Data sources and resources for modeling cost-effectiveness of HIV interventions

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Outline

- Data needed for a cost-effectiveness analysis (CEA)
- Data sources and limitations
- Software for CEA
- Types of models
- Review of CEA concepts

Motivating example: What is the most cost-effective method to promote voluntary male circumcision in Uganda?

- **Target population:** HIV- uncircumcised men ages 18-49
- **Options:**
  1. VMMC promotion at time of HIV test
  2. VMMC promotion plus SMS reminders
  3. VMMC promotion home plus follow-up at 1 and 2 months
- Option 3 may be the most effective but it is likely to incur the most costs.

[Some of the] **Data needed for analysis:**

- Effectiveness of each intervention
- Prevalence of HIV in Uganda, current uptake of MC, ART coverage
- Sexual behavior, age-structure of the population, background mortality rate.
- Costs of interventions and standard of care (ie MC procedure, HIV testing, ART, hospitalization)
- Costs averted by preventing future cases of HIV through MC

Data sources:

- **Published peer-reviewed data**
  - Specific clinical trial or cohort (single study evidence)
  - Literature reviews (e.g. Pubmed): Examine evidence from multiple studies
  - Meta-analyses: pooled evidence from multiple studies
    - Cochrane Collaboration, Cochrane library
- **Ongoing study data**
  - Current clinical trial or cohort study
- **Unpublished data**
  - In country expert opinion
  - Ministry of Health
- **NGO reports**
  - UNAIDS, WHO life tables, WHO-CHOICE website, International drug price indicator Guide, Clinton Health Access Initiative (ART prices)

Published sources:

- Costs of MC, HIV/AIDS treatment, and OIs

The cost of providing comprehensive HIV treatment in PEPFAR-supported programs

Nicolas A. Menzies[a,b], Andres A. Berruti[a,b], Richard Berzon[c], Scott Filler[a], Robert Ferris[c], Tedd V. Ellerbrock[a] and John M. Blandford[a]

Medical male circumcision for HIV/AIDS prevention in Uganda – the cost of disposable versus re-usable circumcision kits

Trop Doct January 2012 42: 5-7,

HIV prevention costs and program scale: data from the PANCEA project in five low and middle-income countries

Elliot Marseille*[1], Lalit Dandona[2], Nell Marshall[1], Paul Gaist[3],

- HIV transmission rates

HIV-1 transmission among HIV-1 discordant couples before and after the introduction of antiretroviral therapy

Steven J. Reynolds[a,b], Frederick Makumbi[c], Gertrude Nakigozi[d], Joseph Kagaayi[d], R H. Gray[e], Maria Wawer[e], Thomas C. Quinn[a,b], and David Serwadda[c]

VIRAL LOAD AND HETEROSEXUAL TRANSMISSION OF HUMAN IMMUNODEFICIENCY VIRUS TYPE 1

THOMAS C. QUINN, M.D., MARIA J. WAWER, M.D., NELSON SEWANKAMBO, M.B., DAVID SERWADDA, M.B., CHUANJUN LI, M.D., FRED WABWIRE-MANGEN, PH.D., MARY O. MEEHAN, B.S., THOMAS LUTALO, M.A., AND RONALD H. GRAY, M.D., FOR THE RAKAI PROJECT STUDY GROUP

Male Circumcision and Risk of Male-to-Female HIV-1 Transmission: A Multinational Prospective Study in African HIV-1 Serodiscordant Couples

Jared M. Baeten[1], Deborah Donnell[2], Saidi H. Kapiga[4,5], Allan Ronald[6], Grace John-Stewart[1], Mubiana Inambao[3], Rachel Manongi[5], Bellington Vwalika[3], and Connie Celum

- Disability adjusted life years for HIV/AIDS

Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010

Joshua A Salomon†, Theo Vos, Daniel R Hogan, Michael Gagnon, Mohsen Naghavi, Ali Mokdad, Nazma Begum, Razibuzzaman Shah, Muhammad

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Ongoing study:

- **Randomized clinical trial**
  - Linkages Study—3 arms of MC promotion
  - Trial will be used to estimate uptake (efficacy) and incremental costs of each intervention
- **Advantages of using a prospective trial:**
  - Detailed costs—not normally recorded
  - Time and motion studies—capture staff time spent on different aspects of intervention
  - Identify areas of inefficiency (wasted resources or time) & modify protocol
  - First-hand assessment of trial quality
  - Quick turnaround of CEA for policymakers

Limitations of data sources:

- **Generalizability**
  - Population chosen for cohort, self-selection into clinical trial
  - Scale-up
- **Time frame**
  - Length of follow-up may be shorter than time horizon of CEA (can be addressed through modeling)
- **Study design**
  - Observational studies may contain selection bias, confounding
  - Clinical trials can have differential loss to follow-up, frequently unblinded which can induce bias, varying quality
- **Effectiveness vs. efficacy**
  - Estimates of MC uptake from an RCT may not indicate real world intervention performance (addressed by obtaining real world estimates of intervention uptake)
  - Costs may also be different in the real world (can separate out intervention costs)

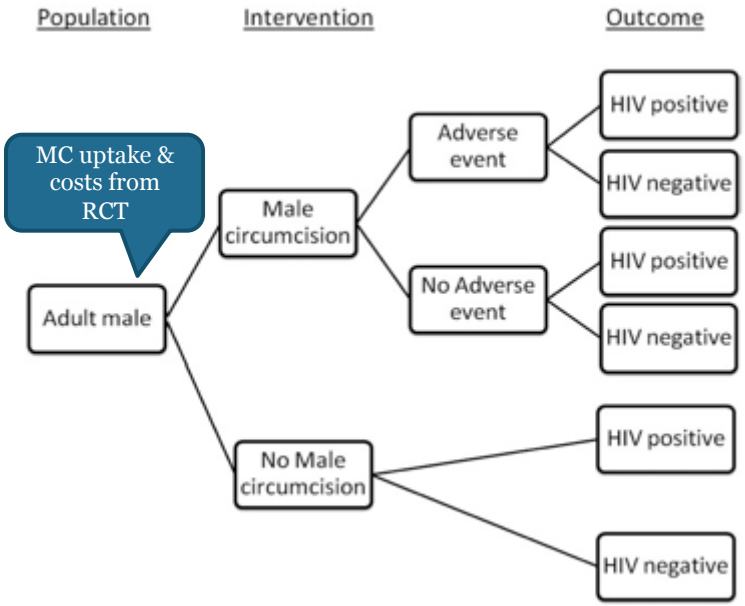
Important to recognize limitations in data and vary uncertain parameters in sensitivity analysis

Synthesizing data into a simulation model

- **Software:**
  - Treeage
  - Microsoft Excel
  - Stella
  - R
  - C++
  - Matlab
  - Java
  - Python

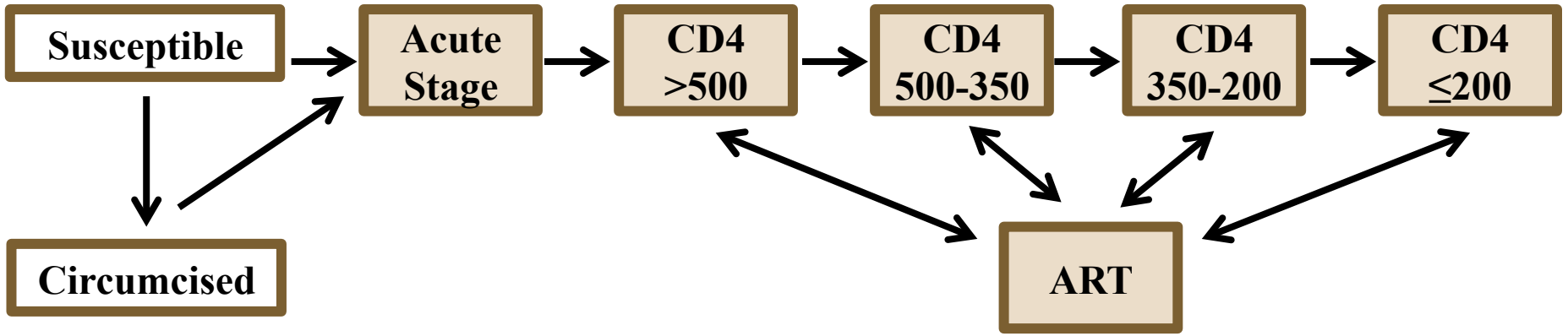
Treeage model

- Advantages
  - Easy to use
  - Visualize decision tree
- Disadvantages
  - Static model—doesn't incorporate herd protection/indirect benefits to women and other men
  - With increasing complexity of interventions, tree can get large/complicated



Source: Aremu O., The cost-utility analysis of adult male circumcision for prevention of heterosexual acquisition of HIV in men in sub-Saharan Africa: a probabilistic decision model. Value in health ,2011,Vol.14(1),p.70-79

Dynamic simulation model:



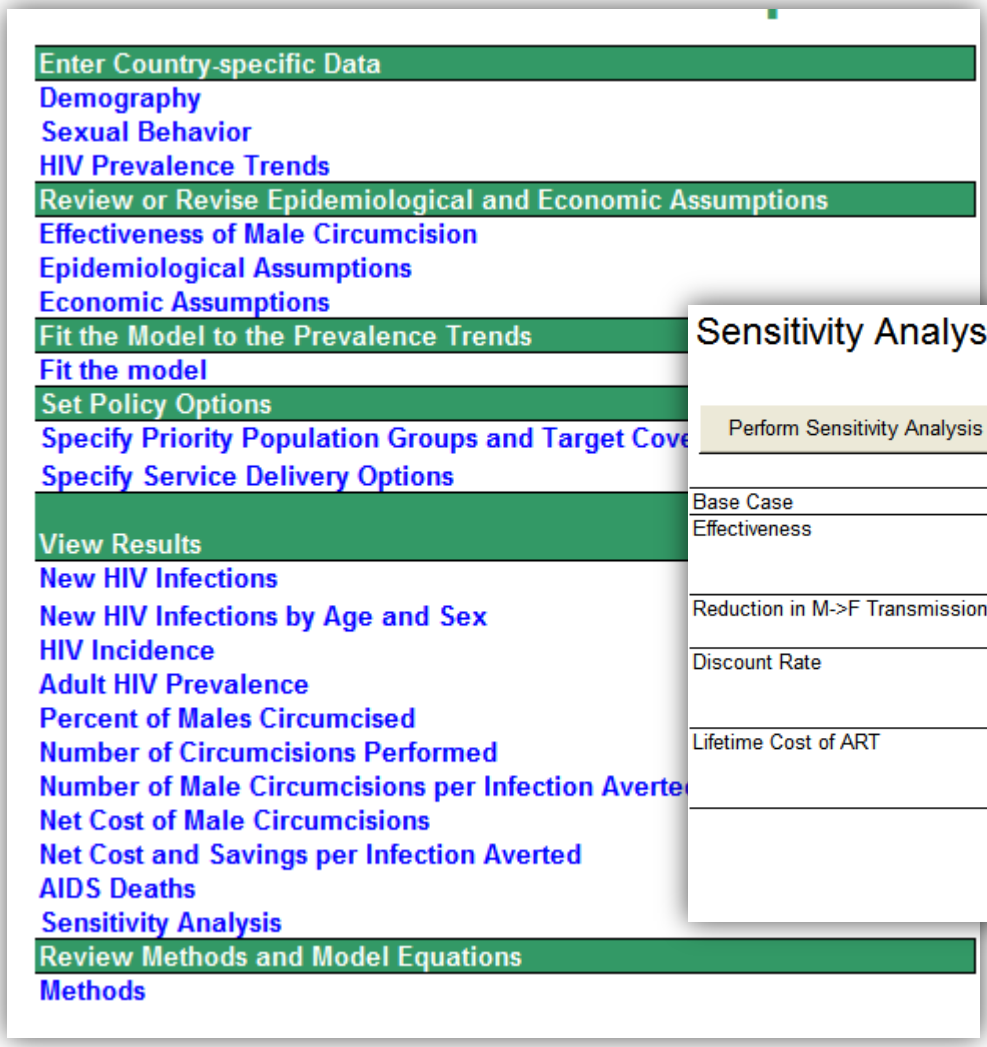
- Incorporates indirect benefits, varies transmission by CD4 count and ART status, estimates intermediate (MC uptake) and long-term outcomes (HIV infections and DALYs averted).

Roger Ying, ISSTDR, 2013

Planning tools and models

- Decision Makers Planning Tool
- Reproductive Health (RH) Costing Tool
- Integrated Healthcare Technology Package (iHTP) Simulation Tool
- Spectrum: PMTCT Cost Effectiveness
- Goals Model
- Planning, Costing and Budgeting Framework (PCBF)
- CORE Plus
- Integrated Health Model
- Planning & Budgeting for TB Control
- Resource Needs Model HIV/AIDS
- One Health Model (synthesis of all modeling tools)

Decision Makers Program Planning Tool



Sensitivity Analysis

Return to Menu

Perform Sensitivity Analysis

	Parameter Values	Results (2009-2025) Infections Averted	Number of Circumcisions per Infection Averted	Net Cost per Infection Averted	Cost Savings per Infection Averted
Base Case		51,518	7.3	$689	$10,569
Effectiveness	30%	25,059	14.7	$1,410	$9,848
	60%	51,518	7.3	$689	$10,569
	75%	65,218	5.8	$545	$10,713
Reduction in M->F Transmission	***0%***	51,518	7.3	$689	$10,569
	30%	67,444	5.7	$508	$10,750
Discount Rate	***3%***	51,518	7.3	$689	$10,569
	5%	51,518	7.3	$741	$10,517
	7%	51,518	7.3	$798	$10,460
Lifetime Cost of ART	$8,000	51,518	7.3	$689	$7,311
	$11,000	51,518	7.3	$689	$10,311
	$14,000	51,518	7.3	$689	$13,311
	Minumum	25,059	5.7	$508	$7,311
	Base Case	51,518	7.3	$689	$10,569
	Maximum	67,444	14.7	$1,410	$13,311

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Model outputs:

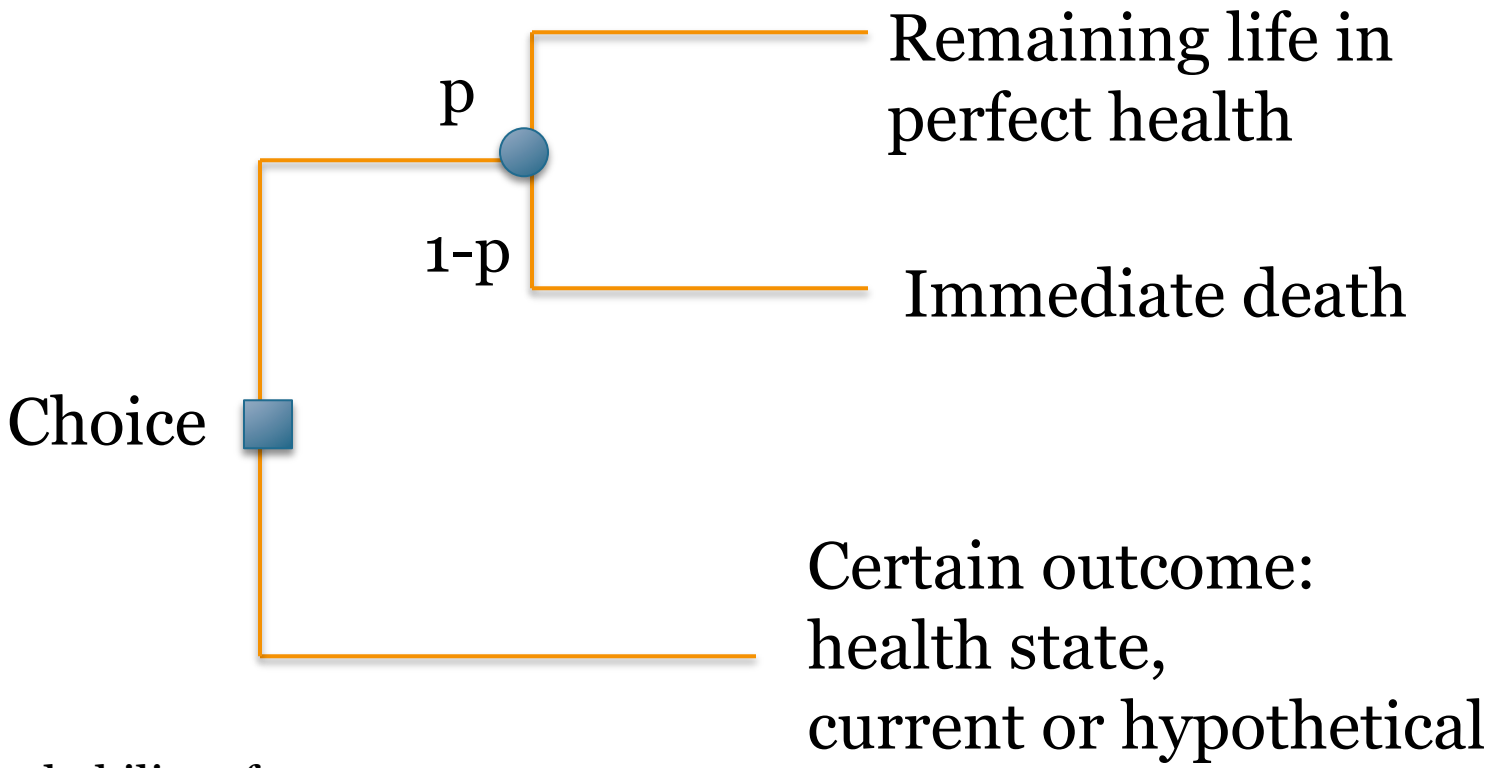
- For each VMMC intervention
  - QALYs
  - Costs

How are QALYs estimated?

- Step 1: Measure utility
  - How you feel about a certain health state, i.e. your health-related quality of life (theoretical or actual)
  - Subjective
  - Between 0 and 1, with 1 representing perfect health and 0 representing death
- Step 2: Multiply utility by years of life lived in that disease state

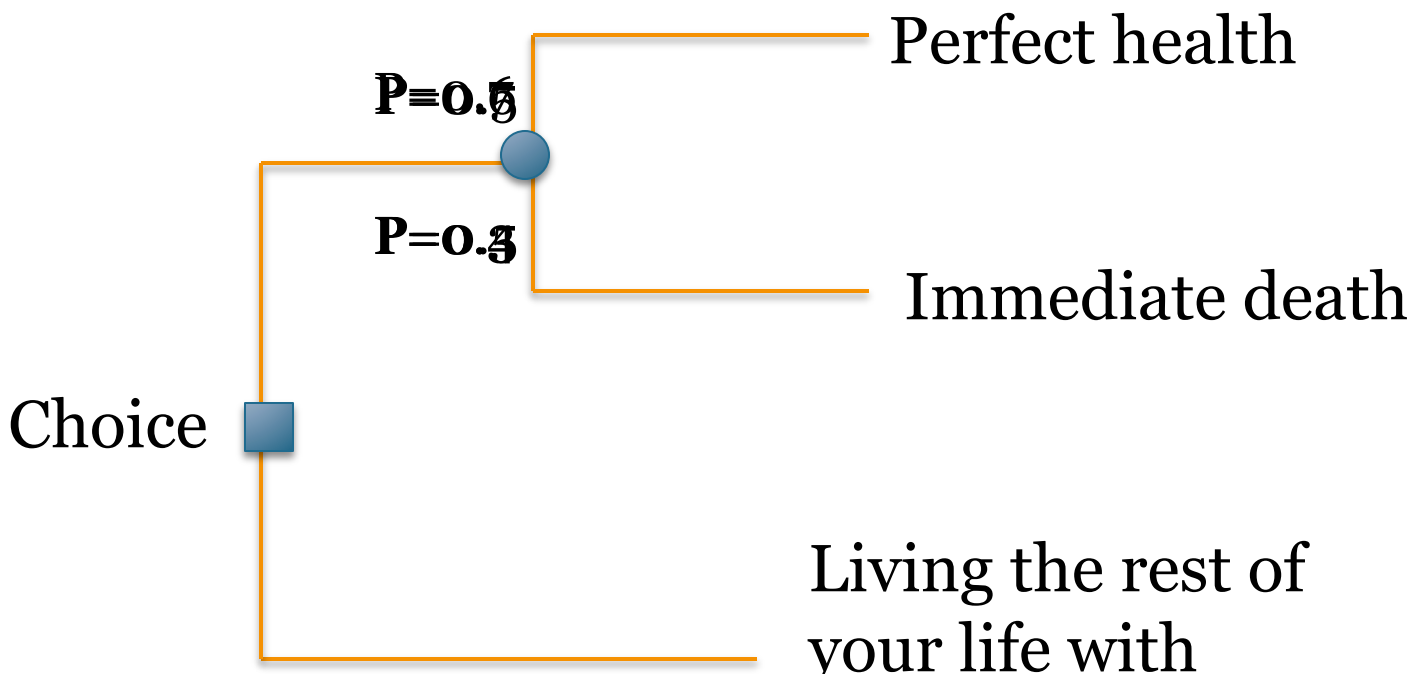
One way of measuring utility: standard gamble

- Choice between a certain outcome and a gamble



P=probability of outcome

Standard gamble example: blindness



At point of indifference between choices:
Utility=0.7*1 +0.3*0=0.70

Living 40 years with blindness would result in 40*0.7=28 quality adjusted life years (QALYs)

How are economic costs estimated?

- Opportunity costs
  - The value of the best alternative foregone
  - Tradeoffs (opportunity costs) are not always explicit but always exist

  - Opportunity costs of VMMC

Discounting

- Reflects time preference
- Reflect opportunity for investment (standard rate of return on long-term riskless investments is 3%)
- Standard discounting rate for CEAs is 3% (generally varies between 2.5-5%--annual return on investments)
- Costs and health outcomes are discounted at the same rate.

Discounting health benefits

- Two interventions for male circumcision
- Circumcise 10,000 babies
  - Cost: $25,000
  - QALYs: 100
  - Discounted QALYs (assuming all benefits occurred at year 30): 41.2
- Circumcise 10,000 men (age 24-35)
  - Cost: $25,000
  - QALYs: 100
  - Discounted QALYs (assuming all benefits occurred at year 5): 86

Turning model output into an incremental cost-effectiveness ratio

Assumptions for competing choice analysis

- Limited budget / resource
- Multiple alternatives
- Objective to maximize total net effectiveness
- Mutually exclusive
- Divisible

VMMC programs

Willingness to pay threshold: $5,200 per QALY gained

Program	Discounted cost ($)	Discounted effectiveness (QALYs)
MC promotion at HIV test	200,000	50
MC promotion + SMS	400,500	45
MC promotion + 3 home visits	300,000	60

VMMC programs

Willingness to pay threshold: $5,200 per QALY gained

Program	Discounted cost ($)	Discounted effectiveness (QALYs)
MC promotion at HIV test	200,000	50
~~MC promotion + SMS~~	~~400,500~~	~~45~~
MC promotion + 3 home visits	300,000	60

ruled out by strong dominance

VMMC programs

Willingness to pay threshold: $5,200 per QALY gained

Program	Discounted cost ($)	Discounted effectiveness (QALYs)	ICERs
MC promotion at HIV test	200,000	50	$4,000
MC promotion + 3 home visits	300,000	60	$5,000

VMMC programs

Willingness to pay threshold: $5,200 per QALY gained

Program	Discounted cost ($)	Discounted effectiveness (QALYs)	ICERs
MC promotion at HIV test	200,000	50	
MC promotion + 3 home visits	300,000	60	,000

VMMC programs

Willingness to pay threshold: $5,200 per QALY gained

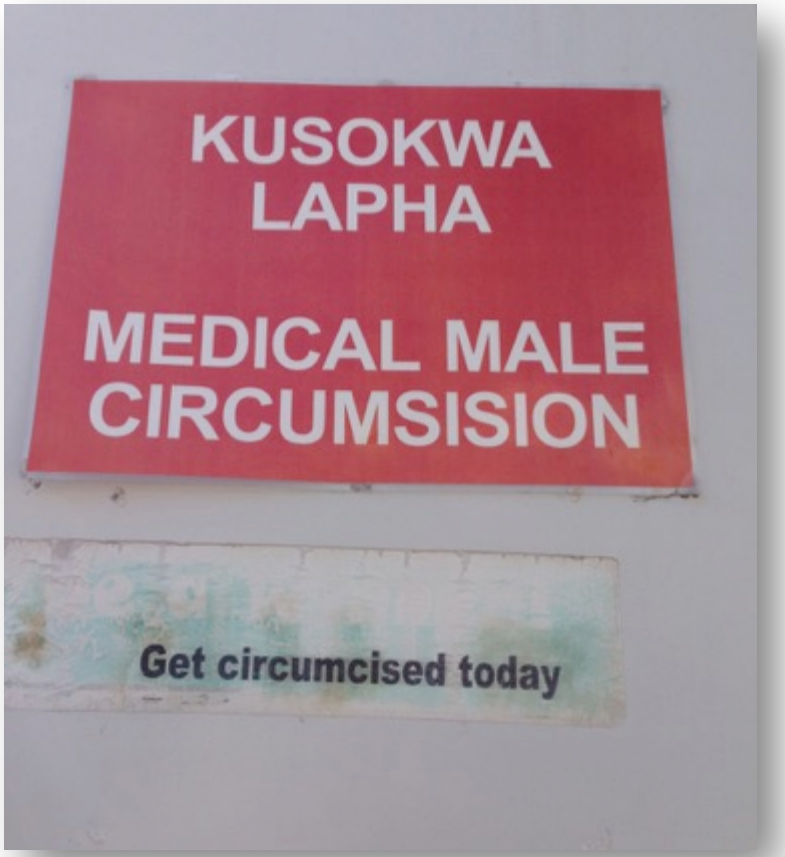
Program	Discounted cost ($)	Discounted effectiveness (QALYs)	Incremental cost	Incremental effectiveness	ICER
MC promotion at HIV test	200,000	50	200,000	50	$4,000
MC promotion + 3 home visits	300,000	60	100,000	10	$10,000

Limitations of economic analyses

- Economic analyses do not address
  - Feasibility
  - Affordability
  - Equity
  - Ethics
- Policy decisions should never be made solely on cost-effectiveness criteria

Thank you!

Study Participants
ICOBI
HSRC
ICRC
Ruanne Barnabas
Roger Ying
Jared Baeten
Connie Celum
HEIST members
Julia Dettinger



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EXTRA SLIDES

Previously developed models

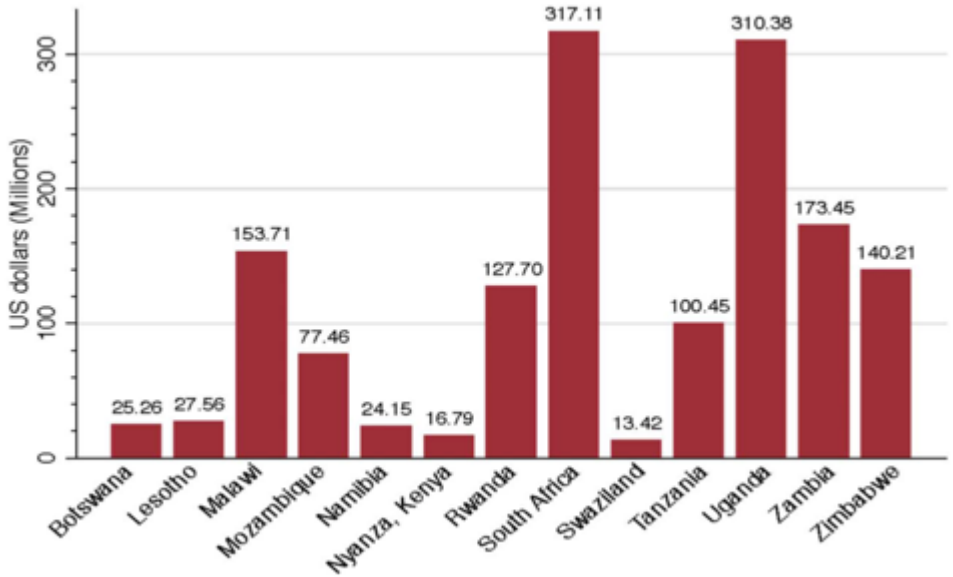
Eg. Decision Makers Program Planning Tool (DMPPT) developed by UNAIDS

- Excel-based model that can estimate costs and effectiveness (infections averted) associated with different scenarios of MC scale-up.
- Scenarios can vary:
  - Priority populations: all males, young adults, newborns, or most-at-risk groups
  - Coverage levels and scale-up rates
  - Service delivery modes: hospital, clinic, mobile van; public, private, NGO
  - Surgical technique used for MC, kit used
  - Task shifting, task sharing
  - Risk compensation
  - Male → Female transmission reduction with MC
  - Population age-structure, birth and mortality rate
  - Sexual behavior
  - Discounting

Example of analysis conducted with DMPPT

Voluntary Medical Male Circumcision: Modeling the Impact and Cost of Expanding Male Circumcision for HIV Prevention in Eastern and Southern Africa

Emmanuel Njeuhmeli[1*9], Steven Forsythe[2,9], Jason Reed[3], Marjorie Opuni[4], Lori Bollinger[2], Nathan Heard[5], Delivette Castor[1], John Stover[2], Timothy Farley[6], Veena Menon[7], Catherine Hankins[8]



Results: Costs of scaling up VMC to 80% by country

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Choosing the right tool

Tool Name	Marginal Budgeting for Bottlenecks	Reproductive Health (RH) Costing Tool	Planning & Budgeting for TB Control	Spectrum: PMTCT Cost Effectiveness	Goals Model	Resource Needs Model HIV/AIDS	CORE Plus	Integrated Health Model	One Mo
Tool developer	**UNICEF / World Bank**	**UNFPA**	**WHO / MRC**	**Constella Futures/ Futures Institute**	**Constella Futures/ Futures Institute**	**MSH**	**MSH**	**UNDP**	**WHO**
Objective	To identify bottlenecks and model impact of reducing them to increase coverage of	To help users estimate cost to scale up a package of reproductive health services from	To help users improve health service delivery by identifying the optimal mix of resources needed for interventions. Can also determine	To evaluate costa and benefits of various strategies to prevent mother-to-child transmission of HIV and	Tool allows users to determine the effect of resource allocation onachievement of HIV/AIDS	To translate strategic program goals into costs and budgets, calculate funding gaps--originally designed for	To estimate the expected number of each type of intervention and the	To estimate scale-up costs of health system as a whole to ensure capacity to deliver	To dev compre budget recomm
Intended users	Health economists & policymakers at MOHs	Health planners at the country level	Planners, decision-makers and managers at all levels of healthcare system, technical assistance	Public sector policy makers and planners	National, multidisciplinary team of government planners and civil society	National and sub-national policy makers and planners, program-specific technical	Planners and managers of government, private	Health system planners	TB prog the cou
Built in interventions	PMTCT including counseling ART, and feeding counseling. Condom use. Cotrimoxazole prophylaxis for HIV+ adults and children of HIV+ mothers, ART for	HIV/AIDS prevention and treatment, family planning, newborn health interventions. Condom promotion for commercial sex workers, MSM, and other vulnerable populations.	6,000 built-in WHO scenarios.	7 interventions: Long-course ZDV, Short-course ZDV (Thailand regimen), Shortcourse ZDV - PETRA Arm A, Short-course ZDV - PETRA Arm B, Neonatal only, Nevirapine HIVNET 012 protocol, Universal	VCT, social marketing, behavior change interventions for high-risk/vlunerable populations including MSM, sex workers, and IDU. Condom promotion, PMTCT, ARVs, M & E, capacity building.	N/A. User inputs strategic plan with coverage target, health outcomes, costs and quantities.	Scenarios-- A: Actual services and actual costs; B: Actual services and normative costs; C: Needed services and normative costs; D: Projected	HIV/AIDS home-based & palliative care, ARVs, treatment of OIs, nutrition, other STIs, facilities, vehicles, human resources, HIV prevention for vulnerable populations, condom	HIV tes patient TB pati HIV tre
Assumptions	Reductions in bottlenecks are hierarchical and reduction of one has a cascading downstream affect, Efficacy stays	Data in tool is from sources like UN Population Division, WHO's Burden of Disease, UNICEF, Demographic Health	Medical equipment and pharmaceutical database based on WHO database, clinical guidelines, epidemiological profiles, other built-in data linked to International Statistical Classification of Diseases	Built-in demographics data, input prices and quantities and effectiveness, HIV vertical transmission rate	Default data on impact values, sexual behavior, costs, STI prevalence, cost-effectiveness interventions, HAART success rate and standard epidemiological	All assumptions are inputted by the user	User inputs intervention prices and quantities, and demographic and epidemiologic information.	Demographic data from UNFPA.	Default Global the Glo 2006-2 WHO/ and ep
Training	5 day training course needed, partially complete user's manual available. Using tool require a	1 to 4 days of training generally needed. Detailed user manual available. Skills required include finance,	3-5 day training workshop suggested and three to six months to use the tool and get results. Post-training help file and resource kit available.	1 day of training to use. User manual available, knowledge of PMTCT programs needed. Tool free on internet.	Several days of training required. Takes users two weeks to set up the tool and get results from it. Users should have knowledge of	2-day training recommended. User's manual available.	3 day training suuggested, users should possess skills in epidemiology,	1-2 day training suggested and user's manual available.	3 days weeks Help d manua user's
Software	Excel file	Excel file	Program-based (non-Excel)	Program-based (non-Excel)	Excel file	Excel file	Excel file	Excel file	Excel fi
Ease of use	Intended for use with UNICEF or World Bank	Training and technical assistance needed to use	Technical assistance required.			Fairly simple to use			User fr
Website	http://www.aidstar-one.com/focus_areas/tre	http://www.who.int/pmnch/topics/economics/cos	\http://www.who.int/pmnch/topics/economics/costing_tools/en/index9.ht	www.futuresinstitute.org/pages/resources.aspx	http://www.futuresinstitute.org/pages/resources.aspx		http://erc.msh.org/toolkit/Tool.cfm?lang	http://www.undp.org/poverty/tools.htm#nact	http://ts/plan
Limitations	The ordering of bottlenecks appears to	This tool does not incorporate budget &	Does not include health outcome, health production function,	Does not consider service availability (counseling,	Does not incorporate macroeconomic conditions.		Does not incorporate	Does not incorporate budget & financing,	Does n effecti

Guidelines for conducting economic evaluations

- Panel on Cost-Effectiveness in Health & Medicine
- Disease Control Priorities (DCP-2)
- WHO-CHOICE
- UNAIDS HIV prevention costing guidelines

Guidelines for conducting economic evaluations

- Perspective
- Discounting
- Opportunity costs
- Time horizon
- Threshold
- Handling uncertainty

Perspective

- Payer perspective
  - Only costs paid by the organization implementing the program (eg MOH, private insurance company, NGO) are included
- Societal perspective
  - All costs in incurred or saved by the program are included, regardless of who experiences them
  - This perspective includes: patient time waiting and receiving care, transport costs, and lost wages resulting from sick days related to the intervention.