Comparison of lifespans of historic populations emphasizing especially dietary and geographic factors
An analysis between 1268-2022

PhD thesis

Bálint Madarász PharmD
Doctoral School of Health Sciences
Semmelweis University

Supervisors: Judit Forrai DDS, D.Sc.
Vince Fazekas-Pongor, MD, Ph.D.

Official reviewers: Péter Balázs MD, D.Sc.
Imre Lázár MD, D.Sc.

Head of the Complex Examination Committee:
Anna Tompa, MD, D.Sc.
Members of the Complex Examination Committee:
Hedvig Győry, Ph.D.
Levente Szilárd Szőcs, PharmD, Ph.D.

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1. Introduction

In Europe, life expectancy is overall high compared to other parts of the world, but certain national and regional differences can be observed here too. In 2020 the highest life expectancy at birth in Europe could be found in Switzerland (83.1 years) and Norway (83.3 years), while the lowest in Bulgaria (73.6 years) and Romania (74.2 years). When focusing on regions instead of individual countries, the Epirus region of Greece (83.8 years), the Balearic Islands in Spain (83.9 years), and French Corsica (84 years) have the highest life expectancy, while the lowest life expectancy can be observed in the North-Western Region of Bulgaria (72.1 years). Differences in life expectancy by region can be explained by several factors, for instance certain economic factors and lifestyle factors, such as diet.

The Mediterranean region generally enjoys a relatively higher life expectancy compared to other parts of Europe. The reason for this may lie in the so-called Mediterranean diet, which is followed in countries bordering the Mediterranean Sea, including Spain, Italy, and Greece in Europe. The Mediterranean diet is distinguished by its emphasis on abundant intake of fruits, vegetables, whole grains, legumes, nuts, and olive oil. It also includes moderate consumption of fish and seafood, limited to moderate consumption of dairy products, and minimal intake of red meat and processed foods. The Mediterranean diet has been extensively researched for its potential health benefits in slowing

down aging and lowering the risk of age-related chronic diseases and may partially explain the relatively high life expectancy observed in Greece, Italy, and the broader Mediterranean area.

Historically, life expectancy was not always as high as it is today. In prehistoric times, life expectancy was estimated at around 30 years and only increased by approximately 10 years across antiquity and up until the Middle Ages. In the Middle Ages, life expectancy was estimated at 40 years of age, and this did not increase significantly up until the 18^{th}-19^{th} century. The steady increase in life expectancy can be attributed to several factors, for instance improvement in sanitation, medical discoveries, economic factors, increased availability and more stable sources of food. To examine the exact effect of these factors on life expectancy in historic population-based studies is somewhat problematic from an epidemiological point of view because of the lack of data. This problem can be addressed by examining populations whose life is relatively well-documented, for instance the nobility or religious groups.

Historic studies conducted on the life expectancy of European rulers indicate that life expectancy in Europe increases from South to North and East to West. The exact reason to this gradient is not fully understood yet, however, regional differences regarding certain lifestyle factors, such as diet may play a key role. The diet favored by nobility is well documented and even in the Middle Ages the capacity to consume large quantities of food and drinks was considered a

display of strength and valor with meat being especially esteemed among the nobility. Over the centuries, new ingredients and dishes, such as sugar and exotic goods appeared on the table of the nobility. The quality and quantity of food became a symbol of social status and were used as tools of power and diplomacy, not just as a source of pleasure.

2. Objectives

To better understand longevity patterns of today, it is important to analyze how lifespan of people changed over the centuries from the past. However, it is challenging to find homogenous groups from the past where individuals' lives were properly recorded, including information on their lifestyle, birth, and death. There are some exceptional groups in this regard, however, whose entire lives were recorded, for instance the nobility, artists, or religious groups like monks and nuns. The latter group's lifestyle was humbler and closer to the average population's, yet still well documented. By focusing on these exclusive groups, we can minimize the possible variability of socioeconomic status, lifestyle, and other factors influencing historic changes in longevity. Thus, the objectives of the present thesis are as follows:

1. Our **primary objective** is to perform a retrospective study analyzing the differences in the lifespan of European rulers who ruled after the Black Death (1346-1353) until today with special emphasis on differences in survival in-between different geographic areas using the Southern European region as reference where Mediterranean diet was characteristic.

2. Our **secondary objective** is to compare the survival of Hungarian Benedictine monks with the lifespan of Southern European and Central and Eastern European rulers. Like rulers, monks represent a relatively well-documented population whose lifestyle follows a set of standard rules.

3. Methods

3.1. Primary analysis: Survival of rulers by geographic regions

3.1.1. Population

To collect our data on European rulers, we utilized various online sources, including Encyclopedia Britannica and cross-referenced our population of rulers with the dynastic tables found in Morby's *Dynasties of the World* (2002). We began our data collection with rulers who were already in power by 1354, a year after the end of the devastation of the Black Death (1346–1353), which often caused rulers to succumb to infection. Our data collection continued until the last ruler for countries that ceased being a monarchy or until the first ruler

still alive if the given country remained a monarchy to this day. We limited our analysis to European rulers to maintain consistency in our sample population.

3.1.2. Variables

We extracted various kinds of information for each ruler, including their sex, birth and death date, age, age of enthronement, duration of ruling, country, and cause of death (natural vs. violent death). The definition of violent death included deaths caused by unexpected events, poisoning, accidents, murders, execution, or war. If we did not have any specific information regarding the cause of death, we assumed a natural death. We coded the residency of each ruler based on where they would have lived at the present day (2023). If a ruler governed in more than one country or moved to another country, their residency was coded according to where they lived the longest. Finally, we classified the countries into the following regions based on the *EuroVoc* Geographical classification: Northern, Western, Southern, Central and Eastern Europe.

3.1.3. Statistical analysis

Normal distribution of continuous variables was tested with Shapiro-Wilk test. As continuous variables followed a non-normal distribution, Kruskal-Wallis tests were used to compare continuous variables (age,

age of enthronement, and duration of rule) among regions. Cox-regression models were created for natural vs. violent death as outcome and age as follow-up. Only those participants were included in the analysis who reached at least the age of 40 years, the approximate life expectancy up until the twentieth century. Since the Mediterranean diet is often associated with health benefits, we used the Southern region as reference in all our analyses.

First, Cox regression models were built including all European rulers who ruled between 1354–2022 and reached the age of at least 40 years. In the regression model, covariates included birth year and region. Birth year was centered around 1700. Linear and quadratic time terms were also introduced in the regression models. Next, similar Cox regression models were built for three time periods separately: 1354–1499, 1500–1749, and 1750+. These three periods were created by taking into consideration two historic events that among others also greatly influenced diet, namely the discovery of Americas and the Industrial Revolution. Thus, our three periods are: End of the second wave of the plague until the Discovery of Americas (1354-1499), the discovery of Americas until the Industrial Revolution (1500-1749), and from the Industrial Revolution onwards (1750-2022). From the regression models, rate ratios (RRs) and 95% confidence intervals were calculated. Finally, Kaplan-Meier curves were plotted showing how survival changed over the three time periods by region, and how survival of every region compared to each other over the three time

periods. For all analyses, statistical significance was set at $p<0.05$. All statistics were conducted in SPSS 24. Kaplan-Meier survival curves were constructed using R ("survminer" package).

3.2 Secondary analysis: Survival of Hungarian Benedictine monks and rulers

Similarly to rulers, monks represent a relatively well-documented group of people with recorded data of date of birth and death and a well-defined lifestyle. This is why we decided to run an additional analysis to compare the survival of Hungarian Benedictine monks to Southern European rulers and Central and Eastern European rulers.

Data of Hungarian Benedictine monks was obtained from the *Directory of the Order of St. Benedict of Pannonhalma 1802-1986* collected by Pál Berkó and Norbert Legányi (Pannonhalmi Szent Benedek-Rend Névtára 1802-1986). This directory provides information about Hungarian monks who served the order between 1802 and 1986. Since the earliest birth date in this directory is from 1728, we decided to restrict our analyses to also only include rulers born after 1728. Additionally, we also excluded all monks who left the order from our analyses and all rulers whose death was coded as non-natural.

Normal distribution of continuous variables was tested with Shapiro-Wilk test. As continuous variables followed a non-normal distribution, Kruskal-Wallis tests were used to compare continuous variables (age).

In our descriptive analysis age was presented as years and interquartile range. Cox regression analyses were constructed similarly to previous analyses by including sex and linear and quadratic time terms for birth year for only monks and rulers who reached the age of at least 40 years. From the regression models, rate ratios (*RR*s) and 95% confidence intervals were extracted. Kaplan-Meier curves were also plotted for this analysis as well. Statistical significance was set at $p<0.05$. All statistics were conducted in SPSS 24. Kaplan-Meier survival curves were constructed using R ("survminer" package).

4. Results

4.1. Results of our analyses examining the survival of European rulers by regions

We identified a total of 863 European rulers. A total of 190 were excluded because they died before the age of 40, resulting in a final sample of 673 rulers from the four European regions: Northern (n=57), Eastern and Central (n=76), Western (n=377), and Southern (n=166). A total of 582 rulers died of natural causes, while 91 were recorded as violent death. The earliest born ruler in our sample was Luigi Gonzaga, born in 1268, and the latest ruler added was Elizabeth II, who passed away in 2022. The majority of the rulers in our sample were male (94%). We observed significant differences in age of rulers among the

regions, but age of enthronement and duration of rule were similar across regions.

When examining our Cox regression models that included all study participants between 1354 and 2022, we find that that hazards did not differ significantly between geographic regions, and these findings were supported by the Kaplan-Meier curves.

When we stratified our analysis by different time periods (1354–1499: End of the Black Death until the Discovery of Americas, 1500–1749: The discovery of Americas until the Industrial, 1750+: From the Industrial Revolution onwards), we found that age of rulers and age of enthronement were similar across regions from 1354 to 1749 but differed significantly after 1750. Duration of rule was similar across all three observed time periods. Within the Western and Northern regions, age of rulers and age of enthronement significantly increased over time, while they remained stable in the Southern region and Central and Eastern European region. Duration of rule significantly decreased over time in the Southern and Western regions but remained stable in the other two regions.

Our Cox regression analyses show that from 1354 to 1499, the Northern region had significantly better survival compared to the Southern region (RR: 0.48; 95% CI: 0.28–0.84). Between 1500 and 1749, the survival of rulers was overall similar. After 1750, the Western (RR: 0.44; 95% CI: 0.28–0.68), Northern (RR: 0.39; 95% CI: 0.20–0.76), and Central and Eastern European (RR: 0.52; 95% CI:

0.28-0.98) regions all exhibited better survival than the Southern region. These findings were supported by the Kaplan-Meier curves. When we examined each region separately, we found that survival of rulers in the Southern region was stable over all three time periods. In the Northern region, survival initially declined between 1500 and 1749 and then increased, while in both the Western and Central and Eastern European regions, survival increased prominently only after 1750.

4.2 Secondary analysis: Comparing the survival of rulers and monks

In our secondary analysis, we included a total of 883 Benedictine Monks born in different parts in Hungary between 1728-1850.

After the exclusion of monks who left the order and did not reach the age of at least 40 years, 318 monks were left along with 34 Southern European rulers and 21 Central and Eastern European rulers. The ages of the three groups were similar and did not differ statistically. Our Cox regression analysis of Hungarian and Benedictine monks reveals that compared to monks, Southern rulers had a significantly worse survival (RR: 1.50, 95% CI:1.02–2.20), while survival was similar for Central and Eastern European rulers. The Kaplan Meier curves further support these findings.

5. Conclusions

In conclusion, our study highlights the complex relationship between geographic location, period, and lifespan of European rulers. Results of our study indicate that the lifespan of Southern European rulers was not longer than that of rulers in other regions. In fact, after 1750, the lifespan of Southern rulers was even lower than the lifespan of other rulers, especially compared to the rulers in the Northern regions.

While the Mediterranean diet is coupled frequently with health advantages, our results suggest that it in itself does not necessarily explain the variations in ruler longevity across different regions. It is also important to consider that rulers in Southern Europe might not have adhered to the Mediterranean diet, and they led a physically less active lifestyle, as common people. This is also corroborated by the diet of Benedictine monks who not only followed a rigorous diet consisting of fish, beans, lentils, peas, prunes, strawberries, oats, wheat, and sigh in moderation – similarly to the Mediterranean diet – but also performed physical activity regularly, which may explain why their lifespan was on par with the ruling classes of the same region.

Overall, our results point in the direction that the cuisine and lifestyle of the courts may have been more alike than distinct from one another. Rulers across Europe had access to a wide variety of foods in plentiful amounts consistently, therefore the dietary habits of the Southern elite may not have been representative of the Mediterranean diet. Additional factors, such as protection against infectious diseases and physical assault, economic security, and access to the best possible

healthcare of a given era, could have also played a pivotal role in the differences observed in the survival of the European elite. These elements might have offset the effect of any regional dietary differences.

6. Bibliography of the candidate's publications

Publications directly related to this thesis

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