

Cancer Risk Management: Providing the  
decision support methods necessary to  
manage the risk cancer poses to  
Canadians

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# Cancer Risk Management Model

CPAC issued RFP September 29, 2008:

“Design and develop an electronic cancer risk management decision-support platform for use by cancer system leaders and policy makers”

# Cancer Risk Management Model

## Purpose of the Model:

- forecast the future burden of cancer and its macroeconomic impacts
- simulate current and future cancer control interventions on both the population and the economy
- inform policy makers concerning future investments in cancer control

# Cancer Risk Management Model

## The Challenge for contractors:

- Construct a model that reasonably reflects current medical practice in Canada for two common cancers (lung, colorectal), including information on costs of care, health utilities, economic impacts
- Put the model into the hands of analysts (web-enabled, easy to use) to enable decision-makers to estimate the impact of new programs (screening) and treatment interventions on key outcomes over time
- Do it according to a tight timeframe

# Statistics Canada Microsimulation Approach

- Builds on POpulation HEalth Model (POHEM) experience at Statistics Canada
- Simulates individual persons (patients)
- Adds-up a representative sample of individuals to create aggregate results for the whole population
- Can report results by province, age, sex, and a range of personal characteristics
- Results include projected disease burden and economic impacts
- Includes competing risk of illness and death from all causes

# Cancer Risk Management Model

Development requires:

- Clinical information - Cancer specific stage distribution, “standard” care paths, microdata on diagnostic and treatment interventions, outcomes, health utilities by disease and treatment stage
- Economic information -- cost of interventions, impact on tax revenues
- Modeling expertise
- Expertise in development of web-enabled platform

# Cancer Risk Management Team

## Project Leadership

- Dr Michael Wolfson (PI)
- Dr Bill Evans (PI)

## Clinical Oncology Expertise

- Dr Craig Earle
- Dr John Goffin

## Health Economics Expertise

- Dr Jeffrey Hoch
- Dr Nicole Mittmann

## Microsimulation Expertise

- Jillian Oderkirk
- Steve Gribble
- William Flanagan
- Chantal Hicks
- Philippe Finès
- Walter Omariba

## Web-enabling Expertise

- Beyond 20/20
- NeoInsight

## CPAC

- Lee Fairclough
- Anthony Miller
- Janey Shin
- Gina Lockwood

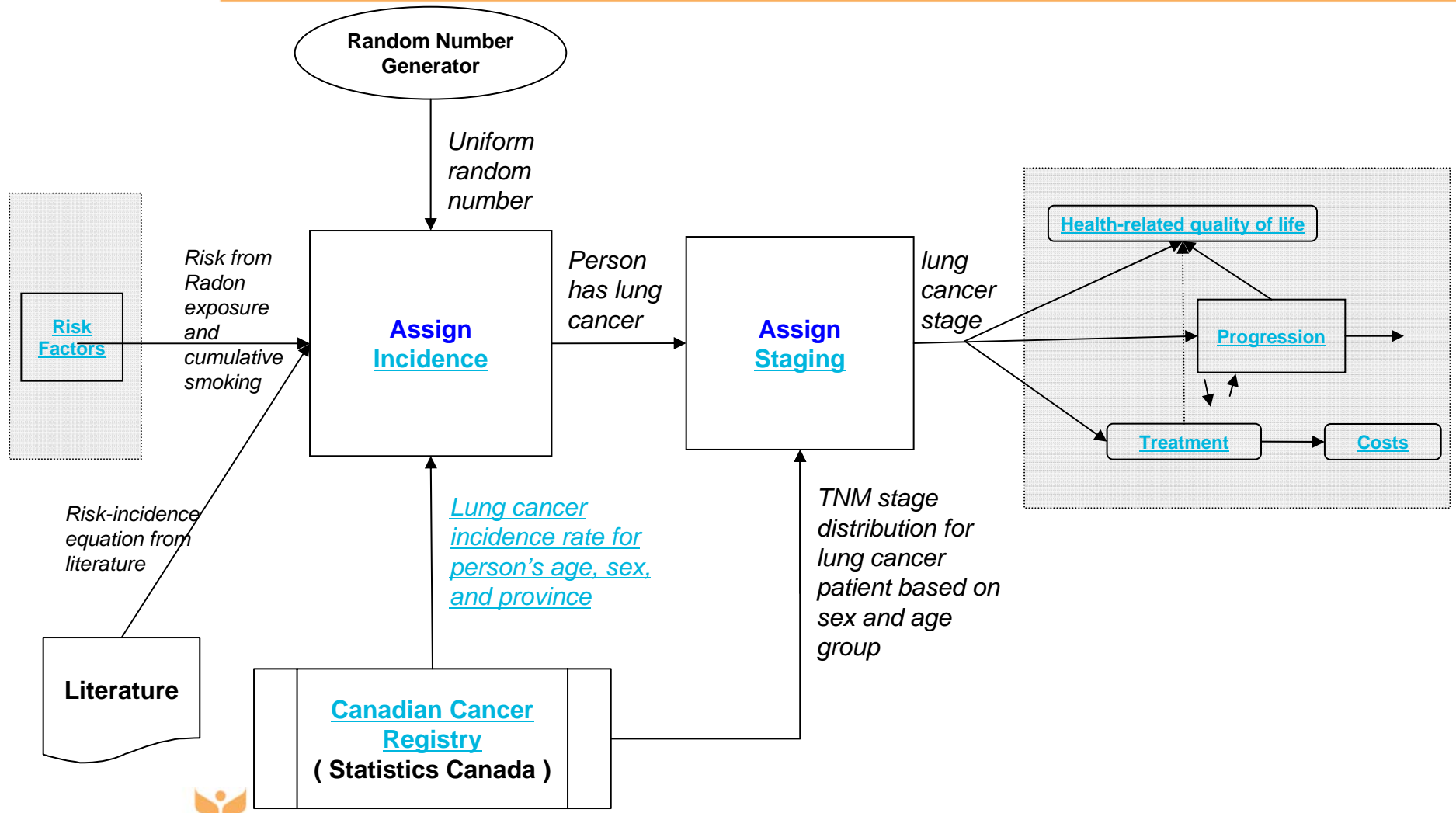
# CPAC Cancer Risk Management Advisory Committee

Member	Title	Organization
Jean-Marie Berthelot	VP, Programs	Canadian Institute for Health Information
Jacques Brisson	Researcher, Centre de Recherche, Hôpital du Saint-Sacrement	Laval University
Adalsteinn Brown	Assistant Deputy Minister, Health System Strategy Division	Ontario Ministry of Health & Long Term Care
Andy Coldman	Provincial Leader, Population & Preventive Oncology	BC Cancer Agency
Steven Heitman	Gastroenterologist & Researcher	Calgary Health Region
Anthony Fields	Executive Lead, VP of Medical Affairs & Community Oncology	Alberta Cancer Board
Eva Grunfeld	Director, Cancer Outcomes Research	Cancer Care Nova Scotia
Jon Kerner	Chair, Primary Prevention Action Group	CPAC
Anthony Miller	Professor Emeritus Consultant, Division of Cancer Prevention	U of T NCI
Steven Ottaway	Head, Healthcare Investment Banking	GMP Securities
Stuart Peacock	Director, Health Economics & Cancer Research Program	UBC
Arlene Wilgosh	Deputy Minister of Health	Manitoba Health
Timo Hakulinen	Director	Finnish Cancer Registry
John McLaughlin	Vice-President, Population Studies and Surveillance	Cancer Care Ontario

# CPAC Cancer Risk Management Technical Committee

Member	Title	Organization
Andy Coldman (Chair)	Vice President, Population Oncology	BC Cancer Agency
Jean-Marie Berthelot	VP, Programs	Canadian Institute for Health Information
Jacques Brisson	Researcher, Centre de Recherche, Hôpital du Saint-Sacrement	Laval University
Bernard Candas	Project Lead, Analytic Networks	CPAC
Sonya Cressman/ Stuart Peacock	Researcher, Centre for Health Economics in Cancer Control/ Director, Health Economics & Cancer Research Program	BC Cancer Agency University of British Columbia
Timo Hakulinen	Director	Finnish Cancer Registry
Juanita Hatcher	Director, Surveillance	Alberta Health Services
Eric Holowaty	Director, Cancer Surveillance Unit	Cancer Care Ontario
Gina Lockwood	Senior Biostatistician	CPAC
Anthony Miller	Professor Emeritus Consultant, Division of Cancer Prevention	University of Toronto U.S. National Cancer Institute
Graham Woodward	Director, Provincial Planning	Cancer Care Ontario

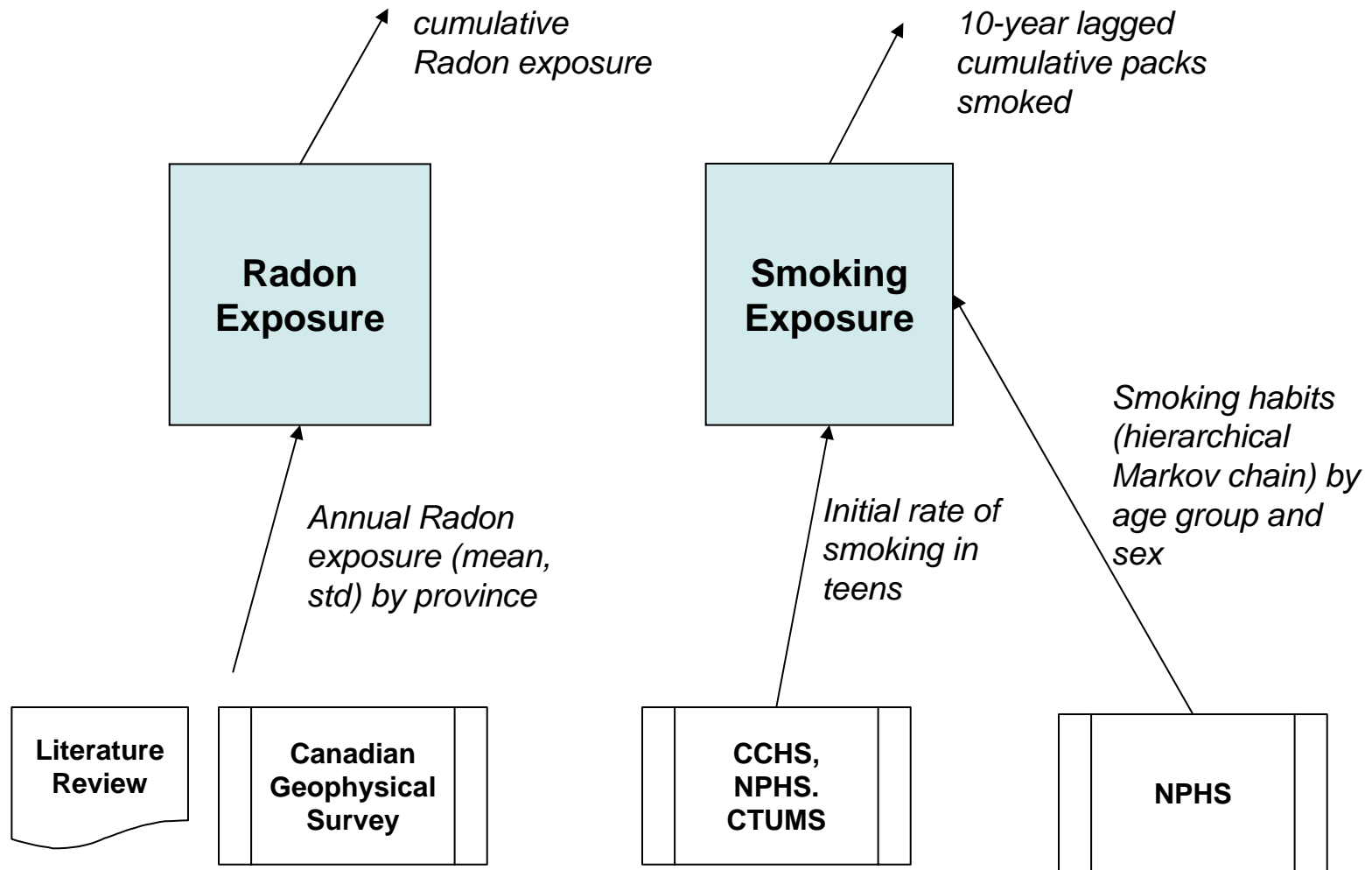
# Incidence and Staging



# Main Data Sources

SOURCE	DATA TYPE
Canadian Cancer Registry	Incidence, Staging, Survival
Canadian Community Health Survey, National Population Health Survey	Smoking rates, Population health utilities
Expert Opinion	Current treatment practice
Canadian Geophysical Survey	Radon Exposure
Literature	Lung cancer risk equation, Screening parameters, Radon mitigation options
Population Health Impact of Disease in Canada study	Health-related quality of life associated with living with cancers
Vital Statistics, Census	Mortality, Birth, Population projections
Census, T1-Family File, SPSP/M	Earnings, Transfers and Taxes
OCCI, OHIP	Physician fees, lab, diagnostic imaging
Hamilton Health Sciences	Chemotherapy delivery
CCACs	End of life care; end of life studies Western Canada

# Risk Factors For Lung Cancer

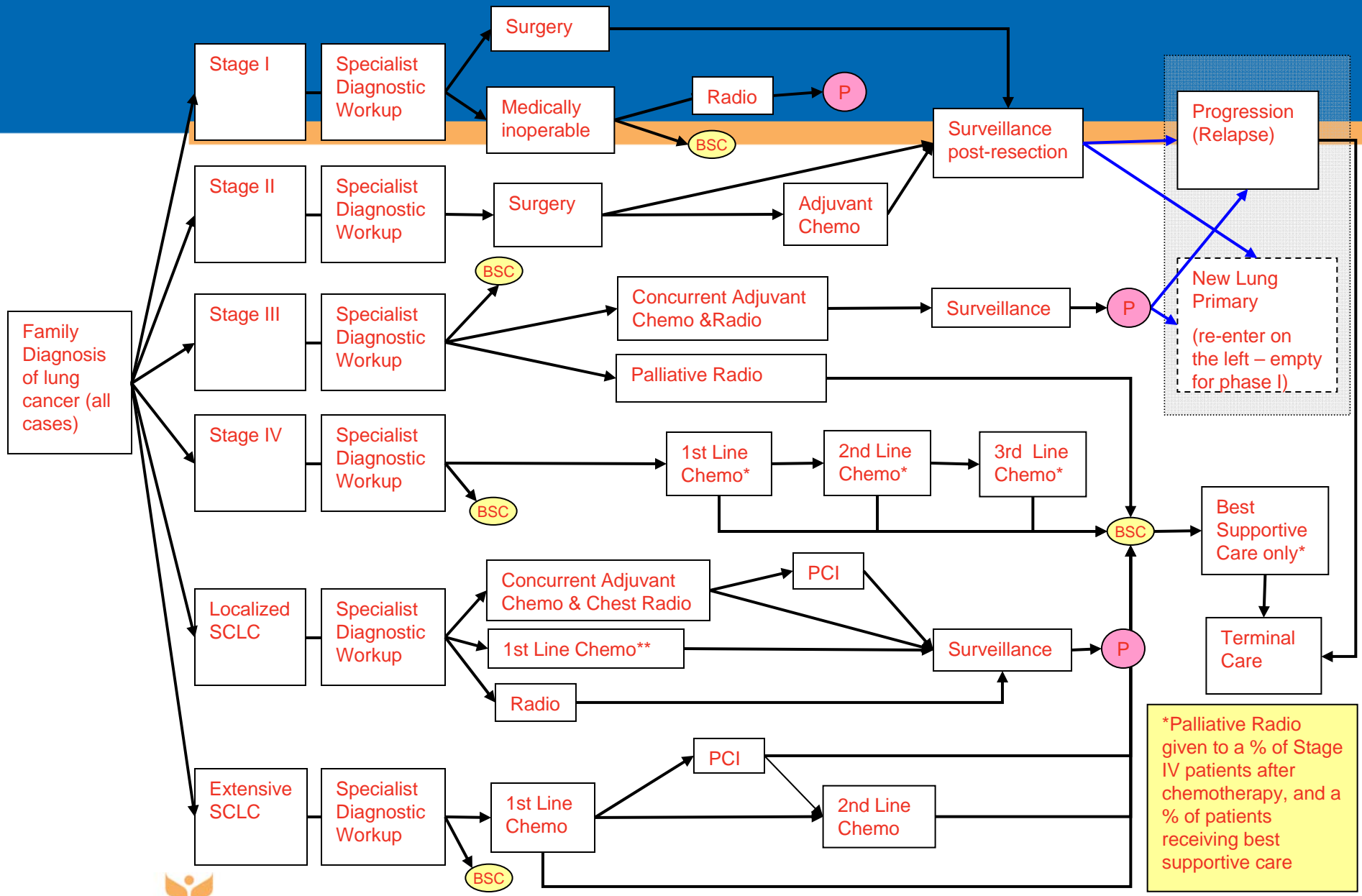


# Cancer Incidence

## Determination of lung cancer diagnosis at current age

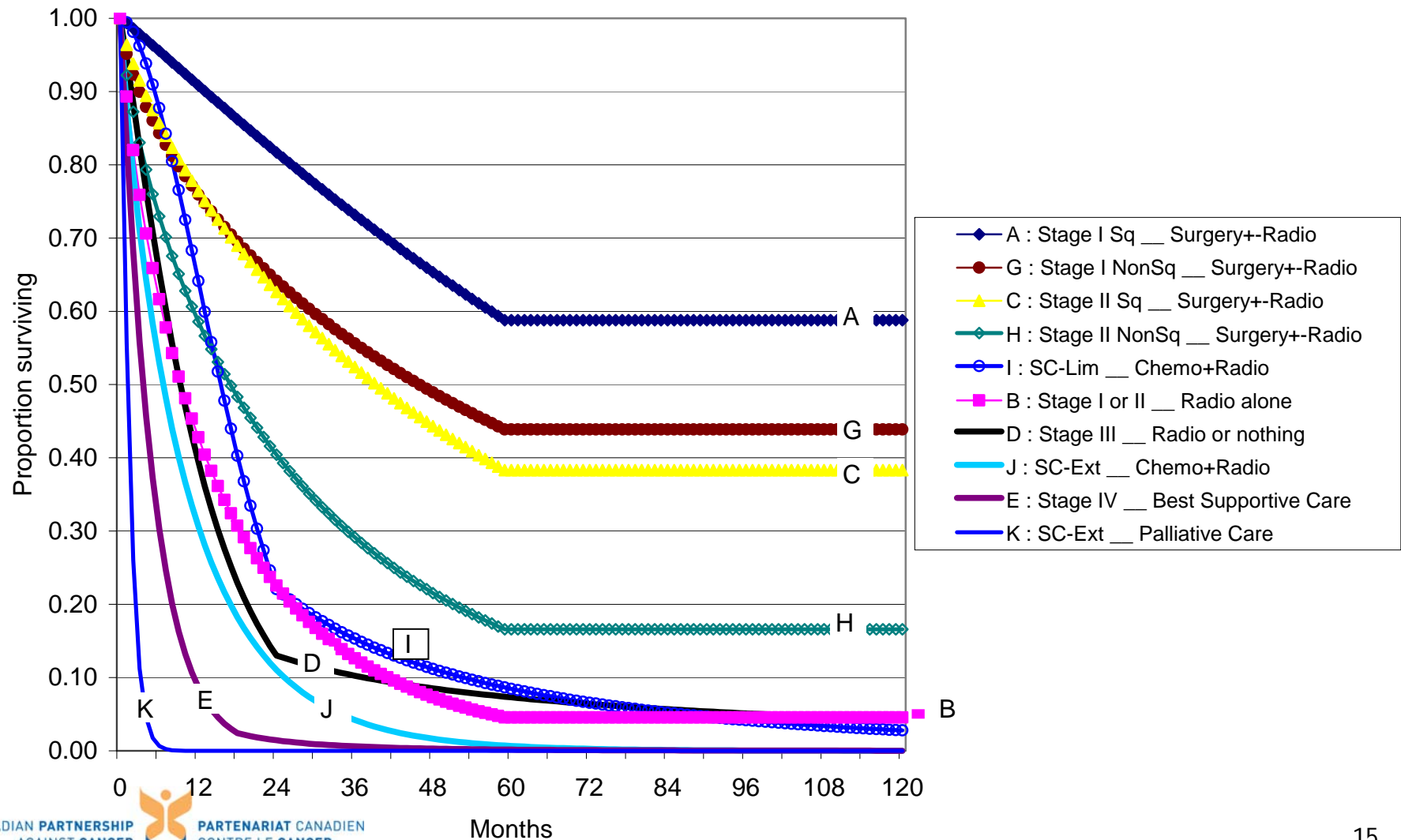


# Lung Cancer Management



# POHEM survival curves for lung cancer

Lung Survival to Death by Stage at Diagnosis (all-cause survival)



# Health-related quality of life associated with Cancer Treatment and Progression

Phase	Cancer Health State	Preference Score
At diagnosis	Very good prognosis	0.891
	Fairly good prognosis	0.853
	Poor prognosis	0.809
	Metastatic disease	0.439
	Acute lymphoblastic leukemia	0.732
	Chronic lymphocytic leukemia	0.940
Treatment	Surgery in-patient	0.732
	Surgery out-patient	0.853
	Radiotherapy curative	0.781
	Radiotherapy palliative	0.507
	Chemotherapy mild toxicity	0.750
	Chemotherapy moderate toxicity	0.742
	Chemotherapy severe toxicity	0.706
	Hormonal therapy	0.896
	Bone marrow transplantation	0.864
Remission	After surgery	0.894
	After radiotherapy	0.891
	After chemotherapy	0.926
	After hormonal therapy	0.912
End of life	Palliative Care	0.484
	Terminal Care	0.179

## Generalized approach from Population Health Impact Study (PHI)

[General Population Health Scores \(PHI\)](#)

[Lung cancer preference scores \(PHI\)](#)

Preference scores measure health utility. A score of 1 represents full health; 0 represents death. More information is available at the [PHI website](#).

# Generalized Treatment Template

(adapted from PHI project)

Treatment by Stage at diagnosis	Treatment Distribution				Treatment Duration (yrs)				Preference Scores			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
diagnosis surgery in-patient surgery out-patient chemo mild toxicity chemo moderate toxicity chemo severe toxicity radio curative radio palliative remission after surgery alone remission after chemo alone remission after radio alone remission after surgery + chemo remission after surgery + radio remission after chemo + radio remission after surgery + chemo + radio no treatment palliative terminal	The % distribution from <a href="#">Lung Cancer Management</a> algorithm will be mapped into these generic treatment groups, which represent cancer-related health states  (columns to be added for local and distant recurrence)				<div style="border: 1px solid black; border-radius: 10px; padding: 5px; text-align: center; width: fit-content; margin: 0 auto;"> <a href="#">Lung Cancer Data from PHI</a> </div>							

# PHI Treatment Algorithm for Lung Cancer

Lung cancer	Treatment Distribution			Treatment Duration (yrs)			Preference Scores		
Treatment by Stage at diagnosis	local	regional	distant	local	regional	distant	local	regional	distant
diagnosis	100%	100%	100%	0.100	0.100	0.100	0.809	0.809	0.439
surgery in-patient	65%	16%	0%	0.077	0.077		0.592	0.592	0.321
surgery out-patient	0%	0%	0%				0.690	0.690	0.374
chemo mild toxicity	0%	0%	0%				0.607	0.607	0.329
chemo moderate toxicity	8%	56%	49%	0.250	0.250	0.250	0.601	0.601	0.326
chemo severe toxicity	0%	0%	0%				0.571	0.571	0.310
radio curative	23%	59%	0%	0.096	0.096		0.632	0.632	
radio palliative	0%	0%	47%			0.058			0.222
remission after surgery alone	58%	7%	0%	Duration of remission subject to survival curves			0.894	0.894	0.894
remission after chemo alone	0%	14%	23%				0.926	0.926	0.926
remission after radio alone	10%	14%	21%				0.891	0.891	0.891
remission after surgery + chemo	0%	0%	0%				0.828	0.828	0.828
remission after surgery + radio	5%	3%	0%				0.797	0.797	0.797
remission after chemo + radio	6%	36%	26%				0.826	0.826	0.826
remission after surgery + chemo + radio	2%	6%	0%				0.738	0.738	0.738
no treatment	19%	20%	30%				0.809	0.809	0.439
palliative	69%	91%	99%	0.417	0.417	0.417	0.484	0.484	0.484
terminal	69%	91%	99%	0.083	0.083	0.083	0.179	0.179	0.179

Note:  
Staging does not match TNM staging planned so some re-interpretation required if we decide to use this data

### Interpretation of Distributions of treatment for localized lung cancer patients

- 65% receive surgery (58% get surgery alone, 5% get surgery and radio; 2% get surgery with chemo and radio).
- 35% do not get surgery (6% get chemo and radio; 10% get radio alone; 19% get no treatment).
- The chemo that is given (8%) is of moderate toxicity; the radio is curative (totals 23%).
- The case-fatality is 69%

# Costing: Bottom-up versus Top-down Costing Approaches

## Bottom-up

- In the "bottom-up" approach, typical treatment patterns are mapped, either from chart review (time consuming and costly) or from expert opinion or literature.
- Each of the boxes in the cancer management diagrams relate to an aspect of the treatment of the cancer, such as surgery, chemotherapy, and radiotherapy, which is costed in detail to arrive a cost per person per type of treatment.
- *Aside: In the simulation model, patients move through the treatment arms and incur the costs of the treatment (as well as any modeled survival benefits). The simulation can report these costs at different levels of aggregation, such as lifetime cost of cancer per patient, or the average cost of chemotherapy in lung cancer patients, etc.*

## Top-down

- The "top down" starts with a total aggregate cost for cancer from a source such as the Economic Burden of Illness in Canada (EBIC) published by PHAC, and estimates the share attributable to lung cancer and to colorectal cancer by taking the proportion of all incident cancer cases that are lung cancers and multiplying it by the total cost of cancers in EBIC.

## Quality Assurance

- Doing both approaches will provide a way to compare/validate and provide a plausible range.

# Lung Cancer Management

## Surgery Stage I

Treatment State	Unit Cost	Physical Unit	Total Cost
<b>Stage I Surgery and Immediate Followup</b>			<b>\$15,913</b>
PET scan	\$2,358.00		\$0
Lobectomy-physician	\$1,530.33	88%	\$1,347
Pneumonectomy-physician	\$1,657.12	12%	\$199
Lobectomy	\$13,596.00	88%	\$11,964
Pneumonectomy	\$19,549.00	12%	\$2,346
LOS for Lobectomy	7.5	88%	
LOS for Pneumonectomy	9.4	12%	
X-ray-chest (X091)	\$33.50	1.0	\$34
CBC	\$8.19	1.0	\$8
Chemistry panel	\$15.51	1.0	\$16

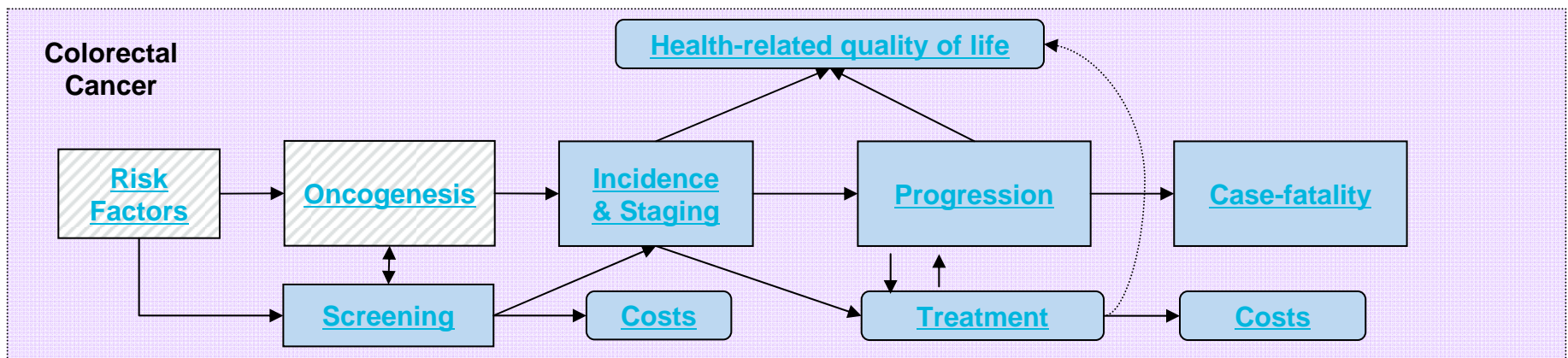
# POHEM Treatment Costs by Stage

Cost of Treatment by Stage	Diagnostic Tests	Pre-op/ Staging Tests	Surgery	Radio	Chemo	Hospital and/or Clinic	Follow-up First Year	Follow-up Subsequent Years	Relapse	Terminal care
<b>Non-Small Cell</b>										
Stage I + II										
Surgery Alone	785	596	1,364	0	0	14,312	696	363	2,381	13,541
Surgery + Post-op Radio	785	632	1,364	3,723	0	14,312	696	363	2,381	13,541
Partial Surgery + Post-op Radio	785	632	1,364	3,723	0	14,312	696	363	2,381	13,541
Radiotherapy Only	785	903	0	3,723	0	11,545	696	363	2,381	13,541
Stage IIIa										
Radiotherapy	785	867	0	3,033	0	11,545	537	739	2,381	13,541
No Radiotherapy	785	826	0	105	0	11,545	363	739	0	13,541
Stage IIIb										
Radiotherapy	785	266	0	1,552	0	11,545	363	739	2,381	13,541
No Radiotherapy	785	0	0	105	0	11,545	363	739	0	13,541
Stage IV										
Supportive Care	785	230	0	0	0	11,545	0	0	0	13,541
<b>Small Cell</b>										
Limited Disease										
Chemotherapy + Radiotherapy	785	369	0	4,379	3,557	5,773	1,215	1,013	2,379	10,015
Extensive Disease										
Chemotherapy + Radiotherapy	785	369	0	1,253	3,235	5,773	868	1,013	2,379	8,726
Palliative Care	785	271	0	0	0	5,773	476	1,013	0	11,700

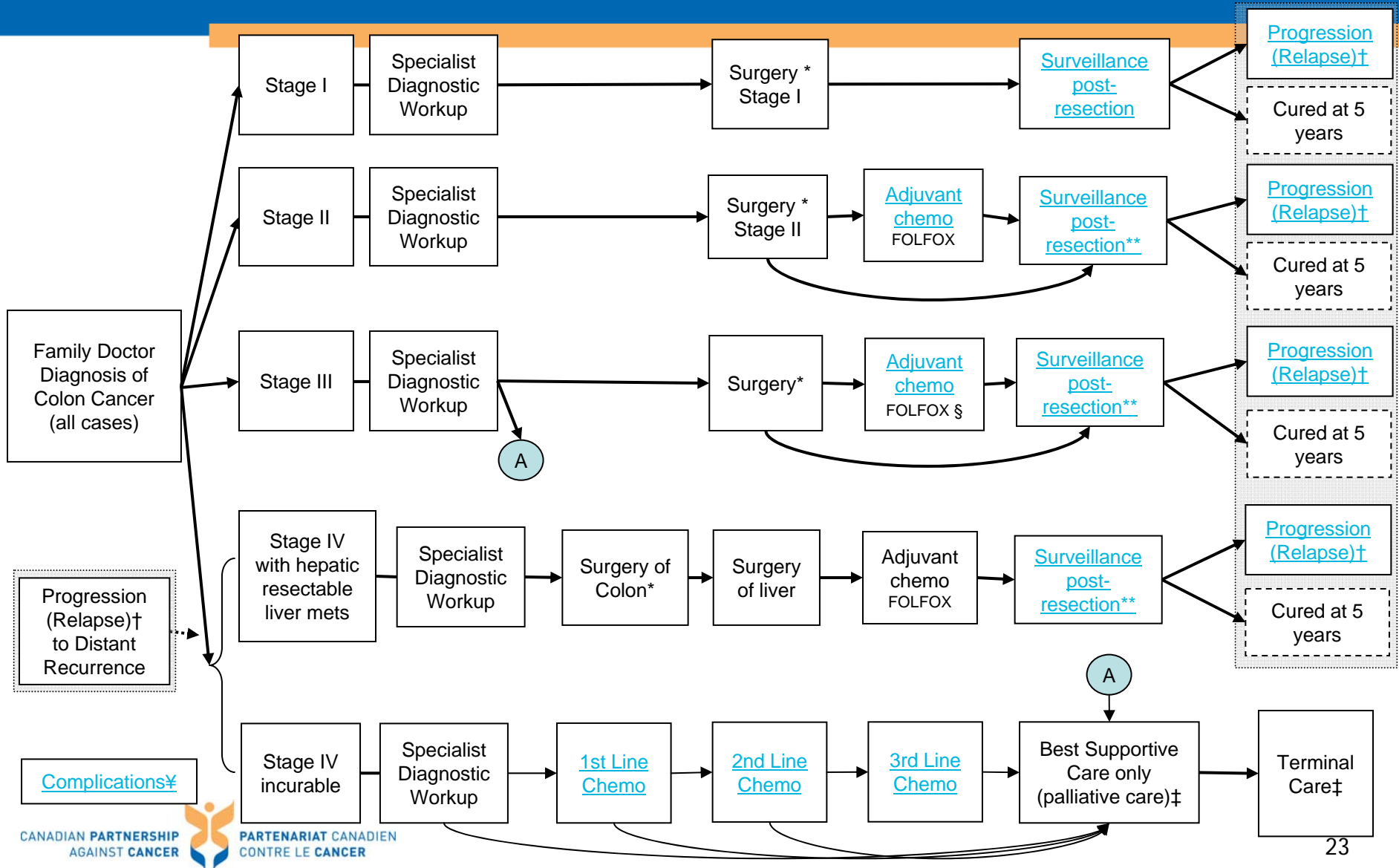
**Note:** actual costing algorithm was more detailed

**Data source:** OHIP and Ontario Case Costing Initiative \$1992 (Costs will be updated)

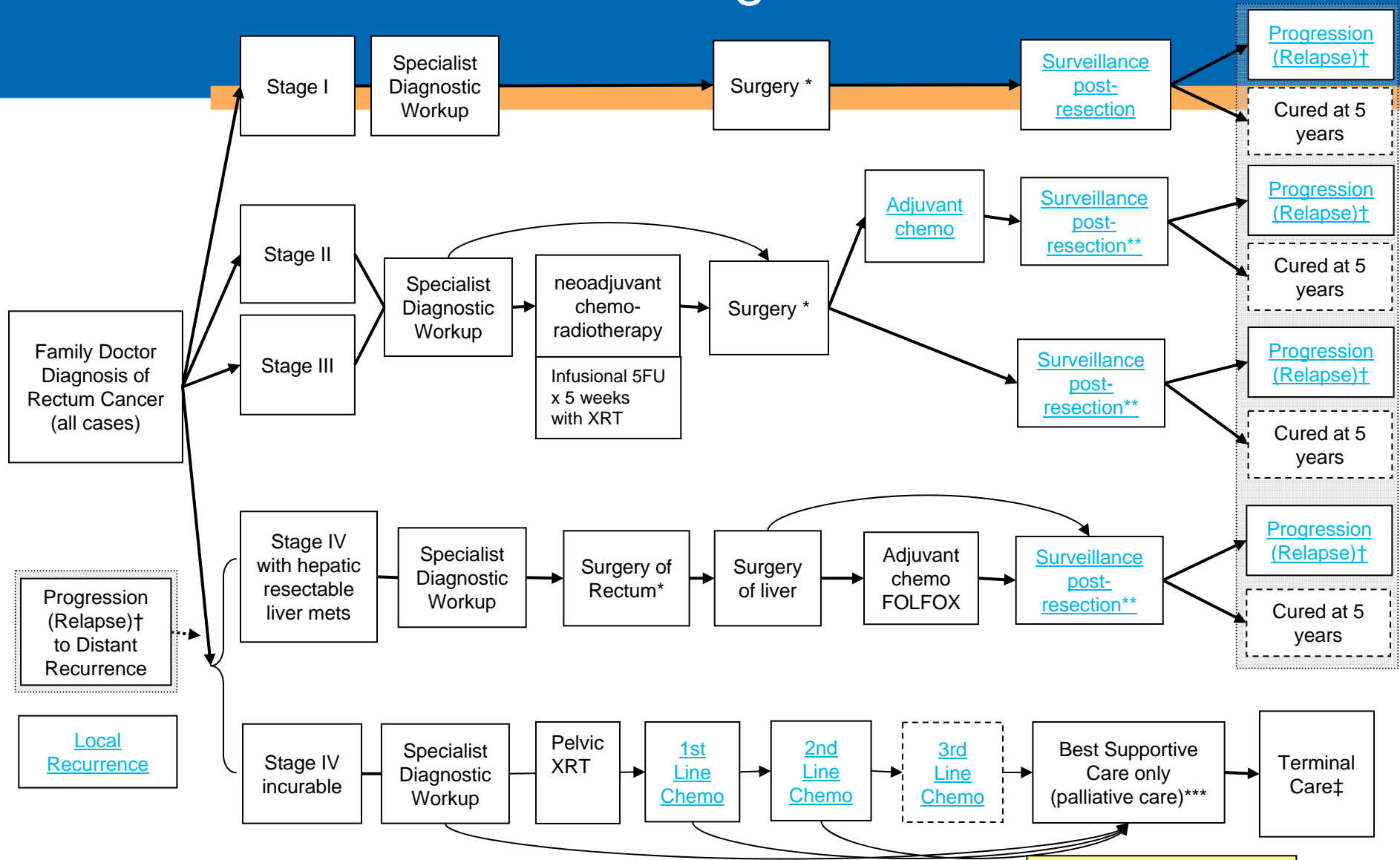
# Colorectal Cancer Person Flow Diagram



# Colon Cancer Management

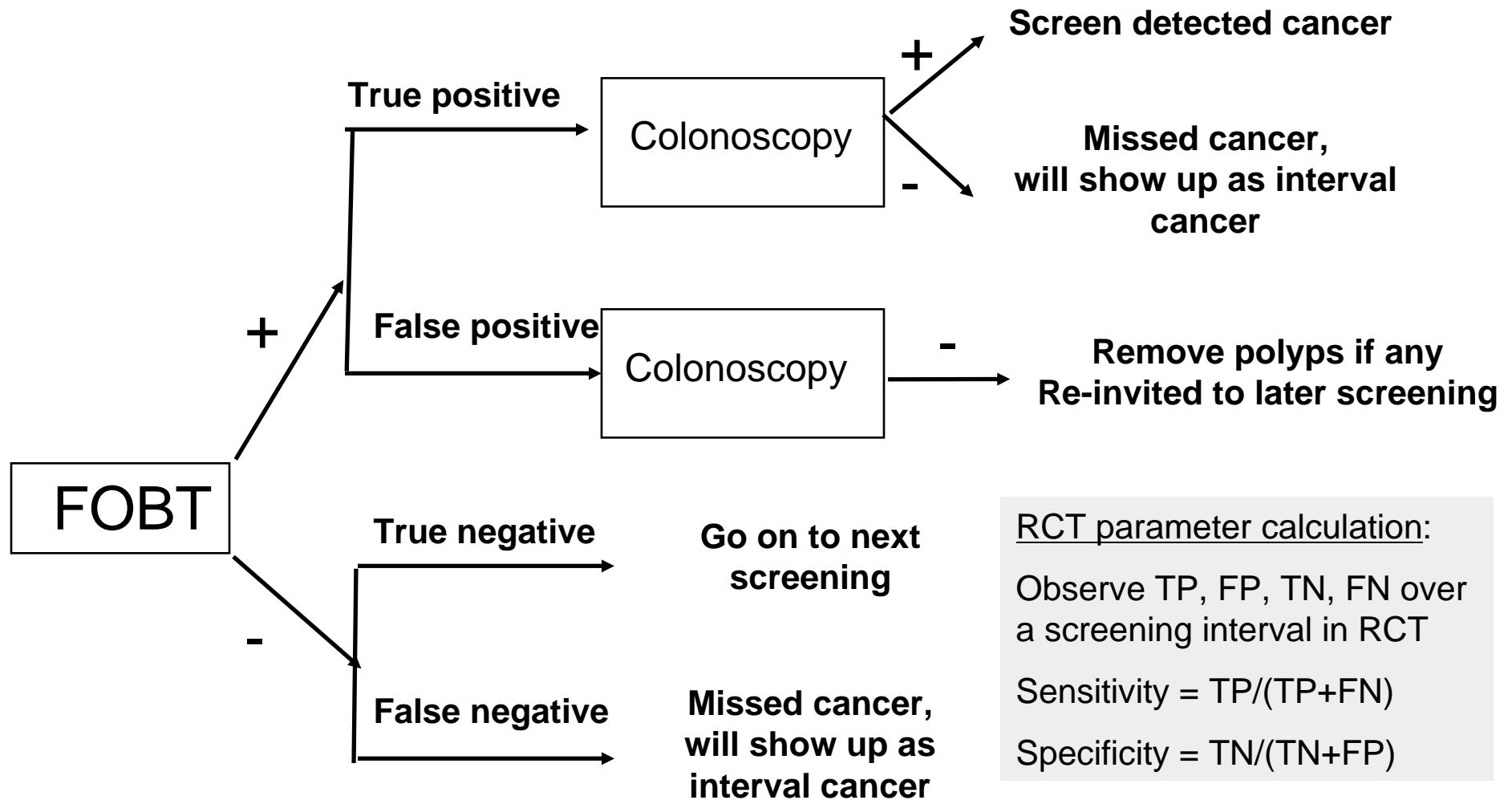


# Rectal Cancer Management



# FOBT Screening Paths

Developed with Health Canada for the National Committee on Colorectal Cancer Screening



RCT parameter calculation:

Observe TP, FP, TN, FN over a screening interval in RCT

$$\text{Sensitivity} = \text{TP}/(\text{TP}+\text{FN})$$

$$\text{Specificity} = \text{TN}/(\text{TN}+\text{FP})$$

# Colorectal Screening Costs

- Include both fixed yearly costs (overhead) and event-driven costs (e.g. cost per FOBT).
- Future year costs can be discounted in the simulation.

## FOBT Screening Costs used in POHEM

Unit Screening Costs	Estimated Cost (\$)	Alternative Cost (\$)
Head Office, Satellite & Promotion (fixed cost per year)	15,000,000	30,000,000
Extra Physician Visits	43.58	58.10
FOBT kit	4.65	9.30
Processing	6.00	8.00
Consultation (positive FOBT)	123.70	161.10
Colonoscopy	350.00	425.00
Polypectomy	147.00	147.00

# Model Validation

## Internal validation

- Ensure that inputs (e.g. relative risks, incidence rates) are consistent with known data

## Face validity

- Inspect simulated individual life trajectories for plausibility

## Data confrontation

- Ensure incidence, progression and case-fatality line up with observed mortality
- Ensure staging and survival line up with health care utilization

## External validation

- CPAC Technical Committee

# Cancer Risk Management – Outputs

## Disease burden impacts:

- Project age-specific prevalence and mortality from lung and colorectal cancers as well as health-related quality of life of living with these cancers (taking into account competing risks of other diseases)
- Change in life expectancy and health-adjusted life expectancy attributable to these diseases and to alternative cancer control interventions
- Report by province, age group, sex and income quintile
- Extensible to other cancers and risk factors in subsequent work

# Cancer Risk Management – Outputs

## Economic Impacts:

- Health care expenditures related to:
  - Diagnosis, treatment, on-going care/surveillance, palliative/terminal care
  - Population-based screening
  - Assumed costs of smoking and radon interventions
- Lost and reduced earnings, consequential changes in taxes and transfers due to premature mortality and reduced functioning while living with cancer
  - Individual by individual
  - Aggregate by province, age group, sex, income quintile
- Extensible to other economic factors (later phase)
  - Lost wages of caregivers
  - Impact on corporations and corporate taxes
  - Costs of government disability programs and medical tax credits

# Documentation

## Conceptual Model

Hyperlinked PowerPoint

Research Questions

hyperlinked →

Data  
Excel Workbooks

Data Dictionary

## Microsimulation

## Cancer Risk Management

Browse

Pilot

Blackbox

Glassbox

Excel Workbooks

Biobrowser  
view individual life paths

# Cancer Risk Management will be used by different types of users

MODE	DESCRIPTION	INTENDED AUDIENCE/USERS
<i>Browse</i>	General user can explore carefully structured baseline scenarios, obtain rapid results on range of projected impacts	Senior health system leaders, planners, policy analysts
<i>Pilot</i>	General users can specify new scenarios using a carefully selected (subset of) parameters, generate new, real-time results	Planners, policy analysts
<i>Black Box</i>	Advanced users can access full range of model and scenario parameters, can generate large-scale simulations (not real time)	Epidemiologists, statisticians, more technical policy analysts
<i>Glass Box</i>	All functionality of Black Box, plus users have option to change/add new modules by accessing open source code and modifying the model	Epidemiologists, statisticians, computer literate users

# Some Key Research Questions

- What is the likely incidence by stage of colorectal and lung cancer over the next 20 years, given current health behaviours and screening and treatment practices?
- How would changes in screening policy affect the number of colorectal cancer treatments by year and by province?
- How would changes in smoking rates affect the number of lung cancer treatments and their costs by year and by province?
- How would the introduction of a new drug or therapy impact on clinical outcomes and costs?
- How cost-effective is the new treatment intervention?
- What would be the likely effect of any of these changes on disease progression, life expectancy and years lived in health?
- What would be the impact on employment rates and on aggregate wages in the economy?
- How would these changes affect governments' expenditures and revenues?

# Cancer Risk Management – Looking Ahead

- Phase 1 rollout of lung and colorectal cancer models planned for fall 2009
- Phase 2 plans include work that will focus on:
  - evaluating impact in other relevant areas in prevention, screening, and treatment
  - other cancer sites