Is Life Expectancy of French Women Going to Plateau and Oscillate?

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Abstract

Some authors have hypothesised that life expectancy at birth could reach 100 years in developed countries in the next decades. Using recent data for French women, it is shown that life expectancy changes from 1993 to 2016 are mainly linked to mortality rates of oldest women. In recent years, it happened that life expectancy of French women oscillated, because of for instance influenza epidemics killing mainly oldest frail people. It is hypothesised that in coming years, life expectancy of French women (and one day of men?) will only very slightly increase and will show oscillations because of increased mortality the years of severe influenza, heatwave and other events threatening the life of frail oldest people. This fate could also be that of the other developed countries in the future, which would mean that life expectancy has begun to plateau.

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Life expectancy at birth (e_0) has strongly increased for two centuries. It was for instance ca 33 and 37 years for French men and women, respectively, in 1806 [1], and it is ca 80 and 85 years today. There has been a debate on the limits of life expectancy since Vaupel [2] hypothesised that “half of the babies born in France this year (1996) will reach age 95 and that most of the girls will reach age 100.” At that time, life expectancy was increasing each year in developed countries, except in some cases such as the former Soviet Union after 1965 [3] where it stagnated and even decreased. Since then, it happened that e_0 could stagnate and even decrease in some countries, such as the USA (e.g., [4, 5]) or the UK [6]. For these two countries, it appears that decreases are mainly due to less wealthy people, particularly young and middle-aged ones in the USA because of what has been called the opioid crisis [7], but elderly people have also been hit because of the austerity policy in the UK [8].

In France, e_0 has decreased in recent years, in 2015 for men and in 2003, 2012, and 2015 for women (arrows in Fig. 1), but it does not seem that France (still?) suffers from the British and US issues. Rather, it has been argued that heatwave [9] and influenza [10] could be the culprits, and that elderly people, who are much frailer than young-

er ones, have suffered and died from them. It would mean that, now, e_0 changes in France are mainly explained by mortality rate changes of elderly people. It was not the case in the past century when e_0 quickly and strongly increased because of vaccination, sanitation, medical care, social progress, and so on, which all strongly decreased mortality rates of, particularly, babies, young, and middle-aged people, at a time when elderly people were less numerous than today. Therefore, it could be that, today, the mortality rate changes of younger people are so small that they have only a minor effect on e_0 , while those of the numerous elderly people have a strong impact. If it were the case, and except if mortality rates of elderly people could strongly decrease in the future, the obvious outcome is that e_0 should not increase in coming years and could oscillate because of “bad” and “good” years. In other words, e_0 could have already plateaued in France, in contrast to the Vaupel’s [2] hypothesis (see also [11, 12]). How to test this hypothesis?

Mortality rates and e_0 of French men and women from 1993 to 2016 were extracted from a database (metropolitan France) of the French National Institute for Statistics and Economic Studies (INSEE, https://www.insee.fr/fr/statistiques/fichier/1911933/irsocsd2013_t67_f.xls). 1993 was the first year used in the computations because it was the first year with a very low infant mortality (5‰) and 2016 is the last year for which data are available. Between 1993 and 2016, the infant mortality was similarly low in metropolitan France (ca in the range 3–5‰) and thus was not expected to strongly make e_0 to vary. For each gender and age group, we computed the yearly changes of mortality rates and of e_0 . For instance, a negative value of the mortality rate change of 15- to 19-year-old men from 1993 to 1994 means that mortality rate has decreased in 1994 for this age group. For this age group, the 1993 and 1994 values were, respectively, 0.72 and 0.69‰, and thus the mortality rate change between 1993 and 1994 is $0.69 - 0.72 = -0.03$ ‰. Similarly, a positive value of the e_0 change from 1993 to 1994 means that e_0 has increased in 1994. The 1993 and 1994 values were, respectively, 73.3 and 73.7 years, and thus the e_0 change between 1993 and 1994 is $73.7 - 73.3 = 0.4$ years. To sum up, the mortality rates of 15- to 19-year-old men has decreased in 1994 when compared to 1993, and e_0 has increased. Yearly changes of mortality rates were then correlated with yearly e_0 changes, for each gender and age group (younger than 1 year of age, 1–4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–79, 80–89, 90–110 years of age; the INSEE table pools nonagenarians and centenarians, as

Fig. 1. Life expectancy at birth (e_0) of French men and women, from 1993 to 2016. The arrows indicate the years when e_0 decreased. The 2017 and 2018 data (including Mayotte), displayed for information, are provisional [17] and not involved in the computations. This is why they are not connected to the year 2016 on the graph.

the number of centenarians is rather low: in 2018, there were ca 1 million nonagenarians and less than 25,000 centenarians). This allows to know whether mortality rate changes of each age group were linked to e_0 changes. The table reports the results of correlations for men and women between yearly mortality rate changes and yearly e_0 changes, and Figures 2 and 3 show the regression graphs.

The Case of Men

The mortality rate and e_0 changes were significantly correlated in men older than 40 years, but also at 5–9 years of age (Table 1): when mortality rates decreased, e_0 increased. Even if a Bonferroni correction made that some results were no longer significant, it remains that many age groups explained a part of the variance of yearly e_0 changes. Figure 2 reports the regression graphs for men older than 60 years of age. The graphs show that, for most of the age groups and years, mortality rates decreased and e_0 increased: most of the points in Figure 2 are located in the upper left quadrant. In other words, from 1993 to 2016, e_0 of men increased and the favourable mortality rate chang-

Fig. 2. Regression of yearly e0 changes (years) according to yearly mortality rate changes (‰) for men older than 60 years of age. On each graph, the number near a point indicates the number of ties for this point. The equation is displayed at the top of the graph, and the r^2 are shown in Table 1.

es of many age groups explained this result. Even when mortality rates of oldest men increased, e0 did not decrease, except in one case (in 2015, see Fig. 1).

Thus, because e0 increases during the whole period are linked with decreased mortality rates at various ages, the increased mortality rates of elderly people have only a minor effect on e0 changes. The e0 of men does not appear to plateau because mortality rates at various ages, and not only at old age, dictate e0 changes, and mortality rates at these various ages are still decreasing. One can thus make the hypothesis that e0 of men will still increase in the coming years.

The Case of Women

Mortality rate and e0 changes were significantly correlated only in women older than 65 years (Table 1). Figure 3 shows that, in contrast to men, many mortality rate increases were linked either to no e0 change or to a decrease, particularly in the oldest age group. In other words, from 1993 to 2016, e0 could either stagnate, increase, or decrease, and the mortality rate changes of elderly women mainly explained this result. Thus, while “bad” years did not decrease men’s e0, they could decrease e0 of women. Particularly, as e0 changes are linked

Fig. 3. Regression of yearly e0 changes (years) according to yearly mortality rate changes (‰) for women older than 60 years of age. On each graph, the number near a square indicates the number of

ties for this point. The equation is displayed at the top of the graph and the r^2 are shown in Table 1. The correlation is not significant in the 60–64 age group (see Table 1).

only with mortality rate changes of elderly women, a “bad” year for 90–110 year-old women (Fig. 3) is often linked with an e0 decrease or a stagnation.

To sum up, one can thus make the hypothesis that e0 of women has maybe begun to stagnate and will now oscillate, depending on “bad” and “good” years. Even if a slight increase could be still observed, the main feature of e0 in coming years could be its oscillations rather than its increase, because these oscillations could be of higher importance (e.g., 15,000 extra-deaths of oldest women because of a flu) than the slight increase. A continuous increase in e0 would be only possible if it were possible to protect these

very old and frail women against influenza, heatwave, and other threats, and to discover new means to decrease their mortality rates. This hypothesis appears to be fragile, as it would mean that very old women would no longer be frail.

Conclusions

It has been hypothesised [2, 11, 12] that median lifespan could still strongly increase in developed countries, up to 104 years for both sexes of the 2007 French birth cohort and 107 years for Japan (Table 1 in Christensen et al. [12]).

One could argue that it is too early to falsify this hypothesis, but recent trends in France show that maybe it is possible right now.

Recent e_0 increases in France were mainly due to elderly and not younger people. For instance, 0- to 64-year-old women added 0.27 years to the 1.92-year e_0 increase between 1998 and 2010, while 65- to 110-year-old ones added 1.65 years (see Table 7 in Prioux and Barbieri [13]). However, as there are more and more women reaching very old ages, there is a small chance to strongly increase e_0 because these women are close to the maximal observed lifespan. Indeed, while “saving” a baby can increase his/her lifespan by decades, “saving” a 90-year-old woman can only add a very few years to her life, in the best of the cases. In addition, because these oldest women are very frail, they are at risk to succumb to threats that are not very dangerous for younger people, such as heatwave and influenza [14]. In such conditions, e_0 cannot strongly increase and can oscillate because of “bad” and “good” years. It seems that this is observed in French women, but not yet in men.

Thus, one can hypothesise that the e_0 of French women is now plateauing and oscillating. Because mortality rates of younger women are now very low and no longer linked to e_0 changes contrarily to those of elderly women, one can add that these oscillations are very probable in coming years. One can further hypothesise that these oscillations will not be striking in men while their e_0 is still increasing, because the still decreasing mortality rates in men of various ages could buffer the oscillations of mortality rates of oldest men. Obviously, if it were possible to protect very old women against deadly threats, their mortality rates could still decrease and e_0 increase without such oscillations, even if e_0 does not reach 100 years and more, as hypothesised by Vaupel [2]. Indeed, stagnation of e_0 is not a new phenomenon and, for instance, e_0 stagnated in Sweden during the 1970s [15]. It could thus be argued that we face a new stagnation and that, one day, e_0 will resume its increase. However, the main difference with previous episodes of stagnation is that e_0 has already strongly increased allowing very frail women to live longer: could e_0 still increase up to, say, 95 years, and thus could very frail women survive for many extra-years without succumbing to episodes of heatwave, influenza, and so on? This is perhaps a too strong hypothesis.

The coming years will tell us whether plateauing of e_0 and oscillations will be observed in France, and in other developed countries. If they were observed, it would be the end of the multi-secular trend of the e_0 increase, and the question would be to know whether this is linked to a biological limit [16] or to other causes.

Table 1. Correlation between yearly mortality rate changes at various ages (in years) and yearly e_0 changes: results for men and women from 1993 to 2016 ($n = 23$ years)

Age range	Men r^2 (% of variance explained)	p value	Women r^2 (% of variance explained)	p value
<1	0.0	ns	6.0	ns
1–4	13.7	ns	0.3	ns
5–9	26.0	0.0130	2.0	ns
10–14	11.5	ns	2.8	ns
15–19	14.8	ns	0.5	ns
20–24	14.2	ns	10.9	ns
25–29	0.8	ns	6.4	ns
30–34	6.7	ns	0.3	ns
35–39	17.0	ns	0.2	ns
40–44	27.7	0.0098	6.2	ns
45–49	19.5	0.0347	8.7	ns
50–54	24.3	0.0169	10.9	ns
55–59	43.5	0.0006	17.0	ns
60–64	53.7	<0.0001	9.7	ns
65–69	52.7	<0.0001	40.1	0.0012
70–79	48.4	0.0002	74.7	<0.0001
80–89	46.6	0.0003	66.9	<0.0001
90–110	59.3	<0.0001	81.1	<0.0001

A Bonferroni correction was applied to the results, and the minimal p value ($p = 0.05$) was thus divided by the number of tests (results in bold are significant if $p \leq 0.05/18 = 0.0028$). A sequential Bonferroni correction [18] provided the same results. ns, not significant.

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The author has no conflict of interest to declare.

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