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SHORT PERIOD MORTALITY SHIFT AND ITS EFFECT TO COHORT MORTALITY

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Abstract

For cohort life table information about mortality for 100 years is needed. As is known Czech Republic and many other regions have problem with this assumption because of some short time periods with weak or no information about mortality patterns in detailed structure. On the other hand information about cohort mortality is very important for many institutions as pension funds, government and others. How to solve problem with this periods with poor information about mortality patterns is the aim of the paper. We would like to quantify impact of short time over- or undervalued mortality (as effect of war or other crises) to total mortality of cohort. Different impact is expected as different period of the lifetime of the cohort is affected by the period with different mortality patterns. This is very important for regions where those periods were in history and where cohort life tables are not constructed yet because of this problem.

Keywords

Mortality patterns, Cohort, Life expectancy, Life table.

JEL classification

J11, I13, C53.

1 Introduction

It is almost 350 years when E. Halley described basic model which we call Life tables now (Pavlik at al., 1986). From that time many other researchers developed this model and tried to use it for many reasons. Mortality patterns and their development became very important for the whole society and now we can find application of life tables in many areas as insurance companies use mortality tables to evaluate their products and governments use it to apply when they realize some kind of pension system.

As the main goal at first was to describe mortality patterns of the population as a whole, now we can find many applications to different subgroups or subpopulation. The goal is the same but there is no general model for the whole population and we have to apply and modify the model in some other areas. Zimmermann at al. (2014) used different mortality model for education groups to estimate difference in present value of retirement pensions for each education groups. Fiala, Langhamrova (2014) applied mortality forecast to evaluate ability and stability of the social system in the Czech Republic from the view of revenues and expenditures.

Application of the life tables is much wider, because mortality is not connected with population of man only, but we can find many useful applications of mortality models in other disciplines also. Krejci (2013) describes models of aging of machinery and equipment in education as aspect of modernity. The model was developed by Krejci and Mazouch (2015) and applied in agriculture in estimation of age of machinery and equipment in the Czech agriculture (Krejci at al., 2015).

Types of the life tables depend on the data we use. We can construct life table from the newest data available – usually for one year and we use information about number of events and exposed population – those type of life tables we call transversal life tables (Pavlik at al., 1986). Transversal life table combine information "what happened" in that current year to all population – through all ages, through all cohorts and analyses current health (and mortality) condition in the population in particular year (or another period).

The other type of data is longitudinal data. It is possible to follow one cohort (usually defined as population born in one year or longer period) but this is very demanding to data and to construct the whole life tables (from birth to the highest ages) we need data about complete cohort – extinct cohort (Pavlik at al., 1986). But cohort models are very important as one of the other source of information of mortality patterns (Mazouch, 2012).Time needed to die out one cohort is more than one hundred years and this problem causes that cohort life tables are available in some countries only. Other possibility is to construct incomplete model as Hulikova Tesarkova and Mazouch (2013) who described basic cohort mortality analysis at higher ages (over 60) on cohorts born in 1890-1910 in the Czech Republic and compared results with France.

As cohort life tables are valuable for the analysis of mortality in many ways we have to find possibilities how to solve the problem with the data. It is known that in history of any country there are periods with weak or absolutely no information about population or events in general. For life tables we need data distributed not only by sex but by age also and this kind of detail is usually missed. Information about numbers of deaths in general is available only. Example of this kind of data we can find in Kučera (1994) where situation of the Czech Republic during the period of the Second World War is described but the numbers of population and concrete numbers of events distributed by age is missing.

Aim of this paper is to evaluate influence of any period of higher (or lower) level of mortality to basic indicator – Life expectancy at birth. As we know that there are no cohort life tables for the Czech Republic as the example of application we can use some transversal tables and we can assume that those are based on some cohort data. Effect of temporary increase of mortality level is measured on four different population (four different models of mortality). Total effect of the change of the life expectancy is measured.

2 Data

As was mention in Introduction cohort life tables for the Czech Republic are not available yet. Also using of cohort life tables from some other country could lead to some confused conclusion because of period effect in the data (cohort could live in some temporary unstable period). To reduce this effect four different period life tables are used to demonstrate four possible scenarios of four different cohorts. Model of period life table is useful and is based on the same assumption as construction of the cohort life tables (for more details see Pavlík at al., 1986).

On the Fig. 1 all four modelled cohorts are presented, two are from year 1937 and two from year 2000, for males and females separately. It is clear that there are differences among all four hypothetical cohorts, the lowest life expectancy at birth have males in year 1937, it is about 56,7 years only, for females in 1937 it is more than 60, 5 and for year 2000 for males and females it is more than 70 (71,65 for males and 78,35 for females). Results are in Table 1.

Table 1. Life expectancy at birth for males and females, 1937 and 2000, Czech Republic (years)

1937		2000	
Females	Males	Females	Males
60,57	56,70	78,35	71,65

Source: CZSO, 2016a.

From the Fig. 1 we can see huge decline of infant mortality and also changing distribution of the death age. Whole distribution is shifting to right in time and is sharper (parameter of kurtosis is changing). This process is called rectangularization (for more details see Hulikova Tesarkova, 2012). As mortality patterns vary in time Czech Statistical Office applies smoothing methods of Gompertz-Makeham for higher ages correspond to CZSO, 2016b.

Fig. 1. Distribution of table deaths for different life tables (males and females 1937 and 2000), (Source: CZSO, 2016a)

3 Methodology

As basic source to construct life tables specific mortality rates are used. According to formula 1 data about number of deaths at age *x* and number of exposed population at age *x* are needed.

$$m_{x,t} = \frac{D_{x,t}}{P_{x,t}}, \tag{1}$$

where $m_{x,t}$ is the mortality rate at age *x* and in year *t*, $D_{x,t}$ is number of deaths at age *x* in year *t* and $P_{x,t}$ is the exposed population at age *x* and in year *t*.

Each hypothetical cohort was divided to fifteen age groups by five years. The first starts at age 10 and covers ages from 10 to 14 (up to 15. birthdays), the second is for age 15-19, the third from 20 to 24 etc. The last group is 80-84. Younger ages (bellow 10) and old ages (85 and older) were not mentioned in our analysis. For younger ages the mortality is very low – except infant mortality (see fig. 1) and for older ages when mortality rate is high the number of deaths decline (the population is small) and effect of mortality level change is negligible.

For each defined age group we assume temporally increase of the mortality.

$$m_x^* = m_x \cdot a, \tag{2}$$

where m_x^* is the temporally changed mortality rate for age *x*, m_x is the real (from life tables) mortality rate at age *x* and *a* is the coefficient of the mortality change.

To demonstrate the impact of the mortality change to overall mortality of the cohort, we assumed that cohort would have one period with mortality level 1.5 times higher than regular level or 2.0 times higher. In the other age groups the mortality is not changed.

This could demonstrate impact of periods as war or some similar problematic periods when population is under worse mortality condition and cohorts are affected by this period in different ages. This situation could be illustrated in Fig. 2, where for five cohort different periods of their life are affected by period with doubled mortality level. Before and after those periods the mortality is regular and we want to measure the effect of this temporary change only. This situation could be for example during the World war when cohort born 1920 was at the beginning of the World War II 19 years old and 25 at the end, cohort 1925 was 14 at the beginning and 20 at the end and so on. One period affected different cohorts in different periods of their lives.

As has been mentioned above the main indicator where the impact would be measured would be the life expectancy at birth (regular values are in Table 1).

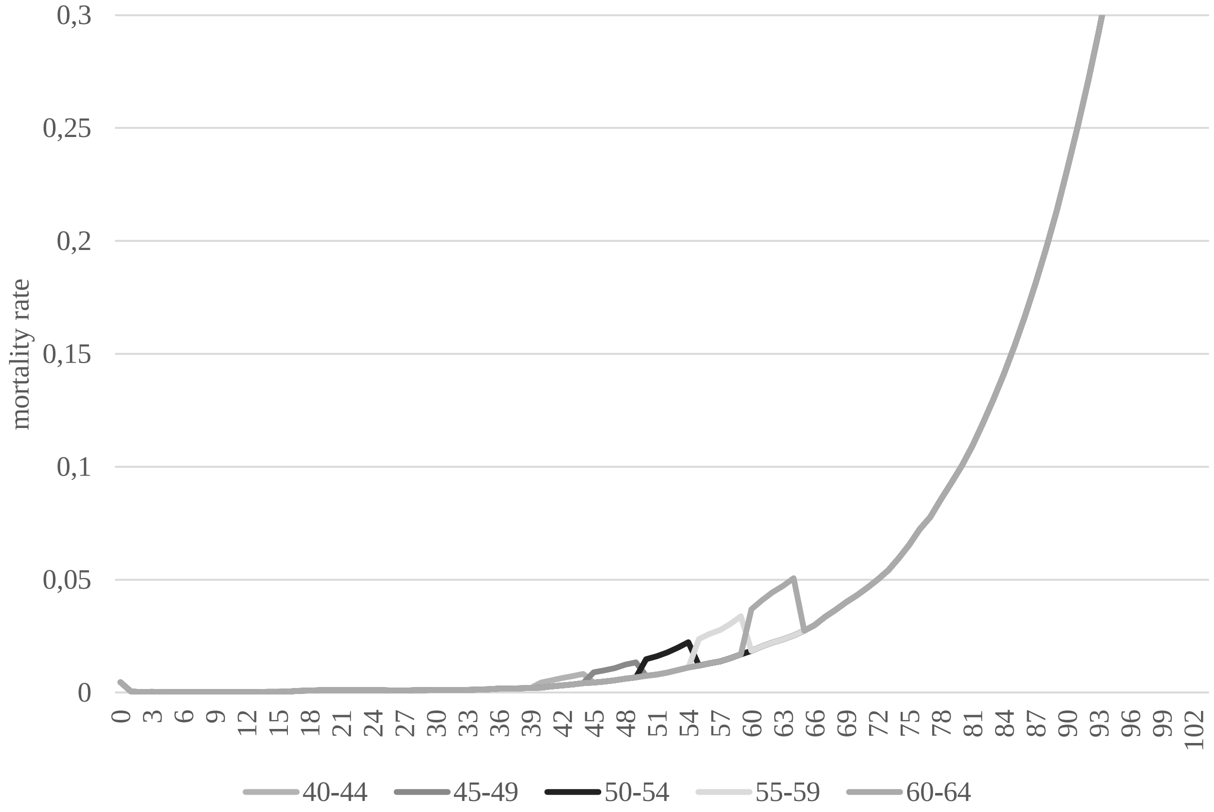

Fig. 2. Temporary increase of the mortality rate of 100 % for different age groups - illustration (Source: own calculation)

4 Results

Results show that impact of the temporary increase of the mortality level to overall life expectancy (at birth) is very small. Results vary among analysed hypothetical cohorts but also in them and the impact depends on the age when the cohort is affected. To compare our results with Fig. 1 (distribution of deaths) we can find that the biggest influence have age groups with the highest number of deaths.

Table 2 represents increase of the mortality of 50 % and we can find that the highest difference is for cohort with mortality patterns as males in 2000 and at age 65-69, the difference between mortality without increase and with increase in this age group is -0,69 year. Life expectancy at birth is more than 70 and this difference is less than 1 % in this indicator.

For cohorts with higher mortality for all age groups – illustrated as mortality in 1937, the effect is higher because the number of deaths is higher for all age groups except the oldest ones. The difference is only slightly higher then 0.5 year. For age groups with really low mortality (as the youngest age groups with mortality from the year 2000) the impact of increase of mortality level is negligible.

Table 2. Difference between regular life expectancy and modelled life expectancy with temporary increase of mortality in selected age groups, coefficient of increase *a* = 1.5

Age group	1937		2000	
	Females	Males	Females	Males
10-14	-0.19	-0.19	-0.03	-0.03
15-19	-0.24	-0.28	-0.05	-0.09
20-24	-0.31	-0.33	-0.05	-0.13
25-29	-0.29	-0.28	-0.04	-0.11
30-34	-0.27	-0.27	-0.05	-0.12
35-39	-0.29	-0.32	-0.08	-0.16
40-44	-0.30	-0.36	-0.12	-0.24
45-49	-0.33	-0.42	-0.19	-0.35
50-54	-0.39	-0.46	-0.25	-0.46
55-59	-0.44	-0.52	-0.32	-0.56
60-64	-0.52	-0.54	-0.39	-0.65
65-69	-0.55	-0.53	-0.51	-0.69
70-74	-0.53	-0.46	-0.60	-0.65
75-79	-0.43	-0.34	-0.66	-0.55
80-84	-0.25	-0.19	-0.57	-0.37

Source: CZSO, 2016a, own calculation.

If the increase of the mortality level for selected age groups would be 100 % (*a* = 2.0) the impact is higher. Distribution of differences is the same, the highest difference is for males, year 2000 and age group 65-69 but the difference is higher -1.33 years. For cohorts 1937 and both males and females the differences are slightly higher than 1 year. Results are in Table 3.

Table 3. Difference between regular life expectancy and modelled life expectancy with temporary increase of mortality in selected age groups, coefficient of increase *a* = 2.0

Age group	1937		2000	
	Females	Males	Females	Males
10-14	-0.37	-0.39	-0.06	-0.07
15-19	-0.49	-0.56	-0.10	-0.18
20-24	-0.62	-0.66	-0.09	-0.26
25-29	-0.57	-0.56	-0.08	-0.22
30-34	-0.54	-0.53	-0.10	-0.24
35-39	-0.57	-0.63	-0.15	-0.31
40-44	-0.59	-0.72	-0.25	-0.47
45-49	-0.66	-0.83	-0.38	-0.69
50-54	-0.77	-0.91	-0.51	-0.91
55-59	-0.88	-1.02	-0.64	-1.11
60-64	-1.01	-1.06	-0.78	-1.28
65-69	-1.06	-1.02	-1.00	-1.33
70-74	-1.01	-0.87	-1.18	-1.25
75-79	-0.78	-0.62	-1.26	-1.03
80-84	-0.44	-0.32	-1.06	-0.67

Source: CZSO, 2016a, own calculation.

5 Conclusion

Aim of this paper was to evaluate influence of any period of higher (or lower) level of mortality to basic indicator – Life expectancy at birth. As the modelled cohort we analysed four different mortality patterns and in each of this model we estimated influence of mortality increase in different age groups (and for different intensity of increase). The results show that differences are not big, surprisingly are small when increase of mortality of 50 % causes only 1% decline of life expectancy at birth.

To discuss our results we have to mention what situation are suitable for this type of analysis. As example we can discuss our results with period of the Second World War. It is known (from Kucera, 1994) that during the WW II the mortality patterns changed but we have very poor information about the real influence of the war. To help measure the influence we can estimate the regular development of the mortality in this period without war by some model bridging years between 1938 and 1945 (the method could be less or more sophisticated but that is not our goal to discuss way how to bridge this period). When we once have estimated data of the period with assumption of no war we can apply our methodology.

From Kucera (1994), pp 48 we know that for Czech lands (area of the Czech Republic) there are no complete data at all. We know about Czech population in Protektorat Bohmen und Mohren but only number of events and we have very weak information about exposed population. That is why we are not able to apply common way of construction of life tables. From the other sources we know that some war lost in population are not recorded in general (Jewish who were killed in concentration camps, prisoners killed in prisons, victims of crimes etc.). The only information we have is about total number of victims with very poor information about the distribution by gender and age.

But this information we can use to estimate how high was increase of the mortality during the war and we can estimate the influence to life expectancy at birth to all cohorts which were living during the War. During the War Kučera (1994) estimates that around 120 thousand people were killed or died as a result of war. This number divided to the period of the war means that in average 20 thousand of people died over the regular mortality per year.

Those numbers do not mean that deaths were distributed randomly but in some cases there was no gender or age selection. On the other hand in some cases some parts of population were exposed to mortality more (as babies and old people were not fighting on the streets). For example there was around two thousands of young people killed during the end of the war (Kucera, 1994). From this perspective the number of deaths which are over the regular mortality for sure seems that for some cohorts the mortality doubled (number of deaths is two time higher than "regular" number of deaths) in this time and the effect to cohort life expectancy at birth is weaker than someone could expect.

There is also high effect of the level of "regular" mortality. As four different hypothetical population were compared, the remarkable effect can be observed in period with higher mortality only (and it is clear because coefficient of increase in relative expression has different impact in absolute values). For some cohort with higher mortality in all periods as were cohorts from 1937 the effect is higher for younger age groups also. For cohorts with better mortality patterns in younger age (for example up to 40) as cohorts from 2000 are the effect of doubled mortality is remarkable in higher ages only. Hypothetical increase of absolute number of deaths (as was mention above in the example of year 1945) has the same impact to all compared cohorts and detailed results can be discussed in future projects.

Future research should focus to estimate at least fragments of information about distribution of deaths during wars and try to estimate level of increase of mortality caused by war and to estimate impact to the cohort indicators with knowledge of the effect of increase of mortality to cohort life expectancy.

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