Incorporating Behaviour in Health Care Discrete Event Simulation Models

Jennifer Sykes [1], Paul Harper [1] & Sally Brailsford [2]

[1, 2] *School of Mathematics,* University of Southampton, Southampton, SO17 1BJ, United Kingdom.
JS@maths.soton.ac.uk

***Abstract* - A proposal is presented for incorporating patient behaviour in a discrete event simulation model of breast cancer and breast cancer screening policies. The behaviour of health care systems is dramatically influenced by the behaviour of the individuals within it. When comparing different health interventions or outcomes it may then be useful to measure the effects of patient behaviour upon the result. It is anticipated that psychological literature may be used to inform the behaviour of entities within a simulation model of breast cancer in order to compare different screening strategies.**

Keywords - Behaviour, Psychological Models, Breast Cancer, Screening

I. INTRODUCTION

Operational Research (OR) techniques have been widely applied to the area of health care and health research. However, the expected outcomes of interventions, plans, or structural changes suggested by these models often differ from those observed in reality.

The actions of people play a vital role in health care systems, resources, and disease progression. For example, when considering different or optimal disease interventions the participation of the patient, or potential patients, in the intervention must be considered. A person's behaviour not only influences their expected health outcomes and care pathways, but can also have an influence upon determining their health status in first place. For example an individual's sexual behaviour will have an influence upon their susceptibility to sexually transmitted diseases.

For the majority of models of health care systems the behaviour of the people involved in those systems is described by a single variable, e.g. the percentage of patients who comply with the regime or message.

It is suggested that the observed gap between modelled expected outcomes and real outcomes may be in part due to the human behavioural aspects of the health care systems which are currently omitted from most simulation models. To this end it is intended to try to incorporate some behavioural parameters into discrete event simulation model(s) in order to attempt to capture their effect(s). One method of achieving this may be to incorporate existing psychological schematic models of health care behaviour, (or an amalgamation of several), into simulation model(s) in an attempt to bridge the gap between modelled and observed systems and increase the functionality and realism of the models.

This paper aims to outline a proposal for including behavioural variables in a discrete event simulation model of breast cancer and breast cancer screening policies. The following section gives an introduction to some of the psychological theory relating to health care behaviour, the third section discusses breast cancer and issues relating to breast cancer screening, while the fourth section describes the proposed model of breast cancer and how it is intended to incorporate behaviour. Section V summarises the proposal.

II. PSYCHOLOGICAL THEORY FOR PREDICTING HEALTH BEHAVIOUR

Psychologists have been interested in human behaviour for many years and a wealth of literature and research considers people's attitudes, motivations, and behaviour in relation to health and health care. Over the years many theories and models have developed for the prediction and explanation of human behaviour in general and of health behaviour in particular, e.g. social cognitive models such as the Health Belief Model, Health Locus of Control, Protection Motivation Theory, the Theory of Planned Behaviour, and Social Cognitive Theory. This Section aims to introduce two of the more traditional and commonly applied theories relevant to health behaviour: the Health Belief Model, and the Theory of Planned Behaviour. For more information about these or any other social cognitive models of health behaviour the reader is directed to the book 'Predicting Health Behaviour' edited by Mark Conner and Paul Norman [6] Conner and Norman, 1995.

A. The Health Belief Model

The Health Belief Model (HBM) was originally developed in 1974, [9] Rosenstock, 1974, and was one of the earliest models of health behaviour. The underlying assumption behind the model is that a person's health beliefs will influence their health behaviour(s). The HBM suggests that the likelihood that an individual will engage in

a behaviour is a function of four subjective perceptions, these being: 1. perceived barriers, psychological or physical, to undertaking the suggested behaviour, 2. perceived benefits of participating in the behaviour, 3. perceived severity of the illness or health outcome in question, and 4. perceived susceptibility to the illness in question. In addition there are two further constructs thought to influence health behaviour within the HBM, and these are health motivation, and cues to action, (triggers to considering action such as symptoms or advertising campaigns).

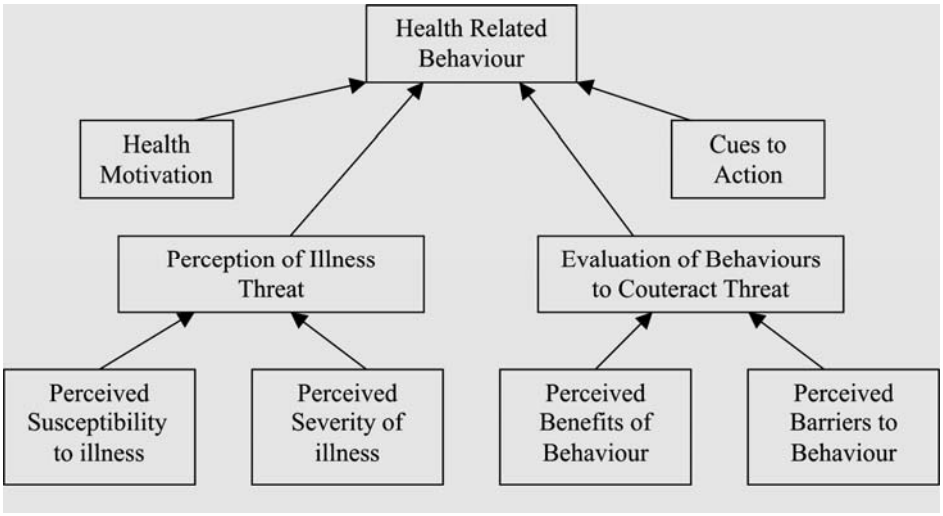

Figure 1. The Health Belief Model

B. The Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) [2] Ajzen, 1991, is an elaboration of a previous model, the Theory of Reasoned Action (TRA), [1] Ajzen, 1988. Both models suggest that people make decisions based upon careful consideration of available information. The theories arose from the belief that attitudes form a causal role in determining behaviour, (when the attitudes are at the same level of consideration as the behaviour).

The idea of the TRA is that a person's attitudes shape their intentions to perform behaviour and these intentions (motivations to perform behaviours), themselves lead on to actions. Taking this idea a step further the TPB also considers perceptions of control in order to extend the scope of the applicability of the theory by including more complex goals and tasks than only those easily performed.

The TPB examines behaviour as a linear regression function of behavioural intentions and perceived behavioural control. The suggestion is that we will be more likely to participate in behaviours that we intend to carry out and that are under our control, while we are prevented from carrying out behaviours that are not within our control. It is assumed that we will put more effort into desirable behaviours that we can control rather than behaviours we have little or no control over or which they do not wish to take part in.

The TPB considers three predictors of intentions to perform behaviours: 1. attitude toward the behaviour, 2. subjective norms relating to the behaviour, and 3. perceived behavioural control.

III. BREAST CANCER

Breast cancer is the second most common cancer in the UK with around 41,000 new cases diagnosed each year. Potential risk factors for the disease include age, a family history, previous breast cancer, early menarche and late menopause [4] Cancer Research UK, 2004.

Once diagnosed, treatment for breast cancer depends on factors such as the patient's age, and the type, size, and spread of the tumour, however, most patients will undergo surgery to remove the tumour. This may be followed by radiotherapy, and/or chemotherapy. Many women will also have hormone therapy using drugs such as tamoxifin or Arimidex.

Early detection and treatment are vital to reduce the severity of the treatment required and to ensure the survival of the patient. A screening programme operates in the UK whereby women aged between 50 and 64 are invited for a mammography every three years. During 2001/02 1.3 million women were screened under the screening programme, and 8,545 cases of breast cancer were identified in England. Coverage and uptake rates of the screening programme varied with location but overall were approximately 79% and 76% respectively in 2001/02 [8] National Statistics, 2003.

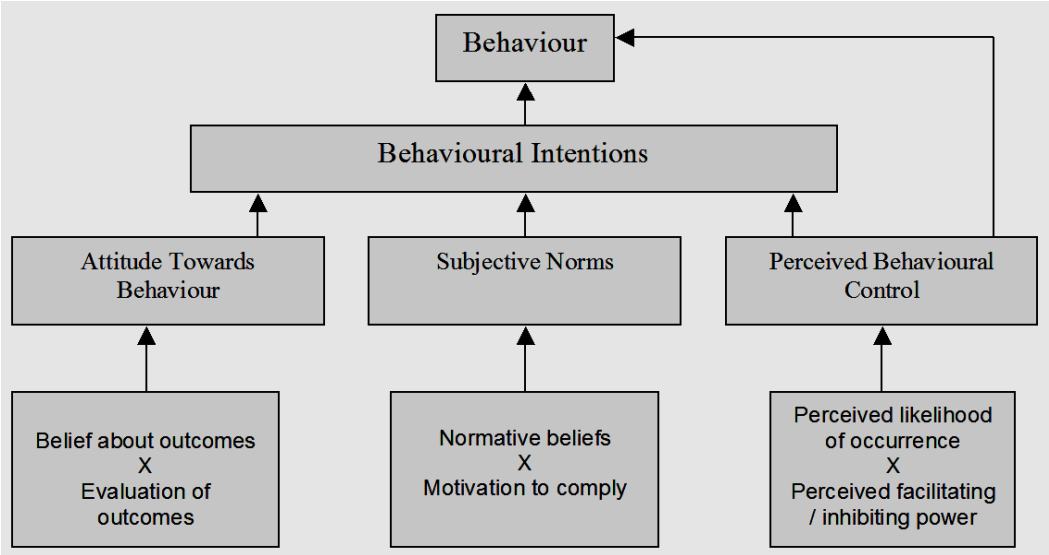

Figure 2. The Theory of Planned Behaviour

Screening for breast cancer may help to identify tumours earlier and reduce the treatment required for the patient as well as improving overall prognosis. Analytical and simulation models are useful tools to aid decisions about which age groups to screen and how frequently. Even the optimal screening programmes will only be successful however, if screening uptake rates are sufficiently high within the target population. The majority of models considering screening strategies for breast cancer treat screening uptake as a single stand alone variable (if at all). It may be the case that comparisons between screening strategies alter when the behaviour of the patient is considered in more detail. It has been shown, for example, that screening uptake rates may be dependent upon, amongst others, factors such as patient age, attendance at previous screening tests, the method and type of invitation, and receiving a recommendation for attendance from a health professional [5] Cleg et al, 2000.

IV. A BREAST CANCER MODEL INCORPORATING BEHAVIOUR

A. Model Proposal

A breast cancer screening discrete event simulation model is currently being developed in Visual Basic using the three phase approach. A discrete event simulation methodology was chosen as it was felt that in order to incorporate behaviour it was necessary for the modelling work to be at an individual level. Figure 3 outlines the proposed model structure.

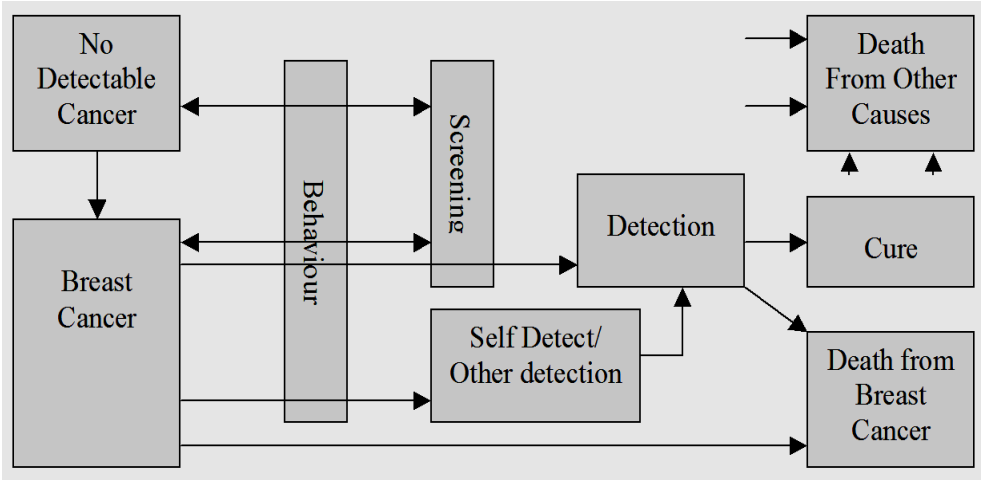

Figure 3. Simulation Model Structure

The simulation will model individual women through time with appropriate age of cancer onsets, and probability of detection being dependent upon the size of the tumour. Based upon work by Atkinson et al it will be assumed that tumour growth is exponential, with doubling time α, such that the tumour size, v, at time t will be:

$$v(t) = c \cdot e^{\frac{t \ln 2}{\alpha}}$$

where c is the volume of a singular tumour cell, [Atkinson et al, 1983]

It is intended to incorporate behavioural variables within the simulation by assigning each entity a number of behavioural attributes that may change over time. These behavioural attributes will work together in order to influence the progression of each individual through the system. Different behavioural models will be applied, such as those discussed in Section 2, in order to determine the way in which these attributes will alter the behaviour of each entity. The aim will be to assess the impact upon the individual's behaviour and the effects upon the system as a whole.

In addition further variables that have been shown in the literature to be associated with screening uptake and self examination behaviour, will be incorporated for example previous screening attendance and method of invitation [5] Cleg et al, 2000.

B. Behavioural Data

In order to evaluate their theories and health interventions psychologists have conducted empirical studies applying the various health behaviour models. It is hoped that statistical results published from such studies may be used in order to help assign quantitative values to the behavioural attributes, and relations between attributes that the theories propose.

Attitudes to, and behaviour relating to, screening programmes and breast cancer screening in particular have been studied in this way and reviews of the numerous experiments and quasi experiments are available, e.g. Chiu, 2003; [5] Cleg et al, 2000; [7] Lagerlund, 2002.

A number of potential problems have been identified. Firstly it can already be seen that it will be difficult to combine the results of the different published studies due to the heterogeneity of the designs, and the transferability of some of the results from different countries (e.g. the USA where there is no national health care provision). There are also problems of differing and conflicting results from studies as to which variables are significant predictors of, for example, screening behaviour, probably due to the design differences within the studies. Some reviews have also criticised a number of the published studies for their lack of design rigor, e.g. Chiu, 2003, however others only considered work that met suitable criteria [5] Cleg at al 2000.

V. SUMMARY

Health care systems are influenced significantly by the behaviour of the people within them. When comparing different health interventions, it may be vital to consider the impact that the behaviour of participants may have upon the potential outcomes. It is therefore intended to investigate the impact of including behavioural information within a discrete event simulation model of breast cancer and breast cancer screening strategies. Psychologists have studied health behaviour for many years and it is anticipated that this research be used to model the behaviour of the entities within the simulation.

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BIOGRAPHY

JENNIFER SYKES received a BSc in Mathematics and Psychology from the University of Reading in 2001. She completed an MSc in Operational Research at the University of Southampton in 2002 and is still there, studying for a PhD.

PAUL HARPER is a lecturer in Operational Research at the University of Southampton. He received a BSc in Statistics from the University of Bath, MSc Operational Research and PhD on Simulation Modelling for Healthcare Resources from the University of Southampton. His research interests include stochastic

modelling, semi-Markov structures, health services research, classification analysis and OR for developing countries.

SALLY BRAILSFORD is a senior lecturer in the School of Management, University of Southampton. She received a BSc in Mathematics from the King's College, London, an MSc in Operational Research and PhD on Modelling of HIV/AIDS at the University of Southampton. Sally has many years experience in the application of a range of management approaches, both quantitative and qualitative, to healthcare modelling, with particular expertise and research interests in DES and SD approaches.