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THE IMPACT OF CHRONIC NON-COMMUNICABLE DISEASES ON THE LIFE EXPECTANCY OF THE POPULATION OF SERBIA IN THE PERIOD BETWEEN 2009 AND 2019

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Abstract

The high prevalence of chronic non-communicable diseases in the morbidity and mortality of the population in Serbia directly affects the dynamics of life expectancy. The top two causes of death are circulatory system diseases and tumours. Among the male population, circulatory diseases accounted for 42.4% to 49.3% of total deaths between 2009 and 2019. For women, the proportion is higher, ranging from 52.6% to 60.5%. Malignant diseases account for 19.8% to 23.8% of deaths among men and 16.7% to 18.9% among women. Respiratory diseases are the third most common cause of death for both sexes in most years of the observed period. During the same time frame, life expectancy increased by about two years, with a slightly more significant rise among men. Based on the calculated mortality tables by cause of death, the analysis shows that eliminating the leading causes of death would significantly contribute to an increase in life expectancy. The greatest positive changes in life expectancy for the period between 2009 and 2019 would occur with the hypothetical elimination of circulatory system diseases as a cause of death. Initially, in 2009, life expectancy would be about 15 years longer for women and about 10 years longer for men. Eliminating tumours would increase life expectancy by approximately 3 years for men and 2.7 years for women. Life expectancy would also be higher in 2019, though the increase would be somewhat more modest for both sexes.

Key words: chronic non-communicable diseases, life expectancy, causes of death, Serbia, mortality tables.

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УТИЦАЈ ХРОНИЧНИХ НЕЗАРАЗНИХ БОЛЕСТИ НА ДУЖИНУ ЖИВОТА СТАНОВНИШТВА СРБИЈЕ У ПЕРИОДУ ИЗМЕЂУ 2009. И 2019. ГОДИНЕ

Апстракт

Висока заступљеност хроничних незаразних болести у морбидитету и морталитету становништва у Србији директно утиче на динамику дужине живота. Прва два рангирана узрока смрти су болести система крвотока и тумори. Код мушког становништва болести крвотока учествовале су у укупном броју умрлих у периоду између 2009. и 2019. године у распону од 42,4% до 49,3%. Код жена је њихов удео већи, у распону од 52,6% до 60,5%. Малигне болести имају учешће од 19,8% до 23,8% код мушког становништва, а код жена од 16,7% до 18,9%. Трећи најзаступљенији узрок смрти у наведеном периоду и код мушкараца и код жена у већини посматраних година јесу болести система за дисање. У истом периоду очекивано трајање живота порасло је за око две године, нешто значајније код мушког становништва. На бази израчунатих таблица смртности по узроку смрти анализа је показала да би елиминација водећих узрока смрти значајно допринела порасту очекиване дужине живота. Највеће позитивне промене у дужини живота у свим годинама од 2009. до 2019. наступиле би хипотетичком елиминацијом болести система крвотока као узрока смрти. У почетној 2009. години животни век жена био би дужи за око 15 година, а код мушкараца за око 10 година. Елиминацијом тумора очекивано трајање живота мушкараца било би веће за око 3, а код жена 2,7 година. Очекивано трајање живота би и у последњој, 2019. години било такође дуже, али би пораст био нешто скромнији код оба пола.

Кључне речи: хроничне незаразне болести, очекивано трајање живота, узроци смрти, Србија, таблице смртности.

INTRODUCTION

Life expectancy is the basic indicator of population mortality. Its meaning is easy to understand, while the calculation is based on the specific methodology of demographic tables, in this case life tables. Although over time, in accordance with the epidemiological transition and changes in the age structure, this indicator was further developed by including morbidity (healthy life expectancy), its primary meaning remained irreplaceable in all demographic analyses. On the other hand, its application goes beyond demographic research because it is an integral part of other indicators, such as the Human Development Index. It is an indicator of economic and social development, that is, the overall progress of all dimensions of human development within a country.

The current values of life expectancy in the world vary by about thirty years between the lowest and highest values. The lowest life expectancy of around 55 years is recorded mainly in some African countries, where the causes of death characteristic of the first and second phase of the epidemiological transition still prevail (Radivojević and Marinković 2019). The most developed countries have the highest values of life expectancy, at around 86 years. On average, women live about 5 years

longer than men worldwide. The difference is explained by the influence of biological (genetics, hormones) and non-biological factors (behaviour, socioeconomic factors, as well as environmental and cultural factors) (Nathanson, 1984). At lower levels of life expectancy, the gender gap is narrower, with disparities in mortality largely driven by biological factors rather than behavioural differences. In 2019, life expectancy in Serbia was 76 years, ten years less than the highest achieved values in the world. Women lived about 5 years longer than men that year, with life expectancies of 78.6 and 73.3 years, respectively.

In the study of the mortality in Serbia, special attention was paid to the analysis of life expectancy (Radivojević, 2006; Radivojević and Marinković, 2016, 2017, 2019). Long-term trends were observed, and periods of faster growth and periods of stagnation in life expectancy, differences by gender, possibilities for further growth, the influence of the cause of death on its dynamics, and other things were identified.

This paper examines life expectancy in Serbia between 2009 and 2019, focusing on how major causes of death, particularly chronic non-communicable diseases and circulatory system disorders, have influenced changes in life expectancy. Despite the relatively short observation period, the analysis aims to identify the key factors affecting life expectancy dynamics during this time. The central hypothesis is that chronic diseases, especially those affecting the circulatory system, have significantly impacted both the level and trends in life expectancy in Serbia. Data originating after 2020 is excluded due to the unique health impacts of the coronavirus pandemic. Although the leading causes of death remained the same as in the decade preceding the pandemic (diseases of the circulatory system and tumours), the third most common are diseases and conditions that can be linked to COVID-19 (Marinković and Galjak, 2021).

METHODOLOGY

Life expectancy shows the average number of years that a person of a certain age lives under the assumption of age-specific mortality from the year of observation. The most commonly used is life expectancy at birth, i.e. at 0 years. This indicator is actually one of the functions in life tables which, as a methodological approach, are based on *a posteriori* (empirical) probabilities.

For the purposes of this paper, life tables were prepared according to the cause of death[1]. They give a hypothetical answer about mortality, if

[1] The Statistical Office of the Republic of Serbia annually publishes Abridged Life Tables, based on age-specific mortality. Probability of death, as the first function in the table, is obtained by converting the death rate into the corresponding probability of death by age;

one cause (or causes) is eliminated. Hence, the increase in life expectancy after the elimination of a certain cause of death shows the influence of that cause at its height. There are numerous methods for constructing cause-eliminated life tables (Namboodiri and Suchindran, 1987). In this paper, the usual (classical) life tables were created first, followed by life tables with the elimination of certain causes of death. In both cases, it is a matter of calculating approximate tables based on the exponential relationship between rates and probabilities of dying (Fergani, N. 1971). Life tables were calculated for all years within the observed period, starting with 2009 and ending with 2019. These are abridged life tables with five-year age groups.

The method for creating life tables starts with transforming the specific death rates by age groups into the corresponding probabilities of dying using the following formula[2]:

$$ {}_nq_x = 1 - e^{-n^*{}_nm_x} $$

Where ${}_nq_x$ is the probability of dying for the age interval (x+n);
${}_nm_x$ is the specific death rate for the age interval (x+n); and
n is the size of the interval.

All other functions in the life tables were calculated by the usual methodological procedure. Life tables calculated in this way include the influence of all causes of death on the functions in the tables, including life expectancy.

The calculation of cause-deleted life tables in which a certain cause of death (R_d) is eliminated is based on the modified mortality rate (m*), which is calculated for the age group (x+n) as follows: $m^* = {}_nm_x - {}_nm_{xd}$. The further procedure of transformation into the probability of dying, and then the calculation of other functions is the same as with classic tables.

Among other methodological procedures, the method of decomposing the difference in life expectancy between men and women was used. This method made it possible to separate the direct and indirect effects of sex-specific mortality on the difference in life expectancy (Arriaga, 1984).

RESULTS AND DISCUSSION

Causes of Death in the Period between 2009 and 2019

The model of the causes of death in Serbia is similar as in the developed countries of the world, and is in accordance with the stage of demographic and epidemiological transition in which the population of

[2]An exponential function for the conversion of death rate to probability of death by age was used by Reed and Merrell (1939). They are used in our official statistics for calculating abridged approximate life tables;

Serbia finds itself. The high prevalence of so-called chronic non-communicable diseases is associated with changes in the age structure. The population of Serbia is among the oldest populations in Europe, with characteristics of a stage of deep demographic age (Penev, 2015).

The two leading causes of death of the population in Serbia in the observed period are diseases of the circulatory system and malignant diseases (Table 1). These are chronic non-communicable diseases whose etiology is mainly related to the modern way of life and lifestyle (in terms of nutrition, physical inactivity, bad habits), although the etiology of certain diseases from this group often remains unknown (Radivojević and Marinković, 2017). However, one of the most frequently cited immediate risks is hypertension and its impact on the development of cardiovascular and cerebrovascular diseases, as well as complications in other diseases. Research on the population of Serbia shows that the presence of hypertension is increasing, and in 2013 it was registered in a third of the adult population (IOPHOS - Batut, 2014). Other factors that are responsible for the appearance of tumours and other diseases include the heavy use of cigarettes and alcohol. Tobacco is certainly one of the most prevalent, with an increasing trend in recent years. The harmfulness of smoking for the onset of many diseases, especially for some of them, has been proven in many studies. According to the EHIS[3] survey from 2019, the prevalence of smoking tobacco products among those aged 15 and over was 31.9%, which is above the average of EU countries. It is estimated that as much as a quarter of all deaths of men are related to smoking. Otherwise, the trend of mortality, which is primarily a consequence of smoking, has been increasing in the last two decades (Marinković, 2017). Obesity as a result of bad eating habits is also a big problem. Every second person in 2013 was overweight (54.4%). In connection with this, there is also the issue of physical inactivity, which is considered to be one of the leading risk factors for overall mortality.

In the male population, diseases of the circulatory system participated in the total number of deaths in the period between 2009 and 2019 in the range from 42.4% to 49.3%. Among women, their share is higher, ranging from 52.6% to 60.5%. Malignant diseases have a share of 19.8% to 23.8% in the male population, and a share ranging from 16.7% to 18.9% in the female population. The third most common cause of death in both men and women in most of the observed years are diseases of the respiratory system.

[3] https://www.stat.gov.rs/sr-latn/istrazivanja/ehis/

Table 1. Share of deaths by cause of death[4] *in the total number of deaths in the male (M) and female (F) population of Serbia 2009-2020*

Year	Sex	(A00-B99)	(C00-D48)	(E00-E90)	(F00-F99)	(G00-G99)	(I00-I99)	(J00-J99)	(K00-K93)	(N00-N99)	(R00-R99)	(S00-T98)	(U00-U89)	Other cause
2009	M	0.5	23.3	2.5	1.0	1.4	49.1	4.9	3.9	2.3	5.2	5.2	-	0.7
	F	0.3	17.8	3.6	0.9	1.3	60.5	3.1	3.1	1.7	4.9	2.0	-	0.8
2010	M	0.5	23.8	2.7	1.2	1.5	49.3	4.7	4.1	2.2	4.5	4.7	-	0.8
	F	0.4	18.0	3.7	1.1	1.4	60.2	3.2	3.2	1.8	4.3	1.8	-	0.9
2011	M	0.5	23.7	2.6	1.0	1.4	48.8	5.8	3.8	2.3	4.6	4.7	-	0.8
	F	0.4	17.9	3.7	1.2	1.5	59.1	3.9	3.0	2.0	4.5	1.8	-	1.0
2012	M	0.5	23.8	2.5	1.1	1.7	48.8	5.7	3.6	2.2	4.6	4.7	-	0.8
	F	0.4	18.5	3.5	1.2	1.7	58.8	4.0	3.0	1.9	4.4	1.7	-	0.9
2013	M	0.6	24.3	2.6	1.2	1.7	48.1	5.5	3.8	2.2	4.6	4.6	-	0.8
	F	0.5	18.7	3.2	1.3	1.9	58.4	4.1	3.0	1.9	4.3	1.7	-	1.0
2014	M	0.6	24.3	2.2	1.2	1.6	48.4	5.6	3.8	2.3	4.9	4.3	-	0.8
	F	0.5	18.8	3.0	1.4	1.9	58.3	4.4	2.8	1.8	4.5	1.6	-	1.0
2015	M	0.6	24.2	2.7	1.3	1.9	47.3	6.2	3.6	2.3	4.9	4.2	-	0.8
	F	0.5	17.9	3.4	1.6	2.2	57.6	4.5	2.9	2.2	4.6	1.7	-	0.9
2016	M	0.6	24.6	2.8	1.3	2.0	46.9	5.7	3.6	2.3	5.2	4.1	-	0.9
	F	0.5	19.0	3.8	1.6	2.6	56.5	3.9	2.8	2.2	4.7	1.5	-	0.9
2017	M	0.6	23.8	3.1	1.4	2.3	47.1	5.9	3.4	2.4	5.1	4.1	-	0.8
	F	0.5	18.5	3.9	1.5	3.0	56.4	4.5	2.7	2.0	4.5	1.6	-	0.9
2018	M	0.7	24.4	2.9	1.2	2.3	47.4	5.8	3.5	2.5	4.5	4.0	-	0.8
	F	0.6	19.1	3.6	1.6	3.1	56.2	4.5	2.8	2.1	3.9	1.4	-	1.1
2019	M	0.8	24.3	2.8	1.2	2.2	47.0	6.3	3.5	2.5	4.7	3.9	-	0.8
	F	0.7	18.9	3.5	1.6	2.9	56.3	4.6	2.7	2.1	4.1	1.6	-	1.0
2020	M	0.8	19.8	2.6	1.2	2.1	42.4	6.5	2.8	2.0	4.9	3.2	11.0	0.7
	F	0.6	16.7	3.4	1.5	2.9	52.6	4.9	2.2	1.8	4.4	1.3	6.6	1.1

Source: SORS

The analysis of the causes of death by age groups additionally confirms the influence of lifestyle and bad habits over a longer period and the prevalence of certain causes. Diseases of the circulatory system are most common in late life in men and women (over 85 years old) when they cause over 65-70% of the total mortality rate (Table 2). Malignant diseases show a greater dispersion by age groups. Nevertheless, they are most prevalent in the middle-aged population. They are the cause of death in almost half of women ages 40 through 59. Among men, the most deaths from malignant diseases are in men ages 50 through 69 (over a third).

[4] International statistical classification of diseases and related health problems – 10th revision (ICD-10) http://www.batut.org.rs/index.php?category_id=151

Table 2. Average values of the prevalence of certain causes of death by age for the period 2009-2019 in both sexes (% in relation to total mortality by age group)

Age	(A00-B99)	(C00-D48)	(D50-D89)	(E00-E90)	(G00-G99)	(I00-I99)	(J00-J99)	(K00-K93)	(N00-N99)	(P00-P96)	(Q00-Q99)	(R00-R99)	S00-T98)
Male													
0	0.3	0.5	0.1	0.5	1.2	0.4	2.2	0.3	0.1	66.9	18.2	7.5	1.8
1-4	3.6	19.4	2.1	3.0	15.8	5.5	4.1	1.9	1.4	0.0	14.2	7.3	21.3
5-9	2.5	23.9	1.1	1.4	17.1	3.9	3.5	2.0	1.0	0.0	7.8	6.3	29.5
10-14	0.9	17.1	0.5	2.2	12.7	7.4	5.2	1.4	0.7	0.0	5.0	8.2	38.7
15-19	0.2	10.9	0.5	0.9	10.8	7.5	3.2	0.7	0.5	0.0	1.7	10.1	52.2
20-24	1.0	10.0	0.3	0.8	4.6	7.6	3.1	1.2	0.4	0.0	1.0	13.0	55.7
25-29	1.5	11.6	0.1	0.7	3.6	10.5	2.8	1.9	0.6	0.0	0.7	14.1	49.8
30-34	2.1	13.6	0.1	1.1	3.0	14.4	3.4	2.9	0.9	0.0	0.8	14.3	40.8
35-39	1.9	17.1	0.2	1.4	3.1	20.0	3.6	4.9	1.3	0.0	0.3	13.4	29.7
40-44	1.4	21.0	0.2	1.7	2.3	27.6	3.6	5.9	1.0	0.0	0.1	10.7	20.6
45-49	1.2	26.0	0.2	1.8	1.9	32.0	3.6	6.2	1.4	0.0	0.2	8.7	13.7
50-54	0.9	31.4	0.2	2.2	1.5	33.5	3.9	5.6	1.3	0.0	0.1	7.1	9.1
55-59	0.9	35.4	0.2	2.5	1.2	34.8	4.3	5.0	1.4	0.0	0.1	5.5	6.2
60-64	0.6	36.1	0.2	2.9	1.2	36.5	5.0	4.5	1.8	0.0	0.0	4.8	4.0
65-69	0.6	33.7	0.2	3.3	1.3	40.2	5.8	3.8	2.1	0.0	0.0	4.0	2.9
70-74	0.6	28.2	0.2	3.2	1.6	45.5	6.3	3.7	2.4	0.0	0.0	3.6	2.5
75-79	0.5	22.0	0.3	3.1	2.1	51.8	6.6	3.2	2.8	0.0	0.0	3.4	2.3
80-84	0.5	15.2	0.3	2.6	2.4	58.6	6.7	3.0	3.0	0.0	0.0	3.9	2.0
85+	0.3	8.8	0.2	1.9	2.0	66.8	5.7	2.3	2.5	0.0	0.0	5.7	1.5
Female													
0 g.	0.5	0.3	0.1	0.6	1.3	0.3	2.7	0.1	0.1	66.0	19.0	7.8	1.2
1-4	3.2	19.5	1.7	4.5	15.4	7.9	9.0	3.7	0.2	0.0	16.0	7.1	10.6
5-9	3.4	32.6	0.9	3.3	10.3	7.1	5.6	1.0	1.1	0.0	5.5	8.8	19.6
10-14	2.0	21.7	0.8	5.3	16.8	5.8	7.3	2.4	0.0	0.0	9.4	4.8	22.8
15-19	1.5	20.4	0.9	3.0	7.8	7.8	5.0	2.9	0.6	0.0	2.7	9.7	34.5
20-24	0.9	18.9	0.3	2.0	6.4	8.0	6.4	1.8	2.0	0.0	2.6	10.9	35.4
25-29	1.3	25.9	0.8	1.6	5.1	12.4	5.5	3.4	0.8	0.0	1.7	9.4	26.1
30-34	2.1	35.9	0.3	1.7	4.9	13.3	4.8	2.6	1.2	0.0	1.1	8.7	18.0
35-39	1.5	41.8	0.7	2.1	4.0	15.7	3.7	3.6	2.1	0.0	0.6	7.5	13.1
40-44	0.8	48.7	0.5	1.6	3.6	18.5	4.2	3.0	1.3	0.0	0.2	6.2	9.1
45-49	0.9	49.7	0.4	1.8	2.6	21.2	3.6	3.5	1.5	0.0	0.2	5.5	6.8
50-54	0.9	52.0	0.3	2.0	2.2	22.5	4.2	3.3	1.7	0.0	0.1	4.2	4.4
55-59	0.8	48.8	0.3	2.5	1.9	27.0	4.6	3.1	1.9	0.0	0.1	3.9	3.1
60-64	0.7	43.1	0.3	3.3	1.7	32.5	4.9	3.5	2.0	0.0	0.0	3.7	2.3
65-69	0.7	34.6	0.3	4.6	1.9	40.3	4.9	3.5	2.4	0.0	0.0	3.4	1.7
70-74	0.7	24.8	0.3	4.7	2.0	50.2	4.6	3.5	2.4	0.0	0.0	3.3	1.5
75-79	0.6	15.9	0.3	4.6	2.4	59.6	4.3	3.2	2.4	0.0	0.0	3.6	1.2
80-84	0.4	9.8	0.3	3.7	2.4	67.1	4.1	2.8	2.0	0.0	0.0	4.2	1.1
85+	0.2	5.3	0.2	2.4	2.0	73.5	3.4	2.0	1.4	0.0	0.0	6.1	0.8

Source: SORS

Mortality rates for the two leading causes of death in Serbia are higher than in most European countries, according to data for 2019 (Figure 1 and 2). Serbia ranks third in terms of the highest mortality due to diseases of the circulatory system, behind Bulgaria and Romania. In the case of malignant diseases, it is on par with Slovenia, Latvia, Slovakia, Croatia and Hungary. When it comes to lung cancer, the occurrence of

which is primarily linked to smoking, Serbia is in the same group as Croatia and Greece, where the rate is around 100 deaths per 100,000 in the male population. For the female population, this rate is similar to Poland, where it is slightly lower – around 40 deaths per 100.000 women.

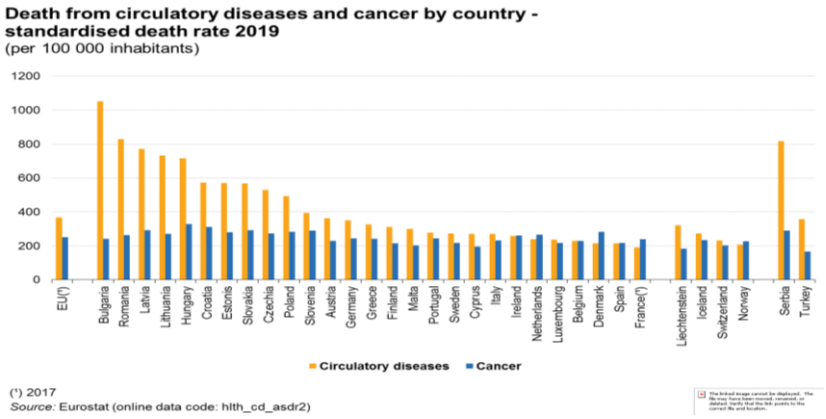

Figure 1. Death from circulatory diseases and cancer by country – standardised death rate 2019
Source: Eurostat

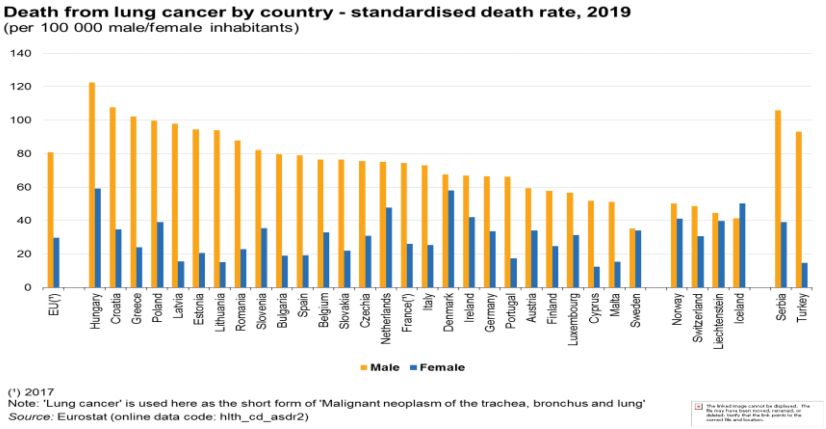

Figure 2. Death from lung cancer by country – standardised death rate, 2019
Source: Eurostat

Expected Life Expectancy by Gender

The life expectancy of women was longer on average by 5.15 years compared to men in the period between 2009 and 2019. The smallest difference of 4.93 years was recorded in 2018, and the largest, recorded in 2009, amounted to 5.35 years (Table 3). Directly, the difference is the re-

sult of the influence of specific mortality by age of men and women, expressed through a direct and indirect effect[5] (Arriaga, 1984). The total effect, direct and indirect, is positive in the observed period for most age groups, which shows the difference in favour of women. The negative values of effects were recorded only in age groups 1-4, 5-9, 10-14 and 85+, which reduces the difference in life expectancy in favour of women. The indirect effect is most pronounced in the 60-64 age group, and the direct effect is most pronounced in the 65-69 and 70-74 age groups.

Table 3. Expected life expectancy at birth of men and women in Serbia, 2009-2019

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Change 2019/2009
Male	71.28	71.67	71.93	72.22	72.54	72.71	72.69	73.14	73.07	73.39	73.31	2.03
Female	76.63	76.90	77.13	77.40	77.84	77.86	77.80	78.19	78.02	78.32	78.56	1.93
Difference	5.35	5.23	5.20	5.18	5.30	5.15	5.11	5.05	4.95	4.93	5.25	-0.10

Source: SORS, authors' calculation

The high proportion of those who died from diseases of the circulatory system and malignant diseases in both sexes raises the question of how much these two causes of death, as well as other causes, contribute to the difference in life expectancy between men and women. In the period between 2009 and 2019, the contribution of all causes of death has a positive sign. Minor annual changes in the achieved effects are observed, as well as their different trends for certain causes. The effects of diseases of the circulatory system and diseases of the respiratory system are increasing slightly (from 1.69 to 1.84 for the former, and from 0.28 to 0.36 for the latter), while the effects of tumours are decreasing (from 1.61 to 1.14). The cumulative effects of all other causes of death oscillate around the value of 2 years. Death due to diseases of the circulatory system has the largest contribution to the difference in life expectancy by gender compared to the contribution of all other causes. During the observed period, a somewhat more favourable situation can be observed in women compared to men when it comes to mortality due to diseases of the circulatory and respiratory systems. It is the opposite with tumours.

[5] The total effect of age-specific death rates on the difference in life expectancy by sex is the sum of the direct and indirect effects. The direct effect refers to the number of years lived within a certain age interval (x,x+n), and the indirect effect to the number of survivors at the end of the age interval;

Table 4. Effects of the cause of death on the difference in life expectancy between men and women in Serbia (in years), Arriaga method

Year	Effects of certain causes of death				
	Circulatory system diseases	Tumours	Respiratory diseases	Other causes	Total
2009	1.68867	1.16063	0.27993	2.22162	5.35084
2010	1.65249	1.21069	0.29950	2.06775	5.23042
2011	1.76704	1.18903	0.37553	1.86245	5.19406
2012	1.79008	1.12774	0.31178	1.95397	5.18356
2013	1.79158	1.18492	0.31037	2.00666	5.29353
2014	1.77608	1.14217	0.29566	1.93740	5.15131
2015	1.74011	1.23053	0.33499	1.80197	5.10760
2016	1.72648	1.10260	0.32169	1.90259	5.05336
2017	1.70884	1.03400	0.29661	1.90742	4.94687
2018	1.81734	1.04845	0.29135	1.76928	4.92643
2019	1.83729	1.13534	0.35556	1.91862	5.24682

Source: Authors' calculations

Life expectancy at birth increased by 2.03 years for men and 1.93 years for women between 2009 and 2019. The effect of diseases of the circulatory system in the male population contributes almost 50% of the total effect, while in women its contribution is as much as 74%. The relative impact of tumours on the difference in life expectancy by gender was 16.11% in the male population and 9.08% in the female population. Diseases of the respiratory system reduce the total effect of the cause of death by about 4% in both sexes.

Table 5. Effects of the cause of death on the difference in life expectancy in Serbia, in 2019 compared to 2009, Arriaga method

	Total effect	Effect of cause of death			
		Circulatory system diseases	Tumours	Respiratory diseases	Other causes
Male	2.02500	0.99747	0.32631	-0.08343	0.78465
Female	1.92097	1.42365	0.17449	-0.09402	0.41685
The share of the individual in the total effect (%)					
Male	100.00	49.26	16.11	-4.12	38.75
Female	100.00	74.11	9.08	-4.89	21.70

Source: Authors' calculations

The Effects of Eliminating the Leading Causes of Death

Tables 6 and 7 provide a comparison of life expectancy with all causes of death (classic life table) versus life expectancy when a specific cause of death is eliminated (cause-deleted life table). The tables display life expectancy data for both 0-year-olds and 65-year-olds, separately for

each gender, under the scenarios where diseases of the circulatory system, tumours, and respiratory system diseases are removed.

Table 6. Life expectancy calculated in total for all causes of death and with the elimination of one of the causes of death

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Life expectancy at birth											
Male											
e_0^0	71.28	71.67	71.93	72.22	72.54	72.71	72.69	73.14	73.07	73.39	73.31
e_0^0 - Circulatory system diseases	81.59	82.83	81.49	81.27	81.83	82.16	81.51	82.04	82.01	82.68	82.59
e_0^0 - Tumours	74.61	75.11	75.19	75.48	75.89	76.08	76.07	76.56	76.38	76.76	76.71
e_0^0 - Respiratory diseases	71.83	72.22	72.56	72.79	73.13	73.33	73.35	73.75	73.70	74.04	74.04
Female											
e_0^0	76.63	76.90	77.13	77.40	77.84	77.86	77.80	78.19	78.02	78.32	78.56
e_0^0 - Circulatory system diseases	91.69	92.14	90.42	90.90	91.16	91.33	90.39	90.38	89.90	90.74	91.24
e_0^0 - Tumours	79.37	79.69	79.80	80.18	80.63	80.70	80.54	81.12	80.86	81.24	81.44
e_0^0 - Respiratory diseases	77.01	77.26	77.53	77.82	78.27	78.34	78.29	78.62	78.50	78.82	79.09
Life expectancy at age 65											
Male											
e_{65}^0	13.73	13.88	13.86	13.98	14.28	14.39	14.30	14.55	14.48	14.65	14.75
e_{65}^0 - Circulatory system diseases	24.18	25.42	23.42	22.92	23.52	23.75	22.96	23.33	23.24	23.77	23.91
e_{65}^0 - Tumours	15.69	15.91	15.70	15.87	16.26	16.40	16.34	16.68	16.59	16.84	16.98
e_{65}^0 - Respiratory diseases	14.19	14.33	14.34	14.46	14.77	14.87	14.83	15.06	15.00	15.17	15.32
Female											
e_{65}^0	15.91	16.09	16.22	16.44	16.80	16.83	16.76	17.05	16.90	17.14	17.29
e_{65}^0 - Circulatory system diseases	31.73	32.07	30.10	30.53	30.68	30.86	29.86	29.77	29.29	30.14	30.52
e_{65}^0 - Tumours	17.18	17.42	17.45	17.74	18.13	18.19	18.08	18.48	18.29	18.64	18.79
e_{65}^0 - Respiratory diseases	16.15	16.35	16.52	16.75	17.12	17.17	17.11	17.36	17.25	17.50	17.66

Source: Authors' calculations

Throughout the observed period, life expectancy for both 0-year-olds and 65-year-olds has increased for both men and women. This upward trend is also evident when tumours and respiratory diseases are eliminated as causes of death, with life expectancy rising by about 2 years by the end of the period. However, the impact of eliminating circulatory system diseases differs. For men, life expectancy at birth increases by one year by the end of the period, despite fluctuations in between. For women, life expectancy at birth is slightly lower at the end of the period compared to the beginning. Similar trends are observed for those aged 65. From 2009 to 2019, life expectancy increased by 1.0 years for men and

1.6 years for women. When specific causes of death are eliminated, the changes in life expectancy are observed for both 0-year-olds and 65-year-olds. It is interesting that the increase in life expectancy for ages 0 and 65 is similar when eliminating diseases of the circulatory and respiratory systems. However, the impact differs when tumours are eliminated. In 2009, the life expectancy increase for men is 3.33 years at age 0 and 1.96 years at age 65, while for women, the increases are 2.74 and 1.27 years, respectively.

The biggest changes in life expectancy in all years between 2009 and 2019 would occur with the elimination of circulatory system diseases as a cause of death. In 2009, the life expectancy of women would be longer by about 15 years, and by about 10 years for men (Table 7). It would also be longer in the last year of observation, but the increase would be somewhat more modest in both sexes. By eliminating tumours

Table 7. Increase (in years) of life expectancy for age 0 and 65 as a consequence of the elimination of a particular cause of death

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Increase in life expectancy at the age of 0 years											
Male											
Circulatory system diseases	10.31	11.16	9.56	9.05	9.29	9.45	8.82	8.90	8.94	9.29	9.28
Tumours	3.33	3.44	3.26	3.26	3.35	3.37	3.38	3.42	3.31	3.37	3.40
Respiratory diseases	0.55	0.55	0.63	0.57	0.59	0.62	0.66	0.61	0.63	0.65	0.73
Female											
Circulatory system diseases	15.06	15.24	13.29	13.50	13.32	13.47	12.59	12.19	11.88	12.42	12.68
Tumours	2.74	2.79	2.67	2.78	2.79	2.84	2.74	2.93	2.84	2.92	2.88
Respiratory diseases	0.38	0.36	0.40	0.42	0.43	0.48	0.49	0.43	0.48	0.50	0.53
Increase in life expectancy at the age of 65 years											
Male											
Circulatory system diseases	10.45	11.54	9.56	8.94	9.24	9.36	8.66	8.78	8.76	9.12	9.16
Tumours	1.96	2.03	1.84	1.89	1.98	2.01	2.04	2.13	2.11	2.19	2.23
Respiratory diseases	0.46	0.45	0.48	0.48	0.49	0.48	0.53	0.51	0.52	0.52	0.57
Female											
Circulatory system diseases	15.82	15.98	13.88	14.09	13.88	14.03	13.10	12.72	12.39	13.00	13.23
Tumours	1.27	1.33	1.23	1.30	1.33	1.36	1.32	1.43	1.39	1.50	1.50
Respiratory diseases	0.24	0.26	0.30	0.31	0.32	0.34	0.35	0.31	0.35	0.36	0.37

Source: Authors' calculations

and diseases of the respiratory system, the life expectancy of men in 2009 would be longer by about 3.0 and 0.5 years, respectively. The increase in women would be slightly lower (2.7 and 1.4 respectively). Contrary to the elimination of the circulatory system diseases, by eliminating tumours, the increase in life expectancy would be somewhat more significant in 2019 than in 2009. Although it is too short a period (2009-2019) to say with certainty what kind of changes we are talking about, the results suggest that the changes are positive with circulatory system diseases, while they are negative in relation to tumours and diseases of the respiratory system.

Figures 3 and 4 illustrate that the trend in life expectancy improvements, achieved by eliminating one of these causes of death, remains consistent across both 2009 and 2019.

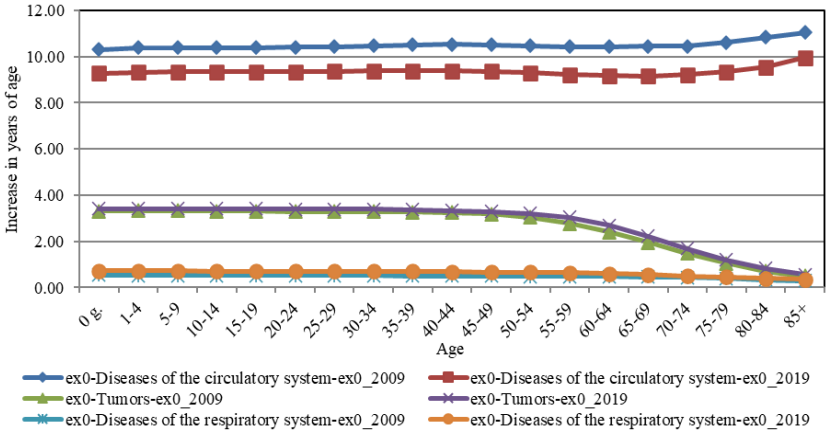

Figure 3. Increase in male life expectancy, by age, after elimination of one of the three leading causes of death
Source: Authors' calculations

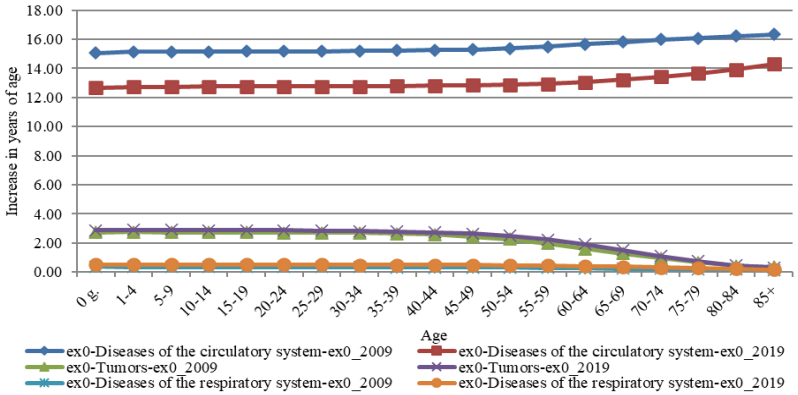

Figure 4. Increase in life expectancy of women, by age, after elimination of one of the three leading causes of death
Source: Authors' calculations

The life expectancy based on life tables where the most common causes of death are eliminated are totally hypothetical. As such, it confirms the importance of certain diseases as a cause of death and provides a theoretical measure of the increase in life expectancy in case of their elimination. On the contrary, the concept of avoidable mortality, although it is also hypothetical, does not completely reject the influence of certain causes of death on the length of life. The method of avoidable mortality was introduced in the seventies (Rutstein et al., 1976)[6] and also indicates the possibility of avoiding a fatal outcome in some cases. Avoidable mortality refers to those cases of death from diseases and conditions that can be avoided with adequate and timely health care or some interventions. The analysis for the population of Serbia, ages 0 through 74, in the period between 2010 and 2019 showed that the positive contribution of the reduction of avoidable mortality to changes in life expectancy is about 70%. For men, the reduction of avoidable mortality rates is more significant, especially for the middle-aged, and it amounts to over 80%. Assuming the elimination of avoidable mortality, the increase in life expectancy could amount to 6.3 years for men, and 3.9 years for women. The analysis also confirmed that the most significant positive trend in the reduction of avoidable mortality in the period between 2010 and 2019 is in cardiovascular diseases, as well as violent causes of death (Marinković, 2022).

CONCLUSION

The analysis confirmed the initial hypothesis regarding the significance of chronic non-communicable diseases as causes of death for life expectancy in Serbia, particularly for its dynamics between 2009 and 2019. The effects of circulatory system diseases and tumours, which together account for about ¾ of all deaths during the observed period, were quantified. Additionally, the impact of respiratory system diseases, which are often the third leading cause of death in Serbia, was also assessed.

Hypothetically, eliminating circulatory system diseases would have increased life expectancy by 10 years for men and 15 years for women in 2009. In the final year of observation, life expectancy would still be longer, though the increase would be more modest for both sexes. In 2009, eliminating tumours and respiratory diseases would result in a life expectancy increase of about 3.0 and 0.5 years, respectively, for men, while the increase for women would be slightly lower (2.7 years for tumours and 0.4 years for respiratory diseases). With the elimination of tumours, the increase in life expectancy would be somewhat more significant in 2019 than in 2009, which is the opposite of the results for circula-

[6] Marinković, 2022.

tory diseases. Given the short period of study (2009-2019), it cannot be stated with certainty whether the changes in circulatory diseases are positive and the changes in tumours are negative.

Chronic non-communicable diseases have the greatest impact on the difference in life expectancy between men and women. Circulatory system diseases individually contribute the most to the life expectancy difference by gender compared to other causes. From 2009 to 2019, the effects (expressed in years) of diseases of the circulatory system and diseases of the respiratory system slightly increased (in the former from 1.69 to 1.84, and in the latter from 0.28 to 0.36), while the effects of tumour-related causes of death decreased (from 1.61 to 1.14). The cumulative effects of all other causes of death fluctuate by around 2 years.

Life expectancy increased by 2.03 years for men and 1.93 years for women from 2009 to 2019. The impact of circulatory system diseases contributed nearly 50% of the total change for men and 74% of the total change for women. The impact of tumours on life expectancy was approximately 16% for men and 9% for women. In contrast, respiratory diseases have a negative effect, reducing the total impact of causes of death by about 4% for both sexes.

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УТИЦАЈ ХРОНИЧНХ НЕЗАРАЗНИХ БОЛЕСТИ НА ДУЖИНУ ЖИВОТА СТАНОВНИШТВА СРБИЈЕ У ПЕРИОДУ 2009-2019.

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Резиме

У раду се анализира очекивано трајање живота становништва Србије у периоду од 2009. до 2019. године, с циљем истраживања промена у овом периоду у контексту степена утицаја болести које највише утичу на смртност. Анализа се фокусира на болести система крвотока и туморе. Циљ је да се квантфикују позитивни ефекти на дужину живота који би се постигли хипотетичком елиминацијом најзаступљенијих узрока смрти.

Према подацима за 2019. годину животни век у Србији износио је 76 година, што је за десет година краће од највиших достигнутих вредности у свету. У тој години, жене су живеле дуже од мушкараца за нешто више од 5 година (78.6 и 73.3 године, редом). У периоду између 2009. и 2019. године, очекивано трајање живота порасло је за око две године, нешто значајније код мушког становништва. Разлика у дужини живота између мушкараца и жена резултат је директног и индиректног ефекта специфичне смртности по старости мушкараца и жена. Директан ефекат се односи на број година проживљених унутар одређеног старосног интервала, а индиректни на број преживелих на крају старосног интервала. У већини старосних група, укупни ефекат је позитиван, што говори о разлици у корист жена. Негативне вредности ефеката су у старосним групама 1-4, 5-9, 10-14 и 85+, чиме се смањује разлика у дужини живота у корист жена. Анализа је показала утицај најзначајнијих узрока смрти, као и осталих узрока, на разлику у дужини живота између мушкараца и жена у посматраном периоду. Сви узроци смрти доприносе разлици у дужини живота у корист жена, при чему болести система крвотока имају највећи утицај на разлику у очекиваном трајању живота по полу. Док се код жена уочава нешто повољнија ситуација у односу на мушкарце када је у питању смртност услед болести крвотока и система за дисање, у случају тумора је обрнуто. Код мушкараца, болести система крвотока доприносе готово 50% укупног ефекта, док код жена њихов допринос износи 74%. Болести система за дисање смањују укупан ефекат узрока смрти за око 4% код оба пола.

Највеће промене у дужини живота од 2009. до 2019. године настале би елиминацијом болести система крвотока као узрока смрти. У 2009. години, животни век жена би се повећао за око 15, а код мушкараца за око 10 година. У 2019.

години, пораст би био присутан, али мањи за оба пола. Елиминација тумора и болести система за дисање у 2009. години довела би до повећања живота мушкараца за око 3,0 односно 0,5 година, док би код жена пораст био мањи (2,7 и 1,4 година). Супротно елиминацији болести система крвотока, код елиминације тумора, пораст у дужини живота био би значајнији у 2019. него у 2009. години. Иако је период посматрања кратак (2009-2019), резултати сугеришу да су позитивне промене присутне код болести система крвотока, док се код тумора и болести система за дисање ситуација погоршава.

У случају елиминације болести система крвотока и система за дисање, приближно је повећање дужине живота лица старости 0 и 65 година, док је при елиминацији тумора разлика приметна. Код мушкараца, пораст је 3,33 (за 0 г.) и 1,96 година (за 65 г.). Код жена, пораст је 2,74 и 1,27 година.