

MODELLING LIFETIME HEALTH CARE COSTS: INSIGHTS FROM AUSTRALIAN INDIVIDUAL HEALTH EXPENDITURE DATA

WORK IN PROGRESS – PLEASE DO NOT QUOTE

(PRELIMINARY RESULTS)

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Authors: Philip Clarke (philip.clarke@dphpc.ox.ac.uk), Health Economics Research Centre, University of Oxford and Tue Gørgens, Research School of Social Sciences, Australian National University (tue.gorgens@anu.edu.au)

Rationale: Health economists have long considered it important to quantify savings in health care costs due to prevention and alleviation of diseases. To date most studies have simply quantified the health care costs associated with a particular type of morbidity and assumed that these costs would be saved if it was prevented. This approach ignores the role competing risks and event-related dependence (i.e. the change in the risk of future disease following an event) is likely to play in determining lifetime health care costs. For example, when an episode of cardiovascular disease is prevented it may also reduce the risk of future vascular events, but people will have more opportunity to develop cancer over their (potentially longer) remaining lifetime. Hence it is important to assess the degree to which the cost associated with treating cancer will reduce any savings that may accrue from prevention.

Objectives: To develop a simulation model to examine the degree to which event-related dependence and competing risk of other diseases influence lifetime health care costs. The simulation model will be used to estimate a profile of health care costs for people with diabetes.

Methodology: We develop a computer simulation model to estimate the life-time costs of (i) vascular disease; (ii) cancer; (iii) other disease; and (iv) all cause mortality. This model has two components. The first component consists of four equations which represent the lifetime incidence of these diseases and death. They capture both competing risks and event-related dependence. The second component is an equation which is used to cost diseases and death. These equations are estimated using administrative hospital and primary care use data on 54,868 males with diagnosed diabetes in Western Australia. We use the model to simulate lifetime costs for several representative individuals. To estimate the potential savings from preventing disease, we compare the lifetime costs for a person who has an event at a given age with a control person who does not. We will explore several currently unresolved methodological econometric issues including: sample selection, unobserved heterogeneity, and censoring issues associated with this type of administrative data.

Results: The estimated average lifetime health care cost (1999 Australian dollars) of a person with diabetes who has any type of vascular disease at age 40 is \$159,458 and for cancer it is \$155,458. Potential savings are in the order of 10% of their lifetime health care costs.

Conclusions: Competing risks and event-related dependence are likely to influence lifetime health care costs of both vascular disease and cancer. It is therefore important to determine their impact on estimates of health care costs when quantifying the burden of disease and when evaluating preventative interventions.

Introduction

A longstanding topic for debate concerning the methodology of cost-effectiveness analysis is the degree to which future health care costs that are unrelated to an intervention under evaluation should be incorporated into the analysis. As Meltzer (1997) has noted on one side of the debate is the view of Russell (1986) that only costs directly related to an intervention should be quantified. These include the direct medical costs of its implementation as well as potential savings resulting from reduced morbidity attributable to that intervention, but exclude any additional costs (health care, food, clothing, etc.) arising from added life years. The opposing view, generally associated with Weinstein (1980), Drummond et al. (1987), Garber and Phelps (1997) and Meltzer (1997), is that all health care costs, including those incurred in added life years, should be included. Of particular importance are health care costs that are incurred when an intervention extends life expectancy. For example, if a person gains extra years of life from the prevention of a stroke, then the cost of treating other diseases such as cancer that may arise over this period should be included when evaluating an intervention to prevent stroke.

While substantial body of theoretical work has been undertaken to justify the inclusion of unrelated health care costs in cost-effectiveness analysis (e.g. Garber and Phelps, 1997, and Meltzer, 1997), the development of reliable methods to estimate future lifetime health costs have received comparatively little attention. In part, this may be due to the complexity of modeling changes in risk and cost associated with the prevention, or treatment of disease. There are four potential types of risk associated with a health-related event. Firstly, there is the risk directly associated with the occurrence of the event. For example, if a person has a heart attack they have a probability of immediate death. Secondly, the occurrence on an event may change the risk of future events. For example, a person who has had a heart attack has a higher risk of future heart attacks and possibly other types of vascular events such as stroke. Thirdly, a reduction in risk from eliminating an event of a particular kind may increase the risk of other kinds of events, because people who live longer have more time to develop other diseases. Fourthly, when risks are a function of age the prevention of a particular event may alter the risk of subsequent events. For example, the widespread use of a vaccination for varicella (chicken pox) may result in some unimmunized individuals having the disease in adulthood which carries a much higher risk of death than in childhood. Health care costs are also likely to depend on a range of factors such as type of event, the age and gender of an individual as well as number and type of co-morbidities and their disease history.

The purpose of this study is develop a simulation model to estimate lifetime medical and hospital costs associated with the prevention of three categories of disease at different ages. The categories are (i) vascular disease; (ii) cancer; and (iii) other diseases. The two former categories constitute the two leading causes of deaths in Australia and are major contributors to health care costs and the burden of disease (Access Economics, 2005).

The study uses administrative data from Western Australian on people with diagnosed diabetes to derive empirical estimates of the changes in life expectancy and changes in lifetime health care costs associated with the prevention of cancer or a vascular disease.

Background

Australia has a national tax financed health insurance system (Medicare) that covers a defined list of benefits including consultation fees for doctors and specialists as well as radiology and pathology services. Patients admitted to a public ward of public hospitals have zero out-of-pocket

costs. Voluntary private insurance can be purchased to cover the cost of treatment and accommodation as a private patient in hospital.

Data

This study uses administrative data from the Australian state of Western Australia (WA) on people with diagnosed diabetes. The data cover a 10-year period from 1 January 1990. The data combine information from four separate sources: (i) hospital records of inpatient episodes (including day-only admissions) for public and private hospitals; (ii) Medicare insurance claims for medical and diagnostic services which include type of service, the amount claimed, out-of-pocket costs, and the postcode of the service provider; (iii) information on prescriptions for pharmaceuticals by drug type and dose; and (iv) WA death records.

People with diagnosed diabetes were identified using any of the following criteria. If they had: (i) used a prescription for a diabetes-related medication; (ii) claimed for an HbA_{1c} test; or (iii) been admitted to hospital with a primary or secondary diagnosis of diabetes (defined as ICD9 250); or (iv) died and diabetes was listed as a cause on their death certificate. Over the 10 year period a total of 112,851 people were identified with diagnosed diabetes using one or more of these criteria. Our preliminary analysis focuses on the 54,868 male subjects. They had 344,458 hospitalizations and 3,187,242 Medicare services (outside hospital) over the 10-year period. Other descriptive statistics are listed in Table 1.

We divide all episodes of hospitalization into three categories of disease based on the principal diagnosis recorded in the hospital discharge records from WA. These are defined using the 9th revision of the International Classification of Diseases (ICD9) system:

- (i) Vascular disease comprises all forms of vascular disease (ICD9 codes 390–459), including myocardial infarctions, heart failure and stroke.
- (ii) Cancer comprises all forms cancer (ICD9 codes 140–239), including skin cancer.
- (iii) Other diseases comprises any disease requiring hospitalization not listed above.

In this period in Australia, all hospital admissions, including episodes of day surgery, were classified into Diagnostic Related Groups (DRG). These groups are intended to reflect episodes with similar average levels of resource consumption. Official DRG cost weights are published at the national and state level for each year since 1992. Separate cost weights are published for public and private hospitals. The cost weights for public hospitals cover all expenses, including accommodation, drugs, medical services etc. The costs for private hospitals exclude fees for medical services, which are covered under Medicare.

To cost inpatient health care usage, we use the national DRG cost weights to assign a cost to each episode. For episodes at private hospitals, we add the Medicare costs incurred while in hospital to the DRG cost weight to reflect total resource use. To cost non-inpatient usage of medical services including pathology and diagnostic services (but not pharmaceuticals), we combine the information in the Medicare records about the patient's out-of-pocket expenses and the insurance benefits to calculate the costs for each person in each month. We then aggregate the total costs of inpatient and non-inpatient health care by year and convert the amount into 1999 Australian dollars using the GDP price deflator on general goods and services.

An important feature of the data is that while Medicare records cover use of services anywhere in Australia, the hospital data cover only to episodes within WA. Hence subjects who migrate into or from WA or who travel interstate are not “under observation” while they are outside WA. Fortunately, the Medicare and Pharmaceutical Benefits Scheme records contain information on the postcode of provider, which we use this to determine periods not under observation.

Methods

Estimating hazard of hospital events and death

Parametric methods for risk estimation have previously been applied in modeling the occurrence of each type of hospital episode (i.e. vascular events, cancer and other events). In this analysis, we assume time at risk begins at birth so that analysis time, t , is equals to the patient’s age. To model the individual hazard of a hospital event or death at time t , we use proportional hazards models of the form $h_j(t | x_j(t)) = h_{j0}(t) \exp(x_j(t)' \beta_j)$, where j indicates the risk type, $x_j(t)$ is a vector of possibly time-varying covariates, and β_j the corresponding coefficients. For hospital events, we assume a Weibull baseline hazard function, $h_{j0}(t) = \lambda_j \gamma_j t^{\gamma_j - 1}$, where γ_j is a shape parameter and λ_j is a scale parameter (or $\lambda_j = \exp(\beta_{j0})$ where β_{j0} is the intercept of the regression). For death, we assume a Gompertz baseline hazard function, $h_{j0}(t) = \lambda_j \exp(\phi_j t)$, where ϕ_j is a shape parameter and λ_j again is a scale parameter. The Gompertz function is widely used to model mortality.

The variables included in $x_j(t)$ are indicators of the elapsed time since the previous vascular event (if any) and the previous cancer event (if any), as well as an indicator of ever having been hospitalized for other reasons. The elapsed time is represented by indicators of whether the previous event occurred less than 1 year ago, between 1 and 2 years ago, 2 and 3 years ago, 3 and 4 years ago, 4 and 5 years ago, or more than 5 years ago. To allow for previous events to affect the risk differently at different ages, these indicators are interacted with dummies representing 10-year age groups. As it turns out, previous cancer event do not significantly affect the risk of a vascular event and vice versa, and consequently we have dropped these cross-event variables from the models.

In this version of the paper we assume that no one experienced any events before they were first under observation; that is, prior to 1 January 1990. At the end of the paper we indicate how we intend to solve the problem of missing covariates. Estimates of the hazards associated with of the hazard ratios, $\exp(\beta_j)$, are reported in table 2.

Estimating costs

Typically, within a defined period of time (e.g. one year) a significant proportion of individuals have no contact with health care providers and so incur no costs. However, amongst the individuals who do make use of health services, the distribution of costs is frequently highly skewed due to the presence of a relatively small number of individuals incurring very high health care costs (Mullahy, 1998).

To model these data we employ two approaches. Firstly, to aid interpretation we estimate a linear model with random effects using generalized least squares (GLS) regression. Secondly, we estimate a generalized linear model (GLM) with a logarithmic link function using estimating

equations (GEE), or generalized method of moments (GMM), techniques. This type of estimator is now commonly used in the analysis of health care cost data (Manning and Mullahy, 2001).

The linear model is of the form $c_{it} = z_{it}'\delta + u_i + v_{it}$, where c_{it} are the total hospital or Medicare costs for the i th patient in year t of the study, z_{it} is a vector of explanatory variables representing previous events, u_i an unobservable individual-specific effect with zero mean and variance of σ_u^2 , and v_{it} is an unobserved variable with zero mean and variance of σ_v^2 . It is assumed that u_i and v_{it} are normally distributed and independent of other variables. The generalized linear model is of the form $c_{it} = \exp(z_{it}'\delta) + u_i + v_{it}$, where the symbols are as just defined except that $u_i + v_{it}$ is assumed to be gamma distributed.

For hospital costs, z_{it} includes age-specific indicators of whether the patient had an event in year t . Separate indicators are included for each of the three types of events, and the effect on costs is allowed to vary with age by interacting these indicators with dummies representing 10-year age groups. For Medicare costs, z_{it} includes the same set of variables as well as six variables which represent long-term effects. Specifically, the additional variables are indicators of whether the patient had a vascular event or a cancer event one year ago, two years, or three years ago.

The estimated coefficients are reported in Table 3.

Simulating outcomes

The main purpose of the model is to estimate the change in life expectancy and the change in lifetime health care costs resulting from the prevention of vascular disease or cancer at different ages. Analytical computation of expected outcomes is not feasible. Instead we compute expected outcomes by averaging over a large number of simulated outcomes. The simulations are based on the previously estimated equations and a probabilistic discrete-time illness-death model (Hougaard, 2001) with annual cycles. The probability of an event of a particular type happening in a particular year can be estimated using the estimated proportional hazard models in Table 2 and the patient's history of event in previous years. Specifically, if $x_j(t)$ is constant between t and $t+1$, then the probability of event j happening in the year between t and $t+1$ is $1 - \exp(H_j(t|x_j(t)) - \exp(H_j(t+1|x_j(t))))$, where $H_j(t|x_j(t))$ is the hazard function integrated from 0 to t .

Figure 1 shows the algorithm for simulating lifetime outcomes for a given patient. To begin, the patient's age and history of previous vascular events, cancer and other diseases are set. The probability of hospitalization with any of the three diseases and the probability of death are then computed using the above formula and the parameter estimates listed in Table 2. Each probability is compared with a random number drawn from a zero-one uniform distribution to determine whether a hospitalization or death occurs in that year. If the patient survived the year, the patient is aged by one year and his/her history variables are updated to reflect both the aging and any events that took place during the year (if any); the simulation procedure is then repeated for next year. If the patient died, the simulation ends and the patient's expected cumulative health care costs are calculated using the estimated cost relationship given in Table 3.

The Monte Carlo error (the differences between individual simulations that are due to chance rather than uncertainty in the parameter estimates) is removed by averaging results across 1000 identical patients.

Illustrative simulations

This type of simulation model has many potential applications. We undertake two such simulations to provide an indication of the scope of the type of questions it can address. For the sake of brevity only costs estimated using OLS have been used in the following simulations, as the GLM cost equations produced similar results.

Simulations involving the prevention of a single event

We simulate hypothetical outcomes for patients of a given age with a given history of previous events. For example, we compare expected outcomes for a 50-year-old patient who had a *single* vascular event at age 49 with the expected outcomes for a 50-year-old patient with no previous events; the difference indicates the change in expected outcomes by preventing a vascular event at age 49. This facilitates estimation of the full economic cost and benefits associated with preventing such an event.

Figures 2a and 2b present the proportion of patients surviving over time and illustrates the different impact of a single vascular disease and cancer event has on survival at 40 and 80 years of age. Figure 3a and 3b shows hospital costs over time. Figure 4a and 4b illustrates Medicare costs over time. The effect of preventing a single hospitalization continues over 8 year period due event related dependence.

Preventing a hospitalization for vascular disease, or cancer has a greater impact on survival for individuals aged 80 years (see Figure 2b). This could be due either to these individuals having more severe types of vascular/ cancer events, or the risk of death for any particular type of event being age related.

In regard to costs, the effect of having an event differs by age. For example, increased hospital costs of a vascular or cancer event continue for up to eight years in 40 year old and only four in an 80 year old. In regard to the latter, it is clear that for vascular disease, the annual average hospital cost is lower for those having an event than for controls due to the lower rate of survival. Hence, in an economic analysis, if one was interested in estimating the difference in all hospital costs, the theoretical work of Meltzer (1997) and others suggests that the “savings” that result from premature death should be taken into account when calculating incremental costs. However, our preliminary estimates would appear that these costs are relatively modest, which may take some of the heat out of the debate surrounding what types of future health care costs should be included in economic evaluations.

The (undiscounted) lifetime hospital and Medicare costs are summarized in Table 4. For example, the estimated average lifetime health care cost (1999 Australian dollars) of a patient who has any type of vascular disease at age 40 is \$159,458 and for cancer it is \$155,458. These costs are 8% and 6% respectively higher than controls. Health care costs for other age groups are also reported in Table 4.

Simulations involving the a change in risk

New therapies and interventions mainly act by reducing the relative risk of disease. To examine how the model can be used to simulate the potential benefits of this type of intervention we assume a hypothetical group of patients receive two different types of therapy. Firstly, a therapy that reduces the risk of all vascular events for males aged 40 years over their remaining lifetime by 30%. This magnitude of risk reduction is not purely hypothetical, as recent trials have demonstrated statin therapy has a benefit of about this size (Heart Protection Study Group, 2003). We compare the effect of this risk reduction with a hypothetical therapy that reduces the risk of all types of cancer by 30%.

Figure 5a and 5b shows the cumulative incidence of vascular and cancer events for the three groups. Interestingly, individuals whose vascular risk is reduced have a higher incidence of cancer events illustrating the effect of competing risks (i.e. those who vascular risk is reduced will live longer and hence have more time to have a cancer event). These reductions in risk translate into gains in life expectancy of 1.51 years and 0.93 years for vascular disease and cancer respectively over a control group whose life expectancy is 35.94 years.

Figure 6a and 6b show the profile of hospital and Medicare costs over the patients remaining lifetime. The greatest scope for reducing health care costs would appear to be associated with reducing the risk of vascular disease. Over a lifetime, individuals with a 30% lower vascular risk incur around \$8000 less in health care costs (undiscounted), while those with 30% reduction in cancer only reduce health care costs by around \$2000 (undiscounted).

Conclusions and future plans

The increasing availability of linked administrative health information suggests that there is great potential for developing simulation models for estimating costs and benefits of treating various types of diseases that are based on large individual level data sets. Such models differ from the traditional Markov type model in that they can potentially incorporate the risks associated with a complex history of different types of events. Such complex modeling is likely to be required if one is interesting incorporating “lifetime costs” and benefits into economic evaluations. This is particularly relevant, when estimating health care costs incurred in the extra years of life that may results from an intervention.

In this study we have developed such a model using a hospital events, Medicare records and mortality information on 54,868 males with diabetes. We have then illustrated how the simulation model can be used to simulate the full economic cost (and benefits) of preventing either a vascular, or cancer event and the potential benefits from reducing the lifetime risk of vascular disease and cancer in this population. Note these estimates should be regarded as pertaining only to people with diabetes, as they have a much higher vascular risk than most people in the general population.

It would appear from our initial work that competing risks, event-related dependence and age-related risk play have an important influence in determining the lifetime health care costs of both vascular disease and cancer. We must stress that the model presented here represents a first cut at the problem and we are likely to undertake many refinements and improvements including:

- Refine the specification of history variables in the hazard models. This will be guided by additional descriptive to statistics (and graphs) on the hazard rates, focusing on first and subsequent events and the possibly of simultaneous events.
- Investigate means of alleviating the problem of missing explanatory variables due to left-censoring. One approach is to estimate the model for years 1995–1999 only; this would work if lagged duration dependence is negligible after 5 years. Another approach is to use all years and integrate out the missing information using simulation methods.
- Compare the current discrete-time simulation model with direct simulation of the estimated continuous-time hazard models.
- Refine the cost equation, perhaps try to model “autocorrelation” in the severity of events, where severity is approximated by costs. Compare assigning expected costs to events with simulating actual costs.
- Estimate of models with random effects to investigate the sensitivity of the conclusions to unobserved heterogeneity.

Our work has only just begun!

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Table 1: Descriptive statistics (54,868 males)

Variable	Statistic
Age category	
Under 40 years	17.0 %
40-50 years	18.73 %
50-60 years	21.79%
60-70 years	22.52%
70-80 years	14.15%
80+ years	5.8%
Proportion having a vascular event	36 %
Proportion having a cancer event	19 %
Proportion hospitalised for other reasons	90 %
Proportion using Medicare services outside WA	19 %
Proportion who died	13 %
GP Consultations: Mean (SD)	75.41 (765.45)
Hospital events: Mean (SD)	4.75 (20.66)

Table 2: Estimated hazard ratios for males at various ages (54,868 males)

Age group	Time since event	Vascular events (n=41,955)		Cancer	Other events (n=202,142)		Death (n=8,102)	
		HR	Z score		HR	Z score	HR	Z score
Vascular events								
40 years	Within previous year	20.56	99.62	-	3.88	84.13	21.68	24.6
	One to two years	5.67	24.8	-	4.01	56.73	5.51	5.59
	Two to three years	3.56	11.91	-	2.38	22.5	4.81	4.11
	Three to four years	2.94	7.52	-	2.21	17.08	4.45	3.3
	Four to five years	2.53	4.91	-	2.59	20.23	5.77	3.48
	Five or more years	2.47	5.42	-	1.79	12.55	8.17	5.49
50 years	Within previous year	13.11	126.96	-	3.75	100.96	9.84	29.96
	One to two years	3.77	29.34	-	3.07	61.73	3.01	6.87
	Two to three years	3.09	18.96	-	3.19	55.52	2.33	3.82
	Three to four years	3.23	16.87	-	2.28	28.82	1.41	1.09
	Four to five years	2.66	10.59	-	1.64	11.92	1.99	2.05
	Five or more years	2.13	8.74	-	1.16	3.49	2.86	4.4
60 years	Within previous year	10.49	148.47	-	3.34	110.2	7.88	47.1
	One to two years	3.11	33.4	-	2.30	50.6	2.05	7.33
	Two to three years	2.54	21.01	-	2.44	46.63	2.29	7.45
	Three to four years	2.30	14.98	-	2.33	37.3	2.09	5.4
	Four to five years	2.62	15.17	-	1.67	15.65	2.15	4.67
	Five or more years	1.92	10.49	-	1.22	5.99	1.97	4.76
70 years	Within previous year	7.94	117.98	-	3.06	97.13	6.53	52.48
	One to two years	3.01	33.44	-	2.05	42.62	1.98	9.5
	Two to three years	2.30	18.53	-	1.96	31.75	1.85	6.86
	Three to four years	2.01	12.14	-	1.10	3.5	1.68	4.76
	Four to five years	1.96	9.61	-	2.21	27.12	1.93	5.13
	Five or more years	1.68	8.29	-	1.61	18.21	1.33	2.24
80 years	Within previous year	6.54	73.18	-	3.67	72.71	5.85	40.69
	One to two years	2.75	20.46	-	2.63	35.28	2.21	9.98
	Two to three years	2.35	13.21	-	2.56	28.26	1.96	6.71
	Three to four years	2.03	8.39	-	2.28	19.99	2.10	6.44
	Four to five years	1.86	5.8	-	2.67	21.14	1.61	3.04
	Five or more years	1.47	3.77	-	1.99	14.96	1.51	2.98

Table 2 (Continued): Estimated hazard ratios for males at various ages (54,868 individuals)

Age group	Time since event	Vascular events	Cancer (n=17,319)		Other events (n=202,142)		Death (n=8,102)		
			HR	Z score	HR	Z score	HR	Z score	
Cancer events									
40 years	Within previous year	-	35.50	58.09	3.92	44.12	21.35	18.43	
	One to two years	-	6.71	11.82	1.88	12.16	1.36	0.43	
	Two to three years	-	5.75	8.71	2.04	12.1	0.95	-0.05	
	Three to four years	-	5.14	6.53	2.09	10.45	0.00	-0.09	
	Four to five years	-	3.21	3.08	1.28	2.29	3.73	1.86	
	Five or more years	-	2.25	2.14	1.16	1.63	4.25	2.49	
50 years	Within previous year	-	27.78	92.91	4.01	73.08	19.13	35.71	
	One to two years	-	6.76	22.23	2.01	21.12	1.26	0.65	
	Two to three years	-	4.88	13.38	1.37	6.95	1.41	0.91	
	Three to four years	-	4.04	9.13	1.71	11.27	1.55	0.97	
	Four to five years	-	2.35	3.62	1.89	11.98	0.80	-0.32	
	Five or more years	-	1.50	1.66	1.05	0.8	1.37	0.71	
60 years	Within previous year	-	23.33	128.32	4.34	106.56	12.64	53.52	
	One to two years	-	6.68	34.75	2.14	32.63	1.77	3.98	
	Two to three years	-	4.10	17.30	1.67	17.9	1.26	1.19	
	Three to four years	-	3.54	12.12	1.40	8.87	1.23	0.89	
	Four to five years	-	2.00	4.20	1.09	1.64	1.96	2.98	
	Five or more years	-	2.23	6.14	1.05	0.98	1.43	1.66	
70 years	Within previous year	-	17.49	111.48	3.33	79.87	7.05	48.44	
	One to two years	-	5.98	35.12	2.23	33.02	1.69	5.46	
	Two to three years	-	3.89	18.33	1.92	21.06	1.09	0.57	
	Three to four years	-	3.05	11.65	2.52	29.95	0.95	-0.31	
	Four to five years	-	1.90	4.53	1.67	13.63	0.95	-0.24	
	Five or more years	-	1.57	3.37	1.25	5.87	1.19	1.09	
80 years	Within previous year	-	11.25	57.46	2.94	43.83	3.79	24.54	
	One to two years	-	4.37	18.10	2.40	26	1.22	1.74	
	Two to three years	-	2.91	9.21	2.06	16.96	1.38	2.56	
	Three to four years	-	2.25	5.46	1.54	7.82	1.03	0.19	
	Four to five years	-	2.12	4.22	1.42	5.3	1.26	1.34	
	Five or more years	-	2.27	5.62	1.59	8.88	1.29	1.78	
History of other events		1.00	15.7	1.00	13.12	1.01	492.	1.00	7.05
Parametric form		Weibull	Weibull	Weibull	Weibull	Weibull	Gompertz		
Γ		3.42	132.2	3.66	99.42	1.14	21.45		
Φ								0.10	62.73

Table 3: Health care cost equations

Age group	Time since event	OLS				GEE			
		Hospital costs		Medicare costs		Hospital costs		Medicare costs	
		β	<i>t</i> stat	B	<i>t</i> stat	β	<i>t</i> stat	β	<i>t</i> stat
Vascular events (year of event)									
40 years		5431	22.63	1198	24.34	0.677	6.36	0.505	18.89
50 years		5322	30.68	1049	32.64	0.722	11.68	0.516	27.09
60 years		6063	42.80	982	39.99	0.854	15.64	0.454	29.35
70 years		6380	41.22	582	21.28	0.864	12.47	0.318	17.75
80 years		5465	23.01	528	11.06	0.759	7.13	0.252	8.49
Cancer events (year of event)									
40 years		2784	6.97	658	22.2	0.491	13.74	0.695	15.66
50 years		3623	13.73	796	37.74	0.593	20.44	0.568	19.59
60 years		3863	19.64	753	43.94	0.595	29.96	0.528	23.81
70 years		3334	15.86	457	23.08	0.497	28.74	0.379	15.32
80 years		2749	8.08	345	10.51	0.452	16.64	0.346	8.01
Other events (year of event)									
40 years		1644	12.94	385	26.76	0.110	3.42	0.332	25.53
50 years		2135	18.57	481	38.7	0.222	8.00	0.342	30.46
60 years		2634	24.78	523	45.97	0.363	14.76	0.343	33.38
70 years		3375	29.19	345	25.31	0.511	19.14	0.255	20.6
80 years		3455	21.02	287	12.43	0.578	14.64	0.226	10.75
Vascular event (1 year ago)				214	21.95			0.171	19.39
Vascular event (2 years ago)				100	9.84			0.091	9.92
Vascular event (3 years ago)				110	10.26			0.092	9.53
Cancer (1 year ago)				231	15.85			0.172	13.03
Cancer (2 years ago)				108	6.93			0.085	6.05
Cancer (3 years ago)				115	6.96			0.091	6.09
Constant		2737	35.59	907	207.1	8.108	440.88	6.816	1663
R ²		0.05		0.09					

Table 4 Simulated life expectancy and lifetime health care costs by age and disease status (undiscounted and 1999 \$Aus)

Age group	Disease group	Hospital costs	Medicare cost	Total costs	Life expectancy (Years)
40 years	Control	84,491	62,938	147,429	34.92
	Vascular	94,896	64,563	159,458	33.86
	Cancer	90,829	64,915	155,745	33.95
50 years	Control	74,430	51,842	126,272	25.63
	Vascular	82,367	53,904	136,271	24.44
	Cancer	80,533	53,944	134,478	24.70
60 years	Control	62,186	38,304	100,490	18.38
	Vascular	69,666	40,115	109,781	16.29
	Cancer	64,497	40,101	104,598	16.05
70 years	Control	44,874	24,074	68,948	11.39
	Vascular	54,260	25,350	79,610	10.07
	Cancer	48,801	25,234	74,035	9.28
80 years	Control	26,062	13,437	39,500	6.94
	Vascular	31,909	14,260	46,170	4.99
	Cancer	31,036	14,691	45,727	5.83

Figure 1

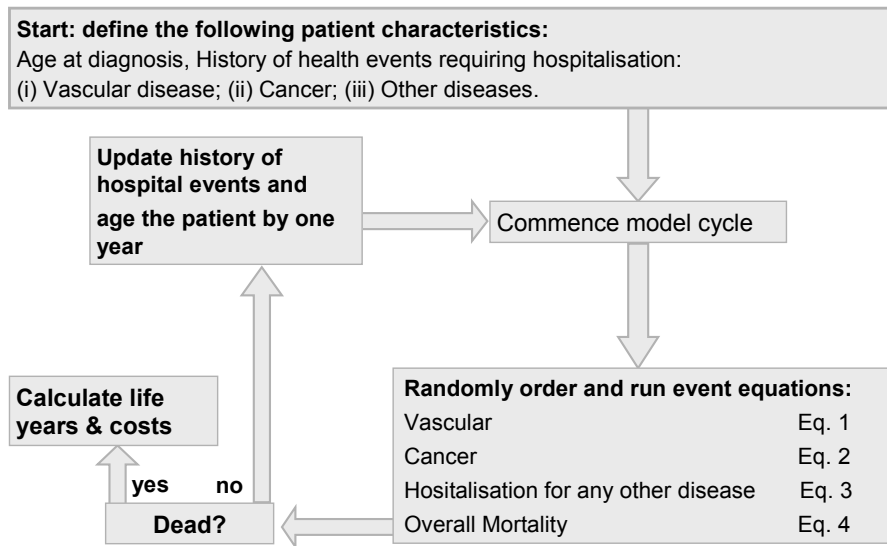


Figure 2a

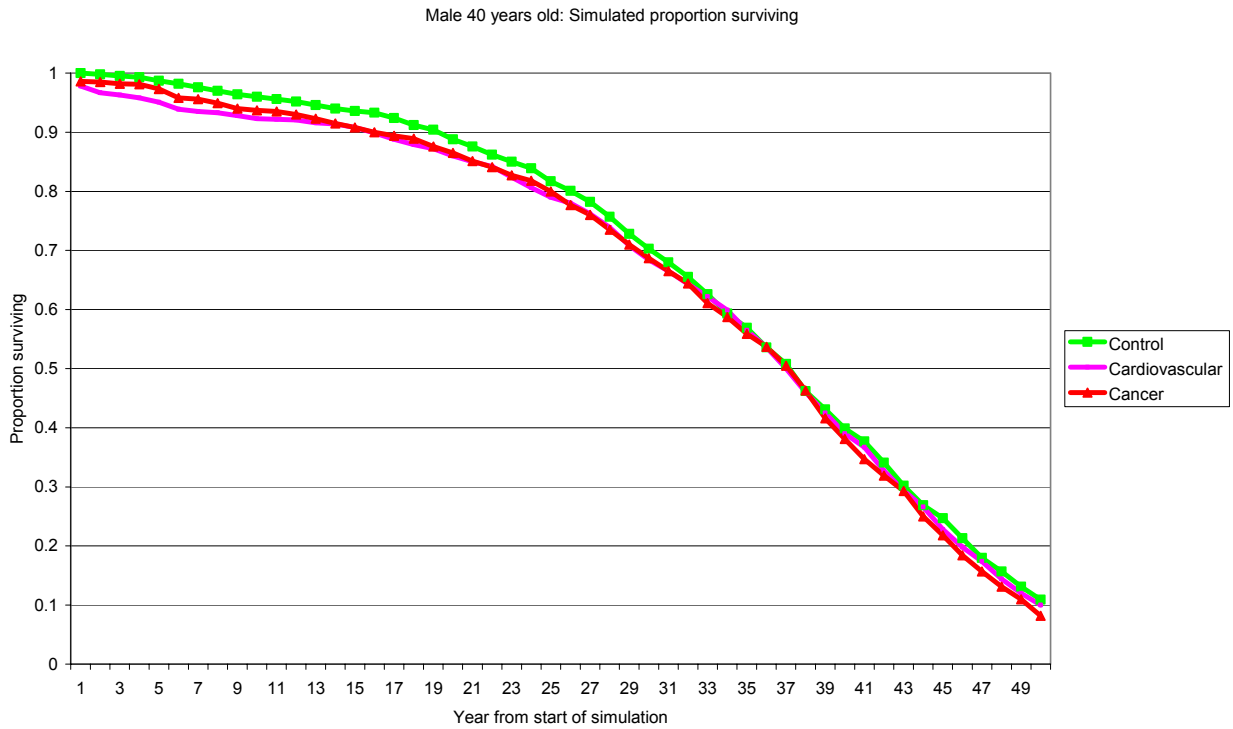


Figure 2b



Figure 3a

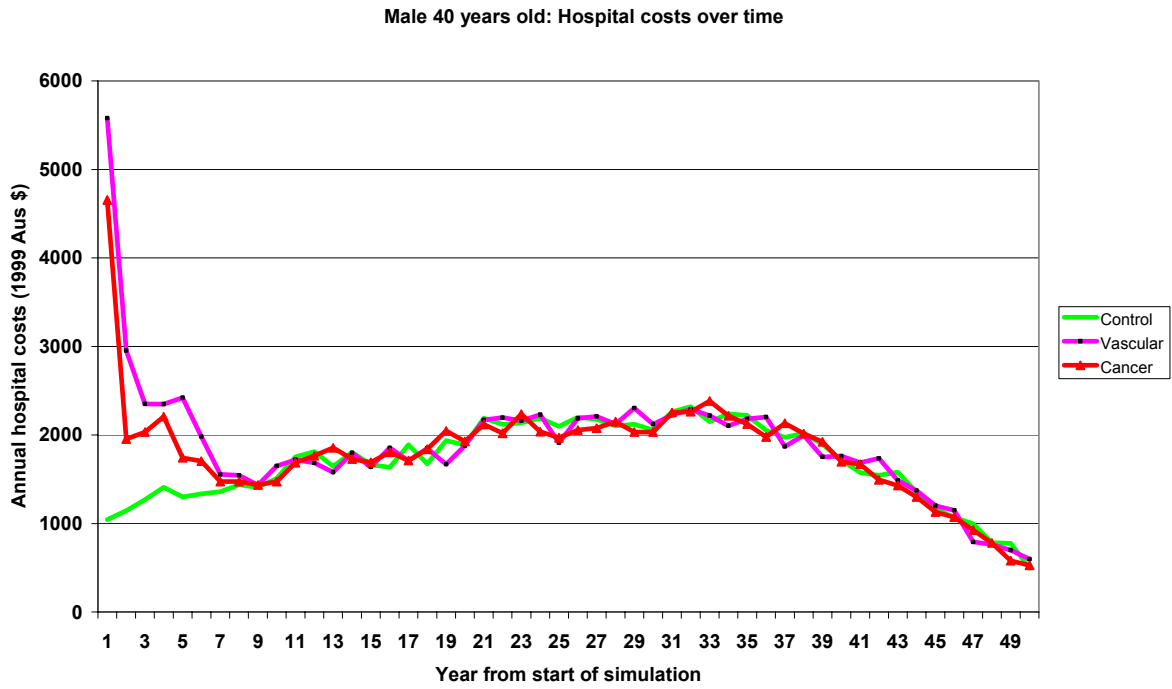


Figure 3b



Figure 4a

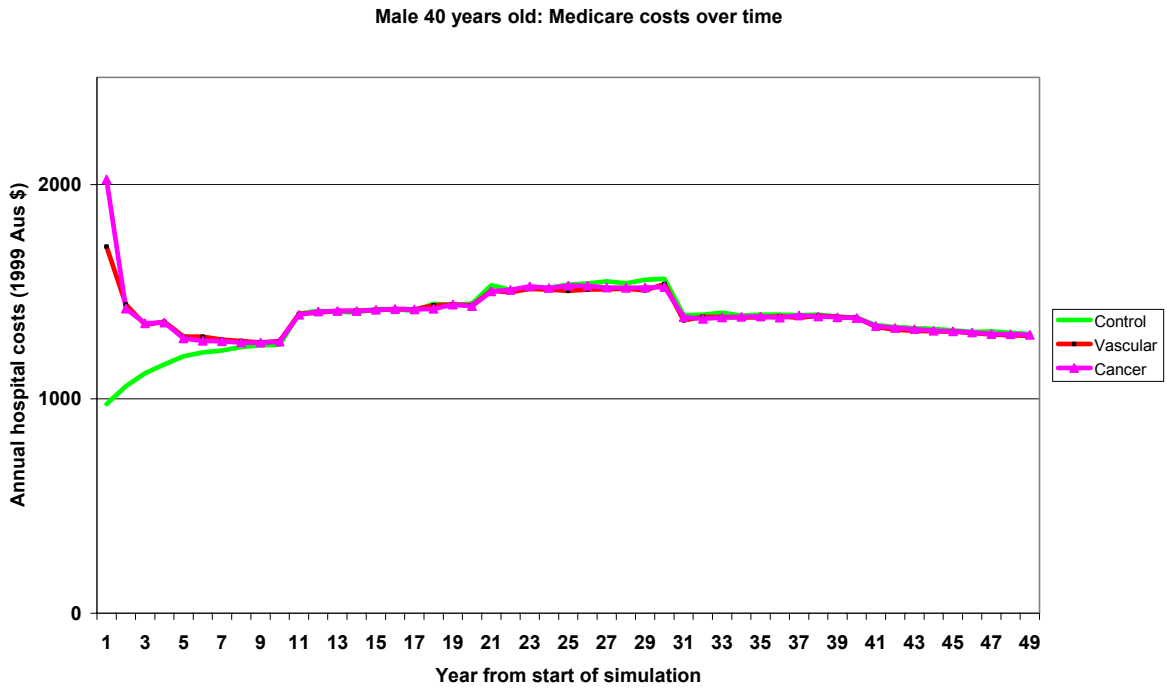


Figure 4b

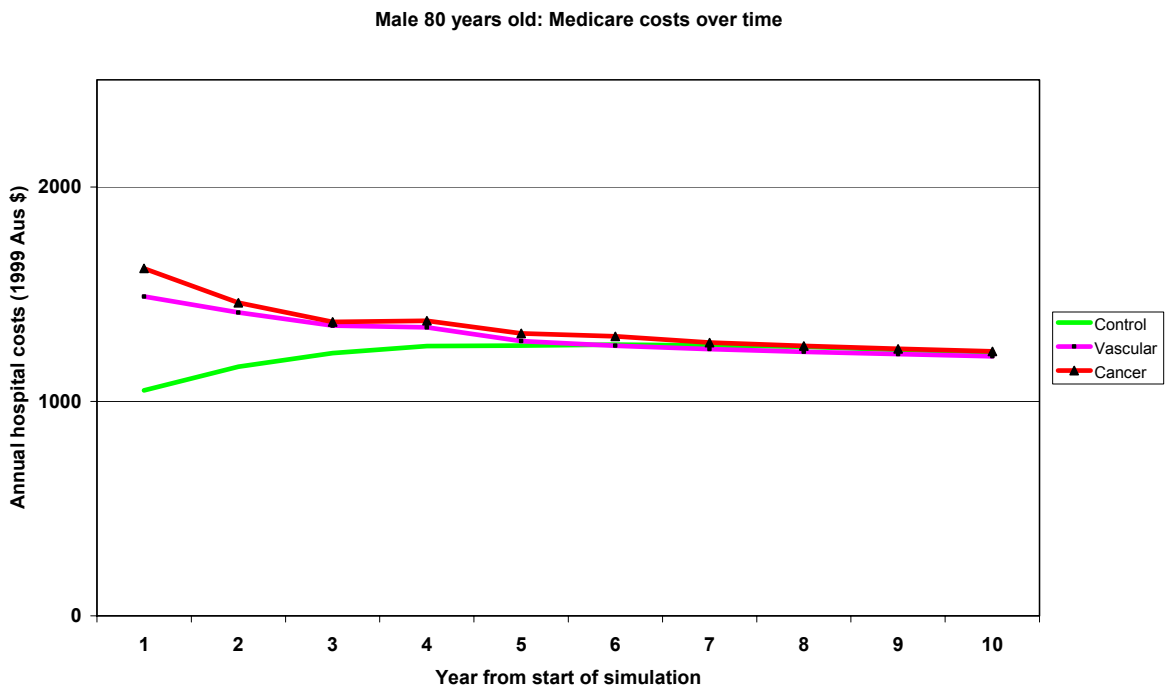


Figure 5a

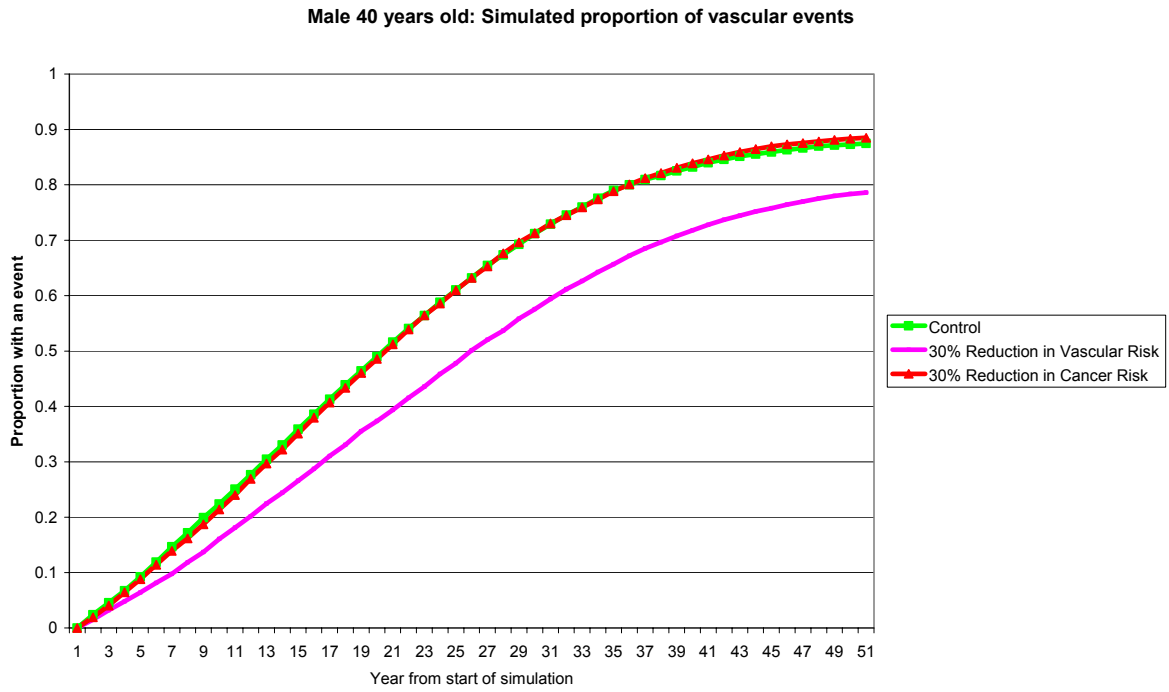


Figure 5b

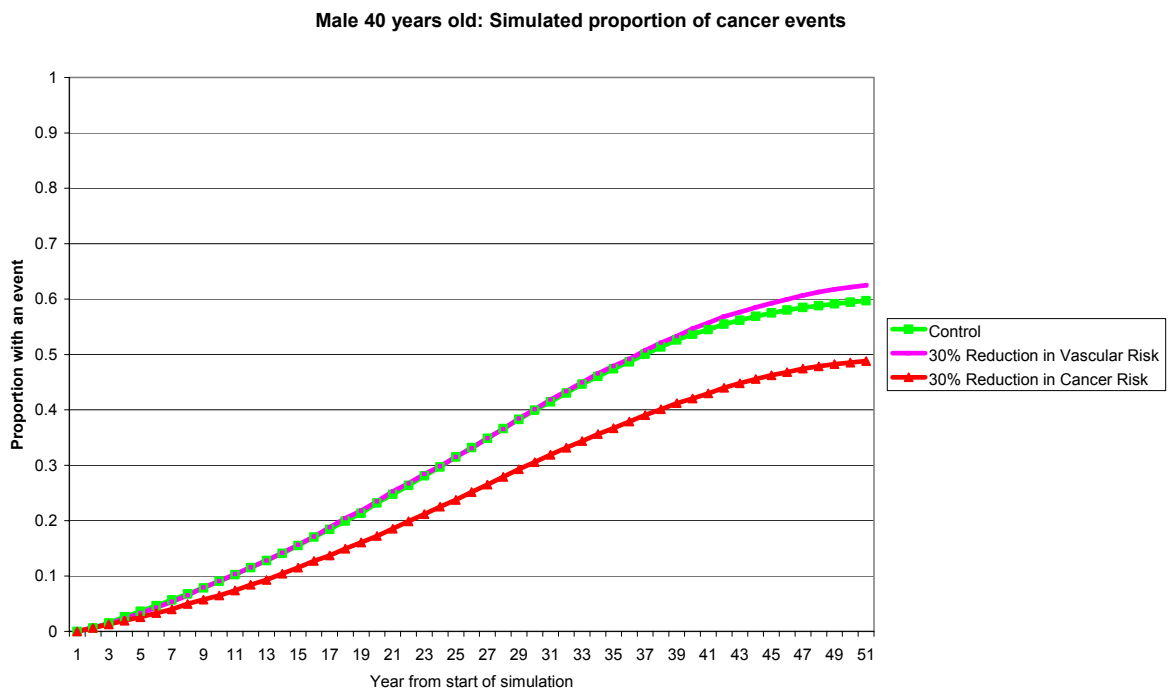


Figure 6a

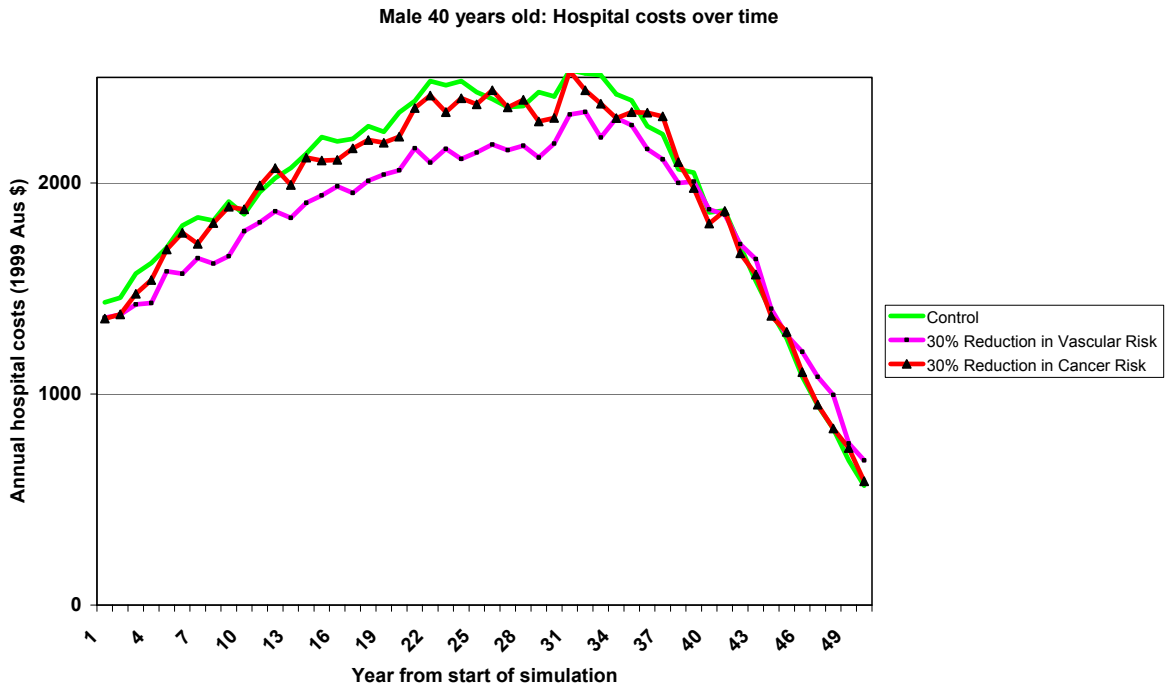


Figure 6b

