MORTALITY IN THE CZECH REPUBLIC DURING THE LAST YEARS

Petra Dotlačilová

Abstract

Population aging has recently been very often discussed topic across European countries. There is more and more talk about people living till higher age. However, this increase is not sufficiently offset by the number of births. Then there is also (or probably will be) a decrease in the number of people of working age.

Closely linked to population aging is the improvement in mortality that has taken place in recent years. Mortality has gradually decreased, and people have lived to an ever-increasing age. The Covid 19 pandemic has had an impact on mortality in recent years. There has been talk from the beginning about the impact it will have on mortality. Will there be no significant reduction in life expectancy?

The aim of this article is to analyse mortality of the population in the Czech Republic in recent years. Furthermore, attention will be focused on modelling the mortality of people aged 60+. Emphasis will also be placed on the analysis of the effects of the pandemic on mortality modelling in the Czech Republic with regard to the evaluation of the suitability of the model used before and during the pandemic.

Key words: mortality, logistic function, Covid 19 pandemic

JEL Code: J10, J11, J19

Introduction

Population aging is one of the topics discussed across Europe. One aspect of aging is the fact that people are living to an older age (Koschin, 1999). If this phenomenon is not compensated by a sufficient number of live births, then the population is gradually aging.

Very often is discussed how to prepare for population aging. For example: reforms of the social system are related to this.

In this paper, Czech population mortality will be analyzed. Attention will be focused on the mortality of people in ages 60+. Greater emphasis will be placed on the years affected by the Covid 19 pandemic.

1 Methodology

As was already mentioned the attention will be focused on mortality of people in ages 60+. Several approaches can be used for analyzing this mortality. One of them is using of analytical functions. The most frequentely used on was Gompertz-Makeham function. This is one of the oldest functions (Burcin et al., 2010 or Langhamrová, Fiala, 2013).

In recent years, logistics functions have been used very often for modelling (Boleslawski, Tabeau, 2001 or Dotlačilová, 2020). One of them will be used in this post as well. The Czech Statistical Office also uses Kannisto model for its calculations (Czech Statistical Office, 2019).

Kannisto model

Kannisto model is a type of logistic function. It is one of the most frequentely used analytical functions for modelling mortality at higher ages. This feature assumes to have a slower increase in mortality (Gavrilov, Gavrilova, 2011).

In this article, Kannisto model was used in shape (Kannisto et al., 1994 or Thatcher et al. 1998):

$$\mu_x = \frac{ae^{b.x}}{1+ae^{b.x}}, \qquad (1)$$

where a and b are unknown parameters of the model, x is the age.

Another point of this paper is the application of the test criterion which could be used for the evaluation of obtained results. This might give us an information about suitability of concrete model (in this paper will be only about evaluation).

Evaluation of expected results

As the evaluation criterion will be used weighted squares of deviations (*WSD*) – minimization criterion. As weight will be used exposure to risk ($m_{t,x}^{(modelled)}$):

$$WSD = \frac{S_{t,x} + S_{t+1,x}}{2} \cdot (m_{t,x} - m_{t,x}^{(\text{mod elled})})^2, \qquad (2)$$

where $m_{t,x}^{(modelled)}$ is modelled mortality curve according to Kannisto (*K*), $S_{t,x}$ is number of living at the beginning of year *t* and $S_{t+1,x}$ is number of living at the beginning of year *t* + 1 (or number of living at the end of year *t*).

Sum of weighted squares deviations is divided into two parts: 1. from 60 to 90 years, 2. from 91 to 100.

It will be calculated like: $\sum_{60}^{90} WSD$ and $\sum_{91}^{100} WSD$.

At first sum of *WSD* is calculated in age interval <60; 90>. The same age interval was used for the estimation of unknown parameters for Kannisto. The second step is calculation of sum of *WSD* in age interval <91; 100>. This criterion could be used for the evaluation of analytical function suitability.

Calculation of mortality tables

In the next part, complete mortality tables will be calculated. At first, age–specific death rates:

$$m_{t,x} = \frac{M_{t,x}}{E_{t,x}}, \qquad (3)$$

where $M_{t,x}$ is the number of deaths in year *t* and at completed age *x*, $E_{t,x}$ is the exposure to risk in year *t* and age *x*.

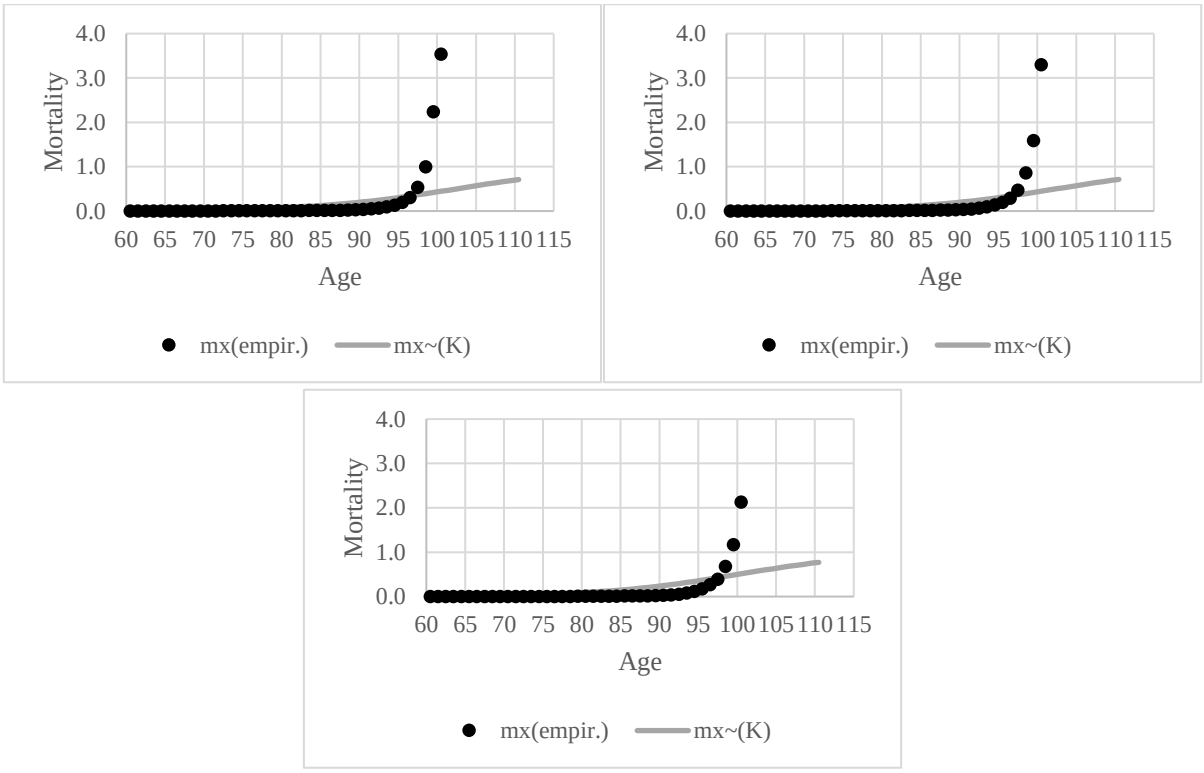
For those over 60+, mortality was modelled using the Kannisto model (1). The next steps were performed according to the algorithm used to calculate the complete mortality tables (Fiala, 2002). Life expectancy was used as an output.

In the last part, an additional indicator was calculated - modal length of life (Langmarová, Arltová, 2014). The value was estimated as the age at which the table number of deaths is maximum. Subsequently, the value was corrected by adding 0.5 (i.e. half of the used age interval) (Dotlačilová, 2019).

2 Results

This paper will analyze mortality in the Czech Republic in recent years. Greater attention will be paid to the impact of the Covid 19 pandemic on mortality.

Fig. 1: Males – modelled mortality from 2018 to 2020



Source: data CZSO (2022), author's calculation

We will first look at modelled mortality using the Kannisto model. When comparing individual years, the biggest difference is probably evident in the age range of 95 - 100 years. From the last figure it is evident that there was an increase in mortality in the year 2020. In the last year we can also see that Kannisto's model is beginning to deviate earlier from the observed deaths rates.

Tab. 1: Males - estimated parameters of Kannisto and test criterion

	2018	p-value	2019	p-value	2020	p-value
beta	0,000011	0	0,000010	0	0,000008	0
gamma	0,111469	0	0,112708	0	0,116627	0
R^2		0,9978		0,9979		0,9987
WSD		15,34		14,32		3616,06
WSD2		3,53		4,88		817,65

Source: data CZSO (2022), author's calculation

The table (Tab. 1) shows estimates of unknown parameters for the Kannisto model and these estimates are supplemented by *p*-values. Then there are the values of the criteria used to evaluate the results obtained (sum of *WSD* in the age range 60 - 90 years and sum of *WSD* for

ages 91 - 100). A closer look at the values obtained shows that the model works relatively well in 2018 and 2019. In 2020, when the covid-19 pandemic began to manifest itself, the values of the criterion are significantly higher.

Tab. 2: Males – values of life expectancy

males	**2018**	**2019**	**2020**
e60	19,4	20,6	18,9
e65	15,5	16,6	15,2
e70	12,0	13,0	11,9
e75	9,0	9,9	9,1
e80	6,5	7,3	6,6
e85	4,7	5,3	4,6
e90	3,3	3,8	3,2
mode	81,5	83,5	82,5

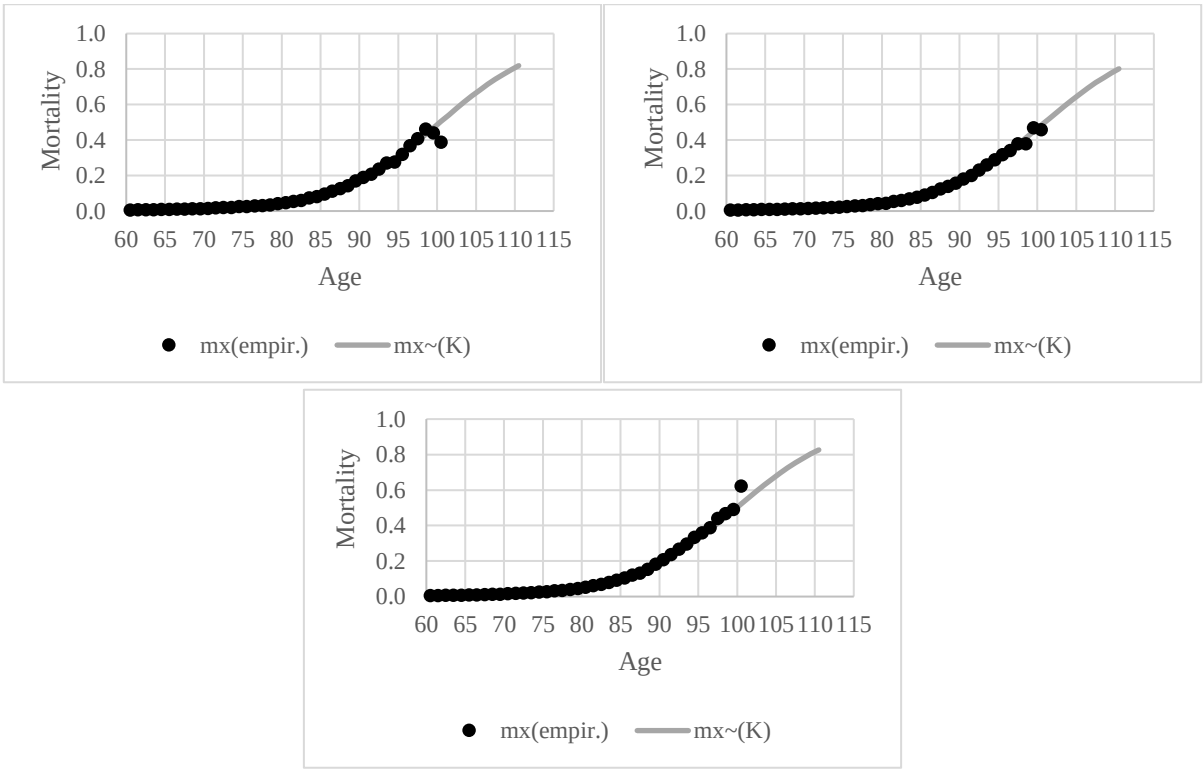
Source: data CZSO (2022), author's calculation

To complement the analysis, the values of life expectancy for persons 60+ (for selected ages) and modal age of death (i.e. the age at which people most often die) are also added.

In recent years, there has been an increase in length of human life (life expectancy and modal age of death). In 2018 and 2019, we can confirm this conclusion based on the results obtained. However, in 2020, life expectancy decreased in most of the selected ages.

The next part will be devoted to the population of females in the Czech Republic.

Fig. 2: Females – modelled mortality from 2018 to 2020



Source: data CZSO (2022), author's calculation

Looking at the individual figures for the females' population in the Czech Republic. We can say that Kannisto's model works relatively well in all analyzed years up to 100 years. However, it is also necessary to draw attention to the fact that mortality also increased for females (not only for males) in the last analyzed year.

Tab. 4: Females - estimated parameters of Kannisto and test criterion

	2018	p-value	2019	p-value	2020	p-value
beta	0,000000	0	0,000000	0	0,000000	0
gamma	0,149120	0	0,146468	0	0,147219	0
R2		0,9991		0,9991		0,9995
WSD		16,47		12,95		10,88
WSD2		18,73		13,71		11,40

Source: data CZSO (2022), author's calculation

From the obtained values of the evaluation criterion it is also clear that the Kannisto model works relatively well not only between the ages of 60 - 90 years but also in the age range of 91 - 100 years. This also applies to 2020, which has already been affected by the Covid-19 pandemic.

Tab. 5: Females – values of life expectancy

females	2018	2019	2020
e60	24,8	25,0	24,1
e65	20,2	20,4	19,5
e70	15,8	16,0	15,2
e75	11,9	12,1	11,4
e80	8,5	8,7	8,1
e85	5,8	6,0	5,6
e90	3,9	4,0	3,7
mode	87,5	87,5	86,5

Source: data CZSO (2022), author's calculation

As already mentioned, there has been an increase in mortality among women in the last year analyzed. This fact is also reflected in the results of the calculation of life expectancy. When comparing the years 2019 and 2020, we can observe a decrease in the values of the average life expectancy of x-year-olds, which is caused by increased mortality.

Conclusion

In this paper, an analysis of mortality in the Czech Republic in recent years has been prepared. Attention was also focused on the impact of the Covid 19 pandemic on mortality. The life expectancy of *x*-years-olds and the modal age at death were used, among other things, for the illustrative development.

The Kannisto model was used to model mortality in people aged 60 and older.

Looking at the figures of modelled mortality, it is possible to say that Kannisto's model works relatively well until 2019. In 2020, it is then possible to observe larger deviations from modelled mortality (this is especially true for males' population). To verify this conclusion, a custom test criterion (sum of weighted deviation counts) was proposed. This criterion provides relatively low values for both selected age ranges. The only exception is 2020 for the males' population. Here the criterion reaches orders of magnitude higher values (we can therefore say that the model chosen here does not work best).

To supplement the analysis, the values of life expectancy in selected ages as well as the estimates for modal age at deaths were also published. By 2020, which is affected by the pandemic, it can be seen that life expectancy has decreased in higher ages. This is directly

related to higher mortality. The decrease is also evident in the values of modal age at deaths. But for modal age at deaths, it should be noted that these are only approximate estimates.

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Contact

Petra Dotlačilová

University of Economics in Prague (Dep. of Mathematics)

Winston Churchill Sq.4, Prague 3, 130 67

petra.dotlacilova@vse.cz