DESCRIBING MORTALITY DIFFERENTIALS FROM THE PERSPECTIVE OF VARIOUS EFFECTS ON LIFE EXPECTANCY AND LIFE DISPARITY USING DECOMPOSITION METHODS: THE CASE OF CZECHIA

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Abstract

The growth in life expectancy has accelerated since the 1990s in Czechia, which preceded a long period of stagnation or even a decrease during the communist era from the 1960s. This article aims to evaluate differences in mortality in terms of the impact of various effects on life expectancy and life disparity before and after the Velvet Revolution in Czechia. Three indicators were considered – life expectancy at birth, temporary life expectancy between ages 0 and 65, and the life disparity measure e-dagger (e†). In the article, we followed the decomposition method according to *Arriaga* (1984). Based on this method, the effect of mortality was further decomposed into an exclusive effect reflecting improved or worsened mortality in the given age group and into an interaction effect reflecting changes in mortality as a whole. Based on the results, it was found that the indirect effect prevailed in the case of life expectancy, while the direct effect dominated in the life disparity measure. Furthermore, we focused on the differences in life expectancy at birth between the sexes and between the two countries forming parts of the former Czechoslovakia – Czechia and Slovakia. For this purpose, we followed the contour decomposition method, so that we distinguished the effect of changes in mortality corresponding to the initial period and the effect of changes corresponding to changes in mortality in terms of time.

Keywords: mortality, life expectancy, life disparity, decomposition method, contour decomposition, Czechia, Slovakia
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INTRODUCTION

In the period from 1960 to 1989, Czechoslovakia was under a communist regime, and since 1989 (following the so-called Velvet Revolution) Czechia experienced a transformation when significant political, economic, and social changes began. The significant progress

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in medicine in most European countries in the last century indirectly increased life expectancy in Europe to above the age of 75. Since life expectancy kept going up, society began to address the issue of longevity and quality of life. Fundamental changes in the state of public health and the mortality rate of its population took place in Czechia when the economy transformed from a totalitarian society with a centrally planned economy to a democratic society with a market economy (*Burcin*, 2009). Healthcare reform took place, private health care was developed, and the availability of effective drugs, especially for the treatment of circulatory diseases, greatly improved (*Fiala et al.*, 2018). In general, mortality has decreased during the era of political and socio-economic changes in society since the Velvet Revolution in Czechia in 1989, especially among infants and middle-aged and elderly persons (*Morávek – Langhamrová*, 2020). The mortality of middle-aged and elderly persons has currently improved the most as a consequence of lower mortality caused by circulatory system diseases (*Arltová et al.*, 2013). Also, thanks to huge progress in medicine and technologies, the mortality of older and the oldest persons has been greatly reduced (*Vrabcová – Arltová*, 2015). In this article, we focused on the evaluation of the mortality of the Czech population before and after the Velvet Revolution, namely in the periods of 1961–1991 and 1991–2019. As the authors *Ginter et al.* (2009) pointed out, there was an evident stagnation of life expectancy among communist countries because of socialized medicine that was negatively affected by a lack of up-to-date medications and the absence of modern diagnostic equipment. However, after the fall of the Iron Curtain, the situation changed and life expectancy began to rise. According to *Rychtaříková* (2004), the decline or stagnation in health conditions from the mid-1960s to the mid-1980s affected most of the population of Central and Eastern Europe, including Czechia. As *Vallin et al.* (1989) noted, this finding did not affect all ages equally. Infant and child mortality continued to decline, but the first age groups to be affected by this reversal in life expectancy during the early 1960s were the elderly, followed rapidly by younger adults. In the immediate pre-transition years (1985–1989), health conditions already slightly improved in Czechia and life expectancy at birth began to increase (*Rychtaříková*, 2004). According to *Arltová et al.* (2013), in the mid-1980s in Czechia, mortality started to decline thanks to further improvement in living conditions, medical discoveries, and progress in medicine. From a historical point of view, Czechia and Slovakia were part of one state – Czechoslovakia – until 1992, when two separate states were created. In the case of comparing the difference in mortality between Czechia and Slovakia, *Fiala et al.* (2018) observed a divergence in mortality with Czechia performing better than Slovakia from 1989 across virtually all age categories (infant mortality, working age, old age). Also, according to the authors, Czechia was historically characterized by demographic patterns of more of a Western type, while Slovakia (where the demographic transition occurred later) followed the more Eastern European pattern.

METHODOLOGY AND DATA

To describe mortality differentials before and after the Velvet Revolution in Czechia, the following indicators were selected – life expectancy at birth, temporary life expectancy between ages 0 and 65, and the life disparity measure e-dagger (e†). Life expectancy is a widely used aggregate indicator, which reflects the overall mortality level of a population and is not affected by its age structure. In addition, the concept of temporary life expectancy at a specific age is used. *Arriaga* (1984) pointed out that life expectancy at higher ages may not reflect the actual mortality of those ages but instead a simplistic assumption based on a model life table or a mathematical function, especially in countries with unreliable statistics. Considering the low number of deaths in old age and the lower reliability of data on the mid-period population in older age, the mortality rates in the highest ages are being replaced by some of the analytical models (*CZSO*, 2021). To model mortality rates in the highest ages, which are used as input data, the Czech Statistical Office uses a logistic curve defined according to Kannisto, the use of which corresponds to the latest studies, especially given the fact that it takes into account the slowing of the increase in mortality with age (so-called deceleration). However, even so, Czechia is considered a country with reliable statistical data.

The temporary life expectancy ${}_{i}e_{x}$ from age x to $x + i$ represents the average number of years that a group of persons alive at exact age x will live from age x to $x + i$ years (*Arriaga*, 1984):

$$ {}_{i}e_{x} = \frac{T_x - T_{x+i}}{l_x} . $$

where T_x, T_{x+i} is the number of years of life to be lived by the life table population at a given age x and $x + i$, and l_x are the number of survivors at age x.

We calculated the temporary life expectancy ${}_{65}e_0$ between ages 0 and 65 representing the expected number of years to be lived by a group of persons living from birth to 65 years.

Finally, the life disparity measure e-dagger (e†) according to the authors *Shkolnikov et al.* (2011) was selected as a dispersion measure that equals the average expected lifetime lost at death. This indicator is also a measure that represents diversity at the age at death equal to a weighted average of inter-individual differences in age at death (*Shkolnikov et al.*, 2011). *Hiam et al.* (2021) identified the indicator as the average gap between an individual's age at death and their remaining life expectancy at that age. This indicator comes from the original idea of the author *Keyfitz* (1977), according to whom "everybody dies prematurely" since every death "deprives the person involved of the reminder of his expectation of life". To calculate e-dagger (e†) representing lifetime losses, a spreadsheet for the calculation of life table dispersion measures by *Shkolnikov and Andreev* (2010) was used. The authors noted that this type of measurement has a long tradition in demography and it was firstly obtained by *Keyfitz* (1977) in his derivation of a formal relationship between a small change in age-specific mortality rates and its effect on life expectancy. The following discrete formula for its calculation of e-dagger $e_x^{\dagger}$ was used in the spreadsheet (*Andreev – Shkolnikov*, 2012):

$$ e^{\dagger} = \Sigma_x \left[d_x \frac{1}{2} (e_x + e_{x+1}) \right] , $$

where ${}_{1}d_x$ and e_x are the life table deaths within age group $[x, x + 1)$ and life expectancies at age x.

Decomposing a difference in life expectancy is useful in estimating what mortality differences in a specific age group contribute to the total change in life expectancy at birth (*Preston et al.*, 2001). The so-called one-dimensional decomposition is most often used, where the difference in life expectancy is considered by age only. In addition, there is also a two-dimensional decomposition, where the difference in life expectancy is divided into age group contributions and according to some socio-demographic characteristics such as causes of death, education, marital status, etc. From a historical perspective looking back to the 1980s, there are two main approaches to decomposing a difference in life expectancy, the continuous approach according to *Pollard* (1982) and the discrete approach using the formula by Arriaga (1984). These two approaches formally lead to the same results, nevertheless the Arriaga formula is easier to apply to traditional life tables (*Preston et al.*, 2001). In life table terms of the number of survivors l_x and the life expectancy e_x, *Ponnapalli* (2005) describes the formula with regards to Arriaga's original proposal as follows:

$$ \Delta_{e_0} = l_x^{\,1} \cdot (e_x^{\,2} - e_x^{\,1}) - l_{x+n}^{\,1} \cdot (e_{x+n}^{2} - e_{x+n}^{1}) , $$

where $l_x^{\,1}$ and l_{x+n}^{1} are the number of survivors at age x and $x{+}n$ for period 1; $e_x^{\,1}$, e_{x+n}^{1} and $e_x^{\,2}$, e_{x+n}^{2} are life expectancies at age x and $x + n$ for period 1, respectively period 2.

For the open-ended age group, the contribution of the given age group to the overall difference in life expectancy at birth is calculated as (*Ponnapalli*, 2005):

$$ \Delta_{e_0} = l_x^{\,1} \cdot (e_x^{\,2} - e_x^{\,1}) . $$

where $l_x^{\,1}$ are the number of survivors at age x for period 1; $e_x^{\,1}$ and $e_x^{\,2}$ are life expectancies at age x for period 1, respectively period 2.

In addition to focusing on the effect of mortality on a change in life expectancy, *Arriaga* (1984, 1989) distinguishes three different effects of mortality changes on life expectancy – direct, indirect, and interaction effects. The direct effect of mortality changes on life expectancy is the change in the number of years lived within a particular age group as a consequence of a mortality change in that given age group. The indirect effect is the number of years of life added to or removed from a given life expectancy because a mortality change within a specific age group produces a change in the number of survivors at the end of the age interval. Both the direct effect and indirect effect take into account a mortality change in a specific age group, independent of the mortality changes in other age groups. The interaction effect results from the combination of the changed number of survivors at the end of the age interval and the lower or higher mortality rates at older ages.

To compute these effects, in life table terms of l_x and e_x, *Ponnapalli* (2005) listed formulas with regards to Arriaga's original proposal as follows:

$$ {}_iDE_x = l_x^{\,1} \cdot (e_x^{\,2} - e_x^{\,1}) + l_x^{\,1} \left(\frac{l_{x+n}^{\,1} \cdot e_{x+n}^{\,1}}{l_x^{\,1}} - \frac{l_{x+n}^{\,2} \cdot e_{x+n}^{\,2}}{l_x^{\,2}} \right); $$

$$ {}_iIE_x = e_{x+n}^{\,1} \left(\frac{l_x^{\,1} \cdot l_{x+n}^{\,2}}{l_x^{\,2}} - l_{x+n}^{\,1} \right), $$

where $l_x^{\,i}, l_{x+1}^{\,i}$ is the number of survivors at the age of x or $x + 1$ in the year 1 or 2; e_x, e_{x+n} is life expectancy at the age of x or $x + n$ in the year 1 or 2.

The direct effect is explained by *Arriaga* (1984) as a result of a change in life years within a particular age group due to the mortality change in that group. The indirect effect is related to a change in the number of survivors at the end of the age interval as a consequence of the mortality change within a specific age group (*Arriaga*, 1984). The effect of the overall mortality change on life expectancy that cannot be explained by, or assigned to, a particular age group refers to the interaction effect (*I*) (*Ponnapalli*, 2005):

$$ {}_iI_x = (e_{x+n}^{\,2} - e_{x+n}^{\,1}) \left(\frac{l_x^{\,1} \cdot l_{x+n}^{\,2}}{l_x^{\,2}} - l_{x+n}^{\,1} \right), $$

where $l_x^{\,1}, l_x^{\,2}, l_{x+n}^{\,1}, l_{x+n}^{\,2}$ is the number of survivors at the age of x and $x + n$ in the year 1 and 2; $e_{x+n}^{\,1}, e_{x+n}^{\,2}$ is life expectancy at the age of $x + n$ in the year 1 and 2.

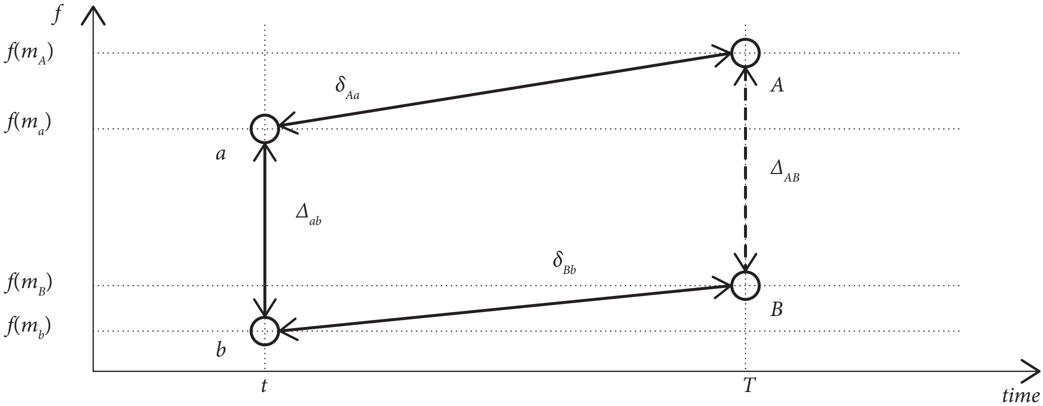
As *Ponnapalli* (2005) noted, the sum of the interaction and exclusive effects is equal to the overall effect. For the open-ended age group, the effect is assumed to be a direct effect.

The decomposition of the other two indicators – temporary life expectancy between ages 0 and 65 and the life disparity measure e-dagger (e†) follows a similar logic, but in the formulas, it is necessary to replace the life expectancy with the other indicator.

Nowadays, the earlier method is generalized to broader decomposition problems. *Andreev et al.* (2002) proposed the algorithm of stepwise replacement as a universal tool for the decomposition of differences between aggregate measures computed from demographic tables. This method can be used to decompose the age components further with respect to age and population composition by social group. Moreover, such decomposition can be accomplished using the same general algorithm including the replacement of age-group-specific mortality rates and age-specific population weights of groups. As an extension of the stepwise replacement method, *Jdanov et al.* (2017) proposed the contour decomposition method based on the original idea of the authors *Arriaga* (1984) and *Pollard* (1982) that permits a difference in an aggregate measure at a final time point to be split into additive components corresponding to the initial differences in the event rates of the measure and differences in trends in these underlying event rates. The method can be useful in the study of divergence and convergence tendencies in the mortality of a population. Using the method, we focused on the difference in life expectancy at birth between sexes and between two countries as parts of former Czechoslovakia (dissolved on 1 January 1993) – Czechia and Slovakia.

According to the authors *Jdanov et al.* (2017), using this method is possible in determining the extent to which the sex or intercountry difference of today is a legacy of past age-specific differences and the extent to which it is a result of differences in age-specific mortality trends. The method splits the age components of a contemporary difference into partitions produced by the initial mortality differences between the two populations (initial age components) and mortality trends in the two populations (trend age components). *Jdanov et al.* (2017) noted that splitting a cross-sectional difference according to the initial difference and the trend is not straightforward because of a difficulty related to the nonlinearity of the functions

Figure 1 Cross-sectional differences and longitudinal changes in an aggregate demographic measure between two populations



Source: Jdanov et al. (2017, p. 1584).

being decomposed, such as life expectancy or lifetime disparity. For any age group, the respective age component of the decomposition of the difference between the two populations at the final time point cannot be obtained by a summation of the age components from the three independent decompositions. The decomposition problem is due to the fact that life expectancy is a highly nonlinear aggregate function of age-specific mortality rates, with respect to populations and years being compared (*Jdanov et al.*, 2017; *Horiuchi et al.*, 2008).

Jdanov et al. (2017) introduced the method clearly as follows (see Figure 1): the between-population difference at the second time point T depends on both the initial age-specific mortality differences at time point t, and on changes in age-specific mortality between t and T. Then, the final difference Δ_{AB} is to be split into age-specific contributions produced by the initial between-population difference in the age-specific rates (initial component) and contributions due to different (within-population) age-specific mortality trends (trend component):

$$\Delta_{AB} = \sum_{i=1}^{n} \Delta_{AB}^{i} \, .$$

The primary requirement is that at every age, the sum of the initial and trend components is equal to the total age-specific component (*Jdanov et al.*, 2017):

$$\Delta_{AB} = \sum_{i=1}^{n} (Initial^i + Trend^i) = \sum_{i=1}^{n} (\Delta_{ab|AB}^{i} + \delta_{ab|AB}^{i}) \, ,$$

$$Initial^i + Trend^i = \Delta_{ab|AB}^{i} + \delta_{ab|AB}^{i} = \Delta_{AB}^{i} \, , \; i = 1, ..., \mathrm{n} \, ,$$

where $\Delta_{ab|AB}^{i}$ and $\delta_{ab|AB}^{i}$ denote the initial and trend component.

For the calculation of contour decomposition, an R-script for the assessment of the cross-sectional and the longitudinal components of a difference between two values of an aggregate demographic measure is provided by the authors *Jdanov and Shkolnikov* (2014).

Life tables produced by the Czech Statistical Office (CZSO) for the period from 1961 to 2019 for Czechia, for men and women, were used as input data. This selected period was further divided into two parts for their comparison over time, the years 1961–1991 and 1991–2019. The years 1961 and 1991, in which the census took place, were selected. The year 2019 was chosen because it is the last year before the outbreak of the Covid-19 pandemic. It is thus possible to compare the two selected periods with each other to a large extent. For a comparison of mortality between Czechia and Slovakia, life tables from the publicly available Human Mortality database were used as input data due to the uniform methodology for calculating life tables.

MORTALITY DIFFERENTIALS IN CZECHIA

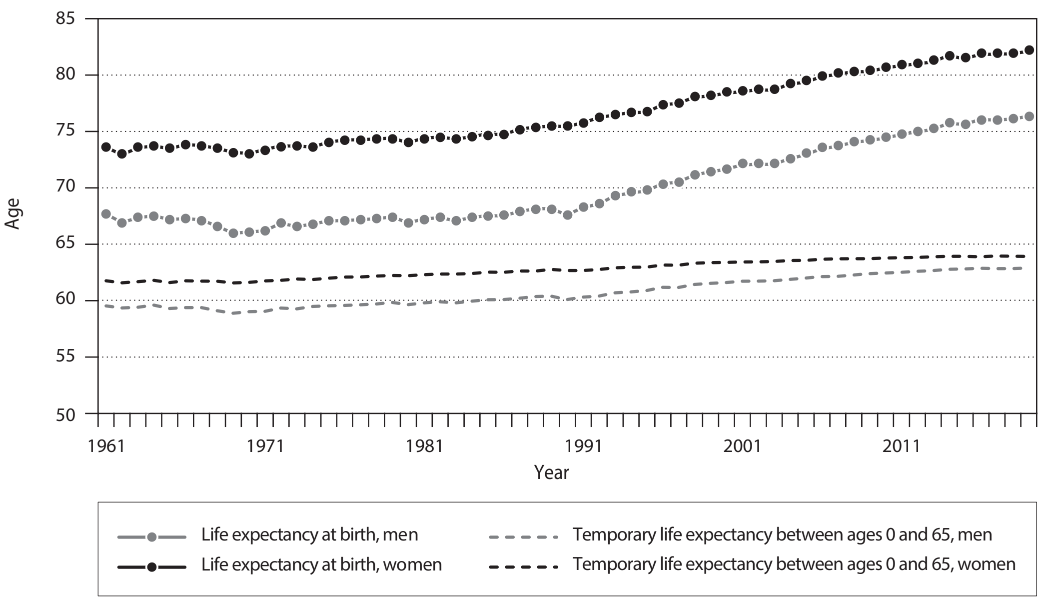
As the first in this part of the article, the differences in mortality in Czechia for the period 1961–2019 were evaluated based on the life expectancy at birth (LE) of men and women. In addition, other life expectancy indicators – the temporary life expectancy between ages 0 and 65 (TLE 65) and the life disparity measure (e†) – were calculated. In the second part of the article, the differences in these indicators in terms of time were distributed by decomposition methods into contributions of age groups according to the influence of direct, indirect, and interaction effects. Finally, we focused on the sex gap in life expectancy to study the impact of changes in mortality between men and women concerning the initial period and in terms of trend. Furthermore, we examined the life expectancy gap between two countries – Czechia and Slovakia – to evaluate convergence or divergence tendencies in mortality.

Life expectancy and life disparity: before and after 1989

The development of life expectancy at birth and temporary life expectancy between ages 0 and 65 by sex in Czechia in the period of 1961–2019 are shown in Figure 2. In the first period 1961–1991, life expectancy at birth tended to stagnate with a moderate increase, both in men and women. Male life expectancy increased from 67.7 years in 1961 to 68.2 years in 1991, and in the case of women it increased from 73.6 years in 1961 to 75.8 years in 1991. In the period 1991–2019, life expectancy at birth increased faster compared to the first period. The highest value of life expectancy was recorded in 2019, looking at its overall development. This year, life expectancy at birth reached 76.3 years for men and 82.1 years for women. Looking at the temporary life expectancy between ages 0 and 65 (Figure 2), gradually increasing values towards the age of 65 can be seen. While in the first period of 1961–1991 for women the value ranged from 61.7 years to 62.7 years in the whole period, for men it exceeded 60.0 years for the first time in 1985. Subsequently, in the second period since 1991, the growth of temporary life expectancy between ages 0 and 65 continued, and this growth was faster in men compared to women.

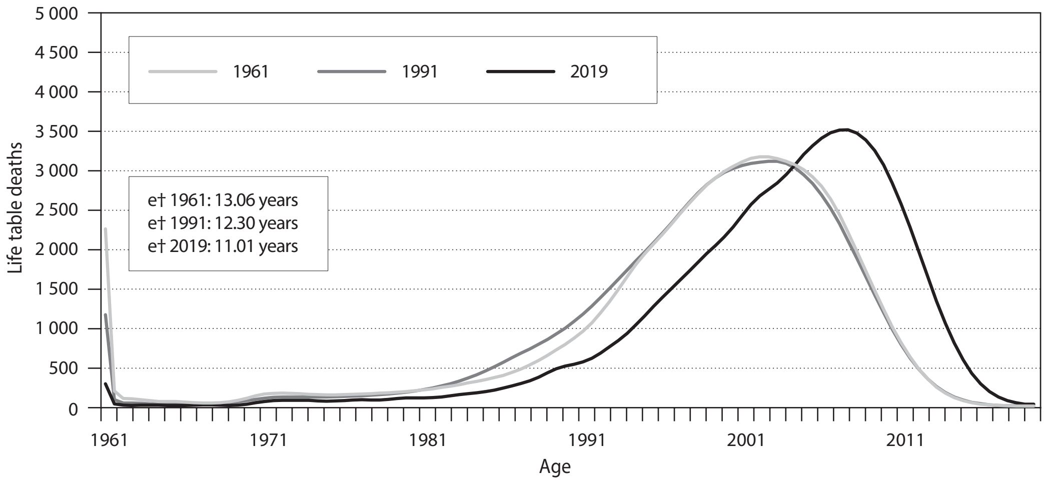
Life table deaths and life disparity (e†) in selected years 1961, 1991, and 2019 are shown in Figure 3 for men and Figure 4 for women. In a comparison

Figure 2 Life expectancy at birth and temporary life expectancy between ages 0 and 65 by sex in Czechia, in 1961–2019



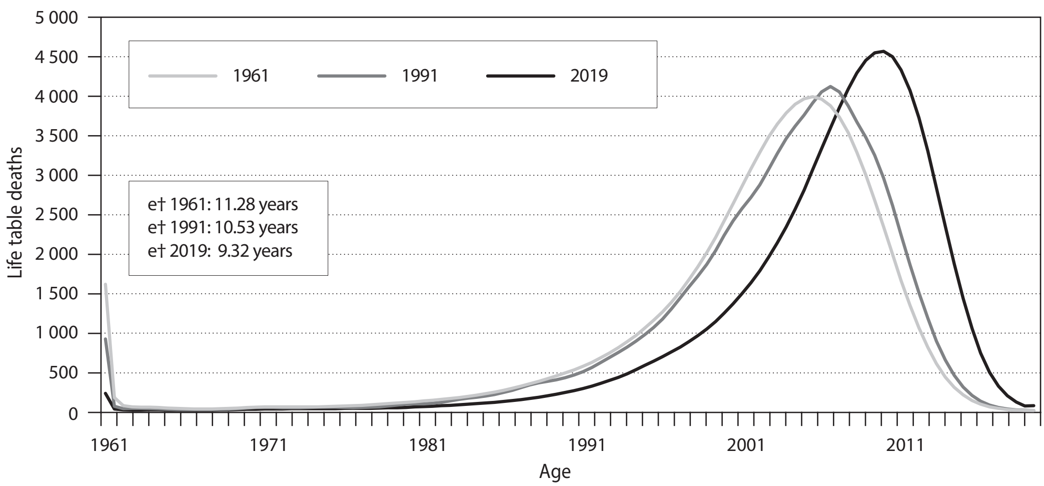
Source: CZSO data, author's calculations.

Figure 3 Life table deaths and life disparity (e†) in 1961, 1991, and 2019 in Czechia, men



Source: CZSO data, author's calculations.

Figure 4 Life table deaths and life disparity (e†) in 1961, 1991, and 2019 in Czechia, women



Source: CZSO data, author's calculations.

between 1961 and 1991, deceased women are still moving towards older age, similar to men, but dying at a younger age compared to women. In terms of variability, looking at the shape of the life table deaths of men and women, lower variability of values in women is evident. The values of the indicator of the life disparity indicator e-dagger (e†) tended to decrease over time, both in men and women. This means that differences in lifespans decrease over time among individuals.

Exclusive and interaction mortality effect

The impact of mortality on the indicators of life expectancy and life disparity can be assessed from several perspectives. The first one is the direct effect (DE), which is associated with the improvement or worsening of mortality in a given age group. The second one is the indirect effect (IE), which means an increase or decrease in the number of survivors as a consequence of the improvement or worsening of mortality in a given age group at the end of a given age interval. If changes cannot be explained by either of these effects, it concerns the interaction effect (I) that is not associated with the improvement or worsening of mortality in a given age group, but with mortality as a whole. The difference in life expectancy is usually broken down by sex and age group. Contributions to a change in life expectancy, temporary life expectancy, and life disparity by age and sex for Czechia are shown in Table 1 for the first period of 1961–1991 and Table 2 for the second period of 1991–2019. In the first period, 1961–1991, life expectancy at birth rose by +0.58 years for men, and by +2.16 years for women. Male mortality improved mainly at the age at birth and up to the age of 44, but at older ages the mortality worsened, mostly in the age group 45–64 years (–0.62 years) and 65–84 years (–0.06 years). The indirect effect was positive in men

Table 1 Contributions of three effects to a change in life expectancy at birth, temporary life expectancy between ages 0 and 65 and life disparity (e†), Czechia, 1961–1991

Indicator	Effect	Age Group						Total
		0	1–14	15–44	45–64	65–84	≥85	
Men								
Life expectancy at birth	Direct	0.01	0.00	0.00	–0.02	0.00	0.00	0.00
	Indirect	0.75	0.32	0.18	–0.61	–0.06	0.01	0.58
	Interaction	0.00	0.00	0.00	0.01	0.00	0.00	0.01
	Total	0.75	0.32	0.18	–0.62	–0.06	0.01	0.58
Temporary life expectancy between ages 0 and 65	Direct	0.01	0.00	0.00	–0.02	0.00	0.00	0.00
	Indirect	0.65	0.28	0.16	–0.32	0.00	0.00	0.78
	Interaction	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.67	0.28	0.16	–0.33	0.00	0.00	0.78
Life disparity (e†)	Direct	–0.76	–0.32	–0.22	0.57	0.07	0.00	–0.67
	Indirect	0.13	0.06	0.03	–0.27	–0.04	0.01	–0.08
	Interaction	0.00	0.00	0.00	–0.01	0.00	0.00	–0.01
	Total	–0.63	–0.27	–0.19	0.30	0.03	0.01	–0.76
Women								
Life expectancy at birth	Direct	0.01	0.00	0.00	0.01	0.04	0.01	0.07
	Indirect	0.51	0.21	0.27	0.29	0.66	0.05	1.99
	Interaction	0.01	0.00	0.01	0.02	0.06	0.00	0.10
	Total	0.53	0.22	0.28	0.31	0.76	0.06	2.16
Temporary life expectancy between ages 0 and 65	Direct	0.01	0.00	0.00	0.01	0.00	0.00	0.02
	Indirect	0.43	0.18	0.19	0.10	0.00	0.00	0.89
	Interaction	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Total	0.44	0.18	0.19	0.10	0.00	0.00	0.92
Life disparity (e†)	Direct	–0.50	–0.21	–0.24	–0.17	–0.35	–0.04	–1.52
	Indirect	0.07	0.03	0.06	0.11	0.44	0.05	0.76
	Interaction	0.00	0.00	0.00	0.00	0.01	0.00	0.01
	Total	–0.44	–0.18	–0.18	–0.05	0.10	0.01	–0.75

Source: CZSO data; author's calculations and processing.

(+0.58 years), and the direct and interaction effects were not significant in terms of mortality differentials. In women as well as in men, the indirect effect of mortality dominated with the value +1.99 years and the other two effects were not significant. Female mortality improved at all ages, mostly in the age group 65–84 years (+0.76 years). When considering age categories only up to the age of 65, the contribution to the difference in temporary life expectancy between ages 0 and 65 of men (+0.78 years) was positive and the highest share of this contribution represented the indirect effect of mortality. The same was true for women, where the value of the contribution reached +0.92 years, mainly due to the indirect effect of mortality. The contribution to the difference in the life disparity indicator (e†) was negative for both men and women, which means a reduction in losses of an expected lifetime. When comparing this indicator among men and women, the reduction of the indicator was similar, and the direct effect dominated this time more than in the case of life expectancy or temporary life expectancy between ages 0 and 65.

In the second period of 1991–2019 (Table 2), the growth in life expectancy at birth accelerated

Table 2 **Contributions of three effects to a change in life expectancy at birth, temporary life expectancy between ages 0 and 65 and life disparity (e†), Czechia, 1991–2019**

Indicator	Effect	Age Group						Total
		0	1–14	15–44	45–64	65–84	≥85	
Men								
Life expectancy at birth	Direct	0.01	0.00	0.01	0.07	0.13	0.02	0.24
	Indirect	0.60	0.20	0.99	2.34	1.87	0.10	6.08
	Interaction	0.07	0.02	0.20	0.72	0.74	0.03	1.78
	Total	0.67	0.22	1.20	3.13	2.74	0.14	8.10
Temporary life expectancy between ages 0 and 65	Direct	0.01	0.00	0.02	0.07	0.00	0.00	0.09
	Indirect	0.53	0.17	0.75	0.94	0.00	0.00	2.38
	Interaction	0.02	0.01	0.04	0.05	0.00	0.00	0.11
	Total	0.55	0.17	0.81	1.05	0.00	0.00	2.58
Life disparity (e†)	Direct	−0.58	−0.18	−0.81	−1.77	−1.13	−0.05	−4.53
	Indirect	0.10	0.04	0.30	1.15	1.32	0.09	3.00
	Interaction	−0.01	0.00	−0.01	0.05	0.19	0.01	0.23
	Total	−0.49	−0.15	−0.53	−0.57	0.38	0.06	−1.29
Women								
Life expectancy at birth	Direct	0.01	0.00	0.01	0.03	0.14	0.04	0.22
	Indirect	0.52	0.13	0.42	1.21	2.32	0.28	4.86
	Interaction	0.04	0.01	0.06	0.27	0.80	0.09	1.26
	Total	0.57	0.14	0.48	1.51	3.25	0.41	6.35
Temporary life expectancy between ages 0 and 65	Direct	0.01	0.00	0.01	0.03	0.00	0.00	0.04
	Indirect	0.43	0.10	0.28	0.38	0.00	0.00	1.19
	Interaction	0.01	0.00	0.01	0.01	0.00	0.00	0.02
	Total	0.44	0.10	0.29	0.41	0.00	0.00	1.25
Life disparity (e†)	Direct	−0.51	−0.12	−0.35	−0.92	−1.62	−0.15	−3.67
	Indirect	0.07	0.02	0.09	0.45	1.44	0.25	2.32
	Interaction	−0.01	0.00	−0.01	0.00	0.13	0.04	0.15
	Total	−0.45	−0.10	−0.26	−0.48	−0.05	0.14	−1.21

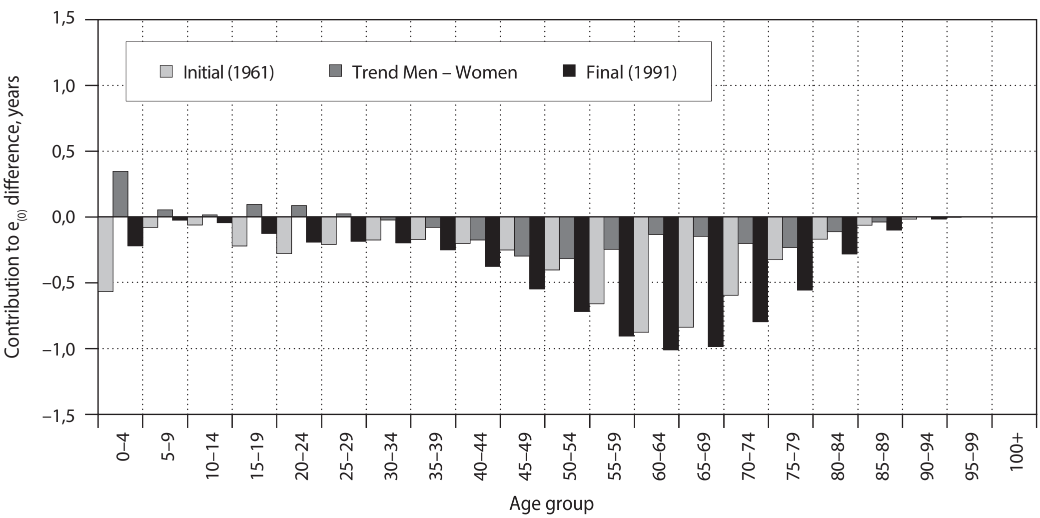
Source: CZSO data; author's calculations and processing.

by +8.10 years for men, and for women less than men, by +6.35 years. Male mortality has improved, especially between the ages of 15 and 85. The highest contributions were in the age group 45–64 years (+3.13 years), followed by 65–84 years (+2.74 years) and 15–44 years (+1.20 years). As in the first period, the indirect effect contributed the most to the improvement in mortality, but the interaction effect increased compared to the first period. Female life expectancy has increased mainly due to improved mortality in older age compared to men, especially in the age group 65–84 years (+3.25 years) and 45–64 years (+1.51 years). From the perspective of individual effects, the indirect effect prevailed in particular, and the interaction effect increased compared to the first period, both in men and women. The increase in temporary life expectancy between ages 0 and 65 was also more significant in the second period of 1991–2019, for men by +2.59 years and for women by +1.25 years. While in men the increase in the value of this indicator was influenced by the improvement in mortality in the age groups 45–64 (by +1.05 years), in women it was age 0 that contributed to the increase (by +0.44 years). In terms of effects, the indirect effect prevailed, other direct and interaction effects were less significant but contributed to the growth of the indicator values as well. Lifetime losses decreased in the second period as well as in the first period, for men by −1.29 years and for women by −1.21 years. In the case of this indicator, there was a significant direct effect, the values of which were negative, however, the indirect effect was also significant but with positive values, which means that the decrease in the values of this indicator was lower as a result.

Initial and trend mortality effects in life expectancy at birth sex gap

The difference in life expectancy at birth between sexes was −5.9 years in 1961, while by 1991 the difference increased to −7.9 years. Figure 5 shows contributions of differences in life expectancy at birth between men and women related to the initial period in 1961 in Czechia, and trend contributions in 1991 looking back to the development since 1961. The initial effect showed the difference in life expectancy between sexes in 1961, which was caused mainly by male excess mortality in the age group 60–64 (−0.88 years), followed by 65–69 (−0.84 years) and 55–59 (−0.66 years). It was also partly influenced by higher infant and child mortality in the age group 0–4 (−0.57 years). The trend effect values indicate a widening life expectancy at birth

Figure 5 Initial and trend contributions of differences in life expectancy at birth between sexes in 1991 in Czechia, looking back at the development since 1961



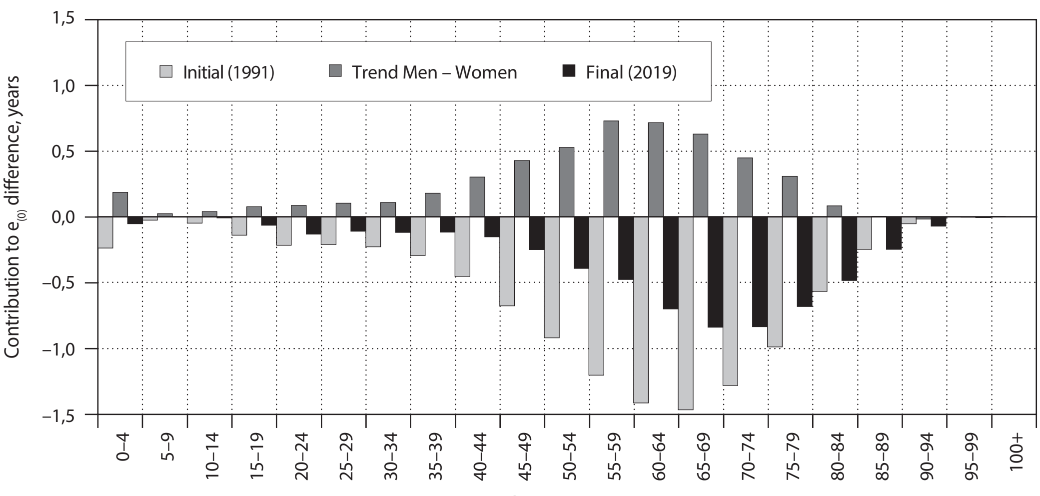
Source: CZSO data; author's calculations and processing.

sex gap between 1961 and 1991. In the case of this effect, the mortality of men aged from 0 to 29 years was improved, but on the contrary, male mortality in upper middle age worsened, namely in the age group 50–54 (−0.32 years). Overall, due to the values of the trend effect, the difference between the life expectancy of men and women deepened between 1961 and 1991, especially as a result of male excess mortality in the age group 60–64 (−1.0 years).

The initial and trend contributions of differences in the life expectancy at birth sex gap in 2019 in Czechia, looking back at the development since 1991, are seen in Figure 6. The difference in life expectancy between men and women decreased from −7.9 years in 1991 to −5.8 years in 2019, which is a positive trend and indicates a decrease in the difference of mortality between men and women in terms of time. In 1991, the effect of initial contributions reflects the difference in life expectancy between men and women, which was mainly influenced by male excess mortality around the age of 60. Thus, when comparing the periods of 1961–1991 and 1991–2019, the contributions were on the contrary positive due to the fact that there was a reduction in the difference in mortality between men and women. In general, between 1991 and 2019, the effect of the trend shows significant improvement or stagnation in male mortality at all ages – especially in the age group 55–59 (+0.73 years). Then, the contributions of the age group 60–64 (+0.72 years) and 65–69 (+0.63 years) followed, which has just led to a reduction in the differences in life expectancy between men and women. In terms of time, the mortality among men between the ages of 55 and 69 improved the most, which also contributed the most to the reduction of the difference in the life expectancy sex gap. In 2019, the difference between the life expectancy of men and women was caused by the male excess mortality between the ages of 60 and 80.

Figure 7 shows the initial and trend contributions of differences in the male life expectancy gap between Czechia and Slovakia in 1991, looking back at the development since 1961. In 1961, the difference between Czech and Slovak male life expectancy was −0.92 years as Slovak men have a higher life expectancy at birth than Czech men (67.6 vs. 68.5 years). In this year, the difference in the life expectancy was mainly caused by the higher mortality of Czech men from the age of 40, especially in the age group of 65–69 years with a contribution of −0.31 years to the difference. On the contrary, child and infant mortality had a positive effect on the difference with a contribution of +0.60 years.

Figure 6 Initial and trend contributions of differences in the life expectancy at birth sex gap in 2019 in Czechia, looking back at the development since 1991

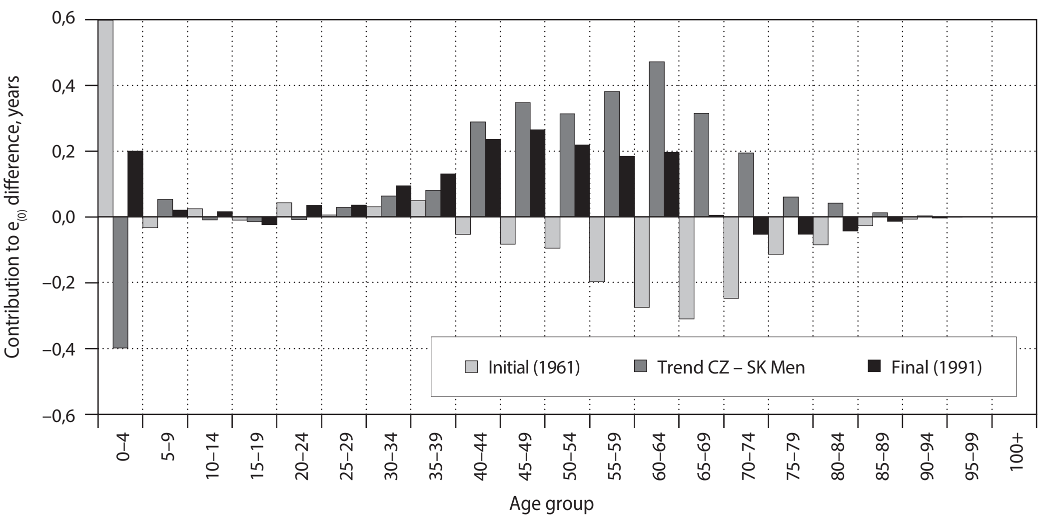


Source: CZSO data; author's calculations and processing.

Between 1961 and 1991, the life expectancy at birth for Czech men increased faster than for Slovak men. In 1991, it was 68.2 years for Czech men and 66.8 years for Slovak men, so the difference was +1.46 years. With the exception of the age groups of 0–4 and 10–24 years, trend contributions were positive. In other words, the life expectancy at birth for men in Czechia increased thanks to the improvement in mortality in almost every age group, especially at the ages of 40 to 74. In 1991, the final contributions were positive with the exception of the age groups of 15–19 years and 70–89 years due to the lower mortality of Slovak men in these age groups. For the second period between 1991 and 2019, the life expectancy of men in Czechia increased faster than in Slovakia. In 2019, the difference was about two years for Czech men. Further improvements in mortality occurred mostly in men between the ages of 65 and 84, while mortality worsened in the ages between 40 and 49 in terms of time. In 2019, the final contributions to the difference in life expectancy at birth between men in Czechia and Slovakia were mostly positive or their values stagnated.

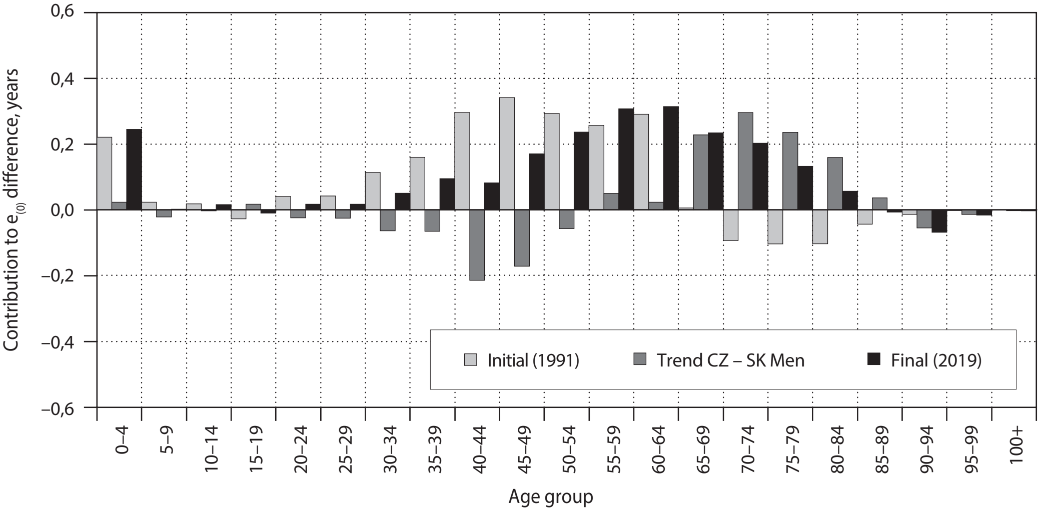
In 1961, the difference in the life expectancy of Czech and Slovak women was +0.52 years. Czech women had a lower mortality especially in the age group 0–4 years with a contribution of +0.75 per year. For women, the initial and trend contributions of differences in the life expectancy gap between Czechia and Slovakia in 1991, looking back at the development since 1961 (Figure 9), were less significant than for men, given that the life expectancy of women in Czechia and Slovakia was very similar and between 1961 and 1991 they continued to approach each other. In this age group, the significance of this contribution to the difference decreased over time (+0.28 years in 1991). Contributions between the years 1961 and 1991 were not so significant, considering that the difference in life expectancy of Czech and Slovak women decreased to +0.49 years. From the point of view of trend contributions, the decrease in the difference was contributed by the decrease in mortality in the age group 0–4 (−0.47 years), while the contributions of the age groups 50–54 (+0.15 years) and 60–64 (+0.10 years) contributed to its increase. In 1991, the final contributions were negative for women aged 15 to 24 and from ages 70 to 94, while the contributions were positive in the remaining age groups. For the second period, between 1991 and 2019, the difference in the life expectancy of Czech and Slovak women widened by +1.1 years (82.1 vs. 80.0 years). With the exception of ages 15 to 19

Figure 7 Initial and trend contributions of differences in the male life expectancy gap between Czechia and Slovakia in 1991, looking back at the development since 1961



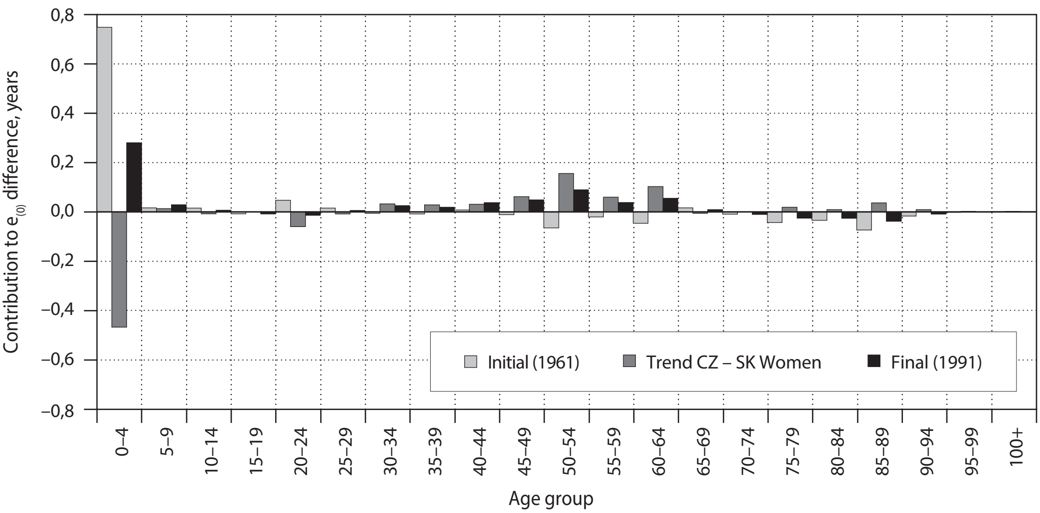
Source: Human Mortality Database data; author's calculations and processing.

Figure 8 **Initial and trend contributions of differences in the male life expectancy gap between Czechia and Slovakia in 2019, looking back at the development since 1991**



Source: Human Mortality Database data; author's calculations and processing.

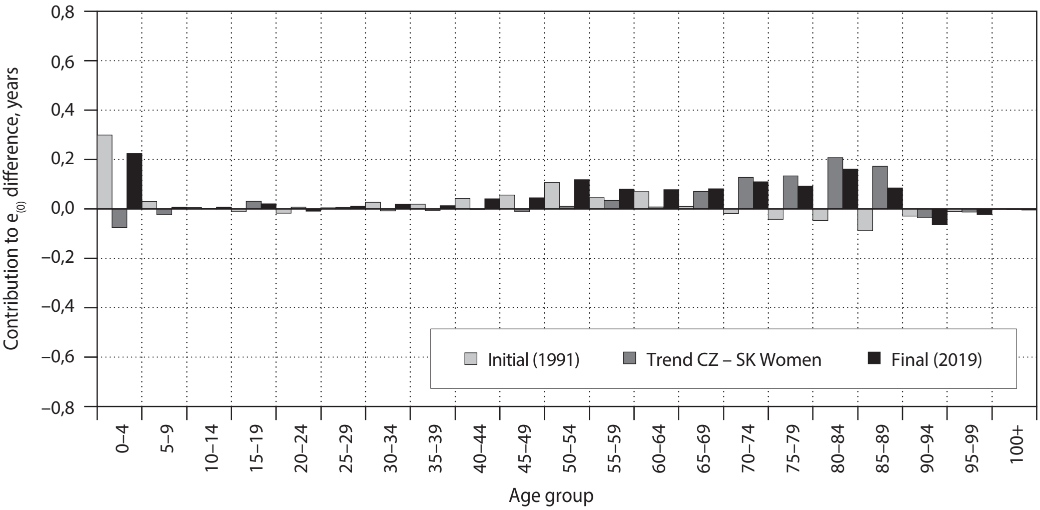
Figure 9 **Initial and trend contributions of differences in the female life expectancy gap between Czechia and Slovakia in 1991, looking back at the development since 1961**



Source: Human Mortality Database data; author's calculations and processing.

and from age 70, Czech women had a lower mortality than Slovak women. The highest positive contribution was recorded in the age group 0–4 (+0.3 years). From the point of view of trend contributions, the improvement in the mortality of women in Czechia aged between 65 and 89 contributed to the deepening of the difference in the life expectancy of Czech and Slovak women. The final contributions in 2019 show a lower mortality for Czech women, with the exception of the 20–24 age group and those over 90 years old.

Figure 10 Initial and trend contributions of differences in the female life expectancy gap between Czechia and Slovakia in 2019, looking back at the development since 1991



Source: Human Mortality Database data; author's calculations and processing.

CONCLUSION

In this article, we first evaluated the trend of three indicators – life expectancy at birth, temporary life expectancy between ages 0 and 65, and the life disparity measure e-dagger (e†). The periods of 1961–1991 and 1991–2019 were selected to compare the mortality level in Czechia during the communist era when life expectancy stagnated or even decreased in the case of men with the era during the transformation after the Velvet Revolution in 1989. Life expectancy and temporary life expectancy between ages 0 and 65 tended to increase over time, more slowly in the first period of 1961–1991 with subsequent faster growth in the period of 1991–2019. The life disparity measure decreased in the observed period, for both men and women.

When evaluating changes in mortality in terms of time, the use of the decomposition method is effective, not only because it can break down its differences by age and sex, but it can also break down its differences into a component expressing the initial differences in a given year and the differences in terms of the trend component. By using decomposition methods, we can further split the difference in mortality according to various effects, namely direct, indirect, and interaction effects. Decomposition of mortality indicators from demographic tables is most often calculated according to age and sex. Depending on the availability of data on other socio-demographic characteristics, additional dimensions can be added to the calculations. One example is the decomposition of life expectancy at birth by marital status or education. Another option is to decompose the indicator by age and sex, and by selected causes of death. The use of the contour decomposition method has proven to be very useful in the assessment of mortality trends and convergent or divergent tendencies in mortality, both in the assessment of differences between the life expectancy of men and women, and from the point of view of the difference in mortality between Czechia and Slovakia.

Using the decomposition method, we broke down changes in life expectancy at birth over time by age and sex. The mortality effect was further decomposed into exclusive and interaction effects. It turned out that the indirect effect had the most significant impact on the change in life expectancy and temporary life expectancy, while the direct effect proved to be more significant in the case of decomposition of the life disparity indicator e-dagger (e†). In examining the life expectancy sex gap, we observed an increase in its value from −5.9 years to −7.9 years for the first period of 1961–1991, however, there was a slight decrease in the second period of 1991–2019 to –5.8 years. Using the contour decomposition method, we distinguished between initial and trend differences in mortality which influence the life expectancy sex gap, with regards to different age groups. Furthermore, we observed the divergence tendencies between Czech and Slovak life expectancy. In 1961, the life expectancy of men in Slovakia was higher than in Czechia, but subsequently, there was a faster increase in life expectancy in Czechia. The life expectancy gap between Czech and Slovak women decreased between 1961 and 1991, but then increased until 2019.

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