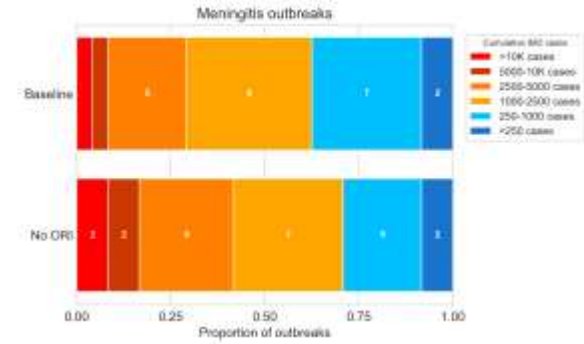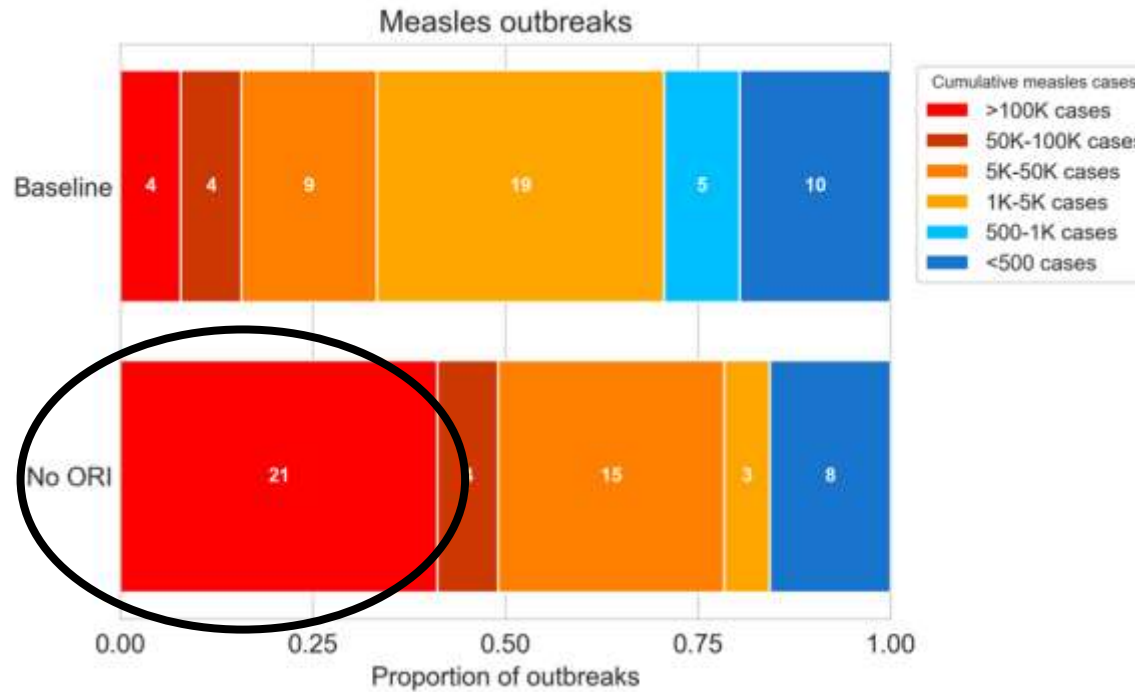
Total impacts

Disease	Years	# outbreaks with ORI *and sufficient data*	Observed cases	Observed / estimated deaths	Estimated cases averted	Estimated deaths averted	Estimated DALYs averted (undiscounted)	Estimated costs averted (discounted; 2023 US$)
Ebola	2018-2022	7	246	121	820 (633 − 1007)	381 (292 − 469)	16, 616 (12,824 − 20,409)	6.72M (5.23M − 8.21M)
Measles	2001-2023	51	2.15M	18,660	4.01M (3.95M − 4.07M)	20,005 (19.6k − 20.4k)	1.27M (1.24M − 1.29M)	710M (692M − 728M)
Cholera	2000-2023	40	800,019	9259	283k (273k − 292k)	5215 (4879 − 5551)	220k (205k − 236k)	156M (145M − 166M)
Yellow Fever	2000-2023	88	29,815	2988	1.50M (1.42M − 1.58M)	300k (284k − 316k)	13.0M (12.2M − 13.8M)	30.7B (26.5B − 34.9B)
Meningitis	2012-2023	24	60,626	4080	21,261 (20,268 − 22,254)	1599 (1404 − 1794)	113k (104k − 122k)	96.6M (86.6M − 106.6M)
Total	2000-2023	210	3.04M	35,108	5·81M (5·75M − 5·87M)	327K (317k − 338k)	14·6M (14·1M − 15·1M)	$31·7B ($29·0B − 34·4B)

Summary

- Over 210 outbreaks of 5 diseases, presence of ORI averted:
  - 5.81M cases;
  - 327k death;
  - 14.6M DALYs;
  - US$31.7B economic costs
- ORI impact was higher with faster response times, confirming the importance and benefits of rapid responses.
- ORI was found to have higher impact in setting with lower baseline immunity, highlighting the importance of routine vaccination campaigns.
- The presence of the ORI reduces the average size of the outbreaks, and the risk of large outbreaks.

Thank you for listening!

Thank you to my co-authors: Alina Muellenmeister, Gabrielle MacKechnie, Stefanie Vaccher, Tewodaj Mengistu, Dan Hogan, Romesh Abeysuriya, Nick Scott

Additional thanks to:

Elizabeth Lee, Andre Arsene Bita Fouda and team, Mark Jit, Han Fu, Caroline Trotter, Katy Gaythorpe, Keith Fraser, Antara Sinha, Allyson Russell, Cassandra Quintanilla, Francisco Luquero, Marguerite Cornu, Rachel Sacks-Davis, and Jane Greig for providing expert advice and data as we developed our disease models and analysis methods .

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Preprint available