ANALYSIS OF MORTALITY OF CZECH POPULATION

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Abstract

It is a well-known fact that human life is being extended. The improving level of medical care or perhaps lifestyle changes have its influence on this. People want to live healthier. They pay more attention to what they eat and also exercise more often. But how will it manifest itself if an extraordinary event (e.g., a pandemic) intervenes in this favourable development?

In last years, the mortality of the Czech population has been affected by the covid 19 pandemic. The focus will therefore be primarily on the analysis of mortality in last years. When will more emphasis be placed on the mortality of persons in higher age?

The aim of this article is to model mortality of the elderly using a logistic function. Subsequently, an evaluation of mortality even among the oldest persons based on the selected criteria. One of these will be adjusted coefficient of determination and the second one will be own proposed criterion.

Key words: mortality, mortality modeling, logistic function, Kannistö model

JEL Code: J10, J11, J19

Introduction

In recent years, thanks to the improvement of medical care or greater emphasis on a healthy lifestyle, human life has been extended (Kannistö et al. 1994 or Koschin, 1999). However, this positive development can be more or less influenced by, for example, a pandemic.

In 2019, covid 19 appeared in the population and scientists began to ask what impact it will have on life expectancy and related mortality.

The article will focus on the analysis of mortality in last years. Attention will be focused on the effects of the pandemic too.

1 Methodology

The paper will focus on the analysis of mortality in the Czech Republic during last years. The attention will be also focused on the effects of the covid 19 pandemic.

Several available indicators can be used to analyze mortality: life expectancy, modal length of life or median length of life can be mentioned (Langhamrová, Arltová, 2014).

In the first part, age specific deaths rates will be calculated, which will then be modeled using a logistic function (Kannistö's model) for persons at aged 60+. The obtained result will be evaluated after that (Dotlačilová, 2019 or Dotlačilová, 2020).

1.1 Kannistö's model

Kannistö's model is a type of logistic function. It is one of the most frequently used analytical functions for modeling mortality at higher ages. This feature assumed to have a slower increase in mortality (Burcin et al., 2010 or Gavrilov, Gavrilova, 2011).

In this article, Kannistö model was used in shape (Kannistö et al., 1994 or Thatcher et al. 1998 or Boleslawski, Tabeau, 2001)):

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

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

The age range from 60 to 90 was used to estimate the unknown parameters of this model. Based on the obtained estimates, the mortality curve was modeled. Using the estimated parameters, the death rate was extrapolated to ages over 90 years.

1.2 Evaluation of expected results

As the evaluation criterion will be used weighted squares deviations (*WSD*) – minimization criterion (Fiala, 2002). As weight will be used exposure to risk ($m_{t,x}^{(modelled)}$):

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

where $m_{t,x}^{(modelled)}$ is modeled mortality curve according to Kannistö (*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 calculated from 60 to 90 years.

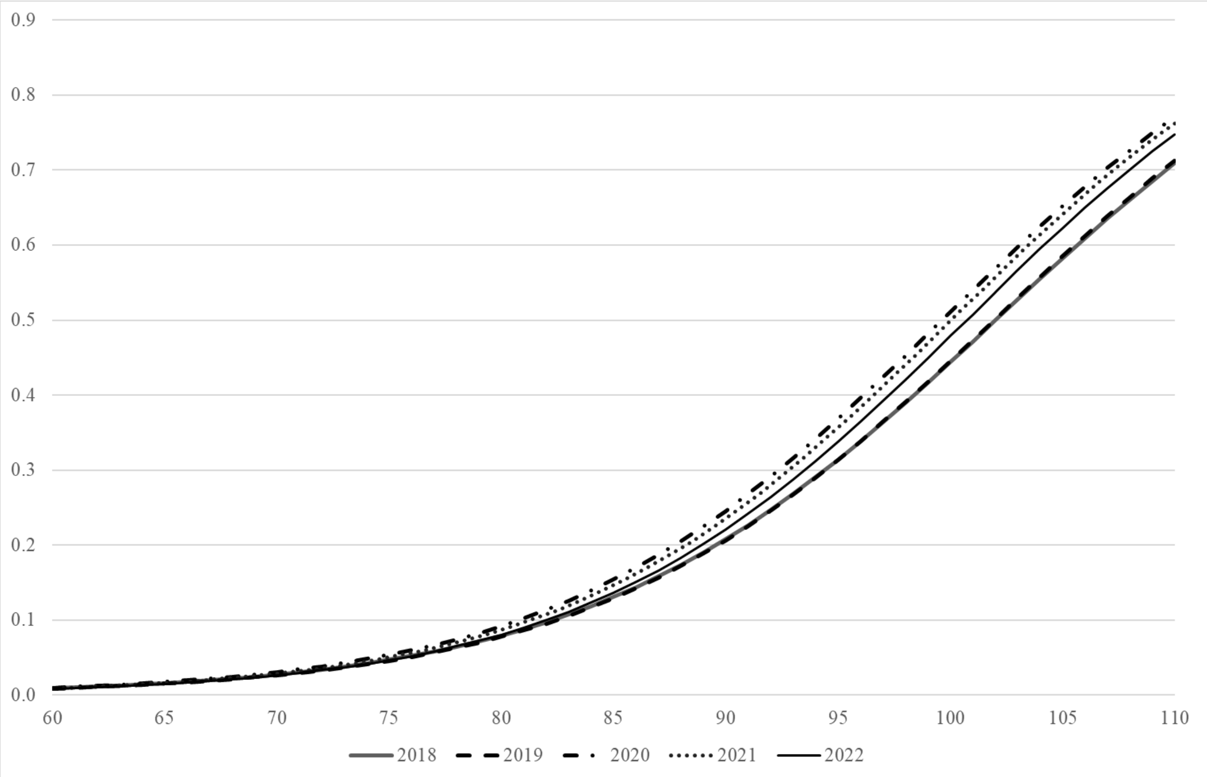
It will be calculated like: $\sum_{60}^{90} WSD$.

2 Results

In this paper, the mortality of the Czech population will be analyzed from 2018 to 2022. With regard to the differentiation of the mortality of males and females, the mortality will be analyzed separately by gender.

As was previously mentioned, the Kannistö model will be used to model mortality, which is mainly used for modeling in the highest ages (Czech Statistival Ofiice, 20019). The results obtained for individual years will then be compared (also taking into account the effects of the pandemic). Last but not least, the obtained results will be evaluated using own proposed criterion of the sum of weighted squared deviations.

Fig. 1: Mortality curve (Kannistö model) – males, 2018-2022



Source: Eurostat database (2024), author’s calculations

The first figure shows the result of modeled mortality according to the Kannistö model in selected years. Due to the nature of the model used, it was possible to expect a similar course of mortality during a human life. What differs is the level of death rate in each year. The impact of the pandemic can also be observed here. While the death rate was lower in 2018 and in 2019, this was not the case in other years. In 2020, it was increased. However, the positive thing is that in the following years there is a decrease again.

The following table lists the values of the adjusted R^2 criterion that can be used to evaluate the suitability of the model used to model the empirical data. This is supplemented by the values of the custom designed sum of *WSD* criterion.

Tab. 1: Adujsted R^2 – males, Czech Republic, 2018-2022

	2018	2019	2020	2021	2022
$R^2_{adj.}$ **Kannistö**	0.9978	0.9979	0.9987	0.9978	0.9979

Source: Eurostat database (2024), author's calculations

Looking at the first table, it is clear that the model used explains more than 99 % of the variability of the analyzed data in the age range from 60 to 90. However, there are small changes in individual years.

The following table contains the sum of *WSD* values.

Tab. 2: Sum of *WSD* values – males, Czech Republic, 2018-2022

	2018	2019	2020	2021	2022
WSD	17.80	18.53	17.39	60.98	20.59

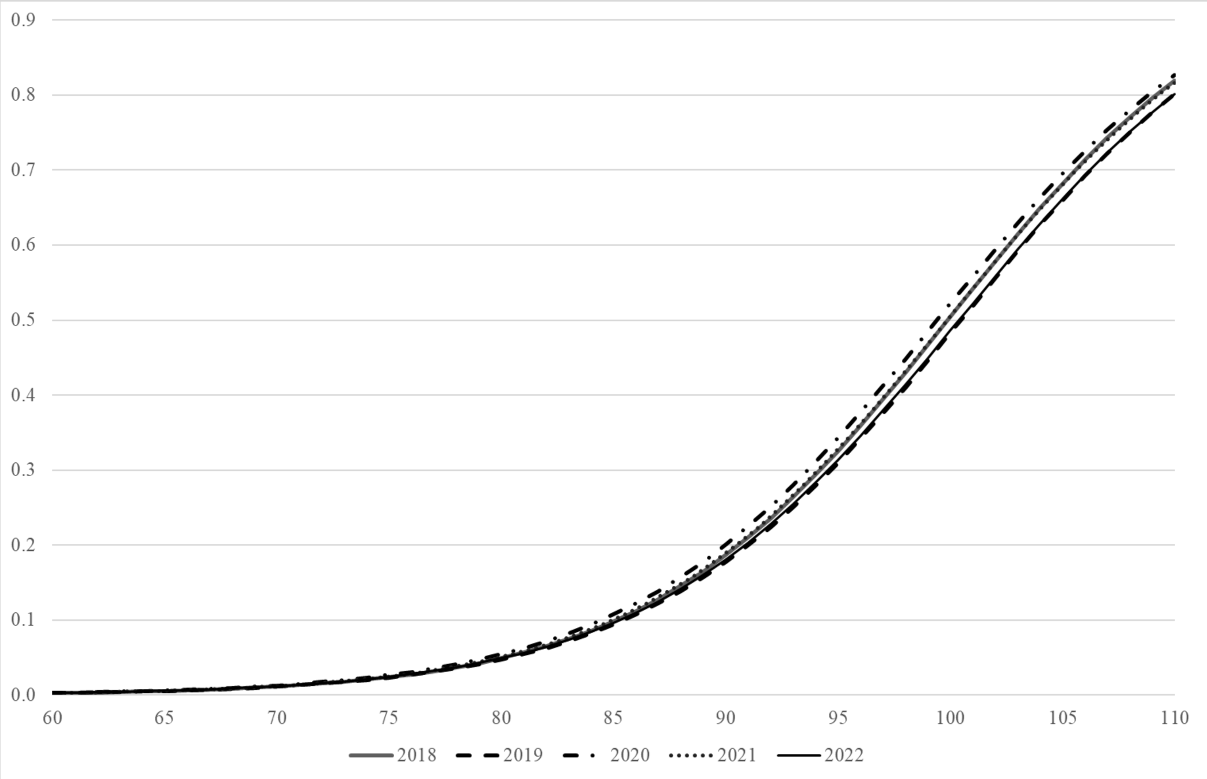
Source: Eurostat database (2024), author's calculations

The second table shows the values of the sum of weighted squared deviations (*WSD*). While the values are similar (with only minor changes) in 2018-2020, a more significant increase can be observed in 2021. From this result, it is probably possible to conclude that in 2020 the use of the Kannistö model is less appropriate than in previous years. This fact can also be caused by the effects of the pandemic.

The second part of the contribution is devoted to the modeling of females' mortality according to the Kannistö model.

The following figure shows the modeled mortality using the Kannistö model.

Fig. 2: Mortality curve (Kannistö model) – females, 2018-2022



Source: Eurostat database (2024), author's calculations

As was the case with males and females, it is possible to conclude that the highest level of death rate is reached in 2020. Here, too, the immediate impact of the pandemic can be seen. With the gradual recognition of covid 19, the death rate began to decrease again (although the decrease has not yet been significant).

To supplement the results, Table 3 shows the results of the adjusted R^2, which again confirms that the used model explained more than 99 % of the variability of the analyzed data in the age range of 60-99.

Tab. 3: adujsted R^2 – males, Czech Republic, 2018-2022

	2018	**2019**	**2020**	**2021**	**2022**
$R^2_{adj.}$ **Kannistö**	0.9991	0.9991	0.9995	0.9995	0.9993

Source: Eurostat database (2024), author's calculations

Table 4 supplements the previous output and shows values of the sum of *WSD*. It is evident from the obtained results that lower values are achieved in the females' population. As with males and females, there is an increase in 2021. This can again be explained by the impact of the pandemic.

Tab. 4: Sum of *WSD* values – males, Czech Republic, 2018-2022

	2018	**2019**	**2020**	**2021**	**2022**
WSD	16.47	12.95	10.88	30.90	10.56

Source: Eurostat database (2024), author's calculations

Conclusion

The article analyzed the mortality of males and females in the Czech Republic from 2018 to 2022. The aim was to model mortality using one of the available logistic functions, Kannistö model. Attention was also focused on the effects of the pandemic. The contribution of the paper can be considered the possibility of evaluating the results using the sum of the weighted squared deviations.

When modeling males' mortality, it is important to mention the fact that in 2020 there was an increase in both males' and females' mortality (probably due to the pandemic).

When assessing the suitability of the model using the adjusted R^2 as well as the own proposed criterion, it is possible to conclude that the values of both examined criteria change more or less in the monitored years. A more significant change can be observed in the criterion of the sum of *WSD* in 2021, when the effects of the pandemic were probably fully manifested in the suitability of the model used. Here, too, it is appropriate to mention that for a more complete view, it would be necessary to model mortality with other models.

Possibilities for the direction of further research: 1) would it be possible to use the proposed criterion to evaluate suitability also in higher things (or will some adjustments be necessary?)?, 2) if so, up to what age can the data be considered sufficiently reliable?, 3) how close do we want to get to the empirical values?

Annexes

Tab. 5: Values of parameters and *p*-values – males, Czech Republic, 2018-2022

	2018		2019	
	value	***p*-value**	**value**	***p*-value**
parameter *a*	0.000011	0.0000	0.000010	0.0000
parameter *b*	0.111469	0.0000	0.112708	0.0000
	2020		**2021**	
	value	**p-value**	**value**	***p*-value**
parameter *a*	0.000008	0.0000	0.000008	0.0000
parameter *b*	0.116627	0.0000	0.117252	0.0000
	2022			
	value	***p*-value**		
parameter *a*	6.92E-06	0.0000		
parameter *b*	0.1173642	0.0000		

Source: Eurostat database (2024), author's calculations

Tab. 6: Values of parameters and *p*-values – females, Czech Republic, 2018-2022

	2018		2019	
	value	***p*-value**	**value**	***p*-value**
parameter *a*	0.000000	0.0000	0.000000	0.0000
parameter *b*	0.149120	0.0000	0.146468	0.0000
	2020		**2021**	
	value	***p*-value**	**value**	***p*-value**
parameter *a*	0.000000	0.0000	0.000000	0.0000
parameter *b*	0.147219	0.0000	0.147468	0.0000
	2022			
	value	***p*-value**		
parameter *a*	4.26E-07	0.0000		
parameter *b*	0.145393	0.0000		

Source: Eurostat database (2024), author's calculations

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