Select Birth Cohorts

by Richard MacMinn[†] (Illinois State University)

and Frederik Weber[‡] (Ludwig-Maximilians-Universität Munich)

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Abstract

Worldwide demographic changes and their implications for governments, corporations, and individuals have been in the focus of public interest for quite some time due to the fiscal risk related to adequate retirement benefits. Through a more detailed analysis of mortality data an additional type of risk can be identified: differences in mortality improvements by birth year, also known as "cohort effects."

Previous contributions have, however, not formalized a suitable measure to further investigate mortality improvements but rather relied on graphical representations without particular focus on individual cohorts but groups of the overall population. No criterion to identify single birth year cohorts as select has been established. A simple criterion for identifying select cohorts is proposed and used here to what country mortality data reveals about the mortality and longevity experience of cohorts. Select cohorts are rare but can be quite different from surrounding cohorts and so may generate financial risks that need to be hedged naturally or artificially with new ART instruments.

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[†] Richard MacMinn, Ph.D. and the Edmondson-Miller-Chair in Insurance and Financial Services at the Katie School of Insurance, College of Business, Illinois State University, Normal, Illinois 61790-5480, USA. richard.macminn@ilstu.edu.

[‡] Frederik Weber, M.Sc. is a graduate research assistant and Ph.D. student at the Institute for Risk and Insurance Management, Munich School of Management, Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 Munich, Germany. fweber@bwl.lmu.de. Corresponding author.

1. Introduction

The 20th century has proven to be an era with far-reaching and dramatic changes to societies all around the world. While demography represents only one aspect of these transitions, it may yet have a enduring effect on mankind and societal structures. A common observation for people all over the world born during the last century is their tremendous increase in life expectancies.[1] Alternatively, people have generally lived longer, healthier lives and have been less exposed to mortality risk than most older generations. Wilmoth (Wilmoth 1998) illustrates both the increase in the life expectancy at birth and the reduction in the death rate over the past century in the United States. The former effect has become known as the "longevity trend," and the latter has been termed "mortality improvement."

Before and just after the turn of the twentieth century primarily younger ages had benefited from mortality improvements, i.e. perinatal and youth mortality had sharply declined, but thereafter it has been the older generations that have benefited most from declining mortality rates. This has been shown for the United Kingdom by Gallop (2006), but similar observations can also be made for most other developed countries. Some of the reasons for this shift may have been the introduction and large-scale diffusion of hygienic standards, medication, as well as pre- and postnatal medical procedures by the beginning of the 19th century, but most demographers and epidemiologists believe that the potential for further mortality reductions is waning. Instead there seems to be agreement that the largest gains not only in longer lives but also healthier lives will be due to the increasing effectiveness of diagnoses and treatments related to medical conditions pertaining to older ages, such as cardiovascular diseases, carcinomas, and mental disorders such as Parkinson's disease. The shift in longevity improvement from younger to older ages has also been referred to as "*the ageing of mortality improvement*"; see e.g. Willets et al. (2004).

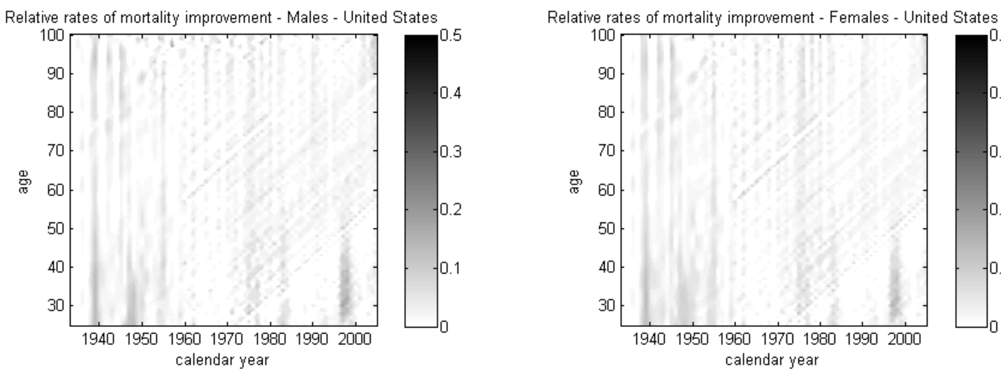
It is uncontroversial that mortality rate reductions represent a significant achievement for public health and social policy. However, the improvements are also a source of fiscal risk for both governments and corporations providing retirement benefits and have in fact already forced some of them to reduce their exposure to this particular risk by, e.g., changing pension schemes from defined benefits to defined contributions, by reducing benefits, or simply by more conservative pricing through the inclusion of loadings for "longevity uncertainty". Furthermore, the reduced supply of old-age provision effectively increases an individual's risk of inadequate retirement funding as providers may not completely insure the individual's longevity risk. Savings or other financial provisions may thus turn out to be insufficient, if they are not already underestimated due to a biased mortality perception. Therefore, not only providers but also individuals are more than ever forced to account for these trends.

Longevity improvements are of great interest for public policymakers and for private insurers, and most governments worldwide are, to a greater or lesser degree, involved in provision of retirement benefits for their citizens. The cost of those benefits can be greatly affected, and in fact already have been, by increasing longevity. Insurance companies offering pensions and annuities typically respond to such a challenge by conservative pricing. Democratic governments generally do not have the option of not offering retirement support of any kind or of drastically reducing its levels. Thus it is to their benefit if estimates of the cost of pension provision can be made accurately and if long-term problems can be diagnosed early.

[1] See for instance Gallop (2006, p.2) or Wilmoth (1998).

The longevity trend, which has well received some attention in the scholarly literature and also in the general public, implies that subsequent generations generally live longer than previous ones. Actually, another type of risk is revealed only when analyzing mortality experience in more detail. Instead of more common mortality rates, Figure 1 shows percentage mortality changes from one birth cohort to another for males and females in the United States.[2] Ages from 25 to 100 are plotted on the vertical axis while the horizontal axis represents calendar years from 1933 to 2005, i.e. points in time.

Figure 1 – Relative changes of central death rates – Males (left) and Females (right) – United States



Source: authors' calculation, based on data from HMD (2008)

Apart from vertical patterns dominating the left halves of both plots, diagonal patterns can also be identified – especially in the right halves. Since these are paths that are followed by single birth cohorts, there are obviously some characterized by especially strong improvements in mortality or longevity. Willets (1999) calls this the "cohort effect," describing it as a "wave of rapid improvements, rippling upwards through mortality rates in the United Kingdom."

From Figure 1 it is evident that the longevity trend has not been a smooth, uniform transition affecting all ages equally at the same time, but different generations or single birth year cohorts have obviously experienced quite different patterns of mortality improvement. While few generations have been unfortunate enough to experience an increased mortality some were benefiting (much) stronger than other cohorts and those have been called "select birth cohorts" (Willets, 1999;2004). The implication is that when a select birth cohort reaches retirement, this cohort's lower mortality will be quite a shock to the retirement system, and Willets (1999) documents such a phenomenon for the generation born in Great Britain in the 1930s, with emphasis on 1931. Members of this generation are now in their late 70s, and if they continue experiencing the same mortality improvements that they did at younger ages, they will be a strong example of the nature of this problem. However, the actual structure of and correlations among single cohorts in various countries and their impact on the prices of retirement instruments remain largely unexplored.

A potentially dramatic fiscal impact and very little existing research on inter-generational fluctuations of longevity trends emphasize the need for an analysis of a single cohort's relationship to overall mortality improvements. More than ever, knowledge of the driving forces, methods for a timely identification of such cohorts, and an adequate appraisal of the financial risk for both individuals and institutions engaging in old age provision is required. The purpose of this study is to reinforce awareness of the

[2] Note that only positive values are plotted in grey shades, the darker spots indicating stronger improvements.

existence of select birth cohorts as well as their respective magnitudes. In particular, this paper attempts to present a suitable measure to capture these fluctuations and, this done, a criterion for identification of "select" cohorts.

The remainder of this paper is organized as follows: the next section notes the appearance of the notion of a cohort effect in the literature. In section three a suitable measure for mortality improvements is presented and a formal criterion for the distinction of select cohorts is introduced. Based on these formal definitions actually experienced mortality data is then analyzed in section four with respect to existence, strength and early identification of identified select birth cohorts. We close with concluding remarks on our findings.

2. The Literature on Cohort Effects

While it may seem straightforward to arrange longitudinal data, i.e. time series, on mortality experience in a two-dimensional fashion, it is less obvious which of the three linearly interdependent coordinates age, period (calendar year), and cohort (birth year) are to be used as axes. The first reorganization of time series data on age-specific mortality rates in a manner that allowed one to distinguish rates pertaining to persons born in the same year was probably due to Derrick (Derrick 1927). Based on a graphical examination of the data, Derrick effectively argued that cohort rates provided a more consistent basis for projecting mortality than period rates. Subsequently, Kermack, McKendrick, and McKinlay (Kermack, McKendrick et al., 1934) provided a convincing demonstration of the power of the cohort method. "They … noted 'a general tendency for numbers of approximately the same magnitude to be arranged diagonally in the Tables … it is now to be noted that a diagonal line in the diagram represents the course of a group of people all born in a particular year'" (Hobcraft, Menken et al. 1982) p. 16.

Despite the early work by Derrick and then by Kermack, et al. (Kermack, McKendrick et al. 1934), mortality data has historically been examined rather in the context of an age-period-cohort model without any particular focus on birth cohorts. However, the notion of a cohort is certainly conceptually important if one believes that mortality-improving advances, e.g., social and genetic changes, that occur at one point in the time continuum have different impacts on different age groups and that those impacts may persist and evolve in different ways. Therefore we follow Ryder (Ryder 1965) who captures this nicely by saying:

> ". . . transformations of the social world modify people of different ages in different ways; the effects of these transformations are persistent. In this way a cohort meaning is implanted in the age-time specification. Two broad orientations for theory and research flow from this position: first, the study of intra-cohort temporal development throughout the life cycle; second, the study of comparative cohort careers, i.e., inter-cohort temporal differentiation in the various parameters that may be used to characterize these aggregate histories." (Ryder, p. 861)

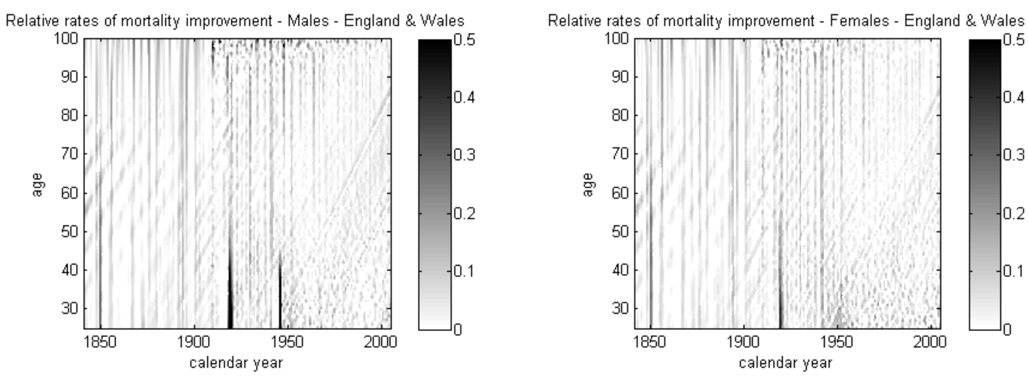
Hobcraft (Hobcraft, Menken et al. 1982), also motivate the cohort notion:

> "Cohort effects occur whenever the past history of individuals exerts an influence on their current behaviour in a way that is not fully captured by an age variable. If only events that occur prior to the initial observation influence cohort behaviour, then the linear model is appropriate. However, cohorts are continuously exposed to influences that affect their biological susceptibilities and social propensities. Obvious examples are wars and epidemics that may break

> out in the middle of a cohort's life and leave an imprint on all subsequent behaviour. If these disturbances affect all cohorts then alive in similar fashion, they can best be treated in the form of lagged period effects. But if, as seems more likely, their imprint is differentiated by age and becomes embodied in cohorts differentially, then a more complex form of cohort analysis is required." (Hobcraft, Menken et al., pp. 10-11)

The graphical representation of mortality data in the spirit of Figure 1 has also been a very common method of display for cohort effects. In contrast to period effects, which relate to influences of a particular point in time, they refer to an "effect of year of birth"[3] of a single generation or a group of persons born during approximately the same time. While both period effects and cohort effects seem to exist for the population in the United States, it is not clear which prevail. For the United Kingdom, Richards (Richards, Kirkby et al. 2006) have demonstrated that an age-cohort model is able to better explain actual mortality experience over the past 40 years than an alternative age-time model. Similar to Figure 1, Figure 2 shows relative mortality improvements for England and Wales and seems to support their conclusion, thus being in line with Willets' (Willets 1999) observation that for the past four decades, people born between 1925 and 1945 have benefited from stronger mortality improvements than those born in adjacent generations.

Figure 2 – Relative changes of central death rates – Males (left) and Females (right) – England and Wales



Source: authors' calculation, based on data from HMD (2008)

While reasons for such effects are less obvious, Willets (Willets 2004) among very few suggests that single cohorts being or being not involved in hostilities during World War I or II, the introduction of vaccinations as well as changes in nutrition quality especially for newborn may have sustaining effects on only very few birth cohorts. For the United Kingdom he notes that drastic changes in smoking prevalence might have been the key driving factor for the identified cohort effect; see Willets (1999). Furthermore, medical research indicates that experience early in life or even *in utero* may be dominant for health and longevity during an individual's course of life. In Figure 1 and especially Figure 2 cohort effects, i.e. diagonal patterns, appear quite frequently but are not so common for the earliest observations. Obviously, several male cohorts in the United States born around 1909, 1920, and especially during the mid-1940s seem to have experienced pronounced improvements; the darker shades depict those cases.

Apart from identifying potential causes and drivers of inter-cohort mortality changes, Willets (2004) tabularizes relative mortality improvement rates for ages 30 to 84 in calendar years 1965-1997 for

[3] See Willets et al. (2004, p.21).

England and Wales and for ages 40 to 100 in calendar years 1950-1999 for Japan, omitting values not in excess of a certain threshold. The resulting graphical pattern is the motivation for his notion of a "cohort effect" for those born in the 1930s in England and Wales. Note that instead of taking raw mortality data, he proposes using smoothed central death rates for the calculation of mortality improvement, and we shall briefly explain this methodology.

The Gompertz Law, i.e., $\ln\mu(x) = x\ln c + \ln B$ so that $\mu(x) = Bc^x$, (see (Bowers, Gerber et al. 1997)) is a common assumption for a parametric mortality model, and it effectively means that the log of the force of mortality is a linear function of age *x*. Since the central death rate can serve as an estimator of the force of mortality (Bowers, Gerber et al. 1997), Willets (2004) assumes such a log-linear relation for a smoothing procedure to aggregate populations across birth years in his investigation of the cohort effect.

Although the combined effect of unusually high mortality improvement over a group of birth cohorts can be investigated, the underlying perspective must be that of a public pension system where it is not a single cohort experiencing accelerated mortality improvements but rather the joint impact of such fluctuations at a given point in time. Consequently, by comparing different cohorts Willets (2004) considers different ages, and this is a concept we critically question in the next section.

3. Identifying Select Cohorts

While select cohorts have not been receiving as much attention in the scholarly discussion as could be expected given their potential financial impact, the establishment of a formal criterion has been almost entirely neglected so far. MacMinn et al. (MacMinn, Ostaszewski et al. 2004) have suggested a number of criteria for identifying select birth cohorts, based on different measures related to mortality experience, and they also showed for a large selection of countries that those measures did in fact not always coincide and no single criterion was able to integrate their observations. Thus, ambiguity persists and one objective of this paper is to provide insight of how such a criterion could be established to allow for additional investigations.

In this section we first describe the mortality improvement measure that we derive from standard mortality data to adequately capture the nature of the unevenness in the longevity trend. Subsequently a formal definition of a "select cohort" based on that particular improvement measure will be established such that from a given set of data for an arbitrary population, "select" cohorts can be identified, and such results will be presented in the following section.

As previous investigations of mortality improvement have all been based on either central death rates m_x, death probabilities q_x, or forces of mortality μ_x,[4] we follow MacMinn et al. (2004) and resort to the former measure. Let ${}^{z}m_{x}$ denote the central death rate for the cohort born in year *z* that is currently age *x*; the left superscript is a notation we introduce for the year of birth of the cohort. Then the difference in mortality of cohort *z* versus the previous cohort *z* – 1 could be measured as ${}^{z}m_{x} - {}^{z-1}m_{x}$. However, previous work (cf. e.g. Richards et al., 2006) has not relied on these absolute rates but rather on relative rates of improvement. We thus define the relative mortality improvement rate at age *x* for the generation born in *z* here as

[4] See e.g. Bowers et al. (1997) for a definition of these actuarial measures, the underlying models, and their interrelationship.

$$ {}^{z}i_x = -\left(\frac{{}^{z}m_x - {}^{z-1}m_x}{{}^{z-1}m_x} \right) = 1 - \frac{{}^{z}m_x}{{}^{z-1}m_x} $$

i.e., this measure captures the reduction of the central death rate of the cohort born in year *z*, ${}^{z}m_x$, relative to that of the previously born cohort at the same age *x*. Note, that this ratio is taken as a negative value in order to have mortality improvements (i.e., decreasing mortality rates) represented as positive values ${}^{z}i_x$.

This measure does not yet indicate a natural criterion for when a particular birth cohort is to be considered *select*, and there has been only limited effort to formally define one. As a general rule, positive improvement rates are to be expected, although it is quite unlikely that a cohort experiences positive values of ${}^{z}i_x$ for all individual ages $x = 0,\ldots,\omega$. Some cohorts might even experience increments of mortality rates at some ages, i.e. mortality deteriorations compared to the cohort born before, but this is rather seldom.

As an alternative to Willets' (2004) approach of showing tabularized values where the threshold for each calendar year was determined as a fraction of the maximum ***across ages***, one could consider a comparison of values at a specific age *x* by only showing improvement rates in excess of a threshold based on values for all years. This would also compare different cohorts, but at a ***fixed*** age, which is more closely related to the definition of relative mortality improvement (recall that for each specific age it compares the mortality improvement with the corresponding value for the adjacent cohort). When applying the alternative "fixed age" criterion to "smoothed" data like that used by Willets, the result is quite different from the one obtained by him: there is no significant evidence of select birth cohorts any more.

Another idea that we pursued was to "narrow" the smoothing period, i.e., we performed a log-linear regression not to periods of ± 4 years as Willets (2004) did, but instead narrowed the period to either ± 2 years or ±1 year. A further narrowing would of course result in not smoothing at all but taking the original mortality rates. We determined that by gradually narrowing the smoothing period, the cohort patterns apparent in Willets' tables are becoming weaker and eventually disappear. The fact that smoothing raw mortality data over a range of 3, 5, or even 9 years seems to conceal certain patterns of a cohort effect is a strong argument to abstain from any sort of smoothing and instead rely on raw data. Indeed, Gallop (Gallop 2006) admits that "the smoothing process chosen, i.e., by Willets, has some effect on the resulting patterns of mortality improvement"[5] but also notes that even without smoothing procedures, cohort effect patterns for the UK and other countries could be identified. Nonetheless, it has to be admitted that aggregating the data may be appropriate for public policymakers, who often deal with the population as a whole, and may be able to smooth out some intergenerational effect through issuance of public debt.

For the purpose of risk management by the private sector and through possible market instruments trading mortality risk, we believe it is necessary to investigate mortality improvement more directly, cohort by cohort. Because if a single cohort does not only exhibit higher improvement rates than the previous cohort, but at the same time also exceeds the respective value of the *subsequent* cohort for a given age, and if this is the case not only for one single year of age but applies to numerous individual ages, then this particular cohort should be of even greater interest and subject to a closer investigation.

[5] See p.9 in Gallop 2006.

Therefore, we chose the paradigm of unsmoothed data also in order to be able to identify single birth year cohorts as select.

Of course, not all ages *x = 0,…,ω* are of particular interest when it comes to the potential financial impact of a select cohort in terms of retirement costs, so that especially the youngest ages may be neglected. We therefore suggest that the generation or cohort born in year *z* be a select birth cohort if for at least *k* percent of ages x = 25, … , 100 the respective mortality improvement rates ${}^{z}i_x$ exceed those of the two adjacent cohorts born in z - 1 and z + 1, respectively.[6] Equivalently but more formally expressed, for the cohort born in year *z* to be considered select, we require that

$$ {}^{z}i_x > \max\left\{ {}^{z-1}i_x , {}^{z+1}i_x \right\} $$

for *k* percent of the ages *x* = 25, … , 100.[7] While the choice of the threshold parameter *k* might be debatable we consider a value of *k=0.50 or 50%* as straightforward and use it in this analysis.

Admittedly, there is no straightforward justification for the established criterion and it is also a form of a local definition (with respect to age), and one could of course study more global measures, such as comparing relative mortality improvements for each cohort at each age with the respective, say, 90th percentile for that age (across all cohorts), see e.g. MacMinn et al. (2005). Previous works of Willets (1999, 2004) or other authors have not provided any specific definition at all and relied exclusively on graphical presentations – merely to indicate the existence of a cohort effect for the UK and Japan rather than to identify single birth years as select cohorts – so that we consider our approach a first step towards a formal definition. Also, our criterion proves to be able to capture even very subtle inter-generational changes of mortality at any given age: both a pattern, where a cohort's mortality is lower than that of neighboring cohorts, and an unusual strong reduction of mortality among a series of such decrements will be captured – if only the subsequent reduction is less intense.

4. The Fortunate Generations – Analysis of Historical Data

To apply the select cohort measure for mortality improvement and identify select cohorts, we use data from the Human Mortality Database (HMD).[8] Although the HMD collects continuously enlarged sets of mortality data, separated by gender and combined, for a wide variety of countries worldwide, the long-term nature of annuity products in addition to the fact that those products are related to the *later* ages in life requires a relatively large number of years to be covered by a data set. Thus, only a relatively small number of countries included in the HMD have proven to be suitable for the present analysis. Due to the large potential fiscal effects of the retiring baby-boomer generations, we also investigated data from the United States despite the paucity of data. A preliminary stage of the subsequent analysis with further results can be found in (MacMinn, Ostaszewski et al. 2004).

[6] Note that lack of observed data may prevent comparisons between cohorts for all ages. We also abstain from identifying cohorts as "select" if comparisons between cohorts are possible only at less than 10 years of age.

[7] By discarding young ages below 25 we neglect infant, childhood, and teenage mortality (or changes therein) which might be subject to instantaneous influences. For ages beyond 100 data is usually only very sparse rendering potential conclusions quite vague. We have refrained from drawing conclusions when the data is too sparse.

[8] The HMD is an online collection of data assembled jointly by the University of California at Berkeley and by the Max Planck Institute for Demographic Research in Rostock, Germany (http://www.mortality.org/)

Our findings of select birth cohorts in eleven countries are given by country and year in in the appendix for males, females and both sexes combined, respectively, identified by their respective year of birth. The North American select birth cohorts are also listed in Table 1a. Canada and the United States have approximately the same number of male select birth cohorts while the United States has considerably more female select birth cohorts. The male select birth cohorts coincided in 1902, 1919, 1929 and 1948 while the female select birth cohorts coincided in 1902, 1912, 1934, and 1944.

Table 1a: North American Select Birth Cohorts

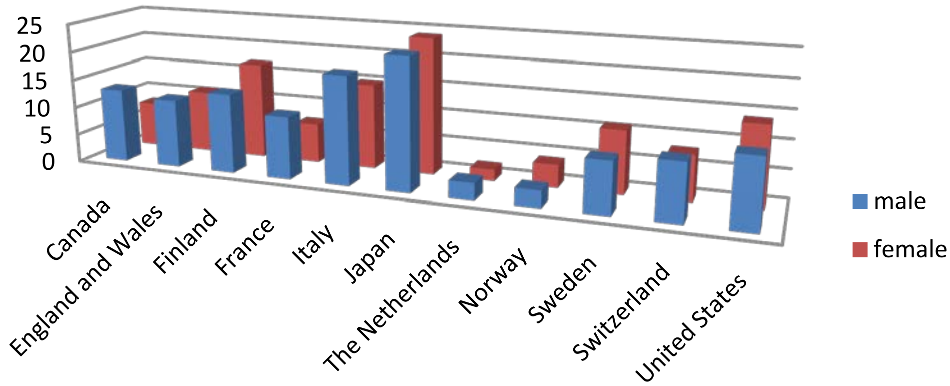
Canada			United States		
M	F	B	M	F	B
1831	***1829***	1835	1871	1899	1887
1835	1869	1869	1902	1902	1899
1837	1902	1879	1909	1909	1902
1849	1912	1881	1919	1912	1909
1869	1934	1889	1921	1919	1912
1887	1944	1891	1929	1921	1919
1891	1954	1899	1934	1929	1921
1902	***1979***	1902	1942	1931	1929
1919		1909	1944	1934	1931
1929		1919	1946	1944	1934
1948		1934	1948	1946	1942
1979		1948	***1987***	1948	1944
1981		***1977***		1970	1946
		1979		1974	1948
		1981			

The select cohorts in the shaded cells have been determined based on only 11-20 years of data and so are tentative select birth cohorts.

The following chart shows the number of select birth cohorts by gender and country from the late eighteenth century to the beginning of the twenty first century. The existence of a select birth cohort is rather rare; Chart one depicts 250 select birth cohorts for the more than 200 years investigated in eleven countries.[9]

[9] As a caveat we note that the years covered by country data sets varied greatly. It was relatively easy for countries such as France to produce many cohorts because of the many years of data while low Dutch cohort numbers are surprising for the same reason and the Japanese cohorts numbers are surprising because of the few years of data.

Chart 1
Number of Select Birth Cohorts

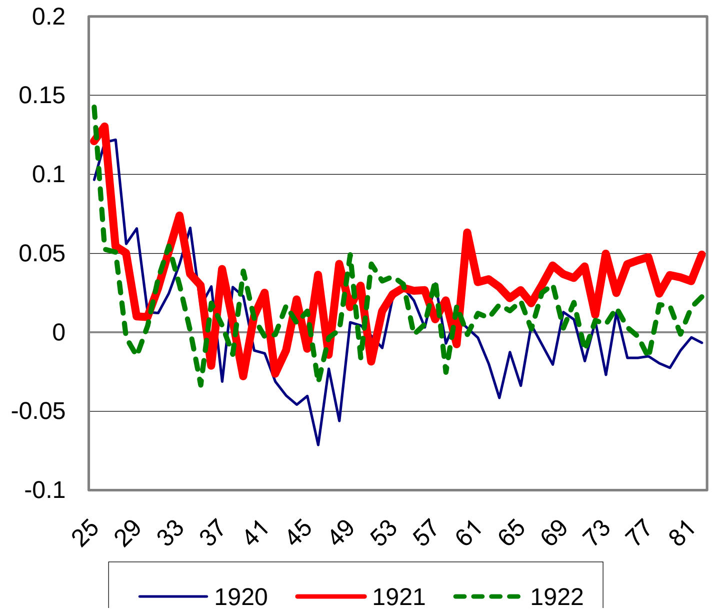


Keeping in mind that these select cohorts have been determined using a threshold percentage of *k*=0.5, which requires a significant strength of improvement to be considered select, it must be noted that the generations listed in differ in the strength of the select cohort effect. Also note that a cohort being select does not mean that it exhibits greater improvements at **all** ages.

In the 200 plus years of data analyzed, 28 years yielded select birth cohorts in two or more countries while 13 years yielded three or more countries with select birth cohorts and finally only four years yielded four countries with select birth cohorts. Hence, while the select birth cohorts appear in each country investigated, they do not seem to be correlated across countries; nor do the select cohorts seem to follow a cycle. Some of the select cohorts do seem quite strong in the sense that the number of years that mortality improvements dominate previous and subsequent generations is exceptionally high; we will note one example.

To illustrate the fluctuations of improvement rates across ages, Figures 3 and 4 show the data for two select birth cohorts, 1921 and 1946, in the United States relative to the previous and subsequent birth cohorts. There was a male select birth cohort in France, Sweden, Switzerland and the United States in 1921. The 1921 male cohort is shown in Figure 3 while the cohorts for the other countries are shown in the appendix. When contrasting the 1921 cohort with the adjacent cohorts, it is clear that the greatest improvements for all three cohorts considered occurred at the younger ages, i.e. roughly during the 1950s and 1960s. Of course, none of the cohorts has experienced higher improvement rates at all ages, but what distinguishes the 1921 cohort from the two others is the fact that it has experienced much stronger improvements at older ages, for example beyond 60. Not so high values for the 1920 and 1922 cohorts do of course not indicate higher mortality, but just less intense improvements. Interestingly, there are negative values for the 1920 cohort which effectively means that those males have in fact experienced a deterioration, or increase, of mortality compared to those born in 1919.

Figure 3– Relative rates of mortality improvement for Males, United States, 1921 cohort vs. adjacent cohorts

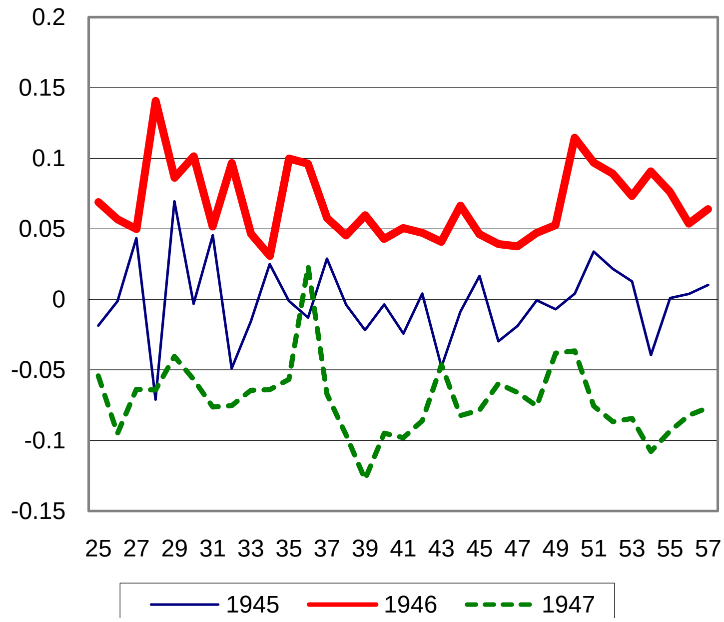


Source: authors' calculation, based on data from HMD (2008)

It is quite unlikely that a single cohort exhibits outstanding patterns just because it might have had a strikingly different exposure to mortality like being favored or discriminated by health care systems due to the specific year of birth. Rather the aggregate effect of all the influencing factors that have been named as potential reasons for mortality improvements seem to interact in an extremely favorable way for those born in 1921.

Figure 4 charts the 1946 male select birth cohort for the United States against the previous and subsequent cohorts. There were also select 1946 birth cohorts in England and Wales, the Netherlands and Japan which are depicted in the appendix. This cohort effect is even more dramatic. Part of the dramatic effect is because the subsequent cohort of 1947 exhibits deteriorations of mortality. The 1946 male cohort does on average exhibit a 7% excess in improvement over the best adjacent generation and so could be considered a super select cohort. Despite the dominance of the 1946 cohort over the adjacent generations, the continued dominance into retirement years is yet to be seen.

Figure 4: Relative rates of mortality improvement for Males - United States, 1946 cohort versus adjacent cohorts



Source: authors' calculation, based on data from HMD (2008)[10]

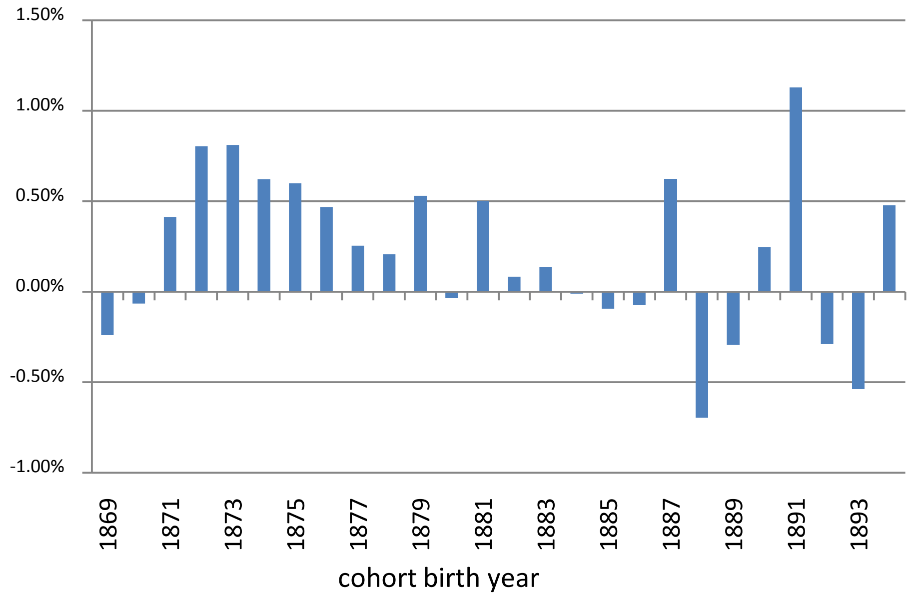
5. Early-Stage Identification or Risk Management

In spite of all efforts to assess the impact on the retirement costs of any cohort that proves to be select, the greatest attention is likely to be paid to methods of predicting such extraordinarily long lives before annuity providers or pension schemes commit to insure an individual's or even an entire cohort's longevity risk. Given the development of the analysis so far, that prediction seems unlikely since the select cohorts follow no apparent pattern or cycle.

As noted, the uncertainty about the further development of longevity alone already places some burden on individuals facing the risk of adequate financial planning for their retirement, but private pension plan providers or governmental agencies in charge of providing old-age income are also affected. The additional risk of a single cohort experiencing unusually strong gains in life expectancy, however, might be important for the latter group. To facilitate an assessment of the fiscal risk as perceived from such providers' perspective, Figure 5 shows the relative changes of the present values of 35-year life annuities starting at age 65 for male cohorts in the United States calculated with a constant interest rate of 3% and assuming that the actually realized mortality rates had already been known at the inception of each contract, i.e. these numbers give the true value or cost of such a life annuity. Data was taken from the HMD and only cohorts whose surviving members have already passed their 100th birthday were considered.

[10] The figure only extends to age 57 due to data limitations.

Figure 5. Percentage change in Life Annuity Value for U.S. Males



Source: authors' calculation, based on data from HMD (2008)

From the years covered in Figure 5, only 1871 was identified as a select birth cohort and not a strong one. Period effects seemed to dominate cohort effects in the United States until at least 1960 and after that the cohort effects seemed to be more prevalent in the data, e.g., see Figure 1. We have not seen the impact of a strong select cohort in the data yet but the trend has been improving mortality numbers for the senior years and if a super select cohort like 1946 continues to dominate then we may well see a spike in the cost of a life annuity for that cohort and could easily hedge that risk ex ante if observing cohorts becomes part of the risk management strategy.

6. Summary and Conclusion

Our analysis indicates that while select birth cohorts seem to exist in the countries studied, they do not appear to be very common and there is no convincing evidence of their correlation across countries. Indeed in some countries like Norway the period effects seem to dominate while in countries such as England and Wales the data hint at select cohorts earlier than the 1900s, although there are strong and continuing period effects, e.g., see Figure 2, there as well. The existence of the select birth cohorts and in some cases super select cohorts makes analyzing the mortality data for select cohorts and in some cases more actively managing the associated risk with financial instruments prudent and possibly value enhancing for the insurer and reinsurer.

Appendix A: List of Select Birth Cohorts Identified

Canada		
M	F	B
1831	***1829***	1835
1835	1869	1869
1837	1902	1879
1849	1912	1881
1869	1934	1889
1887	1944	1891
1891	1954	1899
1902	***1979***	1902
1919		1909
1929		1919
1948		1934
1979		1948
1981		***1977***
		1979
		1981

England&Wales		
M	F	B
1744	***1744***	***1743***
1747	***1746***	***1745***
1749	***1747***	***1746***
1750	***1751***	***1750***
1752	1758	***1752***
1899	1916	1919
1919	1919	1921
1921	1921	1925
1946	1946	1941
1948	1948	1946
1963	***1981***	1948
1970		1970

Finland		
M	F	B
1784	***1780***	***1782***
1788	***1783***	1808
1836	***1784***	1814
1860	***1786***	1820
1871	1822	1822
1876	1828	1836
1916	1853	1847
1919	1869	1860
1921	1871	1866
1925	1903	1869
1941	1921	1871
1945	1947	1876
1947	1961	1885
1983	1971	1903
	1982	1916
	1987	1919
	1989	1921
		1925
		1941
		1945
		1947
		1975

France		
M	F	B
1717	***1719***	***1718***
1721	1914	***1719***
1728	1916	1914
1743	1919	1916
1914	1921	1919
1916	1941	1921
1919	1943	1929
1921		1941
1932		
1939		
1941		

Italy		
M	F	B
1774	1801	***1776***
1776	1910	1801
1780	1912	1910
1801	1914	1912
1821	1917	1914
1910	1919	1917
1912	1921	1919
1914	1923	1921
1917	1932	1923
1919	1935	1929
1921	1939	1935
1923	1942	1937
1929	1945	1939
1942	1957	1942
1945	***1990***	1945
1970		1948
1976		1950
1986		1957
1988		

Japan		
M	F	B
1853	***1857***	***1853***
1859	1865	***1855***
1888	1888	1888
1897	1897	1891
1899	1899	1897
1906	1901	1899
1908	1904	1906
1913	1906	1908
1919	1908	1913
1921	1913	1915
1923	1919	1919
1930	1921	1921
1932	1925	1925
1934	1930	1930
1937	1932	1932
1939	1934	1934
1943	1937	1937
1946	1939	1939
1948	1943	1943
1966	1946	1946
1970	1948	1948
1981	1960	1966
1986	1964	***1979***
	1966	***1981***

The Netherlands		
M	F	B
1758	1919	***1757***
1802	***1988***	1802
1946		1850
		1921
		1946
		1988
		1991

Norway		
M	F	B
1816	***1748***	1816
1968	1816	1835
1979	1978	1979
	1990	***1990***

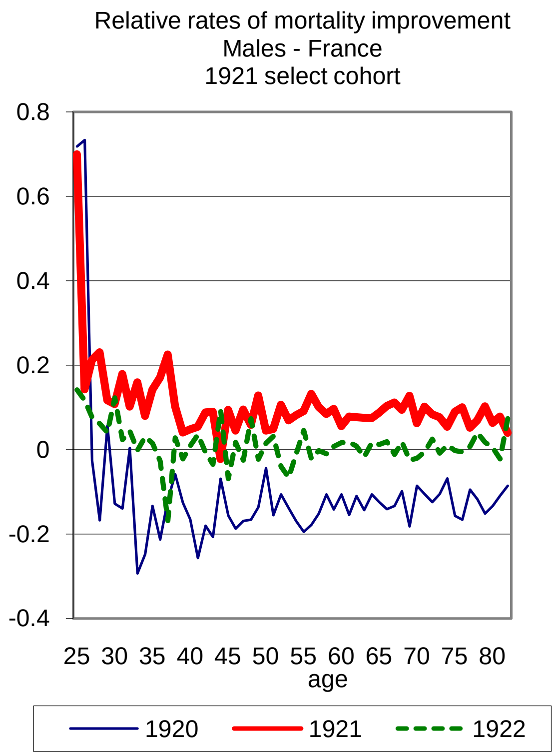
Sweden		
M	F	B
1830	1913	1832
1832	1921	1853
1853	1923	1921
1919	1928	1923
1921	1958	1941
1965	1964	***1984***
1973	1978	***1986***
1979	1980	
1986	***1982***	
	1984	
	1986	

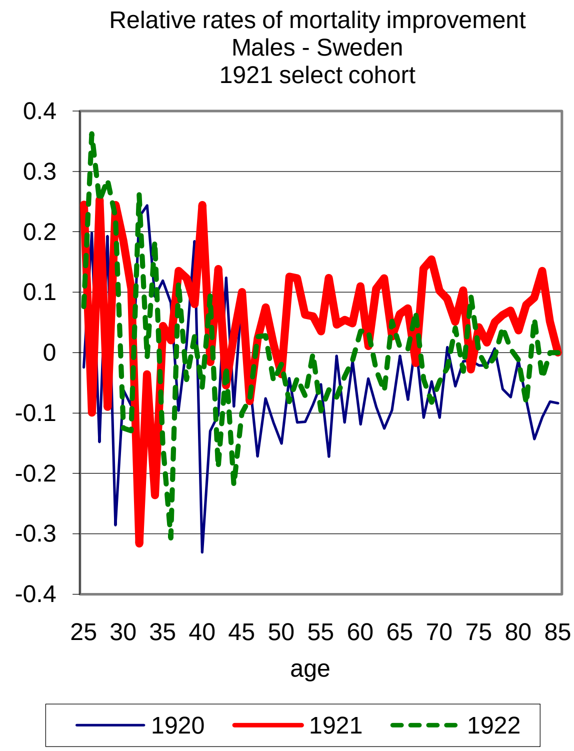
Switzerland		
M	**F**	**B**
1780	***1781***	***1779***
1807	***1783***	***1780***
1813	1818	***1782***
1818	1848	***1787***
1821	1855	1799
1825	1921	1807
1877	1964	1818
1921	***1986***	1855
1928		1921
1981		***1984***
		1991

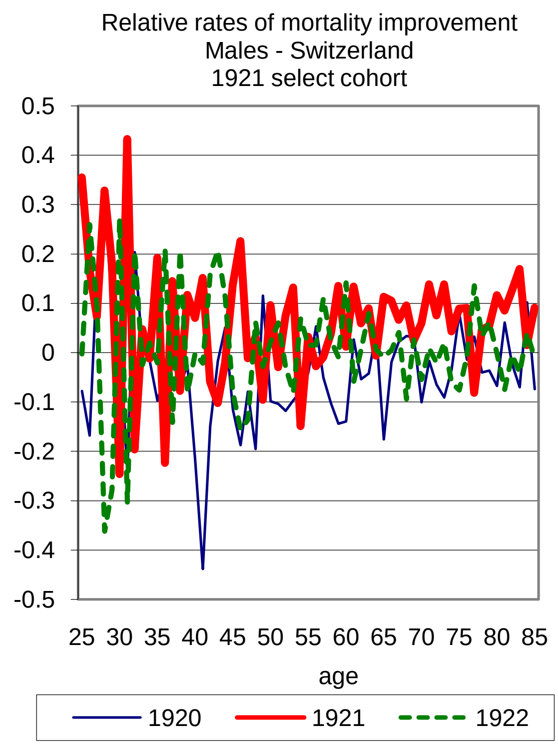
United States		
M	**F**	**B**
1871	1899	1887
1902	1902	1899
1909	1909	1902
1919	1912	1909
1921	1919	1912
1929	1921	1919
1934	1929	1921
1942	1931	1929
1944	1934	1931
1946	1944	1934
1948	1946	1942
1987	1948	1944
	1970	1946
	1974	1948

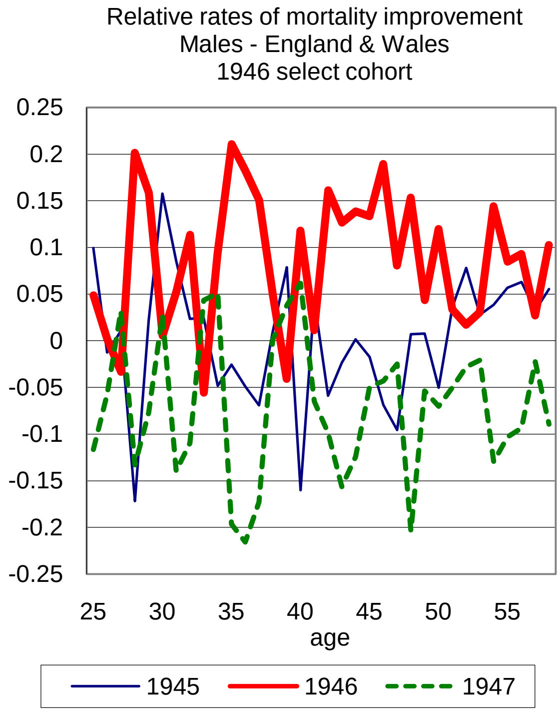
The select cohorts in the shaded cells have been determined based on only 11-20 years of data and so are tentative select birth cohorts.

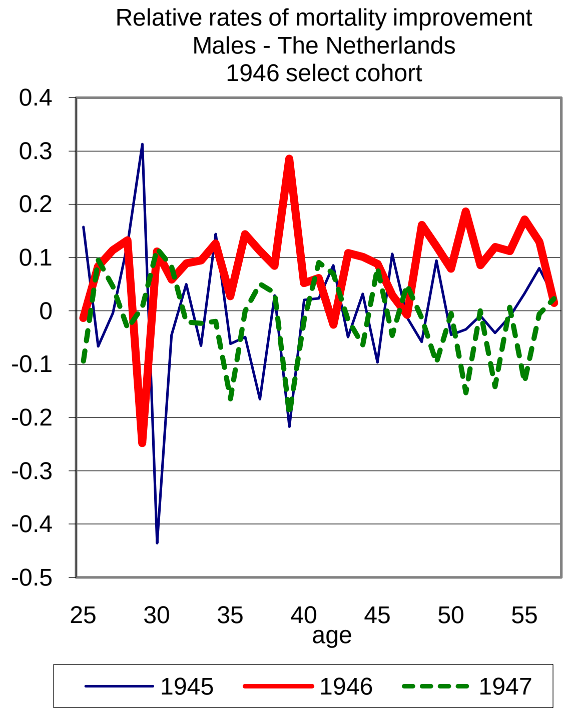
Appendix B: Select Birth Cohorts

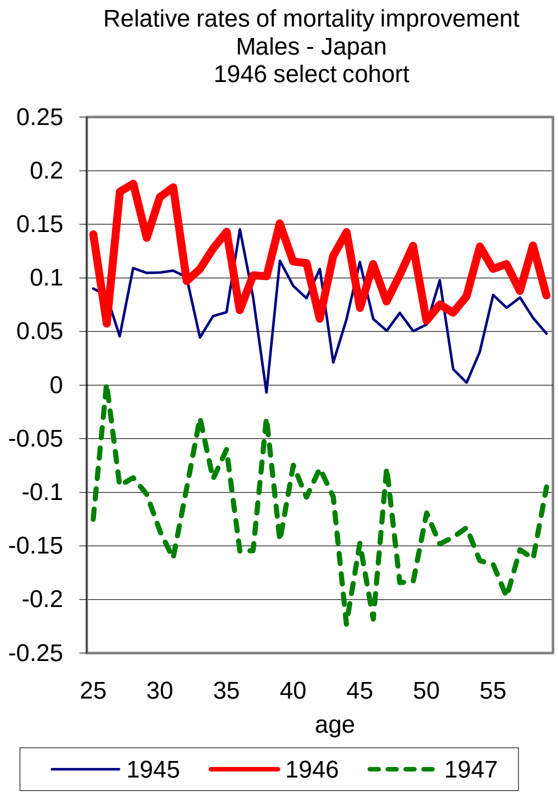




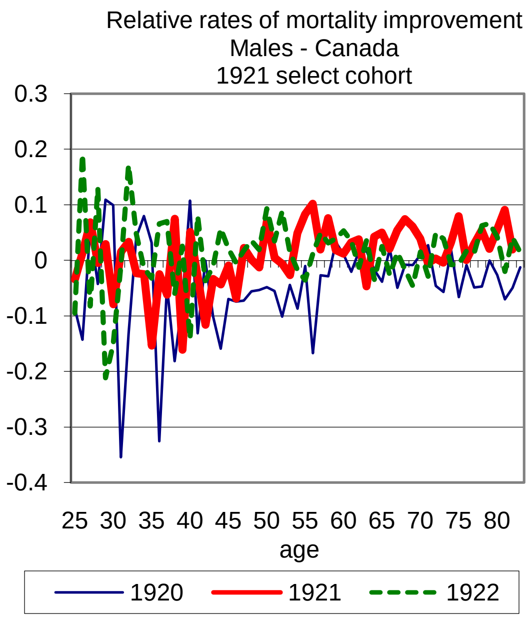


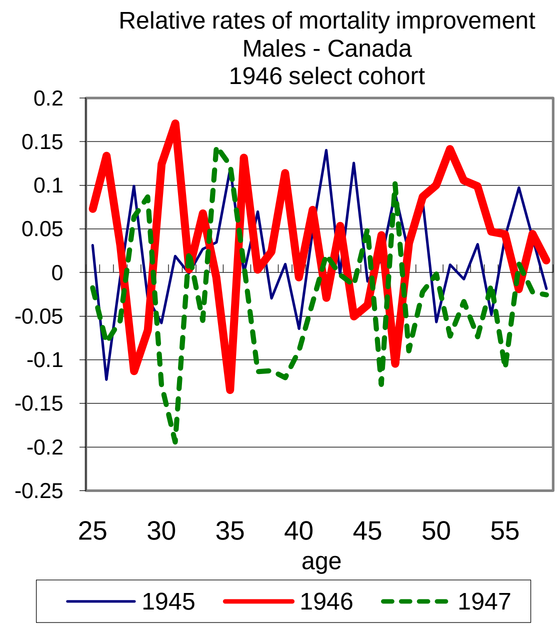

Relative rates of mortality improvement
Males - England & Wales
1946 select cohort
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
25
30
35
40
45
50
55
age
1945
1946
1947

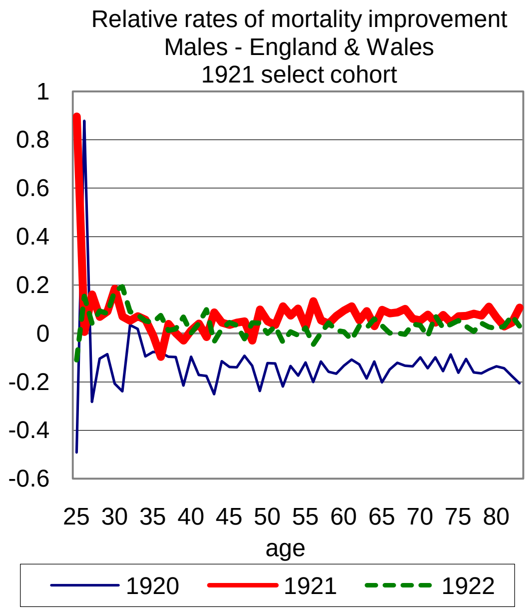

Relative rates of mortality improvement
Males - The Netherlands
1946 select cohort
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
25
30
35
40
45
50
55
age
1945
1946
1947

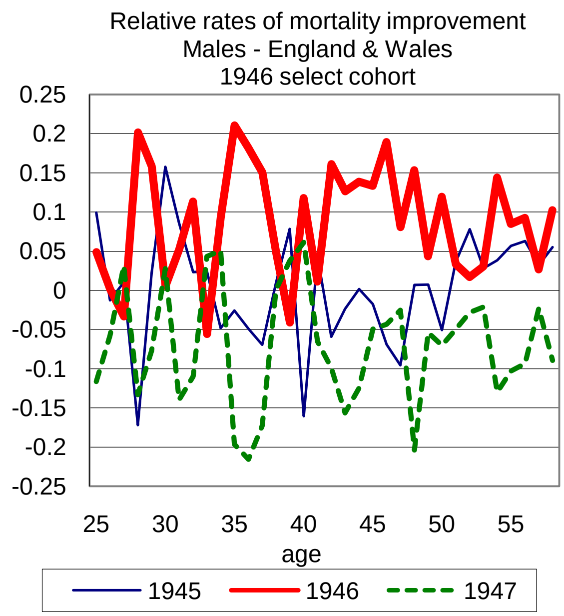

Relative rates of mortality improvement
Males - Japan
1946 select cohort
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
25
30
35
40
45
50
55
age
1945
1946
1947

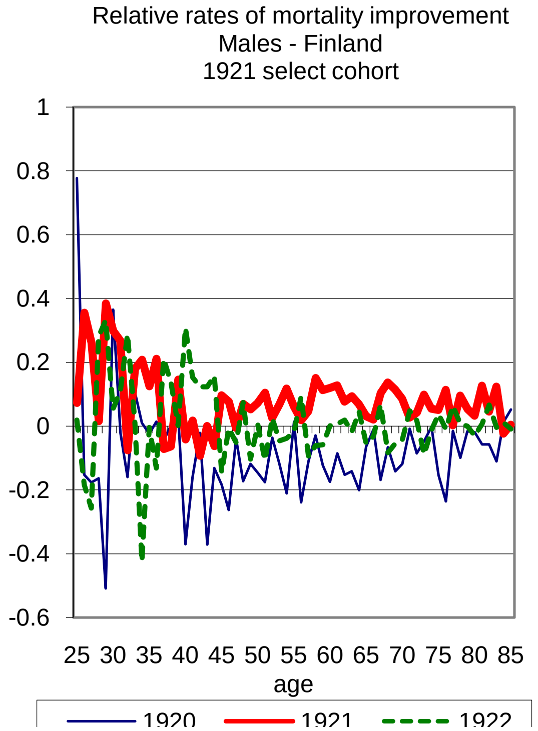
Appendix C: Select and non-select 1921 and 1946 cohorts

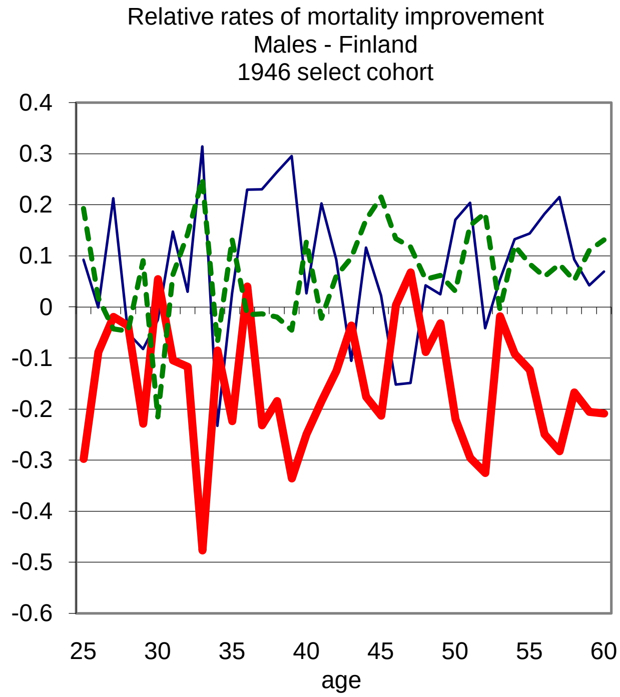


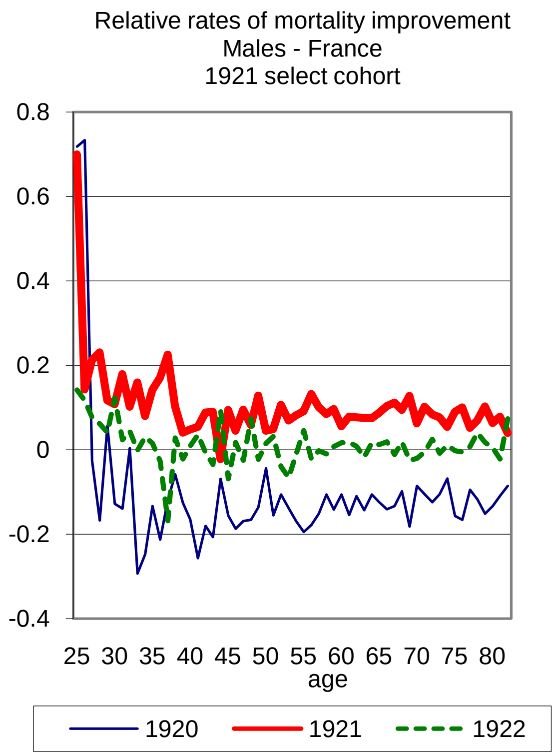


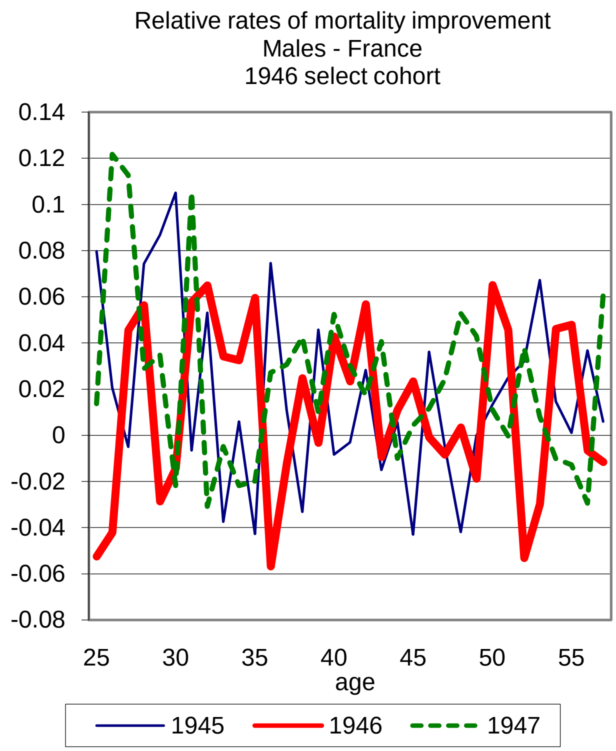


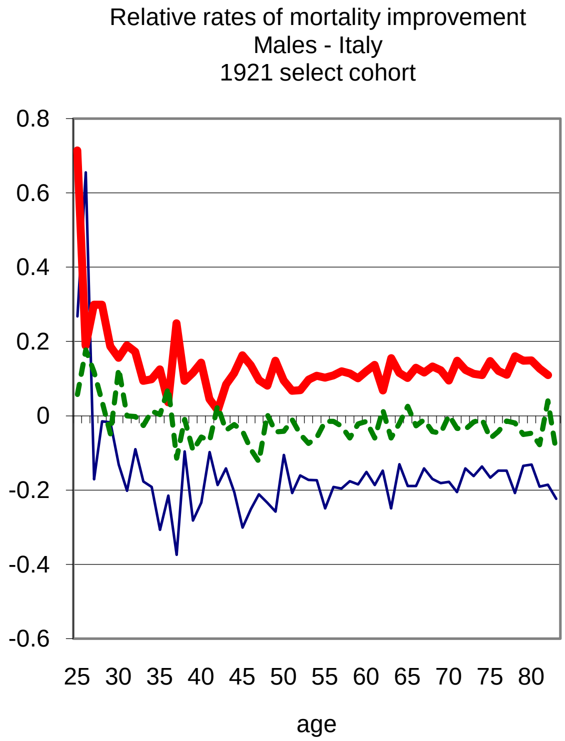


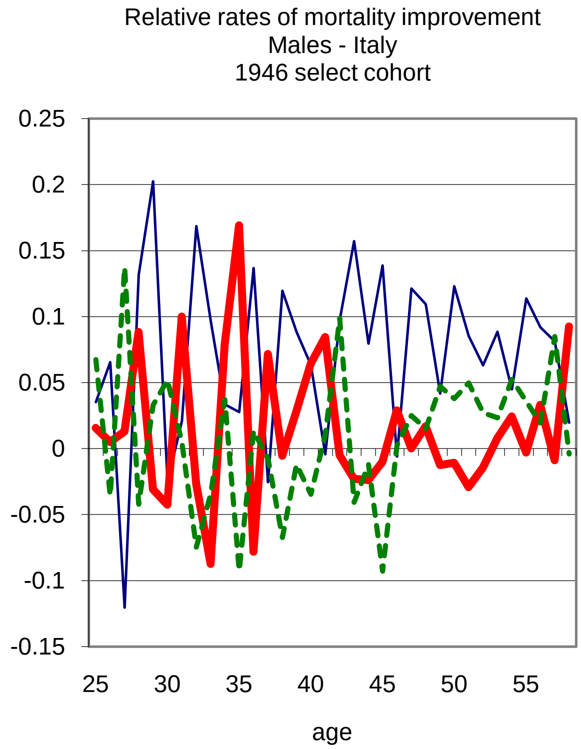

Relative rates of mortality improvement
Males - Finland
1921 select cohort
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
25 30 35 40 45 50 55 60 65 70 75 80 85
age
1920
1921
1922

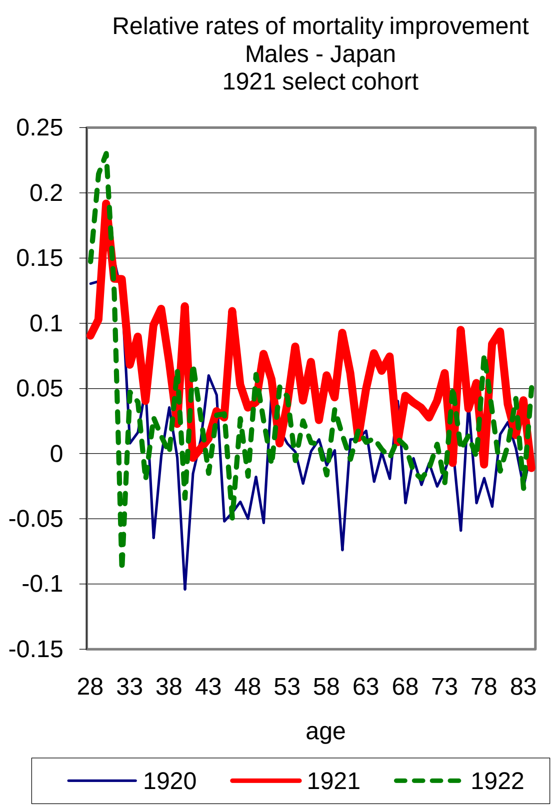

Relative rates of mortality improvement
Males - Finland
1946 select cohort
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
25 30 35 40 45 50 55 60
age

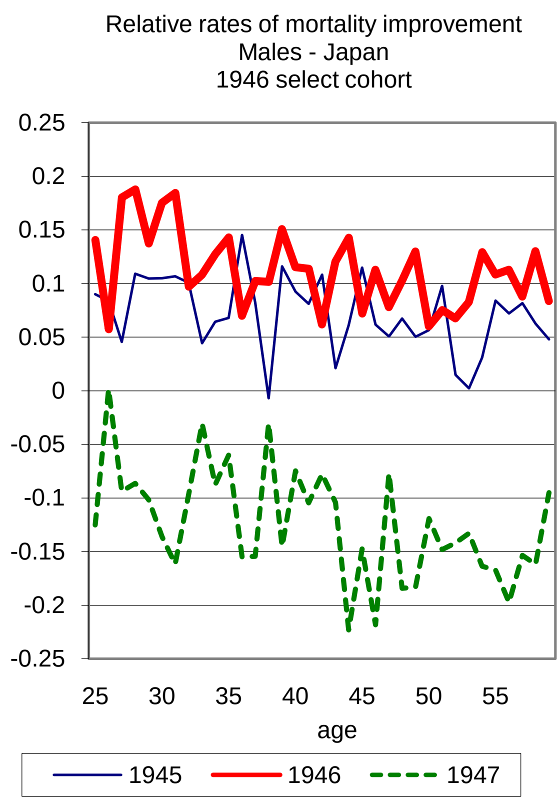

Relative rates of mortality improvement
Males - France
1921 select cohort
0.8
0.6
0.4
0.2
0
-0.2
-0.4
25 30 35 40 45 50 55 60 65 70 75 80
age
1920
1921
1922

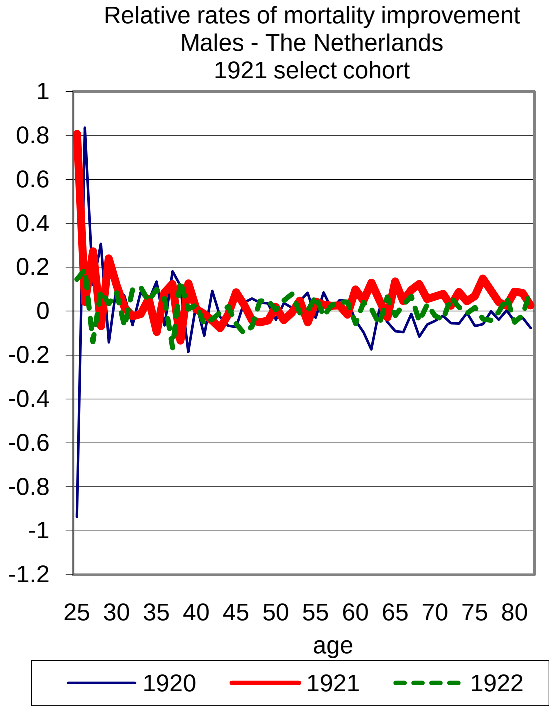

Relative rates of mortality improvement
Males - France
1946 select cohort
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
25 30 35 40 45 50 55
age
1945
1946
1947

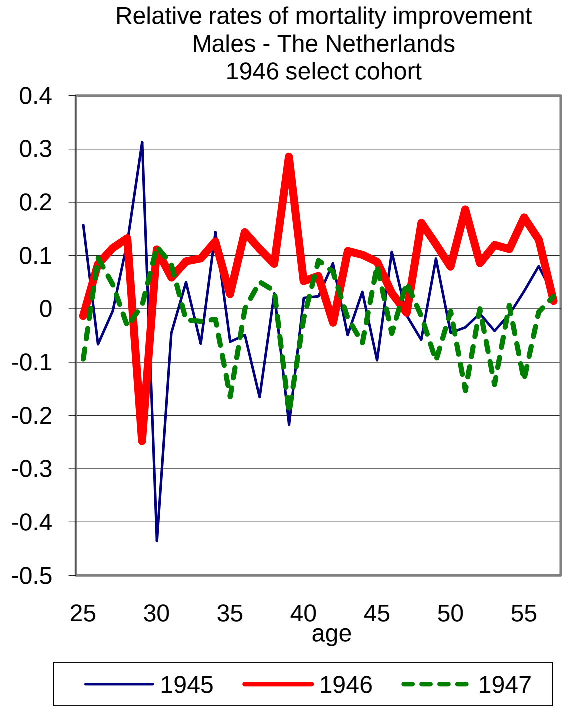

Relative rates of mortality improvement
Males - Italy
1921 select cohort
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
25 30 35 40 45 50 55 60 65 70 75 80
age

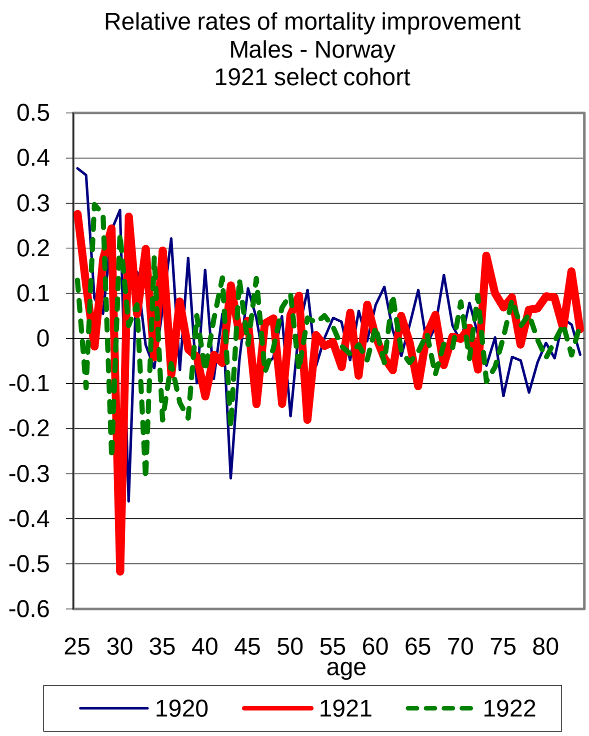

Relative rates of mortality improvement
Males - Italy
1946 select cohort
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
25 30 35 40 45 50 55
age

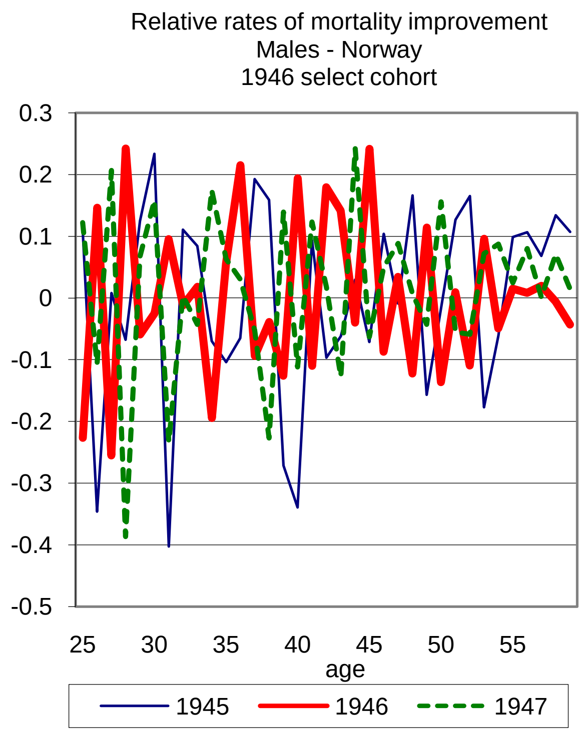

Relative rates of mortality improvement
Males - Japan
1921 select cohort
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
28 33 38 43 48 53 58 63 68 73 78 83
age
1920
1921
1922

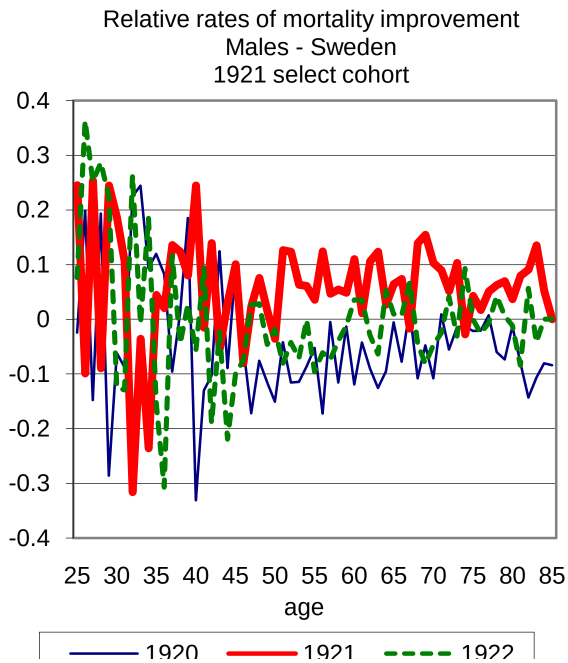

Relative rates of mortality improvement
Males - Japan
1946 select cohort
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
25 30 35 40 45 50 55
age
1945
1946
1947

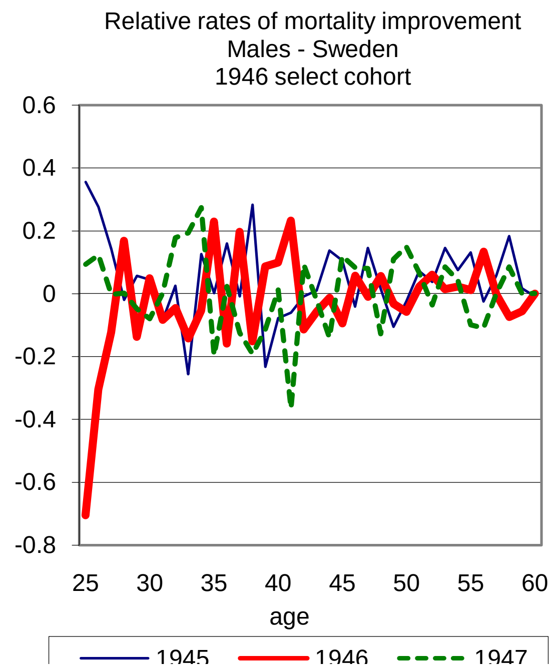

Relative rates of mortality improvement
Males - The Netherlands
1921 select cohort
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
25 30 35 40 45 50 55 60 65 70 75 80
age
1920
1921
1922

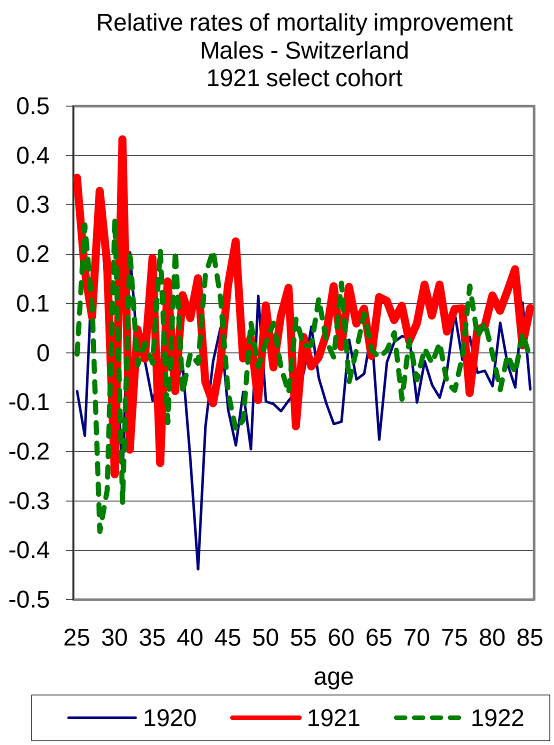

Relative rates of mortality improvement
Males - The Netherlands
1946 select cohort
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
25 30 35 40 45 50 55
age
1945
1946
1947

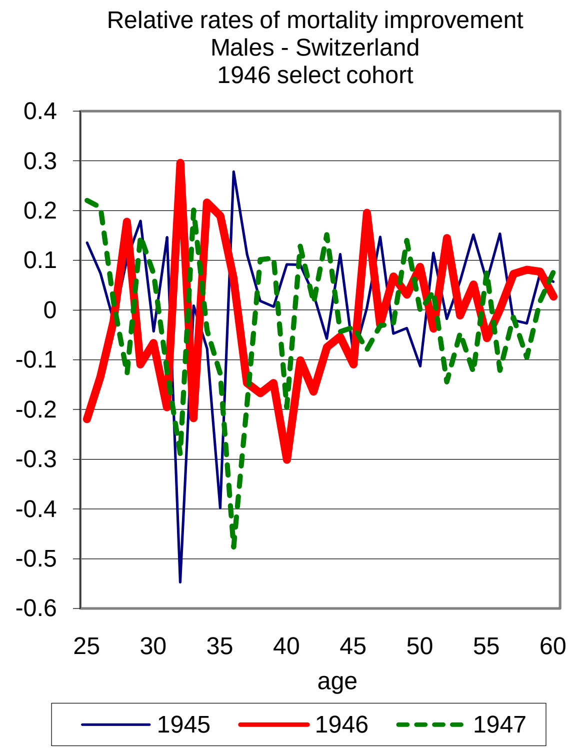

Relative rates of mortality improvement
Males - Norway
1921 select cohort
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
25 30 35 40 45 50 55 60 65 70 75 80
age
1920
1921
1922


Relative rates of mortality improvement
Males - Norway
1946 select cohort
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
25 30 35 40 45 50 55
age
1945
1946
1947


Relative rates of mortality improvement
Males - Sweden
1921 select cohort
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
25 30 35 40 45 50 55 60 65 70 75 80 85
age


Relative rates of mortality improvement
Males - Sweden
1946 select cohort
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
25 30 35 40 45 50 55 60
age


Relative rates of mortality improvement
Males - Switzerland
1921 select cohort
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
25 30 35 40 45 50 55 60 65 70 75 80 85
age
1920
1921
1922


Relative rates of mortality improvement
Males - Switzerland
1946 select cohort
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
25 30 35 40 45 50 55 60
age
1945
1946
1947

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