Understanding recent fluctuations in life expectancy: the uneven progress across social groups 2011-2019

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BACKGROUND

In recent years, there has been a noticeable shift in the trends of life expectancy (LE) in several high-income countries [1]. Unlike the consistent gains observed in previous decades, some countries have experienced a slowdown or even a temporary reduction in LE growth, particularly the United States. Numerous factors have been attributed to explain these recent changes, with the larger contribution expected to come from a shift in infra-population inequalities. Another factor to be taken into account when considering reduced gains in LE is that it is subject to fluctuations linked to large-scale seasonal health episodes that have become recurrent since the beginning of the 2000's. Populations face a succession of critical health conditions leading to peaks in the number of deaths. In France, the 2003 heatwave led to a surge in deaths, especially among the elderly (around 15,000 deaths between August 1 and 20, 2003 in France). And the public health monitoring agency (Santé publique France) has estimated the number of deaths attributable to major influenza episodes for France at around 13,000 during the 2015 and 2016-2017 seasons, 11,000 in 2017-2018, 85% of which occurred among the over-75s. Compared with favorable years, free of such episodes, such as 2014 or 2019 in France, more critical years are characterized by a slowdown in life expectancy gains, or even a decline. Relatively low mortality levels in countries like France change the health status of the population. The number of people weakened by chronic diseases, with which they live, is on the rise. Health episodes can aggravate existing diseases, or existing frailties can limit the ability to recover from these new affections.

Several studies show that regular health episodes increase respiratory and circulatory mortality, more pronounced among women and the least advantaged groups. We can therefore assume that these episodes have a different impact on different social groups: groups with relatively high mortality rates have health conditions that make them particularly vulnerable to these affections. At the same time, groups with relatively low levels of mortality are also made up of frail individuals, such as the elderly or, more generally, people with co-morbidities, whom their living conditions have made chronic, and with whom they live longer. Because of their vulnerability, these individuals are also exposed to these shocks, which can hasten death. Moreover, while health crises have an immediate effect in terms of excess mortality, they can also weaken without killing. Some of the most vulnerable people may manage to survive these episodes, but find themselves more weakened as a result, hastening death in the following years that follow. The result is an immediate spike in mortality, of varying magnitude depending on living conditions. There are also delayed effects of two kinds: (1) the harvest effect, which translates into the immediate death of people who would have died in subsequent years, and results in a rebound in life expectancy in the few next years (cleared of those frail people who died during the crisis); (2) a deferral effect, if individuals weakened by the crisis see their life expectancy shortened, leading in this case to a stall in gains in life expectancy in subsequent years.

Understanding these trends in inequalities is crucial to develop effective policy responses that would address unequal needs, as underscored in the Marmot report. It is also crucial to better document general trends and fluctuations in life expectancies in high income countries. However, despite the policy relevance of the topic and of these studies, they remain too scarce to appropriately monitor trends in mortality differentials. Based on this observation, we propose to measure changes in life expectancy in different social groups, in order to shed light on how these mortality crises are reflected in life expectancy. We have mobilized population-based data that match census variables and vital status, to measure life expectancy by social status and gender on a regular basis, over the decade 2010.

DATA AND METHOD

Dataset: In France, a sample drawn from census files called "permanent demographic sample" (EDP), has been linked to vital statistics since 1968. Although relatively large, representing 1% of the whole French population from 1968 to 2008 and 4% since 2008, the size of this sample requires the use of both models and wide time windows to compute LE by SES. Previous studies using this dataset have disclosed significant LE differentials in France, positioning the country among high-income nations with the widest gaps in LE. Using occupational class (OC) as SES indicator, the most recent estimates for the period 2009-13 disclose a gap of 6.4 years between manual workers and those in higher positions for men (3.2 years for women). These disparities have persisted steadily since the 1970s. While these studies provide valuable long-term comparisons spanning decades, they rely on averaged estimations derived from large time windows. We leverage on changes in the data structure to estimate routine life tables on reduced time windows, and using as much as possible the observation, using non-parametric models. At this stage, the data stops in the year 2019.

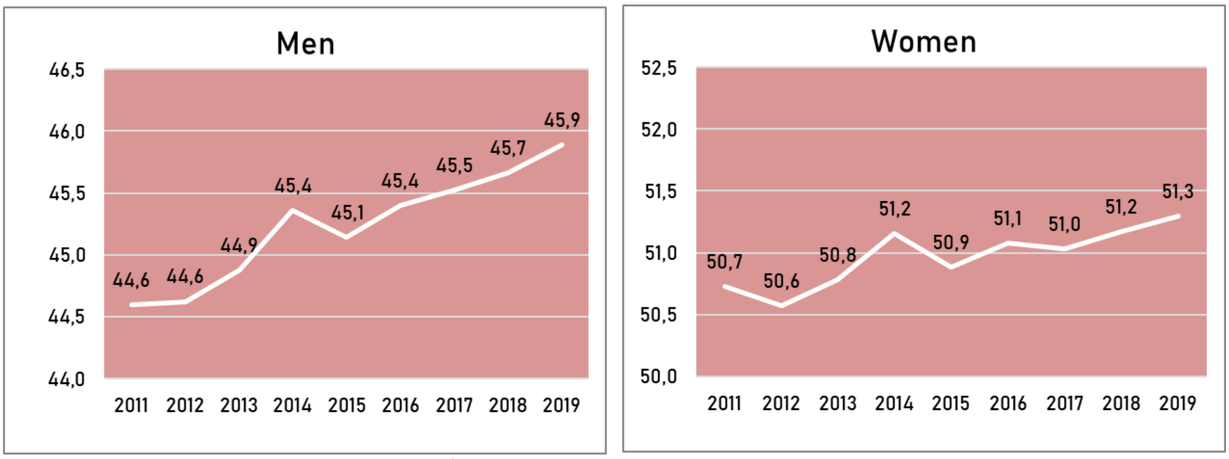
Occupational groups : As traditionally done in the public statistics in France, we use occupational classification to stratify the population into 5 social groups (similar as ESCO classification). Individuals are classified according to their current occupation for employed and unemployed individuals or last occupation for retired individuals: (1) higher-level occupations, including managers and higher-level intellectual positions; (2) self-employed workers, such as craftsmen, farmers, shopkeepers, and business owners; (3) intermediate occupations, including mid-level managers, school teachers, and foremen; (4) skilled and unskilled clerical and sales workers; (5) skilled and unskilled manual workers. It is noteworthy that individuals who reported being inactive at census (meaning not employed, unemployed nor retired) did not report their previous occupation, until 2016 ACSs. If we included them in the overall sample for estimating the whole population's LE, unfortunately, we could not include them in their previous OC (as we did for retired). Females were more commonly found in this situation compared to males (10% vs. 4%); we checked the impact for the final estimates of ignoring the currently inactive members of the OCs. Using recent ACSs providing information on the previous OC, we find that the reintegration of the inactive slightly decreases the LE_{35} in all OCs due to their higher mortality risks. However, because of their low proportion in the OCs (figures on request), changes are not statistically significant, except for male manual workers. Here we concentrate on OCs 1 an 5 which are both ends of the mortality gradient.

Estimation of age*OC specific mortality rates and life expectancy : We used triennial estimates to optimize the size of the sample: around 1,130,000 men and women of whom around 45,000 died, for each of the 6 later 3-year period. For the most recent period, once stratified by sex and OCs, the smallest group is composed of 52,603 individuals and 4,019 deaths. While triennial estimates are robust with these numbers it is noteworthy that the annual estimates are much less stable: in some age, sex and occupational class, there was too few or no death. In this study, we have adopted an approach that makes use of all the available data information and, concurrently, produces smooth age-patterns without enforcing any rigid structure in the estimated patterns. Specifically, we use *P*-splines as an appropriate statistical method for smoothing mortality data. They offer a flexible framework capable of eliminating random fluctuations and noise while retaining significant underlying characteristics. Further- more, they automatically adapt the level of smoothing according to the available data and they can easily deal with small populations. Additionally, *P-splines* can be extended to incorporate additional demographic information through specialized penalties: we added a monotonic increase of mortality with age, one notable benefit of this method is that it exerts its influence only when the monotonic constraint is breached, preserving the smoothness of the estimated mortality age-pattern.

PRELIMINARY RESULTS

LE_{35} of the overall male and female populations are marked by a stalling period in 2011-2012 in men and a slight decrease in female subsequent to a combination of critical health episodes over this year (Figure 1).

Figure 1. Life expectancy at age 35 in men and women, France 2011-2019



Source: EDP. Estimations by the authors

It was followed by resumed gains, more pronounced in men, until the new year of excess mortality in 2015. The following episode occurred in 2017. Triennial estimates showed the largest disparities in male LE_{35} between higher-level occupations and manual workers classes, with a 5.7-year gap in 2017-19 (Table 1). This gap is narrowing from 2011-13, primarily driven by a significant increase for manual workers (from 42.8 to 44 years) and a less pronounced (non-significant) increase for higher-level occupations (from 49 to 49.7 years). For women, the difference in LE_{35} between extreme OCs is smaller compared to men (3.4). However, this gap is on the rise: LE has stalled in unkilled workers (49.7 to 49.9) and has (nearly significantly) increased in higher-level occupations, after 2014-2016. For manual workers, LE_{35} is stalling around 2015. It is worth noting that women consistently have a higher LE_{35} than men, however we found an overlap of LE_{35} in male higher-qualified occupations and female manual workers.

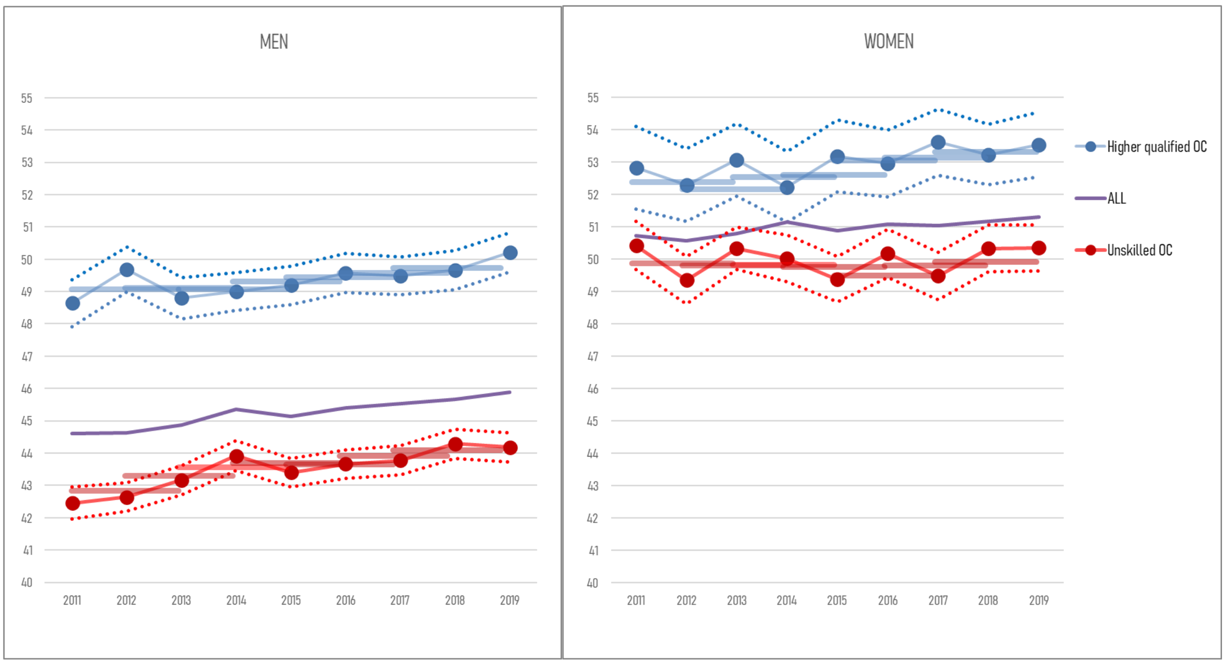
Table 1. Triennial life expectancy at age 35 in higher qualified and unskilled occupational classes Men and women, France 2011-2019

	MEN			WOMEN		
	Higher qualified OC	Unskilled OC	Gap	Higher qualified OC	Unskilled OC	Gap
2011-2013	49.0 [48.6-49.4]	42.8 [42.5-43.0]	6.3	52.4 [51.7-53.0]	49.9 [49.4-50.3]	2.5
2012-2014	49.1 [48.7-49.4]	43.2 [43.0-43.5]	5.8	52.2 [51.6-52.8]	49.8 [49.4-50.2]	2.4
2013-2015	49.0 [48.7-49.4]	43.5 [43.2-43.8]	5.5	52.5 [51.9-53.2]	49.8 [49.4-50.2]	2.7
2014-2016	49.3 [48.9-49.6]	43.6 [43.4-43.9]	5.6	52.6 [52.0-53.2]	49.7 [49.3-50.2]	2.9
2015-2017	49.4 [49.1-49.7]	43.6 [43.3-43.8]	5.8	53.1 [52.5-53.6]	49.5 [49.0-49.9]	3.6
2016-2018	49.5 [49.2-49.9]	43.9 [43.6-44.1]	5.7	53.1 [52.6-53.7]	49.8 [49.4-50.2]	3.3
2017-2019	49.7 [49.3-50.0]	44.0 [43.8-44.3]	5.7	53.3 [52.8-53.9]	49.9 [49.5-50.3]	3.4
Trends	+0.7	+0.9*	↘	+1.3*	+0.1	↗

Source: EDP. Estimations by the authors

The annual estimates ofLE_{35}.disclose fluctuations over the 2010, and within the three-year periods. The stalling LE found in male unskilled OC around the 2012 episode reflect a slowdown in the LE gains, which was followed by accelerated progress until 2014. In the meantime, LE in male high qualified OC has increased, before getting down in 2013. The 2015 episode limited the progress in higher qualified OC, and induced a loss in unskilled OC; the latter resumed gains in 2018, while the former benefitted more from the 2019 conditions. In women, the 2012 excess mortality has affected both higher qualified and unskilled OCs; both OCs was higher in 2013, but not so much in 2014. This suggests the harvesting effect. The 2015 conditions affected unskilled OC meanwhile higher qualified OC benefited LE gains, with small decelerations until 2019.

Figure 2. Annual (and triennial) life expectancy at age 35 in higher qualified and unskilled occupational classes Men and women, France 2011-2019



Source: EDP. Estimations by the authors

DISCUSSION

This research confirms a moderate increase in LE_{35} over the period for both genders and fluctuations: with excess mortality in 2012, 2015 and 2017. It further shows that this increase results from diverging trends across OCs. In men, LE_{35} in higher-level occupations stalls, meanwhile manual workers experienced a 1.2 year gain, closing the gap (+5.7 years in 2017-19). Except in self-employed workers, LE stalls in the other male OCs. By contrast, inequalities are on the rise for women due an inverted pattern compared to men: LE in female higher-level occupations increases in the second half of the period, meanwhile manual workers' LE_{35} stall; the widening gap reached 3.4 years in 2017-19.

Interestingly, annual estimates show different dynamics according to the OC and sex. Women underwent LE losses in 2012 in both OCs while men were not substantially affected, or even underwent a gain in LE that precise year. In 2015, the mortality peak concentrated in unskilled occupations, and more women than in men. The fluctuations that follow mortality peaks differ across OCs and sexes. They suggest harvesting effect when the peak is high. They further suggest a counter tempo in high qualified occupation: this could be explained by a weaking effect resulting in a postponed "harvesting" effect in the most advantaged group. More research is needed but the evidence of OC specific dynamics around the health episode in an important aspect to adapt prevention and care in the contemporary context.

Next steps: improving description of the mortality peaks in France with weekly counts; updating with 2020 data to include COVID-19 experience; documenting change in causes of death.

SELECTION OF REFERENCES

Alexander MJ, Kiang MV, Barbieri M. Trends in Black and White Opioid Mortality in the United States, 1979-2015. Epidemiology. 2018 Sep;29(5):707-715

Blanpain, N. Les hommes cadres vivent toujours 6 ans de plus que les hommes ouvriers. INSEE Première, nº 1584 (2016): 1-4.

Bosworth, B. Increasing Disparities in Mortality by Socioeconomic Status. Annual Review of Public Health 39, nº 1 (1 avril 2018): 237-51.

Camarda CG. MortalitySmooth: An R Package for Smoothing Poisson Counts with P -Splines. Journal of Statistical Software. 2012;50:1-24.

Camarda CG. Smooth Constrained Mortality Forecasting. Demographic Research. 2019;41(38):1091-130.

Case, A., Deaton, A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. Proceedings of the National Academy of Sciences, 2015; 2015112(49), 15078-83.

Chetty R, Stepner M, Abraham S, Lin S, Scuderi B, Turner N, et al. The Association Between Income and Life Expectancy in the United States, 2001-2014. JAMA. 2016 Apr;315(16):1750.

de Gelder R, Menvielle G, Costa G, Kovacs K, Martikainen P, Strand BH, et al. Long-term trends of inequalities in mortality in 6 European countries. Int J Public Health. 2017 Jan;62(1):127-41.

Harper S, Riddell CA, King NB. Declining Life Expectancy in the United States: Missing the Trees for the Forest. Annu Rev Public Health. 2021 Apr;42(1):381-403.

Khieu TQT, Pierse N, et al.. Modelled seasonal influenza mortality shows marked differences in risk by age, sex, ethnicity and socioe conomic position in New Zealand. Journal of Infection. 2017 Sep;75(3):225-33.

Leclerc A, Chastang JF, Menvielle G, Luce D. Socioeconomic inequalities in premature mortality in France: Have they widened in recent decades? SSM. 2006 Apr;62(8):2035-45.

Leon DA, Jdanov DA, Shkolnikov VM. Trends in life expectancy and age-specific mortality in England and Wales, 1970–2016, in comparison with a set of 22 high-income countries: an analysis of vital statistics data. The Lancet Public Health. 2019;4(11):e575-82.

Long D, Mackenbach JP, Klokgieters S, Kale˙diene˙ R, Deboosere P, Martikainen P, et al. Widening educational inequalities in mortality in more recent birth cohorts: a study of 14 European countries. J Epidemiol Community Health. 2023 Jun;77(6):400-8.

Mackenbach JP, Rubio Valverde J, Bopp M, Brønnum-Hansen H, Costa G, Deboosere P, et al. Progress against inequalities in mortality: register-based study of 15 European countries between 1990 and 2015. Eur J Epidemiol. 2019 Dec;34(12):1131-42.

Marmot M, Allen J, Bell R, Bloomer E, Goldblatt P. WHO European review of social deter-minants of health and the health divide. The Lancet. 2012 Sep;380(9846):1011-29.

Montez JK, Zajacova A, Hayward MD, Woolf SH, Chapman D, Beckfield J. Educational Disparities in Adult Mortality Across U.S. States: How Do They Differ, and Have They Changed Since the Mid-1980s? Demography. 2019 Apr;56(2):621-44..

Renard F, Gadeyne S, Devleesschauwer B, Tafforeau J, Deboosere P. Trends in educational inequalities in premature mortality in Belgium between the 1990s and the 2000s: the contri- bution of specific causes of deaths. J Epidemiol Community Health. 2017 Apr;71(4):371-80.

Saurel-Cubizolles MJ, Chastang JF, Menvielle G, Leclerc A, Luce D. Social inequalities in mortality by cause among men and women in France. Journal of Epidemiology Community Health. 2009;63(3):197-202.

Toulemon, L., et M. Barbieri. « The Mortality Impact of the August 2003 Heat Wave in France: Investigating the "harvesting" Effect and Other Long-Term Consequences ». Population Studies 62, no 1 (mars 2008): 39 53

van Raalte AA, Kunst AE, Deboosere P, Leinsalu M, Lundberg O, Martikainen P, et al. More variation in lifespan in lower educated groups: evidence from 10 European countries. International Journal of Epidemiology. 2011 Dec;40(6):1703-14.