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GEOGRAPHICAL DIFFERENTIATION OF MORTALITY IN THE REPUBLIC OF MOLDOVA

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Keywords: *Moldova, regional mortality, life expectancy, causes of death.*

Introduction*. Life expectancy in Moldova after independence either fluctuated in the 1990s or stagnated in the early millennium, followed by moderate improvements since 2010. The objective of the study is to investigate the evolution of regional variations in life expectancy since independence in Moldova and to identify the main demographic components (causes of death and age groups) responsible for interregional mortality inequalities.*

Material and methods*. Five-year average mortality rates by age and cause in the territorial profile were used between: 1991-1995, 2002-2006 and 2012-2016. Abridged life tables and confidence intervals were computed. According to Andreev's method, the difference in life expectancy between the two subpopulations was decomposed.*

Results*. The gap in life expectancy between the best-performing and the worst-performing groups constitutes 6.0 years. Important progress has been made in the municipality of Chisinau and the northern districts of Briceni and Edinet concerning cardiovascular mortality. In 11 districts located mainly in the center, the decline in infant mortality due to respiratory diseases was offset by the growth in adult mortality due to external causes and neoplasms.*

Conclusions*. Regional disparities can be reduced through preventive measures targeting the key risk factors for cardiovascular disease, liver cirrhosis and external causes of death within the backward geographical area.*

Cuvinte cheie: *Republica Moldova, mortalitatea regională, speranță de viață, cauze de deces.*

DIFERENȚIEREA GEOGRAFICĂ A MORTALITĂȚII ÎN REPUBLICA MOLDOVA

Introducere. *Speranța de viață în Republica Moldova, după independență a oscilat în anii 1990 și a stagnat la începutul mileniului, urmată de îmbunătățiri modeste din anul 2010. Obiectivul studiului este de a investiga evoluția variațiilor regionale ale speranței de viață după independență în Republica Moldova și de a identifica principalele componente demografice (cauze de deces și grupe de vârstă) responsabile de inegalitățile interregionale ale mortalității.*

Material și metode. *Ratele medii de mortalitate pe 5 ani în funcție de vârstă și cauză în profil teritorial au fost utilizate pentru trei perioade: 1991-1995, 2002-2006 și 2012-2016. S-au calculat tabelele de mortalitate prescurtate și intervalele de încredere. Diferența privind speranța de viață între două subpopulații a fost descompusă conform metodei lui Andreev.*

Rezultate. *Decalajul în ceea ce privește speranța de viață între grupurile cu cele mai bune performanțe și cele mai slabe performanțe constituie 6,0 ani. S-au înregistrat progrese importante în municipiul Chișinău și în raioanele nordice Briceni și Edineț în ceea ce privește mortalitatea cardiovasculară. În 11 raioane, situate în principal în centru, scăderea mortalității infantile din cauza bolilor respiratorii a fost compensată de creșterea mortalității adulților din cauze externe și neoplasme.*

Concluzii. *Disparitățile regionale pot fi reduse prin măsuri de prevenție care vizează factorii majori de risc pentru bolile cardiovasculare, bolile digestive și cauzele externe de deces într-o zonă geografică problematică.*

INTRODUCTION

After declaring independence in 1991, life expectancy at birth in Moldova began to decline very rapidly due to the severe socio-economic crisis that affected the country after the breakup of the Soviet Union and an abrupt transition to a market economy. Since the late 1990s, mortality in Moldova has largely stagnated, followed by moderate improvements since 2010 for males and 2005 for females. In 2019, life expectancy at birth was 66.6 years in males and 75.0 years in females. Compared to 1991, the gains were 2.6 years and 4.1 years, respectively. The COVID-19 pandemic reduced life expectancy for both sexes by about one year in 2020 (1).

Although national mortality trends and patterns in Moldova have been discussed in several articles (2 - 4), less is known about regional differentiation in life expectancy. At the same time, this type of analysis is of practical relevance to public health policymakers. Understanding the demographic process such as mortality in the dynamics and territorial profile should support the decision-making process. Mortality indicators dominate the health indicators computed for small populations. According to M. Denisenco, among the variety of integral health indicators, the preference is given to life expectancy at birth when it concerns small territories. However, small areas are particularly challenging when life expectancy is estimated in the usual manner. In particular, the absence of deaths in some age groups reduces the standard error of life expectancy estimates and the width of the confidence interval, i.e., the width between the upper and lower confidence limits (5). Experts suggested special methodologies for overcoming this issue (6, 7). Another key issue is determining the minimum population size for which life expectancy estimates are meaningful. British experts consider that for robust calculations of life expectancy estimates, the minimum population size must be at least 5000 persons. The width of the confidence interval for smaller populations exceeds 7 years for a life expectancy of 78.24 years (8). Other studies concluded that population size had to be at least 15000 people or more for a low-mortality population (9).

The current territorial-administrative division of Moldova comprises two levels. Villages (communes) and cities (municipalities) constitute the first level, while 32 districts called “rayon”, the municipality of Chisinau (including the capital with the same name), the municipality of Balti, the Autonomous Territorial Unit Gagauzia and Transnistria belong to the second level (10). The geographical division of the country includes three regions (North, Centre, South), the municipality of Chisinau and Transnistria. The principles of the administrative division were changed only in 1999-2002 when the country was divided into larger counties named “judet”. However, in 2003, the previous classification with some changes was reinstated. In our earlier study (11), the estimates of life expectancy at birth by sex for 35 administrative units (without Transnistria) were produced based on the corrected results of the 2014 population census (fig. 1). Our results showed that there was a mortality gradient between the northern region and the municipality of Chisinau, where life expectancy was high, and the belt of backward districts, mostly located in the centre and the adjacent southern districts, where life expectancy was low. This partition was more apparent in females than in males.

The objective of this study is to investigate the evolution of regional variations in life expectancy since independence in Moldova and to identify the main demographic components (causes of death and age groups) responsible for interregional mortality inequalities. *We hypothesise that* low life expectancy at the national level coexists with regional disparities in mortality, whereas recent improvements have not been geographically uniform. Our research questions are as follows:

1. Which subgroups of the population have the highest life expectancy (best-performing group) and the lowest life expectancy (worst-performing group) and how have they evolved geographically since independence?
2. Mortality from which causes of death and at which age groups explain the difference in life expectancy at birth between the two subgroups?
3. How has life expectancy at birth has changed in the two subgroups since independence and what were the age- and cause-specific components of these changes?

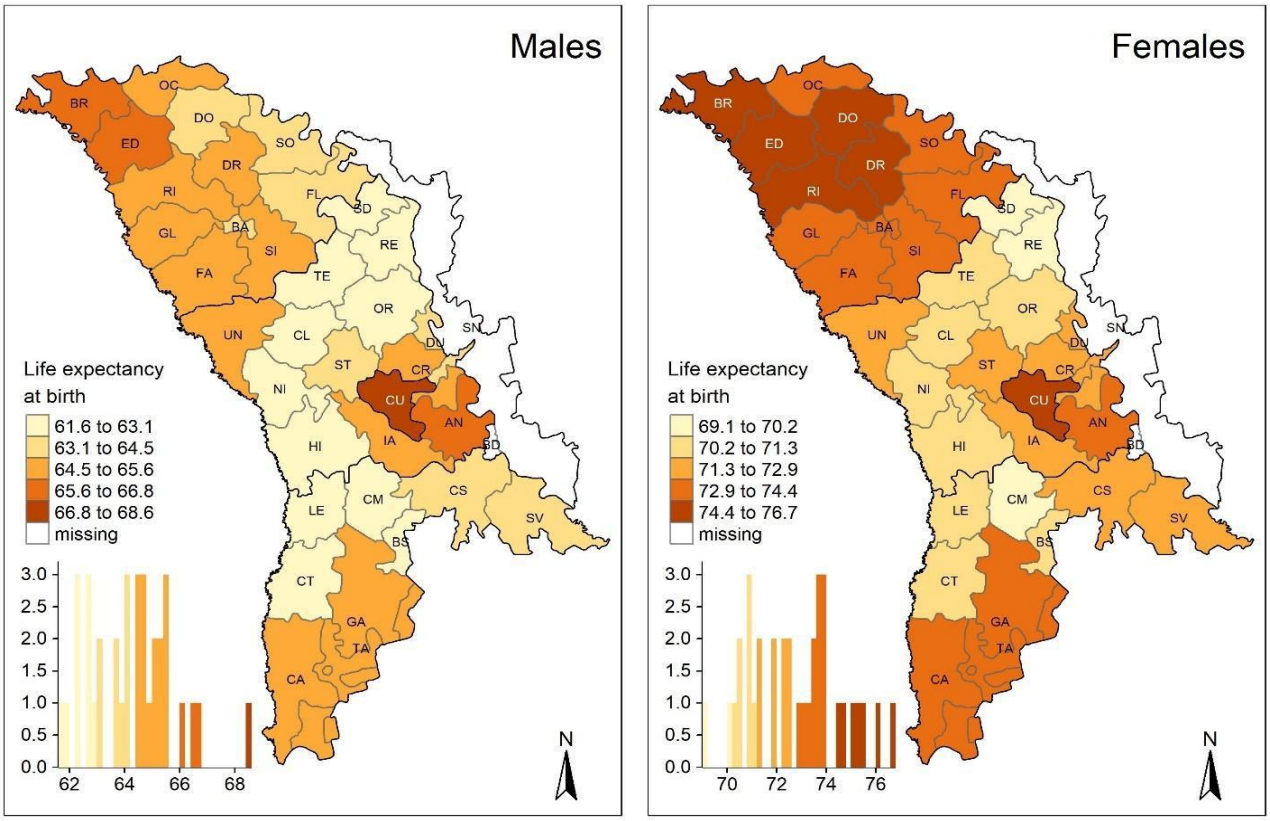

Figure 1. Geographical profile of life expectancy at birth in 2012-2016 based on the adjusted results of the 2014 Population Census, Moldova, by sex.
Source: (11) with modifications
Note: Jenks optimisation method of classification was used

MATERIAL AND METHODS

The regional analysis of mortality was conducted at the second level of territorial-administrative division. The analysis covered three periods: 1991-1995, 2002-2006 and 2012-2016. The three periods can be characterised as the period of socio-economic crisis, the period of stagnation of population health and the period of recent improvements. For the last two periods, we relied on the population censuses conducted in 2004 and 2014, while for the first period we used the annual population estimates in 1993. The results of the 2014 census were adjusted by the National Bureau of Statistics based on the post-census control survey and electricity supplier data. These adjustments resulted from the incomplete population coverage in the municipality of Chisinau where it constituted 59% (12). Since the official statistics do not cover the Transnistria region since 1997, we used the population census conducted in this region independently of Moldova in 2004. The last population census was carried out in Transnistria in 2015, but its results by sex and age were not available. According to the adjusted results of the 2014 census, in 22 of the 35 administrative units, the population size was 40 to 80 thousand; in 8 districts, it was 80 thousand people and more; in 5 districts, it was less than 40 thousand people. The minimum population size was 19 thousand people (Basarabeasca) and the maximum size was 676 thousand people (Chisinau).

The depersonalised database of individual death recorded since 1991 was provided by the National Public Health Agency of the Republic of Moldova. Deaths were registered by the place of residence of the deceased. Causes of death were codified under the 9th revision of the International Classification of Diseases (ICD) for 1991-1995 and its 10th revision since 1996. For Transnistria, mortality data are available until 1997. For the second period (2002-2006), we used death counts by sex and age for 2005-2006

provided by the Transnistrian statistical office. For the third period, mortality data as population exposure for Transnistria are not available. As the data were available at the first level of the territorial-administrative division, they were aggregated according to the current division.

The method described by Chiang was used to construct abridged life tables. The 95% confidence intervals (CIs) for life expectancy were estimated according to Silcocks et al. (6). A hierarchical analysis of age-specific life expectancies was performed for 36 administrative units over three time periods. The hierarchical analysis was done on the logarithms of the life expectancies. The decomposition method according to E.M. Andreev and V.M.Shkolnikov was applied to break down the difference in life expectancy by age and cause between the two population subgroups (13).

Analysis was done in R with the help of several packages (14, 15).

RESULTS

Figure 2 provides information on the differentiation of life expectancy at birth by the district over three study periods. In the early 1990s, life expectancy was the highest in the municipality of Chisinau (69.1±0.4), a few northern districts and the municipality of Balti. In the north of the country, life expectancy was two years higher than the country's average (e.g., in Riscani, Briceni) or close to it (e.g., in Soroca and Floresti). At the other extreme of the pole, there were central districts and some southern districts where the health of the population was much worse relative to the national baseline (66.9 years). In the worst-performing districts (Calarasi, Straseni, Soldanesti, Dubasari, Basarabeasca), life expectancy was about 3 years lower than in Moldova and even 5 years lower than in the capital. Most southern districts and Transnistria had life expectancy closer to the national average.

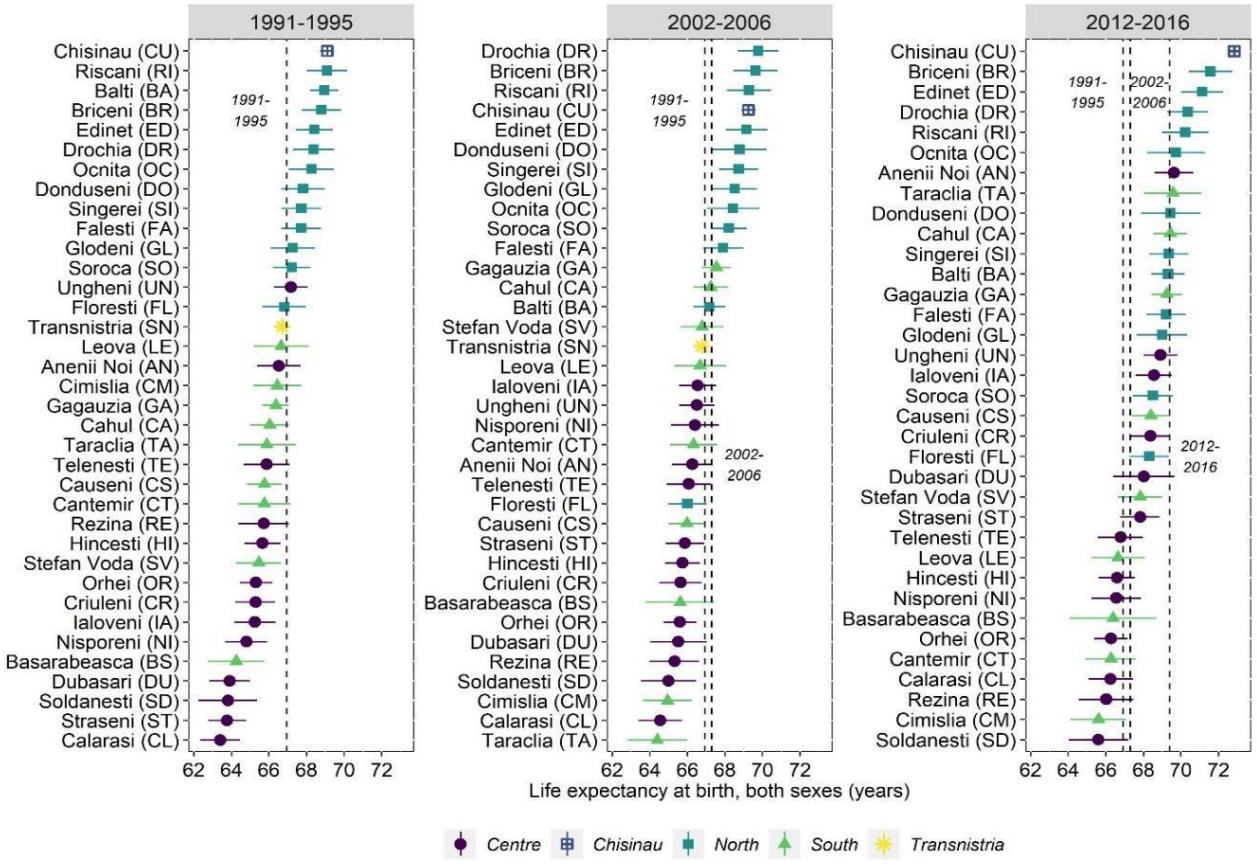

Figure 2. Life expectancy at birth by the district in 1991-1995, 2002-2006 and 2012-2016, Moldova.
Source: calculations based on NPHA, NBS, Transnistrian statistical office data
Note: Vertical lines refer to life expectancy in Moldova over three periods

During the years 2004-2006, the situation remained essentially the same at the national level (67.3 years) and across districts. Changes in life expectancy in 2002-2006 largely fall within the confidence limits in 1991-1995 for most districts, including the municipality of Chisinau. The municipality of Balti was an exception, where the situation worsened considerably (68.9±0.9 years in 1991-1995 vs 67.2±0.7 in 2002-2006).

During the years 2012-2016, life expectancy increased by two years in Moldova (69.4 years), but the progress was not consistent geographically. The most significant gains (more than four years) were achieved in some southern and central districts, which held one of the lowest positions in the early 1990s and at the beginning of the millennium (e.g., Taraclia, Dubasari, Straseni). In the municipality of Chisinau and some neighbouring districts (e.g., Anenii Noi, Ialoveni), life expectancy increased by more than three years. In the municipality of Balti, the recent increase (more than two years) has offset the deterioration in the first 15 years of independence. Contrary, most northern districts that during the previous two periods occupied the leading position alongside the municipality of Chisinau made little progress with a few exceptions (Briceni, Edinet).

Figure 3 demonstrates the results of the hierarchical analysis of age-specific life expectancies performed for 36 administrative units over three periods (without Transnistria for the last period). For the three periods, three clusters were defined. Between 1991-1995 and 2002-2006, the group of districts with the highest life expectancy was represented by the municipality of Chisinau and the northern districts (except for the district of Floresti and the municipality of Balti in the second period). During 2012-2016,

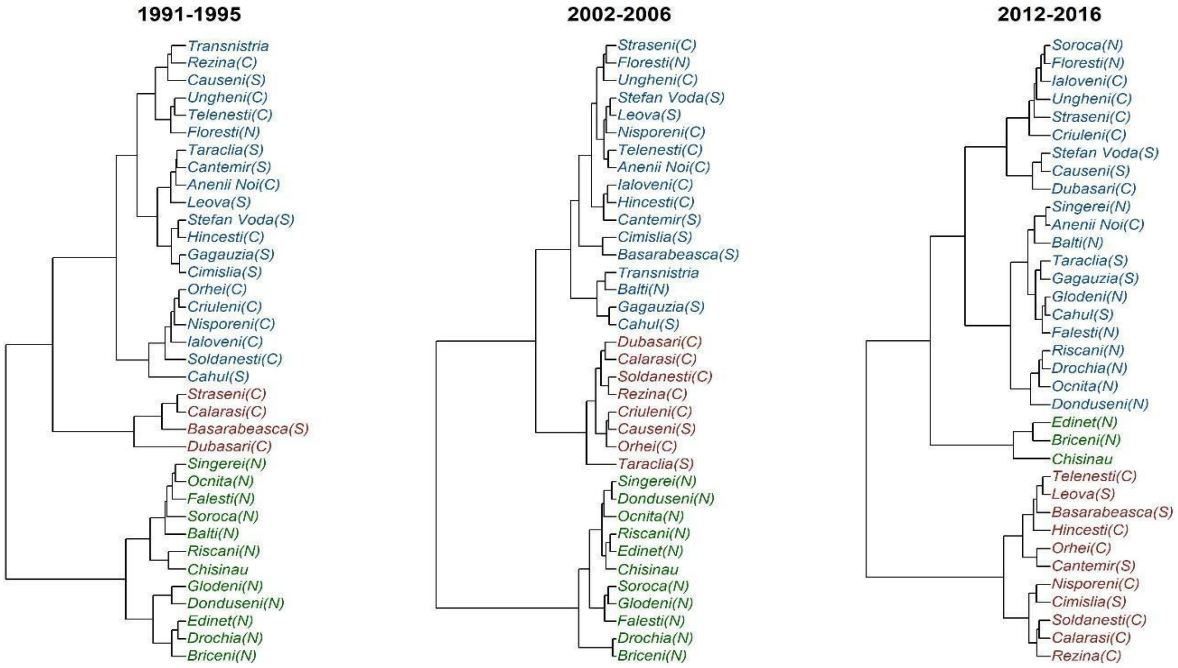

Figure 3. Dendrograms based on the hierarchical analysis of life expectancy by age in 36 administrative units over three periods, Moldova.

Source: see Figure 2

Note: Data for Transnistria are missing for 2012-2016. N=North, C=Centre, S=South

the best-performing group was reduced to three units represented by the municipality of Chisinau and the northern districts of Edinet and Briceni. The group of districts with the lowest life expectancy, which covered mainly the central districts and a few southern districts, widened from four districts in 1991-1995 to eleven districts in 2012-2016. If in the first two periods, the first-level partition was between the best-off group and the rest of the districts, then in the third period, between the worst-off group and the rest of the districts.

Given the results of the hierarchical analysis for 2012-2016, three groups of districts were identified (tab. 1):

1. Cluster 1 "Lagging": eleven districts with the lowest life expectancy at birth. In this regional subgroup, 20% of the Moldovan population live, according to the 2014 census. During the first 15 years of independence, life expectancy at birth stagnated, while the subsequent growth was insignificant (+1.1 years).
2. Cluster 2 "Leading": the municipality of Chisinau and two northern districts (Briceni and Edinet) with the highest life expectancy. In this subgroup, 29% of the population live. The increase in life expectancy was 3.5 years between 1991-1995 and 2012-2016.
3. Cluster 3 "Other": the rest of the districts where life expectancy was close to the national average over the three periods since more than 50% of the Moldovan population live here.

Table 1. Population size and life expectancy at birth in three geographical clusters over three periods. Moldova.

Period	Cluster 1 "Lagging"	Cluster 2 "Leading"	Cluster 3 "Other"	Moldova
Population (thousands, %)				
1991-1995	815 (19%)	910 (21%)	2621 (60%)	4346 (100%)
2002-2006	697 (18%)	851 (22%)	2251 (60%)	3799 (100%)
2012-2016	568 (20%)	809 (29%)	1445 (51%)	2821 (100%)
Life expectancy at birth (years)				
1991-1995	65.2±0.4	69.0±0.3	66.8±0.2	66.9±0.1
2002-2006	65.6±0.4	69.3±0.3	67.1±0.2	67.3±0.2
2012-2016	66.3±0.4	72.5±0.3	69.1±0.2	69.4±0.2

Source: see Figure 2
Note: three clusters were defined based on the hierarchical analysis of life expectancy in 2012-2016 (except for Transnistria included in cluster 3 based on the results for 2002-2006). Population and mortality data do not cover Transnistria for 2012-2016.

Figure 4 illustrates the results of the decomposition of the difference in life expectancy at birth between 1991-1995 and 2012-2016 for the three regional clusters. The difference between the two points in time was broken down by 10-year age groups and seven main groups of causes of death. In Cluster 1, the increase was 1.1 years, mainly due to the decline in mortality from respiratory diseases in children (especially, less than one year) and the elderly and mortality from external causes in young adults. The decline in mortality from respiratory diseases at all ages accounted for 0.74 years of total gains or 66%. The impact of infant mortality reduction from all causes was 1.1 years. These gains were offset by increased adult mortality attributable to neoplasms and external causes of death.

In Cluster 2, life expectancy at birth increased by 3.5 years during the time of independence. These improvements were primarily attributed to a decline in mortality from cardiovascular diseases among older adults (60+), external causes of death among the young (20-39) and middle-aged (40-59) and the residual group of causes of death among infants mainly represented by conditions originated in the perinatal period. The impact of these three causes of death explains 77% of the total increase in life expectancy for this group. The age groups with the largest gains were less than one year (0.8 years or 22%) and 60 years and older (1.4 years or 40%). In Cluster 3, life expectancy at birth increased by 2.3 years between 1991-1995 and 2012-2016. The decomposition outcomes were similar to those of Group 2, but the magnitude of the gains was much more modest, particularly for cardiovascular mortality.

The difference in life expectancy at birth between clusters 1 and 2 over three periods was also broken down by age and cause (tab. 2). In the first two periods, the difference was the same and constituted 3.7 years, while in the third period, it widened up to 6.2 years (+70%). The gap in life expectancy between the two po-

pulation subgroups resulted from the differences in mortality in the age groups 40-59 and 60 years old and over.

These two age groups alone accounted for 60-70% of the difference depending on the period. The inter-group differentiation increased in the third period compared to the previous one mainly due to the health deterioration among the middle-aged and the elderly. The impact of mortality among children (0-19 years) and young adults (20-39) was negative but much less significant. The differentiation of mortality between the two clusters over three periods was largely explained by three causes of death: cardiovascular diseases, digestive diseases and external causes of death. The impact of respiratory diseases was also important in 1991-1995. As was shown before, in Cluster 1, the progress was mainly associated with the decline in mortality from respiratory diseases, especially in the age group of less than one year. Consequently, the influence of this cause of death has gradually diminished. The recent increase in the life expectancy gap between the worst-performing and the best-performing clusters was mainly attributed to the increase in mortality from diseases of the circulatory system. The negative contribution of this cause of death doubled between 2002-2006 (-1.1 years) and 2012-2016 (-2.2 years).

Table 2. Age- and cause-specific components of the difference in life expectancy at birth (e_0) between Cluster 1 "Lagging" and Cluster 2 "Leading" over three periods, Moldova.

Component	1991-1995	2002-2006	2012-2016
Cause-specific components of the difference in e_0 (years)			
Infectious diseases	-0.08	0.02	-0.11
Neoplasms	0.32	0.09	-0.31
Cardiovascular diseases	-1.03	-1.13	-2.24
Respiratory diseases	-0.83	-0.67	-0.43
Digestive diseases	-1.31	-0.99	-1.31
External causes	-0.71	-0.72	-1.28
Other causes	-0.09	-0.29	-0.54
Age-specific components of the difference in e_0 (years)			
0-19	-0.60	-0.61	-0.62
20-39	-0.88	-0.48	-1.09
40-59	-1.53	-1.11	-2.40
60+	-0.73	-1.49	-2.10
Difference in e_0 (years)			
Total	-3.73	-3.69	-6.21

Source: see Figure 2
Note: see Table 1

DISCUSSIONS

Data quality and limitations of the study

From the 1980s onwards, the quality of death registration in Moldova is considered high (16). The increase in senility-related mortality (797 under ICD-9 and item R54 under ICD-10) in the 1990s deserves some discussion. On a national scale, deaths attributed to senility increased drastically in the 1990s when a new directive regarding of the diagnosis of deaths from cardiovascular diseases among people above age 80 was adopted (17). The maximum number of senility deaths achieved 17% of all deaths in 1993 (12% in males and 21% in females). At the same time, cardiovascular mortality decreased sharply, contrasting with the upward trend in overall mortality during the socio-economic crisis of the 1990s. To overcome this problem at the national level, deaths attributed to senility were redistributed by special coefficients between cardiovascular diseases (1). For this regional study, we limited our analysis to the major groups of causes of death, while senility-related deaths were attributed to diseases of the cardiovascular system as suggested earlier at the national level.

Reliability of population exposure for the period of independence is another important data quality issue. Many studies on regional mortality patterns were based on the years surrounding the

population censuses (18, 19). In the absence of reliable intercensal or postcensal population estimates, this approach let us avoid a systematic bias induced by migration flows. In Moldova, the recent period of migration intensified in comparison with the years immediately after independence was proclaimed (20). In addition, the NBS has not estimated postcensal population figures in a regional context at the time of the study. To avoid this type of bias, we relied on the results of the last two national censuses of population and households conducted in 2004 and 2014. As for the early 1990s, the official population counts for the year 1993 can be considered reliable at the national level when compared to the intercensal population estimates earlier produced for Moldova (21).

Main findings and interpretation

The results of the study identified three population clusters with respect to life expectancy. The best-off group was represented by the northern districts and the municipality of Chisinau during the socio-economic crisis of the 1990s and the first decade of the new millennium. The districts that came under the worst-off group were mainly situated in the central and southern regions. The progress in life expectancy seen nationally since 2010 among men and 2005 among women was not geographically consistent. The most important gains were achieved in the municipality of Chisinau and the northern districts of Briceni and Edinet. Only in these three administrative units, identified as the leading cluster, were the lower life expectancy limits higher than the national average in the 2012-2016 period. At the same time, the worst-performing group expanded into eleven districts identified as the lagging cluster. In this population subgroup, life expectancy in the 2012-2016 period was close to the national average in the 1991-1995 period. The two extreme population subgroups, each with about 20% of the population, explained the interregional differentiation of mortality in the country. The third cluster covering other districts expanded during the third period, mainly due to the inclusion of most districts in the north traditionally regarded as the most advanced group.

The breakdown of the difference in life expectancy at birth between the two extreme clusters revealed the causes of death and age groups where the differences in mortality were the greatest. Cardiovascular diseases, digestive diseases and external causes of death constituted the three categories of causes of death responsible for the geographical variations in Moldovan life expectancy. In the worst-performing group, higher cardiovascular mortality mainly affected the middle-aged and the elderly, while higher mortality rates from digestive diseases and external causes of death were observed in young adults and middle-aged adults. The same causes of death and age groups were identified as the three key factors responsible for long-term adverse trends in life expectancy and its short-term fluctuations in Moldova (1). Mortality due to respiratory diseases, especially among children under the age of one, played an important role in the 1990s. This type of infant mortality represented chiefly by pneumonia and closely associated with exogenous factors was of much greater importance in the backward districts compared to the rest of the country. However, the improvements in infant mortality from respiratory diseases were possible in both the best-performing and the worst-performing clusters. As a result, this pathology now plays a smaller role in the interregional differentiation of mortality compared to the 1990s. Mortality from digestive diseases mostly represented by liver cirrhosis at the national level contributed a great deal to the interregional diversity of life expectancy. This type of pathology is closely linked to excessive alcohol consumption in Moldova which has one of the highest levels of alcohol consumption (22). The alcohol drinking pattern is dominated by unrecorded homemade wine traditionally produced by the Moldovan population (23). It is highly likely that in the lagging cluster, the population is more prone to hazardous Mediterranean drinking culture than in the rest of the country.

While progress in the laggard group was primarily related to the decline in infant mortality from respiratory diseases, in the most advanced group, the main contributing factors were positive changes in cardiovascular mortality in the elderly. The latter points out the beginning of the cardiovascular revolution in this geographical area, which spurred sustained growth in life expectancy in developed countries since the 1970s

of the last century (24). At the same time, no similar changes were observed in the backward cluster, where high cardiovascular mortality rates are the main component of poor population health. Positive variations in external mortality also contributed to growth in life expectancy across all three groups. However, in the most disadvantaged group, the decrease in external deaths among children and young adults was offset by the increase in mortality among middle-aged people.

Although neoplasms are second in the cause-specific mortality pattern, this group of causes of death does not have a significant impact on the interregional differentiation of mortality. In the leading cluster, medical advances in the diagnosis and treatment of cancer even contributed positively to the increase in life expectancy between 1991-1995 and 2012-2016. At the same time, in two other clusters, particularly in the backward group, negative trends in cancer mortality begin to have a negative impact on population health. Positive changes in cancer mortality in the best-performing group, contrasted with persistent unfavourable trends in the rest of the country, will only intensify interregional inequalities in mortality in the future.

CONCLUSIONS

1. The hierarchical analysis of age-specific life expectancies identified three geographical population subgroups. Two extreme groups, each with about 20% of the population, contributed to interregional mortality differentiation. The best-performing group was represented by the municipality of Chisinau and the two northern districts of Briceni and Edinet. The worst-performing group included eleven districts situated mainly in the center and the south. Most of the northern units, including the municipality of Balti, have lost their leadership position in terms of life expectancy after independence.
2. Mortality caused by cardiovascular diseases in the elderly, digestive diseases in the middle-aged and external causes of death in young and middle-aged adults were responsible for the differences in life expectancy between the best-off and the worst-off groups. Infant mortality from respiratory diseases had an important impact on mortality differentiation in the 1990s.
3. The recent rise in life expectancy at the national level has been accompanied by a widening gap between the best-performing and worst-performing groups. The most advanced group has benefited from effective control of cardiovascular diseases among the elderly and external causes of death among young and middle-aged adults. In the worst-off group, the moderate progress in infant mortality associated with respiratory diseases was counterbalanced by increased mortality from external causes and neoplasms in middle-aged people. There has been no progress as far as cardiovascular mortality is concerned in this population subgroup.
4. Geographical disparities can be reduced through appropriate preventive measures targeting the key risk factors for cardiovascular disease, liver cirrhosis and external causes of death and the development of social infrastructure within the identified laggard geographical area.

CONFLICT OF INTERESTS

The author declares no conflict of interest.

ACKNOWLEDGMENT

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ETHICAL APPROVAL

No approval was required for this study.

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