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The impact of a migration-caused selection effect on regional mortality differences in Italy and Germany[1]

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Abstract

Regional mortality differences are generally caused by the combination of a huge number of different factors. The aim of this paper is to test the hypothesis that a migration-caused selection effect belongs to this group of factors. In order to test this hypothesis we develop an indirect framework based on the typical biography of migrations. The decisive idea is that if a migration-caused selection effect exists, then there should be a correlation between the demographic age of a population with significant migration movements and its level of mortality. Using data on Italian and German district level for the years 1997 to 1999 we find that in the typical emigration areas of South Italy and North-Eastern Germany the expected correlation indeed exists with high statistical significance. We conclude that the hypothesis of a migration-caused selection effect affecting regional mortality differences cannot be rejected on the basis of this study.

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1. Introduction and aim of the study

Regional mortality differences are known for many countries but are usually examined solely for single nations. One of the very few exceptions is the comparative description of regional mortality differences in several countries by Caselli and Vallin (2002). This study deals with regional mortality differences in Germany and Italy. In both countries survival conditions are not uniquely distributed over the whole national areas. However, a more detailed analysis of regional mortality was done solely in Italy (Caselli and Egidi 1980, Caselli and Reale 1999, Caselli and Vallin 2002, Lipsi and Caselli 2002, Caselli et al. 2003). In Germany there are only a few studies about mortality differences on the regional level (for "Bundesländer" or NUTS2) focusing mainly on descriptive results without any analysis of the driving causes (Paul 1992; Sommer 1998, 2002; Bucher 2002). Mortality analysis on district level was exclusively done for several specific German regions (Wittwer-Backofen 1999, Gröner 2002, Mey 2002, Scholz and Thoelke 2002), but until today not in a complete national context.

It is obvious that regional mortality differences are generally caused by the combination of a huge number of different factors operating on the macro level or on the micro level with significant reflections on the macro level. The factors on the macro level contain the demographic structure (age- and cause-specific mortality as well as other demographic conditions and the social-demographic composition), the economic conditions of the regions (type of development, amount of unemployment, main types of occupation), the medical resources (availability/quality of medical as well as nursing care), and geographical factors (climatic differences, pollution, amount of industry, degree of urbanization). To the micro level factors affecting regional mortality differences on the macro level belong the individual economic status (social status, occupation), the life circumstances (living arrangements, life satisfaction), the lifestyles (smoking, alcohol consumption, nutrition), and the biological respective genetic factors caused by the heterogeneity of populations living in the different regions.

The connection between individual migration and macro mortality combines macro and micro level and is the topic of this paper. We want to know if beside the other mentioned factors also migration affects regional mortality differences inside a country. It is known from several studies that migrants are healthier and thus show lower mortality than the immobile population what was described for various countries and ethnic groups for internal as well as for international migrants (e.g. Feinleib et al. 1981; Balarajan et al. 1984; Shai and Rosenwaike 1987; Tsugane et al. 1989; Nair et al. 1990; Valkonen et al. 1992; Kington et al. 1998; Razum et al. 1998a, 1998b; Singh and Siahpush 2001).[2] Especially in terms of internal migration this phenomenon is explained by a special selection effect which may influence mortality and morbidity rates. This selective migration is expected to operate in two directions entailing the movement of a "select group" of healthy or unhealthy migrants (Shai and Rosenwaike 1987, McKay et al. 2003, Palloni and Arias 2003). The movement of healthier individuals is known as the so-called "healthy migrant phenomenon" (Sharma et al. 1990, Kington et al. 1998). On the other hand, it seems that sick migrants are involved in return migration, for example, to be nearer to family or care-giving institutions (Brimblecombe et al. 2000, Lanska and Peterson 1995, Razum et al. 1998b). The latter phenomenon is also known as "salmon bias" (Palloni and Arias 2003).[3]

Beside this, in the internal migration studies it is apparent that some migrant groups additionally benefit from a protective effect in terms of retention of a lower incidence of particular diseases, as was shown especially for Italy (Buiatti et al. 1985, Vigotti et al. 1988,

[2] One of the few known exceptions are Scottish and Irish immigrants to England and Wales exhibiting higher mortality rates than the general population of England and Wales (Adelstein et al. 1986, Raftery et al. 1990, Wild and McKeigue 1997).

[3] It should be stressed that the lower mortality of migrants is not only affected by physical condition but also by socioeconomic status (Wei et al. 1996, Harding and Maxwell 1998, Van Steenbergen et al. 1999). However, this doesn't hold for all ethnic migrant groups, what provides even more support to the "healthy migrant hypothesis" (Abraido-Lanza et al. 1983, King and Locke 1987).

Ceppi et al. 1995, Fascioli et al. 1995, Barbone et al. 1996) but also for other countries (Mancuso 1977, Coggon et al. 1990, Greenberg and Schneider 1995). Some of these effects may be due to genetic factors or the retention of certain dietary practices, since for instance associations have been found between breast cancer and body size, and daily intake of fat, in particular saturated fat, and alcohol consumption (Toniolo et al. 1989).

It is however unclear, if the healthy migrant phenomenon and the salmon bias are strong enough to contribute to survival conditions on the macro level and thus affect regional mortality differences. Italy and Germany provide an ideal platform for examining if such a migration-caused selection effect on mortality exists since both countries contain areas of considerable emigration movements, namely the South of Italy and the North-Eastern part of Germany (the former GDR). Such a comparative analysis gains most interest from the fact that emigration from the South of Italy to the North and to the Center started in the 1960s with the largest movements until the 1970s (Golini 1974, Ascoli 1979), while in Germany the emigration from the former GDR to West Germany started with the fall of the iron curtain and unification around 1990 (Roloff 2000, Mai 2003b).

2. Research strategy

During the second half of the 20th century regional mortality differences underwent different developments in the two countries. While in Italy they diminished, in Germany they remained at a remarkable level of 8.5 years in life expectancy at birth for men in the years 1997/1999 (compared to 4 years in Italy; see Tab. 1 and 2). Both countries, Germany and Italy, show a geographical differentiation of areas with homogeneous survival conditions. In Italy demographers distinguish between three main mortality regions: the North, the Center and the South (in some recent publications the North is further divided into North-East and North-West). This subdivision holds for historical mortality levels as well as for trends until today. For men it can be observed, that in the 2nd half of the 20th century the Northern and

Central regions show the highest decrease in mortality while South Italy improves only in some regions and deteriorates in others (Caselli et al. 2003). In the development of mortality reduction, the South lag behind considerably but among men (especially in the west coast areas) still shows the better survival conditions than the more developed North (Fig. 1). Consequently, despite the steeper mortality decline in the North, the North-South divide still persists. For women the geography of mortality is different from that of men. While the North shows similar disadvantages, in some parts of the South women's mortality is also higher than or closer to the national average as compared to men (Fig. 2). However, the amount of regional mortality differences is slightly smaller than among men (Tab. 2).

Compared to Italy, in Germany the difference in the span of regional mortality levels between women and men is much higher (see Tab. 1). In Germany there are two completely different kinds of regional mortality differences overlapping each other. Most striking is the distinct East-West differentiation that is due to the special history of these two regions belonging to complete different political and social regimes for some decades during the last century (Höhn and Pollard 1991, Heinemann et al. 1996). Especially the developments in mortality following political Reunification in 1990 have recently attracted international attention and were analyzed in several studies (e. g. Eberstadt 1994; Nolte et al. 2000a, 2000b; Vaupel et al. 2003; Luy 2004c, 2005). Compared to this it is almost unrecognized that especially in Western Germany also a clear North-South gradient in mortality exists. Consequently, like in Italy, there are three regions of different mortality levels, namely the Center-South (in the following simply called "South") with the lowest mortality, followed by the North-West, and the North-East with the highest mortality (see Fig. 3 and 4). Contrariwise to the Italian situation, in Germany the North-South gradient is stable in time as well as between the sexes what becomes clear when recent and historical studies about regional mortality differences in Germany are analyzed (Lee 1984; Paul 1992; Sommer 1998, 2002; Bucher 2002;

Luy 2004a). While the extent of this North-South divergence even increased in time, the East-West German mortality differences are decreasing continuously since reunification (Vaupel et al. 2003; Luy 2003, 2004b, 2004c, 2005).

The goal of this paper is to test the hypothesis that regional mortality differences such as these are at least partly produced by the healthy migrant phenomenon and the salmon bias. However, a direct estimate of the impact of such a migration-caused selection effect on mortality at a low regional level is practically impossible. The complexity of the connection between migration and health can be seen from studies finding that not only place of birth but also place of death (Strachan et al. 1995) or place where men had lived for most of their adult lives (Elford et al. 1990) have an additional impact on mortality. In principle, a study on the connection between migration and regional mortality differences would require both a migration matrix on the level of districts and the statistical separation of population data due to place of birth, place of residence, and age respective year of migration (for deaths as well as for the living population) what is neither available in Italy nor in Germany. Additionally, such a migration matrix would produce a vast amount of data that then has to be combined with information about regional mortality.

Consequently, a comparative analysis of a migration-caused selection effect in Italy and Germany requires an indirect concept based on a powerful indicator. Our approach is based on the fact that migration (national as well as international) shows a clear and well-known age pattern (e.g., see Preston et al. 2001). Emigration as well as immigration occurs mainly at young adult ages between 20 and 40 among women respective 20 and 50 among men, as can be seen in Fig. 5 for in- and out-migration to and from Germany in the year 2001. The biography of internal migration is almost identical (see Capocaccia and Caselli 1990: 26, 29; Mai 2003a: 41). Consequently, if such a migration-caused selection effect exists and is strong enough to contribute to regional mortality differences, there must be a relationship between the population age structure of the regions with significant migration movements and their level of mortality.

The age structure of a population is generally produced by fertility, mortality, and migration. Fertility impacts the base area of a population's age pyramid and leads a population either becoming younger (in the case of high fertility) or older (in the case of low fertility). In contemporary modern societies mortality mainly affects the upper part of the age pyramid and has an aging effect on the population's age structure. Migration occurs mainly in young adult ages and can affect demographic aging in both directions. This depends on two factors: the migration balance and the average age of the population. In a population with an average age above the main migration age groups immigration leads the population to become younger through gaining young adults, emigration areas are becoming older through losing young adults. The same holds vice versa in the case of a population with an average age below the age migration activity starts.

These relationships build the main framework of our indirect research concept. Given that the average ages of the Italian and German emigration areas are above the main migration age we assume that the districts in these areas lose the more healthy migrants the younger their populations are. Thus, since especially the emigration areas of Southern Italy and North-East Germany are clearly geographically restricted, a migration-caused selection effect on mortality should result in a negative statistical relationship between the population age and the level of mortality among the districts of Southern Italy and North-East Germany. In other words: we should expect that the younger the population in the emigration areas the higher is the overall level of mortality and vice versa. This hypothesis is based on the idea, that – if migrants are health-selected – a younger population loses relatively more healthy individuals by emigration than an older population as a consequence of the described age pattern of migrants. Furthermore, if such a migration-caused selection effect on mortality exists, in Germany the relationship between population age structure and mortality should be concentrated on younger adult age groups, while in Italy the relationship should be stronger in older age groups since there the most intensive emigration movements occurred 20 to 30 years earlier.

An important assumption behind this research strategy is that younger districts inside the emigration areas remain younger compared to the other districts even after emigration took place. At a first glance this might seem contra intuitive. However, since we compare the younger emigration areas with other emigration areas that themselves are losing population we think that this assumption is justified. We do not know any case where a former younger emigration area lost so many young people that it became older than other emigration areas that have been older some years before. Even if such a case exists it has to be seen as an exception rather than a common situation.

South Italy and North-East Germany differ considerably regarding the main demographic parameters used in this study. As already described, in Germany the North-East is the region with the highest mortality among both sexes, while the South of Italy is only among women the area with higher mortality. South Italian men generally show a mortality level slightly better than men in the developed North (Fig. 1). Although the absolute regional differences in life expectancy are considerably higher in Germany, most of the regions show a mortality level lying inside the standard deviation around the mean for total Germany, as can be seen in Figures 3 and 4. In contrary to that, especially among Italian men the regions are concentrated in the upper and the lower mortality levels (Fig. 1). Regarding the population age of this regions the differences between South Italy and North-East Germany are even bigger (Fig. 6 and 7; here the demographic age of the various regions is only shown for one sex since the results are almost identical for women and men).[4] While the South of Italy is the youngest of all Italian regions (ruled lines in Figures 6 and 7), the North-Eastern German re-

[4] According to the chosen measure for the demographic age a population is the older the more negative (smaller) the value for Billeter's J is. The measure itself is described in detail in the following section.

gions show a very heterogeneous age structure with an older population in Sachsen, younger populations in Mecklenburg-Vorpommern, Brandenburg, and Berlin as well as populations having a demographic age close to the German average (Sachsen-Anhalt and Thueringen). These heterogeneous preconditions form an ideal platform for testing the existence of a migration-caused selection effect on regional mortality differences. If the expected relationship between population age and mortality level exists in both countries, we can assume that this relationship is indeed influenced by a migration-caused selection and not due to the specific combination of special demographic conditions that by chance could be observed in one of the two countries.

3. Data and methods

The following analysis is based on sex-specific period life tables for the Italian and German districts for the three calendar years 1997 to 1999. The complete Italian life tables were provided by ISTAT (L'Istituto Nazionale di Statistica in Rome, Italy).[5] For Germany abridged life tables were calculated using age-specific population and death data on district level provided by the BBR (Bundesamt für Bauwesen und Raumordnung in Bonn, Germany). The life tables were calculated by standard techniques for transforming age-specific death rates into probabilities of dying (Chiang 1984).[6] Life expectancy at birth (e_0) is used as indicator for overall mortality. For age-specific analysis the chosen indicators are the probability of dying at ages 15 to 40 ($_{25}q_{15}$) and 50 to 75 ($_{25}q_{50}$) as well as the death rate at ages 75 and above (M_{75+}). This choice of indicators was necessary because German data for age-specific

[5] The complete series of life tables for the Italian districts can be downloaded from http://www.demo.istat.it

[6] Since the relationship between population age structure and mortality level is analyzed separately for Italy and Germany, the use of life tables calculated by different methods does not affect the reliability of the gained results.

death numbers on district level end with the age interval 70 to 75 and thus it is not possible to calculate probabilities of dying above age 75 for German districts.

An estimation of the demographic age of a population mainly depends on the chosen measure. Each measure for the demographic age of a population is necessarily a simplification of the complex age structure. This causes problems and restrictions comparable to using the parameter life expectancy or standardized mortality rates as indicators for overall mortality (Vaupel 2002, Luy 2004a). The decision about the used measure requires an orientation on the basic research question of the analysis. For our purpose the measure for the demographic age has to include the complete age range and should be calculated as easily as possible to provide clear and understandable results that can be interpreted unequivocally. Additionally, the measure should be sensitive and able to identify any differences between populations regarding the complete age composition.

As already described, the age structure of a population is produced by fertility, mortality, and migration. Demographic ageing of a population is additionally dependent on the given age structure at a certain moment of time. Fertility affects a population's age composition at the bottom of the age pyramid, mortality in recent times mainly on its top. Migration occurs mainly at young adult ages. For our purposes we need a measure that separates these three population segments. One measure that fulfils all mentioned demands was developed by the Swiss economist Billeter (1954). His measure is almost unknown in international research on demographic aging. In Germany it recently was rediscovered in several studies on demographic aging since it is seen to provide reliable results indicating clearly each difference between and changes in the age composition of populations (e.g. Dinkel 1989, Dinkel and Lebok 1997, Heigl 1998, Heigl and Mai 1999, Mai 2003b). Following a demographic intention, Billeter subdivided the population into three generations: the pre-reproductive population (including the ages 0 to 14, thus the generation of children), the reproductive population (including the ages 15-49, thus the generation of parents), and the post-reproductive population (including the ages 50 and above, thus the generation of grandparents). According to Billeter (1954) these subgroups characterize the actual and future potential of demographic development. The formula for Billeter's J is

$$J = \frac{P_{0\text{-}14} - P_{50+}}{P_{15-49}}.$$

According to Billeter's J demographic aging is defined by a relative increase of the population in post-reproductive ages as against the population in pre-reproductive ages. The measure can provide positive values (if $P_{0\text{-}14} > P_{50+}$) as well as negative values (if $P_{0\text{-}14} < P_{50+}$), what is typical for today's populations of developed countries. The value zero represents a situation where pre- and post-reproductive age groups have the same size, but has no indication like a norm and thus has the same meaning as any other value. The positive or negative sign indicates the relative and absolute majority of pre- respective post-reproductive age groups. Furthermore, the values +1 and –1 indicate that exactly half of the population live in the age groups 0-14 respective 50+. The most important meaning of J for its interpretation is that the smaller (in general the more negative) the value of J is, the older is the population and vice versa. Furthermore, Billeter's J can be used in comparative static perspective (for comparing two populations at a given year) as well as in dynamic perspective (for analyzing the development of demographic aging in a given time-span).

However, regarding the analysis of population ageing Billeter's J cannot be seen as a perfect measure. Obviously, Billeter considered the youngest age groups and thus fertility as the most important feature of a population's demographic development. In Billeter's formula the pre-reproductive age groups is the smallest. Consequently, changes in the ages 0-14 affect Billeter's J much more than changes in the age groups 15-49 and 50+. However, since the denominator of Billeter's formula contains the reproductive age group that is identical to the main migration ages and given that the levels of fertility do not differ significantly between the districts in Southern Italy and North-East Germany Billeter's J is the most suitable measure for the demographic age of a population in the needed context of this study.

For testing the existence of a migration-caused selection effect on regional mortality differences, the 103 Italian districts ("Province") are grouped into the regions North, Center, and South, the 440 German districts ("Kreise") into the regions North-West, North-East, and South (see Tab. 1 and 2). For each of these regions it is examined if among the districts belonging to them a linear relationship exists between the population age (measured by Billeter's J) and the mentioned indicators for overall and age-specific mortality (e_0 respective $_{25}q_{15}$, $_{25}q_{50}$, and M_{75+}). For estimating the power as well as the statistical significance of the correlation Pearson's r is used. The analyses are done sex-specific and separately for Italy and Germany.

4. Results

In the presented results for the relationship between population and overall mortality measured by life expectancy at birth in Figures 8 to 11 we chose identical scales for Italy and Germany in order to allow also a comparison between the two countries. In the graphs the values for Billeter's J are set on the x-axes (with the younger populations on the right side and the older populations on the left side), the indicators for the mortality level on the y-axes. Although the analysis is focused on Southern Italy and North-East Germany the graphs additionally include the districts of North and Center Italy as well as South and North-West Germany. In this way it is possible to assess whether the results for the emigration areas Southern Italy and North-East Germany differ from the others what is an important information in order to support or reject the hypothesis of a migration-caused selection effect.

An Italian-German comparison clearly shows the enormous differences between the two countries regarding their demographic conditions. While the mortality level is much more heterogeneous among German districts (e_0 ranges from 69.89 to 78.42 among German men and from 78.11 to 83.96 among German women, while in Italy e_0 ranges from 73.75 to 77.74 among men and from 79.99 to 83.64 among women; see Tab. 1 and 2), the Italian districts show much more differences in their demographic age (Billeter's J ranges from –0.11 to –0.73 among Italian men and from –0.28 to –1.08 among Italian women, while in Germany J ranges from –0.05 to –0.51 among men and from –0.18 to –0.85 among women; see Tab. 1 and 2). Generally, the German population is younger than the Italian population, but life expectancy is higher in Italy.[7] These results hold similarly for both sexes.

The reason for the higher variability in life expectancy among German districts is mainly due to the high mortality in the North-Eastern regions (graphically represented as black squares in the figures for Germany). On the other side, the reason for the more heterogeneous distribution of population age among Italian districts is a consequence of bigger differences in regional fertility as compared to Germany, resulting in relatively old populations with very low values for J especially in the North and in the Center of Italy (represented by white triangles and grey rhombs in the figures for Italy).

The central research question of this study is if there exists a statistical relationship between population age and the mortality level among the North-Eastern German and South Italian districts. As can be seen in Figures 8 and 9, among men the expected relationship can be found in both regions with high statistical significance. In Southern Italy the relationship is stronger with Pearson's r being –0.552, among North-Eastern German districts Pearson's r equals –0.325. According to the basic hypothesis, if this result is due to a migration-caused

[7] As already mentioned, a comparison of German and Italian life expectancy on district level is slightly distorted by the fact that the used methods for calculating the life tables are different, what finally could influence the absolute parameter values. Anyway, also according to the official life tables for the total populations Italy shows the higher expectancy.

selection effect, then among North-Eastern German districts the relationship with Billeter‘s J should be stronger for mortality at younger adult ages, while among Southern Italian districts the relationship should be more pronounced at older ages. Table 3 shows that exactly these relationships can be found with positive correlation between Billeter’s J and the chosen indicators for age-specific mortality (meaning the younger the population in terms of Billeter’s J the higher the mortality level). Among North-Eastern German districts the correlation with Billeter’s J is strongest with the probability of dying at ages 15 to 40 ${}_{25}q_{15}$ (r = 0.256), followed by the probability of dying at ages 50 to 75 ${}_{25}q_{50}$ (r = 0.247) and the death rate at ages 75 and above M_{75+} (r = 0.214). In all cases the correlation is statistically significant but slightly loses significance at the oldest age groups (see Tab. 3). Among Southern Italian districts no statistically significant correlation can be found between Billeter’s J and ${}_{25}q_{15}$, but a strong statistically significant correlation between J and ${}_{25}q_{50}$ (r = 0.464) and especially between J and M_{75+} (r = 0.730; see Tab. 3).

Among women similar results can be found for the Southern Italian regions (Fig. 10). Here the correlation between Billeter’s J and life expectancy at birth e_0 is strongest of all cases (r = -0.708). Like among men, this relationship is not statistically significant at ages 15 to 40, but highly statistically significant at ages 50 to 75 (r = 0.705) and at ages 75 and above (r = 0.654). Among women in the North-Eastern German districts no statistically significant correlation between population age and mortality level can be found. However, also here the sign of Pearson’s r corresponds to the basic hypotheses (see Fig. 11 and Tab. 3).

Finally we have a look at the correlation between population age and mortality level in the other German and Italian regions. Among German men in the North-Western districts we find a statistically significant positive correlation between Billeter’s J and life expectancy at birth e_0, meaning the younger the population in terms of Billeter’s J the lower overall mortality (or the higher life expectancy at birth). The correlation coefficients indicate that the reason for this finding is located in the mortality of the age groups 15 to 49 where Pearson's r for the relationship between J and $_{25}q_{50}$ equals –0.292 with high statistically significance (Tab. 3). In the Southern districts no significant relationship exists between overall mortality and age of population, but there can be found a statistically significant correlation in opposite directions between J and $_{25}q_{50}$ respective M_{75+}. Almost the same relationships can be stated for women in the Southern and North-Western German districts (see Tab. 3).

Among Italian men in the districts in the North and in the Center as well as among Italian women in the Center there are no statistically significant relationships between population age and the level of mortality. This holds for both, overall mortality and age-specific mortality (see Tab. 3). Beside the findings regarding the South of Italy, only among women in the Northern districts a statistically significant correlation between Billeter's J and the mortality indicators can be found. Here the relationship is exactly contrary to the correlation in the South, meaning the younger the population in terms of Billeter's J the lower mortality (similar to the findings for the North-Western German districts). This result is mainly due to the mortality conditions in the younger and middle adult age groups, with r = 0.431 between J and e_0, r = -0.404 between J and $_{25}q_{15}$, and r = -0.414 between J and $_{25}q_{50}$. The correlation between Billeter's J and the death rate at ages 75 and above (M_{75+}) is not statistically significant.

5. Summary and conclusions

The aim of this study was to test the hypothesis that a migration-caused selection effect belongs to the group of factors contributing to and causing regional mortality differences. This effect is thought to be a consequence of individual decisions of migrating to and living in special areas, causing heterogeneous areas with healthier people in some regions on the one side and areas with more frail populations on the other side. Since a direct investigation of the impact of spatial population movements on mortality at low regional level is not possible we used an indirect indicator providing enough information to support or reject the basic hypothesis.

The decisive idea of this study is that if a migration-caused selection effect exists, then there should be a statistical correlation between the demographic age of a population and its mortality level resulting from the typical biography of migrations that are concentrated at the age groups 20 to 40. Since the South of Italy and North-Eastern Germany (the former GDR) are almost clearly restricted emigration areas, such a correlation should be expected especially in these regions. Furthermore, in North-Eastern Germany the corresponding relationship between mortality conditions and population age should be more pronounced at lower adult ages, since the emigration from the former GDR started around 1990, while in Italy the most intensive population movements from the South to the Center and the North occurred in the 1960s and 1970s. Consequently, in South Italy a migration-caused selection effect should manifest in a correlation between population age and mortality at higher ages than in Germany.

Using the data for the years 1997 to 1999 on Italian and German district level we found that among women and men in South Italy as well as among men in North-Eastern Germany the expected correlation exists with high statistical significance. Among the districts in both regions life expectancy at birth is the lower the younger the populations are in terms of Billeter’s J. Also regarding the correlation between population age and age-specific mortality, the basic hypothesis was strongly supported with a high statistically significant relationship among younger adult ages in North-Eastern Germany and among higher adult ages in South Italy. Only among North-Eastern German women no statistically significant relationship between population age and mortality could be found. However, the directions of the correlation also fit to the basic hypothesis. That in this case the expected correlation is not statistically significant could be explained by the fact that female migration generally arises some years later than male migration and thus the seven to nine years of emigration from

North Eastern Germany could be insufficient for producing a statistically significant migration-caused selection effect among women.

The question is if we should expect the contrary relationship between mortality and population age in the other regions, namely North and Center Italy, and North-West and South Germany. The answer is no, since the immigration areas in both countries are not as clearly geographically restricted as the emigration areas. To figure out a positive migration-caused selection effect in immigration areas it is necessary to concentrate on immigration districts only. The areas of North and Center Italy as well as North-West and South Germany are too heterogeneous regarding migration history to expect such a clear relationship between mortality and population age. But keeping in mind the results of South Italy and North-Eastern Germany it is very likely that at least some parts of the found correlation between population age and mortality in the other regions are due to the healthy migrant phenomenon and the salmon bias.

To conclude, the results of this study provide strong evidence that a migration-caused selection effect affecting regional mortality differences in Italy and in Germany does indeed exist, with a stronger impact in Italy as compared to Germany. To quantify this effect more generally it is necessary to further distinguish subgroups also among the emigration areas and to find an appropriate statistical model for describing the statistical relationship. Including a time perspective might also be helpful, as well as to figure out the main causes of death among which this selection effect is most effective. However, the aim of this paper was solely to find an indirect indicator to test the hypothesis of an existing migration-caused selection effect. The found correlation between mortality and population age in both Southern Italy and North-Eastern Germany are stronger than expected. Consequently, the hypothesis of a migration-caused selection effect affecting regional mortality differences cannot be rejected on the basis of this study. The healthy migrant phenomenon and the salmon bias in fact seem to belong to the group of general factors that are responsible for the existence of regional differences in survival conditions even on the macro level and that work independently from the societal and economic background of the regions.

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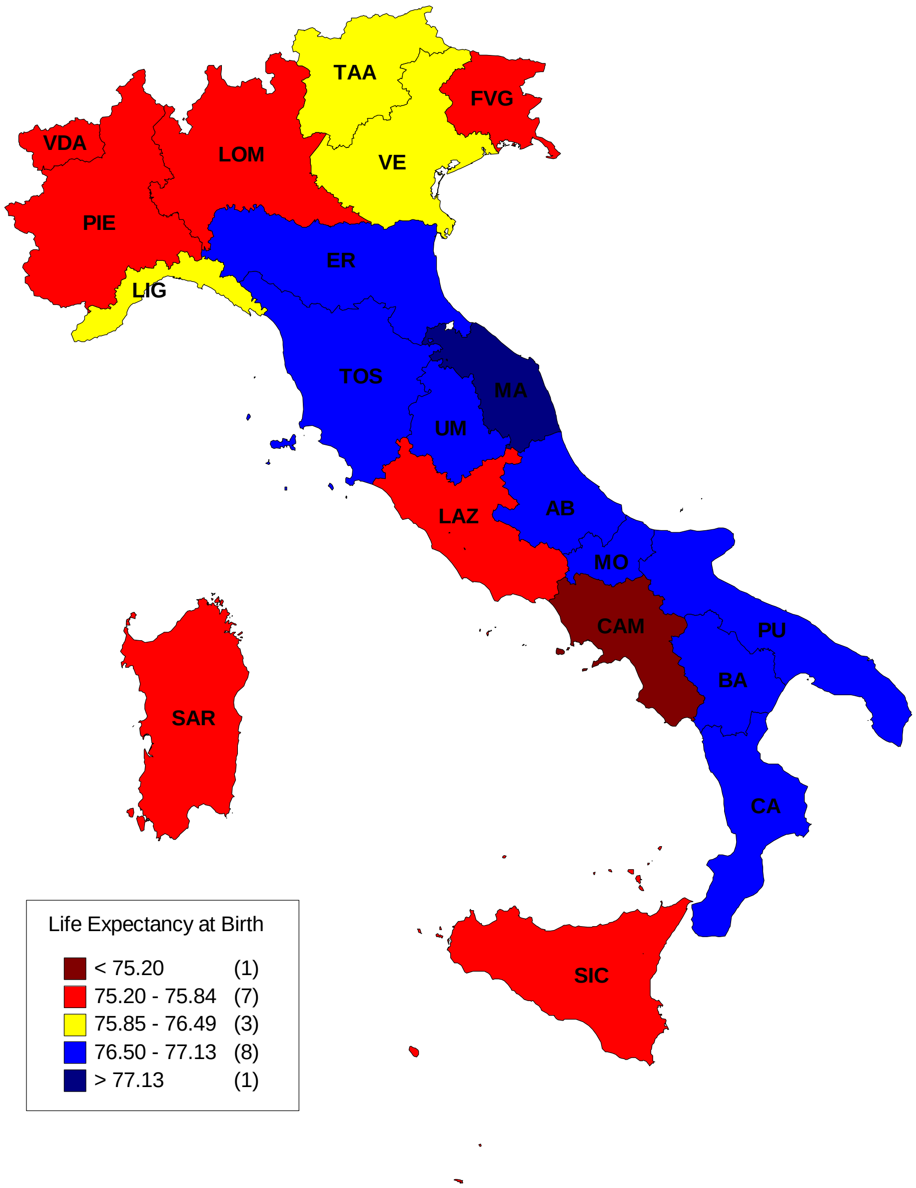
7. Figures and Tables

Fig. 1: Regional mortality differences in life expectancy at birth for Italian men, measured for "Regioni" classified in units of the standard deviation (σ = 0.64), 1997-1999



TAA: Trentino-Alto Adige, VDA: Valle D'Aosta, LOM: Lombardia, VE: Veneto, FVG: Friuli – Venezia Giulia, PIE: Piemonte, LIG: Liguria, ER: Emilia Romagna, TOS: Toscana, UM: Umbria, MA: Marche, LAZ: Lazio, AB: Abruzzo, MO: Molise, CAM: Campania, PU: Puglia, BA: Basilicata, CA: Calabria, SIC: Sicilia, SAR: Sardegna

Fig. 2: Regional mortality differences in life expectancy at birth for Italian women, measured for "Regioni" classified in units of the standard deviation ($\sigma = 0.64$), 1997-1999

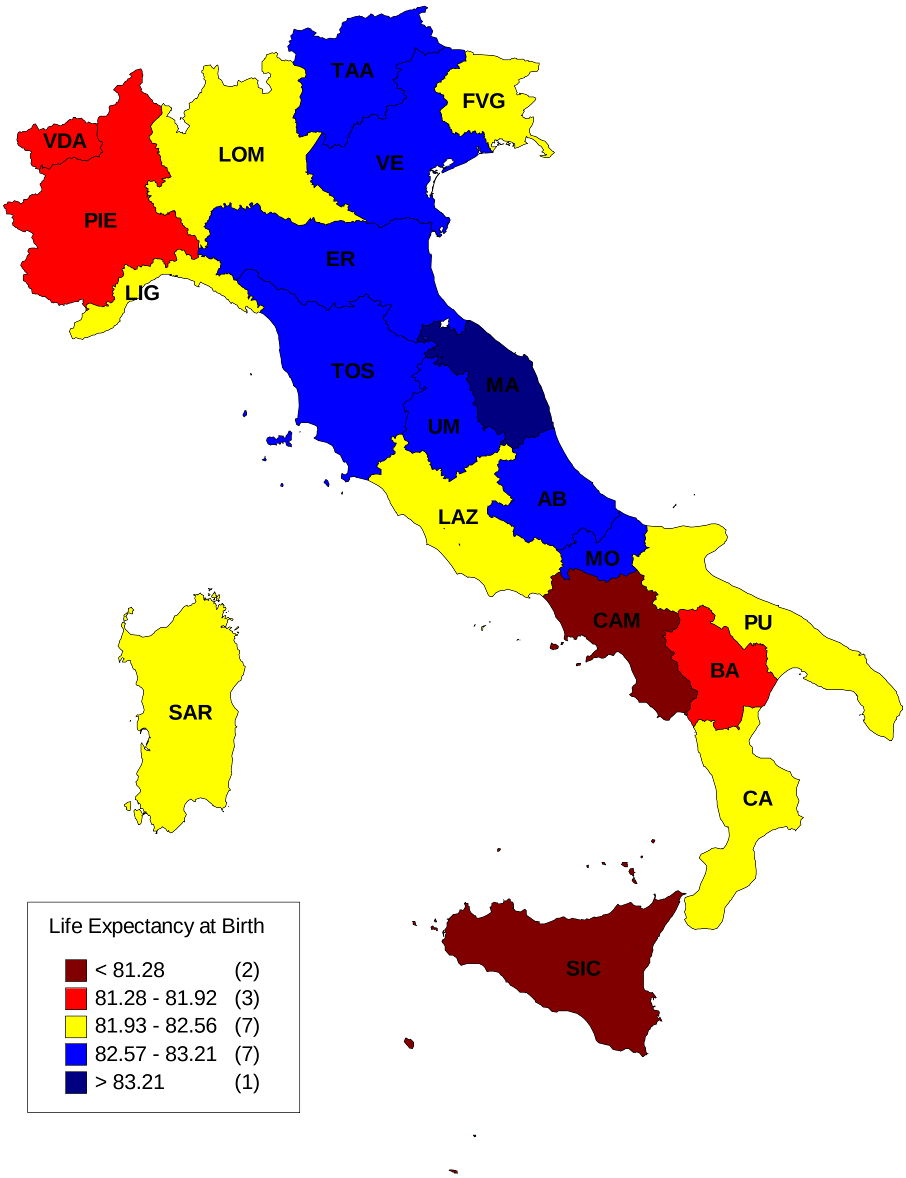


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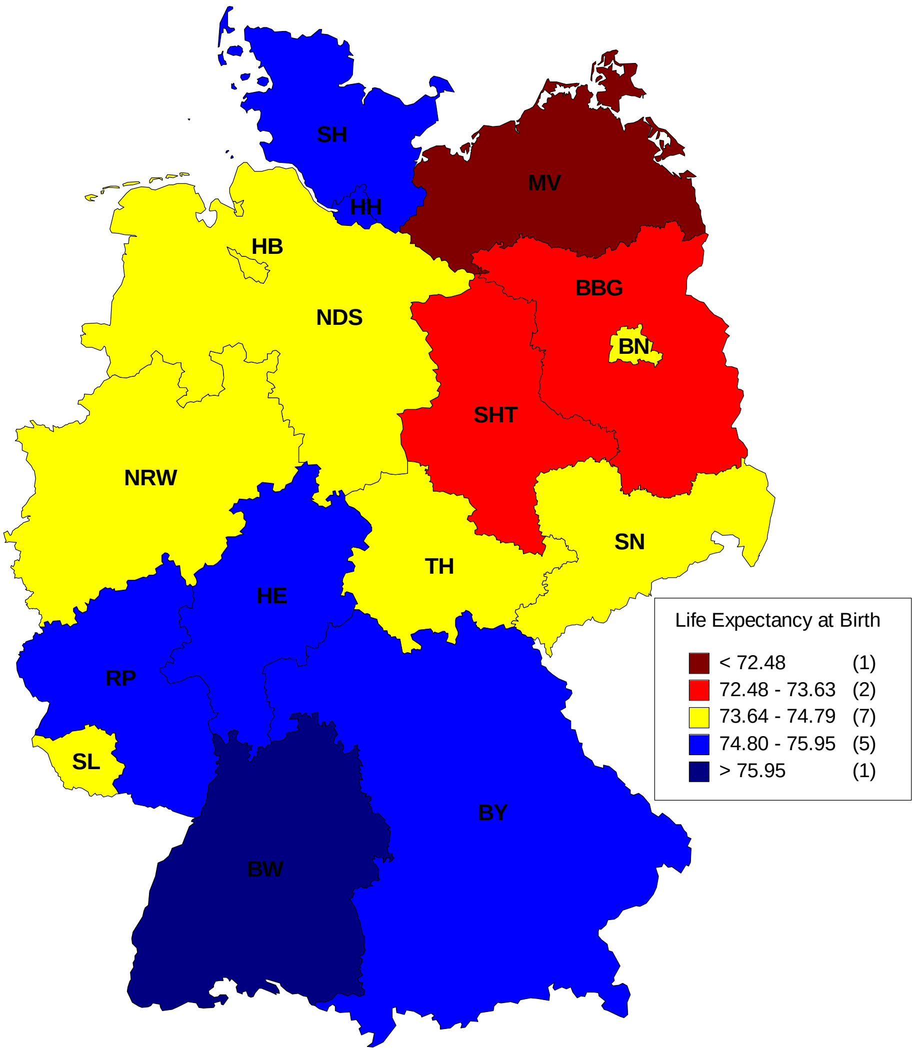
Fig. 3: Regional mortality differences in life expectancy at birth for German men, measured for "Bundesländer" classified in units of the standard deviation (σ = 1.15), 1997-1999



SH: Schleswig-Holstein, HH: Hansestadt Hamburg, MV: Mecklenburg-Vorpommern, HB: Hansestadt Bremen, NDS: Niedersachsen, SHT: Sachsen-Anhalt, BBG: Brandenburg, BN: Berlin, NRW: Nordrhein-Westfalen, TH: Thüringen, SN: Sachsen, RP: Rheinland-Pfalz, HE: Hessen, BY: Bayern, SL: Saarland, BW: Baden-Württemberg

Fig. 4: Regional mortality differences in life expectancy at birth for German women, measured for "Bundesländer" classified in units of the standard dev. (σ = 0.76), 1997-1999

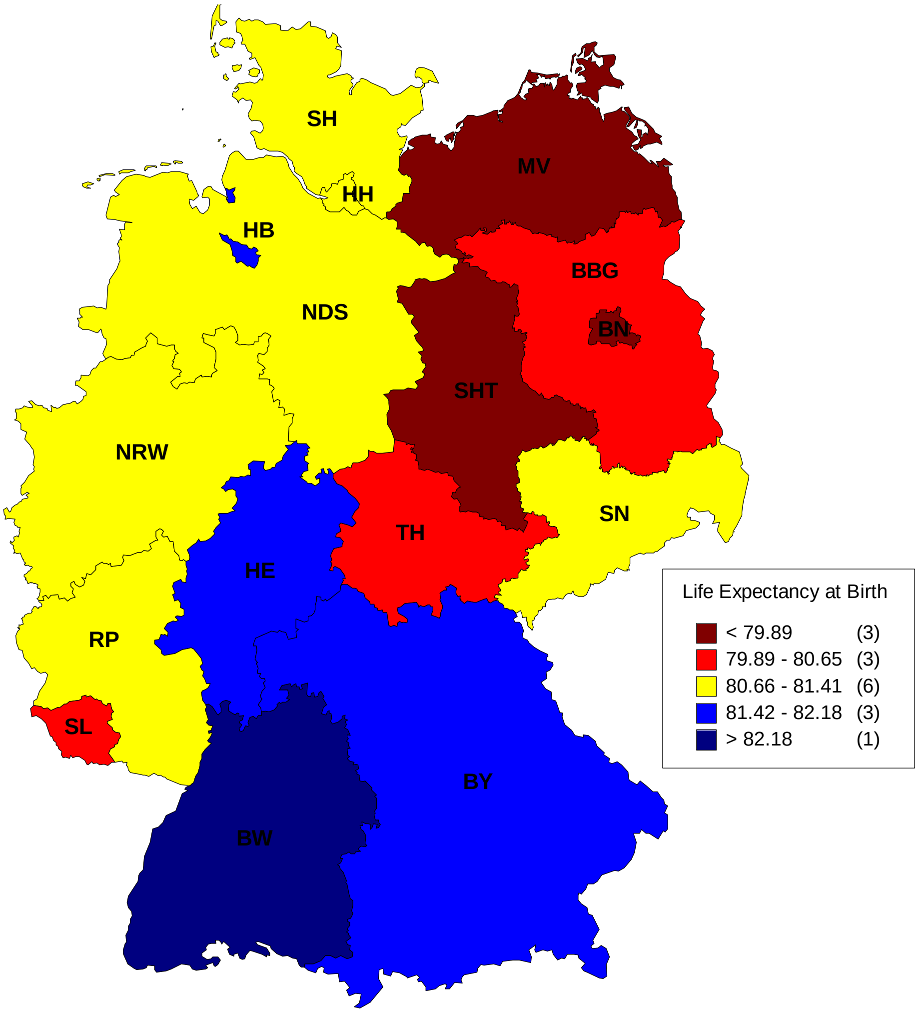


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Fig.5: Age-specific number of migrants to and from Germany, 2001

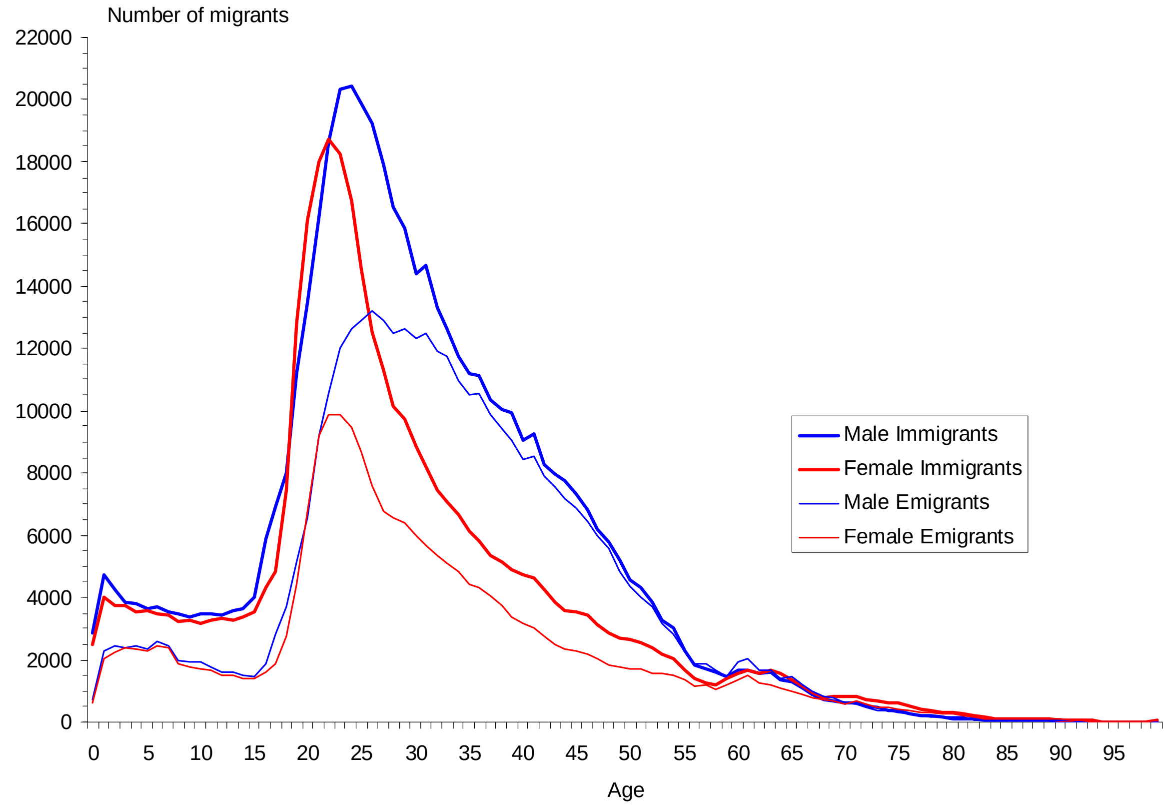
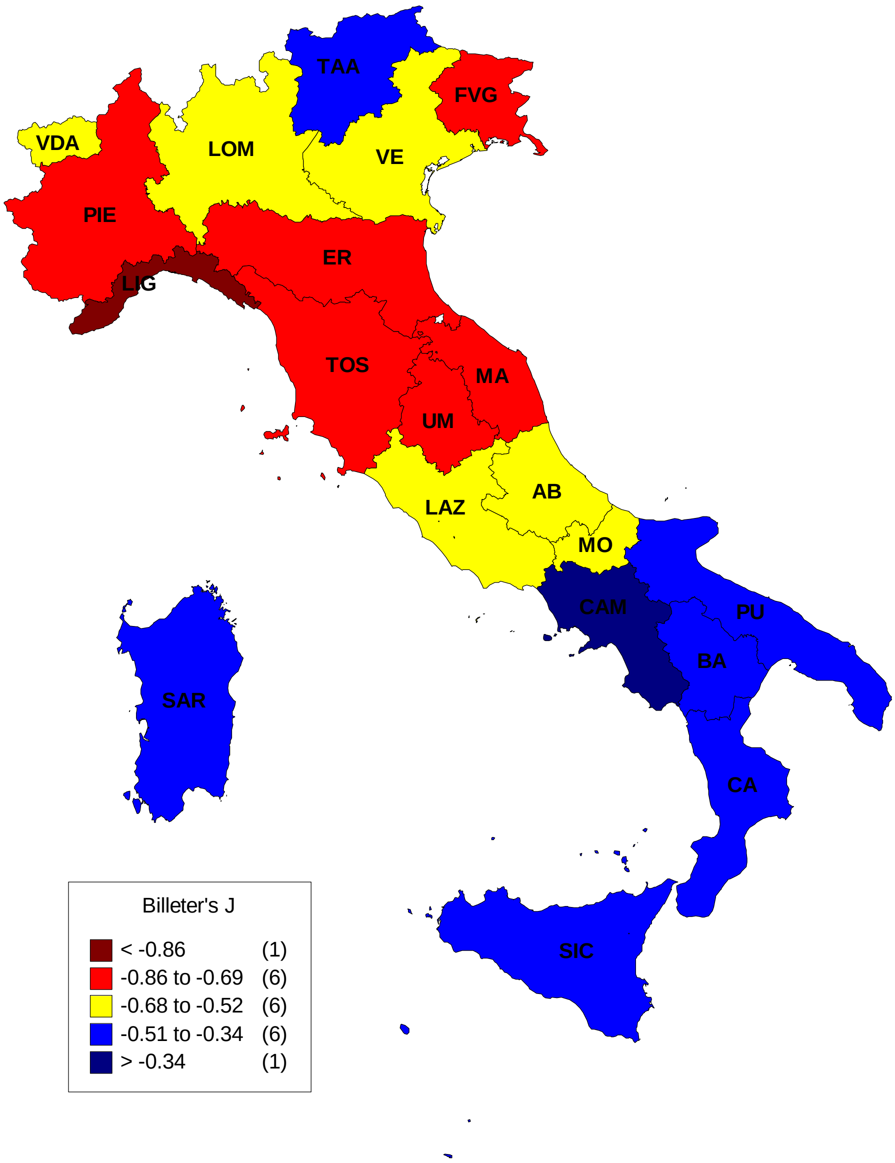
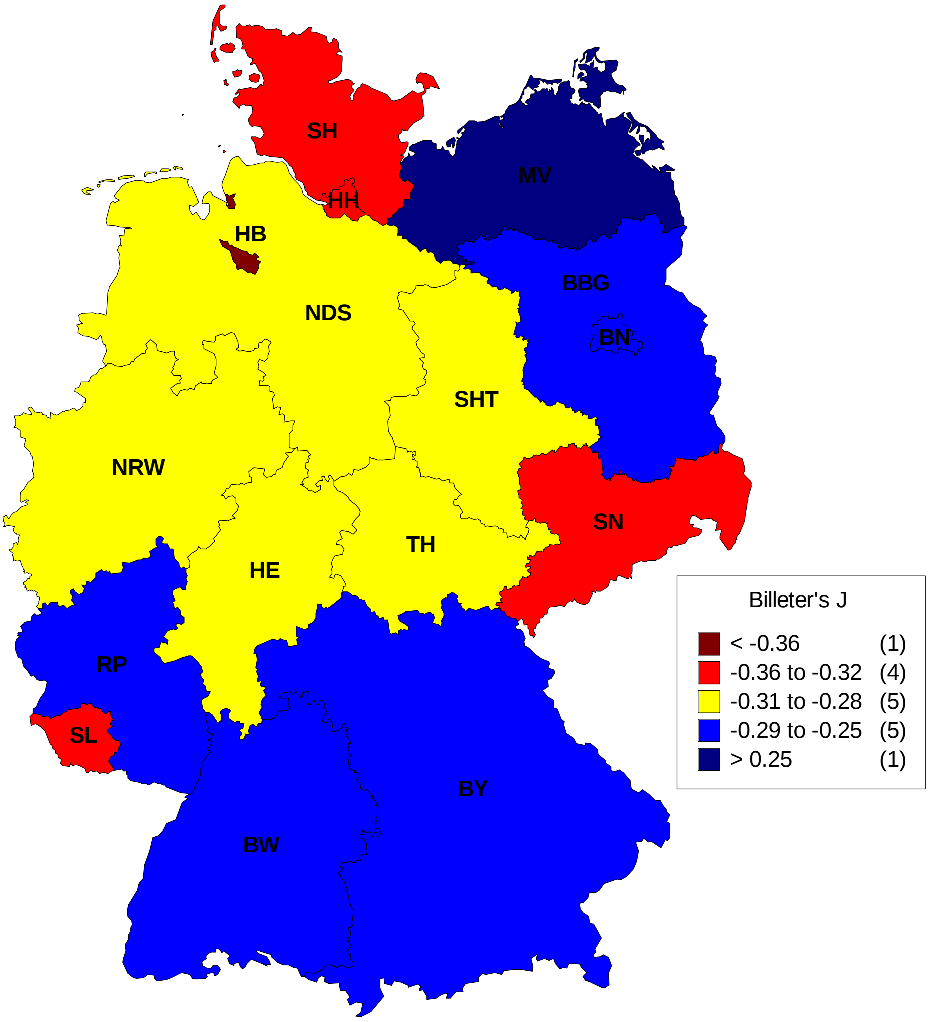


Fig. 6: Billeters' J for Italian women, measured for "Regioni" classified in units of the standard deviation (σ = 0.17), 1997-1999



TAA: Trentino-Alto Adige, VDA: Valle D'Aosta, LOM: Lombardia, VE: Veneto, FVG: Friuli – Venezia Giulia, PIE: Piemonte, LIG: Liguria, ER: Emilia Romagna, TOS: Toscana, UM: Umbria, MA: Marche, LAZ: Lazio, AB: Abruzzo, MO: Molise, CAM: Campania, PU: Puglia, BA: Basilicata, CA: Calabria, SIC: Sicilia, SAR: Sardegna

Fig. 7: Billeter's J for German men, measured for "Bundesländer" classified in units of the standard deviation (σ = 0.04), 1997-1999



SH: Schleswig-Holstein, HH: Hansestadt Hamburg, MV: Mecklenburg-Vorpommern, HB: Hansestadt Bremen, NDS: Niedersachsen, SHT: Sachsen-Anhalt, BBG: Brandenburg, BN: Berlin, NRW: Nordrhein-Westfalen, TH: Thüringen, SN: Sachsen, RP: Rheinland-Pfalz, HE: Hessen, BY: Bayern, SL: Saarland, BW: Baden-Württemberg

Fig. 8: Relationship between Billeter's J and life expectancy at birth e(0) for the 440 German districts with Pearson's r and statistical significance, males 1997-1999

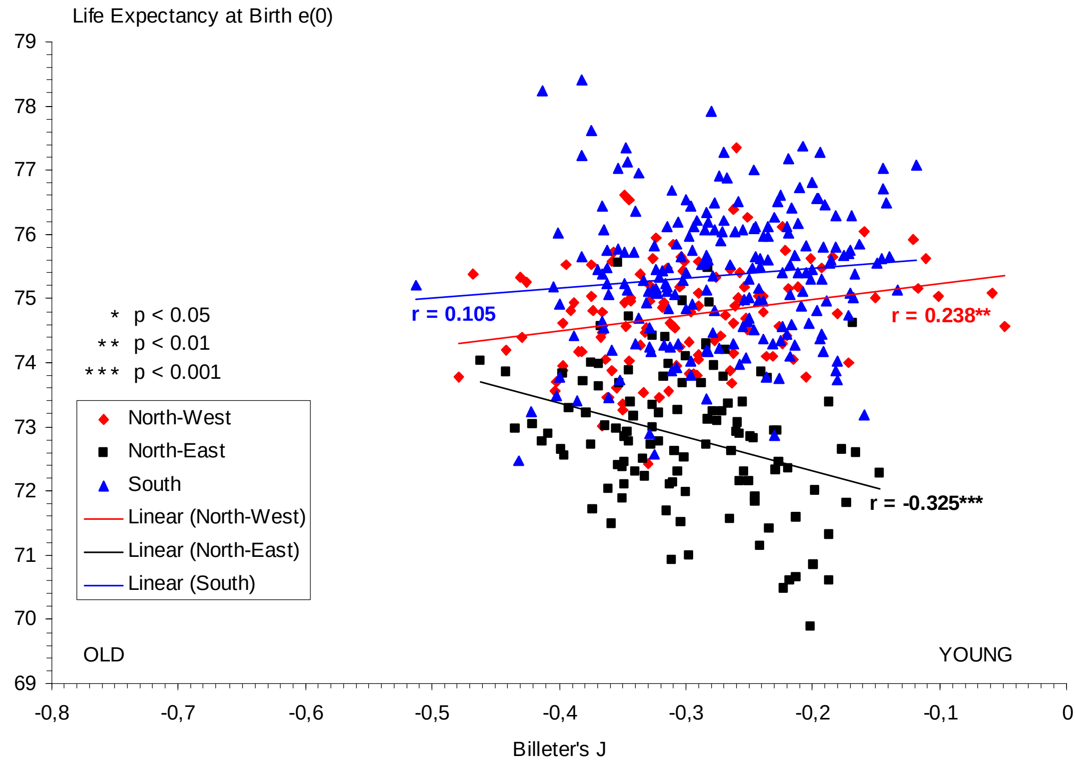


Fig. 9: Relationship between Billeter's J and life expectancy at birth e(0) for the 103 Italian districts with Pearson's r and statistical significance, males 1997-1999

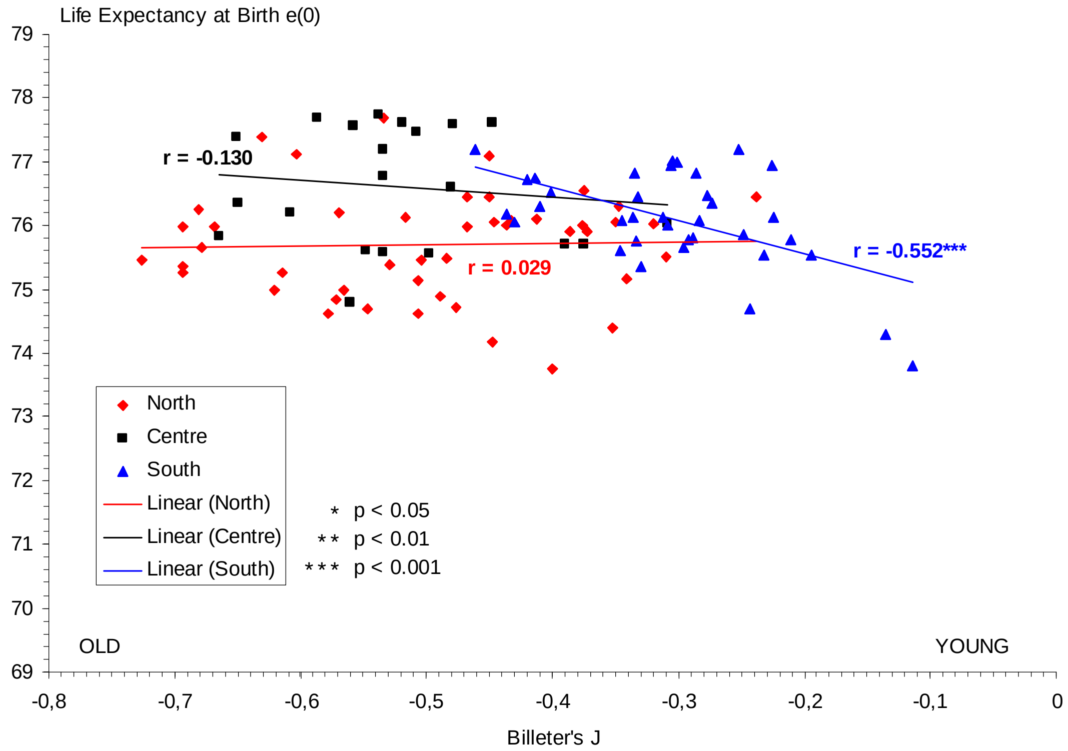


Fig. 10: Relationship between Billeter's J and life expectancy at birth e(0) with Pearson's r for the 440 German districts and statistical significance, females 1997-1999

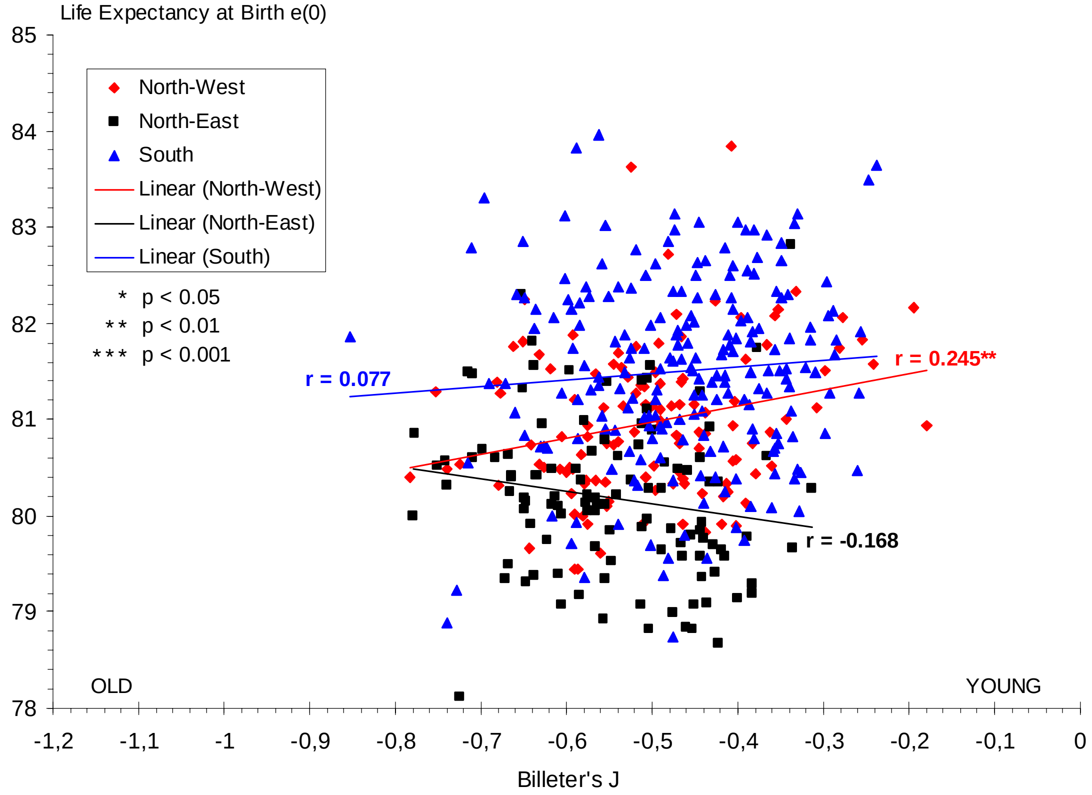
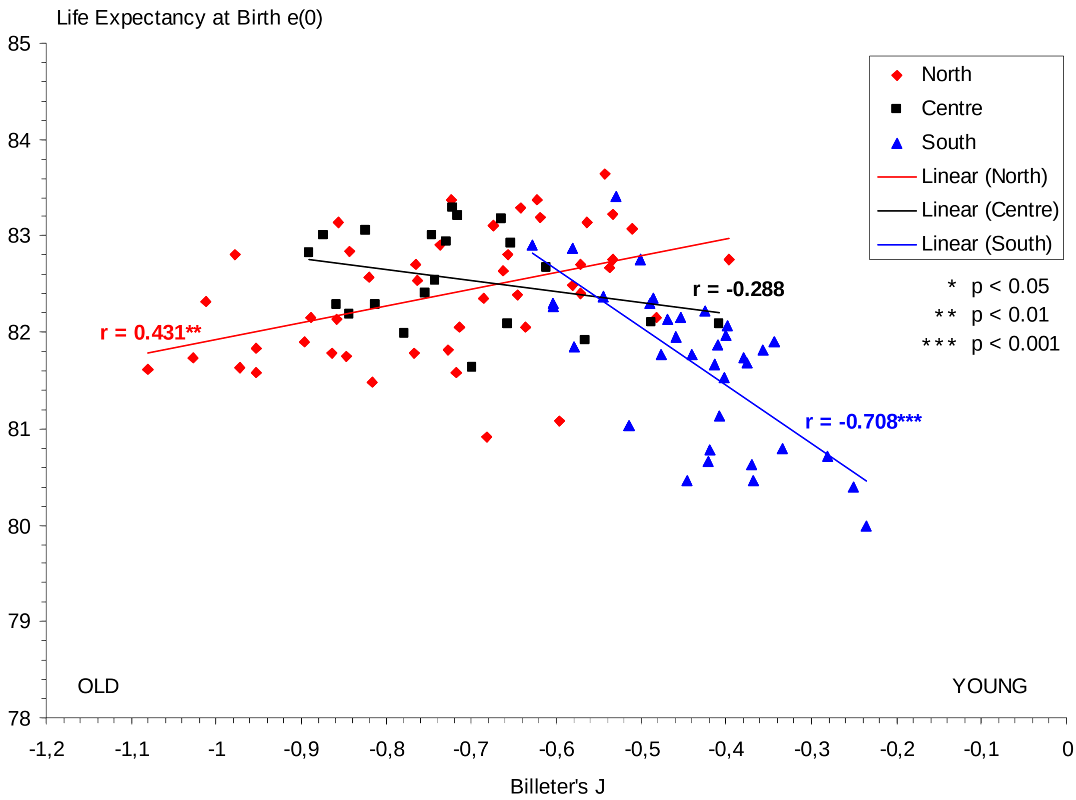


Fig. 11: Relationship between Billeter's J and life expectancy at birth e(0) for the 103 Italian districts with Pearson's r and statistical significance, females 1997-1999



Tab. 1: Number of districts and variance of parameter values for life expectancy at birth and Billeter's J for German regions ("Bundesländer"), 1997-1999

		Men						Women					
		Life Expectancy e(0)			Billeter's J			Life Expectancy e(0)			Billeter's J		
	Districts	Min	Max	Span	Min	Max	Span	Min	Max	Span	Min	Max	Span
NORTH-WEST	**119**	**73.03**	**77.36**	**4.33**	**-0.48**	**-0.05**	**0.43**	**79.44**	**83.84**	**4.40**	**-0.78**	**-0.18**	**0.60**
Bremen	2	73.03	74.18	1.15	-0.38	-0.37	0.01	81.21	81.68	0.47	-0.63	-0.59	0.04
Hamburg	1	74.97	74.97	-	-0.34	-0.34	-	80.94	80.94	-	-0.58	-0.58	-
Niedersachsen	47	73.47	76.54	3.07	-0.48	-0.05	0.43	79.44	83.63	4.19	-0.78	-0.18	0.60
Nordrhein-Westfalen	54	72.43	77.36	4.93	-0.47	-0.11	0.36	79.44	83.84	4.40	-0.72	-0.25	0.47
Schleswig-Holstein	15	73.46	75.94	2.48	-0.43	-0.28	0.15	79.61	81.81	2.20	-0.68	-0.44	0.24
NORTH-EAST	**113**	**69.89**	**75.56**	**5.67**	**-0.46**	**-0.15**	**0.31**	**78.11**	**82.81**	**4.70**	**-0.78**	**-0.31**	**0.47**
Berlin	1	73.96	73.96	-	-0.28	-0.28	-	79.65	79.65	-	-0.49	-0.49	-
Brandenburg	18	70.93	74.93	4.00	-0.37	-0.20	0.17	79.29	81.42	2.13	-0.65	-0.38	0.27
Mecklenburg-Vorpommern	18	69.89	73.78	3.89	-0.35	-0.15	0.20	78.85	82.81	3.96	-0.64	-0.31	0.33
Sachsen	29	71.48	75.56	4.08	-0.46	-0.24	0.22	79.38	82.30	2.92	-0.78	-0.44	0.34
Sachsen-Anhalt	24	71.52	73.88	2.36	-0.44	-0.21	0.23	78.67	81.48	2.81	-0.71	-0.42	0.29
Thüringen	23	71.67	75.48	3.81	-0.41	-0.17	0.24	78.11	81.57	3.46	-0.72	-0.37	0.35
SOUTH	**208**	**72.48**	**78.42**	**5.94**	**-0.51**	**-0.12**	**0.39**	**78.73**	**83.96**	**5.23**	**-0.85**	**-0.24**	**0.61**
Baden-Württemberg	44	74.28	77.17	2.89	-0.51	-0.12	0.39	79.88	83.49	3.61	-0.85	-0.25	0.60
Bayern	96	72.48	78.42	5.94	-0.43	-0.14	0.29	79.23	83.96	4.73	-0.73	-0.24	0.49
Hessen	26	73.41	77.62	4.21	-0.39	-0.21	0.18	79.57	83.12	3.55	-0.63	-0.36	0.27
Rheinland-Pfalz	36	73.23	76.08	2.85	-0.42	-0.19	0.23	78.73	82.32	3.59	-0.74	-0.30	0.44
Saarland	6	73.44	75.22	1.78	-0.36	-0.28	0.08	79.36	81.44	2.08	-0.59	-0.49	0.10
GERMANY	**440**	**69.89**	**78.42**	**8.53**	**-0.51**	**-0.05**	**0.46**	**78.11**	**83.96**	**5.85**	**-0.85**	**-0.18**	**0.67**

Tab. 2: Number of districts and variance of parameter values for life expectancy at birth and Billeter's J for Italian regions ("Regioni"), 1997-1999

		Men						Women					
		Life Expectancy e(0)			Billeter's J			Life Expectancy e(0)			Billeter's J		
	Districts	Min	Max	Span	Min	Max	Span	Min	Max	Span	Min	Max	Span
NORTH	**46**	**73.75**	**77.70**	**3.95**	**-0.73**	**-0.24**	**0.49**	**80.91**	**83.64**	**2.73**	**-1.08**	**-0.40**	**0.68**
Emilia Romagna	9	75.00	77.70	2.70	-0.68	-0.45	0.23	81.59	83.38	1.79	-0.95	-0.62	0.33
Friuli - Venezia Giulia	4	74.84	76.00	1.16	-0.69	-0.44	0.25	81.62	82.80	1.18	-1.08	-0.66	0.42
Liguria	4	75.46	76.25	0.79	-0.73	-0.67	0.06	81.74	82.81	1.07	-1.03	-0.95	0.08
Lombardia	11	73.75	76.11	2.36	-0.55	-0.31	0.24	81.08	83.19	2.11	-0.74	-0.48	0.26
Piemonte	8	74.62	76.13	1.51	-0.69	-0.45	0.24	80.91	82.35	1.44	-0.97	-0.68	0.29
Trentino - Alto Adige	2	76.05	76.44	0.39	-0.35	-0.24	0.11	82.76	83.64	0.88	-0.54	-0.40	0.14
Valle D'Aosta	1	74.17	74.17	-	-0.45	-0.45	-	82.06	82.06	-	-0.64	-0.64	-
Veneto	7	74.88	76.56	1.68	-0.51	-0.32	0.19	81.82	83.23	1.41	-0.76	-0.51	0.25
CENTRE	**21**	**74.80**	**77.74**	**2.94**	**-0.66**	**-0.31**	**0.35**	**81.64**	**83.29**	**1.65**	**-0.89**	**-0.41**	**0.48**
Lazio	5	75.56	76.02	0.46	-0.53	-0.31	0.22	81.64	82.10	0.46	-0.70	-0.41	0.29
Marche	4	76.59	77.62	1.03	-0.52	-0.48	0.04	82.93	83.29	0.36	-0.72	-0.65	0.07
Toscana	10	74.80	77.74	2.94	-0.66	-0.45	0.21	81.98	83.06	1.08	-0.89	-0.61	0.28
Umbria	2	76.36	77.20	0.84	-0.65	-0.53	0.12	82.29	82.94	0.65	-0.86	-0.73	0.13
SOUTH	**36**	**73.79**	**77.19**	**3.40**	**-0.46**	**-0.11**	**0.35**	**79.99**	**83.41**	**3.42**	**-0.63**	**-0.28**	**0.35**
Abruzzo	4	76.19	77.19	1.00	-0.46	-0.40	0.06	82.90	83.41	0.51	-0.63	-0.53	0.10
Basilicata	2	76.81	77.03	0.22	-0.34	-0.30	0.04	81.66	81.76	0.10	-0.48	-0.41	0.07
Calabria	5	75.53	77.19	1.66	-0.30	-0.19	0.11	80.72	82.07	1.35	-0.41	-0.28	0.13
Campania	5	73.79	76.94	3.15	-0.35	-0.11	0.24	79.99	82.76	2.77	-0.50	-0.24	0.26
Molise	2	76.06	76.72	0.66	-0.43	-0.42	0.01	81.86	82.27	0.41	-0.60	-0.58	0.02
Puglia	5	75.80	76.94	1.14	-0.33	-0.22	0.11	81.54	82.30	0.76	-0.49	-0.34	0.15
Sardegna	4	75.35	76.29	0.94	-0.41	-0.31	0.10	81.95	82.37	0.42	-0.55	-0.43	0.12
Sicilia	9	74.69	76.13	1.44	-0.34	-0.21	0.13	80.46	82.14	1.68	-0.51	-0.33	0.18
ITALY	**103**	**73.75**	**77.74**	**3.99**	**-0.73**	**-0.11**	**0.62**	**79.99**	**83.64**	**3.65**	**-1.08**	**-0.28**	**0.80**

Tab. 3: Pearson's r with statistical significance for the relationship between Billeter's J and the used mortality indicators for Germany and Italy, 1997-1999

	e_0		${}_{25}q_{15}$		${}_{25}q_{50}$		M_{75+}	
Germany, Men								
North-West	0.238	**	- 0.057		- 0.292	**	0.093	
North-East	- 0.325	***	0.256	**	0.247	**	0.214	*
South	0.105		0.006		- 0.136	*	0.231	***
Germany, Women								
North-West	0.245	**	- 0.215	*	- 0.441	***	0.110	
North-East	- 0.168		0.181		0.119		0.176	
South	0.077		- 0.181	**	-0.335	***	0.228	***
Italy, Men								
North	0.029		- 0.238		0.130		0.025	
Centre	- 0.130		0.164		0.064		0.065	
South	- 0.552	***	0.078		0.464	**	0.730	***
Italy, Women								
North	0.431	***	- 0.404	**	- 0.414	**	- 0.195	
Centre	- 0.288		- 0.026		0.297		0.342	
South	- 0.708	***	0.113		0.705	***	0.654	***

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$