Practical Example of a Split Benefit Accelerated Critical Illness Insurance Product

ICA2010 Reference Number 33

Anton Brink, Ph.D.

RGA UK Services Limited, 16th Floor, 5 Aldermanbury Square, London EC2V 7HR **T:** +44 20 7710 6831 **F:** +44 20 7710 6890 e-mail:abrink@rgare.com

Abstract

The paper proposes a new multi-state modelling framework for a general buy-back accelerated critical illness (ACI) product. This product allows the insured to receive a critical illness benefit payable on each of two occasions, when one of the ACI qualifying treatments is satisfied, rather than only once as in the standard ACI product. The additional premium cost of this general buy-back product is illustrated for different ages and different proportions of buy-back benefit reinstated, compared to a standard ACI product.

Further examples are provided which take into consideration that only certain qualifying CI conditions are to receive a reinstatement. By introducing another state for the remaining non-qualifying CI conditions in this model, we can allow for the higher subsequent incidence rate to be considered for these conditions. Finally, an example of a particular exclusion from an otherwise qualifying CI condition is provided.

Keywords: Accelerated Critical Illness, Buy-Back Model, Cancer Model, Morbidity, Multi-State Modelling

Introduction

The following paper uses a large U.K. private medical insurance (PMI) database to provide practical applications of a new split benefit accelerated critical illness (ACI) product.

Please note that this paper is not intended to be used as a guide to current pricing of ACI products. Differences in underwriting and claims handling of PMI policyholders compared to ACI policyholders mean that this not viable. However, we still wished to illustrate, albeit with imperfect data, the possibilities of a new product that pays a fixed benefit on meeting one of a number of qualifying CI conditions on the first and second incidence, or on earlier death.

The purpose of the product is to overcome the main limitation of the standard ACI product, which is that only a single claim can be made on the first incidence. If such a claim occurs, then any further coverage required is very expensive to reinstate or requires the exclusion of the CI condition causing the claim. The reason for the high cost is that the claimant is perceived to be at a higher risk of further incidences or of earlier death, in comparison to a healthy policyholder. This problem would not exist if the required reinstatement or "buy-back" had been purchased in advance at policy inception for a small additional amount. This is equivalent to splitting the benefit between a 1st and 2nd incident, with an equal benefit split providing a full "buy-back".

Our interest is in determining the additional "buy-back" premium required at inception for a healthy policyholder, relative to the corresponding premium for a model with no "buy-back". We shall illustrate this with an example for each of the following scenarios:

Scenario I: **General Buy-back Model**
A general "buy-back" option at inception that allows the policy holder to reinstate their ACI coverage automatically following a qualifying event, thus allowing a further benefit payment on a 2nd incident for any of the original ACI conditions.

Scenario II: **General Restricted Model**
A product with a restricted list of qualifying conditions for the benefit payment both on the 1st and 2nd incidence. We shall allow for the possibility of any intermediate non-qualifying conditions (which may increase the subsequent incidence of the qualifying condition) before payment of a qualifying condition (with no reinstatement in this situation).

Scenario III: **Exclusion Model**
The previous scenario, but allowing for the exclusion of a particular sub-category of an otherwise qualifying CI condition, e.g. a cancer only product excluding breast cancer.

Scenario I: General Buy-back Model

In our general "buy-back" model we shall extend the standard ACI model to allow the healthy policyholder to pay an additional premium at inception that provides automatic reinstatement of ACI coverage should any of the qualifying CI conditions be satisfied.

As only a small proportion of healthy policyholders are likely to claim for a 2nd qualifying condition (which we have denoted by 2nd post incident state *B*) this additional premium should be small when compared to a policyholder applying for reinstatement after the 1st qualifying condition (which we have denoted by 1st post incident state *A*).

We have used the term "incident" throughout this paper to mean "claim occurrence".

We can denote the possible policyholder states by extending the multi-model CI framework of Dash and Grimshaw (p. 163, 1990) to include our state *B* as shown in Figure 1 below.

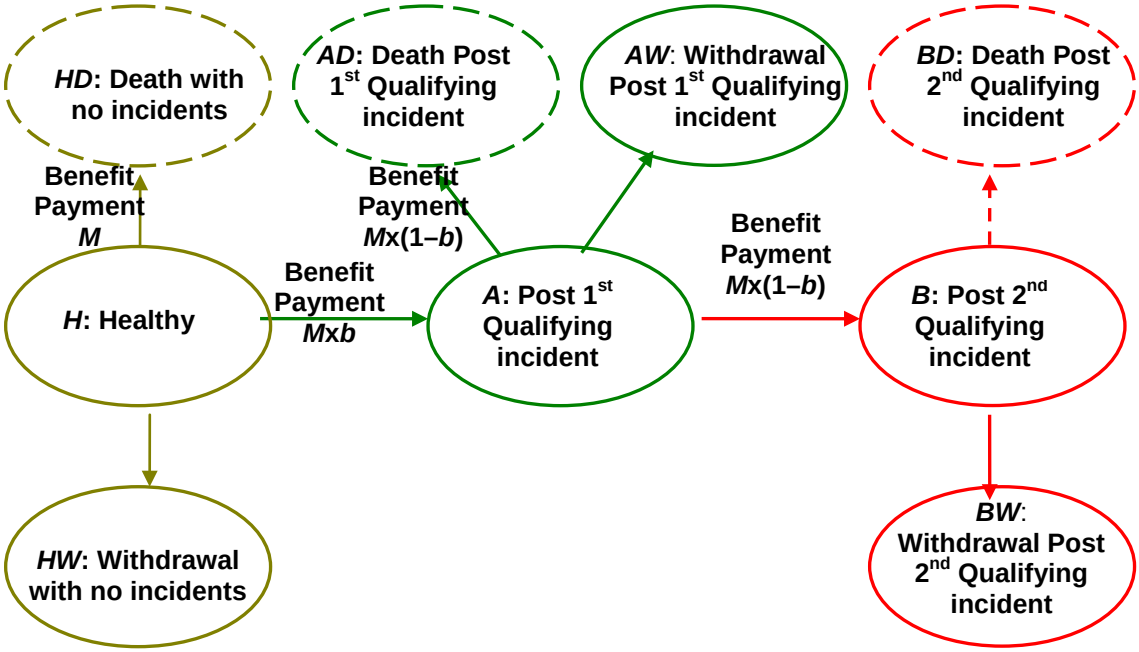

Figure 1: Extended accelerated critical illness model showing the usual healthy state *H* and post 1st incident state *A* in green and introducing a 2nd incident state *B* in red. For completeness, the corresponding absorbing death states *HD, AD, BD* (dotted lines) and for the withdrawal states *HW, AW* and *BW* are also shown.

Figure 1 shows all the possible transitions for a policyholder out of the healthy state *H*.

Our interest is in those transitions that lead to a benefit payment following satisfaction of either the first or second qualifying CI condition. In addition, for an ACI product we are also interested in payments on death from any state (indicated by the dotted circles).

We have split the benefit payment amount £*M* into a first payment £*M* x *b* and a second payment £*M* x (1-*b*), where the proportion *b* payable on first benefit satisfies $0 \leq b \leq 1$. In addition, we

have assumed that the death payment is equal to the remainder of the unpaid benefits, so that the policyholder has always received a total accumulated benefit payment of £*M* on death.

By altering the proportion *b* we obtain a wide range of possible cases for our general buy-back model. Specifically:

Case 1 Setting $b = 1$, we obtain the "standard" ACI model per unit of benefit (as shown by the green circles in Figure 1 only).

Setting $b < 1$, we obtain a reinstatement (as shown by the additional red circles in Figure 1).

Setting $b > 0.5$, then a partial reinstatement of benefit is provided, e.g. if the insurer wishes to exercise caution and offer a lower additional reinstatement premium.

Setting $b < 0.5$, then the insurer is delaying more of the benefit for the 2nd incident, possibly because a 2nd incident is likely to be more traumatic for the policyholder than the 1st incident.

Case 2 Setting $b = 0.5$ to obtain a complete reinstatement, which we shall refer to as our full "buy-back" model. In our actual calculations we have needed to deduct half the benefit payable from a healthy state on death in order to obtain the same magnitude of benefit payment throughout.

Case 3 Finally, on setting $b = 0$, we obtain the extreme case of an unusual delayed ACI model, as it provides CI coverage to an initially healthy policyholder, but only on the 2nd qualifying incident.

Data

Before we can apply the general buy-back model we require some claims and exposure data to determine the transitions between the different states in the model.

For CI business currently insured, once a policyholder makes a valid 1st claim, the CI coverage ceases and no further information is available for that policyholder, resulting in data not being available on 2nd CI incidence rates.

Exposure

Therefore, to make progress with a real example we have instead utilised a large client's Private Medical Insurance (PMI) settled claimant data where repeat claims are recorded. This consists of approximately 50,000 new policyholders each year from 1994 to 2007.

All further analyses are based on female data only.

Female Claim Incidents

The following Figure 2 summarises the female claim counts for 1st and 2nd claim incidents.

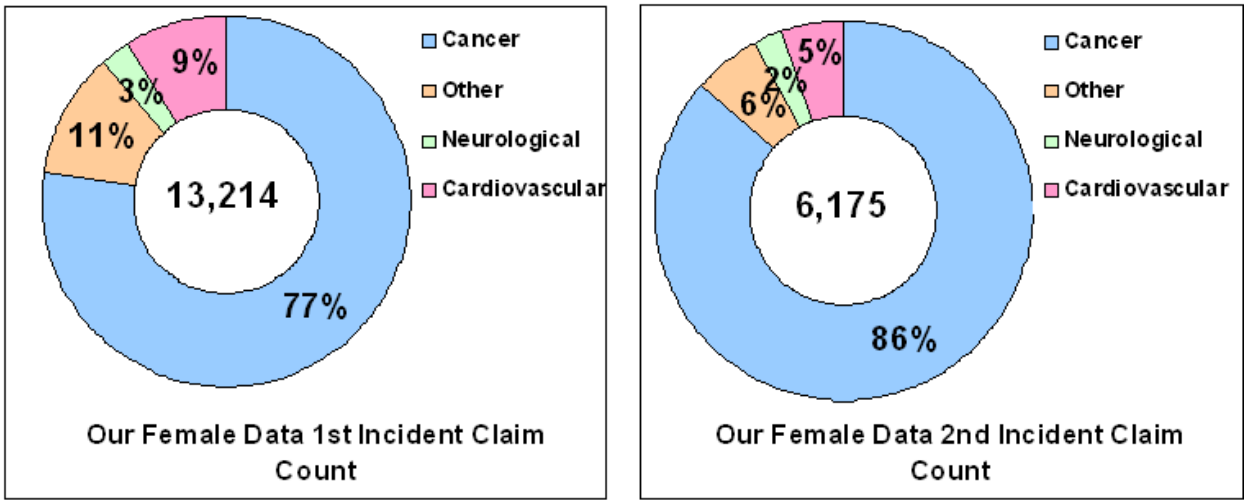

Figure 2: Female claim counts for the 1st and 2nd incidents of claims for the main condition groups, ages 15 to 99

Figure 2 shows a value of 77% for the proportion of 1st incident claims due to malignant female cancer. This compares to a proportion of only 69% from the CIIT00 FNS Table (with E&W age standardised incidence rates, p.12, Brett & DuToit, 2006). Conversely, the incident of neurological disease forms a lower proportion, 3%, compared to 9% from the CIIT00 table.

For the 2nd diagram we note an increase in the proportion of claim incidence due to cancer and a decrease due to cardiovascular conditions. We have no published tables to compare with but this does not seem unreasonable that reoccurrence of cancer may be more common than the other conditions.

Assumptions

Morbidity

PMI claims experience will be used to determine the 1st and 2nd incidence rates, even though this data has the following problems:

- The PMI claim amounts are smaller and more frequent than those which would be paid out in a typical ACI policy, resulting in 1st and 2nd incidence rates which are too high for use in competitive CI pricing. We could have considered only large PMI claim amounts above say £10,000, but this would have reduced the 6,175 PMI female 2nd incidents to

too small a number to allow adequate graduation by condition. We have therefore based our analysis on the full data.

- The PMI claims are not pre-assigned into different incidents; instead they consist of a series of treatments with start and end dates, separated by any number of days. To separate the incidents we needed to assume a fixed time break between the end date of one treatment and the start date of another treatment to separate a 1st incident from a 2nd incident (where each incident may consist of several treatments). A time break of 1-3 months may be too short for a typical cancer treatment, whereas 1-2 years may be too long. So we have assumed a time-break of $\geq$ 180 days between the end date of one treatment and the start date of another treatment, to separate two incidents.

- There is also a different type of claim definition, qualifying criteria, policyholder profile, underwriting approach etc. between PMI and CI claims experience.

Mortality

The client's PMI claimant experience was found not to be credible for determining the incidence of death required in our ACI product after the 1st incident. Therefore, we have used the Dash-Grimshaw (p. 164, 1993) method, together with the tables provided in Robjohns *et al*. (p. 189, 2006) to determine the probability of death due to CI causes for transitions from state *A* to state *D*.

To determine the mortality rate before and after any 2nd incident, we split this mortality rate in the same proportion as the number of deaths observed from the experience before and after the 2nd incident, for each condition and age.

Premium Post 1st incident

We have assumed that the premium post 1st incident will reduce in proportion to the benefit outstanding, i.e. the annual premium payable in state *A* is equal to (1- *b*) multiplied by the premium payable in state *H***.**

Outline of Methodology

Developed Incidence

As there is a delay between the date of diagnosis and settlement of the incidence of the disease, we also applied a grossing up factor to those policyholders still insured at 31 Dec 2007. From our PMI data we know the number of days between the last treatment date and 31 Dec 2007. So assuming the Brett & DuToit (p. 30, 2006) settlement delay curve is appropriate, we found the grossing up factor corresponding to this number of days.

Morbidity Graduation

On dividing the 1st developed claim counts by the corresponding exposure we obtained crude central morbidity incidence rates for transitions from state *H* to state *A* in Figure 1, for each of the main condition groups listed in Figure 2. Assuming the family of Gopertz-Makeham (GM) polynomial curves (p. 182, Forfar *et. al.* 1987) we managed to find a reasonable fit to these crude rates within the age range 20 to 70.

Similarly, we obtained fitted 2nd incidence rates from state *A* to state *B*, and withdrawal rates from state *A* to state *W*, and state *B* to state *W*, for each of the main condition groups.

The incidence rates were used to determine the corresponding probabilities of moving from one state to a neighbouring state in Figure 1, using the Kolmogorov forward differential equations (Booth *et al.*, pp.676, 1999, Haberman and Pitacco, pp.17, 1999).

Profitability of Model

The probabilities allowed us to build a cash flow model to determine the profitability of our general buy-back model in Figure 1 assuming an *n*-year policy term.

This first required the calculation of the profit vectors in state *H* and state *A* (at the end of year *t*), which we shall denote by PRO_t^H and PRO_t^A. From the theory of Haberman and Pitacco (p. 78, 1999) these profit vectors are equal to the required cash flows less the increase in expected prospective reserves. For our general buy-back model these profit vectors are given by

$$PRO_t^H = CF_t^H + {}_{t-1}V_y^H v^{-1} - p_{y+t-1}^{HH}\,{}_tV_y^H - p_{y+t-1}^{HA}\,{}_tV_y^A$$

$$PRO_t^A = CF_t^A + {}_{t-1}V_y^A v^{-1} - p_{y+t-1}^{AA}\,{}_tV_y^A .$$

Where

p_{y+t-1}^{ij} = the annual fitted probability from state *i* to state *j* for a policyholder aged *y*+*t*-1,
v = the annual discount rate, at say a 5% interest rate.

The prospective reserves for a policyholder initially aged *y* and in state *i* = *H* or *A* at the start of year *t* are given by

$${}_tV_y^H = M\sum_{u=0}^{n-t-1} v^{u+0.5}\,{}_up_{y+t}^{HH}\left[\,p_{y+t+u}^{HD} + p_{y+t+u}^{HAD} + p_{y+t+u}^{HBD} + b\,p_{y+t+u}^{HA} + p_{y+t+u}^{HB}\,\right] - \sum_{u=0}^{n-t-1}\pi\; v^u\,{}_up_{y+t}^{HH},$$

$${}_tV_y^A = (1-b)M\sum_{u=0}^{n-t-1} v^{u+0.5}\,{}_up_{y+t}^{AA}\left[\left(p_{y+t+u}^{AD} + p_{y+t+u}^{AB} + p_{y+t+u}^{ABD}\right)\right] - (1-b)\sum_{u=0}^{n-t-1}\pi_{u+t}\,v^u\,{}_up_{y+t}^{AA}.$$

Secondly, as we are interested in the profit for a healthy policyholder aged y at time $t = 0$, we need to take a discrete expectation across the profit vectors, i.e. the profit signature

$$\sigma_t = {}_{t-1}p_y^{HH}\ PRO_t^H + {}_{t-1}p_y^{HA}\ PRO_t^A .$$

Thirdly, to determine how profitable our general buy-back model is for different b, we divided the total discounted profit signature by the total expected annual premium across all n years of the accelerated CI term assurance product to obtain the profit margin

$$PM = \frac{\sum_{t=1}^{n} \sigma_t\, v^t}{\sum_{t=1}^{n} \pi\ v^{t-1}\left({}_{t-1}p_y^{HH} + (1-b)\ {}_{t-1}p_y^{HA}\right)}.$$

Where π = the fixed annual premium payable by the policyholder at the start of each year.

Finally, as we have now built a cash flow spreadsheet to determine the profitability for a fixed annual premium (based on our fitted probabilities), we can also solve in reverse for the premium corresponding to a set profitability of 20%?

General Buy-Back Model Example

The premium required for a 20% profit margin for cases 1 to 3 in our general buy-back model were calculated following the above method, before rescaling so that a 40 year old female with a standard ACI product would require a relative premium value of £100. These relative premiums are shown in the following Table 2.

Table 2: ACI Relative Premium Required for a 20% Profit Margin

Case/ Curve	All Condition CI Model	Transitions with a Benefit Payment (apart from death)	Age 20	30	40	50	60
0g	Standard SACI	H→A *(ex deaths)*	31	46	87	151	214
1g	Standard ACI, b = 1	H→A	33	55	100	170	263
2g	Full Buy-Back ACI, b = 0.5	*H→A*, A→ *B*	21	38	71	123	192
3g	Delayed ACI, b = 0	A→ *B*	10	20	43	78	125

Note: Premiums Relative to a 40 year old female with a standard ACI only product costing £100.

For comparison we have provided the results of the stand-alone critical illness (SACI) model in Table 2 to illustrate the rapidly increasing contribution of deaths to the required premium from age 20 to age 60.

As expected the relative premium increases as the proportion of benefit b payable on the 1st incidence increases.

As well as these relative premium observations for a fixed model or fixed age, the following Figure 3 shows more clearly the increase in relative premium for both increasing *b* and increasing age.

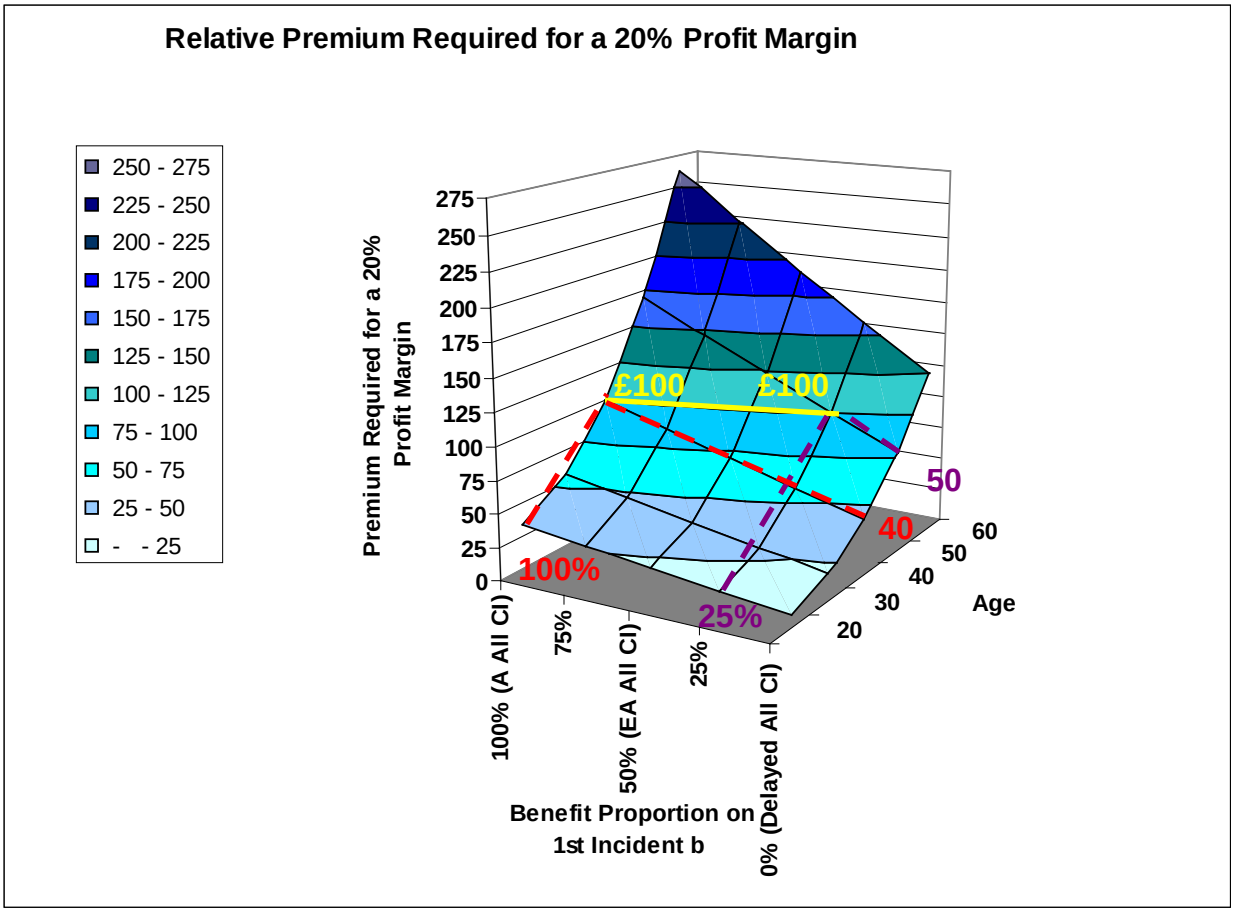

Figure 3: Our general buy-back model showing the increase in initial relative annual premium for a 20% profit margin, as both age increases and *b* increases.

On allowing both the age and *b* dimensions to change, we can traverse along a particular coloured line in Figure 3 while keeping the relative premium level constant. Thus on changing the relative size of the proportion *b* payable upon satisfaction of the first qualifying condition, we can offer all policyholders the same fixed premium regardless of their age.

For example, the yellow coloured line corresponds to a relative premium of £100, which on increasing from ages 40 to 50, corresponds to a value of *b* decreasing from 100% to 25%.

Scenario I: To price our 1st scenario on the additional relative premium required for the full-buy back model compared to the standard ACI model we first need to double the relative premiums and benefits for the full buy-back model because the 1st incident payment in the model is currently equal to 50% of the benefit. Then we need to make a small correction by deducting the

premium for a term policy for non-CI conditions only (as we have doubled the death benefit for healthy lives).

The resulting buy-back benefit is shown in the following Figure 4.

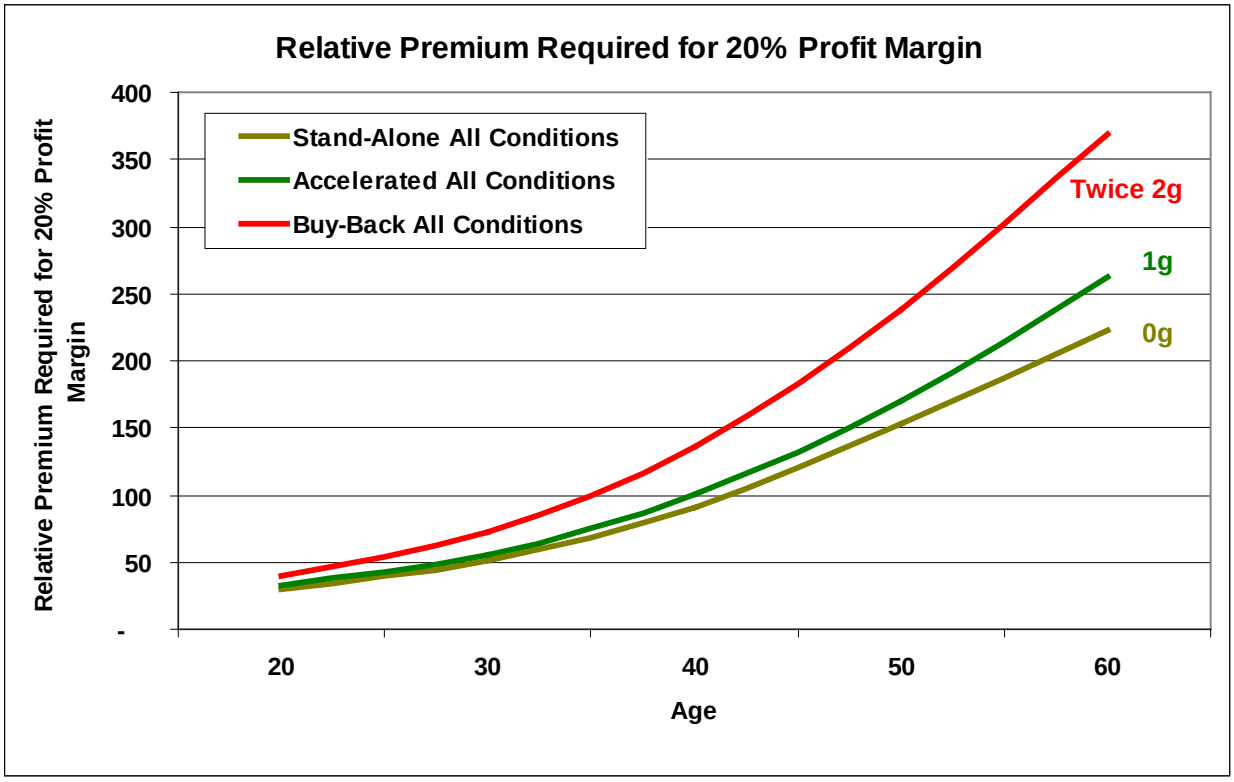

Figure 4: Relative increase in Buy-Back Premium compared to a standard ACI and SACI model.

From Figure 4, it can be seen that on comparing the difference between the buy-back and standard ACI relative premium curves, we require an additional relative premium of £9 at age 20 increasing to £120 at age 60, for the buy-back option. This will be discussed further in the summary at the end of the paper.

Restricted Models

Basic Restricted Model

Consider an example of an unhealthy female policyholder. By "unhealthy" we mean that she has had a previous minor health complaint that would be considered to increase the risk of payment from a CI policy, e.g. slight angina, but have not had a full qualifying CI condition.

The unhealthy life understands that such a pre-existing minor health complaint means that she is at a higher risk of claiming for a related CI condition, e.g. any cardiovascular conditions.

However, she feels that she should not be refused CI outright, but should be offered a similar product which provides coverage for the remaining CI conditions, which are unrelated to her minor health complaint.

Before we can determine such a "restricted" relative premium, we first need to consider the transitions for healthy (or unhealthy) policyholders to either:

- the conditions within the qualifying state *A* or
- those other conditions with no qualifying benefit payment, which we have called A^{other}.

We have extended the partial benefit ACI model to include state A^{Other} and all additional states, as shown in blue in Figure 5 below.

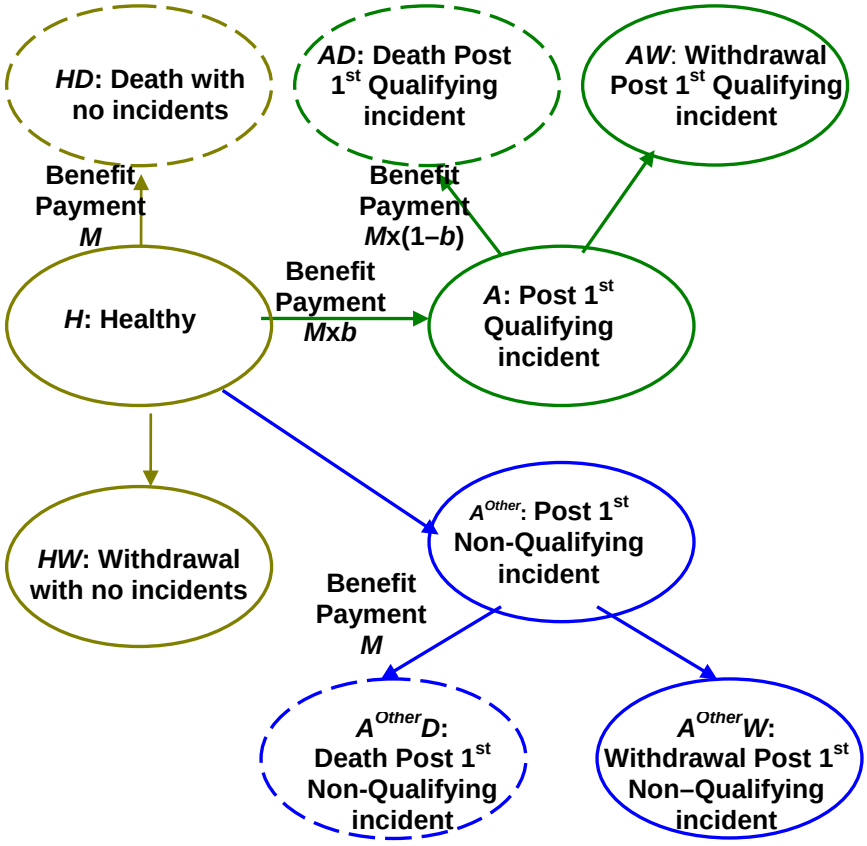

Figure 5: Our restricted basic model showing the usual healthy state *H* and post 1st qualifying conditions state *A* in green and introducing a post 1st non-qualifying condition state A^{other} in blue. For completeness, the corresponding absorbing death states *HD, AD,* $A^{other}D$*, BD* (dotted lines) and withdrawal states *HW, AW,* $A^{other}W$ and *BW* are also shown.

The problem with our restricted basic model above is that it ignores the possibility of an initially (un)healthy policyholder subsequently satisfying one of the non-qualifying conditions as an intermediate step before satisfying one of the qualifying conditions.

In our example, this would correspond to our unhealthy policyholder succumbing unsurprisingly to a heart attack after purchasing the non-cardiovascular CI policy. Although no heart attack payment was made, they then subsequently developed a cancer at a far younger age than a typical healthy policyholder.

We therefore need to consider whether the incidence of a non-qualifying condition to a qualifying condition is far higher than the incidence of a qualifying condition from the healthy state. If this is the case, then our restricted basic model above would under-estimate the required premium.

Scenario II: General Restricted Model

Therefore, to obtain a more accurate premium we need to include the possibility of a transition from state A^{Other} to a new state B, where a full benefit payment occurs only when we have strictly the same qualifying conditions as for the 1st treatment state A. This is shown in Figure 6 below.

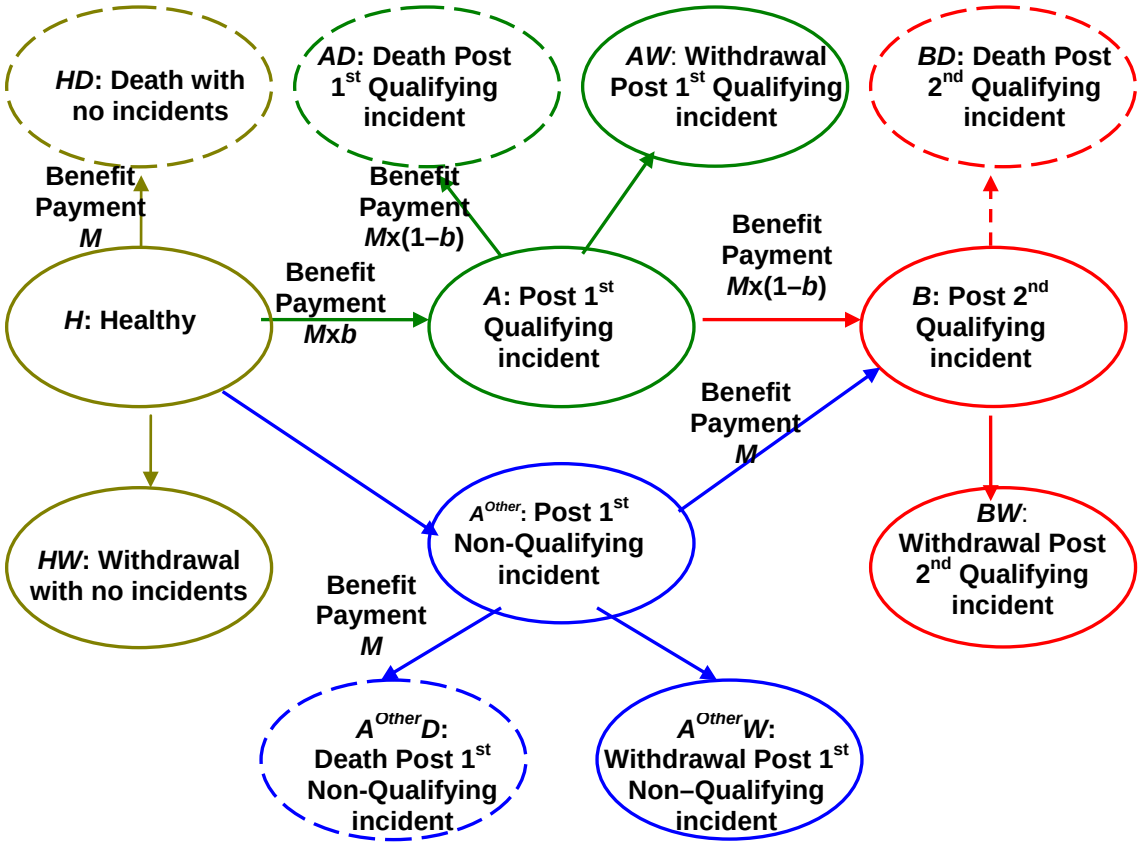

Figure 6: Our general restricted model, showing in addition to the previous restricted basic model, a 2nd treatment state *B* in red for strictly the same qualifying conditions as in state *A*. For completeness, the additional absorbing death state *BD* (dotted red lines) and withdrawal state *BW* are also shown.

In the appendix, we have shown that care is needed in the choice of which conditions to include or exclude, as summing the premiums for individual CI conditions in separate general restricted models does not produce the same premium as a single model including all of these conditions.

Love and Ryan (2007) considered a similar model (with $b = 1$ throughout); however, they considered a transition from state A^{other} to state A, rather than introducing a new state B.

However, our model has the advantage that by allowing the proportion payable on the 1st incident b to be equal to 0, 0.5 and 1, we can obtain the premium for the same 3 cases as discussed in our general "buy-back" model above, but with a restricted set of CI conditions.

Restricted Model Example

To illustrate the 3 cases of the general restricted model, we shall look at a "cancer only" product. For such a product we are primarily interested in benefit payments for any cancer condition for healthy policyholders, excluding other conditions arising from cardiovascular, neurological diseases, etc. However, we may wish to still include the possibility of policyholders requiring cancer benefit after any "other (non-cancer)" treatment.

The relative premium required for a 20% profit margin in each of these models for an initially (un)healthy policyholder is shown in Table 3 below for increasing age.

Table 3: Accelerated Cancer Only Relative Premium Required for a 20% Profit Margin

Case/ Curve	Cancer Only Model from State *H*	Transitions with a Benefit Payment (apart from death)	Age 20	30	40	50	60
	Basic Cancer Only (ex deaths)	$H \to A^{cancer\ (ex\ deaths)}$	24	47	88	145	196
0r	Basic Cancer Only	$H \to A^{cancer}$	26	51	96	160	233
1r	Standard Cancer Only, $b = 1$	$H \to A^{cancer}$, $A^{non\text{-}cancer} \to B^{cancer}$	28	53	100	168	250
2r	Full Buy-Back Cancer Only, $b = 0.5$	$H \to A^{cancer}$, $A^{cancer} \to B^{cancer}$, $A^{non\text{-}cancer} \to B^{cancer}$	19	38	74	127	195
3r	Delayed Cancer Only, $b = 0$	$A^{cancer} \to B^{cancer}$, $A^{non\text{-}cancer} \to B^{cancer}$	10	22	48	88	142

Note: Premiums are relative to a 40 year old female with a standard accelerated cancer only product costing £100.

From Table 3, we see that the standard cancer only case has a larger relative premium than the basic cancer only model. This is due to the incidence of cancer from another non-qualifying condition, which is excluded in the basic cancer case. This possibility adds a relative premium of £2 at age 20 to £17 at age 60.

We shall look at the relative increase in premium for the full buy-back model after first looking at an exclusion model.

Scenario III: Exclusion Model

In a practical CI situation, the underwriter may wish to exclude certain CI qualifying conditions. For example, if the policyholder has a family history of breast cancer, but is herself healthy, then she may be offered the aforementioned cancer only product, excluding breast cancer.

We can easily re-use the restricted general model, by including breast cancer with the other conditions in our state A^{Other}, obtaining the following Table 4 of relative premiums required for a 20% profit margin.

Table 4: Accelerated Cancer (Excluding Breast Cancer) Relative Premium Required for a 20% Profit Margin

Case/ Curve	Cancer (Ex Breast) Model from State *H*	Transitions with a Benefit Payment (apart from death)	Age 20	30	40	50	60
	Basic Cancers (ex breast, ex death)	$H \rightarrow A^{Cancer\ (ex\ breast,\ ex\ death)}$	22	38	62	106	157
0e	Basic Cancers (ex breast)	$H \rightarrow A^{cancer(ex\ breast)}$	24	41	69	116	190
1e	Standard Cancers, (ex breast), $b = 1$	$H \rightarrow A^{cancer(ex\ breast)}$, $A^{non\text{-}cancer} \rightarrow B^{cancer(ex\ breast)}$	26	44	76	132	215
2e	Full Buy-Back Cancers, (ex breast), $b = 0.5$	$H \rightarrow A^{cancer(ex\ breast)}$, $A^{cancer(ex\ breast)} \rightarrow B^{cancer(ex\ breast)}$, $A^{non\text{-}cancer(inc\ breast)} \rightarrow B^{cancer(ex\ breast)}$	9	15	30	60	113
3e	Delayed Cancers, (ex breast), $b = 0$	$A^{cancer(ex\ breast)} \rightarrow B^{cancer(ex\ breast)}$, $A^{non\text{-}cancer(inc\ breast)} \rightarrow B^{cancer(ex\ breast)}$	10	18	37	75	136

Note: Premiums Relative to a 40 year old female with a standard accelerated cancer only product costing 100.

As expected, for a particular case and age, these premiums are all less than the corresponding premiums in Table 3, due to the exclusion of breast cancer from the qualifying benefits.

Scenario II and III: To price our 2nd and 3rd scenarios we have doubled the relative premiums for the full buy-back case 2 in each of our models, to make the 1st incident benefit equal to the same as the standard case (then deducted the excess deaths from the healthy policyholders) as shown in the following Figure 7.

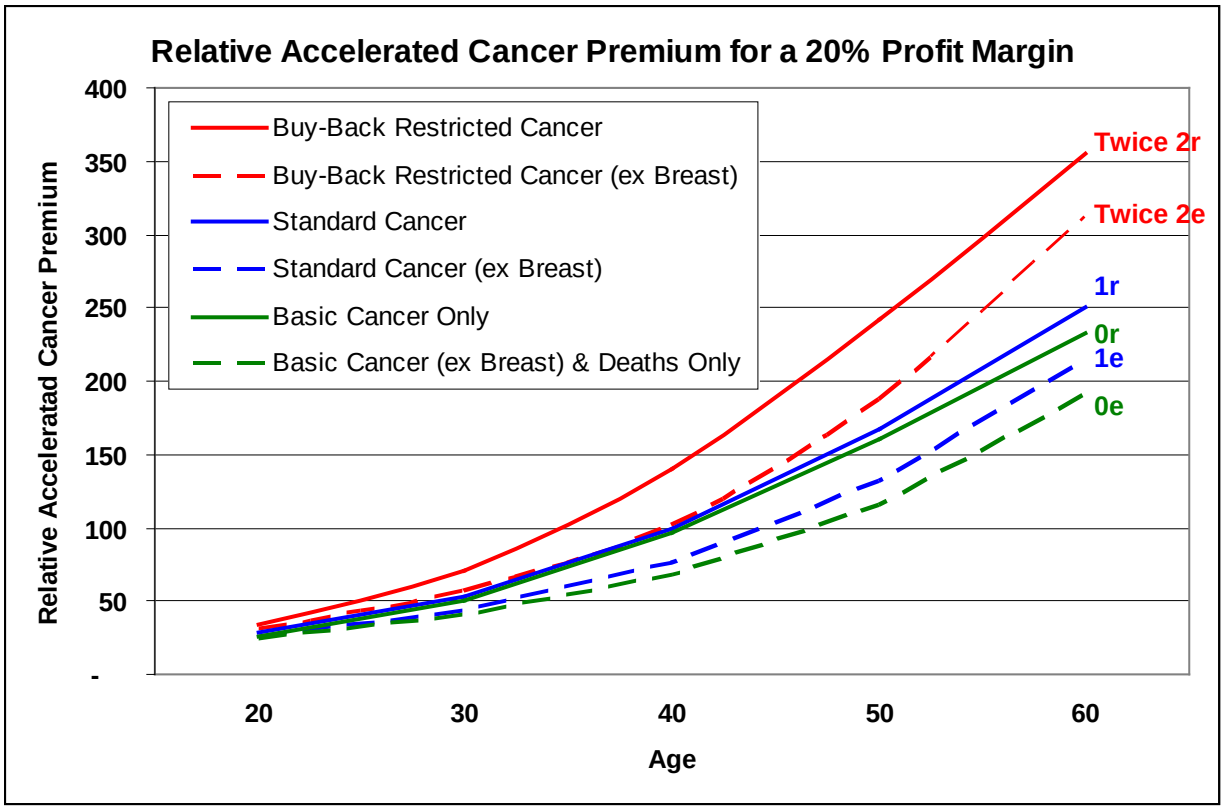

Figure 7: Relative premium required for a 20% profit margin for a restricted cancer only model with buy-back, standard and basic cases, compared to the corresponding cases for a cancer (excluding breast) only model. Premiums relative to a 40 year old female with a standard cancer only product costing £100.

In Figure 7 the relative premium from each case in Table 3 (solid lines) is shown in the same colour as the corresponding case in Table 4 (dotted lines) where breast cancer has been excluded. The corresponding saving in relative premium on excluding breast cancer increases rapidly from age 20 to 50, as the incidence of breast cancer increases.

The increase in the blue "standard" curve compared to the corresponding green "basic" curve with age is due to the inclusion of a qualifying benefit payable after a non-qualifying benefit. This difference is larger for the dotted curves compared to the solid curves, as the dotted curves exclude breast cancer from the qualifying conditions. This indicates that a transition from the non-qualifying breast cancer state to a qualifying cancer state is more significant than say from a cardiovascular state.

The difference between the red and blue solid curves is equal to the additional premium on including a buy-back for the restricted cancer. Similarly, for the restricted cancer (excluding breast cancer) the additional buy-back premium is represented by the difference in the red and blue broken curves. Both of these additional buy-back premiums are shown in Figure 8 below.

Scenarios I, II & III: Required Premium for "Buy-Back" Models

The following Figure 8 provides the results for our scenarios I, II and III concerning the additional relative premium required to include the option of a full buy-back (b = 1) compared to the respective "all conditions", "cancer" or "cancer (excluding breast)" models.

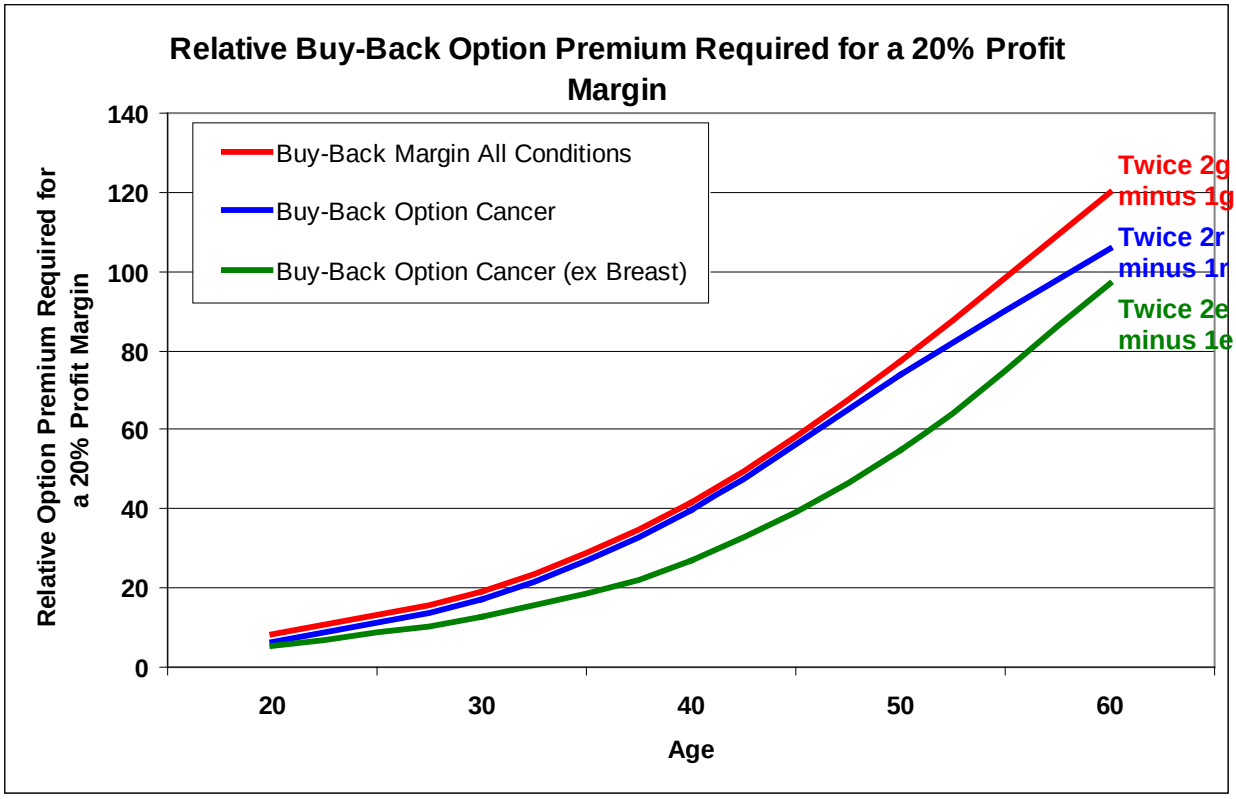

Figure 8: The difference in relative premium between our buy-back models and the corresponding standard models for all, cancer only or cancer (excluding breast) conditions. Premiums relative to a 40 year old female with a standard cancer only product costing £100.

From Figure 8 the full buy-back option increases rapidly with age for all our models.

We note that the buy-back relative premium option for cancer (blue curve) follows the premium for the "all conditions" (red curve) closely form age 20 to age 50, as our data is predominately cancer until this age. After age 50, the cardio-vascular and neurological conditions become increasingly more important resulting in the higher premium for the "all conditions" curve.

In addition, on removing the "breast cancer" (green curve) we have an increasing difference in relative premium from the cancer condition (blue curve) from age 20 to a peak at age 45, before the difference decreases towards age 60.

Taking the above buy-back premium and dividing by the accelerated premium for the corresponding model with no buy-back option we obtained the following Table 5.

Table 5: Buy-Back Premium as a % of the Corresponding Accelerated Non-Buy-Back Model Premium

	Age				
Model	**20**	**30**	**40**	**50**	**60**
All Conditions	29%	36%	42%	45%	46%
Cancer Only	36%	42%	48%	52%	56%
Cancer Only (excluding breast cancer)	33%	34%	39%	45%	52%

Table 5 indicates that an additional buy-back option premium of around 30% to 55% (as age increases from 20 to 60) would need to the added to the underlying accelerated model.

The high buy-back costs may be a result of the use of the PMI data, where small multiple claims have been included as described earlier in this paper. Genuine critical illness data, were it available, would probably result in lower buy-back costs.

Conclusions

The paper has presented a multi-state modelling framework for determining the additional buy-back premium for a model with all the conditions present in our PMI data.

In addition, we have presented a new model restricting the qualifying benefit payments to certain conditions, while still allowing the non-qualifying conditions to act as an intermediary state before a qualifying condition.

We have illustrated the above by determining three different buy-back premium curves by age, when we have “all the conditions”, a restriction to “cancer only” or “cancer only, but excluding breast cancer” satisfying our qualifying benefit.

The buy-back premium curves indicate a rapid increase in premium with age. For our data there is practically no difference in the additional buy-back premium whether considering a cancer only or an all condition product until age 50 (after which the “all condition” buy-back premium becomes slightly more expensive). Although there is a noticeable decrease on excluding certain conditions, e.g. “breast cancer”, this may not be sufficient to outweigh explaining why a popular condition has been excluded.

The buy-back premium increases the corresponding accelerated non-buy back model premium by 30% to 55%, with increasing age from 20 to 60. The fairly high cost of the buy-back option premium is likely to result from including small multiple claims data.

Further Work

As mentioned in the main section, further work is needed on an appropriate PMI claims threshold in order to calibrate the 1st incidence with say a standard CI table. As this would lead to a loss of data, we need to be sure that we could still graduate individual conditions with sufficient credibility.

Bibliography

Booth, P., Chadburn, R., Cooper, D., Haberman, S. and James, D., (1999), Modern Actuarial Theory and Practice, 1st Ed., Chapman & Hall

Brett,. P., and DuToit, J., (2007), A Critical Table: Pricing Critical Illness in the UK on a new Insured Lives Table, Gen Re, [on-line] https://www.genre.com/page/0,1019,ref%253DLifeHealthUKCriticalIllness-en,00.html

Dash, A., and Grimshaw D., (1990) Dread Disease Cover – An Actuarial Perspective, Journal of the Staple Inn Actuarial Society [JSS] (1993) 33: 149-193, [on-line] http://www.sias.org.uk/siaspapers/search/view_paper?id=dreaddisease

Forfar, D. O., McCutcheon, J. J. and Wilkie, A. D. (1988) On Graduation by Mathematical Formula. *J.I.A.* **115**, 1-149 and *T.F.A.* **41**, 97-269, [on-line] http://www.actuaries.org.uk/__data/assets/pdf_file/0016/24901/0001-0149.pdf

Haberman, S., and Pitacco, E., (1999), Actuarial Models for Disability Insurance, Chapman & Hall, CRC Press

Love, H., and Ryan, D. (2007) Disease and Death - improving our understanding of the future. Presented to the Staple Inn Actuarial Society, London, 17 July 2007, [on-line] http://www.sias.org.uk/siaspapers/search/view_paper?id=DiseaseandDeath

Robjohns, N., Galloway, H., Morris, R., Reid, S. K., Wells, J. (2006) Exploring the Critical Path. Presented to the Staple Inn Actuarial Society, London, 6 Dec 2006, [on-line] http://www.sias.org.uk/view_paper?id=CITrends

Appendix

Individual Condition Models are not Additive

We need to be careful when applying the general restricted model, as once we determine the individual premiums for say a cancer only model, then a cardiovascular, neurological and other model, we cannot add them together in a "menu" style to determine a "tailored" product. This is because the total premium will exceed the corresponding premium for a standard ACI product as shown by the heights of the bar-charts in Figure 9 below.

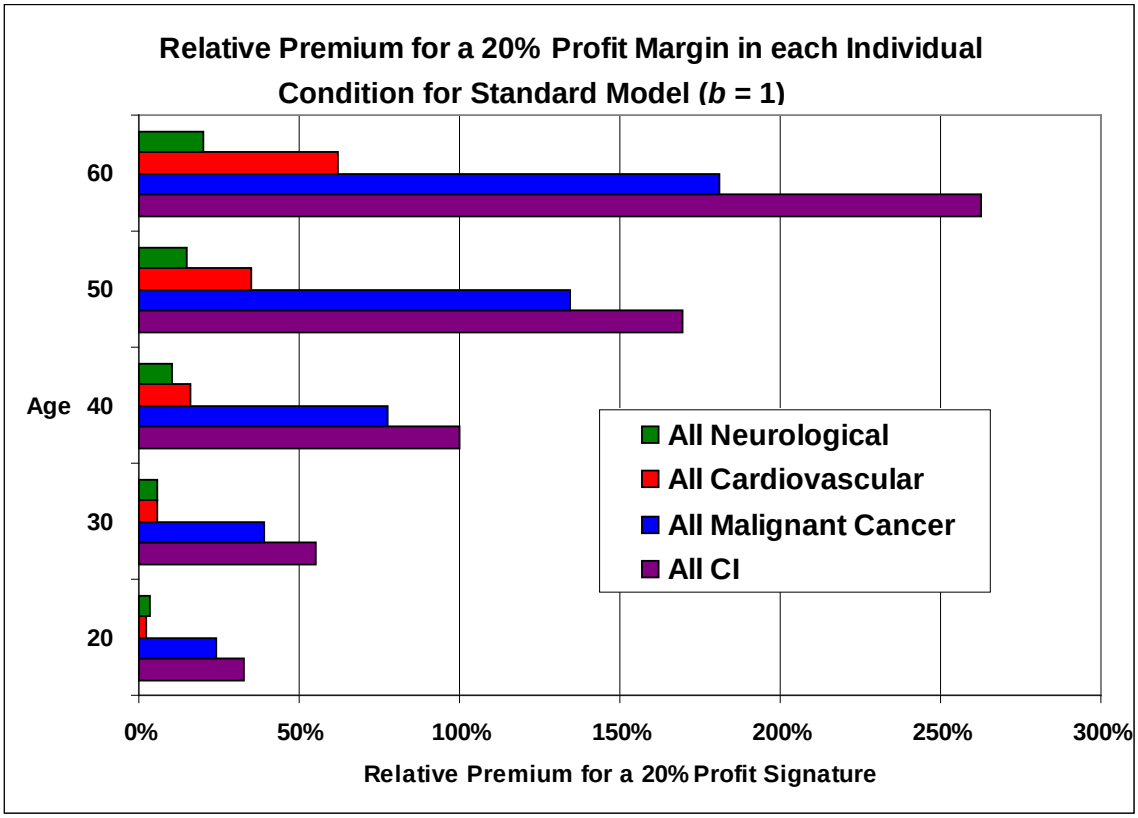

Figure 9: Relative premium required for a 20% profit margin for individual cancer, cardiovascular, neurological and other models, compared to the standard ACI model. Premiums relative to a 40 year old female with a standard ACI only product costing £100.

The reason for this is that upon summing these premiums over the individual conditions the following repeated counting of incidence rates will occur:

- Each condition will become included as one of the "other condition" when it is not the qualifying condition.

- Each individual condition includes "deaths" from both non-qualifying and qualifying conditions.

In practice, this repeated counting is not a problem provided all the selected "menu" qualifying conditions are included at the start within our state *A* and not added afterwards.