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# The Geographic Patterns of the Exceptional Longevity in Croatia

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## ABSTRACT

*The aim of this study was to provide an overview of the exceptional longevity patterns in Croatia. The prevalence of nonagenarians (aged 90 years or more) and centenarians (100 years or more) was calculated from the 1953–2001 census data. The data were analyzed with chi-square test and trend analysis. The results indicate steady and significant increasing trends in both age groups, more pronounced in women. Geographical distribution of the exceptional longevity had a clear coastline-to-mainland gradient, with higher prevalence of exceptionally old people in the coastal parts of the country. Additionally, exceptionally old respondents from the Croatian Adult Health Survey (CAHS) were compared to elderly ones (65–89 years old). The results suggested that exceptionally old respondents had lower prevalence of overweight and obesity and lower blood pressure, thus exhibiting strong survivor phenomenon. At the same time, exceptionally old respondents from the CAHS had higher prevalence of confirmed hypertension in medical history and reported taking blood pressure medication more often. The results of this study suggest that the pattern of exceptional longevity in Croatia has a clear coastline-to-mainland gradient, which is likely to be associated with the different lifestyle and dietary patterns between these two populations.*

**Key words:** longevity, ageing, centenarian, nonagenarian, demography, prevalence, Croatia

## Introduction

The longevity represents a complex human trait determined by the genetic heritage and the environmental effects, but stochastic factors have also been implied<sup>1,2</sup>. The studies of twins and siblings emphasized the genetic component of longevity<sup>3–5</sup>, with heritability of longevity estimated to 0.23 for men and 0.20 for women<sup>6</sup>. Epidemiological surveys documented the increase of the average lifespan for almost three times through the course of human history, with the highest increase observed in the 20<sup>th</sup> century<sup>7,8</sup>. The life expectancy differs considerably among countries, and Japan is known worldwide by the highest expected life expectancy, with almost 85 years for women<sup>9</sup>. Still, caution is needed when we interpret these estimates since it may not be the fact that the entire population is ageing in a similar pattern. The emergence of

exceptionally old sub-groups, such as people aged 95 years and over, might contribute more to this increase<sup>9</sup>.

Croatia is a post-transitional country which faces steady population ageing and the increase in the life expectancy<sup>10</sup>. According to the most recent data for the year 2006 the life expectancy in Croatia was 72.5 years for men and 79.3 years for women<sup>11</sup>. Croatia reveals interesting geographical pattern of longevity with significantly lower prevalence of elderly people in the continental part and the higher prevalence in the coastal and highland parts of the country (along the coast, and in Lika region)<sup>10</sup>. Additionally, the geographical disparities are especially pronounced among Adriatic islands isolates, which have unique genetic background and envi-

ronmental exposures<sup>12–14</sup>. For instance, the island of Ilovik is among such isolates, characterized with high longevity and life expectancy at birth of 95 years<sup>15</sup>.

The aim of this paper was to investigate the demographic and geographic patterns of exceptional longevity in Croatia in the 1953–2001 period, and to compare the prevalence of selected cardiovascular risk factors among the exceptionally old and the elderly respondents from the Croatian Adult Health Survey.

### Material and Methods

The initial dataset for this study was based on the census data obtained from the official publications of Central Bureau of Statistics Republic of Croatia for the years 1953, 1961, 1971, 1981, 1991 and 2001, respectively<sup>16–20</sup>. The 1981 census data contained the estimates for age group of 75 and more years only, hence internal tables of Central Bureau of Statistics were used<sup>21</sup>. We analyzed three age groups of exceptionally old people: 90–94, 95–99 and more than 100 years of age.

Two indices with different implications were calculated from the most recent, 2001 census data: (i) the prevalence of exceptionally old people in the general population, which is indicative for the ageing of the general population, and (ii) the prevalence of exceptionally old people among the elderly ones (number of people 90 or more years of age divided by the number of people 65 or more years of age). The second index theoretically provides more information on the longevity pattern, as it is less sensitive to biases that may occur because of the changes in younger population groups (different natality rates and migration patterns).

In addition to the demographic analysis, we also analyzed data from the Croatian Adult Health Survey (CAHS). This survey conducted in 2003 encompassed a total of 9,070 adults and it is considered to be representative for Croatian population. Data were collected during the interview performed by trained public health nurses and the response rate was 84%. Further details on this project are given elsewhere<sup>22</sup>.

We compared the data from CAHS dataset between two groups of examines, the elderly (65–89 years of age) and the exceptionally old (90 years and more), according to the prevalence of overweight (BMI 25–29.9) and obesity (BMI 30 and more), the prevalence of hypertension (measured systolic blood pressure over 140 or diastolic blood pressure over 90 mmHg), the hypertension in medical history and reported taking anti-hypertensive treatment. Educational status and the level of urbanization in both groups were also analyzed and compared. For data analysis we used chi-square test and linear trend analysis, with  $P < 0.05$  considered significant.

### Results

During the 1953–2001 period, the prevalence of nonagenarians in the general population increased 4.60 times, from 5.71 per 10,000 inhabitants in 1953 to 26.21 per 10,000 inhabitants in 2001. During the same period the prevalence of centenarians increased 4.75 times, from 0.04 per 10,000 inhabitants in 1953 to 0.19 per 10,000 inhabitants in 2001. Centenarian doubling time in the 1953–2001 period for Croatia was 20.2 years.

The linear trend analysis according to gender and three age groups (90–94, 95–99 and 100 and more) showed the increases for both genders. For men, the linear trend was significant for age group 90–94 ( $P = 0.026$ ,  $\beta = 0.86$ ), while it was insignificant for two other groups ( $P = 0.488$ ,  $\beta = 0.36$  for 95–99 years;  $P = 0.063$ ,  $\beta = 0.79$  for 100 and more years). All three age groups in women had significant increasing linear trend ( $P = 0.011$ ,  $\beta = 0.91$ ;  $P = 0.011$ ,  $\beta = 0.91$ ;  $P = 0.037$ ,  $\beta = 0.84$ ), respectively (Figure 1a,b).

The geographic distribution of exceptionally old people in general populations in Croatia has scattered pattern in 2001. The highest prevalence of exceptionally old men was observed in Lika-Senj County and Šibenik-Knin County while the highest prevalence of exceptionally old women was in Lika-Senj County and Dubrovnik-Neretva County (Figure 2a,b). In contrast, the prevalence of ex-

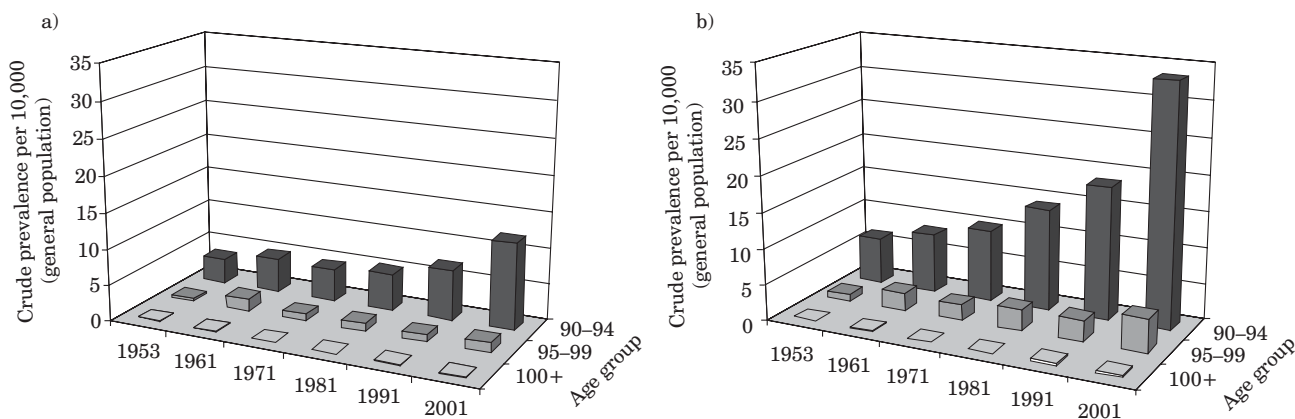


Fig. 1. The crude prevalence of three age groups of exceptionally old people in general Croatian population (per 10,000), based on the 1953–2001 Census of population data; a) men, b) women.

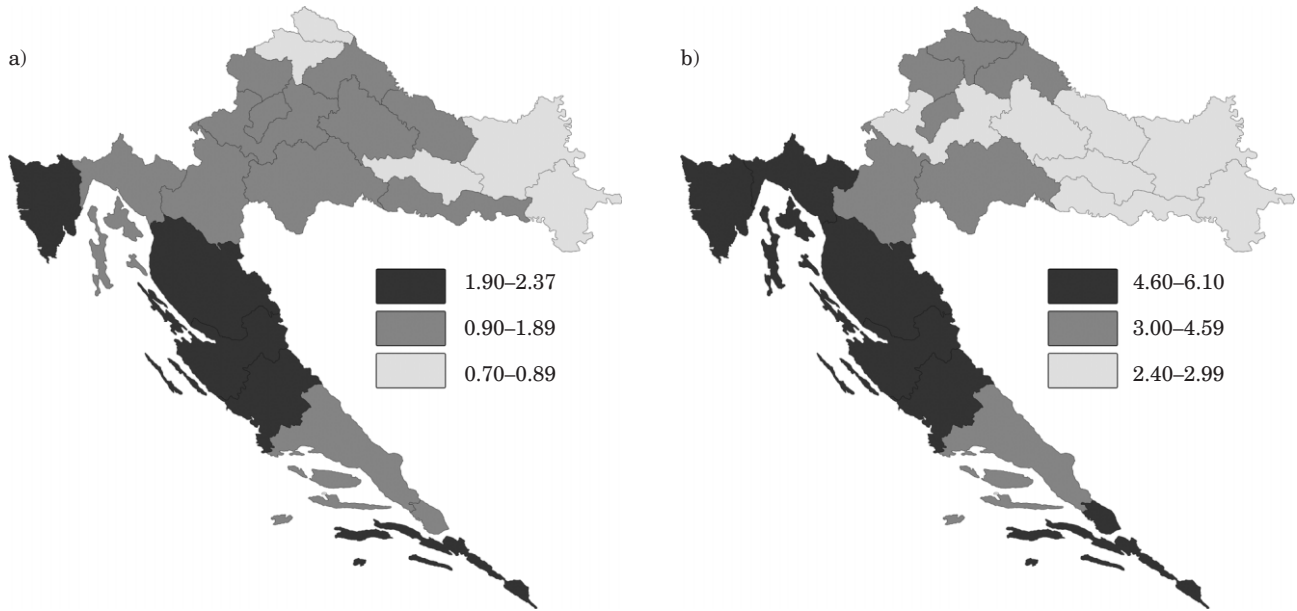


Fig. 2. Prevalence of exceptionally old people (90 and more years) in general population\*1000 based on the 2001 Census data for a) men and b) women.

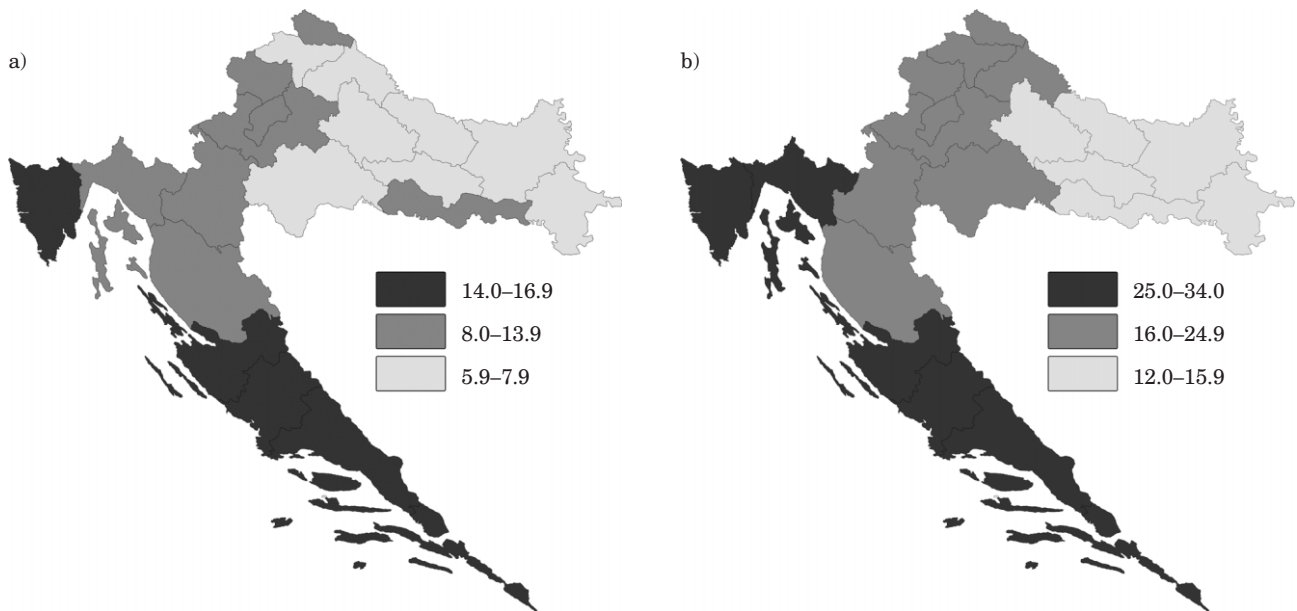


Fig. 3. The prevalence of exceptionally old people (90 and more years) in the elderly (65 years and more)\*1000 based on the 2001 Census data for a) men and b) women.

exceptionally old people among the elderly showed geographical pattern with clear coastline-to-mainland gradient (Figure 3a,b). This kind of analysis showed that the prevalence of exceptionally old people among the elderly group was much lower in some counties traditionally known to have high longevity, such as Lika-Senj County (Figure 3a,b).

When we analyzed the data from CAHS dataset, there was no significant difference between the exceptionally

old examinees and the elderly ones in terms of education ( $\chi^2=2.30$ ,  $P=0.513$ ) or urbanization level ( $\chi^2=5.22$ ,  $P=0.156$ ). The exceptionally old recruits were more commonly women; 78.4% ( $\chi^2=4.63$ ,  $P=0.031$ ) and they had significantly better some of the selected health indicators, such as the body weight and the blood pressure; but they had higher prevalence of some less favorable indicators, such as the hypertension in medical history and the higher prevalence of regular anti-hypertensive treatment use (Table 1).

**TABLE 1**  
THE COMPARISON OF THREE MAIN CARDIOVASCULAR RISK FACTORS PREVALENCE IN EXCEPTIONALLY OLD (90 AND MORE YEARS) AND ELDERLY (65–89 YEARS) RECRUITS FROM THE CROATIAN ADULT HEALTH SURVEY, PROJECTED FOR THE ENTIRE CROATIAN POPULATION

Indicator	Elderly (65–89 years)	Exceptionally old (90 and more years)	P
Overweight	493,419 (72.8%)	9,270 (46.3%)	<0.001
Obesity	183,887 (27.3%)	1,833 (1.0%)	<0.001
Measured elevated blood pressure	467,660 (68.9%)	11,721 (58.6%)	<0.001
Hypertension in medical history	380,854 (56.1%)	11,663 (58.3%)	<0.001
Reported taking anti-hypertensive treatment	323,628 (85.0%)	11,111 (95.3%)	<0.001
Total (projection)	380,854 (100.0%)	11,663 (100.0%)	–

## Discussion

This study re-examined geographical distribution of exceptionally old people in Croatia and confirmed clear coastline-to-mainland gradient. Additionally, it provided further information on the ageing of Croatian population.

Although the centenarians are in general rare, this phenomena was recognized in the human history and examples of extreme longevity individuals dated long time ago<sup>5</sup>. Recently, this subpopulation group increases globally at extremely rapid rate of 8 % per year<sup>5</sup>. The increase in our study was even higher than previously reported, with an average increase during the investigated period of average 9.9% per year. Still, this proportion varied significantly between censuses, with the lowest increase observed in the 1961–1971 period (4.34%) and the highest in the 1981–1991 period (37.69%). These large differences can be attributed to the changing socio-economic and political situation in Croatia or to the small absolute number of exceptionally old people in Croatia, since only 84 of them were registered in the 2001 Census<sup>20</sup>.

The analysis of demographic trends during the past 50 years revealed the highest increase in the 90–94 age group. In that period the prevalence of centenarians grew constantly, with single exception of 2001 Census when it was lower compared to 1991 Census. This reduction could be associated with the 1991–1995 war in Croatia which caused substantial demographic disturbances and probably decreased the life expectancy in 1991 and 1992<sup>11,23,24</sup>. Regional level results showed that coastal parts had much higher prevalence of exceptionally old people compared to the mainland. This finding is in line with the results of the 25 year prospective study which investigated overall survival in Croatia at the regional level<sup>25</sup>. The survival was significantly lower in the continental parts of the country, with the lowest survival recorded in the Virovitica-Podravina County<sup>25</sup>.

According to CAHS study better health indicators among exceptionally old recruits can be explained by the survivor phenomenon. In general, people who survive to the exceptionally old age are more likely to have had better health when they were younger. Still, these people at the same time develop more often chronic diseases earlier in the life, and probably develop the compensatory mechanisms that are strongly contributing to their

longevity<sup>26</sup>. Therefore, previous studies and also this study support the concept that exceptional longevity is facilitated by numerous compensatory mechanisms, and in general that it is not achieved exclusively by the »disease-free« individuals<sup>1,26</sup>. One of the suggestions for future studies could therefore be an investigation of a broad scope of various traits between centenarians and elderly, which would allow the identification of the hypothetical compensatory mechanisms displayed by the exceptionally old people.

Geographical differences of the exceptional longevity in Croatia have a strong coastline-to-mainland gradient which could be influenced either by genetic or environmental factors or their interaction. Since at this time we are lacking the sufficient knowledge about the underlying genetic factors or even a proper genetic structuring of the Croatian population, only epidemiological data can be discussed. One of the possible and the most proximate explanations for observed differences could be related to the overall lifestyle habits and the healthy diet, which are traditionally more favorable in the coastal parts of the country. Traditional dietary pattern in the coastal parts of Croatia is more similar to the Mediterranean diet, known by reduced meat consumption and increased vegetable and fruit intake. This type of diet was previously shown to be associated with better health indices and higher longevity<sup>27,28</sup>. Earlier studies suggested that mainland and coastal parts have different dietary patterns<sup>29</sup>, which could explain e.g. lower incidence of pancreatic and gastric cancer in the islands populations<sup>30</sup>. However, the results of the recent studies suggested that island's population when compared to the mainland population in general had higher life expectancy at lower ages but in the elderly age group the life expectancy was significantly lower<sup>15</sup>. Therefore, it seems that the elderly age groups (65–90 years) in the islands (and possibly even in coastal parts) are exposed to especially strong protective effects, while these effects seem to be reduced in the exceptionally old age groups, causing similar or higher mortality rates when compared to the mainland population<sup>15</sup>.

The use of two types of prevalence indices for exceptionally old people revealed that the previously described pattern explains only the ageing structure of the counties and not the longevity patterns<sup>10</sup>. The analysis of the

prevalence of exceptionally old people in the elderly group once again confirmed strong coastline-to-mainland gradient. Additionally, the results suggest that there was no significant difference between exceptionally old individuals and elderly ones according to educational status, and the timeline difference between these two groups should not be neglected (in extreme cases it can be as much as 30 years; i.e. when 95 years person is compared to a person 65 years of age). If we assume constantly increasing trend in the educational status (that can be seen throughout 1953–2001 census data), we can hypothesize that exceptionally old individuals most likely had higher levels of education compared to elderly, and this could also have beneficial effect on the longevity. This statement can't be properly analyzed from the available data, but in the future studies comprehensive, lifelong information on the education and socio-economic status of individuals should be collected in order to provide a definitive answer whether the education and socioeconomic status is associated with longevity and lifespan.

The limitations and biases within this study are mostly introduced through the comparison of data from long period, which is prone to various biases, primarily

during the 1991–1995 war in Croatia<sup>23,24</sup> that has altered the population structure and affected vital statistics data (or at least reduce the comparability of the data in the periods before and after the war). Also, any comparison of the contemporary centenarians with the contemporary elderly individuals is prone to timeline differences, which also could introduce possible bias.

The ageing is a phenomenon that draws immense attention of modern health and biomedical science, mainly due to the fact that we are still unable to explain some of the basic mechanisms, or provide an answer to even the most basic questions, as why do we age at all<sup>31</sup>? In this complex human trait epidemiological studies can only provide insight by defining the healthy ageing phenotype, but the basic scientists and human geneticists will be the ones who will have to provide the final answer about ageing mechanisms.

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## ZEMLJOPISNI OBRAZAC IZNIMNE DUGOVJEČNOSTI U HRVATSKOJ

### SAŽETAK

Cilj ovog istraživanja je bio prikazati pregled iznimne dugovječnosti u Hrvatskoj. Izračunata je pojavnost devedesetogodišnjaka i stogodišnjaka na temelju podataka iz popisa stanovništva iz godina 1953–2001., i analizirana pomoći hi-kvadrat testa i analize trenda. Rezultati ukazuju na stabilan i statistički značajan trend porasta u obje dobne skupine, koji je bio snažnije izražen kod žena. Zemljopisni obrazac iznimne dugovječnosti pokazao je jasan primorsko-kontinentalni gradijent, s više iznimno starih osoba u primrskom dijelu Hrvatske. Dodatno smo u ovom radu usporedili zdravstvene pokazatelje ispitanika iz Hrvatske zdravstvene ankete iz 2003. godine. Stogodišnjaci i devedesetogodišnjaci su imali bolje zdravstvene pokazatelje od ispitanika koji su imali između 65 i 89 godina. Iznimno stari ispitanici su imali mnogo manju učestalost povišenog krvnog tlaka i povećane tjelesne težine, stoga ukazujući na snažan fenomen preživljenja. Istovremeno, iznimno stari ispitanici imali su veću učestalost povišenog krvnog tlaka u anamnezi, kao i veću učestalost korištenja lijekova za krvni tlak. Rezultati studije potvrđuju jasan gradijent iznimno starih ispitanika obilježen većom dugovječnošću u primorskim dijelovima Hrvatske, koji je moguće povezan s drugačijim životnim i prehrambenim navikama.