Negative demographic trends in Croatia (natural decrease, negative net migration and population aging) are increasingly influencing socio-economic development of the country. Already in early 21st century, the long term decrease of live births and the increase of deaths were recognized as destabilizing factors of population development in Croatia. After the Croatian accession to the EU, the concerns regarding future demographic development of the country raised even more due to intensive emigration to other EU countries, which coincided with the historically low birth rates and high death rates. The focus of this paper is on mortality trends in Croatia in the first two decades of the 21st century. In this period, mortality in Croatia was influenced by different socio-economic, demographic, and epidemiological factors. Given the lack of recent papers dealing with mortality in Croatia, the main aim of this paper is to provide an overview of the changes in selected mortality indicators and contribute to the discussion on recent mortality trends in Croatia. The results of this research indicate that Croatia experienced some positive changes regarding mortality (increase of life expectancy at birth and decrease of infant mortality rates in the first period, in particular), but, some of the trends are not favourable, particularly the changes in the causes of death. Although improvements were observed regarding the share of deaths caused by the diseases of the circulatory system, there was a notable increase in deaths caused by the endocrine, nutritional and metabolic diseases which can be attributed to the unhealthy lifestyle and various behavioural factors.

**KEYWORDS:** mortality, Croatia, age-specific death rate, COVID-19, infant mortality, cause-specific mortality, life expectancy at birth.
INTRODUCTION

Mortality is a negative component of natural change and total population change, and its level is the result of a complex interaction of biological, health and economic factors. Alternately, mortality influences the age, sex and socio-economic composition of the population (Wertheimer-Baletić, 1999). Countries around the world put significant efforts to improve the health of their populations. These efforts are aimed at reducing mortality and increasing the health status (Girosi, King, 2008). Throughout the 20th century, in developed countries, growth in real incomes was accompanied by a historically unprecedented decline in mortality rates that resulted in the increase in life expectancy at birth by nearly 30 years (Cutler et al., 2006). The populations of low-mortality countries have been in an advanced phase of the demographic and epidemiologic transition. Considering the fact that they already experienced strong decreases in infant mortality, the future mortality trends will be driven mainly by mortality in adult ages, primarily the old and oldest-old (Caselli, Drefahl, 2017).

Postulated by Omran in 1971, the epidemiologic transition theory was developed from the demographic transition theory by adding a more thorough discussion on the causes of mortality. It shifts focus to age- and cause-specific mortality associated with the development and characterized by a decline in mortality caused by infectious diseases and reproductive conditions, while chronic non-communicable diseases become major causes of death (Santosa et al., 2014; Hazra, Gulliford, 2017).

Mortality analyses and forecasts are of particular interest to researchers from various disciplines, policymakers, insurance companies, etc., because they provide policy-relevant information. Based on this information the policymakers and governments can (re)direct financial means accordingly, and make necessary institutional arrangements for retirement and health care in line with the actual prospects of cohort survival. The levels of survival to advanced ages reached by recent cohorts are significantly higher than would have been expected in terms of period mortality regimes when these cohorts were young and of working age, or even when they were approaching the age of retirement (Shkolnikov et al., 2011).

Mortality transition in Croatia started in late 19th century, when crude mortality rate fell below 30 per thousand, and it ended in 1950s, when the rate fell below 15 per thousand (Gelo, 1987). On the other hand, fertility transition ended in early 1980s, and Croatia entered the posttransitional stage in late 1980s (Nejašmić, 2005). Since 1991 Croatia had almost continuous natural decrease – the only exceptions were 1996 and 1997, when a small scale baby boom was recorded. Additionally, since 1991 Croatia has recorded a total population decline, which was in the first decade of the 21st century largely caused by natural decrease,
but in the period after 2010, negative net migration was the main cause of population decline in Croatia.

The focus of this paper is on mortality trends in Croatia in the first two decades of the 21st century. In this period, mortality in Croatia was influenced by different socio-economic, demographic, and epidemiological factors. Negative demographic trends (natural decrease, negative net migration and population aging) were increasingly influencing socio-economic development of the country. Already in early 21st century, the long term decrease of live births and the increase of deaths were recognized as destabilizing factors of population development in Croatia (Živić et al., 2005). After the Croatian accession to the EU, the concerns regarding future demographic development of the country raised even more due to intensive emigration to other EU countries, which coincided with the historically low birth rates and high death rates. Concerns related to particularly high rates of natural decrease intensified even more lately due to coronavirus pandemic, which additionally increased the mortality rates and lowered life expectancy (Čipin et al., 2021).

Regardless of the fact that Croatia has faced natural decrease and increasing death rates for the last 30 years, there are not many demographic and geographic papers dealing with this issue, and most of them were published in the early 2000s. Mrden (2000) analysed age- and sex-specific mortality, infant mortality and mortality by causes of death in Croatia for the period from 1950 to 1998. Other authors discussed mortality trends within the analyses of general population trends in Croatia (e.g. Akrap, Živić, 2001; Živić, 2003; Wertheimer-Baletic, 2003, 2004, 2005; Gelo et al., 2005; Čipin, Medimurec, 2019) or in a wider European context (e.g. Nejašmić, 2002; Tcholakov, 2005). Only recently, with the offset of COVID-19 pandemic, the interest in mortality rose to prominence, but mostly to COVID-19 mortality (e.g. Ropac et al., 2020; Čipin et al., 2021; Klempić Bogadi, 2021) and its effects on various aspects of life and socio-economic development (e.g. Mesarić Žabčić, Malnar, 2021; Smolčić et al., 2021; Fürst-Bjelis et al., 2022; Jurić, 2022). This clearly indicates that there is a notable gap in the state-of-the-art regarding contemporary features of mortality in Croatia, so the main aim of this paper is to provide an overview of the changes in selected mortality indicators and contribute to the discussion on the recent mortality trends in the country.
DATA AND METHODS

In this research we analysed the data on general death rates, age-and-sex-specific mortality rates, mortality by causes of death, COVID-19 mortality, infant mortality and life expectancy at birth for the period from 2000 to 2020. The data were retrieved from the Croatian Bureau of Statistics, Croatian Institute of Public Health and Human Mortality Database. However, some of the data were not available for 2000 and 2001, so we took the first available data as a starting point. The data on age- and sex-specific mortality were not available for 2000 and 2001, and for life expectancy at birth for 2000, so as a starting point we took 2002 and 2001, respectively. Most of the data were retrieved from Croatian data bases, but the data for life expectancy at birth and age-and-sex-specific death rates were retrieved from Human Mortality Database, which provides the data for the whole analysed period, while in Croatian sources the data were not compiled in one database (part of the data was not available in a digital format). We also used the EUROSTAT data when comparing Croatia to the EU-27 average. The preliminary data for 2021 are available only for the total number of deaths, so it is not possible to make a complete analysis of the mortality in that year. However, where possible, we will refer to that data to indicate the influence of COVID-19 pandemic on mortality in Croatia.

For more detailed investigation of crude death rates, we employed the joinpoint regression analysis, which has been used often in analysing mortality trends (CHAURASIA, 2020). Accordingly, joinpoint regression software (version 4.9.1.0., National Cancer Institute USA) was used to analyse the changes in mortality trends. The software takes the trend data and fits the simplest joinpoint model that the data allow. The software identifies inflection points for each range of data at which there is a significant change in the slope of the linear trend (KIM ET AL., 2001).

In order to investigate the effect of COVID-19 deaths on mortality, we compared the number of deaths by month from the beginning of the pandemic with the average number of deaths by month for the four-year period before the pandemic (2016–2019). Excess mortality was expressed as a percentage difference between the reported and projected number of deaths (P-score) and it was calculated as follows:

\[
P - \text{score} = \frac{\text{reported deaths} - \text{projected deaths}}{\text{projected deaths}} \times 100
\]

For example, P-score of 100% in a given month in 2020 or 2021 means that the death count for that month was 100% higher than the projected death count for that month (i.e. than the
average death count for that particular month in the four-year period before the pandemic – 2016–2019). We chose the four-year period before the pandemic instead of five-year period (that some authors used, e.g. Karlinsky, Kobak, 2021), because of the increase in mortality caused by remarkably deadly 2014–2015 flu season. Eurostat also uses 2016–2019 period as the baseline for calculating excess mortality, so we can compare the excess mortality in Croatia with the EU-27.

RESULTS AND DISCUSSION

Crude mortality rate

From the beginning of the 20th century the number of deaths in Croatia was decreasing and reached the lowest levels during the 1960s and early 1970s (Gelo et al., 2005), but from the late 1970s it started to increase again due to population ageing (Mrden, 2000). According to the epidemiologic transition theory, mortality decline can be attributed to a changing mix of socio-economic development, lifestyle changes and medical innovations in each period (Zheng, 2014).

In the analysed period, the number of deaths recorded an upward trend, particularly after 2013 and with the onset of the COVID-19 pandemic, which significantly increased the number of deaths and crude death rate in 2020. The average annual number of deaths was 51,838 and in only two years the number of deaths was below 50,000 (Fig. 1). In two of the analysed years the increase in the number of deaths was particularly sharp – in 2015 and 2020. In 2015, the increased mortality was caused by unusually deadly flu season, particularly among the elderly population, which was not only recorded in Croatia, but also in many other European countries (Mølbak et al., 2015; Neli et al., 2015; Raleigh, 2018).

The highest number of deaths was registered in 2020, and it was 10.1% higher than in the previous year. The data for 2021 indicate that this trend continued and the number of deaths increased by additional 10.0%. Such a sharp increase in mortality can be attributed to COVID-19 pandemic, which had a significant influence on mortality, particularly during the second and fourth waves (November-December 2020 and 2001, respectively) (Fig. 10). Mortality rate in that period also increased, but not only due to increased number of deaths, but also due to the fact that it coincided with the declining population in Croatia. Namely, in two intercensal

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1 According to the data for 2021, the number of deaths reached 62,712.
periods (2001–2011 and 2011–2021), the Croatian population decreased by 12.7%\textsuperscript{2}, and the decline was particularly sharp in the second period. Throughout the whole analysed period, crude death rates in Croatia were higher than in the EU-27.

\textbf{SI\textsc{li}ka 1.} \textit{Broj umrlih i stope mortaliteta u Hrvatskoj od 2000 do 2020}
\textbf{FIGURE 1} \textit{Number of deaths and crude death rates in Croatia from 2000 to 2020}
\textit{Izvor/Source: Natural change in population, Croatian Bureau of statistics,}
\textit{https://podaci.dzs.hr/hr/podaci/stanovnistvo/prirodno-kretanje-stanovnistva/, accessed 20 May 2022.}

\textsuperscript{2} At the same time, the number of births decreased by 18.1\%, and the rate of natural decrease lowered from -1.5\% to -5.2\%. 
Joinpoint regression software identified one joinpoint while computing results for mortality rates, which means there are two periods in the trend, the first one from 2000 to 2013, and the second one from 2013 to 2020 (Fig. 2). The slope of the trend was gentle in the first identified period with the Average Percent Change (APC) of 0.4 (95% Confidence Interval, -0.1 to 0.8), but it was not marked as significantly different from zero at the alpha = 0.05 level (P=0.087). In the second period, the slope of the trend was steeper, with the APC equal to 0.9 (95% Confidence Interval, 0.9 to 2.9) and marked as significantly different from zero. The results indicate that from 2013 the increase of mortality rates accelerated. Looking at the whole studied period, the Average Annual Percent Change was 0.9 (95% Confidence Interval, 0.5 to 1.3) marked as significantly different from zero, which shows that there was an overall increase in mortality rates.

The observed increase in mortality in the second period was caused by several factors. In this period Croatia experienced a strong population decline (in comparison to the previous period), largely due to intensive emigration after the accession to the EU. Additionally, it was the period during which the baby-boomers entered the old age, when they are at greater risk of death, particularly from communicable diseases such as the flu or COVID-19 (as it was the case in 2014/2015 and 2020/2021, respectively).
**Age-and sex-specific mortality**

During the 20th century, mortality became concentrated at older ages, non-communicable diseases became the prevailing causes of death, and female survival advantage came to light (GOLDIN, LLERAS-MUNEY, 2019; HOLLINGSHAUS ET AL., 2019). In Croatia, the mortality shift to older ages was also prominent throughout the 20th century, and it was evident in the observed period, too.

The results indicate notable changes in the distribution of deaths across the age groups in Croatia. In almost all age groups the share of deaths in the total number of deaths decreased (Fig. 3). In comparison to the 2000, in 2020 the number of deaths in 0–4 age group decreased by 55.6%, in 5–9 age group by 64.5%, 10–19 age group by 60.2%, 20–39 age group by 50.5%, 40–59 age group by 31.8%, 60–69 age group by 17.9%, and in 70–79 age group by 16.3%. On the other hand, in 80+ age group the number of registered deaths increased by 100.2%. Additionally, in 2000, the largest share of deaths was recorded in 70–79 age group, but in the following periods that share started to decrease gradually with simultaneous increase in mortality for 80+ age group. Consequently, in 2020, the largest share of deaths occurred in the last age group (50.7%). This clearly indicates the transition of mortality to older ages, particularly among the oldest-old population, which is in accordance with the epidemiological transition theory, i.e. its postulates regarding the degenerative and man-made diseases (that particularly affect the older population) as main causes of death, and the improvement in survival of children under 15 (OMRAN, 1971). In this context, it is also important to emphasize the impact of baby boom generations, as they increasingly moved to older ages during 2010s and thus contributed to the transition of mortality.
Age-specific mortality rates have a typical J-shape pattern, indicating somewhat higher mortality rates among infants, after which they decline significantly, reaching the lowest levels among the children aged 5–14. The rates are relatively steady throughout the 20s and early 30s, after which they start increasing, particularly after the age of 60 (Fig. 4). The comparison between the age-specific rates at the beginning and at the end of the analysed period indicate that the at the end of the period the rates were lower, which is in line with the thesis that over the years the mortality hazards have shifted to older ages (BONGAARTS, 2005).
An increase in mortality rates was recorded among both men and women in Croatia. Throughout the whole period, the male mortality was higher than that of women, but the gap between them narrowed (Fig. 5). The narrowing of the gap was the result of higher survival rates among men. Namely, the age specific death rates indicate that the mortality rates decreased more intensively among young adult and middle-aged men than among women (Fig. 4).

Sex gap in mortality can be explained by social/environmental and biological factors. Social perspectives emphasize the importance of social relationships, health-related behaviours, and socio-economic factors in accounting for sex differences in survival, while biological models emphasize the role of biological markers, hormones, and genetics on health outcomes (ROGERS ET AL., 2010). Up to 2009, the share of men in the total number of deaths in Croatia was slightly higher, but from that point on, the share of women became higher, but not significantly. In 2020, the mortality rates increased sharply for both sexes due to COVID-19 pandemic. However, the mortality rate for men was higher.
Analysis of age-specific mortality by sex reveals that in comparison with 2002, in 2020 the age-specific rates for all ages and for both sexes were lower, indicating higher survival rates at all ages (Fig. 4). A particularly notable decrease in mortality was recorded for the ages 18 to 28 for both sexes. A decrease in age-specific mortality was particularly evident among male population. The decrease of mortality of young adult and middle-aged population can be linked to the decrease of deaths by external causes, particularly transport accidents (which decreased from 15.2/100,000 in 2004 to 7.5/100,000 in 2020).

The mortality among both men and women has shifted to older ages, and the mortality in early and middle adult age has decreased. These changes, as well as the sex gaps in mortality are often discussed through intrinsic-extrinsic framework. The intrinsic mortality reflects physiological degeneration processes that are common to both sexes, so the sex gap in intrinsic mortality is converging. On the other hand, men have higher extrinsic mortality rate due to their physiological vulnerability to external factors (infectious diseases, for example) and innate risky behaviour (OWENS, 2002). Consequently, in old age, where intrinsic mortality plays an important role, male and female trajectories may continue to converge, but in the late middle and early old ages, where extrinsic mortality is more dominant, the trajectories are likely to persist (LI ET AL., 2013).
**Infant mortality**

Infant mortality rate (IMR) is considered as one of the principal health status indicators of a country and one of the most important measures of a nation's life expectancy (WANG, 2002). It is associated with socio-economic conditions that influence the health of mothers and infants. Infant and child mortality today are the lowest they have ever been. Over the course of the 20th century, the advances in medicine and public health in western industrialized world produced major reductions in infant mortality rates (KIM, SAADA, 2013).

In Croatia, in late 1960 more than one-third of the infants died in their first year of life, while in early 1970s, that share was more than one-quarter, but in the subsequent periods the country saw a rapid decline in IMRs. The rate continued to decrease in the first decade of the 21st century, but it the second decade it stagnated. At the beginning of the whole analysed period it was 7.4 per thousand (7.1 for girls and 7.7 for boys), while at the end of the period it lowered to 4.0 per thousand (3.7 for girls and 4.2 for boys) (Fig. 6.) The IMR in Croatia is still approximately 21.0% higher than the EU-27 average (3.3). Most of the infant deaths occur in the early neonatal period (between 0 and 7 days after the birth), and after that period the survival rate increases. Similarly, Croatia has a particularly high survival rate of children under five (99.5%), which means that the UN's Sustainable Development Goal 3.2\(^3\) has already been reached.

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\(^3\) Goal 3.2 is to reduce the child mortality rate to at least as low as 2.5% in all countries by 2030. This would mean that more than 97.5% of all newborns would survive the first five years of their life no matter where they are born. [https://sdgs.un.org/2030agenda](https://sdgs.un.org/2030agenda)
International Classification of Diseases (ICD) is used globally and provides important information on the extent, causes and consequences of human disease and death worldwide. Standardized categories and data collection of ICD enable large scale research, and provide the basis for comparable statistics on causes of mortality and morbidity between places and over time. Considering the period analysed in this paper, we used the tenth revision of ICD (i.e., ICD-10). For analysing the mortality by causes we selected three years (beginning, middle and end of the analysed period) and compared the data.

As it has been the case in other industrialized countries for decades, most of the deaths in Croatia have been attributed to non-communicable diseases, primarily cardiovascular diseases and neoplasms. The main cause of death throughout the analysed period were the diseases of the circulatory system, but the mortality per 100,000 inhabitants decreased in total population and for both sexes, particularly for men (Table 1). Mortality rate for the diseases of the circulatory system was much higher for women than for men. The second most important cause of death were neoplasms, and the mortality rate for neoplasms increased in the twenty-year period. The largest increase in mortality rate was recorded for the third most important
cause of death — endocrine, nutritional and metabolic diseases. The mortality rate for COVID-19, which was the fifth most important cause of death in 2020, was notably higher for men than for women.

In 2000, the diseases of the circulatory system accounted for 53.1% of all deaths, but in the following periods that share lowered to 40.0% (Fig. 7). The share of deaths caused by neoplasms recorded an increase until 2015, and remained the second most important cause of death with the share between 23.2% and 26.4%. The share of deaths caused by other groups of diseases was much lower and continuously below 10.0%, but it should be emphasized that in a relatively short period of time, deaths caused by endocrine, nutritional and metabolic diseases increased from 3.1% to 8.3%. In 2020, during the coronavirus pandemic, deaths caused by COVID-19 accounted for 7.9% of all deaths.
The analysis of the cause-specific mortality indicates two dominant trends – reduction in cardiovascular mortality and increase of mortality caused by neoplasms, and endocrine, nutritional and metabolic diseases. Decline in cardiovascular mortality in developed countries may be attributed to improved lifestyle habits and different medical advancements (FERALDI, ZARULLI, 2022), such as preventive health check-ups, improved diagnostics, medication, and advances in cardiovascular medical technology. Simultaneously, the mortality rate for neoplasms increased, but the total number of cancer deaths and their share in total deaths recorded a slight decrease at the end of the analysed period, which may be attributed to screening programs, early detection, and improved treatment. In the last two decades, Croatian
Ministry of Health has introduced several prevention programs related to early detection of
cancers (lung, breast, cervical and colorectal cancers). Nevertheless, in 2019, the overall
mortality from cancer in Croatia was among the highest in the EU-27 (OECD/European Union,
2022).

Mortality rate for endocrine, nutritional and metabolic diseases recorded a particularly
high increase in Croatia, and the disease that contributed to the increase the most was diabetes
mellitus. Diabetes mellitus has been recognized as one of the most important public health
challenges of the 21st century worldwide, and it used to be underrated as a global health threat
(ZIMMET ET AL., 2001).

If we investigate the causes of death further and in more detail, and analyse the leading
causes of death, we can conclude that both at the beginning and at the end of the analysed
period ischemic heart diseases and cerebrovascular diseases were the two leading causes of
death, but their share in total deaths decreased, while some other diseases came to prominence
– diabetes mellitus, hypertensive diseases and atherosclerosis, in particular (Table 2). On the
other hand, causes of death such as pneumonia, chronic liver diseases and cirrhosis, and
malignant neoplasm of stomach, which were among the top ten leading causes of death in 2004,
recorded a decrease in mortality and were not among the ten leading causes of death in 2020.
In the analysed period the incidence of tuberculosis decreased, and medical advances in early
detecting and treating the above-mentioned diseases certainly also contributed to the mortality
decrease. Additionally, the changes in how the death certificate is completed, in determining
the cause of death and changes in the use of cause of death codes contributed to lower number
of deaths being attributed to heart failure (IVANUŠA, KRALJ, 2014).

**Table 2. Ten leading causes of death in Croatia in 2004 and 2020**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Code</th>
<th>Diagnosis</th>
<th>Total number</th>
<th>%</th>
<th>Total number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I20-I25</td>
<td>Ischemic heart diseases</td>
<td>9,173</td>
<td>18.4</td>
<td>7,589</td>
<td>13.3</td>
</tr>
<tr>
<td>2</td>
<td>I60-I69</td>
<td>Cerebrovascular diseases</td>
<td>7,962</td>
<td>16.0</td>
<td>4,950</td>
<td>8.7</td>
</tr>
<tr>
<td>3</td>
<td>E10-E14</td>
<td>Diabetes mellitus</td>
<td>973</td>
<td>2.0</td>
<td>4,697</td>
<td>8.2</td>
</tr>
<tr>
<td>4</td>
<td>I10-I15</td>
<td>Hypertensive diseases</td>
<td>-</td>
<td>-</td>
<td>4,487</td>
<td>7.9</td>
</tr>
<tr>
<td>5</td>
<td>U071-U072</td>
<td>COVID-19</td>
<td>-</td>
<td>-</td>
<td>4,478</td>
<td>7.9</td>
</tr>
<tr>
<td>6</td>
<td>C33-C34</td>
<td>Malignant neoplasm of trachea, bronchus and lung</td>
<td>2,635</td>
<td>5.3</td>
<td>2,819</td>
<td>4.9</td>
</tr>
<tr>
<td>7</td>
<td>C18-C21</td>
<td>Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal</td>
<td>1,564</td>
<td>3.1</td>
<td>2,079</td>
<td>3.6</td>
</tr>
</tbody>
</table>
There are certain differences in the leading causes of death in men and women. In 2004, ischemic heart diseases and cerebrovascular diseases were the two leading causes of deaths in both sexes, followed by malignant neoplasm of trachea, bronchus and lung, heart failure, and chronic liver diseases and cirrhosis in men, and heart failure, malignant neoplasm of breast, and pneumonia in women. On the other hand, in 2020, the leading causes of death in men were ischemic heart diseases, COVID-19, cerebrovascular diseases, diabetes mellitus and malignant neoplasm of trachea, bronchus and lung. Ischemic heart diseases were also the leading cause of death in women, but it was followed by hypertensive diseases, cerebrovascular diseases, diabetes mellitus and COVID-19.

Cause-specific mortality changes should be discussed from the viewpoint of the model of epidemiological transition. Most developed countries are currently at the fourth stage of epidemiologic transition (the age of delayed degenerative diseases), which is characterized by notable advances in medical technology and health care programs. This resulted in decreased mortality in younger ages, delayed age at death, and improved survival at increasingly older ages (WILMOTH ET AL., 2000). Moreover, in this stage degenerative diseases or "lifestyle illnesses" (particularly diseases of the circulatory system or neoplasms) emerge as the leading causes of death (KLENK ET AL., 2016).

Trends in cause-specific mortality in Croatia are similar to those in the EU-27. Before the COVID-19 pandemic, in 2019, the two main broad causes of mortality in the EU-27 were circulatory diseases (35% of all deaths) and neoplasms (26% of all deaths), as it was the case in Croatia, too. In 2020, COVID-19 accounted for 8% both in the EU-27 and in Croatia. If we compare the individual causes of death in Croatia and the EU-27, it is evident that ischemic heart diseases and cerebrovascular diseases were the most common causes of mortality.

<table>
<thead>
<tr>
<th>8</th>
<th>8</th>
<th>J40-J47</th>
<th>Chronic lower respiratory diseases (emphysema, bronchitis, asthma)</th>
<th>1,185</th>
<th>2.4</th>
<th>1,696</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>-</td>
<td>I70</td>
<td>Atherosclerosis</td>
<td>-</td>
<td>-</td>
<td>1,569</td>
<td>2.8</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>I50</td>
<td>Heart failure</td>
<td>2,956</td>
<td>5.9</td>
<td>865</td>
<td>1.5</td>
</tr>
<tr>
<td>Total 10 leading causes</td>
<td></td>
<td></td>
<td></td>
<td>30,172*</td>
<td>60.6</td>
<td>35,229</td>
<td>61.8</td>
</tr>
<tr>
<td>Total deaths</td>
<td></td>
<td></td>
<td></td>
<td>49,756</td>
<td></td>
<td>57,023</td>
<td></td>
</tr>
</tbody>
</table>

*Besides the above-mentioned causes of death, the ten leading causes in 2004 also included pneumonia (1,504 deaths), chronic liver diseases and cirrhosis (1,253 deaths) and malignant neoplasms of stomach (967 deaths).

considering circulatory diseases. As for cancer, both in Croatia and the EU-27 lung cancer was the leading cause of cancer mortality. However, in the EU-27 lung cancer was the main cause of cancer death in men followed by colorectal cancer, while breast cancer was the leading cause of cancer death in women followed by lung cancer (OECD/European Union, 2022). In Croatia, lung cancer was the leading cause of cancer mortality followed by colorectal cancer in both men and women. In 2019, in Croatia, behavioural risk factors, such as dietary factors, tobacco smoking, alcohol consumption and low physical activity, were responsible for 44.0% of all deaths (OECD, 2021).

COVID-19 mortality

The first case of SARS-Cov-2 (coronavirus) infection in Croatia was reported on 25th February 2020, and until the 31st December 2021, as many as 715,245 confirmed cases and 12,538 deaths were reported. The pandemic had a great impact on different socio-economic and demographic processes, but the most evident one was on the mortality, particularly during the second and fourth waves of the epidemic (November and December 2020 and 2021, respectively).

The influence of COVID-19 deaths on mortality can be analysed through excess mortality. If we compare the number of deaths by month in 2020 and 2021 with the monthly averages for the four-year pre-pandemic period (2016–2019), we can observe the increased mortality, particularly in November and December (Fig. 8). In 2020, the number of recorded deaths was 27.3% higher in November and 74.3% in December. In the same period in 2021, the excess deaths were 48.4% and 72.3%, respectively. If we take into account the total number of deaths during the pandemic years, it is evident that in 2020, the annual number of deaths was 8.9% higher than the average for 2016–2019 period, and in 2021, it was 19.7% higher. If we compare the excess deaths in Croatia with the EU-27, we can see that the excess deaths in Croatia were lower during the first wave, which can be attributed to strict lockdown measures, that slowed down the spreading of infection. However, during the subsequent waves, the excess mortality in Croatia was higher, particularly in November–December period in both 2020 and 2021. That can be attributed to untimely introduced and weaker restrictions than at the beginning of the pandemic (Čipin et al., 2021).

Higher excess mortality in Croatia in 2021 might also be attributed to lower vaccination rate in Croatia in comparison to the EU-27. Namely, a study conducted by Watson et al. (2022) revealed that vaccinations against COVID-19 saved tens of millions of lives globally. At the
end of 2021, in Croatia 56.6% of the population was vaccinated with one dose and 53.7% with two doses, while in the EU-27 the vaccination rates were notably higher – 73.0% and 68.4%, respectively (ECDC, 2022).

The available data indicate that COVID-19 had a different impact on the mortality of men and women and on particular age groups. As much as 56.3% of all COVID-19 deaths were recorded in men. In all the age groups from 20-29 to 70-79, mortality was higher for men (Fig. 9), and only in the age groups 80+ the mortality was higher for women, who are simultaneously more numerable at those ages. Excess mortality in older age groups lowered the life expectancy at birth and worsened the general health of the population (ČIPIN ET AL., 2021).

**Figure 9** COVID-19 deaths by age groups from 25 February 2020 to 2 January 2022.

Izvor/Source: https://www.koronavirus.hr/uploads/2_1_2022_izvjesce_tjedno_novo_64eea1e4cf.pdf, accessed: 5 May 2022

**Life expectancy at birth**

Life expectancy at birth is another relevant mortality indicator in a population, and it is closely related to the standard of living and health conditions. Differences in health status are prompted by income differences across countries, and there is a strong correlation between life expectancy at birth and the level of economic development and recent economic growth (Top, Cinaroglu, 2021). The key mechanism behind the increase in human life expectancy is epidemiologic transition (Olshansky, Ault, 1986; Omran, 1971).

On average and worldwide, women live longer than men, and Croatia is no exception. Research on the causes of the male disadvantage emphasize the role of both biological factors (e.g. Y chromosome, mitochondrial DNA and sex hormones) (Giuliani et al., 2018; Marais et al., 2018; Rogers et al., 2010) and behavioural factors (e.g. the tendency of men to engage in more reckless behaviours, which can be observed from mortality hump for men (Goldstein, 2011). According to Oeppen and Vaupel (2002), in many developed countries, in the last two centuries, life expectancy at birth has more than doubled – from 30-40 years to approximately 80 or more years.

The life expectancy at birth increase in Croatia that started in the 20th century, continued in the 21st century, too. In 1950, life expectancy at birth in Croatia was very low...
(56.0 for men and 60.9 for women) in comparison to industrialized western European countries, but in the following 15 years, life expectancy increased rapidly (by approximately 10 years) (Mrđen, 2000). By the end of the 20th century, life expectancy increase was slow and steady and life expectancy gains were higher for women than for men. In most industrialized countries the gap in life expectancy between the two sexes widened until 1970s, and after that it started to narrow (Glei, Horiuchi, 2007; Oksuzyan et al., 2008; 2009). On the other hand, from 1970s onward in Croatia, the gap in life expectancy remained relatively steady.

From 2001 to 2019, the life expectancy at birth for total population increased from 74.6 to 78.4 (by 3.8 years) (Fig. 10). Simultaneously, life expectancy for women increased by 3.4 years, and for men by 4.4 years. The difference in life expectancy between men and women in 2001 was 7.2 years and in 2019 it lowered to 6.2 years. Life expectancy at birth in Croatia is still below the EU-27 average, which was estimated at 81.3 years for total population in 2019, reaching 84.0 years for women and 78.5 years for men. Overall, between 2002 (the first year for which life expectancy at birth data became available for all member countries) and 2019, life expectancy at birth in the EU-27 increased by 3.7 years for total population, 3.1 years for women and 4.2 years for men. In addition, the difference in life expectancy between women and men lowered from 6.6 years to 5.5 years. The same trends were recorded in most of the EU member countries.

The increased mortality in 2020 during the coronavirus pandemic had a negative effect on life expectancy in Croatia – for the total population it decreased by 8.16 months, for men 8.52 months and for women 7.20 months. The same trend was recorded in other EU member states to a lesser or larger degree. Life expectancy at birth in the EU-27 was estimated at 80.4 years in 2020 (10.8 months lower than in 2019), reaching 83.2 years for women (9.6 months lower than in 2019) and 77.5 years for men (1 year lower than in 2019). The excess COVID-19 mortality in 2021 and lower vaccination rates additionally lowered the life expectancy at birth in Croatia – in comparison to 2020, in 2021, life expectancy at birth for both sexes decreased by 1 year, while in the EU-27 it decreased by 0.3 years.

In the last few decades, the gender gap in life expectancy has narrowed in most low-mortality countries (Thorshlund et al., 2013; Hossin, 2021). That convergence was caused by more rapid gain in survival in men. The existing research point out several important factors that might have propelled the convergence trend – increased labour force participation of women and the adoption of health-damaging lifestyles (e.g. smoking and drinking), changes in other social and lifestyle factors, and improved medical treatment of deadly diseases (Hemström, 2016; Sundberg et al., 2018; Hossin, 2021).
Slika 10. Očekivano trajanje života u Hrvatskoj od 2001 do 2020
Figure 10 Life expectancy at birth in Croatia from 2001 to 2020
CONCLUSION

In the last two decades Croatia experienced some positive changes regarding different mortality indicators. Population ageing and intensive depopulation resulted in increased mortality rates, particularly at the end of the research period when they coupled with increased mortality caused by COVID-19. However, the mortality shifted to older ages due to the increasing number of baby boomers entering the older ages and higher survival rates in young and adult ages. Positive trends were also recorded in infant mortality rates in the first analysed period and in life expectancy at birth. Despite the positive trends, those indicators are still below the EU-27 average. On the other hand, the crude death rate recorded a constant increase and was above the EU-27 average throughout the whole period.

Notable changes were recorded in mortality trends according to the causes of death. Although the death rates from the diseases of circulatory system decreased, there was an evident increase in death rates caused by neoplasms and endocrine, nutritional and metabolic diseases, particularly in women. COVID-19 pandemic also had a significant influence on mortality in Croatia – it increased the annual number of deaths and excess mortality, and decreased the life expectancy at birth.

The observed diversification of the causes of death increases the pressure on the healthcare system and largely affects the distribution of health resources. Therefore, there is a need to further analyse the changes in mortality by causes of death by age and sex in order to determine the influence of particular diseases on the years of potential life lost and on the life expectancy at birth and at older ages. Additionally, those results should indicate the role of behavioural risk factors in mortality and serve as a basis for designing and implementing preventive programs aimed at reducing the most important public health challenges.
SOURCES AND BIBLIOGRAPHY


