

DISCUSSION HELD BY THE INSTITUTE OF ACTUARIES

Mr J. B. Orr, F.F.A. (introducing the Steering Group paper): I will take you through some of the background to the scoping study work, the mortality research that was involved, and describe the steering group. Dr Macdonald will talk you through the scoping study. I will talk about the methodology that has been adopted and about an experts' meeting that we held in March. I will provide a brief description of the sessional meeting, and then talk about the October 2009 conference, which we are working towards.

I am a general insurance actuary who, from day-to-day, is not particularly concerned with issues of mortality. Prior to chairing the mortality research committee, I chaired the research steering committee within the Actuarial Profession. For many years the Actuarial Profession has funded research in universities and by other researchers on a responsive basis. We received applications from researchers who would like to do a small piece of research, say for six months or a year, related to an actuarial topic. We then decided whether to fund that or not. The responsive mode is good because we are scattering the funds around and that has led to some quite important research being supported. For example, it has led on to other developments in the field of genetics at Heriot-Watt University.

We needed to do something with a bit more direction and substance and this view was reflected in the Morris Review. We wanted to move from a responsive mode to a directed mode. The question was: what shall we focus on? The then chairman of the CMI Bureau, Brian Ridsdale, came to the research steering committee and said "I think it is clear what area we should be looking at. It should be around mortality developments. There is a history in the actuarial profession of looking at mortality issues and also, with recent financial conditions, specifically low inflation and low interest rates, the importance of mortality has been heightened within, say, valuation assumptions on pension schemes, or when looking at life and annuity business. It is gaining increasing prominence, as well, due to rapid changes in mortality experience and a recognition of the uncertainty around this very complex area."

We recognised that we could not respond to this challenge by ourselves and need input from other interested parties, and other interested practice areas, which are dealing with mortality issues.

The first stage in that process was to set up a mortality research steering group, which I chaired, thanks to my involvement with the research steering committee.

Many of that group are familiar to you. You will be hearing from Dr Macdonald and Dr Morris later, together with Mr Brian Ridsdale. This group represents the practice areas, including demography, epidemiology, medicine, gerontology, etc. What we are trying to do is set up a multi-disciplinary team to survey the current knowledge on mortality and to identify gaps and overlaps, which can then inform our decisions about what future research is necessary.

This is a scoping exercise, a survey of current knowledge on mortality in several professional disciplines. We asked experts from these disciplines to nominate the five most important papers. This then allowed us at least to undertake a 'spider' type search of what were the important areas and identify the overlaps and gaps. What was unusual in this process was whereas we would normally give money to, say, universities, this time, as a profession, we decided that we would enlist our own professional researcher, who is Dr Macdonald, and give her a specific brief. This was a new experience for us given the short term nature of the project, the need to scope the brief clearly and to relate to our appointed researcher.

We had a mortality experts' meeting on 3 March, chaired by Professor Tom Kirkwood, who is an Honorary Fellow of the Faculty of Actuaries and has been a previous Reith Lecturer, whose lectures on ageing and longevity were broadcast on BBC Radio 4. About 40 people attended who had been recruited through the "expert identification" process. We had presentations from Professor Kirkwood on longevity, from the CMI Bureau on its work, and on the scoping study from Dr Macdonald. We have debated questions about what is the current state of knowledge, what area we should be looking at, and recommendations for future activities.

Our aim is to update the actuarial profession, foster future working relationships and to advertise the 2009 conference, which is to be held on the 21 and 22 October 2009 at the Royal College of Physicians of Edinburgh. Professor Tom Kirkwood has agreed to chair and lead the development of this conference. It is going to be organised around three themes which will include looking at drivers of mortality change and the reasons for differences between cohorts. We are still considering the impact of individualised mortality risk and whether that will be the third theme. We are to target the conference at actuaries, people from other disciplines, other practitioners, and also, with the support of the Economic and Social Research Council, PhD students, engaging with researchers of the future. The aim is to create a multi-disciplinary effort, and give actuaries exposure to these other practice areas and sources of knowledge.

The scientific reviewing panel for the conference is going to be chaired by Professor Angus Macdonald. We had thought it possible to have a special edition of the *Annals of Actuarial Science*. As a peer reviewed journal, it is not possible to guarantee inclusion. Therefore we are proposing to issue a special edition of the *British Actuarial Journal* for the conference.

Dr C. Macdonald (introducing the paper): I am going to provide an overview of the findings of the first report of the Actuarial Profession's Mortality Research Scoping Group, which was set up in 2006. The group includes members from a variety of specialties, including the actuarial profession, medicine, medical sociology, demography and the Office for National Statistics.

The main aim has been to map the principal areas of current research and interest in mortality developments across a wide range of disciplines including the actuarial profession, medicine, epidemiology, gerontology, demography, health economics, medical sociology, social policy and psychology.

We are hoping to achieve an overview of research being undertaken by these disciplines. This would highlight areas of overlap with the actuarial profession's research and between research of the other various disciplines. Also of central importance is the identification of gaps in the current research into mortality developments.

The first challenge was how to identify, review and draft a report covering all the professions' research on mortality developments within the original six months available to the project.

We adopted the approach of contacting experts in each of these fields and asked them to nominate what their five most important pieces of research on mortality developments.

This approach has a number of potential weaknesses as well as strengths, the weakness being that this is not a comprehensive review. Also, there is the possibility of bias in the selection of the experts, although many of the people whom we contacted were recommended from several different sources and are clearly key people working in the field.

I emphasise that this is a scoping project designed as a first step of mapping the field of mortality developments. It was not our intention to produce a definitive list of all the literature in this area.

Out of the 38 experts contacted, 22 contributed a list of recommendations, which generated a list of over 90 pieces of research. Further recommendations were made following a meeting of experts held at the Institute in March at which a draft version of the report was also discussed. We then contacted all those who attended and asked for additional comments or recommendations for the paper. A further 40 papers were recommended which have been copied into this version of the report.

The structure of the report has been guided by the literature recommended to us from which a number of common themes have been identified.

The first theme is "The Role of Medicine". This included research which looked at the overall role of medicine in the decline of all causes of mortality, recommended mainly by experts from medicine and medical sociology. This includes the work of Thomas McKeown published mainly in the 1960s and 1970s who argued that, taken as a whole, medicine had contributed little to the overall decline of mortality up until the 1970s. He, instead, emphasised the role played by standards of living and, in particular, diet.

Other recommended papers considered the more recent role of medicine in several geographical

locations and generally viewed medicine in a more favourable light. Of note is the work of John Bunker who calculated the contribution of specific medical interventions that have increased life expectancies in the United States since 1950.

The second theme identified was "Lifestyle and Environment". This has been designed as a catch-all theme and covers non-medical influences on the decline of all causes of mortality. The literature in this area was recommended by experts from the actuarial profession, medicine, medical sociology and demography, and included papers on smoking and mortality, including the work of Doll, and a number of papers on the effect of socio-economic circumstances on mortality.

Very few papers were recommended on the relationship of either obesity or alcohol to mortality and no papers were recommended on the relationship between either diet or physical activity and mortality.

The next theme headed "Causes of Death" included all the research which looked at mortality from specific causes of death. The majority of recommendations covered only two causes of death, coronary heart disease and stroke. We did receive recommendations for cancer from within the scoping group. However, these were outwith the scoping group or for any other causes of death.

The papers which examined mortality from coronary heart disease were recommended by experts from a number of different disciplines. Coronary heart disease received the greatest number of recommendations and of these the majority were for the work carried out by Simon Capewell and colleagues. This investigates the relative contribution of medicine and risk factor reduction to the decline in coronary heart disease mortality using a model which they have developed. Capewell and colleagues applied this model to data from a number of different countries, including Scotland, England and Wales, Ireland and America, over a time period ranging from 1975 to the current century. They have attributed between 40% and 47% of the decline in heart disease mortality to medical treatments and the remainder to risk factor reductions.

They have also identified some adverse trends in coronary heart disease CHD mortality, in particular an increasing BMI, and the prevalence of diabetes.

The next theme is "Mortality within Specific Age Groups". The first age group is children and younger adults whose improving mortality rates drove major increases in life expectancy during the late 19th and early 20th century. However, we received no recommendations for research which examined this age group.

The next age group is middle age where mortality has been improving since at least the 1970s. Although members of the scoping group expressed interest in knowing more about the influences on this increase in middle age life expectancy, we received no recommendations for research specifically in this area.

The main area of interest was papers which were recommended to us on mortality among the oldest old, that is the population aged over 80. These papers were recommended to us by experts from demography, epidemiology, genetics and the actuarial profession, and covered a wide range of issues and, in many cases, reflected conflicting views.

We were able to group this literature into three general subject categories, the first of which describes past trends in oldest-old mortality. This includes the work of Kannisto and Thatcher which suggests that, in the past, octogenarians were unusual and centenarians rare but that in the last decades of the 20th century there has been an unprecedented decline in age specific mortality within the oldest-old themselves.

The second subject category covered the factors which could be influencing this increase in longevity among the oldest-old, including factors such as the genetic determinants of longevity. However, in the literature recommended to us there is no consensus on why mortality among the oldest old is improving.

The third category dealt with future trends in extreme longevity. A number of experts recommended papers by Vaupel, who argues against the idea of a biological maximum for longevity increase, and also papers by Olshansky, who holds an opposite view.

A number of papers explored the issue of active versus inactive life expectancy amongst the

oldest old. These mainly considered the degree to which this increase in life expectancy has been spent in good health.

The next theme which we identified from the literature has been labelled “The Cohort Effect”. This appears to mean slightly different things to different disciplines. For the actuarial profession this refers to a specific cohort, born between 1925 and 1944, identified by research as having seen a greater improvement in their mortality than those in cohorts born on either side of these dates.

The literature recommended by experts from other disciplines appears to see the cohort effect in a slightly different way. In many cases this involved looking at the effect which early life influences can have on successive generations of older people such as the relationship between environmental influences on early life — such as maternal welfare, diet, housing, infection — and the risk of mortality in later life.

The final theme has been entitled “Actuarial Views on the Future of Life Expectancy”. This includes those papers which were recommended by members of the profession and which provide an overview of the profession’s main interests in mortality developments, in particular past trends in mortality, projections for longevity in the 21st century and the possible financial implications of longevity increase. The most commonly recommended papers in this category were those by Willets and colleagues. It is interesting to note that very few experts from outwith the profession recommended actuarial research on mortality developments.

The literature recommended to us covers a wide range from which we have been able to identify a number of common themes. Based on this initial review of the literature, we have identified several questions which appear to be prominent in current research.

These questions include: what role does medicine play in mortality decline, and what role will medicine play in any future declines? What is the relative contribution of medicine and risk factor reduction to the decline in mortality from coronary heart disease?

What is it that causes ageing? Is ageing a separate condition from disease? Is ageing an underlying cause of death? Is there a maximum limit to human longevity and will longevity continue to increase in the future?

For actuarial research the main question was “Will the 1925-44 cohort continue to see greater mortality improvement than those born on either side of these dates?”

Our review of the research literature indicated two types of overlap. The first was overlap in the areas of research being conducted by the various disciplines. For example, there is a large overlap in the research conducted by epidemiology, medicine and medical sociology.

The second area of overlap was amongst papers recommended by experts from the different disciplines. In many instances experts from a variety of disciplines would recommend the same piece of research work. This was most evident in the research conducted by Capewell and colleagues recommended by experts from most of the disciplines contacted.

In the case of literature on the oldest-old, the area of overlap was between the actuarial profession, genetics and demography. This would appear to indicate that, in some instances, experts are aware of research being conducted in disciplines other than their own.

As well as providing an overview of the field of mortality developments the scoping project aimed to identify the gaps in the research not just in actuarial research, but among all the disciplines that investigate mortality.

However, when it came to drafting the paper this proved to be one of the most difficult areas to discuss because an apparent gap in the research could simply be gaps in the literature recommended to us.

One way in which we have been able to see gaps is to look at the subjects covered under the various theme headings suggested for the report. For example, under the heading “Non-medical Influences on Longevity” the lack of recommendations covering the impact of diet, obesity, alcohol and physical activity on mortality trends was evident, as was the lack of recommendations for causes of death other than heart disease and stroke in the section which considered influences on mortality from specific causes of death.

The lack of papers covering cancer was raised during the experts’ meeting in March.

However, despite the fact that we contacted all of those who attended, and asked if they had additional recommendations, very few of them went on to recommend papers on cancer.

Under the heading "Age Groups", it is also interesting that we only received recommendations for papers that looked at oldest-old mortality as opposed to research in, and trends on, mortality among younger and middle aged adults.

Discussion within the scoping project steering group also generated a number of suggestions for possible gaps in the research. This included concern over the lack of attention paid to dementia and frailty as significant causes of death. Related to this was concern regarding inadequacy of current death certificates for not allowing multiple co-morbidities to be listed as causes of death.

Members of the scoping group also wished to know more about factors which may have an adverse effect on future increases in longevity, including obesity and the potential emergence of infections.

They also wanted to know more about the effects which climate change could have on mortality. Given the methodology employed of only using expert recommended papers, it is likely that some of these gaps are not real and the research exists but was not recommended by the experts contacted. If this is the case, it implies that at the moment the experts currently regard other research as more important.

The scoping group is one of the first steps to identifying these gaps in mortality research. By contacting people working in the area at the moment, we can get an indication of what are currently seen as the core issues in current mortality development research. We welcome comments on the report. It is hoped that the project and ensuing discussions will highlight issues and act as a starting point for future interdisciplinary research into mortality developments.

Dr J. Morris (a guest visitor): I am a consultant geriatrician. I have been fascinated working with actuaries on this mortality scoping research group. It is an opportunity to start to think about ageing in a multidisciplinary way. Often researchers have concentrated on the "ologies" but we all know that older people do not die of just one disease.

They die from multiple co-morbidities and yet we in medicine still treat patients how we treated them 50 years ago despite the tremendous change in demography. The death certificates do not demonstrate that. There is only an opportunity to write, at the most, two diagnoses. The next issue is the fact that we have not got any magic bullets. There is a dubious premise that we may be able to find the elixir of life to enable everybody to live for an extremely long time.

A lot of people before they die suffer from dementia. This is poorly diagnosed, and is not always included on the death certificate. We need more collaborative multidisciplinary research on dementia.

Next there is frailty. I hope that we will have an opportunity to develop multidisciplinary research in frailty, and maybe even consider its place on the death certificate. The American definition is that "Frailty is a biologic and physiologic syndrome associated with ageing. It is a result of multisystem dysregulation." In other words, frailty is the consequence of people having multiple co-morbidity. The hallmark of frailty is enhanced vulnerability to stressors. The clinical presentation of frailty is definable and may appear subsequent to the development of physiologic vulnerability including weight loss, weakness, exhaustion, slowed walking speed and low activity.

Sarcopenia, a loss of muscle mass, will appear as part of frailty as will under nutrition, decreased strength and exercise tolerance, slowed motor processing and performance, decreased balance, low physical activity. Cognitive impairment as part of dementia may precipitate the onset of frailty.

People with frailty and/or dementia will often have a poor functional status. This may give rise to an inability to look after themselves or carry out activities of daily living. The societal consequences of an ageing society of dependant and frail people would be significant. People who cannot look after themselves cost money. That has implications for insurance, pensions, care and social care. Overall the bottom line is a high mortality associated with a loss of function

caused by dementia and frailty. Collaborative research on frailty, dementia and mortality needs to be established in the United Kingdom.

Mr R. A. Humble, F.I.A.: As actuaries we need mortality assumptions subdivided by age and gender over a number of future years. This is far removed from the focus of the typical medical researcher who is interested in what factors may improve mortality and lead to better treatment for patients. In consequence, medical research papers tend not to produce results in a format which leads easily to this age, gender, future years split in terms of mortality assumptions.

For example, the paper by Unal *et al.* (2005b) on coronary heart disease, which is referred to in the section 3.3.1.4 of the paper, noted that 48.1% of the reduction in CHD deaths is the consequence of reduction in smoking. Whilst this is an important statistic it is not, unfortunately, split by age or gender. Hence its practical utility for actuaries is rather limited.

Another issue for actuaries is that many medical studies base risk factors on meta analyses of other studies. Perhaps they look at eight or nine other studies, perhaps done in different countries, and amalgamate the results. These other studies themselves also are typically not split by age and gender, and they are representative of the population being studied, which relates to the profile of the people in the particular institution in question. As such, nobody is pretending that these are in any way a stratified sample of the population as a whole, hence drawing meaningful conclusions from them for the population as a whole is really rather difficult.

Reference has been made to cause of death and the unreliability of cause of death statistics. The typical death certificate now has three causes of death. It is a matter of extreme judgment as to what actually gets recorded as being the primary cause. For example, under the ICD classification there was a huge reduction in the number of deaths due to pneumonia in the year 2000 simply because of a change in the convention in the ICD classification.

The paper presented to this Institute on two-dimensional mortality by Richards *et al.* (2007) refers to error rates in cause of death of 9% between major causes, like cancer, respiratory disease and CHD, and as high as 23% for narrower definitions. This emphasises the care that is needed in trying to interpret the statistics.

It is absolutely essential for actuaries and medics to work closely together and to agree at the outset of the research what the nature of the research and the outputs are going to be, particularly in terms of the age and gender splits, which actuaries need.

Another fundamental issue, which is very multi-disciplinary in its nature, is what exactly is the state going to be prepared to pay for? Medical advances may well significantly extend life expectancy but will NHS spending support this extension. Future research in this area must, by its nature, involve actuaries, medics and economists.

Dr S. F. Whelan, F.F.A.: This paper is most helpful as it lists some 121 papers recommended by experts across the whole spectrum of disciplines researching mortality, and provides a useful summary of the findings. The ask-the-experts methodology complements the approach that must be adopted by individual researchers, to find highly cited papers or study the work of very highly regarded individuals.

I am beginning a research project, kindly funded by a Government of Ireland Research Fellowship, with the output being a book on Irish mortality, past and projected. I had done my own scoping of relevant research in mortality trends and projection methods when Dr Madonald's paper was most timely published. My findings from a similar exercise provided a further five research articles that I have found most useful to my preparatory work. My list differs from that of the expert advisers as it does not seek to identify the five most important pieces of research in each area but comprises mainly survey works. Accordingly my list covers the same ground as this Report of the Mortality Research Steering Group, namely, it helps map out this terrain for new researchers.

A danger that any researcher must guard against when beginning with the existing literature is that all too often the very high quality of research already done influences unduly the viewpoint of the researcher on what issues are important. Academic researchers and actuaries may share a

common interest in mortality developments but the aims of each group are quite distinct (cf., B2.5.12 in Background Paper 2 by Adrian Gallop).

The actuaries' professional interest in mortality research is:

- (1) to understand the mortality levels currently experienced by the population as a whole and by different subgroups within the population; and
- (2) to model the development of mortality rates for the groups above in a way that quantifies the uncertainty inherent in the modelling exercise.

It follows that the vast library of mortality research must be filtered for direct relevance for actuarial purposes by asking if the research helps further our knowledge of either current or future levels of mortality or their trends. The public interest dimension of an actuary's work is also best served by using our present understanding of (1) and (2) to highlight policy issues for society, e.g., design of pension systems, healthcare costs, etc.

The seven themes identified by the steering group in the literature on reviewing the experts' reading recommendations are: (a) the role of medicine; (b) lifestyle and environment; (c) causes of death; (d) age groups; (e) active life expectancy; (f) cohort effect; and (g) actuarial views. I shall confine my remarks to (a)-(d).

In (a) the role of medicine, the McKeown Thesis as updated by, *inter alia*, Nolte & McKee, is highlighted in the paper, which shows that medicine has played a less prominent role in reducing mortality in developed countries in reality than in popular reckoning. I would add to that reading list the similar, but more speculative approach, taken by the Nobel Laureate Robert Fogel (2004). Fogel attempts to link nutrition, life expectancies and economic growth through the past and extrapolate trends to the future. Amongst others, he claims that mankind has entered a new phase since 1700, which he terms "technophysio evolution" that has reshaped our bodies, by increasing overall body mass by a half, and even more dramatically, allowed us to reshape our environment. He attempts to relate metrics of lifestyle and environment (such as diet and body mass, real wages, expenditure on healthcare) to developments in life expectancy. The Report points to a gap in the literature on diet and, in general, how socio-economic circumstances impact mortality that Fogel attempts to fill, albeit at times heroically. In particular, Fogel's hypothesis of the development of a more resistant and repairable human body provides a rationale for cohort analysis.

My second recommendation is James Riley's (2001) *Rising Life Expectancy: A Global History*. From a survey of the literature Riley argues persuasively that mortality decline has come from a mix of six key components — wealth and income, nutrition, public health, education, behaviour and medicine. The key point is that the mix has been quite different in different countries, even though the resultant decline in mortality has often been similar. For instance, the rapid mortality decline in sub-Saharan Africa since the Second World War relied heavily on biomedicine, through both prevention and treatment, compared with Britain's greater reliance on general improvements in the standard of living. Riley's thesis is that studies in the apportionment of the mortality decline into different factors are country-specific and the results cannot be generalised.

Disentangling the role of medicine, lifestyle and the environment in the mortality decline of any specific country is very complex, and it is not at all obvious how it can be put to use for the actuaries' narrow purpose. Generally, we do not have reliable information on the decomposition of the exposed-to-risk by the different identified risk factors, nor can we reliably forecast how their intensity in the exposed population will change with time. Accordingly, it is not obvious if a sound understanding of the role of medicine or lifestyle in general on mortality decline can be used to forecast mortality change any better than existing methodologies.

The paper captures well the very patchy and inconclusive nature of research results in these broad areas. A simple conjecture such as exposure to widespread famine and its attendant diseases *in utero* or during infancy must adversely impact mortality later in life (e.g., Barker's foetal origin hypotheses or much of the rationale advanced for cohort effects) proves contentious: Kannisto *et al.* (1997) shows that cohorts born during or before the Finnish famine of 1866-68 do not have lower life expectancies from age 17 years than those cohorts born

subsequently. I hope that my analysis of Irish cohort mortality from 1841 will shed some light on this debate.

The cause of death approach seems more promising for actuarial modelling purposes. However, it is believed that the cause of death entered on death certificates in the UK is incorrect in about one-third of cases (see O'Reilly (2006) and references therein) and, if autopsy rates do not improve, this can be expected to increase further with time as age at death becomes more advanced and the underlying cause of death even less clear. Also, it must be observed that mortality projections derived from current trends in rates by cause of death have been poor to date, systematically underestimating mortality improvements. The reason for this is of interest in itself because it seems to be a bias inherent in many forecasting methods. Projecting mortality rates separately by each underlying cause of death based on current trends and then aggregating the results produces overall mortality improvement rates at each age that tend to decline with increasing forecast time as, quite simply, the weights attached to each underlying cause of death change with time to give greater emphasis to those causes of death with the slower rate of improvement. In aggregate, this forecasting approach leads to reducing rates of decline in sharp contrast to the generally accelerating rates of decline observed to date. [For an overview of forecasting approaches applied in practice see, for instance, Wong-Fupuy & Haberman (2004) and Government Actuary's Department (2001, Appendix H) for approaches used in official national projections.] So again, the case is not obvious that the research on cause-of death is directly useful to the actuary.

We are on firmer ground, of course, when Dr Macdonald's paper surveys the age-specific mortality rates and their trends in recent decades. The Report cites Kannisto (1994) on clarifying the trend in rates at the most advanced ages. I would add Thatcher, Kannisto & Vaupel (1998) as a recommended read. This later book provides a detailed study of the level and trend of mortality since 1960, basing the exercise on the 13 developed countries with the highest quality records in the Kannisto-Thatcher Oldest-Old database. In total the study includes over 32 million deaths over the period 1960-1990 and includes over 120,000 centenarians. The exposed-to-risk was calculated using an extended version of the method of extinct generations. They report that a special case of Perks's Law (or logistic), which they term the Kannisto version (see formulae below) adequately fits the pattern of mortality from age 80 years onwards for both sexes, over different periods, and when fitted to either period or cohort mortality rates. This study suggests that mortality rates at 120 years of age are between 0.5 and 0.65 for both sexes. I would say that I have found the Kannisto version a robust and pragmatic model to employ to help identify trends at the oldest ages in the Irish population and can anticipate its usefulness in even sparser data sets.

Perks's Law (or Logistic Model) (Perks (1932)):

$$\mu_x = c + \frac{a e^{bx}}{1 + \alpha e^{bx}}. \quad (1)$$

Perks's Law-Kannisto Version (Thatcher *et al.* (1998))

$$\mu_x = \frac{a e^{bx}}{1 + a e^{bx}}. \quad (2)$$

Widening out the mortality scoping project, I would suggest studies outside of human mortality to get an understanding for the malleability of animal longevity. In recent years there have been several such surveys in book form, but I recommend Gavrillov & Gavrillova (1991) though it was originally published more than two decades ago.

My fifth and final recommendation is the paper we have before us. I mentioned one reason in my introduction, that is, for its attempt to map out and summarise key research in this multidisciplinary area. However, there is a second and perhaps even better reason to commend it: the Steering Group made a brave attempt in highlighting obviously important areas where there

is a puzzling dearth of research. This is not something that an individual researcher could credibly do and, obviously, it is of immense value. I congratulate Dr Catriona Macdonald, James Orr (Chairman of the Steering Group) and the other members of the Mortality Research Steering Group on bringing this Report to the Profession.

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Mr I. J. Kenna, A.I.A.: Longevity has been improving in the developed countries for the past hundred years. We owe it to our pension funds to attempt to find out if this trend is likely to continue.

In 3.2.4 the authors state that there appears to be no evidence regarding a connection between diet and longevity. Healthy people tend to live long lives and die early as a result of accident, misadventure, suicide or homicide. We should, therefore, turn our attention to what diet will assure a healthy existence.

Dr I. D. Currie (a visitor): Do the authors have a view whether it is best to approach the problem of mortality forecasting using (a) all-cause of death or aggregated data, or (b) individual cause-of death or disaggregated data? I am firmly in the aggregated data camp but the whole thrust of the meeting is to look at individual cause of death. The disaggregated approach identifies drivers of changes in future mortality. The idea is to forecast these, add up these individual forecasts and so arrive at a forecast of total mortality.

There are three difficulties with this approach. First, identifying the cause of death, since even such a coarse division as heart disease, cancer and all others is a problem in itself; the paper refers to the death-certification problem and Dr Jackie Morris also referred to the multiple causes of morbidity. Second, combining the multiple forecasts to give our forecast of aggregate mortality is also extremely difficult since the individual forecasts are dependent. Third, assessing the accuracy of our final forecast is very difficult indeed. This point is crucial in any forecasting

system. I am unhappy with any method that appears to be so secure, so self-confident, that no accuracy measure is required.

My second comment is related to my work on aggregated data. Why have mortality rates fallen so sharply in the last 30 to 40 years? Presumably, it is the very drivers discussed in the paper, but acting in tandem, that have produced these past mortality improvements. These drivers, and others guessed at and not guessed at, will continue to act on future mortality. Our best guide to their effect on the future path of mortality is the pattern in the past. This approach has one crucial advantage- it lets us build a probability model for mortality, which allows forecasting and assessment of accuracy.

The paper is concerned exclusively with mortality. I am a statistician and my contributions, largely through the CMI, have been restricted to the study of mortality. Actuaries should be concerned about the impacts that future mortality will have on their products. Some products will be affected more than others. Unexpected future improvements in mortality are bad news for the seller of annuities. Conversely, sellers of term assurance benefit from under-estimating future mortality improvements.

Stephen Richards and I have just been awarded a grant from the profession to study not mortality *per se* but the impact of mortality forecasts on a range of insurance products. The mortality forecast underpins this work, but it is not our main concern. Our aim is to describe the effect of future mortality on a particular product in probability terms. We will report on this work to a sessional meeting of the Faculty early next year.

Mr A. A. Pinington, F.I.A.: In contrast to the last speaker I position myself firmly “yes we should analyse mortality trends by cause”. I am currently heading up a mortality by cause research group composed mainly of interested actuaries, whose organisations are taking on risk involving longevity. Hence the importance of understanding the potential future prospects for mortality improvement.

We have heard quite a lot about the unreliability of the recorded cause of death for older ages. Indeed, this is a problem, but I do not think it is quite as serious as suggested. It may be that there is systematic mis-recording over long time periods. In practice, from the data used in our model, we find on the contrary that the observed incidence rates behave very consistently from calendar year to calendar year and from age to age.

I do not think that there is material lack of diligence by those responsible for recording the cause of death. Whilst the data is not entirely accurate, it is certainly informative to drill into the detail to discover what it can tell us.

Perhaps some of the concern about reliability of cause comes from the degree of detail. ICD codes run to four digits. If you want to go to the fourth digit, there is going to be lots of potential for misclassification, and there could quite easily be a 23% variance. But if you go down to ICD 2 digit codes, which is just the high-level classification of cause of death, then at least up until age 80, may be even 85, if you are diagnosed as dying from cancer it probably was cancer. Whether they have got the exact cancer right is a different question. If it is lung cancer, they have probably got that right, but specific lung cancer may be not. Likewise for many of the lesser cancers (e.g. acute vs sub-acute myeloid leukaemia, anterior vs posterior wall of bladder, etc.) that could be a problem.

Whilst this is not really the forum for discussing the modelling work that we are undertaking, I would like to expand a little on the concept of the model we are developing. Some in the audience may have seen the film “Perfect Storm”. One of the scenes showed a few people standing around a three-dimensional computer screen where there was a shape emerging (evidently using hologram technology). Consistent with the film’s story-line, they were looking at meteorological data and trying to project what would happen if you heated the ocean over the Atlantic, whilst several other meteorological events were happening elsewhere (specific pressure gradients, wind direction, etc.). Consequently, these hurricanes started forming and clearly were going to converge into one massive storm. The key point here is that they had something which at least three or four different people could observe and discuss whether they thought it was behaving in the way they would have anticipated.

Today's challenge is that when we try to interact across different professions we use the arcane language of our particular discipline, or area of research. So when several disciplines collaborate the expectations and interpretation of what they discuss are different.

Mr Humble, speaking from the actuary's perspective, says he is interested in projecting by age and gender into the future and so we need to keep the data that way. A medical practitioner is likely to be more interested in the percentage improvement, or how effective a drug may be at reducing either morbidity or mortality for a case being managed.

What we really need is a common environment and language, where several professions can interact; an environment where we can extract and look at all the causes that collectively comprise the senescent conditions. Then we can look at what has been the trend of senescent conditions, as a cause of death, and discuss the forces, relative importance and expected results of emerging interventions.

I thank the authors of the paper for the very helpful work that they have done, and are continuing to do, and make an appeal to move away from the two dimensional idiom of paper and letters to the multi-dimensional idiom of computer based modelling.

Dr D. Metz (a visitor): I am based at University College London, a member of the Financial Services Consumer Panel, which advises the Financial Services Authority on consumer matters, and a member of the stakeholders group of the Board of Actuarial Standards.

The report is very helpful in providing more extensive information on the factors that influence the prospects for longevity. The uncertainties in those prospects are greater than a simple actuarial viewpoint.

Uncertainties will diminish with increase in scientific research and knowledge and that will be helpful to actuaries. However, my judgement is that this is unlikely in the medium term. There is an enormous amount of research on those diseases and conditions that give rise to mortality, the subject of the report. So far it has mostly focused on the specifics: how do you treat cardiovascular disease, for instance, based on the scientific understanding of the underlying cause. This has been very successful in some areas like cardiovascular disease, but much less so in other areas such as dementia.

A new approach is emerging based on an increasing understanding of the ageing process at cellular and molecular levels. Ageing is a risk factor for the diseases that kill us. If you understand the ageing process, you will get a much better handle on these diseases. So the prospects for ageing research as it bears on mortality prospects are uncertain but potentially very important.

The National Health Service is required to reduce inequalities in life expectancy. If you travel up the Northern Line from King's Cross to Hampstead (four stops), male life expectancy of the surrounding population increases by 11 years. The result of the pressures to reduce inequality will be broadly helpful in terms of reducing mortality. We are faced with a major problem of uncertainty about longevity, but this is being managed by the actuarial profession.

Failure to manage the uncertainties associated with longevity prospects has the potential to do damage to society. There is the urge to do business in competitive markets to sell annuities, pensions, and other innovative products which manage longevity and, on the other hand, the need to maintain an appropriate prudential allowance for the uncertainty. Actuaries are in the position to assess this risk.

Mr I. P. McKeever, F.I.A.: One aspect possibly missing from the analyses is the effect of education on life expectancy, given the recent publication of the Ogden Tables where they effectively look at the employability of people who are injured in accidents. They found that they could ignore all socio-economic factors in making their adjustments, and the only factor that actually mattered was the level of educational achievement of the person injured. It makes one wonder whether or not education might be an important factor in mortality.

There is some support for this from other areas. The state of Kerala, in India, is one of the poorest states in India but it is also the state with one of the longest life expectancies in India, which rather conflicts with our general expectation that life expectancy is equated with material wealth.

Kerala is also a very unusual state in India in that it encourages the education of females. Women are much better educated in Kerala than they are elsewhere in India, which is likely to increase the level of basic education in the whole state.

If education is an important factor in indicating life expectancy in the UK, it is easy to add an education question on product proposal forms. It may be more important than postcodes, for example, which represent a very rough and ready way of going about it.

Dr J. Powell (a visitor): Mortality is a complex area. We have heard that there are so many interwoven factors driving it.

The scoping project has done a great job in looking at the available literature. I would encourage the study of literature focusing on short term outcomes, such as the transition of people from normal health into diabetes. It does not tell us whether they will live longer having slowed down their trend into diabetes.

We also know something about the transition from normal blood pressure into high blood pressure, and we can measure that quite accurately. Again, many of us are not going to argue about the effects of having high blood pressure.

The data is building rapidly in this middle ground of intermediate endpoints and will be useful to the actuarial profession, as well as the more complex longer term outcomes.

Finally I would not be too worried about cause of death. All-cause mortality maps very well along with specific mortalities into all of these behaviours, be they diet, lifestyle, stress or education. The fit is not brilliant but maybe you are worrying too much about the detail.

Mr P. Goldblatt (a visitor): The expert approach has produced an excellent review of the literature with some areas of limitations, which probably need to be addressed at the second stage of the work.

I believe you should now look at some of the more extensive previous reviews in particular areas. First, I would point you to the ONS recent publication called "Focus on Health", which did try to summarise some of the issues around diet, obesity and physical activity.

The second area I should like to point to is the fact that in this country we have had a cancer registry since the 1940s. It is rather odd that no one was able to come up with any useful literature from that. There have been two reviews; the first one was by Greenberg and Coleman which reviewed some 500 or 600 research studies that had been conducted using the National Health Service Central Register. The majority of those were cancer epidemiology studies.

Following on from that there has been work by Coleman and by Cancer Research UK identifying where there is evidence, both of treatment effects on cancer, and there is recent evidence, for example, on the effectiveness of current, but not past, treatments on breast cancer, to give one example, which is a major cause of death in middle life among women.

The recent ONS publication, the "atlas of cancer for the UK" looks at incidence, mortality and survival and whether reducing mortality has been due to treatments, across the British Isles, including Ireland.

The final example is what Dr Metz was saying about the inequalities in health. The Acheson report provides a wealth of information on socio-economic factors that lead to differences in mortality. There is also a focus on issues like stress and on some specific diseases.

Every other speaker has mentioned death certification. A lot of the concerns about the accuracy are related to the fact that people expect too much of death certification and therefore are disappointed when it does not deliver the answer to everything. It is not there as a tool to look at the epidemiological cause or sequence of what in childhood led to someone dying at 85.

The questions on the medical certificate of cause of death, as laid down by the WHO, are in two parts. The first part looks at the immediate causal sequence. What caused the death now, and what led to that and what third cause — and there are three, not two — led immediately to the sequence of death. That will not pick up what happened to you in childhood if you died many years later.

However, there is a second part to the death certificate, dealing with other factors that may have contributed to the death. This is generally under used by junior hospital doctors, who may

not have the time to go back very far in the patient notes to look at that. Nor often do they have the detailed pathology available, which is available from a post-mortem and which will not always provide an identical set of causes to the notes. There is a lot of literature on errors. The errors are quite systematic and that is why statistically you can get a good relationship year on year, and a good pattern of trends over time. If you want a reference on ageing, I would refer you to the report of the Shipman Inquiry. The issue of quoting old age at death was looked at extensively by Dame Janet Smith in the Shipman Inquiry, and she was strongly against the use of the term old age, at least until a very old age. However, she did not tell us when that should be.

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Mr T. J. Llanwarne, F.I.A.: The authors requested comments on possible gaps. There may be two types of research. These are research on mortality and research on survivability, and survivability appears to be a gap. Maybe the heading for your scoping document should be Mortality and Survivability. Further two gaps concern the drugs and medicines used. Is there any aggregate research on drugs and medicines which is recent? There are some old papers referred to but is there any recent research on pharmaceutical companies and their incidence of blockbuster drugs in the pipeline?

The second thing on the survivability work is something I did not see in the paper. This is preferred annuities.

Mr W. D. B. Anderson F.I.A.: I am a pensions actuary and I find the paper has identified a tremendous amount of uncertainty. On a practical level, an actuary assimilates all that uncertainty looking at historic trends and evidence, and does not focus on what is in the pipeline.

The bit that is missing is what is all the current good work going on? I happened by chance to be talking to an expert in the area of imaging technology for detecting at an advanced level people who may be prone to heart disease. Major developments in this area will occur over the next few years. There is no real consideration of economic incentives here. A number of people mentioned the focus of the NHS on trying to reduce health inequalities. In Scotland I believe GPs have a financial incentive to identify people who have high levels of blood pressure and to put them on hypotensive drugs. There are many areas that could benefit from such an incentive approach.

Mr B. P. Ridsdale, F.F.A. (closing the discussion): It was as a result of the high level of interest in mortality developments, and a belief that more of value could be done if we had a multidisciplinary focus on these issues that the Mortality Research Steering Group was set up only two years after the seminal paper "Longevity in the 21st Century" by Willets *et al.*, was discussed here.

The interest is reflected internationally with the International Actuarial Association setting up a task force on mortality. It is clear from that, that there is a very great international interest in what is going on in the UK. There are many things being done in the UK that are not yet being studied elsewhere.

We asked for gaps, and I would like to summarise a few for the record. On "the role of

medicine in reducing mortality”, Dr Whelan gave us some helpful references. On “the role of lifestyle and environment”, Mr Kenna gave us his observations on the impact of diet on longevity. I would comment that if you ever have the spare time do have a look on Google at the Calorie Restriction Society. It seems to be a United States based organisation of people who have, for the past 20 years or so, been working on the understanding that if you deprive a mouse of about 25% of its minimum calorific requirements for normal sustenance, it lives much, much longer.

We had references on the subjects of lifestyle and “cancer as a cause of death” from Mr Goldblatt, who referred us to “Focus on Health” and the “atlas of cancer for the British Isles”. We were conscious of a shortage of references to major works on cancer.

We had “mortality and survivability” as a recommendation from Mr Llanwarne, and a suggestion to look at United States data on preferred annuities.

A number of our items were suggested by Dr Macdonald as possible areas for future research.

“Socio-economic differences in longevity” were referred to by Dr Metz and Mr Goldblatt. Dr Morris made a call for more work on “dementia and frailty”. That is clearly noted.

We had some talk on methodology and Dr Currie commented on the problems with analysis on an individual basis and gave the case for using probability models for mortality, using aggregated data.

We had a number of items for new research. Mr Pinington referred to his group that is examining mortality by cause. We shall look forward to some output from the group. Mr Humble made a plea if the original briefs for medical research projects took into account the needs not only of medics but also actuaries, statisticians and demographers, perhaps the combination of requirements would produce results which were more useful to other professions.

The problem with classification of cause of death was raised and answered.

The context was widened by Dr Metz commenting that we tend to assume that greater research means better understanding. He pointed us, as an actuarial profession, to the need to manage expectations of consumers, both individual and corporate. He challenged us to consider “managing longevity uncertainty”.

Finally, I should like to thank the team who worked with Dr Macdonald on the brief for the paper and the people who produced the two appendices; Mr Gallop and Mr Orr. I would particularly like, on your behalf, to thank Dr Macdonald, who has served the actuarial profession extremely well. She is now working in another area but it is to be hoped that she will be back with us at other times. She has done a tremendous service to the actuarial profession. Thank you, Dr Macdonald.

I should also like to pass on the profession’s thanks to all the eminent professionals, especially those from other disciplines, who have contributed to our working group, and to the initial discussions, who gave us their recommendations of papers to consider, and who contributed to our experts’ meeting in March and today.

Work in preparation for next year’s conference has already started, and the research, and synthesising of findings, is in some respects of more importance than the conference itself. As Dr Metz and others said, research is of little value unless it is digested, discussed and used. Next year’s conference will aim to do that.

The President (Mr N. J. Dumbreck F.I.A.): I was looking forward to an interesting and stimulating discussion. We have certainly had that this evening. There is general recognition by those contributing to the discussion that this was an extremely valuable piece of research. It has shown that our understanding of this very complex subject is really quite superficial and that there is a whole lot more that could be done to improve that understanding. It is important that we continue with that research.

There are clearly some differences of view on the right way forward and the areas that we should be tackling. I hope that the discussion, when we have had a chance to consider and digest it, will help point us in the right direction.

Overall it has been a very useful meeting. It really now just remains for me to express my thanks and, I am sure, the thanks of all of us to our speakers this evening; Dr Macdonald, Mr Orr, Dr Morris, and Mr Ridsdale, to the other members of the Mortality Research Steering Group, Dr Madhavi Bajekal, Professor David Blane, Adrian Gallop, Martin Hewitt, Professor Angus Macdonald and Dr Trevor Watkins, and also to all of you who have participated in the discussion.