CHANGES IN MORTALITY INEQUALITIES BETWEEN RURAL AND URBAN POPULATIONS IN THE REPUBLIC OF MOLDOVA AFTER INDEPENDENCE

Olga PENINA, PhD in medicine
Nicolae Testemitanu **State University of Medicine and Pharmacy of the Republic of Moldova,**
Doctoral School of Medical Science
https://orcid.org/0000-0002-3884-2751, penina.olga@gmail.com

Abstract. *In the Republic of Moldova, life expectancy started growing moderately since 2005 after decades of deterioration. Little is known about changes in mortality differences between rural and urban populations. The research aimed to analyse rural-urban disparities in mortality by sex and cause of death in the Republic of Moldova since independence. Material and methods. Age-standardized death rates were computed by sex and cause for different periods since 1991. Absolute and relative inequalities in mortality were computed with 95% confidence intervals. Results. A positive rural-urban gradient was identified for major cause-of-death groups, except for neoplasms and infectious diseases. The socioeconomic crisis of the 1990s was accompanied by a reduction in mortality disparities as a result of considerable growth in cardiovascular mortality among urban men and women. In rural areas, the crisis led to an increase in mortality, mainly from respiratory system diseases and digestive system diseases. Recent progress in population health observed nationally after 2005 has been accompanied by a widening rural-urban gap due to faster improvements in urban areas. Conclusions. Even though all-cause mortality was consistently lower for the urban population than for the rural population, the former was more sensitive to the socioeconomic crisis of the 1990s and the COVID-19 pandemic than the latter. To reduce rural-urban inequalities in mortality, preventive measures need to target key risk factors for diseases of the circulatory, digestive and respiratory systems and external causes in rural areas.*
The study was carried out in the framework of Project 21.00208.8007.02/PD "Socio-demographic and regional mortality disparities in the Republic of Moldova"
Keywords: *The Republic of Moldova, mortality, rurality, disparities, causes of death, population health*
JEL: *I100*
UDC: *314.14(478)*

Introduction. Numerous studies have shown that urban and rural areas differ as far as population health is concerned. In many developed countries such as England or Germany, a positive urban-rural gradient for all-cause mortality was observed, suggesting higher death rates in urban areas than in rural ones (Allan et al., 2019). The opposite situation characterised by a negative urban-rural gradient or rural-urban gradient was described for some post-communist countries (Mesceriakova-Veliuliene & Kalediene, 2021) and the USA (James, 2014). Finally, there is a more complex U-shaped relation with lower rates in semi-rural areas and higher rates in urban areas and remote rural areas (Barnett et al., 2001). In the former Soviet Union countries, a rural-

urban gradient in mortality is very common. In Lithuania, death rates among men and women aged 30 and over are moderately higher in rural settings for the majority of causes of death, with the exception of cancer (Jasilionis et al., 2006). In Belarus, a high level of poverty and alcohol consumption underpins higher homicide mortality rates in rural areas and a growing rural-urban divide (Stickley et al., 2009). Sociodemographic aspects of rurality in the republic, including mortality trends and patterns, have been discussed in a number of studies. Moldova's rural population, which makes up 60% of the total population, has higher poverty rates and lower access to medical services. In 2020, the level of absolute poverty was 2.5-fold higher in rural areas compared with urban areas (Buciuceanu-Vrabie Mariana, 2021). Some studies have pointed to the rural-urban gradient for all-cause mortality since 1980 (Paladi et al., 2013).

The goal of the research was to analyse rural-urban disparities in mortality by sex and cause of death in Moldova since independence. Our research questions were as follows:

1. How have rural-urban mortality inequities changed in Moldova since independence?
2. What are the causes of death that account for the mortality gradient between rural and urban populations?

Material and Methods. Data were analysed for the following periods: 1991-93, 2003-05, 2014-16, 2017-19 and 2020. Given the considerable impact of COVID-19 infection on the overall mortality trend in 2020, this year was analysed separately. We used the depersonalized death records by sex, age and place of residence (urban/rural) codified under the 9th revision (1991-93) and the 10th revision (2003-05, 2014-19) of the International Classification of Diseases and Causes of Death (ICD). For the period 1991-93, the population counts were computed on the basis of intercensal estimates for the whole country (Penina et al., 2015) and redistribution of the population by place of residence derived from the official annual figures (National Bureau of Statistics, 2022a). For the period 2003-05, population counts refer to the 2004 Census (National Bureau of Statistics, 2021), while for other periods the official annual estimates based on adjusted 2014 Census results were used (National Bureau of Statistics, 2022b). In this study, ill-defined causes of death, including the item "Senility" were treated as previously suggested at the national level (Penina et al., 2022). In particular, for the period 1991-93, deaths codified under the item "Senility" were attributed to cardiovascular items. For other periods, ill-defined causes of death were proportionally redistributed between other causes.

For the five periods mentioned above, age-specific death rates were produced by sex for all causes and the following seven main groups of causes of death: infectious diseases, neoplasms, diseases of the circulatory system,

diseases of the respiratory system, diseases of the digestive system, external causes and other causes of death. Standardised death rates (SDR) for all causes and main groups of causes of death were computed using the European standard population (European Commission, 2013). 95% confidence intervals (CI) were calculated according to Dobson's method. Absolute and relative disparities were measured by calculating rate difference (RD) and rate ratio (RR) with 95% confidence intervals. RD was calculated as the difference between SDR in rural areas and SDR in urban. RR was calculated as the ratio of SDR in rural areas to SDR in urban areas. The confidence intervals were used to compare an estimate (e.g., SMR in the rural area) against a benchmark value (e.g., SMR in the urban area). If the benchmark value was outside the 95% CI for the estimate, the difference between the estimate and the benchmark was statistically significant (p<0.05). Non-overlapping confidence intervals constructed for RD and RR indicated a statistically significant difference (p<0.05) (APHO, 2010).

The change in rate difference (RD) between the period t and period $t+n$ was calculated as follows:

$$(\text{RD}_{\text{period } t+n} - \text{RD}_{\text{period } t}) / \text{RD}_{\text{period } t} \times 100 \tag{1}$$

The change in rate ratio (RR) between period t and period $t+n$ was calculated as follows:

$$(\text{RR}_{\text{period } t+n} - \text{RR}_{\text{period } t}) / (\text{RR}_{\text{period } t+n} - 1) \times 100 \tag{2}$$

Data were analysed in R.

Results. Standardised death rates with 95% confidence intervals in 1991-93, 2003-05, 2014-16, 2017-19 and 2020 by cause of death and place of residence are shown in Figure 1 for males and Figure 2 for females. Figures 3 and 4 illustrate, respectively, the changes in absolute difference (RD, rate difference) and absolute difference (RR, rate ratio) by sex over the study periods.

Mortality from all causes was higher in rural areas than in urban areas for all time periods (p<0.05), with the exception of the male population in 2020. Taking into account the specificity of the 2020 mortality pattern, the impact of COVID-19 infection was analysed separately. Among rural males and females, standardised death rates were higher for diseases of the circulatory system, diseases of the respiratory system and diseases of the digestive system for all the periods and for external causes, with the exception of 2003-05 (p<0.05). On the contrary, neoplasm mortality was consistently higher in urban areas than in rural areas (p<0.05). Mortality from infectious diseases was not significantly different between urban and rural areas, except in 2003-

05 among men and the last two observation periods among women. Mortality from other causes of death was higher in rural areas only at the beginning of the 1990s *(Fig.1, Fig.2)*.

The maximum values of absolute (RD, rate difference) and relative (RR, rate ratio) differences in all-cause mortality were found in 2014-16 both in males (RD=370 deaths per 100000; RR=1.15 times, p<0.05) and females (325 deaths per 100000; RR=1.2, p<0.05). After excluding 2020 due to a considerable impact of COVID19, rural-urban mortality disparities for all causes were minimal in 2003-05 for males (RD=131 deaths per 100000; RR=1.05, p<0.05) and females (RD=229 deaths per 100000; RR=1.12, p<0.05) (Fig.3, Fig.4).
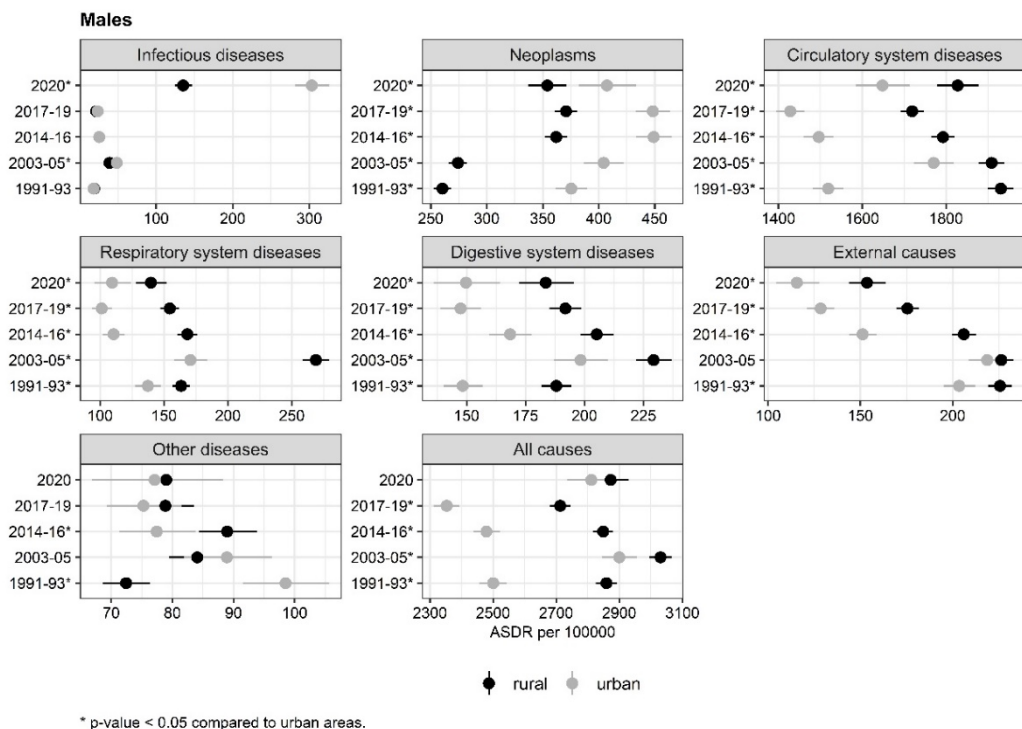

Figure 1. **Age-standardised death rates and 95% confidence intervals for main groups of causes of death by urban-rural residence in 1991-93, 2003-05, 2014-16, 2017-19 and 2020, Moldova, males (per 100000)**
Source: author's calculations based on NBS, NAPH data.

Changes in absolute and relative inequalities in mortality between rural and urban populations were examined for four periods:
   a) The period of stagnation/deterioration of population health (between 1991-93 and 2003-2005);
   b) The period of improvement (between 2003-05 and 2014-16);
   c) The period of recent changes (between 2014-16 and 2017-19);

d) The effect of COVID-19 infection (between 2017-19 and 2020).

Period of deterioration (between 1991-93 and 2003-05)

   Between 1991-93 and 2003-05, standardised death rates in rural areas increased statistically significantly for all causes, infectious diseases, respiratory system diseases, digestive system diseases and other diseases (p<0.05). At the same time, changes in mortality rates from circulatory system diseases and neoplasms were not substantial in rural areas during the period of deterioration (p>0.05). In urban areas, however, both men and women experienced significant growth in cardiovascular mortality (p<0.05). This increase in cardiovascular mortality in urban areas (15% in males and 12% in females between 1991-93 and 2003-05) contrasts with a relatively unchanged situation in rural areas. The deterioration between 1991-93 and 2003-05 in urban settings was also statistically significant for infectious diseases, diseases of the digestive system among men and women and diseases of the respiratory system among men (p<0.05). Unlike cardiovascular mortality, the increase in standardized death rates from respiratory diseases in 2003-05 was much higher in rural areas than in urban areas (e.g., 60% in rural males vs. 20% in urban males) *(Fig.1, Fig.2).*

   Inequalities in all-cause mortality were substantially reduced in 2003-2005 compared to 1991-93 as a result of a faster increase in mortality in urban areas than in rural areas, especially among males. Absolute difference in cardiovascular mortality diminished by 66% in males ($RD_{1991-93}$=412, $RD_{2003-05}$=138 per 100000, p<0.05) and 41% in females ($RD_{1991-93}$=325, $RD_{2003-05}$=192 deaths per 100000, p<0.05). The relative differences for this cause of death decreased considerably ($RR_{1991-93}$=1.27, $RR_{2003-05}$=1.08, p<0.05). However, because of a marked increase in rural mortality from diseases of the respiratory system, relative difference for this type of pathology increased by more than 65% in males ($RR_{1991-93}$=1.19, $RR_{2003-05}$=1.58, p<0.05) and females ($RR_{1991-93}$=1.30, $RR_{2003-05}$=1.93, p<0.05). In 2003-05, urban-rural inequalities in mortality from external causes became negligible both in terms of absolute and relative differences *(Fig.3, Fig.4).*
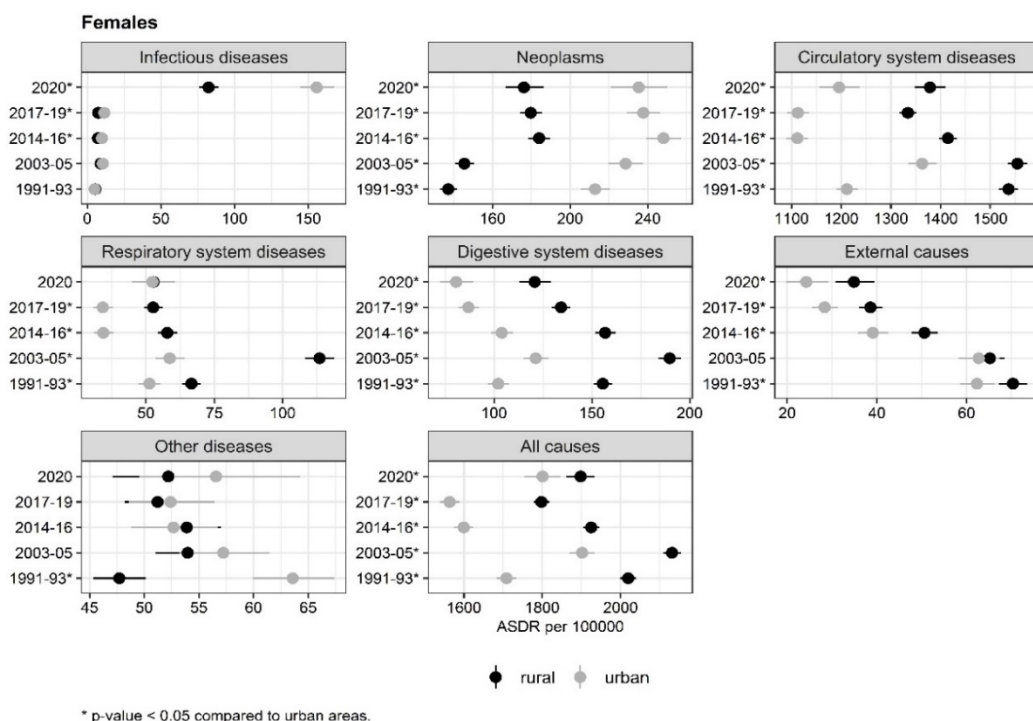
Females

Figure 2. **Age-standardised death rates and 95% confidence intervals for main groups of causes of death by urban-rural residence in 1991-93, 2003-05, 2014-16, 2017-19 and 2020, Moldova, females (per 100000)**
Source: author's calculations based on NBS, NAPH data.

Period of improvement (between 2003-05 and 2014-16)

Between 2003-2005 and 2014-2016, standardized mortality rates among men and women decreased in rural and urban areas for all causes of death and major groups of causes of death (p<0.05), except for neoplasms and the residual group of causes of death for both sexes and diseases of the respiratory system among women. Neoplasm mortality increased during this period in both sexes (p < 0.05). Positive changes in all-cause mortality and cardiovascular mortality were more pronounced in urban areas than in rural areas, particularly among urban males, who experienced a considerable deterioration in their health during the previous period. On the other hand, rural men and women recorded a sharper decline in mortality from diseases of the respiratory system. In rural areas, the growth in neoplasm mortality was stronger in rural than in urban areas, particularly among men *(Fig.1, Fig.2).*

Because of a faster decline in mortality in urban areas compared to rural areas, disparities by place of residence reached the highest levels ever seen after independence. During this period, the absolute difference in cardiovascular mortality between rural and urban settings more than doubled in males ($RD_{2003-05}$=139, $RD_{2014-16}$=296 deaths per 100000, p<0.05) and increased by 58% in

females ($RD_{2003-05}$=192, $RD_{2014-16}$=303 deaths per 100000, $p<0.05$). Relative differences in mortality from diseases of the circulatory system increased by 60% in males ($RR_{2003-05}$=1.08, $RD_{2014-16}$=1.2, $p<0.05$) and 48% ($RR_{2003-05}$=1.14, $RD_{2014-16}$=1.27, $p<0.05$) in females. Progress in mortality from diseases of the digestive system and external causes was also more marked in urban areas than in rural ones. In 2014-16, disparities between urban and rural areas for external mortality among men increased more than six times in terms of absolute difference ($RD_{2003-05}$=8, $RD_{2014-16}$=55 deaths per 100000, $p<0.05$) and by 90% in terms of relative difference ($RR_{2003-05}$=1.03, $RR_{2014-16}$=1.36, $p<0.05$). In 2014-16, neoplasm mortality, by contrast, increased significantly, more in rural areas than in urban areas and more for males than for females. Male absolute inequality was reduced by 33% ($RD_{2003-05}$=-131, $RD_{2014-16}$=-87 deaths per 100000, $p<0.05$) and relative inequality by 66% ($RR_{2003-05}$=0.68, $RR_{2014-16}$=0.81, $p<0.05$) *(Fig.3, Fig.4)*.
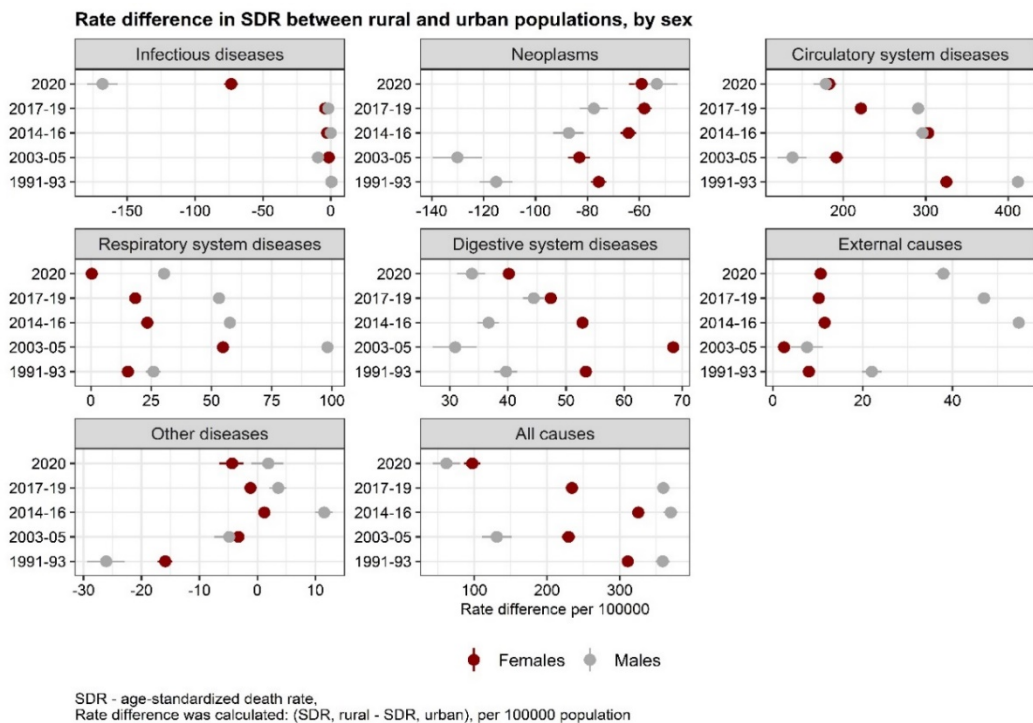

Figure 3. **Rate difference of age-standardized death rates and 95% confidence intervals for main groups of causes of death by sex in 1991-93, 2003-05, 2014-16, 2017-19 and 2020, Moldova (times)**
Source: author's calculations based on NBS, NAPH data.

Recent changes (between 2014-16 and 2017-19)

Between 2014-19 and 2017-19, improvements previously seen between 2003-05 and 2014-16 continued only for certain causes of death, but this time it was more evident in rural areas than in urban areas, particularly among rural women. The reduction of standardised mortality rates among rural men and

women was statistically significant for all causes of death, diseases of the circulatory system and external causes of death (p<0.05). A sizeable decline in mortality was also observed for digestive system diseases among rural women and other diseases among rural men (p<0.05). In urban areas, by contrast, the decline in all-cause mortality was statistically significant only for men, but not for women. As well, changes in mortality caused by diseases of the circulatory system were not substantial in urban areas (p>0.05). Positive changes in urban mortality were important only for diseases of the digestive system and external causes of death (p<0.05) *(Fig.1, Fig.2)*.

Among men, inequalities between rural and urban areas in overall mortality have not changed significantly in both absolute and relative terms (p>0.05). At the level of causes of death, inequalities in absolute and relative mortality among men increased statistically significantly for diseases of the digestive system and decreased for other causes. Among women, the reduction in cardiovascular mortality from 2014-16 to 2017-2019 was more marked in rural areas, which reduced the gap between rural and urban areas. Rate difference for this cause and sex diminished by 27% ($RD_{2014-16}$=303, $RD_{2017-19}$=221 deaths per 100000, p<0.05), while rate ratio by 35% ($RR_{2014-16}$=1.27, $RR_{2017-19}$=1.20, p<0.05) *(Fig.3, Fig.4)*.

Rate ratio of SDR between rural and urban populations, by sex

SDR - age-standardized death rate,
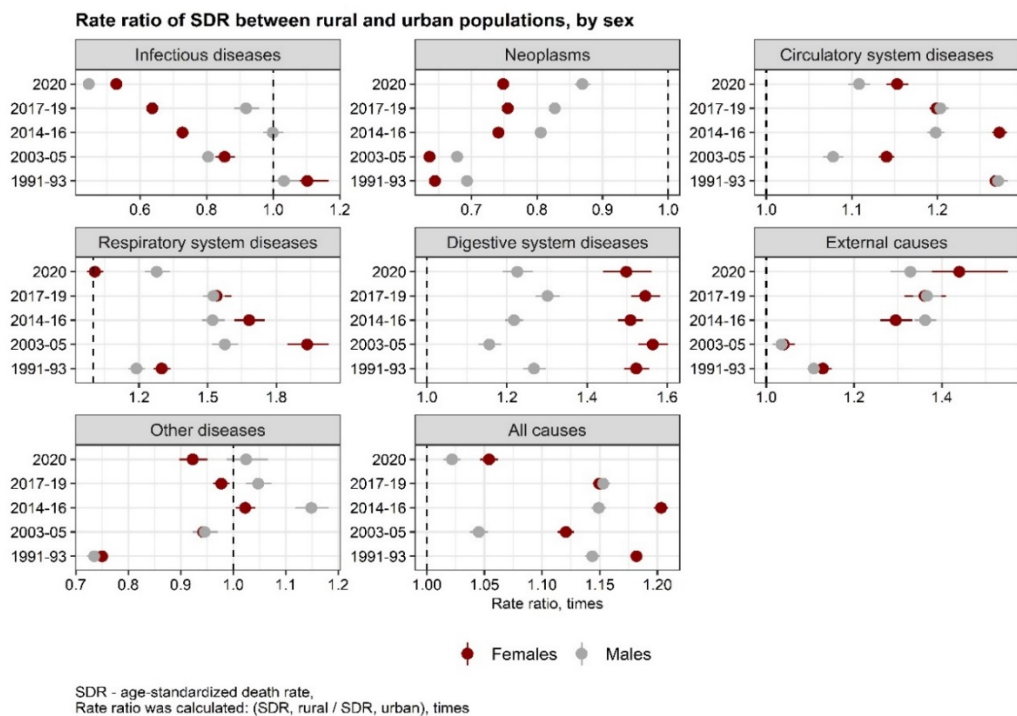Rate ratio was calculated: (SDR, rural / SDR, urban), times

Figure 4. **Rate ratio of age-standardized death rates and 95% confidence intervals for main groups of causes of death by sex in 1991-93, 2003-05, 2014-16, 2017-19 and 2020, Moldova (times)**
Source: author's calculations based on NBS, NAPH data.

The effect of COVID-19 infection (between 2017-19 and 2020)

During the pandemic year, all-cause mortality increased in both areas, but the urban population was more affected than the rural population. Among rural and urban men, there was a statistically significant increase in mortality in 2020 relative to the previous period for infectious diseases and cardiovascular diseases (p<0.05). Among rural women, mortality rates rose statistically significantly in 2020 only for infections, while among urban women, they also increased for diseases of the circulatory and respiratory systems (p<0.05). The most dramatic increase in mortality occurred in the case of infectious diseases. Standardized indicators for this cause of death increased 13 times for urban males and 6 times for rural males, whereas the increase for females was 14-fold and 11-fold, respectively *(Fig.1, Fig.2).*

In 2020, the absolute difference in mortality from all causes was reduced by more than 80% in men and 60% in women (p<0.05) compared to the prior period. The relative difference in overall mortality became nearly nil in 2020 for men (RR=1.02, p>0.05) and women (RR=1.05, p<0.05). Among men, the rate difference between rural and urban areas decreased in 2020 compared to the period 2017-19 for neoplasms, circulatory system diseases, respiratory system diseases, digestive system diseases and external causes of death (p<0.05). Among women, the reduction of the rate difference was important only for diseases of the circulatory, respiratory and digestive systems. As a result of a much larger increase in COVID-19 mortality in urban areas than in rural areas in 2020, the rate ratio for infectious diseases increased by 85% for men and 23% for women *(Fig.3, Fig.4).*

Discussion, conclusions. This study addressed the issue of mortality disparities between rural and urban populations in Moldova since independence. The data were analysed by sex across four different periods for all causes and major groups of causes of death. According to the international recommendations, mortality disparities were analysed in absolute and relative terms. Excluding 2020, when rural-urban mortality differentiation changed dramatically, mortality rates for both men and women were statistically significantly higher in rural areas than in urban areas for all causes of death, circulatory system diseases, respiratory system diseases and digestive system diseases. For neoplasms, a negative rural-urban mortality gradient was detected. Higher risk of death from external causes was associated with rurality throughout all periods except 2003-05.

Rural and urban populations had a different reaction to the sever socioeconomic crisis of the 1990s. Urban men and women experienced a much deeper health deterioration compared to their rural counterparts first and foremost due to a considerable increase in mortality from circulatory system diseases. At the same time, rural population was more affected by respiratory system diseases and digestive system diseases. These differences between rural and urban populations concerning the changes in mortality patterns

during the socioeconomic crisis are very likely reflect their underlying causes. The striking jump in cardiovascular mortality in urban areas mirrors the immense stress the adult population faced after a sudden transition to a market economy and associated with it social and economic turmoils. On the other hand, the rural population remained nearly untouched by cardiovascular mortality deterioration, but experienced a very profound rise in mortality associated with poverty and an excessive alcohol consumption such as diseases of the respiratory and digestive systems. National studies have demonstrated a considerable increase in adult mortality from pneumonia and liver cirrhosis during the socioeconomic crisis of the 1990s (Penina et al., 2022).

Improvements in overall mortality observed at the national level after 2005 were not homogeneous in rural and urban areas. Urban population whose health was affected in the 1990s much more compared to the rural population showed more rapid improvements for circulatory system diseases, external causes of death, digestive system diseases. As a result, disparities in all-cause mortality increased again in 2014-16 and became close to the values observed immediately after proclaiming independence.

Even though the rural-urban gradient in mortality was statistically significant in Moldova since independence, the social and economic perturbations such as the crisis of the 1990s affected more seriously the urban population than the rural population. The consequences of the crisis in the 1990s led to an increase in cardiovascular mortality in urban areas, not rural ones. This fact considerably reduced mortality inequalities between the two areas at the turn of the millennium. The decline in all-cause mortality observed at the national level since 2005 was associated with an increasing gap between rural and urban populations. Although mortality from neoplasms was systematically higher in urban areas than in rural ones, disparities have been reducing recently due to a more rapid deterioration in rural areas. In 2020, the mortality gradient between rural and urban populations disappeared for men and was substantially reduced for women. As in the 1990s, the urban population was more susceptible to the health crisis brought about this time by the COVID-19 pandemic. Admittedly, greater population aggregation in urban areas and poor public transport systems in urban areas have resulted in a more rapid spread of infection here compared to rural areas.

To overcome the problem of inequalities in mortality by place of residence, attention must be paid to population health programmes aimed at reducing the excess rural mortality from circulatory system diseases, digestive system diseases, respiratory system diseases and external causes of death.

Acknowledgements

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