

Longevity Risk Quantification and Management:  
A Review of Relevant Literature

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## I. Executive Summary

One of the largest and least understood risks that insurance and reinsurance companies, pension plan sponsors, and the government are exposed to is longevity risk. Longevity risk from the perspective of an insurance company or defined benefit plan sponsor is the exposure that a company has to unexpected decreases in mortality. This is the opposite of mortality risk, which is exposure to increases in mortality. Longevity risk has developed as experience emerges about the consistent increase in life expectancy, combined with the long term nature of many guarantees that insurance companies have written. It is a risk that is often overlooked, as evidenced by the fact that the current RBC capital formula in the US omits longevity risk from the calculation of insurance risk. Typically, risk discussions only reflect the risk of higher than expected mortality – very rarely is the risk of lower than expected mortality discussed.

This paper is a literature review of available papers, publications, articles, and presentations on the topic of longevity risk. It is intended to be a resource for actuaries and other professionals interested in learning more about this area. Two appendices accompany this paper. Appendix A contains the papers that were referred to and reviewed for the body of this report. Appendix B contains references to other relevant papers that may be of interest to the readers. We encourage readers to review the referenced papers for additional details on any of the points raised within this document.

Some of the key findings of this research are discussed below.

Almost every nation throughout the world is seeing the life expectancy of their population increase due to factors including better diet, increased access to adequate amounts of food and basic healthcare, and advances in medicine. With concurrent declines in fertility rates, many countries are witnessing a demographic shift towards a ‘graying’ population, where the number of people in retirement is rapidly catching up with the number of people in the workforce. All across the globe this is putting strains on existing retirement systems, and leading to a shift in the risk from employers and plan sponsors to individuals.

While most of the trends indicate future life expectancy increasing, there are schools of thought that argue a potential reversal of recent trends. The biggest social issue leading to this conclusion is the dramatic increase in obesity over the past several decades. The widely differing views on future mortality trends indicate that there is a great deal of uncertainty regarding mortality improvement, leading to an ever greater need for action by the industry to understand the fundamental drivers of longevity risk.

One thing is certain, life expectancy today is greater than at any point in history. Many population trends indicate that there is no reason to believe that the short term trends will be any different. Longer life expectancies lead to increased longevity risk from those institutions that have made guarantees based on the entire lifetime of individuals. This includes many insurance companies, as well as government sponsored plans such as Social Security, and also private pension plans.

Historically, retirement programs in the US shifted much of the responsibility for funding retirement to employer based pension plans. These defined benefit plans promised to pay employees over their entire lifetime; therefore eliminating much of the need for retail based guaranteed income products. However, more recent trends indicate that there are fewer and fewer companies offering defined benefit plans to their employees. Because of this, individuals are turning to the retail market to find available solutions to help them manage their own risk of outliving their assets.

As individuals start to look to the retail market to find solutions to help them manage their own personal longevity risk, they are faced with many potential products. Many of these shift the responsibility of providing lifetime income from the individual to the institution selling the product, typically insurance companies. While all of the products discussed in this report offer a guaranteed income stream, there is a wide range of product features and restrictions that have a direct impact to the amount of income one can generate from a given lump sum.

One of the more traditional product options available to individuals is a single premium immediate annuity (“SPIA”). Many experts believe this product is the most efficient way to protect against individual longevity risk. However, that efficiency comes at the cost of liquidity to potential customers as they must give up control of some of their assets in exchange for the promise of protection. The industry has moved to address these objections in the past 10 years. As a result, the market has been flooded with new products designed to provide individuals with income guarantees without giving up full control of their assets. The most popular of these products has been the variable annuity with a guaranteed minimum withdrawal benefit.

The dynamics of greater life expectancy and fewer employer sponsored guarantees has started to drive the sales of guaranteed income products. This is resulting in insurance companies either knowingly or unknowingly taking on a significant amount of longevity risk. Similarly, due to the increasing life expectancy, employer sponsored pension plans face an increasing risk.

Longevity risk should be examined as two separate components – systematic and specific risk. Systematic risk results from incorrect assumptions about the base mortality rate and level of mortality improvement. Specific risk comes from the normal volatility that occurs around any best estimate assumption. While it is possible to diversify much of the specific risk, given the specific risk profile of some exposures it may not be possible to eliminate. Systematic risk can not be diversified away, and needs to be quantified and managed.

The current methods for quantifying longevity risk are overly simplistic, and typically rely on applying shocks to standard mortality tables (e.g. decreasing all mortality rates by 15%). Even the expectations of the base assumption of mortality improvement are heavily dependent on subjective assumptions, and need to be evaluated as such. To date, there has been very little development in advanced modeling techniques to allow for sufficient measurement of this risk.

One of the reasons contributing to the lack of sophisticated quantification in the US is a shortage of data on the insured population. The Society of Actuaries performs periodic insured mortality studies; however the participation is dominated by select industry players. As such, there is still a significant amount of data that is not collected. The

most complete data set in the US comes from Census reports. However, these data are for the general population, which has different mortality characteristics than the insured population and may not be appropriate for use in the quantification of mortality risks and longevity risks.

In the UK, the Continuous Mortality Investigation Bureau (CMIB) is responsible for collecting data on insured lives. As a result, much of the development and research on rate of mortality improvement has been completed in the UK market. Some of the key findings from the UK include the identification of a cohort effect. The analysis on this has shown that there are different rates of mortality improvement depending on which year the individual was born. This information can help the UK insurers to more accurately estimate the future mortality improvement, and therefore have a better estimate of their exposure to longevity risk. In fact, in the UK companies disclose their exposure to longevity risk.

Current longevity risk management techniques in the US market are limited, and consist primarily of traditional methods such as natural hedging and reinsurance. Natural hedging refers to companies that are exposed to both increases and decreases in mortality. Since long-term improvement assumptions are generally thought to apply to the entire population, a decrease in mortality will hurt payout annuity products while improving the profitability of traditional life insurance products. Because of this, companies with well diversified life and annuity lines of business have lower overall exposure to one-directional changes in mortality.

Given the limited ability to quantify longevity risk in the US, the markets are not as efficient as they are for traditional mortality risk. This is true for both reinsurance and capital market solutions. There has been an attempt in recent years to shift longevity risk to the capital markets through swaps tied to mortality indices. To date, there have been limited deals performed in the US. However the UK has seen some recent market activity. For defined benefit plan sponsors not able or willing to assume the increasing longevity risk, a market has started to develop for buyouts of their obligations. This market is in its infancy in the US, but is much more developed in the UK.

In times of high market volatility, Wall Street is likely to try and obtain investments with little to no correlation to their existing invested assets. Therefore, the market for longevity risk is likely to increase and more efficient methods of transferring this risk are likely to emerge during these times.

There is a significant need for future developments in both the quantification and management of longevity risk. With the market dynamics driving individuals to transfer their own personal risk, the exposure that insurance companies and plan sponsors have will continue to grow. Advances in stochastic modeling of non-financial risks, combined with better data on the insured population will help to increase the efficiency of risk management solutions available in the market.

In order for the US to be able to make better assumptions and predictions about future mortality, more data needs to be collected on the improvement of the insured population. Only then will the industry be able to better estimate the amount of longevity risk that they are exposed to.

## II. Background

Longevity risk is becoming increasingly significant for a range of stakeholders, from individuals to employees, insurers, reinsurers and the government. A substantial amount of research has already been carried out covering many facets of longevity risk from a variety of viewpoints. This paper is structured as a literature review, and examines, summarizes, compares and contrasts existing studies, industry surveys, articles and research papers on the topic of longevity risk.

This paper is intended to educate actuaries and other interested parties on the exposure to longevity. This includes topics ranging from emergence and quantification of longevity risk, as well as the current and future risk management techniques. It will also include the products currently in the market that are exposed to longevity risk. This paper will not go into any topic area in significant detail; rather it will refer the reader to a number of particularly relevant papers.

While this report principally focuses on the US market, we also look to other geographies where the insurance market is developed to a comparable or more advanced level and comment on key similarities and differences, particularly where such differences might lead to equivalent US market developments in the future.

The report is split into the following sections.

In Section III we will look at the research that has been performed around historical improvements in mortality, and the schools of thought on how mortality improvement is likely to continue into the future. As part of this review we will examine the differences and similarities between the US and other countries.

Section IV covers how retirement markets have developed. This will include comment on how the regulatory environment has played a role in the direction the market has moved, and will explore the key differences between the US market and other geographies with mature retirement markets.

Section V looks at longevity from the perspective of the individual exposed to this risk and ways in which individuals can manage their own risks.

In Section VI we provide a summary of the products that currently exist that are exposed to longevity risk. We also consider other risks that these products are exposed to, as often longevity is of second order to market or inflation risk. This section will discuss how these products are affected by continuous mortality improvement.

Section VII examines longevity from the perspective of stakeholders who have made a business from assuming longevity risk, either as a primary source of business or as a second order, marginal risk. We will explore the ways in which these stakeholders quantify the amount of risk to which they are exposed and the options available to them to effectively manage this risk, both now and in the future.

Finally, Section VIII includes a brief discussion on where we believe further research could be carried out that would benefit all who have some involvement with longevity risk management.

Appendices are included that contain the papers covered in this paper (Appendix A), as well as other relevant papers that were not included in the body of the report (Appendix B). This is meant to provide a quick and easy reference guide for interested parties wanting to research a particular topic in more detail than the information summarized in the report provides. We owe a great deal to the authors of the papers referenced throughout this paper and in the appendices, and call for them, and others, to continue the quality research in all areas covered by this report.

This report is jointly sponsored by the Society of Actuaries Reinsurance Section, Product Development Section and the Committee on Life Insurance Research in collaboration with Ernst & Young. It is intended to be a resource document for actuaries, risk managers, underwriters, and other interested individuals.

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### III. Observed trends and outlook on mortality

#### *Evidence of increased longevity*

There is a wealth of research being carried out by a range of stakeholders (e.g., government actuarial or pension departments, academic institutions, through experience studies) in developed economies that is focused on the observed trend in mortality witnessed over the last century. The results of this research point to the same undeniable conclusion – people are living longer today than they ever have in the past. <sup>[A-19]</sup>

Significant medical progress, improved hygiene and living standards, generally healthier lifestyles and the absence of both global military conflicts and major pandemic crises are some of the key characteristics of the environment responsible for the rising life expectancy.

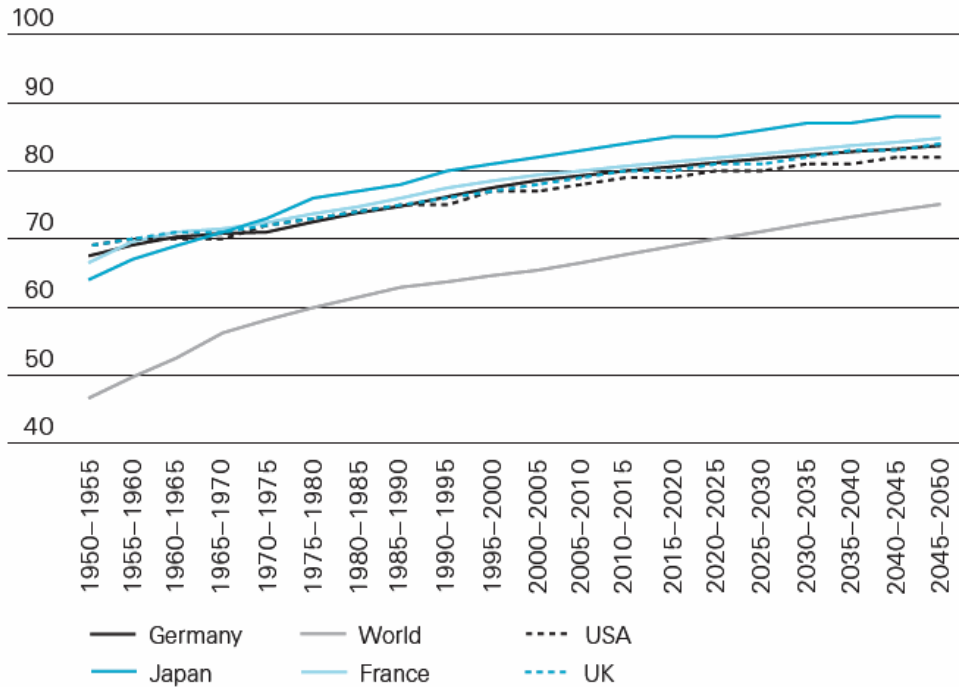
In the United States, the number of centenarians, individuals over the age of 100, has jumped from 15,000 in 1980 to roughly 72,000 in 2000. Projections carried out by the Social Security Advisory Board based on US Census Bureau data indicate that this figure could jump to 4.2 million centenarians by 2050, which is approximately 1% of the projected total population. <sup>[A-19]</sup>

This trend is not only experienced in the US. Increasing life expectancy is a trend shared by the majority of developed countries. Over the last couple of decades, the life expectancy for populations in the developed world have, in general, been increasing by approximately 1.2 months per year. <sup>[A-19]</sup> Globally, life expectancy at birth has increased by 4.5 months per year on average over the second half of the 20th century. This also reflects a large decrease in infant mortality rates across the globe, particularly in developing nations. <sup>[A-17]</sup>

The particular experience of members of the Organisation for Economic Cooperation and Development (OECD) can be looked at to demonstrate the trend towards increased longevity. According to UN World Population prospects, projections of Japanese lives from 1950 through 2050 illustrate that on average life expectancy at birth will increase at a rate of approximately 3.2 months per year for females and 2.7 months per year for males. This is illustrated in Figure 1 below, along with the projections of other selected OECD countries. <sup>[A-17]</sup>



**Figure 1** <sup>[A-17]</sup>  
**Life expectancy at birth in different regions**



Source: United Nations, World Population Prospects, 2004 Revision

Another study focusing on the experience of the UK finds that the expectation of life at birth is now 25 years more than it was 100 years ago, equivalent to an increase in life expectancy of 3 months per year. Table 1 below illustrates the actual and anticipated changes in the expectation at birth. <sup>[A-18]</sup>

**Table 1 - Expectation of life at birth (UK)**

	1911	1951	1991	2031
Males	50	66	73	79
Females	54	71	79	84

Source: 1911 to 1991 – ONS  
 2031 – mid 1998 based Government Actuary's Department population projections

While increases in life expectancy from birth point to overall changes in demographics, a more relevant measure of the changing landscape for insurance companies is the changes in life expectancy of the insured population. For companies exposed to longevity risk, a good measure is change in life expectancy in the age ranges of their policyholders.

Table 2 below illustrates the actual and anticipated changes in the expectation at age 60. <sup>[A-18]</sup> The predicted improvement in life expectancy at these advanced ages is 0.9 months per year for males and 1.1 months per year for females. While these are lower numbers than in the at birth analysis, they illustrate that increasing life expectancies affects all ages. It is important to realize that mortality rates are highest at older ages. Therefore, improvements to older age mortality have more potential to impact life expectancy. <sup>[A-20]</sup>

**Table 2 - Expectation of life at age 60 (UK)**

	1911	1951	1991	2031
Males	14	15	18	23
Females	15	18	22	26

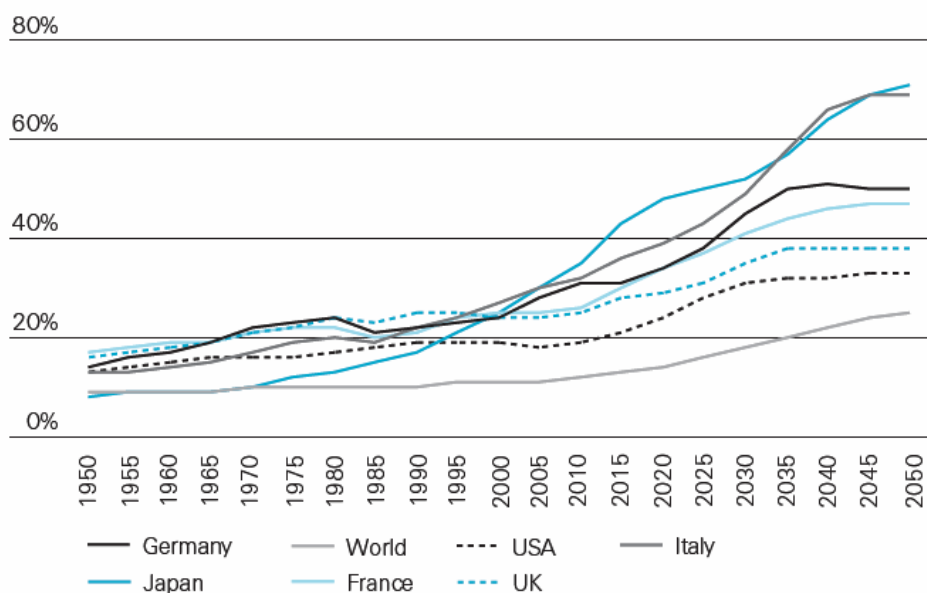
Source: 1911 to 1991 – ONS  
2031 – mid 1998 based Government Actuary's Department population projections

While significant data exists to support the general trend towards increased longevity in developed countries, it is more difficult to report trends at advanced ages in developing countries due to lack of credible data. It will be necessary to improve the recording and processing of information about mortality and morbidity. Additionally, collecting additional data about the causes of the mortality and morbidity events will allow practitioners to apply methodologies to analyze the older and oldest-old age groups specifically. <sup>[A-1]</sup>

During the next few decades most OECD countries are expected to experience what has been called “the demographic time bomb”. The result of higher life expectancy and lower birth rates is unambiguous: the world's population is aging. In 2050, 27% of the European population is expected to be older than 65 years (versus 16% in 2005) and around 10% is projected to be older than 85 (versus 3.5% in 2005). <sup>[A-17]</sup>

This observation is further supported by examining the old-age dependency ratio (the ratio of the population aged 65 and over to that aged between 15 and 64), as illustrated in Figure 2 below. While today the ratio is around 25% in a typical developed country, in 2050 it is estimated to rise to 70% in countries such as Japan and Italy. <sup>[A-17]</sup>

**Figure 2<sup>[A-17]</sup>**  
**Old-age dependency ratio in selected countries**



Source: United Nations, World Population Prospects, 2004 Revision

\* Ratio of the population aged 65+ to the population aged 15-64.

This phenomenon has important implications for pension plans, particularly those where payments to current retirees are in part funded by contributions from current employees. Government sponsored plans are one clear example. Governments of countries that are likely to experience “the demographic time bomb” will have to carefully consider future costs and weigh potential program modifications. With a lower number of workers per retiree, they may have to either reduce the payments in retirement or raise employee contributions, both of which could prove unpopular measures.

While the above observations discuss the population as a whole, research has also found that historical mortality improvements have differed depending on when an individual was born. This has been called the ‘cohort effect’, which describes anomalies in observed mortality improvement for those born in a specific period of time. This has been particularly prevalent in the UK, where during the past four decades people born between 1925 and 1945 have benefited from a higher level of mortality improvement than those born in adjacent generations. The cohort effect has also applied to mortality rates from all the major health-related causes of death. The implication is that the trend is robust and, based on past experience, is highly likely to continue into the future. The transition to retirement of people born in this generation will have implications for the expectation of the post-retirement life expectancy.<sup>[A-20]</sup>

One implication of the cohort effect is the finding that mortality for a population does not improve at constant rates. This is important for companies as they work to refine their assumptions, and could have significant implications to the future pricing of products.

In keeping with the analysis of the cohort effect in the UK, other OECD countries have seen rapid improvements for their own identified cohorts projected well into older ages. In Japan, for example, the fastest rates of mortality improvement for females are presently in the 80 to 89 year age range. This may suggest forecasts using projections of improvement rates by year-of-birth may be more relevant than traditional forecasts based on attained age.<sup>[A-19]</sup> To date, such a cohort effect has not been evident in the US, but more reliable segmentation of data could lead to different conclusions.

Research has indicated that there are also differences in the rate of mortality improvement by gender. In Japan, female life expectancy appears to be increasing quicker than male life expectancy in the general population. There is also evidence that the rate of mortality improvement has been higher at older ages. This trend has been observed in the UK and in Japan, and does not appear to be slowing down. The experience of these countries may be indicative of the future experience of the other OECD countries.<sup>[A-19]</sup>

### ***Mortality improvements in the future***

While it seems apparent that trends in mortality improvement are expected to continue, at least in the near term, mortality changes in a complex manner and is influenced by socioeconomic factors, biological variables, government policies, environmental influences, health conditions and health behaviors. Not all of these factors improve with time and experts’ opinions of the direction and magnitude of these trends vary widely.<sup>[A-16]</sup> Even if the trends in mortality improvement continue, disruptions could be caused by any number of sources: epidemic; pandemic; war and terrorism; natural disaster. While the probability of these events is minimal, it is not zero.<sup>[A-19]</sup>

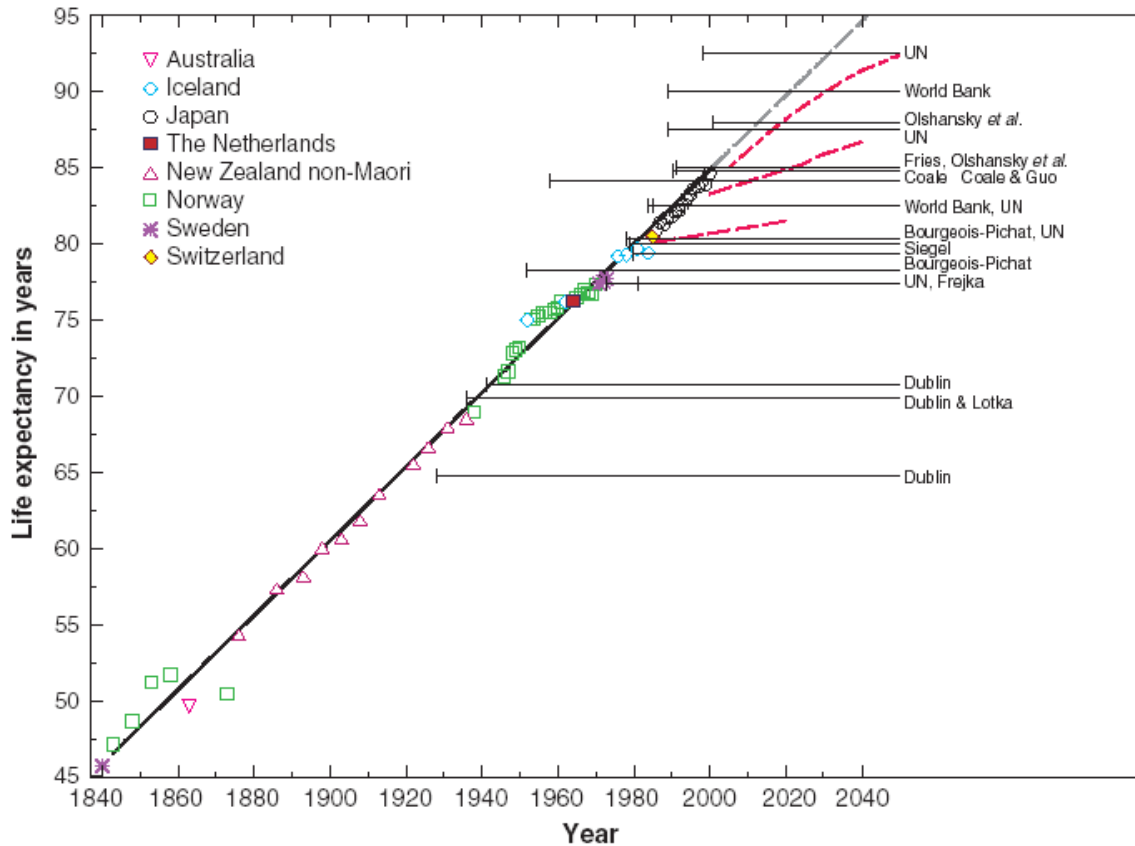
Recent research in the US indicates that future generations may in fact reverse some of the improvement trends due to the significant increase in obesity. In a 2005-2006 survey in the US, 34.4% of adults were characterized as obese. For most of the cohorts this represents nearly a 300% increase since 1970. This has implications to the mortality improvement of the population as a whole because obesity increases the likelihood of health concerns such as type 2 diabetes, cardiovascular risks, cancer, and kidney or gallbladder disease. Each of these is likely to adversely affect the life expectancy of those individuals. <sup>[A-28]</sup> The obesity trends in the US could slow, or even reverse the rate of mortality improvement over the next several decades.

Without looking at the potential impact of obesity, the question of how far increases in life expectancies will continue along the observed path is open to debate. There are generally two very different points of view on the subject of future mortality improvement, either there is a limit to life expectancy or there is not.

Some argue that there is a biological limit to how long an individual can live before the body simply wears out. Supporters of this viewpoint state that improvements to date are a result of better healthcare and diet, and that these improvements are unlikely to be continually repeated. <sup>[A-14]</sup> This theory draws the distinction between age and age-related disease to suggest that medical research has been directed solely towards age-related diseases. One of the supporting mathematical arguments is research showing that the elimination of the three principal causes of death in older people (heart disease, cancer, and cerebrovascular disease) would increase life expectancy only 17 years. It is also noted that future life expectancy might level off or even decline due to factors such as obesity and decreased food-derived health benefits associated with higher levels of atmospheric CO<sub>2</sub>. <sup>[A-19]</sup>

Those that support the opposing view believe that there is no limit to life expectancy in the future; that it is possible to slow the aging process even further so that at some point in the future a 65 year-old may look and feel like today's 55-year old. As supporting evidence they point to the trend in female life expectancy in selected countries which has been increasing steadily at a rate of 3 months per year for the last 160 years, as well as the fact that suggested biological limits on age are generally disproved five years after the projection is made. They take the optimistic view that biomedical research will yield unprecedented increases in survival rates which will serve to continue to extend the mortality curve. <sup>[A-19]</sup>

**Figure 3**  
**Female Life Expectancy**<sup>[A-19]</sup>



Source: Oeppen J, et al. Science 2002; 296: 1029-31

Figure 3 displays the life expectancy at birth for females from 1840 projected through 2040. The solid line is fitted from data points which represent mortality studies from a number of countries. The dashed lines illustrate the projected life expectancy as produced by several research papers. As evident in the chart, life expectancy has steadily increased for all of the countries studied, and while past projections have expected the increases in life expectancy to slow down, the fitted line illustrates consistent increases in life expectancy at birth of 3 months per year from 1840 to 2000.

Another contributor to expected improvements in life expectancy comes from the reduction in smoking-related causes. Diseases such as lung cancer are higher for elderly men and women today than they were in the 1960s. This experience mirrors past trends in cigarette smoking and suggests that deaths from these causes are set to fall rapidly at the highest ages given the reduction in the number of smokers today.<sup>[A-20]</sup>

Rates of mortality from cancer and circulatory disorders are also falling steadily with no sign of slowing. These causes of death are responsible for approximately two thirds of all deaths for people in England and Wales aged 70 and above. In addition, researchers note that medical advances are occurring at an accelerating pace.<sup>[A-20]</sup>

In an attempt to more accurately estimate future improvement rate for insured lives, UK's Continuous Mortality Investigation Bureau published in 2002 a selection of three

projections of future UK mortality rates: the short, medium and long-cohort projections. These three projections refer to the length of time that the cohort exhibits superior mortality improvement than the insured population as a whole. In addition, the projections also differ in terms of the magnitude of improvements, with the short cohort exhibiting lower improvement levels. This is part of a deliberate move away from the false certainty of a single projection, and a step towards explicit recognition of the uncertainty surrounding the path of future improvements. <sup>[A-21]</sup>

The only consistent finding in the research is that there is a large amount of uncertainty about future mortality improvement. It is critical to remember that population projections are dependent on subjective assumptions. Therefore, in performing projections, actuaries need to be conscious of the effects of using these assumptions on the projection results. <sup>[A-18]</sup> Because of this uncertainty, most of the larger UK insurers currently reserve using a mortality table that includes projected improvements that are either a blend of the medium- and long-cohort projection, or where the medium-cohort projection has been applied as a "floor value". <sup>[A-21]</sup>

For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-1]	Roberto Ham-Chande "Shapes and Limits of Longevity in Mexico"
[A-14]	Moshe A. Milevsky "Longevity Risk and Life Annuities "
[A-16]	Samuel H. Cox and Yijia Lin "Natural Hedging of Life and Annuity Mortality Risks"
[A-17]	Veronica Scotti, Dr Dirk Effenberger "Annuities: Private Solution to Longevity Risk"
[A-18]	Institute/Faculty Pension Provision Taskforce "Age of Retirement and Longevity"
[A-19]	Sam Gutterman, Colin England, Alan Parikh and Robert Pokorski "Living to 100 and Beyond: Implications for Retirement"
[A-20]	R. C. Willets, A. P. Gallop, P. A. Leandro, J. L. C. Lu, A. S. Macdonald, K. A. Miller, S. J. Richards, N. Robjohns, J. P. Ryan and H. R. Waters "Longevity in the 21st Century"
[A-21]	Stephen Richards, Gavin Jones "Financial Aspects of Longevity Risk"
[A-28]	Sam Gutterman "Obesity – What it Means for Actuaries"

#### **IV. Development of retirement markets**

The retirement market of a country has a significant impact on the development of both the retail and institutional solutions offered to individuals to fund their retirement. For example, countries that mandate annuitization of a portion of assets have more developed annuity markets. Similarly, countries that have significant employer based pension plans have a reduced need for retail solutions. This section explores how some specific markets have developed.

##### **The retirement market in the US**

In the US the primary source of longevity protection has historically been the combination of Social Security and employment based retirement benefit plans.

###### *Social Security*

Social Security in the United States covers several social insurance programs (Unemployment Insurance, Supplemental Security Income, Disability Insurance), but the largest of these is the Old-Age and Survivors Insurance (OASI) trust, which provides inflation adjusted income to retirees. Benefits are funded through payroll taxes collected from the current generation of workers.

In 2007, the Social Security system paid \$485 billion of OASI benefits to beneficiaries. <sup>[A-27]</sup> The future of Social Security is to be a major political issue as concerns about the solvency and future shortfalls continue to emerge.

One of the unique dynamics impacting the funding of social security is the potential difference in payment increases and contribution increases. Social Security benefits are increased annually with price inflation, while funding contributions increase in line with earnings growth, typically a higher rate than price inflation. <sup>[A-18]</sup> If this is the case, contributions will increase at a higher rate than payments, therefore providing an offset from any unexpected improvements in life expectancy. Because of this, government programs have more limited exposure to longevity risk than employers or individuals. For employers based pension plans future benefits are not directly funded by current employees, and therefore there is no offset to unexpected changes in mortality.

Despite the funding advantage of Social Security, the actual rate of mortality improvement will have a dramatic impact on the overall solvency of the program. Recent Social Security Administration projections have mortality in the United States in 2080 just reaching the levels of mortality in Japan today. Many think that the assumed level of mortality improvement in the Social Security projections is too low. This may point to the inadequacy of the long-term projections and will have significant implications for the financial health of Social Security. Therefore, while projections may show government plans to be well funded in the near to medium term, there is some debate as to whether these assumptions are correct. <sup>[A-19]</sup>

### ***Employment based retirement benefit plans***

Employer based retirement plans became popular in the US during World War II, as a way to defer compensation to employees when wage freezes prohibited increases in workers' pay.

Historically, defined benefit (DB) plans were the most common type of employment based retirement plan; however, defined contribution (DC) plans are quickly becoming the standard. This is primarily due to the significant investment and longevity risk exposure of DB plans.<sup>[A-15]</sup> A newer type of plan called the "hybrid" plan contains design features of both DB and DC plans. These plans allow for a more even split of investment and longevity risk exposure.

The shift from defined benefit to defined contribution plans has been well documented. A recent survey by Watson Wyatt Worldwide states that the percent of Fortune 100 companies offering traditional defined benefit plans to new employees has dropped from 89% in 1985 to 28% in 2007.<sup>[A-32]</sup>

The flexibility inherent in DC plans is attractive to certain employees and nearly all employers. It is generally assumed that younger employees who will likely change jobs many times in their career favor the flexibility and short vesting requirements of DC plans. For employers, DC plans are less costly, less risky, and more easily administered than traditional DB plans. However, DC plans expose employees to longevity risk, as they must determine a way to make their balances provide income for their lifetimes.

One way of avoiding this longevity risk is to convert the lump sum balance to an annuity and transfer the longevity risk to the insurance company. However, over 70% of DC plans do not offer participants the opportunity to purchase a life annuity.<sup>[A-3]</sup> Additionally, retirees have been reluctant to annuitize retirement assets even after a roll-over from a DC plan. This is leading to a significant exposure to the risk of outliving their assets in retirement.<sup>[A-15]</sup>

For DC plans that do offer participants the option to annuitize at retirement, utilization depends on the particular characteristics of the plan. Thrift Savings Plans (TSPs), a relatively new supplemental DC plan first offered to federal government employees in 1997, offered annuity payout rates that were quite competitive when compared to individual retail annuity products. Despite the favorable rates, only 1.2% of employees covered by the TSPs elected to annuitize. It should be noted that the popularity of the annuitization option may change as the TSPs mature.<sup>[A-3]</sup>

The shift away from DB plans, combined with the low percentage of DC plans providing access to annuities, may cause individuals to turn to the retail market to reduce their exposure to longevity risk. However, in the United States it appears as though the majority of people are not turning to the annuity market to manage this risk as less than 5% of retirees have voluntarily purchased a life annuity.<sup>[A-14]</sup>



## Retirement markets in other geographies

### *United Kingdom*

In some respects the retirement market in the UK has developed in a similar manner to the US. There is a base level of government sponsored protection, in part funded by the current workforce through National Insurance contributions. Employer sponsored plans consist of both DB and DC, and the UK has also seen the similar shift from DB to DC plans in recent decades. The UK and the Republic of Ireland allow contributions to pension savings on a pre-tax basis. At retirement, an annuity may be purchased. If it is not, the account must be drawn down subject to legislated limits.

The UK government sponsored retirement plan is a pay-as-you-go plan where the benefit expenditure each year is financed by contributions paid by the current generation of workers. As the number of people over the pension eligibility age increases relative to the number of working people, contribution rates can be expected to increase in order to meet benefit obligations in future years. The Government's Actuarial Department (GAD) predicts the reduction in the number of contributors per pensioner to be 1.8 to 1.3 over the next 60 years which may lead to an increase of nearly 40% in the required contribution rates.<sup>[A-18]</sup>

If the ratio of contributors per pensioner remains constant, the contribution level in the UK would actually decrease. This is because the contributions are based on salary, which typically grows at 1.5% to 2% per annum above the rate of price inflation while the benefit payments are tied to price inflation. These numbers have been used to prove the success of the UK pension plan in controlling its inherent longevity risk. However, because pensions are increasing in line with price inflation and not wage inflation, this control may come at the expense of the standard of living of retirees in comparison with the general working population.<sup>[A-18]</sup>

Similar to the US market, the shift from DB to DC plans has occurred as a result of the increasing cost to the employer of managing a DB plan. The majority of DB plans are now closed to new entrants, and a market has developed for the purchase of these blocks by specialist pension fund managers, who hope to make money from effectively managing the underlying funds. On the sale side the employers want to rid themselves of the added burden of managing the portfolio, so that they can concentrate on their core businesses.

One key difference to the US model is that in the UK the majority of DC plans have included and mandated some form of annuity purchase as a withdrawal option. Under the Pensions Act of 2004, individuals were required to annuitize a significant portion of these accounts.<sup>[A-15]</sup> With the enactment of a separate Act on April 6, 2006 (commonly referred to as "A-Day"), some of these requirements were relaxed. Individuals are still subject to rules about drawdown or annuitization of their retirement assets starting at age 75, but have more flexibility than under the previous regulations.<sup>[A-15]</sup>

The annuitization option and mandate has driven the growth of the immediate annuity market in the UK to a much greater extent than in the US. New business amounted to £7.4bn in 2003. On an industry level, total liabilities were thought to be in excess of £70bn in 2004. Typically, longevity risk only affects the issuing company, however, in the UK, with-profit policyholders have substantial exposure to longevity risk. <sup>[A-29]</sup>

As an increasing proportion of an insurer's liabilities are now annuity related obligations, for many companies longevity risk is now the second largest risk that the company faces after market risk (and in some cases the largest for specialty companies). Companies will need to either further diversify or increase the required capital to mitigate the larger exposure to longevity risk. <sup>[A-20]</sup>

The realization that pay-as-you-go plans may be vulnerable to an aging population has led people to advocate a funded solution. Funded plans are not, however, immune to the effects of an aging population. For example, in DC plans the level of benefit paid is dependent on the plan balance at retirement and the annuity purchase rates in effect at that date. As mortality improves, workers will need to contribute more in order to secure the same level of benefit given the higher annuity rates resulting from the improvement. <sup>[A-18]</sup>

### *Australia*

The Australian retirement market has evolved slightly differently. Rather than letting longevity risk shift back to individuals, the Australian government opted to implement major reforms in 1992. This led to the advent of "superannuation," a three pillar approach to retirement income: a means-tested government pension; compulsory private savings; and voluntary savings. Employers and employees alike are required to contribute to the plan at a rate set by the government. At the time the plan was launched, employees were required to contribute 2% of their income. That figure now stands at 9%. <sup>[A-17]</sup> It is worth noting that the Australian system encourages workers to think about their retirement early in their career. This should decrease the number of people who start to fund for their retirement too late and end up with the majority of their retirement income coming from the government as a result.

### *Other Selected Countries*

Most other social security systems around the world pay benefits in the form of annuities and European countries tend to extend this requirement to private occupational plans. Where annuities are mandated, countries have the option to mandate annuity conversion rates, or to mandate components of the underlying basis such as mortality. <sup>[A-15]</sup>

In response to some of the restrictions of payout annuities, non-annuity forms of payment are gaining popularity with the emergence of 'privatized' social security systems (e.g., Peru, Argentina and Chile). <sup>[A-15]</sup>

The Israeli government system requires workers to participate in the funding of the defined benefit pension plans by contributing a percentage of their pay towards the plan. This reduces adverse selection seen in systems that require annuity purchase at advanced ages; however, insurers are exposed to increased longevity risk by the long term nature of the benefits. <sup>[A-25]</sup>

Other countries, such as Canada, have started to encourage phased retirement to increase the level of economic activity among those nearing retirement. This allows people to reduce their working hours, for health reasons or other personal reasons, while remaining in the workforce and potentially accruing further pension entitlements. <sup>[A-18]</sup>

Other changes to government sponsored plans are being implemented, and have impacts to the broader market. For example, to reduce costs many countries are now increasing the age at which a retiree can begin to receive benefits. Some countries, such as Sweden, Italy and Germany either plan to increase the benefit eligibility age automatically as longevity increases or adjust pension benefits in line with life expectancy. <sup>[A-18]</sup> This may create an opportunity for retail solutions to be used as an interim solution between the retirement age and the benefit eligibility age.

### **External factors and the impact on product development**

A market's existing regulatory environment and government sponsored programs have implications on the retirement income products that are offered by the private sector. As seen above, government intervention in the form of either mandating the form of distribution or the annuity conversion rate, has implications for the broader insurance market.

#### *Annuitization Mandate*

An annuitization mandate works to create depth in the annuity market and reduces adverse selection. <sup>[A-15]</sup> The insurance value of annuitization is sufficiently high that all groups can benefit from mandated annuitization, even those with substandard mortality. <sup>[A-5]</sup> Finally, competition among insurers also may lead to the development of new annuity products with more flexibility than those currently available. <sup>[A-15]</sup>

However, plan sponsors may be reluctant to offer annuities due to the increased administration complexity involved if the terms of the annuity are also mandated. For example, in the US, all life annuities paid to married employees must have a joint and survivor component both on retirement and on death. Also, when selecting a provider, the plan sponsor is required to make an assessment of the default risk of an insurer. In the situation where the government creates more onerous requirements, it may choose to mandate that only employer sponsored benefits below a certain level be annuitized in order to alleviate some of the pressure. However, the decision around where to set that limit would be controversial. <sup>[A-3]</sup>

Another potential component of an annuitization mandate is to set the annuity conversion rates. If these are set artificially high, insurance company reserves are higher than they need to be. Similarly, if sex-neutral tables are mandated (as in Switzerland and portions of the UK market), there is a redistribution of wealth between the population subgroups which results in market distortion. While wealth redistribution may be desirable, the incentive exists to insurers to sell to profitable subgroups and avoid those that are less profitable. <sup>[A-15]</sup>

Mandating the annuitization or purchase of longevity insurance with personal assets also has broad benefits to the competitiveness of products. With a wider pool of individuals to insure, insurers' risks will be lowered and the price of insurance may decrease. From a

social perspective, mandatory pensions reduce the risk of an individual outliving their assets in retirement. As of 2004, the Slovak Republic and Australia were the only OECD countries with mandated personal pension plans. <sup>[A-17]</sup>

A less restrictive approach than strictly mandating longevity insurance may be to require that annuitization be the default distribution option. Studies have shown that the requirement for affirmative action has significant effects on policyholder behavior. Alternatively, the government could mandate that the annuitize option be provided and encourage its use through tax incentives. <sup>[A-3]</sup>

### *Reduction in Government programs*

Reductions in government sponsored pension plans lead to an increased role for the private market to provide solutions to longevity risk. Solutions offered by the private sector address limitations that exist in government run pension plans such as addressing personal preferences; embracing new developments and thinking with regard to new products; and offering superior returns that can not be achieved by the limited investment world available to the public sector. <sup>[A-4]</sup>

### *Government Influence*

Financial regulators have two main responsibilities to the individual: to enhance financial stability by promoting efficient and fair markets and to ensure that retail customers are dealt with fairly. <sup>[A-13]</sup> With respect to the development of longevity solutions, the natural role for government is to educate, sponsor issuance of suitable hedging products, and reduce adverse selection and enhance liquidity through tax incentives. The experience of public systems that have been explicitly privatized shows that government can use these tools to facilitate the transition. <sup>[A-17]</sup>

Various governments including the UK have begun to issue longevity bonds (where payments are linked to the experience of an underlying group of lives) which allow insurers to absorb much of the aggregate longevity risk. The recent reintroduction of the 30 year bond in the US will reduce the riskiness of funding annuities. Likewise, encouraging group annuitization may offset the increasing cost of annuities resulting from improved mortality and aggregate longevity risk. <sup>[A-2]</sup>

Governments are interested in ensuring that individuals have adequate income in their retirement years. By structuring tax benefits to encourage particular types of retirement distributions, they have the power to govern how and when the tax-favored assets are consumed. <sup>[A-15]</sup>

Tax systems provide incentives in one or more of the following ways: progressive personal income tax and deductions from taxable income; specific preferential tax treatment; or preferential tax treatment of the investment income and capital growth. Tax incentives can be applied to pension savings as a whole, or be used more exactly to promote certain distribution channels like annuities. <sup>[A-17]</sup>

For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-2]	SOA Project Oversight Group "Key Findings and Issues - Longevity: The Underlying Driver of Retirement Risk"
[A-3]	Jeffrey R. Brown and Mark J. Warshawsky "Longevity-Insured Retirement Distributions from Pension Plans: Regulatory and Market Issues"
[A-4]	Mark J. Warshawsky "The Market for Individual Annuities and the Reform of Social Security"
[A-5]	Jeffrey R. Brown "Redistribution and Insurance: Mandatory Annuitization with Mortality Heterogeneity"
[A-13]	D. Blake, A. J. G. Cairns and K. Dowd "Living with Mortality; Longevity Bonds and other Mortality-Linked Securities"
[A-14]	Moshe A. Milevsky "Longevity Risk and Life Annuities"
[A-15]	Beverly J. Orth "Managing Longevity Risk in US Retirement Plans Through Mandatory Annuitization"
[A-17]	Veronica Scotti, Dr Dirk Effenberger "Annuities: Private Solution to Longevity Risk"
[A-18]	Institute/Faculty Pension Provision Taskforce "Age of Retirement and Longevity"
[A-19]	Sam Gutterman, Colin England, Alan Parikh and Robert Pokorski "Living to 100 and Beyond: Implications for Retirement "
[A-20]	R. C. Willets, A. P. Gallop, P. A. Leandro, J. L. C. Lu, A. S. Macdonald, K. A. Miller, S. J. Richards, N. Robjohns, J. P. Ryan and H. R. Waters "Longevity in the 21st Century"
[A-25]	Maurice Brandman "Clause 20 of Financial Services Law (retirement plans) 2005 - Israel"
[A-27]	Social Security Administration "The 2008 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds"
[A-29]	Paul Sweeting "Tax-Efficient Pension Choices in the UK"
[A-32]	Jerry Geisel "Defined-benefit plans falling further out of favor, survey finds"

## V. Ways in which individuals can mitigate longevity risk

The trends of the retirement markets in most countries indicate more and more individuals are managing their own personal longevity risk on their own. Combined with the increase in life expectancy witnessed over the last century, the need for more robust planning for the millions of individuals now entering retirement has greatly increased. Although the retirement age has increased, it has not kept pace with the increase in life expectancies. In the United States, more than 78 million baby boomers are approaching retirement and will have to address their increasing longevity risk and need for lifetime income. Many of these retirees will be faced with the difficult choice of the amount level of wealth transfer to dependants, living their desired lifestyle, and the risk of depleting their assets.

As millions of individuals start to transition from the workforce to retirement, they face many new challenges and risks. For most, the primary objective in retirement is to not outlive their assets. There are several risks that can cause an individual to deplete all of their assets, including:

- Poor investment performance,
- Higher than expected inflation,
- Higher than expected health care costs,
- and living longer than anticipated.

For many of these, there are established risk management techniques. For example, diversified asset allocation can help to dampen the impact of poor investment performance. Treasury inflation protection securities, Social Security's cost of living adjustment, and other inflation linked products are available to help individuals with the uncertainties of inflation. And long term care and other types of health insurance can help manage the higher than expected costs arising from those events. However, the solutions available for living longer than expected, longevity risk, are not as clearly defined for most individuals.

Individuals are exposed to two types of longevity risk: select risk (the risk that they themselves will outlive the average expectation of life) and aggregate risk (the risk that the entire population will outlive the average expectation of life). The financial implications of aggregate longevity risk include increased prices for solutions, and are compounded by the additional health related expenses that are associated with advanced age.<sup>[A-2]</sup>

Inaccurate estimates of personal life expectancy can negatively impact a retiree in two ways. A retiree may overestimate one's longevity, and as a result spends less than he/she could have had the assets been annuitized. On the other hand, one may spend aggressively and outlive their invested assets. Women especially are at risk of outliving their assets both because their life expectancy is greater than their male counterparts, and research has shown that generally they start with a smaller pool of assets.<sup>[A-15]</sup>

In a survey conducted by Mathew Greenwald & Associates and by the Employee Benefit Research Institute it was found that over 40% of both pre-retirees and retirees underestimate population average life expectancy by five or more years. Far too few

retirees appreciate that there is a significant chance (20% for men and 33% for women) that they could live beyond their projections. As a result, few retirees purchase annuity products at retirement. <sup>[A-2]</sup>

Recent experience in the UK suggests that individuals underestimate their own mortality by as much 5 years on average. The same study also suggests that expectations of longevity drive the individual's willingness to buy a complementary pension in retirement. Specifically, for every additional year of life people become aware of, those willing to buy a complementary pension rose 0.15%. <sup>[A-17]</sup>

The declining number of defined benefit plans has a significant impact on the need for individual longevity solutions. This guaranteed stream of payments provided by the plan would last an entire lifetime, significantly reducing the chance of outliving one's assets. In fact, a recent study shows that individuals retiring today without a pension plan have over an 80% chance of outliving their assets. For individuals who have a defined benefit plan in place, that number drops to 18%. <sup>[A-22]</sup>

A study commissioned by the SOA released in July 2006 found that only a quarter of the respondents (retirees and pre-retirees) had addressed the longevity risk they were exposed to by purchasing annuities. Most anticipated managing the risk by eliminating all non-mortgage consumer debt before retirement and building savings. Many retirees who take this approach are forced to cut spending when faced with a shortfall, often well before they've reached their average life expectancy. Some deplete all resources outside of Social Security and may build up debt as they struggle to stay in their homes, or pay for nursing home care. <sup>[A-2]</sup>

Premature retirement risk is also an issue. The study suggests approximately 40% of Americans end up retiring earlier than planned as a result of job loss, family needs and health issues. When an early retirement isn't planned, additional stress is placed on the retirement plan as now the individual has fewer assets to last a longer amount of time. Additionally, many retirees fail to consider inflation in their estimates of their retirement income. <sup>[A-2]</sup>

There are many ways in which individuals can manage their personal longevity risk. Similar to other risks that are faced throughout a lifetime, they either decide to "self-insure" by managing their assets or to purchase products to help insure against this risk.

Individuals who decide to self-insure against longevity risk keep their assets in liquid investments. Two key considerations in this management strategy are asset allocation and level of withdrawal. Individuals should keep their assets well diversified and invest according to a defined asset allocation strategy designed to minimize the chance of portfolio ruin. In addition, they need to understand the impact that the level of withdrawals will have on the future lifetime of the portfolio. If individuals trying to self-insure are unsuccessful and end up running out of money, they will be forced to go through their remaining lifetimes without income. This would likely result in relying on children, relatives, or even federal programs to live out their remaining lifetime.

For individuals interested in insuring at least a portion of the longevity risk, there are several products that offer lifetime guarantees. These products include:

- Immediate annuities
  - Standard (e.g. SPIA)
  - Impaired life annuities
- Deferred annuities
  - Accumulation with living benefits
    - Guaranteed lifetime withdrawal benefits
    - Guaranteed minimum income benefits
  - Payout
    - Longevity insurance
    - Advanced life delayed annuities (ALDA)
- Investment based income wrappers
- Reverse mortgages
- Structured settlements

All of the products provide for a minimum level of income that is guaranteed for at least the entire lifetime of the individual. In general, the products that annuitize a balance and turn over the control of the assets to the insurance company result in higher income levels to the purchaser than other products that allow the purchaser to maintain control of the assets (e.g. VA with GLWB where the policyholder has access to the account value). The products will be discussed in more detail in the following section.

For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-2]	SOA Project Oversight Group "Key Findings and Issues - Longevity: The Underlying Driver of Retirement Risk"
[A-15]	Beverly J. Orth "Managing Longevity Risk in US Retirement Plans Through Mandatory Annuitization"
[A-17]	Veronica Scotti, Dr Dirk Effenberger "Annuities: Private Solution to Longevity Risk"
[A-22]	Ernst & Young, LLP "Retirement Vulnerability of New Retirees: The Likelihood of Outliving Their Assets"



## VI. Summary of products with longevity risk exposure

Longevity risk is present in any product where the issuer is exposed to financial losses if the policyholders live longer than expected. This often occurs when payments from the issuer are dependent on the length of time the policyholder remains alive. Traditionally these products have been issued by insurance companies and have been used to hedge against an individual outliving their assets.

In recent years, the number and types of products being issued that are exposed to longevity risk has increased. This can occur despite the fact that longevity risk transfer may not be the primary objective of the transaction.

This section gives a brief overview of products that are available in the market that have exposure to longevity risk. We also consider the other risks that these products are exposed to including financial risk, pricing risk and regulatory risk.

Mortality risk is generally defined as the exposure of a company to higher than expected mortality. Conversely, longevity risk is generally defined as the exposure of a company to a lower than expected mortality.<sup>[A-6]</sup> For products where the payment is conditional on death, such as a Term or Whole Life insurance, mortality risk is measured as the risk that people die sooner than expected. From the insurer's perspective this accelerates the payment of death benefits and results in fewer premiums and policy fees to offset the insurer's cost in issuing the policy. Products where the payments continue as long as one side of the contract is alive have significant exposure to longevity risk. Again, to an insurer, the risk is that people live longer than expected, requiring a greater number of payouts for the same initial amount of premium income.

The International Actuarial Association defines four components of mortality/longevity risk: level, trend, volatility, and catastrophe. These can be broken down into two categories, systematic and specific risk. Systematic risk refers to having the incorrect base assumptions (level and trend), and specific risk refers to volatility around the base assumptions (volatility and catastrophe). Specific risk reduces as the number of lives covered increases; however, systematic risk can not be diversified.<sup>[A-8]</sup> The impact of systematic risk to pension plans and insurers is estimated to be significant and is increasing.<sup>[A-17]</sup>

Adverse mortality experience, whether higher or lower than expected, has implications for reserving and for capital requirements if the ability of the life industry to raise capital becomes impaired based on the market's perception of the variability of life company debt.<sup>[A-20]</sup>

Financial risks include interest rate risk, market risk, inflation risk, and credit spread risk.<sup>[A-17]</sup> Many contracts which involve longevity risk also present some degree of financial risk, due to the fact that the contract period is typically extremely long and the insurer must use the initial premium to pay for benefit payments for many years.

Pricing risk can be thought of as the risk that the assumptions used in pricing a product are not consistent with expectations. If a product is priced using a correct best estimate assumption about the mortality rates, the risk that experience is different to these assumptions is primarily volatility risk and can be diversified away with a large enough

exposure base. If the assumptions used are not consistent with expectations, the product is exposed to systematic risk, and companies are exposed to a much higher level of potential losses. The possible reasons for exposure to systematic risk include incorrect best estimate assumptions, or deliberately under-pricing a product for marketing reasons. Additionally, products that are priced assuming cross-subsidies between issue ages, gender, and/or other risk factors may pose additional risk if actual sales patterns are not consistent with those assumptions.

Regulatory risk is the risk that changes in political or regulatory environments have implications on either of the parties to a particular contract. For example, a change in regulation could increase the reserves for a particular contract thus making it more expensive for a company to maintain and manage. Similarly, regulation could ban certain features or make others mandatory, changing the risk exposure. Regulatory changes have had significant impacts on the health industry, due to healthcare provisions being historically linked with public policy.

### **Immediate annuities**

An immediate annuity is a product that typically provides payments for life and is usually secured in exchange for a lump sum. The traditional terminology for this product type used in the US is single premium immediate annuity (SPIA). Both the frequency and amount of the payment can vary over the term of the contract. They can be structured to provide a fixed level payment, a stream of payments that increase at a pre-specified rate, or a stream of payments that is tied to an underlying equity index (termed a variable immediate annuity or VIA). In some cases the product may include a certain period, during which time the policyholder, or their estate, receives the annuity stream irrespective of when they die. Most of the annuity products sold in the US do not provide a payment stream that is linked to inflation and are therefore susceptible to erosion in value.<sup>[A-17]</sup>

Immediate annuities may be issued as single life or joint-and-survivor policies. In the latter case the annuity payments continue while at least one of the two lives is alive, although the size of the annuity payment may decrease on the death of the primary insured. An example is an annuity whereby the spouse receives 50% of the original payment stream upon the death of the primary policyholder.<sup>[A-17]</sup>

Under some product designs the payout stream of an annuity can participate in mortality risk. In the case of a participating annuity (available in the UK market), annuitants share in both the investment and longevity mortality gains while still benefiting from risk pooling. Individuals can also purchase additional protection in the form of minimum investment returns; or insurance benefits such as a minimum death benefit, minimum withdrawal benefit, minimum accumulation benefit, or a minimum income benefit.

In the current low interest rate environment, the largest risk in immediate annuities lies in correctly pricing the longevity exposure. In the UK, for example, the regulators have explicitly recognized this and as a result the statutory reserving basis for insurers has been the focus of much change over the past few years. These changes have largely resulted from revised projections of mortality improvements on a year-of-birth or "cohort" basis from the CMIB (2002).<sup>[A-21]</sup>

Economic conditions do not directly affect life expectancy – that is, more or less people do not die if interest rates are high or low or the stock market is bullish or bearish. However, insurers tend to back their annuity liabilities with a significant amount of corporate debt. These investments have inherent risk of default, which would leave the insurer with less assets than expected to provide for the annuity payments in situations where economic growth was slowed below expected levels, or the economy was in recession. <sup>[A-21]</sup>

There is also pricing risk involved in immediate annuities. Companies that set prices on their products inconsistent with best estimate assumptions are facing a higher amount of risk that actual experience will be different from expected. This price sensitivity is more prevalent for contracts issued to older individuals. This is because for younger annuitants, the price is more similar to a perpetuity. Perpetuity prices do not incorporate a mortality component, and therefore the price is primarily driven by interest rates. Therefore, annuities issued to younger individuals are less sensitive to the mortality rates used, and therefore have less pricing risk. <sup>[A-7]</sup> The conclusion from this section is that there is less pricing risk to issuing immediate annuities to younger individuals; however, that does not mean that there is less exposure to longevity risk.

Pricing for longevity risk is competitive because annuity rates are simple to understand and easy to compare for insurers. However, it is an open question as to whether every insurer fully appreciates the uncertainty surrounding the longevity risk being taken on. <sup>[A-21]</sup>

The mortality experience of a given block of business can only ever be used to provide an estimate of underlying mortality. Even large blocks of business exhibit substantial variability. This implies that pricing cannot be done purely with central estimates of recent experience data, but that a measure of uncertainty must also be included in the basis or explicitly in the pricing margins. Variability in annuity or pension size causes significant increases in the overall uncertainty. While pensions must be priced according to their expected risk, smaller pensions must also be priced in relation to the additional uncertainty they cause in the portfolio overall. <sup>[A-21]</sup>

The way in which immediate annuities are purchased has significant impact on the risks that any particular contract will be subject to. For example, the US market is principally driven through individual sales. These sales have a greater level of anti-selection risk than group annuities, for example, where all members of a group are included at a set price, irrespective of their relative levels of health. However, group annuities will have higher concentrations of lives from certain socio-economic groups or industries and may be subject to greater systematic risk of misestimation of the average mortality (if the pricing was based off a more generic table). Mandatory annuitization of accumulated funds, as in the UK, also results in different risks compared to the situation where individuals are free to choose whether or not to purchase an annuity. Anti-selection risk will be lower in the case of mandatory annuitizations, as the less healthy lives will also be required to purchase an annuity.

Some commentators point out that retirees do not purchase annuities due to a lack of understanding of how they work and the value they provide. There is a significant fear of dying before the retiree receives sufficient payments so as to recover the value of their investment. Because of anti-selection, often only the healthiest lives purchase annuities. This results in the price of annuities being driven up, and helps to reinforce the argument

that annuities are a poor investment. Finally, inflation-linked annuities are only available from a select number of carriers in the US market. To the consumer, the low initial level of monthly income makes the product unattractive. <sup>[A-15]</sup>

## **Enhanced and impaired life annuities**

A niche market has recently emerged for people who have worse than average health, and for whom standard annuities are prohibitively expensive. Substandard, impaired, or enhanced annuities offer higher annuity payments to individuals who can prove that they are in poor health or are terminally ill. <sup>[A-17]</sup> In 2004, enhanced annuities represented 10% of all individual annuity premiums in the UK. <sup>[A-21]</sup>

As expected, the mortality dynamics of an enhanced annuity portfolio are different from a standard portfolio. Initially elevated rates of mortality will ultimately reduce and converge towards conventional rates. <sup>[A-21]</sup>

A portfolio of enhanced annuities is likely to be weighted towards exposure to a handful of impairments, particularly cardiovascular disease and conditions related to smoking. Pricing bases need to be reviewed regularly to keep current with developments in survivability of these key conditions. For the insurer, there is an increased exposure to medical breakthroughs in a single condition which may prolong an individual's lifetime and this demands that enhanced products are priced on a higher margin than standard annuities. This also has implications in the assessment of future mortality improvements. <sup>[A-21]</sup>

Enhanced and impaired life annuities tend to have similar risks to standard immediate annuities. However, given the higher expected mortality rates assumed for these policies, the longevity risk may be exacerbated, as there is likely to be less data on the mortality experience of particular subgroups of the population. For example, the best estimate assumption of mortality for these special classes of lives will be more subjective due to the fact that there is substantially less data available, due both to relative infrequency of incidence and poor historical reporting of cause of death. The policies often rely on a medical underwriter to evaluate the life expectancy of the individual. A paper published by the Society of Actuaries found that for impaired life annuities, there is significant deviation in the underwriting processes of companies. <sup>[A-23]</sup>

## **Deferred annuities**

### ***Traditional***

Deferred annuities operate principally as vehicles for accumulating tax-deferred savings to be distributed either as an immediate annuity or as a lump sum payment. Deferred annuities in the US fall into three categories: fixed, variable and equity indexed. <sup>[A-17]</sup>

Traditionally, deferred annuities have been purchased as investment vehicles. This limits their exposure to longevity risk. As the market has developed and become more competitive, longevity risk has been introduced from the addition of guarantees to the product offerings. A Guaranteed Minimum Income Benefit (GMIB) for example, offers the policyholder the option to annuitize based on pre-set mortality and interest factors.

This is similar to a Guaranteed Annuity Option (GAO) offered on contracts in other markets, such as the UK. Some companies are also offering Guaranteed Minimum Withdrawal Benefits for Life riders (also called Guaranteed Lifetime Withdrawal Benefits). These allow the policyholder to withdraw a set amount from their policy for as long as they are alive, even if the account value goes to zero.<sup>[A-17]</sup>

If a deferred annuity is annuitized at maturity, it is exposed to a number of risks not present when distributed as a lump sum. These products are in force for significant lengths of time and it is difficult to immunize the cash flows due to the scarcity of assets with the appropriate duration. Deferred annuities are, therefore, exposed to reinvestment risk. Inflation risk is present for the level of costs to the company as well as any benefit payments tied to actual inflation rates. Increasing longevity compounds these effects with the effect being much more pronounced for deferred annuities than for immediate annuities given the longer duration of the expected payment stream.<sup>[A-17]</sup>

The insurer remains exposed to a certain amount of longevity risk; however, in the UK the industry's ability to read demographic trends has improved over the past few decades and this risk can be diversified to some extent by increasing the number of covered lives.<sup>[A-17]</sup>

The relative size of the inherent risks to the insurer of standard deferred annuities depends on the form of the guarantee. For GMIB contracts the movements of long-term interest rates is a very significant risk. If these deviate greatly from the guaranteed rate, the guarantee would become increasingly costly. This is less critical in today's low interest environment, but would be the principal concern if interest rates returned to their early 1980's rates of close to 20%. Longevity is also a key risk. If the GAO is based on overly conservative assumptions for mortality, again the cost of the guarantee is increased. Against current low and stable expectations of interest rates, the miscalculation of longevity risk is of principal concern.<sup>[A-21]</sup>

One risk that annuities with GMWB for Life benefit have is that policyholders will live longer than expected causing claims to be higher than priced for. There is also an element of market risk, especially for the variable annuity products. If the markets were to underperform expectations, the account values would be wiped out sooner than expected, leaving the company to pay more of the withdrawals out of its own coffers. This risk is increased with the addition of features whereby the guaranteed amount increases through a rollout or ratchet.

As blocks of business come under financial pressure, insurers expend more energy towards quantifying mortality and longevity risk. For example, in a decreasing interest rate environment, annuity contracts with embedded mortality dependent options are more likely to be in the money and are therefore more apt to be exercised.

### ***Advanced Life Delayed Annuities***

Advanced-life delayed annuities (ALDA) are a variation on the longevity insurance product described above. ALDAs are inflation-linked annuities sold to individuals in the early years of their life that begin paying at age 80, 85, or 90. There is zero cash value and no mortality insurance benefits that could be commuted at any age. ALDAs are intended to mimic a defined benefit pension benefit at advanced ages for individuals without access to this protection. They do not include the accumulation phase to the

same extent that traditional deferred annuities do, and could be considered to be more tailored towards protection against catastrophic longevity. <sup>[A-9]</sup>

The value hinges on the ability of the insurer to guarantee the annuitization rate and mortality table. Pricing errors for either of these risks could result in significant losses for the insurer. Products of this nature recently released in the North American market have a participating structure where a minimum real rate of return is guaranteed with the caveat that benefits could be ratcheted up based on actual financial experience. <sup>[A-9]</sup>

For policies that have annual premiums, there are some complications. The long premium payment period is not currently supported by most insurers' administration systems. Assets to back the lengthy duration are not available which exposes the insurer to reinvestment risk. Finally, as there is no death benefit offered, policyholders could make years of premium payments and receive no benefit. All of these factors lead to reluctance on the part of insurers to offer this type of product. <sup>[A-9]</sup>

A sub-class of the ALDA product that is currently available in the market is "longevity Insurance." This product provides benefit payments in the future to individuals in exchange for a lump sum premium payment today. Typically, the deferral periods are in excess of 20 years, and allow the individuals to benefit from both interest and mortality in the pricing. The benefit of this product is that it allows individuals to purchase insurance against outliving their assets at a much lower cost than traditional SPIA products.

## **Corporate pensions**

Corporate pensions fall into two broad categories: defined benefit (DB) and defined contribution (DC) plans. Under a DB plan, the employee receives a fixed income stream dependent upon his/her salary, years of employment, retirement age and other factors. The benefit stream is usually fixed (i.e., does not protect the retiree from inflation risk). <sup>[A-21]</sup>

Under a DC plan, contributions are paid into individual accounts by each employee and the employer may contribute an additional amount. At retirement a lump sum amount equal to the current account value is available. The lump sum can be used to provide retirement benefits. The employee can have the flexibility to choose the allocation of their retirement funds, including the potential of purchasing an annuity. Most retirement plans have certain tax advantages, and some provide for a portion of the employee's contributions to be matched by the employer. Typically the funds are effectively locked into the retirement fund prior to reaching a certain age and cannot be withdrawn without incurring a substantial penalty (typically payment of taxes).

Companies funding DB plans are responsible for making the prescribed payments for the entire lifetime of the individual (and potentially beneficiary). Because of this, DB plans have a significant exposure to longevity risk. In fact, DB plans tend to have more exposure to longevity risk than traditional insurance products because the exposure is often a group of people with the same risk characteristics as they are often from the same industry and occupation. This results in a more concentrated socioeconomic profile and, consequently, less diversification than a traditional insurance product line.

Differences in life expectancy by socioeconomic group have been well established in countries where the insurance market is developed. <sup>[A-21]</sup>

In addition to longevity risk, DB pension plans are also exposed to investment and regulatory risk. Investment risk can in part be shared between the plan and the members. Should experience turn out to be worse than expected contributions can be raised to fund the gap, the formula for determining the pension payments can be adjusted to reduce the cost of the payouts or the retirement age can be increased. Because of the rolling nature of a pension plan (different plan features can be in place for many generations of employees), plan administrators also have the option of smoothing deviations in mortality or investment performance over long periods of time. However, changing the features of the plan is not easy, and can lead to disgruntled employees or even strikes.

Regulatory risk exists because of the increased public policy importance placed on employer pensions. Should these not provide the protection to employees that the government thinks desirable, it is possible that the government could step in and force an overhaul of the industry. In 2006, the US government enacted the Pension Protection Act which resulted in significant changes to the accounting, funding, and administration of retirement plans.

DB plans also have an element of inflation risk, to the extent that wage inflation outpaces investment returns, increasing the cost of the pension payments for benefit formulas that are linked to the final salary.

DC plans leave the plan sponsors less exposed to investment risk because the payout at retirement is based solely on the value of the fund. The sponsors are also less subject to longevity risk, as the plan simply returns a lump sum to the members on retirement, rather than a promise of a lifetime stream of payments. However, the reduced risk to the plan sponsor results in significant investment and longevity risk to the plan participant.

All other things being equal, increased life expectancy increases the cost of pension provisions. Employees or employers will need to either contribute more to these plans in the future, or employees will need to retire later, in order to receive the same level of benefits as current pensioners. As the age at which people retire increases, there will be changes in all aspects of our society including the provision of healthcare, the role of the family, and the cost and means of providing pensions. <sup>[A-18]</sup>

It is difficult to predict the impact of future changes in life expectancy on pension plans since there has been limited data collected on the assumed mortality improvements and base tables used in practice. However, it is clearly material as the underlying promise by employers to their employees extends up to 70 or 80 years into the future. Actuaries should be clear in communicating to employers and trustees the nature of the risks behind the promises they are making. Future plans should be designed with consideration for the impact of substantial increases in life expectancy. <sup>[A-20]</sup>

### **Investment based income wrappers**

A recent product development trend has been income guarantees on underlying mutual fund or managed accounts. These contracts typically consist of a base investment in a

specific fund or set of fund. Similar to the GMWB benefit, policyholders can obtain a withdrawal guarantee that provides for payments in the event that the account value is depleted. One of the primary differences between the traditional GMWB products is that the asset manager, not the insurance company, has control of the assets.

### **Reverse mortgages**

A reverse mortgage is a loan to a homeowner, made either as a lump sum or as a series of payments, which is repayable under a series of predetermined conditions (e.g., the death of the homeowner, or entry into a long term care facility). These contracts are known as equity-release mortgages or, more recently, lifetime mortgages in the UK. This product has several advantages for the homeowner: it does not require the sale of the home; it protects against longevity risk if the homeowner chooses to receive the loan as a series of annuity payments; and allows the homeowner access to an asset of significant value.<sup>[A-17]</sup>

Most mortgage lenders allow surviving spouses to continue living in the property until the earlier of their death or move into a long term care facility. Many products also contain a no-negative-equity guarantee whereby any shortfall in property value on redeeming the mortgage will not become a charge on the deceased's estate. This guarantee opens the insurer up to longevity risk.<sup>[A-21]</sup>

### **Structured settlements**

Structured settlements are payments made as a result of a general insurance liability related to human life, (e.g. serious injury, medical negligence or occupational injury). Payments sometimes take the form of a lump sum payable in respect of the injured party's lost earnings and/or the cost of care if seriously injured. However, recently annuities payable for life have been used as a form of settlement.<sup>[A-21]</sup>

This market, while it has the potential to be large, requires specialist underwriting skills. One current problem is the large premium volume that companies see is often a result of a small number of very large cases. Seven-figure settlements are relatively common, and portfolio experience will be far more volatile as a result.<sup>[A-21]</sup> This increases the level of specific risk as there is not a large number of homogeneous risks to allow for diversification.

### **Life settlements**

Purchasers of life settlements are exposed to longevity risk, because lower mortality means that they have to continue to pay the insurance premiums for longer than expected and receive the death benefit later than expected. Most purchasers of this type of contract are not in the primary business of trying to make profits from mortality. Life Settlements are a way of diversifying risk (often purchased by an investment bank or hedge fund) while possibly achieving a high rate of return, as has historically been the case with these portfolios. However, as competition in this field increases and pricing is squeezed, the longevity risk component, particularly at the tail, may become too large of a risk for some players to accept.



The following table highlights some of the key retirement income products available to consumers. The tables are not intended to include all of the possible products or features, but focus on the key characteristics that help to distinguish these products.

**Table 2: Retirement Product Summary**

Product	SPIA	VIA	Longevity Insurance
<b>Description</b>	For an up front, one time premium the policyholder receives fixed payments for the length of the policy, usually the lifetime of the policyholder(s)	For an up-front, one time premium the policyholder receives payments that vary with market performance for the length of the policy, usually the lifetime of the policyholder(s)	For an up-front, one time premium the policy holder receives fixed payments that start after a long deferral period (generally 20+ years)
<b>Available Features</b>	<ul style="list-style-type: none"> <li>▪ Return of premium</li> <li>▪ Cost of living adjustment</li> <li>▪ Certain period</li> </ul>	<ul style="list-style-type: none"> <li>▪ Assumed interest rate options</li> <li>▪ Payment floor</li> <li>▪ Certain period</li> </ul>	<ul style="list-style-type: none"> <li>▪ Return of premium</li> <li>▪ Cost of living adjustment</li> </ul>
<b>Advantages</b>	<ul style="list-style-type: none"> <li>▪ Annuitization leads to higher guaranteed income amounts compared to other options</li> <li>▪ Immune to market fluctuations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Payments can increase with market performance</li> <li>▪ Annuitization leads to higher income amounts compared to other options</li> </ul>	<ul style="list-style-type: none"> <li>▪ Price is significantly lower than complete annuitization</li> <li>▪ Only paying for longevity protection if it's needed</li> </ul>
<b>Disadvantages</b>	<ul style="list-style-type: none"> <li>▪ Lose control of assets</li> <li>▪ Irreversible contract</li> <li>▪ No participation in equity market</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lose control of assets</li> <li>▪ Irreversible contract</li> <li>▪ Payment may decrease</li> </ul>	<ul style="list-style-type: none"> <li>▪ Long deferral payment may result in no payment</li> </ul>

Product	GMWB for Life (or GLWB)	GMIB	Income Wrapper
<b>Description</b>	A rider on a variable annuity that provides a minimum withdrawal amount for the lifetime of the individual regardless of the account value.	A rider on a variable annuity that allows for a guaranteed minimum income level regardless of market performance.	Similar to the GLWB benefit without the investment in the variable annuity. Instead, investments are in mutual funds or a managed account.
<b>Available Features</b>	<ul style="list-style-type: none"> <li>▪ Various accumulation/payout features (ratchets, roll-ups, etc)</li> <li>▪ Diverse investment options</li> </ul>	<ul style="list-style-type: none"> <li>▪ Various accumulation features (ratchets, roll-ups)</li> <li>▪ Diverse investment options</li> <li>▪ Dollar for dollar withdrawals</li> </ul>	<ul style="list-style-type: none"> <li>▪ Diverse investment options</li> <li>▪ Simple accumulation features</li> </ul>
<b>Advantages</b>	<ul style="list-style-type: none"> <li>▪ Participate in market gains</li> <li>▪ Fully liquid account balance</li> </ul>	<ul style="list-style-type: none"> <li>▪ Participate in market gains</li> <li>▪ Annuitization leads to higher income amount than GLWB</li> </ul>	<ul style="list-style-type: none"> <li>▪ Participate in market gains</li> <li>▪ Fully liquid account balance</li> <li>▪ Lower fees than variable annuity</li> </ul>
<b>Disadvantages</b>	<ul style="list-style-type: none"> <li>▪ Restrictions on investments withdrawal amount and impact to guarantee</li> <li>▪ Base VA fees</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lose control of assets when annuitization</li> <li>▪ Base VA fees</li> </ul>	<ul style="list-style-type: none"> <li>▪ Restrictions on investments and withdrawal amounts</li> </ul>

For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-6]	David Blake, Andrew Cairns, Kevin Dowd and Richard MacMinn "Longevity Bonds: Financial Engineering, Valuation and Hedging"
[A-7]	M.A Milevsky and S.D Promislow "Can Life Insurance be used to Hedge Payout Annuities? Part 1 : Modeling Longevity Risk"
[A-8]	Paul Sweeting "The Market for Mortality"
[A-9]	Moshe A. Milevsky "Real Longevity Insurance with a Deductible: Introduction to Advanced-Life Delayed Annuities"
[A-15]	Beverly J. Orth "Managing Longevity Risk in US Retirement Plans Through Mandatory Annuitization"
[A-17]	Veronica Scotti, Dr Dirk Effenberger "Annuities: Private Solution to Longevity Risk"
[A-18]	Institute/Faculty Pension Provision Taskforce "Age of Retirement and Longevity"
[A-20]	R. C. Willets, A. P. Gallop, P. A. Leandro, J. L. C. Lu, A. S. Macdonald, K. A. Miller, S. J. Richards, N. Robjohns, J. P. Ryan and H. R. Waters "Longevity in the 21st Century"
[A-21]	Stephen Richards, Gavin Jones "Financial Aspects of Longevity Risk"
[A-23]	Matthew Drinkwater, Joseph Montminy, Eric Sondergeld, Christopher Raham, Chad Runchey "Substandard Annuities"

## VII. Quantification and management of longevity risk

To ensure that insurers are able to effectively manage the exposure to longevity risk, actuaries must first be aware of the current methods available to quantify and manage this risk. Only then can they take an active role in identifying and creating additional, more efficient risk management techniques to deal with longevity risk.

Longevity risk is receiving increasing attention from ratings agencies and equity analysts. Along with the focus on the amount of existing annuity liabilities and volume of new business written, equity analysts and rating agencies are likely to place much more emphasis on how insurers are managing longevity risk. <sup>[A-20]</sup>

The profitability of long-term payout annuity business is extremely sensitive to deviations from the assumptions used to price the product. This is largely driven by the fact that annuities are long term, spread-based products. The insurer tends to make their profit on the difference between the pricing assumptions and the actual experience. Because the products are very long term in nature, the insurer needs to make assumptions about future investment performance and mortality over thirty to fifty years, and in some cases even further. Although misestimation of the investment returns is likely to be the biggest risk, particularly for deferred annuities and products with investment related guarantees, longevity risk is significant. Insurers need to be able to properly assess the risk to which they are exposing themselves to in order to price these contracts appropriately. <sup>[A-17]</sup>

If mortality experience improves more quickly than what has been allowed for in pricing, there will be a mortality loss on existing annuity business. In Q1 2003, there were four UK insurance companies who, as a result of modifying their mortality assumptions, had announced increases in annuity reserves which were in excess of £50m. Many life assurance companies' responses to this have been to pull back from the annuity market. <sup>[A-20]</sup>

Insurance companies have already declared significant losses as they have been forced to strengthen reserves for annuity portfolios. The future increases in life expectancy, increasing awareness of the risk of providing longevity insurance, changes in legislation and shortages in market capacity and capital, may lead to more expensive annuity rates for individuals. <sup>[A-20]</sup>

### Current quantification techniques

The historic approach to assessing risk of any kind in the US has been to use a factor based approach, through the Risk Based Capital (RBC) framework adopted by the NAIC. This holds true for mortality and longevity risk as well as market based risks. Under the RBC formulaic approach, only mortality risk is currently calculated as part of the C2 capital component (insurance risk). The exposure to increased mortality is not currently accounted for in the RBC formula. Companies are required to hold some percentage of their net amount at risk or reserves to cover the risk that mortality turns out to be different than expected.

When it was implemented, the RBC framework hit writers of life insurance much harder than writers of annuities, in terms of the amount of capital required to cover the insurance risk.

In recent years the US insurance industry has moved towards a more robust process for assessing risk, utilizing stochastic techniques with the development of C3 Phase II. However, the focus of this development has been on economic and market risks. For most insurance and reinsurance companies whose expertise is in the understanding and managing of insurance risks, market movements are typically the largest sources of uncertainty. Despite this, market risk is not always the largest component of required capital (for instance, for smaller insurers the insurance risk element of the RBC framework can make up a significant portion of the total).

As a result, companies for the most part continue to quantify longevity risk using fairly basic methodologies. Although there has been a shift away from the factor based approach, stress tests are now used by most companies looking to assess their level of longevity risk. Recent developments in the use of stochastic modeling of non-market risks including mortality will help insurers to quantify the risk of longevity. The trend component of a stochastic mortality model will allow a company to quantify the exposure of potential volatility around the level of mortality improvement. While additional research needs to be completed on the details of modeling the uncertainty in the trend, by using the framework companies can start to have a better quantification of their risk exposure. <sup>[A-24]</sup>

In the UK, the regulator currently requires insurance companies to produce an Individual Capital Assessment (ICA) on an annual basis. This is similar in principal to the Solvency II regulations that are being developed centrally in Europe through a series of Quantitative Impact Studies (QIS). Under the ICA, companies are required to comprehensively identify the risks to which they are exposed. The risks that are typically assessed by insurance companies are market risk (investment returns, interest rates, foreign exchange, and default), insurance risk (mortality, longevity, lapsation, expense) and operational risk (fraud, legal).

To quantify the impact of these risks, models are run where the base assumptions are stressed in both directions. These results are then combined using a correlation matrix. The better defined risks (e.g. market risks) are typically analyzed through stochastic models to determine the capital required to cover the solvency requirements to a sufficient degree of probability over a specified time period (usually 99.5% over a one year time period). Other risks are assessed through more simplistic approaches (formula based for operational risks and stress tests for others). For longevity risks a typical stress test is to adjust the base mortality downwards by 20% to 30% (consistent with the 25% specified in the QIS 3 Solvency Capital Requirement, or SCR). We note that the QIS approach is slightly more simplistic, as it combines all sources of longevity risk into one stress; whereas under the ICA, companies can separate the trend, volatility and parameter uncertainty risks.

As a result of the ICA, it is estimated that shareholders in UK-listed insurers have direct longevity exposure of upwards of £30bn. Shareholders have further indirect exposure through annuity liabilities held in with-profits funds. These liabilities are tightly regulated, with some degree of public disclosure of the longevity assumptions underpinning reserving practice and margins to cover uncertainty. <sup>[A-21]</sup>

Shareholders in non-insurance UK companies have significantly higher longevity exposure at an estimated £762bn. The liability calculations for these companies are not as tightly regulated, and there is limited disclosure of the longevity assumptions behind them. This is troubling as several FTSE-100 companies have pension plans that are several times their market capitalization (e.g., British Airways, 450% at year end 2004).<sup>[A-21]</sup> Similar exposures are not available in the US market, as longevity risk exposure is not currently disclosed.

Although the methods currently used to measure exposure to longevity risk vary by geography (and to an extent company), insurers and reinsurers are increasingly looking for cost effective ways to reduce the capital required against any one specific risk. The next section discusses methods that companies currently use to mitigate the impact of increasing life expectancies on their book of insured lives.

### **Current management techniques / longevity solutions**

As longevity risk becomes more significant for insurers, large annuity writers and reinsurers of annuities are looking for ways to effectively manage their exposure. To date the traditional methods direct writers use are product design, underwriting, natural hedging and reinsurance. In addition, companies have started to go to the capital markets for solutions to manage and transfer some of their longevity risk exposure.

Strict controls and sufficient analysis in the product design process is an important tool available to insurers to manage their exposure to longevity risk. This is true irrespective of the product in question. Good controls should be developed to identify the significant drivers of risk and ways to mitigate the exposure through small tweaks to the design.<sup>[A-10]</sup> For example, a slight restriction on the terms that need to be met to convert a GMWB rider to a GMWB for Life could greatly reduce the number of policies that are eligible for benefits. However, it is worth noting that while good controls should help identify situations where the risk can be reduced at no extra cost to the policyholder, quite often such measures do reduce the marketability of the product in question. As such, insurers need to strike a balance and examine other means for managing the remaining risk.

Most insurance products are susceptible to anti-selection. With immediate annuities this situation arises because transferring a lump sum for a series of future payments is valued highest by those people who live the longest. While no one knows their actual life expectancy, people may be privy to information which allows them to estimate whether they have a lower life expectancy than average. For example, if their family has a history of respiratory problems, they may have a greater chance of suffering the same. These people are less likely to purchase an annuity, which in turn affects the average life expectancy of people who do purchase immediate annuities. If a company were to price assuming that the portfolio was commensurate to the population as a whole, it is likely that they will underestimate the average life expectancy and charge too low a premium.

One way to reduce the potential impact of this is to issue immediate annuities that are underwritten. This market currently does not exist for the general population with average health characteristics, but has started to develop for substandard or impaired lives. These people would typically view a standard immediate annuity as too expensive, given their expectation that they have a lower than average life expectancy.

The market for substandard annuities is slowly growing in the US. A full development of this market would allow for more transparent pricing and reduce the impact of anti-selection present in the current market. <sup>[A-23]</sup>

Another risk management technique that companies can utilize is a natural hedge. The theory behind this technique is that if an annuity writer also holds a block of life insurance business, decreases in mortality which adversely affect the annuity line (through an increase in the number of payments) should be mirrored by fewer claims in the life block. <sup>[A-10]</sup> The natural hedge would be most successful if the lives that purchased the annuities were exactly the same as the lives that purchased the life insurance policies. However, the lives that purchase annuities can be very different to those who purchase life insurance. Thus, companies that use natural hedging to manage longevity risk are therefore exposed to basis risk. <sup>[A-16]</sup>

As a result of the lower risk resulting from natural hedging, studies have shown that insurers are able to charge lower premiums than similar insurers without utilizing natural hedging. <sup>[A-16]</sup> A well diversified balance sheet with significant exposure to both longevity and mortality risk will allow companies to maximize the impact of the natural hedge.

The final traditional risk management technique for longevity risk is reinsurance. Reinsurance of a block of annuities transfers the longevity risk from the insurer to the reinsurer. Solutions available to insurers include both yearly renewable policies (YRT), as well as coinsurance arrangements. Under a typical YRT structure the insurer receives payments linked to annuity benefits in return for paying a stream of fixed premiums. Reinsurers are professional risk managers and the largest players have a significant amount of liabilities on their books. This allows them to diversify risk across lives, as well as across product lines (thus achieving some degree of natural hedging as discussed above). Some researchers believe that there may be a limit to the amount of longevity risk that reinsurers are willing to accept, particularly in Europe where the size of the reinsured annuity business is significantly larger than it is in the US. <sup>[A-17]</sup>

More recently, the capital markets have started to develop products and solutions that annuity writers can use to manage their longevity risk exposure. Financial institutions are increasingly keen to invest in mortality and longevity given the returns have zero (or negligible) correlation to their portfolio of financial assets. Having exposure of this kind might therefore increase the level of diversification in their overall portfolio; therefore, decreasing the volatility of their entire book of business.

The primary example of these solutions is the mortality swap. The general setup of a mortality swap is similar to an interest rate swap. One party will pay a measure of expected mortality and in return will receive a measure of actual mortality experience.

Insurers have had the option to enter into mortality swaps with reinsurers for some time. One of the first deals that attempted to incorporate longevity risk into an instrument that could be traded in the financial markets was the BNP-EIB Survivor Bond. This structure was effectively a securitization of the longevity risk in an underlying portfolio. <sup>[A-17]</sup> After a great deal of interest and many revisions to the terms, the BNP-EIB Survivor Bond never made it to market. Individuals have since hypothesized that the deal was either priced too high, or was structured in such a way that the capital markets viewed it as too complicated or too exposed to other types of risk. <sup>[A-13]</sup>

In the last few years, as the Life Settlements industry has emerged, investment banks have started to look more closely at ways to sell longevity exposure to the market. Mortality indices are starting to be developed to create a market much like those on existing financial indices, where risk can be openly traded between parties. Credit Suisse, JP Morgan, and Goldman Sachs have all created mortality indices.

The JPMorgan index, called LifeMetrics, was developed as part of an overarching toolkit that enables pension plans, insurers and reinsurers to measure and manage mortality and longevity risk in a standardized manner. The index itself specifically provides data for evaluating current and historical levels of mortality and longevity, and has been designed to facilitate the structuring of longevity securities and derivatives.<sup>[A-29]</sup>

The LifeMetrics Index is based on publicly available mortality data for national populations, broken down by country, age and gender. The LifeMetrics Index consists of a number of components which measure longevity and mortality. The principal components of the index are:

- Crude central rate of mortality (mx)
- Graduated initial rate of mortality (qx)
- Period life expectancy (ex)<sup>[A-26]</sup>

The index is listed on Bloomberg, and is updated annually (dependant on raw data availability). The published data includes the graduated initial rates of mortality for ages 20-90 inclusive for both England & Wales and the United States. Graduated means that a smoothing methodology has been applied to eliminate noise and errant data points from the raw data for central rates of mortality. This creates a stable set of mortality rates which are representative of the "true" underlying mortality rates for the period.<sup>[A-26]</sup>

For a given reference year, raw data is generally published by the relevant government agencies with a time lag which can be multiple years. Therefore the LifeMetrics Index data published in a given year will be based on source data that references a specified prior year. The time lag differs depending on the population geography.<sup>[A-26]</sup>

Credit Suisse's Longevity Index is very similar to LifeMetrics, but the underlying lives are based on the US population only.<sup>[A-31]</sup> The Goldman Sachs index is called "QxX" and has two primary differences from the LifeMetrics index. First of all, the data is based on a population of 46,290 insured lives as opposed to the general population. In addition, the underlying population is also over the age of 65, making it more representative of the retired population.<sup>[A-30]</sup>

There are several limitations of these indices as they currently operate. For example, the lives are either general population or specific to life settlement portfolios and therefore may not be representative of an annuity writer's exposure.<sup>[A-17]</sup> Despite these limitations, the emergence of such indices is a step in the right direction for creating liquidity in the capital markets for longevity risk.

A final potential solution for companies unwilling to retain the significant exposure to longevity risk is to sell or limit future exposure to the risk. Two ways to do this include a sale of the liabilities, or modification of benefit structures. One of the areas where this is starting to emerge is for private pension liabilities.



The management of company pension plans is becoming more expensive partially driven by the global shift to a mark-to-market reporting framework. This will greatly increase the level of a pension fund liability. Under the current approach a pension fund can smooth the liabilities, by assuming that the fund will be managed in the future to reduce or remove any existing deficiency. Under a mark-to-market approach the shortfall will have to be recognized as a liability on the balance sheet. For many companies this could represent a significant portion of their balance sheet.

Those companies that are unwilling or unable to keep this liability on their books have no option but to divest of it. This has led to a quickly developing market of buyout annuities. Particularly in the UK, companies have been set up as expert managers of pension funds and blocks of payout annuities. These companies purchase entire blocks of business and aim to make their money from trimming costs through economies of scale or increasing returns through alternative asset management approaches.

An increasing awareness by plan sponsors of these options has led to a wide variety of approaches intended to manage these risks from closing plans to new entrants (Around one-half of UK DB plans are now closed to new entrants.) and modifying the details of the existing promises (e.g., definition of final salary, increasing retirement age) to winding up the scheme entirely. <sup>[A-21]</sup>

### **Future quantification techniques**

As discussed above, most of the focus of complex modeling of insurance risk has been on the development of market or economic risks, not on mortality or longevity risk. The majority of insurance and reinsurance companies quantify longevity risks through stress testing their assumptions. While there is no sign that regulations will require a more thorough assessment than this in the near future, it is possible that companies who want to better understand their risk exposures will develop increasingly sophisticated approaches.

Stochastic mortality models have been discussed for some time as a method of quantification of risk. However, due to some of the limitations discussed above, they have yet to gain prevalence with insurance industry participants in the US. This is in part due to the lack of relevant data against which to parameterize these models. In the UK for example, the Continuous Mortality Investigation Bureau (CMIB) is responsible for collecting industry wide data on insured lives. This data is publicly available, and provides a substantial set of data that can be used to fit parameters to the form of the stochastic model chosen. If companies in the US want to look outside their own experience (which may be too limited to determine reliable results) the principal source available to them is maintained by the Social Security Administration (SSA), and covers population mortality. The experience of the population as a whole can be very different to the experience of insured lives as shown by the CMIB, reducing the value of population data to the insurance industry. The Society of Actuaries (SOA) is one of the available sources for industry surveys on insured mortality.

While having a large, tailored data set would help companies parameterize stochastic mortality models to more reliable levels, the process of back-casting should only be the starting point, not the ending point of such an exercise. The parameters that fall out of any model should be reviewed by experienced practitioners and adjusted for

reasonableness and for expectations of the future (which may, of course, be very different to the past experience). In the current environment it is still possible to choose model parameters based on a view of future mortality - the key is understanding the limitations of the assumptions chosen.

It is certainly possible that companies will soon start to see the benefit of analyzing a distribution of longevity risk outcomes, as they are now very familiar with market risks. Stochastic models already exist and have been discussed widely in academic and industry circles. These models could be tailored and included in an insurance company's risk management or economic capital processes.

### **Future management techniques / longevity solutions**

One of the primary ways in which companies can understand, limit, and effectively manage their longevity risk is in the product development process. In the annuity market, and particularly for immediate annuities, the current standard of practice does not involve significant price differentiation for health status. This results in annuitants that are selecting against the insurance company, as they expect to live longer than the average individual. Additionally, individuals who believe themselves to be in worse than average health do not purchase these products as they are perceived to be of poor value.

While there are dangers to pricing products based on controllable factors such as diet or smoking, some less obvious characteristics might start to find their way into the underwriting process to enable price differentiation between different classes. One such differentiating factor that is already being utilized in the UK is location. Insurers are beginning to offer different annuity rates to people who live in different areas of the country, using this as a proxy for overall quality of life. However, in the US the criteria that can be used to price insurance contracts must not lead to discrimination, so it is not immediately clear if this will be possible.

The next future development to help the industry with longevity risk is advances in quantification techniques that will allow for a better understanding of longevity risk exposure. This will enable better pricing and create greater liquidity in the capital markets for longevity risk. With better information, two sides to a trade are more likely to come to a compromise on assumptions and pricing, making trades quicker and easier.

Similarly, a more sophisticated understanding of the risk profiles of a portfolio would improve the pricing of longevity solutions. Models are starting to be discussed that analyze mortality by specific causes of death. This additional information may help reinsurers and capital markets to offer more reasonable and fairly priced solutions to the market.

As commented upon in the above sections, the reinsurance market for payout annuities has not been significantly developed. This is likely to change if the demand for payout annuities provided by the private insurance market increases, as one might reasonably expect. <sup>[A-10]</sup> This will result in reinsurance becoming a more attractive method of transferring longevity risk, as increased competition is likely to drive down cost.

Another future development is in the capital markets. Following the proposed EIB-BNP Survivor Bond, there has been much discussion on why it failed to launch and possible new designs. Most of these have been theoretical discussions driven by academia, but it is plausible to think that some of the proposed designs might be incorporated into future attempts at the survivor bond concept. The EIB-BNP was structured as a coupon-based instrument, where the principal was not at risk but the payment of the coupons depended on the underlying mortality. This is akin to a “classical” longevity bond design where coupon payments are proportional to the survivorship rate of the specified reference population. Under the classical design, the payments continue until the death of the last surviving member of the reference population, and the coupon payments are proportional to a longevity index. <sup>[A-13]</sup>

It has also been suggested that Zero-Coupon longevity bonds might have a role to play in making the markets for these instruments more liquid, much as they have done in traditional bond markets. The existence of such bonds would help companies, wishing to hedge their longevity exposure, create specifically tailored positions that better match their underlying portfolio of lives than a single “classical” bond. <sup>[A-13]</sup>

Other hypothesized structures that take their lead from more traditional financial instruments include Geared Longevity Bonds and Longevity Spreads. The advantage of these is that it would allow holders of longevity risk to get a similar hedge position for a much reduced capital outlay. An alternative method of reducing the initial capital required would be to defer the payments. <sup>[A-13]</sup>

One of the additional drivers of additional capital market activity is the increasing need for diversification on Wall Street. Because the risk is uncorrelated with other traditional financial risks, investing in longevity based securities will provide for more diversification. To accommodate this demand, additional tools and instruments that are not currently in the market will be developed. Similarly, existing mortality indices will become more efficient.

Another potential source of future risk management is solutions offered by the government. It has been suggested that the government could be a possible provider of longevity bonds, as they have a role to play in ensuring that markets work efficiently. They would be able to do this at a lower cost than a private institution because they do not require the same risk premium that private investors do. Introducing a liquid, secure market for longevity bonds would certainly facilitate the trading of this risk. However, one of the risks of the government offering solutions in this market is that the taxpayers could ultimately pay the price if experience is unfavorable. <sup>[A-11]</sup>

Much of the research on longevity risk deals with annuity type products. However, many of the additional products discussed in this paper also result in longevity risk exposure to companies. As the markets for these products continue to grow with the baby boomers needing to fund their retirement, future risk management techniques for these other product types will continue to be developed and researched.

The US market is still many years away from a point where longevity risk exposure is consistently quantified across parties, and where the risk can be easily and fairly traded and mitigated through a variety of suitable instruments. While the insurance industry and capital markets can learn from looking at other geographies and to academics, the future of the market for retirement products remains unclear. The direction and speed

that the product development process will progress partially depends on regulatory developments. Changes to the role of the government or government imposed requirements on pension providers or individuals could have significant impact on the demand for longevity products and the amount and type of longevity related risk that insurers have to manage.

For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-10]	Arthur Fliegelman, Moshe Arye Milevsky, Scott A. Robinson "Credit Implications of the Payout Annuity Market on the Life Insurance Industry"
[A-11]	David Blake and William Burrows "An Survivor Bonds: Helping to Hedge Mortality Risk"
[A-13]	D. Blake, A. J. G. Cairns and K. Dowd "Living with Mortality; Longevity Bonds and other Mortality-Linked Securities"
[A-16]	Samuel H. Cox and Yijia Lin "Natural Hedging of Life and Annuity Mortality Risks"
[A-17]	Veronica Scotti, Dr Dirk Effenberger "Annuities: Private Solution to Longevity Risk"
[A-20]	R. C. Willets, A. P. Gallop, P. A. Leandro, J. L. C. Lu, A. S. Macdonald, K. A. Miller, S. J. Richards, N. Robjohns, J. P. Ryan and H. R. Waters "Longevity in the 21st Century"
[A-21]	Stephen Richards, Gavin Jones "Financial Aspects of Longevity Risk"
[A-23]	Matthew Drinkwater, Joseph Montminy, Eric Sondergeld, Christopher Raham, Chad Runchey "Substandard Annuities"
[A-24]	Matthew Clark, Chad Runchey "Stochastic Analysis of Long Term Multiple-Decrement Contracts"
[A-26]	Guy Coughlan, David Epstien, Alen Ong, Amit Sinha, Javier Havia-Portocarrero, Emily Gingrich, Marwa Khalaf-Allah, Praveen Joseph "LifeMetrics – A Toolkit for Measuring and Managing Longevity and Mortality Risks"
[A-29]	Paul Sweeting "Tax-Efficient Pension Choices in the UK"
[A-30]	QxX Index Co., LLC "Amended and Restated Rules for the QxX Indices – April, 2008"
[A-31]	Credit Suisse "Credit Suisse Longevity Index Commentary"

## **VIII. Areas where more research is needed / Gaps in the current literature and research**

In performing this literature review, we have attempted to be comprehensive by identifying and reviewing papers that deal with the subject of longevity risk. Inevitably some papers may have been omitted that readers of this report will view as just as important as those that we have included.

While there was sufficient information on many of the topics that were covered in this review, there were areas in which additional research is needed.

### **Understanding mortality/longevity risk profiles**

Insurance institutions have always specialized in understanding and managing mortality risk. However, mortality risk is dynamic and continuous research is needed to ensure that the industry is up-to-date with the latest trends. Over recent years this has included increasingly detailed analysis into characteristics such as splitting lives into cohorts (as in the UK), focusing on specific causes of death as drivers of mortality and increased granularity of the risk factors by which mortality investigations are conducted. There is still room for more sophisticated analysis which would only help improve the understanding of the mortality and longevity risk profile of a particular block of business.

One of the key areas where research would be most beneficial in the US is around a comprehensive study of insured mortality data, similar to those regularly published by the CMIB in the UK. This would greatly improve the industry knowledge of the risk that it faces, and allow it to design, price and hedge products with mortality and longevity risk more easily. Some potential applications of this include:

- Improved insight into mortality improvement assumptions. Currently the standard tables published by the SOA do not explicitly include allowance for future mortality improvement (projection scales can be used to shift the effective date of a base table). Companies are left to define their own improvement assumptions, often by using their own limited data and/or population data. It is possible that additional data and analysis may be available through reinsurance companies. For smaller or newer companies, the lack of internal data is an obstacle to determining an appropriate assumption and the population level data is likely to have too much basis risk to be useful without adjustment. Having access to a standard set of data on insured lives, including projected improvements, would be extremely valuable to the insurance, reinsurance, and capital markets industries.
- Improved basis for existing and future mortality indices. Current mortality/longevity indices are constructed on a very specific subset of lives. While there is always some level of basis risk involved in trades, the smaller and more unique the portfolio of lives, the greater the potential basis risk. This can lead to the situation where two parties to a trade have very different views on the expected mortality experience, making it difficult to agree to a price. Access to comprehensive insured data would allow for a wider ranging index, based on a much larger group of insured lives that would bring people's estimates closer together and add much needed liquidity to the market.

Greater granularity of the mortality experience studies would also be beneficial to the insurance industry in general. Companies are starting to consider underwriting annuities for a wider variety of factors and already provide substandard rates to those in extremely poor health. More in-depth analysis of the effect of factors such as profession, income and marital status to name a few risk factors might help insurance companies better understand the risk profiles of their books of business.

Also we note that the UK appears to have the most detailed and robust analysis on the topic of longevity risk. While a number of studies have been conducted on most of the developed countries' mortality experience, there are not many that go beyond historical analysis of the improvement of the population as a whole. One paper that we would like to see is to expand on the themes of cohort mortality and other key differentiators of mortality but compare in great detail different geographies around the world. For example, it would be valuable to investigate whether life expectancy differences due to area of domicile are as varied in Germany, Japan or the US as they are in the UK.

This report did not include a literature review of the many medical and social factors that may be driving increases in life expectancy. There is significant research available on these topics, and a similar literature review would be useful to those readers interested in understanding the causes and drivers of life expectancy.

### **Stochastic mortality models**

There is a wealth of literature, mainly from academia, on the subject of stochastic mortality models. These tend to focus on the form of the models and their fit to historic data. Discussion around the practical application of such models is one area where there is substantially less information. It would be valuable to see some in-depth analysis from a company perspective of the relative costs and benefits of implementing stochastic mortality analysis in various parts of the product cycle (pricing, reserving, managing capital, hedging longevity risk, etc.) and across various product categories (payout annuities, life settlements, etc.).

On a more detailed level, the academic research conducted to date typically does a good job of pointing out areas where the analysis could be extended. A few areas that were highlighted include:

- More detailed analysis of continuous stochastic mortality models that could be used for pricing mortality derivatives. <sup>[A-12]</sup>
- Modeling of longevity bonds with multiple cohorts of lives. <sup>[A-12]</sup>
- Further analysis around calibration of the initial mortality term structure. <sup>[A-12]</sup>
- Discussion around using different volatility structures as an alternative to Brownian Motion. <sup>[A-12]</sup>

### **Product / solution design**

It is clear that academic papers are at the forefront of research suggesting new structures for institutional longevity solutions, for example survivor swaps. The academic world has been less vocal on the subject of new products that could be structured to suit the needs of the individual in better managing their longevity exposure. This may be because this is an area where insurance companies specialize, meaning that all product innovations are likely to come from within the industry. However,

insurers typically have to satisfy multiple stakeholders. It might be interesting to see suggestions for new and innovative product ideas from an independent viewpoint.

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For additional information on the topics discussed in this section, please see the following papers.

<i>Appendix Reference</i>	<i>Paper</i>
[A-12]	Daniel Bauer "An Arbitrage-free Family of Longevity Bonds"