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CHANGING MORTALITY DISTRIBUTION IN DEVELOPED COUNTRIES FROM 1970 TO 2010: LOOKING AT AVERAGES AND BEYOND THEM

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ABSTRACT

The methods typically developed in income inequality and poverty research are employed to observe changes in life spans distribution in 35 developed countries. The analyses are performed at two levels, using the same methods when possible: i/ taking the countries as the units with a mean length of life being a single parameter representing the distribution, ii/ utilizing the country life tables (taking people as the units) in order to compare other than mean length of life attributes of mortality distribution. Increasing divergence in the mean length of life across the countries is due to growing distance of the countries below the median, mainly the post-communist ones, to the upper half. The comparisons of the within-country distributions of ages at death by means of the Kullback-Leibler divergence provides similar results. However, poverty and inequality indices calculated at this level yield opposite conclusions. Hence, most of the between-country variation might be attributed to the variation in the mean length of life while the changes in within-country inequality reduced this effect. At the same time, huge alterations in the within-country mortality rankings can be observed. Australia, Japan, Taiwan, Austria and Luxembourg may be said to be the "winners" while most of the post-communist countries are among the "losers".

Key words: mean length of life, mortality distribution, poverty and inequality indices.

1. Introduction

Social inequality has attracted the attention of scholars since the ancient times. It was Plato who declared in "The Republic": "If a state is to avoid (…) civil disintegration (…) extreme poverty and wealth must not be allowed to rise in any section of the citizen-body, because both lead to disasters." (Plato quoted after Cowell, 1977, page 26). Since the end of the XIX Century and V. Pareto's works on income distribution (Pareto, 1896), research on inequality has become one of

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the inherent elements of the modern economics. Considering some opinions that the length of life is one of most comprehensive single indicators of economic development (Hicks and Streeten, 1979, Silber, 1983), as well as attention paid to this indicator by the United Nations (United Nations Development Programme, 2014) or the European Union (European Commission, 2009), the growing interest in inequality among demographers can hardly surprise (see Muszyńska et al., 2014 for a review). In this study some concepts of income inequality and poverty measurement are applied to the changes in mortality distribution observed in 35 developed countries between 1970 and 2010. We employ a set of inequality scalar measures intended to capture various aspects and ranges of mortality distribution. Moreover, indicators developed in well-being poverty research are also utilized for the same purpose. Following Ravallion (1994), poverty may be defined generally as an inability to "attain a level of material well-being deemed to constitute a reasonable minimum by the standards of that society". Employing poverty measures in demographic research was proposed by Silber (1992) who calculated three poverty indices using life tables for 27 countries, setting the "poverty line" at 60 years of age, i.e. typical retirement age for women (in that way, people were considered poor if they "did not have opportunity to enjoy retirement", Silber 1992, p. 415). In the present study the definition of poverty could be interpreted in two ways. When the country mean lengths of life are compared, poverty denotes falling below the broadly conceived "international standard". When individual data on mortality is analysed (as in Silber's study), poverty could be interpreted as "dying too early". It should be said, however, that in the present study all poverty measures following Silber's approach are relative, i.e. they should be considered a vehicle for comparing the life spans distribution, taking the "international standards" as a benchmark. As the final results strongly depend on the poverty line setting, we explore its various level(s), producing indicators for each one. The poverty indices are intended to answer the question of how many people or countries are exposed to demographic poverty but also what the depth and severity of this type of poverty is. Beyond the poverty indices mentioned above we apply the Kullback-Leibler divergence (Kullback and Leibler, 1951) in order to compare the mortality distributions in their whole ranges.

Although the number of studies comparing mortality between countries is large, only a few of them investigate other than mean length of life parameters of within-country distribution. Smits and Monden (2009), and Edwards (2011) calculated inequality indices for the whole world, then decomposing it into between- and within-country inequality. Edwards and Tuljapurkar (2005) and d'Albis et al. (2014) employed the Kullback-Leibler divergence in order to compare within-country distributions. In Muszyńska et al. (2014) the concept of Equivalent Length of Life (Silber, 1983) was incorporated to take into consideration within-country inequality and asymmetry, and to find relations between these parameters and the mean length of life. The latter studies utilized variance and Gini-based measures of inequality/asymmetry while the present one employs a broader set of

distribution characteristics, which makes the conclusions potentially more robust. To our knowledge Silber (1992) is the only study comparing mortality poverty indices calculated by means of individual data. The novel feature of this study is matching comparisons between countries ("macro level") and within countries ("micro level") using, when possible, the same or similar methods at both levels. The following questions are specifically addressed:

1. How did mortality distribution change over time?
2. Were the changes at both levels similar?
3. What parameters should be used to depict those changes?
4. What is the "explanatory power" of the mean length of life in the above-mentioned context?
5. How is the mean length of life related to other characteristics of the distribution?

The data comes from the Human Mortality Database (2011) and covers 35 developed countries (for a complete list see Table A1 in Appendix). For each country the life tables including individual information on the age at death are available (more precisely, aggregate information on the age at death is equivalent to individual information, as the variable of interest is discrete). The calculations are performed for the years 1970, 1980, 1990, 2000 and 2010[2]. All the analyses are carried out for women and men separately. Following some other authors (Edwards, 2011, Edwards and Tuljapurkar, 2005, Smits and Monden, 2009) we decided to eliminate differences in infant and childhood mortality, taking 10 years of age as a cutting point. Moreover, it was our intention to make this study comparable with that by Muszyńska et al. (2014), in which inequality is also analysed for people aged 10 or over. Therefore, all the calculations, including the country mean lengths of life also have been performed for such subsets. Starting mortality analysis form 10 years of age seems to be hardly justifiable when demographic poverty, i. e. early deaths, are considered. Nevertheless, such a choice is less critical in comparing distributions of the deaths, which is the case in the present study: all poverty measures are in fact relative, not absolute. To check the impact of the above-mentioned choice on the results, some calculations were supplementary performed for the whole populations.

The remaining part of this paper is organized as follows. Theoretical issues in inequality and poverty measurement as well as the concept of the Kullback-Leibler divergence are discussed in Section 2. Section 3 reports the results of comparisons of the mean lengths of life across the countries in the form of inequality and poverty indices. Section 4 is devoted to comparisons of within-country distributions based on the life tables. In Section 5 the results displayed in the previous two sections are compared. Section 6 concludes.

[2] More precisely, for all countries the most recent data were used, not necessarily of 2010. For some of them the last available year is 2009 (see Table A1 for the details).

2. Theoretical concepts

In a standard inequality and poverty research the units of measurement are constituted by households or persons. The latter choice is applied in the present study in within-country analyses ("micro level") while at the "macro level" the countries are the units. In the first case the individual asset, being a counterpart of well-being, is the age at death. In the latter case, it is the country mean length of life.

2.1. Inequality indices

The Gini index has gained wide recognition due to its clear geometric interpretation based on Lorenz curve. It may be calculated for a variable y (income or length of life) by means of the following equation:

$$G(y) = \frac{n+1}{n-1} - \frac{2}{n(n-1)\overline{Y}} \sum_{i=1}^{n} r_i y_i \qquad (1)$$

where $\overline{Y}$ is the mean value of y, n stands for the population (or sample) size, r_i denotes the rank of *i-th* unit, after ranking the incomes/lengths of life in descending order. Many other inequality indices have been presented further on. In the present study also Theil's (1967) entropy measure and three indices belonging to Atkinson's (see Cowell, 1977) family representing three levels of inequality aversion have been calculated. However, as they yield conclusions that are generally consistent with those derived from the Gini indices, they are not displayed in the empirical part of this paper.

The Gini index and variation/standard deviation, unlike the Atkinson indices, do not assume any inequality aversion. Hence, equal changes in inequality both in upper and low ranges of distribution result in similar changes in the index value. This may be a limitation, but it may be resolved by using supplementary inequality measures in the form of percentile ratios. Those typically applied in income distribution analysis are based on lower and upper deciles (90/10) or quartiles (75/25), although there are no logical restrictions on these selections. The main disadvantage of those measures is poor responsivity to income transfers. If they do not result in changes of the predefined percentiles, a transfer from a "poor" to a "rich" person does not affect them. In other words, the strong version of the Dalton-Pigou axiom (see Fishburn, 1984) is not passed by these ratios[3].

Inequality measures in the form of percentile ratios offer a possibility of focusing on selected ranges of the distribution, although it is the researcher's responsibility to decide on which ones. As it is rather hard to choose particular range(s), it may be useful to generalize by employing some poverty indices based on a variable poverty threshold, as discussed in the next section.

[3] They pass only the weak version of the axiom: a transfer from a "poor" to a "rich" does not decrease the index.

2.2. Poverty lines and poverty indices

In its most basic approach, poverty measurement requires a decision on two concepts: i/ the poverty threshold (usually referred to as the poverty line) separating the poor from the non-poor, ii/ the method of poverty aggregation over the units, in the present study people or countries. The latter concept refers to the poverty indices theory, which provides index formulas displaying various aspects of poverty, e.g. its incidence (how many poor?) or depth (how poor are the poor?). This issue is addressed in more details below.

Income concepts of the poverty line referring its value to basic needs, mainly defined in terms of consumption, is of scarce utility in demographic context. It seems to be more reasonable to set the poverty line in relative terms, referring its level to the actual population parameters. As it is hard to find a rationale for setting the poverty line at any particular level (e.g. 50% of the mean or 60% of the median is frequently done in income poverty research), it may be justified to produce a wide range of age thresholds to observe changes in poverty indices with respect to those levels. Especially, poverty indices might be computed for the whole range of ages observed. In that way, the poverty rates would take values from zero (below the minimum age observed) to one (over the maximum age). The shape of the curve thus obtained may be one of the forms of presentation of the distribution of deaths with a clear and intuitive interpretation. This issue is discussed in more details in Section 3.3, together with the presentation of the empirical results. An answer to the question "how to aggregate individual measures of poverty into poverty indices?" depends on the type of information we are interested in. In the poverty literature, the objects of interest usually include three aspects of poverty: incidence, depth and severity. The respective indices are presented below.

The proportion of poor units (households, persons, groups, countries), referred to as a head count ratio is a measure of poverty incidence and represents the most common poverty indicator. Formally, it is defined as:

$$H = \frac{q}{n} \tag{2}$$

where q is a number of poor units while n stands for the population size. The head count ratio is not responsive to changes in poverty depth: it remains unchanged if the poor become more poor. Moreover, if some poor improve their positions, however without reaching the poverty line, it also would not affect the head count ratio. When the head count ratio is calculated using country life tables to describe within-country distributions, it may be rewritten using customary demographic symbols:

$$H = \frac{\sum_{X=\omega_{\min}}^{\omega_z} d_X}{\sum_{X=\omega_{\min}}^{\omega_{\max}} d_X}$$

where ω_z denotes an age set as the poverty line.

In the next types of indices the question addressed is: how poor are the poor or what is the poverty severity? The Dalton index, measuring poverty depth, is defined as a relative difference between the poverty line (z) and the mean value (income or age) obtained for the poor $\bar{Y}_P$ [4]:

$$D = \frac{z - \bar{Y}_P}{z} \tag{3}$$

It is worth mentioning that leaving the poverty zone by some poor households may increase poverty depth measured by D. Consequently, this index may decrease with respect to the increase in the poverty line. This is the case for the present data, as displayed by Figures 2a and 2b.

Indices intended to measure poverty severity take into consideration not only poverty incidence and depth but also inequality among the poor. Out of several indices of this type the Sen formula has gained wide recognition due to passing a set of axioms expected to be held by poverty measures (Sen, 1976). Moreover, due to its definition it is possible to find which components, a head count ratio (H), the Dalton (D) or Gini index, are responsible for changes in poverty severity. The Sen index is defined as follows:

$$S = H[D + (1 - D) \cdot G_P] \tag{4}$$

where G_P stands for the Gini inequality index calculated for the poor.

2.3. From comparing parameters to comparing distribution functions: Kullback-Leibler divergence

All the methods described above allow comparisons of single parameters characterizing the distributions. Hence, the resulting differences in mortality distributions depend on the choice of those parameters. Using a set of parameters allows relaxing this impact, although at the cost of clarity of the final results. The scalar measure presented in this section, the Kullback-Leibler divergence (Kullback and Leibler, 1951), is intended to compare the whole ranges of distributions. Informally speaking, it measures the average distance between two probability functions. Mathematically, for two discrete distributions defined over domains from 1 to m, with probability functions P and Q, the Kullback-Leibler divergence (hereafter: KLD) is defined as follows:

$$KLD = \sum_{i=\min}^{\max} \ln\left(\frac{P_i}{Q_i}\right) P_i \tag{5}$$

[4] When income or consumption are variables of interest, a system of weights, reflecting different household sizes, should be applied in calculations. This is not applicable in demographic studies, unless one decides to take into account sub-group (e. g. countries) sizes. This makes the Dalton index equivalent to a popular poverty gap measure.

i.e. as an expected value of a logarithmic difference between probabilities, using probabilities of distribution P (in the present case: min=10 and max=110). KLD is nonnegative and equals zero if and only if the two distributions are identical. The higher the KLD, the larger divergence between the distributions. When comparing more than two distributions (the present case), one can use an average probability function, as it was done by d'Albis et al. (2014), and then calculate the mean value of all KLD with the average distribution as a point of reference.

3. Empirical results: comparisons of mean lengths of life across countries

Using the mean lengths of life for people aged 10 and over in 35 developed countries (see Introduction), the set of inequality and poverty indices presented in the previous section has been calculated for five selected years between 1970 and 2010.

3.1. Indices of mortality inequality

The trend in inequality may be generally said to be increasing over the period investigated, although for females a minor drop between 2000 and 2010 occurred for most of the indices. There is one important exception from that rule, however. The ratio of the ninth and the fifth decile is relatively stable and 2010 levels are even slightly below those of 1970. This means that the prevailing portion of the increase in inequality has occurred due to the increase in inequality below the median length of life. In other words, in some countries the mean length of life was increasing slower than the average pace or even decreased, in spite of the general increases. The results reported in Section 4.3, especially in Tables 6a and 6b, confirm this hypothesis. Moreover, one can indicate the group of post-communist, especially ex-Soviet countries as the main source of that divergence. The inequality for all years has been much higher for males than for females. Also, the increases were stronger for males.

Table 1a. Inequality in mean length of life: females, age 10+.

Inequality measure	1970	1980	1990	2000	2010
Standard deviation	1.341	1.968	2.341	2.862	2.800
Coefficient of variation	0.018	0.026	0.030	0.036	0.035
Gini index·100	0.973	1.422	1.667	1.974	1.843
Q_{75}/Q_{25}	1.023	1.049	1.058	1.055	1.055
Q_{90}/Q_{10}	1.042	1.061	1.073	1.100	1.089
Q_{90}/Q_{50}	1.027	1.031	1.024	1.024	1.023
Q_{50}/Q_{10}	1.014	1.029	1.048	1.074	1.064
Mean length of life	75.58	76.84	78.12	79.52	81.48

Table 1b. Inequality in mean length of life: males, age 10+.

Inequality measure	1970	1980	1990	2000	2010
Standard deviation	2.239	2.970	3.508	4.916	5.546
Coefficient of variation	0.032	0.043	0.049	0.068	0.074
Gini index·100	1.683	2.326	2.730	3.592	3.788
Q_{75}/Q_{25}	1.042	1.060	1.097	1.098	1.115
Q_{90}/Q_{10}	1.070	1.114	1.136	1.188	1.228
Q_{90}/Q_{50}	1.039	1.040	1.029	1.038	1.031
Q_{50}/Q_{10}	1.030	1.0718	1.104	1.145	1.192
Mean length of life	69.24	69.74	70.91	72.44	74.74

3.2. Indices of length of life poverty

The poverty lines are set at the median and first quartile in the length of life distributions obtained for all countries. All indices are calculated twice: i/ using the current information on the country mean length of life for each year and ii/ as an appropriate percentile in 1970 distribution (the poverty lines are then fixed over the whole period observed). Consequently, in the first case all the head count ratios are close to 0.5 (not 0.5 exactly, as the number of countries is odd) or to 0.25. In the second case these values are reached for 1970 only. Using the above-mentioned percentiles as the poverty lines is an arbitrary choice, although the problem of the poverty line selection may be resolved by making the poverty line variable, as presented further on.

Another goal of this part of the study is to compare the head count ratios that are fixed over time, with changes of the remaining indices. The Dalton index values demonstrate that the poor, in terms of mortality, countries have become poorer over the period observed, i.e. the distance between their mean length of life and the percentiles selected as the poverty lines has increased. This is also true, though with some exceptions, for the results based on the first quartile. Both single year values and increases of the Dalton index were higher for males than for females and higher when median poverty line was used. Given stable, by the definition, head count ratios and increases in the Dalton and Gini indices, the Sen indices, being measures of poverty severity (or comprehensive poverty), also displayed an increasing trend. Nevertheless, in 1990 for males and the poverty line set at the first quartile, a massive drop in the Sen index occurred due to the drops in poverty depth and inequality among the poor countries. On the other hand, 2010 value was much above 1970 level, due to strong increases occurring in the remaining years. For females, in 2010 all of them (naturally, except for the head count ratios) dropped as compared to 2000 levels, while the changes for males were in opposite direction.

The head count ratios based on the fixed (at 1970 levels) poverty lines demonstrate serious decreases in poverty incidence. In other words, the number of countries that do not pass “1970 standards” decreased. On the other hand, for

males approximately one sixth of the countries (i.e. six of them) did not reach 1970 median value in 2010. For females such a proportion was three times lower. Moreover, for males the drops observed under the lower poverty line were less important than those observed for the higher one: in 2010 14.3% of the countries were below 1970 quartile. Relative comparisons between two poverty lines are not conclusive for females, as in 2010 all countries were placed at or above 1970 quartile.

Including mortality below 10 years of age slightly changes the absolute values of poverty (and inequality) indices, with no regularities observed. Nevertheless, the basic conclusions on trends remain unchanged.

Table 2a. Length of life poverty (in %), poverty line at median and first quartile of current distribution: females, age 10+.

Indicator	1970	1980	1990	2000	2010
Median	75.34	76,79	78.89	81.78	82.52
Head count ratio	48.571	48.571	48.571	48.571	48.571
Dalton	1.089	2.104	3.582	4.194	3.900
Sen	0.812	1.421	2.236	2.837	2.732
$Gini_{poor} \cdot 100$	0.590	0.840	1.059	1.718	1.795
First quartile	74.91	75.17	75.88	77.55	79.01
Head count ratio	22.857	22.857	22.857	22.857	22.857
Dalton	1.374	1.110	1.191	3.047	2.302
Sen	0.457	0.432	0.438	0.913	0.787
$Gini_{poor} \cdot 100$	0.635	0.788	0.732	0.976	1.169

Table 2b. Length of life poverty (in %), poverty line at median and first quartile of current distribution: males, age 10+.

Indicator	1970	1980	1990	2000	2010
Median	69.12	70.27	72.38	74.39	77.13
Head count ratio	48.571	48.571	48.571	48.571	48.571
Dalton	2.227	4.107	6.164	7.781	8.495
Sen	1.715	2.956	3.983	5.475	6.065
$Gini_{poor} \cdot 100$	1.334	2.064	2.170	3.786	4.361
First quartile	68.07	67.58	67.19	69.15	70.85
Head count ratio	22.857	22.857	22.857	22.857	22.857
Dalton	2.507	3.325	2.023	6.496	6.641
Sen	0.958	1.108	0.665	1.973	2.290
$Gini_{poor} \cdot 100$	1.729	1.577	0.905	2.284	3.618

Table 3a. Length of life poverty (in %), poverty line at median and first quartile of 1970 distribution: females, age 10+.

Indicator	1970	1980	1990	2000	2010
1970 median			75.34		
Head count ratio	48.571	25.714	11.429	11.429	5.714
Dalton	1.089	1.211	1.337	1.544	0.338
Sen	0.812	0.499	0.271	0.256	0.025
$Gini_{poor} \cdot 100$	0.590	0.737	1.052	0.702	0.995
1970 first quartile			74.91		
Head count ratio	22.857	14.286	5.714	8.571	0.000
Dalton	1.374	1.374	1.976	1.366	0.000
Sen	0.457	0.337	0.194	0.171	0.000
$Gini_{poor} \cdot 100$	0.635	0.995	1.440	0.634	-

Table 3b. Length of life poverty (in %), poverty line at median and first quartile of 1970 distribution: males, age 10+.

Indicator	1970	1980	1990	2000	2010
1970 median			69.12		
Head count ratio	48.571	31.429	31.429	22.857	17.143
Dalton	2.227	4.470	4.059	6.444	6.396
Sen	1.715	1.900	1.597	1.961	1.623
$Gini_{poor} \cdot 100$	1.334	1.648	1.064	2.284	3.279
1970 first quartile			68.07		
Head count ratio	22.857	28.571	28.571	22.857	14.286
Dalton	2.507	3.314	2.849	5.006	6.138
Sen	0.958	1.396	1.083	1.640	1.291
$Gini_{poor} \cdot 100$	1.729	1.624	0.970	2.284	3.092

3.3. Poverty incidence and depth as a function of the poverty line

The results displayed in the previous section depend on an arbitrary selection of the poverty line. Given a lack of ground for setting this threshold at any particular level(s), it seems to be justified to calculate indices for the whole range of variability, obtaining in this way a type of distribution function. For clarity of the plots only the datasets for the years 1970, 1990 and 2010 were applied. Changes in the head count ratios and the Dalton indices measuring poverty depth

are displayed by means of Figures 1a - 1b, and 2a - 2b, respectively. The range of the poverty line is set from the lowest to the highest values observed in the whole dataset (the head count ratios equal zero or one, respectively, at these values).

The most obvious observation is on growing ranges of distribution in the succeeding years, as may be deducted from Figures 1a and 1b. This coincides with inequality growths reported in the previous section. For females, this happened solely due to the increases in the maximum age but for males also due to the drops in the minimum value in 2010, as compared to both previous years. Another conclusion is on definitely non-linear growth of the poverty incidence with respect to the poverty line. At the bottom ranges of the distributions, the head count ratios were relatively stable or were growing at moderate pace and then experienced sharp growths, reaching the maximum value, i.e. one. This indicates the existence of the relatively homogenous groups of countries with low life expectancy. For females, for all years such sharp growths may be observed starting from 74 to 75 years of age, but for males the turning points were absolutely different, growing considerably during each 20 year period. Widening ranges of sharp growth may be interpreted as growing polarization of the mean lengths of life, which is reinforced for males by the previously mentioned occurrence. For the Dalton indices no regularities can be observed. Unlike the head count ratios, this index for all years and for both sexes suffered some drops due to the poverty line growth, though the general trend was increasing. As the Sen index depends also on inequality, which is not related directly to the poverty line, the resulting changes would not be informative.

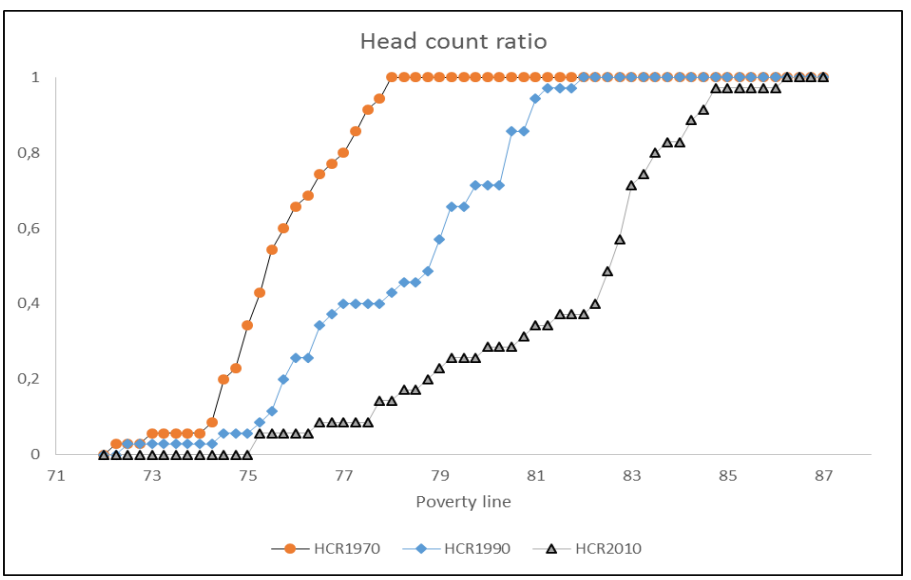

Figure 1a. Length of life poverty incidence depending on poverty line for 1970, 1990 and 2010: females, age 10+.

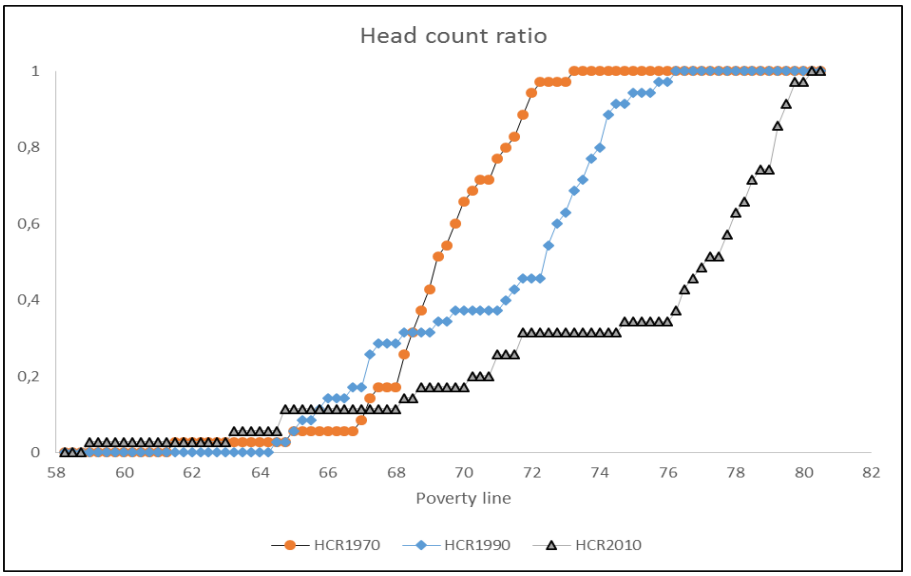

Figure 1b. Length of life poverty incidence depending on poverty line for 1970, 1990 and 2010: males, age 10+.

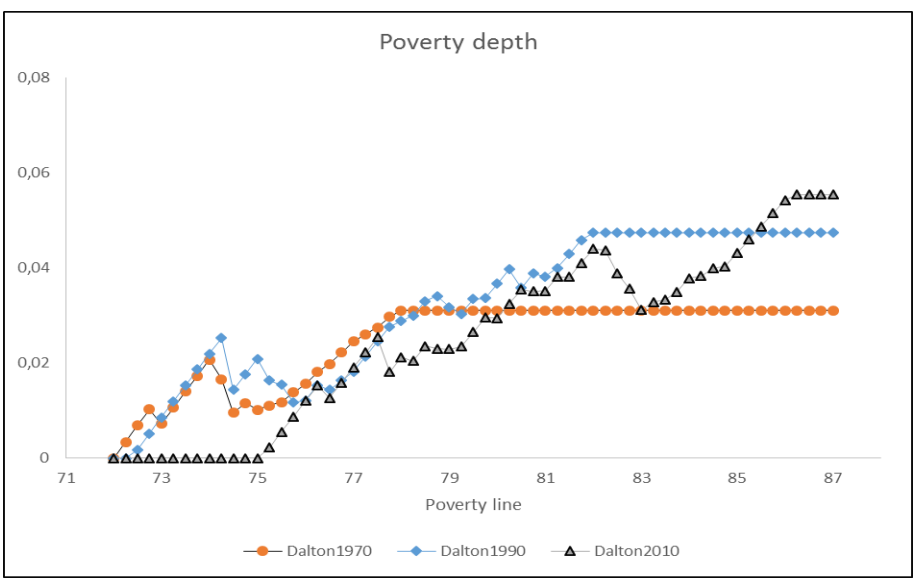

Figure 2a. Length of life poverty depth (Dalton index) for 1970, 1990 and 2010: females, age 10+.

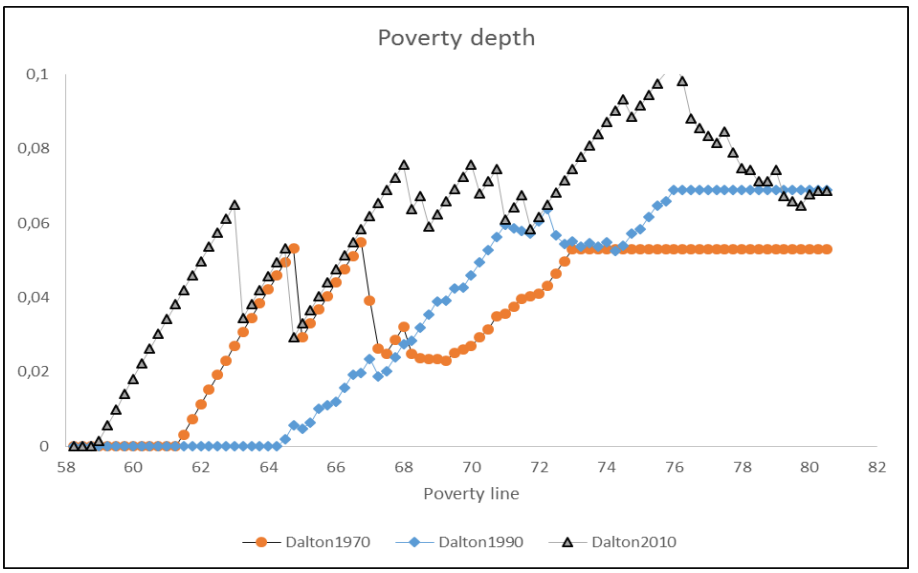

Figure 2b. Length of life poverty depth (Dalton index) for 1970, 1990 and 2010: males, age 10+.

4. Empirical results: comparing distributions within the countries

4.1. Kullback-Leibler divergence

In this section probability functions representing mortality distributions within-country are compared in their whole ranges, using country life tables. Consequently, the results are not sensitive to the choice of a single parameter supposed to represent the distribution (in other parts of this study: the mean length of life or poverty/inequality index). First, the mean probability function for the whole population is constructed and then for each country the Kullback-Leibler divergence (KLD) is calculated. The average indicator is a measure of "overall divergence" across the countries under comparison. Tables 4a and 4b display the mean KLDs for the years 1970, 1980, 1990, 2000 and 2010 (bottom row). Moreover, for each year a list of five countries with highest values (i.e. highest distance from the mean distribution) is included. Divergence in distributions does not necessary result in divergence in the mean values, although makes them very likely.

The trends in the mean KLD values are generally consistent with the trends in the country mean values, reported in the previous sections: the average distance between countries has been growing over the whole period observed. This is true for both sexes and, again, the intensity of this process appeared to be much higher for males. The countries with largest distances from the mean distribution include those with the low and high mean length of life. For instance, in 1970 for males

two high mortality countries (Czech Republic and Russia) and three low mortality ones (Luxembourg, Iceland and Sweden) are present. For two succeeding years only one low mortality country (Iceland) is ranked among those most distant from the mean distribution, while for 2000 and 2010 all countries in Top 5 are high mortality countries. Similar process may be found for females, although in 2000 and 2010 one low mortality country (Japan) was ranked on the top. Generally, for most of the years and for both sexes high mortality countries are more distant from the mean distribution than the low mortality ones.

Table 4a. Kullback-Leibler divergence for five countries with highest distance to mean distribution: females, age 10+.

KLD rank	1970		1980		1990		2000		2010	
	Country	KLD	Country	KLD	Country	KLD	Country	KLD	Country	KLD
1	DEN	0.0451	DEN	0.0965	DEN	0.1228	RUS	0.1483	UKR	0.1720
2	BLR	0.0359	CZE	0.0597	BUL	0.0600	UKR	0.1364	RUS	0.1499
3	ICE	0.0331	ICE	0.0516	JAP	0.0555	BUL	0.1173	BUL	0.1295
4	CAN	0.0272	HUN	0.0459	CZE	0.0542	DEN	0.1067	BLR	0.1187
5	CZE	0.0262	EGE	0.0386	HUN	0.0539	JAP	0.1038	JAP	0.1060
Mean-all countries	-	0.0136	-	0.0221	-	0.0278	-	0.0378	-	0.0380

Table 4b. Kullback-Leibler divergence for five countries with highest distance to mean distribution: males, age 10+.

KLD rank	1970		1980		1990		2000		2010	
	Country	KLD	Country	KLD	Country	KLD	Country	KLD	Country	KLD
1	RUS	0.0444	RUS	0.0954	RUS	0.0854	RUS	0.3423	RUS	0.3224
2	SWE	0.0353	ICE	0.0572	LAT	0.0847	UKR	0.2325	BLR	0.3077
3	ICE	0.0330	LAT	0.0530	HUN	0.0785	BLR	0.1973	UKR	0.2770
4	CZE	0.0296	CZE	0.0477	EST	0.0734	LAT	0.1296	LAT	0.1208
5	LUX	0.0282	EST	0.0465	ICE	0.0729	EST	0.1191	LIT	0.1191
Mean-all countries	-	0.0145	-	0.0231	-	0.0337	-	0.0607	-	0.0673

Note: EGE denotes Eastern Germany; for a full list of countries and abbreviations see Appendix.

4.2. Indices of within-country poverty and inequality

In this section, the within-country mortality distributions are compared by means of poverty and inequality indices. They are intended to indicate other than the mean length of life parameters responsible for growing differences between

mortality distribution functions reported in the previous section. The indices are calculated using within-country information on individual age at death while the poverty lines are based on the "international" median length of life in a given year. Hence, the resulting indices depend on both mean values and shapes of distribution.

The head count ratio is a non-decreasing function of the poverty line and, therefore, is indirectly related to the mean length of life. This is not necessarily true for the Dalton index measuring poverty depth (see Figures 2a and 2b) and, consequently, for the Sen index neither. The head count ratio depends also on the shape of distribution over the whole range while the Dalton index is influenced by distribution below the poverty line only. The Sen index, as a combination of these two measures, as well as the Gini index among the "poor", takes into account the largest set of the distribution attributes.

In Tables 5a – 5b the average values of the three above-mentioned poverty indices are shown. They are supplemented by four inequality indices, namely the Gini index and three decile ratios $9^{th}/1^{st}$, $9^{th}/5^{th}$ and $5^{th}/1^{st}$. Unlike in the between-country mean length of life comparisons (see Tables 1a and 1b) all measures indicate decreasing trend in inequality. The largest relative drops may be observed for the Gini indices and the smallest for 9^{th} and 5^{th} decile ratios, which suggests that inequality decline affected mainly middle and lower ranges of the distributions. In other words, the greatest progress was made in early mortality reduction, at least for those aged 10 years and over.

Table 5a. Average within-country length of life poverty (in %) and inequality: females, age 10+.

Index	1970	1980	1990	2000	2010
Poverty line at the international median					
Head count ratio	48.086	46.967	49.383	47.455	47.250
Dalton	16.248	15.976	15.654	15.344	14.715
Sen	11.541	11.096	11.437	10.863	10.418
Poverty line at the international first quartile					
Head count ratio	24.890	24.432	0.24034	24.747	24.104
Dalton	18.035	17.625	17.265	16.976	16.499
Sen	6.652	6.368	6.135	6.240	5.914
Gini·100	9.351	9.097	8.858	8.561	8.134
Q91	1.531	1.517	1.498	1.483	1.453
Q95	1.148	1.142	1.137	1.130	1.122
Q51	1.333	1.328	1.316	1.311	1.295

Table 5b. Average within-country length of life poverty (in %) and inequality: males, age 10+.

Index	1970	1980	1990	2000	2010
Poverty line at the international median					
Head count ratio	48.456	49.357	48.702	49.203	47.270
Dalton	19.737	19.780	19.601	19.327	18.452
Sen	14.058	14.375	14.100	14.232	13.065
Poverty line at the international first quartile					
Head count ratio	23.831	23.501	23.453	24.451	23.622
Dalton	22.025	21.750	21.544	21.193	19.634
Sen	7.768	7.571	7.461	7.679	6.903
Gini·100	11.659	11.567	11.368	11.018	10.313
Q91	1.729	1.728	1.701	1.683	1.628
Q95	1.192	1.187	1.185	1.177	1.166
Q51	1.451	1.453	1.434	1.425	1.392

Decreasing average mortality inequality does not necessarily result in decreases in average poverty as the latter depend also on the mean length of life. Nevertheless, declines in within-country inequality were strong enough to compensate divergence in average life spans between the countries. As might be expected, the highest reduction has been observed for poverty depth (as a result of reduction of early mortality), the lowest for poverty incidence (as a result of increase in "international" poverty line). The latter peaked in 1990 (females) or in 1980 (males), although 2010 values were slightly below the initial ones. Similar trends are revealed when the first quartile (and also the third one, although these results are not produced here) is applied as the poverty line. The only important differences are in the positions of the peaks and in the magnitude of drops in the head count ratio that have been smaller for the first (and third) quartile. Considering the results reported in this section, together with the results of between-country comparisons, one can conclude that the mean length of life is the only parameter of distribution for which growing divergence between the countries may be observed. In Section 4.4 some relations between this parameter and other distribution attributes are investigated.

Table 6a. Mean length of life and length of life poverty rankings in 1970 and 2010: females, age 10+.

Country	Ranking for:											
	Mean			Head count ratio			Dalton index			Sen index		
	1970	2010	Difference	1970	2010	Difference	1970	2010	Difference	1970	2010	Difference
AUS	19	6	**13**	20	5	**15**	25	15	**10**	25	7	**18**
AUT	27	10	**17**	26	11	**15**	16	8	**8**	20	9	**11**
BEL	18	21	**-3**	19	19	**0**	17	22	**-5**	17	20	**-3**
BLR	5	33	**-28**	8	33	**-25**	31	33	**-2**	11	33	**-22**
BUL	22	31	**-9**	28	32	**-4**	5	24	**-19**	19	31	**-12**
CAN	4	9	**-5**	4	10	**-6**	29	23	**6**	8	17	**-9**
CZE	33	25	**8**	33	25	**8**	8	9	**-1**	30	23	**7**
DEN	35	32	**3**	35	31	**4**	34	29	**5**	35	32	**3**
EGE	30	17	**13**	30	17	**13**	12	7	**5**	26	14	**12**
ENG	12	14	**-2**	13	16	**-3**	19	17	**2**	10	18	**-8**
EST	16	24	**-8**	15	24	**-9**	21	27	**-6**	14	24	**-10**
FIN	23	12	**11**	25	9	**16**	3	20	**-17**	13	15	**-2**
FRA	8	2	**6**	6	2	**4**	24	26	**-2**	9	5	**4**
HUN	32	30	**2**	32	30	**2**	13	28	**-15**	29	30	**-1**
ICE	2	7	**-5**	1	8	**-7**	2	1	**1**	2	6	**-4**
IRE	29	22	**7**	31	22	**9**	23	11	**12**	31	22	**9**
ITA	10	5	**5**	10	6	**4**	10	3	**7**	7	4	**3**
JAP	17	1	**16**	17	1	**16**	18	21	**-3**	16	1	**15**
LAT	21	29	**-8**	18	28	**-10**	28	31	**-3**	27	29	**-2**
LIT	11	27	**-16**	11	27	**-16**	26	32	**-6**	15	28	**-13**
LUX	31	16	**15**	24	15	**9**	32	12	**20**	33	13	**20**
NED	6	18	**-12**	5	18	**-13**	6	16	**-10**	5	19	**-14**
NOR	1	13	**-12**	3	14	**-11**	1	10	**-9**	1	12	**-11**
NZL	13	11	**2**	14	12	**2**	22	14	**8**	12	10	**2**
POL	20	26	**-6**	21	26	**-5**	14	25	**-11**	18	26	**-8**
POR	25	20	**5**	27	20	**7**	15	6	**9**	23	16	**7**
RUS	26	35	**-9**	22	34	**-12**	30	35	**-5**	32	35	**-3**
SPA	9	4	**5**	9	4	**5**	9	2	**7**	6	3	**3**
SUI	7	3	**4**	7	3	**4**	4	5	**-1**	4	2	**2**
SVK	28	28	**0**	29	29	**0**	11	19	**-8**	24	27	**-3**
SWE	3	8	**-5**	2	7	**-5**	7	4	**3**	3	8	**-5**
TAI	34	19	**15**	34	21	**13**	33	18	**15**	34	21	**13**
UKR	15	34	**-19**	16	35	**-19**	27	34	**-7**	22	34	**-12**
USA	14	23	**-9**	12	23	**-11**	35	30	**5**	28	25	**3**
WGE	24	15	**9**	23	13	**10**	20	13	**7**	21	11	**10**

Table 6b. Mean length of life and length of life poverty rankings in 1970 and 2010: males, age 10+.

Country	Ranking for:											
	Mean			Head count ratio			Dalton index			Sen index		
	1970	2010	Difference	1970	2010	Difference	1970	2010	Difference	1970	2010	Difference
AUS	23	2	**21**	25	3	**22**	16	15	**1**	20	6	**14**
AUT	26	16	**10**	28	16	**12**	19	17	**2**	23	16	**7**
BEL	18	19	**-1**	22	19	**3**	8	18	**-10**	16	19	**-3**
BLR	16	34	**-18**	12	34	**-22**	32	33	**-1**	26	33	**-7**
BUL	7	29	**-22**	7	29	**-22**	9	26	**-17**	6	28	**-22**
CAN	10	9	**1**	11	9	**2**	20	14	**6**	13	11	**2**
CZE	31	25	**6**	33	25	**8**	17	20	**-3**	28	25	**3**
DEN	2	17	**-15**	5	18	**-13**	4	6	**-2**	2	15	**-13**
EGE	17	20	**-3**	18	20	**-2**	5	19	**-14**	14	20	**-6**
ENG	12	8	**4**	17	8	**9**	1	9	**-8**	8	9	**-1**
EST	34	28	**6**	32	27	**5**	31	30	**1**	33	29	**4**
FIN	33	23	**10**	34	23	**11**	25	22	**3**	30	22	**8**
FRA	15	14	**1**	13	13	**0**	24	23	**1**	17	17	**0**
HUN	22	30	**-8**	21	30	**-9**	18	29	**-11**	19	30	**-11**
ICE	5	4	**1**	3	2	**1**	28	5	**23**	11	3	**8**
IRE	13	18	**-5**	16	17	**-1**	3	16	**-13**	12	18	**-6**
ITA	9	6	**3**	9	7	**2**	13	3	**10**	9	4	**5**
JAP	11	5	**6**	10	6	**4**	10	13	**-3**	10	7	**3**
LAT	32	31	**1**	29	32	**-3**	33	31	**2**	34	31	**3**
LIT	27	32	**-5**	20	31	**-11**	34	32	**2**	32	32	**0**
LUX	28	15	**13**	30	14	**16**	23	10	**13**	25	14	**11**
NED	4	11	**-7**	6	11	**-5**	2	1	**1**	3	5	**-2**
NOR	3	10	**-7**	2	10	**-8**	7	7	**0**	4	10	**-6**
NZL	14	7	**7**	15	5	**10**	12	11	**1**	15	8	**7**
POL	20	26	**-6**	19	26	**-7**	21	28	**-7**	21	27	**-6**
POR	19	22	**-3**	14	21	**-7**	26	21	**5**	22	21	**1**
RUS	35	35	**0**	35	35	**0**	35	35	**0**	35	35	**0**
SPA	6	12	**-6**	4	12	**-8**	14	12	**2**	5	13	**-8**
SUI	8	1	**7**	8	1	**7**	11	4	**7**	7	1	**6**
SVK	24	27	**-3**	24	28	**-4**	27	24	**3**	24	26	**-2**
SWE	1	3	**-2**	1	4	**-3**	6	2	**4**	1	2	**-1**
TAI	30	24	**6**	31	24	**7**	22	25	**-3**	27	24	**3**
UKR	29	33	**-4**	26	33	**-7**	30	34	**-4**	31	34	**-3**
USA	25	21	**4**	27	22	**5**	29	27	**2**	29	23	**6**
WGE	21	13	**8**	23	15	**8**	15	8	**7**	18	12	**6**

4.3. Poverty rankings: changes between 1970 and 2010

While the results reported in the previous sections focus on the overall size of changes in mortality distributions, in this part of the analysis the alterations in relative mortality are observed for every country separately. More precisely, the changes in the country rankings for the mean length of life and poverty indices based on country data life tables are reported. The poverty lines are set at median values in the actual aggregate (i.e. capturing all countries) distributions. In Tables 6a and 6b for every country rankings (in ascending order for the poverty indices and in descending order for the mean; 1 means "best value") the initial and the last year of observation are compared. A positive difference between the rankings indicates a relative improvement in the ranking, i.e. a decrease in mortality, as compared to the remaining countries.

The comparison of 1970 and 2010 rankings reveals huge alterations in terms of all measures. For all indicators and for both sexes most of the post-communist countries' relative positions worsened seriously. To the highest extent this can be said for some ex-Soviet countries: Russia, Belarus and Ukraine as well as Bulgaria, to the least for the Czech Republic and Slovakia. The Czech Republic's rankings improved in terms of most of measures. Among the richest countries the highest relative deterioration in rankings occurred for Norway and the Netherlands. The main winners are three non-European countries: Australia, Japan and Taiwan, as well as Luxembourg and Austria, and, to less extent, Western Germany. In Eastern Germany, serious ranking improvement occurred for females only. It is interesting that for many countries the Dalton index measuring poverty depth yields rankings quite different from those constructed with the use of the means or the poverty incidence. It may be supposed that this results from different changes in mortality in various age groups. This influenced also changes in the Sen indices. Changes in the mean values and poverty incidence were in most of the cases close to each other. Including mortality below 10 years of age does not alter rankings by the head count ratios and slightly changes those by the mean length of life. More important changes may be observed in rankings by the Dalton and Sen indices, nevertheless even in that case they are moderate.

Additionally, the intensity of the ranking changes during each decade included into the study is measured. For each two succeeding decades Spearman correlation coefficients are calculated (the higher the value, the closer the ranking). It may be observed from the results reported in Tables 7a - 7b that the most important ranking alterations have occurred between 1970 and 1980. All respective correlations were below 0.9 or even 0.8. The results observed after 1990 for men and after 2000 for women indicate much higher stability of the rankings than during the previous periods. It may be also observed that the Dalton and Sen indices appeared to be much more stable over the whole period observed, however with some exceptions occurring during selected decades. Moreover, the rankings for women were less stable than those for men.

Table 7a. Spearman correlations for length of life rankings (mean value and poverty) from 1970 to 2010: females, age 10+.

Measure	1970-1980	1980-1990	1990-2000	2000-2010	1970-2010
Mean	0.7924	0.9230	0.9291	0.9759	0.4431
Head count ratio	0.7992	0.9258	0.9227	0.9678	0.4524
Dalton	0.8599	0.8725	0.7884	0.9347	0.5996
Sen	0.7686	0.9244	0.9392	0.9759	0.5286

Table 7b. Spearman correlations for length of life rankings (mean value and poverty) from 1970 to 2010: males, age 10+.

Measure	1970-1980	1980-1990	1990-2000	2000-2010	1970-2010
Mean	0.7955	0.9608	0.9762	0.9818	0.6462
Head count ratio	0.7515	0.9513	0.9627	0.9711	0.5555
Dalton	0.8826	0.9269	0.9538	0.9006	0.7104
Sen	0.8821	0.9527	0.9499	0.9798	0.7490

4.4. Poverty and inequality versus mean length of life

Referring to the findings presented in Section 3.1, indicating a positive correlation between the mean length of life and inequality at the aggregate levels, one can rise a similar question at the level of single countries. In the present study this question is addressed by means of simple graphical methods as well as using estimates of linear equations taking the general form:

$$I_i = \alpha_1 e_i + \alpha_0 + \varepsilon_i \tag{6}$$

where I_i is a poverty or inequality index for i-th country, e_i stands for a mean length of life while ε_i represents a stochastic disturbance. As may be observed in Figures 3a – 3d, all three measures employed: the Gini inequality index as well as poverty incidence and depth measures[5] are negatively correlated with the mean length of life. This is true for both sexes and for both years observed (1970 and

[5] For the sake of the clarity of the plots, Sen index, which takes values similar to the Gini index, is not included.

2010). It is also evident that the head count ratio is much more sensitive to changes in the mean length of life than two remaining indicators. This finding might be definitely expected, as rising the mean value (i.e. the independent variable in eqn 6) is equivalent to lowering the poverty line. It should be noted, however, that within-country mortality distribution also affects the poverty incidence. As a result, within some small groups of countries, a higher mean may be matched with higher poverty rate. In other words, contrary to the results obtained for the aggregate measures (see Figures 1a - 1b), the relation between poverty rate and the mean length of life is not monotonic. A negative correlation with the mean length of life may be also observed for the Gini and Dalton indices, although the elasticities are much lower than in the case of the previous indicator.

Table 8a. Spearman correlations for length of life poverty and mean length of life rankings from 1970 to 2010: females, age 10+.

Poverty index	1970	1980	1990	2000	2010
Head count ratio	-0.9782	-0.9824	-0.9891	-0.9947	-0.9944
Dalton	-0.2647	-0.4913	-0.6797	-0.6440	-0.6901
Sen	-0.9028	-0.9661	-0.9804	-0.9933	-0.9759

Table 8b. Spearman correlations for length of life poverty and mean length of life rankings from 1970 to 2010: males, age 10+.

Poverty index	1970	1980	1990	2000	2010
Head count ratio	-0.9692	-0.9840	-0.9829	-0.9919	-0.9964
Dalton	-0.6902	-0.7412	-0.8126	-0.8059	-0.8933
Sen	-0.9555	-0.9706	-0.9762	-0.9840	-0.9866

Supplementary Spearman correlation coefficients between rankings produced for the mean length of life and three poverty indices are calculated. They are displayed in Tables 8a – 8b. As might be expected, all correlations are strongly negative, with the lowest absolute value observed for the Dalton index. In that case large disparities between sexes appeared – absolute values for males were much higher than for females. This finding is consistent with the results of regressions of the Dalton index on the mean length of life reported in Tables 10a and 10b.

Finally, for inequality and poverty indices simple regressions generally defined by (6) were run. The estimates are reported in Tables 9a – 12b. They confirm much higher, negative elasticity of the head count ratios than those obtained for remaining indices. Moreover, their absolute values for males appeared to be much lower than for females, although this observation is not confirmed in the case of other indices. R-squared, being a type of measure of linear correlation between the dependent and independent variables, is the only parameter for which a clear increasing trend occurred between 1970 and 2010. This may be interpreted as increasing importance of the mean length of life in determining within-country mortality inequality and poverty.

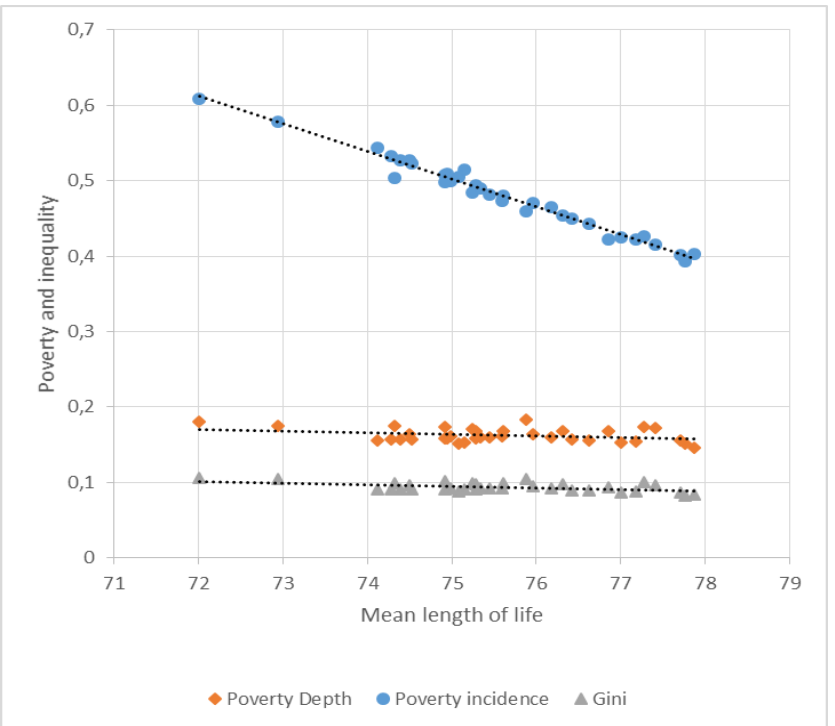

Figure 3a. Length of life poverty and inequality versus mean length of life in 1970: females, age 10+.

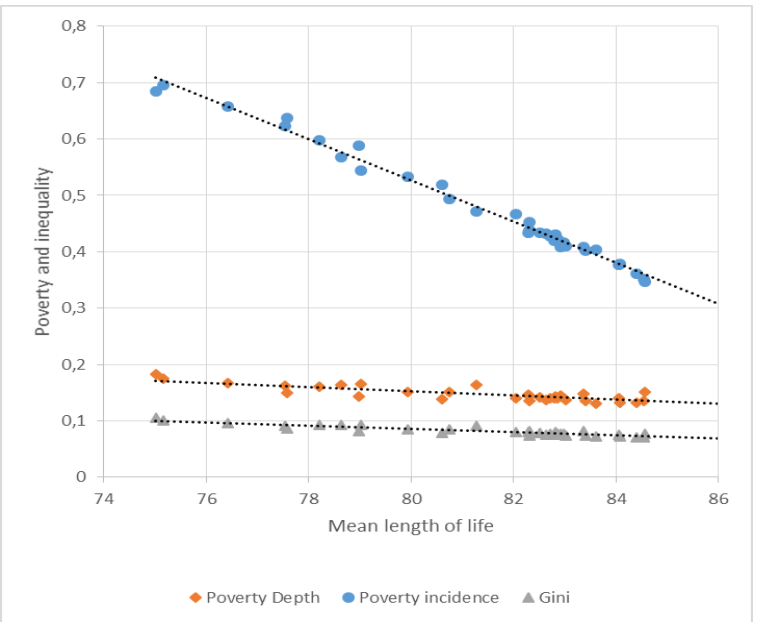

Figure 3b. Length of life poverty and inequality versus mean length of life in 2010: females, age 10+.

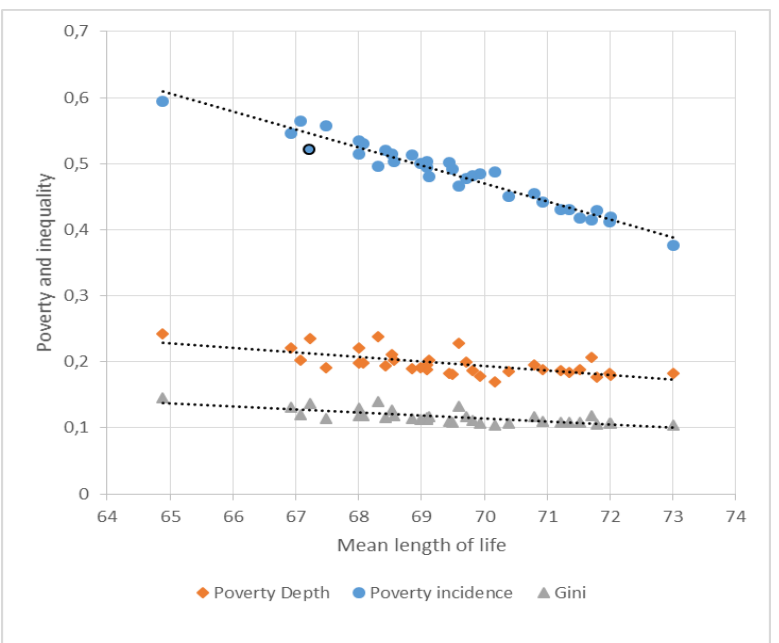

Figure 3c. Length of life poverty and inequality versus mean length of life in 1970: males, age 10+.

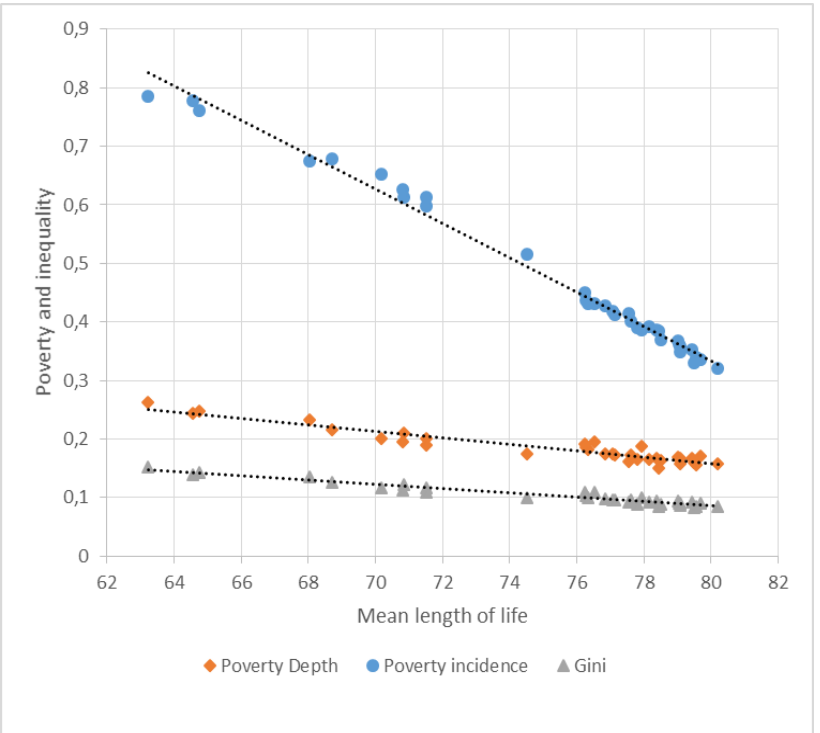

Figure 3d. Length of life poverty and inequality versus mean length of life in 2010: males, age 10+.

Table 9a. Linear regression of length of life poverty incidence on mean length of life: females, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.03677	-0.03549	-0.03692	-0.03600	-0.03650
Intercept	3.26002	3.19668	3.37783	3.33781	3.44603
R-squared	0.97919	0.97910	0.98866	0.98917	0.98983

Table 9b. Linear regression of length of life poverty incidence on mean length of life: males, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.02729	-0.02658	-0.02887	-0.02789	-0.02928
Intercept	2.38019	2.35323	2.54120	2.52031	2.67654
R-squared	0.94597	0.96957	0.98789	0.98558	0.98992

Table 10a. Linear regression of poverty depth (Dalton index) on mean length of life: females, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.00233	-0.00272	-0.00298	-0.00350	-0.00376
Intercept	0.33864	0.36843	0.38911	0.43159	0.45371
R-squared	0.12327	0.29678	0.53951	0.66694	0.68125

Table 10b. Linear regression of poverty depth (Dalton index) on mean length of life: males, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.00679	-0.00733	-0.00586	-0.00598	-0.00549
Intercept	0.66931	0.71104	0.61271	0.62818	0.59755
R-squared	0.43252	0.70653	0.75217	0.87555	0.90255

Table 11a. Linear regression of poverty severity (Sen index) on mean length of life: females, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.01023	-0.01009	-0.01047	-0.01070	-0.01082
Intercept	0.88865	0.88615	0.93240	0.95973	0.98590
R-squared	0.88087	0.94346	0.97617	0.98008	0.97873

Table 11b. Linear regression of poverty severity (Sen index) on mean length of life: males, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.01251	-0.01290	-0.01215	-0.01252	-0.01208
Intercept	1.00993	1.04652	1.00585	1.05304	1.04003
R-squared	0.90656	0.96158	0.97801	0.98823	0.99069

Table 12a. Linear regression of Gini index on mean length of life: females, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.00221	-0.00227	-0.00240	-0.00276	-0.00286
Intercept	0.26021	0.26559	0.27619	0.30476	0.31407
R-squared	0.25835	0.47329	0.70437	0.84075	0.83241

Table 12b. Linear regression of Gini index on mean length of life: males, age 10+.

Parameter	1970	1980	1990	2000	2010
Slope	-0.00445	-0.00468	-0.00395	-0.00390	-0.00364
Intercept	0.42544	0.44288	0.39465	0.39375	0.37709
R-squared	0.54525	0.77642	0.85083	0.93614	0.93714

5. Between-country versus within-country measures: discussion

Differences, both quantitative and qualitative, between the results on inequality at international and within-country levels are the most obvious findings of the present study. There are two types of such differences. First, an increase in mortality inequality between the countries is accompanied by a decrease in average inequality within the countries. Second, the correlation between the average length of life and inequality is positive at the "macro level" (both indicators increased over the period investigated) while at the "micro level" the countries with higher length of life are generally characterized by lower mortality inequality. Both cases are discussed below.

As mentioned previously, the growth in the mean length of life between 1970 and 2010 was not equal. Although the prevailing part of the countries improved considerably their scores, some others (mainly post-communist ones) experienced relatively small growths, and for some of them even a decline in absolute values was observed (Russia and Ukraine for males). This type of changes obviously explains increases of the overall means and inequality and also of poverty depth under fixed poverty incidence. The decreases in average within-country inequality and poverty may be explained by changes in their mortality patterns. All countries were relatively successful in reducing mortality in the low age groups, which obviously contributed to the reduction of the inequality. Main differences between high and low mortality countries in terms of age-at-death distribution occurred for higher age groups. In the first type of the countries (mainly post-communist ones) serious mortality increases between 1970 and 2010 might be observed for middle age groups (see Billingsley, 2011), especially 40-59 years of age. This type of changes resulted in low increases (or even decreases) in the mean length of life and a decrease in inequality, as those age groups are relatively close to the mean values. In the countries characterized by high length of life the changes in the age-at-death distribution were of different type: usually the distribution functions moved towards the upper tails, while the shape was relative stable. In that case the main factor behind decreases in inequality were the above-mentioned decreases in mortality in lowest age groups.

Another type of difference between the results at the "macro" and "micro" level, i.e. the type of the correlation between length of life and inequality and poverty is consistent with some findings on relations between a health care system and mortality. It is confirmed (Hisnanick and Coddington, 1995, Korda and Butler, 2006) that universal healthcare is generally effective in reducing mortality, especially the so-called avoidable mortality. Hence, it reduces inequality as well as improves the length of life. This type of relation is observed in the present research.

5. Concluding remarks

During the four decades observed (1970 to 2010) the mean ages at death in the countries included in the study were getting more and more apart. This process was much more intensive for males. The main source of those changes was in relative, and in some cases also absolute, deterioration of the position of most of the post-communist countries. Using the income distribution nomenclature one can describe the above-mentioned process as a polarization (see Esteban and Ray, 1994 or Wolfson, 1994), resulting in the emergence of two relatively homogeneous groups with growing distance between them. Divergence in mortality distributions has been explored at two levels. First, a set of inequality and poverty indices has been calculated, taking the countries as the units with the mean length of life as a scalar indicator of development. Second, the within-country distributions using country life tables have been compared by means of the Kullback-Leibler divergence and three poverty indices with the poverty lines set at the median values calculated for all countries, supplemented by within-country inequality measures. These results only partly confirmed the conclusions on growing disparities across the countries. The whole distributions became more dissimilar, although the mean length of life appeared to be the only parameter for which growing divergence could be observed. Both poverty and inequality indices, evaluating selected aspects of mortality distribution, converged over the period investigated. This suggests the growing importance of the mean length of life as a scalar representation of the mortality distribution. Another type of differences between the results in between-country and within-country comparisons refers to the signs of correlation between the average length of life and inequality: it is positive at the "macro level" (both the mean length of life and inequality increased between 1970 and 2010) and negative at the "micro level" (the countries with higher length of life are generally characterized by lower mortality inequality). Poverty country rankings supplemented by the mean length of life rankings have indicated a prevailing part of the post-communist countries as main "losers" of the above-mentioned changes, although a few countries among them improved their initial relative positions. Among the remaining European countries also considerable changes in the ranking, in both directions, could be observed in some cases. The countries that might be said to be the main "winners" are usually non-European ones.

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APPENDIX

Table A1. Countries included in the study and the abbreviations

Country	Abbreviation
Australia*	AUS
Austria	AUT
Belgium*	BEL
Belarus	BLR
Bulgaria	BUL
Canada*	CAN
Czech Republic	CZE
Denmark	DEN
Eastern Germany	EGE
England and Wales	ENG
Estonia	EST
Finland*	FIN
France	FRA
Hungary*	HUN
Iceland	ICE
Ireland*	IRE
Italy*	ITA
Japan*	JAP
Latvia	LAT
Lithuania	LIT
Luxembourg*	LUX
Netherlands*	NED
Norway*	NOR
New Zealand*	NZL
Poland*	POL
Portugal*	POR
Russia	RUS
Spain*	SPA
Switzerland	SUI
Slovakia*	SVK
Sweden	SWE
Taiwan	TAI
Ukraine*	UKR
United States	USA
Western Germany	WGE

Asterisks denote countries for which 2009 data instead of 2010 data have been used.