RECORD, Volume 29, No. 2*

Spring Meeting, Vancouver, B.C.
June 23–25, 2003

Session 11L
Longevity Improvement in Canada, the United States and Worldwide

Track: Education & Research, Pension

Moderator: LOUIS ADAM
Panelists: LOUIS ADAM
RICHARD MACMINN†

Summary: Continuous longevity improvement is a great achievement of Western civilization and public policy, but is it also a source of increasing fiscal pressure on the public and private pension systems? This session starts with a study of the pattern of longevity improvement in Canada. The presentation outlines results of a mortality study of Canadian pensioners over the calendar period of 1967 to 2000, with emphasis on the 1995-1999 period. The results are based on records from the Canada Pension Plan (CPP) and the Quebec Pension Plan (QPP). Of particular interest are the cohort clusters of longevity improvement.

MR. LOUIS ADAM: Our first speaker, Professor Richard MacMinn, is the first holder of the Edmondson-Miller chair in insurance and financial services at Illinois State University. He's the editor of the *Journal of Risk and Insurance*. He's also an associate editor for the *Journal of Insurance Issues* and the *Quarterly Journal of Economics and Finance*. He serves as board member of the Asia-Pacific Risk and Insurance Association and is also a member of other associations. He has published extensively in such publications as the *Journal of Risk and Insurance*, *Insurance: Mathematics and Economics*, *Geneva Papers, Journal of Political Economy*, *Quarterly Journal of Economics* and *Journal of Finance*. He has twice won the prestigious Mehr Award in addition to a number of other awards from the American

†Professor Richard MacMinn, not a member of the sponsoring organizations, is Edmonson-Miller chair in insurance and financial services at Illinois State University, Katie Insurance School, Department of Finance, Insurance and Law in Normal, Ill.

Note: The chart(s) referred to in the text can be found at the end of the manuscript.

Risk and Insurance Association, the Casualty Actuarial Society and the General Insurance Research Organization in the United Kingdom.

MR. RICHARD MACMINN: I'm a theoretician ordinarily, but have gained an interest in longevity risk, and I decided to start taking a look at some of the data. While I was in England, I was talking about longevity risk with a number of colleagues and also with some people at Swiss Re. I had a Swiss Re chair for a couple of years in England and discussed some of these problems with them. They introduced me to something called select cohorts as a way of taking a look at one aspect of longevity risk. I'd like to talk a little bit about select cohorts today, define the term, and then show you where I think it exists in a number of different countries, as well as taking a look at other mortality data by countries.

If you go to www.macminn.org/mortality, it will take you to the current version of the presentation. On the Web site, the spreadsheets are linked to the presentation, and so you can drill down into the spreadsheets themselves and take a look at the basic data and how the basic data is actually manipulated.

The topic that I have today is mortality risk from the perspective of Europe, the United States and Japan. As I said, I became interested a couple of years ago and started taking a look at data when I discovered that there are some birth cohorts in a number of countries that seem to do better than other birth cohorts. It became clear, for example, in England, as you'll see in a bit, that several years in the 1930s were very good years from the standpoint of generations that came before and generations that came after. That was a puzzle and was one of the reasons for my interest in taking a look at longevity risk and mortality risk.

I'm also doing some work on genetic testing, so I have an interest in how these mortality figures are going to be changing over time as genetic testing implies changes in medicine which, in turn, implies changes in the mortality figures that we're looking at. Since I'm getting older, I naturally also have an interest in pensions and, therefore, in hedging some of the mortality and longevity risk that is faced by a number of companies. The immediate annuity market, at least in the United States, is rather small compared to the deferred annuity market, and that's another cause for concern and another reason to be interested in the mortality data that you're going to be seeing today.

All of the data that I'll be using comes from the human mortality database at Berkeley. It includes many of the Western European countries, an increasing number of the Eastern European countries, North America, Japan and so on, and I would recommend it as a good source of population data. That's what I'm using exclusively here.

I'd like to give you a bit of perspective on some of this international mortality data from the standpoint of select cohorts and also from the standpoint of how variable this data is. I'll be taking a look at period data and also these select birth cohorts

and looking for some common trends. It might be too much to expect any answers in looking for the data. I've been looking for some explanations, not only for some of the cohorts, but for some of the surprisingly large mortality improvements in a number of decades that you'll see.

There are a number of rationales for mortality improvements, and I'll talk about a few of them as we go along. None of them seems to be so pressing that it can explain the variety of changes that we see in the data, so there's not a lot that I can do here. I do want to identify select birth cohorts in as many countries as I can. When I started taking a look at the notion of select birth cohorts, all I could find in the literature was a mention of some select birth cohorts in the United Kingdom, particularly in the 1930s, and also in Sweden and Japan. But there we came to about the end of the list, so it wasn't clear whether this was a quirk in the data or whether it was really something more. I'd like to seek some causal links for these mortality improvements, and I'd also like to compare the immediate annuity costs using some of this historical mortality data.

Most of the data that you'll be looking at has only been aggregated and manipulated within the last month and a half. I'm still in the process of attempting to refine and correct the data and see more in the data. I have attempted to identify as many select birth cohorts as I can. I've also put some immediate annuity costs together but only for three countries so far; you'll see the variability in those immediate annuity costs for England and Wales, for the United States and also for Japan.

A select birth cohort is a birth cohort characterized by greater rates of mortality improvement than not only previous generations, but also subsequent generations. You would expect the mortality rates to be better as they continue to improve, but you wouldn't expect it necessarily to show greater improvements than in subsequent generations.

A number of birth cohorts have been identified in the literature. As I mentioned, there are England and Wales, 1925 to 1945; Sweden, 1900 to 1910 for women only; and Japan, 1910 to 1920. Most of this is already in the literature, primarily in a piece by Richard Willets that was presented to the Institute of Actuaries in London a couple of years ago. There are a number of additional select birth cohorts that I'll be noting as we go along. In fact, I've seen at least partial evidence of select birth cohorts in almost all of the countries that I viewed, with the possible exception of Hungary.

I've only been working on this latest set of data for about a month and a half, so I don't have a quantitative measure for the select birth cohort. I'm taking a very rough look at the data and seeing whether or not I believe it is a select birth cohort. If its improvement rates are sufficiently good relative to previous and subsequent generations, then I'll identify it as a select birth cohort. England and Wales has already been identified not only by Willets but also by the government actuary

department in the United Kingdom. The Norway cohort in the early 1940s and the cohort in Sweden from 1925 to 1934 are all select birth cohorts for men. The same thing needs to be done for women as well. Sweden does have a female birth cohort earlier, in the 1900s. In Denmark, we have a birth cohort. There is a cohort in France. There are a number of cohorts in Switzerland and Italy. The same is true for Austria, Japan, and I suppose, surprising to my colleagues in the U.K., also in the United States. When I first started taking a look at these birth cohorts, I didn't even view the United States, because people told me that there are no select birth cohorts in the United States. But, after manipulating this data and beginning to take a look, I have identified some possible birth cohorts.

There is a lot of overlap here. The early 1900s have quite a number of countries, not only in Europe but also in Japan, where these select cohorts are being identified. There's a lot of overlap generally with the birth cohorts all through Western Europe, North America and Japan. So there has to be a common thread of an explanation. Some of these birth cohorts you'll find are a 0.5 percent difference between the previous and the next generation. Others are bigger changes. But even if you're talking about 0.5 percent that runs over 20 years or more, you're still talking about cost differences in excess of 4 percent, even at the 0.5 percent change.

Let's take a look at England and Wales, since this is what sparked my curiosity in the beginning. There are some dramatic mortality improvements by period, which you're going to see for quite a number of European countries especially, because the data goes farther back than it does for Japan and for the United States. The database that I'm taking the raw data from is improving all the time and will have longer periods for the United States and Japan in a matter of months. The U.K. government actuary department, as I said, has identified generations born between 1925 and 1945 as a select birth cohort. We're looking at mean improvements there jumping from, just before the select birth cohorts, about 1.8 percent per year to 3.8 percent for the select cohorts. The standard deviation in those mean mortality improvements—which may jump up or down, so I'm not sure that there's anything that you can read into it—has gone from the .04 to the .06.

In most of these countries, we do get a big negative impact, as you might expect, in the 1915-1919 range. We have a war effect here. We also have a less severe war effect for World War II. But in many of these countries we have quite a jump in the 1940s. In the United Kingdom, it's quite a jump in the latter part of the 1940s. In other countries, it's earlier in the 1940s, but here we're getting in excess of 20 percent mortality improvements. We're getting that by age group. For example, the one that runs the highest here is the 20-24 age band. There is a little less variability there, of course, than the 35-39, but you see the same effects for World War I and World War II. You see the effects for the 1940s as well. Maybe you see a bit of an effect for the institution of the national health care in the late 1940s. We do have something going on here that the government actuary department has

identified. I think it was in 1992 that they started talking about this as something that was curious and something that we have no explanation for yet.

In Norway you have some rather noted period effects. The period effects are quite similar to what you see in the United Kingdom, except there are some notable effects in the 1870s, as well as the 1940s. For Norway, there is a select birth cohort. The evidence is not quite as strong, but it looks like one in the 1940s. For the period data we're basically looking at something very similar to what you saw in the United Kingdom, that is, we have an effect for World War I. We have quite a negative impact again in the 1940s, and then there is an upward spike in the latter part of the 1940s.

FROM THE FLOOR: I'm wondering how these improvement rates have been calculated.

MR. MACMINN: The raw data is giving me death rates by age, and we're assuming that the death rates are exponentially driven, e^{a+bt}, and then calculating based on that assumption. All of the rates that you're looking at here are percentage changes, percentage improvements, that is, one minus an exponential term.

FROM THE FLOOR: So it's the percentage change in the death rate?

MR. MACMINN: Yes. The select birth cohort in Norway shows a similar pattern, but it's not quite as strong a select birth cohort as what you saw in England. Still, you're looking at, in some years, as much as 5 percent improvements for the 1940-44 group, and even in years where 1935-39 is doing well, there's a two, 2.5 percent difference between the two. So, we're still looking at potentially significant cost differences between the 1940 cohort and some of the other cohorts.

In Sweden, there is a similar picture, but with a different select cohort. The 1940s again are significant. 1925 and 1930 appear to be select birth cohorts. Mean mortality improvements increased. Standard deviation decreased. Period data again is similar to the United Kingdom, except there is some rather bad news in the 1980s that we didn't see in the United Kingdom and we're not going to see everywhere in Europe. The select cohorts 1925 and 1930 are not quite as strong, but they are there.

Let's take a quick look at France. There are some dramatic period effects here, as is the case in the other European countries. There is the dip after 1915 because of World War I—not as significant a dip in the 1940s—but certainly a rather substantial improvement in the latter part of the 1940s, and France seems to exhibit a cohort in 1935. That cohort is going to show up right here in the data. If it were a bit bigger, you could see a sequence of peaks running across at a diagonal in France, and you'd be able to pick up the cohort there. Here we have 1915 and France as well, and 1935. It doesn't beat 1940-44 in the '40s, but subsequently gains steam and winds up being a very good cohort for France.

The Japanese data is quite interesting because it's similar. The Japanese instituted public health care in their provinces in about 1875. Their mortality improvements at young ages, zero through four, for example, were really remarkable. Even into the 1950s, I think, we're still generating improvements that are quite high. In Japan, we also have a number of cohorts in 1910-15 and again in 1935. The coincidence of these select cohorts is interesting because it overlaps so much with some of the cohorts that we see in other countries, especially in the United States and the United Kingdom.

For three countries we took a look at the cost of an immediate annuity using historical data. I'd rather go from 55 on to the end of a life, but since I wanted the data to actually be historical data, we decided to go ahead and take a look at ages 25-45 for a sequence of years. For people born in 1925, we will take a sequence of 20 years of data for them and calculate the cost of an annuity. Then we will do that by year, and, as you would expect, since longevity and mortality are improving, these become more and more costly instruments over the 20-year course.

Now we get a bit of variance. I did this for England, as well as for two different periods. If you go far enough back, you get rather dramatic variances in the cost of these immediate annuities between previous years. There are much smaller differences, all 0.5 percent or less, for the Japanese data for this period of time from 1925-1955, but we do get some variability.

The United States, where I was told there weren't any birth cohorts, has, as usual, some significant period effects. Unfortunately, I couldn't go back to the 1940s because the data does not extend that far back yet, but we do have some significant period effects. We also have some birth cohorts that can be identified in 1915, 1930 and 1935. Having lived through the 1960s, I can attest to the fact that there was a mortality effect for the 1960s, and you're picking that up in the younger age groups. This happens to be the 20-24 group. They did particularly poorly in the 1960s, as you might expect. In the 1980s, we see a bump up, but then it went back down in the latter part of the 1980s and an increase during the bubble years of the stock market in the 1990s for young adults. There is a similar bump up for the latter part of the 30s, and the early 40 ages, in the 1990s. There is not quite as significant an effect in the 1960s for those groups, and you wouldn't expect that.

The birth cohorts for the United States—the early ones, the 1910 and 1915, for example—are indicated here and seem to be relatively strong, particularly the 1915 group running substantially above the others. This is evidence of a birth cohort in the United States. Again, in the 1930s, there is some evidence that there's a select birth cohort in the United States from the 1930s.

We did the same immediate cost comparisons and took a look at the variances between, but most significantly I wanted to take a look at some differences

between countries. Chart 1 shows the changes in the costs of these immediate annuities over time for the three countries. What you see in pink is England and Wales, blue is the United States, and orange is Japan.
How correlated is this? Is there some way in which, if we had a longevity instrument—such as a survivor bond, which I'm beginning to work on—in the United States, could it be picked up in other countries? If there's sufficient correlation between survivor-bond payoffs, which are essentially the same on the asset side as an immediate annuity is on the liability side, then one could invest in these and hedge the liability risk using a survivor bond in the United States, in Japan, in the United Kingdom or in some of the European countries. The correlation between these changes in costs for immediate annuities is rather significant, running at 59 percent for the United States versus England and Wales, 52 percent between the United States and Japan, and less so between England and Wales and Japan but still running at 33 percent.

We have a mortality experience that I've just run through for you that exhibits some rather similar trends in Europe, the United States and Japan from both a period perspective and a cohort perspective. It's the cohort that I've identified and keyed in on the most. We also have a correlation. It is possible to think of the potential of actually not only diversifying internationally but also using instruments from one country and another if you want to hedge the longevity risk in that country.

There have been some attempted explanations for the existence of these select cohorts. For example, for the cohorts in the United Kingdom, this particular group of people born prior to World War I was growing up at a time when there were improvements in national health. There was a national insurance scheme that was put into effect. It was prior to the institution of the National Health Service, but other changes were going into effect. There were also medical improvements that came out about that time, and then for the latter part of the cohorts in the United Kingdom, there were medical improvements that reduced the risk of heart attacks. There was at least a reduction in risk for cancer. That cohort came with all of these changes happening at about the right time, and that may be why we're seeing cohorts of similar years in other countries as well. On the other hand, the Spanish flu didn't seem to have a big impact. The National Health Service, the institution there, didn't seem to have a big impact. So you can go down the list, and none of it seems to have that big an impact, but all I can give you are guesses.

FROM THE FLOOR: Did you correlate the birth rates in any way?

MR. MACMINN: That's a good question, and I don't have an answer to that. There had been some guesses that the birth rate had been going down also in the United Kingdom. I've heard the guess that this group of people had fewer children than previous generations, and that may have some thing to do with it as well. Yes, that needs to be looked at. That's a good point.

MR. ADAM: I am going to take you on a guided tour through a mortality study using Canadian data. The main topic I'll be addressing will be the issue of the data quality and the conclusions you can derive from good data, or the fact that you have to be quite wary when you're not sure of the quality of your data.

I'll address the topics of quality and source of data trend over time, appropriate classification factors and the adequacy of currently used tables. So, even though I'll speak about mortality improvement, I will also speak about a few characteristics or factors that affect mortality. You can guess that age and sex are, indeed, factors, but there are other factors that could be of some interest to you.

This is a brief survey of my findings from a research project that I started a few years ago on Canadian pensioners' mortality. The results I'm currently discussing are those of July 2002. These results have been compared with data from the Canadian Pension Plan (CPP) and Quebec Pension Plan (QPP). I'd also thank the CPP actuary and QPP actuaries who helped me by providing the data. I'll discuss the relevance of the study, the source and characteristics of data, methodology, types of results and charts of main results.

The first item is data. The data comes from actual individual records of pension paid to individual retirees or pensioners from the CPP and the QPP. So, this is not survey data. It's not data from Statistics Canada. These are actual records of individuals receiving a pension from a specific date until death or the end of the study. Everybody who works in Canada has to participate in either the CPP or the QPP. By combining these two sources of data, you have one good source of data that holds all the information for everybody who worked in Canada since 1966.

The other interesting thing is that I also have the pension amount in these individual records. It allows me to analyze mortality by pension amount, or at least by income level. I also had excellent collaboration from these organizations, and they speak to each other, so even though people may move from one province to another, there is no double counting. These records are well maintained. One interesting thing from a Canadian point of view is that this is 100 percent Canadian data. Well, there's a small asterisk. Yes, indeed, there could be some people who would get out of the country, but they would still have to receive their pension. So that would be the same situation as a private-pension plan, for instance.

There are some limits or particularities of the data. This is data for retirees only. There is no data for spouses, for instance. It's only people over age 60 from a Canadian point of view, in a Canadian context. It refers to all pensions paid from 1967 to 2000 because CPP and QPP were both in inception in January 1, 1966. Actually, the first pensions were paid in 1967. That will explain why I have less data for the old ages.

Source of data will be one of my classification variables. I can analyze mortality either from the CPP data, QPP data, or combine the two to have a Canadian source

of mortality. I can analyze it also by age, from age 60 to the last age possible by calendar year, and, yes, there's a confidentiality issue. I have no IDs in my data. So I cannot identify any individual person, and to be sure that I could not identify any individual, I was given the year and month of birth, but not the day of birth. I have quite a high degree of precision in my data, but not enough to be able to identify any individual in that. I also have the dollar amount of initial pension and also the dollar amount at the end of the study. It allows me to analyze individuals by level of mortality. The income factor will be another variable I will use.

Do I have a lot of data? Table 1 shows a snapshot as of July 1, 1999,of the number of active lives in my study. Why did I choose July 1? It's because it allowed me to compare my data with the census data of Canada to give me an idea of whether I have a lot of coverage in terms of number of people. Since Quebec has approximately one-fourth the total population of Canada, it is not surprising that 25.4 percent of my data is from a Quebec perspective. Also, the data is approximately 53/47 percent male/female. It's not only male data. On average, it's quite well balanced.

Table 1

Retirees as at July 1st, 1999

	QPP	CPP	Total
• **Male**	**469,245**	**1,349,166**	**1,818,411 52.5 %**
	25.8 %	**74.2 %**	**100 %**
• **Female**	**411,084**	**1,235,786**	**1,646,870 47.5 %**
	25.0 %	**75.0 %**	**100 %**
• **Total**	**880,329**	**2,584,952**	**3,465,281 100 %**
	25.4%	**74.6%**	**100 %**

June 2003 Louis Adam, Mortality Study 1967-2000, SOA Meeting 7

How does it compare over time? Chart 2 tells you that when you look at male data, you can see that from the age group 60-64 the level of coverage is around 43 percent. As I move to year 2000, it's close to 83 percent. Why do I have only that level? It's because of early retirement. People are not necessarily in my study as retirees because I only have retirees. When I compared the amount of data I have

in my study to the total number of people in Canada, I have 43 percent of all people in Canada in my study, but when you look at age group 65-69, that goes up to close to 96-97 percent. As you move over time, I have fewer people because, since CPP and QPP were in inception in 1966, there are a few people who were not a member of the CPP or the QPP at that time. The main picture of this is that if you look at it in total, I have approximately 80 percent of the total Canadian population of male figures. It's a lot of people. It's not a small survey.

For females, the picture is not the same because there is the historical effect of women entering the workforce (Chart 3). That explains why the coverage ratio is lower as you move over in time. If I'm in year 2000, and I look at females age 90 and over, I have only approximately 30 percent of those females included in my study. As you go to younger groups like 65-69, you will have figures around 75 percent to 78 percent. That increased quite dramatically over time, while figures for males were more constant.

In terms of classification variables, I have the source of data, QPP and CPP, and the two combined will be referred to as "Canada" data. Gender—male and female—is another classification variable. For age, I used last birthday. The precision of calculation is $1/24^{th}$ of a year because I know the year and the month of birth, but I don't know the date of birth. That's better than a lot of censuses, and, as I told you, it has the same level of precision as data you would have for a private pension plan, for instance.

There was some adjustment made for the day assumption. I had to split both deaths and exposure when someone would die in the same month in which they were born. For instance, if you were born on February 28, and you died in February, year 2000, I had to decide if you died before your 72^{nd} birthday, or after your 72^{nd} birthday. So I applied one-half of each death to 71, one-half to 72. I did the same with the exposure, but the ratio is not one-half/one-half. It's two-thirds, one-third for some reasons that I won't explain here. I have data from age 60 to age 103 in 1999. Those who were born in 1896 or later are those who are in my study.

There are other classification variables. I have individual data that I won't show you by calendar year, but I also made five-year groupings from 1975-79, up to 1995-99. I stopped in 1999 because I had some problems with the CPP data. Then there is my income level factor. The pension amount was transformed into a percentage of the maximum that someone could have received. In terms of date of retirement, it's a function of the yearly maximum pensionable earnings (YMPE). That's the maximum amount on which you contribute and on which your pension is calculated both under the QPP and the CPP. There are some technical differences between the two plans, but at least they were taken into account. They were also adjusted for date of retirement, if it was an early or late retirement. They were also adjusted according to the formula, which changed over time, especially in year 1997-98. Just to give you an idea, the YMPE in Canada in year 2002 was $39,100.

Do I have data for those earning over $80,000 or below $50,000? No. From the CPP or QPP point of view, as soon as you contributed up to the maximum, they had no information about your income level. You are at the maximum. So, for instance, you are at the 100 percent income level. We don't know anything about mortality differences between those below, let's say, 150 percent of YMPE or those at 200 percent at YMPE in term of income level. We just know that they topped the maximum, so to speak.

Out of five classification variables, the first level will be those earning below 35 percent of YMPE. Why 35 percent of YMPE? Because it's currently an eligibility factor for private-pension plans. Actually, if you look at 35 percent of $39,100, it's something like an annual income level of $13,000. So, that is Level #1; Level #2 is those from 35 percent of YMPE up to 94 percent of YMPE; and Level #3 is those earning over 95 percent of YMPE. Levels #2 and #3 combined give me Level #4, and all three combined give me Level #5.

The one that is quite interesting from a private-pension-plan point of view is Level #4, because it excludes low-pension amounts. When people look at data from CPP or QPP, they will have a tendency to say that this is not very interesting data because it has everybody included in it. We'd like to have data for those earning a relatively good salary who could possibly be a member of a private-pension plan. This is why Level #4 was done.

I have data limits, and you have to take that into account when I show you the results afterwards. The volume of data will vary per year. In 1967, the plan's inception, there were only a few retirees. As we advance in time, we have more data. Year 2000 was excluded because there was some underreporting on CPP deaths. Also, I have retirees only. This has an impact on female data. For historical reasons, in the past females were more commonly spouses than actively paid workers under the CPP or QPP. I also have no exposure under age 60 because the survey covers only retirees under the CPP or QPP plan. I have only data for ages 60-64 starting in year 1984 under the QPP, and year 1987 for the CPP. The maximum age at which I can look at my data is related to calendar year minus 1896. For instance, in 1967, I had retirees from age 61 to 71. In the year 2000, I had retirees from age 60 to 104.

There will be only a few formulas, so don't worry. You don't have to remember them by heart. In fact, it's more a counting process. Once you have your classification variable, you count the deaths, you count the exposure, and then you process all these to have your mortality rates and a few other things. I applied these formulas for gender, age, source, year and income level. These five variables were used. Table 2 shows the formulas used to calculate the rate and probability of death. I also calculated the variance with the data I have. In fact, there's an error in methodology. On all these there should be carets because these are estimates and not true variables.

Table 2

Methodology : 1

- Exact exposure and deaths indexed by 5 variables
  - Source, gender, age, year, income level
  - Calculation of rate and probability of death

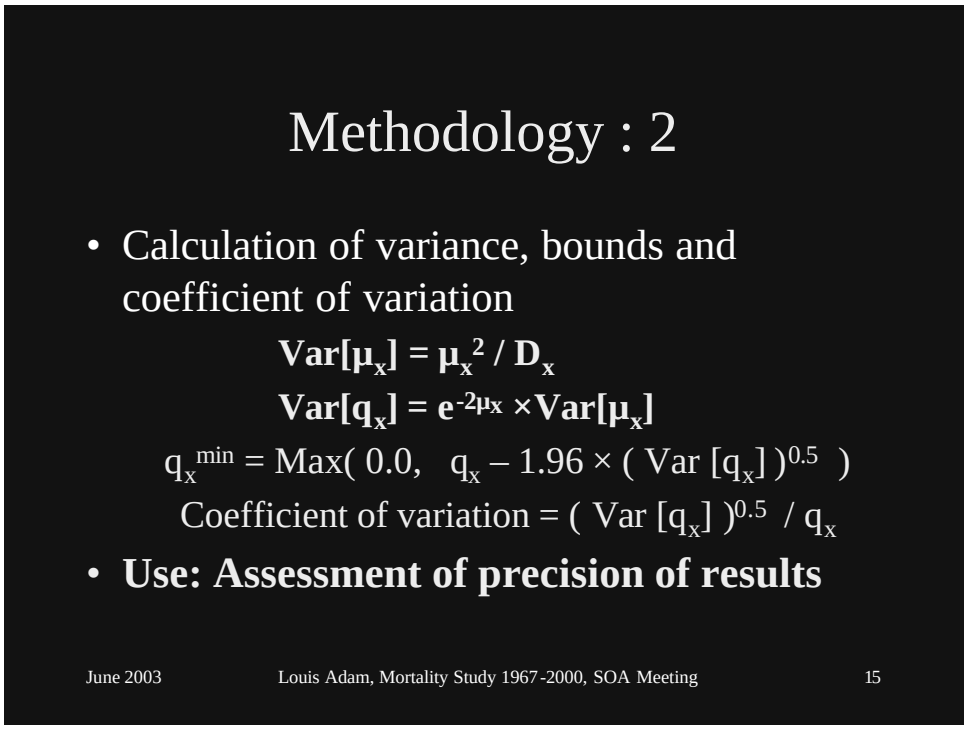
$$\mu_x = D_x / E_x$$

$$q_x = 1 - e^{-\mu_x}$$

June 2003 Louis Adam, Mortality Study 1967-2000, SOA Meeting 14

Table 3 demonstrates the variance of my mortality. It's an adjustment of the variance of the μ_x factor. I also have a confidence interval that I can calculate a minimum value, which is that estimate of the mean minus 1.96 times the standard deviation. That allows me to have a corridor, an interval of confidence for each value that I will calculate. What's the use of that? I can give you an estimate in the middle and also give you an idea of the width of the corridor in which that can be.

Table 3



Smoothing is done according to Gompertz's Law, and then the μ_x would be a loglinear figure. But I've seen in my data that, over age 85, that's not the case. There is a bend in the mortality curve over age 95. It would be easier to see that in a graphical fashion, but let's say that I do not assume that the mortality rate will go up to infinity. There is a kind of trending off to a terminal value, which is a variability of death of .45 for male, .40 for female. I've done some smoothing, especially for five-year groupings, Income Levels 4 and 5, and there's a separate treatment for age below 65, but I won't dwell on that too long.

The next thing to explore is the difference in level of mortality when you compare QPP data to CPP data to all that I combined for Canada? The answer is yes. When you compare a male participating into the QPP, your level of mortality is higher by a factor of at least 5 percent for a long time, until age 85. If you come from the CPP, your level of mortality will be lower than the overall Canadian level of mortality by around 3 percent.

Is there a difference if you come from Quebec compared to the rest of Canada? The answer is yes. I don't have the reasons in my study. I only have figures. If you want conjecture, I will tell you a few things. Smoking tobacco is more prevalent in Quebec. That could be an important factor, but it's not measured in QPP/CPP data. The fact that most of the immigration in Quebec comes from France, compared to the rest of Canada where it comes from Great Britain and the center of eastern Canada and now more recently from Pacific regions, could explain why the mix of

genetic material, so to speak, is not the same in Quebec compared to the rest of Canada for sociological and language reasons. Do we in Quebec eat differently? Maybe we do. Do we in Quebec have a different lifestyle? That's possible also.

Is it the same for females? For females, the CPP and QPP data are very close. Since the data cross each other and I know that I have on average less data for females, the jury could be still out as to what extent it is really significant.

So, I've talked about age, sex and source of data. The next one will be level of income. Is there a difference by level of income? Well, the answer is clearly yes (Chart 4). This line shows the substandard mortality of those earning less than 35 percent of YMPE, Level #1. The most significant thing is that, yes, there seems to be a mortality factor associated with those earning less than 35 percent of YMPE. It's also true for females. If you look at it in a different way, the percentage of excess mortality for males earning below 35 percent of YMPE is in the 10 percent to 20 percent range up to age 70 or 74. So it's quite significant, in fact. It's also true for females.

Now I come to the fifth variable—trend over time. This is a little bit more complicated, but I'll explain to you what I see in those kinds of data. I have quinquennial data from 1975-79 to 1995-99. What I see clearly from this data, even though it's quite variable from year to year, is that there seems to be a trend that mortality improves over time. I have issues with the fact that I see mortality improvement rates on average over an annual basis of 2 to 3 percent per year here because I have less data from ages 60 to 65. With the volume of data I obtain from age 65 to age 85, I see a mortality improvement over time that is quite significant, but that decreases, and I would expect it to be somewhat thinner over time here.

If I have to trend off or if someone would ask me: Based on your data do you think there is mortality improvement over time? I would say, yes, this is what I see over the past 25 years, but that level of improvement is not constant per age. It goes down. A possible explanation for this could be that with improvement in the level of physician care and access to hospitals and things like that, yes, we can maintain people in life. They can survive to a first cardiac arrest or something like that. But after around age 80 to 85, nature regains its ground, and some people will just die because the machine is not functioning properly anymore.

The important thing is that even though you take care of either all income levels or over 35 percent of YMPE, figures are quite similar in terms of mortality improvement over time. There seems to be a different level of improvement for male than for female. If I had to do a kind of rule of thumb or propose a not-too-complicated linear improvement, I would say it would be approximately around 2 percent per year at age 65. At age 75, it would be 1 percent. At age 85, it would be 0 percent. And I would even add some data to suggest that there is a deterioration of mortality over age 85 or 90 or so, but you have to recall that I told you that I have less data when I come to older ages. This is what the data tells me up to now.

I suppose that my mortality level for those earning over 100 percent of YMPE or 35 percent of YMPE is the good source of data. So let's say that 100 percent is the level for my Canadian pensioners' mortality table for the year 1995-99. What's the level of the other mortality tables? For instance, the GAM 83 table would be at that level, which is 100 percent, and then it would go down to 90 percent. So, we would die more than what would be suggested by the GAM 83 table. If I look at it in another way, if I calculate the complete life expectancy at age 65, for instance, under the GAM 83 table, I then have 16.69 years. Using the all-income level I'll have 15.90, and for CPM over 35 percent of YMPE I would have 16.02. If you think is it significant to have a difference of .10 or, let's say, .70 in terms of mortality level, yes, it could be significant if you calculate annuity values with that. To some extent you could say that annuity values at a 0 percent interest rate would be the same as a complete life expectancy. So, a decrease from 16.69 to 15.90 could be significant. At age 80, 7.64 to 7.14, that's a 0.5 difference. So it could be quite significant in the level of reserves you would need or the actual liability the pension fund would have to keep.

MR. CHRISTIAN ROUSSEAU: Were you surprised that the mortality was worse for Canadians than for Americans?

MR. ADAM: When I started that study I thought that Canadian retirees would die less than U.S. retirees because of a general rule of thumb. I thought that general population data in Canada showed that Canadians would die less than in the United States. I was surprised to see the reverse, and I thought it was an error. So I did my figures back, but the evidence proved to me that, yes, this is the level. You have to understand or recall that the GAM 83 table was devised out of data going back to 1960-65 for some deferred annuity contracts issued in the United States. The Canadian content was 0 percent. The GAR 94 table also has zero percent Canadian content. It's true that they compared the level of mortality in GAR 94 to some Canadian plans, but there were no Canadian lives involved in the these two tables that are the most currently used tables even for pension-plan purposes in Canada. So, my point of view is simply to state that this is what I observed from Canadian data. It could eventually be used as a Canadian standard for pension-plan purposes unless people can prove to me that I'm wrong.

MR. ROUSSEAU: Do you think the fact that the data includes certain people who are not covered by a private-pension plan has an impact?

MR. ADAM: That's a good question. I will restate the question. Is there an impact from the fact that I have more people in my study than those who are currently members of the private-pension plans? On the reverse, I would say that it's more interesting because of that because being a member of a private-pension plan in Canada is not compulsory. If you try to have a look at the mortality level of everybody who is or could have been in a private-pension plan, you would be interested in knowing what that level of mortality is. For instance, it could be used if you are in a private insurance company, and you would like to make insurance

quotes or, in fact, annuity quotes for retirees who put money into retirement savings plans (RSPs). If someone never went into a private-pension plan, and then came knocking at your door at age 65 and said he wanted an annuity, you don't have currently a large volume of data. It is true, though, that insurance companies will share their data, but there are other issues of quality of data and comparability of source of data. I do not have these problems when I use CPP and QPP data, because it allows me to have a good level of mortality.

There is also one factor I did not mention. When you look at trends in mortality over time, you cannot totally rely on Statistics Canada data because when you look at it in age—let's say in calendar years 1971, 1981, 1991, 2001—there are changes in methodology that impact the level of mortality you're measuring in 1971 or 1981, and these figures are based on surveys. You're not really sure if the improvement in mortality you're seeing isn't a change in actual mortality or a change in methodology. If Statistics Canada changes a methodology, it doesn't change it retroactively. So, when you see a decrease in mortality, you're not sure if it's an improvement in methodology, improvement in technology or an actual decrease in mortality. In my study, if I'm wrong, I'm consistently wrong all over the period, which is kind of interesting.

MS. FAYE ALBERT: I wanted to know about the trends in mortality. Were the trends that you calculated a combination of the trends that happened over the entire period, or were they calculated for each five-year period? Were you projecting trends into the future?

MR. ADAM: The trends I calculated were the level of mortality in each individual year from, let's say, 1975 to 1999. For some years, for instance, for age 75, I would have q_x values in year 1975 to year 1999. I would have 24 points, and I could calculate 23 degrees in mortality rates. I would take the weighted average of these 23 values. It's weighted by the level of q_x, level of exposure and level of mortality rates I observed.

MS. ALBERT: But there wouldn't be any indication whether the change would be accelerating or not.

MR. ADAM: I could show you from other things I've done that it seems to be accelerating in the past 10 years. But you have to understand that if I look at the average level of mortality over the past 10 years, compared to an average level of mortality over the past 25 years, yes, it seems to be higher over the last 10 years. But it varies so much from year to year that you have to wonder afterward whether it is really significant. Can I trend over the next 30 years with that? I'm not really sure of that.

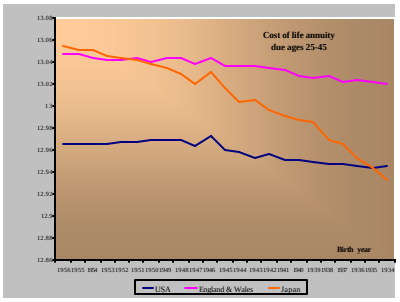
MS. ALBERT: On the basis of what you've just said, it appears to be accelerating. If it were decelerating, then you would think you were anticipating too great an improvement in the future.

MR. ADAM: What I can say is that this is what the data tells me now. It would be interesting to survey that. There is also a factor I should mention for U.S. actuaries. The things I did with Canadian data could, interestingly, be done with U.S. data by sorting out by income level using Social Security data. It could be quite interesting, I think, to have a different point of view in how to make a mortality study for private-pension plan purposes.

Chart 1

Annuity comparisons

- The figure provides a comparison of immediate annuity costs for Japan, England & Wales and the United States



June 23, 2003 64

Chart 2

Data Coverage Ratio: Male

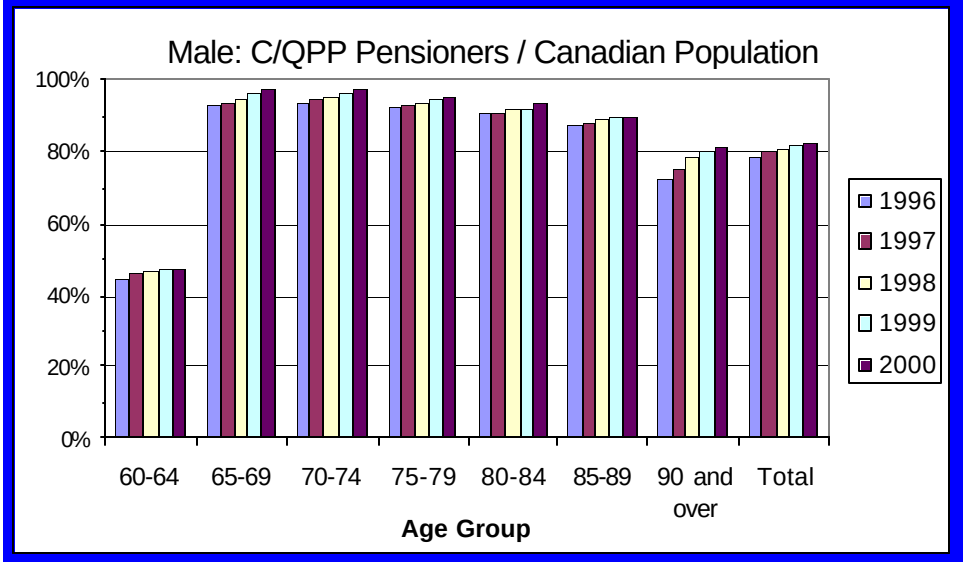


Chart 3

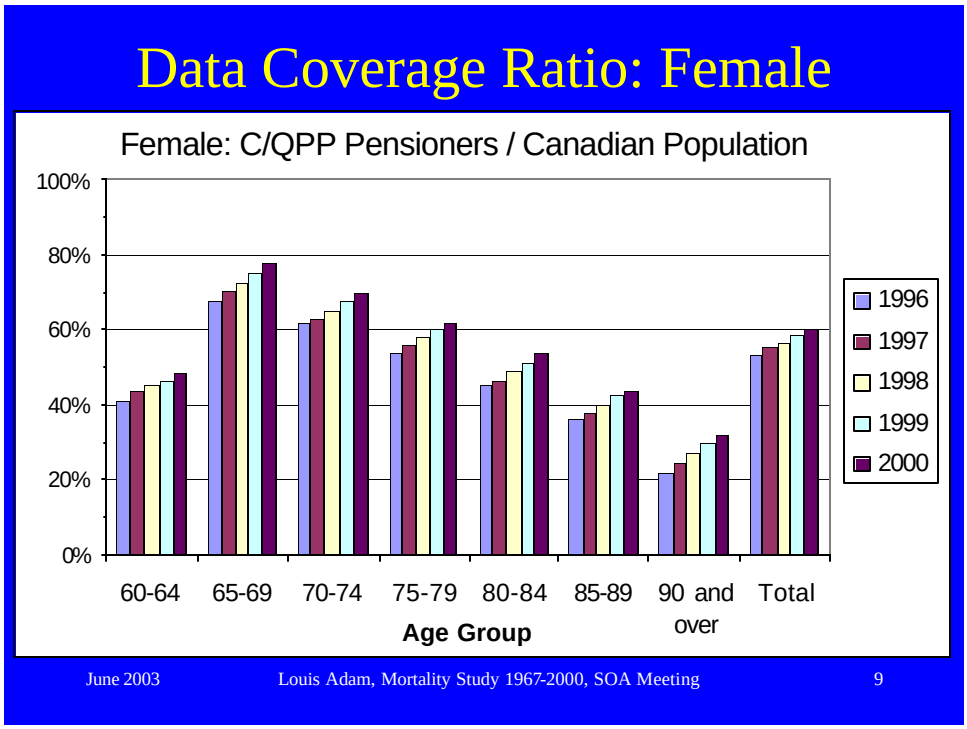


Chart 4