

# Introduction to life and long-term health insurance

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## 1.1 Summary

In this chapter we lay out the context for the mathematics of later chapters, by describing some of the background to modern actuarial practice, as it pertains to long-term, life contingent payments. We describe the major types of life insurance products that are sold in developed insurance markets, and discuss how these products have evolved over the recent past. We also consider long-term insurance that is dependent on the health status of the insured life, rather than simply survival or death. Finally, we describe some common pension designs.

We give examples of the actuarial questions arising from the risk management of these contracts. How to answer such questions, and solve the resulting problems, is the subject of the following chapters.

## 1.2 Background

The first actuaries were employed by life insurance companies in the early eighteenth century to provide a scientific basis for managing the companies' assets and liabilities. The liabilities depended on the number of deaths occurring amongst the insured lives each year. The modelling of mortality became a topic of both commercial and general scientific interest, and it attracted many significant scientists and mathematicians to actuarial problems, with the result that much of the early work in the field of probability was closely connected with the development of solutions to actuarial problems.

The earliest life insurance policies were annual contracts; the purchaser would pay an amount, called the **premium**, to the insurer, nominating an individual whose life was insured under the contract. The insured life might be the purchaser, but could also be a third party. If the insured life died during the year that the contract was in force, the insurer would pay a predetermined lump sum, the **sum insured**, to the policyholder or his or her estate. Each

year the premium would increase as the probability of death increased. If the insured life became very ill at the renewal date, the insurance might not be renewed, in which case no benefit would be paid on the insured life's subsequent death. Over a large number of contracts, the premium income each year should approximately match the claims outgo. This method of matching income and outgo annually, with no attempt to smooth or balance the premiums over the years, is called **assessmentism**. This method is still used for group life insurance, where an employer purchases life insurance cover for its employees on a year-to-year basis.

The radical development in the later eighteenth century was the level premium contract. The problem with assessmentism was that the annual increases in premiums discouraged policyholders from renewing their contracts. The level premium policy offered the policyholder the option to lock in a regular premium, payable perhaps weekly, monthly, or annually, which was fixed for the term of the contract. This was much more popular with policyholders, as they would not be priced out of the insurance contract just when it might be most needed. For the insurer, the attraction of the longer contract was a greater likelihood of the policyholder paying premiums for a longer period. However, a problem for the insurer was that the longer contracts were more complex to model, and offered more financial risk. For these contracts actuarial techniques had to develop beyond the year-to-year modelling of mortality probabilities. In particular, it became necessary to incorporate financial considerations into the modelling of income and outgo. Over a one-year contract, the time value of money is not a critical aspect. Over, say, a 30-year contract, it becomes a very important part of the modelling and management of risk.

Another development in life insurance in the nineteenth century was the concept of **insurable interest**. This was a requirement in law that the person contracting to pay the life insurance premiums should face a financial loss on the death of the insured life – an insurance payout should not leave the beneficiary financially better off than if the insured life had not died. The insurable interest requirement ended the practice where individuals would insure persons (often public figures) with no connection to the purchaser, as a form of gambling. It also, importantly, removed the incentive for a policyholder to hasten the death of the insured life. Subsequently, insurance policies tended to be purchased by the insured life, and in the rest of this book we use the convention that the policyholder who pays the premiums is also the life insured, whose survival or death triggers the payment of the sum insured under the conditions of the contract.

The earliest studies of mortality include life tables constructed by John Graunt and Edmund Halley. A life table summarizes a survival model by

specifying the proportion of lives that are expected to survive to each age. Using London mortality data from the early seventeenth century, Graunt proposed, for example, that each new life had a probability of 40% of surviving to age 16, and a probability of 1% of surviving to age 76. Edmund Halley, famous for his astronomical calculations, used mortality data from the city of Breslau in the late seventeenth century as the basis for his life table, which, like Graunt's, was constructed by proposing the average ('medium' in Halley's phrase) proportion of survivors to each age from an arbitrary number of births. Halley took the work two steps further. First, he used the table to draw inference about the conditional survival probabilities at intermediate ages. That is, given the probability that a newborn life survives to each subsequent age, it is possible to infer the probability that a life aged, say, 20, will survive to each subsequent age, using the condition that a life aged zero survives to age 20. The second major innovation was that Halley combined the mortality data with an assumption about interest rates to find the value of a whole life annuity at different ages. A whole life annuity is a contract paying a level sum at regular intervals while the named life (the annuitant) is still alive. The calculations in Halley's paper bear a remarkable similarity to some of the work still used by actuaries in pensions and life insurance.

This book continues in the tradition of combining models of mortality with models in finance to develop a framework for pricing and risk management of long-term policies in life and health insurance. Many of the same techniques are relevant also in pensions mathematics. However, there have been many changes since the first long-term policies of the late eighteenth century.

We usually use the term **insurance** to refer to a contract under which the benefit is paid as a single lump sum, either on the death of the policyholder or on survival to a predetermined **maturity date**. (In the UK it is common to use the term **assurance** for insurance contracts involving lives, and 'insurance' for contracts involving property.) An **annuity** is a benefit in the form of a regular series of payments, usually conditional on the survival of the policyholder.

## 1.3 Traditional life insurance contracts

### 1.3.1 Introduction

The three traditional forms of life insurance are term, whole life and endowment insurance. These policies dominated insurance markets until the 1980s, and in some countries are still popular today. However, the design of life insurance has broadened significantly in the past few decades. In this section we describe features of traditional life insurance policies. In the next section we review more modern developments.

### 1.3.2 Term insurance

Term (or temporary) insurance pays a lump sum benefit on the death of the policyholder, provided death occurs before the end of a specified term. Typical contract terms range from 10 to 30 years.

The premiums for term insurance are usually very small relative to the sum insured, because the insurer has to pay a death benefit on only a small proportion of the policies issued. If a policyholder who is aged 40 purchases 10-year term insurance, then the probability that the insurer will pay any death benefit on the policy (which is just the probability that the life dies before age 50) might be around 2%. So, around 98% of such policies will expire with no death benefit payable, and the premiums from these policies subsidize the benefits for the 2% for which the death benefit must be paid.

A term insurance policyholder may choose to lapse their policy, which means the policyholder would cease paying premiums. In this case, their insurance cover would also cease, and there would be no further payments by the policyholder or the insurer.

The main purpose of term insurance is for family protection. For a relatively low monthly cost, term insurance can protect the policyholder's spouse and children against financial hardship in the event of the policyholder's death.

Another use of term insurance is to protect businesses against losses arising from the deaths of key employees. In this case the business pays the premiums and receives the sum insured if the insured life dies during the term. The business must demonstrate insurable interest. This type of insurance used to be called **Key Person Insurance**, but is now more commonly called **COLI** for Company Owned Life Insurance.

Most term insurance policies offer a level sum insured, funded by level monthly or annual premiums. A variant is **decreasing term insurance** where the death benefit decreases over the term of the policy. Decreasing term insurance may be used in conjunction with a home loan; if the policyholder dies, the outstanding loan is paid from the term insurance proceeds, sparing the policyholder's family from the potential difficulty, expense and distress of struggling to make the loan payments after the policyholder's death. The death benefit under the policy can be set to match the outstanding loan on the home in each year of the contract.

**Renewable term insurance** offers the policyholder the option to renew the policy at the end of the original term, without further evidence of the policyholder's health status, up to a maximum age. For example, if the maximum age is 85, a policyholder purchasing a 20-year renewable term policy at age 45 would have the option to renew the policy at age 65 for another 20 years. The premium for the renewed contract would be greater than the original, because the probability of paying the death benefit increases, but

insurability is guaranteed, which means that renewal does not depend at all on the health status of the policyholder at that time. In **yearly renewable term insurance** each individual contract has just a one-year term.

**Convertible term insurance** offers the policyholder the option to convert to a whole life insurance at the end of the original term, or, for a renewable term policy, at the end of the first or second renewal. The premium would be recalculated for the new whole life policy, depending on the age at conversion. Conversion does not depend on or require evidence of the policyholder's health status at conversion, but there may be a maximum age at which conversion is permitted (typically, around age 75).

### 1.3.3 Whole life insurance

**Whole life, or permanent, insurance** pays a lump sum benefit on the death of the policyholder whenever it occurs. For regular premium contracts, the premium is often payable only up to some maximum age, typically 80–90 years old. The point of whole life insurance is that it should pay the death benefit whenever the policyholder dies, and it would not meet this objective if policies lapsed at older ages through non-payment of premiums, whether because of financial strain or through decreasing ability of the policyholder to manage their affairs in older age.

In general, whole life insurance will be significantly more expensive than term insurance, relative to the death benefit, as the probability of paying the death benefit (ignoring lapses) is 100%.

Traditionally, if a whole life policyholder decides to discontinue the policy after an initial period, they would be eligible for a **cash value** or **surrender value**, representing the investment part of the accumulated premiums. In the early years of a whole life policy, the cash values tend to be very low. In later years they may be substantial, though typically very much less than the sum insured. Recently it has become common in some countries to offer whole life policies with no cash value payable on surrender.

Life insurance works by combining premiums with the investment income (earned by investing the premiums), such that, by the time the policyholder dies, the premiums plus the investment income are sufficient, on average, to pay the sum insured. For short-term policies, premiums cover most of the sum insured. For long-term contracts the investment income becomes a much more significant component. The term of a whole life contract may be very long – a policy sold to a life aged 40 may still be in force over 50 years later – so the contribution of investment income is much more significant than for most term insurance. However, predicting investment returns over very long terms is very difficult, so insurers tend to calculate premiums using very conservative (that is, low side) assumptions about investment returns, resulting in relatively

high premiums. This means that most policyholders (the ones who do not die very early) earn quite low rates of return on their premiums, compared with, for example, simply paying the same amount into a mutual fund investment over the same period.

Suppose an insurer is pricing a whole life policy at a time when long-term interest rates of 7% per year are available, for a 20-year investment. The insurer may calculate the premium assuming 6% per year interest, allowing the difference of 1%, which is called the **interest spread**, to cover profit and allow a margin for adverse experience. The risk to the insurer is that interest rates could fall below 6% per year at some point during the contract, in which case the interest earned on investments made at that time would fall short of the amount required to pay the sum insured. On the other hand, if the insurer is more cautious, perhaps assuming only 3% per year interest, the investment part of the policy will look quite unattractive for the customer, compared with the 7% per year available from direct investment.

One solution to this problem is to charge the higher premium, but promise to pay back to the policyholder some share of the profits if the investments do well. If the investment experience is very poor, there will be no profits, and no profit-sharing. This is the principle behind **participating** insurance, where 'participating' refers to the policyholders' participation in the distribution of profits. Participating insurance is also called **par** insurance for short, and is more commonly called **with-profit** outside North America.

The policyholders' share of profits is called **dividends** in North America, and **bonuses** elsewhere. We use the term 'dividend' when the profit share is distributed in the form of cash (or cash equivalent, such as a reduction in premium), and 'bonus' when the profit share is distributed in the form of additional insurance. In fact, the form of distribution is an important design feature for participating insurance, with different jurisdictions favouring different distribution methods, with the following being the most common.

**Cash refunds** may be distributed at regular (e.g. annual) intervals, based on the profit emerging in the preceding year. This is common for North American participating insurance.

**Premium reductions** work very similarly to cash refunds. The profit allocated to the policyholder for the year may be used to reduce the premiums due in the period to the subsequent allocation date.

**Increased death benefits** are determined by using the emerging profit to increase the death benefit.

There are many variants of these methods. It is common in North America for policyholders to be given some choice about the distribution – for example,

offering a cash dividend as a standard benefit, but with options to convert to additional death benefit.

In the UK, profits were invariably distributed in the form of benefit increases. Bonuses would be awarded in two stages. **Reversionary bonuses** are applied to contracts in force, increasing the benefits by a specified percentage. There are three variations:

- *simple reversionary bonus* means the bonus rate is applied to the original sum insured only;
- *compound reversionary bonus* means the bonus rate is applied to the total of the sum insured and previous reversionary bonuses;
- *super-compound reversionary bonus* is a method with two bonus rates each year, the first applying to the original sum insured, and the second applying to the total of previous bonus declarations.

**Terminal bonuses** are used to top up the sum insured when the benefit is finally paid. Separating the profit share into reversionary and terminal bonuses allows insurers to take a more cautious attitude to distributing unrealized capital gains.

It is important to note that for all traditional participating whole life insurance, dividends and bonuses are never negative. Only profits are shared, not losses.

Profit distribution methods for participating insurance have an important impact on actuarial management, and on the techniques for pricing and marketing of policies. We note some of the more important considerations here.

- Cash dividends are attractive to policyholders; they are easy to understand, and offer flexibility. If a policyholder is in financial difficulty, the cash may enable the policyholder to maintain the policy longer, as it can be used to offset premiums. If the policyholder wants to increase their death cover, the cash bonus can be used to buy more insurance – but at greater cost, generally, than the reversionary bonus, as it constitutes a new policy and therefore incurs new policy expense charges.
- Cash dividends may be taxable. If the policyholder has no need for the cash, it is not likely to be a tax-efficient asset.
- Reversionary bonuses are more complex for policyholders to understand, but do offer a tax efficient distribution, that is also consistent with the purpose of the policy – to provide a death benefit over long terms.
- Insurers may offer a limited share of profits for policies that are surrendered. This can be particularly unfair when profit is distributed as reversionary bonus, as policyholders who contributed to the profits each year may only receive a small proportion of them on surrender. If profits are shared through

- cash dividends, then, at most, the policyholder would lose one-year's profit share on surrender.
- Cash dividends require the insurer to liquidate assets, which may not be in the best interests of maximizing return. Reversionary bonus means that profits remain under the insurer's management, and so provides more potential for future profit for the insurer.
- Generally, insurers prefer to offer smooth bonuses and dividends, that is, with little variation from year to year. This is generally easier with reversionary and terminal bonus, as the actual payment is delayed until the policy matures.
- Cash dividends are expensive to operate, if every policyholder is paid a dividend each year.

Traditional participating whole life insurance is still popular in North America, but is no longer widely available in the UK or Australia, though some non-participating whole life policies are still marketed. One reason for the relatively greater success of the product in North America is that insurers there offered larger and more predictable cash values, so that policyholders could achieve a reasonable return on their premiums, even if they surrendered the contract.

Whole life insurance may be used by policyholders in a number of ways, for example as follows.

- For older lives, simplified whole life insurance may be used to cover funeral expenses. These policies have a relatively low sum insured, tend to be non-participating, and do not offer any cash value on surrender.
- For older, higher-wealth lives, whole life insurance may be used to reduce inheritance taxes, if the proceeds from insurance are taxed at a lower marginal rate than directly inherited wealth.
- For younger lives, participating whole life insurance can provide a simple, passive long-term investment opportunity, with the advantage of substantial death benefit (compared with premiums) in the event of early death.

As mentioned above, for some policies, particularly those designed for older policyholders (for tax planning or funeral expenses), cash values may not be offered on surrender of the contract. This can reduce the premiums, as the excess funds from lapsed contracts subsidize the remaining policies. This is called **lapse-supported** insurance. However, if policyholders have the ability to sell their policies to a third party, then the lapsation profits may be very low. This has led to the rise of Stranger Owned Life Insurance, or **STOLI**, where an investment firm (usually specializing in this business) makes a cash payment to a policyholder who wants to surrender their policy. The investment firm

then takes over the payment of premiums as long as the original policyholder survives, and receives the sum insured on their death. If the value of the cash settlement to the original policyholder plus the cost of premiums after the sale of the policy is less than the value of the sum insured, then the investment firm makes a profit. If the original policyholder survives longer than expected, then the firm may make a loss. Often the policy is exchanged for a very deep discount on the sum insured, even for quite elderly policyholders, allowing the investment firm to make very significant profits on a large proportion of their policies.

### 1.3.4 Endowment insurance

Endowment insurance offers a lump sum benefit paid either on the death of the policyholder or at the end of a specified term, whichever occurs first. This is a hybrid of a term insurance and a fixed term investment. If the policyholder dies, the sum insured is paid, just as it would be under a term insurance; if the policyholder survives, the sum insured is paid at the end of the contract. Similarly to whole life insurance, the probability of a payout on an endowment insurance, ignoring lapses, is 100%. For similar reasons to the whole life case, endowment insurance typically offers cash values on early surrender, and may be issued in participating or non-participating forms.

Endowment insurance is no longer offered through mainstream insurers in North America or the UK. The main purpose of endowment insurance is as an investment, but the low returns offered and lack of flexibility meant that the contract could not compete with an increasing variety of pure investment options that became widely available in the latter part of the twentieth century. Traditional endowment insurance then evolved into modern insurance/investment hybrids such as the Universal Life or Unit Linked policies described later in this chapter.

It is interesting to note, however, that traditional endowment insurance policies are increasing in popularity in developing nations, notably for microinsurance, where the amounts involved are small. In this context endowment insurance policies may be used in conjunction with microfinance, to support small sum lending to individuals and small businesses who may not have access to traditional banking services.

### 1.3.5 Options and variations on traditional insurance

Insurance riders are optional benefits that a policyholder can select at the issue of a contract. In this section we describe some common riders and other variations associated with traditional insurance.

**Joint life insurance:** For term and whole life insurance, policies issued on 'joint lives' have premiums and benefits that depend on the survival of two people, typically spouses. The most common format is a first-to-die policy, where the death benefit is paid on the first death of the couple, provided (for term insurance) that the death occurs within the policy term.

Joint life policies are increasingly popular as households increasingly rely on the earnings of two partners, not just one.

**Multiple life insurance:** Similarly to joint life policies, multiple life term insurance policies offer a benefit payable on the first death, or on each death, within a specified group of individuals, provided death occurs within the term of the policy. This feature is commonly used to insure business partners.

**Guaranteed cash values:** As discussed above, whole life and endowment insurance policies usually offer cash values on surrender. The policyholder may be able to lock in guaranteed cash values by paying an additional premium. In some jurisdictions, guaranteed cash values are required by law.

**Policy loans:** For policies that offer cash values, policyholders may be able to borrow money from the insurer, using the cash value of the policy as collateral. A common use for this is to pay premiums when the policyholder cannot otherwise raise the necessary funds. When the policy with an outstanding policy loan attached becomes a claim (or is surrendered), the sum insured (or cash value) is reduced by the amount of the outstanding loan and interest.

Allowing policy loans increases the chance that the policyholder will continue with the policy, rather than surrender. Since, in most cases, continuing with the policy offers a better opportunity for the insurer to make profits, it is to the insurer's advantage to facilitate policy loans. Consequently, the interest rates charged on policy loans may be quite low, relative to market rates.

**Accelerated benefits due to terminal illness:** Under this rider, the death benefit will be paid early if the policyholder can provide medical documentation that they are suffering from a terminal illness, and are not expected to live more than one year.

The early payment of benefit on terminal illness is called an **accelerated death benefit**. For the insurer, paying the claim slightly early reduces the incentive for the policyholder to sell the policy on to a third party, in a special kind of end-of-life STOLI called a **viatical settlement**.

**Accidental death benefit:** For a small additional premium, policyholders can choose to have an increased sum insured payable if the cause of death is accidental, rather than through natural causes. Surprisingly, this concept provided the inspiration for the Hollywood feature film *Double Indemnity*, which was released in 1944.

**Premium waiver on disability:** This policy rider allows policyholders to suspend paying premiums during periods of severe illness or disability. The premium waiver would require medical evidence, and would be limited to premiums due during the policyholder's normal working lifetime, typically up to age 65.

**Family income benefit (FIB):** One of the purposes of term insurance is to provide funds to bridge the policyholder's family through the financial strain following his or her death. The FIB rider offers a specified amount to be paid at regular intervals between the policyholder's death and the end of the original contract term. For example, consider a policyholder who takes out a 20-year term insurance, with an FIB rider with benefit \$10 000 per year. Now suppose the policyholder dies 15 years into the policy term. Then, in addition to the regular term insurance death benefit, the FIB would pay the policyholder's family \$10 000 per year for the remaining five years of the original contract.

**Critical illness insurance:** A benefit is paid on diagnosis of one of a specified set of critical illnesses or disabilities, typically including most cancers, stroke and heart disease. Critical illness cover is discussed in more detail in Section 1.7.

## 1.4 Modern insurance contracts

### 1.4.1 Why innovate?

Compared with traditional policies, modern insurance is more complex, apparently more transparent in terms of costs and benefits, with flexibility in premiums and variability in benefits. We explain some reasons below.

1. **Competition with mutual funds and banks for policyholders' savings**  
Insurers developed combined insurance/investment hybrid products to attract savings away from other investment options such as mutual funds. This gives insurers more assets under management, and more chance to generate profits for their shareholders.
2. **Changing demographics and lifecycles impact insurance design**  
Nowadays, many jobs are more short term; as policyholders move in and out of work, insurance needs to offer increased flexibility, to meet policyholders' needs in both good times and bad.

### 3. Developments in science and technology

The science of financial risk management has developed significantly in the past 30 years, offering insurers the possibility of designing valuable guarantees that can be safely risk managed. Also, more powerful computational facilities allow more complex modelling and prediction.

### 4. Better informed customers

Potential policyholders are better informed about how products work, as financial advice has become more reliable (though there are still very many examples of bad financial advice), and is more freely available, through newspapers, or through social media. This has reduced (but, unfortunately, not eliminated) the creation of insurance products that are very profitable for the insurers and the sales intermediaries, but were not really suitable for the individuals persuaded to purchase them.

#### 1.4.2 Universal life insurance

Universal life insurance is a very important product, particularly in North America. It is generally issued as a whole life contract, but with transparent cash values, so that policyholders can view the policy as a form of savings account with built-in life insurance, rather than a whole life contract. Given that most policyholders will surrender their policies for a significant cash value, perhaps when they retire, the Universal Life contract can be seen as an updated and more flexible version of traditional endowment insurance.

Policyholders choose a level of death benefit, which may be fixed, or may increase as the invested premiums earn interest. Premiums are deposited into a notional account (notional, as the assets are not actually separate from the general funds of the insurer). The insurer shares investment profits through the **credited interest rate** which is declared and applied by the insurer at regular intervals, typically monthly, and which reflects (perhaps indirectly) the investment performance of the underlying assets. The credited interest rate cannot be less than 0%, so the account cannot lose value. In some cases, there may be a guaranteed minimum rate which is greater than 0%. Unlike traditional insurance, which uses fixed premiums, Universal Life premiums are quite flexible. Provided there are sufficient funds in the policyholder's account to cover costs, the policyholder may reduce or even skip paying premiums for a period.

The notional account, made up of the premiums and credited interest, is subject to monthly deductions; there is a charge for the cost of life insurance cover, and a separate charge to cover expenses. The **account balance** or **account value** is the balance of funds in the policyholder's account. The account value represents the cash value for a surrendering policyholder, after an initial period (typically 7–10 years) during which surrender charges are applied to ensure recovery of the costs incurred by the insurer in issuing the policy.

#### 1.4.3 Unitized with-profit

Unitized with-profit (UWP) is an evolution of traditional with-profit insurance which was popular for a time in the UK and Australia. It is similar to Universal Life insurance, except that in place of account values, policyholders' funds are expressed in terms of *units*, which are shares in a notional asset portfolio. The units increase in value, through the performance of the underlying investments. Bonuses may be awarded by adding additional units to the account. On death or maturity an additional terminal bonus may be added. On surrender, policyholders receive the cash value of their units, with a surrender penalty applied in the early period of the policy.

After some poor publicity surrounding with-profit business and, by association, unitized with-profit business, these product designs were largely withdrawn from the UK and Australian markets in the early 2000s. However, they will remain important for many years as many companies carry large portfolios of UWP policies issued during the 1980s and 1990s.

#### 1.4.4 Equity-linked insurance

Equity-linked life insurance has an endowment insurance structure, with a fixed term, and with benefits paid on the earlier of the policyholder's death and the end of the contract term. Policyholders, who surrender their contracts before the end of the term will generally receive a cash surrender value at that time. The death, surrender and maturity benefits are linked to the performance of a specified investment fund.

So far this sounds similar to the unitized with-profit policy, but there are two important differences.

- For equity-linked insurance, the fund that determines the return on invested premiums is a real fund, not a notional collection of assets within the insurer's general account, as for the UWP contract.
- Equity-linked insurance benefits may increase or decrease over time, in line with the underlying fund. The UWP and Universal Life benefits will only increase (or stay the same); they cannot decrease.

There are several different varieties of equity-linked insurance, but they operate in similar ways.

1. The policyholder's premiums are invested in an open-ended, mutual fund style account.
2. On death before the maturity date, the death benefit will be at least the value of the accumulated premiums; often there will be a Guaranteed Minimum Death Benefit, or GMDDB, that will increase the payout if the underlying investments have performed poorly over the term of a contract.

3. On early surrender, the policyholder receives the value of the accumulated premiums, with a surrender penalty deducted at early durations.
4. On survival to the end of the contract, the policyholder receives at least the value of their accumulated premiums, possibly more if the policy offers a Guaranteed Minimum Maturity Benefit, or GMMB.

**Unit-linked insurance** is a form of equity-linked insurance sold outside North America. Like the UWP policies, policyholders' funds are expressed in units (or shares) of the underlying assets. Unit-linked policies generally do not offer a GMMB. The death benefit is often a multiple of the value of the policyholder's units at the time of death.

**Variable annuities**, also known as **segregated funds**, are equity-linked insurance policies sold in North America, which are becoming increasingly popular in other areas. Despite the name, the benefit under a Variable Annuity is a lump sum, not an annuity, although the policies carry the option to convert the proceeds to an annuity at maturity. A Variable Annuity policy will offer a GMDB and a GMMB, with additional guarantees available at additional cost.

## 1.5 Marketing, pricing and issuing life insurance

### 1.5.1 Insurance distribution methods

Most people find insurance dauntingly complex. Brokers who connect individuals to an appropriate insurance product have, since the earliest times, played an important role in the market. There is an old saying amongst actuaries that '*insurance is sold, not bought*', which means that the role of an intermediary in persuading potential policyholders to take out an insurance policy is crucial in maintaining an adequate volume of new business. Brokers and other financial advisors are often remunerated through a **commission system**. The commission would be specified as a percentage of the premium paid. Typically, there is a higher percentage paid on the first premium than on subsequent premiums. This is referred to as a **front-end load**. Some advisors may be remunerated on a fixed fee basis, or may be employed by one or more insurance companies on a salary basis. Face-to-face insurance sales focus on higher-wealth individuals who are already connected with financial advisors. For other customers, banks may act as intermediaries, but the rising trend is for **direct marketing**. This covers insurance sold through television advertising, but the more recent developments involve online sales.

The nature of the business sold by direct marketing methods tends to differ from the broker-sold business, as the target audience is likely to be less wealthy. Television advertising is used, for example, for **pre-need** insurance,

which is aimed at older lives and covers funeral costs. Term insurance is a relatively straightforward contract, and as long as the sum insured is not too high, is highly suited to online marketing and issue.

### 1.5.2 Underwriting

It is important in modelling life insurance liabilities to consider what happens when a life insurance policy is purchased. Selling life insurance policies is a competitive business and life insurance companies are constantly considering ways in which to change their procedures so that they can improve the service to their customers and gain a commercial advantage over their competitors. The account given below of how policies are sold covers some essential points but is necessarily a simplified version of what actually happens.

For a given type of policy, such as a 10-year term insurance, the insurer will have a schedule of premium rates. These rates will depend on the size of the policy and some other factors known as **rating factors**. An applicant's risk level is assessed by asking them to complete a **proposal form** giving information on relevant rating factors, generally including their age, gender (where legislation permits), smoking habits, occupation, any dangerous hobbies, and personal and family health history. The insurer may ask for permission to contact the applicant's doctor to enquire about their medical history. In some cases, particularly for very large sums insured, the life insurer may require that the applicant's health be checked by a doctor employed by the insurer.

The process of collecting and evaluating this information is called **underwriting**. The purpose of underwriting is, first, to classify potential policyholders into broadly homogeneous risk categories, and secondly to assess what additional premium would be appropriate for applicants whose risk factors indicate that standard premium rates would be too low.

On the basis of the application and supporting medical information, potential life insurance policyholders will generally be categorized into one of the following groups.

- **Preferred lives** have very low mortality risk based on the standard information. The preferred applicant would have no recent record of smoking; no evidence of drug or alcohol abuse; no high-risk hobbies or occupations; no family history of disease known to have a strong genetic component; no adverse medical indicators such as high blood pressure or cholesterol level or body mass index.

The preferred life category is commonly used in North America, but has not yet caught on elsewhere. In other areas there is no separation of preferred and normal lives.

- **Normal lives** may have some higher-rated risk factors than preferred lives (where this category exists), but are still insurable at standard rates. Most applicants fall into this category.
- **Rated lives** have one or more risk factors at raised levels and so are not acceptable at standard premium rates. However, they can be insured for a higher premium. An example might be someone having a family history of heart disease. These lives might be individually assessed for the appropriate additional premium to be charged. This category would also include lives with hazardous jobs or hobbies which put them at increased risk.
- **Uninsurable lives** have such significant risk that the insurer will not enter an insurance contract at any price.

Within the first three groups, applicants would be further categorized according to the relative values of the various risk factors, with the most fundamental being age, gender and smoking status. Note, however, that gender-based premiums are no longer permitted in some jurisdictions, including the European Union countries.

Most applicants (around 95% for traditional life insurance) will be accepted at preferred or standard rates for the relevant risk category. Another 2%–3% may be accepted at non-standard rates because of an impairment, or a dangerous occupation, leaving around 2%–3% who will be refused insurance.

The rigour of the underwriting process will depend on the type of insurance being purchased, on the sum insured and on the distribution process of the insurance company. Term insurance, particularly if the sum insured is very large, is generally more strictly underwritten than whole life insurance, as the risk taken by the insurer is greater. If the underwriting is not strict there is a risk of **adverse selection** by policyholders. Adverse selection (also called anti-selection) in insurance arises when policyholders use information about their own individual risk profile to make choices that will benefit them, with a potential adverse outcome for the insurer. So, we would expect very high-risk individuals to apply for insurance with larger death benefits than low-risk individuals. Since the risk to the insurer rises with the sum insured, applications involving very large sums insured would generally trigger more rigorous underwriting to counter the adverse selection risk.

The distribution method also affects the level of underwriting. Often, direct marketed contracts are sold with relatively low benefit levels, and with the attraction that no medical evidence will be sought beyond a standard questionnaire. The insurer may assume relatively heavy mortality for these lives to compensate for potential adverse selection. By keeping the underwriting relatively light, the expenses of writing new business, termed **acquisition expenses**, can be kept low, which is an attraction for high-volume, low-sum-insured contracts.

It is interesting to note that with no third party medical evidence the insurer is placing a lot of weight on the veracity of the policyholder. Insurers have a phrase for this, – that both insurer and policyholder may assume ‘utmost good faith’ or ‘*uberrima fides*’ on the part of the other side of the contract. In practice, in the event of the death of the insured life, the insurer may investigate whether any pertinent information was withheld from the application. If it appears that the policyholder held back information, or submitted false or misleading information, the insurer may not pay the full sum insured.

### 1.5.3 Premiums

A life insurance policy may involve a single premium, payable at the outset of the contract, or a regular series of premiums payable provided the policyholder survives, perhaps with a fixed end date. In traditional contracts the regular premium is generally a level amount throughout the term of the contract; in more modern contracts the premium might be variable, at the policyholder’s discretion for investment products such as equity-linked insurance, or at the insurer’s discretion for certain types of renewable term insurance.

Regular premiums may be paid annually, semi-annually, quarterly, monthly or weekly. Monthly premiums are common as it is convenient for policyholders to have their outgoings payable with approximately the same frequency as their income.

An important feature of all premiums is that they are paid at the start of each period. Suppose a policyholder contracts to pay annual premiums for a 10-year insurance contract. The premiums will be paid at the start of the contract, and then at the start of each subsequent year provided the policyholder is alive. So, if we count time in years from  $t = 0$  at the start of the contract, the first premium is paid at  $t = 0$ , the second is paid at  $t = 1$ , and so on, to the tenth premium paid at  $t = 9$ . Similarly, if the premiums are monthly, then the first monthly instalment will be paid at  $t = 0$ , and the final premium will be paid at the start of the final month at  $t = 9\frac{11}{12}$  years. (Throughout this book we assume that all months are equal in length, at  $\frac{1}{12}$  years.)

### 1.6 Life annuities

Annuity contracts offer a regular series of payments. When an annuity depends on the survival of the recipient, it is called a ‘life annuity’. The recipient is called an annuitant. If the annuity continues until the death of the annuitant, it is called a **whole life annuity**. If the annuity is paid for some maximum period, provided the annuitant survives that period, it is called a **term life annuity**.

Annuities are often purchased by older lives to provide income in retirement. Buying a whole life annuity guarantees that the income will not run out before the annuitant dies.

Annuities cannot be surrendered; there is no cash value once the annuity payments commence. The main reason is that allowing surrenders would create unmanageable risk of adverse selection – the lives who are most unwell are most likely to surrender. Annuity pricing assumes that on the annuitant's death, any excess funds built up from investing the premiums are then used to offset the costs of annuities for surviving annuitants.

Types of annuities that may be issued include the following.

- **Single Premium Deferred Annuity (SPDA):** Under an SPDA contract, the policyholder pays a single premium in return for an annuity which commences payment at some future, specified date. The annuity is 'life contingent', by which we mean the annuity is paid only if the policyholder survives to the payment dates. If the policyholder dies before the annuity commences, there may be a death benefit due. If the policyholder dies soon after the annuity commences, there may be some minimum payment period, called the guarantee period, and the balance would be paid to the policyholder's estate.
- **Single Premium Immediate Annuity (SPIA):** This contract is the same as the SPDA, except that the annuity commences as soon as the contract is effected. This might, for example, be used to convert a lump sum retirement benefit into a life annuity to supplement a pension. As with the SPDA, there may be a guarantee period applying in the event of the early death of the annuitant.
- **Regular Premium Deferred Annuity (RPDA):** The RPDA offers a deferred life annuity with premiums paid through the deferred period. It is otherwise the same as the SPDA.
- **Joint life annuity:** A joint life annuity is issued on two lives, typically a couple (that is, married or cohabiting). The annuity, which may be single premium or regular premium, immediate or deferred, continues while both lives survive, and ceases on the first death of the couple.
- **Last survivor annuity:** A last survivor annuity is similar to the joint life annuity, except that payment continues while at least one of the lives survives, and ceases on the second death of the couple.
- **Reversionary annuity:** A reversionary annuity is contingent on two lives, usually a couple. One is designated as the annuitant, and one the insured. No annuity benefit is paid while the insured life survives. On the death of the insured life, if the annuitant is still alive, the annuitant receives an annuity for the remainder of their life.
- **Guaranteed annuity:** A guaranteed annuity is paid for a minimum period, regardless of the survival or death of the annuitant. After the guarantee period, if the annuitant is still alive, the annuity is paid for the remainder of their lifetime.

Annuity sales methods are similar to life insurance, with individual brokers playing an important role for higher-wealth individuals. In addition, as annuities are often used to convert retirement savings into retirement income, pension plan managers may work with retirees on annuity purchase.

There is no underwriting for regular annuities. The risk to the insurer (or annuity provider) is that the annuitant lives longer than expected; it is not considered feasible to seek health evidence that potential annuitants are too long-lived.

## 1.7 Long-term coverages in health insurance

### 1.7.1 Disability income insurance

Disability income insurance, also known as income protection insurance, is designed to replace income for individuals who cannot work, or cannot work to full capacity due to sickness or disability. Typically, level premiums are payable at regular intervals through the term of the policy, but are suspended during periods of disability. Benefits are paid at regular intervals during periods of disability. The benefits are usually related to the policyholder's salary, but, to encourage the policyholder to return to work as soon as possible, the payments are often capped at 50–70% of the salary that is being replaced. The policy could continue until the insured person reaches retirement age.

Common features or options of disability income insurance include the following.

- The **waiting period** or **elimination period** is the time between the beginning of a period of disability and the beginning of the benefit payments. Policyholders select a waiting period from a list offered by the insurer, with typical periods being 30, 60, 180 or 365 days.
- The payment of benefits based on **total disability** requires the policyholder to be unable to work at their usual job, and to be not working at a different job. Medical evidence of the disability is also required by the insurer at intervals.
- If the policyholder can do some work, but not at the full earning capacity established before the period of disability, they may be eligible for a lower benefit based on **partial disability**.
- The amount of disability benefits payable may be reduced if the policyholder receives disability-related income from other sources, for example from workers' compensation or from a government benefit programme.
- The benefit payment term is selected by the policyholder from a list of options. Typical terms are two years, five years, or up to age 65. Once the disability benefit comes into payment, it will continue to the earlier of the recovery of the policyholder to full health, or the end of the selected benefit

term, or the death of the policyholder. If the policyholder moves from full disability to partial disability, then the benefit payments may be decreased, but the total term of benefit payment (covering the full and partial benefit periods) could be fixed.

For shorter benefit payment terms, the policy covers each separate period of disability, so even if the full benefit term of, say, two years has expired, if the policyholder later becomes disabled again, provided sufficient time has elapsed between periods of disability, the benefits would be payable again for another period of two years.

- When two periods of disability occur with only a short interval between them, they may be treated as a single period of disability for determining the benefit payment term. The **off period** determines the required interval for two periods of disability to be considered separately rather than together, and it is set by the insurer.

For example, suppose a policyholder purchases disability income insurance with a two-year benefit term, monthly benefit payments and a two-month waiting period. The insurer sets the off period at six months. The policyholder becomes sick on 1 January 2017, and remains sick until 30 June 2017. She returns to work but suffers a recurrence of the sickness on 1 September 2017.

The first benefit payment would be made at the end of the elimination period, on 1 March 2017, and would continue through to 30 June. Since the recurrence occurs within the six-month off period, the second period of sickness would be treated as a continuation of the first. That means that the policyholder would not have to wait another two months to receive the next payment, and it also means that on 1 September, four months of the 24-month benefit term would have expired, and the benefits would continue for another 20 months, or until earlier recovery.

- **Own job or any job:** the definition of total disability may be based on the policyholder's inability to perform their own job, or on their ability to perform any job that is reasonable given the policyholder's qualifications and experience. A policy that pays benefits only if the policyholder is unable to perform any job requires the policyholder to be very ill before any payments are made. On the other hand, the policy that pays out when the policyholder is unable to do her/his own job, even if they can undertake paid work that is less demanding than their own job, will pay out more often, and will therefore be more costly.
- Disability income insurance may be purchased as a group insurance by an employer, to offset the costs of paying long-term disability benefits to the employees. Group insurance rates (assuming employees cannot opt out) may be lower than the equivalent rates for individuals, because the group policies

carry less risk from adverse selection. There are also economies of scale, and less risk of non-payment of premiums from group policies.

- Long-term disability benefits may be increased in line with inflation.
- Policies often include additional benefits such as **return to work assistance**, which offsets costs associated with returning to work after a period of disability; for example, the policyholder may need some re-training, or it may be appropriate for the policyholder to phase their return to work by working part-time initially. It is in the insurer's interests to ensure that the return to work is as smooth and as successful as possible for the policyholder.

### 1.7.2 Long-term care insurance

In a typical North American long-term care (LTC) contract, premiums are paid regularly while the policyholder is well. When the policyholder requires care, based on the benefit triggers defined in the policy, there is a **waiting period**, similar to the elimination period for disability income insurance; 90 days is typical. After this, the policy will pay benefits as long as the need for care continues, or until the end of the selected benefit payment period.

Common features or options associated with LTC insurance in the USA and Canada include the following.

- The trigger for the payment of benefits is usually described in terms of the Activities of Daily Living, or ADLs. There are six ADLs in common use:
  - Bathing
  - Dressing
  - Eating (does not include cooking)
  - Toileting (ability to use the toilet and manage personal hygiene)
  - Continence (ability to control bladder and bowel functions)
  - Transferring (getting in and out of a bed or chair)
- If the policyholder requires assistance to perform two or more of the ADLs, based on certification by a medical practitioner, then the LTC benefit is triggered, and the waiting period, if any, commences.
- There is often an alternative trigger based on severe cognitive impairment of the policyholder.
- Although the most common policy design uses two ADLs for the benefit trigger, some policies use three.
- At issue, the policyholder may select a definite term benefit period (typical options are between two years and five years), or may select an indefinite period, under which benefit payments continue as long as the trigger conditions apply.
- The benefit payments may be based on a reimbursement approach, under which the benefits are paid directly to the caregiving organization, and

- cover the cost of providing appropriate care, up to a daily or monthly limit. Alternatively, the benefit may be based on a fixed annuity payable during the benefit period. The policyholder may have the flexibility to apply the benefit to whatever form of care is most suitable, but there is no guarantee that the annuity would be sufficient for the level of care required.
- The insurer may offer the option to have the payments, or payment limits, increase with inflation.
- Similarly to disability income insurance, an off period, typically six months, is used to determine whether two successive periods of care are treated separately or as a single continuous period.
- Hybrid LTC and life insurance policies are becoming popular. There are different ways to combine the benefits.
  - Under the **return of premium** approach, if the benefits paid under the LTC insurance are less than the total of the premiums paid, the balance is returned as part of the death benefit under the life insurance policy.
  - Under the **accelerated benefit** approach, the sum insured under the life insurance policy is used to pay LTC benefits. If the policyholder dies before the full sum insured has been paid in LTC benefits, the balance is paid as a death benefit.
  - The policyholder may add an **extension of benefits** option to the hybrid insurance, which would provide for continuation of the LTC benefits for a pre-determined period after the original sum insured has been exhausted. Typically, extension periods offered are in the range of two to five years.
- Premiums are designed to be level throughout the policy term, but insurers may retain the right to increase premiums for all policyholders if the experience is sufficiently adverse. Generally, insurers must obtain approval from the regulating body for such rate increases. In this circumstance, policyholders may be given the option to maintain the same premiums for a lower benefit level.

LTC insurance in other countries is generally similar to the North American design, with some variation that we describe briefly here.

Policies in France, where LTC insurance is very popular, are simpler and cheaper than in the USA; with average premiums of around 25% of those in the USA. Benefits are paid as a fixed or inflation-indexed annuity. The policyholder may choose a policy based on 'mild or severe dependency' or one based on 'severe dependency' only, which is the cheaper and more popular option. Severe dependency is defined as *bed- or chair-bound, requiring assistance several times a day or cognitive impairment requiring constant monitoring*. Mild dependency refers to cases where the individual needs help with eating, bathing and/or some mobility, but is not bed- or chair-bound.

Reasons for the lower premiums, relative to the North American model, include (i) lower average benefits; (ii) lower risk of payment, as the 'severe dependency' requirement is more stringent than the US ADL requirements; (iii) policies are often purchased through group plans facilitated by employers, reducing the expenses; and (iv) individuals in France tend to purchase their policies at younger ages than in the USA.

In Germany, basic LTC costs are covered under the government-provided social health insurance. Individuals can top up the government benefit with private LTC insurance, or can opt out of the state benefit (and thereby opt out of the tax supporting the benefit) and use LTC insurance instead. The benefits are fixed annuities.

In Japan, LTC insurance is offered on a stand-alone basis or as a rider on a whole life policy. The benefit is triggered when the policyholder reaches a specified level of dependency, and additional benefits may be added when the level of dependency increases.

In the UK, regular premium LTC policies are no longer offered, as they never reached the necessary level of popularity for the business to be sustained. In their place is a different kind of pre-funding, called an **immediate needs annuity**. This is a single premium immediate annuity that is purchased as the individual is about to move permanently into residential long-term care. The benefit is paid as a regular fixed annuity, but is paid directly to the care home, saving the policyholder from having to pay income tax on the proceeds. Because the lives are assumed to be somewhat impaired, and the insurer's exposure to adverse selection with respect to longevity is reduced, the benefit amount per unit of single premium may be significantly greater than a regular single premium life annuity at the same age.

### 1.7.3 Critical illness insurance

Critical illness insurance pays a lump sum benefit on diagnosis of one of a list of specified diseases and conditions. Different policies and insurers may cover slightly different illnesses, but virtually all include heart attack, stroke, major organ failure and most forms of cancer. Policies may be whole life or for a definite term. Unlike disability income insurance or LTC insurance, once the claim arises, the benefit is paid and the policy expires. A second critical illness diagnosis would not be covered. Some policies offer a partial return of premium if the policy expires or lapses without a critical illness diagnosis.

Level premiums are typically paid monthly throughout the term, though they may cease at, say, 75 for a long-term policy.

Critical illness cover may be added to a life insurance policy as an **accelerated benefit rider**. In this case, the critical illness diagnosis triggers the payment of some or all of the death benefit under the life insurance. Where

the full benefit is accelerated, the policy expires on the critical illness diagnosis. If only part of the benefit is accelerated, then the remainder is paid out when the policyholder dies.

#### 1.7.4 Chronic illness insurance

Chronic illness insurance pays a benefit on diagnosis of a chronic illness, defined as one from which the policyholder will not recover, although the illness does not necessarily need to be terminal. The illness must be sufficiently severe that the policyholder is no longer able to perform two or more of the ADLs listed in the LTC insurance section. The benefit under a chronic illness policy is paid as a lump sum or as an annuity.

Chronic illness insurance is typically added to a standard life insurance policy as an accelerated benefit rider, similar to the critical illness case.

### 1.8 Mutual and proprietary insurers

A **mutual** insurance company is one that has no shareholders. The insurer is owned by the with-profit policyholders. All profits are distributed to the with-profit policyholders through dividends or bonuses.

A **proprietary** insurance company has shareholders, and usually has with-profit policyholders as well. The participating policyholders are not owners, but have a specified right to some of the profits. Thus, in a proprietary insurer, the profits must be shared in some predetermined proportion between the shareholders and the with-profit policyholders.

Many early life insurance companies were formed as mutual companies. More recently, in the UK, Canada and the USA, there has been a trend towards demutualization, which means the transition of a mutual company to a proprietary company, through issuing shares (or cash) to the with-profit policyholders. Although it would appear that a mutual insurer would have marketing advantages, as participating policyholders receive all the profits and other benefits of ownership, the advantages cited by companies who have demutualized include increased ability to raise capital, clearer corporate structure and improved efficiency.

### 1.9 Other life contingent contracts

In the following sections we discuss benefit and payment streams which, like the life and health insurance premiums and benefits described above, are life contingent, and are subject to actuarial valuation and risk management, but which are not insurance contracts.

#### 1.9.1 Continuing care retirement communities

Continuing care retirement communities (CCRCs) are residential facilities for seniors, with different levels of medical and personal support designed to adapt to the residents as they age. Many CCRCs offer funding packages where the costs of future care are covered by a combination of an entry fee and a monthly charge. The description below, and examples used in subsequent chapters of this book, follow the US industry standard definitions and systems.

There are generally three or four of the following categories of residence in a CCRC.

**Independent living units (ILUs)** represent the first stage of residence in a CCRC. These are apartments with fairly minimal external care provided (for example, housekeeping, emergency call buttons, transport to shopping).

**Assisted living units (ALUs)** allow more individual support for residents who need help with at least one, and commonly several, of the activities of daily living. Most of the support at this level is non-medical – help with bathing, dressing, preparation of meals, etc.

The **skilled nursing facility (SNF)** is for residents who need ongoing medical care. The SNF often looks more like a hospital facility.

**Memory care units (MCU)** offer a separate, more secure facility for residents with severe dementia or other cognitive impairment.

The industry has developed different forms of funding for CCRCs. Not every CCRC will offer all funding options, and some will offer variants that are not described here, but these are the major forms in current use.

- Residents can choose to pay a large upfront fee, and monthly payments which are level, or which are only increasing with cost of living adjustments. The resident is guaranteed that all residential, personal assistance and health care needs will be covered without further cost. This is called a **full life care contract**, or **life care contract**.
- Under a **modified life care contract**, residents pay lower monthly fees, and possibly a lower entry fee, but will have to pay additional costs for some services if they need them. For example, residents may be charged a higher monthly fee as they move into the ALU, with further increases on entry to the SNF or the MCU. Typically, the increases would be less than the full market cost of the additional care, meaning that the costs are partially pre-funded through the entry fee and regular monthly payments.
- **Fee-for-service contracts** involve little or no pre-funding of health care. Residents pay for the health care they receive at the current market rates.

- Fee-for-service contracts have the lowest entry fee and monthly payments, as these only cover the accommodation costs.
- Prospective residents entering under full life care or modified life care must be sufficiently well to live independently when they enter the CCRC, and a medical examination is generally required. Entrants who are already sufficiently disabled to need more care are eligible only for fee-for-service contracts.
- Under full or modified life care contracts, the CCRC may offer a partial refund of the entry fee on the resident's death or when the resident moves out. This may involve some options, for example, the resident can choose a higher entry fee with a partial refund, or a lower entry fee with no refund.
- There are some CCRCs that offer (partial) ownership of the ILU, in place of some or all of the entry fee. When the resident moves out of independent living permanently, or dies, the unit is sold, with the proceeds shared between the resident (or her estate) and the CCRC.
- It is common for couples to purchase CCRC membership jointly, and different payment schedules may be applied to couples in comparison with schedules for single residents entering the CCRC.

The average age at entry to a CCRC in the USA is around 80, with full life care entrants generally being younger than modified life care entrants, who are younger than fee-for-service entrants, on average.

The full life care and (to a lesser extent) modified life care contracts transfer the risk of increasing health care costs from the resident to the CCRC, and therefore are a form of insurance.

### 1.9.2 Structured settlements

When a person is injured because of a negligent or criminal act committed by another person, or by an institution, legal processes will determine a suitable amount of compensation paid to the injured party (IP) by the person or institution who caused the injury (the responsible person, RP). Often cases are solved outside of the formal court system, but, if the issue is settled through a court case, the IP might be referred to as the plaintiff, and the RP as the defendant.

The compensation may be paid as a lump sum, but in some jurisdictions it is more common for the payment to be paid as an annuity, or as a combination of a lump sum and an annuity. If the injury is very serious, such as paralysis, loss of limbs, or permanent brain damage, the settlement will be a whole life annuity. Less severe injuries may be compensated with a term life annuity, extending to the point where the individual is expected to be recovered. Annuity payments may increase from time to time to offset the effects of inflation. The reason for using an annuity format rather than a lump sum

is that the annuity better replicates the losses of the IP, in the form of lost wages and/or ongoing expenses associated with medical care or additional needs arising from the injury. Rehabilitation costs and any expenses associated with re-training for the workplace would also be covered through the settlement.

A **structured settlement** is the payment schedule agreed between the IP and the RP, usually through their lawyers, or through an insurer when the RP's liability is covered by an insurance policy. The annuity part may be funded with a single premium immediate annuity purchased from an insurer or from a firm that specializes in structured settlements.

Structured settlements are often used for payments under **workers' compensation** insurance. Workers' compensation (also known as Workers' Comp, or Employer's Liability) is a type of insurance purchased by employers to fund the costs of compensating employees who are injured at work. Structured settlements are also commonly used in medical malpractice cases, and for other personal injury claims, such as from motor vehicle accidents.

Replacement of income will normally be at less than 100% of pre-injury earnings, and there are several reasons for this.

- In some countries (including the USA and the UK) income from a structured settlement annuity is not taxed. Hence, less annuity is required to support the IP's pre-injury lifestyle.
- The insurer wants to ensure that the IP has a strong incentive to return to work.
- The amount of compensation may be reduced if the IP is determined to be partially at fault in the incident.

The annuity will typically include some allowance for inflation. This may be a fixed annual increase, or the annuity may be fully indexed to inflation.

In cases of potentially severe injury, there is often a period of uncertainty as to the extent of damage and long-term prognosis for the IP. For example, it may take a year of treatment and rehabilitation to determine the level of permanent damage from a spinal cord injury. In such cases there may be an interim arrangement of benefit until the time of **maximum medical improvement**, at which point the final structured settlement will be determined.

Structured settlements evolved from a system where the entire compensation was in a lump sum form, but paying compensation as a lump sum requires the IP to manage a potentially very large amount of money. There is a strong temptation for the IP to overspend; research indicates that 80%–90% of recipients spend their entire lump sum compensation within five years. Even a fairly prudent individual who invests the award in stocks and bonds could lose 30% of their funds in a stock market crash. An annuity relieves the IP from

investment risk and from **dissipation risk**, which is the risk of overspending, leading to subsequent financial hardship. The move from lump sum to annuities in structured settlements has led to two different approaches to determining the payments.

The **top-down approach** starts with determination of an appropriate lump sum compensation, and then converts that to an annuity.

The **bottom-up approach** starts with a suitable income stream, and then converts that to a capital value.

Because the purpose of the settlement is to restore the IP to their former financial position, as far as possible, the bottom-up method seems most appropriate.

In some areas of the USA the IP may transfer their annuity to a specialist firm in exchange for a lump sum, under a '**structured settlement buy-out**'. After concerns that the buy-out firms were making excessive profits on these transactions, the market has become more regulated, with buy-outs in many areas prohibited or at least requiring court approval. Structured settlement buy-outs are not permitted in Canada, where the structured settlement provider must ensure that the payments are going directly to the IP.

### 1.10 Pensions

Many actuaries work in the area of employer-sponsored pension plan design, valuation and risk management. Pension plans typically offer employees (also called plan members) lump sum and annuity benefits (or a combination of these) when the employee retires. Some plans also offer benefits if the employee dies while still employed. Pension benefits therefore depend on the survival and employment status of the member, and are quite similar in nature to life insurance benefits – that is, they involve investment of contributions long into the future to pay for future life contingent benefits. In this section we give a slightly more detailed description of the different types of pension plan that actuaries typically work with.

#### 1.10.1 Defined Benefit pensions

**Defined Benefit (DB)** pension plans provide members with lifetime retirement income, with the amount of annual pension determined using a formula that depends on the member's salary and period of service. The pension plan may also offer a lump sum retirement benefit, usually a multiple of the annual pension.

The benefits are funded by contributions paid by the employer and (usually) the employee over the working lifetime of the employee. The contributions are invested, and the accumulated contributions must be enough, on average, to pay the pensions when they become due.

The annual pension benefit in a defined benefit pension plan, which we denote as  $B$ , is typically determined from the formula

$$B = \alpha S n \quad (1.1)$$

where  $\alpha$  is the plan **accrual rate**, typically around 1%–2%;  $n$  is the number of years of employment within the plan ( $n$  does not need to be an integer) and  $S$  is one of the following measures of the retiree's pensionable salary, depending on the plan type:

**Final Salary Pension Plan:**  $S$  is the retiree's average salary over the last few years of employment (typically three to five years). This type of plan is also sometimes (and more accurately) called a Final Average Salary plan.

**Career Average Earnings Pension Plan:**  $S$  is the average salary earned by the retiree over their entire period of employment within the plan.

**Career Average Revalued Earnings Pension Plan:**  $S$  is the average salary earned by the retiree over their entire career, but with all salaries adjusted for inflation to values at retirement.

The interpretation of the benefit formula is that during each year of pensionable employment, the employee accrues  $\alpha S$  of annual retirement pension.

DB plans may also offer **withdrawal benefits** for employees who leave before retirement age. A typical benefit would be a pension based on the benefit formula above, but with the start date deferred until the employee reaches the normal retirement age. Employees who leave to move to a new employer may have the option of taking a lump sum with the same value as the deferred pension, which can be invested in the pension plan of the new employer.

Some pension plans also offer **death in service** benefits, for employees who die during their period of employment. The benefit might be a lump sum payment, where the amount depends on the salary at the time of death, and a pension for the employee's spouse, based again on formula (1.1), but with a different accrual rate.

#### 1.10.2 Defined Contribution

**Defined Contribution (DC)** pensions work more like a bank account than an insurance or annuity contract. Employees and their employer pay a predetermined contribution (usually a fixed percentage of salary) into a fund, and the fund earns interest. When the employee leaves or retires, the proceeds are available to them as a lump sum. The employee may use the proceeds to buy an annuity. Alternatively, they may live on the funds without purchasing an annuity, drawing down some amount each year until the retiree dies, or the funds are exhausted.

Using the DC funds to purchase a life annuity offers the security of lifetime income, but takes away the flexibility provided by having the money readily available. If the retiree does not buy an annuity, they run the risk that their funds will expire before they do. This is another example of dissipation risk.

### 1.11 Typical problems

We are concerned in this book with developing the mathematical models and techniques used by actuaries working in long-term insurance and pensions. The primary responsibility of the life or health insurance actuary is to maintain the solvency and profitability of the insurer. Premiums must be sufficient to pay benefits; the assets held must be sufficient to pay the contingent liabilities; bonuses and benefits payable to policyholders should be fair.

Consider, for example, a whole life insurance contract issued to a life aged 50. The sum insured may not be paid for 40 years or more. The premiums paid over the period will be invested by the insurer to earn significant interest; the accumulated premiums must be sufficient to pay the benefits, on average. To ensure this, the actuary needs to model the survival probabilities of the policyholder, the investment returns likely to be earned and the expenses likely to be incurred in maintaining the policy. The actuary may take into consideration the probability that the policyholder decides to terminate the contract early. The actuary may also consider the profitability requirements for the contract. Then, when all of these factors have been modelled, the actuary must use the results to set an appropriate premium.

Subsequently, at regular intervals over the term of the policy, the actuary must determine how much money the insurer should hold to ensure that, with very high probability, the funds will be sufficient to cover future benefits and expenses. This is called the valuation process. For with-profit insurance, the actuary must also determine a suitable level of bonus or dividend.

The problems are rather more complex if the insurance also covers morbidity (sickness) risk, or involves several lives. All of these topics are covered in the following chapters.

The actuary may also be involved in decisions about how the premiums are invested. It is vitally important that the insurer remains solvent, as the contracts are very long-term and individual policyholders rely on the insurer for their future financial security. The selection and management of investments can increase or mitigate the risk of insolvency.

The pensions actuary working with defined benefit pensions must determine contribution rates which will be sufficient to meet the benefits promised, allowing for investment proceeds, and using models that allow for the working patterns of the employees. Sometimes, the employer may want to change the

benefit structure, and the actuary is responsible for assessing the potential cost and impact. When one company with a pension plan takes over another, the actuary will assist with determining the best way to allocate the assets from the two plans, and perhaps how to merge the benefits. On a smaller scale, when a pension plan member divorces, an actuary may be involved in assessing a fair division of the pension assets.

### 1.12 Notes and further reading

A number of essays describing actuarial practice can be found in Renn (1998). This book also provides both historical and more contemporary contexts for life contingencies.

The original papers of Graunt and Halley are available online (and any search engine will find them). Anyone interested in the history of probability and actuarial science will find these interesting, and remarkably modern.

Charles *et al.* (2000) gives more information on the behaviour of recipients of compensation under structured settlements.

### 1.13 Exercises

#### Shorter exercises

**Exercise 1.1** Explain why premiums are payable in advance, so that the first premium is due now rather than in one year's time.

**Exercise 1.2** It is common for insurers to design whole life contracts with premiums payable only up to age 80. Why?

**Exercise 1.3** Is term insurance lapse-supported? Justify your answer.

**Exercise 1.4** Explain with reasons which of the following contract types will have the highest initial fees for a healthy life entering an independent living unit:

- (A) Full life care,
- (B) Modified life care,
- (C) Fee-for-service.

#### Longer exercises

**Exercise 1.5** (a) Why do insurers generally require evidence of health from a person applying for life insurance but not for an annuity?

(b) Explain why an insurer might demand more rigorous evidence of a prospective policyholder's health status for a term insurance than for a whole life insurance.