LIVING TO 100 SYMPOSIUM*

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Session 4B: Mortality Measurement and Prediction Q&A

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ETHAN KRA: Question on the first paper where you showed the effect of month of birth on mortality and that it appeared in different points but at different months. In other words, there was no uniformity of which months were the better months to be born in versus the worst months to be born in. Was there any test for whether this was just random noise versus being statistically valid as a result that the differences were not just random? In no way am I implying that I did any such testing. This is just a pure question.

LEONID A. GAVRILOV: Okay first of all, it was tested for statistical significance and since we have such large numbers for the entire population of the United States the differences were highly statistically significant. But more important is that it is not the property of one particular year but here you have this data for each calendar year of birth, so you have from here to here, so you have about 14 years study of birth cohort. And in each birth cohort, you have exactly the same picture, although it might be some shift in one year, you have one month earlier, this big. And another year of birth you have one month later. But it is reproducible from year to year. So we consider this as just the beginning of the study because what we have found is, gross underestimate of seasonal effects. Because these are United States taken together so here's data for Alaska which is quite different climate from Florida and so if there is any seasonality, then this might be very different in southern states and northern states, and you should make breakdown for different states of United States and the effects of month of birth might be much larger and different. So when we aggregate data you work against yourself. So you decrease the signal. So we are aware of these kinds of problems and we are going to pursue this kind of studies.

NATALIA S. GAVRILOVA: And we did no formal test for periodicity yet.

LEONID A. GAVRILOV: But we made analysis for statistical significance here, so we had estimates of a life expectancy at age 80 and here you have this 95 percent confidence interval for life expectancy. And you can see that if you compare those born in May or June their life expectancy is statistically significantly different from those who are born in January for example. The question was when you analyze only one birth cohort,

people born in particular one year, you don't know whether this is periodic or specific for this particular year. So it might not be seasonality at all, simply in this particular year, there was some kind of fluke and the question is how general is this effect? And for this reason we make analysis for 14 years and extinct birth cohorts. And you can see that within each year, you have this periodicity, so it is from the previous slide, that you must say, if you have a statistically significant difference but from this slide you can see, that this effect is seasonal and is replicated from one year to another. So when there are some debates about cohort and period effects, sometimes people claim that there are no strong cohort effects. I would say that there are no strong cohort effects if you aggregate by year of birth. But if you study by month of birth, you might find pretty strong cohort effects and people did not care about this much. So it's definitely something to look in. Thank you.

JASON GOLDSTEIN: Jason Goldstein, Penn Mutual Life Insurance Company. Along these same lines, I've been studying seasonality of deaths, not by birth month but actual month of death and it's a pretty easy pattern to follow. There's a lot more deaths in the winter months in North America, and also there's a lot more deaths in the summer months, or our summer months, in Australia, because you know, the seasons are reversed. Can you say anything along those lines, if you've seen anything? It's easier to understand that, than to understand why this phenomenon is happening with the month of birth, especially since you can't measure until 80 years later. I just want to know if that kind of has the same seasonality or people also seem to hang on to life as their next birthday happens, and then they die right after, at an extremely old age. I don't know if you could say anything that ties in?

LEONID A. GAVRILOV: Two thoughts. First is their birth day effect as a possible explanation of seasonality. We did not test this hypothesis.

NATALIA S. GAVRILOVA: Actually we did one study where we took into account month of death in the Cox proportional hazard model, although probably it's not the best one, but actually we used both, month of birth and month of death and we found that this effect still exists even if you take into account the month of death. At least, it still exists. It's not explained by month of death.

LEONID A. GAVRILOV: And also when they first found this phenomenon, we were very much concerned that somehow month of death might create an illusion of season-of-birth effect. So for this reason, we analyze life span for each particular person, basically in months of their life span. So, that's how, because if you think in aggregated categories like in years, then it might happen so, that this is seasonality of death, making it somehow translated in the illusion.

JASON GOLDSTEIN: I thought it was interesting you said that the number one month to be born is January. And we made a study that the number one month when you die is January.

LEONID A. GAVRILOV: Exactly. And those who were born in December, they are in fact younger than those who are born in January. Almost one year younger if they were

born in some particular....so that's you need to correct for them. So how we corrected for this, for each particular person, Natalia, she's coauthor and she's the main driving force of this study, She first calculated life span for each particular person in months, not years and then we made this analysis.

FROM THE FLOOR: A question also for the same authors. It's well known that there is a marked variation in the relative frequency of birth days between a year. January is a month where there is relatively fewer people born than another month, and as you have shown, people born in January have a higher life expectancy. My question to you is have you made a comparative analysis of the rate of frequency of birth days as opposed to days of life expectancy?

LEONID A. GAVRILOV: Yes, we can do this and we in fact, plan to do this because it makes sense. For example, there might be a period of months of birth caused by extreme seasonality of birth itself, simply because for those who are born prematurely, and may have much poorer survival in later life. Also these individuals will have some kind of seasonality in their appearance. But in any case, it is still interesting to find out. So if we're talking about the possible mechanism, so we observe this effect for sure. Now we are asking why. And we are trying to get funding from the National Institute of Aging for this kind of research and it takes time because of Iraq War they don't have money. So in our proposal, one of the hypothesis is exactly to study this seasonality might be related. Another interesting hypothesis there is a seasonality of infectious diseases in the past, and so you can coordinate with this, different possible mechanism for this. Thank you.

FROM THE FLOOR: In the slides, I think you stated there's a theoretical level limiting values for $\underline{q_x}$ of 0.439 for women and 0.544 for men. Just wondering given the better more comprehensive database that you have now, does it confirm these numbers or are they close together?

LEONID A. GAVRILOV: Well, we hope to find some kind of leveling off, but that's the problem, we just did not find this.

GARY MOONEY: Going back to the birth month, you could convert that into month of conception which would be May or September and May, the mothers heading into the summer months and in September she's heading into the winter months and there's been recent studies showing the importance of vitamin D and so it could be an effect such as that.

LEONID A. GAVRILOV: Yes and if that is true then, there might be great difference in seasonality in United States in northern states and in southern states, because in northern states people are particularly vulnerable for this, so there should be a very high amplitude of this seasonality effects, and also what might be interesting is that if we are lucky to split this ethnicity, then those who have a darker skin color, might be much more effected by this vitamin deficiency, so from the hypothesis, the adult there is some testable predictions that can be done if we have this data.

JEAN-MARIE ROBINE: Leonid, you know that when we observe this deviation from the Gompertz, it is when we're fitting the mortality rate with the Gompertz model between the age of 40 to 85, so much earlier than you did. Some colleagues proposed to fix the mortality rate with two successive Gompertz. The first Gompertz from age 40 to 85, then a similar Gompertz from age 85. So this is creating a kind of "logistic" with a first slope, a second one and why not a third one. It's an important question because it is true that when we are fitting the Gompertz from age 40 to 85, there is a strong deviation after 85, but if we start at 85, the fit is much better. But I agree with you, it is true that if we start even at 90, we are always observing a Gompertz slope which is becoming more and gentle. The basic idea is to start from age 30 or 40 and see from this age if the mortality is doubling every 8 years. So it's not really a question or a comment, it's just to get your feeling on that, because this idea of leveling off was also associated with the fact we were fitting the Gompertz from age 40 to 85 and seeing a deviation from 85. But if you start later, if you start at 90 or 95, of course, somewhere we can say you are already on the plateau. Maybe the plateau is increasing a little bit.

LEONID A. GAVRILOV: Well, if you look for real data, you can see that somewhere after age 95, there is some kind of profound plateau on Swedish data and in many cases, when data from Kannisto and others are used, there are really profound deviation from the Gompertz law. And we expected when we studied mortality after age 90, we expected to see some kind of similar deviation from Gompertz. Here are the real data and, it's not so.

JEAN-MARIE ROBINE: I think what I want to say is on this graph. Here you are fitting the Gompertz from 80 and in fact, most of the fellows are seeing the turning point is around 85. So if you fit before, so if start from age 30, you're fitting line will be much like that. And the division much more important. So this is creating this idea of plateau and I'm not challenging you. I think you're right. There is no plateau. It's always increasing.

NATALIA S. GAVRILOVA: But we started from age 80 and did not see any turning point, and I tried also to use some Social Security data although I could not find the same birth cohort. We found only 1900 is the earliest cohort in Social Security that y also have similar slope. It's not different slope.

Q: Yes, but what I just want to end is the scientific question is trying to explain the deviation we have from the Gompertz usually fitted from 30 or 40 to 85. Not from the Gompertz fitted above age 80, because already some colleagues were saying, if you are not fitting just one Gompertz but two Gompertz, one for young age and one for old age, you will fit perfectly well your data. Two lines is more or less making a logistic projectory.

LEONID A. GRAVILOV: Okay and here is the answer. Look at here at the data. Starting at age 80, you see this wonderful straight line for Gompertz law. So if the hypothesis, which you told is correct, then there will be no deviation between this

Gompertz line and the real data if you start after age 80. Despite this, still you have after age 90, for Swedish life tables, not smooth, not processed, that mortality is lower than predicted by Gompertz law. Even if you make this Gompertz estimate start at age 80, even in this case there is deviation of real data from the Gompertz function, so we expected to find something like that. So we also took extinct birth cohorts, started at age 80 and we expected that the real data should go downwards compared to Gompertz function and that's what we were looking for and to our surprise, we did not find such profound changes that were described in the literature.

JEAN-MARIE ROBINE: Because the profound change described in their literature is compare to a fitted line, not starting at age 80, but starting at age 30 or 40, compared to Gompertz himself seeing the exponential increase is between 30 and 60.

JACOB S. SIEGEL: Just listening to this, I keep thinking, well really, biology doesn't know these numbers by heart. Why isn't there a kind of smooth transition to these different levels rather than a point of sharp juncture? Now the Medicare data clearly, if you look at them from age 85 on, show this deceleration in the mortality rate, but of course, that's an arbitrary decision to pinpoint the data beginning at age 85. You would think, however, that the mortality rate and its rate of increase should have a smooth transition age by age, since as I said, in real life, things don't suddenly reach an age where our body, as it were, sharply changes its direction.