AN ANALYSIS OF PENSIONER MORTALITY

BY PRE-RETIREMENT INCOME

David Knox and Andrew Tomlin

Centre for Actuarial Studies

The University of Melbourne

January 1997

Abstract

The existence of a relationship between the socio-economic status of an individual and their mortality rates is often accepted but is difficult to measure. This study analyses the relationship between an individual's final salary prior to retirement and their mortality rates during retirement. A strong inverse relationship is found which is consistent with previous studies in North America. Some of the implications of these results for voluntary annuity markets and public pension policy are also discussed.

Keywords

Mortality, income, annuity, pension policy

The authors wish to thank Mr Peter Agnew of the office of the Australian Government Actuary within the Insurance and Superannuation Commission for his work in preparing the data for this project and also acknowledge the financial support received from the Australian Research Council - Small Grant No. S11947411.

1 Introduction

Most retirement income schemes around the world, whether they be national schemes, occupational plans related to employment or personal pension plans, provide retirees with a lifetime pension payable from the real (or notional) assets accumulated during the individual's working career. In many instances, these pensions are paid until the death of the individual retiree or his/her spouse.

It is apparent that the total costs of these pensions is directly linked to the longevity of the pensioners. Yet, the life expectancy of all pensioners within a particular scheme or group is not the same. Indeed, there is considerable evidence that mortality rates are linked to the socio-economic status of the individual, which may be measured, at least in part, by occupation, wealth, lifetime income or education, or a combination thereof. Traditionally actuaries have used occupation as a factor in estimating life insurance premiums but have not used any of these socio-economic factors in the annuity market. This is partly due to the marketing difficulties that that such a proposition would cause and, in many cases, the lack of any valid data. Notwithstanding these problems, the existence of a significant relationship between these measurable parameters and post retirement mortality rates needs to be considered in the pricing of personal annuities in a voluntary retail market.

The possible link between socio-economic status and mortality is also important in both the design and equity considerations of national pension schemes as these schemes have important redistributive functions within a society. Some writers (eg, World Bank, 1994 and Atkinson, Creedy and Knox, 1996) have raised the issue of intragenerational equity involved in national pension plans due to the links between an individual's lifetime income and their mortality. As a result, it has been suggested that the provision of a lifetime pension may introduce inequity into national retirement income schemes as those with longer lifetimes receive pensions that exceed the accumulated value of their contributions at the expense of those who die earlier. Of course, this result is not wrong or unfair if the scheme is developed on an insurance basis where there will always be 'winners and losers' due to the pooling of the risks. However, the real issue is whether an inbuilt or predictable bias is present which favours a particular group of pensioners.

It should also be stressed that there are different issues within national and private sector schemes. In national schemes, all individuals may be eligible for a pension which is paid from contributions and taxes received from a variety of sources. These public arrangements reflect social and political decisions made within a particular society at a particular time. However, even in these schemes, it is feasible that the presence of differential mortality may lead to financial redistribution through the national pension arrangements that works in a manner contrary to other principles normally adopted by the society (for instance, significant regressivity may occur whereas progressivity is often a feature of tax and social security systems).

In contrast to national or universal plans, annuities in the retail sector must be priced to take into account all significant known factors. If this policy is not followed, adverse selection will occur and the private sector market is likely to become less effective. In some cases, this may mean that annuity providers will, for very good

reasons, assume that selection will occur thereby making the annuity market less attractive to potential investors.

In considering both national and personal arrangements, a fundamental question exists as to the extent and significance of any relationship between a socio-economic factor (say, income) and mortality. If, as is suggested above, lower income individuals have an expected higher mortality rate (and hence lower life expectancy), then this factor needs to be considered in the design of public pension plans and in the determination of annuity prices. Of course, it is also recognised that the existence of such a relationship does not mean that there is an easy practical solution to the dilemma that differential mortality may present.

The purpose of this paper is to test whether a significant relationship between income and mortality exists within the Australian context and then to compare these results with those previously published from other international studies. Section 2 discusses the data and methodology adopted while Section 3 presents the results and compares them to other international studies. Section 4 analyses some of the consequences of these results while Section 5 presents some conclusions.

2 The Data and Methodology

An investigation into the links between lifetime income and mortality after retirement requires income data and mortality records for many individuals over many years. Ideally, a longitudinal study would be conducted comparing lifetime income and post-retirement mortality. However, such records are virtually impossible to obtain as they would require detailed recording over a 50, 60 or 70 year period. Furthermore, within the Australian context, most superannuation benefits are taken in a lump sum form so that even the mortality experience of pensioners is difficult to obtain. With these limitations in mind, this study has concentrated on the data available from one of the largest pension schemes in the country, namely the Commonwealth Superannuation Scheme, which is a pension scheme for federal public servants.

This scheme provides a pension related to the member's final income and completed years of service for all individuals who retired prior to 30 June 1994. No commutation of the employer funded pension is permitted thus enabling each retiree's final salary to be calculated from the current indexed pension and the dates that each individual joined and retired from the scheme. As noted above, it would be preferable if the investigation was able to use lifetime income. However this measure is unavailable and as a proxy for lifetime income, the individual's final salary will be used. Whilst this is not ideal, it represents an appropriate measure for those who have had a reasonable career in the public service. In terms of the existing pensioners, the majority are males who have been employed in the public service for at least two decades. Hence, the level of final salary should provide a good indication of the level of their lifetime earnings. It should also be noted that manipulation of the final salary to improve the individual's pension is unlikely to occur in the public sector.

The raw data for this study was provided by the Australian Government Actuary and comprised records on Commonwealth Superannuation Scheme pensioners and dependent (widowed) pensioners for the years ending 30 June 1991, 1992, 1993 and 1994. (Invalid pensioners were excluded from the data.) Using the data fields relating to the pensioner's date of birth, indexed pension, date joined scheme, date exited scheme and date of death (if relevant), a salary at retirement was able to be determined for each pensioner and a mortality rate calculated for any age or income group. All salaries were converted to 1994 dollars. Further details of the methodology used for calculating salaries are given in Appendix A.

Records of pensioners who had retired before the age of 55 were ignored as these represented retrenchments where a choice of lump sum payment or pension was given. Pensioners with a date of retirement before 30 June 1976 were also excluded as their pensions were calculated using a different method. Data on widowed pensioners were insufficient for an analysis of mortality to be carried out in respect of widows.

Table 1 summarises the number of records available for each year.

Table 1: The number of records available for the investigation

Year	Males	Females
1 July 1990 - 30 June 1991	24,626	5,674
1 July 1991 - 30 June 1992	25,886	6,106
1 July 1992 - 30 June 1993	27,417	6,604
1 July 1993 - 30 June 1994	28,508	7,107
Total	**106,437**	**25,491**

To calculate the pensioner mortality rates for each age and income grouping, the number of deaths together with the exposure for each group was calculated (as outlined in Appendix A) and summed over the four years.

Pensioners with an observed annual salary at retirement of more than $60,000 were grouped into one income band to obtain sufficient numbers of exposed lives and expected deaths for the statistical analysis. Pensioners with an annual salary of less than $20,000 were considered likely to have been contributing to the superannuation fund whilst employed in a part-time capacity such that their final salary was unlikely to be a true indication of their total lifetime income. This group was therefore excluded from the analysis and this accounted for less than 2% of males and less than 5% of females. The number of records available for pensioners aged 84 and over was negligible and these pensioners were also excluded from the study.

3 The Results

3.1 Male Pensioners

Table 2 shows the total years of exposure (E) and the number of observed deaths (O) for each age-income group and the resulting mortality rate (Q). The number of expected deaths (Exp) for each age-income grouping is also shown, based on the experienced mortality rate for the particular age group as a whole.

As a check on the validity of the results, the calculated mortality rates for male pensioners were compared with the corresponding mortality rates assumed for male pensioners in the Public Sector and Commonwealth Superannuation Schemes in the Australian Government Actuary's report on long term costs using data to June 1993 (Duval, 1994). Although this data is only available for pensioners at quinquennial ages, Table 3 shows that the mortality rates calculated in this study are very similar to the Actuary's assumptions. This result is not surprising as the Actuary is likely to have based his assumptions, at least in part, on the Scheme's experience.

Table 3: Comparison of male pensioner mortality rates: The Actuary's assumptions and this study's results

Age	The Actuary's assumptions	Male pensioners in this study
55	.004	.001
60	.007	.005
65	.013	.011
70	.023	.022
75	.041	.041
80	.072	.067

To test the hypothesis that mortality rates are equal at different income levels within a particular age group the chi-square test statistic with 4 degrees of freedom was used. There was very strong evidence to suggest that mortality rates were <u>not</u> equal at different income levels in the age groups 60-64 years ($p<0.001$), 65-69 years ($p<0.001$), 70-74 years ($p<0.001$) and 75-79 years ($p<0.001$). However, the chi-square statistic was not significant ($\alpha=0.05$) for the 55-59 and 80-84 age groups. This lack of significance in these two groups is likely to be caused by different factors. First, the younger age group represents early retirements only, such that this group is likely to have its own characteristics. Second, there is a lack of data in the older age group. In addition, Wilkins et al (1989) showed that the mortality disparities diminish markedly after age 74 and it is possible that the lack of significance in the older age group is also reflecting a reducing income effect at older ages.

Figures 1a and 1b graph the observed mortality rates for the 4 age groups, where there are significant results, and highlight the general direction of the relationship between income and mortality rates.

Table 2: The mortality experience of male pensioners:
exposed-to-risk (E), observed number of deaths (O), mortality rates (Q) and expected deaths (Exp)

	55 - 59 Years				60 - 64 Years				65 - 69 Years			
Salary ($1994)	E	O	Q	Exp	E	O	Q	Exp	E	O	Q	Exp
20,000-30,000	1461.2	8	0.0055	6.1	4515.1	56	0.0124	37.8	7060.8	137	0.0194	109.1
30,000-40,000	2560.1	10	0.0039	10.7	6670.3	64	0.0096	55.8	9010.3	154	0.0171	139.2
40,000-50,000	2690.4	13	0.0048	11.2	5966.8	47	0.0079	49.9	8008.7	127	0.0159	123.7
50,000-60,000	1669.0	7	0.0042	7.0	4038.1	27	0.0067	33.8	5710.9	73	0.0128	88.2
> 60,000	1454.4	3	0.0021	6.1	3803.8	15	0.0039	31.8	6197.4	65	0.0105	95.7
Total	9835.2	41	0.0042	41.0	24994.2	209	0.0084	209.0	35988.2	556	0.0154	556.0

	70 - 74 Years				75 - 79 Years				80 - 84 Years			
Salary ($1994)	E	O	Q	Exp	E	O	Q	Exp	E	O	Q	Exp
20,000-30,000	4198.0	157	0.0374	110.2	1870.9	112	0.0599	86.2	192.1	16	0.0833	13.8
30,000-40,000	5943.7	172	0.0289	156.1	2691.3	128	0.0476	124.1	341.0	22	0.0645	24.5
40,000-50,000	4706.3	94	0.0200	123.6	1913.5	95	0.0496	88.2	242.0	17	0.0702	17.4
50,000-60,000	3087.2	60	0.0194	88.2	1086.2	30	0.0276	50.1	181.2	16	0.0883	13.0
> 60,000	4193.9	98	0.0234	95.7	1875.6	70	0.0373	86.4	270.7	17	0.0628	19.4
Total	22129.1	581	0.0263	581.0	9437.5	435	0.0461	435.0	1227.0	88	0.0717	88.0

Figure 1a: Mortality rates and income

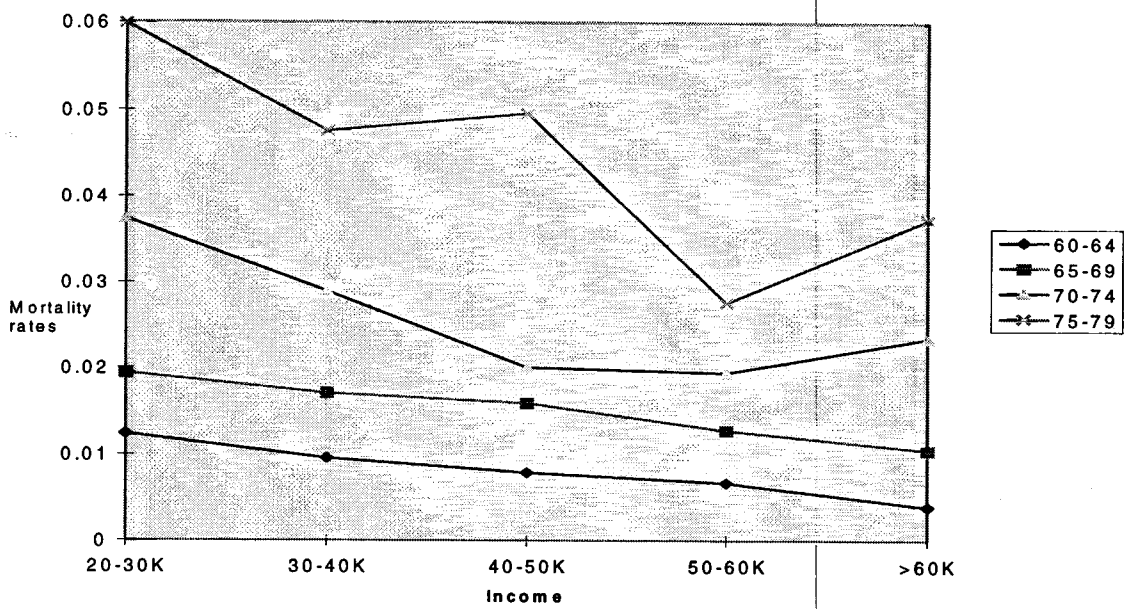
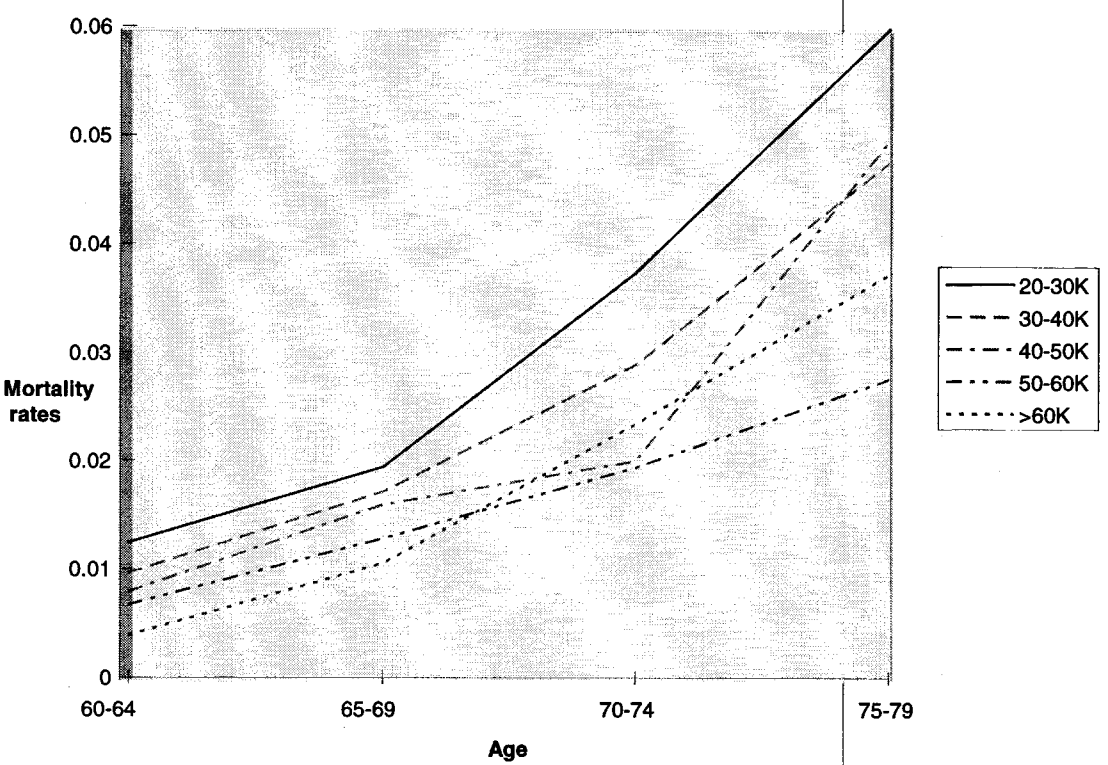


Figure 1b: Mortality rates by age



The data suggests that for male pensioners between the ages of 60 and 80 mortality is related to income with a trend towards lower mortality rates as income increases. This can also be seen from an inspection of the age-specific standardised mortality ratios (SMR) for each income group in Table 4. The standardised mortality ratio is the ratio of observed to expected deaths multiplied by 100.

As a measure of relative mortality between income levels we may also calculate the ratio of the SMR for the lowest income group to the SMR for the highest income group. As Table 4 shows, the SMR of the lowest income level is well over twice that of the highest income level for male pensioners aged 55-64. Although this disparity in death rates between high and low income earners is not as pronounced for the older age groups the ratio of SMRs is always greater than one. As will be shown below, these ratios have also been used in other international studies and therefore provide a useful point of comparison.

Table 4. Age-specific standardised mortality ratios (SMR) by income level.

	Age Group					
Salary (1994 A$)	55-59	60-64	65-69	70-74	75-79	80-84
20,000-30,000	131	148	126	142	130	116
30,000-40,000	94	115	111	110	103	90
40,000-50,000	116	94	103	76	108	98
50,000-60,000	101	80	83	74	60	123
> 60,000	49	47	68	89	81	88
Ratio of SMR for lowest: highest income	2.67	3.15	1.85	1.60	1.60	1.32
Ratio of SMR for extreme values	2.67	3.15	1.85	1.92	2.17	1.32

3.2 International comparisons

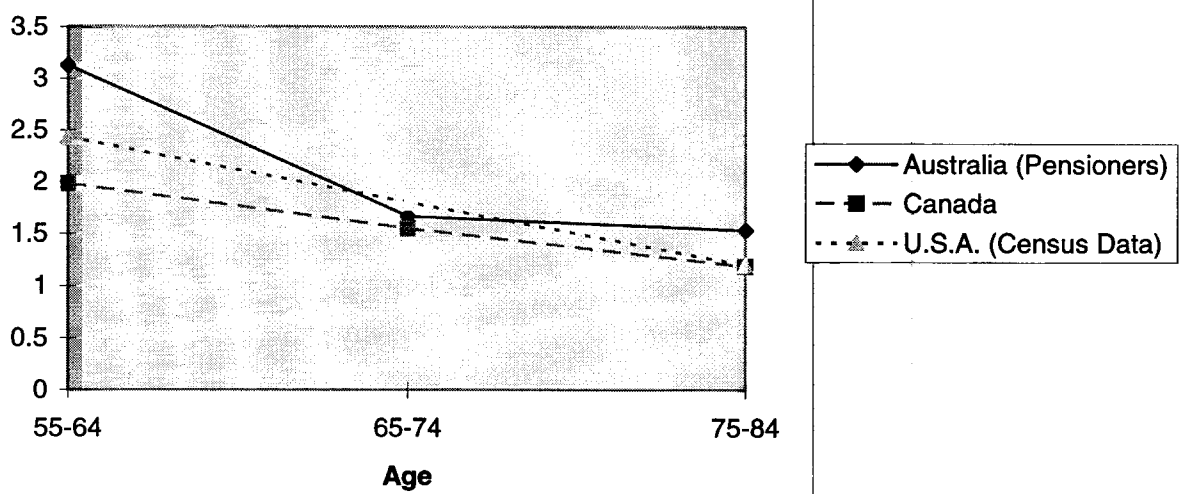
The direction of these Australian results is also supported by other international studies, including a United States national longitudinal mortality study conducted under the auspices of the National Institutes of Health (Rogot, Sorlie, Johnson & Schmitt, 1992). This 1979-1985 follow-up mortality study of 1.3 million persons involving twelve census sample "cohorts" found that white males aged 55 or more exhibited an inverse relationship of mortality level with income. The standardised mortality ratio in the lowest income bracket was at least twice the standardised mortality ratio in the highest income bracket for white men aged 55-64 years.

In Canada, a collaborative study by Health and Welfare Canada and Statistics Canada (Wilkins, Adams & Brancker, 1989) was conducted based on a male residents of Canada's Census Metropolitan Areas in 1986. Census tracts within each Census

Metropolitan Area were assigned to one of five income quintiles according to the proportion of residents with low total family income as determined by the national low-income cut-off. The Canadian data showed that, for males aged 55 to 84, the higher the percentage of poor in a quintile, the higher the death rate.

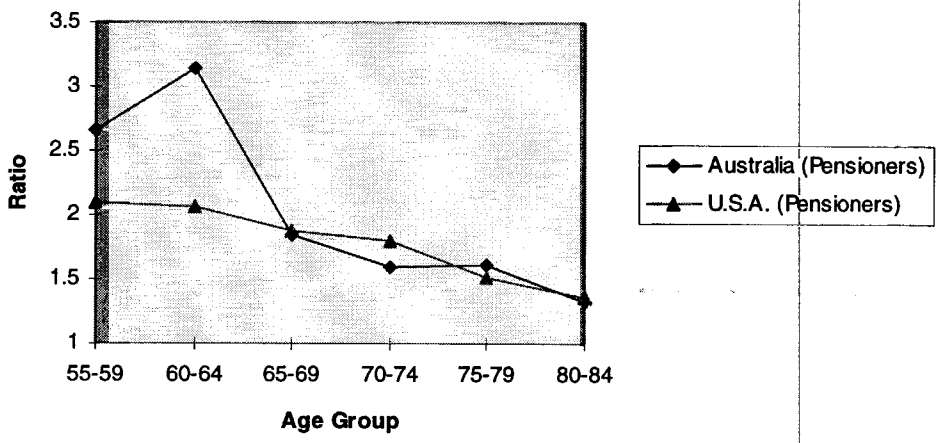
Figure 2 shows the ratio of the age specific SMR for the lowest income grouping to the age specific SMR of the highest income group for each of these North American population studies as well as the Australian pensioner data for the same age groups. The similarity of the ratios, particularly for ages 65-84, is remarkable, particularly given the different approaches taken. These three studies also confirm the suggestion that the income effect decreases with age.

Figure 2: Ratio of age specific SMRs - lowest to highest income groups



A more directly comparable study with these Australian results is the investigation of the mortality of non-disabled annuitants in the United States covered under the Civil Service Retirement System (Virga, 1996). For the fiscal years 1988-1994, pensioners were pooled into five-year age groupings for each of five indexed final salary levels. Mortality rates were seen to decline significantly as the amount of final salary increased with the differential between the highest and lowest salary levels also declining with increasing age. Figure 3 shows the ratio of the mortality rates of the annuitants in the lowest salary band (less than $30,000 pa) with the mortality rates for those in the highest salary band (greater than $80,000 pa) and compares them with the corresponding Australian age groups. The greater differential in mortality rates found for Australian pensioners age 55 to 64 years may reflect the fact that the definition of invalidity changed as at June 1990 thereby making it harder for a person to receive an invalidity pension. Although it is conjectural, it is possible that this change had a more significant impact on lower income earners who retired as normal pensioners in the early 1990s and were therefore aged under 65 for the period under study.

Figure 3. Pensioners only



Other overseas studies have estimated the influence of wealth or total assets on mortality despite the difficulties involved in collecting comprehensive and accurate wealth data over a sufficient length of time (Attanasio and Hoynes, 1995; Menchik, 1993; Jianakoplos et al., 1989). Each of these studies has found that an inverse relationship exists between wealth and mortality thereby confirming the trends found in this Australian study.

Furthermore, the three studies discussed above suggest a similarity in the experience in the three countries and a declining relationship between income and mortality rates as age increases. This latter result may be considered to be a form of a "select period" after retirement such that the significance of differential mortality reduces as the retiree ages.

These findings, which suggest that differential mortality amongst retirees is definitely present but that its importance reduces over time, are important for both the pricing of annuities in the private sector and for intragenerational equity in national pension systems.

3.3 Female Pensioners

In this Australian study, the number of female pensioner records available were considerably less than for male pensioners. Table 5 shows the experience and suggests that no consistent trend was evident across income levels for female pensioners. Indeed test statistics were insignificant at the 5% level for all age groups.

While the evidence from overseas (Rogot et al., 1992; Virga, 1996; Wilkins et al., 1989) indicates that female mortality rates also vary inversely with income level, no such relationship was discernible from this, albeit smaller, set of data. One possible reason for the lack of a relationship between the level of income and rate of mortality for females is that many of these female pensioners worked during a period where the

level of household income and/or wealth may have been primarily determined by the income earning capacity of the male member of the household. In addition, a significant proportion of these women is likely to have been employed in a part-time capacity for some of their working lives or have been out of the work force for a number of years. Hence, it is suggested that household or total family income may be better socio-economic indicators than the level of female income. It is also interesting to note that in the most directly comparable international study (Virga, 1996), there was evidence for differential mortality amongst female annuitants. However the evidence was not as strong as the male ratios shown in Figure 3 with the female ratios for age groups 65-69 and 70-74 being 1.70 and 1.28 respectively whilst the corresponding male ratios were 1.88 and 1.81.

Table 5. The mortality experience of female pensioners:
exposed-to-risk (E), observed number of deaths (O), mortality rates (Q) and expected deaths (Exp)

	55 - 59 Years				60 - 64 Years				65 - 69 Years			
Salary ($1994)	E	O	Q	Exp	E	O	Q	Exp	E	O	Q	Exp
20,000-30,000	1683.3	7	0.0042	6.0	4162.4	23	0.0055	24.5	4346.1	43	0.0099	42.8
30,000-40,000	1074.3	3	0.0028	3.9	2186.6	15	0.0069	12.9	2399.4	20	0.0083	23.6
> 40,000	584.9	2	0.0034	2.1	1125.3	6	0.0053	6.6	1171.8	15	0.0128	11.5
Total	3342.5	12	0.0036	12.0	7474.2	44	0.0059	44.0	7917.2	78	0.0099	78.0

	70 - 74 Years				75 - 79 Years				80 - 84 Years			
Salary ($1994)	E	O	Q	Exp	E	O	Q	Exp	E	O	Q	Exp
20,000-30,000	2000.4	23	0.0115	21.4	550.1	15	0.0273	17.0	30.9	0	0.0000	1.1
30,000-40,000	1292.7	7	0.0054	13.8	458.2	20	0.0437	14.2	59.1	4	0.0677	2.1
> 40,000	732.0	13	0.0178	7.8	285.4	5	0.0175	8.8	24.4	0	0.0000	0.9
Total	4025.1	43	0.0107	43.0	1293.6	40	0.0309	40.0	114.4	4	0.0035	4.0

4. Some Consequences of Differential Mortality

4.1 Expectation of Life

One of the consequences of differential mortality is that there will be differing life expectancies for individuals of the same age. The extent of these differences will determine the importance of differential mortality for public pension policy and the retail annuity market.

Assuming a uniform distribution of deaths for each year, the expectation of life at age x may be calculated as

$$e_x = 0.5 + \sum_{n=1}^{\infty} (l_{x+n} / l_x)$$

To determine the effect of differential mortality on life expectancy, the expectation of life was calculated for the following three groups of males pensioners in the study:

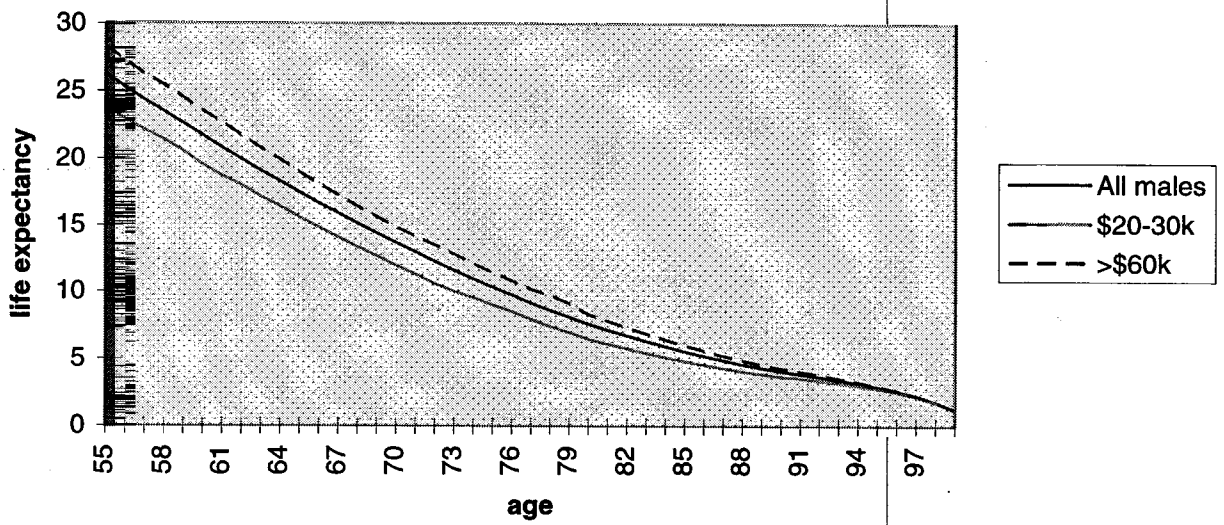
1. all male pensioners,
2. male pensioners with a final income between $20,000 and $30,000; and
3. male pensioners with a final income of over $60,000.

Since the data is limited for male pensioners over the age of 79, estimates of mortality rates at these older ages were based on the assumed mortality rates used in the Government Actuary's Report. To find the corresponding age-specific rates for the two income groups, the ratio of the particular income group's mortality rate for ages 70 to 79 years to the corresponding figure for all income groups was determined and averaged over the 10 year age span. This differential ratio was then used at age 80 but reduced in a linear manner to become 1.0 at age 100. As a result of this process, mortality rates were calculated for all ages over 80 for the two income groups with the adjustments in the differential ratio allowing for the reducing effect of differential mortality with increasing age, which was mentioned earlier.

Figure 4 illustrates the different life expectancies for the total group and the two income groups. The disparity in mortality rates of male pensioners from different income groups means that, as shown in Figure 1b, a 75 year old pensioner in the high income group has approximately the same risk of dying as a pensioner aged 70 years from the low income group. Whilst the differences in life expectancies at a particular age may not appear as large, they are significant for both annuity pricing and public policy considerations. For example, based on this study, a 65 year old male with a final salary of less than $30,000 has a life expectancy of 15.6 years whilst those with a final salary of more than $60,000 could be expected to live 19.0 years.

In view of these differences in life expectancies, it is now appropriate to discuss their importance on voluntary annuity markets and public pension policy.

Figure 4:life expectancy of male pensioners by income



4.2 The voluntary annuity market

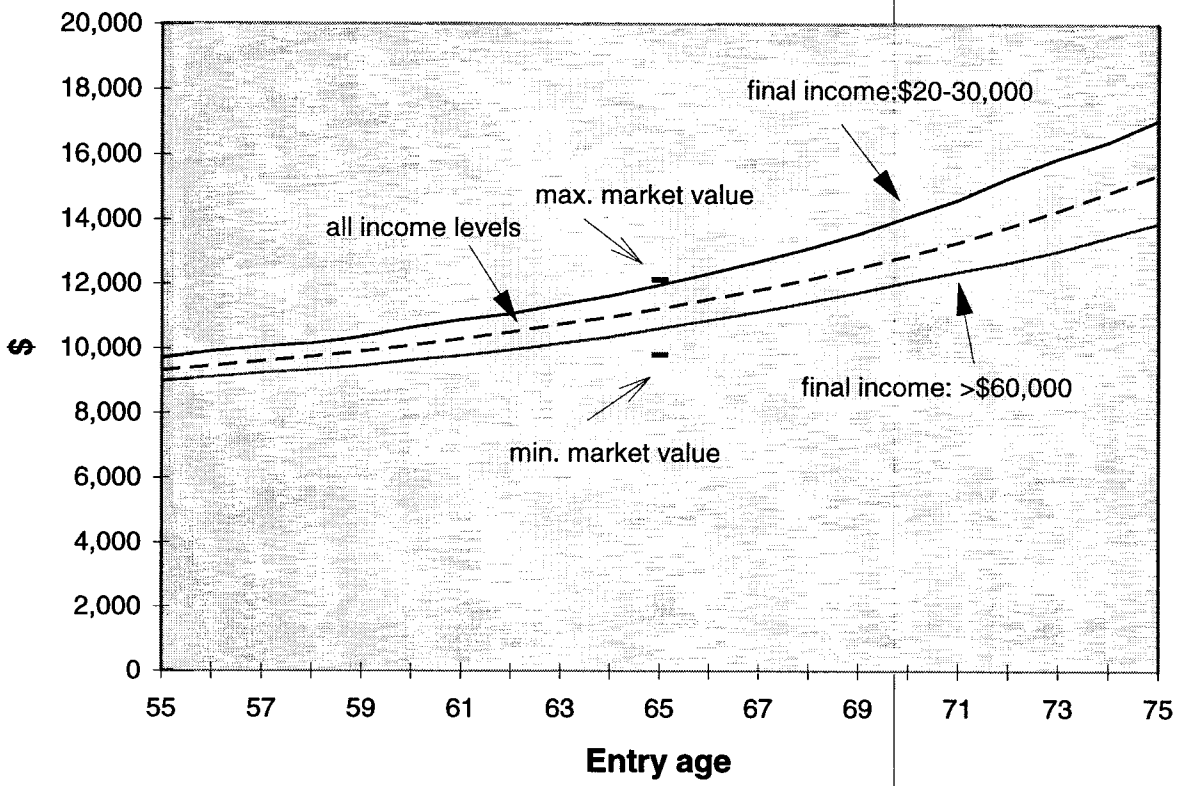
A differential in life expectancies across income groups has significant implications for life insurance companies offering annuity products in a voluntary private sector market. As is well known, the pricing of any insurance product (including annuities) should take into account all known factors which may influence the probability of a claim or, in the case of an annuity, the individual's life expectancy. Of course, it is also recognised that in some cases the insurer must ignore certain variables due to existing social custom or legislation, marketing pressure or the difficulty in obtaining the relevant data from the insured. In terms of annuities for retirees, it may be particularly difficult to obtain appropriate information that enable the insurer to estimate the individual's socio-economic status. Nevertheless, annuity providers should be aware of the consequences of differential mortality.

To further illustrate these effects, the level income stream arising from a life annuity with a present value of $100,000 was calculated corresponding to the life expectancies experienced by all male pensioners and by male pensioners in the highest and lowest income groups. An interest rate of 8% per annum was assumed and expenses were ignored. Figure 5 shows the level of annual income for this given purchase price for entry ages from 55 to 75. It is interesting to note that the calculated income levels are comparable with the immediate annuities currently offered by Australian life insurance companies. For example, a male aged 65 years can currently purchase for $100,000 a level income (without any guarantee) of between $9,804 and $12,136 per annum (Rice Kachor, 1996). Yet, if the annuity purchasers are primarily high income earners, the more aggressive life offices offering the higher income streams, may be exposing themselves to a significant long term risk.

Within many existing retail annuity markets, the insurers assume that the expected mortality rates are equivalent for all individuals of the same age and gender irrespective of their lifetime income or accumulated wealth. However, based on this and other studies, it is extremely likely that lifetime

income levels and/or wealth are an important factor in determining life expectancies. It is therefore reasonable to expect that, on average, lifetime annuities will not be an attractive investment for individuals with lower incomes. On the other hand, higher income earners may find lifetime annuities, where mortality rates may be based on some population average together with some allowance for mortality improvement, to be a very attractive proposition. Of course, as was noted above, the pricing of annuities by an individual's lifetime income, final salary or accumulated personal wealth would be an extremely difficult, if not impossible, task and could also have a significant effect on the insurance company's reputation. Nevertheless, without some allowance for differential mortality in the pricing of annuities, it is reasonable to expect that the purchasers of annuities will suffer below average mortality and that life insurance companies must allow for this adverse selection in their pricing processes.

Figure 5: Annual level lifetime income purchased for $100,000



4.3 Public Pension Policy

There exists an enormous variety of designs within national pension plans around the world. In some cases, a universal or means tested age pension is paid from general taxation revenue with no direct link to an individual's taxation payments. That is, the size of the pension is not related to the individual's earning history. In other cases, there is relationship between the individual's pension contributions during his/her lifetime and the size of the pension received. In some cases, a regressive scale exists such that the first tier of contributions results in a higher pension payment than subsequent contribution tiers. In other words, the "rate of return" received by the individual is

higher for the band of contributions linked to lower incomes than for contributions related to higher salaries. Such a scheme design is generally supported for reasons of intragenerational equity.

However, it is also important to consider the effects of differential mortality on the intragenerational equity within public plans. If higher income earners have longer life expectancies, then they will receive, on average, the public pension for a longer period of time. The net effects will depend on the actual design within the public program.

For instance, in a flat rate universal pension program, higher income earners will, on average, receive the age pension for an additional period, perhaps up to five years longer than lower income earners. The equity of this arrangement should not be considered in isolation but should be reviewed in the context of the total taxation system for income and other retirement products. For instance, if higher income earners have paid considerably higher income taxes during their lifetime and/or paid higher taxes on the retirement benefits arising from their superannuation or pension plans, it could be argued that the end result is not as inequitable as it may appear.

On the other hand, where the public pension is linked to lifetime earnings and/or contributions, a different set of circumstances arises. In these cases, the higher income earner will be receiving a public pension that is both larger and is likely to be paid for a longer period than the lower income earner. Again, it is important to consider the intragenerational equity issues within the broader context of taxation and Government support.

Equity within national pension plans cannot be defined precisely and will vary according to the social and political decisions made by each community. Nevertheless, it is important to acknowledge that the link between lifetime income and mortality is likely to be present in most circumstances and therefore needs to be considered in the design of national schemes. It should also be acknowledged that the strength of this link is unlikely to be constant over time or between countries.

A related issue for a Government's pension policy is linked to any legislation that may require the retirement benefit arising from an occupational pension plan to be taken, either wholly or to a very large extent, as a lifetime pension. The likely outworkings of such a policy are that through these occupational pension plans there would be a significant subsidy from low income earners to high income earners due to the differences in the expected longevity of each group. If such an outcome is considered undesirable, the effects of differential mortality could be ameliorated by an alternative pension arrangement. For instance, one way forward is for the individual's pension to be paid from an allocated or segregated account, possibly with appropriate minimum and maximum limits, to ensure that the funds are preserved for a reasonable number of years. On early death, the remaining assets could be passed on to the individual's estate rather than be used to support other pensioners. Of course, it is recognised that such an arrangement radically changes the nature of a group pension plan but it is consistent withe recent developments in a number of countries and the growing importance of individual responsibility and entitlements. Such a development also removes any intragenerational inequity that may arise due to differential mortality.

5 Conclusions

There is considerable international evidence suggesting that socio-economic variables affect mortality rates. In practice, this means that there exists an inverse relationship between mortality rates and the level of lifetime earnings or wealth. However the strength of this relationship has never previously been assessed amongst Australian retirees.

This study, using data from the Commonwealth Superannuation Scheme for public servants, shows that there is a significant inverse relationship for male pensioners between the individual's final salary and their rate of mortality in retirement. The results also confirm previous North American studies and suggest that there is a similar relationship in the United States, Canada and Australia.

The strength of the relationship between an individual's income and mortality has important implications for the pricing of annuities in a voluntary private sector market. It was noted that as income or wealth is normally not used in annuity pricing, it may be expected that an element of adverse selection will occur so that the mortality rates of annuitants will be considerably less than the population average.

It was also suggested that the presence of differential mortality should be an important consideration in seeking intragenerational equity within national and occupational pension plans. The actual implications for a particular country's pension policy will depend on a number of factors including the design features of public and occupational pension plans, the link between the size of any public pension and the level of lifetime contributions, the overall taxation structure, the strength of the differential mortality and the social and political values adopted by the society. Hence, there will not be one solution for all circumstances. The important consequence is that policy makers recognise the existence of differential mortality and, as necessary, make the appropriate policy decisions.

APPENDIX A

The data set for each year included a pension scheme ID, the sex, date of birth and date of death (if applicable) of the pensioner, the dates s/he joined and exited the pension scheme and the pension as indexed on 1 July for that year based on the Consumer Price Index movement from the previous March to March quarters.

To determine the total number of lives exposed to the risk of dying at each age, the age of each pensioner on 1 July of each year in the four year period was recorded (age x) and the fraction of the year in which the pensioner was age x and age x+1 calculated. The pensioner's salary at retirement was then determined, its equivalent value in 1994 A$ calculated and his/her death noted, if it had occurred. The total number of lives exposed to the risk of dying at each age (E_x) and the observed number of deaths at age x were then summed over the four year period for each income range and each age group.

Salaries at retirement were calculated from the indexed pension according to the following equation:

Indexed pension at 1 July = Salary x Benefit Multiple x Discount Factor x Indexation

where:

- the Benefit Multiple is determined by a set of accrual rates corresponding to the number of years the pensioner has contributed to the pension scheme;
- the discount factors are awarded for early retirement; and
- salaries were incremented by the Consumer Price Index movements in subsequent years to obtain a salary figure in 1994 dollars.

References

Atkinson, M. E., Creedy, J. and Knox, D. M. (1996) Alternative Retirement Income Strategies: A Cohort Analysis of Lifetime Redistribution, Economic Record, 72, 217, June, 97-106.

Attanasio, O. P. and Hoynes, H.W. (1995) Differential Mortality and Wealth Accumulation, National Bureau of Economic Research, Working Paper No. 5126, May.

Duval, D. (1994) Public Sector Superannuation Scheme and Commonwealth Superannuation Scheme. A Report on Long-Term Costs, Australian Government Publishing Service.

Jianakoplos, N.A., Menchik, P.L. and Irvine, F.O. (1989) Using Panel Data to Assess the Bias in Cross-Sectional Inferences of Life-Cycle Changes in the Level and Composition of Household Wealth, Measurement of Savings, Investment and Wealth, University of Chicago Press.

Menchik, P.L. (1993) Economic Status as a Determinant of Mortality Among Black and White Older Males - Does Poverty Kill?, Population Studies, 47(3), November, 427-36.

Rice Kachor Research Pty Ltd. (1996) Annuity and Pension League Table, February.

Rogot, E., Sorlie, P.D., Johnson, N.J. and Schmitt, C. (1992) A Mortality Study of 1.3 Million Persons by Demographic, Social, and Economic Factors: 1979-1985 Follow-Up, NIH Publication No. 92-3297, July. (National Institutes of Health, National Heart, Lung and Blood Institute).

Virga, M.R. (1996) Earn More, Live Longer - Variation in Mortality by Income Level, Pension Section News, No. 28, March, Society of Actuaries.

Wilkins, R., Adams, O. and Brancker, A. (1989) Changes in Mortality by Income in Urban Canada from 1971 to 1986, Health Reports 1/2, 137-74.

World Bank (1994) Averting the Old Age Crisis, Oxford University Press.

RESEARCH PAPER SERIES

No.	Date	Subject	Author
1	MAR 1993	AUSTRALIAN SUPERANNUATION: THE FACTS, THE FICTION, THE FUTURE	David M Knox
2	APR 1993	AN EXPONENTIAL BOUND FOR RUIN PROBABILITIES	David C M Dickson
3	APR 1993	SOME COMMENTS ON THE COMPOUND BINOMIAL MODEL	David C M Dickson
4	AUG 1993	RUIN PROBLEMS AND DUAL EVENTS	David C M Dickson Alfredo D Egídio dos Reis
5	SEP 1993	CONTEMPORARY ISSUES IN AUSTRALIAN SUPERANNUATION – A CONFERENCE SUMMARY	David M Knox John Piggott
6	SEP 1993	AN ANALYSIS OF THE EQUITY INVESTMENTS OF AUSTRALIAN SUPERANNUATION FUNDS	David M Knox
7	OCT 1993	A CRITIQUE OF DEFINED CONTRIBUTION USING A SIMULATION APPROACH	David M Knox
8	JAN 1994	REINSURANCE AND RUIN	David C M Dickson Howard R Waters
9	MAR 1994	LIFETIME INSURANCE, TAXATION, EXPENDITURE AND SUPERANNUATION (LITES): A LIFE-CYCLE SIMULATION MODEL	Margaret E Atkinson John Creedy David M Knox
10	FEB 1994	SUPERANNUATION FUNDS AND THE PROVISION OF DEVELOPMENT/VENTURE CAPITAL: THE PERFECT MATCH? YES OR NO	David M Knox
11	JUNE 1994	RUIN PROBLEMS: SIMULATION OR CALCULATION?	David C M Dickson Howard R Waters
12	JUNE 1994	THE RELATIONSHIP BETWEEN THE AGE PENSION AND SUPERANNUATION BENEFITS, PARTICULARLY FOR WOMEN	David M Knox
13	JUNE 1994	THE COST AND EQUITY IMPLICATIONS OF THE INSTITUTE OF ACTUARIES OF AUSTRALIA PROPOSED RETIREMENT INCOMES SRATEGY	Margaret E Atkinson John Creedy David M Knox Chris Haberecht
14	SEPT 1994	PROBLEMS AND PROSPECTS FOR THE LIFE INSURANCE AND PENSIONS SECTOR IN INDONESIA	Catherine Prime David M Knox

15	OCT 1994	PRESENT PROBLEMS AND PROSPECTIVE PRESSURES IN AUSTRALIA'S SUPERANNUATION SYSTEM	David M Knox
16	DEC 1994	PLANNING RETIREMENT INCOME IN AUSTRALIA: ROUTES THROUGH THE MAZE	Margaret E Atkinson John Creedy David M Knox
17	JAN 1995	ON THE DISTRIBUTION OF THE DURATION OF NEGATIVE SURPLUS	David C M Dickson Alfredo D Egídio dos Reis
18	FEB 1995	OUTSTANDING CLAIM LIABILITIES: ARE THEY PREDICTABLE?	Ben Zehnwirth
19	MAY 1995	SOME STABLE ALGORITHMS IN RUIN THEORY AND THEIR APPLICATIONS	David C M Dickson Alfredo D Egídio dos Reis Howard R Waters
20	JUNE 1995	SOME FINANCIAL CONSEQUENCES OF THE SIZE OF AUSTRALIA'S SUPERANNUATION INDUSTRY IN THE NEXT THREE DECADES	David M Knox
21	JUNE 1995	MODELLING OPTIMAL RETIREMENT IN DECISIONS IN AUSTRALIA	Margaret E Atkinson John Creedy
22	JUNE 1995	AN EQUITY ANALYSIS OF SOME RADICAL SUGGESTIONS FOR AUSTRALIA'S RETIREMENT INCOME SYSTEM	Margaret E Atkinson John Creedy David M Knox
23	SEP 1995	EARLY RETIREMENT AND THE OPTIMAL RETIREMENT AGE	Angela Ryan
24	OCT 1995	APPROXIMATE CALCULATIONS OF MOMENTS OF RUIN RELATED DISTRIBUTIONS	David C M Dickson
25	DEC 1995	CONTEMPORARY ISSUES IN THE ONGOING REFORM OF THE AUSTRALIAN RETIREMENT INCOME SYSTEM	David M Knox
26	FEB 1996	THE CHOICE OF EARLY RETIREMENT AGE AND THE AUSTRALIAN SUPERANNUATION SYSTEM	Margaret E Atkinson John Creedy
27	FEB 1996	PREDICTIVE AGGREGATE CLAIMS DISTRIBUTIONS	David C M Dickson Ben Zehnwirth
28	FEB 1996	THE AUSTRALIAN GOVERNMENT SUPERANNUATION CO-CONTRIBUTIONS: ANALYSIS AND COMPARISON	Margaret E Atkinson
29	MAR 1996	A SURVEY OF VALUATION ASSUMPTIONS AND FUNDING METHODS USED BY AUSTRALIAN ACTUARIES IN DEFINED BENEFIT SUPERANNUATION FUND VALUATIONS	Des Welch Shauna Ferris
30	MAR 1996	THE EFFECT OF INTEREST ON NEGATIVE SURPLUS	David C M Dickson Alfredo D Egídio dos Reis

31	MAR 1996	RESERVING CONSECUTIVE LAYERS OF INWARDS EXCESS-OFF-LOSS REINSURANCE	Greg Taylor
32	AUG 1996	EFFECTIVE AND ETHICAL INSTITUTIONAL INVESTMENT	Anthony Asher
33	AUG 1996	STOCHASTIC INVESTMENT MODELS: UNIT ROOTS, COINTEGRATION, STATE SPACE AND GARCH MODELS FOR AUSTRALIA	Michael Sherris Leanna Tedesco Ben Zehnwirth
34	AUG 1996	THREE POWERFUL DIAGNOSTIC MODELS FOR LOSS RESERVING	Ben Zehnwirth
35	SEPT 1996	KALMAN FILTERS WITH APPLICATIONS TO LOSS RESERVING	Ben Zehnwirth
36	OCT 1996	RELATIVE REINSURANCE RETENTION LEVELS	David C M Dickson Howard R Waters
37	OCT 1996	SMOOTHNESS CRITERIA FOR MULTI-DIMENSIONAL WHITTAKER GRADUATION	Greg Taylor
38	OCT 1996	GEOGRAPHIC PREMIUM RATING BY WHITTAKER SPATIAL SMOOTHING	Greg Taylor
39	OCT 1996	RISK, CAPITAL AND PROFIT IN INSURANCE	Greg Taylor
40	OCT 1996	SETTING A BONUS-MALUS SCALE IN THE PRESENCE OF OTHER RATING FACTORS	Greg Taylor
41	NOV 1996	CALCULATIONS AND DIAGNOSTICS FOR LINK RATION TECHNIQUES	Ben Zehnwirth Glen Barnett
42	DEC 1996	VIDEO-CONFERENCING IN ACTUARIAL STUDIES – A THREE YEAR CASE STUDY	David M Knox
43	DEC 1996	ALTERNATIVE RETIREMENT INCOME ARRANGEMENTS AND LIFETIME INCOME INEQUALITY: LESSONS FROM AUSTRALIA	Margaret E Atkinson John Creedy David M Knox
44	JAN 1997	AN ANALYSIS OF PENSIONER MORTALITY BY PRE-RETIREMENT INCOME	David M Knox Andrew Tomlin
45	JUL 1997	TECHNICAL ASPECTS OF DOMESTIC LINES PRICING	Greg Taylor
46	AUG 1997	RUIN PROBABILITIES WITH COMPOUNDING ASSETS	David C M Dickson Howard R Waters
47	NOV 1997	ON NUMERICAL EVALUATION OF FINITE TIME RUIN PROBABILITIES	David C M Dickson
48	NOV 1997	ON THE MOMENTS OF RUIN AND RECOVERY TIMES	Alfredo G Egídio dos Reis
49	JAN 1998	A DECOMPOSITION OF ACTUARIAL SURPLUS AND APPLICATIONS	Daniel Dufresne
50	JAN 1998	PARTICIPATION PROFILES OF AUSTRALIAN WOMEN	M. E. Atkinson Roslyn Cornish

51	MAR 1998	PRICING THE STOCHASTIC VOLATILITY PUT OPTION OF BANKS' CREDIT LINE COMMITMENTS	J.P. Chateau Daniel Dufresne
52	MAR 1998	ON ROBUST ESTIMATION IN BÜHLMANN STRAUB'S CREDIBILITY MODEL	José Garrido Georgios Pitselis
53	MAR 1998	AN ANALYSIS OF THE EQUITY IMPLICATIONS OF RECENT TAXATION CHANGES TO AUSTRALIAN SUPERANNUATION	David M Knox M. E. Atkinson Susan Donath
54	APR 1998	TAX REFORM AND SUPERANNUATION – AN OPPORTUNITY TO BE GRASPED.	David M Knox
55	APR 1998	SUPER BENEFITS? ESTIMATES OF THE RETIREMENT INCOMES THAT AUSTRALIAN WOMEN WILL RECEIVE FROM SUPERANNUATION	Susan Donath
56	APR 1998	A UNIFIED APPROACH TO THE STUDY OF TAIL PROBABILITIES OF COMPOUND DISTRIBUTIONS	Jun Cai José Garrido
57	MAY 1998	THE DE PRIL TRANSFORM OF A COMPOUND R_k DISTRIBUTION	Bjørn Sundt Okechukwu Ekuma
58	MAY 1998	ON MULTIVARIATE PANJER RECURSIONS	Bjørn Sundt
59	MAY 1998	THE MULTIVARIATE DE PRIL TRANSFORM	Bjørn Sundt
60	JUNE 1998	ON ERROR BOUNDS FOR MULTIVARIATE DISTRIBUTIONS	Bjørn Sundt
61	JUNE 1998	THE EQUITY IMPLICATIONS OF CHANGING THE TAX BASIS FOR PENSION FUNDS	M E Atkinson John Creedy David Knox
62	JUNE 1998	ACCELERATED SIMULATION FOR PRICING ASIAN OPTIONS	Felisa J Vázquez-Abad Daniel Dufresne
63	JUNE 1998	AN AFFINE PROPERTY OF THE RECIPROCAL ASIAN OPTION PROCESS	Daniel Dufresne
64	AUG 1998	RUIN PROBLEMS FOR PHASE-TYPE(2) RISK PROCESSES	David C M Dickson Christian Hipp
65	AUG 1998	COMPARISON OF METHODS FOR EVALUATION OF THE n-FOLD CONVOLUTION OF AN ARITHMETIC DISTRIBUTION	Bjørn Sundt David C M Dickson
66	NOV 1998	COMPARISON OF METHODS FOR EVALUATION OF THE CONVOLUTION OF TWO COMPOUND R_1 DISTRIBUTIONS	David C M Dickson Bjørn Sundt
67	NOV 1998	PENSION FUNDING WITH MOVING AVERAGE RATES OF RETURN	Diane Bédard Daniel Dufresne
68	DEC 1998	MULTI-PERIOD AGGREGATE LOSS DISTRIBUTIONS FOR A LIFE PORTFOLIO	David C M Dickson Howard R Waters
69	FEB 1999	LAGUERRE SERIES FOR ASIAN AND OTHER OPTIONS	Daniel Dufresne