An Integrated Discrete-Event/Systems Dynamics Simulation Model of Breast Cancer Screening for Elderly US Women

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Motivation and Objectives
It is expected that half of newly diagnosed breast cancer cases from this time forward will be in women 65 and older. This along with the ageing US population is evidence that elderly women will become the prevalent patient cohort in the breast cancer population. This research utilizes a two-phase modeling approach:

1. A natural history model of breast cancer incidence and progression in random samples of elderly U.S. women; and
2. An integrated discrete-event/system dynamics (DES-SD) screening and treatment model which uses knowledge about breast cancer within those same populations gained from the natural history model to estimate the benefits of different screening and treatment policies on individuals.

Research Questions
1. How can we obtain a database of women with appropriate breast cancer risk factors to sample from?
2. How can we model the risk of having a cancer detected based on specific breast cancer risk factors?
3. How can we model the disease progression within the body?
4. How can we determine the stage of breast cancer at diagnosis?
5. How can we model population growth for 65+ US women

Phase I Natural History Model Details (Cont.)

b. Barlow Risk Model
i. Determines the 1-year probability of being diagnosed with invasive breast cancer or ductal carcinoma in-situ (DCIS) as a function of BCSC risk factors (age, race, BMI, etc.)

2. Disease Progression Submodel
a. Gompertzian Primary Tumor Growth Model
i. Determines age-specific primary tumor growth rate and size of the tumor at any time.

b. Plevritis Stage Progression Metastasis Model
i. Determines stage (local, regional, distant) of invasive cancers at diagnosis as a function of primary tumor size.

3. Survival and Mortality Submodel
b. Breast Cancer Death: Gompertzian lethal tumor size

4. Population Growth Submodel
a. Fit a model to population growth for US women over 65; and
b. Determine the number of women who turn 65 each year and enter model

Phase I Natural History Model Results
Run Parameters:
• Initial Population Size = 20,582 (0.10% of Female 65+ Pop in 2000)
• 10 Randomly Sampled Populations (or Replications)

Phase I Conclusions
• Incidence: Estimated incidence with perfect annual screening is significantly higher than SEER data from actual population.
• Deaths: Cancer Deaths are much higher than SEER data as expected with elevated incidence and no treatment.
• Stage Distribution: More local cancers and very few distant cancers as expected with older population and perfect annual screening
• Detection Method: Very few clinical as expected with perfect annual screening.
• We claim these are reasonable estimates of given performance measures for 2001-2020 with the stated assumptions

Future Work - Phase II Integrated Screening Model
• An SD model will govern population level behavior.
• The current level of screening and treatment will be determined.
• Screening policies will be simulated and compared statistically.
• Costs of screening and treatment will be estimated.