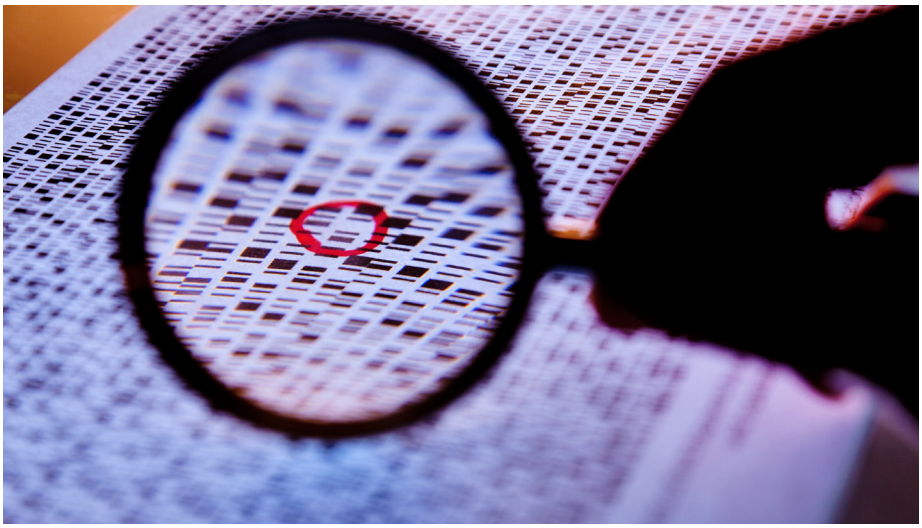
CI Pricing Detectives

A considerable amount of investigatory and skilled fine-tuning work is required to calculate sufficiently reliable 'incidence rates' to price Critical Illness Insurance (CI). This is because it's a long-term, often complex product that's affected by rapid medical progress and product evolution, as well as by risk data availability, inconsistency and interpretation issues. To help pricing actuaries to tackle these many challenges, we open a case on deriving CI incidence rates.



The investigation begins

CI pays a benefit to the policyholder according to each policy's specific medically defined conditions[1]. Pricing requires careful examination of each definition and then calculation of the respective incidence rates, which begins with either insured population claims experience (ideal if available) or general population data, followed by numerous considerations and adjustments. Our investigation starts with the pricing approaches for different types of CI product, before moving on to giving evidence on deriving incidence rates depending on the main data source.

How CI product type impacts incidence rate calculation

The popularity of CI product type – *accelerated, additional and standalone CI* – differs by market. For example, accelerated CI is the main form in the U.K., whereas standalone CI dominates in Canada[2].

- Accelerated CI cover provides a prepayment of all or part of the sum insured of the underlying life policy.
- Additional CI provides additional benefits without affecting the mortality sum insured of the main life policy.
- Standalone CI has no underlying life cover; in contrast to the other two forms of CI, the benefit of a standalone CI is usually paid out once, after which the insurer's liability ends.

Pricing additional and standalone CI is based on the individual respective calculated incidence rates of CI conditions.

For accelerated CI covers, where CI and mortality 'compete' for the claim payment, estimated mortality rates must be included and adjusted (as opposed to summed) to take into account the overlap between death and CI incidence rates. See **Adjustment for accelerated CI** (box, next page) for more information.

In many markets, however, pricing is further complicated by products that offer multiple payments; Multiple-benefit CI and Severity-based CI are the two main variations.

Multiple-benefit CI

For a Multiple-benefit cover, it is necessary to calculate many combinations of incidence rates. Consider, for example, a product covering three conditions: Cancer, Heart Attack and Kidney Failure. **Figure 1** shows that fifteen separate incidence rates would need to be calculated. This would be a challenge given the limited availability of data to calculate the second, third and further incidences.

This problem is overcome at the product design stage by allocating conditions to groups that are uncorrelated with one another and by allowing the policyholder to claim only once from each group[3]. For example, in the case of figure 1 it would be assumed that the probability (P) relationships are:

P[Cancer|Heart Attack]
≈ P[Cancer|Kidney Failure]
≈ P[Cancer|Healthy]).

Under this assumption, the number of incidence rates to calculate falls from fifteen to three.

However, pricing challenges remain:

- The design-stage creation of uncorrelated groups requires medical research data and input from the medical profession.

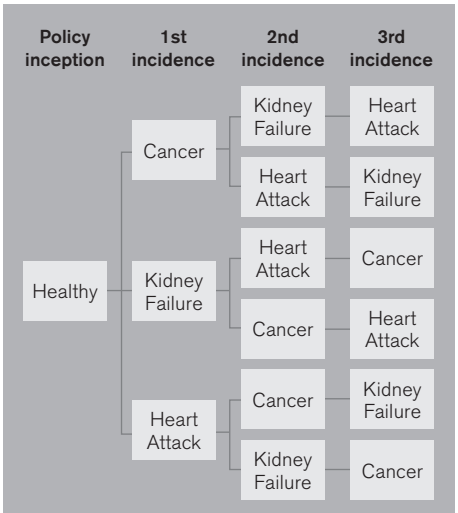


Figure 1: CI claims possibilities for a standalone Multi-benefit CI policy with three conditions; Cancer, Heart Attack and Kidney Failure. Source: PartnerRe.

[1] 'Roots and Developing Structure of Critical Illness Insurance', PartnerRe 2015.
[2] Critical Illness Insurance – International Overview; SCOR Global Life, April 2011.
[3] As long as the delay between claims meets the defined waiting period (i.e. the time that must pass before a claim can be made).

- In practice, it is impossible to build groups that are perfectly independent. The second- and third-incidence rates remain conditional probabilities with low correlation; an additional loading for this correlation must be considered.
- At the pricing stage, it remains challenging to find data with the right granularity to calculate the group incidence rates, including for differences by gender, smoking status and other rating factors.
- The impact of the waiting period[3] on subsequent claims requires survival rate calculations for each condition.
- Varying policy lapse rates before and after the first, second and third incidences also need to be considered.

Severity-based CI

In this insurance, a portion of the sum assured is paid depending on the severity of the condition. It allows for multiple payments for the same condition and the policy remains inforce after a payment. The most common severity-based cover disease is breast cancer, which is assessed by progressive stages of the disease ranging from 0 to 4. The pricing challenges are that:

- Modelling is similarly complex to Multi-benefit, but without the added complexity of correlations.
- Finding sufficient statistics to calculate the rates for each progression of a disease is often a problem.
- The scaled benefit complicates reserving.
- Assessing the impact of future screening programs is problematic. Early-stage cancers are especially exposed to such changes.
- There is high anti-selection risk.

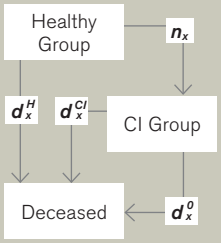
Deriving CI incidence rates from insured population data

In certain markets, it is possible to access direct insured population claims experience and exposure data. This is the most relevant data source for pricing, requiring minimal adjustment for differences in the insured groups and definitions. In the U.K. for example, the CMI[4] regularly publishes reference industry tables for CI incidence rates from pooled industry data. In China, the CIRC published market CI experience data and incidence rates for the main CI conditions in 2013[5].

Adjustment for accelerated CI

Understanding how the formula for calculating incidence rates for an accelerated CI is derived and its assumptions gives added confidence to the user. To illustrate, we use a simple multi-state model with three states:

- **Healthy group:** Lives who have not been diagnosed with the CI being considered. Let us assume there are L_x^H healthy lives at age x.
- **CI group:** Lives at age x that have already been diagnosed with the CI being considered. We assume there are L_x^{CI} lives in this group at age x.
- **Deceased:** Lives that died at age x.



The number of lives moving between different states at age x is given by:

- n_x Number of healthy lives diagnosed with the CI condition
- d_x^H Number of healthy lives that die from any cause
- d_x^{CI} Number of lives with the CI condition that die from the CI condition
- d_x^0 Number of lives in the CI group that die from a cause other than the CI condition

If d_x represents the total number of deaths from all causes, then:

(1) $d_x = d_x^H + d_x^{CI} + d_x^0$

If k_x is the proportion of all deaths from the CI condition, then:

(2) $d_x^H + d_x^0 = (1 - k_x)d_x$

A CI claim payment will occur for the following movements:

(3) $n_x + d_x^H$

So the accelerated incidence rate is:

(4) $\frac{n_x + d_x^H}{L_x^H} = i_x + \frac{d_x^H}{L_x^H}$

where i_x is the standalone CI incidence rate.

We make now the key assumption that the probability of a sick life dying from a cause other that the CI condition is the same as the probability of a healthy life dying from a cause other than the CI condition.

(5) $\frac{d_x^0}{L_x^{CI}} = \frac{d_x^H}{L_x^H}$

From equation (2) we have:

$d_x^H + d_x^0 = (1 - k_x)d_x$

And using equation (5) to eliminate d_x^0 from this equation gives:

$d_x^H + \frac{d_x^H L_x^{CI}}{L_x^H} = (1 - k_x)d_x$

$\frac{d_x^H}{L_x^H}[L_x^H + L_x^{CI}] = (1 - k_x)d_x$

$\frac{d_x^H}{L_x^H} = (1 - k_x)\frac{d_x}{L_x^H + L_x^{CI}}$

(6) $\frac{d_x^H}{L_x^H} = (1 - k_x)q_x$

where q_x is the portfolio mortality rate at age x

From (4) and (6), the accelerated CI incidence rate is therefore:

$\frac{n_x + d_x^H}{L_x^H} = i_x + \frac{d_x^H}{L_x^H}$

$= i_x + (1 - k_x)q_x$

In this way, the incidence rates for accelerated CI can be calculated using mortality rates, the standalone CI rate and the proportion of deaths due to the considered illness.

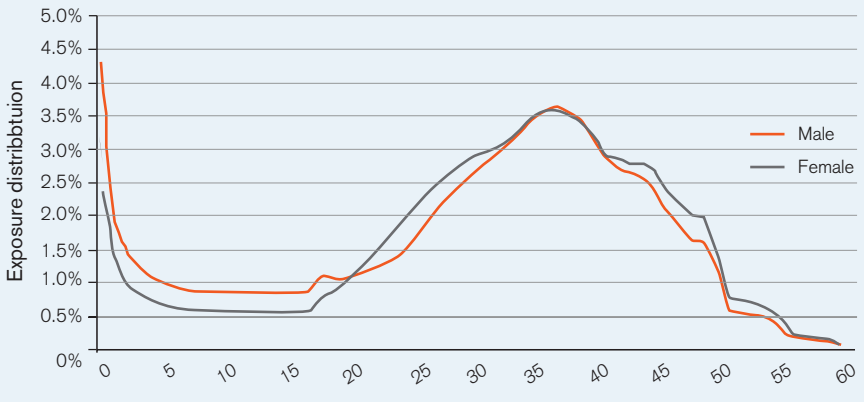


Figure 2: Age distribution of Chinese CI inforce policies in 2010. The average policyholder age for accelerated CI is 29.3 for males and 31.1 for females. 70% of the insured are aged between 25 and 49, and most of them have a whole of life policy. Source: China Insurance Regulatory Commission, 2013.

In general, company claims experiences will however differ due to varying sales channels, underwriting practices, claims processes including IBNR and conditions covered. These differences will need to be identified and the rates adjusted accordingly. Of particular note:

Adjust for change in the covered conditions

The first check when running an experience analysis on insured portfolio data is to analyze changes in the condition definitions which were used over the investigation period: Any change in the number of conditions, has a definition

[4] Continuous Mortality Investigation (CMI).
[5] China Life Insurance Experienced Critical Illness Table (2006–2010), 2013.

become harsher or more lenient, and how do the past and current definitions compare? In the U.K. for example, angioplasty used to be a common CI condition. The introduction of improved angioplasty techniques reduced the severity of the disease to the policyholder but led to more CI claims. Most insurers subsequently removed the cover/definition, which had an immediate effect on their experience.

Adjust for lack of data for older ages
Insured experience is often concentrated at younger ages (see example in **figure 2**, previous page) and therefore lacks credibility for higher ages. The pricing actuary will need to consider what supplementary data sources can be utilised and how to extrapolate the incidence curve; sources may include population statistics or experience from other insurance products.

Adjust for IBNR differences
It can take several years before all the CI claims from any one year of exposure are reported and settled. The incidence rate will therefore be underestimated if no adjustment is made for IBNR practices in the pooled data. Also, a change in experience over time may be due to an adjustment of the IBNR practice rather than to a real change in the level of risk. There is also substantial variation to consider in IBNR between conditions[6], see **figure 3**.

A common best practice used to assess how reasonable the final derived rates including IBNR are, is to check them against population incidence rates.

Adjust for underwriting quality
Underwriting quality impacts incidence rates and this varies by condition, as some risk factors are easier to detect than others (heart attacks compared to cancer for example). When analyzing the experience of a portfolio, it is therefore important to consider changes in underwriting practices over the investigation period and to assess how this has contributed to the observed experience.

Adjust for change in the product mix
CI has been one of the most innovative areas in the insurance industry since its initial launch, equating to a short product life cycle in some markets. This change in the product mix over time distorts pooled industry data. Different risk profiles and risk factors must be analyzed. In addition, market knowledge is required to make product mix judgements if this information is not available.

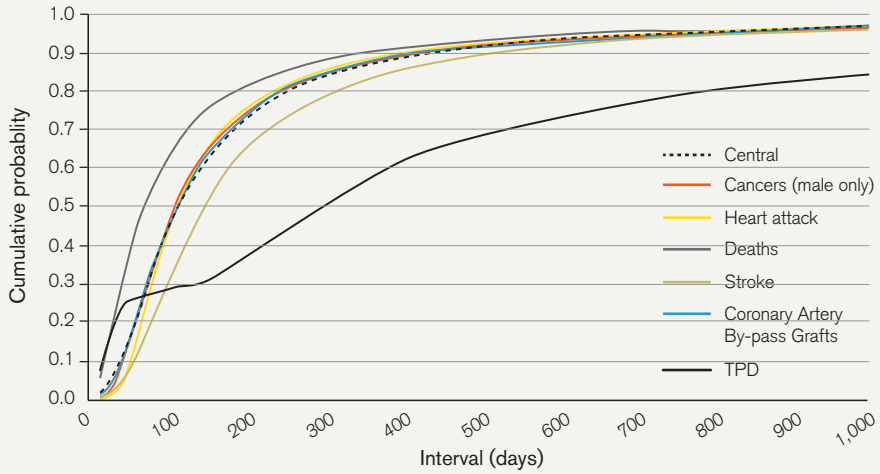


Figure 3: Cumulative claim development distributions by cause in the U.K. The graph shows the variation between conditions in the modeled probability of a claim being reported at various durations in time after a diagnosis. In particular, TPD[7] is markedly different, necessitating particular attention in an IBNR assessment. Source: CMI.

Adjust for socio-economic group
Higher socio-economic groups tend to have lower incidence rates than the general population. This varies by condition, however, and is, for example, generally true for heart attack and stroke, but is not the case for certain cancers due to better access to screening programs.

The exact socio-economic class information is rarely available, therefore a good proxy can be to use distribution channel as a rating factor in addition to salary information, as a change in a portfolio's socio-economic mix is usually observed when there is a change in distribution channel.

Deriving CI incidence rates from general population statistics

If there is no available insured population data, insurers will utilize general population statistics obtained from government statistical departments, international health organizations and medical institutions. There are many limitations to such sources, as detailed below, but with adequate adjustments it can be possible to derive reliable incidence rates:

- ***There has been no underwriting in population data.*** Any underwriting/selection effect has to be estimated using external data.
- ***The data often consists of mortality rates (not incidence rates) by cause.*** To translate to incidence rates, the pricing actuary will need to use condition survival rate data to accelerate the incidences (as incidence will occur before death) and to gross up incidences (to allow for incidences where the policyholder survives).
- ***Data availability varies substantially by disease type.*** While data for core diseases including cancer[8] is readily available, this is not the case for many other less common diseases, such as kidney failure. Without sufficient data, expert judgement from Life underwriters and medical doctors must be used to help determine the accuracy of the definitions available for public data and to assess the impact of additional conditions on CI incidence rates. This can be a flat loading applied on top of the main conditions rates.
- ***The condition definition in the population statistics may be different to the corresponding insured definition.*** The expertise of underwriters and medical doctors will again be needed

[6] Continuous Mortality Investigation, Critical Illness Committee, Working paper 43, February 2010.
[7] Total and permanent disability cover (TPD)
[8] e.g. the WHO CI5plus database, CDC, http://www.cancer.org, Globocan.

to assess the impact of this on the incidence rates,

- ***Important rating factors, including smoking status and socio-economic class, are typically not embedded.*** Actuaries will derive these from markets with more granular data, making adjustments for the specifics of the market in question.
- ***The format of the data is not ideal.*** The data is often less granular than the pricing actuary would ideally like and requires considerable processing before it can be used.
- ***Incidence rates change over time.*** It is important to allow for this so that the rates used at the time of pricing are appropriate. This is done by rolling the data forward to the time of pricing using trend assumptions.

If population incidence rates (rather than mortality rates) are available from hospital data, it is important to consider the following points:

- Are the rates (per individual) 'first occurrence only' or for 'all occurrences' of the same disease? Typically a policyholder is only covered for a CI condition if they have not been diagnosed with it before. If the population data covers all occurrences, the incidences should be adjusted to reflect this.
- The underlying lives will cover everyone in the population. However, only those who have not been diagnosed with the condition can be covered, so the number of lives must be reduced to reflect the prevalence of the condition in the population. Failure to do so would result in incidence rates that are too low.
- Population incidence rate data will also need to be adjusted for strongly correlated conditions. For example, Coronary Artery Bypass Graft will often follow a heart attack; two separate incidences would be reported, but the CI insurance would only pay out once. The U.K.'s Hospital Episodes Statistics (HES) Dataset previously enabled such analysis.

Further contract-related adjustments

The aforementioned adjustments will provide base critical illness incidence rates. The pricing actuary will then need to consider how to allow for a variety of other contract features, as and when included, such as waiting period, waiver of premium and TPD definition. These will typically vary by country and company.

As ever more features are added to CI, such as buy back, reinstatement of CI, multi-pay and partial payments, the actuary will need to develop approaches for pricing these additions.

It is also important to assess the impact of exclusions (typically HIV, self-inflicted injuries leading to a CI claim and alcohol and drug abuse) on public data or to compare the exclusions when using insured experience data.

And finally, adjusting for the future

CI is mainly a long-term product. Over the product's term (mortality and morbidity) incidence rates will evolve due to changes in multiple risk factors including medical advances, lifestyle and regulation, and this will need to be allowed for in the pricing. This is a particularly challenging area for pricing actuaries.

Medical advances

Developments in medical science will impact CI diagnosis and treatment, with many CI conditions being detected earlier and treated with more success and more routinely compared to the past, reducing the mortality rate of critical illnesses and preventing more severe critical illnesses from developing. This has a positive effect on mortality rates and severe CI rates. In contrast, where earlier detection meets a CI definition, incidence rates will increase over time.

It is recommended to consult with a medical specialist in order to assess the impact of medical progress on CI definitions and to consider 'time-proofed' definitions to keep pace with medical progress.

Lifestyle changes

Increasingly sedentary lifestyles, poor diet and reducing physical activity levels have been observed in many countries[9], increasing obesity rates and the risk factors for diseases such as heart disease and stroke. Although gradual over time and complex to predict, where such trends are identified, an estimated associated future deterioration in CI rates will need to be considered.

Government and health initiatives

Regulatory rulings, such as the introduction of national screening programs, are likely to cause sudden changes in incidence rates. Equally, other government health initiatives, such as Singapore's 'National Steps Challenge'[10], will impact lifestyle risk factors and therefore the incidence rates of conditions such as heart attack and stroke. These are complex to predict, but by working closely with governments, expected changes can be identified and allowed for.

Helping Life insurers to develop optimal CI pricing practices

With extensive international experience of CI risk assessment and pricing, PartnerRe's team of Life medical underwriters and pricing actuaries can help insurers in global markets to develop and/or strengthen their CI pricing procedures. We help our clients to identify optimal approaches specific to their market and to deal confidently with the many challenging pricing features discussed in this paper.

Please contact us to find out how we can help your business. For the contact details of our Life specialists by region, please go to www.partnerre.com/risk-solutions.

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[9] 'A Matter of Style', PartnerRe 2015.
[10] www.healthhub.sg/programmes/37/NSC