ASSESSING PREMATURE MORTALITY: AN INDICATOR SELECTION ANALYSIS USING DATA FROM MOLDOVA, CZECHIA, AND SWITZERLAND

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Irina PAHOMII,

PhD Student, Department of Demography and Geodemography, Faculty of Science, Charles University, Prague, Czechia

Scientific Researcher, Center for Demographic Research, National Institute for Economic Research, Academy of Economic Studies of Moldova

https://orcid.org/0000-0002-6595-9146
e-mail: braga.pahomiiirina@gmail.com

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SUMMARY

Premature mortality is a very complex concept, and even though it is widely studied in the specialised literature, there is no broad agreement on its definition. This study aims to compare two different models of premature mortality analysis to highlight the more appropriate one for the national context. The actuality of this study is determined by the mortality level observed in the Republic of Moldova and particularly by the issue of adult male mortality level. To achieve this objective, the following indicators were compared: proportion of deaths up to a certain age threshold, Potential Years of Life Lost (PYLL), lifespan disparity and age threshold derived from lifespan disparity. Analysis was carried out in a comparative aspect. For this purpose, this study analysed data from Czechia and Switzerland. In the case of the Republic of Moldova, it is quite complicated to identify a universally accepted set of indicators that would allow the monitoring of premature mortality. The classical indicators are impacted by the age and number structure of the population. The dynamic approach indicators are exempted from the influence of age and number structure of the population but have a more complex methodology and are more complicated to interpret. However, establishing and promoting such a set of indicators is unquestionably necessary. It is important to note that the choice of indicators for monitoring premature mortality is influenced by existing scientific and actuarial interests or the goals set.

Keywords: *premature mortality, PYLL, lifespan disparity, age threshold*

Mortalitatea prematură este un concept foarte complex şi, deşi este larg studiat în literatura de specialitate, nu există un consens asupra definiţiei sale. Acest studiu îşi propune să compare două modele diferite de analiză a mortalităţii premature pentru a-l evidenţia pe cel mai potrivit contextului naţional. Actualitatea acestui studiu este determinată de nivelul de mortalitate observat în Republica Moldova şi în special de problematica nivelului de mortalitate a bărbaţilor adulţi. Pentru atingerea acestui obiectiv, au fost comparaţi următorii indicatori: proporţia deceselor până la un anumit prag de vârstă, Ani Potenţiali de Viaţă Pierduţi (APVP), disparitatea duratei de viaţă şi pragul de vârstă derivat din disparitatea duratei de viaţă. Analiza a fost efectuată sub aspect comparativ. În acest scop, studiul analizează date din Cehia şi Elveţia. În cazul Republicii Moldova, este destul de complicat să se identifice un set de indicatori universal acceptaţi care să permită monitorizarea mortalităţii premature. Indicatorii clasici sunt influenţaţi de structura pe vârste şi numărul populaţiei. Indicatorii de abordare în dinamică sunt scutiţi de influenţa structurii de vârstă şi numărul populaţiei, dar au o metodologie mai complexă şi sunt mai complicat de interpretat. Cu toate acestea, stabilirea şi promovarea unui astfel de set de indicatori este, fără îndoială, necesară. Este important de menţionat că alegerea indicatorilor pentru monitorizarea mortalităţii premature este influenţată de interesele ştiinţifice şi actuariale existente sau de obiectivele prestabilite.

Cuvinte cheie: *mortalitate prematură, APVP, disparitate de viaţă, prag de vârstă*

Преждевременная смертность – очень сложное понятие, и, хотя оно широко изучается в специальной литературе, единого взгляда по его определению нет. Целью данного исследования является сравнение двух различных моделей анализа преждевременной смертности, чтобы выделить наиболее подходящую для национального контекста. Актуальность данного исследования определяется уровнем смертности, наблюдаемым в Республике Молдова, и, в частности, вопросом уровня смертности взрослых мужчин. Для реализации этой цели сравнивались следующие показатели: доля смертей до определенного возрастного порога, Потерянные Годы Потенциальной Жизни (ПГПЖ), потери продолжительности жизни из-за преждевременной смерти и возрастной порог, полученный из данного показателя. Анализ проводился в сравнительном аспекте. С этой целью в исследовании были проанализированы данные по Чехии и Швейцарии. В случае с Республикой Молдова, довольно сложно определить общепринятый и единственный набор показателей, который позволил бы осуществлять мониторинг преждевременной смертности. «Классические» показатели подвержены воздействию возрастной и численной структуры населения. Показатели «динамического» подхода освобождены от влияния возрастной и численной структуры населения, но имеют более сложную методологию и более сложны для интерпретации. Однако создание и продвижение набора показателей для мониторинга преждевременной смертности, несомненно, необходимо. Важно отметить, что на выбор показателей для мониторинга преждевременной смертности влияют существующие научные или актуарные интересы или поставленные цели.

Ключевые слова: *преждевременная смертность, ПГПЖ, потери продолжительности жизни из-за преждевременной смерти, возрастной порог*

INTRODUCTION

Mortality is a basic demographic process, but at the same time, it is also a process with a high socioeconomic impact. Every death is an irreparable loss with substantial implications at a personal and societal level, but premature deaths usually create more profound and complex consequences.

The Republic of Moldova is characterised by the mortality pattern specific to East European countries. It is distinguished by the high-level mortality of the adult population, especially in the case of males, which determines the stagnation of life expectancy levels and maintenance of the deep gender gap. In this regard, premature mortality becomes one of the more critical aspects of mortality analysis because it allows us to focus on the exact group and analyse it exclusively to understand and react/intervene in the specific population segment.

Even though premature mortality is a subject of great importance and is widely studied in the specialised literature, there is no broad agreement on its definition. This study aims to compare two different methods of analysis of premature mortality – the classic and the dynamic one – and to present which is the best and most efficient in research and evidence of premature mortality. The actuality of this study is determined by the mortality level observed in the Republic of Moldova and particularly by the issue of adult male mortality level.

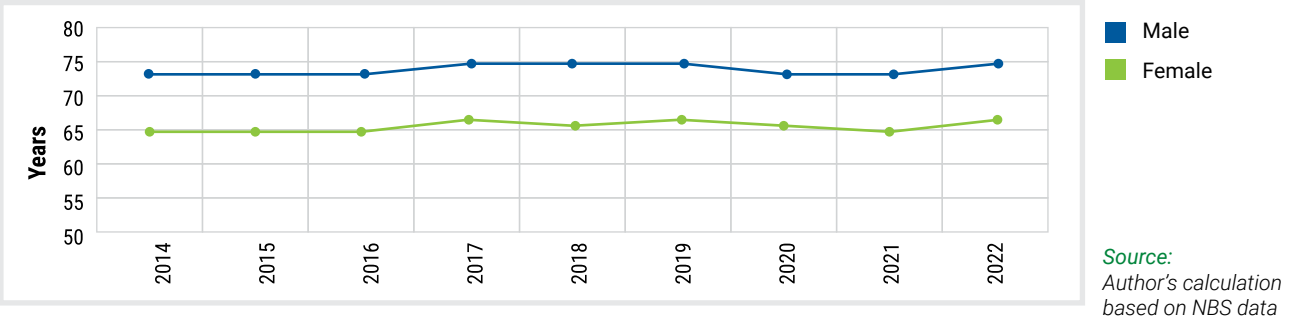
Premature mortality is an essential tool for analysing the population's health level and the health system as a whole. The earlier deaths suggest the existence of more health problems in the population, but also some intervention deficiency or inadequate preparation of the health system to respond to the existing issues. Also, premature mortality is highly linked to the quality of primary care. Studies in the field highlighted that proper and qualitative primary care can help avoid and reduce premature mortality (Or, 2001; Nolte, Scholz, & McKee, 2004; Plümper, Laroze, & Neumayer, 2018).

BACKGROUND

In the period 2014-2022, the evolution of life expectancy at birth followed a similar trajectory for both sexes (Fig. 1). The period 2014-2017 was characterised by a clear upward trend in life expectancy at birth for both sexes, followed by a period - 2018-2019 - of stagnation in the case of women and fluctuations in the case of men. The Covid-19 pandemic strongly marked the period 2019-2021. However, the reductions in life expectancy at birth observed for both sexes overturned the general and stable tendency of evolution observed earlier. Nevertheless, 2022 is characterised by a compensatory rebound in life expectancy at birth for both sexes.

It is essential to mention that gap between sexes remained constant throughout the analysed period.

Figure 1.
Life expectancy at birth by sexes, 2014-2022



Source:
Author's calculation based on NBS data

Despite the recent trend of increasing life expectancy at birth, the Republic of Moldova remains one of the countries with the lowest values of this indicator in the European region (Penina, 2022). In the case of the Republic of Moldova, the results are much more modest due to high premature mortality, especially among men. The issue of adult population mortality, mainly male mortality, is a characteristic pattern in the ex-Soviet Eastern European space (Penina, 2022; Kuznetsova, 2021; Grigoriev, et al., 2020). However, the life expectancy at birth indicator is composite, presenting more of an overall average of the mortality situation, which can mask certain specific features (Andreev, 2021). In this context, premature mortality becomes a very effective tool in analysing the mortality situation, focusing research attention on a specific population group, namely the group with the highest potential for development and productivity.

LITERATURE REVIEW

The concept of premature mortality is very complex, with a high interrelation with all life aspects – health, social, and economic. Premature mortality is extensively researched in the field literature (Committee on Population; National Research Council, 2015). For the first time, Dempsey introduced the concept in the second half of the '40s (Dempsey, 1947). After that, the concept of premature mortality was developed, and different aspects were analysed. However, a broad agreement on it does not exist. Premature mortality represents the total number of deaths that take part up to one age threshold, or in other words, are all untimely deaths. So, the main debates are around the age at which one death could be considered premature or normal/late. It is necessary to highlight that in this research, we will focus mainly on two distinct approaches – the classical and dynamic ones.

The classical approach is supposed to have a stable age threshold set by the researcher. However, the dynamic approach uses the dynamic age threshold, determined by the evolution of general mortality. Mazzuco and colleagues compared two approaches and presented a different one through a combination of the first two (Mazzuco, Suhrcke, & Zanotto, 2021). Although specific methodological approaches regarding premature mortality analysis can be outlined in general terms, there is still no consensus on the age threshold, even within the same approach. So, in the research from the field, different ages were used as the exact age threshold – 65 (French National Institute for Statistic and Economic Studies, 2023; Eurostat, 2002; Eames, Benshlomo, & Marmot, 1993), 70 (OECD, 2011), 75 years (Wong, Shapiro, Boscardin, & Ettner, 2002).

The second approach is focused on linking premature mortality with the evolution of general mortality (Ray, 2017; Vaupel, Zhang, & van Raalte, 2011). Ray mentioned that premature mortality is unattained life expectancy (Ray, 2017). So, he states directly the link between premature mortality and the evolution of general mortality. In this case, the general idea is that one death could be considered premature or not regarding the general level of mortality. Therefore, in one case, the same age of death could be considered premature, while in another, a "late" one. Other researchers link premature mortality with inequality in lifespan (Shkolnikov, Andreev, Zhang, Oeppen, & Vaupel, 2011; Vaupel, Zhang, & van Raalte, 2011). This approach allows us to highlight the link between health, inequalities and mortality. In their research, Shkolnikov and colleagues analysed lifespan inequality through the lifespan disparity indicator and mentioned that lifespan disparity represented the lost life years due to death (Shkolnikov, Andreev, Zhang, Oeppen, & Vaupel, 2011). Vaupel and colleagues analysed the link between lifespan disparity and life expectancy at birth. They highlight the age at which death could be considered premature in light of lifespan disparity. Also, they stated that a reduction in mortality up to this age could reduce lifespan disparity and increase life expectancy at birth (Vaupel, Zhang, & van Raalte, 2011).

The subject of premature mortality is studied from different perspectives at the international level, but last time, the subject started to be more studied at the national level as well. In this research, we will focus on the methodological part of this issue, which will be analysed through the national studies and documents that treat the subject of premature mortality in this light.

At the national level, the importance of premature mortality is reflected in the National Program for the Prevention and Control of Non-Communicable Diseases. This program analyses premature mortality in the context of non-communicable diseases, focusing on specific causes of death. Additionally, the age group representing the target of the premature mortality concept is highlighted, which is 30-69 years old (Ministry of Health, 2022). In a broader context, premature mortality goes beyond this age group and requires a set of specific indicators that would allow monitoring the evolution of life expectancy at birth. Also, most studies that analyse premature mortality in the national context use a classical approach with some exact age thresholds stated by researchers (Pahomii, 2018; Raevschi, 2017; Penina & Raevschi, 2017). In the national studies, the age threshold of 65 (Pahomii, 2018) and 70 (Penina & Raevschi, 2017; Raevschi, 2017) are more often used.

DATA SOURCES AND METHODS

This research is based on the data available on the National Bureau of Statistics (NBS) database. In order to perform the proposed analysis, the mortality and exposure population data were retrieved from the NBS database. The used mortality data are represented by the number of deaths by age and sex. The exposure population is available with an open interval of 85+ years. Because of that, our analysis used that open-age interval.

In this research, the classical as well as the dynamic approach was applied in the analysis of premature mortality.

In order to achieve the proposed objectives, life expectancy at birth, the proportion of deaths, PYLL (Potential Years of Life Lost) by the specific ages, lifespan disparity and age threshold derived from the lifespan disparity were calculated. Life expectancy at birth was calculated to present the general situation on mortality. The share of premature mortality, PYLL up to specific age, lifespan disparity and age threshold derived from lifespan disparity were calculated to assess the level of premature mortality.

The share of premature mortality was calculated up to 65, 70 and 75 years, and these ages also were used as age thresholds for PYLL calculation. These ages are most often used in research on premature mortality in the field. The OECD materials define PYLL as "a summary of premature mortality" (OECD, 2023). The calculation principle is straightforward; it involves summing up deaths occurring at each age and multiplying this with the remaining years to live up to a selected age threshold.

Lifespan disparity ($e^{\dagger}$ - *e-dagger*) is the measure of lifespan variation, and it is defined as the average remaining life expectancy when death occurs or life expectancy/life years lost due to death (Vaupel & Romo, 2003; Shkolnikov, Andreev, Zhang, Oeppen, & Vaupel, 2011). It weights the average remaining life expectancy at age x by the number of life table deaths at age *x* (Kibele, 2012).

The discrete form of this is expressed as follows:

$$e^{\dagger} = \sum_{y=0}^{\omega-1} d_{\alpha} \bar{e}_{\alpha} \quad (1.1)$$

Where,
ω- is the highest age group, in our case, 110 years;
ē - is the average remaining life expectancy;
α- age.

The age threshold derived from $e^{\dagger}$ was calculated in the base of the formula proposed by Zhang and Vaupel (Zhang & Vaupel, 2009) So, the age threshold can be identified based on the following relationship:

$$e^{\dagger} = e(a) * (1-H(a)) \quad (1.2)$$

Where,
$H(a)$ – cumulative hazard to the age a;
a – age.

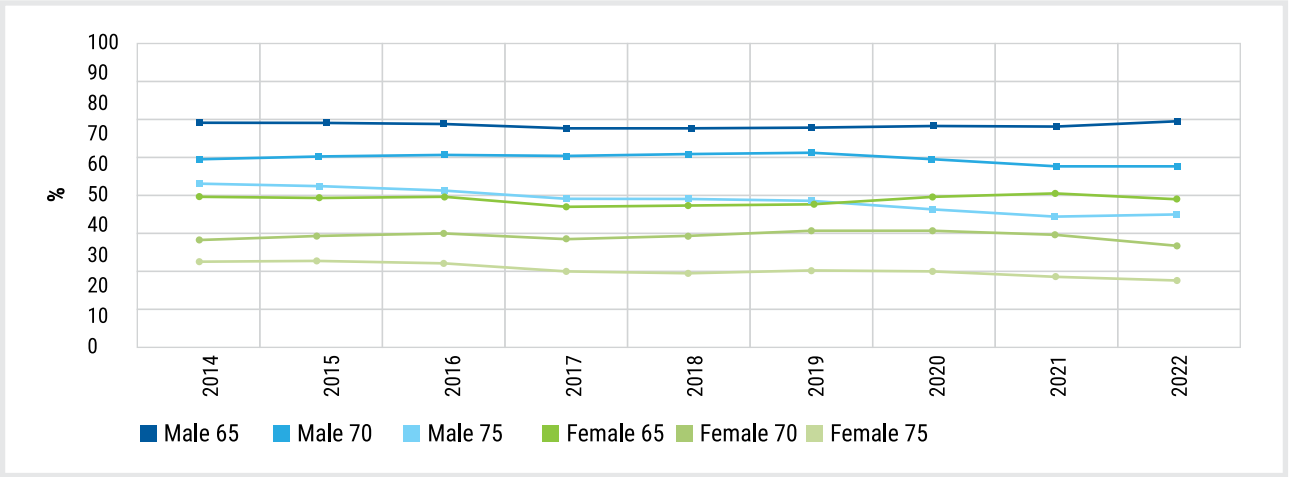
Data used in the analysis include the period 2014-2022. The analysis refers to this period in order to avoid issues caused by the quality of data. The data starts with 2014 and refers to the population with stable residence. Thus, long-term migrants are excluded from the population, which allows us to avoid the problem of overestimating the number of the population.

MAIN RESULTS

In the context of this research, various age thresholds, considered classical in premature mortality analysis, were analysed. The analysis of the proportion of deaths before specific age thresholds clearly shows existing disparities between sexes (*Fig. 2*). During the analysed period, the differences between sexes ranged between 20 and approximately 30 percentage points. Additionally, between 2014 and 2022, there was an observed reduction in the proportion of premature mortality for the age threshold of 65 years. Specifically, the proportion of deaths before the age of 65 decreased by 10.3% for men and 6.4% for women during this period, resulting in 43.5% for men and 21.6% for women in 2022. The proportion of deaths before 70 and 75 remained essentially constant for both sexes. Although there seemed to be a slight decrease in the proportion of deaths before 75 in the case of women, this trend was disrupted during the pandemic.

However, in 2022, specific signs, although still not significant, indicate a reduction in the proportion of deaths before 75, suggesting a potential return to the decreasing trend observed earlier. For men, the proportion of deaths before the age of 70 remained practically constant throughout the analysed period, and there was even a slight increase in the proportion of deaths before the age of 75 in 2022. It is essential to mention that the impact of the pandemic is less reflected in the observed data for men than women based on this indicator.

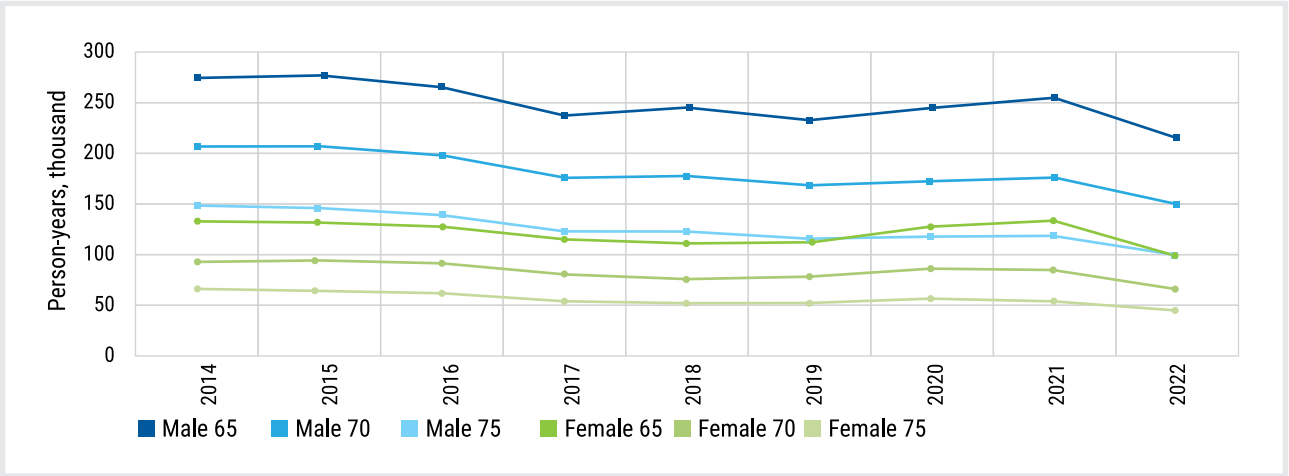
Figure 2.
Share of deaths at specific ages by sex, %



Source: Author's calculation

The PYLL (Potential Years of Life Lost) indicator analysis presents the evolution of premature mortality through potential years of life lost. PYLL was also calculated based on three age thresholds to capture the differences they determined. The evolution of PYLL for all analysed age thresholds clearly shows a decreasing trend in premature mortality until 2019 (Fig. 3), followed by an increase in premature mortality during the pandemic from 2019 to 2021 and a compensatory decrease observed in 2022. Disparities between sexes remained practically at the same level throughout the analysed period, and this situation applies to all age thresholds. Additionally, it is necessary to highlight that the evolution of the PYLL indicator is much more consistent for women. In contrast, fluctuations were observed for men even during the pre-pandemic period.

Figure 3.
PYLL at specific ages by sex, person-years, thousands



Source: Author's calculation

Lifespan inequality is a relatively new method of analysing premature mortality, focusing more on the disparities in the observed lifespan within a population. The evolution of lifespan inequality has shown a fluctuating pattern for both sexes (Fig. 4). It is essential to mention that the indicator evolved differently for both sexes, with the pre-pandemic period until 2019 and the period from 2019 to be highlighted separately.

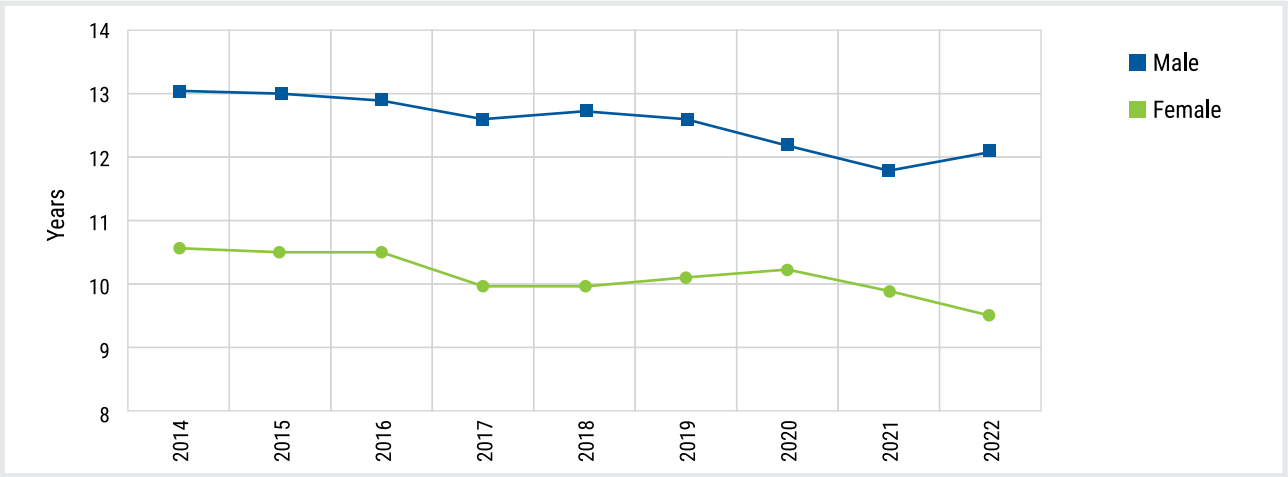
A slow but constant indicator reduction is observed for males until 2018. Subsequently, the reductions continue during the pandemic, intensifying in 2021. This suggests that the inequalities in the age of death for men have continuously decreased, but the reasons for these reductions will be addressed later. In 2022, an increase in the indicator was noticed for men. Overall, over nine years, inequalities between men decreased by 0.9 years.

For females, the period from 2014 to 2016 is characterised by stagnation. Inequalities in the age of death for women caused a loss of 10.6-10.5 years during this period. However, in 2015, a reduction of 0.5 years was observed, reaching ten years, and the reduction continued at a much slower pace the following year, only 0.1 years. The pandemic and post-pandemic periods determine the significant differences between the sexes. While reductions continued for men, a rise in inequalities was observed for women, leading to an increase in the indicator. However, this increase was observed only for 2019-2020, after which the reduction trend and return to the previous trend continued. In 2022, the lifespan disparity for women was 9.5 years, with a reduction of 1.1 years in the indicator compared to 2014.

Disparities between sexes remained practically identical during the analysed period. At the beginning of the reference period, the differences between men and women were 2.4 years, reaching a maximum of 2.7 years in 2018 due to antagonistic trends observed for both sexes in that year. The minimum values were observed in 2020-2021, with a difference of 1.9 years. By the end of the analysed period, disparities between sexes were 2.6 years.

Figure 4.

Lifespan inequality measured by e†, by sex, years

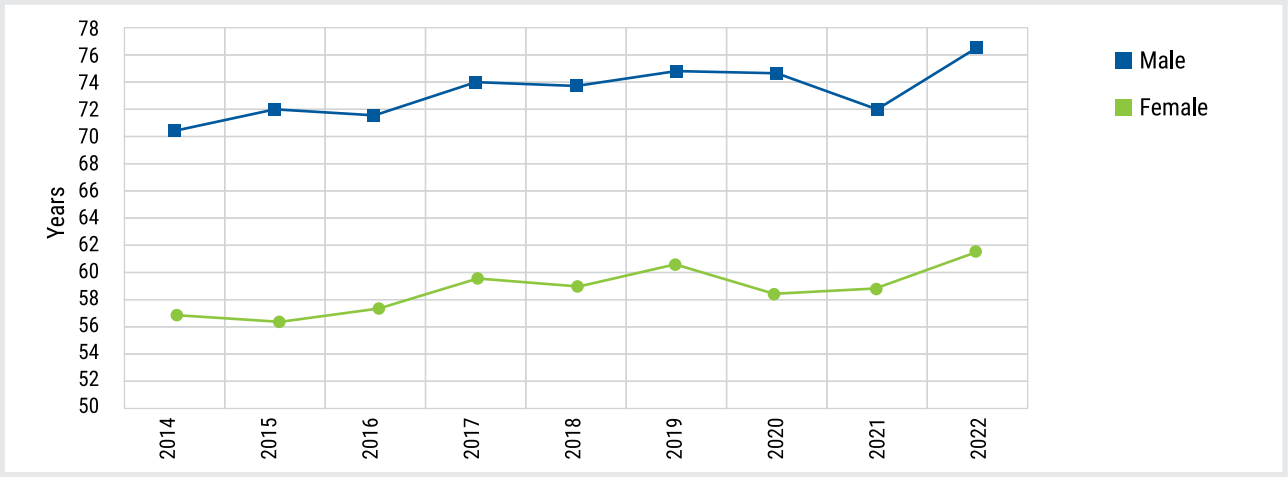


Source: Author's calculation

Lifespan disparity could be reduced, but to decrease the differences in life duration and age at death, mortality must be reduced for specific age groups. Thus, the age threshold derived from $e^{\dagger}$ indicates the age until mortality reduction positively impacts reducing the variation in age at death. In other words, this age threshold separates "early" from "late" deaths. Therefore, we can conclude that this age is, in fact, the age threshold for premature deaths.

Figure 5.

Age-threshold derived from $e^{\dagger}$ - $a^{\dagger}$, by sex, years



Source: Author's calculation

Because this indicator is derived from $e^{\dagger}$, it defines different age thresholds for males and females. One of the alarming factors is the increasing disparities between sexes during the analysed period (*Fig. 5*). In 2014, the disparities between sexes were 13.4 years, and at the end of the analysed period, they reached 14.9 years. The highest difference between sexes was observed in 2020 when the female age threshold was 16.1 years higher compared to males. In 2014, females started with values of 70.2 years for the age threshold, and this threshold increased by 6.3 years by the end of the analysed period, reaching 76.5 years. The age threshold registered for males at the beginning of the observed period was 56.8 years, and it increased by only 4.7 years until 2022, reaching 61.6 years. For both sexes, a decrease in the age threshold was noticed during the pandemic period. The reduction was more pronounced for females, reaching the reduction peak in 2021, and a compensatory increase was observed in 2022. Similarly, for males, a compensatory increase was observed in 2022, the beginning of which was noticed as early as 2021.

DISCUSIONS

The classic and dynamic approaches have its strengths and weaknesses. Thus, one of the classic approach's main strengths is its transparent methodology and replicability due to methodological simplicity. However, the indicators used in this research also have certain limitations.

The population's age structure heavily influences the indicator of the proportion of deaths up to a certain age. Therefore, these indicator is straightforward to interpret but can introduce significant errors, especially for comparing different populations or periods. Moreover, the analysis demonstrated how much the chosen age threshold influences this indicator. PYLL is another indicator exposed to the influence of population structure and size, but standardisation procedures can reduce this impact. PYLL can be considered an indicator with a higher level of credibility, which also allows for international comparisons, as it is used by several international organisations (OECD, 2023; Eurostat, 2002). Thus, if the issue of errors induced by population size and structure for this indicator can be eliminated, another aspect and topic of discussion remain – how the age threshold is chosen. Methodologically speaking, there is no clear solution; the age threshold is often selected depending on the research interest (Mingot, Rué, & Borrell, 1991; Wise, Livengood, Berkelman, & Goodman, 1988). While there is typically a reference to the evolution of overall mortality levels, it is not mandatory to adhere to it. One solution is adopting the age threshold promoted by international organisations, but in this case, we must ensure its usefulness and accurate reporting concerning national realities. We must consider the relatively high level of premature mortality in males and the significant discrepancies caused by this between sexes.

Lifespan disparity helps identify and highlight health disparities within a population. This indicator is more complex to analyse comparatively between different populations and has a more complex methodology than indicators from the classic approach. However, lifespan disparity allows for capturing the connection between mortality and health. It is important to note that premature mortality results from inequality in opportunities for better health or healthcare services. A high variation in the age of death indicates that the average does not characterise most of the population. Similarly, age thresholds derived from lifespan disparity allow for establishing the threshold at which deaths can be considered premature or "late" (ZhangF & Vaupel, 2009). It is essential to mention that reducing mortality before this age also reduces lifespan disparity, while reducing mortality after this age increases lifespan disparity.

Each approach is valid, and each set of indicators can be applied depending on the research interest. For international monitoring and comparability, the classic approach is more practical and is accepted and used by several international organisations. In scientific terms, the dynamic approach is more effective as it proposes methodologically justified solutions. However, results obtained through the dynamic approach are more complex to interpret compared to the classic approach. For this reason, a clear purpose and approach must exist in analysing premature mortality to create and promote an efficient scientific framework with a high degree of applicability and utility.

CONCLUSIONS

The analysis of the indicators has shown that regardless of the method of analysis considered, the differences between sexes remain very pronounced. Thus, the premature mortality rate among males is 1.5-2 times higher than among females. At the same time, there is a decreasing tendency of premature mortality in

both sexes. Indeed, the trend in premature mortality fluctuates and is relatively slow, but the overall trend is toward reduction. The impact of the Covid-19 pandemic is undeniable and has been recorded for each of the utilised indicators.

In the case of the Republic of Moldova, it is quite complex to identify a universally accepted set of indicators that would allow for the monitoring of premature mortality. However, establishing and promoting such a set of indicators is unquestionably necessary. This fact is primarily determined by the relatively high level of premature mortality, especially among males. Additionally, the choice of indicators for monitoring premature mortality is influenced by existing arguments or the goals set in the initial stages. Suppose the Republic of Moldova aims to create a framework that could be reported and integrated into the international statistical system or international statistical/informational bodies. In that case, these indicators must align with the options these organisations promote. In this case, most international bodies operate with PYLL to analyse and monitor premature mortality.

If the goal is to examine the evolution of premature mortality at the national level while promoting targeted actions and policies, then indicators from a dynamic approach are more valuable. These indicators outline the situation regarding premature mortality and highlight the existence of inequalities in terms of mortality. Moreover, identifying an age up to which reducing mortality allows for the reduction of inequalities in the population is extremely valuable. In this scenario, the efforts and actions of all stakeholders can be focused on specific population groups, enabling the maximisation of efforts' effectiveness and an increase in equity in terms of population health.

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