

Cost-Effectiveness of Measles Rubella Elimination

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Study Objective

To assess the cost and cost-effectiveness of four scenarios for measles rubella control and elimination

- Using results on impact from five groups of modelers

Methods

Perspective: Health provider

Time horizon: 2018-2047

Scenarios: Basecase, Continuing Trends, Continuous Improvement, Intensified Investment

- Comparator = Basecase

Use existing cost data

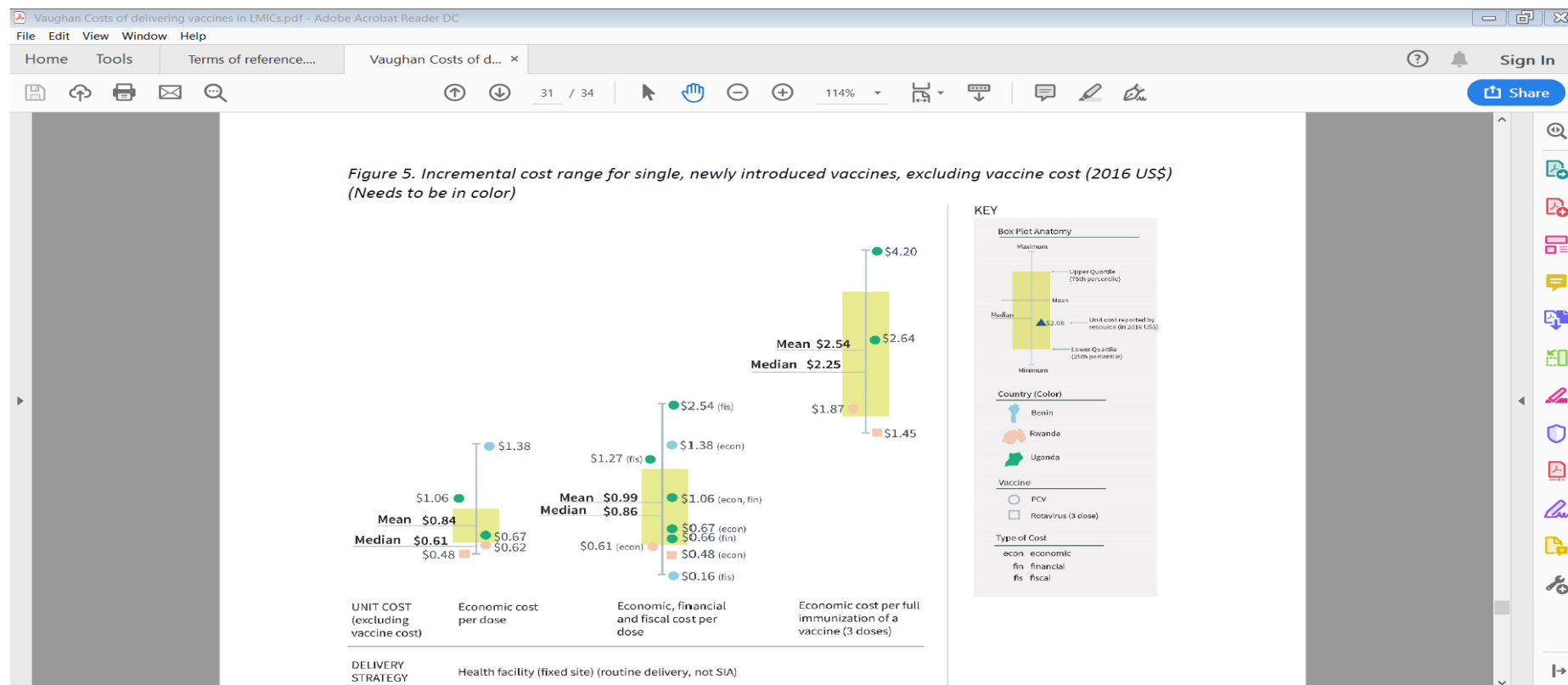
- Vaccination – routine and SIA
- Cost of illness – measles and congenital rubella syndrome
- **Discounting**
 - 3% costs, 0% DALYs
 - 3% costs, 3% DALYs

Health Systems

- Difficult to quantify but will describe existing studies

Routine Immunization Delivery Costs

Based on ICAN's Cost Catalogue of Routine Immunization Delivery Costs (2016\$):



Source: K. Vaughan, A. Ozaltin, M. Mallow, F. Moi, C. Wilkason, J. Stone, L. Brenzel, The costs of delivering vaccines in low- and middle-income countries: Findings from a systematic review, *Vaccine: X* (2019)

Routine Immunization Costs

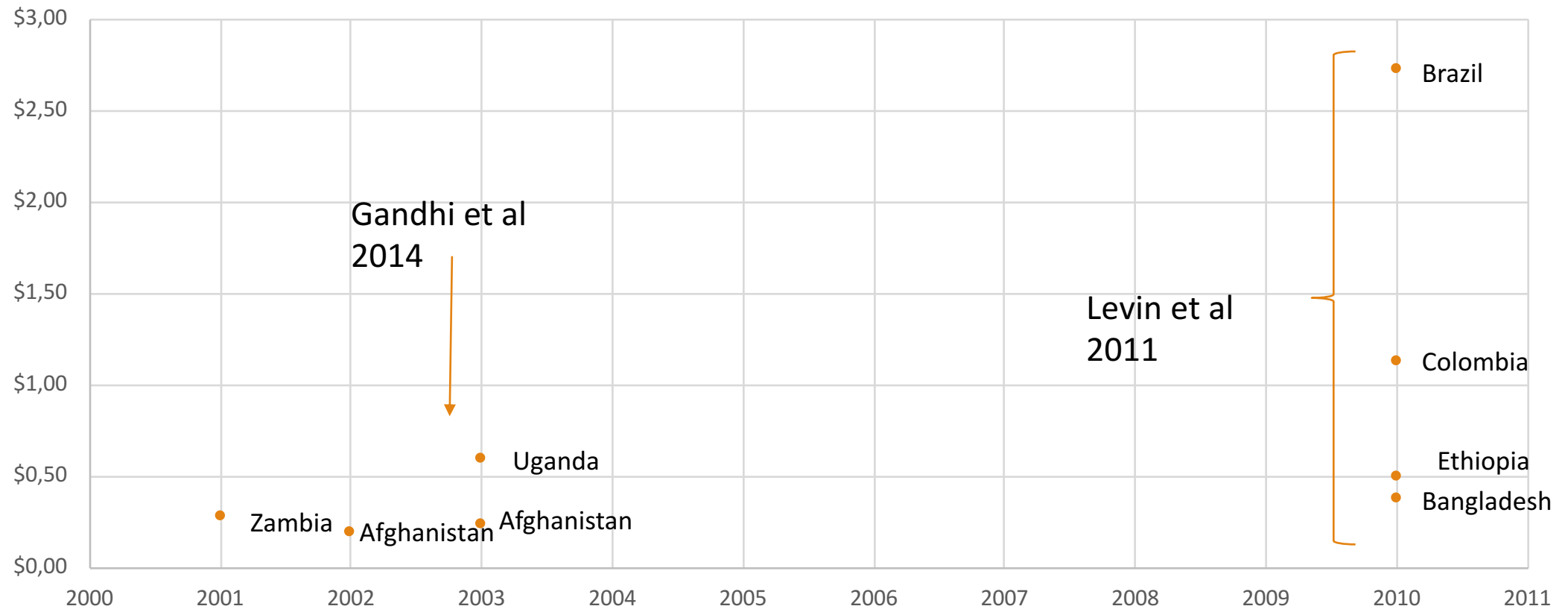
Income Group	Country	Year		Source
Low	Benin Uganda	2011 2011	Labor, transport, vaccines, injection supplies, Cold chain equipment; human	AMP Report 2014*; Guthrie 2014*
Lower-Middle	Moldova Vietnam	2011 2010	Labor, transport, vaccines, injection supplies, Cold chain equipment; human resources	Goduadze 2015* Mvundura 2014
Upper-Middle	China Thailand	2015 2009	Retrospective costing studies that estimate full, supply chain costs of routine delivery of vaccines.	Yu 2018 Riewpaiboon 2015

*Gates Foundation funded six EPIC (Expanded Program on Immunization Costing and Financing of Routine Immunization) studies

Measles/Rubella RI Cost per Dose (2018 USD)

Income Group (number of countries)	Delivery Cost (Economic)	Vaccine Price (MR)	Total	Cost per Measles Dose	Cost per Rubella Dose
Low (n=2)	\$1.38	\$0.66	\$2.04	\$1.71	\$0.33
Lower-middle (n=2)	\$1.50	\$2.25	\$3.75	\$2.63	\$1.13
Upper-middle (n=2)	\$1.84	\$2.25	\$4.09	\$2.97	\$1.13

SIA Cost Per Dose



Source: Levin et al. 2011 (primary data collection); Gandhi 2014 (systematic review)

Measles/Rubella SIA Cost per Dose (2018 USD)

Income Group	Delivery Cost (Economic)	Vaccine Price	Total	Cost per Measles Dose	Cost per Rubella Dose
Low- and lower-middle (n=6)	\$0.72	\$0.66	\$1.38	\$0.99	\$0.39
Upper-middle Income (n=2)	\$2.32	\$0.66*	\$2.98	\$2.59	\$0.39

*10 dose vial

Surveillance Costs

Based on recent review of surveillance study by CDC – Erondy 2019

Separated out single antigen studies

- Chad and Niger (Irunzun-Lopez et al 2016) – meningitis surveillance: per capita costs of \$0.12 and \$0.03
- Kenya and Uganda (Mueller 2009) – malaria surveillance (per capita of (\$0.03 - \$0.05)
- Ghana (Kaburi 2017) – meningitis surveillance

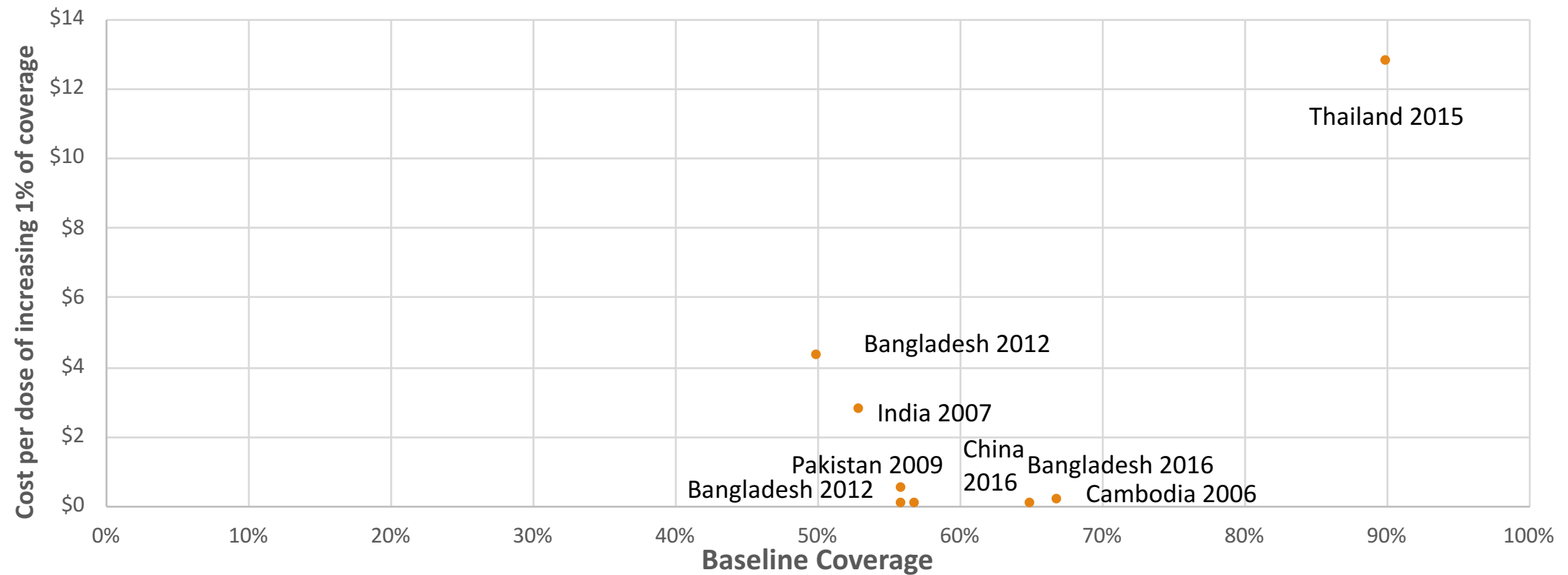
Assuming \$0.10 - \$0.50 (2018 USD) per dose, increasing from low coverage (<70%) to high coverage (90%+)

Cost of Increasing Routine Coverage

Systematic Review by Ozawa et al. 2018 – identified 42 studies of increasing coverage

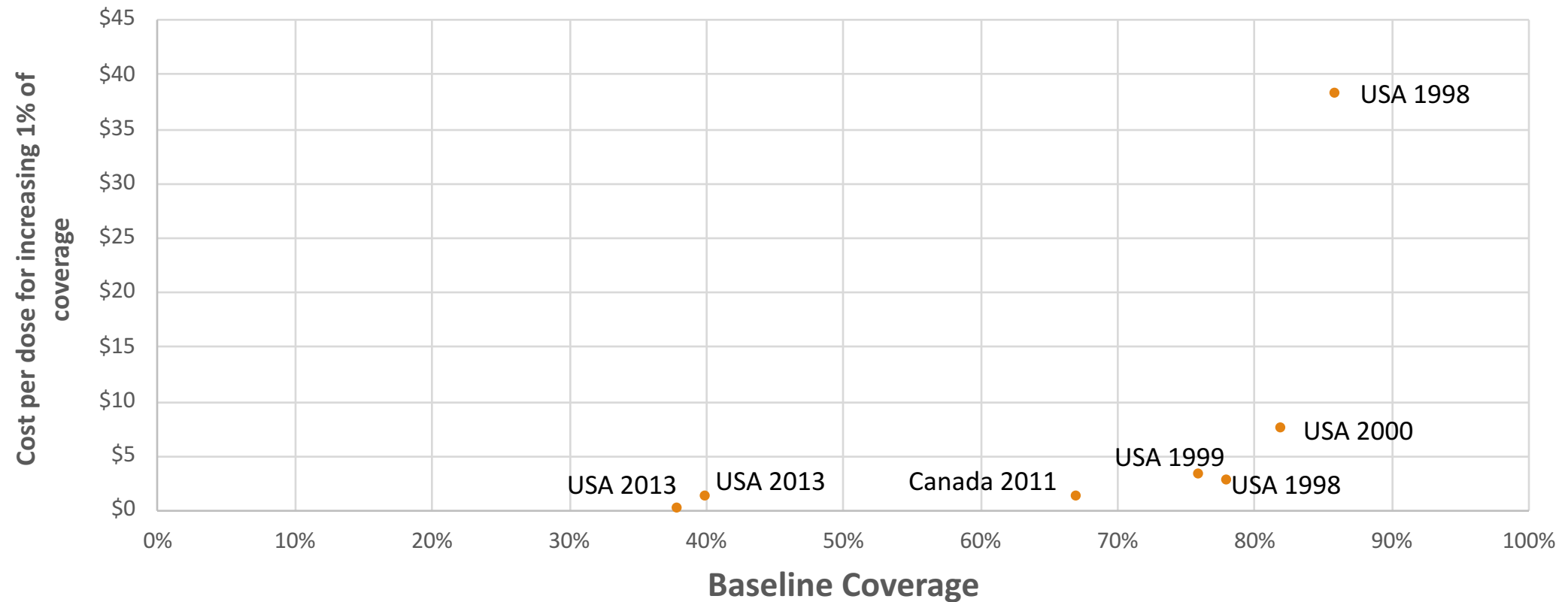
- Reanalyzed data on cost of increasing coverage
 - Removed studies from high-income countries, SIAs, and vaccine introduction
- Eight studies met criteria (list studies separately)
 - **Cambodia** (Soeung 2006): Microplanning, performance agreements, and monitoring in Cambodia
 - **India** (Pandey 2007): Removing barriers and missed opportunities to immunization in India
 - **Pakistan** (Andersson 2009): Social mobilization with adults in rural communities in Pakistan
 - **Bangladesh** (Uddin 2012; Hayford 2014)
 - Modified EPI schedule, community support groups, training and removing geographic barrier policies
 - Use of screening checklist by health care workers, provider training, and removing geographical barriers
 - Extended clinic hours, training, active surveillance and community participation targeting children
 - **China** (Zhou 2016) Social mobilization and training of health staff in China
 - **Thailand** (Kaewkungwal 2015): Mobile phone reminders for highland minority and stateless populations in northern Thailand

Costs of Increasing Coverage LMICs



Source: Ozawa 2018

Costs of Increasing Coverage – USA & Canada



Source: Ozawa 2018

Cost of increasing Coverage (2018 USD)

Income Group	<60%	60-69%	70-79%	80-89%	90%+
Low (n=1)	\$1.81	\$1.91	\$2.00	\$2.25	\$2.75
Lower-Middle (n=3)	\$2.73	\$2.82	\$2.91	\$3.16	\$3.66
Upper-Middle (n=2)	\$3.10	\$3.20	\$3.29	\$3.64	\$4.14

Includes cost of improving communications/social mobilization, cold chain and surveillance

Treatment Cost for Measles and Rubella (2018 USD)

Income Group	Direct Cost of treatment
Measles	
Low and Lower-middle	\$20.34*
Upper-middle	\$278.48**
Rubella CRS	
Low and Lower-middle	\$4,731
Upper-middle	\$6,864***

* Based on studies in Bangladesh (Levin 2011), Ethiopia (Driessen 2015, Wallace 2014), Tajikistan (Levin 2011) and Uganda (Levin 2011);

** Based on studies in Colombia (Acharya 2002), Brazil (Acharya 2002) and Romania (Njau 2019);

*** Based on study in Romania (Njau 2019)

Effect of Measles Elimination on Health Systems

Studies have found both positive and negative effects of measles SIAs on health systems

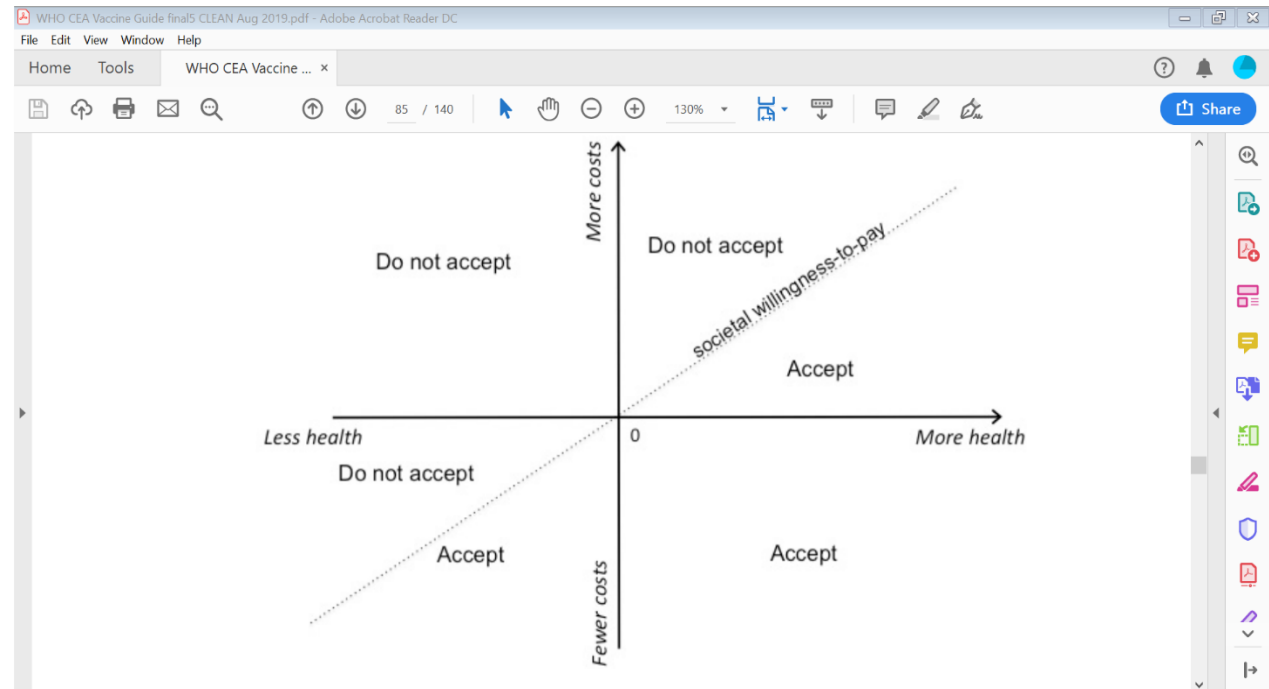
- Hanvoravongchai P (2011) conducted a six country study on the impact of measles elimination activities on health systems and found 'while weaker health systems didn't always benefit sufficiently from AMEAs, in more developed health systems, disruptions to health service delivery are unlikely to occur.
- Opportunities to strengthen the routine immunization service and health system should be actively sought to address system bottlenecks in order to incur benefits to eradication program itself as well as other health priorities.
- Other studies on the impact of polio eradication activities (Closser et al 2014, Levin et al 2002) have had similar findings.

Conclusion: Cannot quantify the impact

Cost-effectiveness Analysis

$$CE = \text{Net Cost (Additional Cost – Treatment Savings)}$$

DALYs averted



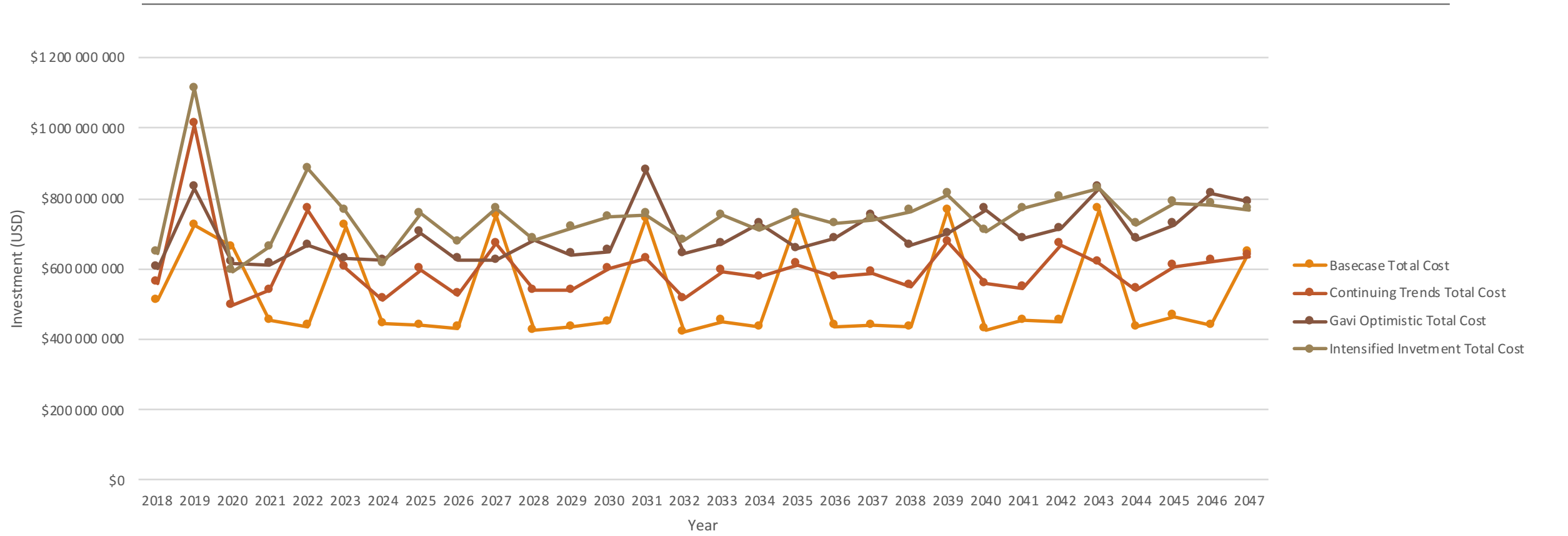
Source: WHO Guide for Standardization of Economic Evaluations of Immunization Programmes, 2019

Results

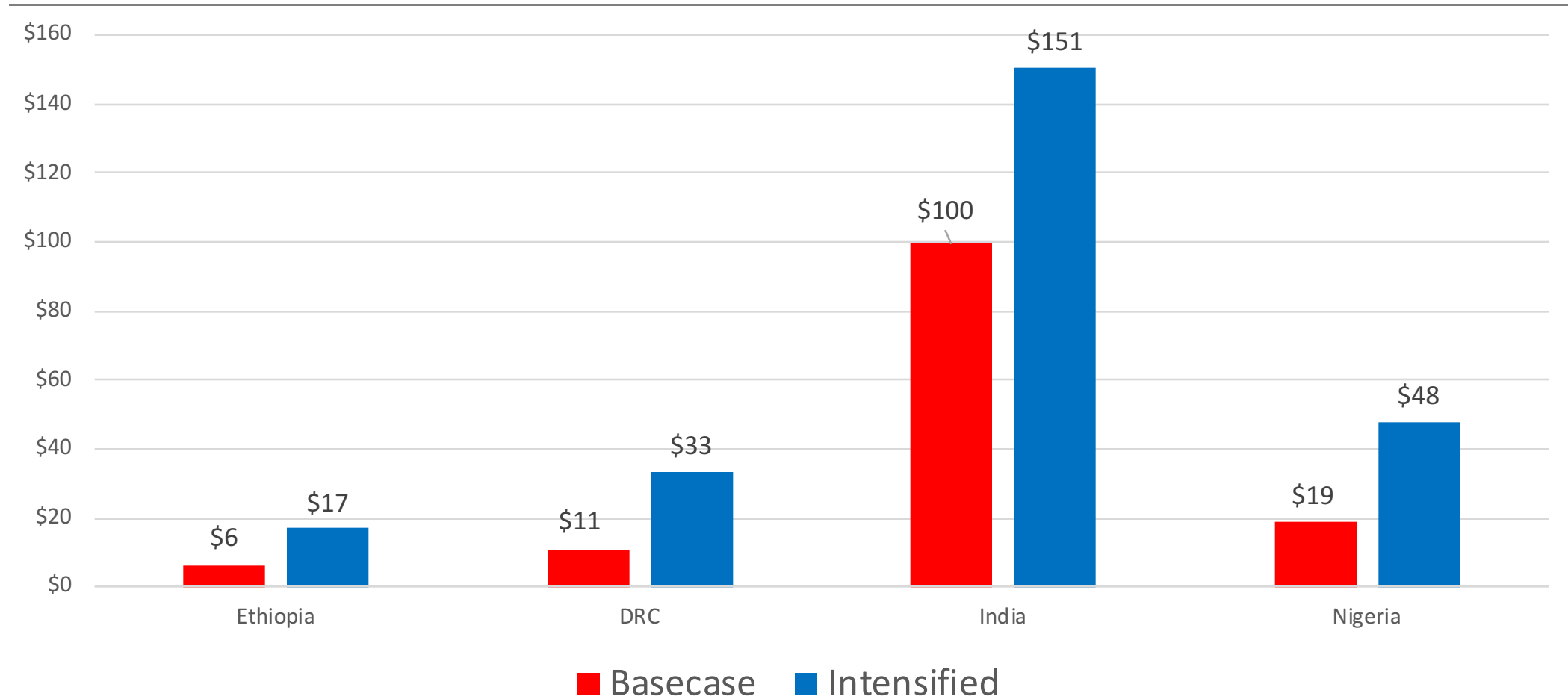
Costs of Measles Vaccination, 2018-2047 (2018 USD)

Scenario	No. of Vaccinations (billions)	Vaccination Costs Undiscounted/Discounted (billions)
Basecase	7	\$15.8/\$10.4
Continuing Trends	7.6	\$18.1/\$11.9
Constant Improvement	7.2	\$20.9/\$13.5
Intensified Investment	7.7	\$22.5/\$14.7

Measles Vaccination Cost by Year, Four Scenarios



Measles Vaccination Costs, Average Annual Undiscounted Cost in Selected Countries (Millions, 2018 USD)



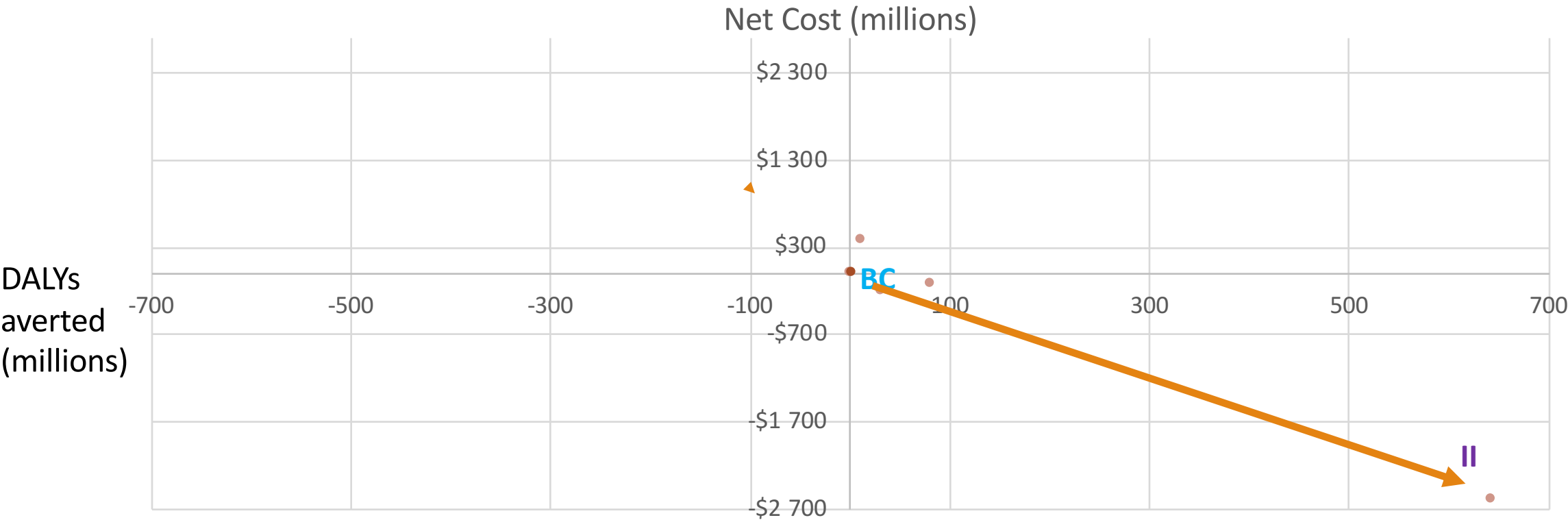
Cost and Effects of Measles Vaccination (PSU Model) (2018 USD) (millions)

Scenario	Undiscounted /Discounted Vaccination Costs	Cost Treatment Savings (Discounted Direct)	Net Costs (Add't Vacc Costs – Cost Savings)	Cases/deaths averted	DALYs averted	Cost per DALY averted
Basecase	\$15,838/ \$10,413	0	0	0	0	NA
Intensified Investment	\$22,497/ \$14,664	\$6,845	-\$2,595	379	642	Cost saving

Cost and Effects of Measles Vaccination (PSU Model) (2018 USD) (millions)

	Vaccination Costs BC - un/discounted, II – un/discounted	Cost Treatment Savings (Discounted)	Net Costs (Add't Costs – Cost Savings)	Cases averted	DALYs Averted	Cost per DALY averted
Ethiopia	\$182/\$118 \$509/\$316	\$267	-\$68	26	31	Cost saving
India	\$2,987/\$1,980 \$4,517/\$2,953	\$603	\$369	48	10	\$39
Nigeria	\$490/\$352 \$1,437/\$869	\$1,197	-\$681	40	80.4	Cost saving

Cost per DALY averted, PSU Model, 2018-2047 (2018 USD)



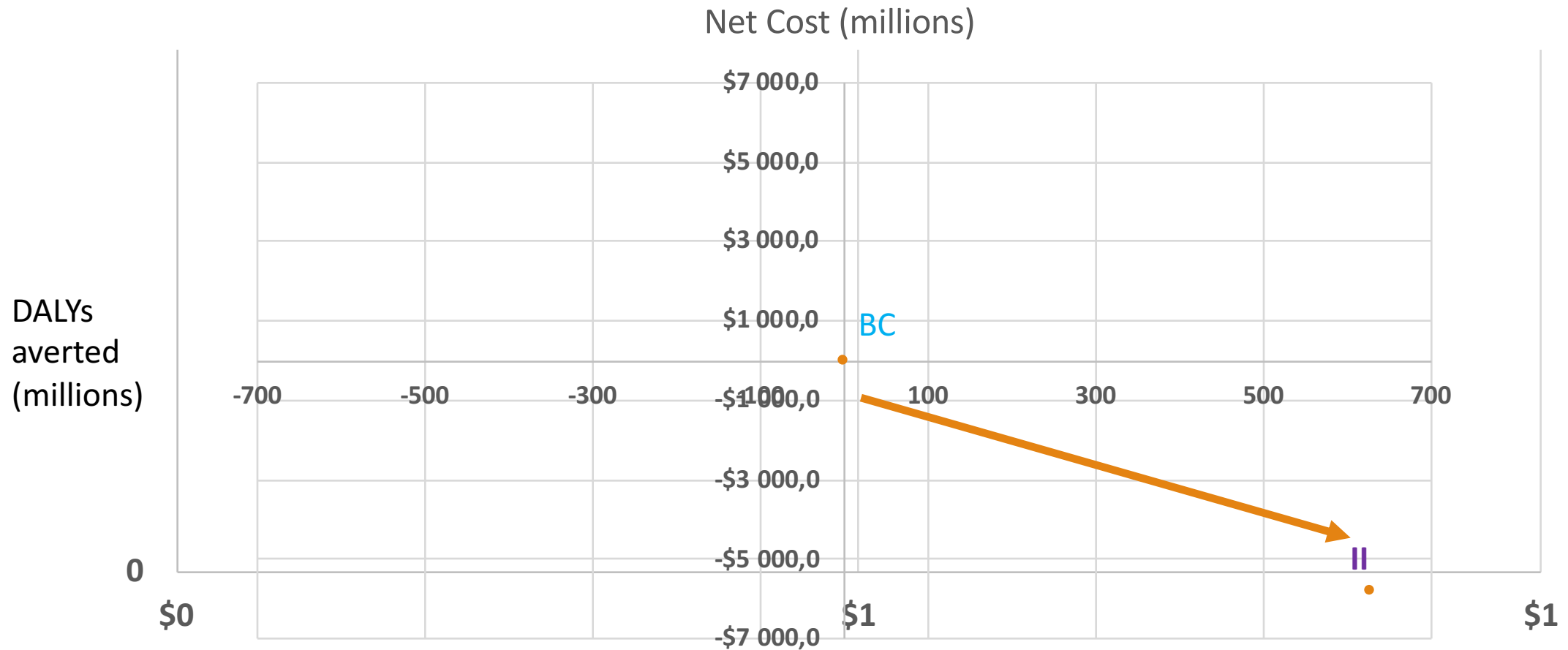
Cost and Effects of Measles Vaccination (LSHTM Model) (2018 USD) (millions)

Scenario	Vaccination Costs (un/discounted)	Cost Treatment Savings (discounted)	Net Costs	Cases averted	DALYs averted	Cost per DALY averted
Basecase	\$15,838/ \$10,413	0	0	0	0	
Intensified Investment	\$22,497/ \$14,664	\$7	-\$5.8	476	630	Cost saving

Cost and Effects of Measles Vaccination (LSHTM Model) (2018 USD) (millions), 2018-2047

Scenario	Vaccination Costs BC - un/discounted, II – un/discounted	Cost Treatment Savings (discounted)	Net Costs (Add't Costs – Cost Savings)	Cases averted	DALYs averted	Cost per DALY averted
Ethiopia	\$182/\$118 \$509/\$316	\$14.1	\$184	1.4	1.8	\$104
India	\$2,987/\$1,980 \$4,517/\$2,953	\$2,284	-\$1,311	170	167	Cost saving
Nigeria	\$564/\$353 \$1,437/\$869	\$1,265	-\$749	99	202	Cost saving

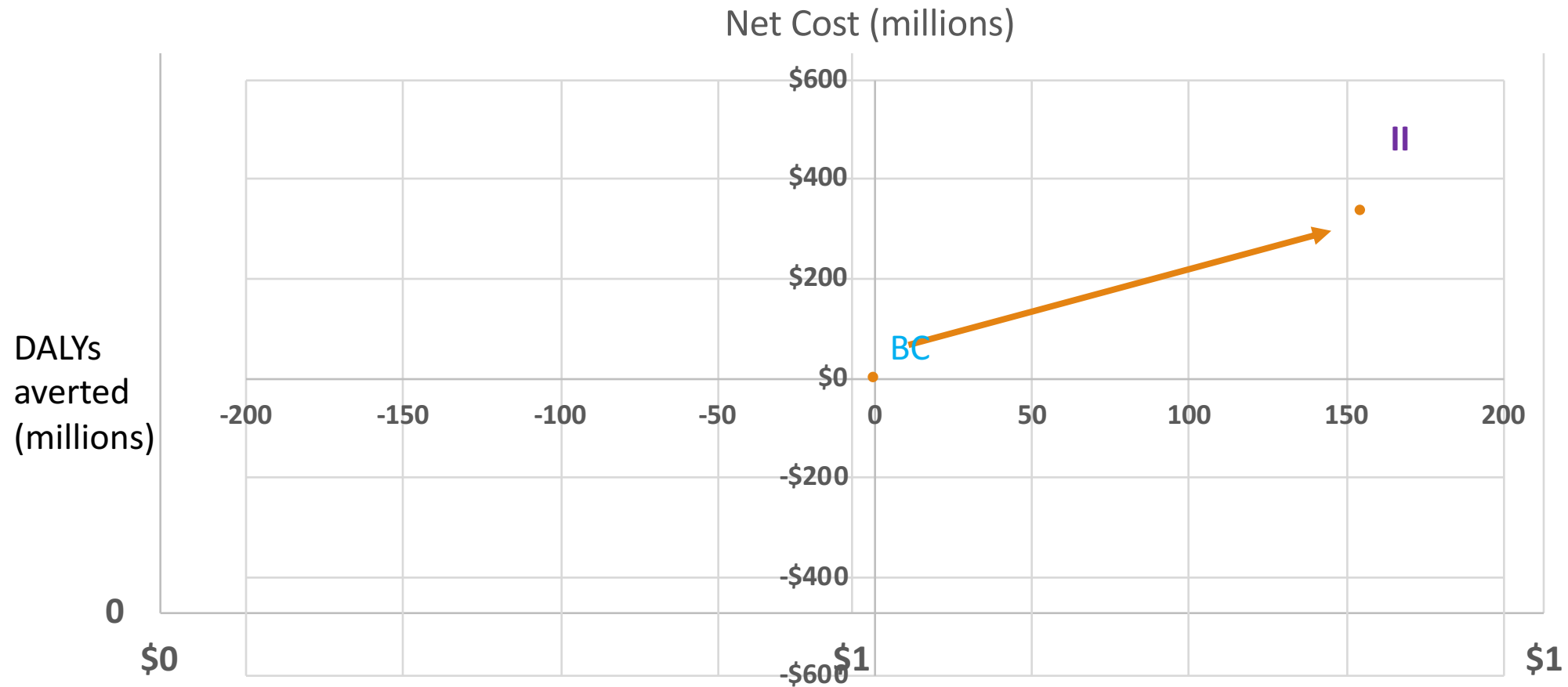
Cost per DALY averted for LSHTM Model, 2018-2047, (2018 USD)



Cost and Effects of Measles Vaccination (Nigeria Model) (2018 USD) (millions)

Scenario	Vaccination Costs (un/discounted)	Cost Treatment Savings (discounted)	Net Costs (Add't Vacc Costs – Cost Savings)	Cases/deaths averted	DALYs averted	Cost per DALY averted
Basecase	\$564/ \$353	0	0	0	0	
Intensified Investment	\$1,437/ \$869	\$851	\$335	71	155	\$2.17

Cost per DALY averted for Nigeria Model, 2018-2047, (2018 USD)

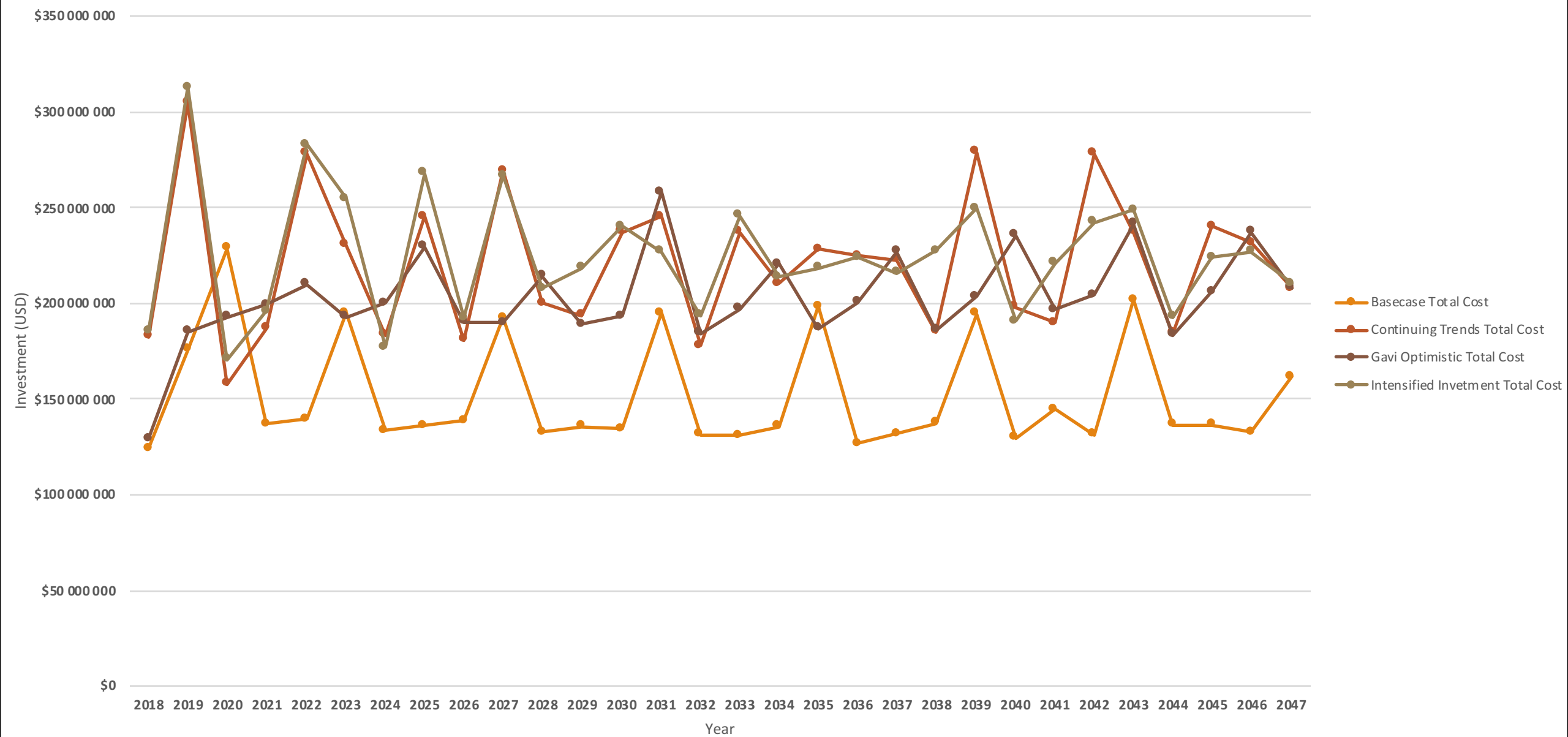


Rubella

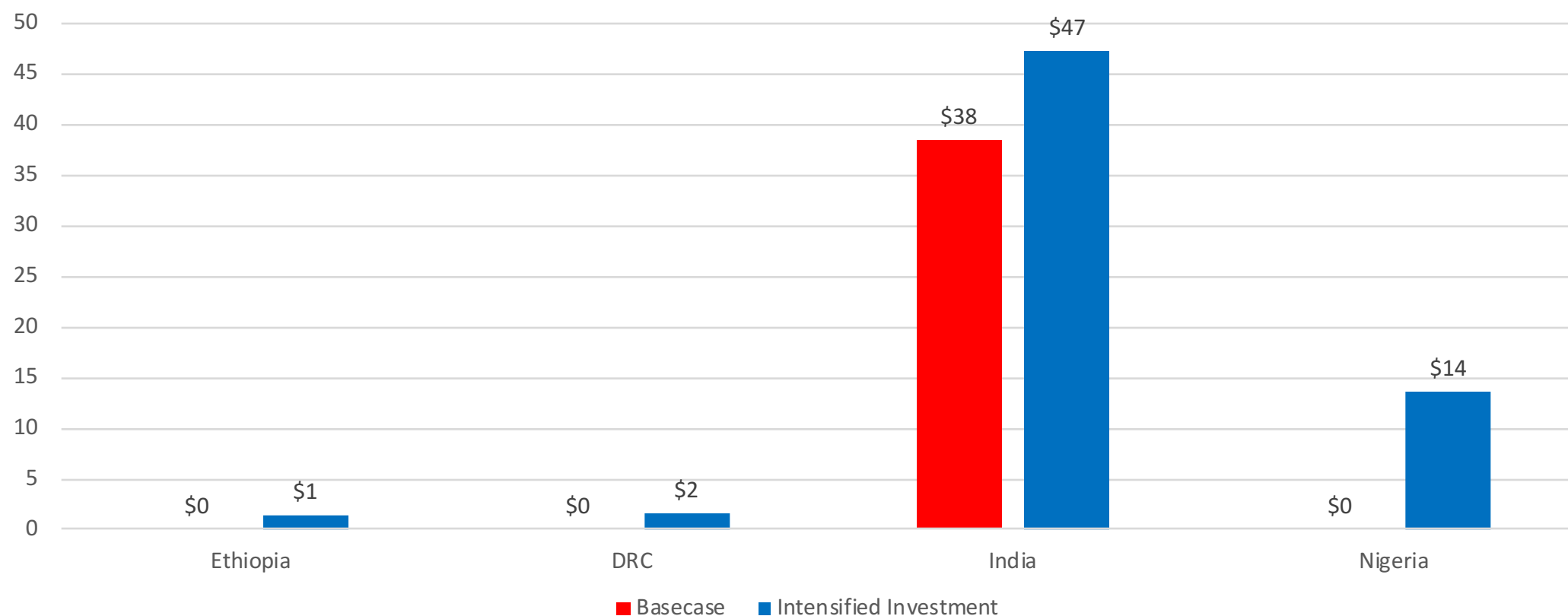
Costs of Rubella Vaccination, 2018-2047 (2018 USD)

Scenario	No. of Vaccinations (billions)	Vaccination Costs (un/discounted) (billions)
Basecase	4.5	\$4.6/\$3.0
Intensified Investment	7.4	\$6.7/\$4.4

Rubella Vaccination Costs (2018 USD), 2018-2047



Rubella Vaccination Costs, Annual Undiscounted Cost in Selected Countries (Millions 2018 USD)



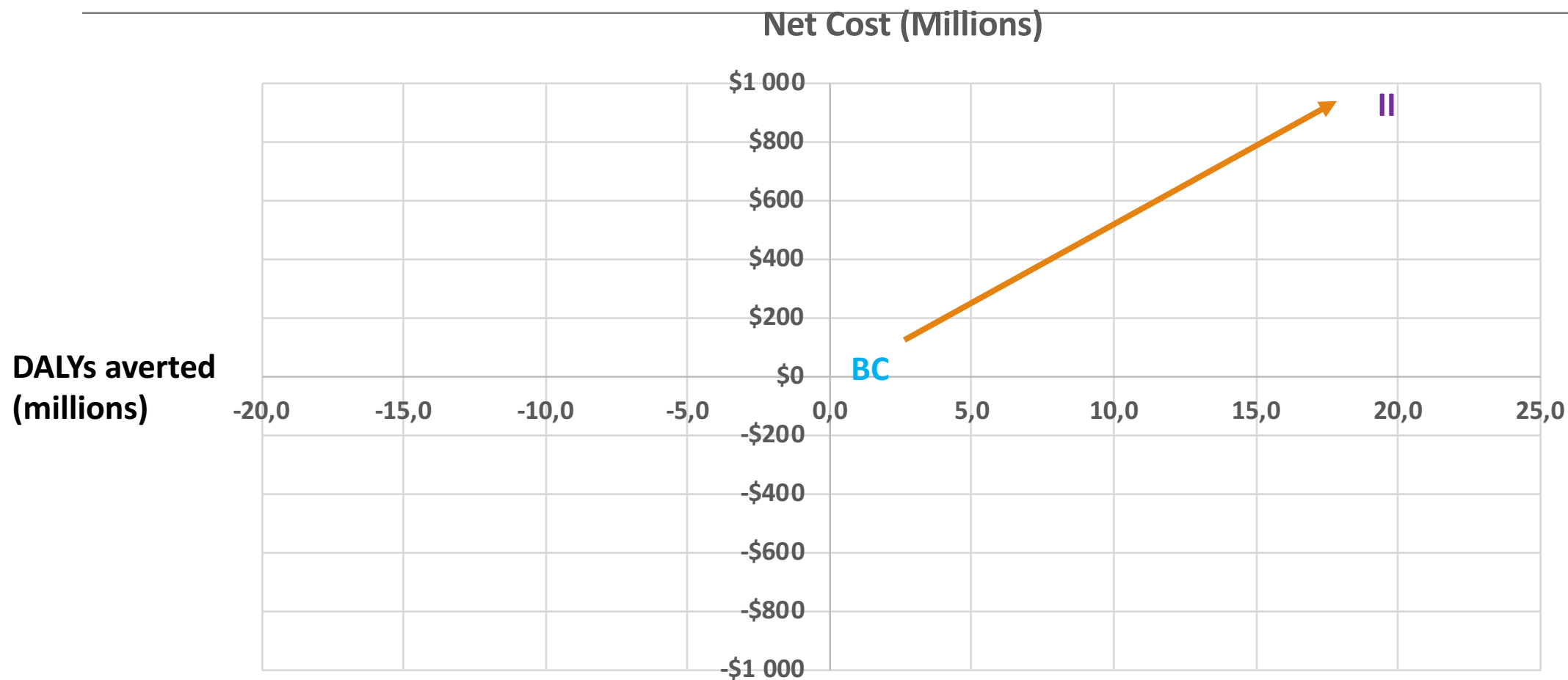
Cost and Effects of Rubella Vaccination (JHU Model) (2018 USD) (millions)

Scenario	Vaccination Costs (Un/discounted)	Cost Treatment Savings (discounted)	Net Costs	DALYs averted	Cost per DALY averted
Basecase	\$4,561/\$3,001	\$626	0	0	NA
Intensified Investment	\$6,747/\$4,421	\$201	\$995	18.1	\$55

Cost and Effects of Rubella Vaccination (JHU Model) (2018 USD) (millions), 2018-2047

Scenario	Vaccination Costs BC - un/discounted, II – un/discounted	Cost Treatment Savings (discounted)	Net Costs (Add't Costs – Cost Savings)	Cases averted	DALYs Averted	Cost per DALY averted
Ethiopia	\$0/\$0 \$69.5/\$42.5	\$25.5	\$16.9	0.044	1.1	\$15.9
India	\$1,154/\$752 \$1,436/\$950	\$64	\$134	74	1.9	\$70.85
Nigeria	\$0/\$0 \$669.2/\$407	\$99	\$308	163	4.7	\$65.58

Cost per DALY averted for JHU Model, 2018-2047, 2018 USD



Cost and Effects of Rubella Vaccination (PHE Model) (2018 USD) (millions)

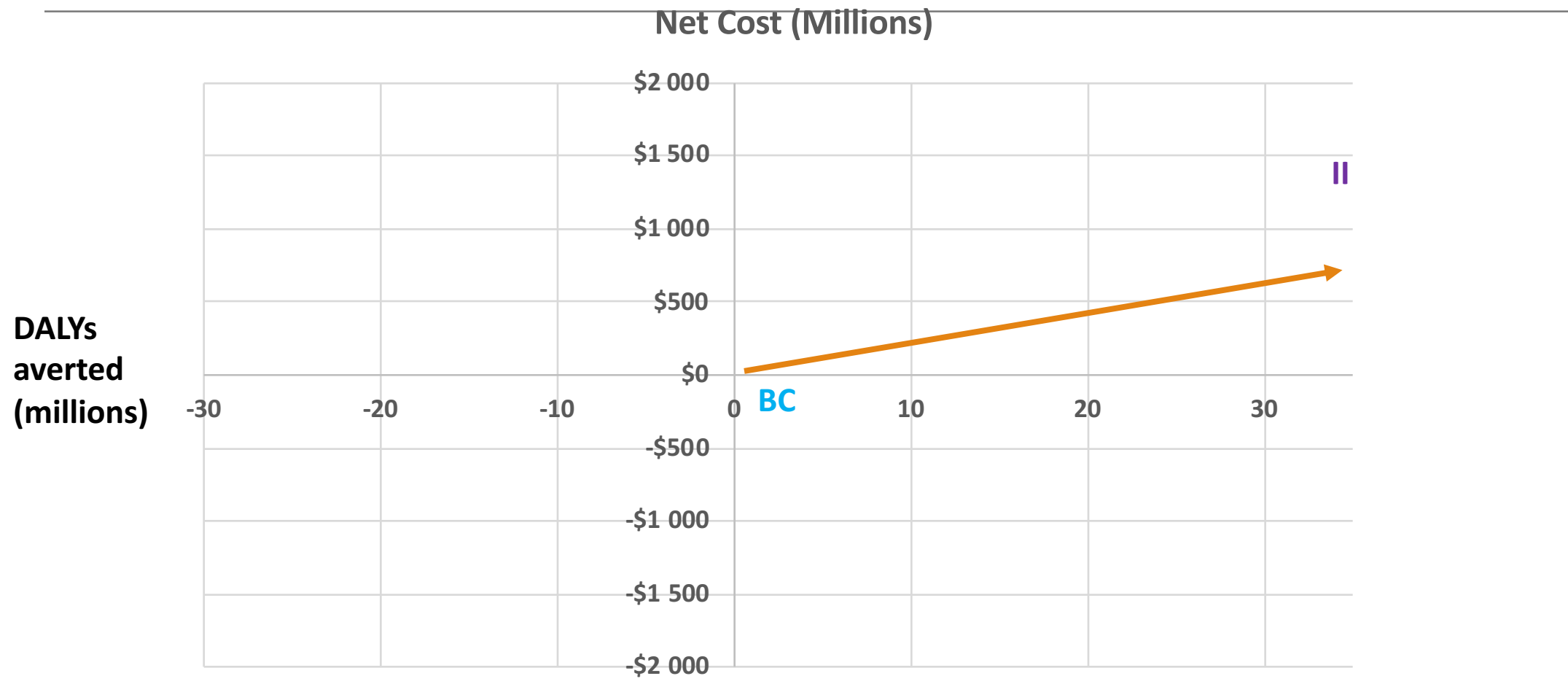
Scenario	Vaccination Costs (un/discounted)	Cost Treatment Savings (discounted)	Net Costs (Add't Costs – Cost Savings)	Cases averted	DALYs averted	Cost per DALY averted
Basecase	\$4,561/ \$3,001	0	0	0	0	NA
Intensified Investment	\$6,747/ \$4,421	\$1,111	\$719	1.1	31.7	\$22.69

Cost and Effects of Rubella Vaccination (PHE Model)

(2018 USD) (millions), 2018-2047

Scenario	Vaccination Costs BC - un/discounted, II – un/discounted	Cost Treatment Savings	Net Costs (Add't Costs – Cost Savings)	Cases averted	DALYs averted	Cost per DALY averted
Ethiopia	0/0 \$69.5/\$42.5	\$53.9	-\$11.4	0.088	2.6	Cost saving
India	\$1,154/\$752 \$1,436/\$950	\$57.1	\$140.8	0.063	1.8	\$80
Nigeria	\$0 \$669.2/\$407	\$225.7	\$181.6	0.366	10.2	\$18

Cost per DALY averted for PHE Model, 2018-2047, 2018 USD



Conclusion

Average annual measles vaccination costs in the intensified investment scenario ranges from \$11 million in Ethiopia to \$98 million in India

Average annual rubella vaccination costs ranges from \$1 million in Ethiopia to \$32 million in India in the intensified investment scenario.

All three scenarios are more cost-effective than the base case for measles and rubella, but intensified investment is the most cost-effective

Measles:

- In both models, Intensified Investment scenario is more cost effective than the Basecase.

Rubella: Results are similar for the JHU and PHE models

- Intensified Investment is more cost-effective than Basecase.

Analysis had several limitations: limited cost data on treatment, surveillance, increasing immunization coverage, and outbreak responses