Cohort Mortality developments in Greece

1. Introduction

Longevity in Greece has been studied in detail in a series of publications (see for example, Zafeiris and Kostaki, 2019; Zafeiris, 2019 etc.). According to Kotzamanis et al. (2016), the observed mortality transition in both genders between the years 1961 and 2014 resulted in a continuous and almost linear improvement of life expectancy at birth. The same general scheme emerges for the life expectancy in the other ages, although with varying rates of change. In absolute values, the gains are higher in the younger ages and smaller in the older ones. However, these analyses are based on period mortality rates and ignore the fact that in reality represent the mortality experience of a hypothetical and not a real cohort of people (Preston et al. 2001; p. 42).

This is essential because cohort effects may influence mortality rates, a fact which has been observed a lot of time ago, naming, for example, the pioneering work of Kermack et al. (1934; 2001). In this publication, it was recognized that *'the expectation of life was determined by the conditions which existed during the child's early years'* (about Kermack and a concise review of the literature see Davey Smith and Kuh, 2001). The cohort effects are generally conceptualized as variation in the risk of a health outcome according to the year of birth, often coinciding with shifts in the population exposure to risk factors over time (Keyes et al. 2010). Such factors may vary from prenatal ones (Christensen 2007) up to smoking habits (Doll 2004).

Closely related to the concept of cohort effect is the problem of natural selection, which acts on a population over time. In that sense, mortality is regulated by three determinants: age-related changes within individuals, the environment in which they live, and qualitative differences between individuals (Partridge, 1997). For a cohort of people, the individuals at highest risk tend to die (or exit from the population) first. This differential selection can produce patterns of mortality for the whole population, which are surprisingly different from the patterns for its subpopulations or individuals (Vaupel and Yashin, 1985). In that way, in periods of significant mortality change, the age specific rates are affected significantly because the elevated mortality of the past tends to "keep" the more robust people in the population and remove the frailer ones.

Additionally, observed period mortality rates may be affected by the so-called tempo effect (Bongaarts and Feeney, 2002, 2003, 2005). According to Bongaarts and Feeney (2002, p.20), there is a bias in the estimated life expectancy at birth when "a rising (falling) mean age of persons at the occurrence of an event results in a temporary decline (increase) in numbers of events during the period of change". Thus, the tempo effect is positive when the mean age at death is rising and negative when the mean is declining (Bongaarts and Feeney, 2003).

Overall, as Guillot and Canudas-Romo (2016) note, the observed period mortality of a population reflects not only the current mortality conditions but is also "the product of past exposures and behaviours that have accumulated over the entire life span of individuals". In the times of mortality transition, i.e. when mortality decreases, it is typically expected that period life expectancies will underestimate real life expectancies, which correspond to the longevity of real cohorts (Borgan and Keilman, 2019); i.e. cohort analysis of mortality is essential in order to evaluate the real mortality trends observed in a population.

Therefore, the first scope of this paper is to analyse the mortality transition in Greece from the cohort perspective. The method used will be presented in the data and methods section. In this paper we utilize cohort data for the period 1941-1960 which is provided by the former Director of ELSTAT G. Siampos to the Laboratory of Social Analyses of the University of Thessaly.

2. The geographic setting. A brief introduction into the recent history of Greece.

The modern population profile of Greece was primarily shaped by the historical events of the period 1912-1923, which correspond to the Balkan wars, the First World War, the Asia Minor Campaign and eventually the signing of the Treaty of Lausanne. During this period, Greece initially extended to include Macedonia, part of Thrace, Epirus, the Aegean islands and Crete as well as a large part of Asia Minor, but ultimately it was limited to its current borders, except for the Dodecanese islands, which were annexed in 1948. After the defeat of Greece in the Greek–Turkish War of 1919–1922 a mass influx of refugees are observed entering the country (see Clogg 2002, pp. 85-113).

In 1940, after the outbreak of the Greek-Italian war, the country entered a new period of insecurity and severe deterioration of living conditions along with social and economic destruction. Later, the defeat by the Germans led to the triple occupation of the country by the Germans, Italians and Bulgarians (see Clogg 2002, pp. 98-141). In 1944, Greece was liberated, but in the period 1946-1949, it was afflicted by a bloody civil war.

As Zafeiris and Kostaki (2019) summarize, the period 1961–2014 is characterized by enormous developments in the economic, political, and social characteristics of Greece. As they note, a timetable of the most important events during that period may contain the following (see also Clogg, 2002, pp. 166–238): 1. 1961–1967: Economic development and political instability, 2. 1967–1974: Military dictatorship (military junta), 3. 1974: Restoration of democracy, progressively: political stability and social and economic growth 4, 1980: Greece re-joined NATO 5, 1981: Greece became member of the European Union, 6. 2001: EURO was adopted as the national currency, 7. 2004: Olympic games took place in Athens, 8. After 2008: Economic crisis led to strong austerity policies: All the socioeconomic indicators of the country were burdened (decline of GDP, high unemployment rates, increase of the people at risk of poverty or social exclusion, cuts in the budget for social protection and health etc.).

3. Data and Methods.

The period full lifetables were initially constructed separately for the two sexes of the Greek population, based on the most recent available and revised death and mid-year population data of the Greek Statistical Authority (ELSTAT) and other sources for the years 1941–2017 [Laboratory of Demographic & Social Analyses (LDSA) data collection. Department of Planning and Regional Development University of Thessaly, School of Engineering www.ldsa.gr]. However, it must be noted that data have been revised several times after 1961, while data for the period 1941-1960 remain in its original and thus unrevised form. Therefore, a minor discrepancy exists in the calculated life table variables between the years 1960 and 1961, but this does not significantly affect the results. Of course, the 1941-1960 data could have been omitted, but in that case, the necessary time depth and interpretative power of the analysis would have been limited. Additionally, by including this period in the analysis, a gap in the literature about mortality transition in Greece is attempted to be covered because it is the first time that the results of mortality analysis for this period are published.

The original calculations were carried out according to Calot and Sardon (2004; See also Calot and Franco, 2001; Calot, 1999), using the original software which was developed by Calot himself.

Another problem needs to be resolved. This problem deals with the accuracy of period life expectancy calculations and the cohort analysis of mortality. A methodology to “correct” the period observed life expectancy at birth is the one developed by Bongaarts and Feeney (2002); however, this method has been extensively criticized (see for example Guillot, 2006). Other approaches focus solely on cohort mortality (see for example, Guillot, 2011), like the truncated cross-sectional average length of life (Canudas-Romo and Guillot, 2015). However, one of the most parsimonious and effective methods is the one used by Borgan and Keilman (2019) for the comparison of the longevity of women in Italy, Japan and Scandinavia, which also has the advantage that can be applied both on period and cohort data.

According to this method, the period life tables are used as a basis for the cohort analysis. In that way, someone born in year c will be x years old in the calendar year t=c+x. Thus, the one-year probability of death for a cohort born in year c in the calendar year c+x is:

$$q_x^{(c)} = q_{x,c+x}$$

the probability that a woman who is born in year c will survive at least to age x

$$l_x^{(c)} = \prod_{i=0}^{x-1}(1 - q_i^{(c)}), x = 1,2\ldots$$

The problem with this approach is that it needs at least about 100 years in order to have a complete cohort life table, which is impossible based on the available data for Greece. Borgan and Keilman (2019), facing the same problem, used instead of the ordinary life expectancy at birth, the partial one between birth and several ages denoted with the term α, which can be calculated as:

$$e_{0/a}^{(c)} = 0.3 + 1.2 * l_1^{(c)} + \sum_{i=2}^{a-1} l_i^{(c)} + 0.5 * l_a^{(c)}$$

Then, they calculated the expected years lost before age a for a cohort c as:

$$a - e_{0/a}^{(c)}$$

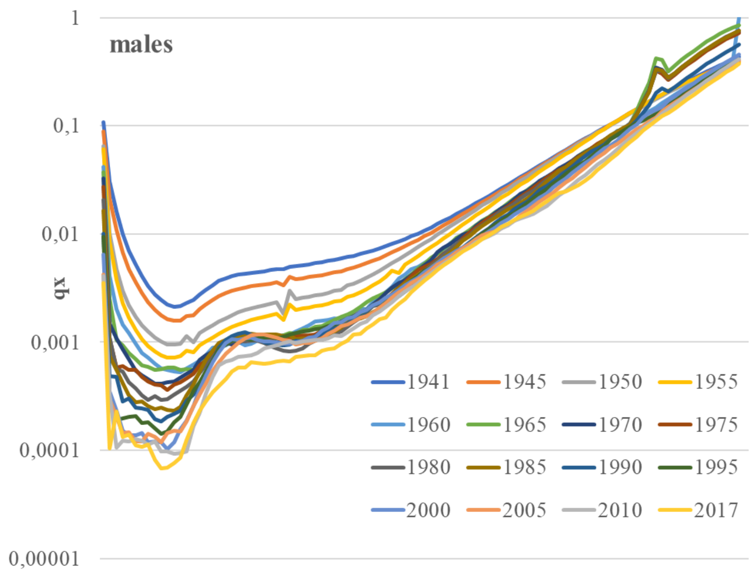
This measure will be used in this paper and serve for comparing male and female mortality transition in Greece. This idea comes from Arriaga's (1984) publication, in which life expectancy between two specific ages x and x+i is given by:

$$e_x^{x+i} = \frac{T_x - T_{x+i}}{l_x}$$

By using this formula, several life expectancies between specific ages will also be discussed in this paper It is well known that the ordinary life expectancy at birth, is affected by the infant, child, young and middle-aged adult mortality (Horiuchi et al., 2013). The same happens with partial life expectancy. Thus, such approach will give the opportunity to compare mortality experience between specific ages which are free of the developments at younger ages than the one used each time.

5. Results

In the following paragraphs, the period and cohort calculations will be discussed in parallel. However, it must be kept in mind that in the period analysis the mortality experience of a hypothetical cohort in a calendar year is studied. On the contrary, in the cohort analysis, the mortality history of people born in the same year but died numerous years later is studied, also considering the different socio-economic circumstances.



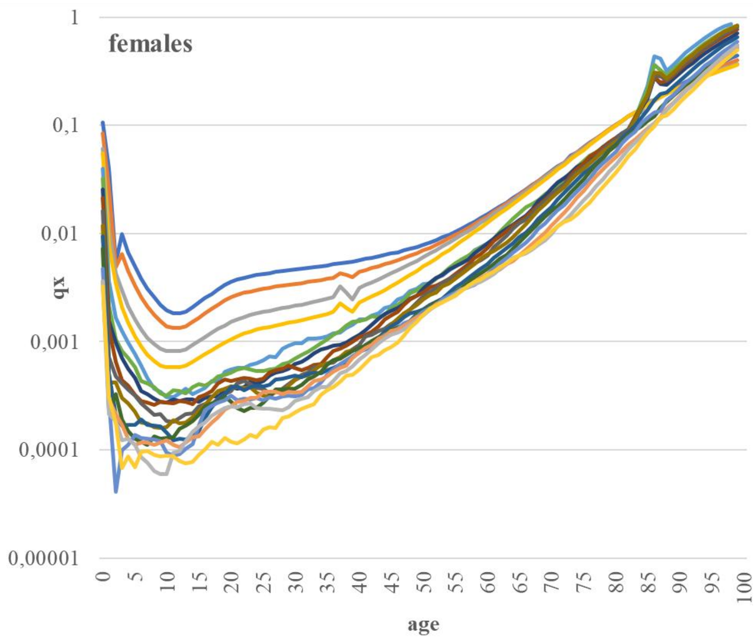


Figure 1: Probabilities of death, period perspective.

The period probabilities of death for chosen years illustrated in Figure 1 have the typical shape of mortality pattern and a reasonable decrease through years The period before 1960 is much diversified; mortality rates were very high in both genders in 1941, and they progressively decrease significantly in the years after, and especially during the 1950s.

This trend is then followed though any developments are smaller and refer mainly to younger ages and secondarily to middle life years. In all cases, the mortality rates are as expected higher in males, and the accident hump more severe for males than for females. Also, there is a problem with the mortality rates of the very old ages, because they are too scanty for several years. However, this problem does not significantly affect the results of cohort analysis as they are not taken into consideration in our analysis.

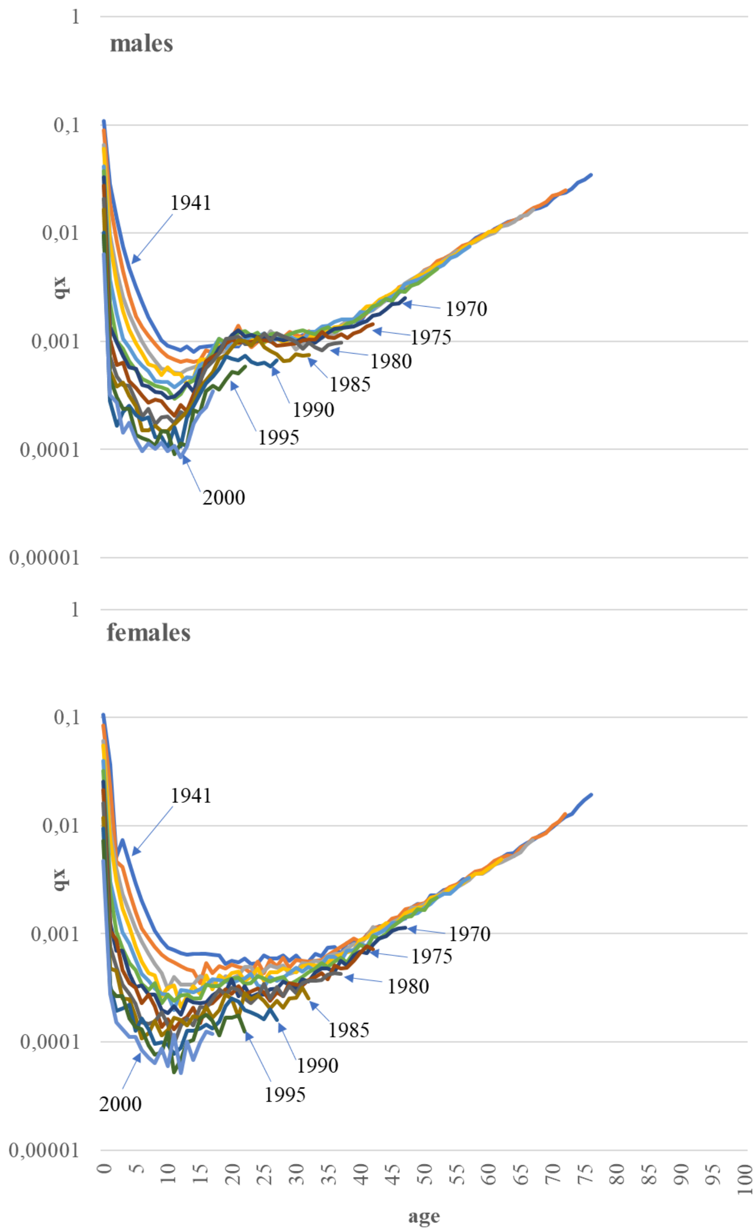


Figure 2: Probabilities of death, cohort perspective.

If the same mortality rates are considered from the cohort perspective, some interesting findings must be noted (Figure 2). First, mortality decreases over time in the younger ages, but the decrease is not as sharp as the one observed in period analysis (see Figure 1). Second, the developments in middle adulthood are not as crucial as those observed in the period analysis. It should be noted, however, that the age of many of the younger cohorts of people is low during the time of the analysis for this work, so that mortality rates cannot be recorded for them. For this reason, the estimation of mortality rates “stops” at different ages in Figure 2. Therefore, any estimation of ordinal cohort life expectancy at birth is not possible, and the partial life expectancy at birth and the expected years lost from birth until different ages will be used subsequently.

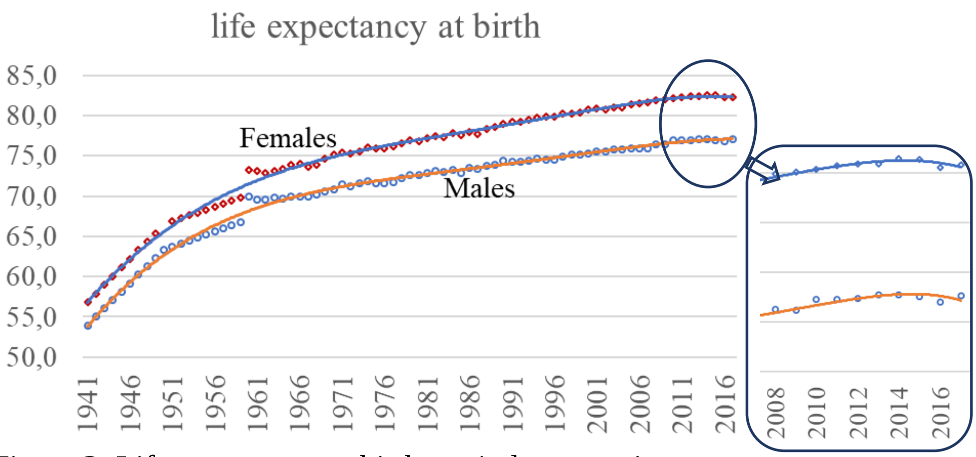


Figure 3: Life expectancy at birth, period perspective.

In Figure 3, the developments of longevity by gender for the period 1941-2017 are presented. After the severe famine crisis of 1941, emerged in the first year of the triple occupation of the country by the Germans, Italians and Bulgarians (see Hionidou, 2006), life expectancy at birth is increasing rapidly for both genders, even if it remains at low levels. This trend still holds after the liberation of the country in 1944. A new phase of historical and economic developments begins by this time, mainly corresponding to the civil war and its preparatory political events, which afflicted Greece until at least 1949. In this era, the longevity of the population remains low but rapidly increasing. This trend weakens over time, and in the 1960s, it becomes more moderate.

A significant gap is observed for the life expectancy at birth, comparing the year 1961 with its previous one, due to the different data sources used in the analysis. Data after 1961 have been revised several times after their original publication by the National Statistical Authority (ELSTAT), while data before 1961 are in their original and unrevised form as discussed in the data and methods section. Thus, a small inconsistency of the results of the analysis is expected.

In any case, the rates of longevity improvement in Greece slowdown in the years after, and life expectancy at birth steadily increases until 2013. The economic recession which afflicted Greece after 2008 must be emphasized at this point, even if a direct relationship between this crisis and the halting of the improvement of longevity seen in Figure 3 cannot be established. Even though such a finding is expected because of the economic hardship of the people and the problems of the health and social security systems to cover the needs (see for example Kentikelenis et al. 2014; Simou and Koutsogeorgou, 2014), a more extended time series should be needed in order to thoroughly verify it as an effect of this crisis on the Greek population.

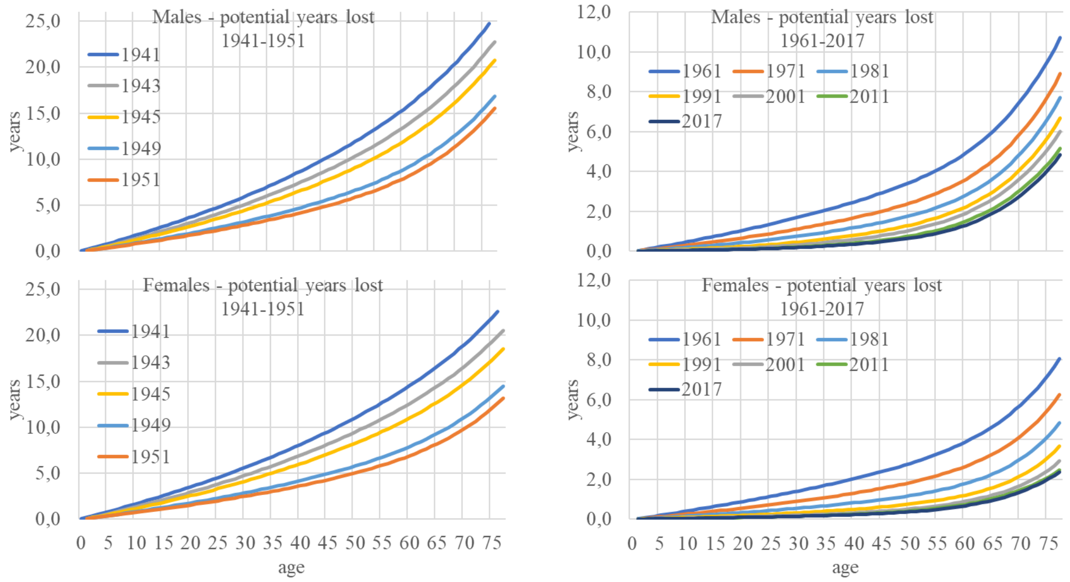


Figure 4: Potential years lost, period perspective.

If we study mortality developments from the period perspective (Figure 4), enormous mortality developments are observed. In 1941 males lose almost 25 years of life between their birth and the age of 77 years, which corresponds to the highest observed age in the cohort analysis. At the same time, females lose almost 22.6 years. Ten years later, in 1951, these figures are reduced to 15.5 and 13.2 years respectively, thus in a small amount of time, a very sharp decrease in mortality is observed. This mortality transition continues in the 1960s and the year 1961, a male loses 10.7 years of life and a female 8.1, thus mortality transition continuous but with a smaller pace. Gradually, the loses will be confined to only 4.8 years in males and 2.4 in females in 2017; thus, mortality transition is furtherly slowing down in the last years studied.

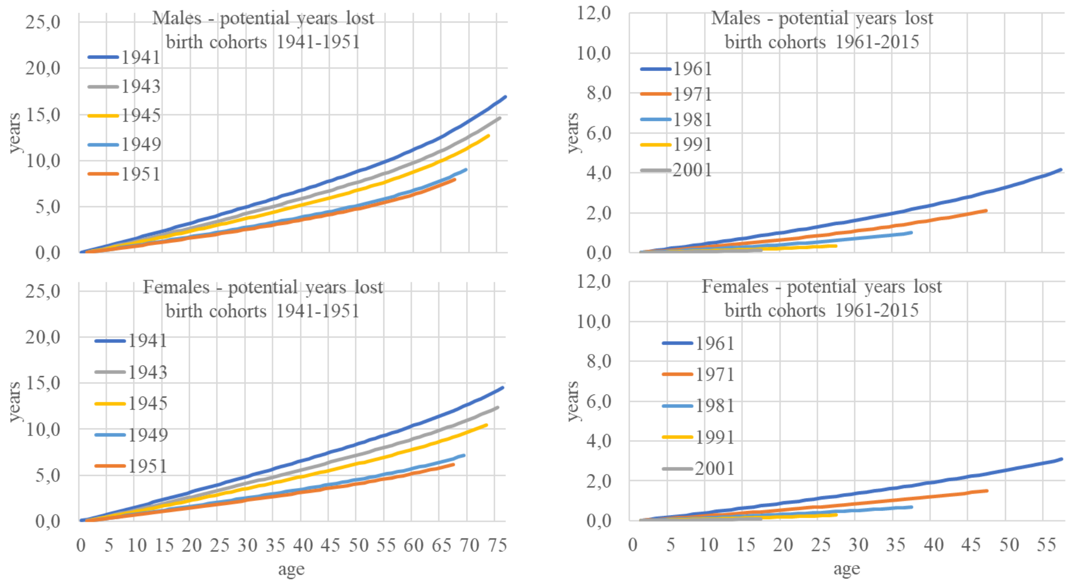


Figure 5: Potential years lost, cohort perspective.

The same precipitation of curves is observed in cohort analysis (Figure 5). The potential years lost curves are “moving” in parallel towards smaller values, even though the mortality rates for some ages are not yet observed. However, a significant difference is also observed. As it will be demonstrated in the following paragraphs, the number of the potential years lost of the different cohorts tend to be smaller than those estimated by the period analysis.

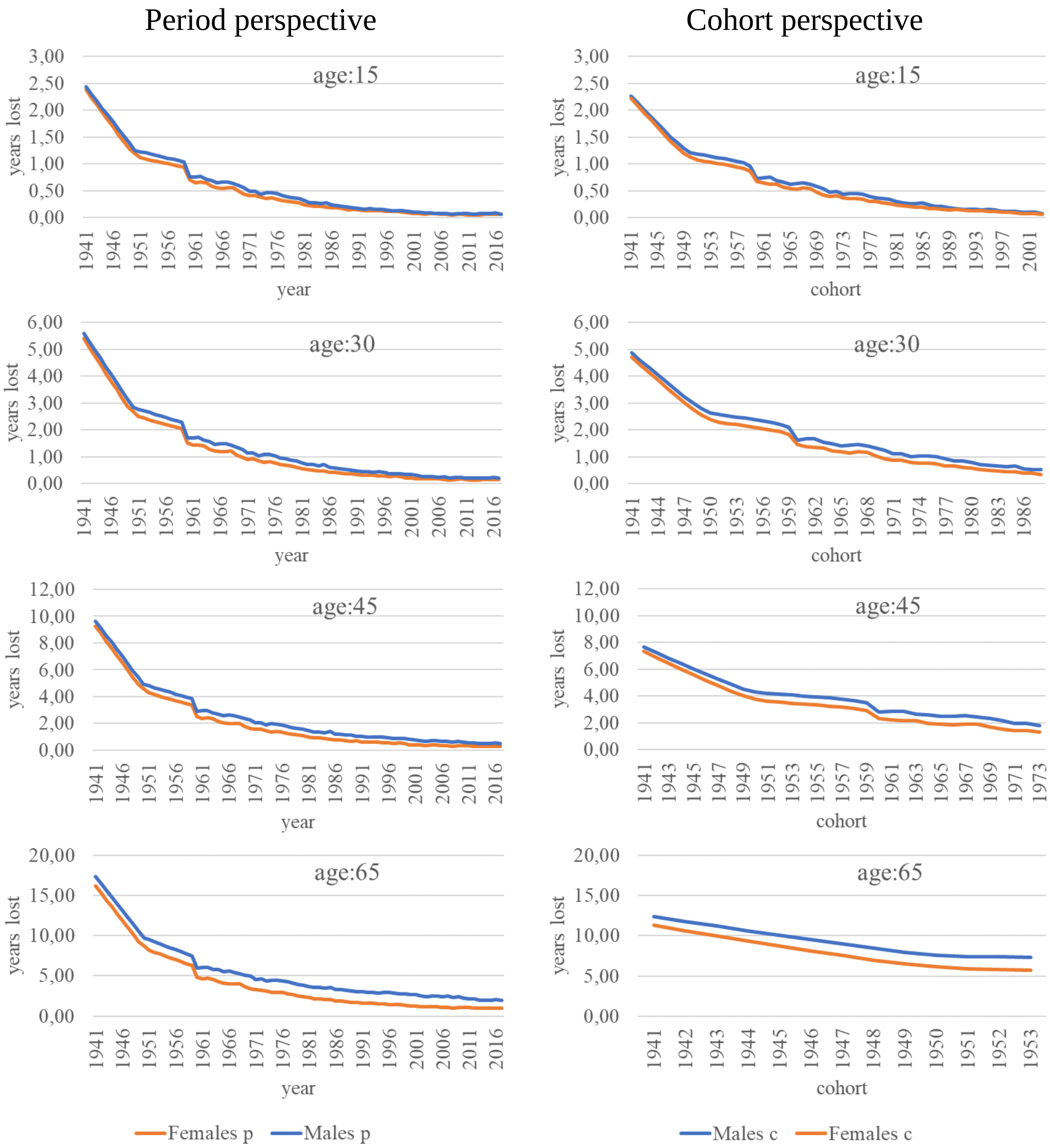


Figure 6: Potential years lost at specific ages, period and cohort perspective.

Indeed, if the temporal trends of the potential years lost are studied for several ages (Figure 6), an almost parallel course is observed comparing period and cohort measures. Of course, the age at which our observation stops in the cohort approach depends on the time of the cohort formation. It should also be mentioned that for the analysis of the period perspective, many individuals belong to older cohorts than those included in the cohort analysis. For example, people aged 15 years in 1941 are born in 1935-1936, and those aged 65 in the same year were borne in the 19th century. This problem will be discussed later in more detail. At the same time, the members of the different cohorts spent a significant part of their lives in different socio-economic circumstances, mainly in a regime of social and economic development, accompanied by significant improvements of the health and social protection system of the country, especially after the 1980s.

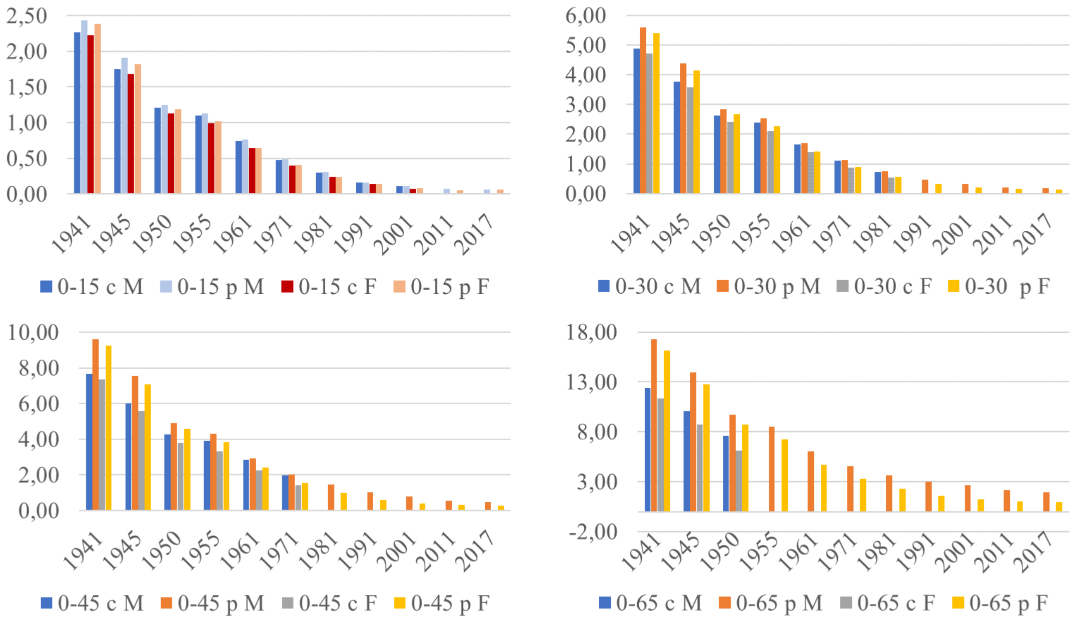


Figure 7: Potential years lost at specific ages, comparing period and cohort perspective.

During this process, the years lost are always higher in the period perspective than in the cohort one (Figure 7). Also, they are higher in males than in females, as expected because mortality is always lower for women. In other words, the real mortality levels tend to be overestimated in the period analysis. However, besides the formal definition of a life table, which serves as a model of what would happen to a hypothetical cohort if a certain set of mortality conditions pertained throughout its life (Preston et al. 2001; p. 42), it must be stressed out that the mortality trends of a real cohort are very different. As discussed in the introduction section, the recorded mortality of this real cohort depends on the circumstances each time of observation and on its history, the known cohort effects or the influence of the selection mechanism of human evolution.

Undeniably, in Figure 7, we observe the period effects on mortality, but do any other factors are evidenced too? In the earlier periods studied, the effects of a probable pestilence and famine on mortality, especially during the foreign occupation of the country, are without question. According to Hionidou (2006), the nutritional crisis prevailed throughout the occupation, exhibiting at the same time significant temporal and geographic fluctuations. For example, while famine hit Athens in the winter of 1941, other regions, such as Epirus, Macedonia and the Peloponnese, suffered mainly in the winter of 1942-1943, because of the influence of other factors. Also, the deaths of people who were killed in action or executed during this period must be added, as well as the Jewish genocide casualties (see Zafeiris 2015). Later, according to Christodoulakis (2016), there were more than 43,000 battle deaths during the civil war of 1946-1949, while the seriously wounded were almost 87,000. However, according to Averof-Tositsas (2010) the civil war casualties were almost 51,000 persons. Therefore, the Greek population has spent a significant amount of time on health and life aggravating circumstances, a factor which undoubtedly affected the future mortality trends of the cohorts formed during that time, or in general the people that were alive during this era.

However, another factor must be taken into consideration. Following a very crude division, the people at these days can be classified into two major categories. The first one includes those born within the borders of the country and the second one refers to the refugees from Asia Minor, Euxenous Pontus, Eastern Thrace, Anatolic Rumelia (southern Bulgaria) and elsewhere along with their children. The refugees' group comes mainly after the Greek-Turkish and the Greek-Bulgarian disputes (see also Zafeiris, 2015). These people represent the survivors of an extremely challenging process. It is not only that they survived the wars and they were forced to migrate to Greece in harsh conditions, but also that they spend their lives in a challenging way concerning fundamental aspects of their existence: housing, nursing, food sufficiency and social and health conditions (for a brief valuation of these conditions see Zafeiris and Kaklamani, 2019).

Undoubtedly, natural selection has played an essential role in these adverse circumstances by removing -among others- the ‘frailer’ members of this population. However, other agents may have acted too. For example, the population’s low socio-economic profile suggests that significant potentiating effects, due to malnutrition and other factors, may have been observed (for the term see Pelletier et al., 1995). We also know that the low levels of socio-economic development relate to elevated levels of mortality (see for example Behm 1980). Therefore, while natural selection tends to develop a no ‘frail’ population, the health and mortality levels of this population are aggravated in a significant way by several factors.

This scheme also refers to the first population, i.e. those borne within the Greek borders, as Greece those days was an impoverished country (for an appreciation of the Greek economy in the 19th and early 20th century see Kostis and Petmezas 2006), a situation which was accompanied by insufficient health infrastructure and severe problems in its social protection sector. It is characteristic that the first official united social security institution (IKA) was enacted in 1932, and the relevant law was fully applied later (see https://www.ika.gr/gr/infopages/gene-ral/history.cfm). Thus, this is an open area for further scientific research for demography, epidemiology, evolution and other disciplines.

Afterwards, a developing country is moving towards economic growth and development, and this is imprinted in the progressive decrease of the mortality levels at least until a few years after the emergence of the economic crisis in 2008, when this trend is halted. During this process of mortality transition, longevity increases, but, with a faster pace than period measurements reveal.

However, all this discussion is based on partial life expectancy between birth and some specific ages. Taking into consideration, as said in the Data and Methods section, that life expectancy at birth is affecting by the mortality developments in the younger/middle ages w if we avoid that and study different time fragments of the human life span, which are the real longevity trends within these fragments?

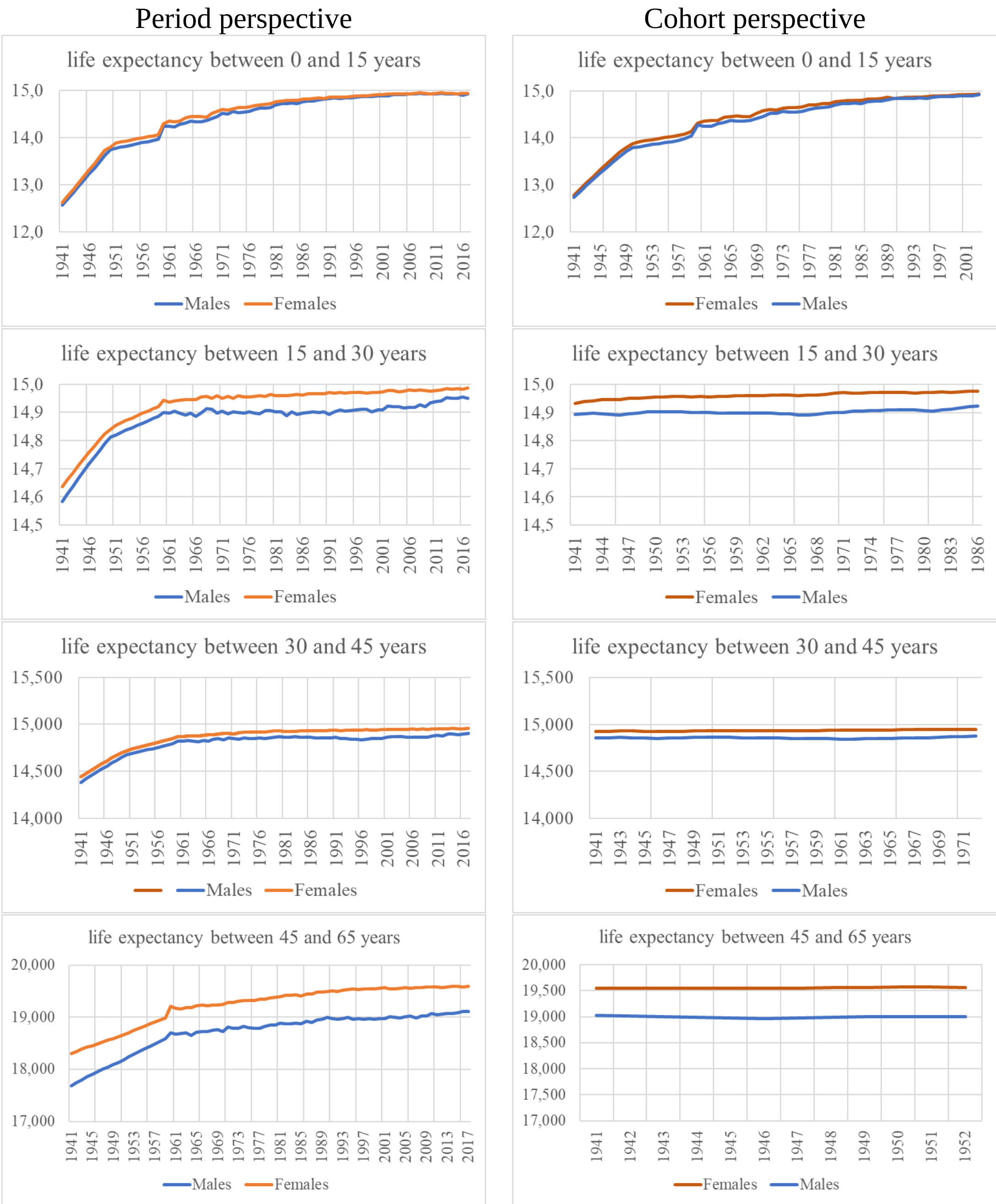


Figure 8: Partial life expectancy at birth between specific ages, period and cohort perspective.

In Figure 8, the period and cohort life expectancy at birth between specific ages are seen. However, between period and cohort rates, a significant difference exists. While “cohort perspective” refers to all cohorts formed after 1941, the relevant period perspective, besides the previously mentioned cohorts, may include data from cohorts formed before 1941. For example, for calculating period partial life expectancy between 15 and 30 years the younger members of the population in the year 1956 were born about the year 1941 while the older ones about 1926. The same is the case for people aged between 30 and 45 years in this year, who were borne well before 1941.

In that way, the sharp increase of partial life expectancy observed when studying developments from the period perspective mainly refers or is partially influenced by the mortality of the cohorts formed before World War II, or in some cases even before the Balkan Wars, World War I and the Greek-Turkish war of 1919-1922. This effect then depends on the ages and the year studied. While for age group 0-15 years it disappears after 1956, for ages between 45 and 65 years it disappears after the year 2006. In any case, moving towards present time, any developments become smaller in all the partial life expectances studied.

If the same trends are studied from the cohort perspective, some interesting findings are observed. In this approach, it is seen that the observed mortality decrease is mainly governed by the developments in the younger age group of 0-15 years. Therefore, it is the infant, child and young juvenile mortality, which mainly governs longevity in the post-World War II era. The developments in all the other age groups studied are minimal.

6. Conclusions

In this paper, the method proposed by Borgan and Keilman (2019) was used in order to study cohort mortality in Greece. In that way, the partial life expectancy between birth and specific ages was calculated and the years lost between birth and these ages were studied. Same analysis was made in the period data, in which the life expectancy at birth as a measure of longevity was additionally calculated and presented.

Results of the period analysis indicate a rapid mortality transition in the first years, which subsequently slows down and is halted in the last years of the study. In both period and cohort analysis, the potential years lost curves are “moving” in parallel towards smaller values, even though the mortality rates for some ages are not yet observed in the cohort perspective. The number of potential years lost of the different cohorts tends to be smaller than this estimated by the period analysis.

This finding indicates that besides the socio-economic and other circumstances, which prevail in a period, significant cohort effects affect mortality rates as well as the evolutionary force of selection, which eliminates from the population its more frail members. However, in the higher mortality regime of the past, early lifetime events like malnutrition, several diseases and the socio-economic environment may have aggravated not only period rates but also the future mortality of the cohorts.

Finally, the study of partial life expectancies between specific ages indicates two facts. The first deals with the nature of the period and cohort analysis. When analysing period partial life expectancy quite frequently, older cohorts than those included in the cohort analysis are taken into consideration. The second fact is that after the 1950s mortality transition in Greece is mainly related to the improvements in longevity in the young ages and not in the rest of ages.

References

Arriaga, E. (1984). Measuring and explaining the change in life expectancies. *Demography*, 21, 83–96.

Averof-Tositsas, E. (2010) By Fire and Axe: Greece 1946-49 and the Precedents. Athens: Estia editions (in Greek).

Behm, H. (1980). Socio-economic determinants of mortality in Latin America. *Population Bulletin*, 13, 1-15.

Bongaarts, J., Feeney, G. (2002). How long do we live? *Population and Development Review*, 28(1), 13-29.

Bongaarts, J., Feeney, G. (2003). Estimating mean lifetime. *Proceedings of the National Academy of Sciences*, 100(23), 13127-13133.

Bongaarts, J., Feeney, G. (2005). The quantum and tempo of life-cycle events. Policy Research Division Working Paper. New York City: Population Council, 207. (http://www.popcouncil.org/)

Borgan, Ø., Keilman, N. (2019). Do Japanese and Italian Women Live Longer than Women in Scandinavia? *European Journal of Population,* 35, 87-99. https://doi.org/10.1007/s10680-018-9468-2

Calot, G. 1999. L' analyse démographique conjoncturelle. In The joy of demography. Édité en l'Honneur de D.J. van de Kaa, ed. A. Kuijsten, H. de Gans and H. de Feijter, 295–323. Amsterdam, NethurD La Haye: Publications, e0056, doi:10.1136/bmjopen-2014-005619.

Calot, G., Franco, A. (2001). The construction of life tables. In Life tables: Data, methods, models, ed. G. Wunsch, M. Mouchart and J. Duchêne, (pp. 31–75). Dordrecht: Kluwer.

Calot, G., and J. P. Sardon. 2004. Methodology for the calculation of Eurostat's demographic indicators. Luxemburg: Office for Official Publication of the European Communities.

Canudas-Romo, V., & Guillot, M. (2015). Truncated cross-sectional average length of life: A measure for comparing the mortality history of cohorts. *Population Studies*, 1–13. doi:10.1080/00324728.2015.1019955

Christensen, K. (2007). Early life events and later life health: Twin and famine studies. In T. Bengtsson (Ed.), Perspectives on mortality forecasting. V. Cohort factors: How conditions in early life influence mortality in later life (pp. 31–39)., Social Insurance Studies no. 5 Stockholm: Swedish Social Insurance Agency.

Christodoulakis, N. (2016). Conflict dynamics and costs in the Greek Civil War 1946–1949. *Defence and Peace Economics*, 27 (5), 688-717.

Clogg, R. 2002. A concise history of Greece. 2nd ed. Cambridge: Cambridge University Press.

Davey Smith, G., Kuh, D. (2001). William Ogilvy Kermack and the childhood origins of adult health and disease. *International Journal of Epidemiology*, 30, 696–703.

DOI: 10.1080/10242694.2014.1000010

Doll, R., Peto, R., Boreham, J., & Sutherland, I. (2004). Mortality in relation to smoking: 50 years' observations on male British doctors. *British Medical Journal*, 328, 1519–1528.

Guillot M., Canudas-Romo V. (2016) Revisiting Life Expectancy Rankings in Countries that Have Experienced Fast Mortality Decline. In: Schoen R. (eds) Dynamic Demographic Analysis. The Springer Series on Demographic Methods and Population Analysis, vol 39. Springer, Cham

Guillot, M. (2006). Tempo effects in mortality: An appraisal. *Demographic Research*, 14, 1–26.

Guillot, M. (2011). Period versus cohort life expectancy. In R.G. Rogers & E.M. Crimmins (Eds.), International handbook of adult mortality. New York: Springer.

Hionidou, V. (2006). Famine and death in occupied Greece, 1941-1944, Cambridge University Press,

Horiuchi, S., Ouellette, N., Cheung S. L. K. and Robine, J-M. (2013). Modal age at death: lifespan indicator in the era of longevity extension. *Vienna Yearbook of Population Research,* 11, 37-69.

Kentikelenis, A., Karanikolos, M., Reeves, A., McKee, M and Stuckler, D. (2014) Greece's health crisis: from austerity to denialism. Lancet, 383(9918), 748-53. doi: 10.1016/S0140-6736(13)62291-6.

Kermack, W. O., McKendrick, A. G., McKinlay, P. L. (1934). Death-rates in Great Britain and Sweden. Some general regularities and their significance. *Lancet* 226, 698–773. Reprinted in International Journal of Epidemiology (2001), 30(4), 678–83.

Keyes, K. M., Utz, R. L., Robinson, W., & Li, G. (2010). What is a cohort effect? Comparison of three statistical methods for modeling cohort effects in obesity prevalence in the United States, 1971-2006. *Social science & medicine* (1982), 70(7), 1100–1108. doi:10.1016/j.socscimed.2009.12.018

Kostis, K., Petmezas S. (2006), The development of Greek economy in the 19th century. Athens: Alexandreia (In Greek).

Kotzamanis, B., Kostaki, A., Bergouignan, C., Zafeiris, K. N. & Baltas, P. (2016). The population development of Greece (2015-2050). Dianeosis. Athens. Available at: https://www.dianeosis.org/research/demography/

Partridge L. (1997). National Research Council (US) Committee on Population; Wachter KW, Finch CE, editors. Between Zeus and the Salmon: The Biodemography of Longevity. Washington (DC): National Academies Press (US); 1997. 5, Evolutionary Biology and Age-Related Mortality. Available from: https://www.ncbi.nlm.nih.gov/books/NBK100403/

Pelletier, D. L., Frongillo, E. A., Schroeder, D. G., Habicht, J.-P. (1995). The effects of malnutrition on child mortality in developing countries. *Bulletin of the World Health Organization*, 73 (4): 443-448.

Preston, S. H., Heuveline, P., Guillot, M. (2001). Demography: Measuring and Modeling Population Processes. 1st Edition. Oxford: Blackwell Publishers.

Simou, E., Koutsogeorgou, E. (2014) Effects of the economic crisis on health and healthcare in Greece in the literature from 2009 to 2013: a systematic review. Health Policy, 115(2-3), 111-119. doi: 10.1016/j.healthpol.2014.02.002.

Vaupel, J. W., Yashin, A. I. (1985). Heterogeneity's ruses: some surprising effects of selection on population dynamics. *Journal of the American Statistical Association*, 39(3), 176-85.

Zafeiris, K. N. (2015). On the bridges between Demography and Biological Anthropology: what a census can tell us about the composition of the modern Greek population. In: Simitopoulou, K., Zafeiris, K., Theodorou, T, Papageorgopoulou C. (eds.), Anthropological Pathways. Festschrift for Professor N. I. Xirotiris. Mystis: Herakleion.

Zafeiris, K. N. (2019). Mortality Differentials Among the Euro-Zone Countries: An Analysis Based on the Most Recent Available Data, Communications in

Statistics: Case Studies, Data Analysis and Applications, 5:1, 59-73, DOI: 10.1080/23737484.2019.1579682

Zafeiris, K. N., Kostaki, A. (2019). *Recent mortality trends in Greece, Communications in Statistics - Theory and Methods*, 48:1, 112-126, DOI: 10.1080/03610926.2017.1353625

Zafeiris, K., Kaklamani, S. (2019). Completed fertility during the twentieth century: an example from six settlements in northern Greece. *Journal of Biosocial Science*, 51(1), 118-137. doi:10.1017/S0021932018000019