

# **Derivation of Dread Disease Incidence Rates for Hong Kong**

## *Abstract:*

Based on the data collected as part of Gen Re's 2003 Dread Disease survey, this paper derives incidence rates for the major Dread Diseases – Cancer, Heart Attack and Stroke – for Hong Kong insured lives. Various assumptions on trends are made, and further experience surveys will be required to corroborate the data. A more comprehensive paper is underway to present findings about the pricing for all conditions typically covered under Dread Disease policies.

## **Introduction**

Since its introduction in 1983 the Dread Disease product has met with varying success. After an initial runaway success in South Africa, sales there dropped off in the mid 90s with modern health insurance concepts stealing the limelight. More recent changes to health insurance regulations have given a new boost to Dread Disease style products. In the UK, the product was introduced in 1996 and after a slow start has become a main product segment for risk product providers. Some 1.2 million new policies are written annually, notably about half of those being acceleration benefits for mortgage protection products. In Continental Europe, where there is a much greater reliance on social security systems, sales have continued to be slow. In the U.S. and Canada, on the other hand, there are signs that Dread Disease products are becoming more widely accepted with sales increasing recently. In Asia and Australia, where the product has been introduced since 1987, the product has been very successful. Gen Re's third survey, covering the period until 31.12.2000, registered 4 million in-force policies in Malaysia, Singapore and Hong Kong. After allowing for the market share of the participating companies, this translates into some 15% of the population enjoying dread disease cover. In Hong Kong, the figure is about 17.5%.

Considering the rapid aging of the Hong Kong society combined with the fragile status of the public health insurance system, Dread Disease remains the product of choice to provide coverage, potentially on a whole life basis, for a range of severe diseases at affordable premium rates. Benefits can be used to mitigate costs, pay for life style changes, etc. Considering the relatively low penetration rate of the product, there should

still be enormous scope for Dread Disease sales in Hong Kong and other Asian territories.

Pricing Dread Disease has been a major challenge for actuaries right from the beginning. Actuaries had to rely on population incidence rates and even such data was often only available from other countries. In view of this scarcity of local data and the uncertainty of foreign data, actuaries tended to build in significant margins of safety into their Dread Disease pricing models. Our survey aims to overcome this uncertainty and to produce a credible industry experience to form the basis for pricing and reserving.

In this paper, we specifically look at the derivation of incidence rates for the 3 major diseases – cancer, heart attack and stroke - based on the industry experience of the Hong Kong market.

## **Data**

The exposure and claims data collected for Gen Re's most recent Dread Disease survey were used. This Dread Disease survey covered the study period from year 1996 to 2000. Fifteen Hong Kong life insurance companies participated, with an estimated market coverage of 74% measured by life insurance policies.

Only standard lives were included in the survey.

The participating companies provided in force census data by age, sex, smoking status, benefit type (acceleration or additional) and duration (0, 1, or 2+) as at the beginning of each calendar year of 1996 to 2001. Risk exposure at age  $x$  last birthday was calculated as the sum of average numbers of lives aged  $x$  last birthday in each calendar year.

Detailed claim information corresponding to the in force data was requested, including information such as attained age at claim, cause of claim, ID number, date of diagnosis, etc.

To avoid double-counting, we also asked for in force data to be provided by number of lives (as opposed to number of policies). Similarly, we tried to match up the claims from a same life using ID number, where provided, and/or the date of birth/sex/date of claim/cause of claim.

Claims with diagnosis date falling within the study period between 1/1/1996 and 31/12/2000 were included. Since the companies were requested to provide all claims submitted on or before 30/9/2001, claims incurred but not yet reported (IBNR) should have been reasonably allowed for. Only admitted claims were used, that is, no allowance was made for claims reported but not yet admitted.

According to the survey, Cancer, Heart Attack and Stroke made up over 85% of all the claims.

## **Methods**

The approach to deriving incidence rates from the experience of accelerated Dread Disease business is different from that from the experience of additional type business. According to the survey data, 82% of the in force policies provided accelerated Dread Disease benefits as at 31 December 2000, whilst only 18% provided additional benefits. In order to maximize the data volume so as to achieve higher credibility, we derived the incidence rates from data pertaining to accelerated Dread Disease policies.

The methodology for pricing accelerated Dread Disease benefit is described in detail in one of Gen Re's publications and is attached in Appendix A for reference. This pricing formula was initially developed by Dr. Wolfgang Droste in 1985 and was first published in 1986 in South Africa. It became the standard pricing formula used by actuaries world-wide.

A death with accelerated dread disease policy pays benefit upon death or first diagnosis of a covered disease, whichever occurs first. The cover comprises two components - death component and dread disease acceleration component.

Let's denote

$i_x$  = probability of incidence of a dread disease between age  $x$  and  $x+1$

$a_x$  = proportion of deaths due to dread disease as against all deaths between age  $x$  and  $x+1$

$q_x$  = mortality at age  $x$

$l_x$  = Number of lives at age  $x$

$ld_x$  = Number of lives aged  $x$  who have previously suffered from a Dread Disease

$ki_x$  = Number of lives aged  $x$  suffering from a Dread Disease for the first time

The pricing formula of risk premium for death with accelerated Dread Disease cover is

$$q_x + i_x - a_x q_x$$

The aim of this paper is to find out the incidence rates  $i_x$ .

### Exposure

According to the pricing model,  $i_x = \frac{ki_x}{l_x - ld_x}$

$l_x - ld_x$  represents the number of “healthy” lives aged  $x$  at the beginning of the observation period. Using  $l_x - ld_x$  as denominator we obtain the initial rates, while using exposure figures of the survey as denominator we obtain the central rates.

$$\text{Central Rate}_x = \frac{\text{Number of claimants aged } x \text{ last birthday}}{\text{Risk Exposure at age } x \text{ last birthday}}$$

Central rate can be converted to initial rate by applying the following formula:

$$\text{Initial Rate}_x = \frac{\text{Central Rate}_x}{1 + \frac{1}{2} \times \text{Central Rate}_x}$$

It is generally difficult for people who were previously diagnosed to have the covered Dread Disease to acquire Dread Disease policies, hence it is reasonable to assume that the insured lives in force are healthy lives.

An adjustment was made for the initial waiting period as:

$$\text{Exposure at Duration } 0 = \text{Number of lives at Duration } 0 \times \frac{1 - \text{waiting period in days}}{365}$$

The total exposure under study was 2.2 millions life-years.

### Claims

$ki_x$  denotes the number of lives aged  $x$  suffering from a dread disease for the first time. Care must be taken when it comes to determine what claims obtained from the survey should be included in  $ki_x$ .

According to the pricing model described in Appendix A, the so-called “sudden deaths” (i.e. someone dies immediately or almost immediately after becoming afflicted by a dread disease) should be counted in  $ki_x$ .

In practice, a number of potential Dread Disease claims may instead be classified as death claims even deaths had not occur immediately, because death occurred either before the Dread Disease was reported or before the Dread Disease claim had been processed; in particular, the evidence required to verify a Dread Disease claim is far more extensive than that required to verify a death claim, and there may also be some variation between the practices of different companies

Now that we have assumed the insured lives in force are healthy lives, any death claims that have a covered Dread Disease as cause of death should be counted in  $ki_x$  as well. These “sudden deaths” will form part of the proportion of deaths due to the covered disease ( $a_xq_x$ ) and be subtracted in the calculation of the risk premium.

For example, cancer claims in this context include both cancer claims in form of Dread Disease claims and death claims where the claimant died from cancer.

Some surveyed companies were not able to provide the death claims associated with the acceleration type Dread Disease policies. Data pertaining to these companies were excluded and this means the exposure to be used was reduced from 2.2 million life-years to 1.9 million life-years.

### Overlaps

There is no need to allow for overlaps between diseases as the claims figures are obtained from the actual experience of insured lives. This is contrary to deriving incidence rates from population data, where overlaps between diseases have to be taken into account to avoid overestimating the cost of insurance.

For example, a person who suffered a prior heart attack and so claimed the benefit would not be able to make a stroke claim even if after recovering from the heart attack he suffered a stroke. As a result, overlap between heart attack and stroke has been allowed for implicitly.

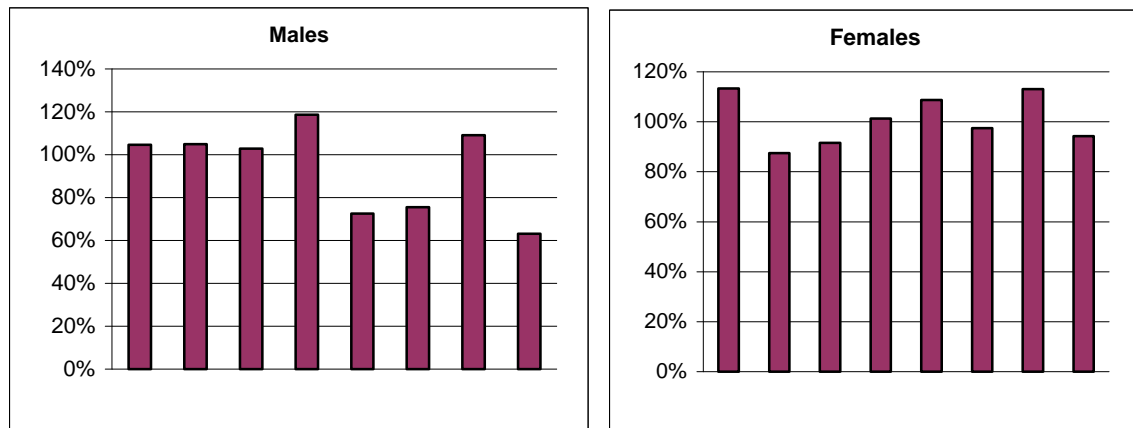
Care must be taken when using incidence rates derived from claims experience where a certain number of dread diseases are covered to price for a product covering less diseases, as the overlapping effect may not be present any more.

### *Dread Disease Definitions*

The definition of Dread Diseases used by different companies varies to some extent. However, this was ignored and all the claims from different companies were pooled together. Claims experience may be affected by definitions used as well as underwriting and claims handling standards.

The following figures provide a comparison of the claims experience of the eight Hong Kong companies that reported at least 10 duration 2+ claims under accelerated Dread Disease policies for both sexes. The number of expected claims was calculated using the graduated incidence rates for duration 2+ Acceleration Dread Disease claims for Hong Kong, Malaysia and Singapore. Claims from all causes, including but not limited to Cancer, Heart Attack and Stroke, were included. The overall A/E ratio for all participating Hong Kong companies was 98.3% for male and 106.7% for female. The incidence rates and other related information can be found in Gen Re's Dread Disease Survey 2003 Report.

Ratios of number of actual claims to number of expected claims (A/E) by company:



### Trends

The mid-point of the survey period weighted by exposure is around the end of year 1998, which means the incidence rates derived relate to year 1998. In deriving a set of incidence rates for current (end of 2004) use, it is necessary to consider the underlying trends and adjust the rates accordingly.

Comments were made in the Results section on any discernable trends in the experience for each disease.

While the past offers us some guidance to the future, we must consider any improvement or deterioration as a result of new methods of detection, availability of new medical procedures, the environment, social behavior, and many other important factors.

The trend in incidence rates reflects both underlying natural (real) trends and (artificial) trends in the rate of detection of diseases. As an example of the impact of medical science and technology, since the 1970s computed tomography (CT) and magnetic resonance imaging (MRI) have become diagnostic tools for neurological disorders, improving the diagnosis and its classification into subtypes. Greater use of technology over time may

have resulted in the detection of milder stroke cases that would otherwise not have been diagnosed. These may cause an artificial increase in stroke incidence rates. A similar situation is occurring with new clinical definitions for myocardial infarction.

The log linear regression method was used to calculate the improvement/deterioration in incidence per annum.

Let  $y$  be the incidence rate,  $x$  be the year, a log-linear model is simply

$$\ln(y) = ax + b \rightarrow y = (e^a)^x e^b \rightarrow e^a - 1 = \text{change per annum}$$

Theoretically, the projected incidence rates in 2004 should be the rates observed from the survey multiplied by an adjustment factor of  $(1 + \text{change per annum})^{2004 - 1998}$ . In consideration of the low credibility of the change per annum figure due to the small number of claims in each year, we decided not to fully adhere to the theoretical approach. In stead, an estimated trend adjustment was made with reference to both the change per annum and statistics from other sources, such as population statistics and industry experience of other market.

## Results

The best estimate incidence rates for cancer, heart attack and stroke applicable to 2004 were derived by the following three steps:

1. Calculate the crude incidence rates, which are the central rates as defined above
2. Graduate the crude rates
3. Adjust the rates to allow for trends

## Cancer

### 1. Crude rates

In order to remove the initial selection effects from the ultimate rates, it was decided to calculate the claim incidence rates only for policies that had been in force for two years or longer.

A total of 1647 Cancer claims were collected, details are given in the table below:

Age at claims 20-64	Number of claims							
	Male				Female			
Duration	0	1	2+	All	0	1	2+	All
Claims reported as Dread Disease claim	103	120	403	626	156	175	619	950
Claims reported as Death claim due to Cancer	13	10	28	51	4	7	9	20
Total number of Cancer claims	116	130	431	677	160	182	628	970

The crude incidence rates were compared with population cancer incidence in 2000.

There was some underwriting effect in male insured lives, however, anti-selection was seen in young age female lives.

### *Male lives (Duration 2+)*

Age	Insured lives			Population <sup>1</sup> Incidence per 1,000 (all sites but skin)	Insured lives / Population Ratio
	Number of claims	Risk Exposure	Incidence per 1,000		
20-24	4	31,896	0.125	0.209	60%
25-29	25	81,492	0.307	0.371	83%
30-34	50	120,885	0.397	0.498	80%
35-39	103	125,672	0.772	0.898	86%
40-44	129	81,356	1.487	1.661	90%
45-49	59	41,551	1.324	2.612	51%
50-54	39	16,007	2.124	3.878	55%
55-59	14	4,643	2.369	6.239	38%
60-64	8	1,062	7.535	9.691	78%
20-64	431	504,564	0.854		

**Female lives (Duration 2+)**

Age	Insured lives			Population	Insured lives /
	Number of claims	Risk Exposure	Incidence per 1,000	Incidence per 1,000 (all sites but skin)	Population Ratio
20-24	13	38,982	0.333	0.235	142%
25-29	47	101,569	0.463	0.417	111%
30-34	94	120,415	0.781	0.758	103%
35-39	157	103,643	1.515	1.373	110%
40-44	145	67,046	2.163	2.302	94%
45-49	91	38,461	2.366	3.237	73%
50-54	51	16,700	3.054	4.015	76%
55-59	28	5,179	5.406	5.073	107%
60-64	2	1,175	1.702	6.283	27%
20-64	628	493,171	1.273		

**2. Graduation**

The graduation approach followed was to use cubic splines with variable knots; however, there was insufficient exposure to follow a very rigorous approach and we chose between the rates graduated using not more than two knots, with smoothing at the younger ages for some of the rates. Because data at the younger and older ages were sparse, graduations were performed for age range 20-64 only.

**3. Selection effect**

The number of expected claims for duration 0 and 1 was calculated using the duration 2+ incidence rates. The initial selection effect is not as marked as in life business experience.

Duration	No. of actual claims	Male		A/E	Female		
		No. of expected claims	A/E		No. of actual claims	No. of expected claims	A/E
0	116	131	88.9%	160	221	72.3%	
1	130	133	97.5%	182	226	80.5%	
2+	431	431	100.0%	628	628	100.0%	
All	677	695	97.4%	970	1075	90.2%	

#### 4. Trends

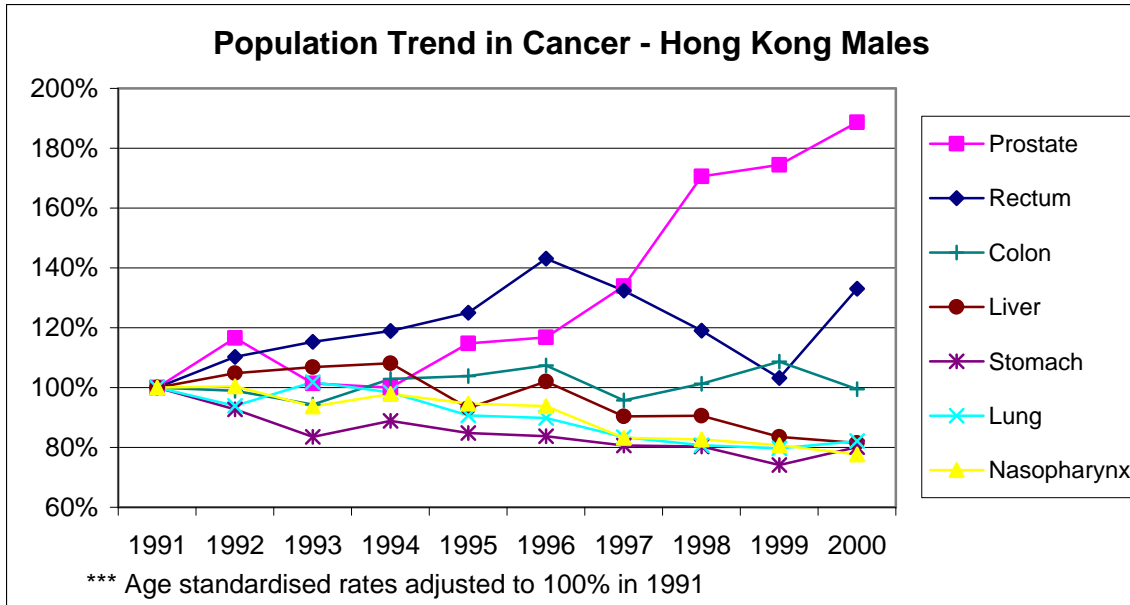
The number of expected claims in each year was calculated using the graduated incidence rates for 1996-2000. The ratios of number of actual claims over number of expected claims are shown below:

A/E ratio for Cancer claims, age 20-64						
	1996	1997	1998	1999	2000	Change p.a.
Male	95%	102%	104%	103%	96%	+0.2%
Female	106%	98%	116%	93%	95%	-2.6%

In order to better understand the trends in cancer incidence, the population incidence rates for each year from 1991 to 2000 were analyzed to investigate the trend in population. During this period the crude incidence rates for “all ages” have been increasing in both sexes, mainly due to population aging. A slightly decreasing trend was seen after age adjustment.

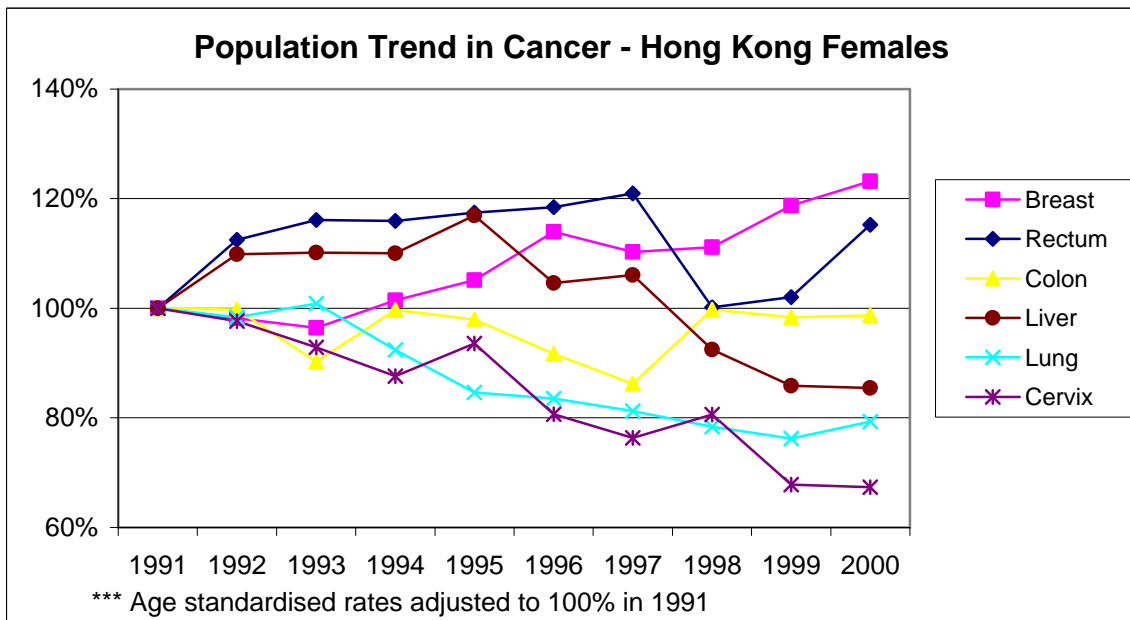
Age standardized Cancer incidence rates per 100,000 - Hong Kong population (all ages)											
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Change p.a.
Male	303.2	299.9	290.6	292.0	282.8	286.1	269.8	271.1	268.3	268.6	-1.5%
Female	216.2	213.0	202.5	202.3	201.8	203.7	198.3	197.3	198.7	203.1	-0.7%

A closer look at the trends by cancer site is given by the two charts below.



The incidence rates were age standardized using the World Standard Population and expressed as percentages of the 1991 incidence rate.

The incidence of prostate cancer in males increased by 89% over the 10 years. This could be because of increased screening for this type of cancer. The rectum is the other major cancer site where increase was observed. Other than that, the incidence rates of most of other major cancer sites have been decreasing.



In females, breast cancer increased by 23% over the same period, and cancer of the cervix went down by 33%. The latter was probably due to better screening for pre-malignant disease, which can be treated quite easily, hence reducing the number developing into full-blown cancer.

As discussed in the Methods section, the trends in both insured lives and general population were taken into consideration in determining the necessary adjustment to the incidence rates derived from the survey data, in order to obtain the incidence rates suitable to be used for 2004. We decided that the rates should be reduced by 2% to allow for the trends.

Adjustments were also made to the rates for males aged 50-64 by referring to the population incidence as we believe that the underwriting effect for this age range should not differ significantly from that for other ages. Indeed, as data were sparse at older ages, the resulting incidence rates are subject to bigger random error. Adjustments of up to +50% were made and the adjustment factors were tapered to avoid humps in the rate curve.

The adjusted incidence rates are set out in Appendix B.

### **Heart Attack**

The number of Heart Attack claims came second after Cancer:

Age at claims 20-64	Number of claims							
	Male				Female			
Duration	0	1	2+	All	0	1	2+	All
Claims reported as Dread Disease claim	20	15	63	98	4	6	15	25
Claims reported as Death claim due to Heart Attack	4	4	11	19	2	1	1	4
Total number of Heart Attack claims	24	19	74	117	6	7	16	29

## 1. Crude rates

The duration 2+ incidence rates were calculated for male lives. Since the number of duration 2+ claims for female lives was small, incidence rates were derived using data for all durations.

Crude Heart Attack incidence rates per 1,000 for Heart Attack

Age	Male (Duration 2+)			Female (All durations)		
	Number of claims	Risk Exposure	Incidence per 1,000	Number of claims	Risk Exposure	Incidence per 1,000
20-24	1	31,896	0.031	2	115,175	0.017
25-29	0	81,492	0.000	1	194,174	0.005
30-34	5	120,885	0.041	5	203,070	0.025
35-39	10	125,672	0.080	4	172,723	0.023
40-44	22	81,356	0.270	6	113,588	0.053
45-49	16	41,551	0.385	5	65,651	0.076
50-54	13	16,007	0.812	2	27,479	0.073
55-59	5	4,643	1.077	2	7,516	0.266
60-64	2	1,062	1.884	2	1,418	1.410
20-64	74	504,564	0.147	29	900,795	0.032

## 2. Graduation

In view of the scarcity of the claims number, incidence rates were calculated by 5-year age groups and graduated using parametric method. Various models were fitted and the R-squared were compared to find the model with best fit. For male lives, cubical model was adopted. For females, cubical model and power model were adopted for age 20-40 and 41-64 respectively.

## 3. Selection effect

The number of expected claims was calculated using the graduated incidence rates and the table below shows the A/E ratios by duration. The result is surprising as one would expect to see some positive initial selection effect for circulatory system diseases like

Heart Attack. The risk factors such as blood pressure and cholesterol should have been underwritten and bad risks have been identified. However, it is too early to draw any firm conclusions about the negative selection based on only a small number of claims at duration 0 and 1.

Duration	Male			Female		
	No. of actual claims	No. of expected claims	A/E	No. of actual claims	No. of expected claims	A/E
0	24	21.0	114.2%	6	5.8	102.7%
1	29	21.8	87.1%	7	6.1	115.2%
2+	74	74.5	99.4%	16	17.9	89.5%
All	117	117.3	99.8%	29	29.8	97.3%

#### 4. Trends

The A/E ratios below indicate an annual increase of 6% pa (males) and 29% pa (females) from 1996 to 2000.

A/E ratio for Heart Attack claims, age 20-64						
	1996	1997	1998	1999	2000	Change p.a.
Male	76.4%	94.2%	116.5%	70.5%	117.7%	+5.9%
Female	72.5%	27.3%	65.7%	177.7%	101.6%	+29.0%

Since the annual deterioration rates were calculated based on a small number of claims, we would like to compare these figures with statistics from a second source. In the absence of population incidence rates, comparison was made with Taiwan insured lives experience. Data from Taiwan Life Insurance Association<sup>2</sup> also suggests that Heart Attack incidence is on the rise.

Age adjusted Heart Attack incidence rates per 1,000 - Taiwan insured lives (all ages)						
	1996	1997	1998	1999	2000	Change p.a.
Male	0.069	0.080	0.098	0.110	0.119	+15.0%
Female	0.007	0.004	0.012	0.013	0.011	+22.8%

However, it is difficult to conclude the appropriate level of trend adjustment because of the short period under consideration and the high volatility of the experience. The per annum increase of 5.9% and 29% means that the incidence rates have to be adjusted up for as much as 41% and 361% to project the current level of Heart Attack incidence.

We finally decided that an adjustment of +75% be used to reflect the increasing trend.

This is somewhat arbitrary, but we will monitor the experience closely and report an update of the trend data as part of our next Dread Disease survey report.

**Stroke**

**1. Crude rates**

There were less Stroke claims than Heart Attack claims in males and more Stroke claims than Heart Attack claims in females.

Age at claims 20-64	Number of claims							
	Male				Female			
Duration	0	1	2+	All	0	1	2+	All
Claims reported as Dread Disease claim	10	11	53	74	15	8	22	45
Claims reported as Death claim due to Stroke	2	1	5	8	2	1	2	5
Total number of Stroke claims	12	12	58	82	17	9	24	50

The duration 2+ incidence rates were calculated for male lives. Since the number of duration 2+ claims for female lives was small, incidence rates were derived using data for all durations.

Crude Stroke incidence rates per 1,000

Age	Male (Duration 2+)			Female (All durations)		
	Number of claims	Risk Exposure	Incidence per 1,000	Number of claims	Risk Exposure	Incidence per 1,000
20-24	0	31,896	0.000	2	115,175	0.017
25-29	2	81,492	0.025	6	194,174	0.031
30-34	6	120,885	0.050	6	203,070	0.030
35-39	16	125,672	0.127	7	172,723	0.041
40-44	13	81,356	0.160	6	113,588	0.053
45-49	12	41,551	0.289	12	65,651	0.183
50-54	6	16,007	0.375	9	27,479	0.328
55-59	2	4,643	0.431	1	7,516	0.133
60-64	1	1,062	0.942	1	1,418	0.705
20-64	58	504,564	0.110	50	900,795	0.052

2. Graduation

The crude rates were smoothed by following the same approach as that for Heart Attack.

For male lives, power model was adopted with some manual adjustment for age under 30.

For females, exponential model was used.

3. Selection effect

The results below show that there was some positive initial selection effect in males,

while in female lives, strong negative selection in duration 0 was seen.

Duration	Male			Female		
	No. of actual claims	No. of expected claims	A/E	No. of actual claims	No. of expected claims	A/E
0	12	17.5	68.6%	17	10.0	169.6%
1	12	17.7	67.8%	9	10.3	87.7%
2+	58	56.5	102.6%	24	28.6	84.0%
All	82	91.7	89.4%	50	48.9	102.3%

#### 4. Trends

The A/E ratios indicate that the increasing trend in Stroke incidence is even steeper than that in Heart Attack incidence.

A/E ratio for Stroke claims, age 20-64						
	1996	1997	1998	1999	2000	Change p.a.
Male	71.9%	50.2%	110.1%	134.6%	109.7%	+20.1%
Female	79.0%	45.5%	49.4%	110.9%	164.0%	+40.6%

The industry experience of Taiwan was studied and it also shows a deteriorating trend.

Age adjusted Stroke incidence rates per 1,000 - Taiwan insured lives (all ages)						
	1996	1997	1998	1999	2000	Change p.a.
Male	0.039	0.038	0.057	0.056	0.069	+16.3%
Female	0.020	0.018	0.019	0.018	0.024	+3.6%

The comments for the trend in Heart Attack incidence also apply here. An adjustment of +75% was made to obtain the incidence rates for 2004 based on the same rationale.

### Pricing Model for Accelerated Dread Disease<sup>3</sup>

#### 4.1.1 Accelerated Benefit

For pricing accelerated benefits, the cost for “death or first diagnosis of a covered disease, whichever occurs first” has to be derived. The first approaches to pricing this type of benefit tried to estimate the costs for lost premiums and lost interest for the death cover due to the “accelerated” (earlier) payment on diagnosis of a covered disease, which resulted in a relatively complicated formula. In contrast to these first attempts in pricing an accelerated benefit, our recommended methodology yields a simple straightforward formula.

The following derivation of a formula for the accelerated benefit starts only one with is dread disease being covered. In a further step described below, the incidence for the whole Dread Diseases is obtained by combining the single incidences.

The parameters relevant for the model are named as follows:

$l_x$	=	Number of lives at age x
$ld_x$	=	Number of lives aged x who have previously suffered from a Dread Disease
$ki_x$	=	Number of lives aged x suffering from a Dread Disease for the first time
$d_x$	=	Number of deaths between age x and x+1
$dn_x$	=	Number of deaths due to non-Dread Disease causes amongst lives who have suffered a Dread Disease

## Appendix A

$dd_x$  = Number of deaths due to Dread Disease amongst lives who have suffered a Dread Disease

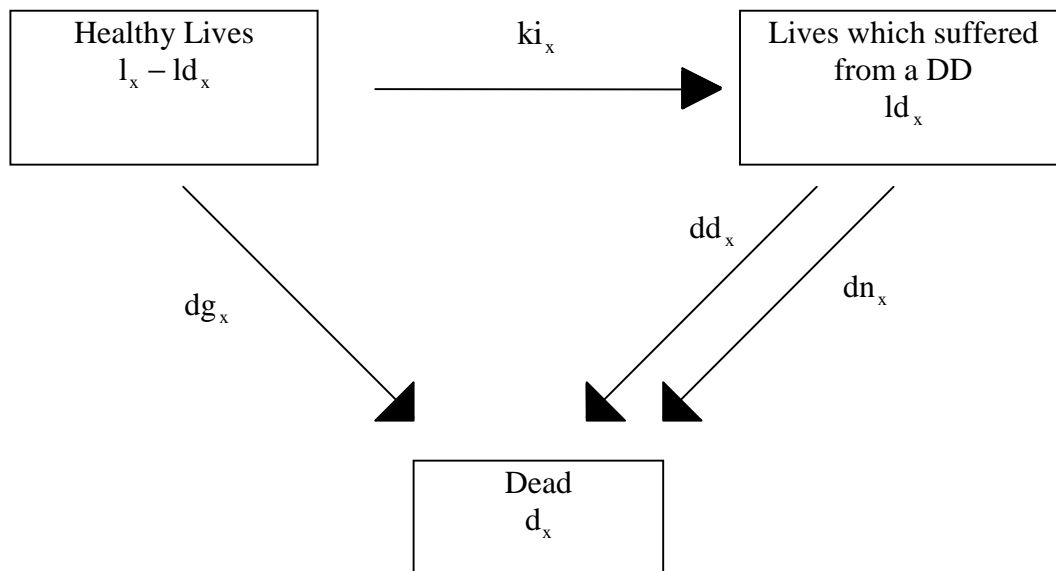
$dg_x$  = Number of deaths between age  $x$  and  $x+1$  amongst lives who never had a Dread Disease

$i_x$  = Probability for incidence of a Dread Disease between age  $x$  and  $x+1$

$a_x$  = Proportion of deaths due to Dread Disease as against all deaths between age  $x$  and  $x+1$

$q_x$  = Mortality at age  $x$

The probability of death or (diagnosis of) Dread Disease is derived from a decrement model with two decrements (mortality and morbidity).



It must be kept in mind that so-called “sudden deaths” (i.e. someone dies immediately or almost immediately after getting afflicted by a Dread Disease) are counted in both the number of new Dread Disease cases  $ki_x$  and the total number of deaths due to Dread

Disease  $dd_x$ . I.e. the case deaths due to Dread Disease amongst healthy lives cannot occur.

The portfolio of lives at age  $x$ , who have never suffered from a Dread Disease - i.e.

$l_x - ld_x$  - is decreased by new Dread Disease cases ( $ki_x$ ) and deaths of healthy lives ( $dg_x$ ). The number of lives who have suffered a Dread Disease is reduced by deaths due to Dread Disease ( $dd_x$ ) and other causes ( $dn_x$ ).

Consequently, the total number of claims under a policy covering the events “death or Dread Disease whatever occurs first” is:

$$ki_x + dg_x .$$

Usually, there are no statistics on  $dn_x$  or  $dg_x$ . However, data to derive  $i_x$ ,  $a_x$  and  $d_x$  can normally be obtained. Thus, the term  $ki_x + dg_x$  will be replaced by a term which uses only these 3 variables.

In a first step one derives

$$dd_x = a_x \cdot d_x .$$

Now, the number of deaths due to non-Dread Disease causes can be described as:

$$(1) \quad dg_x + dn_x = (1 - a_x) \cdot d_x$$

From (1) one obtains the total number of claims due to death or Dread Disease as

$$(2) \quad ki_x + dg_x = ki_x + (1 - a_x) \cdot d_x - dn_x .$$

As mentioned before, the value of  $dn_x$  in the above formula normally cannot be derived from statistical data as there are no corresponding surveys. However, it is reasonable to assume that the mortality due to non- Dread Disease causes is higher amongst lives who

suffered from a Dread Disease than amongst those who never suffered from a Dread Disease:

$$(3) \quad \frac{dn_x}{ld_x} = \frac{dg_x}{l_x - ld_x} \cdot (1 + m_x) , \text{ where } m_x \geq 0$$

Solving equation (3) and substituting  $dn_x$  in (1), one arrives at

$$dg_x + \frac{dg_x \cdot ld_x}{l_x - ld_x} \cdot (1 + m_x) = (1 - a_x) \cdot d_x$$

Transformation of the equation and substitution of  $d_x$  with  $q_x \cdot l_x$  yields

$$(4) \quad \frac{dg_x}{l_x - ld_x} = \frac{(1 - a_x) \cdot q_x \cdot l_x}{l_x + m_x \cdot ld_x}$$

To derive premiums for a death benefit with 100% accelerated Dread Disease, equation (2) has to be divided by the number of healthy lives ("active lives"), which renders

$$(5) \quad \frac{ki_x + dg_x}{l_x - ld_x} = \frac{ki_x}{l_x - ld_x} + \frac{(1 - a_x) \cdot q_x \cdot l_x}{l_x + m_x \cdot ld_x}$$

$$= i_x + \frac{(1 - a_x) \cdot q_x}{1 + m_x \cdot \frac{ld_x}{l_x}}$$

where  $i_x = \frac{ki_x}{l_x - ld_x}$  is the incidence rate of Dread Disease.

Term (5) depends on  $m_x$  and decreases with  $m_x$  increasing.

Thus, choosing  $m_x = 0$  yields an upper estimate:

Let  $qi_x$  =Probability to die or to suffer from a Dread Disease  
between age x and x+1,

then

$$qi_x = i_x + (1 - a_x) \cdot q_x$$

$$= q_x + (i_x - a_x \cdot q_x).$$

One thus obtains a formula which requires  $i_x$ ,  $a_x$  and  $q_x$  only.

Now,  $i_x - a_x q_x$  denotes the premium for the Dread Disease acceleration part of the cover comprising death plus accelerated Dread Disease.

In the formulas mentioned above,  $i_x$  denotes the probability to get afflicted by any one of the Dread Diseases covered and  $a_x$  denoted the proportion of deaths from any of the Dread Disease covered amongst all deaths. Let  $i_x^k$  denote the incidence for disease k and  $a_x^k$  denote the proportion of deaths from disease k amongst all deaths. This renders

$$qi_x = q_x + \left( \sum_k i_x^k - \sum_k a_x^k \cdot q_x \right) = q_x + \sum_k (i_x^k - a_x^k \cdot q_x)$$

However, this formula only yields an approximate figure for  $qi_x$ , as the correct calculation of  $i_x$  is made via a product as described in the following formula:

$$i_x = 1 - \prod_k (1 - i_x^k)$$

Due to practical reasons, usually the formula using the sum is applied when calculating Dread Disease incidence. As

$$1 - \prod_k (1 - i_x^k) < \sum_k i_x^k$$

this yields a small margin that may be understood as safety margin.

## Best Estimate Incidence rates per 1,000 for Insured Lives (2004)

Age last	Cancer		Heart Attack		Stroke	
	Male	Female	Male	Female	Male	Female
20	0.17	0.25	0.02	0.01	0.05	0.03
21	0.17	0.27	0.02	0.01	0.06	0.03
22	0.17	0.30	0.03	0.01	0.06	0.03
23	0.17	0.33	0.03	0.01	0.06	0.04
24	0.18	0.35	0.04	0.02	0.06	0.04
25	0.19	0.36	0.04	0.02	0.06	0.04
26	0.22	0.37	0.05	0.02	0.07	0.04
27	0.25	0.40	0.05	0.02	0.07	0.04
28	0.28	0.44	0.05	0.02	0.07	0.04
29	0.32	0.49	0.06	0.02	0.08	0.05
30	0.37	0.56	0.07	0.02	0.08	0.05
31	0.42	0.66	0.08	0.02	0.08	0.06
32	0.47	0.77	0.09	0.03	0.09	0.06
33	0.54	0.90	0.10	0.03	0.11	0.07
34	0.60	1.06	0.11	0.04	0.12	0.07
35	0.67	1.22	0.13	0.04	0.14	0.08
36	0.74	1.38	0.15	0.05	0.15	0.09
37	0.82	1.52	0.18	0.05	0.17	0.09
38	0.91	1.65	0.21	0.06	0.19	0.10
39	0.99	1.77	0.24	0.07	0.21	0.11
40	1.08	1.88	0.28	0.07	0.23	0.12
41	1.17	1.99	0.33	0.08	0.26	0.13
42	1.28	2.08	0.38	0.08	0.29	0.15
43	1.40	2.17	0.43	0.09	0.32	0.16
44	1.58	2.26	0.50	0.10	0.35	0.17
45	1.77	2.35	0.57	0.11	0.38	0.19
46	1.98	2.44	0.64	0.12	0.42	0.20
47	2.21	2.53	0.73	0.14	0.46	0.22
48	2.44	2.62	0.82	0.16	0.50	0.24
49	2.70	2.72	0.93	0.19	0.54	0.26
50	2.96	2.82	1.04	0.22	0.59	0.29
51	3.25	2.93	1.16	0.26	0.64	0.31
52	3.54	3.05	1.29	0.30	0.69	0.34
53	3.86	3.18	1.43	0.35	0.74	0.37
54	4.09	3.32	1.58	0.41	0.80	0.40
55	4.36	3.48	1.74	0.47	0.87	0.44
56	4.72	3.65	1.92	0.54	0.93	0.48
57	5.18	3.88	2.10	0.62	1.00	0.52
58	5.77	4.13	2.30	0.72	1.08	0.57
59	6.50	4.36	2.51	0.82	1.16	0.62
60	7.16	4.52	2.74	0.93	1.24	0.67
61	8.21	5.01	2.85	1.06	1.32	0.73
62	9.38	5.51	2.94	1.21	1.42	0.80
63	10.18	6.02	3.04	1.37	1.51	0.87
64	10.61	6.58	3.13	1.52	1.61	0.95

**Reference:**

<sup>1</sup> Cancer Stat 2000. Hong Kong Cancer Registry, Hospital Authority of Hong Kong.

<sup>2</sup> Taiwan Individual Dread Disease Benefits Experience Morbidity and Persistency Rate Report.

<sup>3</sup> *Destination Dread Disease – A comprehensive survey of an intriguing product*, by Dr. Karsten Kroll. GeneralCologne Re Publication Number 45, 2001

**Acknowledgement:**

We would like to thank all the companies that participated in Gen Re's Dread Diseases survey:

American International Assurance Company (Bermuda) Limited

China Life Insurance Company Limited

CMG Asia Limited

Dah Sing Life Assurance Company Limited

Eagle Star Life Assurance Company Limited

HSBC Life (International) Limited

ING Life Insurance Company (Bermuda) Limited

Manulife (International) Limited

MassMutual Asia Limited

MLC (Hong Kong) Limited

New York Life Insurance Worldwide Limited

Pacific Century Insurance Holdings Limited

Standard Life (Asia) Limited

The Prudential Assurance Company Limited

Winterthur Life Hong Kong