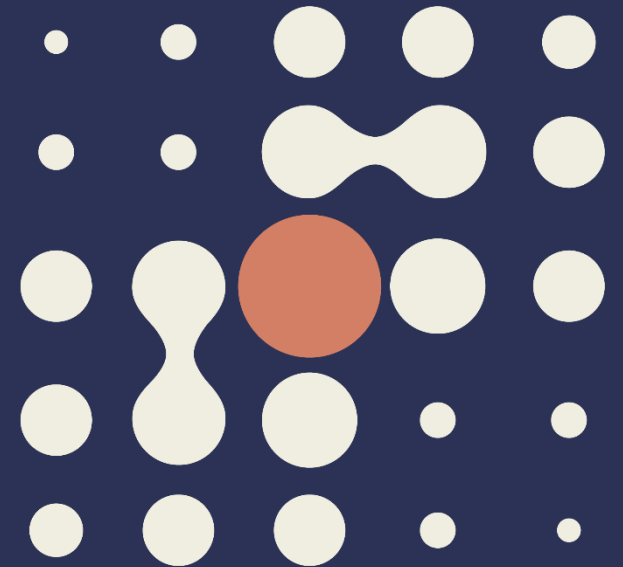# Context-responsive modelling to inform HPV vaccination strategies:
From introduction, vaccine target expansion, to integration with screening

CHIC Symposium | Nairobi, Kenya

October 2, 2025

Irene Man, **Rachel Wittenauer**, Iacopo Baussano
Public Health Decision Science Team, IARC/WHO

International Agency
for Research on Cancer

World Health
Organization

Agenda

1. Introduction (IARC & team)

2. How does IARC support country HPV vaccination programs?
   - Introduction
   - Vaccine target expansion
   - Full integration

3. Group Discussion (led by Rachel Wittenauer)

IARC- International Agency for Research on Cancer

**WHO specialized cancer research agency
(in Lyon, France)**

"Cancer research for cancer prevention"

Public Health Decision Science Team (Dr Iacopo Baussano)
in **Early Detection, Prevention, & Infections Branch** (Dr Partha Basu)

Collect high-quality local data through field studies
to measure cancer burden and impact of preventive interventions

Evaluate local impact of cancer prevention using quantitative tools
to guide decisions on policies and programs

Country-level evaluations to support **cervical cancer elimination**

International Agency for Research on Cancer

World Health Organization

Our vision:
Public Health (and Decision Making) as an integral component of Medicine.

- Therefore, by definition, **health is a value per-se**, it is not a commodity.

- The very nature of Medicine is promoting life and health, and it is grounded in **four fundamental (*prima facie*) ethical principles**: Beneficence, Non-Maleficence, Autonomy, and Justice.

- These principle are **inherently locally-defined**, i.e., specific to each culture and population and set the context with which PH decisions must be taken.

- Furthermore, decision making is result of a **collegial negotiation between local stakeholders** (medical and technical experts, civil society representatives, and political leaders) each one with specific visions and agendas to be combined **to reach a final decision**.

Our perspective:
Context-responsive Public Health Decision Modelling

Global perspective	Local perspective

Context-free & aspirational

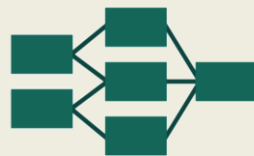**Context-responsive & pragmatic**

Impact evaluation, accounting for local settings, relevant to local stakeholders:

- Health needs
- Resources
- Feasibility
- Acceptability
- Sustainability

Our modelling platform:

METHIS
Modelling tools for
HPV infection-related cancers

Website

* Development funded by the Gates Foundation

How our work supports HPV vaccination programs?

Vaccine introduction → **Sustainability & Optimization** → **Full Integration**

Case study 1: Planning for introduction How to decide on HPV vaccination introduction among so many priority health areas? How to plan the implementation for maximum impact within resources?

Bonjour et al. Lancet Public Health. (2021).
Man et al. Lancet Oncol. (2022).
Wittenauer et al. HPV World. (2025).
Fuady et al. Glob Oncol. (2024).

Case study 2: Prioritizing vaccine target populations Who to vaccinate first? Older women, boys/men, other special populations/regions?

Dillner et al. Prev Med (2021).
Man et al. eLife. (2023).
Man et al. JNCI Monogr. (2024).
Online interactive decision tool

Case study 3: Optimizing dose schedule
Is there any difference in health impact? Is the second dose still cost-effective? And how can saved resources best be reallocated?

Man et al. JNCI Monogr. (2024).
Carvalho et al. BMJ Glob Health. (2023).

Case study 4: Complementing vaccination with screening How to control cervical cancer in older women? How to accelerate elimination through HPV-FASTER?

Bosch et al. Nat Rev Clin Oncol. (2016).
Mühr et al. Nat Commun. (2024).

Case study 5: Monitoring vaccination impact
What is the current progress? And how to adapt to reach elimination?

Website of CHRONOS
Sayinzoga et al. Lancet Glob Health. (2023).

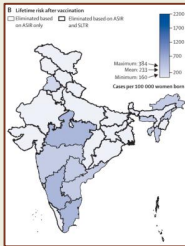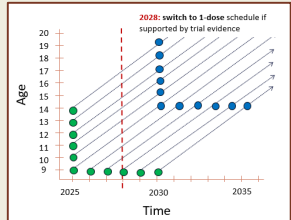**Continuous: collecting and monitoring country-specific HPV data**

How our work supports HPV vaccination programs?

Vaccine introduction

Case study 1: Planning for introduction How to decide on HPV vaccination introduction among so many priority health areas? How to plan the implementation for maximum impact within resources?
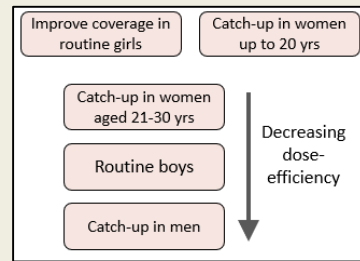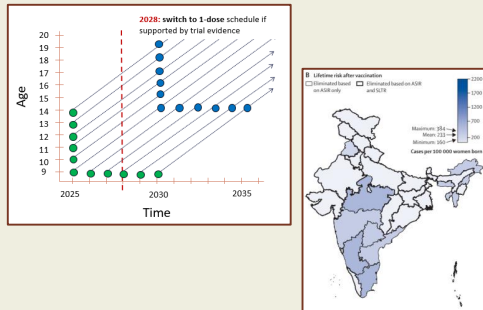

Bonjour et al. Lancet Public Health. (2021).
Man et al. Lancet Oncol. (2022).
Wittenauer et al. HPV World. (2025).
Fuady et al. Glob Oncol. (2024).

Introduction – Deciding on inclusion of HPV in EPI prgm.

- First step:
  Quantify **local disease burden**
  and **benefit of HPV vaccination**

- **Impact on health** and **economic** outcomes, depending on **local stakeholders & context**:
  - Cancer cases and deaths
  - Treatment costs
  - Productivity loss
  - Catastrophic costs

- **Ultimately, to support introduction decision** and prioritization of different health problems (other vaccines, cancers)

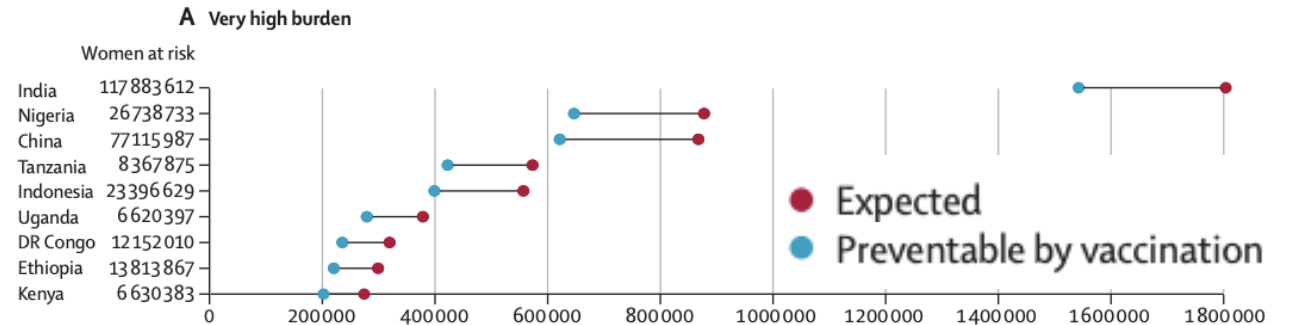HPV types attributable fractions by world region: Wei et al. Lancet (2024)
CC treatment costs in 8 countries: Fuady et al. Glob Oncol (2024)

Expected & preventable cervical cancer cases in 185 countries
(in the lifetime of 10 birth cohorts)

Bonjour et al., Lancet Public Health (2021)

Preventable financial burden in Bhutan
(in the lifetime of 10 birth cohorts)

Direct medical costs	961,000 USD
Direct non-medical costs	1,059,000 USD
Income loss	344,000 USD
No. households with catastrophic costs	450 households

Fuady et al. (manuscript in preparation)

Introduction – Planning implementation

Information Gap

Main question: How can the India MOH use/distribute the limited available doses to achieve maximum protection for the most girls as they plan for national introduction?

Context:

- Number of doses be available in 2025 expected insufficient to reach all eligible girls (aged 9-14, using a 2-dose schedule with 6 months in between doses)

- For each year that vaccination is delayed, each birth cohort of (12 million girls) are left behind → price of this inaction = 160,000 preventable cervical cancer cases

Modelling Approach

We worked with NITAG members to explore feasible and acceptable scenarios, then estimated expected impact with India-specific parameters

Lifetime cancer risk after vaccination, by region in India
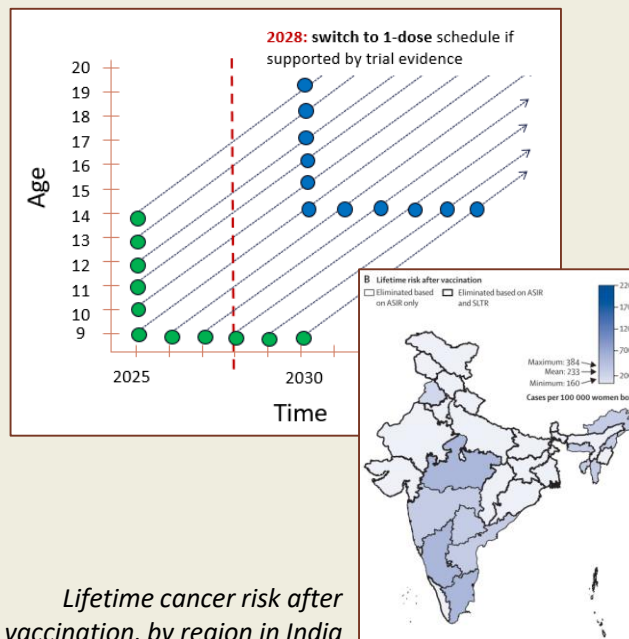
Results and Impact

Ultimately, we presented the most impactful strategies for the Government of India to consider (in particular, extended dose schedule)

N° 301

RACHEL WITTENAUER, PHD

Early Detection, Prevention & Infections Branch, International Agency for Research on Cancer (IARC/WHO), Lyon, France
wittenauerr@iarc.who.int

Challenges in HPV vaccine introduction in India – an evidence-based, pragmatic solution

More on modelling introduction in India:
Man et al. Lancet Oncol. (2022).
Carvalho et al. BMJ Glob Health (2023).
Wittenauer et al. HPV World. (2025).

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How our work supports HPV vaccination programs?

Sustainability & Optimization

Case study 2: Prioritizing vaccine target populations Who to vaccinate first? Older women, boys/men, other special populations/regions?

Improve coverage in routine girls | Catch-up in women up to 20 yrs

Catch-up in women aged 21-30 yrs

Decreasing dose-efficiency

Routine boys

Catch-up in men
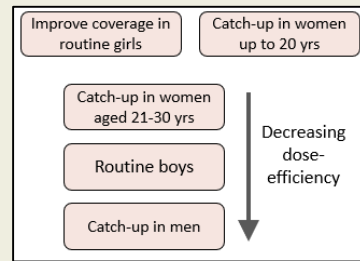
Dillner et al. Prev Med (2021).
Man et al. eLife. (2023).
Man et al. JNCI Monogr. (2024).
Online interactive decision tool

Sustainability and optimization – Expanding vaccine target

- **Health is a value per-se.**
  Innovative resource mobilization approaches are needed

- **If <u>unlimited</u> resources, vaccinate everyone (who benefits from it)**
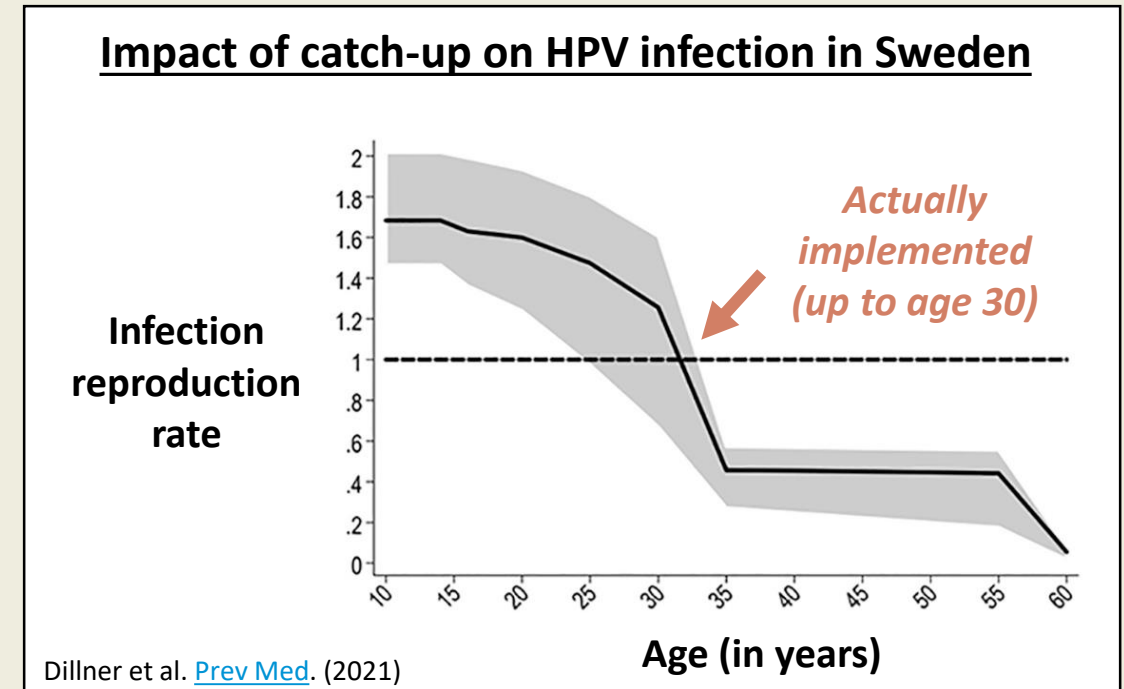
  - ✓ **Large catch-up** to **stop HPV transmission** and **reach elimination asap**

  - ✓ **Gender-neutral vaccination** to **increase resilience** against future disruption and to **maximize long-term benefits**

  More on gender-neutral vacc. and resilience:
  Elfström et al. J Infect Dis (2015); Man et al. eLife. (2023)

Impact of catch-up on HPV infection in Sweden

Infection reproduction rate

Actually implemented (up to age 30)

Age (in years)

Dillner et al. Prev Med. (2021)

Sustainability and optimization – Prioritizing vaccine target

- **Under <u>limited</u> resources, prioritization of vaccine target needs to be done**
  (e.g., subpopulations, by gender, age, region, etc)

- **According to indicators representing different values, to be selected based on the local context & data availability**
  (e.g., <u>dose-efficiency</u>*, cost-effectiveness, or equity)

Rule of thumb based on dose-efficiency *

(= no. doses needed to prevent one cervical cancer)
This indicator can be often evaluated and speaks to policy-makers.

First, with similar high dose-efficiency

| Improve coverage in routine girls | Catch-up in women up to ~20 yrs |

Catch-up in women aged ~21-30 yrs

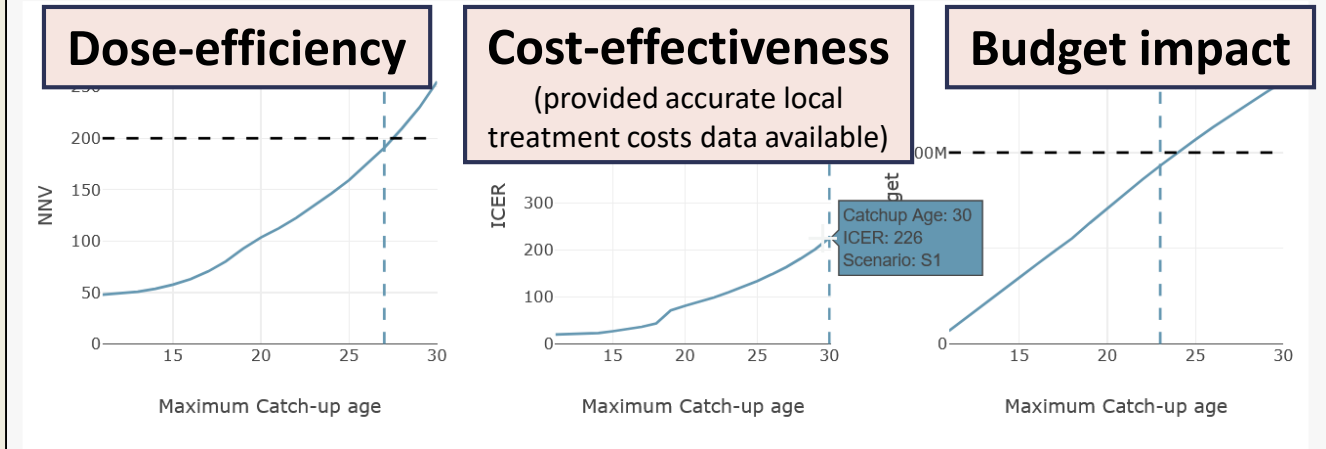Routine boys

Catch-up in men

Decreasing dose-efficiency

Man et al. JNCI Monogr. (2024)

See also meeting's Technical Brief.

Sustainability and optimization – Catch-up decision tool

- **Interactive user-friendly tool to support detailed planning of age range of female catch-up**

- **Also supports selecting cost-effective delivery strategies** (e.g., outreach vs school)

- **First version online**
  - Ready for: Kenya, Nigeria Gradually online for other LMICs
  - Your feedback is welcomed. Link: https://phds.shinyapps.io/methis_cutool/

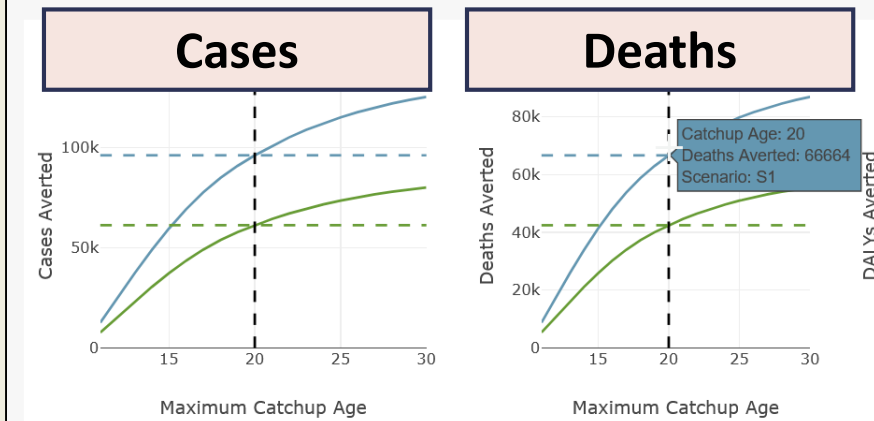*Macacu and Dagne et al (manuscript in preparation)*

Optimizer Module
This module reports the optimized age for catch-up vaccination based on user-defined thresholds for efficiency, cost-effectiveness, and 5-year budget. Users can also modify several cost parameters

Dose-efficiency

Cost-effectiveness (provided accurate local treatment costs data available)

Budget impact

Catchup Age: 30
ICER: 226
Scenario: S1

Impact Module
This module shows the impact of HPV vaccination on cases, deaths, and DALYs.

Cases

Deaths

Catchup Age: 20
Deaths Averted: 66664
Scenario: S1

Cost Parameters
Vaccine cost per full course
4.5

Supply Dose Cost
0.5

School Delivery
6.21

Out of School D
9.31

Out of School P
11

Customizable: costs parameters and efficiency thresholds

13

How our work supports HPV vaccination programs?

Sustainability & Optimization

Case study 3: Optimizing dose schedule

Is there any difference in health impact? Is the second dose still cost-effective? And how can saved resources best be reallocated?

Man et al. JNCI Monogr. (2024).
Carvalho et al. BMJ Glob Health. (2023).

Sustainability and optimization – Optimizing dose schedule

- **Gradually, countries switched to 1-dose based on high & long-lasting efficacy** demonstrated by trials data:
  - KENSHE vaccine trial - Barnabas et al. NEJM. (2022)
  - IARC India vaccine trial - Malvi et al. JNCI Monogr. (2024)
  - Etc.

- **Modelling allows projection and comparison of health and economic impact by dose schedule:**
  - Projecting impact to the population-level
  - Projecting trial data beyond 15 yrs
  - Exploring 1-dose protection assumptions *

Dose schedule cost-effectiveness analyses in Bhutan

Which dose?	Cost-effective?
1st dose	**Always** cost-effective
2nd dose	**Not** cost-effectective

Man et al. (manuscript in preparation)

*1-dose protection duration assumptions

HPV 16/18 efficacy
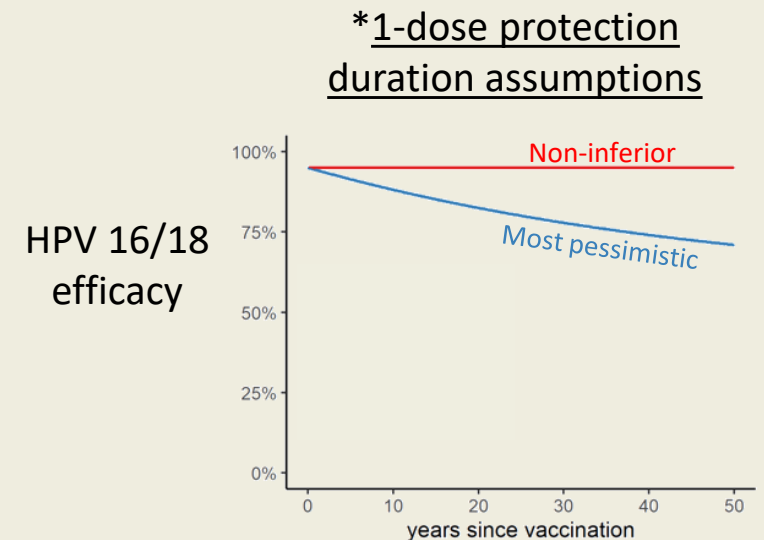
More on single-dose modelling:
Man et al. Lancet Oncol. (2022); Carvalho et al. BMJ Glob Health (2023); Man et al. JNCI Monogr. (2024)

How our work supports HPV vaccination programs?

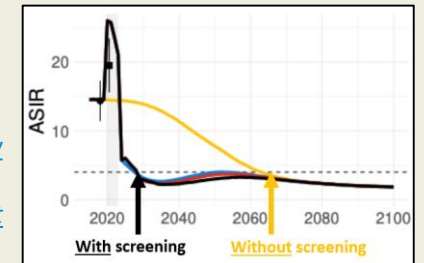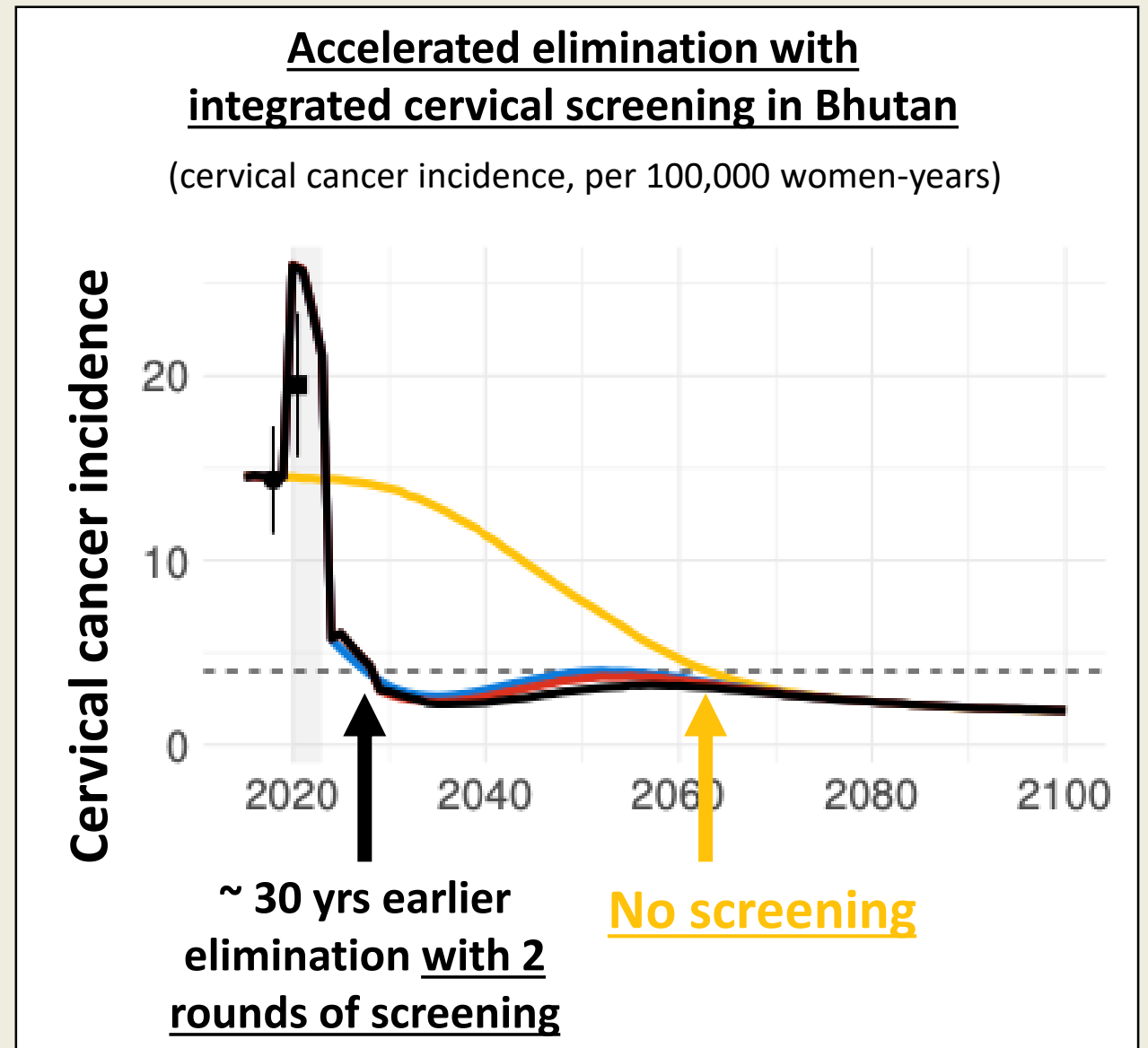**Case study 4: Complementing vaccination with screening** How to control cervical cancer in older women? How to accelerate elimination through HPV-FASTER?

Bosch et al. Nat Rev Clin Oncol. (2016). Mühr et al. Nat Commun. (2024).

Full integration – Designing cervical screening

- **Even with optimal HPV vaccination, substantial burden remains in older women**

- **As a complement:** integrate cervical screening to accelerate elimination

- Support **design the exact screening algorithm** (e.g., number of screening rounds, which age) and to **plan the resources needed** (e.g., number of colposcopies, HPV tests)

Accelerated elimination with integrated cervical screening in Bhutan

(cervical cancer incidence, per 100,000 women-years)

Cervical cancer incidence

~ 30 yrs earlier elimination <u>with 2 rounds of screening</u>

No screening

Gini et al (manuscript in preparation)

More publications on FASTER and integrated screening:
Bosch et al. Nat Rev Clin Oncol. (2016); Mühr et al. Nat Commun. (2024).

How our work supports HPV vaccination programs?

Case study 5: Monitoring vaccination impact

What is the current progress? And how to adapt to reach elimination?

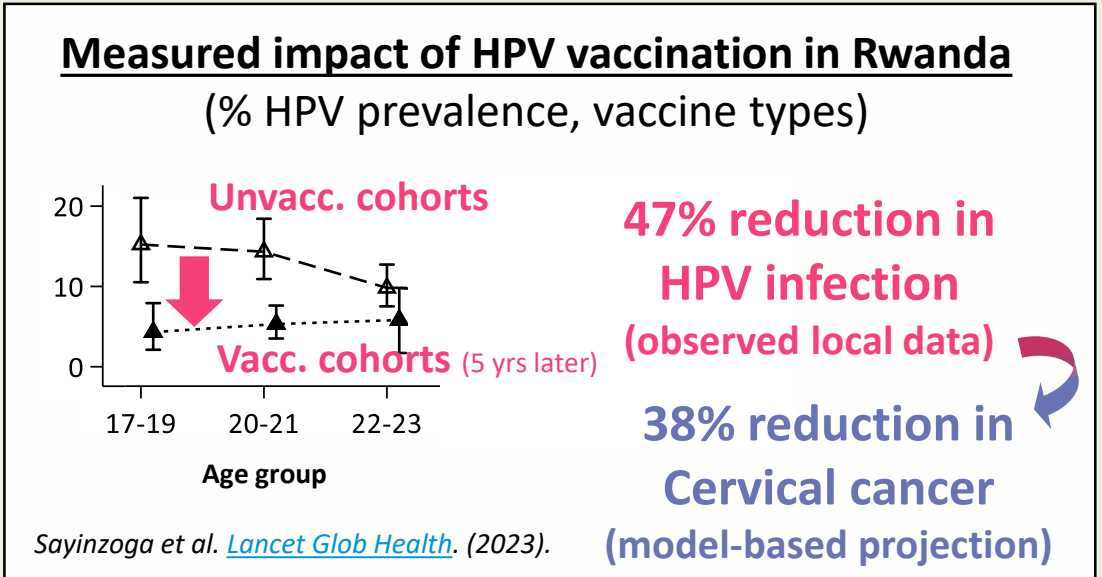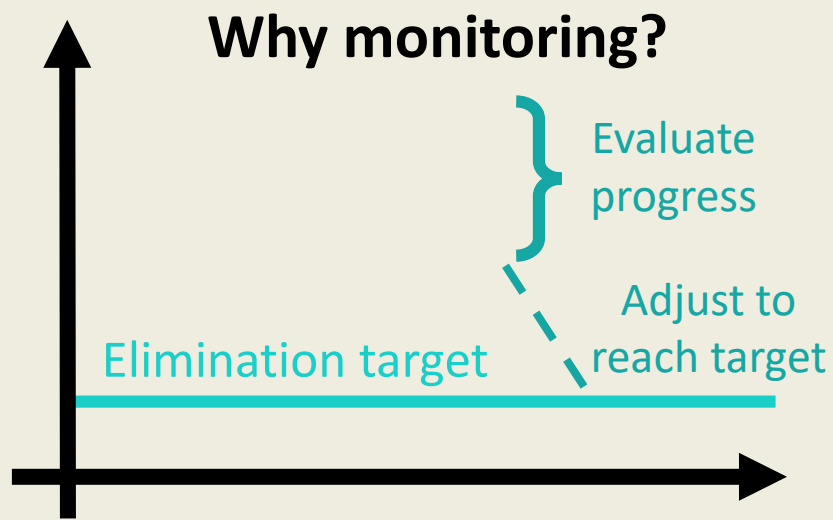*Website of CHRONOS*
Sayinzoga et al. Lancet Glob Health. (2023).

CHRONOS

Continuous: collecting and monitoring country-specific HPV data

Continuous monitoring – Evaluating progress to elimination

CHRONOS
MONITORING
HPV VACCINATION IMPACT

Website

- **IARC's centre of Excellence** to **coordinate** and **transfer knowledge and material** on monitoring local population HPV vaccination impact through **repeat HPV prevalence surveys**

- As recommended in the **WHO Framework of Monitoring** Cervical Cancer Elimination, complementing coverage monitoring [link]

- Allows to project **impact on cervical cancer** (before measurable in cancer registries)

Why monitoring?

Evaluate progress

Adjust to reach target

Elimination target

Measured impact of HPV vaccination in Rwanda
(% HPV prevalence, vaccine types)

Unvacc. cohorts

Vacc. cohorts (5 yrs later)

Age group

17-19   20-21   22-23

47% reduction in HPV infection (observed local data)

38% reduction in Cervical cancer (model-based projection)

Sayinzoga et al. Lancet Glob Health. (2023).

Other past CHRONOS country surveys:
Baussano et al. Ann Intern Med. (2020); Sayinzoga et al. Lancet Glob Health. (2023); Baussano et al. Vaccine. (2025)

Continuous monitoring – Adjusting to reach elimination

- **CHRONOS is a good starting point for context-responsive modelling**

- Combining with **additional data** allows **detailed projections:**
  - Alternative strategies
  - Health and economic outcomes

Feasibility of elimination under different scale-up strategies in Rwanda

Strategy	Long-term cervical cancer incidence (per 100,000 women-years)	Elimination?
No vaccination	18.9	No
Current strategy girls-only ~ 90% coverage	5.4	No
Switch to gender-neutral	4.4	Almost
Switch to 9-valent	2.0	**Yes**

Man et al. JNCI Monogr. (2024).
Sayinzoga et al. Lancet Glob Health. (2023).

How our work can support your country

Public health decision modelling

Published results

- ✓ **Ready**: Standardized output on topics covered here, ready-to-use for policy-makers, public health officials, programme managers, researchers

- ✓ **Soon available: full catch-up tool, cost-effective 9-valent price, evaluation strategies to reach vulnerable populations, screening design tool...**

In collaboration

- ✓ Adaptable and advanced output

- ✓ Guidance in adapting and using models

- ✓ **Pre-requisite**: local data and resources, engaged collaborators (public health background and quantitative skills)

Data collection for monitoring

Published results

- ✓ **Ready:** Results from existing surveys. Rwanda ([link](#)), Bhutan ([link](#)), Armenia ([link](#)) See also [WHO HPV Dashboard - Effectiveness studies](#)

- ✓ **Soon available: Zimbabwe (also in WLWHIV), Eswatini, Uganda, Laos**

In collaboration

- ✓ Standardized materials (e.g., protocols, SOPs, training toolkits for local field and lab staff)

- ✓ Training & support to design and implement study

- ✓ Community of practice with participating countries

- ✓ **Pre-requisite**: local resource and engaged collaborators

METHIS
Modelling tools for
HPV infection-related cancers

Website

CHRONOS
MONITORING
HPV VACCINATION IMPACT

Website

In summary

✓ **Modelling can be a useful tool to support HPV vaccination programs at any stage, incl. expansion of target populations and sustainability of programs**

✓ **Local data is the basis for monitoring and impactful modelling**

✓ **Our IARC Public Health Decision Science Team is here to partner with you**

✓ **Shared goal of sustainable, effective cancer control programs for all**

Acknowledgements
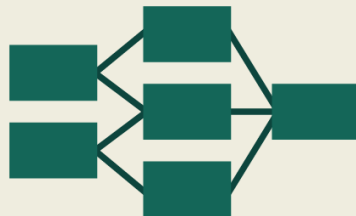
IARC - Public Health Decision Science Team

Funding

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CHRONOS
MONITORING
HPV VACCINATION IMPACT

Website

Discussion

Warm-up question

Raise your hand if...

Your country's program is currently thinking about:

- ✓ Planning for vaccine introduction and rollout

- ✓ Expanding and optimizing the current national program

- ✓ Looking towards the future for integration

- ✓ Data for monitoring success continuously

Discussion 1

What are some HPV vaccination <u>sustainability/ optimization areas</u> that your country's HPV program is considering for the future?

Examples: conducting a catch-up campaign for older girls, reaching out-of-school girls, gender neutral vaccination, switch to single-dose?

Share ideas with your table (5 minutes)

Discussion 2

What questions do you have about <u>designing HPV vaccine programs</u> that you feel modelling evidence hasn't addressed fully yet?

Examples: Missing evidence on _____? How does X compare to Y on what is most effective in a program?

Share ideas with your table (5 minutes)

Thank you!

Please do reach out or come say hello if you want to discuss anything further (questions, collaborations, suggestions... we would love to hear from you).

Irene Man

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LinkedIn: https://www.linkedin.com/in/rachelwittenauer/

International Agency for Research on Cancer

World Health Organization