One vaccine to counter many diseases? Modelling the economics of oral polio vaccine against child mortality and COVID-19

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HIGHLIGHTS

- Recent reviews summarize evidence that some existing vaccines, such as oral polio vaccine (OPV), have heterologous or non-specific effects, potentially offering protection against multiple pathogens.
- We conducted economic evaluations of the non-specific effects of OPV in two settings: (1) Reducing child mortality in a high-mortality setting (Guinea-Bissau) with three annual campaigns in which children receive OPV incremental to routine immunization. (2) Preventing COVID-19 in India, in which OPV would be co-administered alongside COVID-19 vaccines.
- For child mortality, headline cost-effectiveness was $650 per child death averted. For COVID-19, assuming OPV had 20% effectiveness, incremental cost per death averted was $23,000-65,000 if it were administered simultaneously with a COVID-19 vaccine less than 200 days into a wave of the epidemic. If the COVID-19 vaccine availability were delayed, the cost per averted death would decrease to $2600-6100. Estimated benefit-to-cost ratios vary but are consistently high.
- Economic evaluation suggests the potential of OPV to efficiently reduce child mortality in high mortality environments. Likewise, within a broad range of assumed effect sizes OPV could play an economically attractive role against COVID-19.

BACKGROUND

- Non-specific effects of live-attenuated vaccines (LAVs) have led to reductions in mortality and morbidity by more than can be explained from prevention of the targeted disease alone (Chumakov et al. 2020). Only two studies have undertaken economic analyses that incorporates the non-specific effects of vaccines (Byberg et al. 2017, Thompson et al. 2021).
- OPV is used in many countries as it is safe and effective at protecting children against lifelong polio paralysis. Past studies have demonstrated OPV's non-specific effects against acute respiratory diseases induced influenza and other viruses, and OPV's reduction in infant and child mortality. Beyond health benefits, OPV is attractive because it is safe, inexpensive, does not require trained medical staff, and exists in 3 serotypes that could be used sequentially to extend the protection

METHODS

Setting 1. High child mortality environment

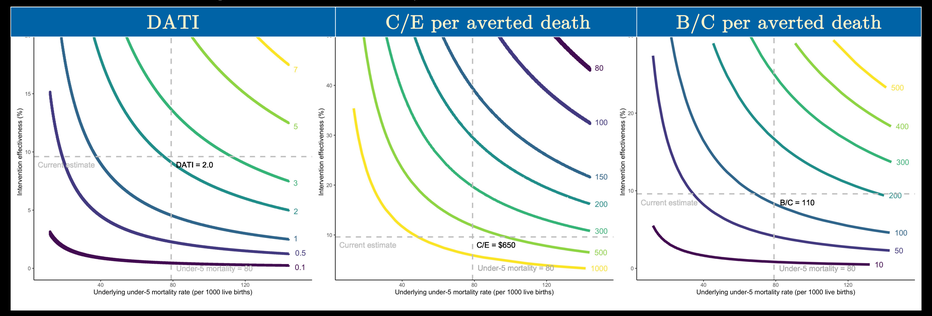
- Large non-specific effects in **high child mortality** settings (25-67% reduction). Currently not accounted for in economic evaluations
- Intervention for evaluation:
  - Birth cohort of 1 million in a high child mortality setting (78/1000 live births in 2019), given one bi-valent OPV campaign dose each year for three years on top of routine immunization
  - Effect: First dose mortality rate reduction (MRR) 0.90, each additional dose MRR 0.92
  - Cost (2020 USD): vaccine $0.15, delivery $1.03, wastage 10%
  - Benefit: VSL $71,000 (GNI per capita $2230 PPP) per BCA reference case (Robinson et al. 2019).

Setting 2. COVID-19 in countries with long vaccine delays

- Bridge use of OPV until COVID-19 specific vaccines become available: long delays due to development, trials, manufacturing, administration. Most parts of the world expected to have high coverage by mid-2022-2023
- Preliminary results on BCG (another LAV) protection against COVID-19 severity; other ongoing study on BCG and measles vaccines (Avidan et al. 2021; Netea et al. 2021). No study on OPV against SARS-CoV-2, but strong scientific support from biological and clinical evidence (Chumakov et al. 2021)
- Dynamic, compartmental susceptible-exposure-infectious-recovered (SEIR) model built and calibrated with Indian national seroprevalence data from wave 1
  - 0.7% seed infection; 23% infected by 250 days; 3.2-3.8% symptomatic; IFR ~0.1%; peak daily infections on day 250. Time period: 365 days starting early May 2020
- Two immunization schedules adding OPV to the COVID-19 vaccine
  - (1) Simultaneous administration: both administered t days after beginning of a wave
  - (2) COVID-19 vaccine delayed: OPV administered t days after beginning of wave and COVID-19 vaccine becomes available with d day delay after OPV (i.e., t+d days after beginning of wave)
- Cost (COVID-19/OPV): vaccine $10/$0.15, delivery $1.5/$1.0, wastage 10%/10%
- Benefit: VSL $388,000 (US VSL 9.4 million; income elasticity 1.5)
- Vaccine parameters:

	COVID-19 vaccine (1 dose, based on J&J)	OPV
Vaccine coverage	30%	
Effectiveness against infectivity	74% [65-95]	0
Effectiveness against infections (susceptibility)	74% [65-95]	20% [5-64]
Effectiveness against disease severity	95% [75-99]	20% [5-64]
Days from administration until fully effective	28 days [7-35]	1 day [1-10]

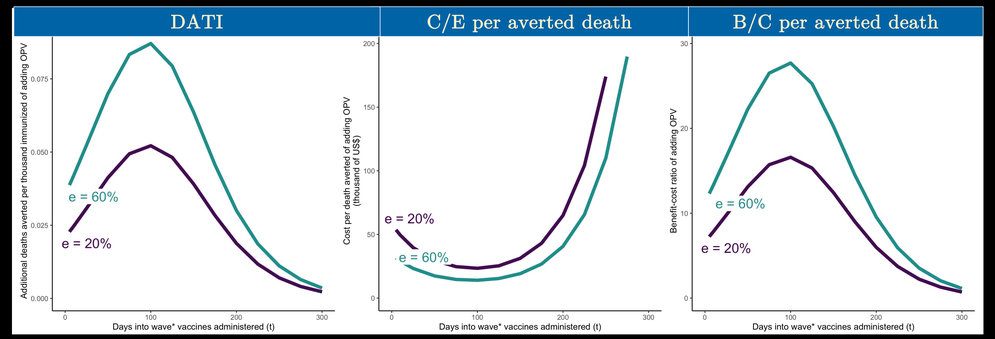
RESULTS Setting 1. Child mortality



Each curve shows combinations of the underlying under-5 mortality rate and intervention effectiveness that makes deaths averted per 1000 doses (DATI), cost-effectiveness (C/E), and benefit-cost (B/C) ratios constant along the curve. E.g., the green curve on in panel A shows combinations that result in DATI = 2. **Headline results: campaign effectiveness at 9.5%, DATI 2.0, C/E $650 per averted death, B/C 110.**

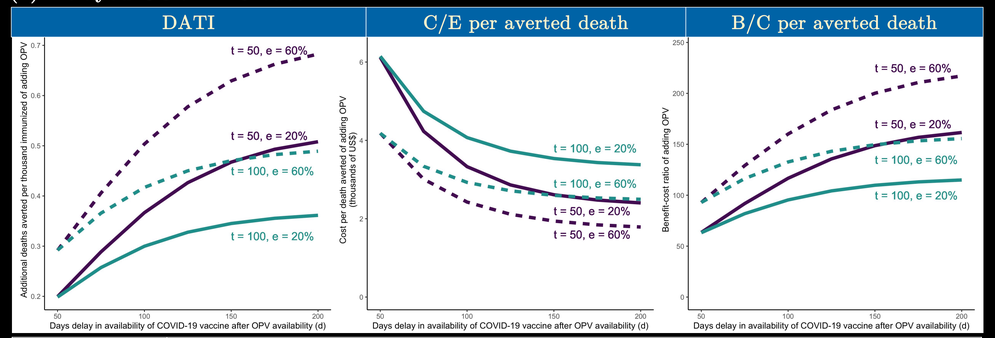
RESULTS Setting 2. COVID-19

(1) Simultaneous administration of COVID-19 vaccine and OPV



Headline results: at OPV 20% effective against COVID-19, DATI = 0.02-0.05, C/E $23000-65000, B/C 6-17.

(2) Delayed COVID-19 vaccine



	Days into wave* that OPV is administered (t)											
	t = 50						t = 100					
	e = 20%			e = 60%			e = 20%			e = 60%		
Delay of COVID-19 vaccine (d)	DATI	C/E	B/C	DATI	C/E	B/C	DATI	C/E	B/C	DATI	C/E	B/C
50 days	0.2	$6100	60	0.3	$4200	90	0.2	$6100	60	0.3	$4200	90
100 days	0.4	$3300	120	0.5	$2400	160	0.3	$4100	100	0.4	$2900	130
150 days	0.5	$2600	150	0.6	$1900	200	0.3	$3500	110	0.5	$2600	150

e = OPV effectiveness against COVID-19 * Based on India's first wave of COVID-19.

DISCUSSION

- Favorable outcomes in both settings, even with low OPV effectiveness
- Time delay critical for incidence and death for COVID-19
- Limitations: no empirical estimates on OPV effect on COVID-19; basic and country-specific models
- Potential alternative uses of live-attenuated vaccines, additional economic and social costs of pandemics would lead to more favorable outcomes
- Rare occurrence of vaccine-associated paralytic polio not considered but qualitatively will not impact main results