Session VII: Social Insurance: Perspectives and Implications

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Sam Gutterman: Welcome to the last session of the symposium. I very much appreciate all of you who stayed for this session; rather than referring to it as the bitter end, I will characterize it as being its climax, the most exciting session of the week! This session is cosponsored with the Committee on Social Security of the Society of Actuaries. We are honored and privileged to have on our panel two in-person presenters, with the third through a surrogate. The three panel members represent practice in and experience of three different countries.

First, Jean-Claude Menard, the chief actuary of the Canada Pension Plan. Jean-Claude is also chairman of the Technical Committee of the International Social Security Association (ISSA). He'll be followed by Chresten Dengsoe from Denmark, the chief actuary of ATP and vice chairman of the Technical Committee of ISSA – we are very honored to have these two ISSA representatives. They have really interesting presentations.

I am the surrogate presenter, because Steve Goss was unable to be here. I will be presenting his thoughts.

Jean-Claude Menard: Thank you, Sam. I feel privileged to be here at this and during this week at this conference, indeed the same conference as the one attended by Tom Perls, Jay Olshansky, Steven Austad, Leonard Hayflick and Jean-Marie Robine and no offense to the other speakers, but I was, amazed by the quality of speakers in this conference and I would like to thank the organizing committee for that.

So today I will talk about Canadian mortality trends over the past century: the Canada Pension Plan, mortality experience and the mortality projections for the most recent actuarial report on the Canada pension plan table this fall before Parliament, and I will conclude with an international comparison of projections made by social security actuaries around the world and the use of stochastic processes to measure uncertainty of results.

So over the last century life expectancy at birth has increased by an estimated 29 years in Canada with most of the change occurring before 1950. Most experts agree that the rapid increase in life expectancy at birth that occurred during the 20th Century will not continue, and that future increases in life expectancy will have to take place at older ages as opposed to younger ages.

Cohort life expectancy differs from the period life expectancy presented in the previous slide by including future mortality improvements to the calendar year mortality rates. Based on this approach over the last century, life expectancy at birth for cohorts increases even more, averaging an estimated 33 years, and it could go even further once all these cohorts are extinguished.

Since the early 1970s in Canada male and female life expectancy at age 65 has increased by about four years to 18 and 21 years for males and females respectively. The gap between female and male life expectancies at age 65 has also narrowed recently.

Like American trees the Canadian population has been aging at an increasing rate especially since the inception of the Old Age Security Program in 1952. Since the Old Age Security Program provides a monthly retirement benefit to almost all Canadians age 65 and over, its administrative database allows an accurate measurement of the level and trend in mortality experienced by the oldest portion of the Canadian population.

When marital status, income and sex are considered together, the difference in the remaining life expectancy at age 65 could be as high as 10 years. Both married males and females experience better mortality than their single counterparts. I have heard that marital status tends to impact men more than women. The difference is three years for men and one year for a woman at age 65. As people age, the marital status has lesser impact on life expectancy. If you want to know more about this, you have the source at the bottom of the graph, it has been released in November 2006 by our office and we hope in the next three years to update this study.

The next slide expresses CPP retirement beneficiary mortality rates relative to the rates for the general population. For males and females, retirement beneficiary mortality rates at ages 60 to 64 because you could claim your benefit as early as age 60 for the Canada Pension Plan, these rates are significantly lower than for the general population. This is because retirement beneficiaries between the ages of 60 and 64 do not include CPP disability beneficiaries, and are thus somewhat healthier than the general population.

For males mortality rates after age 65 are higher than for the general population, and this is an unexpected result since CPP beneficiaries are generally thought to have higher socioeconomic status than non-CPP beneficiaries and should therefore have lower mortality than the general male population.

Part of the answer lies in the difference between the census survey data used in constructing the CHMD life tables for Canada and the administrative data rely upon the calculation of the CPP mortality rates.

At age 60, male beneficiaries with a maximum pension live three years longer than male beneficiaries with a lower pension. In general, both genders exhibit expected patterns of convergence to the general population mortality for each level of pension as age increases, but there's a significant difference if you are younger, let's say, than 75.

Over the next few slides I will show how we determine our assumption for the most recent actuarial report based on historical data and future expectations. The increase in life expectancy at birth was quite rapid before 1965, mainly due to reduction in mortality rates under age 45. For males, 97 percent of the total increase in life expectancy was caused by a reduction of mortality below age 45, while for females it was 75 percent.

Over the last 20 years, 1985 to 2005, more than half of the increase in life expectancy has been caused by the reduction in mortality rates after age 65. We expect this trend to continue in the future and even to accelerate. And when I say more than half, what I'm using here for males is the 2.6 years for elderly mortality compared to the 4.8 totals, change in life expectancy and for females the 1.7 versus 2.8.

This table shows the improvement rates by sex and age groups over the last 30 years divided into two 15-year sub periods. For people age 65 and over, there was an acceleration of annual improvement rates for males and when I say annual improvement rates, my wife is an economist and when I say mortality improvement she said, well, mortality improves so more people die. Well, unfortunately not. At some point we need to change our way to speak so let's say that what you have in front of you is the annual mortality reduction rate, and we see a clear increase, acceleration for males from one percent to 2.1 percent and almost no change for females from 1-1.1 percent at age 65 and over. And when we expand the analysis to people age 0-84, the same trends apply for both males and females.

For the CPP projections, we do not make an assumption on life expectancy. Life expectancy is a result based on mortality rates. Higher mortality improvement rates or higher mortality reduction rates will cause a higher increase in life expectancy.

The most recent data that we have is 2006, so the initial period of projection, 2007-11, are based on actual experience over the last 15 years by age and sex. Mortality improvements are expected to continue in the future, but at a slower pace than most recently observed over the 15-year period ending in 2006. The ultimate improvement rates, 2031+, are set to about half of the improvements experienced by females over the last 15 years and these ultimate improvements are in the model forever. Legislation requires us to do projections for the next 75 years. However, our model is going much further than that especially when we look at the unfunded liabilities and if we want to apply the open group versus the closed group approach, we need to go much further than 75 years.

For the age group 65-74, mortality rates have dropped significantly over the last 40 years for females and mostly over the last 30 years for males. However, this reduction is expected to slow down in coming years due to already low mortality rates, but let's check the next group.

This was the situation. This is the graph showing the moving 15-year average in improvement rates and in 1996, you see deceleration of the improvement and some kind of level-off for males, but definitely deceleration for females.

We add 10 more years, and then we have this. So since 1996, elderly mortality rates have been decreasing at a faster pace than in the previous decade. With the same annual improvement rates, the reduction rates and mortality rates, the impact would not be the same at each age. For example, the assumed male improvement rates for the next 10 years would lead to only 1 percent more survivors from age 45 to 55, while it would lead to 16 percent more survivors from age 75 to 85. And why? This is because mortality rates at older ages are higher. Therefore, the same reduction in mortality rates yield to more survivors the following year at older ages. And here, I'm referring to this graph. Although these 2.1 percent reduction rates for age group 45-64 and 75-84 are the same at 2.1 percent, they are applied to much higher mortality rates and, of course, this leads to more survivors in the pension plan than a pension plan that becomes more costly.

For the age group 75-84, mortality rates have continually decreased over the last 80 years. The reduction was about 45 percent in the last 40 years, so it's moving from 80 deaths per 1,000 to 45 deaths per 1,000 compared to only 25 percent over the previous period of 40 years. A further reduction of 35 percent is projected over the next 40 years from 45 deaths to 29 deaths per 1,000. So at least at this age, if you look at the United States, there seems to be an even bigger disconnect with our American counterparts, so it's good for us that we live longer, but it puts pressures on any pension plan.

What we have here is the mortality rates of the age 85-99. So an ultimate and lower reduction rate of 0.5 percent is assumed for the age group 85-89 as mentioned in Slide 14. For the age group 90+, the annual reduction rate is fixed at 0.4 percent, which is close to the experience over the last 15 years.

As a result mortality rates are assumed to decrease from 127 deaths per 1,000 to 98 deaths per 1,000 over the projection period for the age group 85-99.

On Wednesday Jean-Marie raised the issue of the disparity between countries and here in 2020, if the projections are right, Canadian male mortality rates are expected to be 10 percent lower than U.S. female mortality rates. In other words, a male in Canada will live longer than a female in the United States as a group. At least mortality rates will be lower, and it's interesting we are in 2010, I'm talking about 2008 and I see projected Canadian male mortality rates are lower than U.S. female mortality rates. In 2008 you should understand that the most recent available data is 2006, but nevertheless there's a big reduction in mortality rates.

Now for the 100+, current mortality rates in Canada at least for the oldest are about the same level as 25 years ago. For this age group, data quality is a major concern. The reduction in projected mortality rates is less than for others groups going from 362 deaths per 1,000 to 328 deaths over the projection period.

Despite major increase in life expectancy at birth, the maximum life span did not increase significantly in the last century. Few people live beyond 110 years. The Vaupel graph shows the probability of survival for a male newborn from 1925 to 2075 based on period life tables. The squaring of the survivor curve is the result of expected lifetimes increasing and the maximum age that can be attained being about 120 years. As indicated on the graph by the intersection of the vertical line at age 65 with the survival curves, the probability of reaching age 65 increased substantially in the past. Based on period life tables of 1925, males had a 57 percent probability of reaching age 65. This figure increased to 87 percent in 2010, and is projected to reach 93 percent by 2075.

Based on period life tables of 1925 at that time about 70 percent of females could expect to die between the ages of 24 and 84; that is 15 percent of females died prematurely before age 24, while 50 percent died after age 84. Removing the 15 percent of the people in accord at the two extremities in my view allows for a better assessment of the cost associated with financing retirement. By 2010 this range moved forward and narrowed at an age range of 72 to 95 years and this trend is expected to continue in the future. In 2075 it is expected that 70 percent of females will die between the age of 79 and 98.

While the probability of reaching age 65 has significantly increased in the past, it is expected to only increase marginally in the future, at least in Canada, reaching 95 percent by 2075. In my view it is much more important to look at the probability of reaching age 85 in the future to properly assess the cost of pension plans. For females the probability is expected to increase from 56 percent to 72 percent in 2075.

What you have in the next slide is an international comparison, Canada with some other countries and because actuaries around the world are projecting life expectancies far into the future. This graph shows the projection of life expectancy at age 65 until 2040. The purple bar, first portion, shows the life expectancies in 2005, the burgundy bar shows the additional life expectancy in 2020 and the third yellow bar shows the additional life expectancy in 2040. The three vertical dotted lines show the position of Canada in 2005, 2020 and 2040 and if any of our assumptions are right and if the assumptions of the others are also right, it is expected by 2020 Canada will have the highest life expectancy at age 65, but obviously everybody could be wrong.

For females, Canada is a bit further down the road, ranked sixth. So I will move right away to the stochastic scenarios that we have done. Based on the mortality experience by age and sex of the last 81 known years, 1926 to 2006, a stochastic approach was used to generate low- and high-cost scenarios over the 75-year projection period. It was projected that on average, the life expectancy of a male age 65 in 2050 will be in the range of 29 to 25 years with 80 percent probability and for a female this range is between 20 and 28 years. You could find different valuations like one from the OECD and the confidence interval is much shorter, much smaller, because mainly they use G7 countries and G7 countries are, of course, a much bigger population than only the Canadian population, but at least this gives you the idea of the stochastic tests that we have done. And based on these stochastic tests, right now the plan is financially sustainable for the long term with a 9.9 percent contribution rate. Obviously if we have a lower life expectancy in a model, then we could finance the plan with only a contribution rate of 9.3 percent. However, if the in future life expectancies are higher than best estimate, then the contribution rate will need to be increased.

To conclude, I would say for a pension plan actuary the future challenge is not to project how many people will still be alive at age 100, but more so at age 85. So thank you very much for your attention.

Chresten Dengsoe: It's a pleasure for me to be here. It's the first time I joined this conference as an actuary and a pension fund and I'll get back to that. I've been mostly focused on the financial issues. From a financial point of view with the number of centenarians it's not really very important, but it's been really interesting to follow the discussion these last three days, and it's given me some ideas about things we'll go back and have a look upon.

But I guess that most of you know very little about Denmark and nothing of ATP so I might just say a few words about Denmark and ATP before I go on. Denmark is a small Scandinavian country in the northern part of Europe, approximately five million inhabitants. We tend to rely much more on collective solutions than the United States does, and ATP, where I work, is such a collective solution. It's a compulsory pension fund for all Danes, which means that it's among the largest pension fund in Europe. We have liability between $90 and $100 billion and the product that you get from ATP is basically a deferred annuity so all Danes from age 16 until age 65 will have to contribute to ATP, and then they will get this annuity from the age of 65. It's a life-long annuity.

ATP is, as I said, one of the larger pension funds so we have the critical mass to do a lot of things inside, so I have a staff of some 25 people doing actuarial analysis and asset liability management and a lot of other different things, so we have a lot of expertise in-house. I have some Ph.Ds. in statistics and actuarial science and they've been looking in to the mortality and longevity and improvements of that and I'm going to give a presentation of a few of the things that we've been doing within the last few years.

I'm going to limit myself to two parts. The first part is looking back. It's about how Danish mortality has evolved historically. We were in a very good position in the sense that we have reliable data going back as far as 1835, so we have like 170 years of history that we can look into. I usually tell my two kids that one of the great things about being an actuary is when you have this joy of numbers. I mean, there's new numbers coming up all the time, and there are old numbers you can look at. I'm going to start to look at old numbers and I'm going to tell you a little bit about how we have decomposed this gain in life expectancies that we've seen. The other part is about the future, about prognosis. We have developed a framework that we use for prognosis, because, as I told you, Danes from the age of 16 pay money into ATP and some of them will live for another 90 years or so, even more than 90 years actually, so ATP is a fully funded scheme (I don't think I said that), but it's a fully funded scheme so being able to actually calculate the liabilities of ATP we have to have some kind of prognosis, so that's going to be the second part of it.

First part of it is looking at history. This chart is maybe a little complicated. So there are three axes here. This axis is the calendar time so it goes all the way back from 1835 to 2006. This axis is the H and this axis is the mortality. So what you can see here and this is for males, it's basically that you can see this part of it where you can see the decrease in mortality among infants and children.

The thing is that at 1835 life expectancy was 36 years. I think maybe I should say a few words about life expectancy. We all know that the concept of life expectancy is not a very good concept or it's only a good concept and the good thing about life expectancy is that it's based on something you'd actually observed. And the other thing is that you can do some historical analysis, but of course it doesn't really make much sense to look at life expectancy when you want to do prognosis or when you want to calculate your liabilities.

In 1835 life expectancy was 36 years for Danish males and as you see here in 2006 the number was 76 years, so that's an increase of 40 years within that timeframe. And as you can see, you can actually see some of the historical things in the colors here. You can see the Spanish flu, you can see the cholera epidemics and you can see World War II, which is kind of neat.

Then if you look at Danish females, it's basically the same idea. Then just to illustrate what I'm going to talk about later, you can actually see that the life expectancy in 1835 was 40 years for females, and it was 80 years in 2006, so also a change of 40 years there. And what we've done is to see, how to explain these 40 years. And the thing is that half of it can actually be attributed to child and infant mortality, that's 21 years. Then there is another 13 years that can be attributed to what's going on before the age of 60 and then lately there's six years that basically surround what's going on after the age of 60. And the important thing here is if you're a funded pension scheme, then it's really important what's going on after the age of 60 because that's where people get their money. From a financial point of view that's really important.

I'm not going to go into details. We've written a paper on this, and it's a very fascinating subject, but I don't have the time to go into all the details so I just wanted to show you one slide on this. And this is the expected lifetime given that you have actually reached a certain age. So if you look at 1835 here (let's see if I can get this one), then a newborn as I said, a newborn female could expect to become 40. But if you look at the green one, the green one is someone that is 20, so if you reach the age of 20 back in 1835, then you would actually get an expected lifetime of 60, so you would get an additional 20 years, if you just reached the first 20 years. So there's really quite a difference there and you can see how that changed over time. And now even though Danes don't live as long as most other countries do, then I mean you can see at the age, a newborn will be around 80 for females and you won't really gain anything if you obtain the age of 20 or 40 or even 60 because almost everyone will get there.

What we have done is that we've looked at the 40 years of life expectancy gains and we've divided it into three calendar periods. The first one is the black. It's from 1835 to 1900 and the next one is the red one it's from 1900 to 1950 and the last one is from 1950 and until 2006, and then we've looked at these life expectancy gains and we've decomposed it. I'm not going to go into the techniques; it's a fairly complicated technique, but it's basically a sensitivity measure that gives you the ability to say, 'where did that actually come from?' You can see on this slide that we've divided the population into different age groups. Zero is what I think you call infants; 10 is from age 1-10 and so on. What you see here is, first of all, you have 13 years from 1835 to 1900. There was a gain of 18 years from 1900 to 1950 and then much less from 1950 to 2006, but what you can see if you look at the black one, you can see what happened until 1900 was basically that you got most of the gain among children, but also quite a lot from infants, but not very much from the older ones. And then you look at the red one then you can see, that's actually from 1900 to 1950. That's where you got a lot of gain from the infants and, of course, that matters an awful lot if you have infant mortality because if you can get them through the first year then they will probably live for a long time.

And then if you look at the green one, which is the last one, you can see where we got quite a lot of the nine years coming from the older generation. There's still something coming from infants and children, but more and more coming from the elderly ones.

So this is a way to illustrate where would you expect to get gains in the future? You would expect future gains to come from the older part of the population.

In conclusion, we have developed a methodology for decomposing life expectancy gains and, as I said, half of it in Denmark has been due to reductions in infant and child mortality.

The second part of my presentation is about how to model mortality in small populations, and ATP is a pension fund of a bit more than four million members. So usually we look at ourselves as a large pension fund, and we have smaller pension funds coming to us to get our data and we were actually surprised that even four million members was not enough for us to make a good prognosis of how mortality is going to develop in the future. It wasn't really robust. It depended much too much on which calendar years we would take and how we would do it and then a colleague of mine got the idea about using international data when you want to do a prognosis and that's what I'm going to talk about. I'm going to talk about the same framework and I'm going to talk about what we call coherent and incoherent mortality projections.

First bit about the development in Danish mortality. So far we've seen very little improvement at the highest ages and we have had years with stagnation or even increase from 1980 to 1995, but then from 1995 we've had some fairly high annual rates of improvement and that's of course why we've started to look more into this.

When we do simple projections, and when we say simple projections it's like Lee-Carter projections and projections like that; the results are unstable and they are not plausible. That is probably one of the things that we realize: if you've only got, like we have, 4 million members then you don't get very plausible results when you do these simple projections. We have to do long-term projections, and that's where it gets implausible. Because when you do these simple Lee-Carter projections, you end up with those that are 50 years actually having higher mortalities than those being 60 and so.

When we looked into the models, and we've been looking a lot into the uncertainty around mortality models, then there is a problem around what you could call the long-term uncertainty and the short-term deviations here. A lot of those models that are random walk models do actually have these problems and it's illustrated here with U.S. data and Danish data.

We know of good data from the United States from around 1935. If you look at that from 1935, the development in the United States and in Denmark have been fairly similar actually, but there is, of course, this difference: Denmark is only five million people so there is much more short-term variability when you look at the Danish data. When you then do what we call the simple projections, you actually get completely different uncertainty around this. It’s like the uncertainty in Denmark should be much higher than that in the United States, and this is basically just because of the number of people. So what we did is we looked at it, and as we see it there has been similar mortality evolution in most of the developed countries we looked at. We’ve looked at 19 countries, and we expect that mortality levels are likely to continue to evolve in parallel somehow. But, when we do projections, we get a very different story. So, we’ve done Lee-Carter projections on these 19 different countries, and these are the results. As you can see, the first part is what’s been observed and the second part, the straight lines, is what you would get from a Lee-Carter projection on these different countries, and is that plausible? Probably not. Another way to show it is if you look at the different countries on a relative scale, you would see that the mean is what you’ve seen in all countries. Then you would see that most countries would be within the band of 0.75 and 1.5, but if you do the projections you’ll see that they diverse. Denmark, which has had a really bad story for the last 15 years, would just go up and up. Japan, which has had a great story within the last 50 years, would go down and down and down and is this really plausible? Well, we doubt it.

So the challenge for us was to produce something that was plausible, that reflected the underlying trend. The idea we got was to start to estimate an underlying trend for more regular reference data so it was actually to go outside your own data and that’s what we did. Because when we looked at all these 19 countries together we saw that there was a very, very steady decline in mortality levels. It’s very nice and regular patterns. You simply put all the data from all 19 countries together and analyze them altogether. And what we saw was that the Danish data fluctuated around this stable international trend. So historically we had had life expectancy that was higher. It was actually one of the highest in the world. And right now for the last 20 to 30 years we’ve been falling behind the international trend and we’re optimistic people so we think we will be catching up again. This is temporary. So the model we've built is basically a model where you have an international trend and then you have a spread which explains the Danish deviation from the international trend, but you model that you will be coming back on the international trend again.

Sam Gutterman: I'm now putting another hat on. It is important to note that this presentation was prepared by Steve Goss, chief actuary of the U.S. Social Security Administration. It is not a 20-minute presentation on how the Social Security Administration (SSA) projects mortality. You can find that well described in a really good article updating Alice Wade's presentation of three years ago at this Symposium, which just came out in the *North American Actuarial Journal*. Steve believed it was more relevant and interesting to discuss here some of the key issues that face the U.S. Social Security system and its trustees in their projection of Social Security mortality.

Three aspects will be addressed. The first is the derivation of the historical and projected probabilities of mortality rates. Second, some international perspectives are given and last, observations on smoking and obesity. He subtitled it, "Principal Drivers for the Future, or the Latest Trends of Different Factors that Will Arise."

Since 1900 the average rate of decline in mortality for all ages has been about 1.08 percent˜ of possibly more relevance to this audience is an average rate of decline at age 65 and later of about 0.76 percent per annum.

That period covered two extraordinary periods in the United States. First, between '36 and '54, the post-World War II period, which encompassed the significant effect of the role of antibiotics the period of '68 to '82, which was encompassed the effect of the introduction of social health insurance (Medicare and Medicaid in '65), as well as medical advances, favorably affecting cardiovascular disease and its risk factors. It will be interesting to see what effect the recent coverage of prescription drugs will have over the last couple of years for those aged 65 and older in increasing utilization of drugs and their effect on mortality at these ages I'm sure that Steve will be focusing on that in the future.

This is a log graph of United States male death rates. I don't believe we have to dig any deeper now – it represents the current projection of the Old Age Security and Disability Income beneficiaries as prepared by the Social Security Administration trustees. You can see that this represents a significant improvement over historical experience, but note that the projected rates between 2006 and 2100. That's a heroic projection period for anyone to make. The overall rates for females are similar to those of males, but just a little smaller; however, they exhibit a very similar pattern.

This slide has a lot of numbers on it, showing mortality experience for individual historical periods in the current trustee's report projections. A few items of note:

- For the historical period included there was a reported increase in mortality for ages 85+ for that period, at a -0.18 percent rate – we'll discuss that in a moment.
- Regarding the projections you see projected improvements for all demographic groups.
- For the last 25 years in the aggregate there has been an overall reduction of 0.82 percent per annum, with projected rates over the next quarter century of about the same aggregate rate.

Now let's go address Steve's comments about experience over age 85. There has been substantial improvement in mortality between these two periods, particularly covering the early effects of the introduction of social health insurance (Medicare) in the United States in the latter period. In contrast, reported mortality rates for older ages have increased over the last quarter of century, in particular for death rates over age 90, also alluded to this morning. Death rate experience was worse in 2006 than in 1982 – we haven't made much progress lately.

Many leading demographers and actuaries are interested and concerned with mortality of these ages. The data is derived from Medicare records, probably the most reliable source of data for ages over 85 for reasons alluded to during the session.

Sam Preston has expressed the belief that historical age overstatement at these very high ages, as well as the change in age overstatement, has been a key factor in reported mortality rates for these ages. This sounds like a consensus conclusion reached by a number of researchers.

This slide shows mortality at age 65 and later. What I alluded to earlier, a crossover at about age 90s of reported experience where the 2006 experience has been worse than that previously reported. That now assumes that we have better data at those ages and improvements will occur for both genders, shown here for females on a log scale.

The future. These are projections of the Social Security trustees, although Steve Goss does confirm they're reasonableness through his actuarial opinion regarding the trustees' projection.

I'm going to skip very quickly over the next section. Social Security technical panels, of which the Social Security Administration (or its Advisory Council) convenes one about every four years that provide their perspectives and advice regarding projections. The Lee-Carter extrapolation was recommended by an earlier panel, with alternative projections recommended recently, including a compression of mortality rates at the very old ages. According to Steve, the current panel that met three weeks ago, held some interesting discussions on this topic.

Different tech panel projections are shown on this slide, most with higher assumed mortality improvement than that of the trustees.

The U.S. has a periodic review of SSA's models and assumptions about every four years. The 2007 technical panel projected about a 1.0 percent annual aggregate improvement in mortality rates for all ages, compared with the current trustees' report, which has a smaller improvement assumption over the long term, varying somewhat by attained age group.

The next slide compares the projections presented at the corresponding panel at the 2007 Living to 100 panel three years ago covering improvement assumptions made by the Canadian and United Kingdom social insurance actuarial staff, as well as that of the United States. Note that recent mortality improvement in Canada has been higher than the U.S., but the projection for ultimate future improvement is somewhat lower than the U.S.

Moving to other international comparisons, Steve particularly wanted to note Vaupel and Oeppen's article and paper of 2002 regarding the trend of 'best nations' life expectancy experience'. This paper analyzed the best period experience on life expectancy at the time. Should we expect that the apparently linearly improving trend in life expectancy continue or is this historical trend a mere coincidence that may not apply in the future? Can the United States ever be expected to rise to the top? Right now the United States is certainly not one of the leaders in life expectancy in the world.

We saw a great illustration yesterday on the video tape from YouTube of a remarkable straight line, linear trend in life expectancy. Between 1840 and 2000 it displays an almost incredibly linear pattern in terms of the slope of the best nation's mortality. Steve's question is whether this is going to continue or will this time series flatten out.

Three weeks ago Sam Preston presented this historical trend at the Social Security's quadrennial technical panel. Denmark and the Netherlands, that experienced among the longest life expectance in mid-century, have fallen from trend since 1950 for males and from 1980 for females. The United States and the United Kingdom are holding at a low position for males, and the relative position of the United States has fallen since 1980, particularly since 1980 for females, presumably because of their late change in smoking habits. Open and important questions involve figuring out more of the reasons for these trends and designing approaches to fix them.

This leads to the last part of Steve's presentation, which addresses what are the factors that will determine future trends? How should we develop our projections? We've had some really interesting methods described by Chresten who described certain problems associated with the Lee-Carter technique, particularly in the use of a naïve approach as input factors change, such as known trends in smoking, which I'll discuss in a moment. Smoking has been a significant driving factor in mortality trends, both in the United States, and in the rest of the world. When the projected effect of obesity is included, what approaches should actuaries or others take? Should mortality be studied and projected by cause (that some demographers have criticized) or should a naïve statistical projection be made because it is useless to develop a rigorous approach to this speculative effort?

A recent paper by Preston, Glei and Wilmoth argued that smoking has been the key mortality driver in the most recent past. In fact, the paper indicates that it is expected to remain a leading driver in changes in mortality in the near future as well. In that paper, the authors point out that U.S. males were leaders in smoking (the United States has often served as leaders in many things, but it is unfortunate that Americans are not serving as a successful role model for mortality). U.S. males actually led females in mortality improvement over the last few decades and have been ahead of European males. Certainly based on historical experience, it has been a key driver on recent experience. In addition, it significantly helps explain the relative improvement in the male-to-female mortality ratios since 1982.

Here's an interesting graph showing trends in per capita consumption of manufactured cigarettes. You'll see the leadership of the United States in the upper blue line where between the 1930s and the 1980s the United States had the largest per capita consumption of cigarettes. Also shown are smoking habits of most European countries, with Switzerland close behind the United

States, while others experienced a lower peak of smoking, but with what looks like a delayed decrease. I believe that the United Kingdom, not on this slide, is somewhere in-between the European countries shown.

The assessment of a comparison between smoking prevalence and corresponding disease-related mortality is demonstrated in a couple of papers that Preston co-wrote over the last several years. The following graphs illustrate the relationship between daily cigarettes use per capita and lung cancer mortality rates, and comparisons of life expectancy and gender. Male smoking prevalence peaked in the 1960s, while that of females peaked in the '80s. Male lung cancer peaked in the '80s, with female rates did not peak until the early 2000s.

What can be seen is the long lag period between smoking prevalence and resulting mortality. In fact, this has been a primary driver in the United States between male and female mortality trends. You can see that males have been catching up to, but not reaching females in terms of life expectancy over the last couple of decades – as I alluded to, a primary reason is that women started smoking heavily later also decreased after male smoking did. You'll see that this difference between males and females is demonstrated in terms of the average number of years spent as a cigarette smoker prior to age 40 in different birth cohorts. The differences between male and female smoking habits have been really significant drivers of the difference between U.S. male and U.S. female mortality.

The next graph has a dashed line and a solid line, representing what life expectancy at age 50 would be with and without smoking.

The estimated difference in expectations of life at age 50 and the estimated sex difference without smoking are shown, with a significant decrease in life expectancy between the sexes being due to historical changes in smoking habits.

I’ll end very quickly with a brief discussion of obesity. This is a topic that I discussed at length earlier in the symposium. The technical panel in the middle of December suggested that this is a factor that may significantly affect mortality, similar to the effect of smoking, with a long lag time between weight and its affect on mortality.

David Cutler, whom I very much respect, in 2009 argued that the negative effects of obesity may overwhelm the positive effects of reduced smoking. While I personally don’t believe that this effect is quite as strong as David has pointed out, it will certainly be a significant factor, although the future trend is not clear.

Regarding the prevalence of obesity, again the United States is a leader, in this case again an unfortunate leader, but as can be seen in international comparisons, other countries are catching up. In this comparison, Great Britain is in second place for men and in third place, slightly behind Spain, for females.

You saw earlier the essence of this graph – trends of obesity. The length of time that people will be obese has gradually increased; only after 2050 will the large increase in obesity (from, for example, those people who are obese in their 20s) affect those aged between 60 and 70 and become a prevalent driver of mortality, so beware of these trends in the future.

The last point that I’ll make is mortality projection by cause. It is not currently viewed as being a popular approach by demographers, but yet we’ve seen some demographers and economists who, although they’ve espoused statistical extrapolation saying, “oops, wait a second now, we’ve identified this primary driver of smoking, and maybe a future driver of obesity, and there’s always a problem of interdependence of causes,…”.

In Steve’s opinion mortality analysis by cause will remain useful for analytical purposes in the study of future mortality, as well as for speculative purposes. This table shows current annual mortality rates by cause. Steve’s staff projects mortality rates by cause over the short term based on recent trends. Aggregate trends for all causes are projected over long-term periods, that is, after 25 years from the projection date. Historically there are a number of causes of death for those over age 85 where there've been increases in mortality rates for both men and women, in particular due to cancer, driven at least to some extent by smoking habits. For those in ages 65 to 84, there has been a consistent improvement over the last few decades.

The future will remain interesting in this field. I believe that as we continue to update our experience, we will have to update our expectations as well.

Sam Gutterman: Now to the audience – who would like to start the questions or additional comments?

Jay Olshansky: I have a comment, two comments actually. First of all, I thought these were wonderfully crystal clear presentations from all three of you, so thank you for that, and I was particularly pleased to see a plausibility check because plausibility checks simply are not done often enough. I have two plausibility checks for you, it's actually for all three. Too bad Steve isn't here.

The first one is, of course, we know that all the action is going to have to come at middle and older ages in the future if life expectancy is going to rise and so if you actually reduce death rates by 1 to 2 percent, at let's say ages 50 and over or 65 and over, what you will discover is within about three decades we run out of causes of death to reduce, which means implicit in your assumption after about three decades is that something other than heart disease, cancer and stroke for the most part are going to have to be reduced significantly. This is another way of saying we're going to have to influence biological processes of aging after about three decades. So it's okay if you make that assumption just so you make it explicit that that's what your assumption is after about three decades, so that's plausibility check No. 1.

Plausibility check No. 2 has to do with this best practice life expectancy material that was presented a few moments ago and I'm a little surprised that Denmark actually isn't using this, although I'm pleased that you're not. So a plausibility check here is fairly straight forward. The underlying assumption of this is that there's a fundamental difference between period life expectancy and cohort life expectancy, because this underlying assumption is that half the babies born today will live to 100, which means if period life expectancy today is 80, they're predicting that cohort life expectancy is actually 100, right? A 20-year difference between period and cohort life expectancy is predicted from the best practice life expectancy assumption. So if you go back to the 20th Century, we can look at the difference between period and cohort life expectancy from 1900, and you discover that the difference was only about six-seven years. For babies born in 1900 it was roughly 48, the cohort life expectancy was closer to about 53-55 depending on where you're talking about, so under conditions of extraordinarily rapid reductions in death rates during the course of the 20th Century, the difference between period and cohort life expectancy was only a few years. So what is the basis for predicting a three-fold increase in the difference between period and cohort life expectancy, based on this best practice concept? Which is another way for me to say, it fails the plausibility check. So those are two plausibility checks I would suggest just comments not necessarily questions.

Chresten Dengsoe: I'm not quite sure if I understood all of that. I have to apologize for that. That's because it's not my mother language, but as far as the first plausibility check goes, I tend to look at this in a different way. We've observed for 170 years that life expectancy is just rising and rising and rising. There's been an increase in life expectancy for many years and that goes for all the countries we're looking at, no matter how far you go back. So I find it very unlikely that it shouldn't go on for more than 30 years the next three years. I'm not able to explain it. I find it very unlikely that it shouldn't go on for more than 30 years. I don't know if I got that quite right, I'm sorry if I didn't get that quite right, but to me it seems plausible that life expectancy will rise also beyond 2040.

The other part about the difference between the period mortality and the cohort mortality, I'm not quite sure what you're talking about when you talk about best practice, but I can say the model we use in Denmark will maintain this difference around five, six, seven years or something between the two. So we don't have that problem as far as I see it.

Jean-Claude Menard: In terms of plausibility check, just to show you something here. My first point is in this graph I put a comment, 2006-26 more predictable. In our work it's important for us to look at what could reasonably happen in the next 30 years and beyond that, we need to make an assumption, but frankly we don't know. And we add a big discussion in our group about this recent trend because the moving 15-year average annual reduction rate in my view is a strong indicator, and we were thinking of doing this even further in the future so higher in the future, so further acceleration and then go down and maybe stop the reduction rates later. We don't know.

The other thing that we have done is just to do some things. The compression and looking at the past 15 years. If mortality rates decrease at the same pace in Canada, and it has been a huge pace especially for people older than 75, a life expectancy of 100 could be attained in 140 years for males and 120 years for females. Using the age mapping because there's also another technique that consists of saying let's say that the mortality rate at age 60 will suddenly be the mortality rate at age 70 so you just move the survival curve to the right. Life expectancy of 100 is also achievable if the maximum life span increases to 142 year for males and 134 years for females. So to some extent I agree with your comment that in the next three decades, but again the next three decades for pension plans for many countries it's where the baby boomers attain their retirement age, so, yes, it is important to ask us what could happen after 30 years, but in my view we need to assess correctly the next 30 years. I'm less concerned about the period after 2050 in my work.

Sam Gutterman: I agree with the application of plausibility checks. However, I am also concerned with the use of simple extrapolation. I refer to a refereed paper three or four years ago on obesity that projected more than 100 percent of the U.S. population was going to be obese in 20 years. Simple extrapolations of any types will likely prove quite dangerous.

Eric Stallard: I have several comments; whoever wants to address them can do so. Let me quickly point out that the Vaupel-Oeppen graph that Sam showed with a 0.24 year increase in life expectancy per year was for females. The corresponding graph for males had a 0.22 year increase per year, nearly 9% lower, and, according to Ron Lee, for the period 1950-2000 the rate of increase for males dropped to 0.15 years per year. My first comment is that males have not done as well as females over that 160-year period.

My second comment relates to the 2007 Technical Panel. I was on that panel. The panel's recommendation for the central, or intermediate, forecast was for an overall improvement rate of 1.0 percent per year which can be compared with the tables Sam showed where the Social Security projections currently are using an improvement rate of 0.76 or 0.77 percent per year. Originally, at the time the panel looked at the data, the Social Security projections were using improvement rates of 0.70 percent per year; an increment of 0.30 percent per year, bringing the rate to 1.0 percent per year, was recommended for the intermediate alternative.

A critical concern of the panel was that the uncertainty was asymmetric. The recommended bounds ranged from 0.30 percent to 1.0 percent on the lower end, a range which included the 0.70-percent intermediate value in the Social Security projections. The range on the upper end went from 1.0 percent to 2.0 percent.

The panel was motivated by the desire to appropriately reflect the potential effects of the higher rates of improvement seen in the international data. However, the panel did not feel that the evidence from the international experience was sufficiently compelling to recommend re-channeling the historically-based direction of the U.S. projections. Instead, the panel decided to represent those trends by recognizing, in the high-cost projection, the possibility that at some time the United States may significantly change its long-term track. This introduced an asymmetry that was new. No prior technical panel had recommended such a large degree of asymmetry at the upper end.

The panel kept the low end at 0.30 percent. This recommendation reflected Jay's input. I talked with Jay numerous times and have read almost everything he's written on the topic.

Jim Vaupel had a strong influence on the upper end due to the arguments that he made supporting his position.

The panel was very comfortable with its recommendation for the intermediate value. There was greater uncertainty regarding the recommended values for the lower and upper bounds. I've since talked to Bruce Carnes, Jay's collaborator, and I asked how low could the lower bound get? He opined that the plausible lower bound was actually a -0.5 percent per year change, so rather than having an improvement, things could get worse. That was the plausible lower bound. Vaupel's results indicated that the plausible upper bound could be around 2.5 percent per year change. These are the plausible bounds for the long-term projections.

There's a lot of uncertainty. The effects of smoking and obesity have not been appropriately quantified. Those effects could be very large and could cause additional shifts. So the uncertainty is huge. Anybody working with these data needs to take that uncertainty into account in their decision-making models.

My third comment is a reply to Jay's comments about causes of death. If you have exponentially increasing hazard rates for various causes of death like heart disease, cancer, and almost all the chronic diseases of the elderly, it is possible to reduce those rates by very significant fractions. Nothing has to disappear. You just simply lower each exponential curve, observing that the point at which you got, say, a 10 percent probability might be moved over four, five or six years. So it is possible to keep all of the current causes and yet have proportional reductions that could be very, very large. You don't have to eliminate anything. Smallpox is the main example of a disease that has been eliminated, but the rest of the improvement that we see at older ages is due to the reduction of the various mortality hazard rates.

Jay Olshansky: Okay, just really quickly, I want to agree with Eric's point about this great deal of variability clearly, but there's one thing worth being reminded of, and that is if all of the action is going to come at older ages and we all agree to that, it has to come for the population principally over the age of 65. The driving force is not going to be previous statistics. The driving force is going to be basic biology and if we don't recognize that it's basic biology that influences mortality risk, we're going to come up with these numbers of 142 and 135 life expectancy estimates or 100-year life expectancy estimates and it doesn't take very long to delve into the biology. Read a few of Len's papers and you'll get an idea that it is simply implausible to push human survival into regions of the life span that have never been experienced before.