

Technical Appendix for Kalkowska and Thompson “Health and Economic Outcomes Associated with Polio Vaccine Policy Options: 2019-2029”

We use updated prospective (Table A1) income level-specific cost estimates reported elsewhere (Thompson & Kalkowska, 2020a). We estimate the disability-adjusted life-years (DALY) values over time by income level based on average life-expectancy using the entire global income groups (Table A2). To estimate the US\$2019 per DALY values by income level, we use gross national income (GNI) per capita (Atlas method, 2018 current estimate adjusted to US\$2019) using all countries in the WBIL (Table A1). We calculate societal willingness-to-pay (S) per case avoided by income level (il) by year (yr) in US\$2019 as $S_{il}(yr) = DALY(yr) \times \$/DALY_{il}(US\$2019)$. By using a constant $\$/DALY$ in US\$2019, we implicitly assume that any inflation that would occur over time (e.g., a 3% increase in GNI per capita per year) cancels out with the discount rate used to account for the time value of money (e.g., a discount rate of 3%). Thus, computing all costs in US\$2019 ignores any uncertain time-variation in the inputs, except for the DALY per case estimates (Table A2) that vary due to changes in life expectancy that we considered to ensure consistency in all of demographic inputs for the model.

We calculate cumulative financial costs (FC) by income level as a sum of RI vaccine cost (RIC), SIA vaccine cost ($SIAC$):

$$FC_{il}(yr) = RIC_{il}(yr) + SIAC_{il}(yr)$$

We calculate RIC by income level over time as a sum of RI costs from all blocks in given income level using the number of surviving infants (si) in given block multiplied by number of vaccine doses used in the RI schedule of that block ($ndose$) and vaccine price per dose ($vpdose$) adjusted for wastage (w) and administration cost per dose ($apdose$), using WBIL specific prices:

$$RIC_{il}(yr) = \sum_{bl=1}^{nbl_{il}} si_{bl}(yr) \times ndose_{bl}(yr) \times (vpdose(il_{bl}) \times w(il_{bl}) + apdose(il_{bl}))$$

We calculate $SIAC$ by income level over time as a sum of SIA costs from all blocks in given income level using the number of kids in given block that received a dose during the SIA campaigns (calculated as target population (tp) times true coverage (tc)) multiplied by vaccine price per dose ($vpdose$) adjusted for wastage (w) and administration cost per dose ($apdose$), using income level specific cost inputs (Table A1):

$$SIAC_{il}(yr) = \sum_{bl=1}^{nbl_{il}} tp_{bl}(yr) \times tc_{bl}(yr) \times (vpdose(hil_{bl}) \times w(hil_{bl}) + apdose(hil_{bl}))$$

We calculate several incremental economic outcomes for the alternative option (AO) compared to the reference case (RC) including the: (i) ICER in US\$2019 per polio case (i.e., $ICER_{case}$), (ii) the ICER in US\$2019 per DALY (i.e., $ICER_{DALY}$), and (iii) the INBs in US\$2019 as follows:

$$ICER_{case} (AO vs. RC) = \frac{\sum_{yr=T_0}^{T_{end}} [(FC_{AO}(yr) - FC_{RC}(yr)) - T \times (PP_{RC}(yr) - PP_{AO}(yr))]}{\sum_{yr=T_0}^{T_{end}} (PP_{RC}(yr) - PP_{AO}(yr))}$$

$$ICER_{DALY} (AO vs. RC) = \frac{\sum_{yr=T_0}^{T_{end}} [(FC_{AO}(yr) - FC_{RC}(yr)) - T \times (PP_{RC}(yr) - PP_{AO}(yr))]}{\sum_{yr=T_0}^{T_{end}} DALY(yr)(PP_{RC}(yr) - PP_{AO}(yr))}$$

$$INB (AO vs. RC) = \sum_{yr=T_0}^{T_{end}} (T + S(yr)) \times (PP_{RC} - PP_{AO}) - (FC_{AO} - FC_{RC})$$

where

FC_{RC} = financial costs associated with the reference case

FC_{AO} = financial costs associated with the alternative policy

PP_{RC} = number of polio cases with the reference case

PP_{AO} = number of polio cases with the alternative policy

T = treatment costs per polio case

We report the ICERs by income level and the INBs both by income level and as a global aggregate. For ICERs, we use “cost-saving, life-costing” (CSLC), “cost-saving, life-saving” (CSLS), and “dominated” labels to describe ICERs with negative incremental costs and negative prevented cases, negative incremental costs but positive prevented cases, and positive incremental costs but negative prevented cases, respectively.

Table A1: Updated prospective economic model inputs by World Bank Income Level (WBIL) for vaccine, treatment, and surveillance costs in US\$2019

Input	LI	LMI	UMI	HI
Number of countries	31	48	54	68
Number of people (millions)	724	3,065	2,709	1,215
Number of children under 5 years old (millions)	112	313	188	65
Number of surviving infants (millions)	24	63	37	13
Vaccine price per dose				
- OPV (any formulation)	\$ 0.15	\$ 0.15	\$ 0.33	\$ 8.75
- nOPV (formulations containing any nOPV)	\$ 0.30	\$ 0.30	\$ 0.66	\$ 8.75
- IPV, full dose, standalone	\$ 2.50	\$ 2.65	\$ 4.75	\$ 14.27
- IPV, fractional dose, standalone	\$ 0.50	\$ 0.53	\$ 0.95	NA
- IPV component, combination, full dose	\$ 3.50	\$ 4.00	\$ 6.59	\$ 27.11
- IPV, vaccine patch (dose-sparing)	\$ 1.70	\$ 1.73	\$ 2.95	\$ 27.11
Administration costs per dose				
- OPV in RI or SIAs	\$ 0.95	\$ 0.95	\$ 2.51	\$ 3.18
- IPV given with 3 rd OPV dose in RI (full)	\$ 1.00	\$ 1.00	\$ 3.00	NA
- IPV single antigen in RI or SIAs	\$ 1.78	\$ 1.78	\$ 4.69	\$ 17.06
- IPV intradermal device (incremental)	\$ 0.30	\$ 0.30	\$ 0.30	NA
- IPV combination (hexavalent) in RI	\$ 0.30	\$ 0.30	\$ 0.78	\$ 2.84
- IPV vaccine patch in RI or SIAs	\$ 0.95	\$ 0.95	\$ 2.51	\$ 3.18
Effective vaccine wastage				
- OPV in RI	0.2	0.2	0.15	0.1
- IPV in RI	0.15	0.15	0.1	0.05
- IPV in IPV/OPV or OPV+IPV RI	0.2	0.2	0.15	0.1
- IPV, fractional, in RI	0.3	0.3	0.2	NA
- IPV, fractional, in IPV/OPV or OPV+IPV RI	0.4	0.4	0.2	NA
- OPV or IPV in SIAs	0.25	0.2	0.1	0.1
- IPV, vaccine patch	0.02	0.02	0.01	0.01
Number of doses in RI schedule				
- OPV-only (pre-2015)	3	3	3	NA
- OPV+IPV (started in 2015)	3+1	3+1	3+1	NA
- IPV/OPV sequential	2+2	2+2	2+2	3+1
- IPV-only standalone or patch	2	2	2	3
- IPV-only, combination	4	4	4	4
Treatment costs per case	\$ 711	\$ 7,107	\$ 71,065	\$ 710,652
\$ per disability-adjusted life-year (DALY)	\$ 866	\$ 2,310	\$ 9,140	\$ 45,600

Abbreviations: DALY, disability-adjusted life year; GNI, gross national income; IPV, inactivated poliovirus vaccine; LI, low-income; LMI, lower middle-income; N/A, not applicable; OPV, oral poliovirus vaccine; oSIA, outbreak response SIA; pSIA, planned, preventive SIA; RI, routine immunization; SIA, supplemental immunization activity; UMI, upper middle-income; WBIL, World Bank Income Level

Table A2: Disability-adjusted life-years (DALYs) per case for 2019-2029 (WBIL population (GPEI countries) weighted)

Year	LI	LMI	UMI	HI
2019	13.20	13.49	13.87	13.20
2020	13.22	13.50	13.88	13.22
2021	13.24	13.51	13.89	13.24
2022	13.26	13.52	13.90	13.26
2023	13.28	13.53	13.90	13.28
2024	13.30	13.54	13.91	13.30
2025	13.32	13.55	13.92	13.32
2026	13.33	13.56	13.93	13.33
2027	13.35	13.57	13.93	13.35
2028	13.37	13.58	13.94	13.37
2029	13.38	13.59	13.95	13.38

Abbreviations: HI, high-income; LI, low-income; LMI, lower middle-income; UMI, upper middle-income