Estimating lives saved & cases averted from introducing PCV & rotavirus vaccine in Chad, Guinea, Somalia and South Sudan

Global Advocacy for PCV (GAP) Project

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Overview

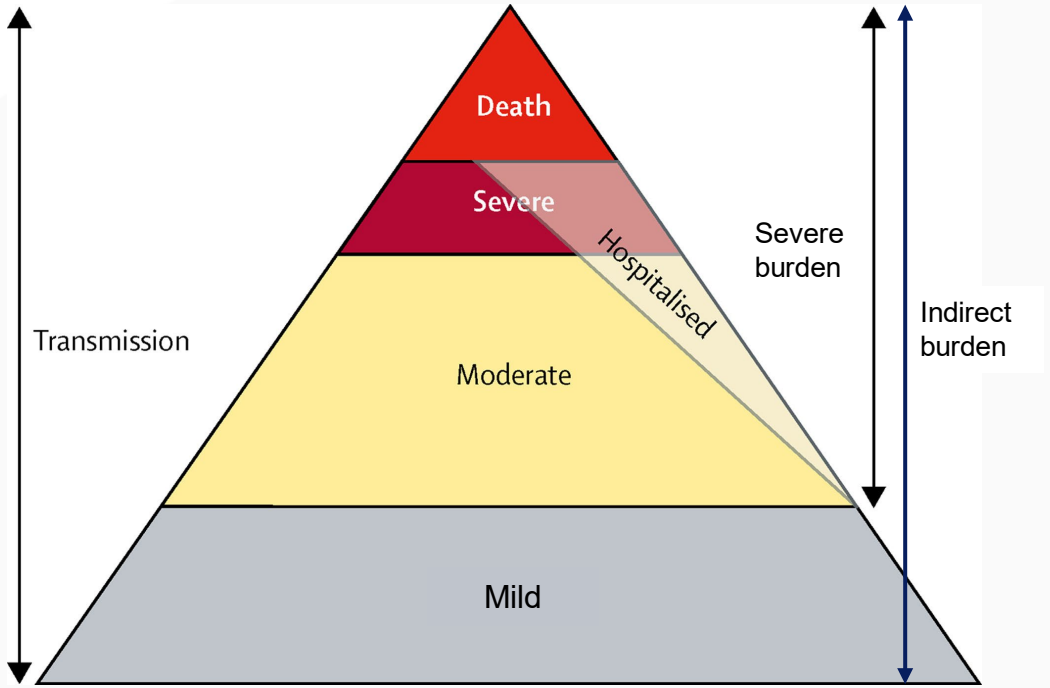
I. Modelled impact of vaccines: Assumptions and inputs

II. Three outputs

- Lives saved
- Cases averted
- Costs averted

III. Discussion

Mortality and disease prevalence pyramid



Estimating lives saved & cases averted from introducing PCV & rotavirus vaccine (RV)

Why: Quantifying the potential impact of new vaccine introduction on saving children's lives and reducing the suffering due to pneumonia and diarrhea provides vital impetus for informed decision-making on introduction and scale-up of PCV and rotavirus vaccines.

How: The Lives Saved Tool (LiST)*, developed by the Institute for International Programs (IIP) at Johns Hopkins Bloomberg School of Public Health is a modelling approach that estimates the impact of scaling up health and nutrition interventions on newborn, child, and maternal health.

* https://www.livessavedtool.org/

The Lives Saved Tool (LiST)

The Lives Saved Tool (LiST), is a linear, deterministic, mathematical disease modelling tool that calculates changes in cause-specific mortality and risk outcomes driven by changes in intervention coverage and intervention effectiveness.

Inputs: coverage and effectiveness of interventions (eg: vaccines)

Outputs: population level of risk factors (eg: disease cases) and deaths and cause-specific lives saved

Scenarios: Our team used this modelling tool to estimate how many additional children's lives can be saved and cases averted in Chad, Guinea, Somalia and South Sudan between 2024 and 2030 with the following scenarios:

1. PCV is introduced in 2024
2. PCV is introduced in 2024 with yearly PCV catch up from 2024 to 2030
3. RV is introduced in 2024
4. Both PCV and RV are introduced in 2024
5. Both PCV and RV are introduced in 2024 with yearly catch up from 2024 to 2030

Assumptions used in LiST model - 1:
Under-5 Mortality and Cause-specific Death Estimates (deaths due to Acute Lower Respiratory Illnesses*)

Country	Under-5 mortality rate, 2021[1] (per 1000 live births)	% Deaths among 1-59m children due to pneumonia [2]	% Deaths among 1-59m children due to diarrheal diseases [2]
Chad	107.7	30%	17%
Guinea	98.73	23%	12%
Somalia	111.78	26%	16%
South Sudan	98.69	29%	15%

[1] IGME UN Inter-agency Group for Child Mortality Estimation: https://childmortality.org/.
[2] WHO and the Maternal Child Epidemiology Estimation group (MCEE) 2017 https://www.who.int/data/gho/data/indicators/indicator-details/GHO/distribution-of-causes-of-death-among-children-aged-5-years-(-)

Assumptions used in LiST model - 2:
Pathogen attributable fraction and Vaccine Efficacy

Cause-specific mortality

Pneumonia deaths attributable fraction for *Streptococcus pneumoniae*	0.245 [1, 2]
Meningitis deaths attributable fraction for *Streptococcus pneumoniae*	0.213 [1, 2]
Diarrhea attributable fraction for Rotavirus	All cases: 0.055; Severe / fatal cases: 0.268 [3,4]

Vaccine Efficacy

PCV 3-dose schedule vaccine efficacy for vaccine-type invasive pneumococcal disease	80% [5]
PCV 3-dose schedule vaccine efficacy vaccine-type meningitis mortality	84% [6]
Rotavirus vaccine efficacy against severe rotavirus diarrhea	46.1% [7]

[1] Wahl, B., et al, Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15. *Lancet Global Health* 2018, 6(7), e744–e757.
[2] Johnson, et al. Systematic evaluation of serotypes causing invasive pneumococcal disease among children under five: the pneumococcal global serotype project. PLoS Med, 2010 7(10), e1000348.
[3] Mohan, V. R., et al. Rotavirus Infection and Disease in a Multisite Birth Cohort: Results From the MAL-ED Study. JID, 216(3), 305–316. https://doi.org/10.1093/infdis/jix199
[4] Fischer et al. Global burden of childhood pneumonia and diarrhoea. The Lancet 2013; 381(9875): 1405-16. http://www.ncbi.nlm.nih.gov/pubmed/23582727
[5] Lucero MG et al. Pneumococcal conjugate vaccines for preventing vaccine-type invasive pneumococcal disease and pneumonia with consolidation on x-ray in children under two years of age. Cochrane Database Syst Rev 2009. http://www.ncbi.nlm.nih.gov/pubmed/19821336
[6] Davis, S., et al. (2013). The effect of Haemophilus influenzae type B and pneumococcal conjugate vaccines on childhood meningitis mortality: a systematic review. BMC public health, 13 Suppl 3(Suppl 3), S21. https://doi.org/10.1186/1471-2458-13-S3-S21
[7] Lamberti, L. M., etal (2016). A Systematic Review of the Effect of Rotavirus Vaccination on Diarrhea Outcomes Among Children Younger Than 5 Years. The Pediatric infectious disease journal, 35(9), 992–998.

Assumptions used in LiST model - 3:
Vaccine Coverage

For all 4 countries, we assumed PCV & RV introduction in 2024 and linearly scaled it to 90% coverage in 2030 in line with the IA2030 goals. [1]

	2023	2024	2025	2026	2027	2028	2029	2030
PCV	0%	12.9%	25.7%	38.6%	51.4%	64.3%	77.1%	90%
RV	0%	12.9%	25.7%	38.6%	51.4%	64.3%	77.1%	90%

[1]Immunization Agenda 2030: A Global Strategy to Leave No One Behind, 1 April 2020, World Health Organization. https://www.who.int/teams/immunization-vaccines-and-biologicals/strategies/ia2030

Assumptions used in LiST model - 4:
Catch-up Vaccination

Catch up vaccination for PCV is intended to be a single-dose PCV vaccine for children aged 12 to 59 months who have not received the recommended full PCV schedule.

Assumptions

- PCV single-dose efficacy against VT-IPD: 58%.[1]
- PCV catch-up campaign coverage: 58% of the eligible population* each year.[2]

Catch up vaccination coverage assumptions shown below are based on population projections by the UN World Population Prospects 2022[3]

2024	2025	2026	2027	2028	2029	2030
58%	31%	44%	35%	38%	34%	35%

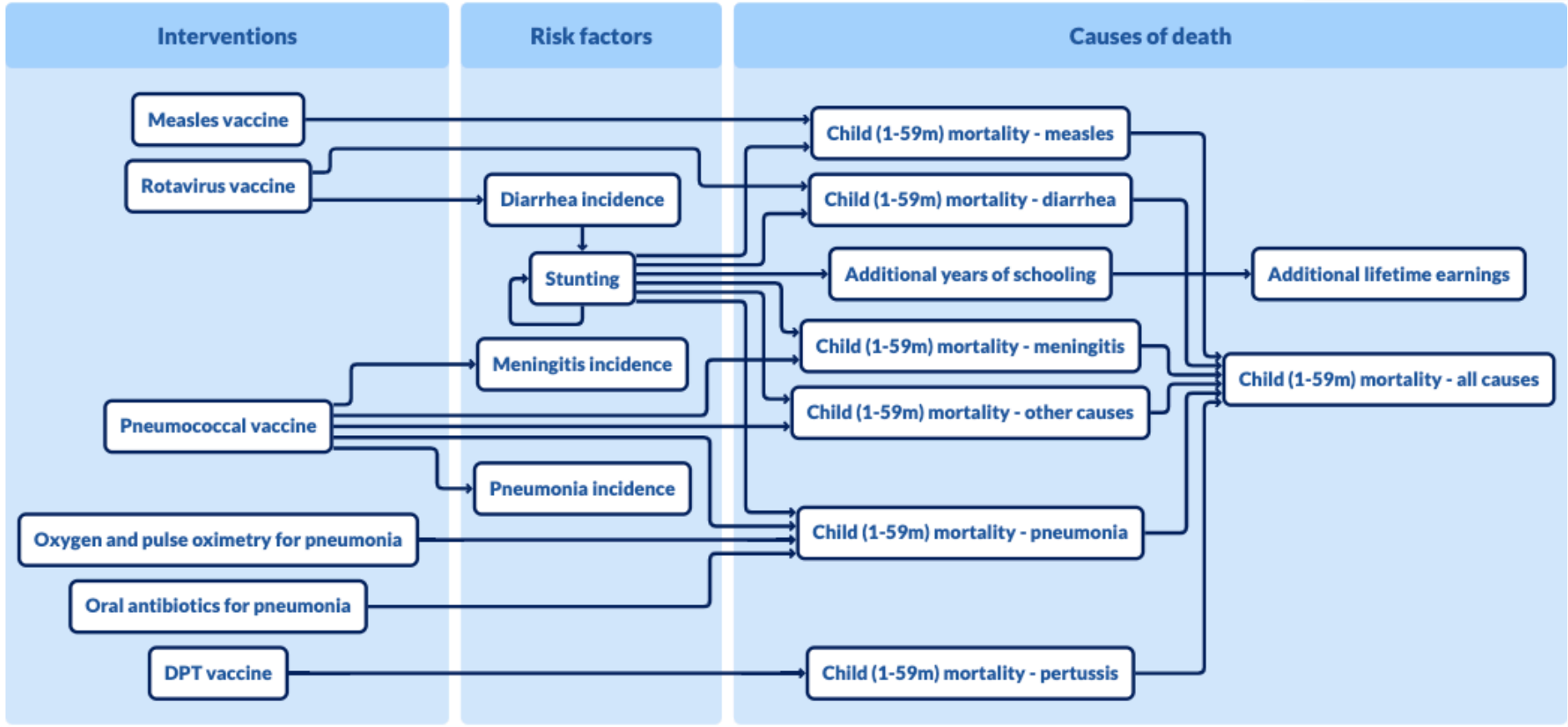
[1] Lucero MG et al. Pneumococcal conjugate vaccines for preventing vaccine-type invasive pneumococcal disease and pneumonia with consolidation on x-ray in children under two years of age. Cochrane Database Syst Rev 2009. http://www.ncbi.nlm.nih.gov/pubmed/19821336

[2] Allison Portnoy, Mark Jit, Stéphane Helleringer, Stéphane Verguet, Impact of measles supplementary immunization activities on reaching children missed by routine programs, Vaccine, Volume 36, Issue 1, 2018, Pages 170-178, ISSN 0264-410X, https://doi.org/10.1016/j.vaccine.2017.10.080.

[3] https://population.un.org/dataportal/home

* Eligible population per year = Total 12-59 m – [(children caught up on the last calendar year – children caught up in the last calendar year who are now >5 years) + children covered by routine PCV in previous year]

The LiST Visualizer: How the interventions are linked to reductions in cause-specific mortality



https://listvisualizer.org/

Results – I: Potential lives saved of children aged 1 month to 59 months cumulatively from 2024 to 2030 in 5 scenarios

Country	1. PCV Only	2. PCV + PCV Catch up	3. RV Only	4. PCV + RV	5. PCV + PCV Catch up + RV
Chad	18,983	22,284	4,430	23,409	26,710
Guinea	7,227	8,678	1,650	8,875	10,326
Somalia	15,258	18,140	4,164	19,418	22,299
South Sudan	5,507	6,800	1,357	6,862	8,155

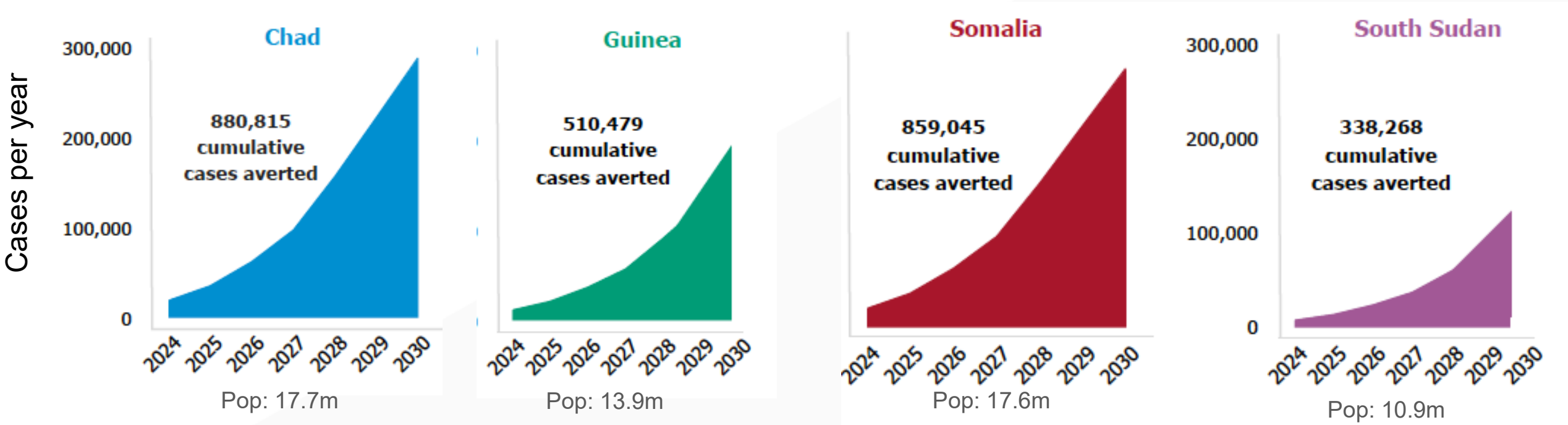
Results – II: Potential cases averted of children aged 1 month to 59 months cumulatively from 2024 to 2030 in 5 scenarios

Potential cases of severe pneumonia, meningitis and diarrhea averted

Country	1. PCV Only [1]	2. PCV + PCV Catch up [1]	3. RV Only	4. PCV + RV [2]	5. PCV + PCV Catch up + RV [2]
Chad	99,381	159,981	719,102	820,089	880,815
Guinea	55,862	91,609	418,191	474,666	510,479
Somalia	103,590	168,578	689,030	793,921	859,045
South Sudan	41,266	66,047	271,764	313,439	338,268

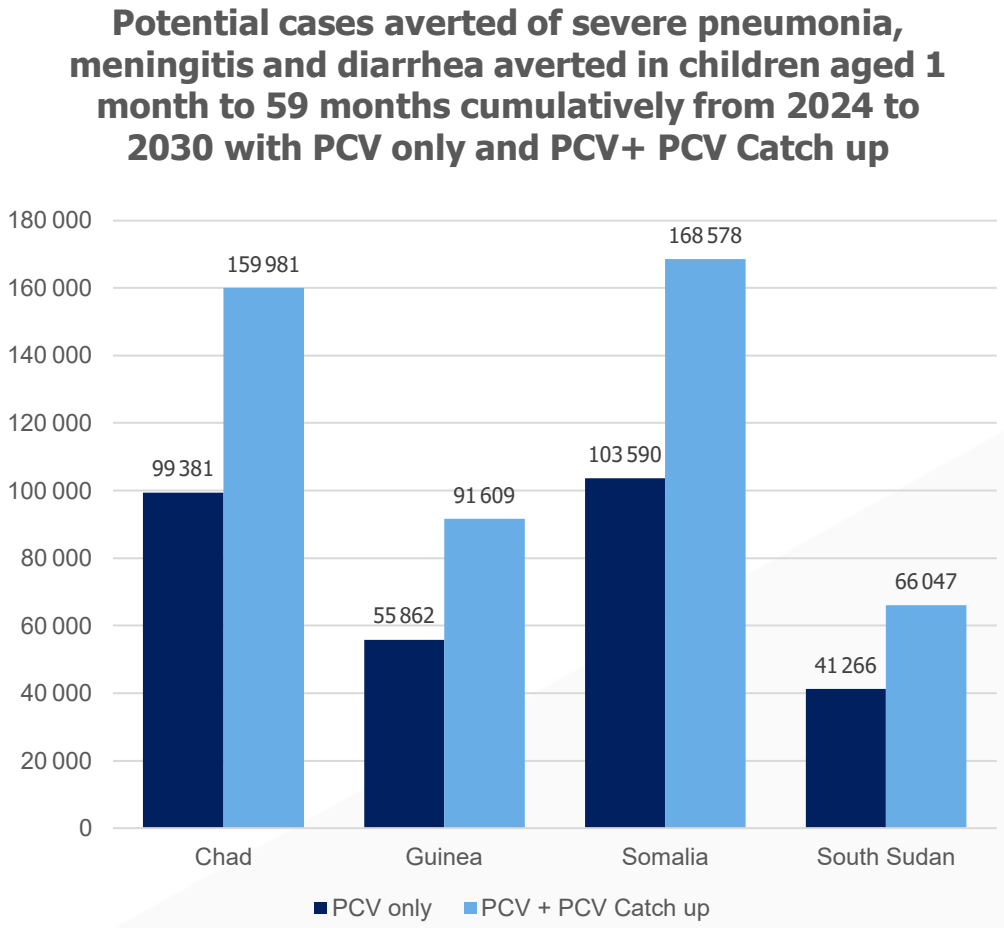
[1]Pneumonia + meningitis cases
[2]Pneumonia + meningitis cases + diarrhea.

Results – II: Potential cases averted of children aged 1 month to 59 months by year from 2024 to 2030 with PCV + PCV catchup + RV



Total potential cases averted: 2.6 million

Potential cases averted: Spotlight on PCV Catch up



Advantages of PCV catch-up

- Additional lives saved
- Community protection
- Reduction of zero-dose burden
- Attention to other routine vaccines
- Increased opportunity for other child health measures

Economic benefits of PCV & RV in Chad, Guinea, Somalia and South Sudan

Methods: 3 approaches - cost of illness averted (COI), value of statistical life (VSL), and value of statistical life-year (VSLY) to estimate observable and unobservable economic benefits between 2024 and 2030 for PCV and RV in Chad, Guinea, Somalia and South Sudan.

Categories of calculated averted costs for each PCV and RV:

1. **Treatment** = country-specific costs of treating the vaccine preventable disease and associated sequelae, based on published literature modified by care-seeking rates and severity and severity-specific length of visit.
2. **Transportation** = mean cost (country-specific) to get to and from a facility to seek treatment.
3. **Wages** = median wage in the country, shadow price proxy for caregiver time spent taking and with a child at a facility for the severity-specific mean duration of illness.
4. **Productivity loss due to disability** = measured by quality-of-life reduction associated with length of illness duration (severity specific) and any longer-term morbidity consequences, modified by disability weight for condition or specific sequelae (e.g. meningitis). Valued using median wage for future productive years (16-50y) only.
5. **Productivity loss due to death** = calculated for future years of working ages - 16-50 using median wage in the country and assumes 40 hour/5days work as a proxy of productivity loss from those years.
6. **Total** = above mentioned categories combined.

Results – III: Total potential averted costs cumulatively from 2024 to 2030 for PCV only and RV only

PCV only

Country	Treatment costs	Total averted costs[1]
Chad	$ 575,498	$ 211,956,688
Guinea	$ 606,341	$ 106,261,999
Somalia	$ 1,233,795	$ 119,610,655
South Sudan	$ 773,240	$ 28,295,738

Rotavirus vaccine only

Country	Treatment costs	Total averted costs[2]
Chad	$ 614,981	$ 50,237,364
Guinea	$ 761,461	$ 24,980,219
Somalia	$ 515,081	$ 32,637,033
South Sudan	$ 767,470	$ 7,720,169

[1] Treatment + transportation + caregiver wages + Productivity of Life (PL) disability + PL deaths.
[2] Treatment + transportation + caregiver wages + PL deaths.

Results – IV: Total potential averted costs cumulatively from 2024 to 2030 for PCV + PCV catchup + RV

Country	Treatment costs	Total averted costs[1]
Chad	$ 1,541,391	$ 300,481,581
Guinea	$ 1,755,690	$ 153,500,055
Somalia	$ 2,523,079	$ 176,112,886
South Sudan	$ 3,605,482	$ 43,567,326

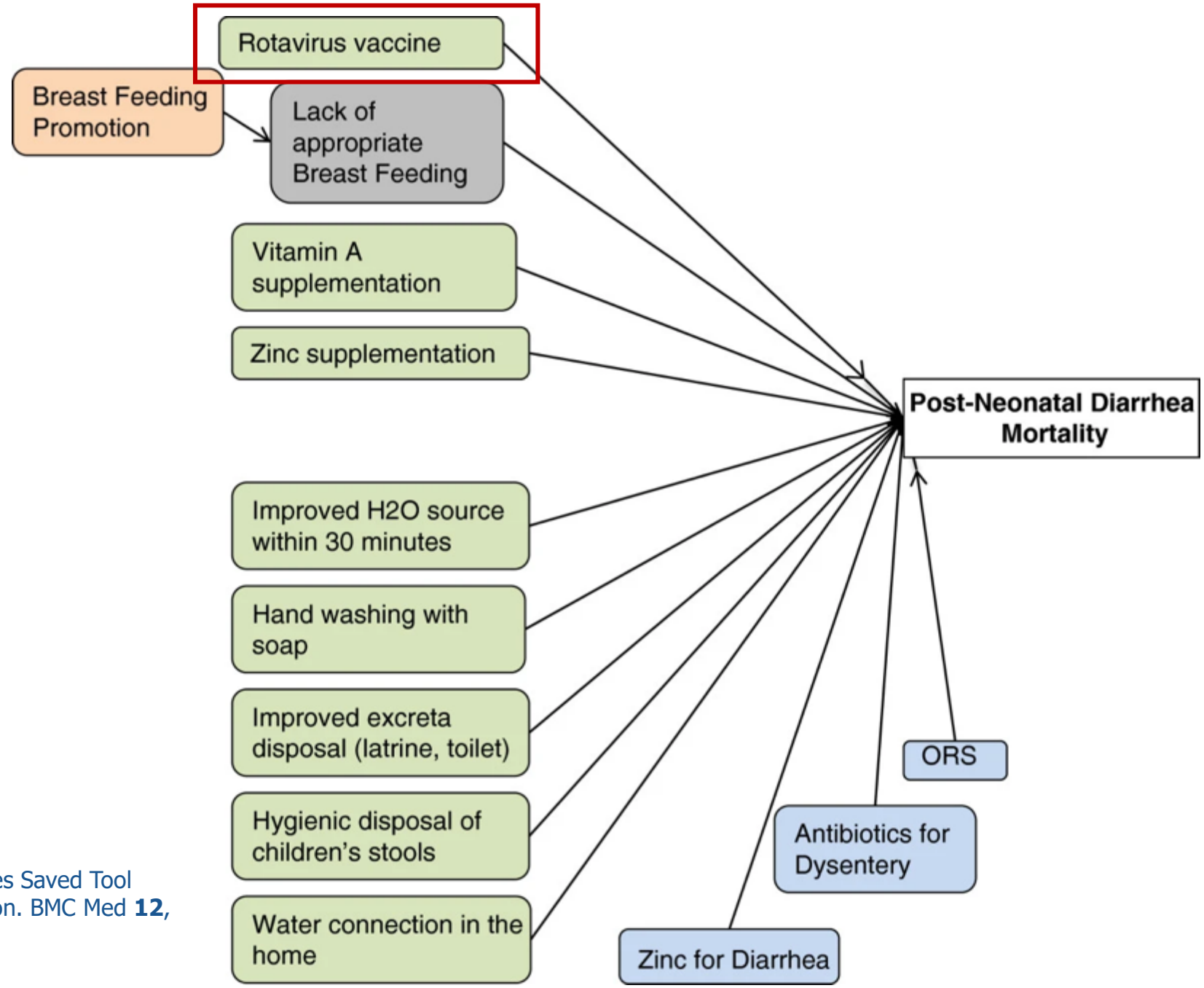
[1] Treatment + transportation + caregiver wages + PL disability + PL deaths.

Discussion

- Caveats – modelled estimates
- Only PCV and rotavirus vaccines considered – other routine vaccines also have a role in preventing childhood pneumonia and diarrhea (DTP, Hib, measles)
- The big picture: it is not only about vaccines (prevention and treatment, distal factors)

Vaccines are only part of the solution:

Interventions with direct impact on diarrhea mortality



Source: Fischer Walker, C.L., Walker, N. The Lives Saved Tool (LiST) as a model for diarrhea mortality reduction. BMC Med **12**, 70 (2014).

Conclusion

1. **Vaccine Advocacy and Public Health Messaging**
2. **Importance of incorporating catch-up in routine immunization**
3. **Primary health care: bundling of interventions**

Vaccination saves lives Modelling in 98 countries

Vaccination saved 37 million lives between 2000 and 2019

We project that it could save 32 million more by 2030.

Source: Vaccine Impact Modelling Consortium https://www.sciencejournalforkids.org/articles/how-many-lives-do-vaccines-save/

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