The Economics of Vaccination

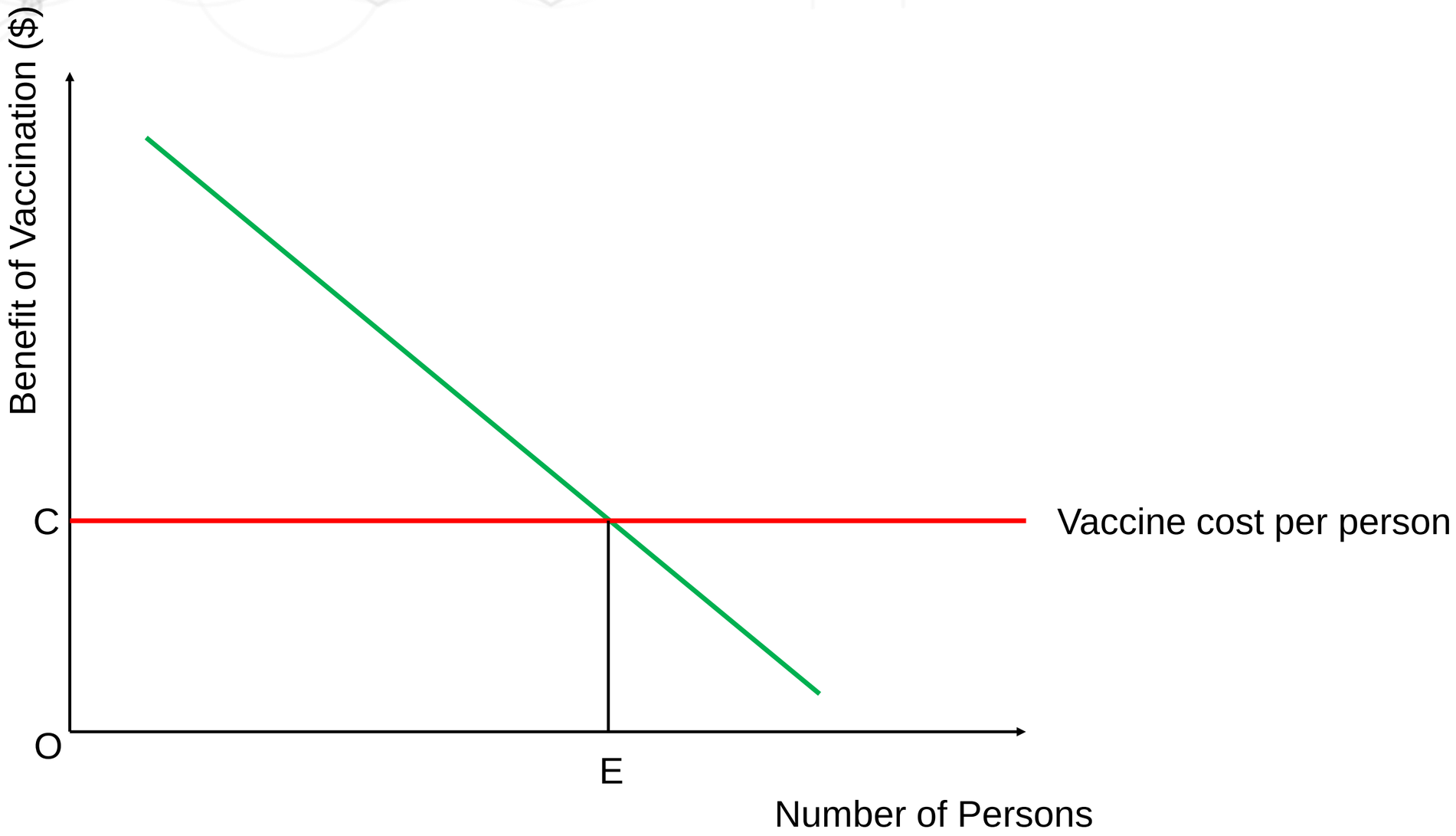
Ajay Mahal

Hanoi, October 18, 2017 (Vaccinology Conference)

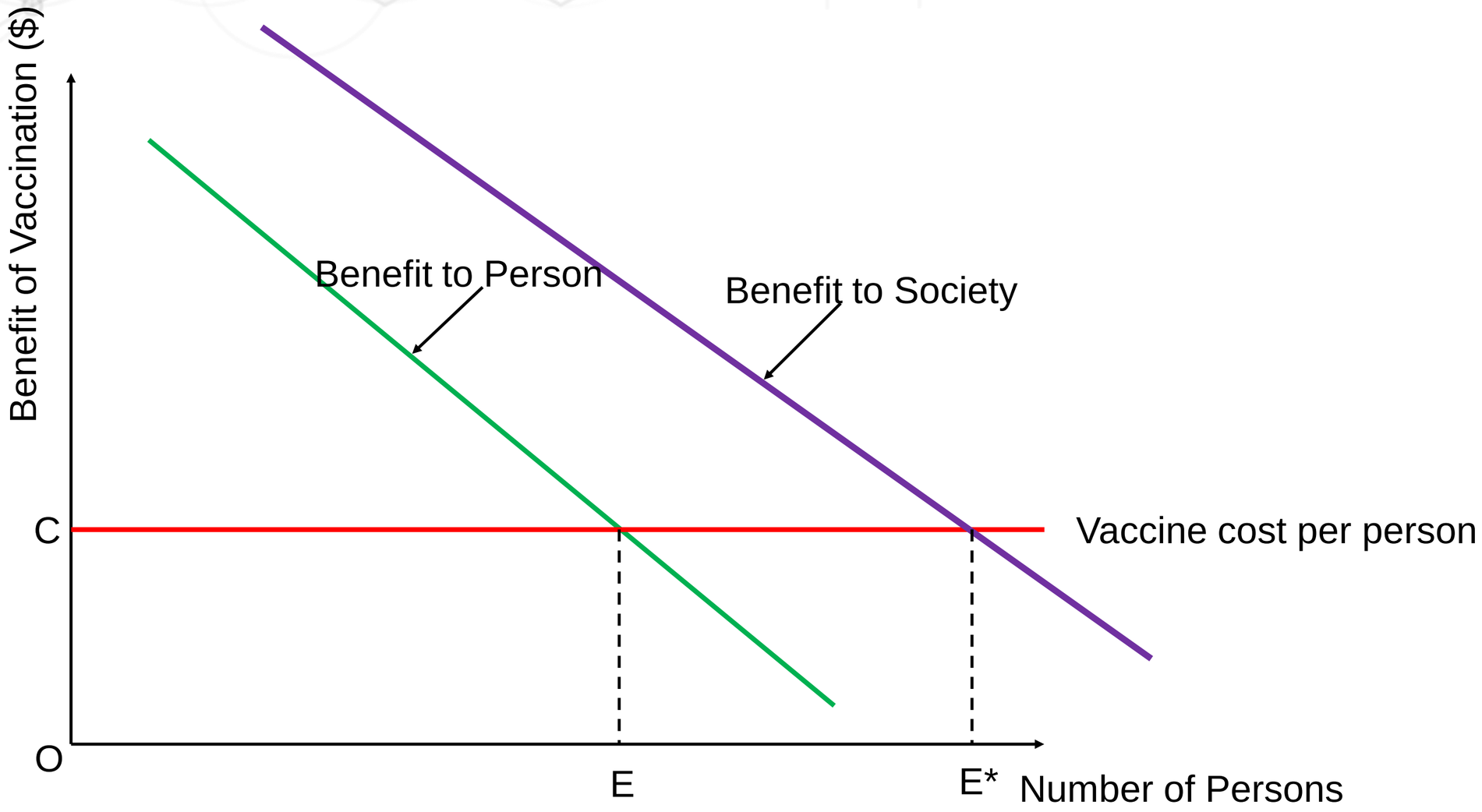
Introduction: How Do Economists Think About Vaccines?

- Individual, household and organizational behaviours related to vaccine use, development and production
- The consequences of those behaviours
- Policy measures to address these consequences, and their effectiveness

Individual and Household Behaviours towards Vaccination: Choices and Consequences



Individual and Household Behaviours towards Vaccination: Choices and Consequences



The Benefits of Vaccination: A Listing

(Source: Barnighausen et al, PNAS 2017)

Table 1. Framework of vaccination benefits

Perspective		Benefit categories	Definition
Broad	Narrow	Health care cost savings	Savings of medical expenditures because vaccination prevents illness episodes
		Care-related productivity gains	Savings of patient's and caretaker's productive time because vaccination avoids the need for care and convalescence
		Outcome-related productivity gains	Increased productivity because vaccination improves physical or mental health
		Behavior-related productivity gains	Vaccination improves health and survival, and may thereby change individual behavior, for example by lowering fertility or increasing investment in education
		Community health externalities	Improved outcomes in unvaccinated community members, e.g., through herd effects or reduction in the rate at which resistance to antibiotics develops
		Community economic externalities	Higher vaccination rates can affect macroeconomic performance and social and political stability
		Risk reduction gains	Gains in welfare because uncertainty in future outcomes is reduced
		Health gains	Utilitarian value of reductions in morbidity and mortality above and beyond their instrumental value for productivity and earnings

Cost-Effectiveness of Vaccines: Averted Health Care Expenses and Productivity Gains for Vaccinated Child's Household (Source:

Table 10.2 Approximate Range of Cost-Effectiveness of Various Childhood Vaccines, Various Contexts (2012 U.S. dollars per DALY averted)

< US$100/DALY[a]	US$100 to <US$1,036/DALY[b]	Over US$1,036/DALY[c]
Original EPI-6: BCG, DTP, measles, polio	*Haemophilus influenzae* type B	Cholera (final price point pending)
Hepatitis B	Yellow fever, where endemic	Pneumococcus, low-child-mortality countries
Pneumoccocus, high-child-mortality countries	Japanese encephalitis, where endemic	Rotavirus, low-child-mortality countries
Rotavirus, high-child-mortality countries	Pneumococcus, medium-child-mortality countries	
	Rotavirus, medium-child-mortality countries	
	Meningitis A, where endemic	

Source: For details on sources and references, see table 17.1 of chapter 17 of this volume (Horton and Levin 2016).
Note: EPI = Expanded Program on Immunization; BCG = Bacille Calmette-Guérin; DALY = disability-adjusted life year; DTP = diphtheria, tetanus, and pertussis. For vaccines, cost-effectiveness is sensitive to vaccine price as well as variability in underlying disease burden by country.
a. Vaccines in the first column are very cost-effective in all low-income countries because cost per DALY averted is less than per capita gross national income (GNI) of even the poorest low-income country (World Bank definition of "low-income country" is per capita GNI of less than US$1,035 in 2012 and in 2012 the per capita income of the poorest low-income country was approximately US$250).
b. Vaccines in the second column are very cost-effective in all lower-middle-income countries (World Bank definition of "lower-middle-income country" is per capita GNI in 2012 ranging between US$1,036 and US$4,085).
c. Vaccines in the third column may be very cost-effective in upper-middle-income countries (World Bank definition of "upper-middle-income country" is per capita GNI in 2012 ranging between US$4,086 and $12,615).

Rates of Return on Vaccine Spending
(Source: Ozawa et al, Health Affairs 2016)

EXHIBIT 2

Estimated Return On Investment (ROI), Economic Benefits, And Costs Of Immunization Programs For 10 Antigens, By Country Group, 2011–20

	Low- and middle-income countries ($n = 94$)	Uncertainty range	Gavi-supported countries ($n = 73$)	Uncertainty range
RETURN ON INVESTMENT (NET BENEFITS DIVIDED BY COSTS)				
Cost of illness only	16.11	9.78–24.91	17.58	11.19–26.11
Broader economic benefits	43.83	26.65–66.65	47.80	32.44–67.43
ECONOMIC BENEFITS				
Cost of illness only	$586 billion	$442–$756 billion	$544 billion	$413–$701 billion
Broader economic benefits	$1.53 trillion	$1.12–$1.96 trillion	$1.43 trillion	$1.16–$1.72 trillion
Cost of immunization programs	$34 billion	$23–$46 billion	$29 billion	$21–$38 billion

SOURCE Authors' analysis based on health impact estimates derived from Gavi's 2014 strategic demand forecast and dose estimates from Gavi's 2014 adjusted demand forecast (Notes 8 and 25, respectively, in text). **NOTES** ROI estimates are rounded to two decimal points. Costs and economic benefits are reported in 2010 US dollars and rounded to three significant figures.

VALUE OF VACCINES

By Sachiko Ozawa, Samantha Clark, Allison Portnoy, Simrun Grewal, Logan Brenzel, and Damian G. Walker

Return On Investment From Childhood Immunization In Low- And Middle-Income Countries, 2011–20

ABSTRACT An analysis of return on investment can help policy makers support, optimize, and advocate for the expansion of immunization programs in the world's poorest countries. We assessed the return on investment associated with achieving projected coverage levels for vaccinations to prevent diseases related to ten antigens in ninety-four low- and middle-income countries during 2011–20, the Decade of Vaccines. We derived these estimates by using costs of vaccines, supply chains, and service delivery and their associated economic benefits. Based on the costs of illnesses averted, we estimated that projected immunizations will yield a net return about 16 times greater than costs over the decade (uncertainty range: 10–25). Using a full-income approach, which quantifies the value that people place on living longer and healthier lives, we found that net returns amounted to 44 times the costs (uncertainty range: 27–67). Across all antigens, net returns were greater than costs. But to realize the substantial positive return on investment from immunization programs, it is essential that governments and donors provide the requisite investments.

The Long Run Benefits of Vaccination: Antenatal Maternal Vaccination against Tetanus in

Setting: Randomized Trial of Antenatal Maternal Vaccination in MATLAB, Bangladesh in 1974. Explored schooling outcomes of children born during 1975-79 to the study population in 1996

Findings:

- Increase of 0.25 years of schooling among children whose parents had no schooling
- Estimated wage gain of 2.5% for children born to parents with no schooling; and a population-wide average gain of 1.2%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SOCIAL SCIENCE & MEDICINE

The effect of maternal tetanus immunization on children's schooling attainment in Matlab, Bangladesh: Follow-up of a randomized trial

David Canning [a,*], Abdur Razzaque [b], Julia Driessen [c], Damian G. Walker [d], Peter Kim Streatfield [b], Mohammad Yunus [b]

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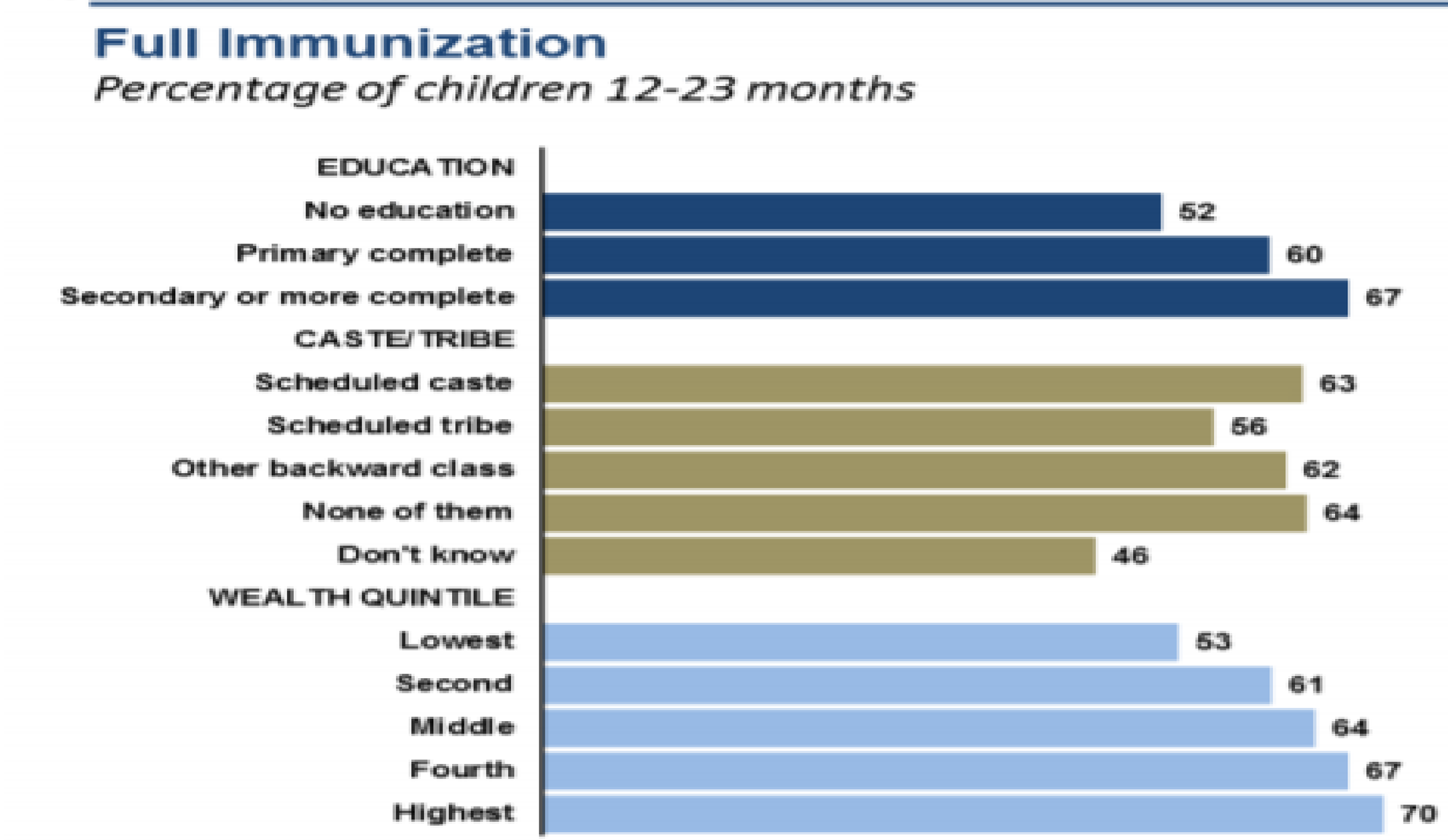
[d] Bill and Melinda Gates Foundation, USA

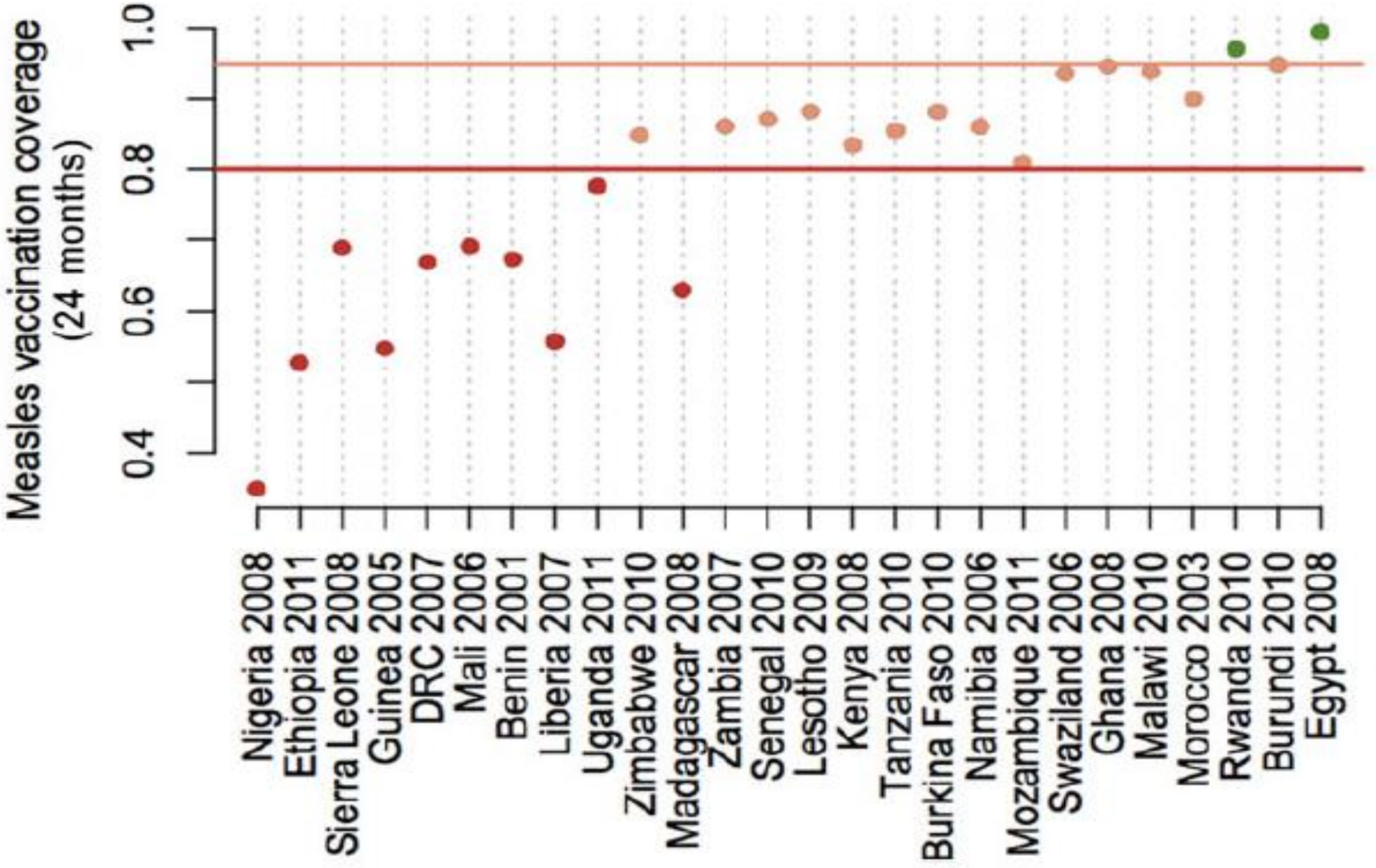
Are Private Benefits Really that Small?
Other Arguments

- Strongly Held Beliefs
- Psychology: Distant health gains (even if to oneself) seem small relative to immediate costs
- Strategic Behaviour
- Principal (the child) and the Agent (the parent or the guardian)
- Equity: costs to families can be too high relative to income

How Do Economists Think About Vaccines? Moving from "Efficiency" to Equity (Source: IIPS 2017)



Measles Vaccination Rates at 24 months in Remote Communities in African Countries relative to 80% and 95% coverage thresholds; Source: Metcalf et al (2014)



Available Policy Action

- Influence Household Behaviours

Limiting access to schooling in the absence of complete immunization (e.g., Australia, Italy, USA)

Lower the cost to the household (subsidized provision of vaccines, setting up immunization camps near communities, school health programs)

Provide financial incentives (conditional cash transfers)

Conditional Cash Transfers in Indonesia: Implications for Immunization Rates

Poor households in 588 “supply-ready "sub-districts (259 treatment, 329 control); Payments to households (USD 18-54 quarterly) were c*onditional* on specific health and education visit/enrollment guidelines being met.

Key Findings:

- Child vaccination rates were up to 30% higher among children 0-12 months old in districts where the CCT program was operational (smaller effects among child 12-23 months)

- *Equity enhancing*: increases in immunization rates (among 0-12 months) of up to 52% observed among children of less educated mothers

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World Development

Volume 98, October 2017, Pages 497-505

New Evidence on the Impact of Large-scale Conditional Cash Transfers on Child Vaccination Rates: The Case of a Clustered-Randomized Trial in Indonesia

Dian Kusuma [a, b], Hasbullah Thabrany [b], Budi Hidayat [b], Margaret McConnell [a], Peter Berman [a], Jessica Cohen [a]

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https://doi.org/10.1016/j.worlddev.2017.05.007

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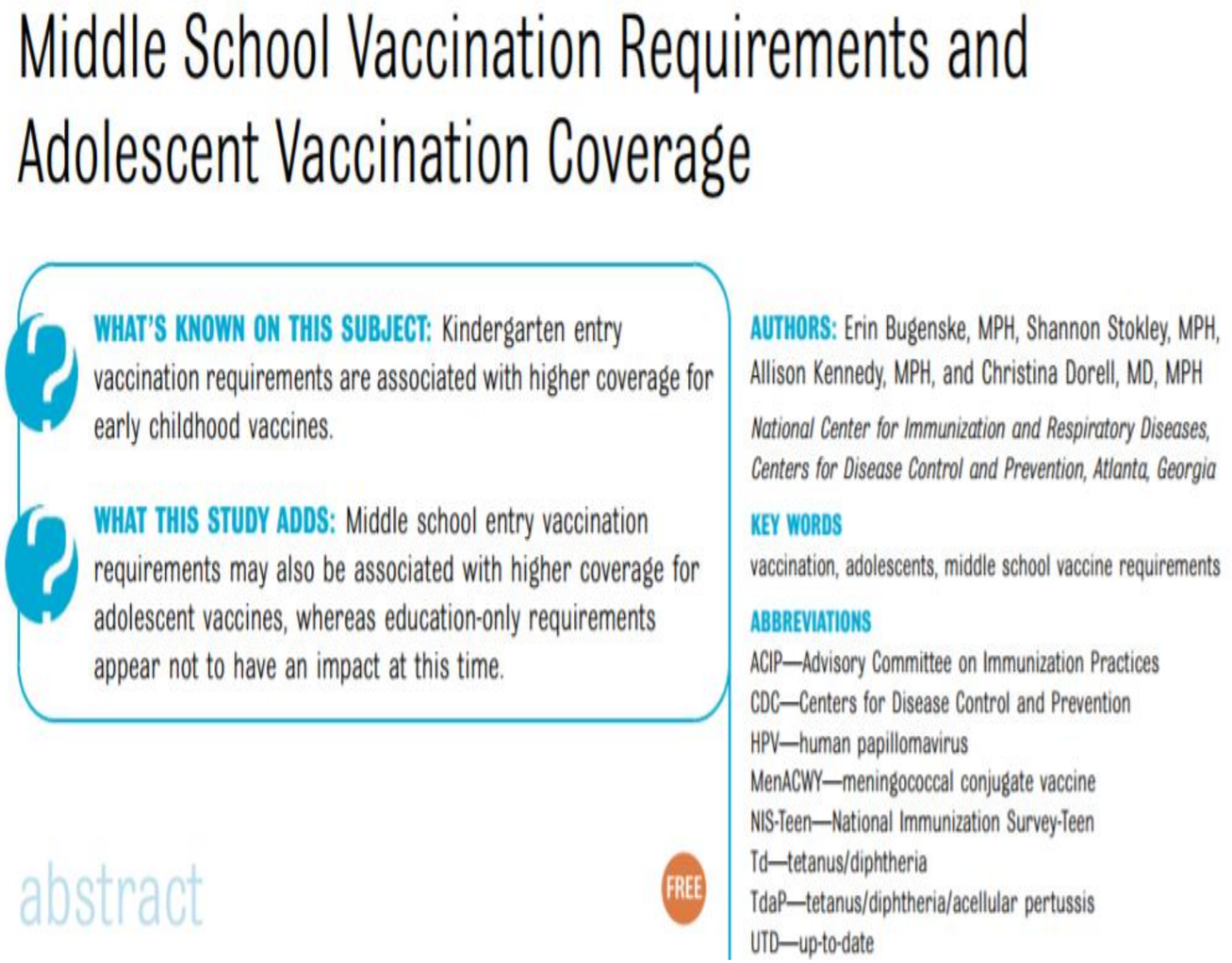
Vaccination Requirements by Schools (Washington D.C.)

Source: Bugenske et al. (2012), Pediatrics

Compared change in coverage for US states that had middle school immunization requirements for 3 vaccines recommended for adolescents, versus those that did not, or had education requirements only

- Tetanus/Diphtheria/Pertussis (71% versus 53%)
- Meningococcal Conjugate (80% versus 70%)
- HPV (no difference)



Middle School Vaccination Requirements and Adolescent Vaccination Coverage

WHAT'S KNOWN ON THIS SUBJECT: Kindergarten entry vaccination requirements are associated with higher coverage for early childhood vaccines.

WHAT THIS STUDY ADDS: Middle school entry vaccination requirements may also be associated with higher coverage for adolescent vaccines, whereas education-only requirements appear not to have an impact at this time.

abstract

FREE

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KEY WORDS

vaccination, adolescents, middle school vaccine requirements

ABBREVIATIONS

ACIP—Advisory Committee on Immunization Practices
CDC—Centers for Disease Control and Prevention
HPV—human papillomavirus
MenACWY—meningococcal conjugate vaccine
NIS-Teen—National Immunization Survey-Teen
Td—tetanus/diphtheria
TdaP—tetanus/diphtheria/acellular pertussis
UTD—up-to-date

What are the Limits to Government Action?

The amounts involved are NOT large, but not trivial either!

- *Benefit Spill-overs*:

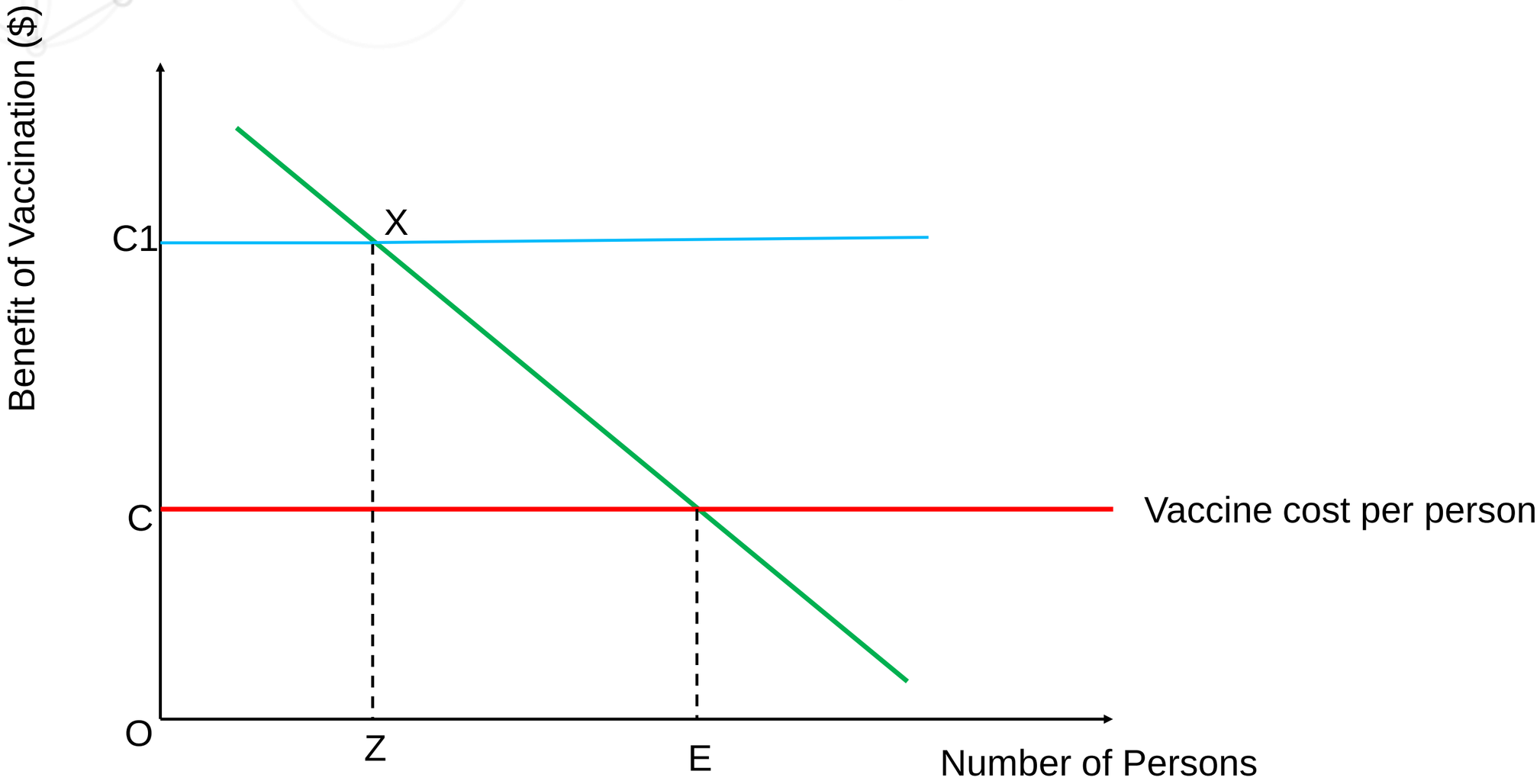
  Over time: Long-term gains not consistent with the election cycle in democratic societies – current governments don't keep the benefits from "spilling over" to future governments

  Over space: National benefits may not be consistent with international gains (and infectious conditions do not have national boundaries).

  Incidentally, the same argument exists for settings where decentralization of health services and expenditure responsibilities has occurred

- *The Line Item Budget, Competing Ministries and Divisions and Interventions*

Complications on the Supply Side of Vaccines: Limited Competition



Where Do Monopolies in Vaccine Supply Come From?

- Patent Protection

- Reverse Engineering (unlike in drugs) not possible to carry out so potential competitors face entry barriers upon expiry of patents. Complex manufacturing processes and regulatory requirements

- Natural monopolies: high fixed costs but low sharp declines in variable costs as production ramps up. This is the same reason you see large companies in railways, telecommunications and postal services

Vaccine 35 (2017) 4064–4071

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Review

The complexity and cost of vaccine manufacturing – An overview

Stanley Plotkin[a], James M. Robinson[b,*], Gerard Cunningham[c], Robyn Iqbal[d], Shannon Larsen[b]

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Addressing Monopolies

- *Battle of Titans*: Large Buyers versus Large Sellers (UNICEF, PAHO) – UNICEF purchases 40% of all vaccine doses for children worldwide.

- *Enlightened Self-Interest (??)*: Tiered-pricing (or price discrimination)

- *Promotion of Competition*: Technology-transfers and Product Development Partnerships to help low-cost suppliers in middle-income countries. Many suppliers are from middle-income countries

- But new challenges from lower prices – *exit of producers in high income countries.*

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COMMENTARY

OPEN ACCESS

Are good intentions putting the vaccination ecosystem at risk?

Michael Watson[a,*] and Eliot Faron de Goër[b]

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ABSTRACT

Vaccination is made possible by an interconnected and interdependent ecosystem of vaccine producers, vaccination policy makers and implementers, and vaccine procurers and funders. The future of vaccination depends on the continued health of this ecosystem and its ability to produce, purchase, deliver, and innovate. However, the number of vaccine producers that also do significant research and development has decreased over the last several years. Many of these R&D-based producers have been forced to cease production of critical vaccines, despite global shortages, so that in several cases only one or two producers remain. We discuss the reasons for these changes and what might be done to maintain a healthy vaccination ecosystem.

ARTICLE HISTORY
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KEYWORDS
economics; funding; health policy; non-governmental organization; vaccination program

New Vaccine Development: Another Round of Incentive Issues

- Without firm commercialization possibilities, it is difficult to justify investments in R & D.

10.7 years from pre-clinical development phase to market entry; 6% chance of market entry (Pronker et al. 2013)

Risk-adjusted costs estimated to vary from USD130 million to USD 500 million (Plotkin et al 2017)

- Some kind of pre-commitment to purchase a specific VALUE of vaccine supplies is important, otherwise purchaser can always renegotiate once the investments have been made and products developed (GAVI)

- Prizes to winners but these need to be very large, due to competitors and potentially winner-take-all!


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RESEARCH ARTICLE

Risk in Vaccine Research and Development Quantified

Esther S. Pronker, Tamar C. Weenen, Harry Commandeur, Eric H. J. H. M. Claassen, Albertus D. M. E. Osterhaus

Published: March 20, 2013 • https://doi.org/10.1371/journal.pone.0057755

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The Role of Health Systems in Vaccine Delivery: Relooking at the Economic Cost-Benefit Calculus

We often think of vaccines as a silver bullet, with supply chain or personnel issues thrown in. The costing and economic benefit calculations are undertaken as simple accounting exercises. Some model of “routine immunization” plus supplemental activities is assumed

A Final Note: How do we think about health system implications in the context of economic evaluation?

What happens to routine health service delivery functions as the number of doses and vaccines increases?

If users of vaccination services do not visit a crumbling public health system, what then? Are there complementarities in investments?

How does one balance the increased needs of rapidly ageing societies in LMICs and chronic conditions with a child vaccination program?

More Evidence on the Impact of India's Conditional Cash Transfer Program, Janani Suraksha Yojana: Quasi-Experimental Evaluation of the Effects on Childhood Immunization and Other Reproductive and Child Health Outcomes

Natalie Carvalho, Naveen Thacker, Subodh S. Gupta, Joshua A. Salomon

Published: October 10, 2014 • https://doi.org/10.1371/journal.pone.0109311