BHIVA British HIV Association

Autumn Conference
Friday 24th November 2023
etc.venues 155 Bishopsgate, London

BHIVA WORLD AIDS DAY

WORLD AIDS DAY

Modelling to inform HIV programmatic policy in southern and east African settings

Andrew Phillips, UCL

Conflict of Interest

I have no conflicts of interest

Modelling to inform HIV programmatic policy in southern and east African settings

Outline

HIV in southern and east Africa – incidence trends

How models are used to inform policy

Examples of modelling that has informed policy

Capability building for modelling

Modelling to inform HIV programmatic policy in southern and east African settings

Outline

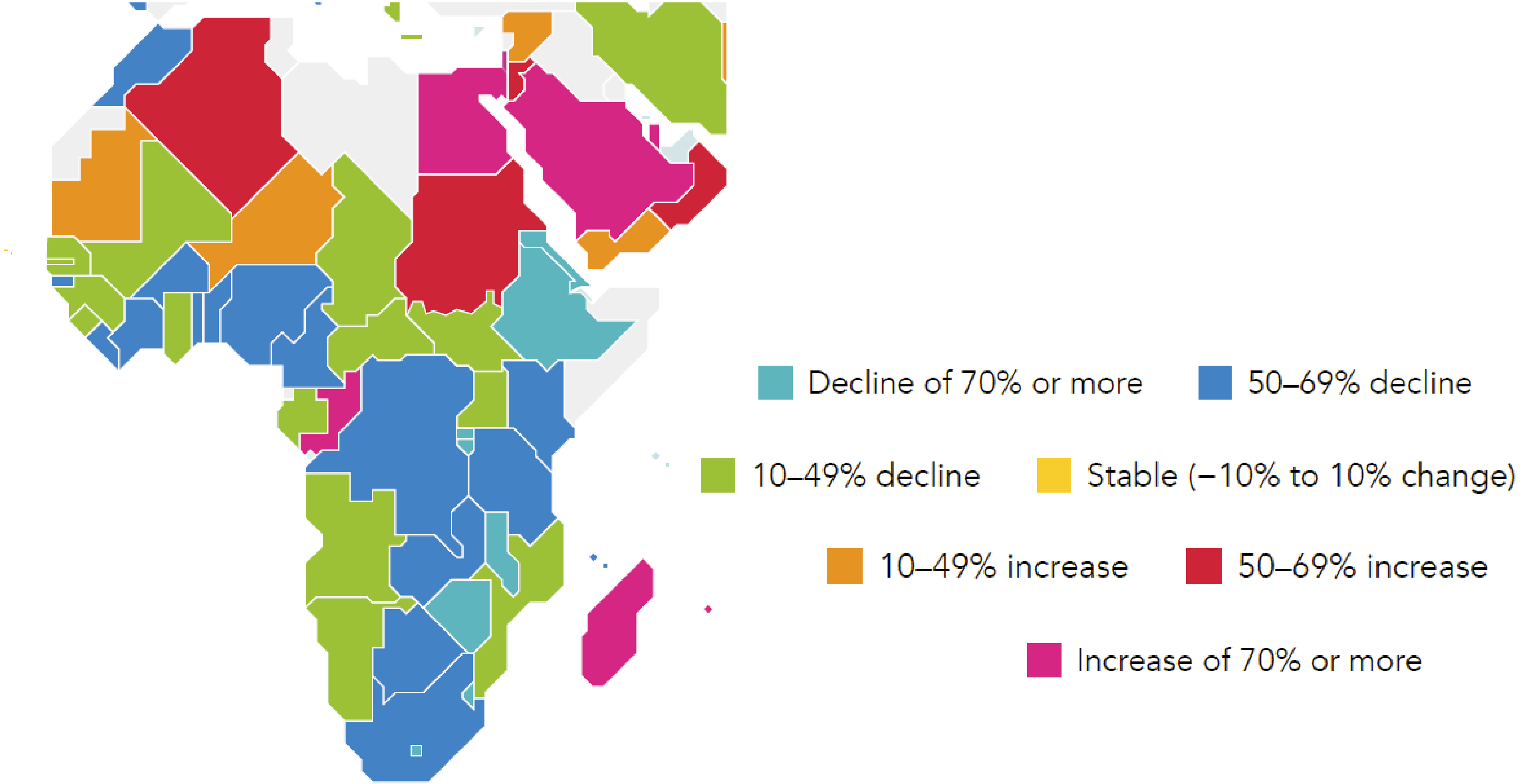
HIV in southern and east Africa – incidence trends

How models are used to inform policy

Examples of modelling that has informed policy

Capability building for modelling

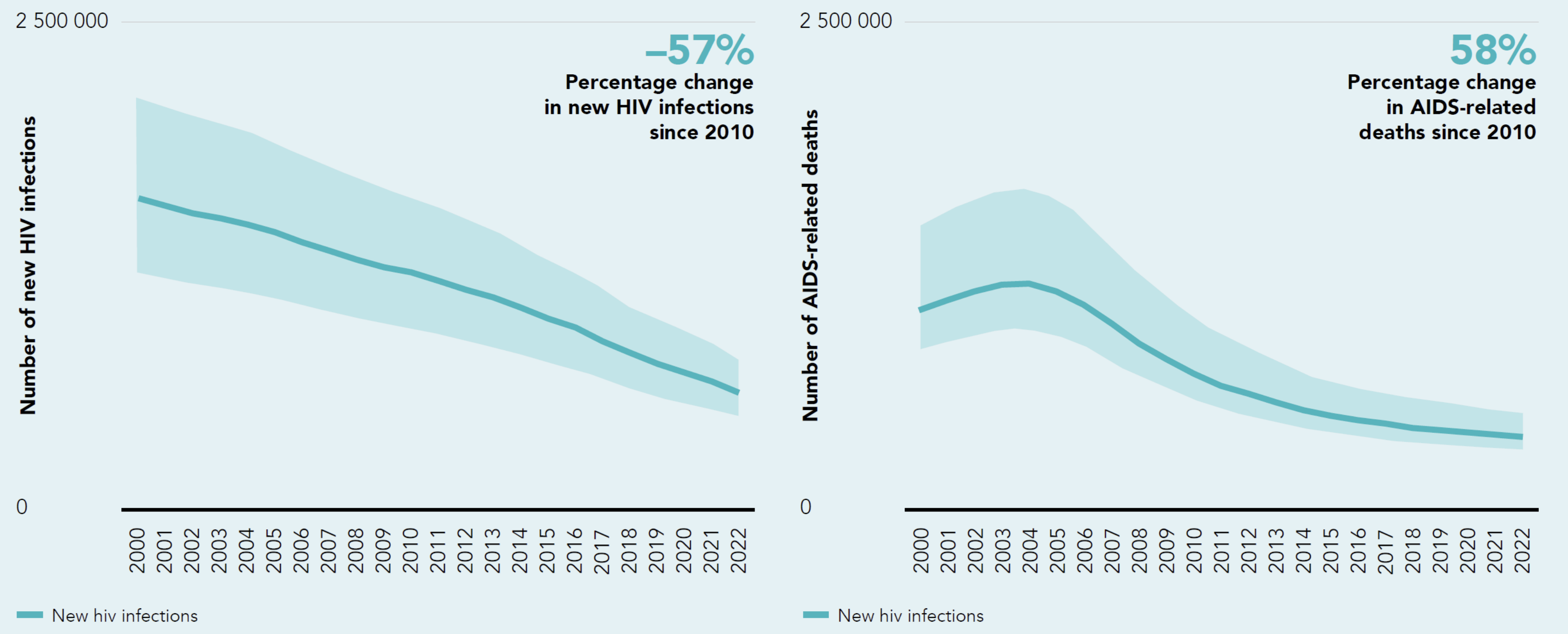
HIV in Africa – change in incidence 2010-2022



UNAIDS 2023

HIV incidence in east and southern Africa

Figure 6.1 Number of new HIV infections and AIDS-related deaths, eastern and southern Africa, 2000–2022



UNAIDS 2023

Based on Spectrum AIMS model

Reasons for the decline

- Increased proportion of PLHIV on ART and virally suppressed
- VMMC
- Some effect of PrEP (although PrEP uptake generally low)

(earlier declines due to decline in condomless sex)

Viral load suppression in all PLHIV - Examples

Malawi	2020	87.3%
Zimbabwe	2020	77.3%
Eswatini	2021	88.6%
Uganda	2020	75.4%
Lesotho	2020	81.0%
Mozambique	2021	64.1%

PHIA surveys https://phia.icap.columbia.edu/

Viral load suppression in all PLHIV - Examples

Malawi	2020	87.3%
Zimbabwe	2020	77.3%
Eswatini	2021	88.6%
Uganda	2020	75.4%
Lesotho	2020	81.0%
Mozambique	2021	64.1%

So, for example, Malawi has an HIV prevalence in adults of 8.9% but a prevalence of unsuppressed HIV of only 1.1%

PHIA surveys https://phia.icap.columbia.edu/

Outline

HIV in southern and east Africa – incidence trends

How models are used to inform policy

Examples of modelling that has informed policy

Capability building for modelling

How can we predict the implications of alternative policies ?

If we are considering introducing a policy, we would like to have thought through the longer-term implications for health.

How can we do this ?

We are likely to have some evidence from randomized trials to inform the effectiveness of the intervention(s), but how do we translate this into predicting the **long-term health outcomes** for **all relevant policy options** ?

We generally use **models** to predict these.

Individual-based models

An **individual-based** model is designed to simulate experiences of people in a population over time

Each time the model is run it generates a simulated "data set" of variable values for a cohort of individuals representing the population of interest

Example

Status of a population at a certain time

Person	Var 1	Var 2	Var 3	Alive / dead
1				
2				
3				
4				
5				
.				
.				
9999				
10,000				

Example

Status of a population at a certain time

Person	Var 1	Var 2	Var 3	Alive / dead
1				
2				
3				
4				
5				
.				
.				
9999				
10,000				

→

Status of the population 3 months later
(Note that any time step length can be chosen)

Person	Var 1	Var 2	Var 3	Alive / dead
1				
2				
3				
4				
5				
.				
.				
9999				
10,000				

Example

Status of a population at a certain time

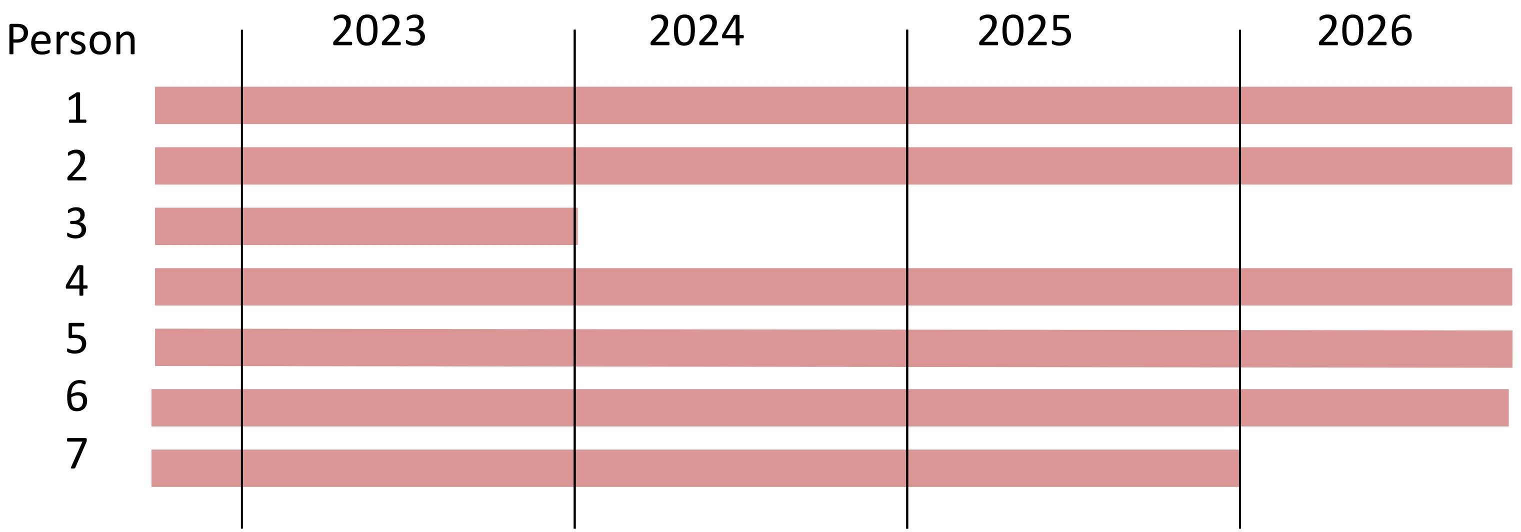
Person	Var 1	Var 2	Var 3	Alive / dead
1				
2				
3				
4				
5				
.				
.				
9999				
10,000				

Status of the population 3 months later
(Note that any time step length can be chosen)

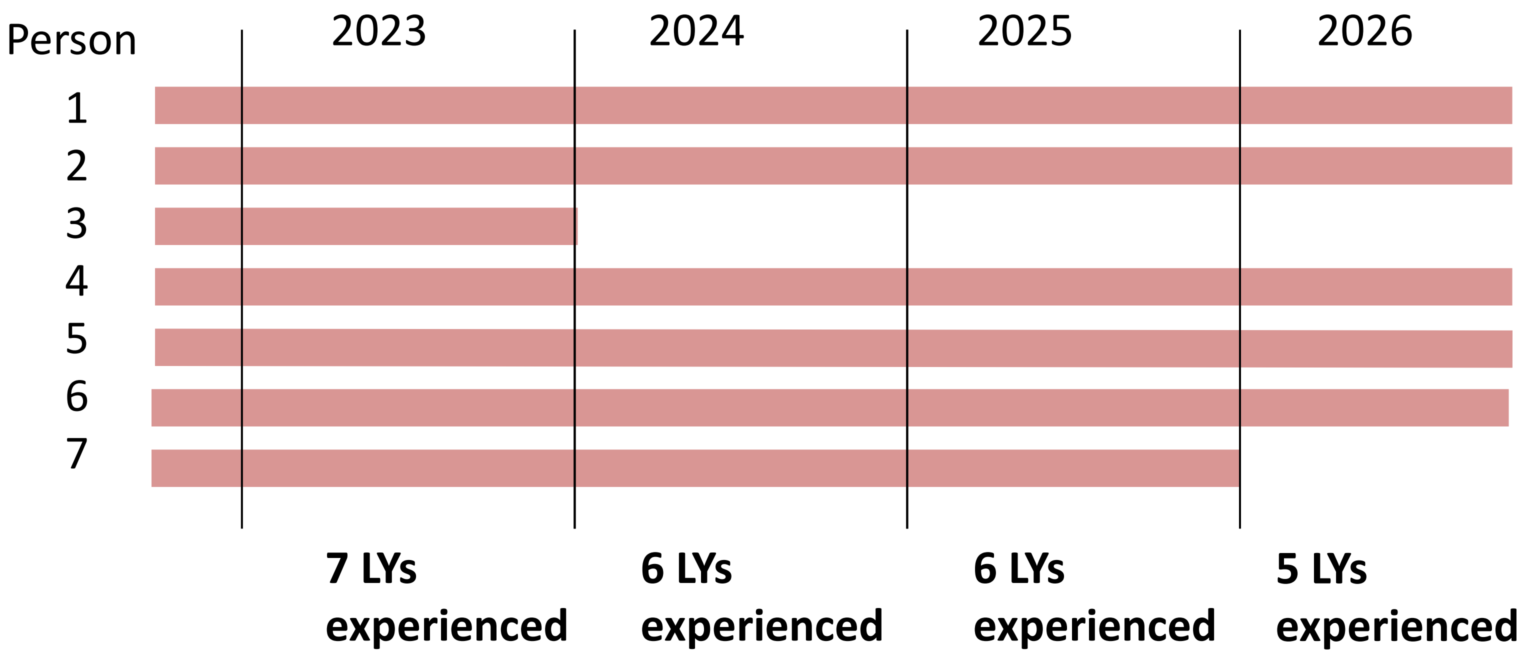
Person	Var 1	Var 2	Var 3	Alive / dead
1				
2				
3				
4				
5				
10,000				

Developing an individual-based model is mostly about specifying the expressions which determine how each variable is updated from one time step to the next.

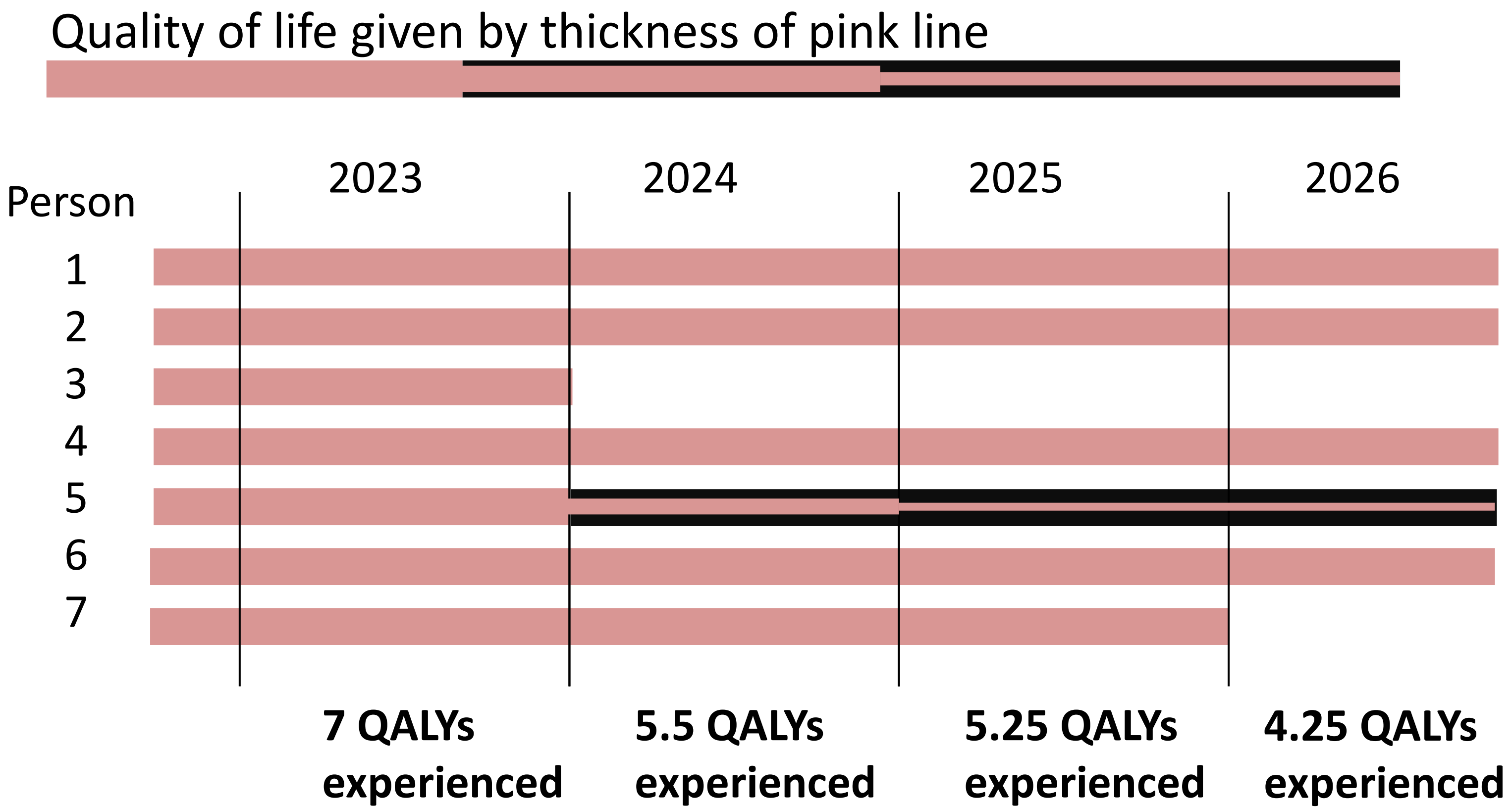
Individual-based models



Measures of health - Life years



Measures of health - QALYs – Quality adjusted life years

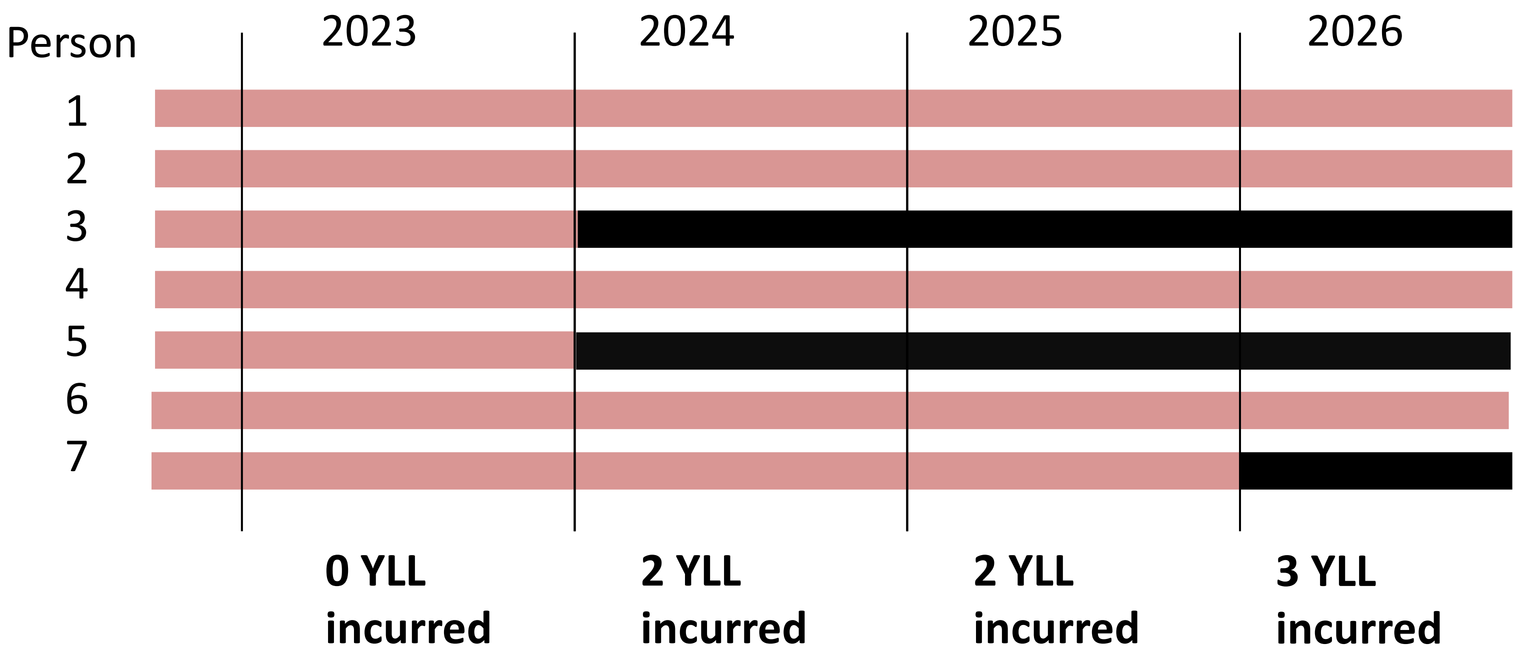


(QALYs incurred given by width of pink)

Measures of health - Years of Life Lost

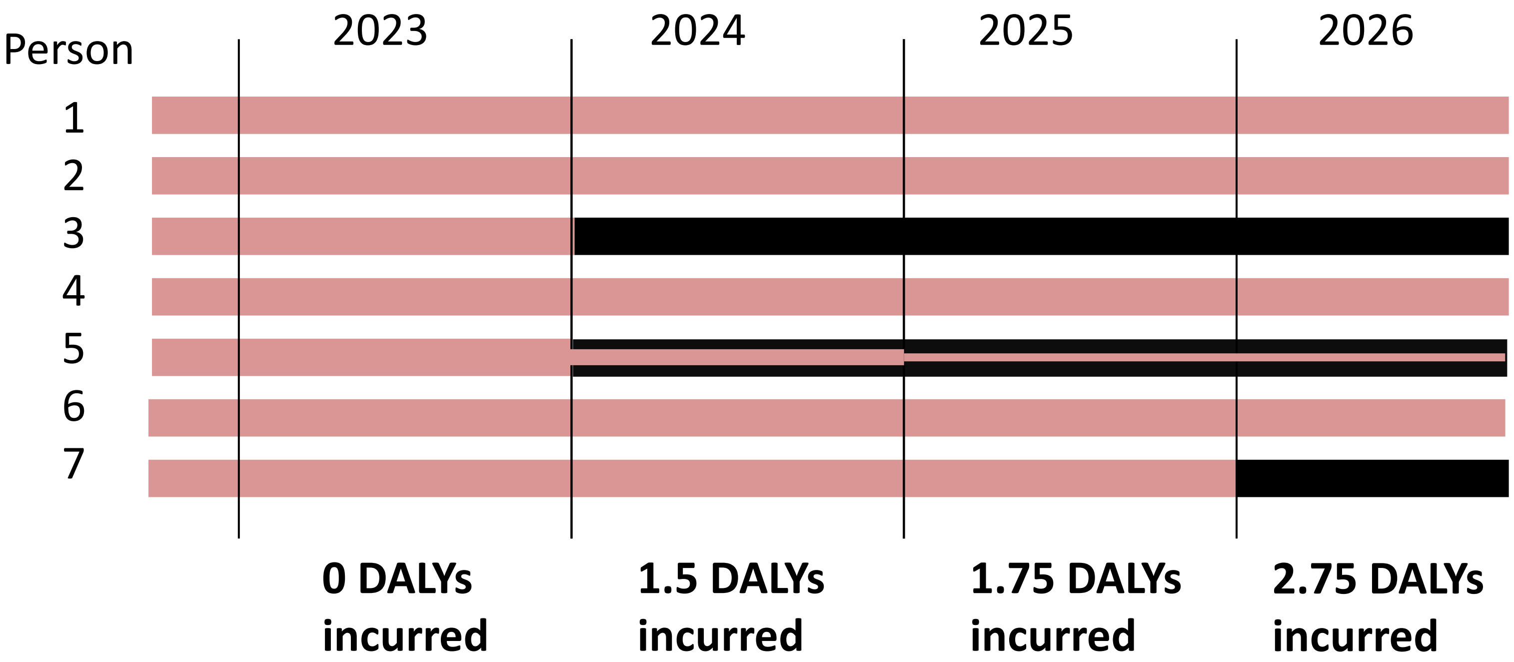
person is alive

person is dead - line continues until when person would have been age 90



DALYs - Disability adjusted life years

extent of being free from disability given by thickness of pink line



(DALYs incurred given by width of black)

Cost-effectiveness analysis as a means of maximising population health

Often the policy questions involve the trade-off between health benefits provided by the intervention and cost to the health care system.

A certain amount of resource spent on an effective intervention can avert loss of healthy life years ie. can avert DALYs (or increase QALYs)

Cost effectiveness analysis is about allocating resources across the whole health care system so that we incur as low a number of DALYs as possible across the population with the budget available.

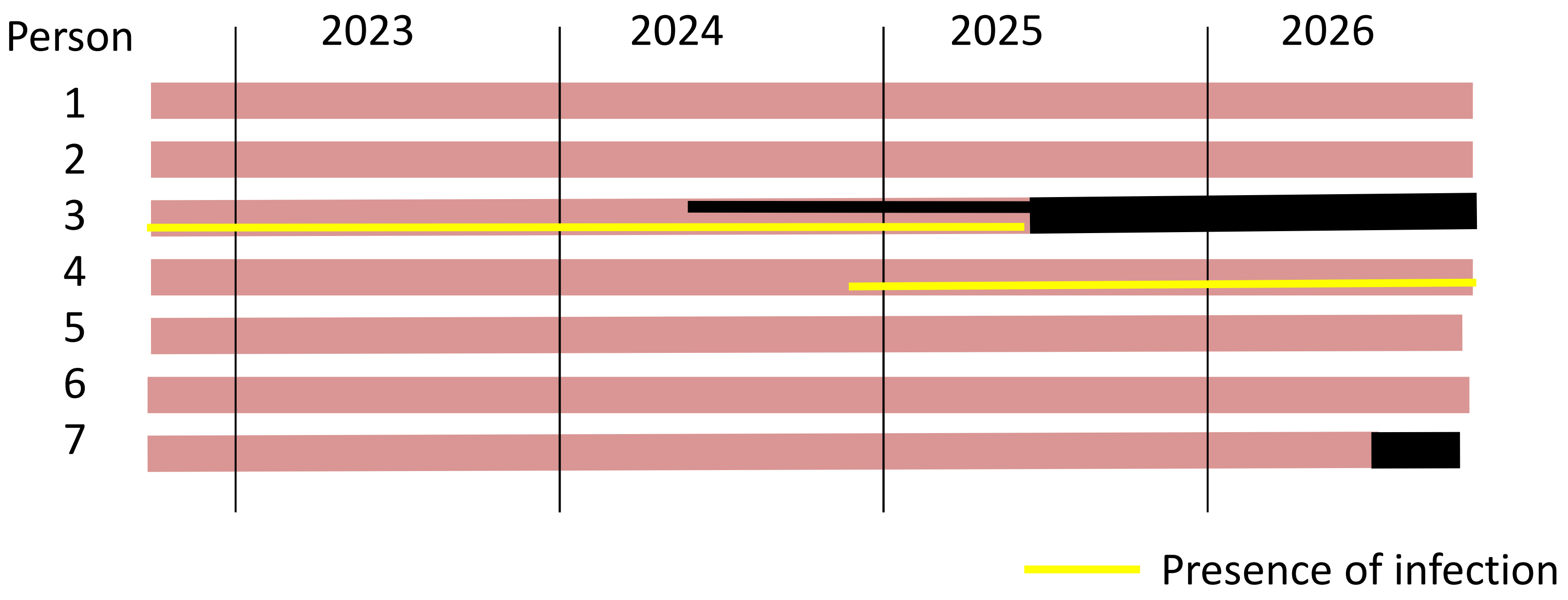
Individual-based models of Infectious Diseases

In some **individual-based** models, the experience of each individual is entirely independent of the other individuals.

In other models, a person’s health experience can depend on others.
A common example of this is in modelling of **infectious diseases**.

But there are also other examples, such as when a person’s health choices (e.g. diet) are influenced by others in their social network.

Modelling infection within a population - individual based models



We consider the outcomes of a whole population of people, including those who could potentially be susceptible to infection as well as those already infected.

Modelling infection within a population - individual based models

Example

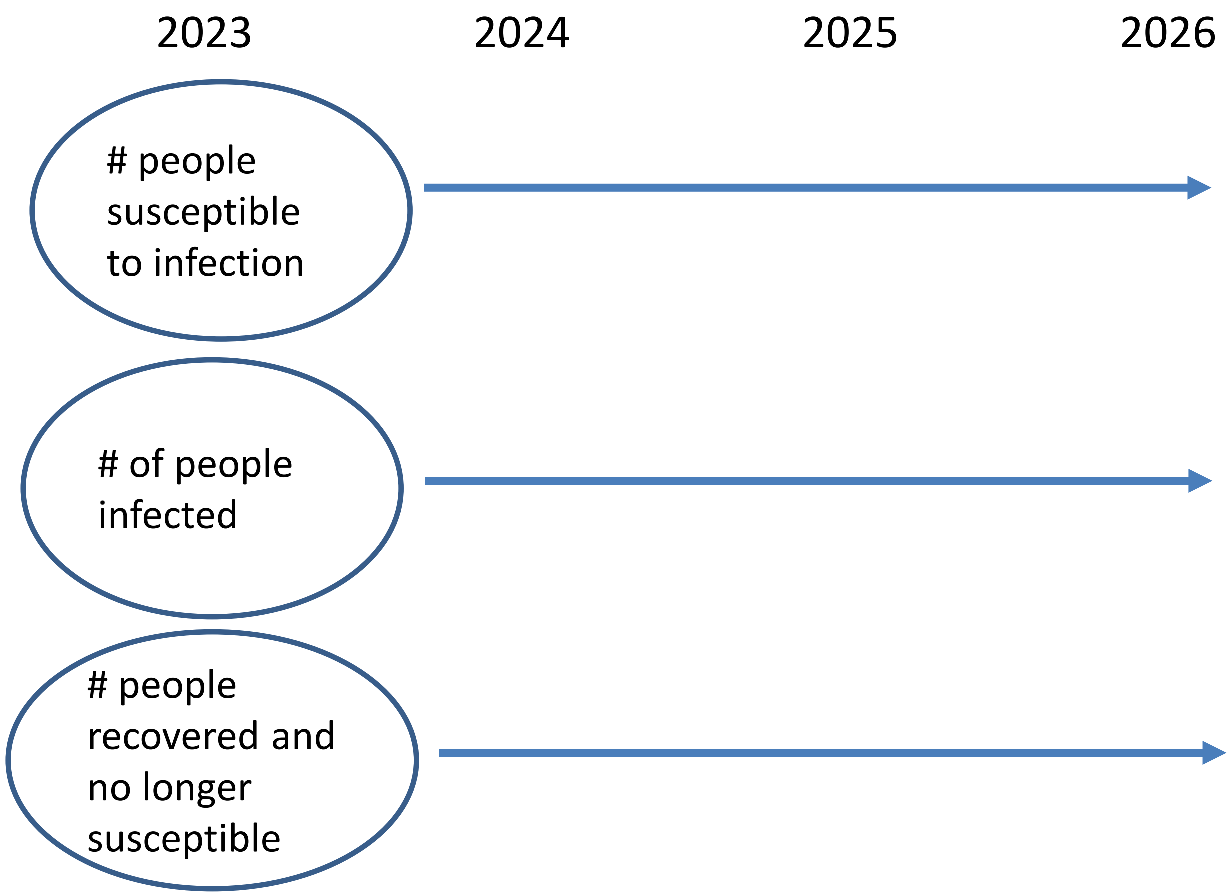
A simulated woman has condomless sex with a man within a given age group

Given what we know about the prevalence of unsuppressed HIV in simulated men in that age group, and the risk of HIV transmission given unsuppressed HIV, we can calculate the probability she becomes infected.

We generate a random number between 0 and 1 and if this is below the probability value then she is modelled to acquire HIV.

Modelling infection within a population - Compartmental models

Conceptually similar to individual-based models, in that we model susceptibility to infection and infectiousness, but instead of tracking individuals over time we track the size of subgroups (compartments) within the population; e.g....



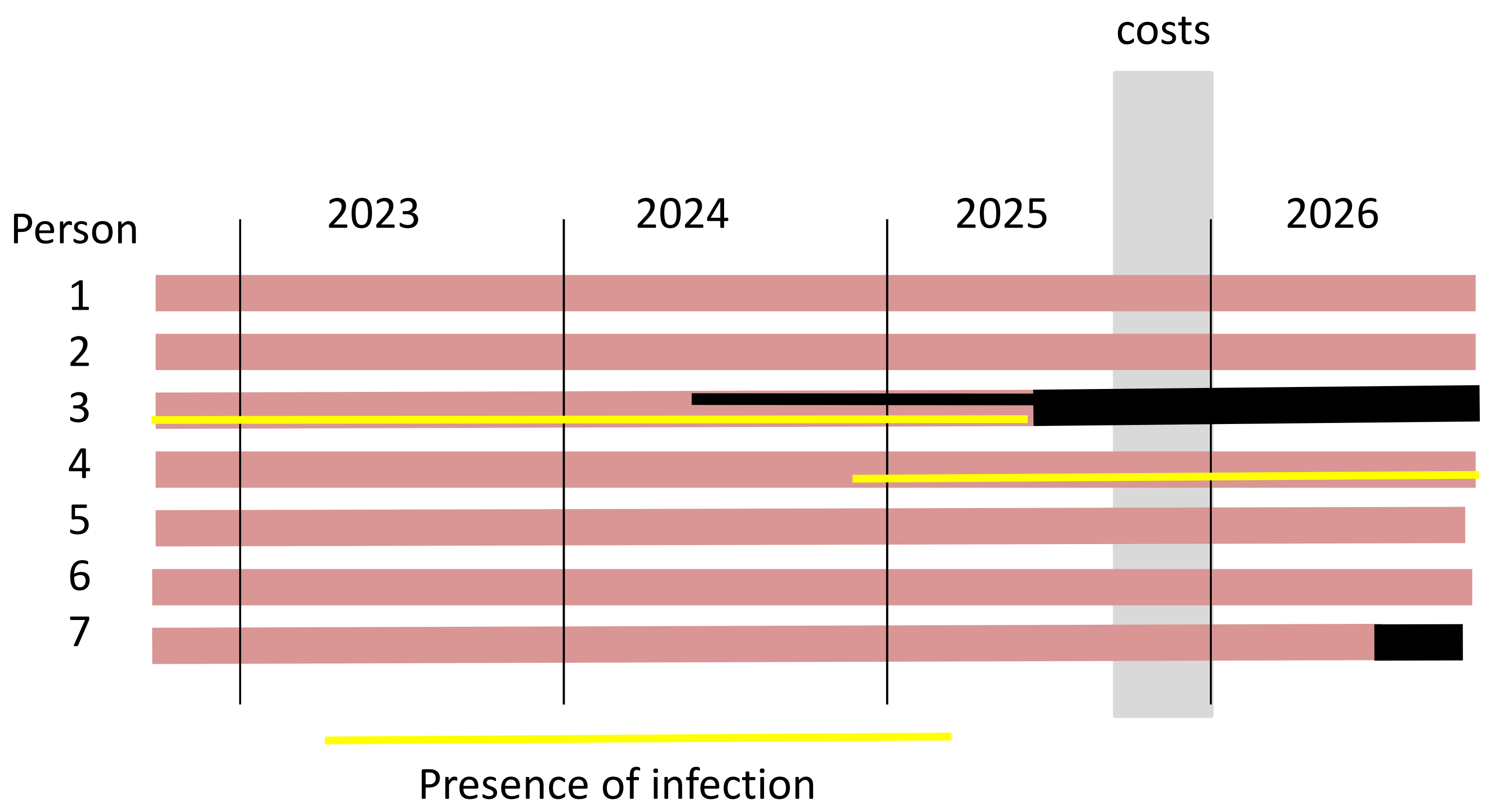
Types of mathematical models

Dynamic models: allow outcomes for a person to be influenced by others in the population, such as when modelling infectious diseases. Models which are not dynamic are often referred to as **static**.

Other types of model include **decision tree** and **Markov state-transition models.**

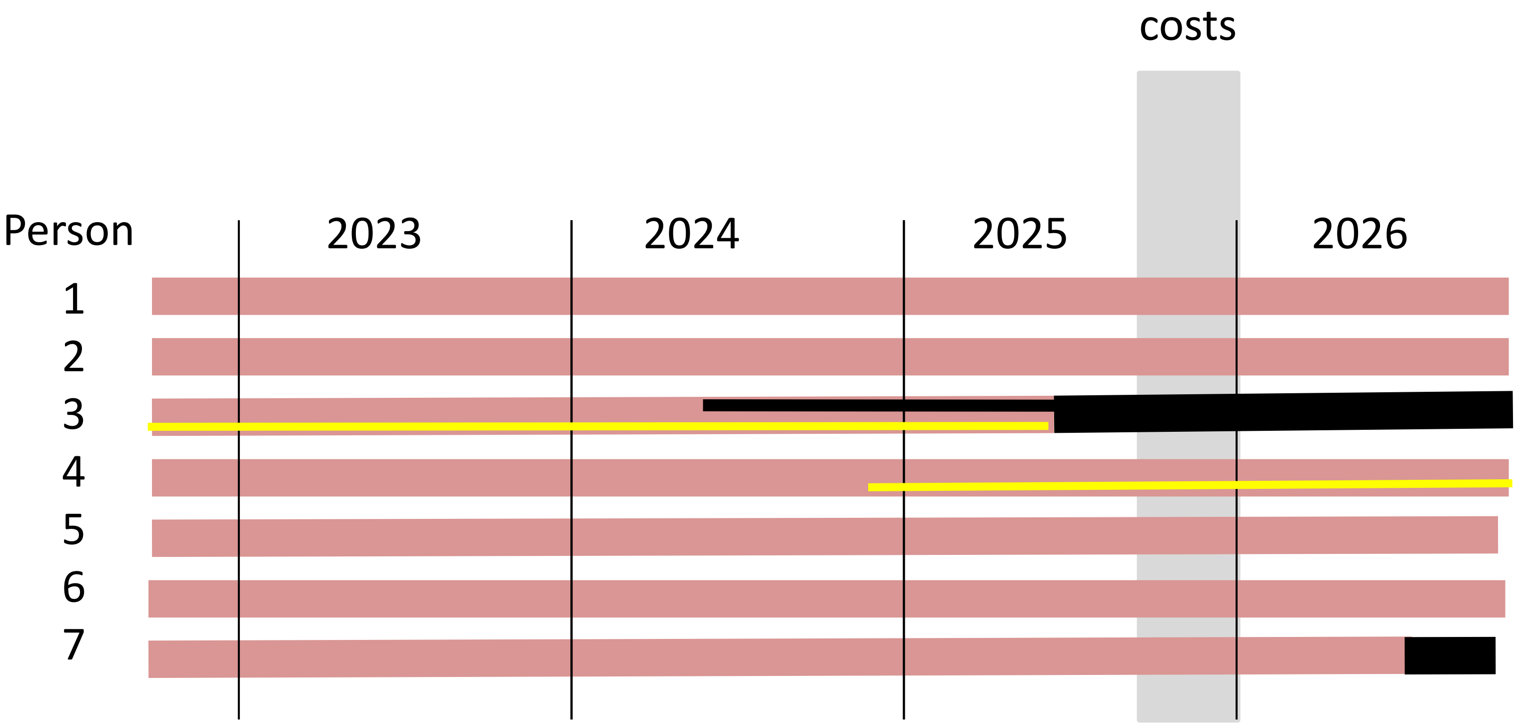
Returning now to **individual-based models**.......

Costs incurred



At any one time point we consider costs incurred in each living person.   We can sum these over any time period

Costs incurred

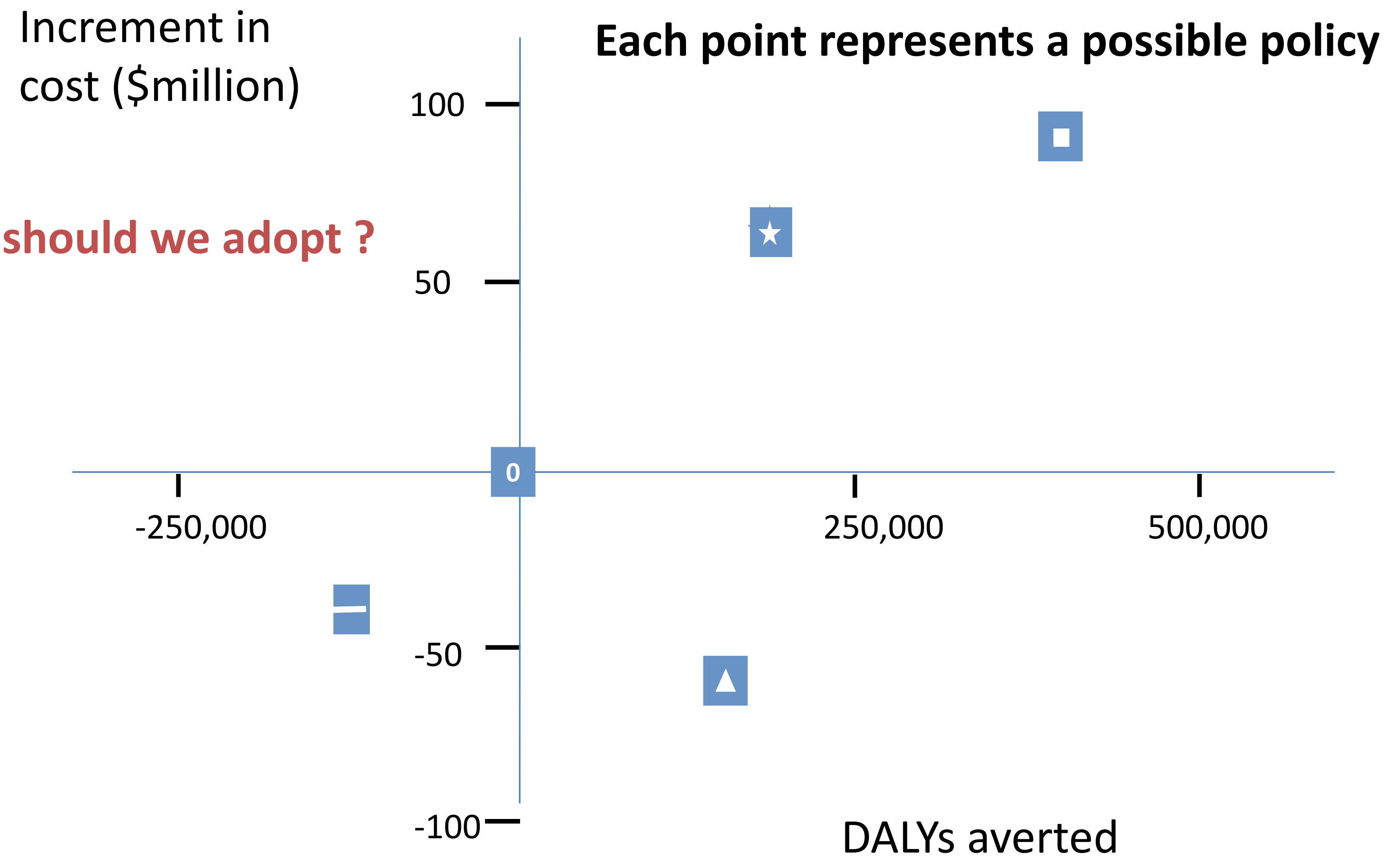


Components of costs considered might include:

- Testing for presence of infection
- Clinic attendance costs
- Drug costs
- Hospitalisation costs
- Costs of monitoring

Summarizing results from a modelling exercise - Cost and effectiveness of alternative policies plotted on a “cost- effectiveness plane”

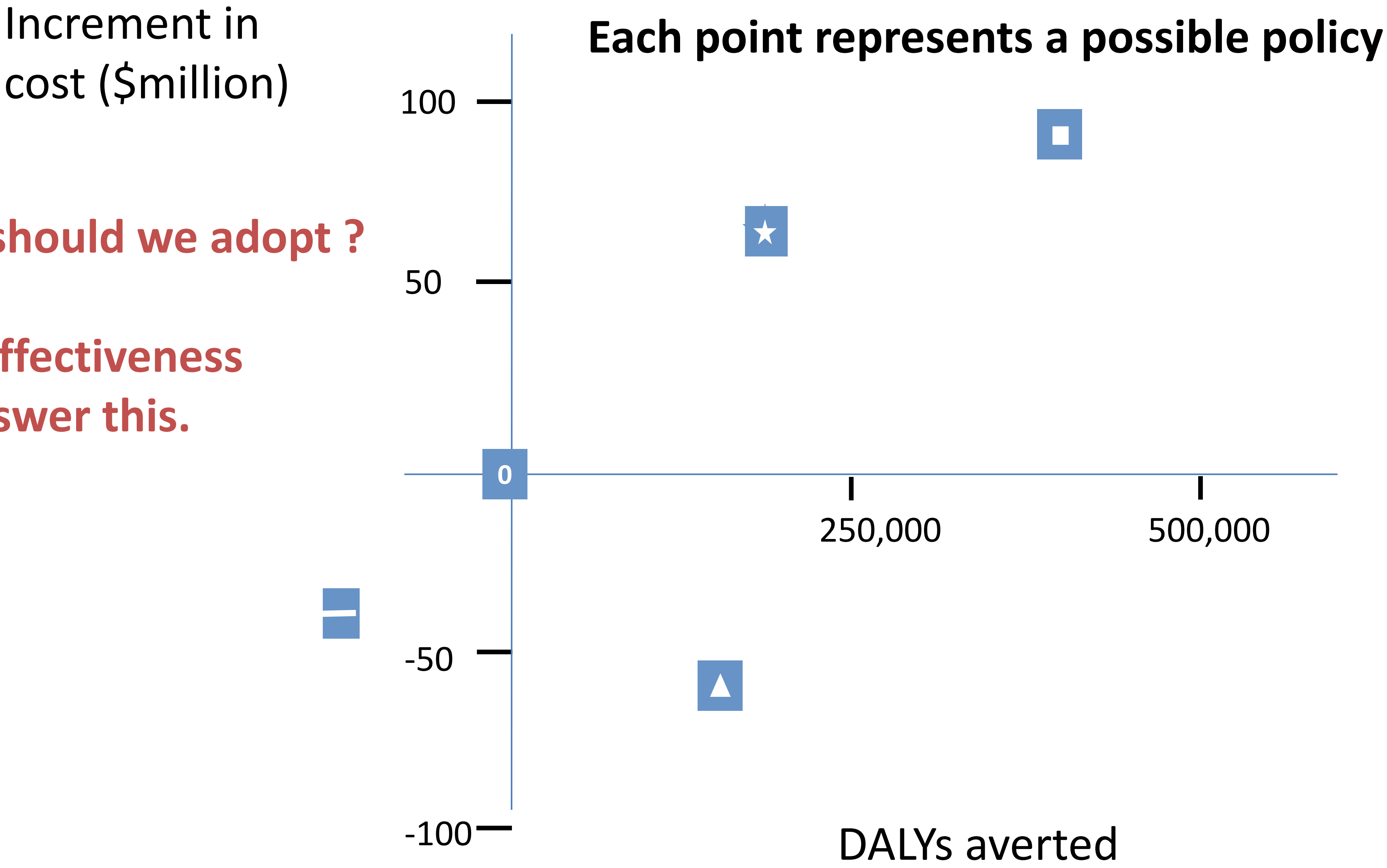
Which policy should we adopt ?



Cost and effectiveness of alternative policies plotted on a cost-effectiveness plane

Which policy should we adopt ?

We use cost-effectiveness analysis to answer this.

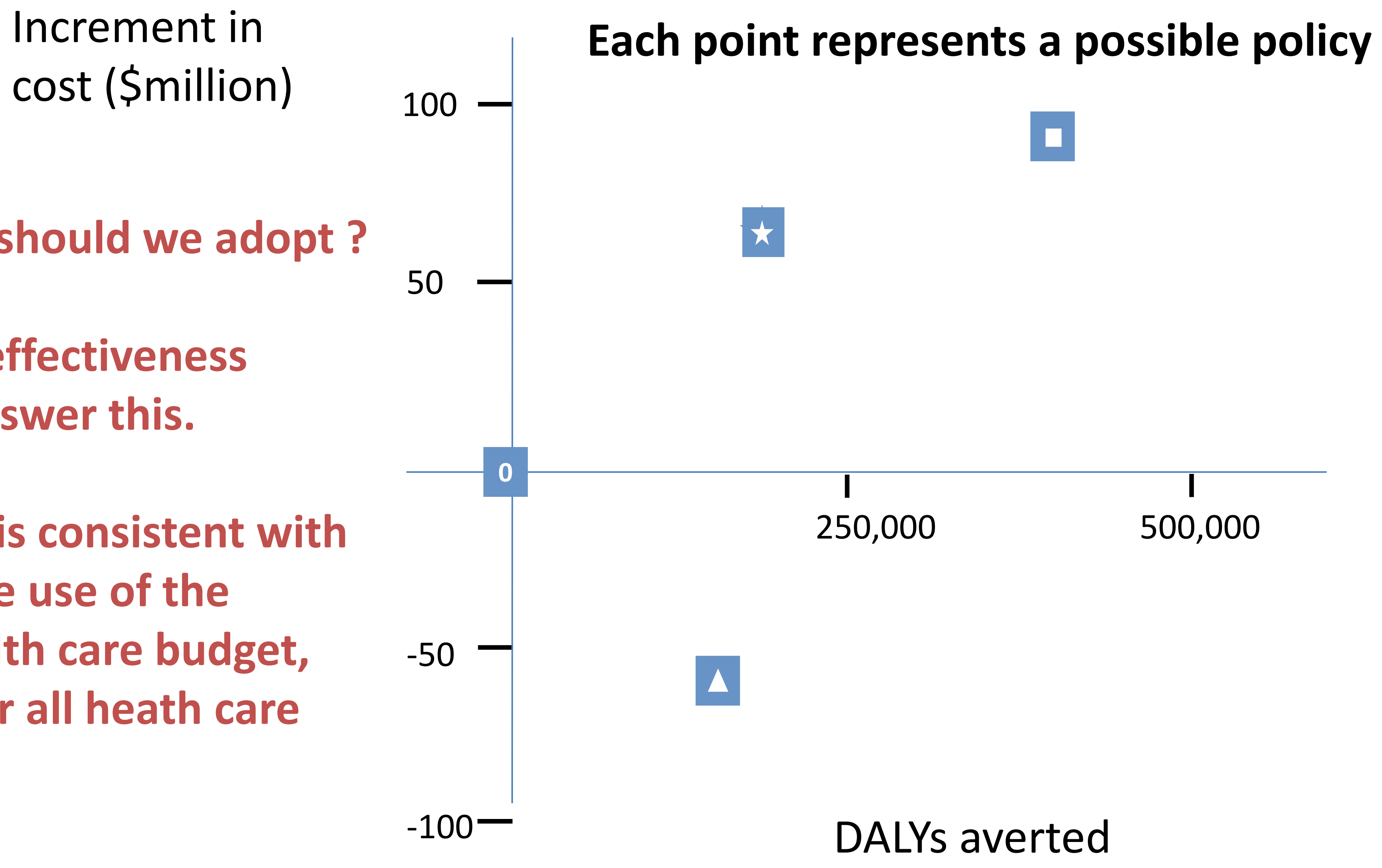


Cost and effectiveness of alternative policies plotted on a cost-effectiveness plane

Which policy should we adopt ?

We use cost-effectiveness analysis to answer this.

Which policy is consistent with optimizing the use of the available health care budget, accounting for all heath care needs ?



Modelling to inform HIV programmatic policy in southern and east African settings

Outline

HIV in southern and east Africa – incidence trends

How models are used to inform policy

Examples of modelling that has informed policy

Capability building for modelling

Immediate ART initiation

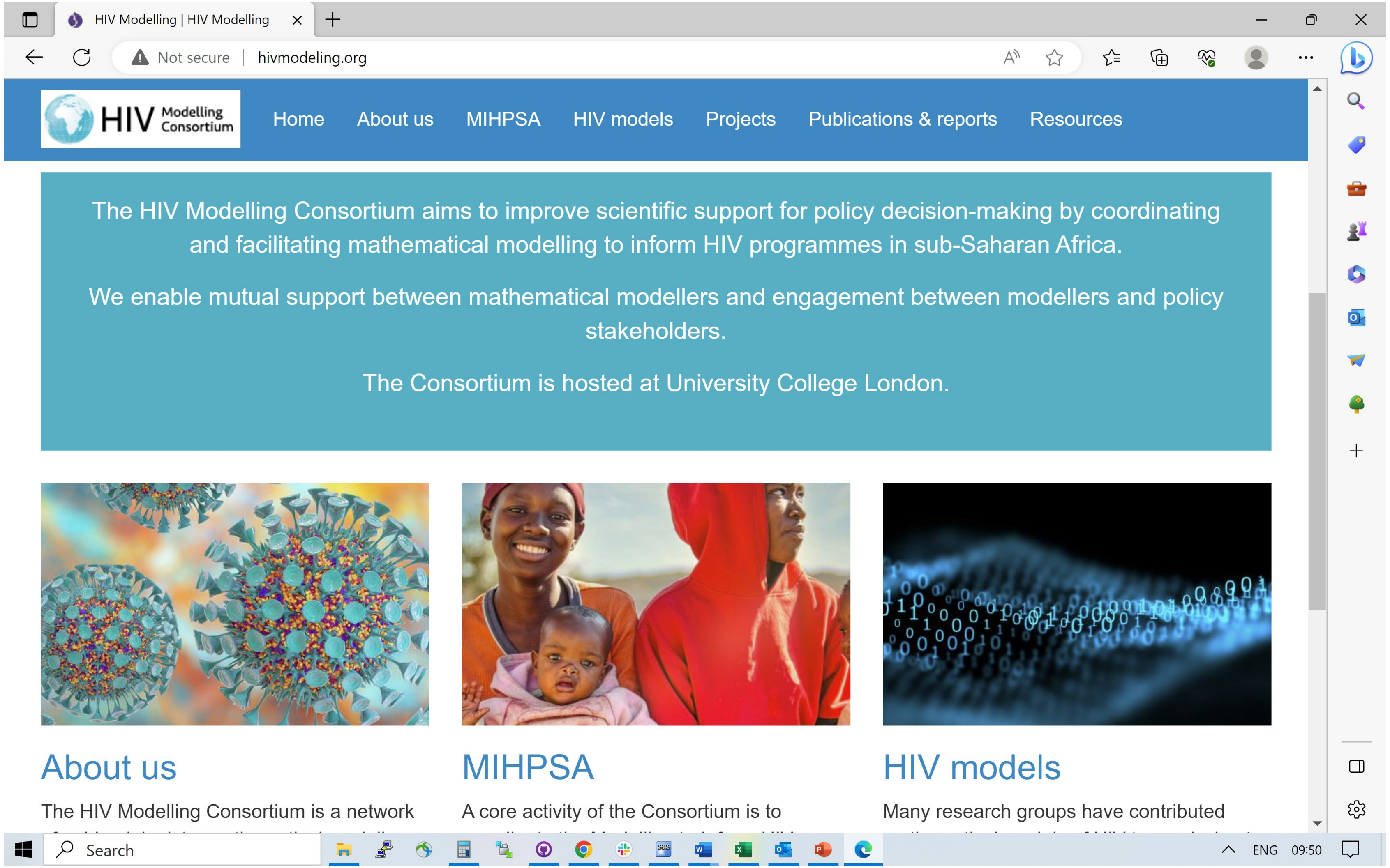
Health benefits, costs, and cost-effectiveness of earlier eligibility for adult antiretroviral therapy and expanded treatment coverage: a combined analysis of 12 mathematical models

Jeffrey W Eaton, Nicolas A Menzies*, John Stover, Valentina Cambiano, Leonid Chindelevitch, Anne Cori, Jan A C Hontelez, Salal Humair, Cliff C Kerr, Daniel J Klein, Sharmistha Mishra, Kate M Mitchell, Brooke E Nichols, Peter Vickerman, Roel Bakker, Till Bärnighausen, Anna Bershteyn, David E Bloom, Marie-Claude Boily, Stewart T Chang, Ted Cohen, Peter J Dodd, Christophe Fraser, Chaitra Gopalappa, Jens Lundgren, Natasha K Martin, Evelinn Mikkelsen, Elisa Mountain, Quang D Pham, Michael Pickles, Andrew Phillips, Lucy Platt, Carel Pretorius, Holly J Prudden, Joshua A Salomon, David A M C van de Vijver, Sake J de Vlas, Bradley G Wagner, Richard G White, David P Wilson, Lei Zhang, John Blandford, Gesine Meyer-Rath, Michelle Remme, Paul Revill, Nalinee Sangrujee, Fern Terris-Prestholt, Meg Doherty, Nathan Shaffer, Philippa J Easterbrook, Gottfried Hirnschall, Timothy B Hallett*

oa OPEN ACCESS

Interpretation **Our estimates suggest that earlier eligibility for antiretroviral therapy is very cost effective in low income and middle-income settings,**

HIV Modelling Consortium (hivmodeling.org)



A collaboration between all major modelling groups working on HIV in context of sub-Saharan Africa

Dolutegravir replacing efavirenz as first line ART - 2017

Cost-effectiveness of public-health policy options in the presence of pretreatment NNRTI drug resistance in sub-Saharan Africa: a modelling study

oa OPEN ACCESS

Andrew N Phillips, Valentina Cambiano, Fumiyo Nakagawa, Paul Revill, Michael R Jordan, Timothy B Hallett, Meg Doherty, Andrea De Luca, Jens D Lundgren, Mutsa Mhangara, Tsitsi Apollo, John Mellors, Brooke Nichols, Urvi Parikh, Deenan Pillay, Tobias Rinke de Wit, Kim Sigaloff, Diane Havlir, Daniel R Kuritzkes, Anton Pozniak, David van de Vijver, Marco Vitoria, Mark A Wainberg, Elliot Raizes, Silvia Bertagnolio, Working Group on Modelling Potential Responses to High Levels of Pre-ART Drug Resistance in Sub-Saharan Africa*

Interpretation A future transition from first-line regimens containing efavirenz to regimens containing dolutegravir formulations in adult ART initiators is predicted to be effective and cost-effective in low-income settings in sub-Saharan Africa at any prevalence of pre-ART NNRTI resistance. The urgency of the transition will depend largely on the country-specific prevalence of NNRTI resistance.

Trade off being modelled was not just around costs

Potential effects of disruptions to HIV programmes due to COVID-19

Potential effects of disruption to HIV programmes in sub-Saharan Africa caused by COVID-19: results from multiple mathematical models

Britta L Jewell, Edinah Mudimu*, John Stover*, Debra ten Brink*, Andrew N Phillips*, Jennifer A Smith, Rowan Martin-Hughes, Yu Teng, Robert Glaubius, Severin Guy Mahiane, Loveleen Bansi-Matharu, Isaac Taramusi, Newton Chagoma, Michelle Morrison, Meg Doherty, Kimberly Marsh, Anna Bershteyn, Timothy B Hallett, Sherrie L Kelly, for the HIV Modelling Consortium*

Interpretation During the COVID-19 pandemic, the primary priority for governments, donors, suppliers, and communities should focus on maintaining uninterrupted supply of ART drugs for people with HIV to avoid additional HIV-related deaths. The provision of other HIV prevention measures is also important to prevent any increase in HIV incidence.

Trade off being modelled was not around costs

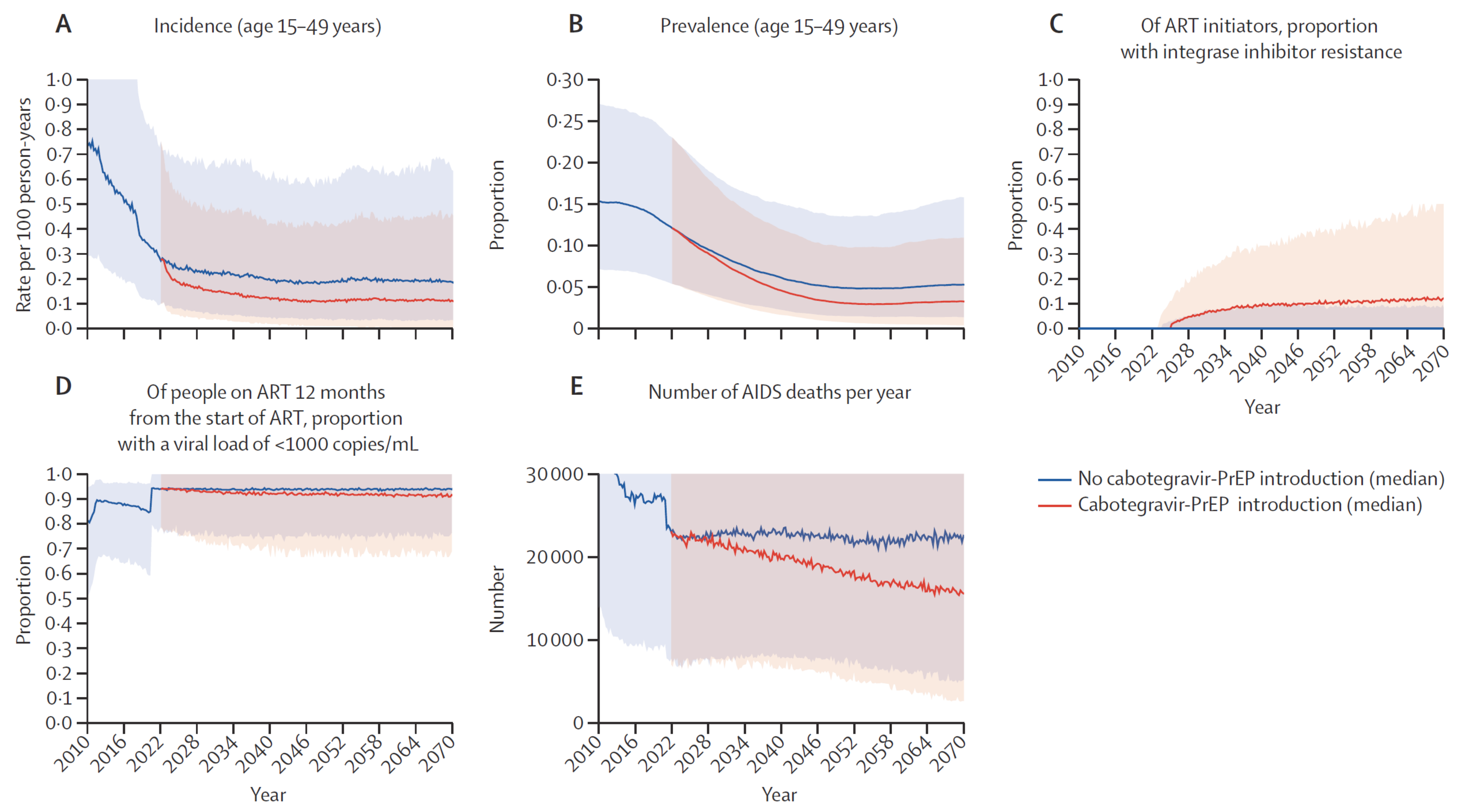
Cab-LA PrEP introduction

Predicted effects of the introduction of long-acting injectable cabotegravir pre-exposure prophylaxis in sub-Saharan Africa: a modelling study

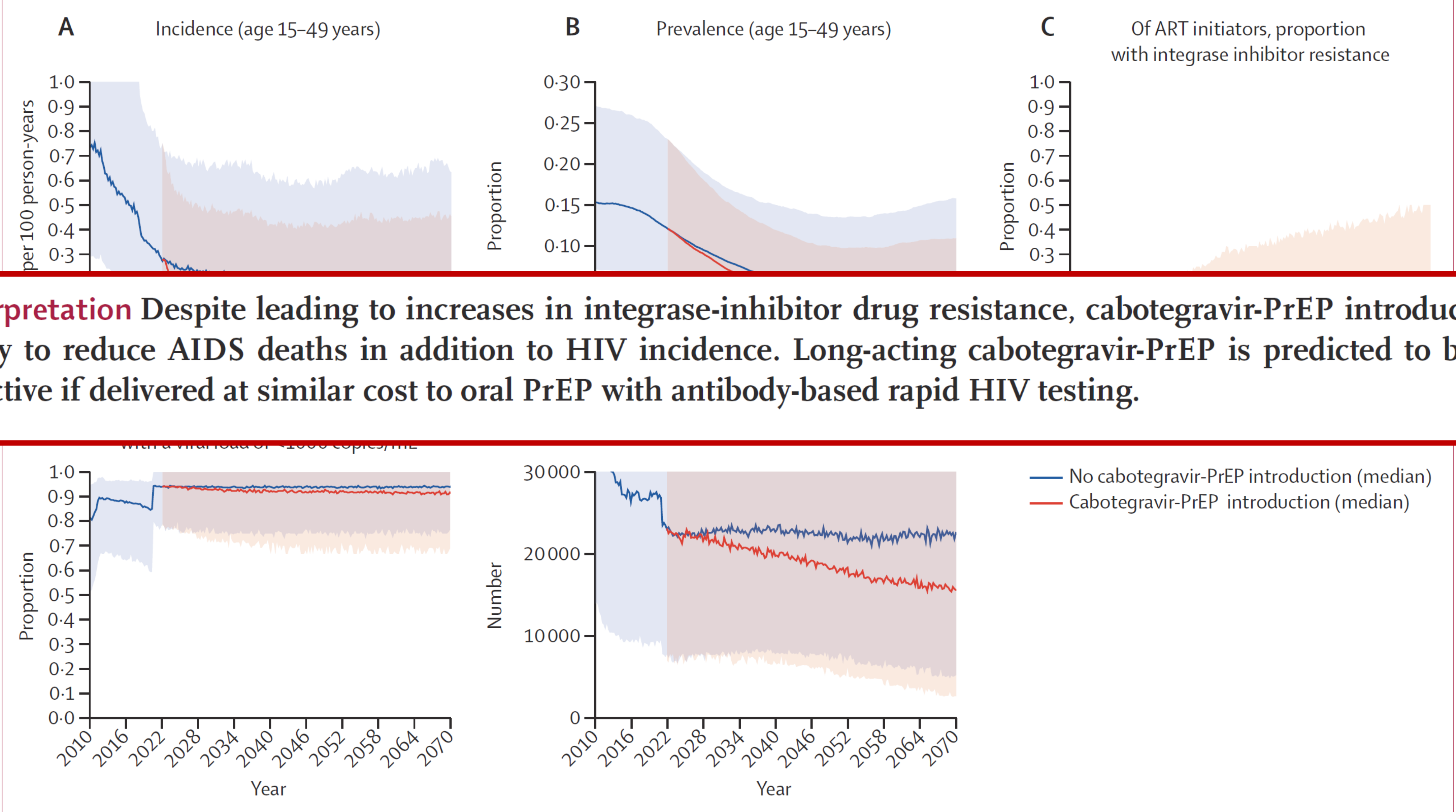
Jennifer Smith, Loveleen Bansi-Matharu*, Valentina Cambiano*, Dobromir Dimitrov, Anna Bershteyn, David van de Vijver, Katharine Kripke, Paul Revill, Marie-Claude Boily, Gesine Meyer-Rath, Isaac Taramusi, Jens D Lundgren, Joep J van Oosterhout, Daniel Kuritzkes, Robin Schaefer, Mark J Siedner, Jonathan Schapiro, Sinead Delany-Moretlwe, Raphael J Landovitz, Charles Flexner, Michael Jordan, Francois Venter, Mopo Radebe, David Ripin, Sarah Jenkins, Danielle Resar, Carolyn Amole, Maryam Shahmanesh, Ravindra K Gupta, Elliot Raizes, Cheryl Johnson, Seth Inzaule, Robert Shafer, Mitchell Warren, Sarah Stansfield, Roger Paredes, Andrew N Phillips, on behalf of the HIV Modelling Consortium*

Trade off being modelled was not just around costs

Cab-LA PrEP introduction



Cab-LA PrEP introduction



Interpretation Despite leading to increases in integrase-inhibitor drug resistance, cabotegravir-PrEP introduction is likely to reduce AIDS deaths in addition to HIV incidence. Long-acting cabotegravir-PrEP is predicted to be cost-effective if delivered at similar cost to oral PrEP with antibody-based rapid HIV testing.

Modelling to inform HIV programmatic policy in southern and east African settings

Outline

HIV in southern and east Africa – incidence trends

How models are used to inform policy

Examples of modelling that has informed policy

Capability building for modelling

Capability building for modelling

- Modelling has the potential to help inform policy decision making and hence improve population health. We all have a stake in this.
- But this depends on our models being as well informed as possible.
- To achieve this requires widespread engagement with modelling.
- It is critical that epidemiologists and clinical disease specialists are able to understand modelling sufficiently to help to critique existing models and help to improve them.
- We are aiming to develop material to help those with no prior experience learn about individual based models by building (initially) simple models themselves.

Capability building for modelling

Building and Understanding Individual Based Models to Inform Health Policy

Note: this project is still under development and changes will be made over time.

Update 30 Oct 2023: first iteration of parts 14 to 19 (building a transmission model) added

Welcome to this tutorial to help you self-learn how to build individual-based models to inform health policy. This is intended to be an accessible introduction which requires no existing knowledge.

What is an Individual-based Model ?

Each time the model program is run it generates values of variables that represent the characteristics of individuals and simulates how these change over time.

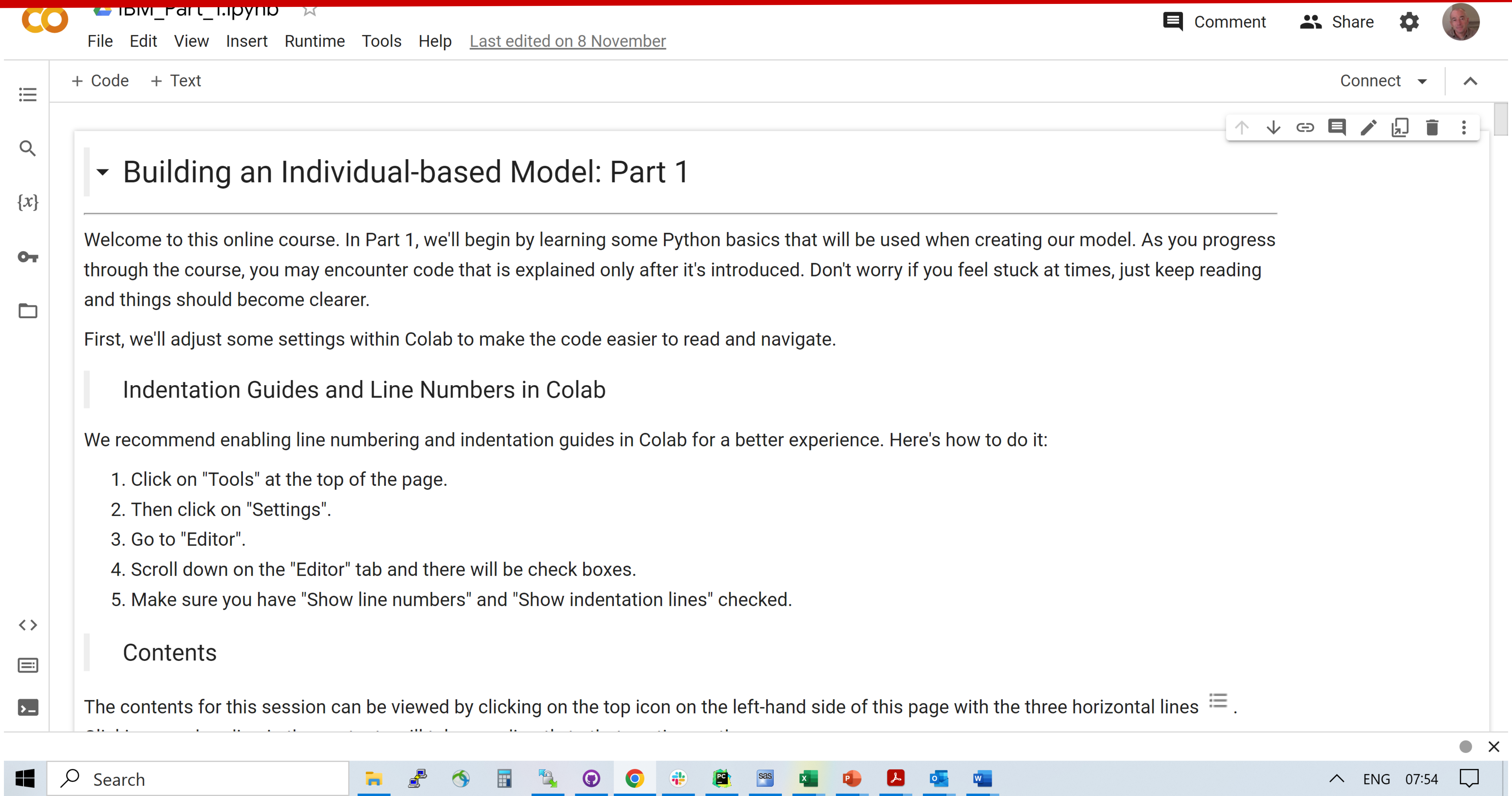
This can be accessed at:

hivmodeling.org

in "Resources"

https://docs.google.com/document/d/1fH0qKeLpvSRBNEePDYS9eaet4qJCQBOvr9kbJlyJVq4/edit

Capability building for modelling



BHIVA

British HIV Association

Autumn Conference

Friday 24th November 2023

etc.venues 155 Bishopsgate, London

BHIVA WORLD AIDS DAY

WORLD AIDS DAY

www.bhiva.org

#BHIVA23 Follow us on social media