Life Expectancy and Mortality Differences between Populations on Croatian Islands and the Mainland

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Aim To examine the differences in life expectancy and mortality between the populations on Croatian islands and the mainland, and among the islands themselves.

Method Data on population size and mortality collected in Croatia in 2001 were analyzed by life table and standardized mortality rates.

Results Life expectancy at birth (95% confidence interval) of the population on Croatian islands was 76.4 yr (75.7-77.1) which was significantly higher than life expectancy at birth of general Croatian population which was 73.8 yr (73.5-73.9) or mainland Croatian population which was 73.7 yr (73.6-73.8). Island population had higher life expectancy until the age of 80 and again in the oldest age group, 95+. More than 10% of inhabited islands in Croatia had life expectancy at birth over 80 years. Two inhabited islands, Ilovik (Kvarner islands) and Lopud (South Dalmatian islands), had one of the highest life expectancy at birth recorded in the literature, with 95.0 and 90.6 years respectively. Mortality rates on islands were significantly lower for age groups 50-64 and 65-79 years, and this difference persisted for all island groups compared with general Croatian population.

Conclusion Residents of Croatian islands had a higher life expectancy than general or mainland Croatian population. Life expectancy at birth on Croatian islands was lower than in other European Mediterranean countries, but it resembles that in the neighboring Slovenia, and it is considerably higher than in central and eastern Europe and Balkan countries.
Life expectancy is one of the most important demographic indicators used to compare different population groups. It is defined as the mean number of years a cohort of people might expect to live according to the current age-specific mortality rates. Life expectancy is the main outcome measure of life table analysis. In general, it reflects differences in mortality, but is relatively resistant to differences in age structure and other population characteristics (1,2). It has mostly been applied for comparison of different countries (3,4), regions (5-7), and specific socio-economic groups (8,9) in terms of health and health care. Life expectancy is generally considered to reflect differences in mortality quite well, but also to be insensitive to age structure of the population, changes in birth rates, and other demographic phenomena (10,11).

Low mortality and high life expectancy in European Mediterranean population prompted much interest and has been a focus of research in many studies (12-14). Low intake of saturated fats and high intake of monosaturated fats, as well as high consumption of fruit and vegetables have been proposed as the main factors underlying the low mortality in the Mediterranean (12-17).

This study was the first attempt to investigate the differences in life expectancy and mortality between population on Croatian islands and the mainland, and among the islands themselves, as well as to compare the results on Croatian islands with life expectancy in Mediterranean population of European countries.

**Subjects and Methods**

**Data collection**

For life expectancy calculation we used data on population size and mortality statistics. Data on population size were taken from the most recent 2001 Census (18). According to it, there were 4,437,460 inhabitants in Croatia, and 121,486 of them (2.7% of the total Croatian population) were living on the islands. Mortality statistics and indicators were calculated from data collected by the Croatian National Institute of Public Health and Croatian Central Bureau of Statistics. Mortality data for all deceased residents in Croatia in 2001 were taken from Mortality Database at the Croatian Central Bureau of Statistics (19). In year 2001, 15,366 deaths were registered on Croatian islands (3.1% of total 49,552 deaths in Croatia). Since these figures are based on compulsory registration, it is considered that the data encompass the entire population.

**Description of islands**

There are 1185 islands in Croatia, and 67 of them are inhabited. We analyzed 28 inhabited islands for which we had complete and routinely collected data. Croatian islands belong to six maritime counties (Figure 1): Primorsko-goranska, Ličko-senjska, Zadarska, Šibensko-krknska, Splitsko-dalmatinska, and Dubrovačko-neretvanska. Traditionally, there are four distinctive groups of islands: Kvarner islands (islands from Primorsko-goranske County), North Dalmatian islands (islands from Ličko-senjska, Zadarska, and Šibensko-krknska County), Middle Dalmatian islands (islands from Splitsko-dalmatinska County), and South Dalmatian islands (islands from Dubrovačko-neretvanska County).

![Map of Croatian islands.](image)
Statistical analysis

The data were divided into five-year age categories running from 0–4, 5–9, and so on, up to the age category of 95+. In data analysis, we applied standard demographic analysis, such as life table analysis and the calculation of standardized mortality rates.

Life table analysis was carried out according to the method described by Chiang (1,2). Life expectancy was calculated for each island, groups of islands from the same county, four traditional groups of islands, and all islands together. It was then compared to the life expectancy in the general and mainland population of Croatia, as well as to the life expectancy of mainland population in the maritime counties.

The differences in mortality between populations of Croatian islands and Croatia as a whole were examined by means of life table analysis, a method which consists of applying the current-age-specific mortality rates to a hypothetical cohort (10,20,21).

In the analysis, we also used the standardized mortality ratio, which is sensitive to differences in age distribution between population on Croatian islands and the mainland (11,20,21).

For the calculation of standardized mortality rates, indirect age standardization was applied, using general Croatian population as the standard: the national Croatian age-specific mortality rates were applied to the age categories of specific groups of islands. Relative risks were calculated for general mortality, as well as for mortality of each age category compared to the general Croatian population.

Results

According to the population census in 2001, 2.7% of the total population in Croatia lived on islands. Their age structure was less favorable than the Croatian average, with a higher share of people older than 65 years than on the Croatian mainland (20.3% vs 15.5%) and a lower share of children younger than 15 years (15.4% vs 17.1%). When the groups of islands are compared, North Dalmatian islands stand out, with 25.0% of people older than 65 and 14.2% of children younger than 15 years (Table 1).

When we compared life expectancies of the mainland and island populations of Croatia, the island population had higher life expectancy until the age of 80. For the age groups above 80 years, island population had slightly lower life expectancy than the mainland population. However, in the oldest age group (95+) the island population again had higher life expectancy than the Croatian mainland (Figure 2).

Life expectancy at birth was significantly higher on the islands (76.4 years) than on the

Table 1. Population size and number of deaths in Croatia, its mainland, coast, islands, and groups of islands in 2001

<table>
<thead>
<tr>
<th>Region</th>
<th>Population size</th>
<th>Number of deaths</th>
<th>Share of population younger than 15 y (%)</th>
<th>Share of population older than 65 y (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>4 437 460</td>
<td>49 552</td>
<td>17.0</td>
<td>15.6</td>
</tr>
<tr>
<td>Mainland</td>
<td>4 315 974</td>
<td>48 016</td>
<td>17.1</td>
<td>15.5</td>
</tr>
<tr>
<td>Coast</td>
<td>1 305 522</td>
<td>13 840</td>
<td>16.9</td>
<td>15.5</td>
</tr>
<tr>
<td>Islands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kvarner islands</td>
<td>121 486</td>
<td>1536</td>
<td>15.4</td>
<td>20.3</td>
</tr>
<tr>
<td>North Dalmatian</td>
<td>38 687</td>
<td>415</td>
<td>15.8</td>
<td>17.0</td>
</tr>
<tr>
<td>Middle Dalmatian</td>
<td>28 865</td>
<td>428</td>
<td>14.2</td>
<td>25.0</td>
</tr>
<tr>
<td>South Dalmatian</td>
<td>34 927</td>
<td>461</td>
<td>15.6</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Figure 2. Life expectancy by age on Croatian islands – comparison with mainland and Croatia in whole. Closed bars – Croatia; open bars – mainland; gray bars – islands.
mainland (73.7 years), or Croatia as a whole (73.8 years). The difference was almost 3 years and it remained constant at the age of 15 and 45. At age of 65, life expectancy on the islands was still higher, but the difference was about 1.5 years, while at the age of 90, life expectancy was higher on the mainland than on the islands. Among all islands, South Dalmatian islands had the highest life expectancy in all age groups, except at the age of 90 (Table 2). Knowing that life expectancy is highly sensitive to fluctuations in the mortality in the highest age groups, and that the number of deaths on the islands was small, we wanted to determine the sensitivity of the outcomes. In order to do so, we lowered the age of the highest age group to 80+ and found that the results were similar to that of the 95+ age group (Table 3).

Life expectancy at birth was above the Croatian average age of 73.8 years in all groups of Croatian islands. Life expectancy increased toward the south, except for the Middle Dalmatian islands. Only 5 out of 67 inhabited Croatian islands (Iž, Dugi Otok, Vis, Ćiovo, and Krpanj) had lower life expectancy at birth than the Croatian mainland or Croatia as a whole, but the rest of them had higher life expectancy at birth than the rest of the country.

More than 10% of inhabited islands in Croatia had life expectancy at birth over 80 years: Cres (83.1 years), Ist (86.9 years), Prvić (81.0 years), Zlarin (81.7 years), Mljet (81.3 years), Sipan (81.0 years), and Koločep (82.0 years). Ilovik (Kvarner islands) and Lopud (South Dalmatian islands) had one of the highest life expectancies at birth recorded in the literature, with 95.0 and 90.6 years, respectively (Figure 3).

Crude mortality rates differed between the islands and the Croatian mainland, as well as between different groups of islands. Generally, islands had higher crude mortality rate than the mainland. However, when we compared the groups of islands, Kvarner and South Dalmatian

### Table 2. Life expectancy for population of Croatia, its mainland, coast, islands, and groups of islands with highest age group 90+ in 2001

<table>
<thead>
<tr>
<th>Region</th>
<th>0</th>
<th>15</th>
<th>45</th>
<th>65</th>
<th>90</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>73.8</td>
<td>60.3</td>
<td>31.7</td>
<td>15.5</td>
<td>3.4</td>
<td>(73.5-73.9)</td>
</tr>
<tr>
<td>Mainland</td>
<td>73.7</td>
<td>60.3</td>
<td>31.7</td>
<td>15.4</td>
<td>3.4</td>
<td>(73.6-73.8)</td>
</tr>
<tr>
<td>Coast</td>
<td>75.0</td>
<td>61.6</td>
<td>32.0</td>
<td>16.2</td>
<td>3.5</td>
<td>(74.8-75.2)</td>
</tr>
<tr>
<td>Islands</td>
<td>76.4</td>
<td>63.0</td>
<td>34.2</td>
<td>16.9</td>
<td>3.0</td>
<td>(75.7-77.1)</td>
</tr>
<tr>
<td>Kvarner islands</td>
<td>75.9</td>
<td>62.8</td>
<td>33.9</td>
<td>17.0</td>
<td>3.5</td>
<td>(74.7-77.3)</td>
</tr>
<tr>
<td>North Dalmatian islands</td>
<td>76.7</td>
<td>63.2</td>
<td>34.7</td>
<td>17.1</td>
<td>2.8</td>
<td>(75.2-78.2)</td>
</tr>
<tr>
<td>Middle Dalmatian islands</td>
<td>76.2</td>
<td>62.6</td>
<td>33.9</td>
<td>16.3</td>
<td>3.0</td>
<td>(75.0-77.0)</td>
</tr>
<tr>
<td>South Dalmatian islands</td>
<td>77.3</td>
<td>63.6</td>
<td>34.8</td>
<td>17.5</td>
<td>2.9</td>
<td>(75.5-79.0)</td>
</tr>
</tbody>
</table>

*Confidence interval.
†Significantly above Croatian average.
‡Significantly below Croatian average.

### Table 3. Life expectancy for population of Croatia, its mainland, coast, islands, and groups of islands with highest age group 80+ in 2001

<table>
<thead>
<tr>
<th>Region</th>
<th>0</th>
<th>15</th>
<th>45</th>
<th>65</th>
<th>90</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>73.8</td>
<td>60.3</td>
<td>31.7</td>
<td>15.5</td>
<td>3.4</td>
<td>(73.5-73.9)</td>
</tr>
<tr>
<td>Mainland</td>
<td>73.7</td>
<td>60.3</td>
<td>31.7</td>
<td>15.4</td>
<td>3.4</td>
<td>(73.6-73.8)</td>
</tr>
<tr>
<td>Coast</td>
<td>75.0</td>
<td>61.6</td>
<td>32.0</td>
<td>16.2</td>
<td>3.5</td>
<td>(74.8-75.2)</td>
</tr>
<tr>
<td>Islands</td>
<td>76.4</td>
<td>63.0</td>
<td>34.2</td>
<td>16.9</td>
<td>3.0</td>
<td>(75.7-77.1)</td>
</tr>
<tr>
<td>Kvarner islands</td>
<td>75.9</td>
<td>62.8</td>
<td>33.9</td>
<td>17.0</td>
<td>3.5</td>
<td>(74.7-77.3)</td>
</tr>
<tr>
<td>North Dalmatian islands</td>
<td>76.7</td>
<td>63.2</td>
<td>34.7</td>
<td>17.1</td>
<td>2.8</td>
<td>(75.2-78.2)</td>
</tr>
<tr>
<td>Middle Dalmatian islands</td>
<td>76.2</td>
<td>62.6</td>
<td>33.9</td>
<td>16.3</td>
<td>3.0</td>
<td>(75.0-77.0)</td>
</tr>
<tr>
<td>South Dalmatian islands</td>
<td>77.3</td>
<td>63.6</td>
<td>34.8</td>
<td>17.5</td>
<td>2.9</td>
<td>(75.5-79.0)</td>
</tr>
</tbody>
</table>

*Confidence interval.
†Significantly above Croatian average.
‡Significantly below Croatian average.
islands had lower, while North and Middle Dalmatian islands had higher crude mortality rates than the mainland. After standardization according to the age, mortality rates were compared to those of the Croatian general and mainland population. Standardized mortality rates for islands in general and each of the island groups were significantly lower than those of Croatian population and Croatian mainland population. South Dalmatian islands had the lowest standardized mortality rates compared with Croatian population (0.79) and Croatian mainland population (0.78) (Table 4).

When we calculated ratios between the mortality rates on islands and in the general Croatian population for fifteen-year age categories, statistically significantly higher mortality rate was found on islands in 5-19 years age group (2.69). However, when we analyzed the groups of islands, higher mortality rate in that age group was present only for Kvarner islands, but it did not reach statistical significance. Mortality rates on the islands were significantly lower in age groups 50-64 and 65-79 years, and this difference persisted for all island groups compared to general Croatian population (Table 5).

When mortality rates between islands and the general Croatian population were compared by five-year age groups, statistically significantly lower mortality rates were present on the islands

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**Table 4.** Mortality rates and standardized mortality rates for population on Croatian mainland, coast, islands, and groups of islands in 2001*

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of deaths per 1000 inhabitants</th>
<th>SMR (95% CI) in comparison with Croatia</th>
<th>SMR (95% CI) in comparison with Croatian mainland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainland</td>
<td>11.1</td>
<td>1.01 (1.00-1.01)</td>
<td></td>
</tr>
<tr>
<td>Coast</td>
<td>10.4</td>
<td>0.91 (0.90-0.93)</td>
<td>0.91 (0.89-0.92)</td>
</tr>
<tr>
<td>Islands</td>
<td>12.6</td>
<td>0.83 (0.78-0.89)</td>
<td>0.83 (0.79-0.87)</td>
</tr>
<tr>
<td>Kvarner islands</td>
<td>10.7</td>
<td>0.81 (0.71-0.92)</td>
<td>0.81 (0.71-0.92)</td>
</tr>
<tr>
<td>North Dalmatian islands</td>
<td>14.8</td>
<td>0.83 (0.73-0.94)</td>
<td>0.83 (0.72-0.94)</td>
</tr>
<tr>
<td>Middle Dalmatian islands</td>
<td>13.2</td>
<td>0.88 (0.77-0.99)</td>
<td>0.87 (0.77-0.99)</td>
</tr>
<tr>
<td>South Dalmatian islands</td>
<td>12.2</td>
<td>0.79 (0.66-0.93)</td>
<td>0.78 (0.66-0.93)</td>
</tr>
</tbody>
</table>

*Abbreviations: SMR – standardized mortality rates; CI – confidence interval.

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only in the following age groups: 50-54, 55-59, 60-64, 65-69, 70-74, and 75-79 years (Figure 4).

Discussion

Population of Croatian islands had a significantly higher mean age and lower mortality rates than the general Croatian population. This was an evident and consistent finding of our study.

As a whole, Croatian islands population had significantly higher life expectancy from birth until the age of 80 and again in the oldest age group, 95+, than the general or mainland Croatian population. This difference remains persistent for all four distinctive groups of Croatian islands in comparison with general or mainland Croatian population. If life expectancy for each island in four distinctive groups of Croatian island is compared, it becomes apparent that life expectancy is above the Croatian average age in 85% of analyzed inhabited islands.

Mortality rates on Croatian islands were significantly lower in age groups 50+. There was a north-south cline in our results, with increased life expectancy and decreased mortality rates toward the south. In comparison with the population of the Croatian mainland, the differences for age 0, 15, 45, and 65 years were 2.7, 2.7, 2.5, and 1.4 years, respectively.

A possible explanation for these consistent findings could be Mediterranean lifestyle, especially the diet (22-27), although it is not possible to rule out the genetic factors in some specific cases (28-30). It is possible that in some isolated islands the combination of population genetic phenomena, such as founder effect and subsequent genetic drift, can bring rare longevity-enhancing genetic variants of large effect to unusually high frequency, which is then reflected in the increased life expectancy in the whole population (eg, Ilovik island).

Living conditions on Croatian islands had many other specific and mainly favorable characteristics as opposed to the mainland: pleasant microclimate, less pollution, and slower pace of life (28-30). The strong sense of family and community might also have positive influence on general health and life expectancy. However, their geographic isolation and less accessible health services might act in opposite direction, especially among the older age groups. This is possibly reflected in the finding that the residents of Croa-
tian islands have a higher life expectancy in all age
groups, except the oldest. The longer life expec-
tancy seen on Croatian islands could be due to
the Mediterranean lifestyle. Higher life expectan-
cy among people from Mediterranean has often
been observed (22,23). The Mediterranean diet
is characterized by a high intake of vegetables,
legumes, fruits, and cereals; a moderate to high
intake of fish; a low intake of saturated fats, but
high intake of unsaturated fats, particularly olive
oil; a low intake of dairy products and meat; and
a modest intake of alcohol, mostly wine. Current
evidence suggests that such a diet may be benefi-
cial to health (22-27). The strongest association
is in the southern parts of Croatian islands, prob-
ably because people follow a genuinely Mediter-
ranean diet, which is consistent with the results
reported for Greece and Spain (24).

With a life expectancy of 76.4 years at birth,
Croatian islands population is closer to the life
expectancy at birth of EU members (78.2 years)
than population on the Croatian mainland
(73.7 years). Life expectancy at birth on Croa-
tian islands was lower than in other European
Mediterranean countries (Greece, Albania, Ita-
ly, Spain, Portugal). The difference ranges from
0.65 years higher life expectancy in Portugal to
3.85 years higher life expectancy in Italy. Life ex-
pectancy at birth on Croatian islands is as high as
in neighboring Slovenia, and considerably higher
than in Balkan countries, such as Romania with
71.27 years, Bulgaria with 71.91 years, or Serbia
and Montenegro with 72.9 years. Hungary, Po-
land, and other countries of Central and Eastern
Europe have higher life expectancy at birth than
the Balkan countries, but lower than Croatian is-
lands or Mediterranean Europe (31).

Mortality rates on islands were significantly
lower for age groups 50-64 and 65-79 years, and
that difference persisted in all island groups com-
pared with general Croatian population. Mor-
tality differed substantially between older (50+
years) population on islands and the mainland
Croatia.

Dietary patterns and lifestyle factors are as-
associated with mortality from all causes, coronary
heart disease, cardiovascular diseases, and cancer
(12-17). Among individuals aged 70 to 90 years,
adherence to a Mediterranean diet and healthy
lifestyle is associated with a more than 50% lower
rate of all-causes and cause-specific mortality (25).

The “Albanian paradox” of high adult life ex-
pectancy in a low-income country can be most
plausibly explained by diet, ie, low consump-
tion of total energy, meat, and milk products but
high consumption of fruit, vegetables, and carbo-
hydrates (26). Low level of adult mortality is
remarkably consistent with other Mediterranean
countries, and is in sharp contrast to all other
central and eastern European countries (27).

Further studies will be necessary to explain
what proportion of the observed differences can
be attributed to differences in the prevalence of
diseases, cultural and socio-economic differences,
and genetic factors in the isolated population.

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