

Incorporating human behaviour into DES: an example for breast cancer.

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Why model behaviour?

- OR models are widely used in evaluation of healthcare interventions
- Human behaviour can influence outcomes: e.g. adherence with medication, compliance with screening programs
- Models which ignore human factors can give misleading or erroneous results
- But can we capture human behaviour adequately in a simulation model?

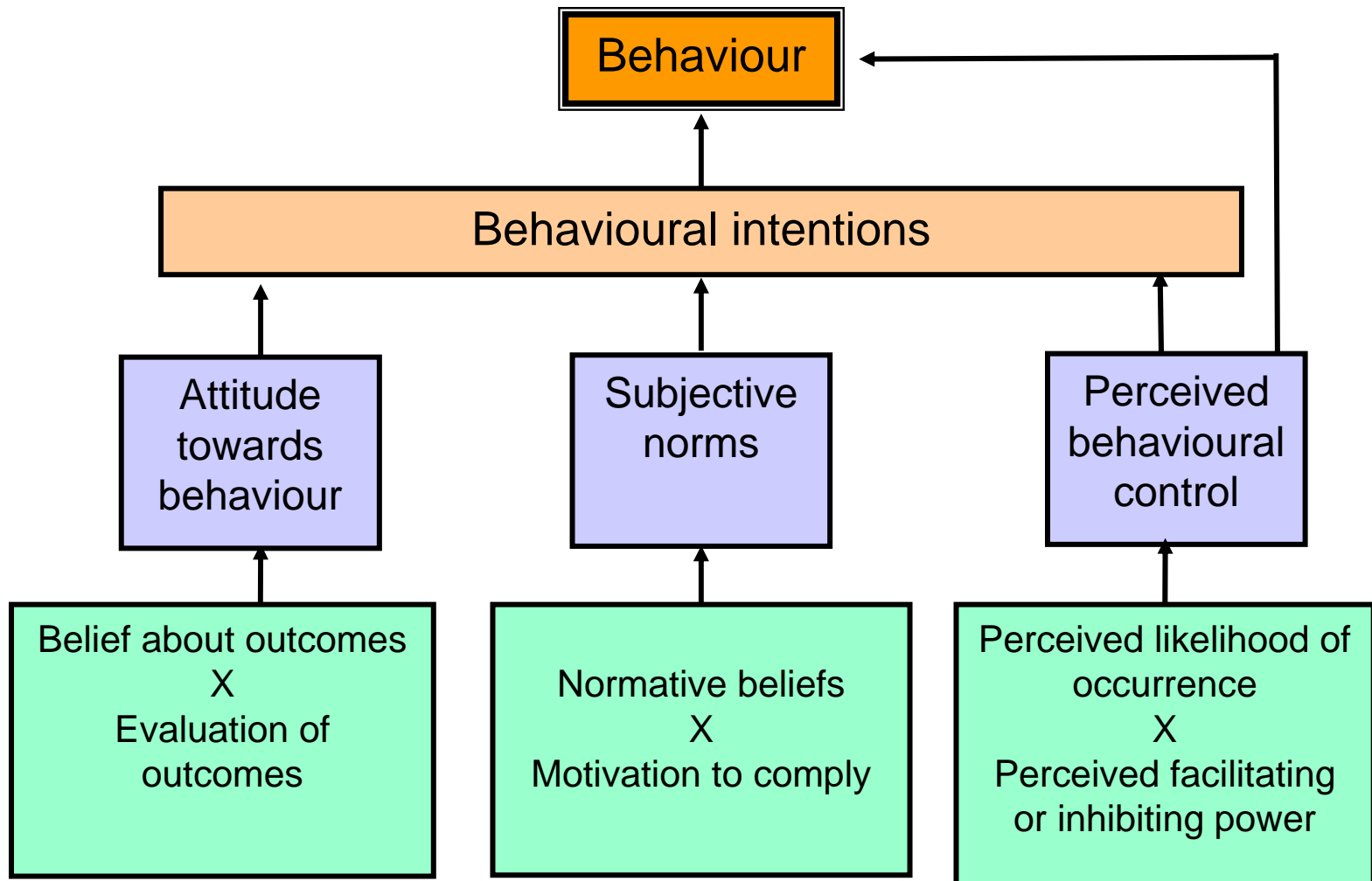
Current approach

- Model behaviour at a global level:
e.g. a fixed probability of taking the drug
- Our research questions: Is this good enough? Can we obtain added insights by more detailed models?
- If yes, then we could provide useful information to health providers to increase compliance and adherence

Psychological models

- The Health Belief Model
(Rosenstock & Becker, 1974)
- The Theory of Planned Behaviour
(Ajzen, 1988)
- Widely used and recognized in the field of health psychology
- Not adopted to date by OR modelers

The Theory of Planned Behaviour



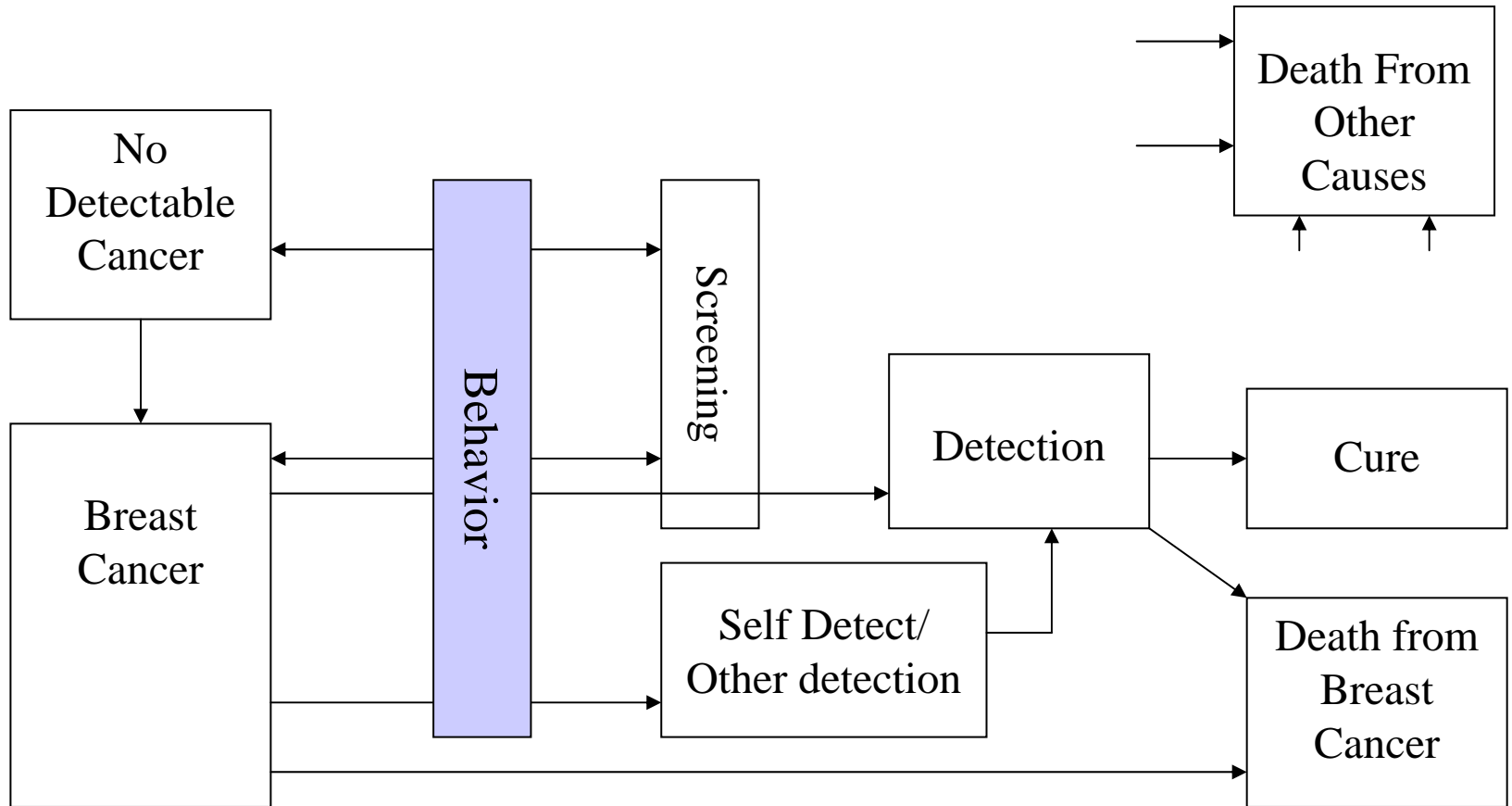
UK breast cancer screening program

- Introduced in 1988 following trial evidence from many countries
- Initially offered to women aged 50-64, every 3 years
- From 2001, offered every 3 years from ages 50-70, and over 70 on request
- Over 1.4 million UK women screened every year, with approx 75% uptake of invitations

Modelling screening programs

- One of the classic areas for the applications of simulation modelling in healthcare (Knox, 1973; Habbema et al, 1985 (MISCAN); Zoetelief et al, 1997)
- Our model was coded in Microsoft VB and uses a three-phase DES approach with five B-activities:
 - Develop cancer
 - Be invited for screening
 - Detect the cancer by means other than mammography
 - Die from breast cancer
 - Die from other causes

Breast Cancer Screening Model



Model parameters

- Physiological
 - Incidence, age of onset; tumour growth rate; death rates from breast cancer and from other causes; survival after treatment
- Screening
 - Start and end ages; interval; test sensitivity according to tumour size
- Psychological
 - Probability of attendance

Model outputs

- Number of screens performed
- Number of cancers detected
- Number of cancer and non-cancer deaths
- Statistics relating to tumour size at detection (for validation)
- Life years saved (calculated by comparing with baseline run)
- We did not include costs or perform cost-effectiveness analyses

Age of cancer onset

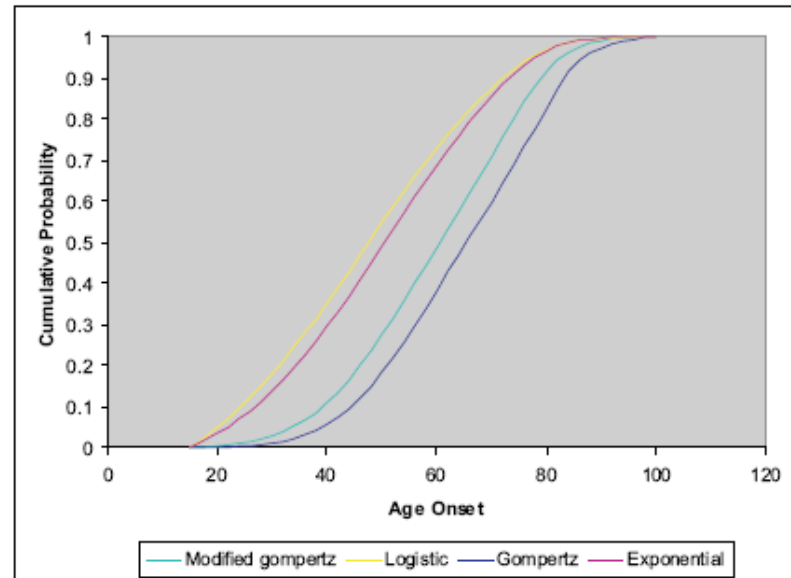
- Fitted to data from UK South West Cancer Intelligence unit – database of 26,298 patients between 1981 and 2000
- Age at onset was back-calculated from tumor size at presentation, using four tumor growth models (exponential, logistic, Gompertz, modified Gompertz)

Age of the tumor, t , in years

Logistic:
$$t = \frac{1}{365b} \left[\left(\frac{-1}{c} \right) \ln \left(\left(\frac{N(D)}{N(\infty)} \right)^{-c} - 1 \right) \right]$$

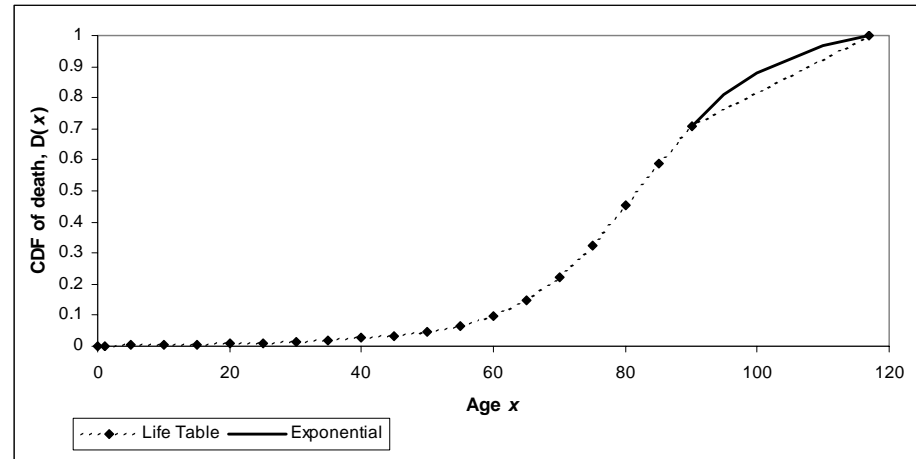
Gompertz:
$$t = -\frac{1}{12b} \left[1 - \left(\frac{\log(N(D))}{\log(N(\infty))} \right) \right]$$

$N(D)$ is the number of cells at detection, estimated by calculating the volume of the tumor based upon the assumption of spherical growth
 b is the intrinsic growth rate, and c is a generalising factor

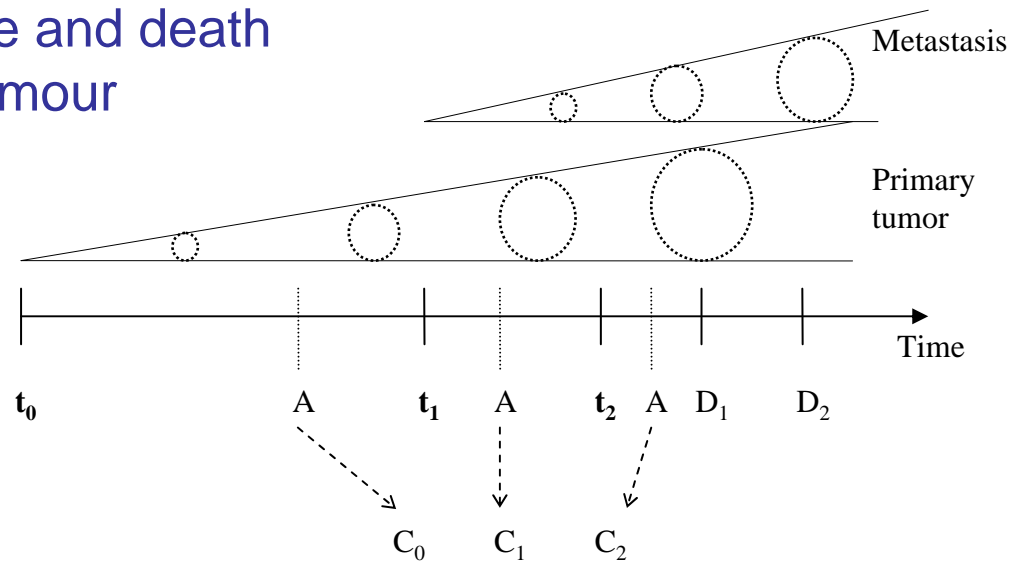


Mortality

- Natural death inferred from UK life tables (cause-eliminated)



- Breast cancer cure and death are functions of tumour size and spread



Attendance at Screening

- “Global” percentage
- “Local” percentage
- Theory of Planned Behaviour
- Baker and Atherill model (2000):
probability of attendance is a function of
previous attendances

Data for the TPB

- Rutter (2000) tested TPB's ability to predict attendance at breast cancer screening appointments
- 2058 women completed questionnaire before appointment date
- TPB scale variables significantly predicted attendance/non attendance

TPB probability of attendance

- Logistic regression found relationship between TPB variables and attendance

$$\ln\left(\frac{\pi(\underline{\beta}, \underline{X})}{1 - \pi(\underline{\beta}, \underline{X})}\right) = \beta_1 + \beta_2 X_1 + \beta_3 X_2 + \beta_4 X_3$$

- Assumed attendance result of Bernoulli trial and used maximum likelihood to find regression coefficients

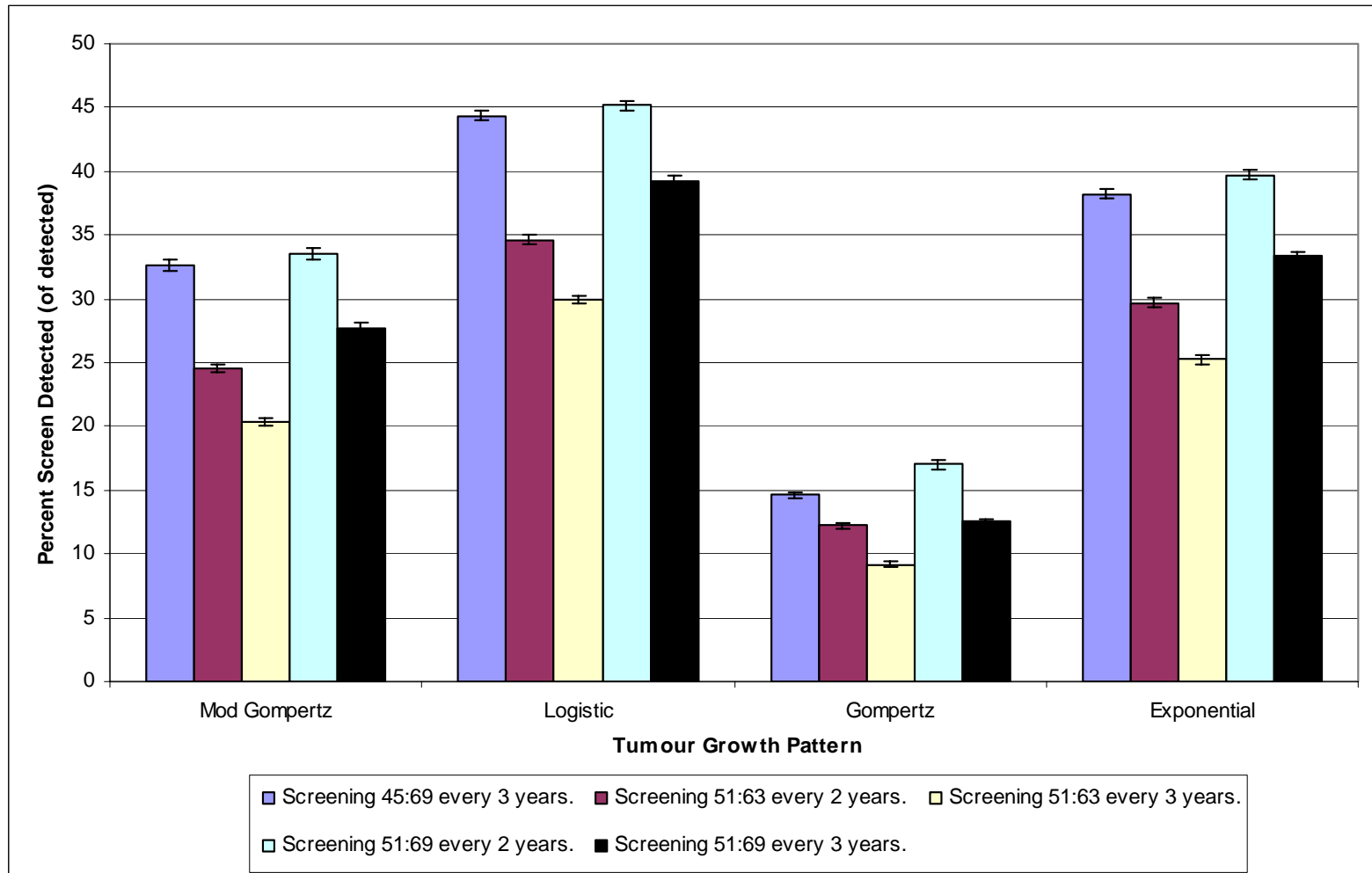
π = probability of attendance

Scenarios

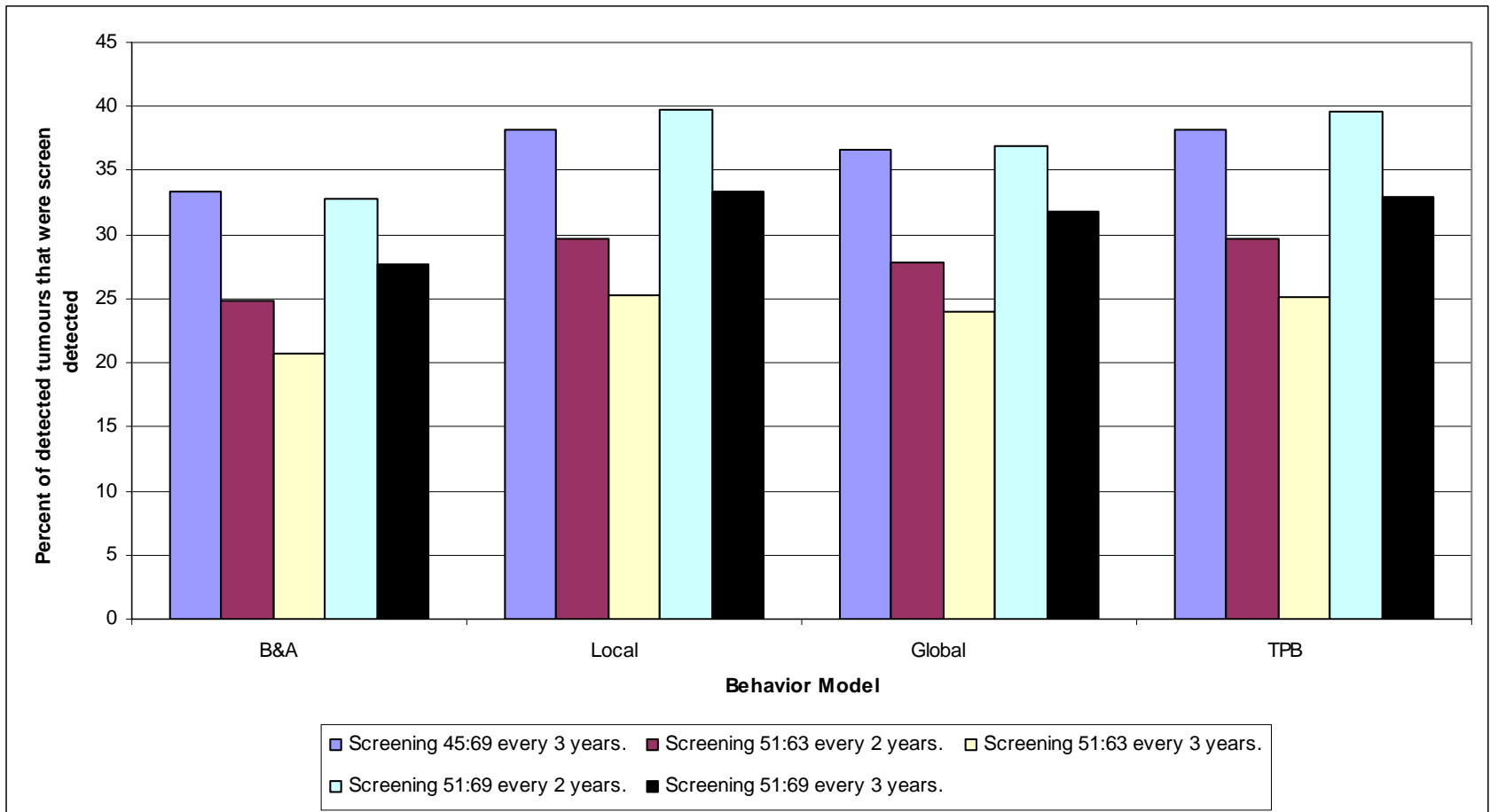
- Four different growth models
- Four different behavioural models
- Five screening strategies

Scenario	Start Age	End Age	Frequency
1	51	69	3 years
2	51	63	3 years
3	51	69	2 years
4	51	63	2 years
5	45	69	3 years

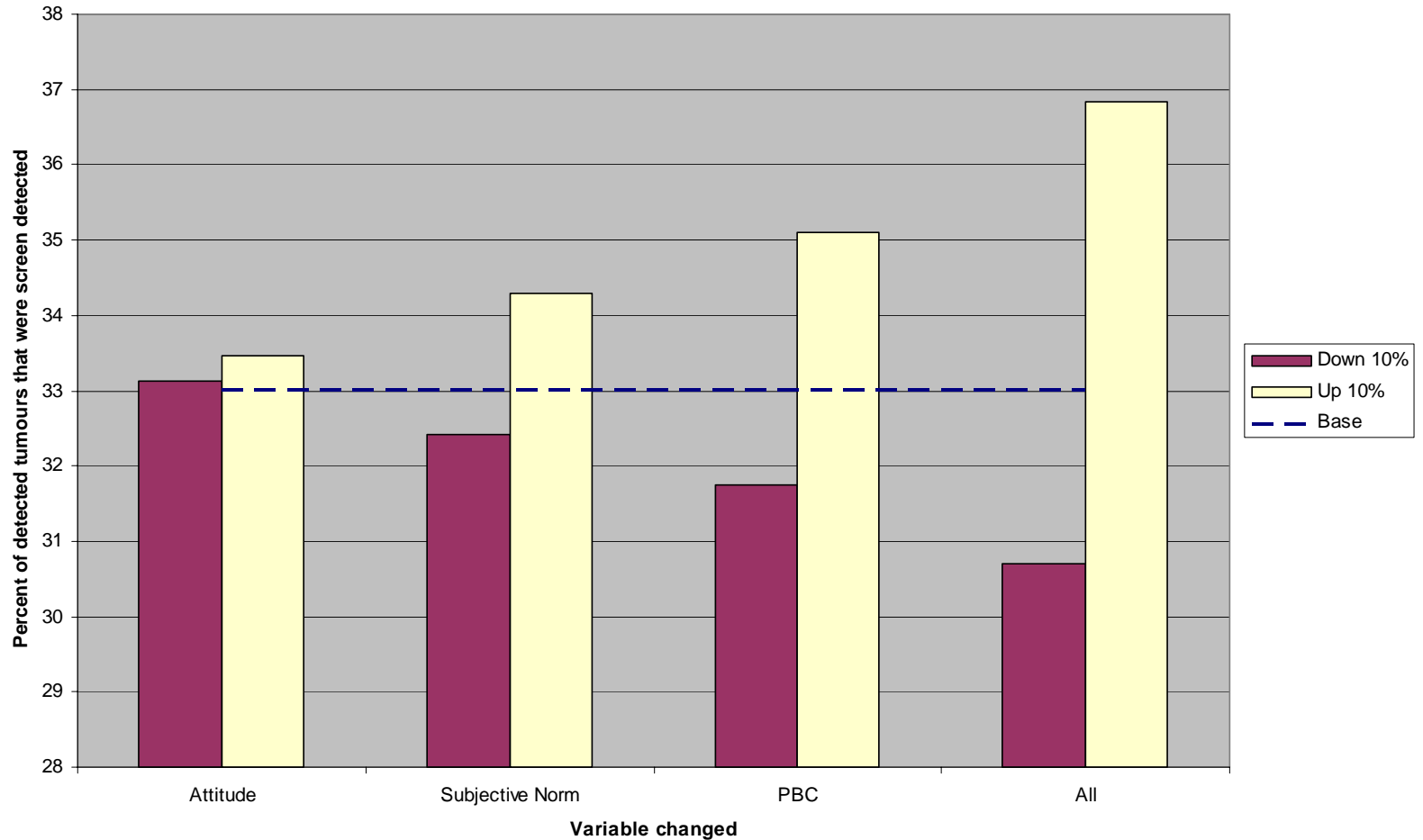
Numbers of tumours detected for different growth models



Numbers of tumours detected for different behaviour models



% change in tumours detected for a $\pm 10\%$ change in TPB variables



Key Findings

- Significant benefits (detected tumors and life years saved) by screening from age 45 to 69 (every three years) or from 51 to 69 (every two years)
- The added structure of TPB provided a valuable insight and permits for sensitivity analysis on the constructs. For example, the model demonstrated that by increasing the TPB construct values of the population by 10%, a 4% increase in detected cancers could be achieved without altering the current screening regime.
- This now needs to be translated into targeted action (i.e. how to increase construct values for those invited for a mammogram) e.g. raise awareness, reduce errors. Further work with psychologists and public health planners.
- Full cost-effectiveness study. Other applications.

Acknowledgement

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