BIG DATA in Health Sciences

Innovations for health care, medical product development and regulatory science

Stochastic Process for Disease Screening and Surveillance

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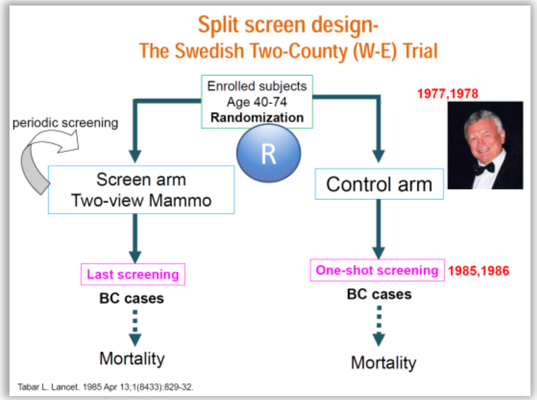
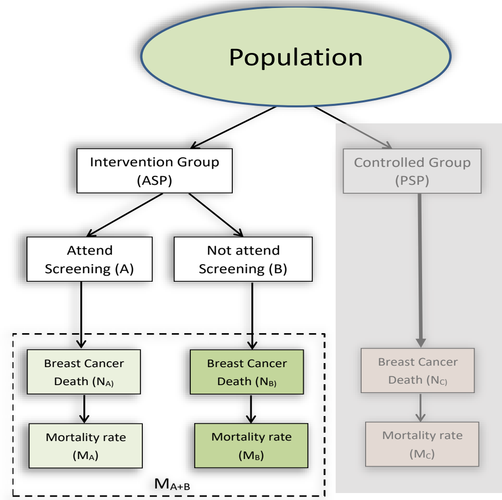
Outline

- Stochastic Process and Health Economic Decision Making Model
- Personalized Prevention Model with Stochastc Process -An Example of Breast Cancer
- Several New Applications with Stochastic Process
- Emerging Issues of Disease Screening and Surveillance

Evolution of Breast Cancer Prevention





Before screen era
- 1977

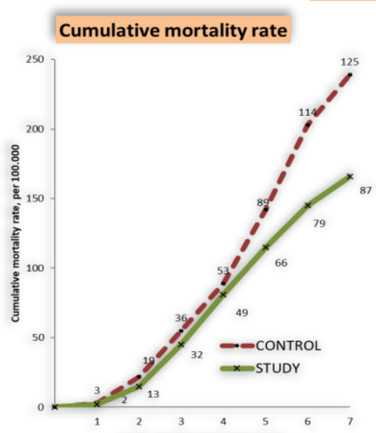
Trial period
1977-1988

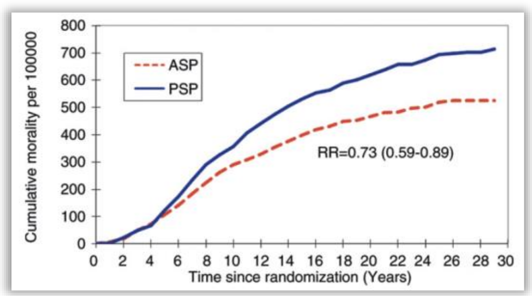
Service screening programme
1988 -

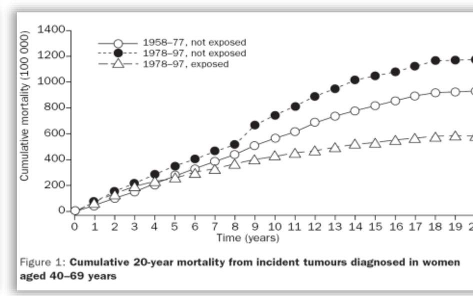
Assessment

Evidence-based
Health Policy Making

Assurance







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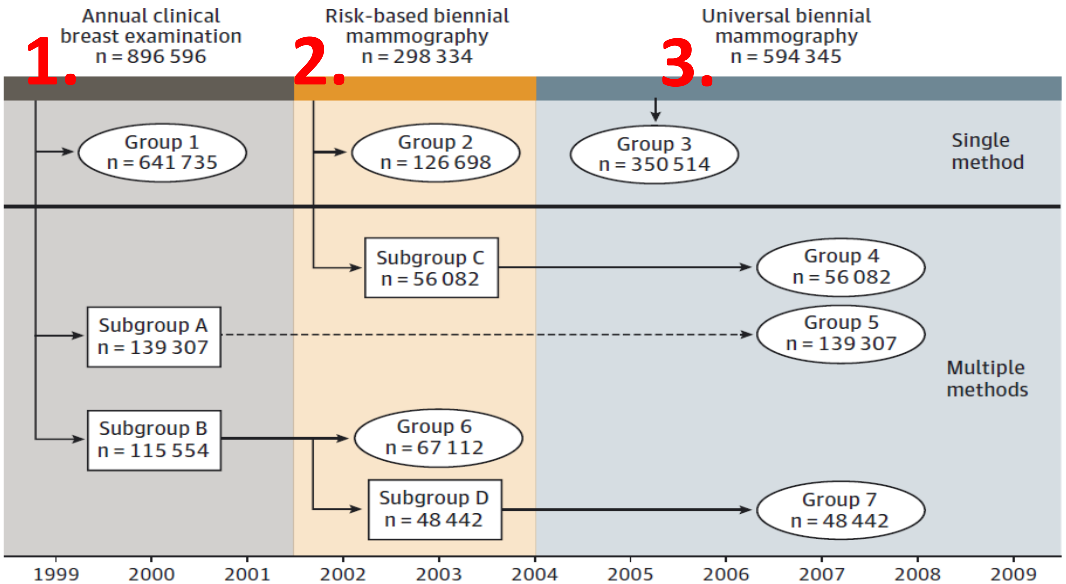
Original Investigation

Population-Based Breast Cancer Screening With Risk-Based and Universal Mammography Screening Compared With Clinical Breast Examination

A Propensity Score Analysis of 1 429 890 Taiwanese Women

Figure. The 3 Taiwanese Breast Cancer Mass Screening Programs in Chronological Order from 1999 Through 2009



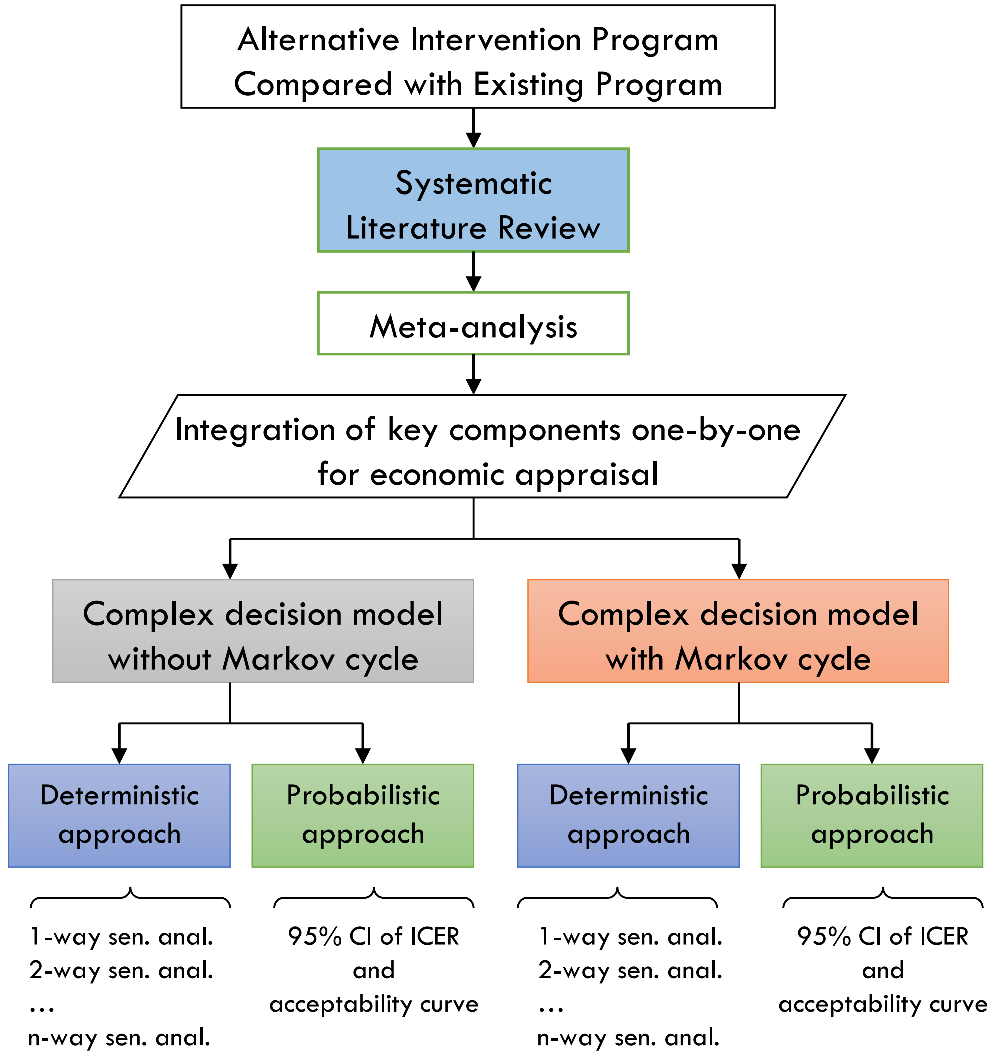
- ✓ Mortality reduction:

  41% (RR=0.59, 0.48-0.73)

- ✓ Advanced breast cancer reduction:

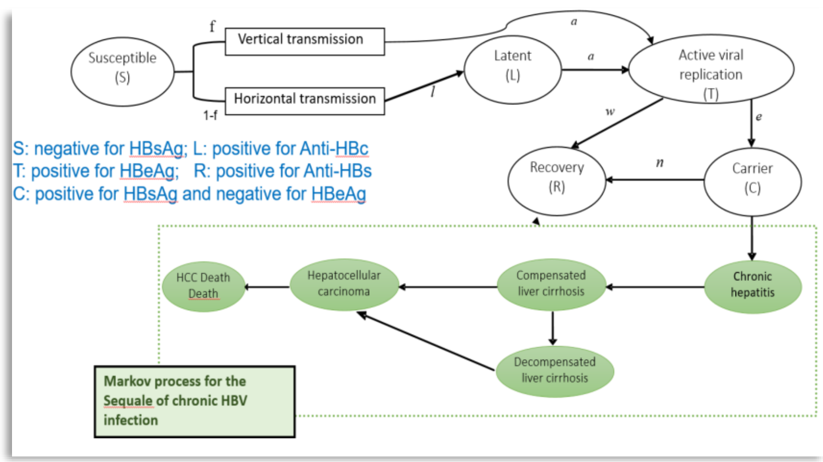
  30%(RR=0.70, 0.66-0.74)

Big Data Analysis for Health Decision-Making



Stochastic model for hepatitis B virus infection through maternal (vertical) and environmental (horizontal) transmission with applications to basic reproductive number estimation and economic appraisal of preventive strategies

- HBV disease progression is essential for
  - elucidating the spread of HBV among population (dynamic of HBV infection)
  - assessing the efficacy of interventions
  - economical appraisal of population-based preventive strategies.
- HBV transmission:
  - Vertical: maternal route
  - Horizontal: environmental route
- HCC progression natural history



Hui-Fang Hung · Ya-Chuan Wang ·
Amy Ming-Fang Yen · Hsiu-Hsi Chen

Stoch Environ Res Risk Assess (2014) 28:611–625
DOI 10.1007/s00477-013-0776-0

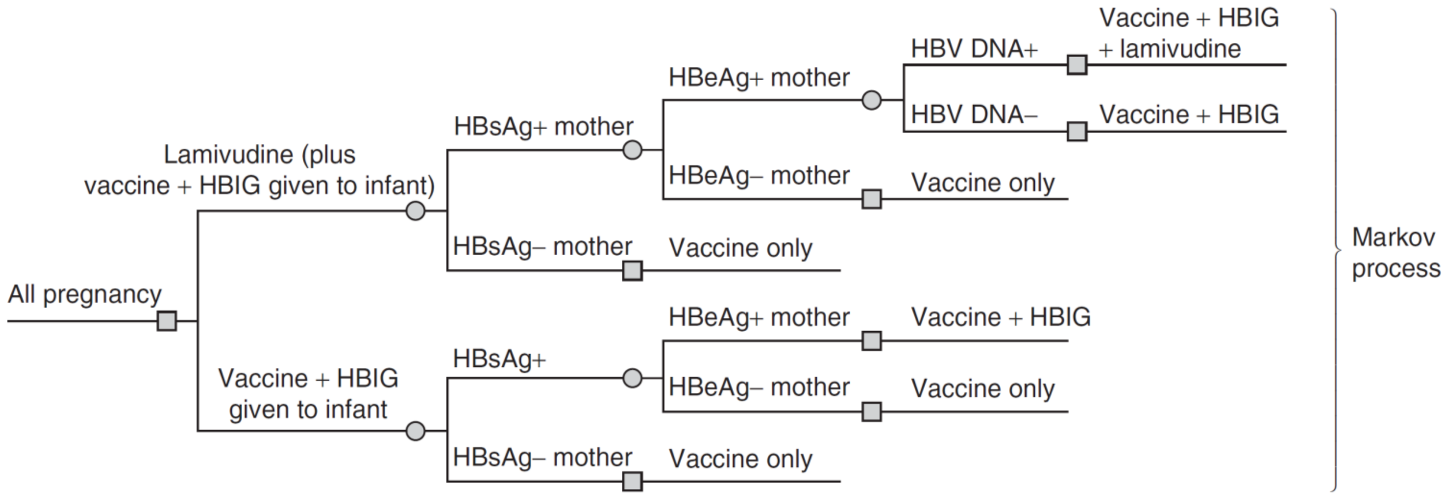
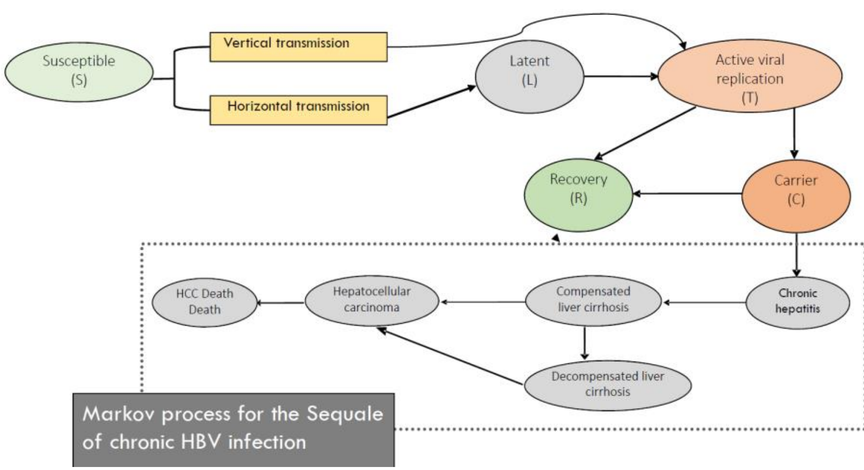
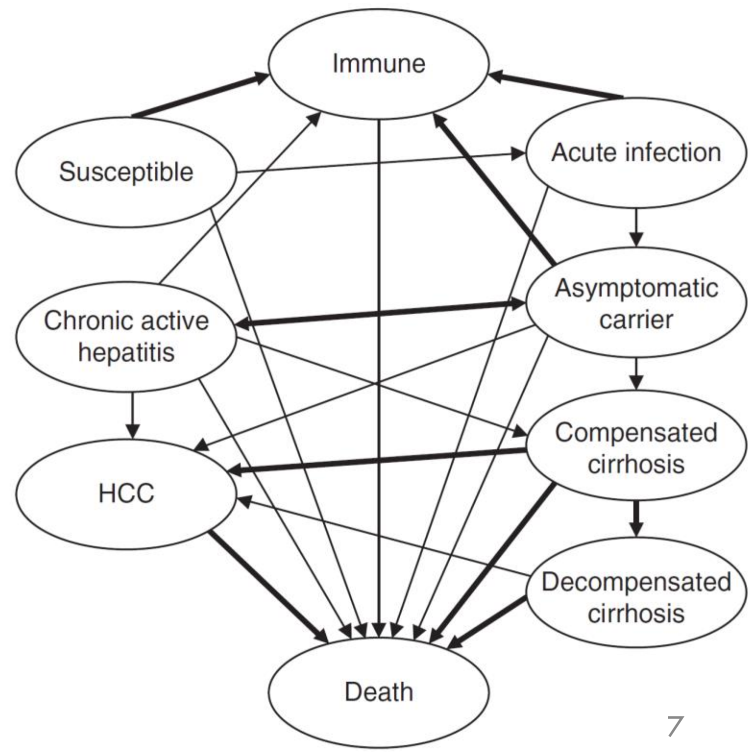
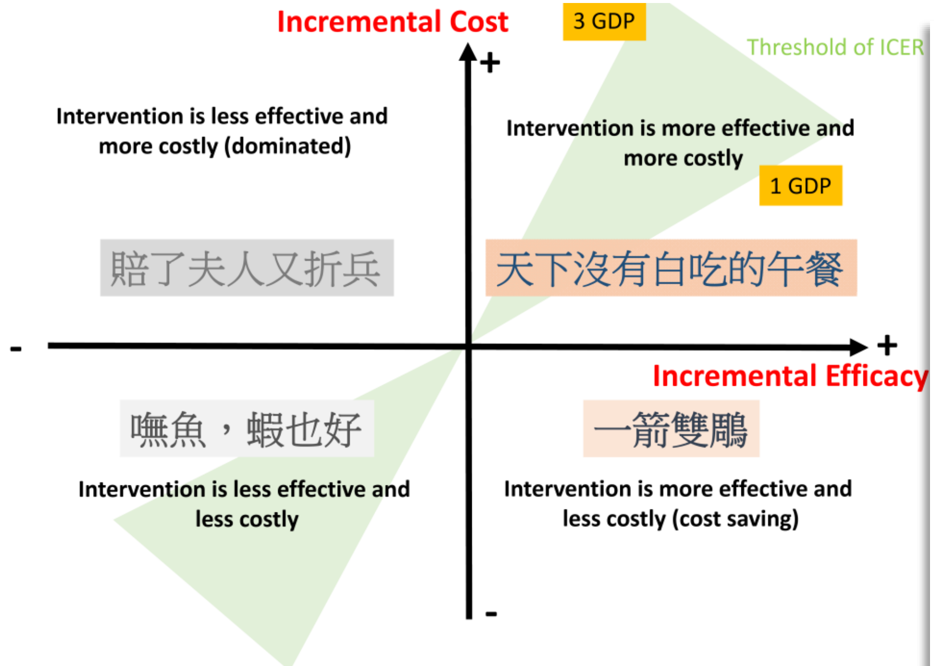


Fig. 1. Decision strategies used in the cost-effectiveness analysis of supplemental prophylactic lamivudine use. **HBeAg** = hepatitis B e antigen; **HBIG** = hepatitis B immunoglobulin; **HBsAg** = hepatitis B surface antigen; **HBV** = hepatitis B virus; **+** indicates positive; **–** indicates negative.

Big Data Analysis with Markov Decision Model







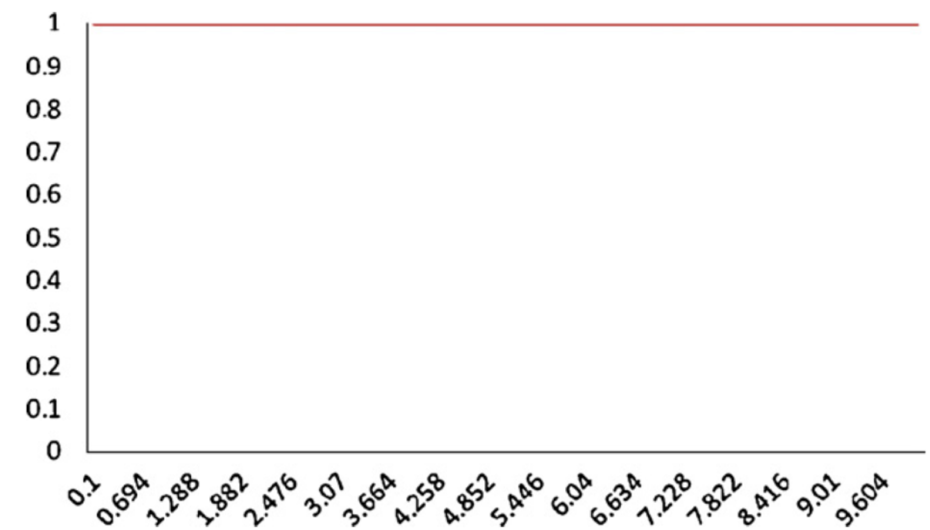
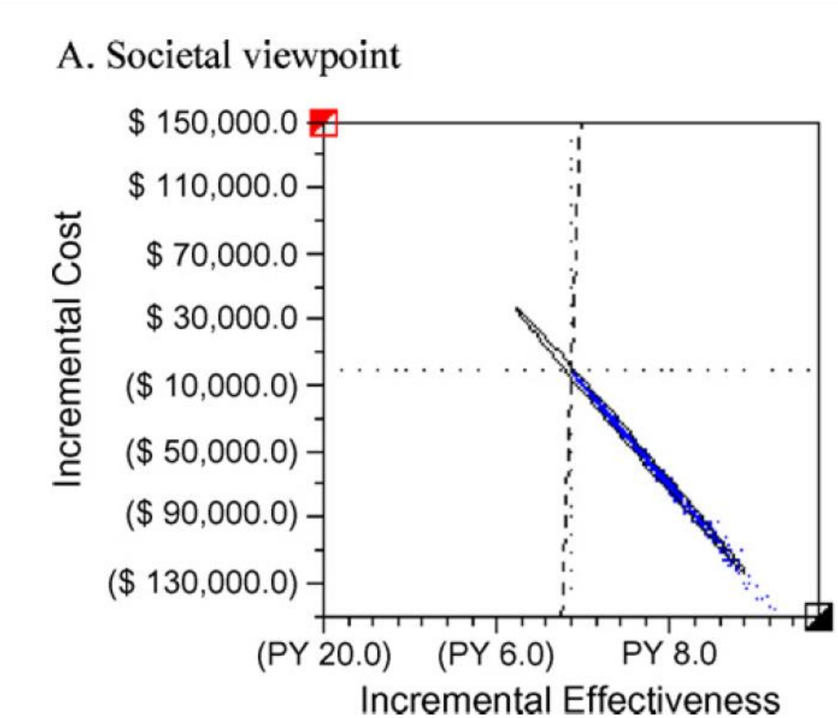
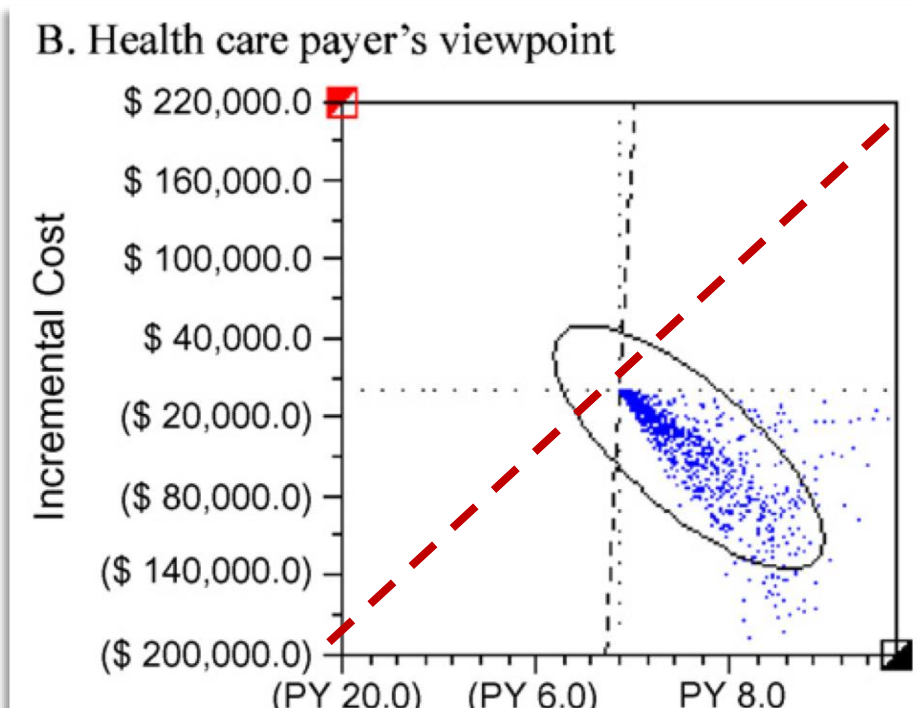
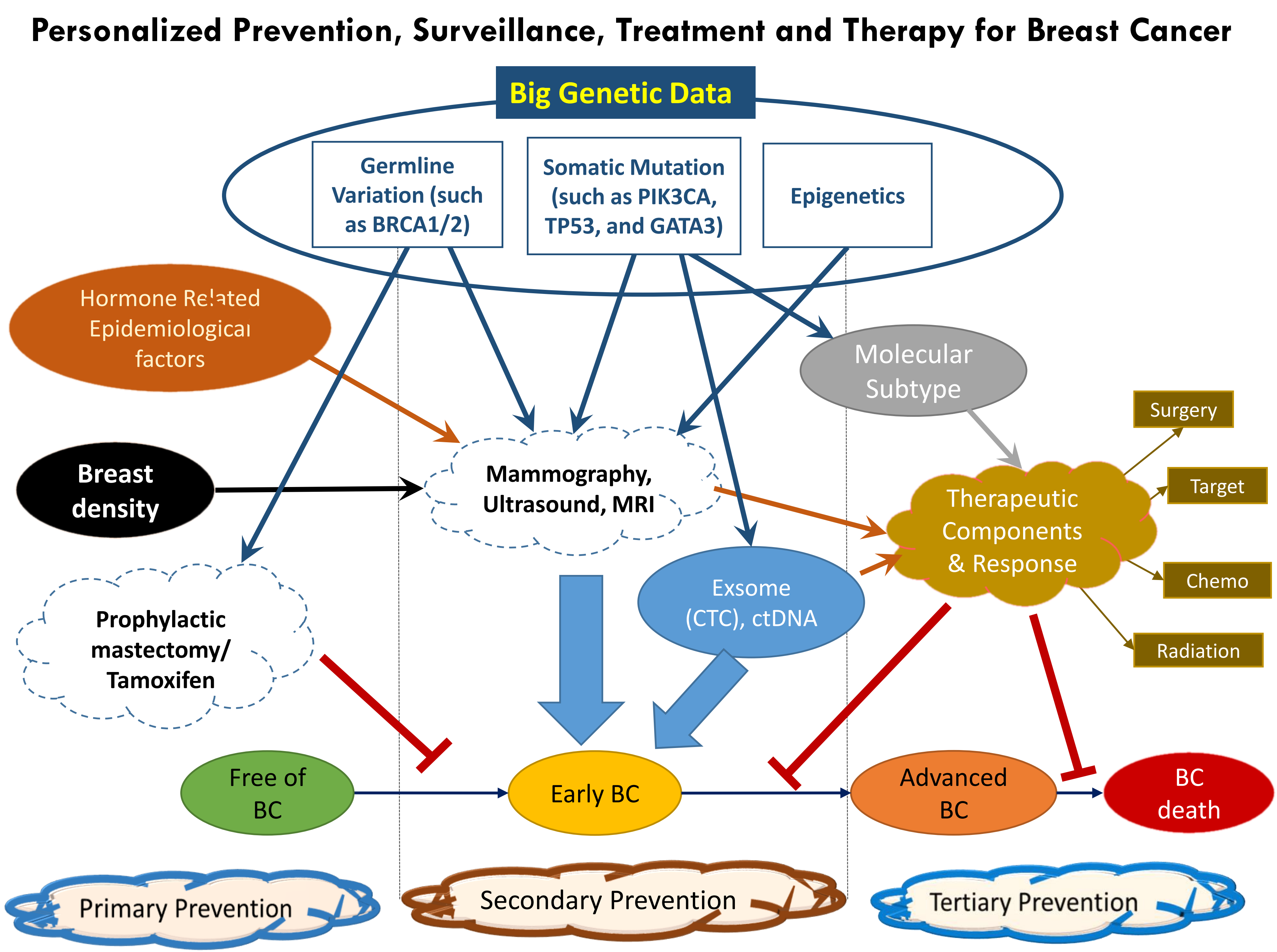


Fig. 4. Acceptability curve for vaccination vs. no-vaccination groups (Health care payer's viewpoint).



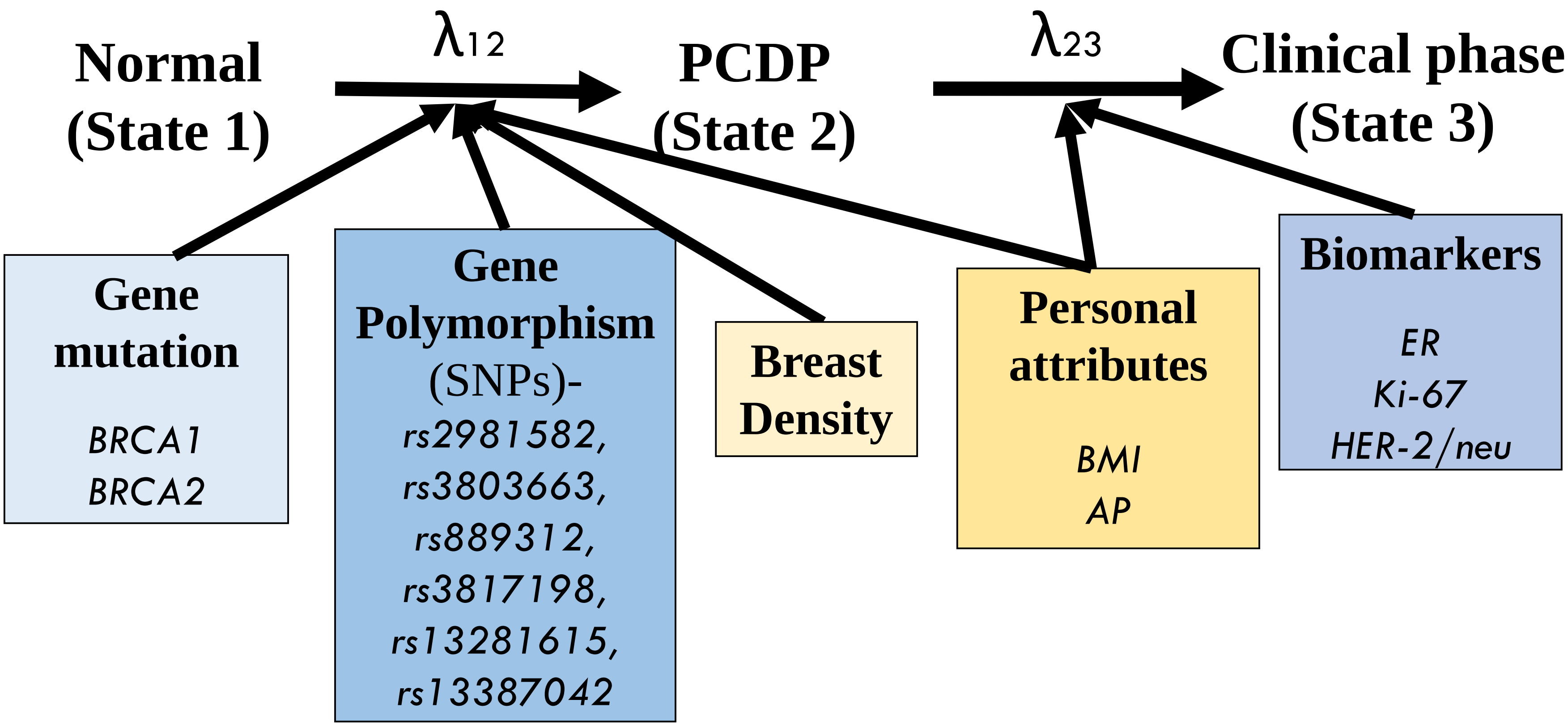


Personalized Prevention Model-An Example of Breast Cancer



Personalized Prevention, Surveillance, Treatment and Therapy for Breast Cancer
Big Genetic Data
Germline Variation (such as BRCA1/2)
Somatic Mutation (such as PIK3CA, TP53, and GATA3)
Epigenetics
Hormone Related Epidemiological factors
Molecular Subtype
Surgery
Breast density
Mammography, Ultrasound, MRI
Target
Therapeutic Components & Response
Chemo
Prophylactic mastectomy/ Tamoxifen
Exsome (CTC), ctDNA
Radiation
Free of BC
Early BC
Advanced BC
BC death
Primary Prevention
Secondary Prevention
Tertiary Prevention

Multi-state, Multi-factorial Breast Cancer Progression



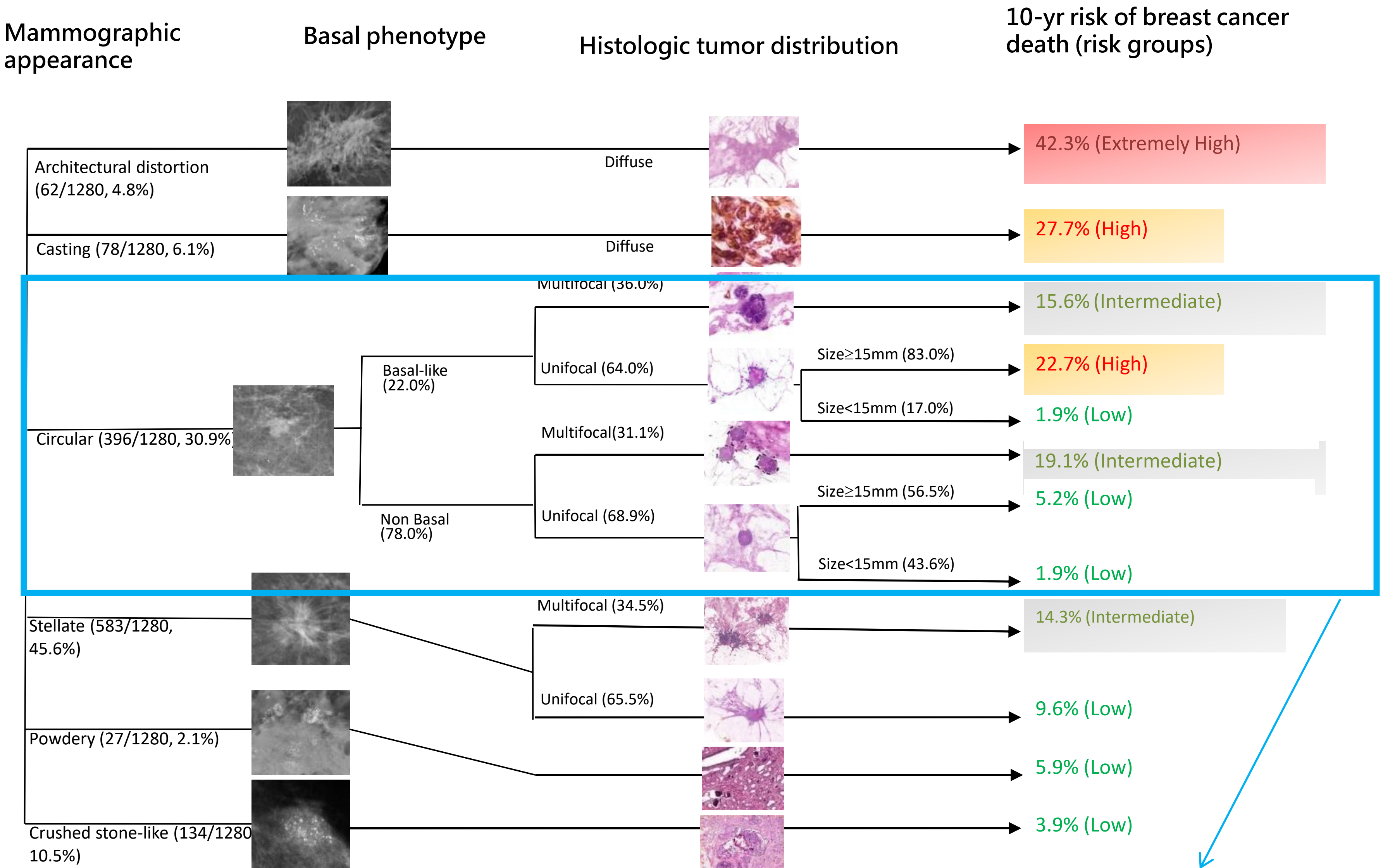
$$\lambda_{12} = \lambda_{12j} \times \exp\left(\sum_{i=1}^{3} \beta_i \times \text{Breast Density} + \sum_{i=4}^{10} \beta_i \times \text{SNP}_i + \beta_{11} \times \text{BMI} + \beta_{12} \times \text{Age at first pregnancy}\right)$$

j=0,1,2 for noncarriers, BRCA1 and BRCA2 carriers

$$\lambda_{23} = \lambda_{230} \times \exp\left(\beta_{13} \times \text{BMI} + \beta_{14} \times \text{Age at first pregnancy} + \beta_{15} \times \text{ER} + \sum_{i=16}^{17} \beta_i \times Ki67 + \sum_{i=18}^{19} \beta_i \times HER2\right)$$

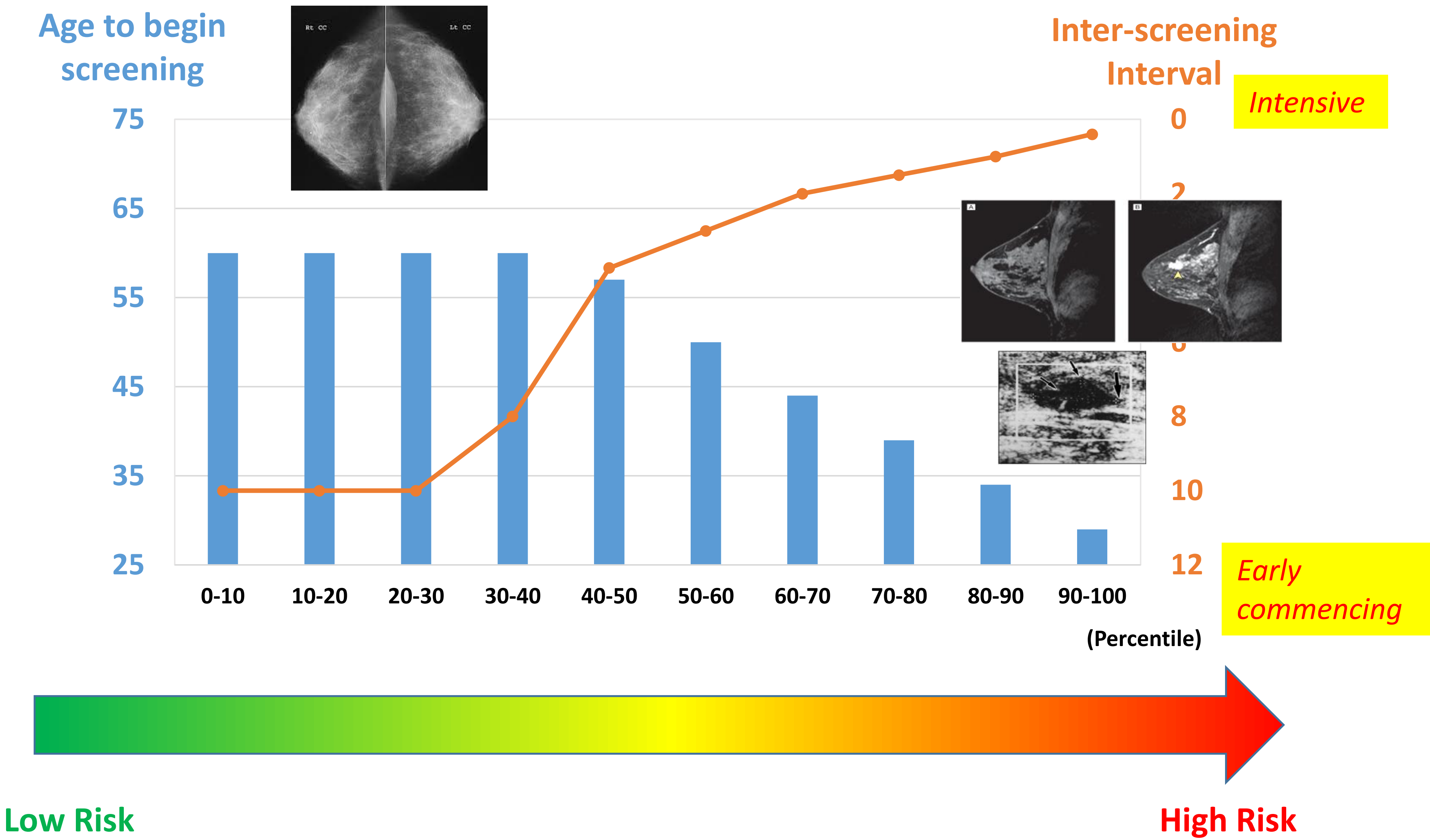
Individually tailored screening of breast cancer with genes, tumour phenotypes, clinical attributes, and conventional risk factors. BJC 2013; 108.

Multi-disciplinary Breast Cancer Risk



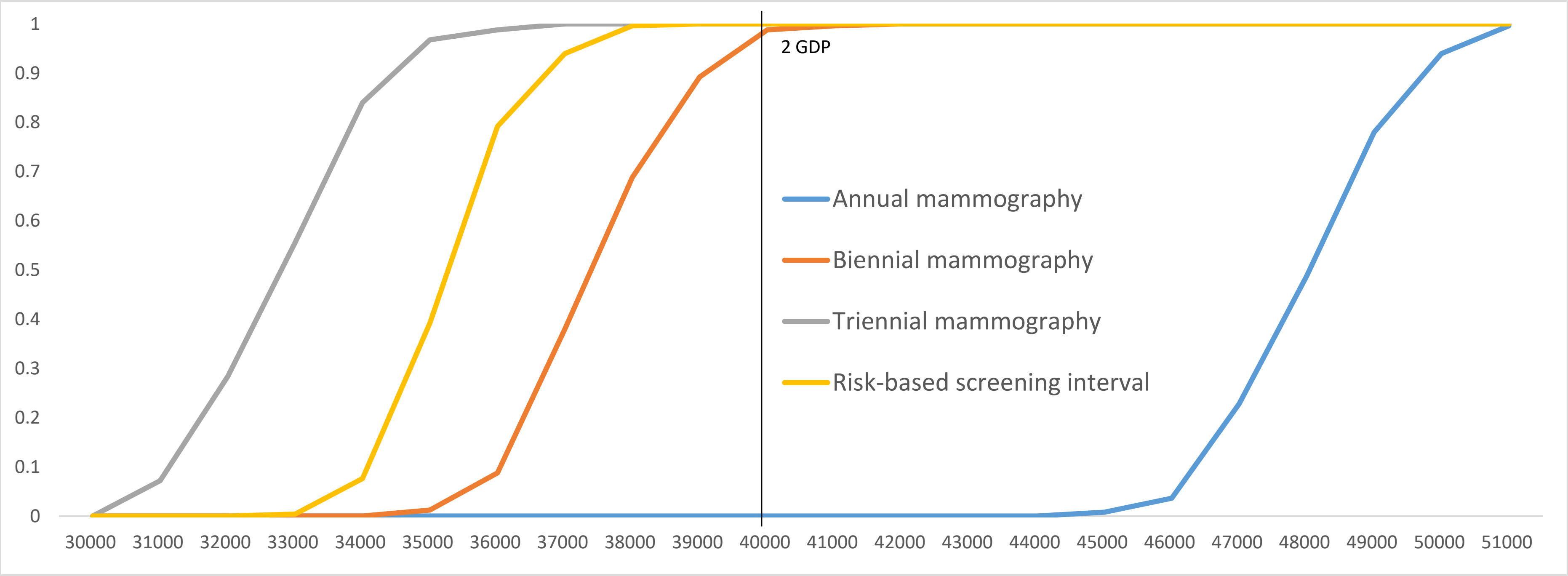
Heterogeneous among Circular type

The recommend age to begin screening and inter-screening interval for screening by percentiles of risk score



Economic Evaluation

Acceptability curve of primary and secondary breast cancer prevention for **non-BRCA Carrier**



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Bayesian negative-binomial-family-based multistate Markov model for the evaluation of periodic population-based cancer screening considering incomplete information and measurement errors

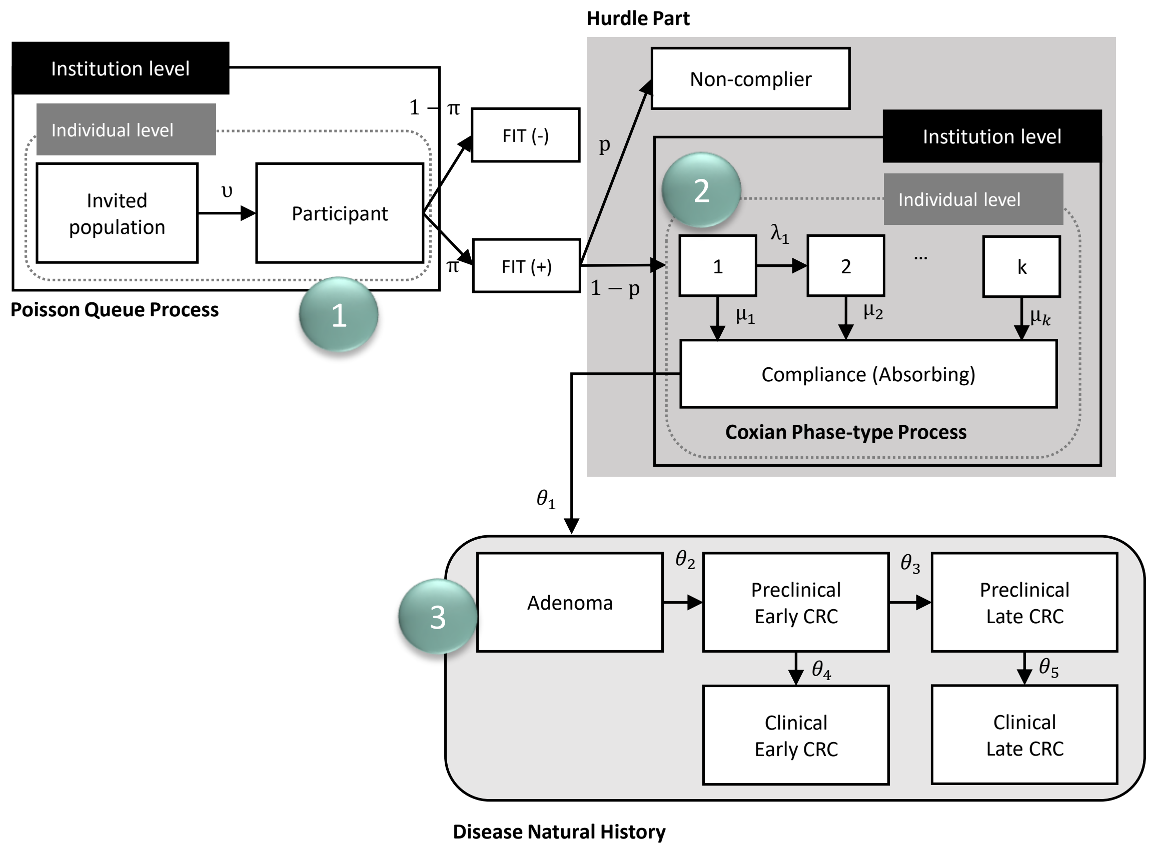
Chen-Yang Hsu,[1] Ming-Fang Yen,[2] Anssi Auvinen,[3] Yueh-Hsia Chiu[4] and Hsiu-Hsi Chen[1]

- **How many rounds of screens** are required before identifying a asymptomatic breast cancer – **2.77** rounds

- **Can a subject be categorized as very low risk** for stopping screening after several rounds of screening with negative results – **8** rounds

Queue Hurdle Coxian Phase-type Model incorporating with Disease Natural History

Coverage rate (%)	Compliance rate (%)	Advanced CRC Reduction (%)
3% of Positive rate		
30	60	6
	90	8
50	60	8
	90	14
90	60	15
	90	23
7% of Positive rate		
30	60	12
	90	18
50	60	20
	90	29
90	60	33
	90	46



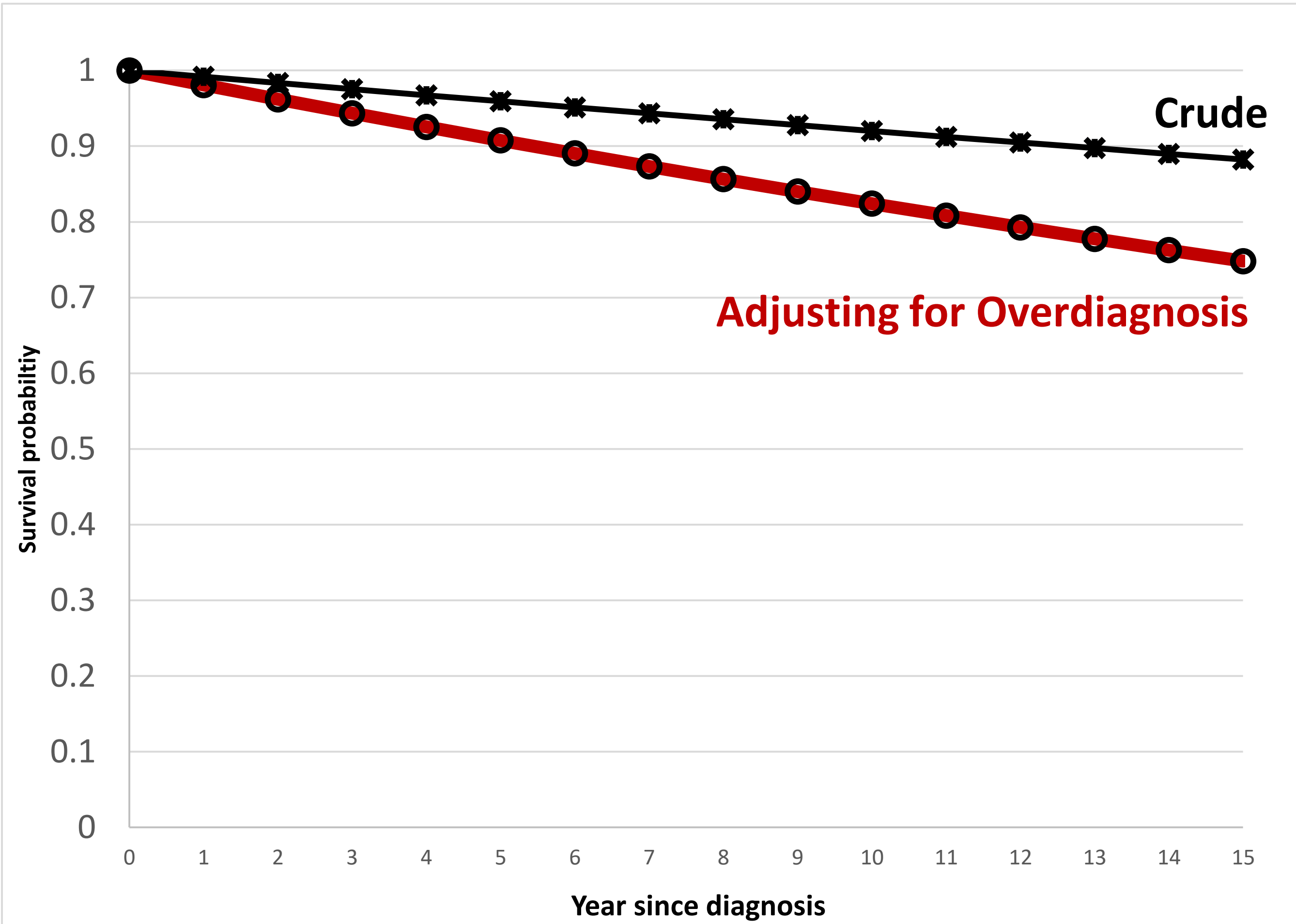
Random Walk Model for Drift (p-q) of f-Hb Concentration (Fecal Immunological Test) and Gambler's Ruin Probability

State group	p (95% CI)	q (95% CI)	f-Hb (μg/g)	Ruin probability	Expected Days
Cancer	0.823 (0.806,0.842)	0.177 (0.159,0.194)	400	0.785 (0.736,0.739)	486 (475,496)
Advanced adenoma	0.776 (0.745,0.804)	0.224 (0.196,0.255)	200	0.711 (0.660,0.759)	257 (248,267)
Nonadvanced adenoma	0.708 (0.691,0.728)	0.292 (0.272,0.309)	150	0.588 (0.5530.626)	211 (205,216)
Normal	0.262 (0.261,0.264)	0.738 (0.736,0.739)	20	<0.001	2.10 (2.09,2.11)

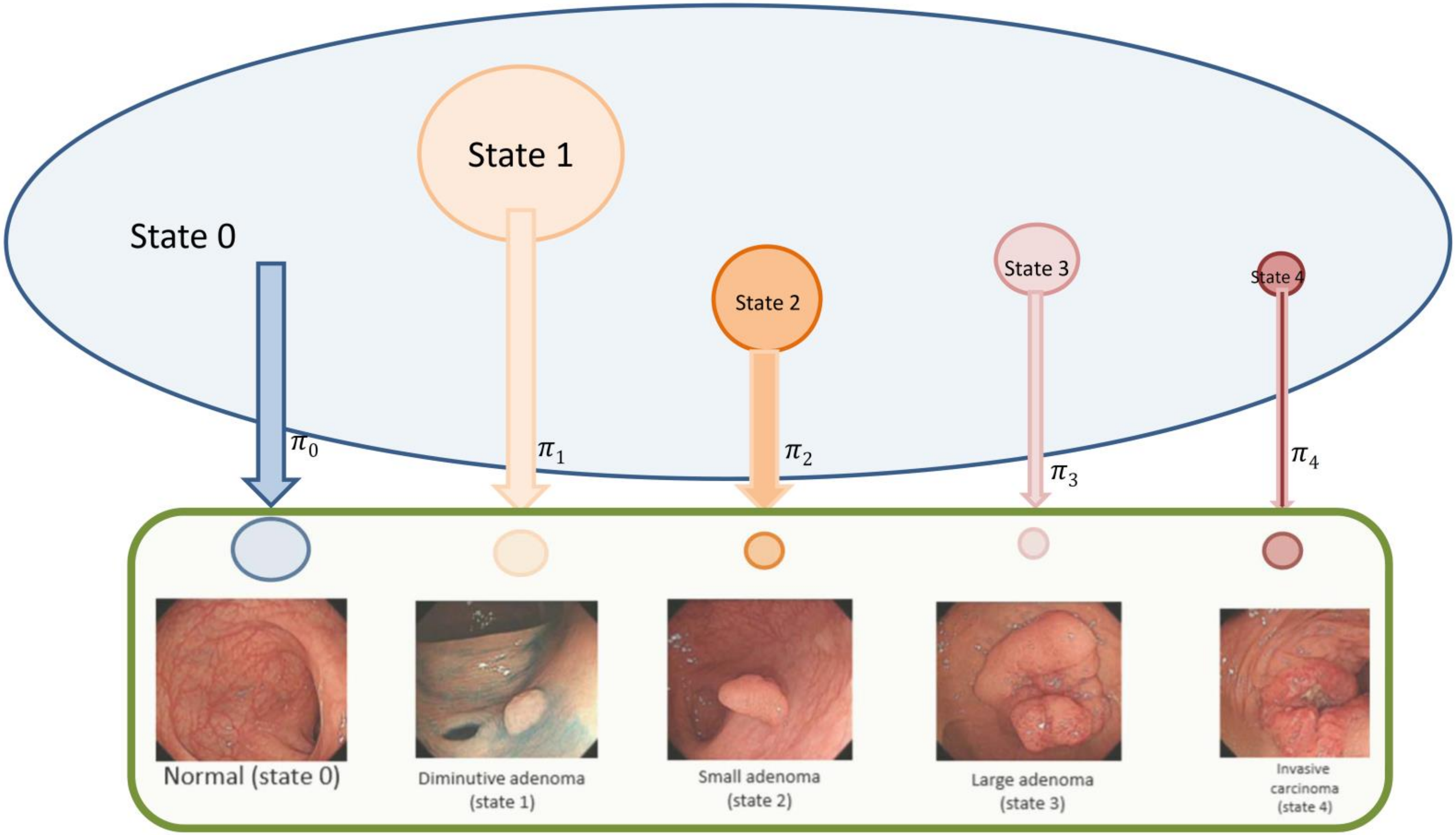
Emerging Issues in Disease Screening and Surveillance

- Overdiagnosis in disease screening
- Efficient approach for information extraction
- Emerging infectious disease outbreak

How Overdiagnosis Affect Survival of Breast Cancer ?



Sampling Design for Multi-state Outcome with Costly Biomarkers



Stochastic model for non-standard case–cohort design

Tony Hsiu-Hsi Chen,[*,†] Ming-Fang Yen, Ming-Neng Shiu, Tao-Hsin Tung and Hui-Min Wu

Institute of Preventive Medicine, College of Public Health, National Taiwan University, Room 207, 19 Hsuchow Road, Taipei 100, Taiwan

Statistics in Medicine *Statist. Med.* 2004; **23**:633–647 (DOI: 10.1002/sim.1610)

Compartment model in Infectious disease

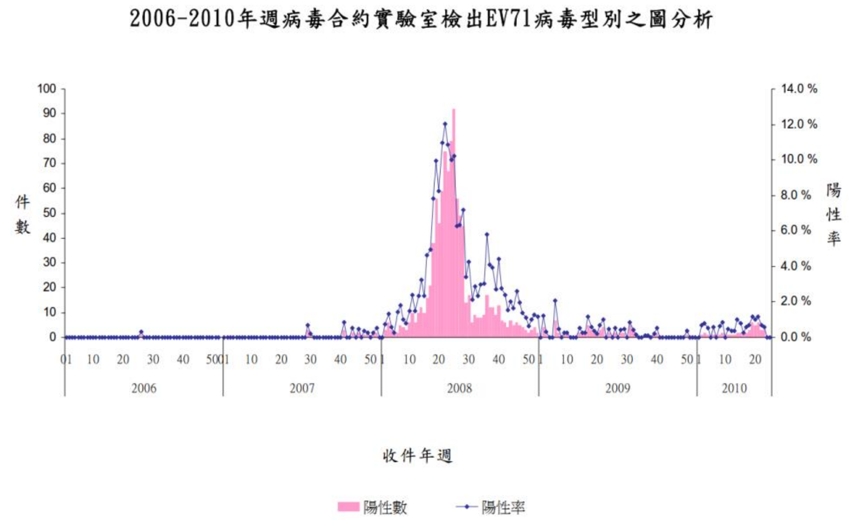
Basic Reproductive Number (R_0)

2000: 1.22

2001: 1.21

2005: 1.59

2008: 1.18



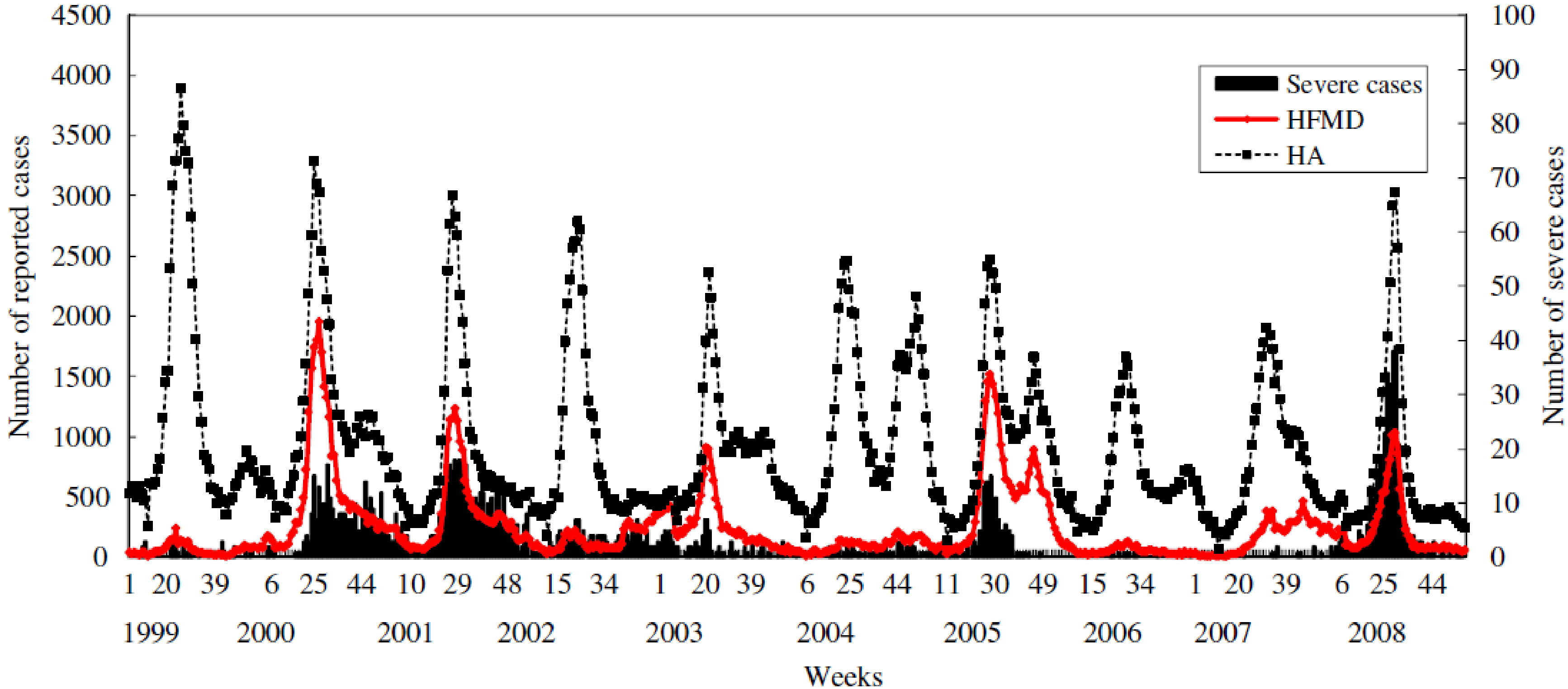
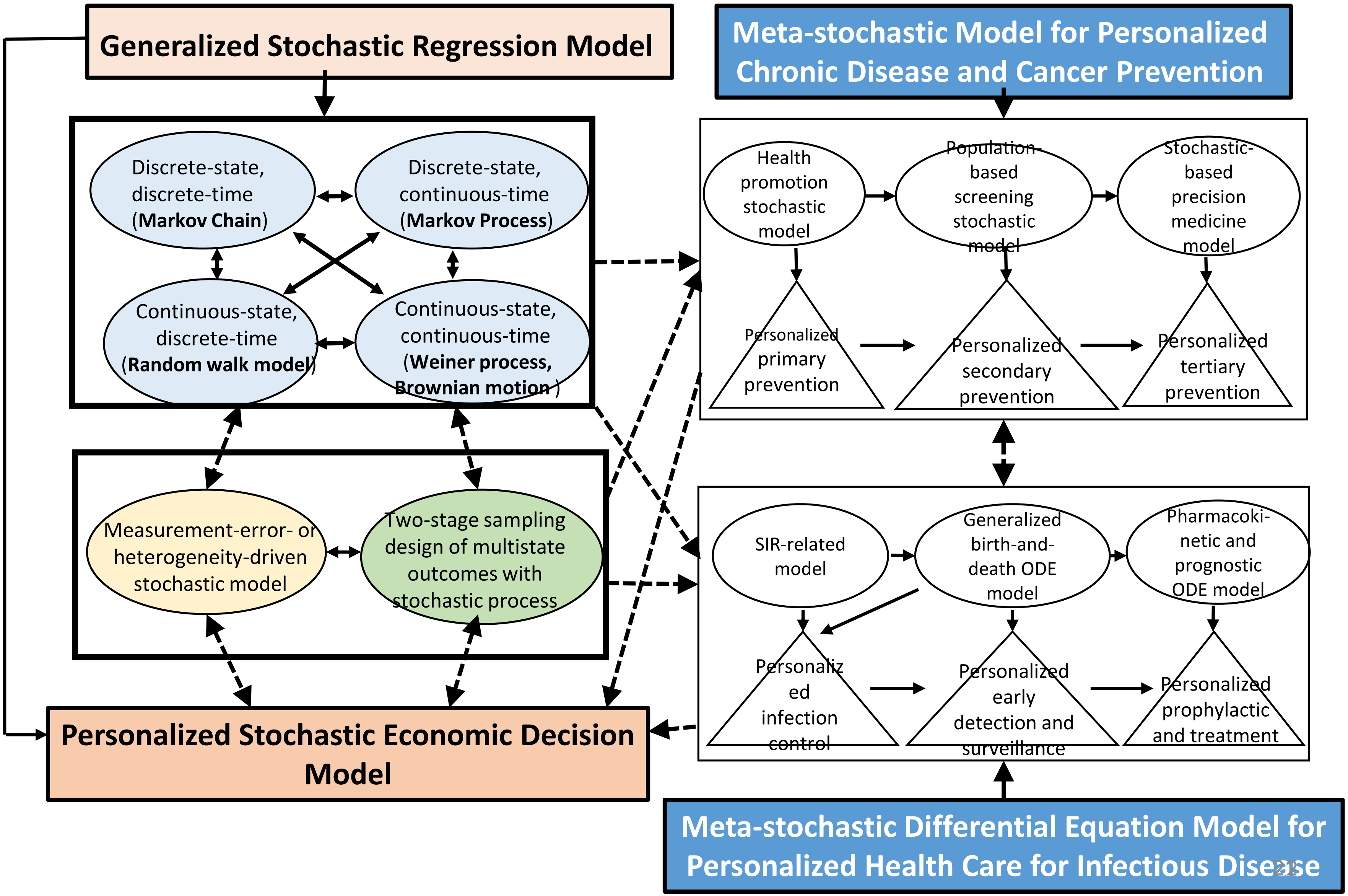


Fig. 1. The reported cases of hand, foot, and mouth disease (HFMD) or herpangina (HA) in a physician-based sentinel surveillance system and the severe cases of HFMD or HA in Taiwan from 1999 to 2008.

Integrated Framework of Stochastic models for Health Care Decision Making





Thank you for your attention