KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY-KUMASI

PRICING CRITICAL ILLNESS INSURANCE USING THE DASH AND GRIMSHAW MODEL

By

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Declaration

I hereby declare that this submission is my own work towards the award of the M. Phil degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which had been accepted for the award of any other degree of the university, except where due acknowledgement had been made in the text.

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Abstract

Critical Illness Insurance is a new product and its now gaining grounds on the Ghanaian insurance industry market. This research is aimed at developing a fair pricing system for a critical illness insurance using the Dash and Grimshaw model which has embedded multi-state(decrement) model. Due to the uncertainty in the future and the possibility of an individual being diagnosed of some critical illness, it is important to cover oneself against this possible adverse financial trauma. This research considered five critical illnesses thus cancer, heart attack, stroke, kidney failure and Coronary Artery Bypass Graft. Data on the incidence rates for all the critical illnesses was used to compute the stand alone rates, acceleration rider benefit rates and premium rate from ages 20 to 80 inclusive using the Dash and Grimshaw model. Results from my computations showed that incidence rates and its corresponding premium rates are directly proportional to one's age. Also the difference in stand-alone and accelerated rates was directly proportional to one's age.

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Dedication

This work is dedicated to Mr. Kofi Armadi and Mrs Mary Owusu Amardi for making my dream come true.

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Acronyms

ABI .... Association of British Insurers

APV .... Actuarial Present Value

CABG .... Coronary Artery Bypass Graft

CAG .... Cerebral Angiography

CHD .... Coronary Heart Disease

CIBT93/94 .... Critical Illness Base Table for the year 1993 and 1994

CI .... Critical Illness

CII .... Critical Illness Insurance

CIIT00 .... Critical Illness Insured Table for the year 2000

CMI .... Continuous Mordibility Invesment

DD .... Dread Disease

ELT 15 .... English Life Table number 15

FNS .... Female Non – Smoker

HA .... Heart Attack

HD .... Huntington's Disease

HES .... Hospital Episode Statistics

KD .... Kidney Failure

LMI .... Linear Matrix inequalities

MJLS .... Multiple Jump Linear Systems

MOT .... Major Organ Transplant

MS .... Multiple Sclerosis

MSGP .... Mordibility Statistics from General Practice

ONS .... Office of National Statistics

OPCS .... Office of Population Census and Survey

TPD .... Total and Permanent Disability

TSAIR .... Total Stand - Alone Incidence Rate

UK .... United Kingdom

USA .... United States of America

Chapter 1

Introduction

1.1 Background of the Study

Critical illness insurance was formed by Dr. Marius Barnard in 1983, south Africa. Dr. Barnard saw the need for insurance that paid a “living benefit" to the individuals who survived a real disease to counterbalance lost pay and pay extra liabilities. He discovered as much patients “didn't lose their life, they lost their life savings” following surviving deadly mishap illnesses for example, cancer, stroke or heart diseases.

Dr. Barnard states that “before the age of 65, the possibility for suffering a condition keeping somebody off work for more than six months is 15 times higher than that of kicking the bucket. With expanding life expectancy, there is a higher possibility of encountering an ailment and surviving longer. Dr. Barnard says, “Critical illness insurance provides one with money related freedom when one needs it most. One needs insurance not just a direct result one would die, but because you are going to live. ” This is an item intended to provide one with choices.

Likewise those traditional life and disability insurance policies by generally have an alternate focus, not many insurers in the past were eager to cover those needs of the critically sick. However, this gap has been filled over the last two decades or so, likewise another type of cover have been created in a large number businesses which gives to payments in the event of a serious ailment. In this thesis, such results are termed Critical Insurance (CI) insurances.

Critical Illness Cover is becoming imperative in the developed and developing countries, like ours, as the problems of demographic aging comes to bare.

Solutions to these pressures, together with demands from a population that is better educated and more prosperous, are increasingly being found through insurance by the many sectors. This research aims at increasing the need for insurers to consider CII as a very important product and developing a fair pricing system using the multiple decrement approach.

On 6 October 1983 in South Africa, CII was propelled under the dread disease insurance. Since 1983, the policy has been acknowledged under a number insurance markets around the globe. Different names of the insurance cover include: trauma insurance, serious illness insurance and living assurance. In 1987, critical illness was effectively started in England. Today more than 70 U. K. insurance companies offer critical illness policies. This will be principally because of those linking from claiming critical illness insurance and mortgage insurance. About 46% of home foreclosures in Canada are an immediate result from claiming serious illnesses.

Critical illness was launched in Australia in 1990. Practically all Australian life insurance companies offer critical insurance policies today. Recently, critical illness insurance policy was introduced in japan that main blankets heart attack, stroke, and cancer. Over 500,000 policies were sold clinched alongside only 10 months and 6 million policies sold for its fourth year.

Since its inception in Canada in 1994, critical illness coverage quickly developed to a 200 million dollar showcase. This is a confirmation of the purchaser necessity for critical illness insurance and the need to fiscal security over life and death.

In Ghana, some insurance companies like GLICO have a specific policy on dread disease. Some other insurance companies have products which has embedded critical illness insurance cover. Those calendars about insured illness vary between insurance organizations. In 1983, four illnesses were covered, i.e Heart attack, cancer (life-threatening), stroke and coronary artery by-pass surgery. Cases for different policies that might chance to be covered are: Alzheimer's disease, aortic surgery, Aplastic anemia, bacterial meningitis, Benign brain tumor, Blindness, Coma, Deafness, heart attack, heart valve replacement, kidney failure, loss of limbs, loss of speech, major organ transplant, major organ failure on waiting list, motor neuron diseases, multiple sclerosis, Occupational HIV infection, Paralysis, Parkinson's disease, severe burns.

Because of the certainty that those occurrence of a state might diminishing over time and both the diagnosis and treatment may prove over time, the financial related requirement to blanket some illnesses regarded critical a decade prior need aid never again regarded necessary today. Likewise, some of the conditions covered today might no longer be necessary a decade or later on.

The actual conditions covered rely on upon those market compelling reasons for the cover, rivalry amongst insurers, and also those policyholder's perceived value of the benefits offered. For these reasons, conditions for example, diabetes and rheumatoid arthritis, among others, may become the normal cover offered in the future. (source: http://www. Barronsfinancialservices. Com /Products/Living Benefits/Critical Illness/historyci.Php).

1.2 Problem Statement

The current pricing of CII is based on the insurers' perspective and comparison with other method of pricing other life insurance products. This method is defective since CII entails more than just life expectancy and age at issue. A comprehensive approach is therefore needed in relation to all the aspects of the pricing of CII premiums.

1.3 Objectives of the Study

The objectives of this study is to;

a) Develop an incidence rate table for Stand-Alone Rider and Acceleration Rider for the five prevalent Critical Illnesses. .i.e. Cancer, Heart-Attack, Stroke, kidney failure and CABG.

b) Develop a premium rate for Acceleration rider benefits using the Dash and Grimshaw model.

1.4 Research Methodology

This research work made use of categorical data for analysis. Secondary data was taken from the Hospital Episode Statistic, Office of the National Statistic and some insurance companies in Ghana. Dash and Grimshaw model was used to generate acceleration benefits and premium rates. Data analysis will be made possible with the help of excel and the R statistical package.

1.5 Significance of the Study

A product like CII in the Ghanaian market will go a long way to help the insured since it protect them (i.e clients) against serious financial risks. The data from the survey would therefore be of great importance to the various insurance companies in the country. It will increase the selling of Critical Illness product which will intend increase their net income. At the end of this research work, the various insurance companies will have a better and scientific means of evaluating and selling the Critical Illness insurance product.

1.6 Justification of the Study

Current premium rates for CII varies from insurer to insurer. This is due to a lack of standard premium rate and its corresponding incident rate for the various products sold. Some insurers charge higher premiums which normally results in the low patronage of the product whereas others charge relatively low premium which also results in the company running at a loss. Thus necessitated the determination of an accurate pricing formula. Pricing critical illness is also the key objective of any insurance industry that sells such a product. This research work considers the various premiums and incidence rates for the age group of twenty to eighty years will serve as a platform for insurers to know which group of the population are most vulnerable to suffer one condition or the other. This research work will give customers an insight into CII and also give them a reason to protect themselves against adverse future financial loss and also gives them an idea about the pricing. This is what makes this project justifiable.

1.7 Organization of the Study

This research work consist of five main chapters, the abstract summarizing the whole research work, table of content, list of figures, list of abbreviations, dedications and acknowledgment being the preludes. Chapter one contains an introduction, background of the study, objectives of the research, methodology, significance and justification of the study and organization of the thesis. Chapter two deals with literature review, chapter three discusses the various method and models employed in the research and chapter four deals with the analysis and discussion of findings. The last chapter contains the summary of results, conclusions and recommendations.

Chapter 2

Literature Review

2.1 Introduction

This chapter reviews previous researches completed on decrement models and its connection to pricing an insurance and life insurance as a whole product.

2.2 General Insurance Modelling

Beck et al. (2001) affirms that we live in a society that fears any form of uncertainness and to which every last bit transforms would viewed as risk-taking. Various studies, specifically on the standard from claiming precaution, hint at that the people need to live in a protected society. This belief of vulnerability and dread heads people with demonstrate special thoughtfulness regarding the preferences for security. The fundamental reason for insurance is to gather a means for transferring (whole or part) on payment insurance premium, the economic impact that is included in probabilistic events.

The probabilistic nature of risks and their quantification have prompted actuarial science, which is In view of likelihood hypothesis and statistics. So, the task of risk evaluation lies principally on actuaries who have produced over time different models through which they attempted to establish some linkage between the event of risks and they will recognize how they manidae. Econometric modeling is intended on depict this connection, to determine the likelihood of risks and also to get their economic impact on insurer, and hence deciding premiums that reflect the reality of the risks.

Insurance in some sense is as old as the story of mankind. This could be traced to the two types of economist in the human society: money economies (financial instruments, with markets e.t.c) and natural economist (involving barter trading without standardized financial instruments or money). The latter form is of more ancient type than the former, in that insurance, the category is seen as neighbors helping each other in the community. For instance, if one household got burnt down by fire, others in the neighborhood help built a new one. This kind of social aid continued should the same happened to others in the society. This form of insurance has lived to the present day in some areas where modern economy with money markets and standardized financial instruments is not widespread. This sort of social help continued should the same happen to the other society. This form of insurance has lived till today in some societies around the world where modern economy with money markets and standardized financial instrument is not widespread. (Trenerry, 1926).

On the other hand, insurance in the modern financial economy is views as part of the fiscal cycle. The ancient means of transferring risk were first practiced by the Babylonians and the Chinese traders in the 2nd and 3rd millennia BC respectively. The Babylonians developed a scheme for the early Mediterranean sailing where merchants were recorded in codes of Hammurabi, c in 1750 BC. If a merchant obtained a loan to finance his shipment, in return, he would pay an additional amount to the lender for his surety to cancel the loan in the event that the shipment got lost or stolen at sea. Likewise, the Chinese merchants travelling ominous river rapids redistribute their wares over several vessels to reduce the loss that might result from the cap size of a single vessel (Vaughan, 1997).

According to Mehr and Cammack (1976), Achaemenian monarchs were the first to officially insure their people by means of registering the process in a government attorney's office. With this arrangement, gift worth over 10,000 Derricks (Achaemenian gold coin) were registered in specific offices and presented to the monarch by heads of different ethnic groups. Other presents were also fairly assessed by the sister courts and then registered in the special offices. In that way, a person will receive help from the monarch and the court provided his/her gift is registered whenever he/she is in trouble. A decade later, dwellers of Rhodes devised the idea of general average where merchants paid proportionally divided premiums in order for their goods to be shipped together. The premiums collected would then use to reimburse any merchant whose goods were jettisoned as a result of storm or sinkage.

Greeks and Romans are specifically recognized as the originators of life insurance and health insurance in 600 BC when they formed guilds called benevolent societies" to care for the deceased family, and also pay funeral expenses of members in the event of death. Guilds in the middle ages aided the same goal. Likewise, Talmud transact in many features of insuring goods prior to the recognition of insurance in the 17th century. In England, individuals contributed amount of money to friendly societies which in turn could be used in cases of emergency (Mehr and Cammack, 1976). In the 14th century, insurance policies were viewed as unique contracts believed to have originated from Genoa where insurance policies were supported by assurances of landed estate. These contracts enabled insurance to be distinguished from other form of investment, a separation of duties that first yield result in marine insurance, became more complicated in post-Renaissance Europe and specialized varieties developed. London's growing importance as a center for trade increased demand for marine insurance in the late 17th century. Edward Lloyd opened a coffee house in 1680 that subsequently became a famous haunt for merchants, ship captains and ship owners and eventually served as reliable source of the latest shipping news. It subsequently became a meeting ground for persons willing to insure ships and cargos and those prepared to underwrite such ventures (Kingston, 2007).

Insurance known today might be followed of the incredible fire from London which ate up over 13,200 houses in, 1666. Consequently, Nicholas Barbon made an insurance operator office in 1681 to insure building blocks and frames believed first fire insurance organization in England. Later in, 1732, United States additionally needed its 1st protection scope structured done Charles town (present day Charleston), south Colombia, on underwrote fire protection. Benjamin Frankling aided popularized and institutionalized the act for insurance, specifically against fire in the form of Aeolian insurance.

2.3 General Health Insurance Pricing.

As stated by Finn and Harmon (2006),the Irish health services framework offers a tax financed, widespread privilege to the public at an ostensible client fee, nonetheless half of the Irish population buy private health insurance. This paper pragmatically models the affinity to insure as a function of individual and household characteristics using a panel data analysis comparing three different methods, a static, chamberlain - Mundlak and dynamic specification. Utilizing board information from 1994 to 2000, they checked if affinity to insure is truly a function of heterogeneity or state reliance. A reach for individual and household qualities is shown to influence propensity to insure .Generally speaking the positive impact of education and income and the negative impact of poor health status remain potent across three classifications. In moving toward a changing classification Finn and Harmon (2006) showed that persistence is a highly important factor of demand for private health insurance and also that it decreases the size of the coefficients on the repressors. The latter point points out that while education, income and to a smaller extent health status have a great effect on chance of insuring, these impacts are overstated where no attempt is made to control for unnoticed heterogeneity or state reliance.

2.4 Multiple Decrement Models

As an extension of multiple decrement models, multi-state model of transitions was discussed in this paper when the transitions among the states are governed by Markov models. There are many instances in health insurance, disability income insurance, and vehicle insurance where the member's movement are back and forth among states and may return to states they have previously left. For example, in disability income insurance, while modeling workers' eligibility for various employee benefits, the states considered are (i) active, (ii) temporarily disabled, permanently disabled, and (iv) dormant which may include retirement, death, or withdrawal that can be defined as separate states. A Markov model is proposed to describe the probabilities of moving among these various states, including the chances of moving back and forth between active and temporarily disabled states some number of times. In vehicle insurance in modeling insured automobile drivers' ratings by the insurer, the states considered are (i) preferred, (ii) standard, and substandard. Thus, these states describe the insured's driving record. The probabilities of transitions among these states can also be modeled by a Markov chain. Sometimes a state "gone" is considered to describe that the member is no longer insured. In health insurance, in long-term care, a commonly used model is continuing care retirement communities. In this model, Indi duals may move among states such as (i) non-dependent living, (ii) momentarily in health center, (iii) permanently in health center, and (iv) gone. In insurance it is of interest to see the financial impact of these transitions. Multiple state models have proved to be appropriate models for an insurance policy in which the payment of benefits or premiums depends on being in a given state or moving between a given pair of states at a given time. This paper also explores a Markov chain model to decide premium in continuing care retirement communities model in health insurance and a Markov process model for disability income insurance in employee benefit schemes. Arnold and Brockett (1983) on the identification for dependent multiple decrement/competing models, it said in the study of multiple decrement lifetimes one considers a group of x lives. As long as the members are alive, the group is said have survived. In reality, the indidual lives are mostly put together in annuity or insurance, or some other popularly known undertaking, and often are related by blood, marriage or some joint undertaking which simultaneously presents the individuals to common hazards and death risks. Generally, the joint survival function of the group should show dependence between the component lives. The mode of analysis often used for multiple decrement estimation however presumes independence of the joint lives and joint life insurance payable upon the first death in the group is evaluated with this assumption.

2.5 Application of multiple decrement to the pricing of Insurance

The early history of these models has been described by Seal (1977) and Daw (1979) in some detail and our purpose here is just to review some important historical developments in terms of the theory and its practical applications to insurance problems.

The problem are as follows:

For two states say M and N such that components in state M have mutually exclusive probabilities, maybe dependent on the time spent in state M, and the chances of leaving state M because if (i) death or (ii) movement to state N, then what is the likelihood of a component moving to state N and dying there within a given interval of time? Bernoulli's state M comprised of lives who had never had smallpox, while state N constituted of those who had been infected by smallpox and would either die from it, almost directly, or lived and no more be suffering from that it. In an attempt to find a solution to this problem, Bernoulli started with Edmund Halley's (Breslau) life table and effectively formulated the first twofold decrement life table with one of those related solitary decrement tables and in addition acknowledging the viability of inoculation and derivation a scientific model of the nature of smallpox. During the next 50 years, there were a number of commitments from other writers on the subject, including Jean d'Alembert and Jean Trembley.

Lambert (1772) clarified how numerical information might a chance to be used to investigate Bernoulli's issue and laid the practical foundation for the double decrement model and life table. He obtained an approximate formula for the rate of mortality and thereby setting down a practical connection between the double decrement model and the underlying single decrement models.

Despite this progress by the early 1800s there were two outstanding problems, namely

1. deriving accurate practical formulae for application to numerical data, linking the discrete and continuous cases; and

1. obtaining exact results in a convenient form (d'Alembert had derived an exact results in terms of an integral that was difficult to evaluate).

These problems were attacked successfully and independently by Cournot (1843) and Makeham (1874). They were the first to set down the fundamental relations of multiple decrement models: in modern notation:

$$\mu_x^k = (a\mu)_x^k \text{ for k = 1, 2, 3.....m} \tag{2.1}$$

$$(a\mu)_x = \sum_{k=1}^{m} (\mu)_x^k \tag{2.2}$$

Which follows that

$$n(ap)_x = \prod_{k=1}^{m} nP_x^k \tag{2.3}$$

Makeham (1874) also contains an analysis of the partial forces of mortality for different causes of death, suggesting an interpretation of his well-known formula for the aggregate force of mortality $\mu_x = A + Bc^x = \left(\sum_i = 1^m B_j\right) c^x$ to represent separate contributions from $m + n$ causes of death. Makeham went on to use connection between forces of decrement to interpret the prior development of the theory; he demonstrated that the earlier results of Bernoulli and d' Alembert satisfied this addictive law for the forces of decrement and this multiplicative law for the probabilities (or corresponding I_x functions)

In an internal report in 1875 (which was not placed in the public domain) on the invalidity and widows' pension scheme for railway officials, Karup described the properties and use of singe decrement probabilities and forces of decrement in the context of an illness-death model (with no recoveries permitted), i.e. the "independent or pure" probabilities of mortality and disablement. Hamza (1900) represents an important development by providing a systematic approach to disability benefits in both the continuous and discrete cases. Hamza's paper is significant, setting down a notation which has been widely adopted in the following decades and which forms the basis for the notation we have utilized.

Du Pasquier took a dramatic step forward by providing a rigorous, mathematical discussion of the invalidity or sickness process with the introduction of a three state-death model in which recoveries were permitted. He derived the full differential equations for the transition probabilities and showed that these lead to a second-order differential of Riccati type which he then solved for the case of constant forces of transition. Du Pasquier work is very significant, presenting an early application of Markov Chains, and laying the foundations for modern actuarial applications to disability insurance, long-term care insurance and critical illness.

Despite the interest and importance of these problems to actuaries and the consistent contribution made to the actuarial literature since the mid-nineteenth century, these contributions have essentially been rediscovered and renamed as the Theory of competing risk by Fix and Neyman (1951), and other statistical workers.

2.6 Life Insurance Pricing

Heber et al. (2013) in their project analyzed premium rates in a basic form that would be used by insurance companies. The purpose of their project was to understand, analyze, and replicate insurance premiums that clients will spend on purchasing their life insurance or life annuities for retirement. This also gives individuals a good idea what they can expect to pay under different insurance contracts, assuming no expenses and profit earned by the insurer. So far we have used a standard life table from the book Actuarial Mathematics by Bowers, Gerber, Hickman, Jones, and Nesbit. We took this life table and then generated probabilities of survival, life expectancy, discount rates, and actuarial present values for both life annuities and life insurance. Future implementation can be done using real-world life tables. By using Microsoft Excel we have created a user friendly application for determining what one's price will be while purchasing contracts from an insurance company. These pricing values are determined given their age, market interest rate, desired death benefit amount, and term length. The pricing values will be returned to the user in a way that they may compare prices. They can compare life insurance prices according to annual prices verse monthly prices for whole life verse term life insurance. It will also allow them to see what payments are necessary now for future life annuities for retirement.

In a paper by Brennan and Schwartz (1976), they viewed the harmony estimation of equity-linked life insurance policies with asset guarantee; such policies give profits which rely on the execution of a reference portfolio liable on a base guaranteed benefit. The benefit is disintegrated into a sure sum and promptly exercisable call choice on the reference portfolio. A numerical methodology to figuring out the value of the call choice is introduced and the risk minimizing investment technique to be followed by the issuer of the policy is derived.

Wang (1995) proposes a premium principle, here the risk loadings would force by a proportional diminishing in the hazard rates. This premium standard may be scale invariant and added substance to layers. It is demonstrated that this standard will produce stop-loss contract as an optimal reinsurance agreement in a competitive market when reinsurer is less risk-averse than the direct insurer. Finally, expanded cutoff points variables are computed in view of this guideline.

Life insurance is defined according to Bowers et al. (1986), as a contract between a policyholder and the insurer in which the insurer promised to pay a designated beneficiary the amount assured in exchange for a fixed or sequence of periodic premium(s) upon the death of the insured. It therefore provides insurance against the likelihood of death often on a guarantee bases over a longer period of time. However, it is possible for one to insure the risk of death over a relatively shorter period of time, such as a year, as it is usually done under general insurance (Deaton, 2004). Life insurance policies are legal contracts with a policy document specifying the terms of which compensation will be provided for. Specific preclusions are often made to limit the insurer's liability. Common examples, are such relating to claims of fraud, suicide, riot, war, and others (Kwadwo Duodu and Amankwah, 2012).

Life based policies are grouped into two major forms as:

Temporary policies - example term insurance, designed mainly to provide benefits usually of a lump sum in the event of the specified event.

Permanent policies (remains in force until policy matures) example whole life, universal life and variable life, the rationale is to facilitate the growth of capital either by single or periodic premiums. There are 23 life insurance companies licensed to underwrite life policies in Ghana as at June, 2015. Funeral, Keyman, Group life, Credit and Mortgage, whole life, Endowment and Term policies aresome products of life policies found in the Ghanaian insurance market (National Insurance Commission) result in unnecessarily large benefits, since there will be insufficient time for the Dread Disease benefit to be used for any of the purposes suggested. Secondly, there could be difficulties in verifying the validity of a Dread Disease claim-for example, although the death certificate could record 'Heart Attack' as the primary cause of death, but it may be clear that this event satisfied the required definition of a Dread Disease. Worldwide, most CI products are still offered with a prepayment benefit in combination with whole life, term or endowment insurances. However, each of the two main forms has its special advantages.

A decision for or against a prepayment or additional payment should be made in consideration of the actual insurance demand. In this context, it should be noted that the inclusion of an additional payment benefit leads to higher premiums than the inclusion of a prepayment cover.

2.7 Illness Insurance Modelling

In a paper presented by Macdonald et al. (2005) they explained briefly a model about Huntington's disease (HD), an exceedingly penetrant, dominantly inherited deadly mishap neurological issue. In spite of it being a single-gene disorder, mutations would vary on their effects, contingent upon the number about times that the CAG trinucleotide will be rehashed done a sure locale of the HD gene. The model covers: (a) rates of onset, contingent upon CAG repeatable period and also age; (b) post-onset rates about mortality; and (c) the appropriation for CAG repeatable lengths in the number. Utilizing these, they considered the dread disease and life insurance market. They evaluated premiums in view of hereditary test effects that unveil the CAG repeatable length, or that's only the tip of the iceberg basically looking into a family history of HD. These fluctuate generally with age and policy term; a few would exceptionally high, however, an expansive number of cases could be cover ordinary underwriting breaking points. They also thought that as of the conceivable costs of unfriendly selection, as far as expanded premiums, under different time permits moratoria on the utilization of hereditary information, including family history. These uniformly extremely small, due to the rareness about HD, but do indicate that the cost might make a significant part bigger to relative terms assuming that family history has not been utilized within underwriting. They also made clear some challenges included on applying a ban that appreciate basically a dichotomy between 'carriers' and 'non-carriers' for any mutation in gene when those mutations are, actually stochastic in their impacts. These complexities propose that confinements on the disclosure, as opposed on the use, from hereditary information, whether it will be made illustrative principle, might deny insurers for data required for risk management regardless of not utilized within underwriting. Macdonald et al. (2005) constructed a model for the improvement for Coronary Heart Disease (CHD) or stroke that possibly involves, or incorporates pathways through those major risk figures for premium when underwriting to dread disease protection. Their principal was to come up with a model that could be used to evaluate the effect on insurance of hereditary data pertinent to CHD or stroke. Their model might have been parameterized utilizing information starting with the Framingham Heart Study in the US. They stretched out this model to incorporate different CI's, such as, tumors and kidney failure, and portray percentage requisitions of the model.

As stated by paul Brett Furthermore Johann du Toit, 2006 in their report on pricing critical illness insurance, they set table for the United Kingdom market, which could be utilized as benchmark or reference point for reserving furthermore background for examination by UK insurance organizations. Their paper depicts the development of that table. In spite of the fact that the paper might have been for a large portion investment to actuaries operating in the UK market, they accepted it highlights a lot of people helpful issues which will be for utilization should actuaries working in distinctive geological markets.

The CMI in May 2005 published CI experience for an extensive segment of the UK life security industry for the quadrennium 1999-2002, including about 7.4 million life years of exposure and 11,803 claims. The CMI is hesitant should publish an insured life table because of the graduation about this information due to the immaturity of the dataset, its restricted age range and the uncertainties that exist within the dataset because of the necessity to estimate dates of diagnosis and the application of grossing up determinants. They additionally accepted that actuaries in the insurance industry needed a table that best fits the data better than the standard tables which would right now used, to be specific CIBT93 and CIBT02. The tables were both dependent on the populace data and not the insured lives data and didn't distinguish between smoke and non-smoker. Whilst they had sensitivity for the CMI's perspective, they also accepted it might be better off having a live table with conditions or cautions than not having any at all.

The new table introduced in their paper was dependent on the draft rates starting with CIBT02, reshaped to reflect the background information from those CMI to the quadrennium 1999 – 2002. They named their rates, CIIT00. The rates comprise of 4 tables subdivided toward sex and smoker status; CIIT00 MNS, CIIT00 MSM, CIIT00 FNS and CIIT00 FSM.

In addition to testing the goodness of fit of the rates against CMI encounter they have tried it against the encounter of a few of the biggest CI providers in the UK for which our agency needed the information. Paul Brett and Johann du Toit felt that the outcomes do show that CIIT00 may be an appropriate table to utilized when analyzing experience and reserving bases.

The actuarial contribution to health and sickness insurance is closely linked with the evolution of friendly societies in Ghana and other corresponding institutions in other countries. The society is a mutual association which gives financial assistance to its members in times of sickness and old age. Its operations are based on insurance principles, the benefits being paid from a fund accumulated from the member's regular contributions. The actuarial profession began to be concerned with friendly society finance during the nineteenth century. As their techniques developed, actuaries advised on the rates of contribution and on the accumulation of funds to meet the future liabilities being promised. The first attempt to produce age-related sickness rate was made by Price (1792) at the request of a House of Commons Committee. The rates were used to produce tables of contributions for given levels of benefit in respect of incapacity for work. Finlaison (1829) presents a classic investigation of annuities which contains sickness rates based on six years" data. Finlaison calculated the present value of a standard set of friendly society benefits at different ages and the equivalent age-dependent contribution rate for all. This work represents the first investigation into sickness rates.

Hubbard (1852) contains the first investigation into the sickness experience with an analysis by sex and occupation. For example, we find the first published analysis of data on length of hospitals stays for each spell of sickness for different types of occupation. In 1855, K.F. Heym published work on the organization of friendly societies, with special reference to Leipzig, in which he advocated the use of premiums which were dependent on age at entry. He also published age related sickness rates and probabilities of being disabled, based on date collected from local patterns of sickness benefits. Heym is regarded by some commentators as the "creator of invalidity insurance science".

Angus et al. (2004) provides an account of investigations into the sickness and mortality experience for 1893-97 of the Manchester Unity Friendly Society which had become one the standard works of sickness insurance for almost nine decades. Although methods have now moved on from Watson's approach, it is still possible to appreciate his clear presentations and analysis of data cross-classified by several factors. Earlier investigations had revealed that occupation was an important variable, but Watson's consideration of the combined effect of occupation and region was new.

The friendly society movement has declined in importance during the twentieth century; however, there is now a resurgence of interest in many countries in long-term disability income insurance (or permanent health insurance), long-term care insurance for the elderly, critical illness protection and other types of related cover offered by life insurance companies. It is with these important modern applications in mind that this project has been carried out.

2.7.1 Pricing in Long Term

Contrary to short term pricing, the randomness of loss of a long term insurance (life) product relates to an individual's mortality table. Here, the span of the loss but not the exact period the event occurred is normally known with assurance

(Bowers et al., 1986). This suggest the need for the inclusion of time value of money in terms of interest rates and mortality, into, the determination of the required insurance cover's premium (price). Similarly as indicated by Bacinello (2001), expected losses for long term insurance products depends on the mortality, rates of interest and a loading, for the variability in the actual mortality. This formed the basis for calculating most long term life insurance premiums of which assumptions are made (Wang, 1995).

2.8 A Markov Model for the Pricing of Insurance

Aase (2001) article displays a valuation hypothesis of futures contracts and derivatives on some contracts when the underlying conveyance takes after a stochastic process that has jumps of random claim sizes at uncertain time points of disastrous event. Application of the methods is made on insurance futures and options, new instruments to risk management propelled by the Chicago Board of Trade. Numerous closed evaluation formulas are obtained dependent on a partial, competitive harmony supposition both for futures contracts and for futures derivatives, for example, caps, call options, and spreads, assuming steady relative risk repugnance for the delegated agent.

In a paper presented by Zhang and Boukas (2009),the steadiness and stabilization issues of a population about continuous-time and discrete-time Markovian Jump Linear Systems (MJLS) with partially unknown transition probabilities are analyzed. The framework under thought is more general, which blankets the frameworks with totally known and totally unknown transition probabilities two unique situations — the last is thus switched linear systems under discretionary exchanging. Also, in contrast with the unsure transition probabilities contemplated recently, the idea from partially unknown transition probabilities suggested in this paper doesn't require any idea of the unknown components. The addition states to stochastic steadiness and stabilization of the underlying frameworks are determined by means of LMIs formulation, and the connection with the steadiness criteria currently gotten for the common MJLS and switched linear systems under discretionary switching, are laid open by those suggested population about mixture frameworks (systems). Two numerical cases are provided to show the validity and possibility of the developed outcomes.

2.9 Dash and Grimshaw CII Pricing Model

A Dread Disease contract pays out a lump sum on the diagnosis of any of a number of underwritten diseases. The most commonly covered were heart attack, coronary artery disease requiring surgery, cancer and stroke. The benefit could take either of two main forms—it may provide an acceleration of all or part of any death benefit or it may be an additional benefit. It could be sold in conjunction with many conventional products or as a stand-alone policy. Dread Disease contracts were originally developed in South Africa in the early 1980's, although cancer riders had previously been sold in the U.S.A., Japan and Israel. To some extent the marketing of these contracts was insensitive and preyed on people's fears in a distasteful way. This may explain some initial reluctance amongst U.K. insurers to enter this market; however with marketing literature now emphasizing more positive aspects, this appears to have been overcome.

Unlike conventional life assurance and Permanent Health Insurance, Dread Disease covers do not meet any specific need or indemnify the claimant against any loss of earnings or any expenses incurred. Neither does the claimant have to fulfill any criteria for Disability Dread Disease covers pay out on diagnosis regardless of the extent of ill-health. Indeed the marketing literature for one product stresses that you can "receive your life assurance before you die" and others suggest that the claimant could return to work the following day with a much healthier bank balance. This promotional emphasis may hide the fact that in some cases Dread Disease cover can meet a genuine need for example, to pay medical expenses, to allow prolonged convalescence or early retirement, to purchase special equipment or to modify one's home. However, it can be seen as incomplete in that the insured may suffer a severe and debilitating disease that is not covered by the contract. (Dash, et al., 1993) A paper presented to the Society on 16 January, 1990, Dash et al. stated that, the variables needed to price a critical illness insurance differs entirely from those required to price other life insurance products. They also stated that, for an acceleration product, we need incidence rate of the particular illness, its proportion of death with age specific and the mortality of the ages in order to price the insurance.

Chapter 3

Methodology

3.1 Introduction

This chapter deals with the methods employed in the collection of data, population and sample size, survey process and the method of analysis. We want to use the multiple decrement model (Dash and Grimshaw model) to price CII which we think will give us fair pricing.

3.2 Data Description

Secondary data was used throughout this research work. Data on incidence rates (i_x) was taken from the CIBT93, data on proportion of death (k_x) and 28-day mortality rate (q_x^i) was taken from the HES between 1993-1994. Mortality rates for healthy lives was taken from the ELT 15.

3.3 CII Pricing Assumptions

The key assumption in pricing a critical illness product is the set of rate of occurrence developed for the conditions covered. An incidence rate is the probability that someone will be diagnosed with a particular critical illness

Incident rates are based on current U.K's population statistics, and are adjusted to reflect the insured population. We must start with U.K's population statistics because we do not have insured experience due to the product's recent entry in the Ghana. The adjustments to reflect the insured population will be tailored to the specific product, market and distribution systems.

Another country's experience should be used for comparison only, as that country's experience can differ markedly from the United States.
The finances received could be used to:

- pay for the costs of the care and treatment;
- pay for recuperation aids;
- replace any lost income due to a decreasing ability to earn; or even
- fund for a change in lifestyle

This project has been therefore designed to bring some fairness in the pricing of CII using the Dash and Grimshaw model.

3.4 The Stand-Alone Benefit

The Stand-Alone product pays a sum assured if the insured is diagnosed of one of the conditions stated in the policy or contract, if and only if the policyholder survives after 28-30 days following diagnosis. This period is known as the "Survival Period". It is therefore very necessary for policyholders to know that if they are unable to live during the so-called survival period, they will not receive payments made to the heir(s). Because of this defect it is advantageous to opt for additional benefit (payment). However, this will comes with an increase in the premium payable by the policyholder.
In the case of a CI claim, an extra benefit is due with the underlying primary insurance remaining the same. As a general principle, the CI benefit is issued as a lump sum. However, it is also possible to segregate the annuities into 3-5 parts'. With this kind of cover the policyholder must live pass a certain short time interval to be able to push for a claim. Two issues could emerge for an extra benefit assuming the event of death occurs quickly after the occurrence of a CI. Stand-Alone rates calculated using the likelihood of the policyholder going past the 28-day survival period, which is of course dependent on the type of CI

he or she was suffering from.

3.4.1 Pricing Formula for Stand-Alone Product

Risk premium $= i_x(1 - q_x^i)$ where i_x is the incident rate of the CI and q_x^i is the proportion of lives who could not live during the survival period following a CI. The deduction of $i_x q_x^i$ from the incident rate i_x is needed since no payment is made on this contract if the insured dies within the survival period.

3.5 The Acceleration Benefit (Prepayment Benefit)

The Prepayment product provides a combination of a death benefit and Critical Illness cover. A payment is made when either the policy holder dies, or he or she is diagnosed as having one of the conditions specified in the policy wording. Typically, a proportion of the sum assured is paid when a Critical Illness is diagnosed and the balance is paid on death. This type of Critical Illness product is very popular in the U.K. and Irish markets. The design can be beneficial to insurers, since it reduces some of the uncertainty surrounding the pricing of the product. For example, when a Critical Illness benefit is attached to a whole-life assurance or endowment assurance, a Critical Illness claim would simply be bringing forward the payment that would ultimately have been made on death. The advantages of offering the Dread Disease as an acceleration of the death benefit are as follows:

1. The cost of the Dread Disease cover is substantially lower than that for an additional benefit, increasing sales potential.

2. Any uncertainty in the premium rates charged may be reduced for an

acceleration benefit where we are concerned only with the addition required to the mortality rate.

The usual form is a rider to a life insurance policy providing for full or partial prepayment of death benefit in the event of a CI claim. The CI sum insured is then paid out as a lump-sum benefit. The amount if CI benefit is given as a percentage of the life sum insured. As soon as the CI benefit has been paid, the sum insured under the main policy is reduced by this amount and at the same time the premiums to be paid decrease accordingly.

To calculate the Accelerated incidence rates, the Dash and Grimshaw model, has been used. The values k_x are calculated using the Office of Population Census and Statistics (OPCS). The values of $q_x$is taken from Life Table 15 (LT15). These were compared to crude population mortality rates derived from OPCS by cause for 1992-1993, the central year of the Base table.

3.5.1 Pricing Formula for Acceleration Product

To calculate the Acceleration product, we use the Dash and Grimshaw model for risk premium which is given by: Risk premium $= i_x + q_x(1 - k_x)$ where i_x is the incident rate of the critical illness, k_x is the proportion of deaths caused by Critical Illness, and q_x is the mortality rate.

The i_x term covers the cost of the Critical Illness element of the benefit. The $q_x(1 - k_x)$ term covers the cost of the mortality element of the benefit, but only in respect of deaths due to a cause or causes other than Critical Illness.

3.5.2 Policy Standards

Any CI to be inculcated in the CI policy (contract) must fulfill the following conditions, which reflect marketing, medical and actuarial inclusions:

a) It must be convinced by the general public that these CIs could take them to their graves or make them lose their entire life saving.

b) It must have clearly stated and precise definitions.

c) There must be adequate information for pricing.

d) It must not permit anti-selection by applicants.

The primary ailment included in most CI contracts are Heart Attack, Cancer and Stroke.As specified earlier, it may necessary that the contract wording holds unequivocally worded definitions. In the 90's, insurers in the U.K came together and decided to make the definitions of the conditions in the CI contracts standardized. This prompted a statement of best practice being issued by the ABIs in 1999, which was upgraded in 2003(ABI, 2003) It has demonstrated to be very successful as the insured no longer need to analyze the illness definitions in thoroughly when trying to find the differences between insurers. Also is implies that any inter-office claim experience that is gathered is made more valuable, since the definitions utilized by every insurer are the same.

3.6 Decrement

Lets first introduce some basic actuarial notation before describing different mortality assumptions. The symbol (x) is used to denote a life-aged-x. $T(x)$ be the random future lifetime of (x). To make a probability statement about $T(x)$, we use the following notations when $t \geq 0$

$$_tq_x = Pr\,(T(x) \leq t) \tag{3.1}$$

$$_tp_x = 1 - tq_x = Pr\,(T(x) > t) \tag{3.2}$$

The interpretation of $_tq_x$ is the probability that an individual aged(x) will die within t years, while $_tp_x$ is the probability that the insured aged (x) will survive in the next t years. Let K_x denote the curtate future-lifetime of (x) which is the number of future years completed by (x) before death, K_x is actually the greatest integer in $T(x)$. Then the relationship is given as

$$Pr\,(K_x = k) = Pr\,(k \leq T(x) < k + 1) \tag{3.3}$$

$$= kP_x - k + 1\rho_x$$

$$=_{k+1} q_x -_k q_x =_k |q_x$$

3.6.1 Discrete Time multiple state models for Life and other Contingencies

Multi-State transition models are probability models that expresses the random movements of a subject among various states. Mostly, the subject is an individual life, but it may just as well be a piece of machinery or a loan contract in whose survival or failure you are interested in. In this section,discrete cash flow models are generalized to situations where in each period an entity (life, machine, etc.) can move from the current state to several other states, and perhaps even return to the current state after leaving it. The three-factor method for calculating an Actuarial Present Value (APV) which are the amount due at time, let say k, the probability that this payment is made, and a discount factor for k periods, remains the same, but now the probability factor will come from a multi-state transition model-known as Markov chain which was described earlier and will be revisited later.

3.6.2 Two State Model

This represents a single life theory where individuals have two possibilities (i.e two possible states). In this model the only two state are either dead or alive.

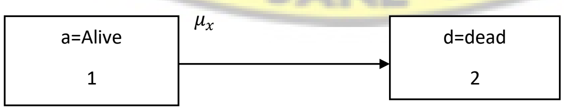


Figure 3.1: Two State Model

A discrete life annuity due of 1 per year paid to or by life (x) will result in a series of payments equal to 1 at the start of each period while life (x) remains is state 1. A discrete while life insurance of 1 on life (x) will result in a one-time payment of 1 at the end of the period during which life (x) makes a transition from state 1 to state 2 (i.e. dies).

3.6.3 Three State Model

We suppose that we have a double decrement model for insured lives where state (1) healthy, and state (2) sick and (3) dead. We might look at this situation as a 3-state model. In this model there is possibility of movement from state 1 to 2, 2 to 1, 1 to 3, 2 to 3. However, it is not possible to move from state 3 to any other state (absorbing state).

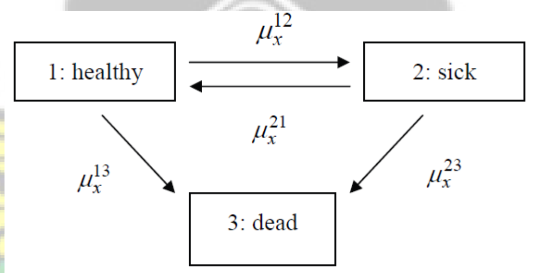


Figure 3.2: Three State Model

From the diagram, μ_x^{12} is the probability an individual in state 1 moves to state 2, μ_x^{21} represents the probability that an individual in state 2 moves back to state 1.(thus, a sick person becomes healthy again). Generally, μ_x^{xy} is the probability that an individual in state x moves to state y. So, in our case an individual receives a payment benefit (sum assured) when he/she moves from state 1 to 2.

3.6.4 Four State Model

Let us consider a joint life insurance policy on lives (x) and (y), premiums are paid so far as both (x) and (y) are alive and benefit is paid to the heir when the second death occurs (last survivor status). We might look at this situation as a 4-state model:

1. state 0-both (x) and (y) are surviving
2. state 1-(x) is surviving, but (y) is deceased
3. state 2-(y) is surviving, but (x) is deceased
4. state 3-both (x) and (y) are deceased

In a joint life status, benefit is paid when we hit either state 1 or state 2,but in a joint life status as discussed earlier, benefit is paid when we only hit state 3.

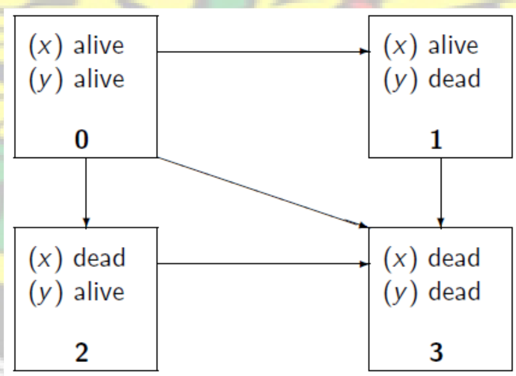


Figure 3.3: Four State Model

Just as explained earlier, in this model state three is the absorbing state. A series of premiums would be paid at the start of each period while the status remains in state 0. Premiums would cease when the status moves from state 0 to state 1, state 2 or perhaps even state 3 (if both lives dies in the same period).If the movement is to state 1 or 2, then the benefit is paid at the end of the period when the transition to state 3 eventually occurs. In cases benefit is paid to the surviving life (i.e x or y) when we get to state 1 or 2, thus joint life status. However, some policies allows for benefits to be paid if and only if both x and y are dead. (i.e state 3). In each of these three models, the possible transitions at the end of each period are very limited. In the single life model there is a one-time transition from state 1 to state 2. In the multiple decrement model there is only one transition that ever occur. It is either from state 0 to state 1 or from state 0 to state 2. In the multiple life model there are possibly two transitions of state: one after the first death from state 0 to either state 1, state 2, or state 3, and then usually a second transition to state 3 after the second death. If both deaths occur in the same period, then there is only one transition.

3.7 Multiple States Model for Life Contigencies

The evolution of an insured risk can be viewed as a series of events which ascertain the cash flows of premiums and benefits when insurances of the person are concerned, for instance disablement, recovery, death, marriage, birth of a child, onset of a particular illness (critical illness), etc.

Assuming that the evolution of a risk can be put in terms of the presence of the risk itself, at each point in time, in particular state that belongs to a specified set of states, or state space. Furthermore, it is assumed that the prior events agrees to transitions from one state the other.

The graph Fig. 3.1 illustrates a set of four states, numbered 1 to 4 (nodes of the graph), and a set of possible direct transitions between states, denoted by pairs such as (1, 2), (2, 1),(1, 3), etc. (arcs). "Indirect" transitions can be represented by the sequences of arcs: for example, a transition from 2 to 3 can be represented by the (2, 1), (1, 3).

For instance, let us suppose that state 1 is the state at policy issue. Possible paths of the insured risk are as follows 1 (until the policy term);

1 - 2 - 4;

1 - 2 - 1 - 3 - 4

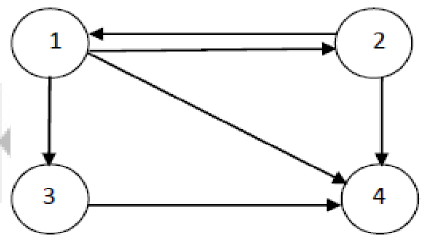


Figure 3.4: Multiple States Model for Life Contigencies

From a merely intuitive point of view, it appears that:

1. states 1 and 2 are transient states: this implies that it is possible to leave and to re-enter these states;

2. state 3 is a strictly transient state: this means that it is not possible to enter this state once it has been left;

3. State 4 is an absorbing state: here, movement to other state is not possible

A rigorous definition of these types of states will be given in terms of transitional probabilities. Formally, we denote λ by the state space. It is assumed that λ is a finite set. Then denoting the states by integral numbers, we have:

$$\lambda = 1, 2, 3, ..., N \tag{3.4}$$

The set of directional transitions is denoted by τ. In general, τ is a subset of the set of pairs (i, j)

$$\tau \subseteq \{(i, j) \perp i \neq j; i, j \in \lambda\} \tag{3.5}$$

If state 1 is the initial state at time 0, it is assumed that all the states $j \in \lambda$ can be reached from state 1 by direct or indirect transitions. The pair (λ, τ) is called a multiple state model. It is also noted that multiple state model (λ, τ) simply describes the 'uncertainty', that is the "possibilities" with respect to insured risk, as far as its evolution is concerned. Let us suppose that we are at policy at issue, that is at time 0. The time unit is one year. Let $s(t)$ denote the random state occupied by the risk at time, t, $t = 1, 2, 3, \ldots, n$. Of course, $S(0)$ is a given state; we can assume for example $S(0) = 1, S(t); t = 0, 1, 2, 3, \ldots,$ is time-discrete stochastic process, with values in the finite set λ. The variable t is often called seniority. It represents the duration of the policy; when a single life is concerned, whose age at policy issue is x, $x + t$ represents the attained age.

Any possible realization $s(t)$ of the process is called a sample path; thus, $s(t)$ is a function of the discrete positive variable t with values in λ.

3.7.1 Benefits and Premium

A very important concept in insurance is introduced here, thus are benefits and premium. A premium is a sum of money that you pay regularly to an insurance company for an insurance policy. Also a benefit is the sum of money you (insured) receive at the end of an insurance contract, the amount to receive however depends on the amount of premium that was paid during the contract period.

For a fully discrete whole life insurance, let b the benefit on the life age (x) and P be the level annual benefit premium to be paid at ages $x, x+1, \ldots, x+k(x)$. The random present value of premium if given by

$$P\ddot{a}_{\overline{k(x)+1}} \tag{3.6}$$

$$= E\left[P\ddot{a}_{\overline{k(x)+1}}\right]$$

$$= PE\left[P\ddot{a}_{\overline{k(x)+1}}\right]$$

$$= P\ddot{a}_x$$

By the equivalence principle is given by;

$$P\ddot{a}_x = bA_x \tag{3.7}$$

Where $\ddot{a}_x$ is the compound interest annuity, A_x is the actuarial present value. Lets denote the $s(t)$ as a sample path of stochastic process such that $P_1(t)$ is the premium at a rate say, $r_1(t)$, paid by the insured while the risk was in state 1, $b_2(t)$ be a discrete annuity at rate $R_2(t)$ paid by the insurer while the risk is now in state 2;

$C_{13}(t_3)$ = lump sum paid by the policyholder at time t_3 when there is a transition from state 1 to 3

$C_{34}(t_5)$ = lump sum paid by the policyholder at time t_5 when there is a transition from state 3 to 4

$d_3(t_4)$ = lump sum paid by the insurer at a fixed time t_4 because the risk is in 3. We can develop a graph showing the clear picture of this as given below.

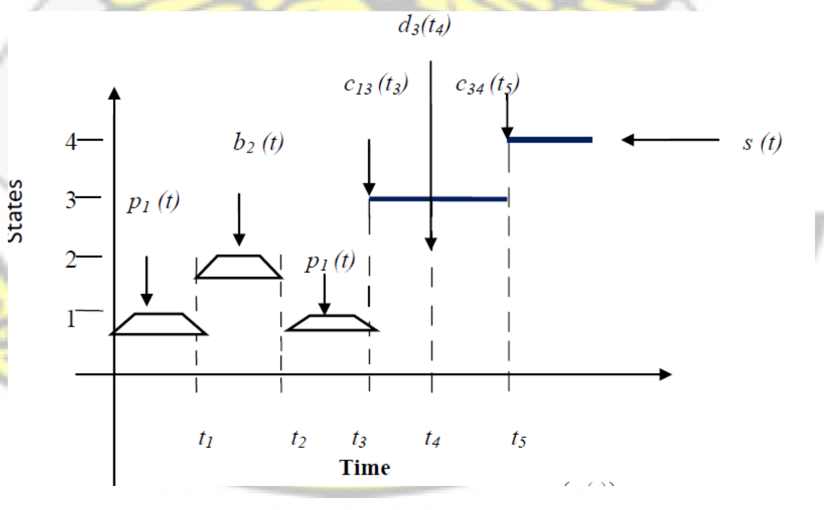


Figure 3.5: Benefits and Premium

3.7.2 Reserves

The benefit reserve at duration t on a policy issued at age x that is still in force t years later is defined to be excess actuarial present value at age $x + 1$ of future premium including any premium due age $x + 1$. This excess represents a liability for the insurer (money out-less money in) calculated at the end of the year. It is called the tenth year terminal benefit reserve.

Consider a fully discrete whole life insurance of 1 that is issued on a life age x. Assume that the policy is still in force t- years later, when life x has survived to age $x + t \longrightarrow APV$ at age $x + t$ of a life annuity due of future premium P_x oer year is $P_x \ddot{a}_{x+t}$. The access of the APV of future benefits over future premiums is denoted ${}_tV_x$ is that the terminal benefit reserve and given by

$$ {}_tV_x = A_{x+t} - P_x \ddot{a}_{x+t} \tag{3.8} $$

Considering CI contracts that runs beyond a year, reserves for future claims payments should be developed. As a general principle, such reserves are evaluated for each contract in ordinance with formulae corresponding to those ones for mortality reserves. Also to such individual actuarial reserves, additional reserve is recommended to cover claim variations and any declined tendencies of the CI risk.

Mortality after critical illness

To evaluate the acceleration benefits, the probability of the policyholder not surviving after been diagnosed of a CI is used to calculate the overlap of CI with death. By acknowledging this overlap, the occurrence rates for the underlying life insurance may be reduced, with respect to the insured lives who got a CI benefit no death benefit of that sum becomes due in the case of death at some other time. Instead of evolving the actuarial bases of the primary insurance however, the overlap is commonly acknowledged by granting a discount on the CI incidence rates.The diagram below illustrates the situation further.

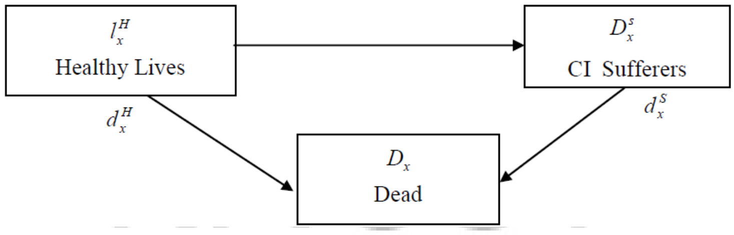


Figure 3.6: Mortality after critical illness

The overlap corresponds precisely of the number d_x^H for death pertaining to CI sufferers. However, there would scarcely any dependable facts and figures on the mortality CI sufferers. This may be the reason a close estimation model was developed to assist figure out the cost of an acceleration benefit. On the support from this model, the frequency rate for an acceleration product is estimated as follow:

Additional rate of CI^{AAC} the mortality $= i_x - k_x, q_x$ (Which represents the Dash and Grimshaw model)

i_x being the CI incidence rate taking out survival period (i.e all deaths due to CI must be considered) and k_x being the proportion of deaths caused by a CI. The k_x can be deduced from cause-of-death-statistics

3.8 The Dash and Grimshaw CII Pricing Model

The spontaneous method for pricing an acceleration benefit is to develop a multiple (multi-state) decrement model for the population of insured lives denoted by l_x

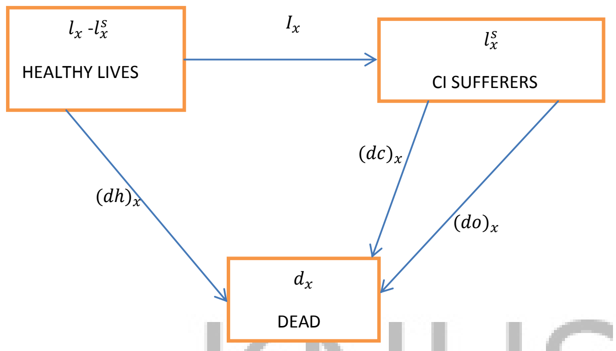


Figure 3.7: Derivation of Approximate Risk Premium Formula for an Acceleration Product

For the purpose of this project, the method of pricing an acceleration product for the risk premium by Dash and Grimshaw will be adapted. The method is an estimate, thus, it employs a discrete time representation of the continuous model. The cover with respect to this research work is for a year and the benefit is a unit sum assured.

The discrete time model is shown in the figure 3.7, where I_x is the number of incidences of CI between age x and $x+1$, and $(do)_x$ is the number of deaths which is not as a result of CI amongst lives suffering from CI between ages x and $x+1$. Now the decrements are summarized as follows:

I_x = number of incidences of CI from the population of healthy lives.

$(dh)_x$ = number of deaths among healthy lives.

$(dc)_x$ = number of deaths from the population of CI sufferers due to Critical Illness.

$(do)_x$ = number of deaths from the population of CI sufferers due to other than the CIs stated in the policy contract.

It can be realized that the three states are **healthy**, **CI sufferers**, and **dead**. The number of deaths amongst CI sufferers must to be partitioned into two, thus, those where deaths was due to CI and those where death was due to another cause. The total claims between age x and $x+1$ on a CI acceleration product per unit sum assured is given by

$$I_x + (dh)_x \tag{3.9}$$

However, the definition above inculcates 'instant/sudden deaths'. So for instance a life that dies immediately from his/her first heart attack will be counted in both I_x and $(dc)_x$. This implies that every CI deaths are considered $(dc)_x$. Hence:

$$(dc)_x = k_x d_x \tag{3.10}$$

Where $d_x = q_x l_x$ and q_x = mortality rate of insured population l_x

k_x is the proportion of deaths due to CI in that particular population l_x between ages x and $x + 1$

d_x is the number of deaths in the population between ages x and $x + 1$

Furthermore, putting the deaths due to causes other than CI into perspective

$$(dh)_x + (do)_x = (1 - k_x)d_x \tag{3.11}$$

Therefore the total claim cost can be further-expressed as

$$I_x + (dh)_x = I_x + (1 - k_x)d_x - (do)_x \tag{3.12}$$

Similarly as noted earlier, we have dependable information for I_x and k_x. Also, d_x follows the assumption of insured lives mortality used in pricing the life cover. To finish up the pricing the values of $(do)_x$ for which data is not available can be used which the already existing approach for pricing CI have varied. In view of this, three different methods and merits for each.

3.8.1 Mortality of Critical Illness sufferers

Under this approach, data that is available on mortality experience of insured who suffered a CI is used. This gives us figures for the sum of the mortality rates:

$$\frac{(dc)_x}{l_x^s} + \frac{(do)_x}{l_x^s} \tag{3.13}$$

knowing that,

$$(dh)_x = d_x - (dc)_x - (do)_x \tag{3.14}$$

Now every element required to develop a multiple decrement table from which we can derive the required rates straightforward is available. The trouble with this method is that the data is not sufficient to have enough confidence in the rates. Due to this difficulty, we must consider another methods that do not directly utilize the mortality after a CI.

3.8.2 Proportion of Deaths

Assuming a factor is defined by f_x as the proportion of deaths among CI sufferers caused by CI in the year of age x to $x+1$

$$f_x = \frac{(dc)_x}{(do)_x + (dc)_x} = \frac{k_x d_x}{(do)_x + k_x d_x} \tag{3.15}$$

Thus $(do)_x$ is obtained if suitable values of f_x can be arrived at. some other suggests that f_x is relatively constant between 0.80 and 0.85 for many ages. Regrettably, data to validate this have not been located.But expanding the approach described in the section after this proposes that f is almost unity. This highlights the risk in depending on assumptions to which premium rates will be reactive since the higher value for f_x brings about notably higher premiums.

3.8.3 Extra Mortality

This method deals with the comparison of CI sufferers from causes other than CI with the mortality of healthy lives. Assuming the later is in excess of the former by an extra mortality m.

Then we have

$$\frac{(do)_x}{l_x^s} = \frac{(dh)_x}{l_x - l_x^s}(1+m) \tag{3.16}$$

and also

$$(dh)_x + (do)_x = (1 - k_x)d_x \tag{3.17}$$

and taking out$(do)_x$ from the equations above gives

$$\frac{(dh)_x}{l_x - l_x^s}\left(l_x + ml_x^s\right) = (1 - k_x)\, d_x \tag{3.18}$$

So if we know m and l_x^s then we can obtain $(dh)_x$, and the first equation provides $(do)_x$, all the values required. A further review of the algebra can help find the net premium for a CI acceleration benefit:

$$\frac{I_x + (dh)_x}{l_x - l_x^s} \tag{3.19}$$

$$= \frac{I_x}{l_x - l_x^s} + \frac{(1 - k_x)q_x l_x}{l_x + ml_x^s}$$

$$= i_x + \frac{(1 - k_x)q_x}{1 + ml_x^s/l_x}$$

Where i_x is the incidence rate of Critical Illness.

If $m = 0$, then the rate can be re-expressed as:

$$i_x + (1 - k_x)q_x$$

So that the additional premium on the mortality rate is:

$$i_x - k_x q_x$$

This approach is relatively the best of those ones described earlier and premium rates shall be deduced on this basis. A comprehensive model of the derivation above is shown below:

The total number of claims between age x and $x + 1$ on an acceleration Critical Illness policy is given by

$$I_x + (dh)_x \tag{3.20}$$

The challenge is then to obtain suitable data to estimate these quantities and specifically $(dh)_x$. A good estimation to the above equation is found by making reasonable deductions as follows:

d_x = the number of deaths in the population between age x and $x+1$

k_x = proportion of deaths in the population between aged x and $x+1$ which are due to CI (note that K_x must not include deaths that occurs suddenly following the onset of CI)

since

$$(dc)_x = k_x d_x \tag{3.21}$$

and $d_x = (dh)_x + (dc)_x + (do)_x$, it continues that the total number of deaths not caused by CI is

$$(dh)_x + (do)_x = (1 - k_x)d_x \tag{3.22}$$

suppose that the probability of CI sufferers from causes not due to CI is the equal to the mortality of healthy lives, then

$$\frac{(dh)_x I_x}{l_x - (Ic)_x} = \frac{(dh)_x}{l_x - (Ic)_x} \tag{3.23}$$

where l_x is the number of lives aged x exact and $(Ic)_x$ is the number of lives aged x suffering from CI.

From the two equations above, $(do)_x$ can be eliminated to obtain

$$\frac{(dh)_x I_x}{l_x - (Ic)_x} = (1 - k_x)\, d_x \tag{3.24}$$

At this stage, equation 3.1 expresses the number of claims between age x and $x+1$ on an acceleration CI contract. To change this into an occurrence (incidence) rate, the healthy population must divided by $(l_x - (Ic)_x)$

, therefore, incidence rate for the acceleration product is

$$\frac{l_x}{l_x - (Ic)_x} + \frac{(dh)_x}{l_x - (Ic)_x} \tag{3.25}$$

The two equations above can be re-expressed as

$$i_x + (1 - k_x)q_x \tag{3.26}$$

where the incidence rate $i_x = I_x/(l_x - (Ic)_x))$ and the mortality rate is $q_x = d_x/l_x$ Therefore, equation above gives an elementary expression for the risk premium rate for an acceleration CI product. This model is utilized in estimating fair premium rate for CI products for the purpose of this research.

Chapter 4

Data Analysis and Results

4.1 Introduction

This chapter features preliminary analysis on the number of persons killed by the some critical illnesses in the study. How to price the insurance using the the Dash and Grimshaw (multiple decrement) model is looked at. The main concern is on these five critical illnesses: cancer, heart attack, stroke, kidney failure and CABG.

4.1.1 Preliminary Analysis

Here we take a primary look at the incidence rates of the top most critical illnesses. The CIBT 1993 was adopted and has been presented in the appendix.

It realized that incidence rates of cancer is relatively higher than the rest of the other critical illnesses, followed by heart attack, stroke with MOT having the lowest incidence rate. From the results it is also realized that as ages of persons increases the rate at getting one of these critical illnesses also increase which in turn increases the stand - alone and accelerated rates. However, incidence of cancer is higher is females than in males but this was the other way round for heart attack. For incidence of stroke, there is no clear evidence of being higher than the other with respect sex since they keep alternating. Generally, as age increases both stand – alone rates and accelerated rates increases as indicated in the graph below. From the graph we realize that, accelerated rates (male and female) are relatively higher than the stand – alone rates. Also deaths in male are higher in males than in females.

Here, we present a base table for critical illness incidence rate with cost for extra

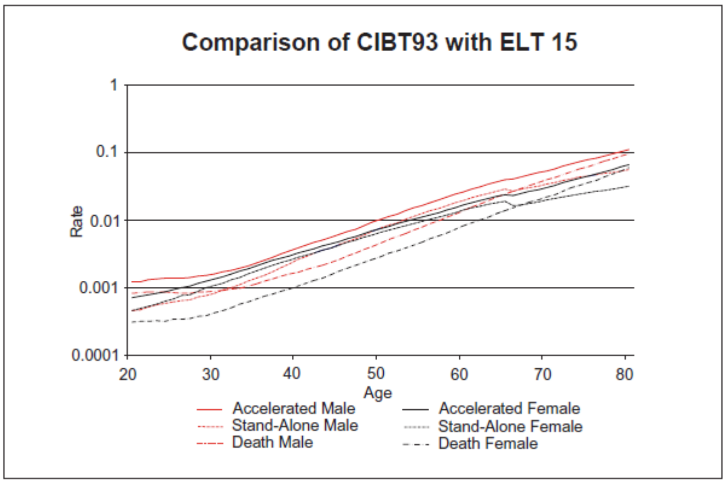


Figure 4.1: Comparison of CIBT93 with Population Mortality

mortality, stand-alone rate, acceleration rate and premiums to be paid for stand-alone rates for ages between 20 to 80 years for the five critical illness considered.

4.2 Cancer

Table 4.1: Critical illness incidence rate – cancer (males)

1	2	3	4	5	6	7	8	9	10	11	12
20	603	334.96	0.18	2.16	0.00006	2.16	8.4267	0.0878	1.42	2.16	0.00216
21	756	357.45	0.21	2.31	0.00007	2.31	8.6371	0.0876	1.55	2.31	0.00231
22	738	375.82	0.2	2.46	0.00007	2.46	8.8479	0.0881	1.68	2.46	0.00246
23	754	375	0.2	2.67	0.00007	2.67	8.8558	0.0904	1.87	2.67	0.00267
24	773	387.17	0.2	2.87	0.00007	2.87	8.8636	0.0935	2.04	2.87	0.00287
25	825	390.34	0.21	3.08	0.00007	3.08	8.5656	0.097	2.25	3.08	0.00308
26	850	402.53	0.21	3.29	0.00006	3.29	8.4709	0.1007	2.43	3.29	0.00329
27	934	411.42	0.23	3.49	0.00007	3.49	8.478	0.1049	2.6	3.49	0.00349
28	908	419.52	0.22	3.71	0.00007	3.71	8.6897	0.1101	2.75	3.71	0.00371
29	914	419.46	0.22	3.93	0.00007	3.93	8.9019	0.1158	2.89	3.93	0.00393
30	1009	409.81	0.25	4.14	0.00007	4.14	9.1147	0.1217	3.03	4.14	0.00414
31	1235	399.12	0.31	4.36	0.00007	4.36	9.328	0.1277	3.17	4.36	0.00436
32	1019	389.39	0.26	4.58	0.00007	4.58	9.7471	0.134	3.27	4.58	0.00458
33	1004	370.49	0.27	4.94	0.00008	4.94	9.962	0.1406	3.54	4.94	0.00494
34	1126	358.25	0.32	5.3	0.00008	5.3	10.5888	0.1475	3.74	5.3	0.0043
35	969	350	0.28	5.66	0.00009	5.66	11.6291	0.1544	3.86	5.66	0.00566
36	1090	338.26	0.32	6.02	0.0001	6.02	12.2776	0.1623	3.95	6.02	0.00602
37	1262	325.3	0.39	6.39	0.00011	6.39	13.7208	0.1719	4.03	6.39	0.00639
38	1097	315.45	0.35	7.21	0.00011	7.21	14.9793	0.185	4.44	7.21	0.00721
39	1196	320.34	0.37	8.05	0.00012	8.05	16.0364	0.1998	4.84	8.05	0.00805
40	1397	318.62	0.44	8.88	0.00013	8.88	17.2021	0.2156	5.17	8.88	0.00888
41	1749	311.99	0.56	9.72	0.00014	9.72	18.5812	0.231	5.43	9.72	0.00972
42	1944	318.96	0.61	10.56	0.00015	10.56	20.1758	0.2459	5.6	10.56	0.01056
43	1906	327.52	0.59	12.03	0.00017	12.03	21.8839	0.2595	6.35	12.03	0.01203
44	2250	339.37	0.67	13.51	0.00018	13.51	24.0206	0.2725	6.96	13.51	0.02402
45	2386	362.17	0.66	14.98	0.0002	14.98	26.6957	0.2852	7.37	14.98	0.01498
46	3155	397.14	0.8	16.47	0.00023	16.47	29.7063	0.2973	7.64	46.47	0.04647
47	3105	306.9	1.02	17.99	0.00025	17.99	33.1638	0.3081	7.77	17.99	0.01799
48	3059	302.27	1.02	21.2	0.00029	21.19	37.1826	0.3162	9.44	21.19	0.02119
49	3241	304.44	1.08	24.43	0.00032	24.42	41.4564	0.3231	11.04	24.43	0.02442
50	3402	288.22	1.19	27.68	0.00036	27.68	46.42	0.3293	12.39	27.68	0.02768
51	3627	263.16	1.4	30.96	0.0004	30.95	51.8778	0.3351	13.58	30.96	0.03095
52	3712	241.88	1.56	34.24	0.00044	34.22	57.7395	0.3401	14.6	34.24	0.03422

Table 4.2: Critical illness incidence rate – cancer (males)

1	2	3	4	5	6	7	8	9	10	11	12
53	4009	256.27	1.59	38.74	0.00049	38.72	64.2391	0.3436	16.67	38.74	0.03872
54	4544	257.84	1.79	43.32	0.00055	43.3	71.4029	0.3463	18.59	43.32	0.0433
55	4779	255.84	1.9	47.87	0.00061	47.84	79.7001	0.3486	20.09	47.88	0.04784
56	5157	250.26	2.1	52.47	0.00068	52.43	89.0706	0.3506	21.24	52.48	0.05243
57	5855	244.78	2.45	57.18	0.00076	57.14	99.4603	0.3522	22.15	57.19	0.05714
58	5978	239.71	2.56	65.22	0.00085	65.16	111.1587	0.3528	26	65.23	0.06515
59	6054	230.49	2.7	73.3	0.00095	73.23	124.2526	0.3529	29.45	73.31	0.07323
60	6351	228.25	2.86	81.42	0.00107	81.33	139.1932	0.3528	32.32	81.43	0.08133
61	7401	233.43	3.27	89.78	0.0012	89.67	156.0106	0.3525	34.8	89.79	0.08967
62	7857	234.01	3.47	98.01	0.00134	97.88	174.8779	0.3517	36.5	98.02	0.09788
63	8281	228.02	3.77	110.51	0.00151	110.34	196.491	0.3502	41.7	110.52	0.11034
64	8883	220.83	4.19	123.39	0.00169	123.18	219.9171	0.3483	46.64	123.4	0.12318
65	9302	215.61	4.51	135.93	0.00188	135.67	244.6622	0.3462	51.23	135.95	0.13567
66	9502	214.24	4.46	148.43	0.00208	148.12	271.0949	0.3436	55.29	148.45	0.14812
67	10231	213.63	5.03	161.36	0.0023	160.99	299.6439	0.34	59.49	161.38	0.16099
68	10345	204.58	5.33	174.83	0.00253	174.39	329.1736	0.3344	64.76	174.85	0.17439
69	10620	199.28	5.63	188.39	0.00276	187.87	360.2085	0.3278	70.32	188.41	0.18787
70	10985	193.52	6.02	202.18	0.00301	201.57	392.9175	0.3207	76.19	202.21	0.20157
71	11234	196.09	6.08	215.41	0.00331	214.7	431.165	0.3134	80.26	215.44	0.2147
72	11668	195.56	6.34	229.09	0.00364	228.26	474.5692	0.306	83.86	229.12	0.22826
73	12236	195.24	6.69	243.57	0.004	242.6	521.7056	0.2982	87.99	243.6	0.2426
74	8672	123.55	7.55	259.39	0.00437	258.25	569.7189	0.2902	94.06	259.43	0.25825
75	7431	111.8	7.12	272.15	0.00475	270.86	619.7199	0.2821	97.34	272.19	0.27086
76	7380	178.28	6.65	284.71	0.0052	283.23	677.6744	0.2738	99.13	284.76	0.28323
77	8079	118.36	7.33	300.32	0.00569	296.61	741.7506	0.2654	103.46	300.37	0.29661
78	8225	114.97	7.7	316.16	0.00622	314.2	810.2217	0.2565	108.34	316.22	0.3142
79	7641	106.98	7.69	330.91	0.00678	328.66	883.674	0.2474	112.29	330.98	0.32866
80	6835	96.16	7.65	345.56	0.00738	343.01	961.581	0.2382	116.53	345.63	0.34301

From Table 4.1 and Table 4.2, 1= age of sufferer, 2 = HES data on number of cancer sufferers, 3=population per 1000, 4= prevalent rate adjustment, 5= crude rate i_x(adjusted), 6= 28 day Mortality rate (ELT 15 q_x^i), 7=stand - alone rate $[i_x(1-q_x)]$, 8= LT 15 population q_x (per 10,000), 9= proportion of death from cancer (k_x), 10= Extra cost for accelerated rate ($i_x - q_x \times k_x$), 11= accelerated rate $[i_x + q_x(1-k_x)]$ and 12= premium to be paid by this client for a stand-alone product.

Further Discussion of Results for Cancer Cases

The definition of cancer from the ABI is adopted here and the source of data has been stated already. The stand – alone rates (column) five and eight. For the accelerated rate we used columns five, eight and nine. For column 12 (premium to be paid by this client for a stand-alone product) we used the relation

$$P = \frac{x}{1000} \times b \qquad (4.1)$$

Where P = premium, x= stand - alone value (for a particular age) and b = benefit. For our premium on the table (column 12) above we calculated for are a benefit of 1. So for example if an individual (male) aged 60to enjoy a benefit of say 2000 at the end of one year, then the premium for a stand- alone product will be $\frac{81.33}{1000} \times 2000 = 162.66$. However, the premium to be paid if this was an accelerated product will be $\frac{81.43}{1000} \times 2000 = 162.86$. The difference we see here is attributed to the fact that the accelerated product inculcates some additional risk (mortality risk). So basically as age increases, the mortality rate also increases and this will also increase the cost of an accelerated product. In all, as age increases all the corresponding quantities increases.

4.3 Heart Attack

Table 4.3: Critical Illness Incidence Rate - heart attack(males)

1	2	3	4	5	6	7	8	9	10	11	12
20	0	334.96	0	0.09	15	0.08	8.4267	0.0041	0.05	0.09	0.00008
21	3	357.45	0	0.14	15	0.12	8.6371	0.0055	0.1	0.14	0.00012
22	7	375.82	0	0.16	15	0.14	8.8479	0.0068	0.1	0.16	0.00014
23	13	375	0	0.23	15	0.2	8.8558	0.0081	0.16	0.23	0.0002
24	5	387.17	0	0.31	15	0.26	8.8636	0.0092	0.22	0.31	0.00026
25	12	390.34	0	0.31	15	0.26	8.5656	0.0104	0.22	0.31	0.00026
26	17	402.53	0	0.37	15	0.31	8.4709	0.0118	0.27	0.37	0.00031
27	9	411.42	0.01	0.45	15	0.38	8.478	0.0135	0.33	0.45	0.00038
28	26	419.52	0.01	0.58	15	0.49	8.6897	0.016	0.44	0.58	0.00049
29	20	419.46	0.01	0.75	15	0.64	8.9019	0.0188	0.58	0.75	0.00064
30	37	409.81	0.02	1.09	15	0.93	9.1147	0.0218	0.89	1.09	0.00093
31	48	399.12	0.03	1.43	15	1.22	9.328	0.0254	1.2	1.43	0.00122
32	68	389.39	0.04	1.87	15	1.59	9.7471	0.0303	1.58	1.87	0.00159
33	81	370.49	0.05	2.27	15	2.01	9.962	0.0378	1.99	2.37	0.00201
34	89	358.25	0.06	3.11	15	2.64	10.5888	0.0456	2.62	3.11	0.00264
35	110	350	0.08	3.79	15	3.22	11.6291	0.0558	3.14	3.79	0.00322
36	155	338.26	0.09	4.85	15	4.12	12.2776	0.065	4.02	4.85	0.00412
37	159	325.3	0.11	5.95	15	6.22	13.7208	0.074	4.94	5.59	0.00622
38	225	315.45	0.13	7.32	15	7.47	14.9793	0.0852	6.09	7.32	0.00747
39	250	320.34	0.15	8.79	15	8.65	16.0364	0.0908	7.33	8.79	0.00865
40	314	318.62	0.18	10.48	16	8.65	17.2021	0.099	8.78	10.48	0.00865
41	377	311.99	0.21	11.92	16	10.01	18.5812	0.1072	9.93	11.92	0.01001
42	438	318.96	0.24	14.12	16	11.86	20.1758	0.1155	11.79	14.12	0.01186
43	492	327.52	0.27	15.57	17	12.92	21.8839	0.124	12.86	15.57	0.01292
44	675	339.37	0.3	17.04	17	14.14	24.0206	0.1327	13.85	17.04	0.01414
45	671	362.17	0.34	19.32	17	16.04	26.6957	0.1413	15.55	19.32	0.01604
46	846	397.14	0.37	21.4	17	17.76	29.7063	0.1498	16.95	21.4	0.01776
47	847	306.9	0.41	23.11	18	18.95	33.1638	0.1578	17.88	23.11	0.01895
48	858	302.27	0.46	25.6	18	20.99	37.1826	0.1648	19.47	25.6	0.02099
49	977	304.44	0.5	28.42	18	23.3	41.4564	0.1714	21.32	28.42	0.0233
50	1021	288.22	0.55	30.84	18	25.29	46.42	0.1771	22.59	30.84	0.02529
51	1082	263.16	0.59	33.46	18	27.44	51.8778	0.1839	23.92	33.46	0.02744
52	1111	241.88	0.64	36.52	18	29.95	57.7395	0.1896	25.57	36.52	0.02995

Table 4.4: Critical Illness Incidence Rate - heart attack(males)

1	2	3	4	5	6	7	8	9	10	11	12
53	1227	256.27	0.69	40.52	18	33.23	64.2391	0.1945	28.02	40.53	0.03323
54	1372	257.84	0.75	44.09	19	35.71	71.4029	0.199	29.88	44.1	0.03571
55	1576	255.84	0.8	47.84	19	38.75	79.7001	0.2033	31.63	47.85	0.03875
56	1594	250.26	0.85	51.79	19	41.96	89.0706	0.2071	33.34	51.8	0.04196
57	1670	244.78	0.91	56.55	20	45.24	99.4603	0.2098	35.34	56.56	0.04524
58	1675	239.71	0.97	60.27	21	47.61	111.1587	0.2106	36.86	60.28	0.04761
59	1854	230.49	1.02	63.94	21	50.51	124.2526	0.2104	37.8	63.95	0.05051
60	1858	228.25	1.08	67.51	22	52.65	139.1932	0.2096	38.33	67.52	0.05266
61	1940	233.43	1.14	71.53	22	55.59	156.0106	0.2088	38.96	71.54	0.05559
62	2025	234.01	1.19	75.1	23	57.83	174.8779	0.2078	38.76	75.11	0.05783
63	2089	228.02	1.25	78.8	23	60.68	196.491	0.2064	38.23	78.82	0.06068
64	2190	220.83	1.31	83.07	23	63.96	219.9171	0.2049	38.01	83.09	0.06396
65	2196	215.61	1.36	86.9	24	69.04	244.6622	0.2032	37.18	86.92	0.06904
66	2262	214.24	1.42	90.8	24	69.01	271.0949	0.2017	36.13	90.82	0.06901
67	2294	213.63	1.47	97.45	24	74.06	299.6439	0.2002	33.72	97.47	0.07406
68	2306	204.58	1.52	97.45	24	74.06	329.1736	0.1989	31.97	97.47	0.07406
69	2281	199.28	1.57	100.18	24	76.14	360.2085	0.1978	28.92	100.21	0.07614
70	2360	193.52	1.62	104.33	24	79.29	392.9175	0.1968	27.02	104.36	0.07929
71	2373	196.09	1.66	108.07	24	82.13	431.165	0.1954	23.81	108.1	0.08213
72	2563	195.56	1.7	114.45	24	86.98	474.5692	0.1935	22.61	114.49	0.08698
73	2615	195.24	1.74	121.04	24	91.99	521.7056	0.1905	21.65	121.08	0.09199
74	1865	123.55	1.78	125.28	24	95.21	569.7189	0.187	18.76	125.33	0.09521
75	1763	111.8	1.81	129.41	25	97.06	619.7199	0.1831	15.93	129.46	0.09706
76	1696	178.28	1.83	133.88	25	100.41	677.6744	0.1793	12.41	133.94	0.10041
77	1808	118.36	1.85	136.33	25	102.25	741.7506	0.1753	6.29	136.39	0.10225
78	1811	114.97	1.87	138.64	25	103.98	810.2217	0.1713	-0.12	138.71	0.10398
79	1742	106.98	1.88	146.25	25	109.69	883.674	0.1672	-1.46	146.32	0.10969
80	1621	91.6	1.88	150.02	26	111.01	961.581	0.1672	-6.73	150.1	0.11101

From Table 4.3 and Table 4.4, 1= age of sufferer, 2 = HES data on number of heart attack sufferers, 3=population per 1000, 4= prevalent rate adjustment, 5= crude rate i_x(adjusted), 6= 28 day Mortality rate (ELT 15 q_x^i), 7=stand – alone rate $[i_x(1-q_x)]$, 8= LT 15 population q_x (per 10,000), 9= proportion of death from heart attack (k_x), 10= Extra cost for accelerated rate $(i_x - q_x * k_x)$, 11= accelerated rate $[i_x + q_x(1-k_x]$ and 12= premium to be paid by this client for a stand-alone product

Further Discussions of Results Heart Attack Cases

Form the study its clear that unlike cancer, the incidence of heart attack in males are higher than females. The stand – alone rates were computed using column five and eight. Also the accelerated rates were computed using five, eight and nine. Incidence of heart attack is relatively lower than the incidence of cancer per the study. This implies that it cost an individual higher to for cancer than heart attack per the study. So the office premium for an individual aged 60 to enjoy 2000 as a benefit at the end of the year will be $\frac{52.66}{1000} \times 2000 = 105.32$

4.4 Stroke

Table 4.5: Critical Illness Incidence Rates-Stroke(males)

1	2	3	4	5	6	7	8	9	10	11	12
20	38	334.96	0.02	0.82	0.0444	0.78	8.4267	0.0102	0.73	0.82	0.00078
21	32	357.45	0.02	0.95	0.0467	0.91	8.6371	0.0113	0.85	0.95	0.00091
22	44	375.82	0.02	1.12	0.0489	1.07	8.8479	0.0125	1.01	1.12	0.00107
23	43	375	0.02	1.03	0.0511	0.98	8.8558	0.0137	0.91	1.03	0.00098
24	54	387.17	0.02	1.17	0.0533	1.11	8.8636	0.0149	1.04	1.17	0.00111
25	25	390.34	0.02	1.19	0.0556	1.12	8.5656	0.016	1.05	1.19	0.00112
26	65	402.53	0.02	1.17	0.0578	1.1	8.4709	0.0172	1.03	1.17	0.0011
27	53	411.42	0.02	1.2	0.06	1.13	8.478	0.0186	1.05	1.2	0.00113
28	44	419.52	0.02	1.45	0.0622	1.36	8.6897	0.0202	1.28	1.45	0.00136
29	65	419.46	0.02	1.45	0.0644	1.36	8.9019	0.0219	1.25	1.45	0.00136
30	79	409.81	0.02	1.63	0.0667	1.52	9.1147	0.0237	1.42	1.63	0.00152
31	63	399.12	0.02	1.89	0.0689	1.76	9.328	0.0255	1.65	1.89	0.00176
32	87	389.39	0.02	1.95	0.0711	1.81	9.7471	0.0273	1.68	1.95	0.00181
33	87	370.49	0.02	2.2	0.0733	2.06	9.962	0.029	1.93	2.22	0.00206
34	67	358.25	0.02	2.25	0.0756	2.31	10.5888	0.0307	2.17	2.5	0.00231
35	115	350	0.02	2.72	0.0778	2.51	11.6291	0.0324	2.35	2.72	0.00251
36	102	338.26	0.02	2.91	0.08	2.68	12.2776	0.0339	2.47	2.91	0.00268
37	110	325.3	0.02	3.27	0.0822	3	13.7208	0.035	2.79	3.27	0.003
38	104	315.45	0.02	3.68	0.0844	3.37	14.9793	0.0354	3.15	3.68	0.00337
39	119	320.34	0.02	4.29	0.0867	3.92	16.0364	0.0354	3.72	4.29	0.00392
40	171	318.62	0.02	4.93	0.0889	4.49	17.2021	0.0353	4.33	4.93	0.00449
41	192	311.99	0.04	5.56	0.0911	5.05	18.5812	0.0353	4.9	5.56	0.00505
42	212	318.96	0.07	6.13	0.0933	5.56	20.1758	0.0357	5.41	6.13	0.00556
43	212	327.52	0.13	6.22	0.0956	5.63	21.8839	0.037	5.41	6.22	0.00563
44	225	339.37	0.25	6.45	0.0978	5.82	24.0206	0.0387	5.52	6.45	0.00582
45	263	362.17	0.47	6.63	0.1	5.97	26.6957	0.0406	5.54	6.63	0.00597
46	263	397.14	0.47	7.12	0.1022	6.39	29.7063	0.0424	5.87	7.12	0.00639
47	288	306.9	0.47	8.09	0.1044	7.25	33.1638	0.0438	6.63	8.09	0.00725
48	339	302.27	0.47	9.35	0.1067	8.35	37.1826	0.0446	7.69	9.35	0.00835
49	438	304.44	0.47	10.67	0.1089	9.51	41.4564	0.0451	8.8	10.67	0.00951
50	440	288.22	0.47	12.13	0.1111	10.78	46.42	0.0454	10.02	12.13	0.01078
51	462	263.16	0.47	13.18	0.1133	11.69	51.8778	0.0457	10.81	13.18	0.01169
52	451	241.88	0.47	14.1	0.1156	12.47	57.7395	0.046	11.45	14.11	0.01247

Table 4.6: Critical Illness Incidence Rates-Stroke(males)

1	2	3	4	5	6	7	8	9	10	11	12
53	459	256.27	0.47	15.72	0.1178	13.87	64.2391	0.0462	12.75	15.73	0.01387
54	522	257.84	0.47	17.11	0.12	15.06	71.4029	0.0464	13.8	17.12	0.01506
55	654	255.84	0.47	18.77	0.1222	16.48	79.7001	0.0466	15.05	18.78	0.01648
56	660	250.26	0.47	21.14	0.1244	18.51	89.0706	0.0469	16.69	21.15	0.01851
57	714	244.78	0.47	23.51	0.1267	20.53	99.4603	0.0474	18.8	23.52	0.02053
58	791	239.71	0.47	25.97	0.1289	22.63	111.1587	0.0482	20.61	25.98	0.02263
59	814	230.49	0.47	28.5	0.1311	24.76	124.2526	0.0492	22.39	28.51	0.02476
60	939	228.25	0.47	31.07	0.1333	26.93	139.1932	0.0504	24.06	31.08	0.02693
61	991	233.43	0.59	34.17	0.1356	29.54	156.0106	0.0515	26.13	34.18	0.02954
62	1061	234.01	0.74	37.64	0.1378	32.45	174.8779	0.0527	28.42	37.66	0.03254
63	1196	228.02	0.93	38.97	0.14	33.51	196.491	0.054	28.35	38.99	0.03351
64	1258	220.83	1.16	39.86	0.1422	34.19	219.9171	0.0554	27.68	39.88	0.03419
65	1411	215.61	1.46	41.43	0.1444	35.45	244.6622	0.0568	27.53	41.45	0.03545
66	1363	214.24	1.46	44.6	0.1467	36.72	271.0949	0.0584	27.21	43.06	0.03672
67	1563	213.63	1.46	47.6	0.1489	37.96	299.6439	0.0603	26.53	44.63	0.03796
68	1698	204.58	1.46	47.9	0.1511	40.66	329.1736	0.0629	27.19	47.93	0.04066
69	1771	199.28	1.46	51.9	0.1533	43.94	360.2085	0.0659	28.17	51.93	0.04394
70	1802	193.52	1.46	56.62	0.1566	47.75	392.9175	0.069	29.49	56.66	0.04775
71	1903	196.09	1.63	61.32	0.1578	51.64	431.165	0.0722	30.19	61.36	0.05164
72	2196	195.56	1.83	68.27	0.16	57.35	474.5692	0.0754	32.47	68.31	0.05735
73	2377	195.24	2.05	76.89	0.1622	64.42	521.7056	0.0787	35.82	76.94	0.06442
74	1802	123.55	2.3	83.94	0.1644	70.14	569.7189	0.0821	37.19	83.99	0.07014
75	1829	111.8	2.57	98.62	0.1667	74.73	619.7199	0.0854	36.74	98.68	0.07473
76	1829	178.28	2.57	93.22	0.1689	79.72	677.6744	0.0888	35.73	93.28	0.07972
77	1882	118.36	2.57	95.86	0.1711	83.93	741.7506	0.0922	32.84	95.93	0.08393
78	1987	114.97	2.57	104.19	0.1733	87.42	810.2217	0.0958	28.17	104.26	0.08742
79	2030	106.98	2.57	114.4	0.1756	92.92	883.674	0.0993	24.95	114.48	0.09292
80	1931	96.16	2.57	121.07	0.1778	99.92	961.581	0.1029	22.58	121.16	0.09992

From Table 4.5 and Table 4.6, 1= age of sufferer, 2 = HES data on number of stroke sufferers, 3=population per 1000, 4= prevalent rate adjustment, 5= crude rate i_x(adjusted), 6= 28 day Mortality rate (ELT 15 q^i_x), 7=stand -alone rate $[i_x(1-q_x)]$, 8= LT 15 population q_x (per 10,000), 9= proportion of death from stroke (k_x), 10= Extra cost for accelerated rate ($i_x - q_x \times k_x$), 11= accelerated rate $[i_x + q_x(1-k_x]$ and 12= premium to be paid by this client for a stand-alone product

Further Discussions of Results Stroke Cases

The definition of the diseases is from the ABI. Generally incidence of stroke between males and females keeps alternating with regards to the cases recorded. The stand-alone rates are computed using the figures obtained in column five and column eight. The accelerated rates are computed by using the elements in column five, seven and eight from the data. The stand-alone rate and its corresponding accelerated rates computed from the table are what is used to determine the office premium and its corresponding chargeable premium to the insured. Just as the other critical illnesses the office premium increases as age increase.

4.5 Kidney Failure

Table 4.7: Critical illness incidence rate – kidney Failure

1	2	3	4	5	6	7	8	9	10	11	12
20				0.2	0.00006	8.4267	0.2	0.0012	0.2	0.2	0.0002
21				0.22	0.00007	8.6371	0.22	0.0012	0.22	0.22	0.00022
22				0.24	0.00007	8.8479	0.24	0.0012	0.24	0.24	0.00024
23				0.26	0.00007	8.8558	0.26	0.0013	0.26	0.26	0.00026
24				0.28	0.00007	8.8636	0.28	0.0013	0.28	0.28	0.00028
25				0.29	0.00007	8.5656	0.29	0.0014	0.29	0.29	0.00029
26				0.3	0.00007	8.4709	0.3	0.0015	0.3	0.3	0.0003
27				0.31	0.00007	8.478	0.31	0.0016	0.31	0.31	0.00031
28				0.31	0.00007	8.6897	0.31	0.0017	0.31	0.31	0.00031
29				0.32	0.00007	8.9019	0.32	0.0018	0.32	0.32	0.00032
	20-29	141	3873.67								
30				0.32	0.00007	9.1147	0.32	0.002	0.32	0.32	0.00032
31				0.33	0.00007	9.328	0.33	0.0022	0.33	0.33	0.00033
32				0.33	0.00007	9.7471	0.33	0.0023	0.33	0.33	0.00033
33				0.34	0.00008	9.962	0.34	0.0024	0.34	0.34	0.00034
34				0.34	0.00008	10.5888	0.34	0.0023	0.34	0.34	0.00034
35				0.35	0.00009	11.6291	0.35	0.0022	0.35	0.35	0.00035
36				0.36	0.0001	12.2776	0.36	0.002	0.36	0.36	0.00036
37				0.37	0.00011	13.7208	0.37	0.0018	0.37	0.37	0.00037
38				0.38	0.00011	14.9793	0.38	0.0017	0.38	0.38	0.00038
39				0.39	0.00012	16.0364	0.39	0.0015	0.39	0.39	0.00039
	30-39	156	3576.42								
40				0.4	0.00013	17.2021	0.4	0.0012	0.4	0.4	0.0004
41				0.41	0.00014	18.5812	0.41	0.001	0.41	0.41	0.00041
42				0.42	0.00015	20.1758	0.42	0.0008	0.42	0.42	0.00042
43				0.43	0.00017	21.8839	0.43	0.0007	0.43	0.43	0.00043
44				0.44	0.00018	24.0206	0.44	0.0007	0.44	0.44	0.00044
45				0.45	0.0002	26.6957	0.45	0.0007	0.45	0.45	0.00045
46				0.47	0.00023	29.7063	0.47	0.0008	0.47	0.47	0.00047
47				0.48	0.00025	33.1638	0.48	0.0009	0.48	0.48	0.00048
48				0.5	0.00029	37.1826	0.5	0.001	0.5	0.5	0.0005
49				0.51	0.00032	41.4564	0.51	0.0013	0.51	0.51	0.00051
	40-49	163	3289.39								
50				0.52	0.00036	46.42	0.52	0.0016	0.52	0.52	0.00052
51				0.52	0.0004	51.8778	0.52	0.002	0.52	0.52	0.00052
52				0.52	0.00044	57.7395	0.52	0.0023	0.52	0.52	0.00052
53				0.52	0.00049	64.2391	0.52	0.0025	0.52	0.52	0.00052

Table 4.8: Critical illness incidence rate – kidney Failure

1	2	3	4	5	6	7	8	9	10	11	12
54				0.51	0.00055	71.4029	0.51	0.0026	0.51	0.51	0.00051
55				0.5	0.00061	79.7001	0.5	0.0026	0.5	0.5	0.0005
56				0.48	0.00068	89.0706	0.48	0.0026	0.48	0.48	0.00048
57				0.46	0.00076	99.4603	0.46	0.0026	0.46	0.46	0.00046
58				0.43	0.00085	111.1587	0.43	0.0026	0.43	0.43	0.00043
59				0.41	0.00095	124.2526	0.41	0.0026	0.41	0.41	0.00041
	50-59	176	2528.46								
60				0.38	0.00107	139.1932	0.38	0.0025	0.38	0.38	0.00038
61				0.36	0.0012	156.0106	0.36	0.0024	0.36	0.36	0.00036
62				0.33	0.00134	174.8779	0.33	0.0024	0.33	0.33	0.00033
63				0.31	0.00151	196.491	0.31	0.0025	0.31	0.31	0.00031
64				0.28	0.00169	219.9171	0.28	0.0028	0.28	0.28	0.00028
65				0.26	0.00188	244.6622	0.26	0.0031	0.26	0.26	0.00026
66				0.23	0.00208	271.0949	0.23	0.0035	0.23	0.23	0.00023
67				0.2	0.0023	299.6439	0.2	0.0039	0.2	0.2	0.0002
68				0.16	0.00253	329.1736	0.16	0.0041	0.16	0.16	0.00016
69				0.13	0.00276	360.2085	0.13	0.0042	0.13	0.13	0.00013
	60-69	112	2191.87								
70				0.1	0.00301	392.9175	0.1	0.0043	0.1	0.1	0.0001
71				0.08	0.00331	431.165	0.08	0.0042	0.08	0.08	0.00008
72				0.06	0.00364	474.5692	0.06	0.0042	0.06	0.06	0.00006
73				0.04	0.004	521.7056	0.04	0.0043	0.04	0.04	0.00004
74				0.02	0.00437	569.7189	0.02	0.0045	0.02	0.02	0.00002
75				0.01	0.00475	619.7199	0.01	0.0047	0.01	0.01	0.00001
76				0	0.0052	677.6744	0	0.005	0	0	0
77				0	0.00569	741.7506	0	0.0052	0	0	0
78				0	0.00622	810.2217	0	0.0054	0	0	0
79				0	0.00678	883.674	0	0.0056	0	0	0
80	70-80	19	1848.72	0	0.00738	961.581	0	0.0057	0	0	0

From Table 4.7 and Table 4.8, 1= age of sufferer, 2 = age groups, 3=HES data on number of sufferers (for the age group), 4= population, 5= crude rate i_x(adjusted), 6= 28 day Mortality rate (ELT 15 q_x^i), 7=ELT 15 Population q_x per(10,000), 8=stand- alone rate $[i_x(1 - q_x)]$, 9= proportion of death from kidney failure (k_x), 10= Extra cost for accelerated rate ($i_x - q_x \times k_x$), 11= accelerated rate $[i_x + q_x(1 - k_x]$ and 12= premium to be paid by this client for a stand-alone product.

Further Discussions of Results Kidney Failure Cases

From the data it can seen clearly that the incidence of kidney failure is very low as compared to that of cancer, heart attack and stroke. This means premiums chargeable for kidney failure will be relatively low. In the same way, for an individual aged 60 the office premium chargeable for a stand - alone product will be $\frac{0.38}{1000} \times 2000 = 0.76$. This figure looks very much unrealistic though but if the individual is to pay 25 in loadings then the premium will be $0.76 + 25 = 25.76$ to be able to enjoy the 2000 benefit at the end of the year.

4.6 Coronary Artery Bypass Graft

Table 4.9: Critical Illness Incidence Rates - CABG

1	2	3	3	4	5	6	7	8	9	10	11
20	0	334.96	0	0	0	0.00006	0	8.4267	0	0	0
21	0	357.45	0	0	0	0.00007	0	8.6371	0	0	0
22	0	375.82	0	0	0	0.00007	0	8.8479	0	0	0
23	1	375	0.02	0	0	0.00007	0	8.8558	0	0	0
24	0	387.17	0	0	0	0.00007	0	8.8636	0	0	0
25	0	390.34	0	0	0.01	0.00007	0.01	8.5656	0	0.01	0.0001
26	1	402.53	0.02	0	0.01	0.00006	0.01	8.4709	0	0.01	0.0001
27	1	411.42	0.02	0	0.01	0.00007	0.01	8.478	0	0.01	0.0001
28	3	419.52	0.07	0	0.02	0.00007	0.02	8.6897	0	0.02	0.0002
29	1	419.46	0.02	0	0.01	0.00007	0.01	8.9019	0	0.01	0.0001
30	1	409.81	0.02	0	0.02	0.00007	0.02	9.1147	0	0.02	0.0002
31	0	399.12	0	0	0.03	0.00007	0.03	9.328	0	0.03	0.0003
32	4	389.39	0.09	0	0.05	0.00007	0.05	9.7471	0	0.05	0.0005
33	5	370.49	0.12	0	0.11	0.00008	0.11	9.962	0	0.11	0.00011
34	12	358.25	0.31	0.1	0.16	0.00008	0.16	10.5888	0	0.16	0.00016
35	23	350	0.6	0.1	0.22	0.00009	0.22	11.6291	0	0.22	0.00022
36	17	338.26	0.46	0.1	0.31	0.0001	0.31	12.2776	0	0.31	0.00031
37	24	325.3	0.68	0.1	0.42	0.00011	0.42	13.7208	0	0.42	0.00042
38	36	315.45	1.05	0.1	0.56	0.00011	0.55	14.9793	0	0.56	0.00055
39	50	320.34	1.44	0.2	0.79	0.00012	0.78	16.0364	0	0.79	0.00078
40	68	318.62	1.96	0.2	0.97	0.00013	0.96	17.2021	0	0.97	0.00096
41	94	311.99	2.77	0.2	1.18	0.00014	1.17	18.5812	0	1.18	0.00117
42	85	318.96	2.45	0.2	1.48	0.00015	1.46	20.1758	0	1.48	0.00146
43	112	327.52	3.15	0.3	1.78	0.00017	1.76	21.8839	0	1.78	0.00176
44	163	339.37	4.42	0.3	2.04	0.00018	2.01	24.0206	0	2.04	0.00201
45	195	362.17	4.95	0.3	2.61	0.0002	2.58	26.6957	0	2.61	0.00258
46	230	397.14	5.33	0.4	3.14	0.00023	3.1	29.7063	0	3.14	0.0031
47	271	306.9	8.12	0.4	3.65	0.00025	3.6	33.1638	0	3.65	0.0036
48	277	302.27	8.43	0.4	4.38	0.00029	4.33	37.1826	0	4.38	0.00433
49	313	304.44	9.46	0.5	5.07	0.00032	5.2	41.4564	0	5.07	0.00052
50	383	288.22	12.23	0.5	5.93	0.00036	5.86	46.42	0	5.93	0.00586
51	350	263.16	12.24	0.6	6.57	0.0004	6.49	51.8778	0	6.57	0.00649
52	436	241.88	16.58	0.6	7.37	0.00044	7.29	57.7395	0	7.37	0.00729
53	412	256.27	14.79	0.7	8.24	0.00049	8.15	64.2391	0	8.24	0.00815
54	488	257.84	17.41	0.7	9.32	0.00055	9.22	71.4029	0	9.32	0.00922
									0		
55	579	255.84	20.82	0.8	10.14	0.00061	10.02	79.7001	0	10.14	0.01002
56	624	250.26	22.94	0.9	11.522	0.00068	11.38	89.0706	0	11.522	0.01138
57	654	244.78	24.58	0.9	12.7	0.00076	12.52	99.4603	0	12.7	0.01252

Table 4.10: Critical Illness Incidence Rates - CABG

1	2	3	3	4	5	6	7	8	9	10	11
58	742	239.71	28.48	1	13.59	0.00085	13.39	111.1587	0	13.59	0.01339
59	726	230.49	28.98	1	14.14	0.00095	13.92	124.2526	0	14.14	0.01392
60	734	228.25	29.59	1.1	15.05	0.00107	14.79	139.1932	0	15.05	0.01479
61	719	233.43	28.34	1.1	15.42	0.0012	15.14	156.0106	0	15.42	0.01514
62	852	234.01	33.5	1.2	15.94	0.00134	15.63	174.8779	0	15.94	0.01563
63	793	228.02	32	1.3	16.2	0.00151	15.79	196.491	0	16.2	0.01579
64	817	220.83	34.04	1.3	16.46	0.00169	16.1	219.9171	0	16.46	0.0161
65	733	215.61	31.28	1.4	16.05	0.00188	15.68	244.6622	0	16.05	0.01568
66	736	214.24	31.61	1.4	15.68	0.00208	15.3	271.0949	0	15.68	0.0153
67	681	213.63	29.33	1.5	15.2	0.0023	14.82	299.6439	0	15.2	0.01482
68	630	204.58	28.33	1.5	14.47	0.00253	14.09	329.1736	0	14.47	0.01409
69	633	199.28	29.22	1.6	13.46	0.00276	13.09	360.2085	0	13.46	0.01309
70	506	193.52	24.06	1.6	12.67	0.00301	12.29	392.9175	0	12.67	0.01229
71	459	196.09	21.54	1.7	11.62	0.00331	11.25	431.165	0	11.62	0.01125
72	457	195.56	21.5	1.7	11.44	0.00364	11.04	474.5692	0	11.44	0.01104
73	382	195.24	18	1.7	10.77	0.004	10.37	521.7056	0	10.77	0.01037
74	367	123.55	27.33	1.8	9.86	0.00437	9.47	569.7189	0	9.86	0.00947
75	212	111.8	17.44	1.8	8.65	0.00475	8.29	619.7199	0	8.65	0.00865
76	162	178.28	12.6	1.8	7.61	0.0052	7.27	677.6744	0	7.61	0.00761
77	123	118.36	9.6	1.8	5.47	0.00569	5.21	741.7506	0	5.47	0.00547
78	97	114.97	7.76	1.9	4.02	0.00622	3.82	810.2217	0	4.02	0.00402
79	73	106.98	6.28	1.9	3.07	0.00678	2.91	883.674	0	3.07	0.00291
80	34	96.16	3.25	1.9	2.39	0.00738	2.26	961.581	0	2.39	0.00226

From Table 4.9 and Table 4.10, 1= age of sufferer, 2 = HES data on number of s CABG sufferers, 3=population per 1000, 4= prevalent rate adjustment, 5= crude rate i_x(adjusted), 6= 28 day Mortality rate (ELT 15 q_x^i), 7=stand − alone rate $[i_x(1 - qx)]$, 8= LT 15 population q_x (per 10,000), 9= proportion of death from CABG (k_x), 10= Extra cost for accelerated rate ($i_x - q_x \times k_x$), 11= accelerated rate $[i_x + q_x(1 - k_x]$ and 12= premium to be paid by this client for a stand-alone product.

Further Discussions of Results CAGB Cases

The definition of the diseases is from the ABI. Generally incidence of CAGB between males is higher than in females. The stand-alone rates are computed using the figures obtained in column five and column eight. The accelerated rates are computed by using the elements in column five, seven and eight from the data. The stand-alone rate and its corresponding accelerated rates computed from the table are what is used to determine the office premium and its corresponding chargeable premium to the insured. Like with other discussions, suppose a male individual currently at age 60, wants to buy a critical illness product of CABG with a benefit of 2000 to be enjoyed at the end of one year. Then, the office premium to be paid by this client for a stand-alone product is given by $\frac{14.79}{1000} \times 2000 = 29.58$. The incidence of CABG recorded were lower than that of cancer, heart attack and stroke but higher than that of kidney failure.

Chapter 5

Conclusion and Recommendations

5.1 Introduction

This section of the research work focuses on the various conclusions drawn from the findings of the analysis conducted in the previous chapter and suggested alternatives and recommendation to aid in giving the insurer and the insured a fair pricing model.

5.2 Summary of Results

In this research work, we realized that as age increases, the probability of an individual being diagnosed of some critical illness also increases in general. We also found out that the incidence rate of some critical illness differs with gender. For example the incidence rate of cancer in males were found to be higher in females than in males, whereas incidence rate of heart attack was also higher in males than in females. On the other hand, cancer had the highest incidence rate among the five critical illnesses that we considered. Finally, the additional deaths recorded made it clear that male mortality was higher than that of the females.

5.3 Conclusion

This research work was aimed at developing incidence rates table for Stand-Alone Rider and Acceleration Rider, for the five prevalent Critical Illnesses. That is Cancer, Heart-Attack, Stroke, kidney failure and CABG and also to develop premium rates for Acceleration rider benefits using the Dash and Grimshaw model.

- Stand-alone rates and acceleration rates increases with age for the first three critical illnesses. Thus, cancer, heart attack and stroke.
- Premium rates for acceleration rider benefit given by $P_x = i_x + (1 - k_x)q_x$ increases with age for the first three critical illnesses.

However, for kidney failure and CABG, the occurrence rate from mid age (50 years) shows a downward trend thereby decreasing the premium rate.

5.4 Recommendations

With regards to the state of CII in Ghana we first recommend that the education of CII should be intensified to enable the general public to really understand the need for them to secure their lives against adverse financial loss or possible death just because they could not afford to pay for treatment of a CI. Even though the study revealed that the premiums for accelerated product was expensive, we would still recommend that individuals go for them since their heir can receive some amount of money if they (insured) should die without being diagnosed or treated. Further Studies can be carried out on the experience rates in claims among other diseases specified in the policy wording, the application to the model developed on the premiums and reserves. Finally we recommend that a further research will be carried out to develop premium rates for Acceleration rider benefits using for the other critical illnesses we stated in chapter one.

REFERENCES

Aase, K. K. (2001). A markov model for the pricing of catastrophe insurance futures and spreads. *Journal of Risk and Insurance*, pages 25–49.

Angus, D. C., Barnato, A. E., Linde-Zwirble, W. T., Weissfeld, L. A., Watson, R. S., Rickert, T., Rubenfeld, G. D., Group, R. W. J. F. I. E.-O.-L. P., et al. (2004). Use of intensive care at the end of life in the united states: an epidemiologic study. *Critical care medicine*, 32(3):638–643.

Arnold, B. C. and Brockett, P. L. (1983). Identifiability for dependent multiple decrement/competing risk models. *Scandinavian Actuarial Journal*, 1983(2):117–127.

Bacinello, A. R. (2001). Fair pricing of life insurance participating policies with a minimum interest rate guaranteed. *ASTIN Bulletin: The Journal of the IAA*, 31(2):275–297.

Beck, T. et al. (2001). *Deposit insurance as private club: is Germany a model?*, volume 2559. World Bank, Financial Sector Strategy and Development Department.

Bowers, N. L., Gerber, H., Hickman, J., and JONES, D. N. (1986). Actuarial mathematics. *Society of Actuaries.*

Brennan, M. J. and Schwartz, E. S. (1976). The pricing of equity-linked life insurance policies with an asset value guarantee. *Journal of Financial Economics*, 3(3):195–213.

Daw, R. (1979). Smallpox and the double decrement table: a piece of actuarial prehistory. *Journal of the Institute of Actuaries*, 106(3):299–318.

Deaton, A. (2004). Health in an age of globalization. Technical report, National Bureau of Economic Research.

Finlaison, J. (1829). *Report of John Finlaison, Actuary of the National Debt, on the Evidence and Elementary Facts on which the Tables of Life Annuities are Founded: Ordered by the House of Commons, to be Printed 31 March 1829*. HM Stationery Office.

Finn, C. and Harmon, C. P. (2006). A dynamic model of demand for private health insurance in ireland.

Fix, E. and Neyman, J. (1951). A simple stochastic model of recovery, relapse, death and loss of patients. *Human Biology*, 23(3):205–241.

Hamza, E. (1900). The disability risk and underlying factors, studies of the central pension security institute. *Journal of the Institute of Actuaries*, 18(5):154–160.

Heber, D., Conaway, A., Nakamichi, D., and Cheng, J. (2013). Life insurance pricing.

Kingston, C. (2007). Marine insurance in britain and america, 1720–1844: a comparative institutional analysis. *The Journal of Economic History*, 67(2):379–409.

Kwadwo Duodu, F. and Amankwah, T. (2012). An analysis and assessment of customer satisfaction with service quality in insurance industry in ghana.

Macdonald, A. S., Waters, H. R., and Wekwete, C. T. (2005). A model for coronary heart disease and stroke with applications to critical illness insurance underwriting i: the model. *North American Actuarial Journal*, 9(1):13–40.

Makeham, W. (1874). On an application of the theory of the composition of decremental forces. *Journal of the Institute of Actuaries*, 18(5):317–322.

Mehr, B. D. and Cammack, M. J. (1976). Adverse selection, aggregate uncertainty, and the role for mutual insurance contracts. *Journal of Business*, pages 493–510.

Poku, S. (2009). Exploring the implications of separating life insurance from general insurance business. thesis.

Seal, H. L. (1977). Studies in the history of probability and statistics. xxxv: Multiple decrements or competing risks. *Biometrika*, 64(3):429–439.

Trenerry, C. F. (1926). *The origin and early history of insurance: including the contract of bottomry*. The Lawbook Exchange, Ltd.

Vaughan, D. (1997). *The Challenger launch decision: Risky technology, culture, and deviance at NASA*. University of Chicago Press.

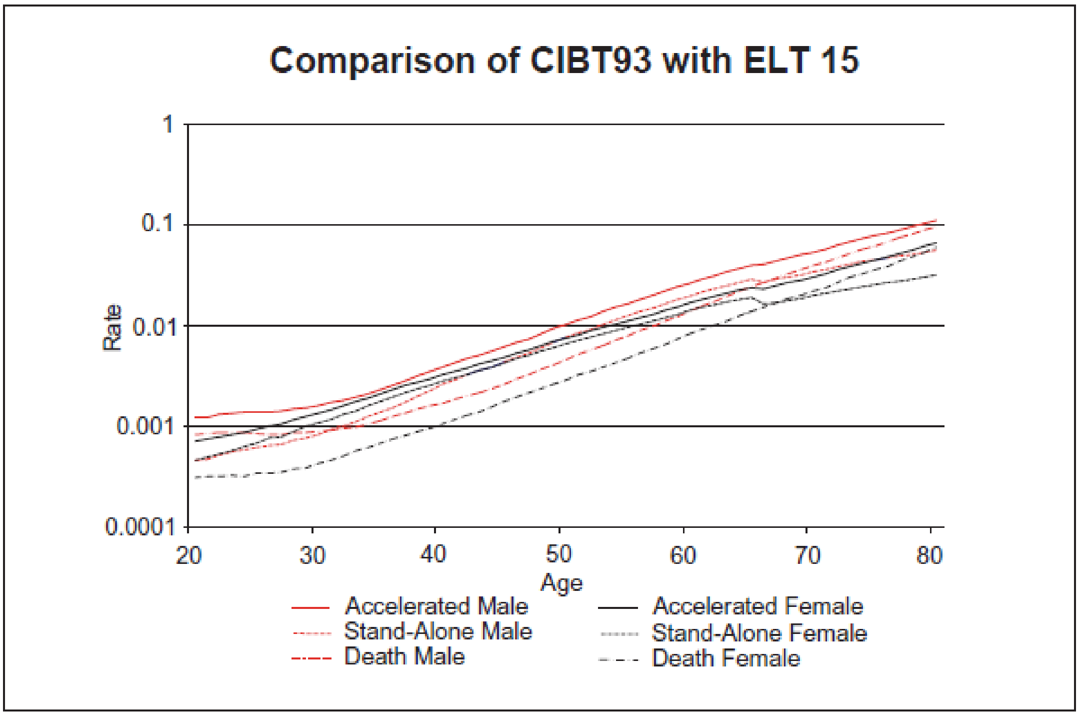
Wang, S. (1995). Insurance pricing and increased limits ratemaking by proportional hazards transforms. *Insurance: Mathematics and Economics*, 17(1):43–54.

Zhang, L. and Boukas, E.-K. (2009). Stability and stabilization of markovian jump linear systems with partly unknown transition probabilities. *Automatica*, 45(2):463–468.

Appendix

Comparison of CIBT93 with Population Mortality

The graph on the following page shows a comparison of Stand-Alone and Accelerated incidence rates from CIBT93 with population mortality rates from ELT 15. The graph plots both male and female rates using a logarithmic scale.



Comparison of CIBT93 with Population Mortality

The Base Table (male) - CIBT93 Incidence Rates per 10,000

Age	Cancer	HA	Stroke	CAGB	MS	KF	MOT	TPD	TSAIR	Additional	TAIR
20	2.2	0.1	0.8	0	0.1	0.2	0.1	1.2	4.7	7.6	12.3
21	2.3	0.1	0.9	0	0.1	0.2	0.1	1.1	4.8	7.7	12.5
22	2.5	0.1	1.1	0	0.2	0.2	0.1	1.1	5.3	7.9	13.2
23	2.7	0.2	1	0	0.2	0.3	0.1	1.1	5.6	7.9	13.5
24	2.9	0.3	1.1	0	0.2	0.3	0.1	1.1	6	7.9	13.9
25	3.1	0.3	1.1	0	0.3	0.3	0.1	1.1	6.3	7.6	13.9
26	3.3	0.3	1.1	0	0.3	0.3	0.1	1.1	6.5	7.4	13.9
27	3.5	0.4	1.1	0	0.4	0.3	0.1	1	6.8	7.4	14.2
28	3.7	0.5	1.4	0	0.4	0.3	0.1	1	7.4	7.5	14.9
29	3.9	0.6	1.4	0	0.5	0.3	0.1	1	7.8	7.6	15.4
30	4.1	0.9	1.5	0	0.5	0.3	0.1	1	8.4	7.8	16.2
31	4.4	1.2	1.8	0	0.6	0.3	0.1	1	9.4	7.9	17.3
32	4.6	1.6	1.8	0.1	0.6	0.3	0.1	1.1	10.2	8.2	18.4
33	4.9	2	2.1	0.1	0.7	0.3	0.1	1.1	11.3	8.3	19.6
34	5.3	2.6	2.3	0.2	0.7	0.3	0.1	1.1	12.6	8.7	21.3
35	5.7	3.2	2.5	0.2	0.8	0.4	0.1	1.1	14	9.4	23.4
36	6	4.1	2.7	0.3	0.8	0.4	0.1	1.2	15.6	10.2	25.8
37	6.4	5.1	3	0.4	0.9	0.4	0.2	1.2	17.6	10.8	28.4
38	7.2	6.2	3.4	0.6	0.9	0.4	0.2	1.3	20.2	11.7	31.9
39	8	7.5	3.9	0.8	0.9	0.4	0.2	1.3	23	12.3	35.3
40	8.9	8.8	4.5	1	1	0.4	0.2	1.4	26.2	13.1	39.3
41	9.7	10	5	1.2	1	0.4	0.2	1.6	29.1	13.8	42.9
42	10.6	11.9	5.6	1.5	1	0.4	0.3	1.8	33.1	14.7	47.8
43	12	12.9	5.6	1.8	1.1	0.4	0.3	2	36.1	15.6	51.7
44	13.5	14.1	5.8	2	1.1	0.4	0.3	2.2	39.4	16.5	55.9
45	15	16	6	2.6	1.1	0.5	0.4	2.5	44.1	17.7	61.8
46	16.5	17.8	6.4	3.1	1.1	0.5	0.4	2.9	48.7	19	67.7
47	18	19	7.2	3.6	1.1	0.5	0.5	3.2	53.1	20.6	73.7
48	21.2	21	8.3	4.3	1.2	0.5	0.5	3.6	60.6	22.5	83.1
49	24.4	23.3	9.5	5	1.2	0.5	0.6	4.1	68.6	24.5	93.1
50	27.7	25.3	10.8	5.9	1.2	0.5	0.6	4.7	76.7	26.6	103.3
51	30.9	27.4	11.7	6.5	1.2	0.5	0.7	5.4	84.3	28.9	113.2
52	34.2	29.9	12.5	7.3	1.2	0.5	0.8	6.2	92.6	31.2	123.8
53	38.7	33.2	13.9	8.1	1.2	0.5	0.8	7.2	103.6	34.1	137.7
54	43.3	35.7	15.1	9.2	1.2	0.5	0.9	8.3	114.2	37.5	151.7
55	47.8	38.7	16.5	10	1.2	0.5	0.9	9.5	125.1	40.9	166
56	52.4	41.9	18.5	11.4	1.2	0.5	0.9	11	137.8	44.7	182.5
57	57.1	45.2	20.5	12.5	1.2	0.5	0.8	12.7	150.5	49.5	200
58	65.2	47.6	22.6	13.4	1.2	0.4	0.7	14.6	165.7	54.9	220.6
59	73.2	50.5	24.8	13..9	1.2	0.4	0.7	16.8	181.5	60.1	241.6
60	81.3	52.7	26.9	14.8	1.2	0.4	0.6	19.3	197.2	66.7	263.9
61	89.7	55.8	29.5	15.1	1.2	0.4	0.5	21.5	213.7	73.5	287.2
62	97.9	57.8	32.5	15.6	1.2	0.3	0.5	23.9	229.7	81.9	311.6

The Base Table (male) - CIBT93 Incidence Rates per 10,000

Age	Cancer	HA	Stroke	CAGB	MS	KF	MOT	TPD	TSAIR	Additional	TAIR
63	110.3	60.7	33.5	15.8	1.2	0.3	0.4	26.7	248.9	90.4	339.3
64	123	64	34.2	16.1	1.2	0.3	0.3	29.7	268.8	99.6	368.4
65	135.7	66	35.4	15.7	1.1	0.3	0.3	33	287.5	110.3	397.8
66	148.1	69	36.7	15.3	1.1	0.2	0.2		270.6	135.9	406.5
67	161	71.2	38	14.8	1.1	0.2	0.2		286.5	149.3	435.8
68	174.4	74.1	40.7	14.1	1.1	0.2	0.1		304.8	164.1	468.8
69	187.9	76.1	43.9	13.1	1.1	0.1	0.1		322.3	179.7	502
70	201.6	79.3	47.8	12.3	1	0.1	0.1		342.2	197	539.2
71	214.3	82.1	51.6	11.2	1	0.1	0.1		360.8	217	577.8
72	228.3	87	57.3	11	1	0.1	0		384.7	214	625.7
73	242.6	92	64.4	10.4	0.9	0	0		410.3	268.96	678.5
74	258.3	95.2	70.1	9.5	0.9	0	0		434	296.2.	730.2
75	270.9	97.1	74.9	8.3	0.9	0	0		451.9	327.1	779
76	283.2	100.4	79.7	7.3	0.8	0	0		471.4	361.6	883
77	298.6	102.2	83.9	5.2	0.8	0	0		490.7	399.6	890.3
78	314.2	104	87.4	3.8	0.7	0	0		510.1	441	951.1
79	328.7	109.7	92.9	2.9	0.7	0	0		534.9	488.1	1023
80	343	111	99.9	2.3	0.6	0	0		556.8	539.9	1096.7

The Base Table (female) - CIBT93 Incidence Rates per 10,000

Age	Cancer	HA	Stroke	CAGB	MS	KF	MOT	TPD	TSAIR	Additional Death	TAIR
20	2.1	0	1	0	0.2	0.1	0.1	1.2	4.7	2.6	7.3
21	2.3	0	1.1	0	0.3	0.1	0.1	1.1	5	2.6	7.6
22	2.5	0	1.1	0	0.4	0.2	0.1	1.1	5.4	2.6	8
23	2.8	0	1.2	0	0.4	0.2	0.1	1.1	5.8	2.6	8.4
24	3.2	0	1.2	0	0.5	0.2	0.1	1.1	6.4	2.5	8.9
25	3.5	0	1.4	0	0.6	0.2	0.1	1.1	6.9	2.6	9.5
26	3.9	0.1	1.6	0	0.7	0.2	0.1	1.1	7.7	2.5	10.2
27	4.2	0.1	1.6	0	0.8	0.2	0.1	1	8	2.6	10.6
28	5	0.1	1.8	0	0.9	0.2	0.1	1	9.1	2.7	11.8
29	5.8	0.2	1.8	0	1	0.2	0.1	1	10.1	2.6	12.7
30	6.5	0.2	1.9	0	1.1	0.2	0.1	1	11	2.7	13.7
31	7.3	0.3	1.8	0	1.2	0.2	0.1	1	11.9	2.8	14.7
32	8	0.4	2.1	0	1.3	0.2	0.1	1.1	13.2	3	16.2
33	9.2	0.5	2.1	0	1.3	0.2	0.1	1.1	14.5	3.2	17.7
34	10.4	0.5	2.4	0	1.4	0.2	0.1	1.1	16.1	3.3	19.4
35	11.5	0.6	2.7	0	1.5	0.2	0.1	1.1	17.7	3.6	21.3
36	12.7	0.7	3	0	1.6	0.2	0.1	1.2	19.5	3.8	23.3
37	13.9	0.8	3.3	0.1	1.7	0.3	0.2	1.2	21.5	3.9	25.4
38	15.5	1	3.6	0.1	1.7	0.3	0.2	1.2	23.7	4.1	27.8
39	17.1	1.1	3.9	0.1	1.8	0.3	0.2	1.3	25.8	4.4	30.2
40	18.7	1.2	4.3	0.1	1.9	0.3	0.2	1.4	28.1	4.6	32.7
41	20.3	1.4	4.7	0.2	1.9	0.3	0.2	1.6	30.6	4.8	35.4
42	22	1.7	4.9	0.2	2	0.3	0.2	1.8	33.1	5	38.1
43	24.6	1.9	4.9	0.3	2	0.3	0.2	2	36.2	5.4	41.6
44	27.2	2.2	5	0.3	2.1	0.3	0.2	2.2	39.5	5.9	45.4
45	29.8	2.6	5.3	0.3	2.1	0.3	0.2	2.5	43.1	6.1	49.2
46	32.4	2.9	5.8	0.3	2.1	0.3	0.3	2.9	47	6.7	53.7
47	35.1	3.3	6.2	0.3	2.2	0.3	0.3	3.2	50.9	7.4	58.3
48	38.5	3.9	6.7	0.4	2.2	0.3	0.3	3.6	55.9	7.7	63.6
49	41.9	4.4	7.4	0.7	2.2	0.3	0.3	4.1	61.3	8.4	69.7
50	45.2	4.7	8	0.8	2.2	0.3	0.3	4.7	66.2	9.7	75.9
51	48.7	5.5	7.9	1	2.3	0.3	0.3	5.4	71.4	10.4	81.8
52	52	6.3	8.8	1.2	2.3	0.3	0.4	6.2	77.5	11.1	88.6
53	55.3	7.3	9.8	1.3	2.3	0.3	0.4	7.2	83.9	12.1	96
54	58.6	8.1	10.3	1.5	2.3	0.3	0.4	8.3	89.8	13.4	103.2
55	61.9	9.3	10.9	1.7	2.3	0.3	0.4	9.5	96.3	14.9	111.2
56	65.2	10.6	12	2	2.3	0.3	0.4	11	103.8	16.4	120.2
57	68.5	12.1	12.9	2.1	2.3	0.2	0.4	12.7	112.2	18.4	129.6
58	73	13.3	13.8	2.3	2.3	0.2	0.3	14.6	119.8	20.8	140.6
59	77.9	15.1	15.4	2.5	2.3	0.2	0.3	16.8	130.5	23.4	153.9
60	82.9	16.9	16.7	2.7	2.3	0.2	0.3	19.3	141.3	26.2	167.5
61	87.8	18.4	18.3	2.9	2.2	0.2	0.2	21.5	151.5	30.3	181.8
62	92.9	19.9	20.2	3.2	2.2	0.1	0.2	23.9	162.6	34.2	196.8

The Base Table (female) - CIBT93 Incidence Rates per 10,000

Age	Cancer	HA	Stroke	CAGB	MS	KF	MOT	TPD	TSAIR	Additional Death	TAIR
63	96	22.2	21.1	3.6	2.2	0.1	2	26.7	172.1	37.9	210
64	99.3	24.3	21.6	3.9	2.1	0.1	0.2	29.7	181.2	43.1	224.3
65	102.6	26.2	22.6	3.9	2.1	0.1	0.2	33	190.7	49.4	240.1
66	105.8	28.4	23.4	4	2.1	0.1	0.1		163.9	69.3	233.2
67	109	30.7	24	4.1	2	0.1	0.1		170	77.4	247.4
68	114.1	32.7	26.3	4	2	0	0.1		179.2	87.5	266.7
69	118.9	34.9	28.7	3.8	1.9	0	0.1		188.3	97.3	258.6
70	124	37.3	31.5	3.7	1.9	0	0		198.4	106.3	304.7
71	128.8	40.2	35	3.6	1.8	0	0		209.4	117.9	327.3
72	134	44	39.8	3.7	1.8	0	0		223.3	134.1	257.4
73	138.9	47	43.9	3.4	1.7	0	0		234.9	153.9	388.8
74	143.5	50.5	47.2	3	1.6	0	0		245.8	170.3	416.1
75	147.8	53.1	51.9	2.7	1.5	0	0		257	188	445
76	151.8	55.8	55.9	2.2	1.5	0	0		267.2	211.8	479
77	156.4	58.8	59.6	1.4	1.4	0	0		277.6	240.1	517.7
78	161.4	61.9	65.2	1.1	1.3	0	0		290.9	270.3	560.9
79	166.5	65.2	72.2	0.8	1.2	0	0		305.9	304.3	610.2
80	171.3	68	78.7	0.6	1.1	0	0		319.7	343.1	662.8

English Life Tables No.15, 1990-92

English Life Table No 15.1

Age	Males			Females			Age	Males			Females		
x	l_x	q_x	e_x	l_x	q_x	e_x	x	l_x	q_x	e_x	l_x	q_x	e_x
0	100000	.00814	73.413	100000	.00632	78.956	60	86714	.01392	17.850	91732	.00830	22.079
1	99186	.00062	73.019	99368	.00055	78.462	61	85507	.01560	17.095	90971	.00922	21.259
2	99124	.00038	72.064	99313	.00030	77.505	62	84173	.01749	16.357	90132	.01015	20.452
3	99086	.00030	71.091	99283	.00022	76.528	63	82701	.01965	15.640	89217	.01129	19.657
4	99056	.00024	70.113	99261	.00018	75.545	64	81076	.02199	14.943	88210	.01266	18.875
5	99032	.00022	69.130	99243	.00016	74.559	65	79293	.02447	14.267	87093	.01399	18.111
6	99010	.00020	68.145	99228	.00015	73.570	66	77353	.02711	13.612	85875	.01523	17.361
7	98990	.00019	67.158	99213	.00014	72.581	67	75256	.02997	12.978	84567	.01676	16.621
8	98972	.00018	66.171	99199	.00014	71.591	68	73001	.03292	12.363	83150	.01844	15.896
9	98953	.00018	65.183	99185	.00013	70.601	69	70598	.03602	11.767	81617	.02017	15.185
10	98935	.00018	64.195	99172	.00013	69.610	70	68055	.03930	11.187	79970	.02190	14.487
11	98917	.00018	63.206	99159	.00014	68.620	71	65381	.04311	10.624	78219	.02399	13.800
12	98899	.00019	62.218	99145	.00014	67.629	72	62562	.04745	10.080	76343	.02693	13.127
13	98880	.00023	61.230	99131	.00015	66.638	73	59593	.05217	9.557	74287	.03014	12.476
14	98857	.00029	60.244	99116	.00018	65.649	74	56484	.05697	9.056	72048	.03284	11.848
15	98828	.00040	59.261	99098	.00022	64.660	75	53266	.06197	8.572	69682	.03569	11.234
16	98789	.00052	58.285	99077	.00026	63.674	76	49965	.06777	8.106	67195	.03919	10.631
17	98737	.00075	57.315	99051	.00031	62.691	77	46579	.07418	7.658	64561	.04356	10.044
18	98663	.00087	56.358	99020	.00031	61.710	78	43124	.08101	7.232	61749	.04833	9.478
19	98577	.00083	55.406	98989	.00032	60.729	79	39630	.08838	6.825	58765	.05373	8.934
20	98496	.00084	54.452	98957	.00031	59.748	80	36128	.09616	6.438	55607	.05961	8.413
21	98413	.00086	53.497	98926	.00032	58.767	81	32654	.10411	6.070	52293	.06568	7.914
22	98328	.00089	52.543	98894	.00033	57.786	82	29254	.11279	5.718	48858	.07216	7.435
23	98241	.00089	51.589	98862	.00033	56.805	83	25954	.12235	5.382	45332	.07933	6.974
24	98154	.00088	50.635	98829	.00033	55.823	84	22779	.13270	5.063	41736	.08757	6.532
25	98067	.00086	49.679	98797	.00034	54.842	85	19756	.14372	4.762	38081	.09731	6.111
26	97983	.00085	48.721	98763	.00035	53.860	86	16917	.15585	4.478	34375	.10833	5.715
27	97900	.00085	47.762	98729	.00036	52.878	87	14280	.16848	4.213	30651	.11859	5.349
28	97817	.00087	46.802	98694	.00038	51.897	88	11874	.18061	3.968	27017	.12860	5.002
29	97732	.00090	45.842	98656	.00040	50.917	89	9730	.19246	3.734	23542	.14146	4.667
30	97645	.00091	44.883	98617	.00043	49.937	90	7857	.20465	3.508	20212	.15550	4.354
31	97556	.00094	43.923	98574	.00047	48.958	91	6249	.21911	3.285	17069	.17006	4.065
32	97465	.00097	42.964	98528	.00052	47.981	92	4880	.23655	3.071	14166	.18573	3.797
33	97370	.00099	42.005	98477	.00057	47.006	93	3726	.25575	2.872	11535	.20126	3.551
34	97273	.00106	41.046	98420	.00063	46.032	94	2773	.27483	2.693	9214	.21790	3.322
35	97170	.00116	40.090	98359	.00069	45.061	95	2011	.29311	2.531	7206	.23619	3.112
36	97057	.00127	39.136	98291	.00075	44.092	96	1421	.31104	2.383	5504	.25344	2.925
37	96933	.00138	38.185	98217	.00082	43.124	97	979	.32919	2.244	4109	.26820	2.754
38	96800	.00149	37.237	98136	.00090	42.160	98	657	.34783	2.114	3007	.28352	2.588
39	96655	.00160	36.292	98048	.00098	41.197	99	428	.36712	1.991	2154	.30331	2.422
40	96500	.00172	35.349	97952	.00107	40.237	100	271	.38705	1.874	1501	.32489	2.269
41	96334	.00186	34.409	97847	.00117	39.279	101	166	.40760	1.764	1013	.34562	2.133
42	96155	.00201	33.473	97733	.00129	38.325	102	98	.42870	1.660	663	.36186	2.011
43	95961	.00219	32.539	97607	.00142	37.374	103	56	.45030	1.562	423	.37992	1.887
44	95751	.00240	31.609	97469	.00158	36.426	104	31	.47428	1.468	262	.40045	1.758
45	95521	.00266	30.684	97315	.00177	35.483	105	16	.49634	1.384	157	.43618	1.621
46	95266	.00297	29.765	97142	.00198	34.545	106	8	.51841	1.306	89	.45994	1.518
47	94983	.00332	28.852	96950	.00219	33.612	107	4	.54041	1.234	48	.48389	1.425
48	94668	.00371	27.947	96738	.00241	32.685	108	2	.56225	1.166	25	.50791	1.338
49	94316	.00415	27.049	96504	.00266	31.763	109	1	.58385	1.104	12	.53190	1.257
50	93925	.00464	26.159	96247	.00294	30.846	110				6	.55574	1.183
51	93489	.00519	25.279	95964	.00326	29.936	111				3	.57932	1.114
52	93004	.00577	24.408	95652	.00357	29.032	112				1	.60255	1.050
53	92467	.00642	23.547	95310	.00390	28.134	113						
54	91873	.00714	22.696	94938	.00428	27.242	114						
55	91217	.00797	21.856	94532	.00475	26.357							
56	90490	.00890	21.027	94082	.00531	25.481							
57	89684	.00995	20.211	93583	.00592	24.614							
58	88792	.01112	19.409	93029	.00660	23.757							
59	87805	.01243	18.622	92415	.00739	22.912							