# Assessing Cancer Control Initiatives in Canada The Oncology Simulation Model (OncoSim)

## Overview, Methods, and Applications

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*[Formerly the Cancer Risk Management Model]*

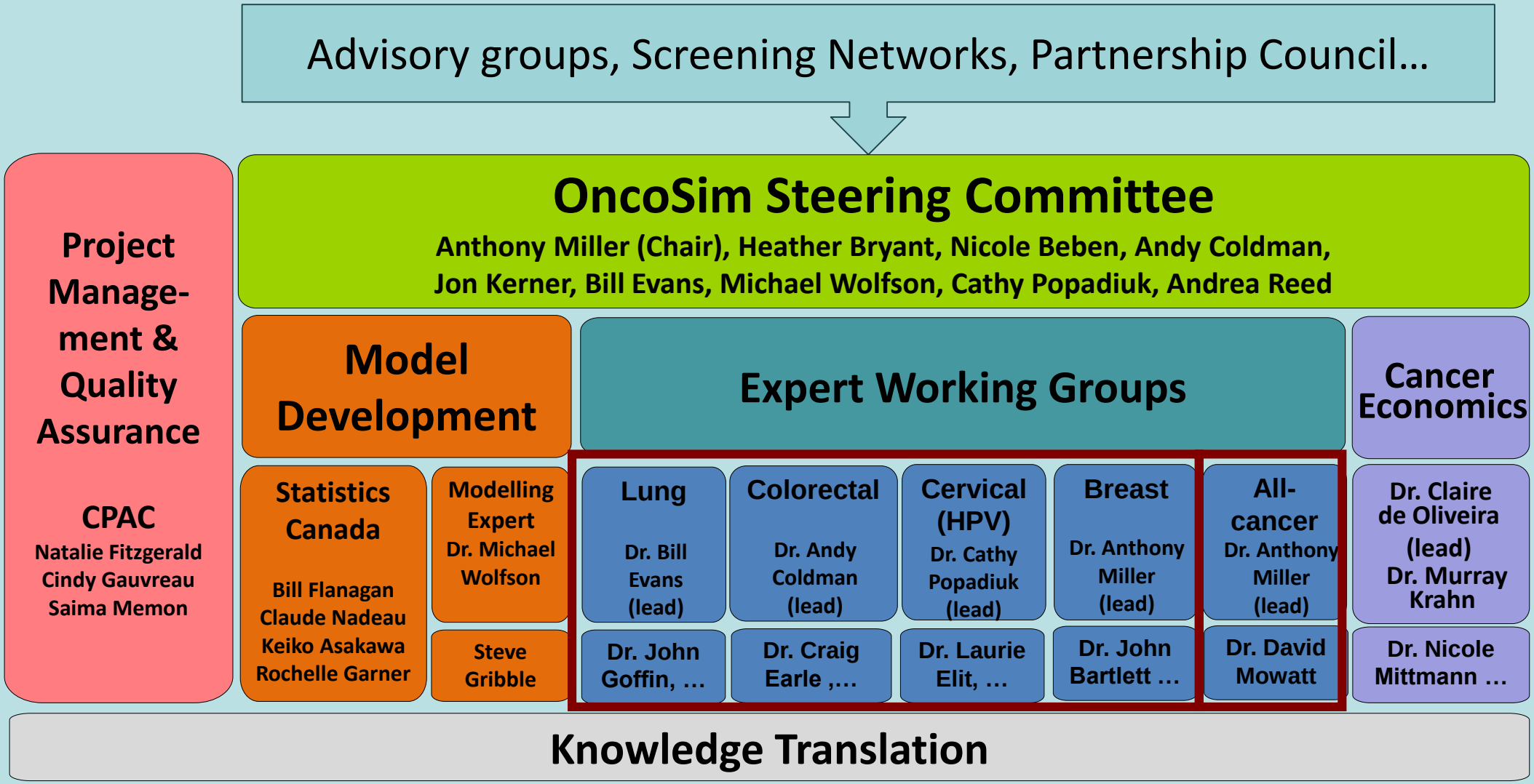
***OncoSim development is continuing as a collaboration between Statistics Canada and the Canadian Partnership Against Cancer through funding from Health Canada***

# OncoSim - Objectives

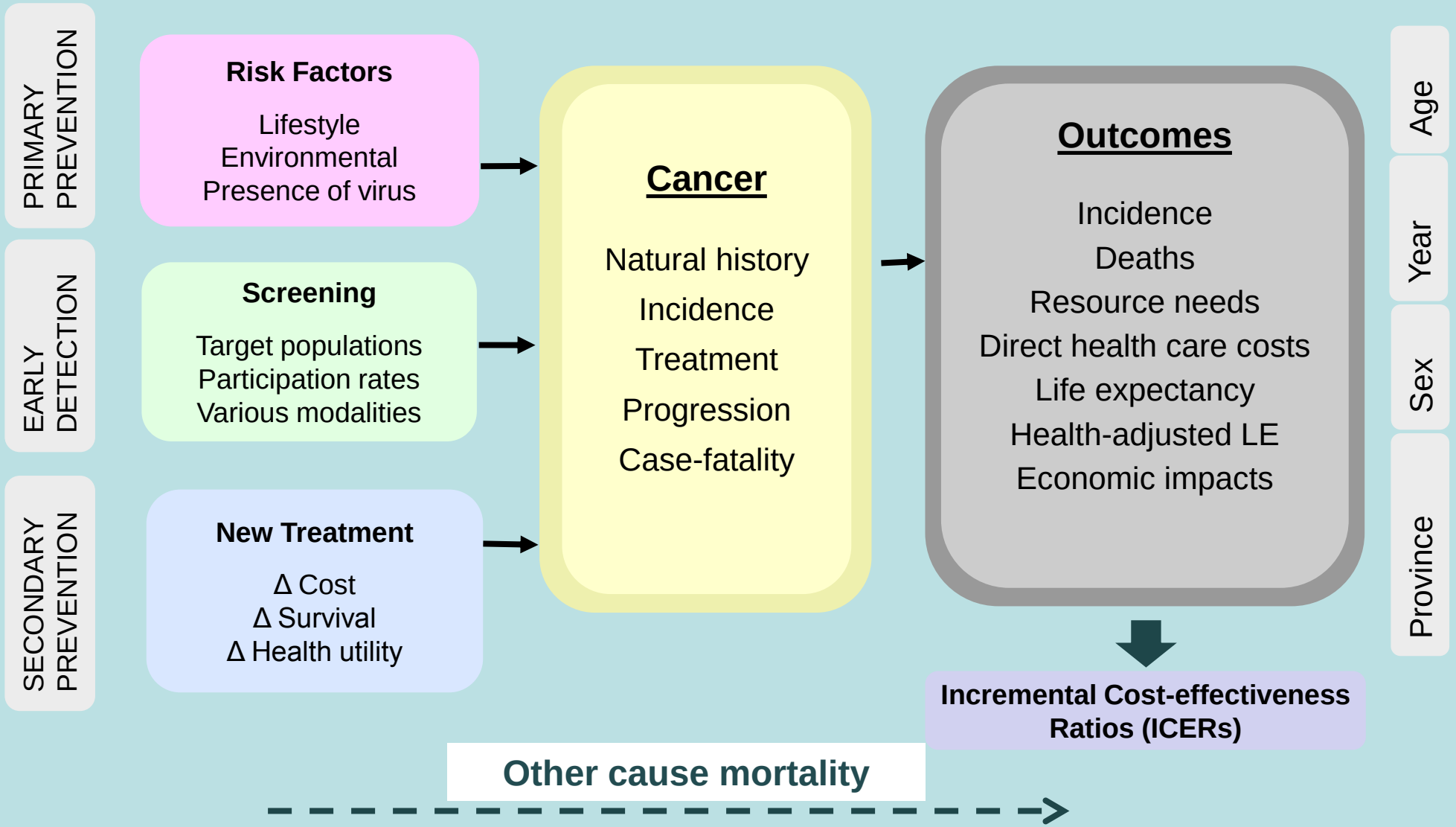
- Provide a comprehensive, web-based platform that projects **population-based health** and **economic** impacts of cancer control programs in Canada

- **Mobilize** this information for health system leaders and their advisors to help **inform policy decisions** to reduce the burden of costs and disease posed by cancer on the population

# How OncoSim is organized



# Conceptual framework



# Sample key policy questions

**LUNG CANCER**

- Under what conditions would screening by low-dose computed tomography be most cost-effective in Canada? (e.g., what smoking history and age eligibility, screen interval, adjunct smoking cessation program)

**COLORECTAL CANCER**

- What would be the cost and benefit of moving a 3$^{rd}$ line chemotherapy drug (expensive) to 1$^{st}$ line compared with investing resources into screening?

**CERVICAL CANCER**

- What would be the cost-effectiveness and resource impact of alternative cervical cancer screening programs in conjunction with human papillomavirus (HPV) vaccinations?

**BREAST CANCER**

- What would be the impact of moving from primarily age-based to “precision health” risk-based breast cancer screening on women's’ health-adjusted life-years and ICERs?

# OncoSim Engine: Microsimulation

- **Discrete-event, continuous time, competing risk microsimulation model**
- **Uses both interacting-agent (HPV, genotypes and pedigrees) and non-interacting agent (oncogenesis, major cancer sites) models**
- **Empirically based, representative of the Canadian population**
  - risk factors, demography, incomes, health status
- **Individual-level simulation**
- **Results at various levels (geography, population/patient groups) by aggregations over synthentic but representative population sample**
- **Projections to 2050 and ‘what-if’ scenarios for comparative analysis**

# Many Diverse Data Sources Integrated

| Data Type | Source |
|---|---|
| **Mortality, Birth, Population projections** | Vital Statistics (1950-2005), Census (2006, 2011) |
| **Incidence, Staging, (Survival)** | Canadian Cancer Registry (1992-2010) |
| **Cancer Survival by stage** | British Columbia Cancer Registry Data (1992-2012)<br>Chart review (1991-92), Literature (1981, 1990-2000, 2005), |
| **Smoking rates** | Canadian Community Health Survey (CCHS) (2000-2007), National Population Health Survey (1994-2004), Canadian Health Survey (1979) |
| **Time use data** | General Social Survey (2005) |
| **Earnings, Transfers, and Taxes** | Census 2006, SPSD/M* v16.1 (2005) |
| **Total health care expenditures** | Canadian Institute for Health Information (2006) |
| **Health care costs:** diagnosis, treatment, follow-up, palliative and terminal care | Ontario Case Costing Initiative (2007-2008), Provincial formulary (2009), Provincial Ministries of Health (2009) |
| **Current treatment practice** | Expert Opinion, Ontario admin data |
| **Screening, Lung cancer risk equation, Radon exposure, sexual network, HPV virus transmission** | Canadian Breast Cancer Screening Database, British Columbia admin data, CCHS, Reports, Literature |
| **Health status** | Classification and Measurement System (CLAMES), CCHS |

*Social Policy Simulation Database and Model

# Innovative Use of Data - Examples

- **Smoking Dynamics**
  - Various Canadian national health surveys to derive transition matrices among smoking status (never smoked, light, heavy or former smoker)
- **Breast Cancer Genetics**
  - union formation / dissolution and parity-specific fertility rates + Mendelian and polygenic risk biological inheritance
- **Treatment Practice**
  - Linked provincial-level administrative data to obtain the distribution of breast cancer treatment by type (e.g., surgery, radiotherapy) and by biology (e.g., age, hormone receptor, tumour grade)
- **Survival**
  - Provincial-level cancer registry to estimate breast cancer survival by progression (initial diagnosis → recurrences → breast cancer death)

# Model Assessment

**Consultation (external)**

Current practice/costs reviewed by experts from across Canada not involved in building model

Case study evaluations

**Face Validity**

Inspect simulated individual life trajectories for plausibility

**Internal validation**

Ensure model outputs are consistent with model inputs

Example: Do incidence rates generate the expected number of cancer cases?

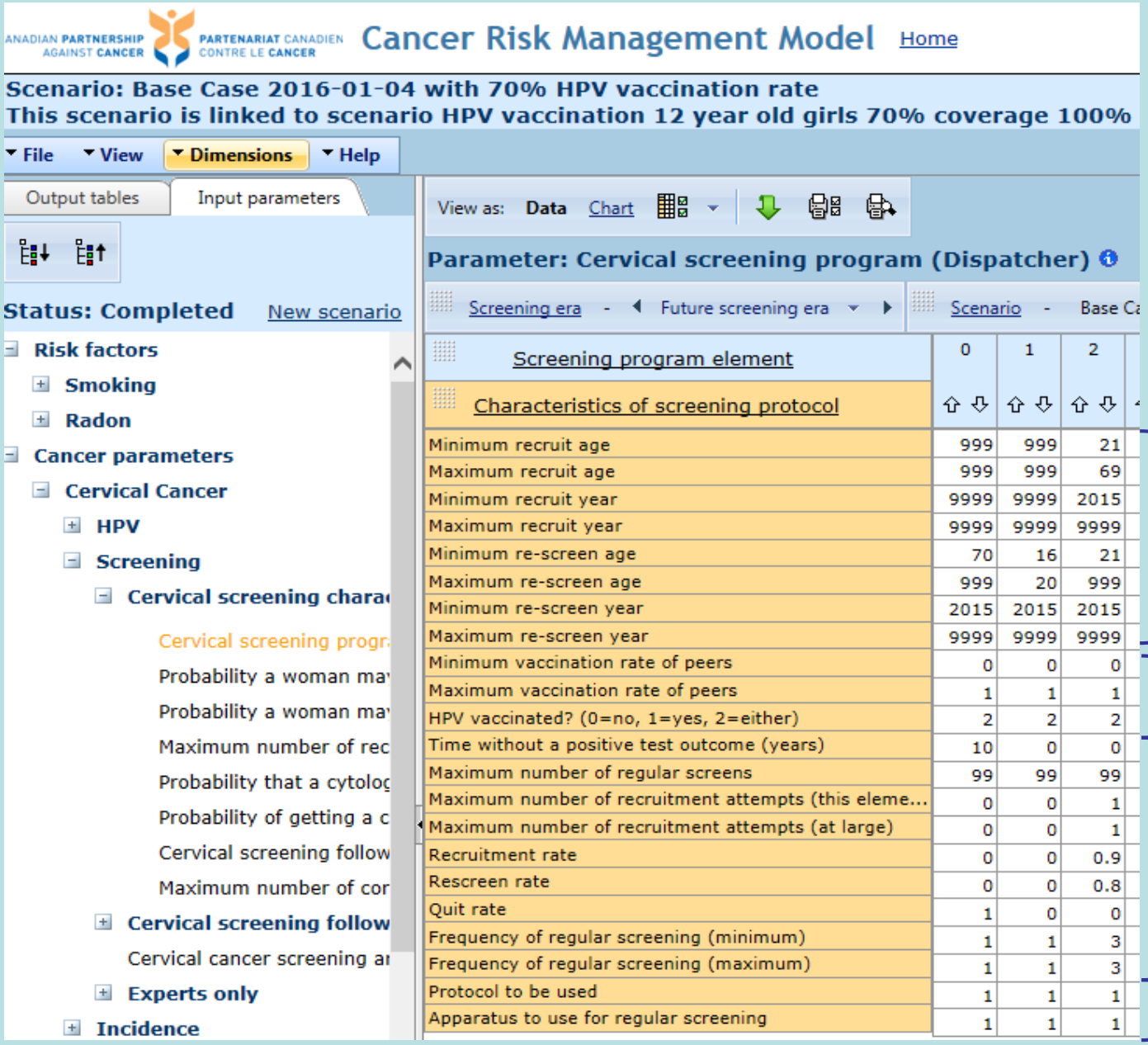
**External validation**

Ensure model outputs are consistent with other data sources not used to build model

Example: Can we replicate outcomes from other studies (e.g., RCTs)?

**Calibration ( model fitting )**

An iterative process of parameter estimation to ensure that the underlying model processes can match a pre-selected set of target data




# "Dispatcher" A useful feature in OncoSim allowing users to set up complex scenarios

Control screen age & year

Control screening by vaccination status

Control screening rate, frequencies and termination

Control screening modality and follow-up protocols

# Application – An Example

What would be the health and economic impact of various human papillomavirus (HPV) vaccination and cervical cancer screening strategies?

- What the cost-effectiveness and budgetary impact would be if we…
  - continue the status-quo vaccination and screening strategies into the future?
  - did not vaccinate at all and/or stop screening?
  - change screening modality?
  - tailor screening programs based on vaccination status?

# Sample scenarios

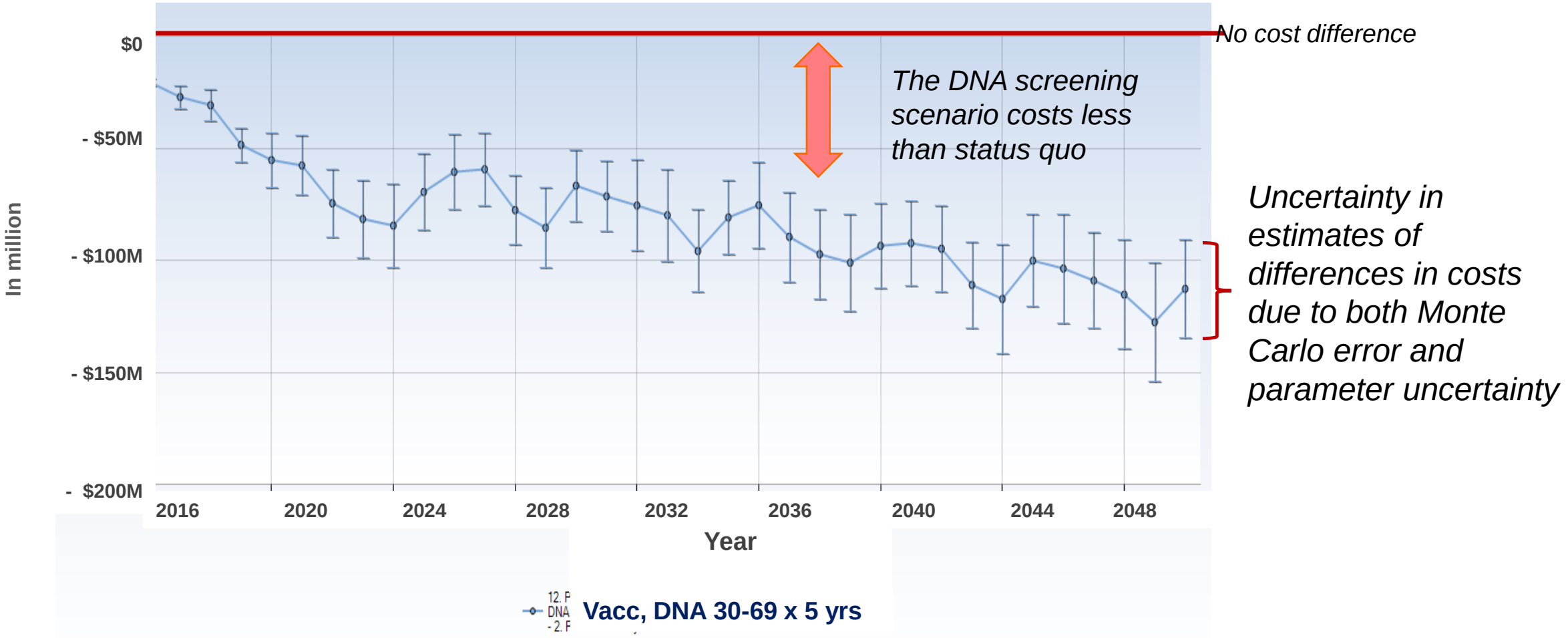
| Scenario | Screening | |
|---|---|---|
| **No vaccine, No screen** | No screening | 1 |
| **Vaccine, No screen** | No screening | 2 |
| **No vaccine, Cytology** | Cytology, 21-69 x 3 years | 3 |
| **Vaccine + Cytology (Status quo)** | Cytology, 21-69 x 3 years | 4 |
| **Vaccine + HPV DNA screening** | • Cytology, 21-29 x 3 years<br>• **HPV DNA**, 30-69 x 5 years | 5 |
| | **HPV DNA**, 30-69 x 5 years | 6 |
| **Vaccine + Tailored programs** | • Cytology, 21-69 x 3 years **for unvaccinated**<br>• No screening **for vaccinated** | 7 |
| | • Cytology, 21-69 x 3 years **for unvaccinated**<br>• HPV DNA, 30-69 x 5 years **for vaccinated** | 8 |

**Key assumptions:**
Vaccine start year = 2008
Alternative screening strategies start year = 2015

Vaccinate 12-year girls annually, 70% vaccination rate, perfect vaccine efficacy, quadrivalent vaccine

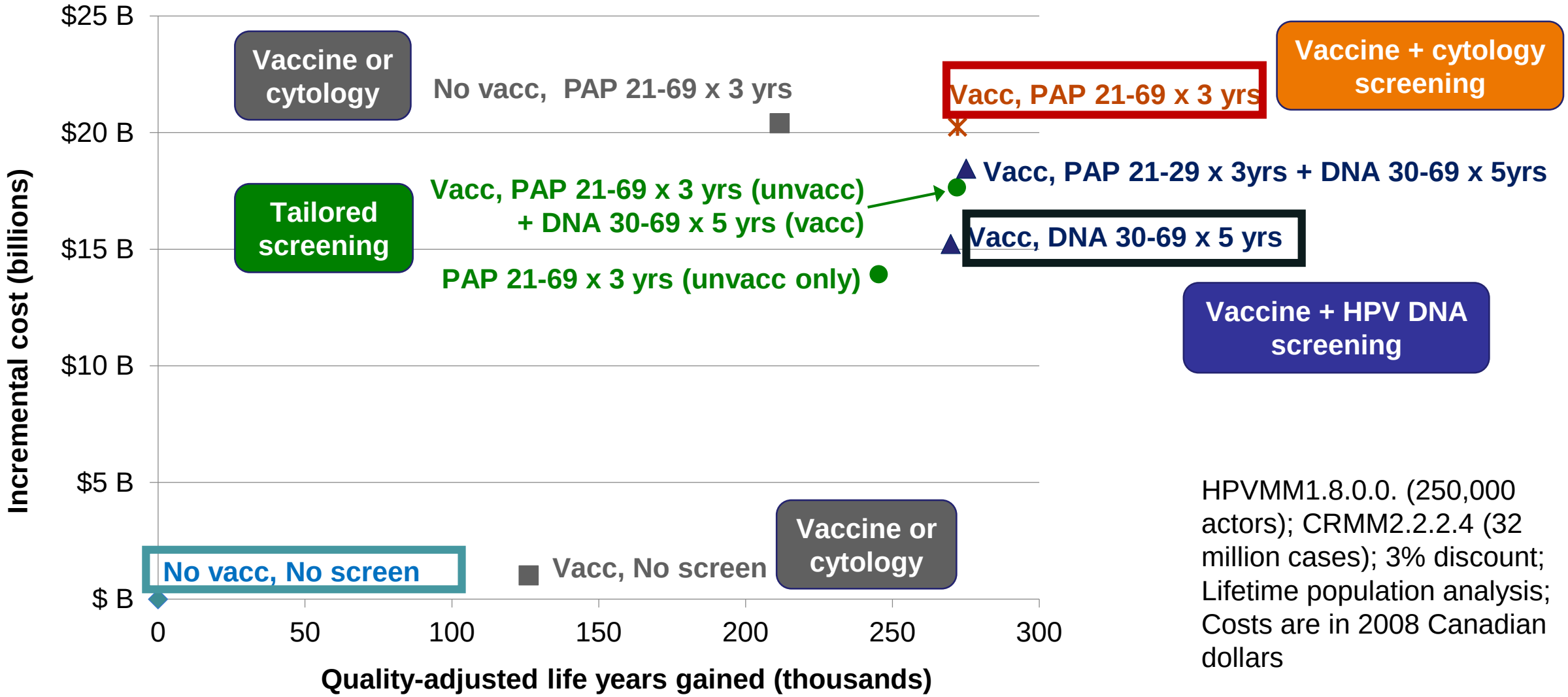
# Incorporating Uncertainty

## Difference in total costs from status quo (include costs of vaccine, screening and treatment)




HPVMM1.8.0.0. (250,000 actors); CRMM2.2.2.4 (32 million cases); Costs are in 2008 Canadian dollars undiscounted; **Results are demonstration only - Not for citation**

# Cost-effectiveness




HPVMM1.8.0.0. (250,000 actors); CRMM2.2.2.4 (32 million cases); 3% discount; Lifetime population analysis; Costs are in 2008 Canadian dollars

**Results are demonstration only - Not for citation**

# How the model has been used

- **National screening networks support**
  - Cervical, Colorectal, Lung and Breast screening networks
- **Canadian Task Force on Preventive Health Care Guidelines:**

Colorectal cancer screening (March 2016)


CME GUIDELINES CMAJ

Recommendations on screening for colorectal cancer in primary care

Canadian Task Force on Preventive Health Care*

*CMAJ* Podcasts: author interview at https://soundcloud.com/cmajpodcasts/151125-guide

**Competing interests:** None declared.

This article has been peer

Colorectal cancer is the second most common cause of cancer-related death in men and the third most common in

rently, all Canadian programs recommend screening with guaiac fecal occult blood testing (gFOBT) or fecal immunochemical testing (FIT).

Lung cancer screening (April 2016)


CMAJ GUIDELINES CME

Recommendations on screening for lung cancer

Canadian Task Force on Preventive Health Care*

*CMAJ* Podcasts: author interview at https://soundcloud.com/cmajpodcasts/151421-guide

Lung cancer is the most common cause of cancer-related deaths and the most commonly diagnosed cancer among Canadians — an estimated 26 600 Canadians were diag-

radiography.[6] Ongoing trials of screening with low-dose CT[7–10] are expected to provide more evidence on the effectiveness of screening for lung cancer with low-dose CT. The current recommendations

**Competing interests:** None declared.

This article has been peer reviewed.

*Model evaluation available at: [www.canadiantaskforce.ca/ctfphc-guidelines](www.canadiantaskforce.ca/ctfphc-guidelines)*

# How the model has been used

- **Canadian Cancer Society, Canadian Cancer Statistics** (www.cancer.ca/statistics)
  - Projections of lung, colorectal and cervical cancer screening impact using OncoSim (2015)
  - Analysis of impacts of HPV vaccination and alternate screening methods on cervical cancer (2016)
- **Canadian Partnership Against Cancer Systems Performance Reports:**
  - Special appropriateness report – impact of inappropriate surgery in stage IV breast and colorectal cancer
- **Canadian Partnership Against Cancer, cervical screening in Canada**
  - Special feature on cervical cancer screening in young women
- **Alberta STE* Report, Institute of Health Economics**
  - Impact of low dose computed tomography for the screening of lung cancer in adults (www.health.alberta.ca)

***STE = " Social and System Demographics Analysis, Technology Effects and Effectiveness, Economic Analysis"**

# OncoSim: Methodological challenges

- Incorporating parameter uncertainty in a large-scale population health microsimulation model (vs small models, e.g. TreeAge)
  - Probabilistic Sensitivity Analysis (PSA) becoming common practice in health economics
  - need to move to super-computing / cloud CPU clusters
- Calibrations
  - calibration targets more numerous as model becomes more comprehensive
  - calibration targets not always coherent / mutually consistent
- Data requirement / gaps
  - keeping the model up-to-date as new data emerge
  - lack of nationally representative data (e.g., treatment practice, cancer staging – recall that Canadian health care largely in provincial jurisdiction)

# OncoSim: Strengths

- **OncoSim is a powerful, accessible and user-friendly tool**
  - allows policy makers and researchers to run complex simulation models straightforwardly via the internet platform / user interface
- **OncoSim can:**
  - compare a wide variety of interventions
  - assess various clinical and economic outcomes and trade-offs
- **Models are calibrated, reflecting current and past socio-demographic and clinical behaviours of the Canadian population**
  - allowing the assessment of resource use and budgetary impact at the national and regional level

# OncoSim: Policy Challenges

- General Policy Context
  - pervasive inability for the “system” to dis-invest in useless or ineffective interventions
  - lack of trust in “black box” methods
  - lack of “receptor capacity” (n.b. economics, cancer better than most; but clinical leaders often “quantitatively challenged”)
  - vested interests resistant to challenges to their prerogatives
- Credibility / Scepticism on Modeling
  - difficulties getting simulation model results published in leading academic journals
  - quantitative results “not real world data”
  - not based on “gold-standard” evidence, i.e. RCT
- Timeliness / Relevance / Model Flexibility
  - need to anticipate relevant policy questions / react to changing policy priorities
  - early planning for knowledge translation and mobilization – key for policy impacts
  - ability to incorporate emerging policy questions into model functionality (e.g. new evidence on risk factors, new screening scenarios, diffusion of new treatments)