BOARD FOR ACTUARIAL STANDARDS

ACTUARIAL MORTALITY ASSUMPTIONS: DISCUSSION PAPER

MARCH 2008

FOREWORD BY THE CHAIRMAN

It is excellent news that people are on average living so much longer than was the case 60 years ago. A man retiring at 65 in 1948, when the universal state pension was introduced in the UK, lived on average for another 12 years. Such a man retiring now will probably live for another 21 years.

But this good news has a price. As we all now recognise, the cost of pensions has increased significantly. Furthermore, the rapid pace of change makes the future increasingly uncertain to predict. Insurers have also encountered problems in responding to these rapid changes.

It is important, in planning for the future in whatever context, not to underestimate the scope for future improvements in mortality. Equally, it is just as important not to overstate the possibilities, which could have serious economic consequences by tying up capital unnecessarily. Difficult judgements have to be made, be it by insurers or pension schemes. In their advice, actuaries must strike a carefully considered balance.

I hope this important paper will serve two purposes: first to explain the complex issues involved, and second to discuss the part that technical actuarial standards might play in the overall regulatory framework. We are not the only body considering the subject. The Pensions Regulator has recently issued a consultation paper on good practice when choosing mortality assumptions for defined benefit pension schemes. This includes proposals for a new approach in the way the regulator applies scrutiny to these assumptions during the scheme funding process.

There are evidence based grounds on which actuaries can advise on appropriate assumptions for future mortality. In particular, these days there is plenty of up-to-date and relevant data on both current rates of mortality and how they have improved over recent years. But it must always be remembered that this is one area in which the past is no strong guide to the future. The forces affecting mortality are many and varied: medical advances, public health measures, lifestyle changes (eg smoking and obesity, to name but two) and real or potential pandemics such as AIDS or bird flu.

While the future may be impossible to predict, assumptions still have to be made, and those making them need the best possible information. Actuaries advising on them should focus on the challenge of how best to communicate the choices to be made, the uncertainty surrounding those choices, and their implications.

The Board has been greatly assisted in this review by the members of the Mortality Research Working Group, by over 50 practitioners who kindly agreed to be interviewed, and by other academics, practitioners and stakeholders. Our thanks are due to them all.

We are particularly anxious to get feedback on the questions posed in this paper from those who will be affected by the answers, not just from the actuaries themselves. Please take the trouble to give us your views.

Paul Seymour
March 2008

CONTENTS

1 INTRODUCTION & SUMMARY

AUDIENCE AND AIMS OF THIS PAPER

1.1   This paper has been written for anyone who is likely to be affected by standards that the Board for Actuarial Standards (the BAS) may publish on mortality assumptions. The intended audience includes actuaries, the entities that actuaries advise, the regulators of and shareholders in those entities, and those for whom those entities provide services (typically, but not exclusively, pension benefits, life insurance policies, or annuities).

1.2   Assumptions about future mortality rates are required in many actuarial calculations, and they play a significant role in the costs of pensions and the solvency of life insurance companies. Whoever sets the assumptions – pension scheme trustees, insurance company directors, actuaries or others – they are based on actuarial information. This paper looks at the evidence on which mortality assumptions are based, methods of deriving them, and how information about them should be communicated.

1.3   This paper, and the responses to it, will inform the BAS's thinking as it develops a new book of actuarial standards.

A number of technical terms are used in this paper. Appendix A contains a glossary explaining those with which some readers may be unfamiliar.

SUMMARY

1.4   This paper presents the results of a review that the BAS has conducted into the mortality assumptions used in actuarial calculations in the UK. The paper discusses the contexts in which mortality assumptions are used (section 2), a number of concepts that arise when considering mortality assumptions (section 3), and some general considerations that apply to standards for mortality assumptions (section 4). Sections 5 and 6 consider two aspects of mortality assumptions, current mortality rates and future changes in mortality, in more detail.

1.5   The principal points that have emerged from the BAS's review are the following:

- Differences between the future mortality rates that are assumed in various actuarial calculations and those that actually occur can have adverse effects on pension scheme members, scheme sponsors, life insurance policyholders and annuitants, and life insurance companies whether the assumptions are over- or underestimates (see section 2).

- Future mortality rates are most unlikely to match assumptions exactly, however those assumptions are derived. Assumptions about future mortality are inevitably subject to high levels of inherently unquantifiable uncertainty. Communication of the extent and impact of the uncertainty is vital if users of actuarial information are to be able to rely on it when making decisions (see section 3).

- The BAS believes that actuarial calculations should separate out the assumptions for current mortality rates and future changes in mortality.

Mortality assumptions should not take the form of margins in other assumptions (see section 3).

- Standards for mortality assumptions could include standards for reporting on mortality assumptions and may include criteria that assumptions should meet. Standards might specify limits to be placed on assumptions, but there are significant practical difficulties in doing so (see section 4).

- Because of the high levels of uncertainty surrounding any predictions or forecasts of future mortality rates, there is no consensus on the best type of model to use for deriving assumptions about future changes in mortality. There is also no consensus on long term trends (see section 6).

- The BAS's research leads it to conclude that evidence-based judgements cannot be used to differentiate between the future changes in mortality likely to be experienced by different small subgroups of lives within the UK (see section 6).

1.6   The paper outlines a number of possible requirements that might be included in future BAS standards, and invites comments on them (see sections 5 and 6).

RESPONSES TO THIS DISCUSSION PAPER

1.7   Details of how to respond to this paper are set out in Section 7, *Invitation to comment*. Comments should reach the BAS by **20 June 2008**.

2 BACKGROUND

INTRODUCTION

2.1 People in the UK are living longer than ever. A man living in England or Wales aged 65 in 1950 had an average subsequent lifetime of around 12 years, based on the mortality rates observed over the period from 1950 to 2005. Although life expectancy is inevitably uncertain, because we do not know what mortality rates will be in the future, estimates for a male 65 year old today are generally between 18 and 25 years. The recent rapid changes in mortality rates have important implications for pension scheme funding and the solvency of life insurance companies.

2.2 There has been concern that the mortality assumptions being used in actuarial calculations have not kept up with the pace of change. In the Foreword to his Review of the Actuarial Profession, Sir Derek Morris said that there was a widespread perception that the actuarial profession had not responded as effectively or as fast as might have been expected to major changes in demographics in the UK in the last decade or more.

2.3 Although assumptions about future mortality are crucial elements of many actuarial calculations, in many cases it is not actuaries who are responsible for deciding what they should be. It is often pension scheme trustees, the boards of life insurance companies, or the boards of sponsoring employers, who have that responsibility. These decision-makers, who often have little expertise in this area, rely on actuaries for advice, and they and their regulators are rightly eager to know that the advice can be relied upon.

2.4 In view of the FRC's strategic goal that users of actuarial information can place a high degree of reliance on its relevance, transparency of assumptions, completeness and comprehensibility, and of the widespread impact of mortality rates, the BAS decided to investigate the mortality assumptions used in actuarial calculations, and to consider what actuarial standards for mortality might be desirable.[1]

2.5 The BAS is not the only body that is currently considering mortality assumptions. The Pensions Regulator has recently issued a consultation paper on good practice when choosing mortality assumptions for defined benefit pension schemes (see [14]). This includes proposals for a new approach in the way the regulator applies scrutiny to these assumptions during the scheme funding process.

2.6 The International Actuarial Association (IAA) has set up a mortality task force. It will address issues of data collection and research, by investigating what data is being collected, and whether guidelines are needed to ensure that appropriate data is collected, and will conduct a survey of current international research on mortality to determine future needs in this area. The UK Actuarial Profession is also addressing the issue of research, by conducting a study of mortality research being carried out across a wide

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[1] The Financial Reporting Council (FRC) is the UK's independent regulator responsible for promoting confidence in corporate reporting and governance. The BAS is an operating body of the FRC.

range of academic disciplines, looking particularly at the key factors underlying changes in mortality, and any gaps in the research.

MORTALITY AND ACTUARIAL CALCULATIONS

2.7   Assumptions about future mortality rates play a major part in many actuarial calculations in the fields of life insurance and pensions, and are also used in general insurance, long term care, and other calculations.

2.8   Mortality assumptions play a significant role too in a wide range of public sector and government matters, such as unfunded public sector pension plans and social security arrangements. In addition there are a number of matters that depend on future demographics, such as the long term costs of health care. However, the work in this area is outside the scope of BAS standards.

2.9   Mortality assumptions are by no means the only assumptions that play a significant role in actuarial calculations. In some calculations, their effect is outweighed by those of other assumptions; in others, their effect may be mitigated through the effects of discounting (see paragraphs 3.35 to 3.45).

Life insurance

2.10   Mortality assumptions are used in the calculations performed to determine how much capital life insurance companies should hold, the prices they charge for their products, and surrender values. Life insurance products include protection policies such as term insurance, the protection element of some options (such as guaranteed annuity options) attached to policies that primarily serve as investments, annuities and deferred annuities, and lifetime mortgages. Mortality assumptions are also used in calculating the embedded values that appear in annual reports and accounts, and in calculations for mergers and acquisitions and transfers of business. For policies that pay benefits on death, such as term insurance, improving mortality rates result in lower premiums and lower capital requirements. For policies that pay benefits on survival, such as annuities, guaranteed annuity options and lifetime mortgages, they result in higher premiums and higher capital requirements.

2.11   If the assumptions that are used overestimate future mortality rates (ie, people live longer than assumed), and other assumptions are held constant:

a) In relation to protection products such as term insurance, customers will pay more than they need have done, and insurance companies will make higher than expected profits on these products. The effect on insurance company profits will be slightly counterbalanced by the effect of the extra capital they will have had to hold in respect of these policies.

b) In relation to annuities and deferred annuities, customers will pay less than the benefits are worth (annuity rates will be higher), and insurance companies will make lower than expected profits on these products. Insurance companies will hold less capital in respect of annuities than they should, and there will be a greater risk of insolvency.

2.12   If the assumptions underestimate future mortality rates (ie, people die sooner than assumed), the effects on insurance companies and their customers will be reversed. Term insurance business will be less profitable than anticipated, with a greater risk of insolvency for insurance companies, and annuity

business will be more profitable. Customers will pay less than the benefits are worth for term insurance, and more than they need have done for annuities and deferred annuities.

2.13 The overall effect on an individual insurance company will depend on the mix of business that it writes and on its reinsurance arrangements.

2.14 Both over- and underestimation of future mortality rates may have adverse consequences for consumers, through protection products and annuities and deferred annuities respectively. Lower annuity rates hit members of defined contribution pension schemes particularly hard, as the amount of pension they receive in retirement depends on annuity prices at the time they retire.

2.15 Insurance contracts transfer risks between policyholders and the providers of risk capital (insurance companies). They also transfer risks between generations. For example, high annuity rates are beneficial for the current generation of consumers, who get more income for the price they pay. They may be detrimental for future generations, though, if insurance companies lose money or even become insolvent as their annuity holders live longer than was expected when rates were set.

Pension schemes

2.16 Mortality assumptions are used in the calculations of contribution rates to defined benefit pension schemes and of the pension scheme liabilities that appear in the employer's accounts. They are also used in the calculation of transfer values, in some calculations of a member's benefits on retirement, in calculations for mergers and acquisitions, in the calculation of the costs when a pension scheme buys out its liabilities with an insurance company, and in connection with the operations of the Pension Protection Fund.

2.17 If the assumptions that are used overestimate future mortality (ie, people live longer than assumed), the effects on pension schemes, their members, and their sponsors (the employers) are likely to be as follows:

a) Contribution rates will be set too low, leading to the possibility that pension schemes will not have enough funds to pay pensions as they become due. If this happens, members may receive less than their full pension entitlement.

b) Pension scheme liabilities will be underestimated in companies' accounts, and the charges to the Profit and Loss accounts understated. As the true pension costs emerge in later years, corrections will be needed.

c) Buyout costs are less than the actual costs of providing the benefits, so insurance companies make less profit than expected, or lose money (see paragraph 2.11). Buyout operators other than insurance companies, ie who are not regulated by the FSA, might scale back the benefits paid for the schemes they have taken on. If this happens, members may receive less than their full pension entitlement.

2.18 If the assumptions underestimate future mortality (ie, people die sooner than assumed), the effects will be reversed:

a) Contribution rates will be set too high, leading to extra costs for scheme sponsors, and the possibility that schemes will unnecessarily close (to new entrants or entirely).

b) Pension scheme liabilities will be overestimated in companies' accounts.

c) Buyout costs will be more than the actual costs of providing the benefits, so schemes pay more than necessary, possibly leading to reductions in benefits for scheme members as the schemes are unable to afford the full benefits.

2.19   Both the over- and underestimation of future improvements in mortality can thus have adverse effects on pension scheme members and their employers.

Other calculations

2.20   Mortality assumptions are also used in fields other than life insurance and pensions. Three examples, very different from those described above, are structured settlements in non-life insurance, long term care insurance, and life interests and reversions.

2.21   A structured settlement is an alternative to a one-off lump sum for a compensation award. Also known as a periodical payment, it is paid to a claimant as a series of payments over time. In the UK, structured settlements usually occur in connection with personal injury claims, such as those awarded as a result of a road traffic accident. To date, relatively few structured settlements have been put in place. The usual practice is for compensation to be a lump sum estimated to be sufficient to enable the claimant to secure an agreed level of income. This leaves the mortality risk and investment risk with the claimant. The lump sum equivalent to the agreed level of income is calculated on the basis of the factors given in *Actuarial Tables for use in Personal Injury and Fatal Accident Cases*, more commonly known as the Ogden Tables (see [10]). The latest edition of the Ogden tables incorporates mortality rates derived from the 2004-based population projections for the United Kingdom produce by the ONS. Because the take-up of structured settlements remains limited, non-life insurance companies have very little exposure to mortality risks from this source.

2.22   Although insurance policies intended to cover long term care costs were introduced into the UK in 1991, the market has remained small. There are currently two types of policy. For the first type – pre-funded plans – assumptions about changes in mortality for healthy lives are not generally nearly as significant as assumptions relating to claim inception rates and claim durations. Mortality assumptions play a more significant role in the second type, known as immediate needs annuities. However, assumptions about future changes in mortality rates do not have much effect compared to assumptions about the overall levels of mortality, as these annuities tend to remain in payment for, on average, two to three years (although a significant number of annuities are in payment for up to ten years).

2.23   Mortality assumptions are used in the calculation of the present values of possible future receipts from a will, settlement or intestacy, or from life policies and similar contracts. For example, an actuary might be asked to value an interest in a trust for inheritance tax purposes.

PANDEMICS

2.24   Paragraphs 2.7 to 2.23 describe the role of assumptions concerning long term mortality trends in actuarial work. Pandemics or other adverse circumstances which produce significant short term variations in mortality rates also affect a wide range of actuarial calculations.

2.25 As well as the obvious areas of life insurance, annuities, and pensions, many lines of non-life insurance would be adversely affected by a pandemic that had significant effects on the economy. For instance, trade credit insurance claims would increase dramatically in the event of ports or other transport links failing to operate.

2.26 Moreover, the effects of a pandemic on life insurance, annuities and pensions could be rather wider than simple mortality effects. For example, the stock market could be affected both through a downturn in economic activity and through direct effects on the functioning of the market, leading to possibly significant effects on the solvency of life insurance companies and pension schemes.

2.27 Assumptions about the occurrence of pandemics and their effects are used in stress and scenario testing while calculating capital requirements and business planning.

THIS REVIEW

2.28 In conducting this review, the BAS has looked especially at the forms that mortality assumptions may take, how they can be chosen, and the ways in which they are communicated by actuaries to others.

2.29 The BAS's Mortality Research Working Group provided valuable input on the state of research in a number of fields. The members of the group are listed in Appendix D. The group's report provides a discussion of the factors that affect future mortality rates, and how actuaries can draw on information and techniques from a number of different research areas (see [2]).

2.30 More than 50 practitioners were interviewed about how they go about setting mortality assumptions, and what they considered the important issues to be. These interviews revealed a broad range of practices and views. Some actuaries were very confident that they were fully aware of all the information available and competent to advise their stakeholders on the merits of the assumptions they proposed. Others were rather less confident, and indicated that they would like further information, either in the form of guidance from the CMI or other bodies, or in the form of technical standards.

2.31 Discussions were held with a number of other stakeholders in various fields about their view of mortality trends, the significance of mortality assumptions in actuarial calculations, and their views on the form that potential standards should take.

2.32 The BAS is very grateful to all those who gave so willingly of their time and expertise while this review was being conducted.

As explained in paragraphs 2.7 to 2.27, both the over- and underestimation of future mortality can have adverse effects on pension scheme members, scheme sponsors, life insurance policyholders and life insurance companies.

The BAS would welcome respondents' views on the significance of the effects described in paragraphs 2.7 to 2.27.

3   CONCEPTS

INTRODUCTION

3.1   Many actuarial calculations depend on assumptions about future mortality rates, as discussed in paragraphs 2.7 to 2.23.

3.2   Mortality rates are different for different groups of people. In particular, they are different for people of different ages, and for men and women. Figure 3-1 shows that women of a given age are less likely to die within a year than men of the same age, and that mortality rates for adults increase sharply after age 60.

Figure 3-1: Mortality rates by age and sex
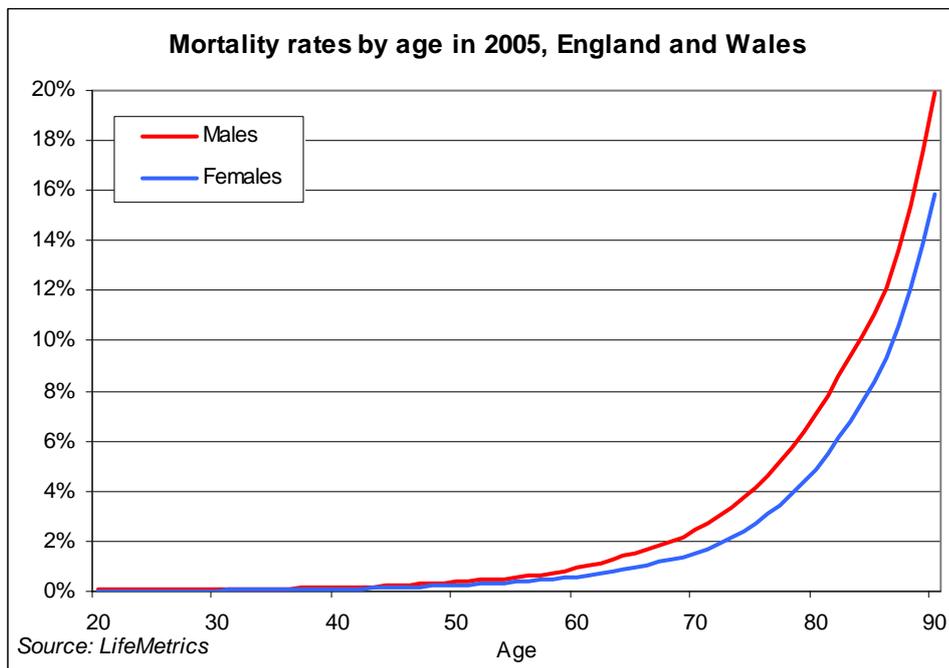
3.3   There are other factors that are correlated with mortality rates, including lifestyle factors such as whether people smoke, socio-economic class, and geographic location. These factors and their interactions are discussed in more detail in paragraphs 5.10 to 5.13.

3.4   If mortality rates were stable over time, it would be possible to analyse past mortality experience and use the resulting rates as assumptions for future rates. However, mortality rates are changing. In the UK, mortality rates have decreased quite substantially in the recent past. Figure 3-2 shows male mortality rates for ages 20-90 at 10 yearly intervals since 1961, expressed as a percentage of the rates for 1961. It shows that, for example, a 52 year old in 1961 was twice as likely to die within a year as a 52 year old in 2001.

Figure 3-2: Historic mortality rates by age and year of death
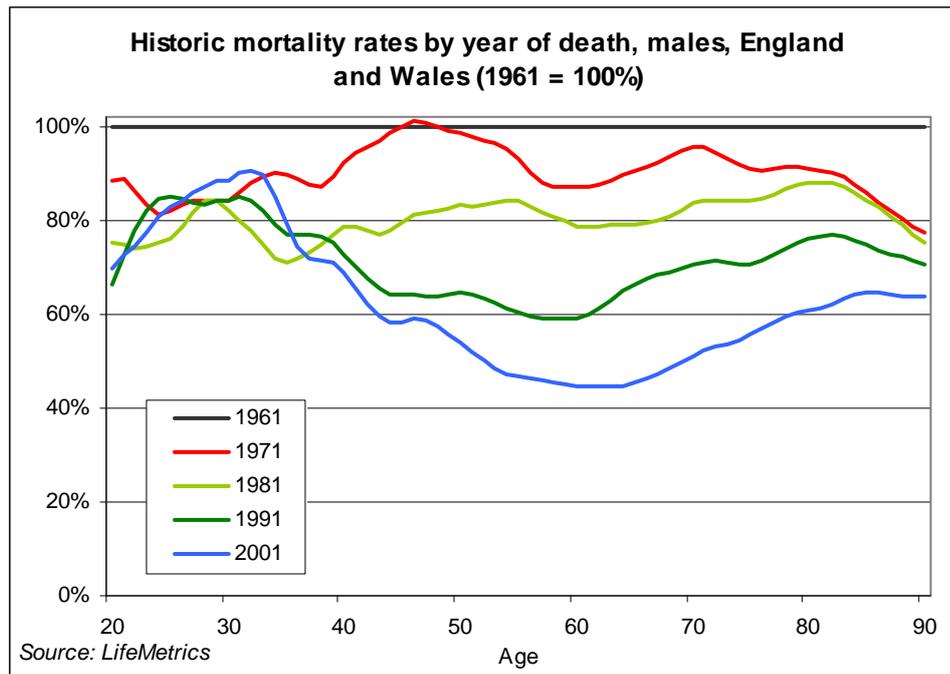
3.5   The chart shows that the improvements have mainly taken place at ages greater than forty. The actual changes are more significant at older ages, where the underlying mortality rates are higher (a 40% reduction in the probability of dying from 10% to 6% at age 80, say, is more significant than a 40% reduction in the probability of dying from 0.40% to 0.24% at age 45).

3.6   It also shows that the improvements for those aged around 70 were greater over the period from 1991 to 2001 than they were in earlier periods. Similarly, the improvements for those aged around 60 were greater over the period from 1981 to 1991. It thus illustrates what is known as the *cohort effect* – the level of improvements varies with the year of birth. In this case, those born in the years around 1930 appear to be experiencing much greater improvements than those born significantly earlier or later.

RISK AND UNCERTAINTY

3.7   Any assumptions about future mortality rates, however they are derived, are subject to risk and uncertainty. Actual mortality rates are most unlikely to match the assumptions exactly.

3.8   A distinction that is often made by economists and actuaries is that between quantifiable risk and inherently unquantifiable uncertainty.[2] There are many circumstances in which a number of different outcomes are possible. In some circumstances, the probabilities of the various outcomes can be derived from analysis or by observing past experience and drawing statistical inferences. For example, if we have a jar containing balls of two different colours, it is possible to take a sample from the jar and from that sample to estimate the proportion of balls of each colour. On the other hand, there are circumstances in which there is no basis, other than judgement, on which to assign probabilities. An example of this is an estimate of the probability of a violent

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[2] This distinction dates back to Frank H Knight's 1921 book, *Risk, Uncertainty, and Profit*. It is discussed in the BAS's consultation paper on its Conceptual Framework (see [1]).

revolution occurring in a specified country. Circumstances of the first type, where there is a mathematical basis for assigning probabilities, are said to exhibit *risk*; those of the second type, where there is no mathematical basis for so doing, are said to exhibit *uncertainty*.

3.9   Turner (see [18]) argues cogently that statements about future life expectancy, and hence about future mortality rates, are judgments about uncertainty, rather than risk – they are far closer to the category "I believe that there is a 50% probability that country X will have a violent revolution in the next 25 years" than to the category "there is a 95% probability that the percentage of red balls in the whole jar lies between 37 and 43%."

Sources of uncertainty

3.10   The uncertainty inherent in mortality assumptions arises from a number of sources, including those discussed in paragraphs 3.11 to 3.15.

3.11   The first is modelling error. Whatever method is used to derive the assumptions, they will be based on some sort of model of what the future will hold – this may be, for example, a model of the causes of future changes in mortality rates, or an extrapolative model based on past changes. To the extent that the model is not an accurate reflection of reality, the assumptions will differ from the actual outcomes. Moreover, any differences between the model and reality are often magnified over time; a model that provides a satisfactory approximation over the short term may be far from accurate over the long term.

3.12   The second source of uncertainty is parameter error: it is impossible to get exact estimates for model parameters because the data available is limited and inaccurate. Every model depends on parameters that are used to calibrate it – in other words, align its theoretical framework with the concrete situation in which it is being applied. Inevitable data limitations mean that the estimated parameter values will differ from the theoretical values.

3.13   A major difficulty when considering changes in mortality is the timescale; actuaries need to make assumptions about mortality rates for 40 or more years. Effective calibration of the models requires data spanning a long period. Collection methods and the composition of the population from which data is collected may change over time. Data collected over long periods is therefore often inconsistent, and may well provide unreliable estimates for the parameters.

3.14   A third source of uncertainty is random variation (sometimes known as process error). Even if the assumed mortality rates were an accurate estimate of the true underlying rates, random variations in the actual numbers of deaths, and hence in the observed rates, would be expected. The uncertainty due to process error is more significant if the model that is used to derive the assumptions is one in which the outcome in one period influences the outcomes in later periods. For large groups of people the difference between the observed and underlying rates would be expected to be small. However, for small groups of people the uncertainty from this source may be much larger than the uncertainty from modelling and parameter errors.

3.15   Other sources of uncertainty include data error and error due to expert judgement. In addition to affecting model parameters, so that the model fails to match actual future developments, inaccurate data can mean that the model fails to start from a position that matches reality. In the field of

mortality, inaccurate data is especially prevalent in the areas of estimating the numbers of older people that are alive (and hence the mortality rates at older ages) and in recorded causes of death. Expert judgement is significant because any model will require some choices or decisions – no model can be implemented in a completely automatic manner. Each decision is a potential source of error.

Communicating risk and uncertainty

3.16   The BAS believes that it is of the utmost importance that users of actuarial information understand the extent and implications of any risk or uncertainty surrounding it (see [1]). In the case of mortality assumptions uncertainty is unavoidable and any quantification can only be subjective.

3.17   Although the use of a single assumption is often necessary in many actuarial calculations, it may be misleading if it is not qualified with an indication of the extent of the uncertainty surrounding it.

3.18   While there are many ways in which the extent of the uncertainty can be communicated, including the use of fan charts, confidence intervals, the use of probabilistic projections, and ranges of possible outcomes, they all have significant limitations. In particular, many forms of quantification themselves rely on assumptions or models of risk. They do not allow for risk or uncertainty outside the scope of their models.

3.19   One way of presenting the impact of uncertainty is to represent a range of possibilities in terms of equivalent changes in discount rates (see [19]). For example, suppose that it is possible to arrive at a best estimate of current mortality rates within a range of plausible outcomes. An actuarial function such as an annuity value, or a more complex result appropriate to the actual calculations being carried out, could be calculated on the best estimate basis. The discount rates that would have the same effect as changing to the other possible outcomes could then be determined (see also Appendix B). This method of presentation has the advantage of providing an intuitive way of comparing the effects of uncertainty with other changes in mortality, and indeed any other, assumptions. However, the range that is presented must inevitably be derived from subjective judgements.

3.20   The use of scenarios is another way in which the extent of the possible uncertainty can be explored and communicated.

MAKING ASSUMPTIONS

3.21   Because mortality rates are changing over time, using past rates as estimates of future rates would be misleading. There are two[3] general approaches that can be taken:

a) Derive separate assumptions for rates of mortality at a specified base date, and changes to mortality rates for each time period after the base date;

b) Use margins in other assumptions (such as interest rates) to allow for base mortality, future changes, or both.

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[3] In theory, there is a third, deriving future mortality rates directly with no reference to past rates. The BAS does not know of any way of doing this in practice.

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3.22   The first approach is the most common, and appears to have a number of advantages.

Base mortality and future changes

3.23   In theory, the level of past mortality is a fact, and can be approached through standard statistical techniques, while future mortality rates can only be estimated.

3.24   In practice, there are some difficulties in determining past mortality rates for a specific group of people (see section 5). However, these difficulties are reasonably well understood, and there is some consensus on how they should be addressed. There is no such consensus around how to address the difficulties involved in estimating future mortality rates, or future changes in mortality rates. There is, however, general agreement that the difficulties involved are severe, and that future mortality rates cannot be predicted with any certainty (see paragraphs 3.10 to 3.15 and section 6).

3.25   Given these differences, it is appropriate to address the past and the future separately. In addition, given that the future does to a certain extent depend on the past, it is reasonable to start from the known, in the form of mortality rates obtaining at a known date in the recent past, and to estimate the future with reference to those base rates. The overwhelming majority of practitioners use this approach, which can readily be explained to the users of actuarial information. The different issues in the estimation of past mortality rates and future changes can be separated, with the implications of each assumption clarified.

Margins in other assumptions

3.26   Instead of using explicit mortality assumptions, some actuaries use margins in other assumptions, such as interest rates (as explained below). However, in recent years this approach has generally become less common in actuarial work, as transparency and ease of explanation have been given more weight.

3.27   However, the use of a margin in interest rates instead of an explicit allowance for mortality changes is not uncommon in pension funding and related calculations. Research conducted by consultants suggested that when valuing pension liabilities, adjusted discount rates might give good approximations to the effects of constant rates of reduction in mortality. One firm of consultants found that for typical pension schemes, reducing the discount rate by around 0.25% pa had a similar effect on aggregate liability values to adopting the improvement factors that were commonly used in around 2000 – those in the "92" series tables (see paragraph C.3).

3.28   It is argued that the adjusted discount rate approach avoids the drop off in improvement rates seen when using some of the more common improvement factors currently in use, such as the Interim Cohort projections (see paragraphs C.3 to C.8). It is also claimed by some that the approach is easy to explain, easy to work with and gives results of the right magnitude, and, in some circumstances, can be more appropriate than highly detailed assumptions that are difficult to work with, may not be closer to the emerging experience and may convey spurious accuracy.

3.29   However, the adjusted discount rate approach can only ever be an approximation. The actual adjustment that should be made to allow for a given rate of change in mortality rates depends on, among other things, the

age and gender profile of the scheme members, the benefit structure, and the assumed rate of inflation. The approach does not work when projected benefit cashflows are required, for example for the purposes of selecting assets that match the liabilities by term and amount.

3.30   Explicit assumptions for mortality changes need not have the undesirable characteristics that are addressed by the use of implicit margins. It is possible to use a constant rate of improvement as an explicit assumption, for example; and it is not necessary to use a projection that has undesirable characteristics. Although margins in other assumptions may be easy to work with, they may be difficult to explain. And the communication of the risk and uncertainty involved in any assumptions about future changes in mortality (see paragraphs 3.7 to 3.20) may be difficult when a margin appears in other assumptions.

SMOOTHING OF RATES

3.31   It seems intuitive that mortality rates should not jump sharply between ages; that the rate at age 65, for example, should be closer to the rates at ages 64 and 66 than it is to those at ages 60 and 70. Evidence from large investigations supports this intuitive view, but the crude mortality rates derived by simply dividing the number of actual deaths by the number of people are by no means smooth. These crude rates are therefore adjusted (a process known as *graduation)* to produce tables of rates that progress smoothly between ages.

3.32   A practical reason for using smoothed mortality rates in calculations is that it is often desirable that the results progress smoothly with age. Irregularities (jumps or other anomalies) are hard to justify in practice. The calculations could in theory be performed using crude mortality rates, and then the results smoothed, but this can be difficult if the calculations are complex. This would also mean that each time an index, value or premium is required it would need to be smoothed or graduated. It is more effective to smooth or graduate the most fundamental quantity, ie the mortality rate.

OLD AGES

3.33   There is relatively little data on mortality experience at ages above 90 or so. There are comparatively few people alive at those ages, even after the recent improvements in mortality, and the data that is available is in many ways less reliable – for example, improbably large proportions of deaths appear to occur at ages ending in a 0 or 5.[4] Some published mortality tables therefore contain rates only up to age 90 or so. Others treat the oldest ages as special cases, using different techniques and forms of data from those used at younger ages. Still others use some form of extrapolation for the oldest ages (often known as oldest-old). In this case, a maximum life-span may be chosen, often 120 years, at which the mortality rate is assumed to be 100%.

3.34   The use of a maximum life-span can cause difficulties when it comes to applying changes, especially improvements, to a base table. If improvements are applied at all ages, the rate at the maximum age becomes less than 100%, but there are no rates to apply at the older ages that then become possible. One approach is not to apply improvements at the maximum age; this can result in large differences between the rates at that age and the rates at earlier

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[4] Some of the peak at age 100 appears to be genuine, but this does not apply at ages such as 95 and 105.

ages. Another is to interpolate between the adjusted rate of improvement at a specific age and a zero rate of improvement at the maximum age.

SIGNIFICANCE OF ASSUMPTIONS

3.35   Although much of the recent publicity has focused on assumptions for future improvements in mortality, they are by no means the only material assumptions used in actuarial calculations. Other assumptions used in, for example, pension scheme calculations might include current mortality rates, other decrements (such as withdrawals), the age at which pensions will be taken, the proportion of members who have dependants, age differences between members and their dependants, and so on. In addition, nearly all actuarial calculations make assumptions about the time value of money through the use of a discount rate (or rates).

3.36   Richards and Jones discuss the effects of mortality improvements on various types of insurance contracts and in pensions (see [16]). They conclude that longevity risk, ie the risk that people will live for longer than expected, is highly significant for immediate and deferred annuities, and defined benefit pension schemes. However, other risks, such as long term interest rate risk, inflation risk, and default risk on bonds, may have comparable impacts.

3.37   The effects of assumptions about changes in mortality rates expected to occur many years in the future are to some extent mitigated by the effects of the discounting that occurs in most actuarial calculations.

3.38   For small groups of lives, the effects of mortality assumptions are likely to be outweighed by the uncertainty due to random variation (see paragraph 3.14).

3.39   There are several possible ways of representing the significance of different assumptions in the context of the calculations being performed. One way is to express the effect of a change in assumptions in terms of the percentage difference it makes to the overall result. Another is to represent it in terms of the equivalent change in another assumption, such as the discount rate. The first may be more effective when considering the overall significance of an assumption, the second when considering the relative significance of two different assumptions.

Relative significance

3.40   In order to investigate the relative significance of mortality assumptions in different calculations, the BAS performed some simple analysis (described in Appendix B). We have looked at three simple actuarial functions – for a deferred annuity, an annuity in payment, and an annuity in payment with a contingent dependant's annuity – and compared the effects of varying several of the assumptions. The result of each variation is then expressed as the change in discount rate that would have the same effect (see [19]). For example, on our base assumptions, the value of an annuity of £1 per annum in payment to a male currently aged 65 is £15.06. If the assumption about the base level of mortality is changed to one that assumes a level that is 20% lower, the value changes to £16.10. This is exactly the same change that would be produced if we kept the original base mortality level, but reduced the discount rate by 0.61%.

3.41   We first looked at the effects of changing the base mortality, ie the assumptions about the levels of current mortality (see paragraphs 3.23 to 3.25). We looked at two changes: reducing the current mortality rates by 20%,

and taking three years off the ages of the lives in question. These changes are typical of the adjustments that are often made to published tables, and have the same effect as an increase of up to 0.9% in the discount rate. To put this in context, the Bank of England's Monetary Policy Committee usually changes interest rates in increments of a quarter of a percent (0.25%), and the nominal discount rates currently used in pension scheme calculations for contribution rates are around 6% (real rates are around 2.5%).

3.42   We next looked at the effect of changing the expected future changes in mortality. We looked at a number of variations, listed in Appendix B, including several assumptions currently used by practitioners. The variations have the same effect as changes of up to about 1.3% in the discount rate, though most of them are under 0.5%.

3.43   We also looked at the effect of varying the assumed age at which the deferred annuity commences payment, and the assumed age difference between the annuitant and dependant for the annuity in payment with a dependant's annuity.

3.44   Changing the assumed age at which the deferred annuity commences payment by 5 years in either direction, assuming no change in the amount of the annuity, had the same effect as a change in discount rate of nearly one percent, slightly more for males than females. This shows that this assumption is highly significant compared to the illustrated changes in mortality assumptions if there is no reduction in pension on early retirement.

3.45   Changing the assumed age difference between the annuitant and dependant by two years in each direction has little effect for females (equivalent to a change in less than one tenth of one percent in the discount rate), and only slightly more for males, for whom the equivalent change in discount rate is around 0.15%.

SUMMARY STATISTICS

3.46   The use of standard statistics, such as life expectancies or rates at specified ages, may be useful in facilitating comparisons between different sets of mortality assumptions. Such single figure statistics often act as useful summaries, although by their very nature they invariably omit some information. For example, life expectancy (or expectation of life) is a statistic that is often used. Life expectancy is the average number of years before death, and can be calculated at any age from mortality rates for that age and all older ages. There are two commonly used variants, *period life expectancy* and *cohort life expectancy*. Life expectancy at a given age contains no information about mortality rates at younger ages.

Period life expectancy

3.47   A standard statistic that is often used in the communication of mortality rates, by both actuaries and non-actuaries, is period life expectancy. Period life expectancy is based on mortality rates at a specific date (or period). So, for example, the period life expectancy of a man aged 65 in, say, 2008, uses the mortality rates for all ages from 65 upwards as they are expected to be in 2008. In other words, period life expectancy takes the mortality rates at a specific date and assumes that they do not change.

3.48   In spite of the name, period life expectancy does not necessarily provide an estimate of anyone's expected remaining lifetime. The combination of

mortality rates that are used – in our example the mortality rates for 65 year olds in 2008, 66 year olds in 2008, 67 year olds in 2008, and so on – will only apply to a single person if mortality rates do not change in the future.

Cohort life expectancy

3.49   Cohort life expectancy, on the other hand, is based on the mortality rates that are expected to be experienced by the lives in question, using assumptions about future changes in mortality rates. The cohort life expectancy of a man aged 65 in 2008 uses the mortality rates for 65 year olds in 2008, the expected rates for the same group of people (66 year olds) in 2009, for 67 year olds in 2010, and so on.

Summary statistics for base mortality rates

3.50   Period life expectancy provides a useful summary of the mortality rates prevailing at any one time, and can thus be used to summarise assumptions about base mortality rates, but its name is misleading. During a period in which mortality rates are generally improving, like the present, the period life expectancy is significantly less than actual estimated life expectancy. Figure 3-3 and Figure 3-4 compare period and cohort life expectancies for a person alive and aged 65 in the year shown along the horizontal axis of the graphs.

Figure 3-3: Period and cohort life expectancies for males age 65 (Source: ONS)
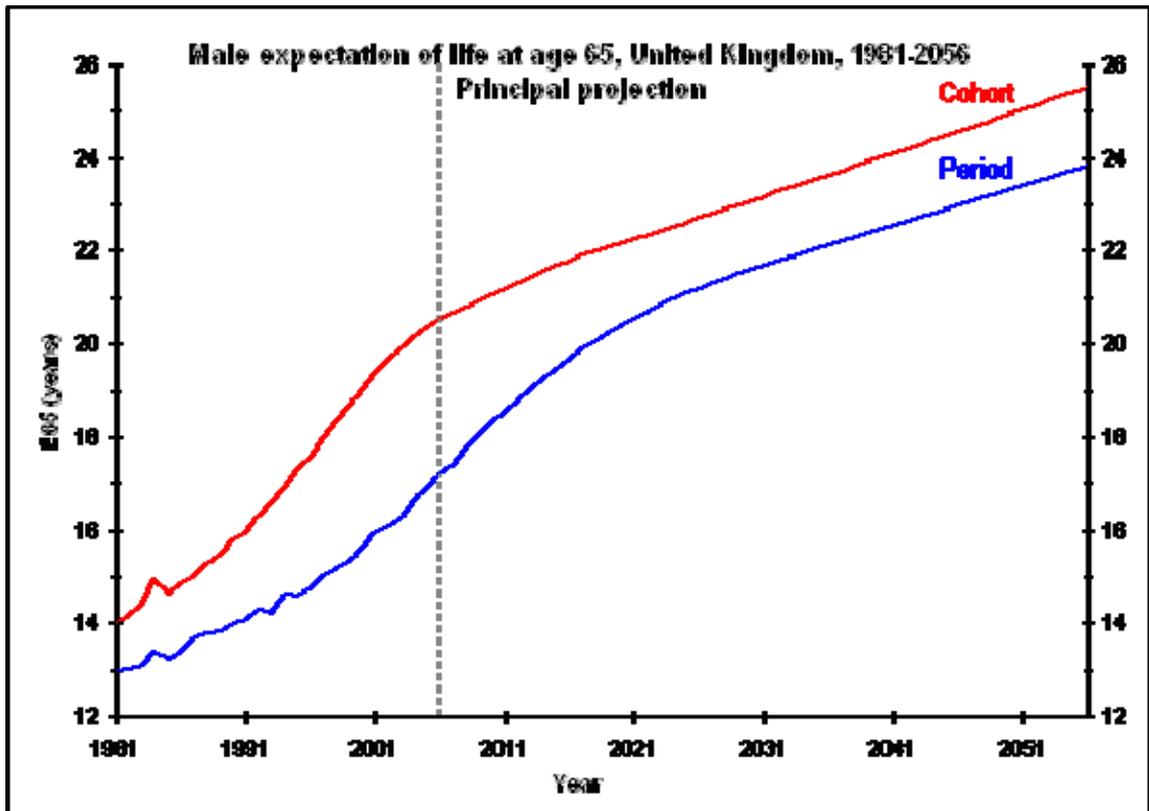
Figure 3-4: Period and cohort life expectancies for females age 65 (Source: ONS)
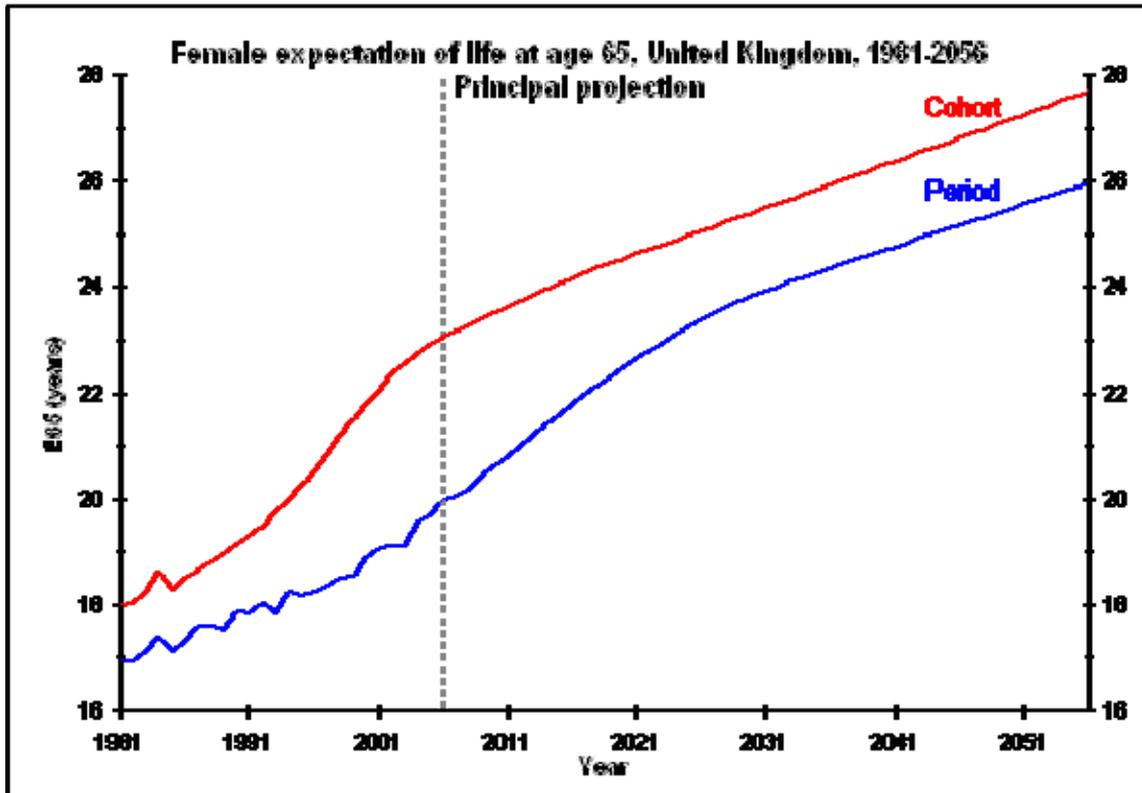
3.51   These graphs show that period life expectancies are around three years less than cohort life expectancies for lives aged 65 in 2006. It is also noteworthy that the assumptions incorporated in the ONS projections mean that the gap would have peaked at the current time. This is because the ONS projections assume that future rates of improvement will generally be less than the current rates.

3.52   Period life expectancy is often used to communicate the effects of mortality improvements, by comparing life expectancies for the same age in two different years. If period life expectancies show, for example, an increase of one year over a period of five years, this leads to statements such as "people are living for a year longer than they were five years ago". This is misleading as the period life expectancy is not an estimate of how long anyone will live unless it is assumed that there will be no future changes to mortality rates.

3.53   The effective communication of the effects of mortality improvements is clearly important. The use of a term which, although it has a clear technical meaning, is likely to be misunderstood by those without a technical background, does not assist clear communication and is likely to create problems in the future.

3.54   Period life expectancy is, apart from the misunderstandings that it engenders, a statistic that is suitable for comparing base mortality rates. It summarises mortality rates over a range of ages, and places more weight on deaths at ages closest to the age for which the statistic is being calculated.

Summary statistics for future changes in mortality

3.55   The use of cohort life expectancy does not in general pose the same problems as the use of period life expectancy, as it is an estimate of the average number of years of life remaining. However, because it depends on both base

mortality rates and future changes in mortality, it cannot be used to summarise either.

3.56   An obvious way of summarising assumptions about future changes in mortality is to compare the expected mortality rates at two different times. Indeed this is what is usually done, using period life expectancies to summarise each set of rates.

3.57   It is also possible to use annual rates of change for specific ages and calendar years, which are independent of base rates. An annual rate of change may convey information about changes at other ages and in other calendar years, as long as rates of change progress smoothly between ages and years. The use of several statistics may provide more information than a single statistic, but makes it harder to perform comparisons.

3.58   Another possibility would be to use an average of rates of change over a range of ages or a range of calendar years (or both). Such statistics are independent of base rates, and are more flexible than life expectancies, as the ranges used can be more varied. A weighted average would overcome some of the problems caused by the over-representation of rates for ages at which few people are alive, but the choice of weights is critical.

Benchmarks

3.59   One way of providing more information to the users of actuarial information is to compare assumptions to standard benchmarks. This can be done through the use of summary statistics: for example, for base mortality, mortality rates at specified ages could be used.

3.60   The use of benchmarks can provide a valuable context in which to set the assumptions, particularly if the benchmarks are appropriate. For example, one possibility would be to use, say, four standard benchmarks for future changes in mortality. Each one could represent the effects of a different scenario, such as deaths from heart disease halving within the next ten years. By comparing the assumptions chosen to the benchmarks, it would be possible to explain the assumptions in terms of possible scenarios.

3.61   A number of difficulties are associated with using benchmarks. For base mortality rates, where it is sometimes possible to derive assumptions that are very specific indeed to the particular group of lives under consideration, standard benchmarks might have little relevance. For future changes in mortality, where the outcomes are so uncertain, any benchmarks would necessarily be highly speculative, and their very existence might be misleading. There is also the question of who should prepare the benchmarks, and the criteria to use in developing them.

INTERNATIONAL COMPARISONS

3.62   The UK is not alone in seeing rapid changes in mortality rates. Richards et al describe reductions in mortality rates in a small number of countries over the decades 1980-1990 and 1990-2000 (see [17]). Japan, France, Canada, USA and UK all showed substantial reductions in both decades for ages 65-74. Reductions were slightly less for ages over 75, but in many cases still substantial. It is interesting to note that the group that showed the largest percentage reduction, Japanese females, is also the group that had the lowest mortality rates in 1990. Instead of the gap between Japanese females and others closing up, it widened.

3.63   Although mortality is improving in these and many other countries, there are some countries, such as Russia and some African countries, in which mortality rates are increasing.

3.64   The prevalence of cohort effects is by no means universal; indeed in some countries there is a significant cohort effect for either males or females, but not for the other sex (see [17]).

3.65   Another recent paper summarises the types of mortality assumptions that are used in the pensions field in a number of European countries and the USA (see [19]). In many countries it is not accepted practice to allow for future mortality improvements.

The discussion in paragraphs 3.7 to 3.20 leads the BAS to believe that, in order for mortality assumptions to be communicated in a clear and transparent manner to the users of actuarial information, the extent and impact of the inherent uncertainty surrounding them must be explained.

For the reasons set out in paragraphs 3.21 to 3.30, the BAS believes that actuarial calculations should use separate assumptions for base mortality and future changes in mortality, and that mortality assumptions should not take the form of margins in other assumptions.

Paragraphs 3.35 to 3.45 discuss the significance of mortality assumptions in actuarial calculations. The BAS believes that it is the impact of assumptions on the overall result that is important.

For the reasons set out in paragraphs 3.47 to 3.54 the BAS believes that, while period life expectancy is a useful summary statistic, the term is misleading. It is the BAS's view that when the words "life expectancy" or "expectation of life" are used, they should be accompanied by a statement of whether the statistic in question incorporates subsequent changes to mortality rates or is based on rates prevailing at the date of the statistic. Paragraphs 3.55 to 3.58 discuss possible summary statistics for future changes in mortality. Paragraphs 3.59 to 3.61 discuss the use of benchmarks in the communication of mortality assumptions.

The BAS would welcome respondents' views on

- **appropriate methods of communicating the extent and impact of the inherent uncertainty involved in mortality assumptions; and**

- **whether the use of separate assumptions for base mortality and future changes in mortality, not taking the form of margins in other assumptions, would be desirable; and**

- **appropriate methods of communicating the significance of assumptions, both in absolute terms and relative to that of other assumptions.**

The BAS would like to know whether respondents foresee any practical difficulties in communicating the assumptions about subsequent changes in mortality rates underlying life expectancy statistics. It also seeks views on and suggestions for summary statistics for changes in mortality, as discussed in paragraphs 3.55 to 3.58.

The BAS would welcome views on the use of benchmarks, as discussed in paragraphs 3.59 to 3.61, and whether the development of standard benchmarks for future changes in mortality should be encouraged.

4   STANDARDS

THE PURPOSE OF STANDARDS

4.1   The BAS is an operating body of the FRC, which has as one of its strategic goals that users of actuarial information can place a high degree of reliance on its relevance, transparency of assumptions, completeness and comprehensibility. The standards that the BAS will develop will be intended to help it achieve this goal. The BAS recognises that in many cases the assumptions to be used in actuarial calculations are determined by the trustees of pension schemes, or the Boards of life insurance companies, and not by actuaries. In these cases, the BAS is concerned with the information that trustees and Boards are given before they take their decisions.

4.2   The BAS also has the aim of promoting high quality actuarial practice through a set of actuarial standards, primarily of a technical nature, that are coherent, consistent and comprehensive.

4.3   Following its consultation on a Conceptual Framework for actuarial standards, the BAS has concluded that it will develop standards that are essentially mandatory (rather than being recommendations) and principle-based (rather than rule-based) (see [1]). BAS standards will be intended to help the users of actuarial information.

4.4   The mortality (and other) assumptions for some calculations are specifically required, by regulation, to be prudent. For other calculations, best estimates are required, or assumptions are required to be market consistent. For still others, nothing is currently stated in regulations about the type of assumptions they should be. Questions regarding the concepts of best estimates and prudence will be consulted on in later documents as the BAS develops its new book of standards.[5]

4.5   While the BAS is not a prudential regulator, its standards will contribute to reducing the likelihood of insolvency, and the fairer treatment of consumers, the primary responsibility for which lie elsewhere.

ADOPTED PROFESSIONAL GUIDANCE

4.6   The BAS has adopted 37 Guidance Notes that were originally issued by the Actuarial Profession. These Guidance Notes (GNs) cover various aspects of actuarial work in life insurance, pensions, and other fields. Some of them are designated as Practice Standard (which effectively means that they are mandatory) and others as Recommended Practice. Mortality and longevity receive very little mention in the GNs.

4.7   Some of the life GNs say that assumptions about future mortality should take into account recent relevant experience and trends of the industry and, if credible, the insurer. There are some explicit requirements to consider adverse mortality outcomes, or to perform sensitivity analyses. GN44, *Mathematical Reserves and Resilience Capital Requirement*, which is Practice Standard, states that the use of a birth-year cohort approach will normally be appropriate when considering future mortality improvements for annuitants.

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[5] The first consultation paper on the book of standards is expected to be published in April 2008.

GN2, *Financial Condition Reports*, which is Recommended Practice, states that mortality is likely to be stable or to have a stable trend.

4.8 GN9, *Funding Defined Benefits - Presentation of Actuarial Advice*, is the only pensions GN to mention mortality explicitly. It is Practice Standard, and does not mention recent relevant experience and trends. It does, however, require the consideration of risks due to unanticipated future changes in mortality, or variations in future mortality experience compared with that assumed. It also requires the actuary to consider to what extent mortality assumptions should reflect any available information about variations arising from annuity size, occupation, regional factors, duration and the mortality experience of the pension scheme.

GENERIC AND TOPIC-SPECIFIC STANDARDS

4.9 The BAS has proposed two types of standard: specific standards, which will apply to particular areas of work, and generic standards, which will apply more widely (see [1]).

4.10 The use of a generic standard or standards for mortality assumptions would promote consistency across the different actuarial fields, making sure that the same overarching principles applied whatever the specific purpose of the calculations being made. In particular, any principles set out in generic standards would apply regardless of the particular groups of lives in respect of whom assumptions were being made, including impaired lives, lives in countries other than the UK, and so on.

4.11 Principles set out in generic standards could cover, for example, reporting requirements for mortality assumptions, methods by which sub-group characteristics could be taken into account in setting assumptions, or criteria that assumptions should meet (see paragraphs 4.13 to 4.26).

4.12 On the other hand, it could be argued that the constraints operating in the different fields are so varied that specific standards are required, either in addition to or instead of generic standards.

OPTIONS FOR STANDARDS

4.13 There are various possible options for standards, ranging from none, through standards for reporting only, standards prescribing criteria that assumptions should meet, to standards prescribing limits on assumptions to be used. More detailed proposals for possible standards are presented in sections 5 and 6.

4.14 For the avoidance of doubt, any references in this paper to standards for mortality assumptions should be taken to refer, when appropriate, to standards for information given to decision-makers about the mortality assumptions they may adopt.

No standards

4.15 The argument in favour of not setting any standards for mortality would be that none is needed. Actuaries are capable of exercising professional judgement, the argument goes, and are doing so. Standards have not been required hitherto, and nothing has gone wrong.

4.16 This is a difficult argument to support. BAS standards are intended to increase the confidence that users of actuarial information can place in it. Although no insurance company has yet become insolvent citing faulty

mortality assumptions as the reason, the failure of mortality assumptions for guaranteed annuity options to match recent developments contributed to severe financial consequences for a number of insurance companies, including Equitable Life. Improvements in mortality rates much greater than those assumed have also contributed to the rising costs of pensions. The existence of technical standards for mortality assumptions would increase the reliance that users of actuarial information and other stakeholders could place on them.

Reporting standards

4.17 One option would be for the BAS to set reporting standards for mortality assumptions: simply to specify the information that should be provided about the assumptions. Such standards would build on the BAS's proposed generic reporting standard, amplifying some areas that are especially relevant to mortality. There are a number of forms that such standards could take, and issues that they could cover, including:

- How to describe the assumptions that have been chosen (this might cover matters from the names of published tables through to implications, such as implied life expectancies or annuity values)

- Required statements about analyses that were performed (or not performed) in order to come up with the assumptions

- Required statements about the level of uncertainty in the assumptions, and its possible financial effects

- Required statements about supporting evidence and its source

- Required statements about the way in which the assumptions exhibit prudence, or are best estimates, or are neither

4.18 Standards that are limited to reporting can easily be generic standards, applicable across different areas of actuarial work. The same standards can be applied in all situations, including mortality for impaired lives, and for best estimates, ranges and prudent assumptions.

4.19 Reporting standards also directly address the issue of giving users of actuarial information confidence that they understand the information, and how their decisions are affected by it.

Criteria that assumptions should meet

4.20 The BAS could also set standards that prescribe criteria that assumptions should meet. Various possibilities are discussed in more detail in sections 5 and 6, including options such as requiring that assumptions should be justified on the basis of evidence, specifying appropriate forms that evidence might take, and how to act in the absence of adequate evidence. Standards could, for example, specify appropriate methods for taking into account the characteristics of the specific group of lives in respect to which the mortality assumptions apply.

4.21 Standards of this type could be framed as generic standards. However, some standards of this type might have to be specific. For example, it is unlikely that a criterion requiring assumptions to bear some relationship to an external benchmark would be broadly applicable.

Limits on assumptions

4.22   The final option is for the BAS to set standards that prescribe limits on assumptions.

4.23   Standards that set limits would need to take account of the fact that there are different constraints in different areas of work. For example, sometimes regulations require best estimates, and sometimes a prudent choice of assumptions; and a prudent assumption in one context may be rash in another. It might be necessary to have a number of specific standards, applying separate limits to mortality assumptions in life insurance and pensions, for example. Although the same methodologies could be used, it would be illogical for the BAS to require the same outcome in all cases.

4.24   In addition, the standards might not be able to take account of all possible contexts in which they might be used, including the consideration of impaired lives and lives from countries other than the UK. Limits that are reasonable for normal UK lives might be totally unsuitable for others.

4.25   There are risks in imposing limits, not least that they might, with hindsight, turn out to be misguided, and to result in financial losses.

4.26   Where the actual setting of assumptions is for the entity to decide for itself, the BAS might require that assumptions outside certain limits should be clearly indicated as not complying with BAS standards.

IMPACT OF STANDARDS

4.27   The BAS's aim is to increase the confidence that users of actuarial information have in the information. Because BAS standards for mortality assumptions are likely to affect both funding levels of pension schemes and capital requirements of insurance companies, it is difficult to estimate the impact they will have (which will in any case depend on the type of standard). It is potentially easier to gauge the effect of highly prescriptive standards than that of reporting standards.

4.28   There may also be broad social effects, such as possible closures of pension schemes, reductions (or increases) in benefits to members or the prices paid for annuities by members of defined contribution pension schemes (see paragraphs 2.7 to 2.19). Changes in the calculation of surrender values, or, for some life insurance policies, rate reviews, may also have social effects. However, the BAS is not responsible for social policy, but for ensuring that decision makers are given reliable information.

4.29   Much (though by no means all) actuarial work in the pensions field concerns planning, rather than valuation (ie, arriving at a provisional estimate rather than crystallising an amount to be applied in a transaction or recorded in a formal document – see [1]). The impact of changes in assumptions often falls on the annual contributions to pension schemes, which can be adjusted over a period, rather than requiring an immediate payment of the full amount of the change in liabilities.

4.30   BAS standards may affect the costs of pension schemes, insurance companies, or indeed any users of actuarial information. Costs are likely to increase if standards effectively mandate that more work is required. Again, it is not always easy to estimate the extent of this effect, as existing practice varies between practitioners.

The BAS has stated its intention to issue two types of standard: generic and specific. Paragraphs 4.9 to 4.12 set out some of the advantages and disadvantages of each as a mechanism for addressing mortality assumptions. Paragraphs 4.13 to 4.26 outline possible forms standards might take, including no standards at all, reporting standards, standards specifying criteria that assumptions should meet, through to standards specifying limits to be placed on assumptions. For the reasons set out in paragraphs 4.17 to 4.19, the BAS believes that reporting standards are vital in increasing the transparency of assumptions and their comprehensibility to users of actuarial information.

There are two types of impacts that BAS standards for mortality assumptions might have:

- Impacts on funding levels of pension schemes, or capital requirements for insurance companies, and the related social effects

- Impacts on the costs incurred by the users of actuarial information

For the reasons set out in paragraphs 4.27 to 4.30, the BAS believes that it will be especially difficult to assess the first type of impact.

The BAS would welcome any general comments that respondents may have on the various possibilities for standards, and in particular whether they agree that

- **there should be some standards for mortality assumptions, as argued in paragraphs 4.15 to 4.16; and**

- **that reporting standards would play a significant role in increasing the transparency of mortality assumptions and their comprehensibility to users of actuarial information, as argued in paragraphs 4.17 to 4.19.**

Concrete examples of possible standards follow in Sections 5 and 6, which therefore provide an opportunity for making detailed comments.

The BAS would also welcome any general comments that respondents may have on how to assess the likely impact of possible BAS standards for mortality assumptions.

5 BASE MORTALITY

INTRODUCTION

5.1   Although it is in theory possible to determine past mortality rates, there are some significant difficulties in practice. Many factors affect rates of mortality, including, among others, age, gender, state of health, socio-economic group, and whether the people in question smoke or not. The actual mortality rate of any specific group of lives therefore depends on its composition, as well as on random variation.

DERIVING ASSUMPTIONS

5.2   If there is sufficient data, the past mortality experience of the group over recent years can be used to estimate the mortality rates at a particular point of time. This can be done either by smoothing the crude death rates that were experienced by the group or by fitting a statistical model. In the latter case, detailed information about the lives in the group, such as the factors discussed in paragraphs 5.10 to 5.13, may be used. For either of these methods to provide a reasonable estimate, the group must be large enough that the estimates are statistically valid using data from a fairly small number of years. If the data is collected over a long period, it will include the effects of changes in mortality rates as well the effects of changes in the composition of the group. This may make it difficult to estimate past mortality rates for any given time.

5.3   With less data, it is possible to compare past mortality experience to published rates, such as the mortality tables published by the Continuous Mortality Investigation of the Actuarial Profession (the CMI) or Office for National Statistics (the ONS). It may be possible, with enough data, to use the experience to determine the most appropriate published table; otherwise, a published table can be chosen based on a judgement about the similarity of the lives on which it is based to those for which mortality assumptions are being set. Once a published table has been selected, the rates that it contains can be adjusted to reflect the actual experience, either by taking a proportion of the rates, or by adjusting the ages to which they apply.

5.4   If there is not enough data for either of the above methods to be used, it may be possible to use characteristics of the groups under consideration to adjust published tables (see paragraphs 5.10 to 5.13). The extent to which it is possible to take specific factors into account depends crucially on the data that is available. Life offices often have quite detailed information for current policyholders, including addresses, some details of medical history, smoking and other lifestyle factors. In general, pension schemes have less detailed information.

5.5   Whether experience is used to derive mortality rates directly, or published tables are adjusted by using characteristics of a group of lives, the resulting rates will only be suitable for use if the lives whose information was used are similar to the lives for which the mortality assumptions are intended to provide estimates of future mortality. For example, if the composition of the group has changed over the period the future mortality experience of the current members of the group may have little in common with the past experience. Similarly, the current pensioners in a scheme may have very

different characteristics from those of the active and deferred members, who will receive pensions in the future.

Adjustment methods

5.6 There are two principal methods of adjusting published tables. First, percentage adjustments can be applied to the mortality rates in the table. If the same adjustment is applied at all ages, the general shape of the table (ie, the relationships between rates at different ages) is preserved. Different adjustments can be applied at different ages, in which case the shape of the table is changed. However, if there are large changes in the adjustment applied between adjacent ages the resulting mortality rates are unlikely to progress smoothly by age. It is also possible to introduce anomalies such as unjustified reductions in mortality rates as age increases.

5.7 The second commonly used adjustment method is to treat lives as older or younger than they actually are – in other words, use an age adjustment. With this method, the overall shape of the table is preserved, although the age at which particular features are exhibited will change.

5.8 It is, of course, possible to combine the two adjustment methods. Whatever the adjustment method used, it is usually necessary to apply special treatment at the very oldest ages (see paragraphs 3.33 to 3.34).

Adjusting for recent changes

5.9 The rates derived from experience, or by adjusting published tables, will probably relate to a period some years before the date as at which the calculations are being performed. They must therefore be adjusted to take account of changes in mortality rates that occurred between the date at which they apply and the effective calculation date. This can be done by using published information about known changes (see paragraphs 6.32 to 6.34). Possibilities include:

- From time to time the CMI publishes the ratios of actual mortality rates to those expected on the basis of specific tables. The ONS publishes similar statistics.

- The smoothed past rates of improvement produced by an extrapolative projection such as Lee-Carter or P-spline.

- A simple percentage adjustment to the mortality rates.

FACTORS THAT CORRELATE WITH MORTALITY

5.10 A number of factors correlate with mortality rates and changes in mortality rates; not all of them are suitable for use in deriving assumptions for base mortality rates in the UK.

5.11 Some factors have a very significant direct impact on mortality rates, but are little used in practice by actuaries working in life insurance or pensions. On the other hand, some factors have very little direct influence, but are extremely useful in practice. A classic example is postcode. Moving house from one postcode to another does not generally have a direct effect on anyone's life expectancy. However, mortality rates are correlated with postcode. This is because postcode is in turn correlated with other factors such as lifestyle and wealth that do influence mortality rates. Postcode is therefore a useful proxy for these other factors.

5.12   Most proxy variables correlate with more than one factor directly linked to mortality, and there is considerable overlap among them. It is therefore important to allow for the interactions between factors.

5.13   The utility of a factor depends on whether information about that factor is available for the members of the group under consideration, and on the availability of quantitative information about its effect on mortality rates. Table 5-1 lists a number of factors that may correlate with mortality rates. It is based on the report of the BAS Mortality Research Working Group which contains a discussion of these factors and their effects on mortality rates (see [2]). The table gives one view of the level of impact of the factors on mortality rates and their possible utility in actuarial work, based mostly on the availability of reliable data. Any such characterisation can only be approximate, as different data is available under different circumstances. Within the broad category of life insurance, for example, practice varies greatly between, say, pricing impaired annuities and reserving for term insurance. Factors that are of little interest to actuaries have not been included, and this list is by no means comprehensive; there are other variables that have more influence on mortality rates than those given here.

Table 5-1: Factors correlating with mortality rates

Factor	Direct influence on mortality rates	Usefulness as a proxy variable in	
		life insurance	pensions
Age	Very high	Very high	Very high
Gender	Very high	Very high	Very high
Medical history	Very high	Very high	Very low
Genetics	High	Very low	Very low
Smoking status	High	Very high	Very low
Diet	High	Very low	Very low
Obesity	High	Moderate	Very low
Occupation/socio-economic class	High	Low	Moderate
Alcohol consumption	Moderate	Moderate	Very low
Regular exercise	Moderate	Very low	Very low
Exposure to stress	Moderate	Very low	Very low
Wealth	Moderate	Very low	Very low
Marital status	Moderate	Very low	Moderate
Education	Moderate	Low	Low
Degree and method of medical underwriting applied	Low	High	Very low
Family medical history	Low	High	Very low
Geographical location	Low	Low	Low
Postcode	Low	Moderate	High
Benefit amount	Low	High	High

PUBLISHED MORTALITY TABLES

5.14   The two main sources of published mortality tables in the UK are the ONS and the CMI.

5.15   The ONS publishes mortality tables containing smoothed rates based on census data every ten years for England & Wales, and for Scotland. Interim life tables, based on population estimates, are produced annually for the constituent countries in the UK (see [13]). The rates in the interim life tables are not smoothed, and are given by age for males and females.

5.16   The CMI publishes mortality tables derived from the pooled experience of life insurance companies. It has been found that the mortality experience of insured lives differs from that of the population as a whole – indeed variations are seen between different types of life insurance. The most recent tables were published in 2006, based on experience from 1999-2002, and are known as the "00" series tables, reflecting the fact that the rates they contain are appropriate for the year 2000 (see [6], [7]). The "00" series contains tables derived from the experience of the following types of assurance and types of lives:

a) Permanent Assurances

b) Temporary Assurances

c) Immediate Annuitants

d) Pensioners

e) Widows

f) Retirement Annuitants

g) Personal Pensioners.

5.17   The "00" tables give rates by age and sex, and, for some tables, separately for smokers and non-smokers, early and normal retirements, and duration since the start of the policy.

5.18   Many practitioners use the CMI's "92" series tables, which were published in 1999 based on experience from 1991-1994 (see [3]). There are fewer tables than in the "00" series, and there are no separate rates for smokers and non-smokers.

5.19   The CMI has recently consulted on the publication of tables based on the pooled experience of self-administered pension schemes (see [9]). These tables are based on experience from 2000-2006, and contain rates appropriate for the year 2003. They give rates by age and sex, and by pension amount. It is expected that the final tables will be published in 2008.

5.20   LifeMetrics publishes crude mortality rates and graduated mortality tables as part of its toolkit for measuring and managing longevity and mortality risk (see [12]). The current range includes tables for males and females in England and Wales for all years from 1961 to 2005. The tables are based on death and population data from the ONS. The graduated tables are primarily intended for use in evaluating current and historical levels of mortality and longevity.

Impaired lives

5.21   The BAS is not aware of any tables published in the UK for impaired lives. In 2004 the CMI published an analysis of the experience of impaired lives, but no graduated tables were included (see [5]). This is because there is too little data on impaired lives in the CMI dataset to produce credible tables.

5.22   Adjustments are usually made to published tables that apply to standard lives in order to allow for mortality impairments. A common method is to use information about the medical condition to apply an age adjustment. Some insurance companies apply an additional level of mortality to standard tables and others use disease-specific mortality curves derived from their own datasets.

Using recent tables

5.23   Both the ONS (and its precursors) and CMI have been publishing mortality tables for many years. The first English Life Tables were based on census data from 1841. The earliest tables for assured lives published by CMI were based on experience from 1924-29.

5.24   Mortality rates have changed greatly in the past (see paragraphs 3.4 to 3.6). Not only have the overall levels changed, but the relationships between mortality rates at different ages and between the sexes have also changed. Because of these changes, the most recent available tables are usually the most suitable as the foundation for base mortality rates.

5.25   If sufficient experience is available, some practitioners choose the published table that most closely reflects the observed relationships between mortality rates at different ages. This can result in the choice of a table based on experience from fifty or even more years ago. The rates in the published table chosen in this way are often scaled down by large percentages, and the ages to which they apply adjusted down by large numbers of years, in order to make the base mortality rates reflect the recent experience of the group of lives in question.

5.26   Although this practice may have a theoretical justification, it presents significant barriers to communication with users of actuarial information. On the one hand, they are told that mortality rates are changing rapidly, and on the other, they are asked to rely on patterns of mortality dating from many years ago.

5.27   An alternative is to use recently published tables, and to vary the adjustments applied to the published rates by age, thus reflecting the observed relationships between rates at different ages (see paragraphs 5.6 to 5.8).

RISK AND UNCERTAINTY

5.28   Whatever the method of setting the assumptions for base mortality, there are significant risks and uncertainties involved, as described in paragraphs 3.7 to 3.15.

5.29   If the past mortality experience of the group over recent years is used to estimate the mortality rates at a particular point of time, model error will occur if the model used to perform the estimation does not reflect the underlying mortality rates that are being estimated.

5.30   If a published table is used, there are two sources of model error. The first is the possible model error in the published table itself: ie, the differences between the model used to create the table and the underlying experience on which it is based. The second is any difference in composition that there may be between the group of lives on whose experience the table is based, and that for which the assumptions are being developed. This is described by some commentators as *basis risk*.

5.31   When a published table is used it is often adjusted on the basis of experience or on the basis of group characteristics. It may also be adjusted in order to bring the rates up to the effective date of the calculations (see paragraph 5.9). Any adjustments made to a published table are based on a model, often a very simple one. For example, an adjustment may be made to allow for the effect of the industry in which a pension scheme's members work by making a uniform adjustment to mortality rates across a broad range of ages. To the extent that such an adjustment fails to reflect the true effect of the factor in question, model error will be introduced.

5.32   In the same way as for model error, parameter error may be present whether base mortality rates are derived directly from experience or from a published table. It is, of course, particularly significant when the available data is sparse or unreliable – also a source of data error.

5.33   Many judgements must be made in the course of setting assumptions for base mortality, each a possible source of error.

5.34   Finally, random variation is, as ever, particularly significant for small groups of lives.

5.35   The magnitude of the uncertainty can be expressed by presenting a range in terms of summary statistics (see paragraphs 3.46 to 3.61). However, the range that is presented will inevitably be subjective. The use of scenarios can assist in communicating an assessment of the extent of the uncertainty.

5.36   It may be more useful to present the effects of uncertainty in mortality assumptions in terms of the impact on the overall result of the calculations. The impact of the uncertainty in base mortality rates will be affected by the assumptions about future changes. The greater the assumed future changes, the greater the effect of uncertainty in base rates.

REPORTING ON BASE MORTALITY RATES

5.37   As discussed in paragraphs 4.13 to 4.26, standards for base mortality assumptions might take many different forms, ranging from reporting standards through criteria that assumptions should meet to limits on assumptions.

5.38   Paragraphs 5.41 to 5.49 below outline a number of possible requirements that could be imposed by reporting standards. Different requirements might be appropriate in different contexts, and the list of possibilities is not complete. The emphasis is on transparency and comprehensibility.

5.39   Reports would also be expected to comply with any applicable requirements requested by their intended recipients, or required by other regulators. For example, the Pensions Regulator has recently consulted on a number of issues connected with mortality assumptions (see [14]), and recommends the use of the CMI's naming convention for published mortality tables (see [8]).

5.40   Any applicable provisions in the BAS's generic reporting standard (expected to be consulted on in the next few months) would also apply to mortality assumptions.

Base mortality rates

5.41   If the base mortality rates are derived by graduating, or fitting a statistical model to, the mortality experience of a group of lives, the following aspects of the graduation should be disclosed:

a) The source of the data used;

b) The amount of experience and the reasons for considering it credible;

c) The graduation method or model used including, if appropriate, the variables used in fitting the model; and

d) The estimated values of any parameters.

5.42   If the base mortality rates are based on a published table, the following information should be given:

a) The published table that was used, and the reasons for choosing it; and

b) Any adjustments that were applied to it, and the reasons for doing so.

Adjustments

5.43   If the adjustments to a published table are based on the experience of a group of lives, the following information should be given:

a) The source of the data used for the adjustments; and

b) The amount of experience and the reasons for considering it credible; and

c) The adjustment method used, including the estimated values of any parameters.

5.44   If the adjustments to a published table are based on characteristics of the group of lives under consideration, the following information should be given:

a) The characteristics on which the adjustments are based; and

b) The methods used to make the adjustments, and the reasons for their choice.

5.45   The method used to update the base mortality rates from the effective date of the graduated experience or published tables to the date at which the calculations are being performed should be described, with the reasons for using it.

Summary

5.46   The base mortality rates, including all adjustments, should be described using appropriate summary statistics (see paragraphs 3.46 to 3.61) in order to facilitate comparisons between different sets of assumptions.

5.47   If any action to mitigate mortality risk has been taken, such as reinsurance, the way in which the assumptions reflect the mitigation should be explained.

5.48   The sources, extent and impact of the risk and uncertainty in the base mortality assumptions should be described (see paragraphs 5.28 to 5.36).

5.49   A statement should be provided about whether the base mortality rates are a best estimate, a prudent assumption or neither, together with reasons why they are so considered.

CRITERIA FOR BASE MORTALITY RATES

5.50   Standards might specify criteria that base mortality rates should meet. Paragraphs 5.51 to 5.55 outline a number of possible criteria that might be specified in standards. Different requirements might be appropriate in different contexts, and the following list is not complete.

5.51   Base mortality rates should generally exhibit a smooth progression between ages. Any exceptions, such as the age assumed to be the maximum lifespan, should be identified and explained.

5.52   Any adjustments made to published tables should be made on the basis of evidence. The source of the evidence and the reasons for believing it to be applicable should be given.

5.53   The most recent applicable published tables should be used (see paragraphs 5.23 to 5.27). If an older published table is used (for example, if a table from the "92" series is used instead of one from the "00" series), the reasons for using the proposed table should be explained, including any supporting evidence.

5.54   In order to use tables graduated from experience or based on fitted statistical models (see paragraph 5.2), the data should meet specified requirements such as the minimum volume required, the length of the period to which it relates and how recent it is.

5.55   In order to adjust published tables from experience (see paragraph 5.3), the data should meet specified requirements such as the minimum volume required, the length of the period to which it relates and how recent it is.

LIMITS ON BASE MORTALITY RATES

5.56   As explained in paragraphs 4.22 to 4.26, there are a number of difficulties associated with setting limits on mortality assumptions. In particular, the BAS has not encountered any cogent arguments for setting limits on the assumptions for base mortality. As set out in paragraphs 5.1 to 5.9, base mortality assumptions may be very specific to the group of lives in question. Fixed limits would have to be so broad, or have so many exceptions, as to have no practical effect.

5.57   The only area in which it might be possible or desirable to set limits would be in the area of specifying which published tables it would be permissible to use. For example, there might be a requirement to use tables published after a certain date.

Paragraphs 5.23 to 5.27 set out reasons why it may be desirable to use the most recent published tables when deriving assumptions for base mortality, rather than older ones that may provide a better fit to experience.

Paragraphs 5.37 to 5.49 outline some possible standards for reporting on assumptions about base mortality. Paragraphs 5.50 to 5.55 outline some possible standards specifying criteria that assumptions should meet, and paragraphs 5.56 to 5.57 explain why the BAS believes that standards setting limits for base mortality would not be practicable, with one possible exception.

The BAS welcomes respondents' views on the desirability or otherwise of using the most recent applicable published tables, taking into account both the communication problems and the practicality of setting a limit on the tables to be used.

Views would also be welcomed on any of the possible requirements for reporting on assumptions about base mortality, criteria that assumptions should meet, or limits that should be observed when setting assumptions. The BAS is particularly interested in

- **any practical problems that might arise in complying with them; and**

- **whether they would further the BAS's aim of increasing the transparency of assumptions and their comprehensibility to users of actuarial information.**

6 FUTURE CHANGES IN MORTALITY

INTRODUCTION

6.1 Changes in mortality rates are influenced by many factors, all of them inevitably uncertain in scale and timing, and there is an ever-present risk of pandemic and other one-off events. Therefore, future mortality rates will always be uncertain. Quantifying the degree of uncertainty can assist with decisions actuaries make or about which they give advice to other decision makers. The difficulties involved in predicting mortality rates for use by actuaries and others are heightened because of the long time scales involved – 40 or even 60 years are not uncommon – although the impact of inaccuracies over such time scales may be mitigated by other factors in models and by the process of discounting.

DERIVING ASSUMPTIONS

6.2 With enough data, it is possible to derive past mortality changes from experience and extrapolate them into the future. However, much more data is required than for the graduation of base mortality rates, so this is a procedure that is rarely possible in practice for individual pension schemes or for many insurance companies. Moreover, although there is general agreement that different groups of lives are likely to exhibit different rates of change in mortality rates in the future, there is no consensus on the form that the differences will take. This means that using the past experience of a particular group of lives will not necessarily give an appropriate estimate of future changes for that group (see paragraphs 6.22 to 6.24).

6.3 There are two basic approaches to deriving assumptions for future changes in mortality rates. The first is to build a model, either from scratch or based on one that is publicly available (see paragraphs 6.8 to 6.21).

6.4 The second approach, and the one that is commonly used, is to use published projections, for example, one of those in the CMI library (see [8]). Published projections are often based on the notion of an annual change in mortality rates. For example, a 1% improvement at age 65 in 2010 would mean that a 65 year old has a probability of dying within a year that is 99% that of a 65 year old in 2009. Some projections give changes by calendar year only, in which case they apply to all ages in that calendar year. Others give changes by calendar year and age (or calendar year and birth year). These allow the representation of the cohort effect – those born in some years show more rapid improvements than others.

6.5 Published projections may be adjusted – for example, a minimum rate of improvement may be applied (see paragraphs 6.28 to 6.31).

6.6 Approximations may sometimes be used – instead of using different factors for each year of birth, for example, those for an average year of birth can be used, or the same factors can be used for all future calendar years. Alternatively, a margin in the discount rate may be used instead of explicit assumptions about future changes in mortality, as discussed in paragraphs 3.26 to 3.30. If any of these approximations, or indeed any others, are used the assumptions may be less transparent, and it may be difficult to explain the effects of the uncertainty in the assumptions.

Longevity market

6.7 The prospect of a market in longevity (ie, future mortality rates) is increasingly discussed, together with the influence that such a market would have on the assumptions used in actuarial calculations. The BAS understands that a limited number of transactions has taken place, but the market does not yet have the depth or liquidity that would be required if it was to be used to set assumptions. There would also be a number of practical problems to be overcome. Although it appears unlikely that market pricing will be a possible base for assumptions in the near future, the possibility should be kept under review.

MODELLING FUTURE CHANGES

6.8 There are three basic approaches to modelling future changes in mortality: extrapolation, expectation and explanation (see [2]). Extrapolative models extend historic patterns and trends into the future. Methods based on expectation use the opinions of experts or surveys (ie, the opinions of large numbers of people) about future developments. Explanatory models (sometimes known as causal models) attempt to model causes and effects. The dividing lines between the different types of model are not always clear cut: extrapolative models may be influenced by expert judgement of overall trends, and causal models may extrapolate the effects of individual causes.

6.9 A model using one of the three basic approaches described in paragraph 6.8 may be either *deterministic* or *stochastic*.

6.10 A deterministic model is one that produces only one set of possible results for given inputs (data and parameters). For example, a simple deterministic model for a single variable that increases by a set amount each year might take the form $x_t = a + bt$.

6.11 A stochastic model, on the other hand, produces many sets of possible results for a single set of inputs. This is because it includes both a non-random part that describes structural changes through time, and a source of randomness that perturbs the structure. A simple stochastic model for a single variable that increases by a set amount each year, more or less, might take the form $x_t = a + (b + \varepsilon)t$, where ε varies randomly.

6.12 A single set of results from a stochastic model is of little use on its own. Stochastic models are used in conjunction with random number generators to produce large numbers of possible sets of outcomes. It is then possible to analyse the results statistically to give the mean outcomes, the median, or indeed any other percentile. Stochastic models thus provide a way of analysing some of the uncertainty surrounding the future outcomes.

6.13 A number of significant difficulties arise when modelling future mortality changes (see [2]).

6.14 First, even a thorough understanding of past changes may not provide a good guide to the future, which is inherently uncertain. Current trends may not continue and it may be very difficult to say which of them will change and how.

6.15 Second, there is rarely sufficient data available to allow models to be validated satisfactorily. Although more data is now being collected, the amount and quality of historic data remain a problem.

6.16   Third, a major problem facing builders of all models of future mortality is that of understanding past changes in mortality rates. For example, it is often argued that the UK has a pronounced cohort effect, in that the mortality of those born in (approximately) the early 1930s has improved faster than that of those born earlier or later. There is also evidence of a cohort effect in other countries, including Japan, Germany, and the USA (see [17]). However, the existence of cohort effects has not been found in populations in which such effects might be expected to exist, such as nineteenth century Finnish famine victims, and it would be possible for crossover effects to exist in which an advantaged group has relatively large numbers of frail survivors who experience higher than expected mortality in later life. There is no single generally accepted theory about the cause of the observed cohort effect in the UK, so there are differing views on the extent to which cohort-related effects will feature in future changes in mortality.

6.17   There is also no agreement about the likely long term trends (see [2]). Some academics argue that since a significant improvement in mortality has already occurred, it cannot happen again. Since there is no evidence of large declines in mortality rates at the very oldest ages, the maximum lifespan (currently around 120 years) is unlikely to increase, and mortality rates cannot continue to improve indefinitely. Others take a different view. There has been a linear increase in the highest life expectancy at birth recorded for all countries since 1841, due to a variety of causes. There is no reason to suppose that this will change: the causes in the future will be different from those in the past, but the overall effect is likely to continue. In addition, the argument continues, there is no reason to suppose that there is a biological maximum lifespan.

6.18   In spite of the problems, some sort of model has to be used if assumptions are to be made about future mortality changes. Indeed, even an assumption that there will be no changes in the future uses a (very simple) model. Although the most common approach is to use (or adapt) a published projection (see paragraphs 6.28 to 6.31), it is possible, given enough suitable data, to use a published model or even to construct a new model.

6.19   Few practitioners construct their own models for future mortality changes. Those who do often incorporate some element of causal modelling, sometimes in order to represent the effects of particular scenarios (such as a change in the mortality rate from or incidence of a specified disease or group of diseases).

6.20   Several stochastic extrapolative models have been published, often with supporting software which can be used on any suitable data set. Two of them have also been used to produce published projections. Practitioners may wish to use these models directly, rather than using the published projections, for several reasons. First, they may wish to use their own data set. Second, they may wish to explore more of the results than are presented in the published projections (which typically contain only the medians). Third, they may wish to explore the effects of using different parameters.

6.21   A number of potential pitfalls are associated with using extrapolative models. When fitting the model to past data, judgement has to be used to balance the desire for a good fit against the danger of over fitting. In some cases, an extra year of data can produce a major alteration in the projections that are

produced. Figure 6-1 shows age-cohort P-spline projections based on ONS data up to 2003, 2004 and 2005, taken from the CMI library (see [8]).[6] The projections based on data to 2004 are very different from those based on data to 2003, showing much larger improvements. This characteristic, which is by no means unique to the P-spline model, is known as the *edge effect*: projections are heavily influenced by the trends in the most recent years.

Figure 6-1: P-spline age-cohort projected annual rates of changes in mortality
based on data to 2003, 2004 and 2005 for birth years 1930-34

P-spline age-cohort projected annual rates of change for females born in 1930-1934

Source: CMI library
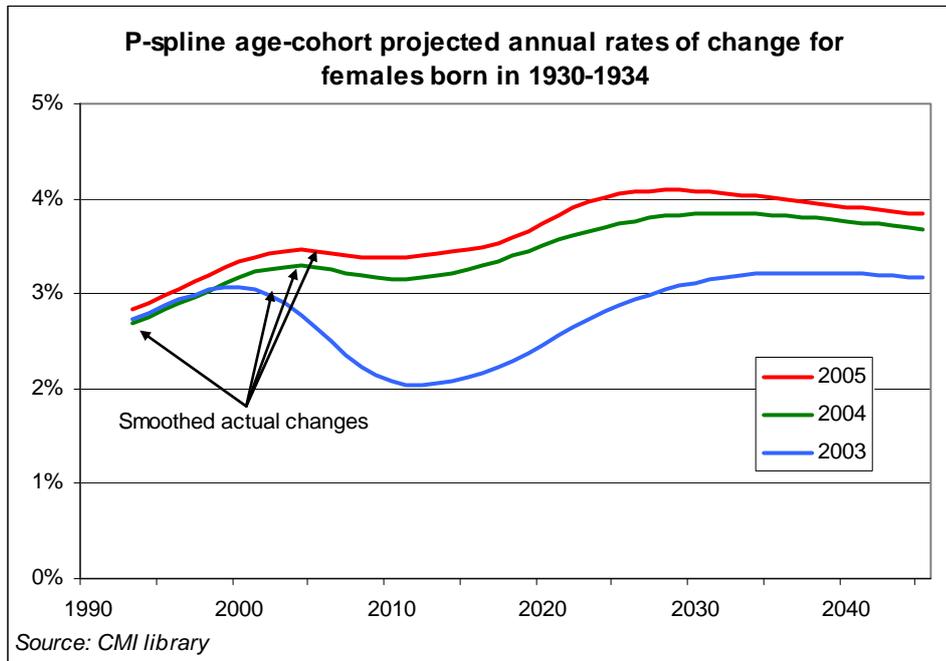
FACTORS AFFECTING CHANGES IN MORTALITY

6.22   Any changes in factors that affect base rates of mortality will affect future changes in mortality. However, although there is fairly general agreement about what they are – socio-economic group, lifestyle and behavioural changes, improvements in healthcare, and improvements in infrastructure – there is much less agreement about what their effect will be.

6.23   Take socio-economic group as an example. In the past, the mortality of lower socio-economic groups has improved more slowly than that of the higher groups. There are three possibilities for the future: that this trend will continue; that, in the future, the mortality of lower groups will improve faster than that of higher groups; or that there will be no difference in the rates of change. An argument in favour of the first view is that the relative rates of improvement are at least partly caused by better access to the latest medical advances, and that this differential is likely to continue. A contrary argument is that recent improvements have been largely due to lifestyle changes, such as better childhood nutrition and giving up smoking, which have been adopted more rapidly by those in higher socio-economic groups. Fewer changes in lifestyle are now available to the higher groups, the argument continues, but there are still many changes open to those in the lower groups, so their mortality can be expected to improve more rapidly in the future.

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[6] See paragraphs C.16 to C.18 for an overview of the P-spline model.

6.24   It is clear that mortality is likely to change in different ways for different groups of people, but much less clear what the differences will be.

PUBLISHED PROJECTIONS

6.25   The principal source of projections of future changes in mortality rates in a form suitable for use by actuaries is the CMI library, containing 54 projections (see Appendix C). The projections are very diverse, both in terms of the models and datasets from which they are derived, and in terms of the future changes that they project.

6.26   Figure 6-2 shows some of the projected changes for those born in the years 1930-34. The equivalent projections for those born in the years 1960-64 are shown in Figure 6-3. All the projections included in these charts are described in Appendix C.

6.27   The charts demonstrate the wide variety of projected changes, ranging from a long term acceleration to a fairly rapid tailing off. They also illustrate the widely differing starting points for the projections, in terms of the assumptions that they (implicitly or explicitly) incorporate about current rates of change.

Figure 6-2: Projected annual rates of change in mortality rates from the CMI library for birth years 1930-34
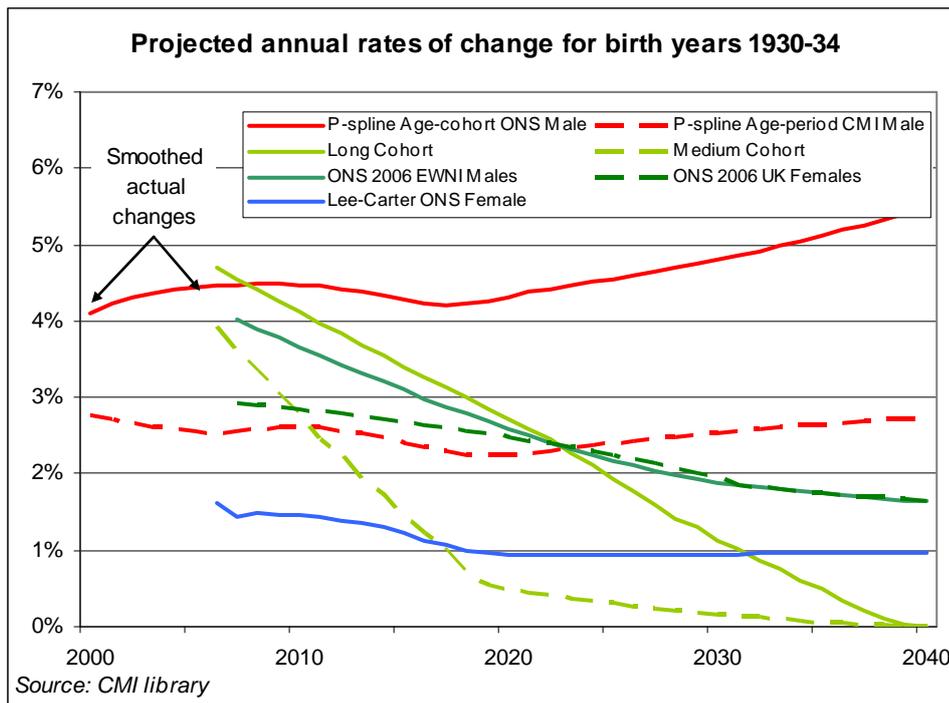
Adjusting published projections

6.28   The CMI library contains examples of adjustments that can be made to published projections. For example, it is possible to use a blend of two different projections, to apply a percentage adjustment to the improvement factors, or to apply a lower limit to the improvement factors (sometimes known as an *underpin*).

6.29   Percentage adjustments may be used when projections (such as the Interim Cohort projections) that are based on male lives only are applied to female lives.

Figure 6-3: Projected annual rates of change in mortality rates from the CMI library for years of birth 1960-64

Projected annual rates of change for birth years 1960-64
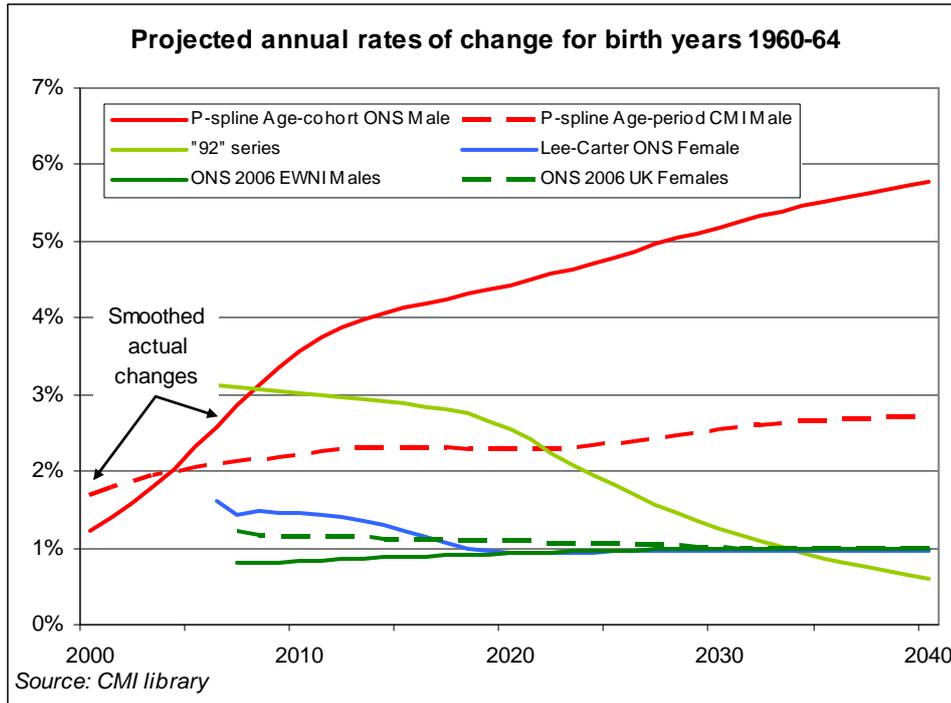
6.30 It is especially common to apply an underpin to the Interim Cohort projections. This is because, being based on the "92" series projections, they assume a long term tailing off of improvements. There is a view that such an assumption is not appropriate, especially when setting prudent assumptions for annuity business and pensions.

Figure 6-4: Effect of an underpin

"92" series projected annual rates of change for birth years 1960-64
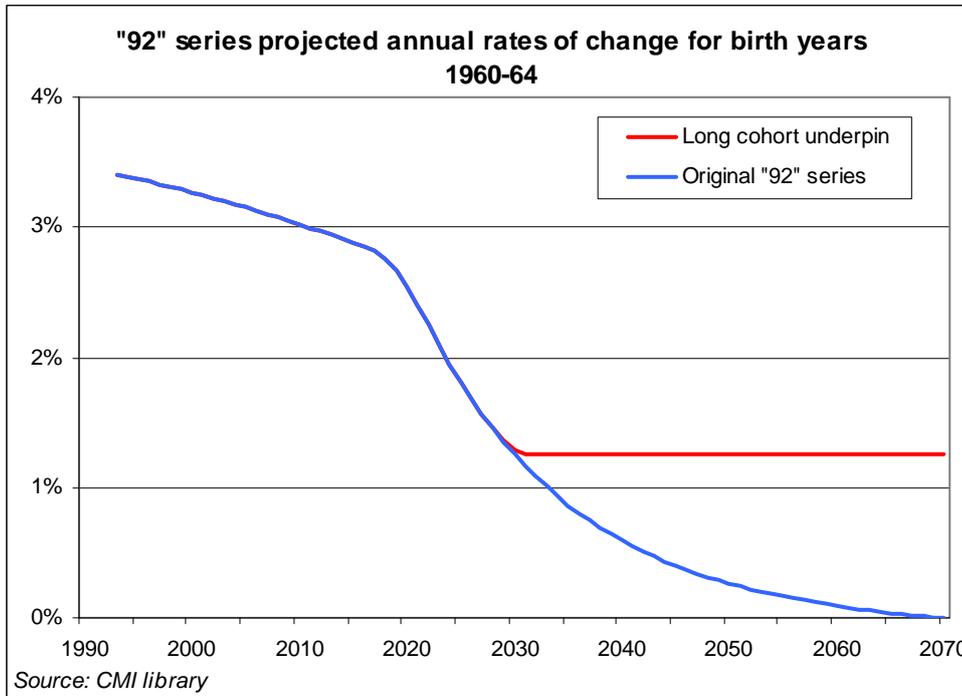
6.31 The application of an underpin can result in rates of change that do not progress smoothly between ages or calendar years, as shown in Figure 6-4,

which illustrates the effect of a 1.25% underpin. Note that those born in the years 1960-64 are outside the scope of the cohort effect modelled in the Interim Cohort projections, so the Long Cohort projection is the same as the "92" series projection.

RECENT CHANGES IN MORTALITY RATES

6.32   There is a variety of information available on recent changes in mortality rates. Any of the mortality tables that are published at regular intervals, such as the LifeMetrics indexes (see paragraph 5.20) and the interim life tables from the ONS (see paragraph 5.15), can be used to provide indications of actual changes. However, these do not give smoothed rates of improvement. From time to time, the CMI publishes comparisons of observed mortality rates compared to those expected on the basis of published tables. And some of the projections in the CMI library include smoothed actual rates of improvement for past years, as well as projected future rates of improvement.

6.33   The CMI library projections (see Appendix C) illustrate the difficulties of smoothing past changes. The P-spline age-cohort and P-spline age-period models can give very different results on the same data set. The basic Lee-Carter model performs little if any smoothing, so demonstrates the extent of the smoothing performed by the P-spline models. Figure 6-5 shows the results of applying the three models to the same data – in this case, the 2005 ONS data for females. The results from the two P-spline models show significant differences, especially in the recent trend.

Figure 6-5: Smoothed actual rates of change for the ONS data for females up to 2005
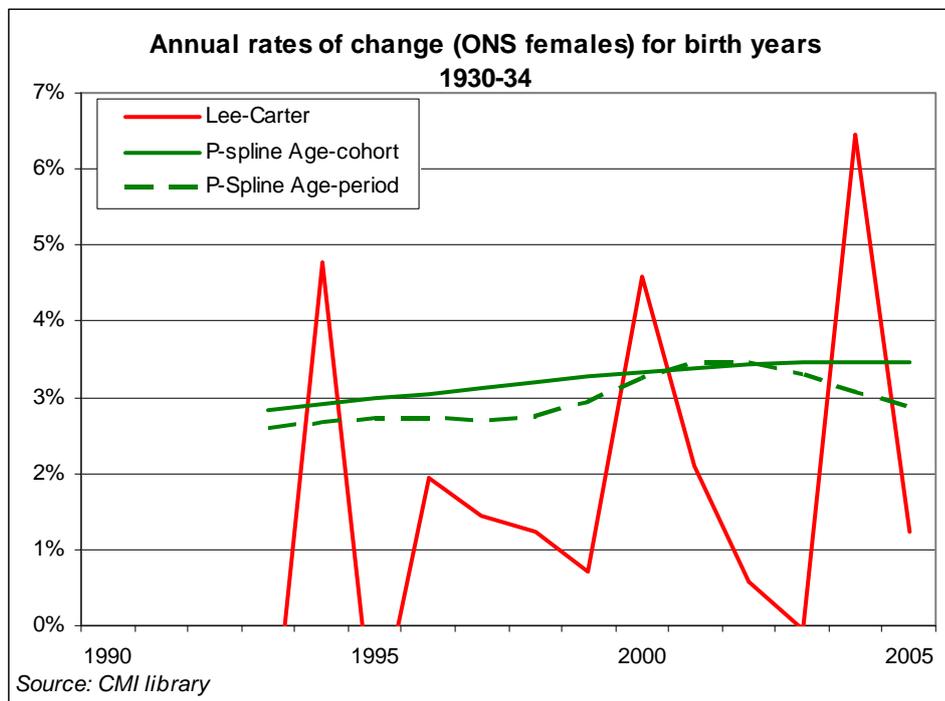
6.34   Figure 6-6 shows the results of applying the three models to the 2005 CMI data for males, and compares them to the results incorporated in the Interim Cohort projections. The two P-spline models produce similar results, but they are very different from those from the Interim Cohort projections, which used a different dataset.

Figure 6-6: Smoothed actual rates of change for the CMI data for males up to 2005

Annual rates of change (CMI males) for birth years 1930-34

Source: CMI library
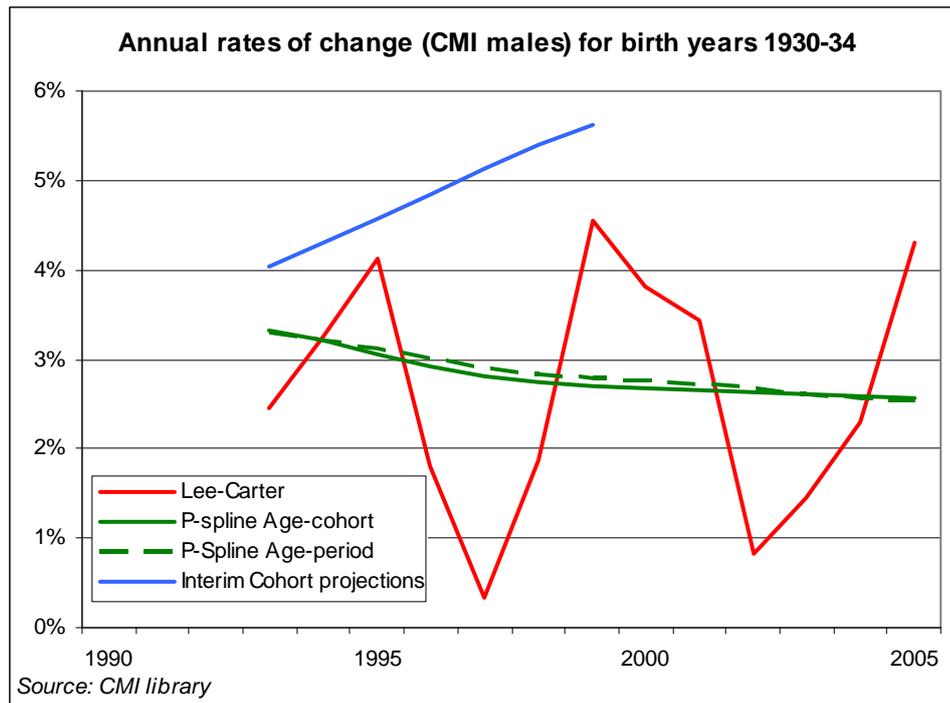
ASSUMPTIONS FOR SPECIFIC GROUPS OF LIVES

6.35   It is evident that deciding on assumptions for future changes in mortality is fraught with difficulty. There is no consensus on answers to any of the questions that are raised.

6.36   The difficulties encountered when modelling future changes are severe, and no single form of model has significant clear-cut advantages over the others. There is no widespread agreement on likely long term trends: whether indefinite improvements are possible, or whether a fixed maximum lifespan will mean that improvements eventually cease. There are also many differing views on the causes of the changes that have been seen in the past (see paragraphs 6.8 to 6.21).

6.37   The published projections that are available in the UK reflect the problems encountered when modelling future changes in mortality, by giving widely differing estimated outcomes (see paragraphs 6.25 to 6.31). This applies even to estimates of recent changes (see paragraphs 6.32 to 6.34).

6.38   Any assumptions for changes in future mortality will therefore inevitably be based on subjective judgements about the form of model, or published projections, that should be used. Moreover, although it is clear that mortality is likely to change in different ways for different groups of people, it is much less clear what the differences will be (see paragraphs 6.22 to 6.24). It is therefore impossible to rely on evidence-based judgements to differentiate between the future experience of small subgroups of the general population.

6.39   It is important that those making decisions should be aware of any reliance on subjective judgement. The BAS proposed in a previous consultation that its generic reporting standard should require a distinction between subjective and objective judgement when presenting justifications for assumptions (see [1]).

RISK AND UNCERTAINTY

6.40   The risks and uncertainties involved in modelling future changes in mortality are immense, arising from many sources (see paragraphs 3.7 to 3.15).

6.41   Because there is no way of telling what the future holds, there is no way of telling whether any model of future mortality changes will be borne out in practice. There is a wide range of models in use, with no consensus on the long term changes that can be expected. It is possible, though very unlikely, that one of the current models will prove to be accurate, but most of them will not.

6.42   For any given model, the parameters that are used may be very difficult to estimate. For example, paragraph 6.21 demonstrates how the addition of a single year of data can cause significant changes to the results produced by the P-spline model.

6.43   Many judgements must be made in the course of setting assumptions for future changes in mortality, each a possible source of error.

6.44   Finally, random variation is as significant as ever. The use of stochastic models can help to estimate the extent of this uncertainty, but their results are only as valid as the underlying model.

6.45   The magnitude of the uncertainty can be expressed by presenting a range in terms of summary statistics (see paragraphs 3.46 to 3.61). However, the range that is presented will inevitably be subjective. The use of scenarios can assist in communicating an assessment of the extent of the uncertainty.

6.46   It may be more useful to present the effects of uncertainty in mortality assumptions in terms of the impact on the overall result of the calculations. The impact of the uncertainty in future changes in mortality will be affected by the assumptions about base mortality rates. However, the uncertainty in the future mortality rates (rather than in either the base rates or in future changes) may be more important to the users of actuarial information.

REPORTING ON FUTURE CHANGES

6.47   As discussed in paragraphs 4.13 to 4.26, standards for future changes in mortality might take many different forms, ranging from reporting standards, through criteria that assumptions should meet, to limits on assumptions.

6.48   Paragraphs 6.51 to 6.58 below outline a number of possible requirements that could be imposed by reporting standards. Different requirements might be appropriate in different contexts, and the list of possibilities is not complete. The emphasis is on transparency and comprehensibility.

6.49   Reports would also be expected to comply with any applicable requirements requested by their intended recipients, or required by other regulators. For example, the Pensions Regulator has recently consulted on a number of issues connected with mortality assumptions (see [14]), and recommends the use of the CMI's naming convention for base mortality rates and future changes (see [8]).

6.50   Any applicable provisions in the BAS's generic reporting standard (expected to be consulted on in the next few months) would also apply to mortality assumptions.

Future changes

6.51   If the future changes in mortality are based on anything other than published projections, the following information should be given:

   a) An explanation of the model and the reasons for choosing it;

   b) The source of any data used in calibrating it;

   c) The estimated values of any parameters that were used; and

   d) The amount of experience (if any) and the reasons for considering it credible.

6.52   If the future changes in mortality are based on one or more published projections, the following information should be given:

   a) The published projection or projections that were used, and the reasons for choosing them;

   b) Any adjustments that were applied to the published projections, and the reasons for applying them; and

   c) Any approximations that were used, the reasons for considering them to be valid, and an assessment of the impact of the approximation.

Summary

6.53   The future changes in mortality should be described using appropriate summary statistics (see paragraphs 3.46 to 3.58) in order to facilitate comparisons between different sets of assumptions.

6.54   The assumed future mortality rates (ie, resulting from assumptions about both base rates and future changes) should be described using appropriate summary statistics (see paragraphs 3.46 to 3.58) in order to facilitate comparisons between different sets of assumptions.

6.55   The future changes in mortality should be compared to those that would result from the use of benchmark projections (see paragraphs 3.59 to 3.61).

6.56   If any action to mitigate mortality risk has been taken, such as reinsurance or the purchase of mortality swaps, the way in which the assumptions reflect the mitigation should be explained.

6.57   The sources, extent and impact of the risk and uncertainty in the assumptions about future changes in mortality should be described (see paragraphs 6.40 to 6.46).

6.58   A statement should be provided about whether the assumed future changes in mortality are a best estimate, a prudent assumption, or neither, together with reasons why they are so considered.

CRITERIA FOR FUTURE CHANGES

6.59   Standards might specify criteria that the assumed changes in future mortality, or the assumed future mortality rates (ie, resulting from assumptions about both base rates and future changes) should meet. Paragraphs 6.60 to 6.64 outline a number of possible criteria that might be

specified in standards. Different requirements might be appropriate in different contexts, and the following list is not complete.

6.60   Future changes in mortality should differentiate between the sexes.

6.61   Future changes in mortality should take both age and year of birth into account, in order to allow for possible cohort effects.

6.62   Future rates of change in mortality should generally exhibit a smooth progression between ages in the same calendar year, and between calendar years for the same age. Any exceptions should be identified and explained.

6.63   Future rates of change in mortality should generally exhibit a smooth progression from actual past rates of change.

6.64   Future mortality rates should generally exhibit a smooth progression between ages in the same calendar year, and between calendar years for the same age. They should exhibit plausible relationships between rates for different ages and sexes.

LIMITS ON FUTURE CHANGES

6.65   As explained in paragraphs 4.22 to 4.26, there are a number of difficulties associated with setting limits on mortality assumptions. In particular, the risk of setting limits that turn out to be misguided is especially significant for assumptions about future changes. As opinions on the future course of mortality are so varied, setting limits would almost inevitably rule out some assumptions based on well-founded reasoning.

6.66   The only area in which it might be possible or desirable to set limits would be in the area of what constitutes a prudent assumption. For example, there might be a requirement that a prudent assumption for annuity business or pensions should include some allowance for future improvements (as opposed to deterioration or no change) for at least a certain period. This would prevent the use of assumptions that assume that past improvements tail off in the near future.

For the reasons set out in this section, and especially in paragraphs 6.35 to 6.39, the BAS believes that there is no objective basis for differentiating the future changes in mortality likely to be experienced by a particular small group of lives from those likely to be experienced by the population as a whole.

Paragraphs 6.47 to 6.58 outline some possible standards for reporting on assumptions about future changes in mortality, Paragraphs 6.59 to 6.64 outline some possible standards specifying criteria that assumptions should meet, and paragraphs 6.65 to 6.66 explain why the BAS believes that standards setting limits for future changes would not be practicable, with one possible exception.

The BAS would like to know whether respondents agree that there is no objective basis for differentiating the future changes in mortality likely to be experienced by a particular small group of lives from those likely to be experienced by the population as a whole. If respondents disagree, the BAS would be interested in examples to the contrary, together with supporting evidence.

Views would also be welcomed on any of the possible requirements for reporting on assumptions about future changes in mortality, criteria that assumptions should meet, or limits that should be observed when setting assumptions. The BAS is particularly interested in

- **any practical problems that might arise in complying with them; and**

- **whether they would further the BAS's aim of increasing the transparency of assumptions and their comprehensibility to users of actuarial information.**

7   INVITATION TO COMMENT

QUESTIONS

7.1   The BAS invites the views of those stakeholders and other parties interested in actuarial practice who wish to comment on the content of this document. In particular the BAS would welcome views on the following issues:

  1 Do respondents have any views on the significance of the adverse effects that the over- or underestimation of future mortality may have on pension scheme members, scheme sponsors, life insurance policyholders and life insurance companies, as set out in section 2?

  2 The BAS has discussed some of the issues surrounding mortality assumptions in section 3. In that context:

   a) Do respondents have views on appropriate methods of communicating the extent and impact of the inherent uncertainty involved in mortality assumptions?

   b) Do respondents agree that the use of separate assumptions for base mortality and future changes in mortality, not taking the form of margins in other assumptions, would be desirable?

   c) Do respondents have views on appropriate methods of communicating the significance of assumptions, both in absolute terms and relative to that of other assumptions?

  3 Some proposals regarding the use of summary statistics and benchmarks in reporting on mortality assumptions are considered in section 3.

   a) Do respondents foresee any practical difficulties in communicating the assumptions about subsequent changes in mortality rates underlying life expectancy statistics?

   b) Do respondents have suggestions for summary statistics that can be used to describe changes in mortality rates?

   c) Do respondents think that the use of benchmarks is useful, and if so, should the development of standard benchmarks for future changes in mortality be encouraged?

  4 The BAS would welcome any general comments that respondents may have on the various possibilities for standards set out in section 4. In particular:

   a) Do respondents agree that the BAS should set some standards for mortality assumptions?

   b) Do respondents agree that reporting standards would play a significant role in increasing the transparency of assumptions and their comprehensibility to users of actuarial information?

   c) Do respondents have any comments on how to assess the likely impact of possible BAS standards for mortality assumptions?

5 In section 5 the BAS considers possible standards for assumptions about base mortality.

    a) Do respondents believe that it would be desirable for a BAS standard to require the use the most recent applicable published tables, taking into account both the communication problems and the practicality of setting a limit on the tables to be used?

    b) Do respondents have any comments on the proposals for possible requirements for reporting on assumptions about base mortality, criteria that assumptions should meet, or limits that should be observed when setting assumptions? Respondents are asked to focus on:

        • any practical problems that might arise in complying with them; and

        • whether they would further the BAS's aim of increasing the transparency of assumptions and their comprehensibility to users of actuarial information.

6 In section 6 the BAS considers possible standards for assumptions about future changes in mortality.

    a) Do respondents agree there is no objective basis for differentiating the future changes in mortality likely to be experienced by a particular small group of lives from those likely to be experienced by the population as a whole? If respondents disagree, the BAS would be interested in examples to the contrary, together with supporting evidence.

    b) Do respondents have any comments on the proposals for possible requirements for reporting on assumptions about future changes in mortality, criteria that assumptions should meet, or limits that should be observed when setting assumptions? Respondents are asked to focus on:

        • any practical problems that might arise in complying with them; and

        • whether they would further the BAS's aim of increasing the transparency of assumptions and their comprehensibility to users of actuarial information.

7.2   In addition to the specific questions listed above, the BAS invites respondents' views on any other aspects of possible standards for mortality assumptions in actuarial calculations. To ensure that the significance of their point is fully appreciated by the BAS, respondents are encouraged to indicate how their comments address the BAS's aim of increasing the transparency of assumptions and their comprehensibility to users of actuarial information.

RESPONSES

7.3   For ease of handling, we prefer comments to be sent electronically to **basmortality@frc.org.uk**.

Comments may also be sent in hard copy form to:

The Director
Board for Actuarial Standards
5th Floor, Aldwych House
71-91 Aldwych
London
WC2B 4HN

7.4   Comments should reach the BAS by **20 June 2008**.

7.5   All responses will be regarded as being on the public record unless confidentiality is expressly requested by the respondent. If you are sending a confidential response by e-mail, please include the word "confidential" in the subject line of your e-mail.

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A   GLOSSARY

A number of technical terms, or terms which may be unfamiliar to some readers, are used in this paper. The terms are usually explained when they arise in the paper. For additional reference purposes, they are listed below, together with an explanation of the meaning ascribed to them in this paper. **The BAS does not intend this glossary to serve as a reference source for interpreting other documents.**

"00" series	*Mortality tables* published by the *CMI* in 2006, based on experience from 1999-2002.
"92" series	*Mortality tables* published by the *CMI* in 1999, based on experience from 1991-1994.
Actuarial Profession	The collective term for the Institute of Actuaries and the Faculty of Actuaries.
Annuity	An arrangement through which a beneficiary receives regular payments during his or her lifetime. Annuities are often sold by life insurance companies.
Annuity rate	The price of an *annuity*, expressed in terms of the level of income bought by a fixed sum.
BAS	The Board for Actuarial Standards.
Base mortality	The *mortality rates* prevailing at a particular point in time, often the effective date of an actuarial calculation.
CMI	The Continuous Mortality Investigation of the *Actuarial Profession*.
Cohort effect	The effect seen when the rate of change in *mortality rates* depends on year of birth (see paragraph 3.6). It is sometimes used to refer to the observed phenomenon that *mortality improvements* are greater for those born in the 1920's and 1930's than for those born earlier or later.
Cohort life expectancy	*Life expectancy* calculated using changes to mortality rates that occur, or are expected to occur, after the date to which the life expectancy applies. Compare *period life expectancy*.
Deferred annuity	An *annuity* in which there is a delay (the period of deferment) between the date at which the *annuity* is bought and the date at which the payments to the beneficiary start.

Defined benefit pension scheme	A pension scheme in which the contribution rates are adjusted in order to provide sufficient funding for the benefits, which are defined under the terms of the scheme.
Defined contribution pension scheme	A pension scheme in which the benefits provided depend on the amount of accumulated contributions. The contribution rates are defined under the terms of the scheme.
Embedded value	The sum of the net assets and the present value of the profit stream expected from policies already in force for a life insurance company.
Expectation of life	Another term for *life expectancy*.
FRC	The Financial Reporting Council, the UK's independent regulator responsible for promoting confidence in corporate reporting and governance. The *BAS* is an operating body of the FRC.
FSA	The Financial Services Authority.
GAD	The Government Actuary's Department.
GN	Guidance Note. The *BAS*'s GNs were originally issued by the *Actuarial Profession*.
Graduation	The process of smoothing *mortality rates* (see paragraph 3.31).
Guaranteed annuity option	A guarantee that at the termination of a life insurance policy the policyholder will be able to convert the lump sum proceeds of the policy into an *annuity* at a rate at least as good as a minimum rate that is set at the time of the inception of the policy.
Interim Cohort projections	Projections of future changes in *mortality rates* published by the *CMI* in 2002 (see paragraph C.4). The projections assume that the *cohort effect* for lives born in the years around 1926 will continue for varying periods.
Investment product	A life insurance product with the primary purpose of providing investment returns to the policyholder.
Lee-Carter	An extrapolative model for projecting *mortality rates* (see paragraph C.19).
Life expectancy	The average number of years before death, calculated for a person of a given age at a specific date. See also *cohort life expectancy* and *period life expectancy*.
Long Cohort	One of the *Interim Cohort projections*, in which the *cohort effect* is assumed to last until 2040.

Longevity	Sometimes used as a synonym for *life expectancy*, but more often has connotations of greater *mortality improvements* (hence longer life) than expected.
Medium Cohort	One of the *Interim Cohort projections*, in which the *cohort effect* is assumed to last until 2020.
Modelling error	The difference between model outcomes and actual outcomes caused by the fact that the model is not an accurate reflection of reality (see paragraph 3.11).
Mortality improvement	A reduction in *mortality rates*, meaning that people live longer than before. Mortality improvement is usually expressed as the percentage difference between the mortality rate for a specified age in a given year and the rate for the same age in the previous year.
Mortality table	A set of *mortality rates* and associated factors tabulated by age.
Mortality rate	The number of people that die in a year expressed as a proportion of the number of people alive. The initial mortality rate uses the number of people alive at the start of the year; the central mortality rate uses the average number of people alive during the year.
ONS	The Office for National Statistics.
P-spline	The penalised spline model, which is an extrapolative model for projecting *mortality improvements* (see paragraph C.16).
Parameter error	The difference between model outcomes and actual outcomes caused by the fact that estimated values of model parameters are not the same as the theoretical values (see paragraph 3.12).
Period life expectancy	*Life expectancy* calculated using the mortality rates prevailing at a specific date. Compare *cohort life expectancy*.
Process error	The difference between model outcomes and actual outcomes caused by the fact that actual outcomes incorporate random variation (see paragraph 3.14).
Protection product	A life insurance product, such as *term insurance*, whose primary purpose is to pay benefits on the occurrence of specified events.
Risk	Possible outcomes whose probability of occurrence can be mathematically quantified (see paragraphs 3.7 to 3.9). Compare *uncertainty*.

Short Cohort	One of the *Interim Cohort projections*, in which the *cohort effect* is assumed to last until 2010.
Surrender value	A lump sum paid to a life insurance policyholder in lieu of all future benefits under the policy.
Term insurance	A life insurance policy which pays the sum insured on the death of the policyholder within a specified period.
Transfer value	A lump sum paid by a pension scheme in respect of a member, in lieu of all future benefits in that scheme.
Uncertainty	Possible outcomes whose probability of occurrence cannot be mathematically quantified (see paragraphs 3.7 to 3.9). Compare *risk*.
Underpin	A lower limit applied to rates of *mortality improvement*.

B SIGNIFICANCE OF MORTALITY ASSUMPTIONS

B.1 The BAS has performed some simple analysis in order to investigate the relative significance of mortality assumptions in different calculations. We have looked at three simple actuarial functions – for a deferred annuity, an annuity in payment, and an annuity in payment with a contingent dependant's annuity – and compared the effects of varying several of the assumptions. The result of each variation is then expressed as the change in discount rate that would have the same effect (see [19]).

B.2 We have also looked at the effect of the variation on the annuity value, as a percentage change.

B.3 The simplistic assumptions used for these calculations are purely illustrative, and are not suitable for any practical application.

B.4 A base discount rate of 6% nominal (2.5% real) was used for all calculations. We investigated the effect of changing this, and found that the absolute level of the discount rate made little difference to the results.

B.5 The values for which assumptions were made are shown in Table B-1.

Table B-1: Assumptions used in calculations

Assumption	Explanation
Discount rate	Discount rate used for all future years
Inflation rate	Inflation rate applied to all annuities in deferment and in payment
Base mortality rates for 2008	Mortality rates assumed to be current for 2008
Future changes in mortality	Annual rates of change in mortality rates for all years from 2009 onwards
Age	Age in 2008

B.6 The variations on the base assumptions that were analysed for each function are shown in Table B-2. The variations affect only the assumption that is indicated. For example, the second variation rates the base mortality rates down by three years, but no age rating is applied to the future changes.

B.7 The variations in the assumptions for base mortality represent the types of adjustments that are often made to published mortality tables.

B.8 Of the variations in the assumptions for future changes, Medium and Long Cohorts, and Long Cohort with a 1.5% underpin represent assumptions used by at least some practitioners. The BAS does not believe that constant improvements are in widespread use, though it is claimed that broadly the same effect is gained from the use of a margin in the discount rate (see paragraphs 3.26 to 3.30). As far as the BAS is aware, the ONS projections are used mainly within government, and the P-spline projection is not widely used.

Table B-2: Variations used in calculations

Variation	Description	Assumption	Change
1	80% base rates	Base mortality rates for 2008	Mortality rates for the base assumptions multiplied by 80%
2	Base rates – 3 years	Base mortality rates for 2008	Age taken to be 3 years less than actual age
3	LC with 1.5% underpin	Future changes in mortality	Long Cohort projection with 1.5% underpin
4	Constant 2% improvement	Future changes in mortality	Constant annual reduction in mortality rates of 2% for all ages and calendar years
5	ONS 2006 improvement	Future changes in mortality	2006 ONS projection, for males or females as appropriate
6	P-spline improvement	Future changes in mortality	P-spline age-cohort projection, based on 2005 ONS data for EWNI males or females as appropriate
7	No improvement	Future changes in mortality	No changes in future mortality
8	Medium Cohort	Future changes in mortality	Medium Cohort projection

DEFERRED ANNUITY

B.9   Deferred annuity functions for both males and females were analysed. The base assumptions are shown in Table B-3.

Table B-3: Assumptions used for deferred annuity

Assumption	Value for males	Value for females
Discount rate	6%	6%
Inflation rate	3.5%	3.5%
Base mortality rates for 2008	RMD00 in deferment, IML00 in payment	RFD00 in deferment, IFL00 in payment
Future changes in mortality	Long Cohort projection	Long Cohort projection
Age	45 in 2008, 65 when annuity commences payment	45 in 2008, 60 when annuity commences payment

B.10   The variations that were analysed in addition to those shown in Table B-2 are shown in Table B-4, and the results in Tables B-5 and B-6.

Table B-4: Variations used for deferred annuity

Variation	Description	Assumption	Change
9	Early payment	Age at which annuity commences payment	5 years younger than base assumptions
10	Late payment	Age at which annuity commences payment	5 years older than base assumptions

Table B-5: Results for deferred annuity (males)

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.24%	7.36%
2	Base rates – 3 years	-0.33%	10.52%
3	LC with 1.5% underpin	-0.19%	5.87%
4	Constant 2% improvement	-0.23%	7.23%
5	ONS 2006 improvement	-0.08%	2.58%
6	P-spline improvement	-1.32%	49.77%
7	No improvement	0.56%	-15.26%
8	Medium Cohort	0.14%	-4.00%
9	Early payment	-0.92%	32.02%
10	Late payment	1.09%	-27.54%

Table B-6: Results for deferred annuity (females)

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.16%	4.62%
2	Base rates – 3 years	-0.26%	7.51%
3	LC with 1.5% underpin	-0.16%	4.65%
4	Constant 2% improvement	-0.20%	5.78%
5	ONS 2006 improvement	-0.07%	1.97%
6	P-spline improvement	-0.67%	20.61%
7	No improvement	0.38%	-9.86%
8	Medium Cohort	0.11%	-3.11%
9	Early payment	-0.85%	26.89%
10	Late payment	0.95%	-22.75%

B.11 For both males and females, changes in the date at which the deferred annuity becomes payable can be highly significant. The variations in future changes in mortality cover a wider range than the variations in base mortality.

ANNUITY IN PAYMENT

B.12   Immediate annuity functions for both males and females were analysed. The base assumptions are shown in Table B-7, and the results in Tables B-8 and B-9.

Table B-7: Assumptions used for annuity in payment

Assumption	Value for males	Value for females
Discount rate	6%	6%
Inflation rate	3.5%	3.5%
Base mortality rates for 2008	IML00	IFL00
Future changes in mortality	Long Cohort projection	Long Cohort projection
Age	65 in 2008	60 in 2008

Table B-8: Results for annuity in payment (males)

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.61%	6.93%
2	Base rates – 3 years	-0.87%	10.09%
3	LC with 1.5% underpin	-0.12%	1.27%
4	Constant 2% improvement	0.01%	-0.09%
5	ONS 2006 improvement	-0.19%	2.02%
6	P-spline improvement	-1.16%	13.76%
7	No improvement	0.88%	-8.77%
8	Medium Cohort	0.39%	-4.02%

Table B-9: Results for annuity in payment (females)

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.32%	4.43%
2	Base rates – 3 years	-0.55%	7.74%
3	LC with 1.5% underpin	-0.14%	1.94%
4	Constant 2% improvement	-0.12%	1.62%
5	ONS 2006 improvement	-0.11%	1.43%
6	P-spline improvement	-0.75%	10.77%
7	No improvement	0.57%	-7.13%
8	Medium Cohort	0.24%	-3.12%

B.13   Again, the variations in future changes in mortality cover a wider range than the variations in base mortality.

ANNUITY IN PAYMENT WITH DEPENDANT'S ANNUITY

B.14   We analysed an annuity in payment, with a dependant's annuity that becomes payable when the annuitant dies. We looked at males (with a female dependant) and females (with a male dependant). The base assumptions are shown in Table B-10.

Table B-10: Assumptions used for annuity in payment with dependant

Assumption	Value for males (with female dependant)	Value for females (with male dependant)
Discount rate	6%	6%
Inflation rate	3.5%	3.5%
Base mortality rates for 2008	IML00 for annuitant, IFL00 for dependant	IFL00 for annuitant, IML00 for dependant
Future changes in mortality	Long Cohort projection	Long Cohort projection
Age	65 in 2008 for annuitant, 62 in 2008 for dependant	60 in 2008 for annuitant, 63 in 2008 for dependant
Proportion of annuity to dependant	50%	50%

B.15   The variations that were analysed in addition to those shown in Table B-2 are shown in Table B-11, and the results in Tables B-12 and B-13.

Table B-11: Variations used for annuity in payment with dependant

Variation	Description	Assumption	Change
11	Smaller age difference	Age	Age difference between annuitant and dependant reduced by 2 years
12	Larger age difference	Age	Age difference between annuitant and dependant increased by 2 years

B.16   As before, the variations in future changes in mortality cover a wider range than the variations in base mortality. The assumption about the age difference between the annuitant and dependant appears to be more significant for male annuitants with female dependants than for female annuitants with male dependants.

Table B-12: Results for annuity in payment (males) with female dependant

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.44%	5.58%
2	Base rates – 3 years	-0.63%	8.20%
3	LC with 1.5% underpin	-0.14%	1.68%
4	Constant 2% improvement	-0.06%	0.73%
5	ONS 2006 improvement	-0.14%	1.71%
6	P-spline improvement	-1.02%	13.75%
7	No improvement	0.73%	-8.31%
8	Medium Cohort	0.34%	-4.00%
11	Smaller age difference	-0.15%	1.85%
12	Larger age difference	0.15%	-1.78%

Table B-13: Results for annuity in payment (females) with male dependant

Variation	Description	Equivalent change in discount rate	Percent change in annuity value
1	80% base rates	-0.31%	4.30%
2	Base rates – 3 years	-0.49%	6.99%
3	LC with 1.5% underpin	-0.15%	2.06%
4	Constant 2% improvement	-0.12%	1.72%
5	ONS 2006 improvement	-0.10%	1.42%
6	P-spline improvement	-0.85%	12.66%
7	No improvement	0.57%	-7.32%
8	Medium Cohort	0.25%	-3.38%
11	Smaller age difference	0.05%	-0.69%
12	Larger age difference	-0.06%	0.79%

C PUBLISHED PROJECTIONS OF FUTURE CHANGES IN MORTALITY

INTRODUCTION

C.1 The CMI library (see [8]) contains 54 projections of future changes in mortality. It uses a standard format, giving factors that practitioners can apply directly to base mortality rates. The inclusion of a projection in the library is not intended to imply that it is suitable for use in any practical application, and the library explicitly states that it is the users' responsibility to ensure that any projection they use is appropriate for the purpose to which they are putting it.

C.2 However, the CMI library is, as far as the BAS is aware, the source of most of the projections that are actually used by practitioners. This appendix gives brief descriptions of most of the projections that it contains (projections that illustrate how to apply adjustments to other projections in the library are omitted). The BAS believes that it is important that practitioners understand the drawbacks as well as the advantages of any projections that they use.

"92" series and Interim Cohort projections

C.3 When the CMI published the "92" series tables in 1999, they included a projection of future mortality changes (which in fact were all improvements). The projection was based on male assured lives. No projection was produced for females.

C.4 Within a very few years it became obvious that mortality rates were improving much faster than anticipated in the "92" series original projections. In addition, clear evidence for the cohort effect was emerging. In particular, the experience of those born in the years around 1926 was significantly better than those born in earlier or later years.[7] In 2002 the CMI published the "Interim cohort projections", which were intended as interim and ad hoc adjustments to the "92" series projections (see [4]). They were based on smoothed actual rates of improvement in the period 1993-99 and projected future rates of improvement for the cohort born in the years around 1926, and the original "92" series projections for those outside that cohort.

C.5 Because of the uncertainties involved in projecting future mortality changes, the CMI believed that it was not appropriate to publish a single projection. Instead, they published three, known as the Short, Medium and Long Cohort projections. For those born in the years around 1926, the cohort effect was assumed to diminish over a period of years, so that, for the Short Cohort projection, changes in future mortality rates return to the "92" series level by 2010. For the Medium Cohort projection the changes return to the "92" series level by 2020, and by 2040 for the Long Cohort projection.

C.6 Again, no projections were produced for females. It appears that, in the past, mortality has changed at different rates for males and females, so the Interim

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[7] The cohort effect in the CMI data is centred around those born in earlier years than that in the ONS data, which is centred on 1931.

Cohort projections may be unsuitable for use as assumptions for future changes in mortality for females, at least in their unadjusted state.

C.7 Figure C-1 shows the projected changes for those born in the years 1930-34. The projections for those born in the years 1960-64 are shown in Figure C-2. Note that in the latter case the Interim Cohort projections are exactly the same as the "92" series projections, as the lives were born many years after 1926.

Figure C-1: "92" series and Interim Cohort projections projected annual rates of change in mortality rates for birth years 1930-34
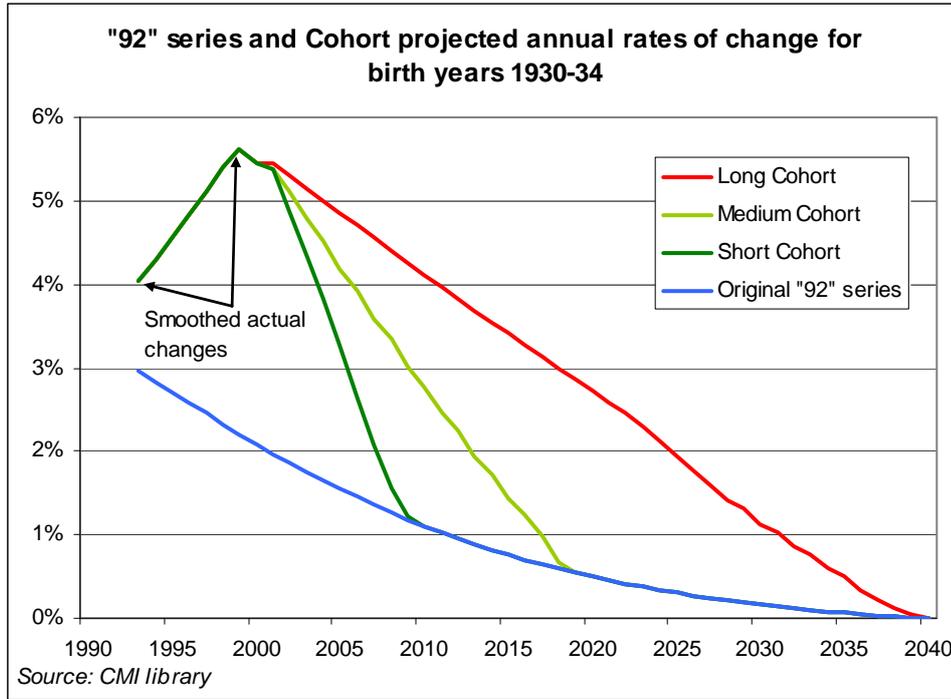
Figure C-2: "92" series and Interim Cohort projections projected annual rates of change in mortality rates for birth years 1960-64
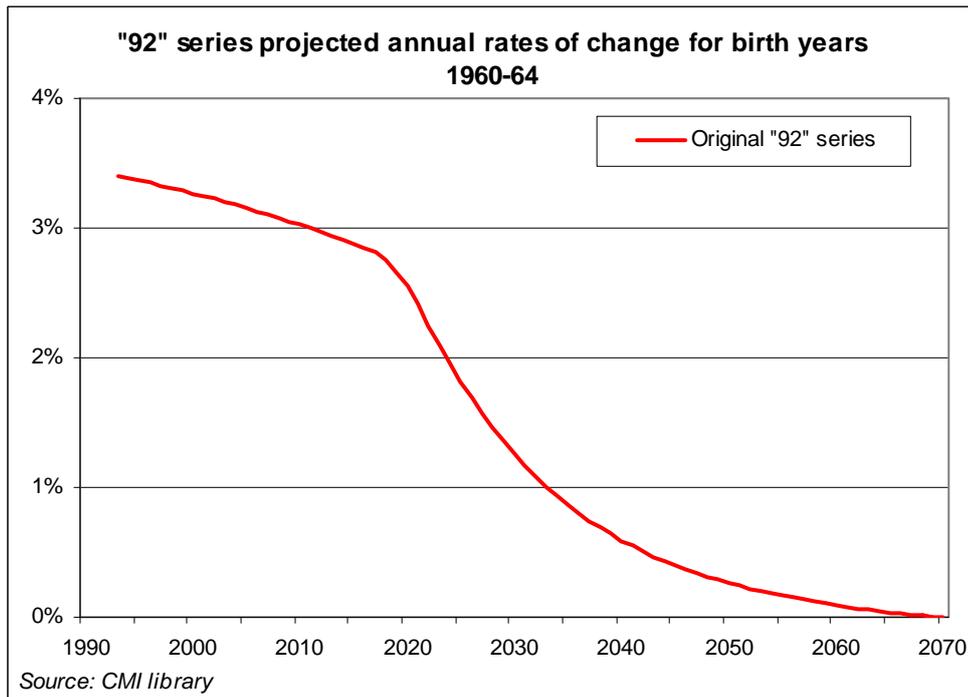
C.8   The charts show that both the Interim Cohort projections and the original "92" series projections assume rapid decreases in rates of improvement at some stage, whether as a result of a diminishing cohort effect or not.

ONS projections

C.9   Recent ONS mortality projections involve interpolation between assumed recent rates of mortality improvement and assumed long term rates of improvement. The assumed long term rates, the period over which recent rates converge to the long term rates, and the pattern of convergence, are all determined by the ONS after consultation with an external expert panel, the offices of the three Registrars General and users of the projections. The overall methodology has been the same for some years, but the assumptions are updated for each projection (which are usually published every two years).

C.10   The ONS published new mortality projections in 2007 (the 2006-based projections), based on data to 2005, and using revised assumptions. The principal projection gives a cohort life expectancy of 25 years for a 65 year old in 2050. The previous estimate, based on data to 2004, was 23.6 years. Over the course of two years, the estimate changed by nearly 18 months.

C.11   The general methodology is to assume that the annual rates of improvement will converge to assumed reductions in mortality rates[8] in the 25th year of the projections. Improvement rates in the first 25 years of the projection are assumed to make a smooth transition from current (estimated) rates to these rates. Assumptions are also made about changes in mortality rates after the 25th year of the projections; currently it is assumed that the rate of improvement will remain constant. The pattern of convergence from the current rates to the assumed long term rates varies by birth year for those born before 1960.

C.12   Some of the details in the assumptions were changed between the 2004-based and 2006-based projections. For the 2004-based projections the long term annual rates of improvement were the same for all ages and birth years from 2029. For the 2006-based projections, it is assumed that the mortality experience of those born during the period 1923-1940 will continue to improve more rapidly than that of those born outside that period. This is a significant change and reflects some of the criticisms that had been made about previous projections. There is currently no evidence that the differentials exhibited by this cohort are declining, and similar cohort effects seen in other countries suggest that they may well persist into the oldest ages. In the 2006-based projections, the long term fixed rates of improvements after 2031 vary by year of birth, and are higher for those born during the period 1923-1940 (and lower for those born in 1911 and earlier) than for others. The assumed short term rates of improvement are generally higher for the 2006-based projections than for the 2004-based projections, because mortality improvements were greater than expected in the years 2005 and 2006.

C.13   In 2005, the Pensions Commission and Government Actuary's Department (GAD) compared earlier mortality forecasts to actual outcomes and more recent forecasts. They found that the actual mortality rate for 65 year old

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[8] The ONS uses the central mortality rate, which expresses the number of deaths as a proportion of the average number of people alive over the year.

males in 2003 was around 41% lower than had been predicted by GAD forecasts in 1984, only 20 years earlier. In the past couple of decades, most projections produced by the ONS (and by the GAD before them) have shown higher mortality improvements than the preceding projection.

C.14 The ONS produces projections for the UK and constituent countries. The same rates of mortality improvement are used for males in England, Wales and Northern Ireland, and a slightly different set for males in Scotland. The same rates of improvement are used for females in each of the countries. The most recent projections, based on data to 2006, show quite significant changes from the previous ones, based on data to 2004. Figure C-3 shows the projected changes for those born in the years 1930-34. The projections for those born in the years 1960-64 are shown in Figure C-4.

C.15 The 2004 projections for males in Scotland differed very little from those for males in England, Wales and Northern Ireland. The difference was slightly more pronounced in the 2006 projections, especially at younger ages. The effects of the convergence of improvement rates to assumed long term rates after 25 years can clearly be seen.[9]

Figure C-3: ONS projected annual rates of change in mortality rates for birth years 1930-34

ONS projected annual rates of change for birth years 1930-34

2004 EWNI Males	2006 EWNI Males
2004 Scottish Males	2006 Scottish Males
2004 UK Females	2006 UK Females

Source: CMI library

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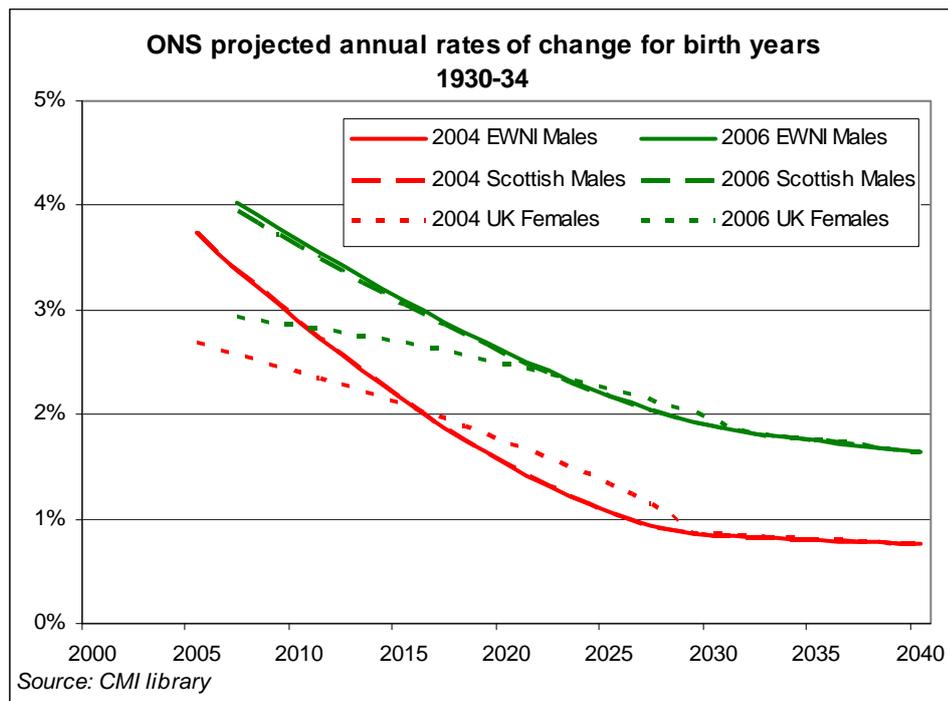
[9] Note that the long term constant rates of improvement are in terms of *central* mortality rates, which express deaths as a proportion of the average number of people alive over the year. The graphs show improvements in *initial* mortality rates, which express deaths as a proportion of the number of people alive at the beginning of the year. A constant rate of improvement in central mortality rates actually means a slightly decreasing rate of improvement in initial mortality rates as mortality rates increase with age.

Figure C-4: ONS projected annual rates of change in mortality rates for birth years 1960-64
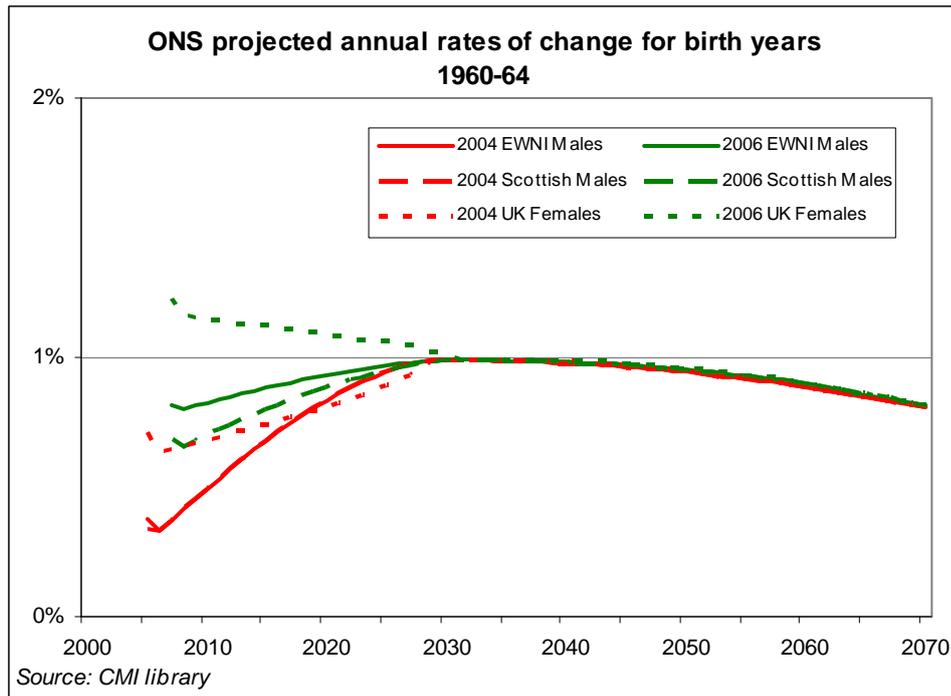
P-spline projections

C.16 The penalised spline model (often known as P-spline) is a stochastic parametric smoothing model. It was originally developed as a method of smoothing, or graduation. It can be applied to mortality data in (at least) two ways – to either age-cohort data (ie, death rates classified by age at death and year of birth) or age-period data (ie, death rates classified by age at death and calendar year of death). The CMI library contains P-spline projections based on data from the ONS for males and females, and on data from the CMI (covering assured lives) for males. Both age-period and age-cohort projections are included.

C.17 Figure C-5 shows the projected changes for those born in the years 1930-34, based on data up to 2005. The projections for those born in the years 1960-64 are shown in Figure C-6. The charts show smoothed actual changes up to 2005, and projections thereafter.

C.18 The charts show no clear consistent relationship between the age-cohort and age-period models, and also demonstrate how the smoothing of actual changes varies between the models. For both sets of birth years, the long term projected improvements for males using the age-cohort model based on ONS data are much higher than other projections.

Figure C-5: P-spline projected annual rates of change in mortality rates based on data up to 2005, for birth years 1930-34
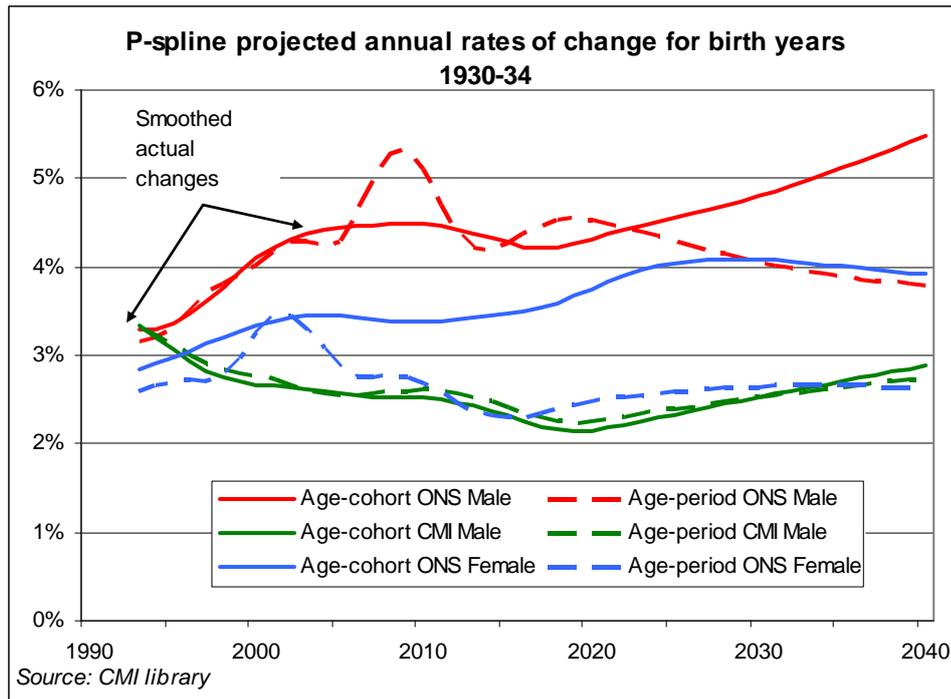
Figure C-6: P-spline projected annual rates of change in mortality rates based on data up to 2005, for birth years 1960-64
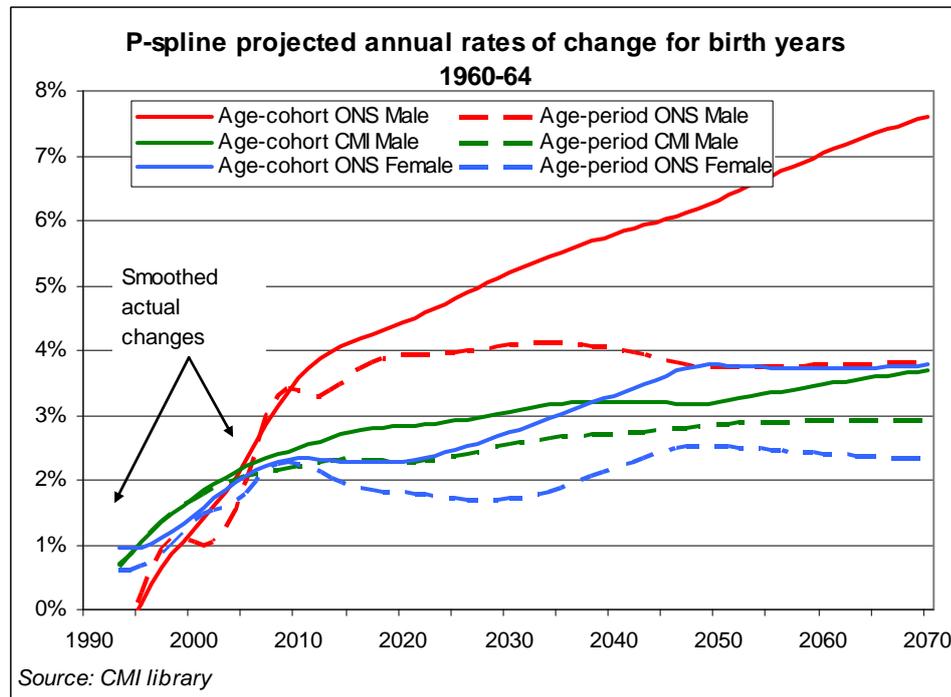
Lee-Carter projections

C.19   The Lee-Carter model is a stochastic time series model that has been successfully applied to US and other mortality data (see [11]) and has become the demographic benchmark method for projecting mortality rates. However, the basic model has been much less successful when applied to UK data, largely because it smoothes out the cohort effect. There is a modified version

of the Lee-Carter model (known as Lee-Carter APC, for Age-Period-Cohort) that does allow for cohort effects (see [15]).

C.20 The CMI library contains projections using the basic Lee-Carter model based on data from the ONS for males and females, and on data from the CMI (covering assured lives) for males.

Figure C-7: Lee-Carter projected annual rates of change in mortality rates based on data up to 2005, for birth years 1930-34
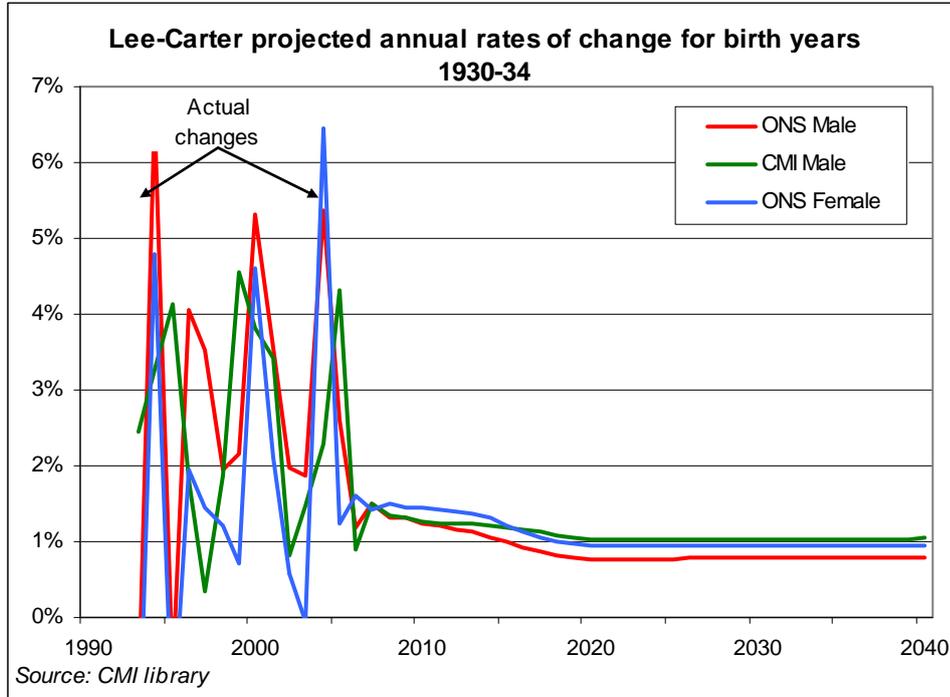
Figure C-8: Lee-Carter projected annual rates of change in mortality rates based on data up to 2005, for birth years 1960-64
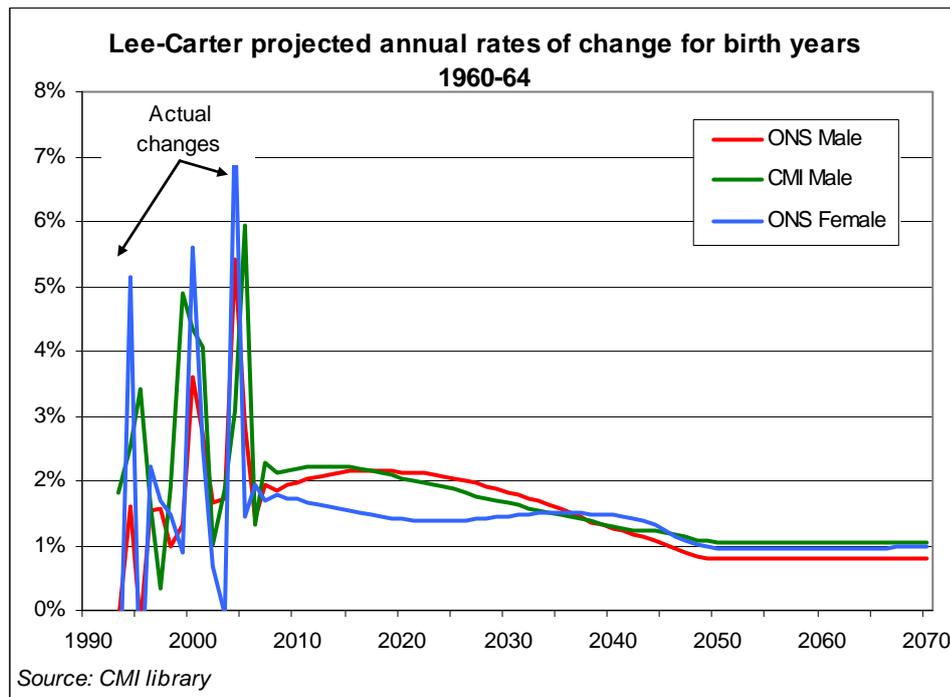
C.21   Figure C-7 shows the projected changes for those born in the years 1930-34, based on data up to 2005. The projections for those born in the years 1960-64 are shown in Figure C-8. The charts show smoothed actual changes up to 2005, and projections thereafter. The basic Lee-Carter model does not smooth rates by calendar year in the data to the same extent as the P-spline model, as is apparent from the charts, although there are other versions of the model that do smooth the data.

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