Sections and local group meeting reports.

How long could a human live?

Written by **Gilbert MacKenzie** on March 20th, 2023. Posted in Section and local group meeting reports.

The Northern Ireland local group of the RSS held an online meeting on Wednesday, February 22nd., 2023 at 1 pm (GMT), using MS Teams.

The speaker was Professor Anthony Davison, EPFL, Lausanne, Switzerland

Professor Davison explained that this was an interesting question, in general, and especially among the ultra-rich - note The Palo Alto Longevity Prize of $1m offered in a life science competition dedicated to ending aging. Moreover, the fact that Jeanne Calment, a French woman, lived for 122 years and 164 days, should give us pause for reflection.

The scientific study of longevity is, however, beset by a variety of statistical problems, namely: data, models and extrapolation. Professor Davison dealt with these in turn. On data, the sample was to be *representative*, but he noted that some existing data-bases were opportunity samples with age-biassed ascertainment. Typically, subjects were obtained by “net-casting” individuals above a threshold age - say 100 years (centenarian). Existing data were often unreliable, as some records were over a century old, making validation difficult. The study *observation scheme* chosen might impose censoring and truncation constraints which would have to be accommodated when modelling, but which were sometimes ignored. The effects of these constraints were discussed in general and in relation to the ISTAT and IDL international data-bases on longevity, both of which involved truncation and censoring.

Professor Davison’s model choice was the Generalized Pareto Distribution (GPD) which modelled exceedances above a threshold age, say u. The Survival function is then:

$$Pr[(X-u)/a_u > t | X > u] = \begin{cases} (1+\xi t/\sigma)^{-1/\xi} & (\xi \neq 0) \\ \exp(-\xi t) & (\xi = 0) \end{cases}$$

where , in the latter case, the distribution is Exponential. Interestingly, in the flexible GPD, the limit for X is $u - \sigma/\xi$ when $\xi < 0$, and ∞ when $\xi \geq 0$. Thus, ξ is the target parameter in any analysis of longevity.

Next Professor Davison spent some time developing the likelihood function, which took the complicated pattern of interval censoring and truncation into account, before turning to discuss the world literature between 1980 and 2020. Numerous authors had suggested that the human lifespan must be finite ($\hat{\xi} < 0$), but this conclusion appeared rather dependent on the threshold u chosen. Dutch data plotted $\hat{\xi}$ against u, and showed an increasing trend in $\hat{\xi}$ as u increased over the range 98-108 years. In fact $\hat{\xi}$ became positive when u exceeded 106 years and, although, the confidence intervals were wide, they did not include 0.

Anthony turned to the analysis of the world IDL data-set, the main findings of which in relation to $\hat{\xi}$ are summarised in Table 1. It is clear that positive values cannot excluded. Other results showed that survival for each successive year after age 108 had a probability of 0.5, equivalent to coin tossing. There

Table 1 - Results of fitting the GPD to the 2021 IDL supercentenarian (aged > 110 years) data, by region: estimates of ξ (95% CIs) with p-values for a likelihood ratio test of the null hypothesis of Exponential distribution

Area	$\widehat{\xi}$		p-value
North Europe	-0.03	$(-0.21, 0.16)$	0.55
South Europe	0.05	$(-0.09, 0.18)$	0.46
Europe	0.01	$(-0.08, 0.11)$	0.78
North America	-0.04	$(-0.13, 0.05)$	0.4
World	-0.01	$(-0.08, 0.05)$	0.74

were no differences between: (a) earlier and later birth cohorts, (b) countries, and (c) men and women (except that after age 108 French men have mean survival time of 0.9 years and a coin flip probability of 0.33).

Overall, the analysis with combined data-sets confirms previous work showing: an increasing hazard before age 108 years, when the asymptotic regime seems to start; an Exponential distribution fits above age 108 years and (almost!) no sign of variation in the model beyond that threshold, suggesting that the 95% CI for the human lifespan is roughly $(130, \infty)$.

This was an excellent talk covering a comprehensive amount of material and the audience congratulated Anthony in the usual way. A short discussion ensued. The most striking point was that an Exponential model applied to lifetimes > 108 years. This was rather surprising, as one might have expected heterogeneity from such diverse sources. Professor Davison re-assured the meeting about the finding and agreed that it might imply an genetic explanation.

The Chair thanked the speaker on a very stimulating talk and concluded the meeting by thanking everyone for their attendance and support.

References

Belzile, Davison, Rootz´en and Zholud (2021). Human mortality at extreme age. Royal Society Open Science.

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